INDUSTRIAL SOLVENTS

POLLUTION PREVENTION HANDBOOK

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Prepared for the Department of Environmental Resources by:

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Through a Cooperative Agreement between U.S. EPA, and the Center for Hazardous Materials Research (CHMR), CHMR established and is operating a Pollution Prevention Technical Assistance Center for EPA Region III and the Region III States.

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This handbook has been prepared to provide information and guidance for identifying pollution prevention opportunities in the use of industrial solvents. The information and guidance is intended to help the user identify and implement pollution prevention practices in order to comply and, where possible, exceed the broad set of Federal, State, and local environmental regulations which apply to industrial solvent use.

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1.1 SOLVENT TOXICITY

Although organic solvents have excellent cleaning properties, many of them are considered hazardous to human health and the environment. The negative environmental and health-related attributes of solvents, particularly halogenated ones include:

- Toxicity
- Flammability
- Ability to dissolve landfill liners
- Ability to carry other toxics
- High volatility
- Contribution to smog
- Long half-life
- Toxic degradation products
- Resistance to biodegradation
- Stratospheric ozone depletion

In addition, solvent wastes were among the first to be banned from land disposal by the U.S. Environmental Protection Agency. Figure 1-1 provides a suggested "toxicity rating" for many common organic solvents used in industrial activities. (A more complete description of these common solvents and solvent categories is also provided in Section 2.3.4.) These solvents are organized into four groups as follows:

**Group I**

Organic solvents listed in Group I are generally preferred substitutes for those listed in Groups II thru IV. These organic solvents are **NOT** currently:

- Listed hazardous air pollutants (HAP)
- Listed SARA 313 toxic chemicals
- Listed CERCLA hazardous substances
- Suspect or demonstrated carcinogens

Many of these organic solvents are nevertheless flammable or ignitable, and wastes generated from their use may be subject to RCRA regulatory requirements.

In addition, depending on the industrial process and site specific considerations, any organic solvent may emit VOCs which may be subject to the Clean Air Act provisions which require states to attain and maintain National Ambient Air Quality Standards (NAAQS) for ozone.

**Group II**

Organic solvents listed in Group II are **NOT** currently listed "hazardous air pollutants" and are generally preferred substitutes for those listed in Groups III and IV. However these organic solvents are:

- Listed SARA 313 toxic chemicals and/or
- Listed CERCLA hazardous substances

and efforts should be made to identify less toxic substitutes for these organic solvents.

**Group III**

Group III organic solvents are all listed "hazardous air pollutants," and many are also:

- Listed SARA 313 toxic chemicals
- Listed CERCLA hazardous substances

**Group IV**

Organic solvents listed in Group IV are all:

- Halogenated (chlorinated) hydrocarbons
- Listed hazardous air pollutants (HAPs)
- Listed SARA 313 toxic chemicals
- Listed CERCLA hazardous substances

Many of these organic solvents are also suspect or demonstrated carcinogens.
### GROUP I

<table>
<thead>
<tr>
<th>Chemical Name</th>
<th>Category</th>
<th>CAS</th>
<th>TWA</th>
<th>depF</th>
<th>FL/P</th>
<th>mm</th>
<th>V.P.</th>
<th>CAA</th>
<th>NAP</th>
<th>313</th>
<th>Tox</th>
<th>CERCLA</th>
<th>Haz.</th>
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</thead>
<tbody>
<tr>
<td>d-limonene (major ingredient of terpenes)</td>
<td>AllHyd</td>
<td>5989-27-5</td>
<td>N.L.</td>
<td>120</td>
<td>-</td>
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<td>N-alkyl pyrrolidine (NAP; 2-pyrrolidinone)</td>
<td>Amine</td>
<td>616-05-5</td>
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<td>230</td>
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<td>N-methyl-2-pyrrolidine (NMP)</td>
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<td>44</td>
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<td>isopropyl alcohol (isopropanol; rubbing alcohol)</td>
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<td>33</td>
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<td>mineral spirits (petroleum distillates/naphtha)</td>
<td>AllHyd</td>
<td>8002-05-9</td>
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<td>40</td>
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### GROUP II

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<th>Ether</th>
<th>60-29-7</th>
<th>400</th>
<th>440</th>
<th>49</th>
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<td>Acetone</td>
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<td>67-64-1</td>
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<td>78-92-2</td>
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<td>75</td>
<td>24</td>
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<td>no</td>
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<td>82</td>
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<td>no</td>
<td>5000</td>
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<td>n-butyl alcohol (n-butanol)</td>
<td>Alcohol</td>
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<td>50</td>
<td>99</td>
<td>6</td>
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<td>Yes</td>
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### GROUP III

<table>
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<th>Methyl alcohol (methanol)</th>
<th>Alcohol</th>
<th>67-56-1</th>
<th>200</th>
<th>52</th>
<th>92</th>
<th>Yes</th>
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<tr>
<td>Methyl ethyl ketone</td>
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<td>78-93-3</td>
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<td>71</td>
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<td>Yes</td>
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<td>Ethylene glycol monoethyl ether (cellosolve; 2-ethoxyethanol)</td>
<td>GlyEth</td>
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<td>120</td>
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<td>CAS</td>
<td>TWA</td>
<td>degF</td>
<td>VP</td>
<td>min</td>
<td>CAA HAP</td>
<td>313 Tax.</td>
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<td>xylene</td>
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<td>43</td>
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<td>Alcohol</td>
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<td>230</td>
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<td>cyclohexanone</td>
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<td>morpholine (diethyleneimide)</td>
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<td>20</td>
<td>100</td>
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<td>formaldehyde (formalin)</td>
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**GROUP IV**

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<th>degF</th>
<th>VP</th>
<th>min</th>
<th>CAA HAP</th>
<th>313 Tax.</th>
<th>CERCLA Haz.</th>
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<tr>
<td>methylene chloride</td>
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<td>1,1,1-trichloroethane (methyl chloroform)</td>
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<td>nap</td>
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<td>Yes</td>
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<td>100</td>
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<tr>
<td>1,1,2-trichloroethane</td>
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</table>

**Notes:**

- Propylene glycol mono-methyl ether acetate does not have a CAS #. Its ingredients include 1-methoxy-2-acetopropane (97%) with CAS # 108-65-8; and 2-methoxy-2-acetopropane (3%) with CAS # 70457-70-4.
- Glycol ether acetate is a generic name for a group of organic solvents.
- Not listed by OSHA in Table 2-1-A "Limits For Air Contaminants", 29 CFR 1910.1000
- Flash point in degrees F
- Vapor pressure mm Hg at 68 degrees F
- Listed as a "toxic chemical" pursuant to the CAA
- Listed as a "hazardous substance" pursuant to SARA title III, Section 313
- Not applicable

<table>
<thead>
<tr>
<th>Chemical Abstract Service Number</th>
<th>TWA Time Weighted Average (NIOSH/OSHA recommended exposure limit concentrations ppm for up to a 10-hour workday during a 40-hour workweek)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAS</td>
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</tbody>
</table>
1.2 POLLUTION PREVENTION IS AN ECONOMICALLY SOUND ENVIRONMENTAL STRATEGY

Economic factors influence environmental action. Higher disposal costs, increased liability, and new regulations have caused us to seek ways to address costs, and at the same time to lessen the accompanying environmental demands.

There exists opportunities for industry to meet and, in many cases, exceed these demands. The most rational and effective means is to reduce or prevent pollution at the source through cost-effective changes in production, operations, and use of raw materials.

Indeed pollution prevention is the premier waste management strategy because unlike pollution control which costs money, waste reduction can save money.

1.2.1 INCREASED PROFITS THROUGH POLLUTION PREVENTION EFFORTS

Initially, many companies implemented pollution prevention because of new regulations and rising waste disposal costs. However, nearly all these companies later realized other, equally important benefits, including:

- Lower operating costs from the substitution of less expensive raw materials
- Lower energy costs through the use of newer, more efficient equipment
- Improved product quality
- Increased safety from reduced employee exposure to hazardous materials
- Reduced regulatory requirements
- Improved public image

Experience in pollution prevention efforts indicate that sound resource management results in simultaneous economic and ecological benefits. These experiences show that:

- Waste reductions can range from 20 to 98 percent.
- Payback periods for waste reduction investments typically range from immediate to 5 years.
- Firms which handle fewer hazardous materials reduce hazards to their workers and the environment — and experience fewer long-term liability claims.

Thousands, even millions, of dollars are being saved, not just in disposal costs, but in reduced expenditures on energy, fuel, water, and raw materials. In other words, waste reduction is economically as well as ecologically sound.

It's simply good business!

1.2.2 THE POLLUTION PREVENTION HIERARCHY FOR WASTE MANAGEMENT DECISION-MAKING

Over the past two decades, Americans have developed an increased awareness of the harmful effects from uncontrolled pollutant releases. Initially this led to a waste management strategy which emphasized control and cleanup of pollution after it is generated.

Now the nation is turning its attention to preventing waste problems by reducing the generation of waste at its source. As a result, the following new hierarchy for waste management decision-making is evolving as the new national policy for waste management.

- First, consider source reduction options — any activity that reduces or eliminates the generation of a waste within a process.
- Next, consider recycling — this is the use, reuse, or reclamation of a waste either on- or off-site after it is generated by a particular process.
- Next, consider treatment to reduce the toxicity of the waste.
- Finally, and only as a last resort, consider land disposal.

1.2.3 SOLVENT POLLUTION PREVENTION

Due to the diverse problems associated with solvent use, they should be used only when no other cleaner is suitable for the job. Waste solvents can be reduced by:

- Eliminating the need to use solvent
- Finding adequate substitutes for solvent
- Minimizing losses from solvent use
- Segregation, recycle, and reuse

Chapters 2.0 through 4.0 provide further information on this pollution prevention approach. The following provide numerous examples which illustrate the benefits of this approach.
1.3 CASE STUDY EXAMPLES OF SOLVENT POLLUTION PREVENTION

1.3.1 ACETONE CLEANING
Solvent Substitute

At Wellcraft Marine Corporation, a Florida manufacturer of recreational boats, acetone was used as a solvent to clean polyester resin from tools and equipment. In 1989, Wellcraft was responsible for 18.5 percent of Florida’s acetone emissions. Today, as a result of a solvent substitution, the company produces less than one percent of the total.

Need for change

According to the 1989 Toxic Release Inventory (TRI) data, Wellcraft released almost 2 million pounds of acetone to all media that year, including 1.3 million pounds of air emissions.

The TRI data, coupled with three minor acetone related fires at the company's facilities, persuaded company officials to investigate operational changes to cut emissions.

Solvent substitution

Wellcraft set up a chemical screening committee to consider and evaluate solvent substitutes. After two years of testing and evaluation the committee found and approved a low vapor-pressure solvent, diacetone alcohol (DAA), which works as well as acetone but is less volatile. Tests indicated that due to the significantly lower vapor pressure, DAA would emit 90.9 percent fewer VOCs than acetone.

Working together with employees

Although DAA was the right solvent substitute for Wellcraft, more testing and employee training had to be completed to ensure a smooth transition. Employees were introduced to procedural modifications and different maintenance routines. Management also responded to the workers concerns by explaining DAA’s overall benefits, namely: DAA is less flammable and will make the workplace safer; and volatile emissions that contribute to smog will be reduced.

Benefits

The solvent substitution was a winner for Wellcraft and its employees. The company’s effort to replace acetone solvent:

- Saved over $200,000 per year from
  - Reduced solvent purchases
  - Reduced operational costs
  - Reduced utility (electric) costs
  - Reduced waste treatment/disposal costs
  - Met state/federal waste-minimization goals
  - Reduced potential liabilities
  - Protected worker & public health & safety
  - Protected the environment

1.3.2 SUBSTITUTE SOLVENT CLEANER IN PRINTING

An industrial laundry in Minneapolis, Minnesota was notified to urgently resolve an explosive atmosphere problem discovered at its facility. One customer, the John Roberts Co., came to the assistance of the laundry by examining its solvent blends and their uses.

The evaluation found that the press operators were using a highly volatile solvent as an all-purpose cleaner. The highly volatile emissions were caused by the cleaner, a blend of acetone, toluene, methyl ethyl ketone and isopropyl alcohol. It was also estimated that 46 percent of the solvent evaporated before it was used, resulting in exceptionally high emissions -- and an expensive and inefficient operation.

Solvent substitution

A solvent substitute was considered that would accommodate the company’s production pace. The substitute blend was a combination of Filmcol A2/200, Toluol, Rule 66 mineral spirits and a small amount of 1,1,1-trichloroethane.

Procedural changes, solvent recycling

The company also determined that a substantial excess solvent remained in the shop towels prior to laundering. As a result, the company:

- First, reviewed and adapted operational procedures to eliminate excess solvent added to the soiled towels
- Second, installed a commercial-grade centrifuge to wring out and retain the solvent from the shop towels.

The centrifuge recovered nearly 100 gallons of spent solvent a week, that otherwise would have gone into the laundry’s effluent. The company was also able to reuse the recovered solvent to clean press ink trays, thereby eliminating the need to purchase 55 gallons of virgin solvent normally used for this purpose.

Benefits

- Volatile/toxic emissions were greatly reduced to within regulatory limits.
- Reduced evaporative losses, significantly reduced overall solvent purchase.
- Annual cost is $15,000 for part-time personnel, maintenance and energy.
- Annual savings is $52,000 from solvent substitution and centrifuge recovery.

(Source: Hazmat World, February 1992)
### 1.3.3 Electronics Manufacturer

**Substitutes For CFC Solvent Cleaners**

IBM's Rochester plant, which manufacturers computers and components, recently won the 1992 Minnesota Governor's Award for Excellence in Pollution Prevention for eliminating CFCs.

According to TRI data, the facility emitted 775,000 pounds of CFCs in 1988 -- the fifth largest volume of emissions in the country that year. On December 18, 1991, the plant shut down the last cleaner that used CFCs.

The plant converted the majority of its cleaning processes to aqueous systems, eliminating the need for solvent-based cleaning.

Aqueous systems were found to be at least as effective as CFCs for cleaning and processing parts. The aqueous systems, which contain small amounts of surfactant, were excellent for removing organic contamination, as well as normal particulates and contaminants.

In addition, it was necessary to develop processes which would eliminate surface moisture after cleaning. Plant engineers developed baskets and fixtures to hold parts so the water would drain away as they were raised out of the rinse baths.

The aqueous process is similar to a dishwasher, in which a small amount of soap, or surfactant, removes the particles and dirt from the surface. The system then rinses parts with de-ionized water, which leaves an ultra-pure surface and dries them quickly to avoid water spotting & recontamination.

The facility estimates it spent $8 million in capital on the program and will save $16.2 million over the next seven years.

(Source: Hazmat World, April 1992)

### 1.3.4 Waterborne Chemical Milling Maskant For The Aerospace Industry

Malek, Inc., a San Diego based coatings technology firm, has developed a waterborne chemical milling maskant for use by the aerospace industry in order to lighten parts that are too thin or fragile to be machined by traditional methods.

According to the company "traditional maskants contain as much as eighty percent Perchloroethylene...and only about twenty percent solids. Malek's formula contains less than five percent solvent, fifty percent solids, and the remaining forty-five percent is water. The company claims that Volatile Organic Compound (VOC) emissions are reduced by more than 90%.

The new process is more efficient in terms of surface area coverage per gallon of maskant, and in terms of operating time -- "It requires only two immersions to achieve the same results as four dips in a perc based maskant tank". According to Jerry Talson, production manager for Caspian Inc., a San Diego based chemical milling firm, "From an operational standpoint...there's very little difference in Malek's maskant and the perc based product we used before".

Malek's figures indicate real world costs of $.31 per applied square foot for Malek's product versus $.64 for a typical solvent based maskant. The lower cost of using Malek's maskant is a result of savings from improved operating efficiency -- combined with the reduced cost of pollution control equipment, reduced costs of maintaining that equipment, reduction in the quantity of perc used for thinning and cleanup, and the reduced cost of waste disposal.

### 1.3.5 "Low-waste" Painting Technology Installed By Aerospace Industry

The Aircraft Division of Northrop currently operates a 50-year old production facility located in Orange County, California, which employs 3000 people. The company recently faced a major decision: whether to mothball the existing facility and build a new one in another location; or to renovate and modernize existing production processes.

According to John Simpson, Vice President for Environmental & Physical Resources... "At a time when California has lost 60,000 aerospace jobs over the last four years, Northrop has decided to keep its business in Los Angeles. Staying in California, where environmental regulations for industry are more stringent than anywhere in the world, requires a substantial investment. We are making that investment because sound environmental practices make good business sense. We regard the area's tough standards as a part of doing business."

For Northrop, this means the development and use of clean technologies, such as a fully modernized, state-of-the-art paint and processing facility which will "control emissions at levels never before achieved by the aerospace industry."
1.3.6 Painting & Coatings

"Low-waste" Application Technology For Auto Assembly

A large auto assembly plant (60 cars per hour), converted from a traditional spray coating process to an electrostatic spray painting technique for application of the colored base coat. The electrostatic process uses one third as much paint as the conventional process to put the same amount of paint on the car. In addition to reducing raw materials costs and waste from overspray, this clean technology reduced emissions of toluene and methyl ethyl ketone (MEK) by two thirds. The plant estimates that this process conversion will pay for itself in two years.

Material Substitution & "Low-waste" Curing

A manufacturer of finished steel light standards replaced the air-dried, acrylic finish on the light standards with a powder coating cured with medium and short wave infrared radiation (IR). The same work crew now produces up to 120 finished poles a day, rather than 30. Costs for raw materials (paint) have been cut in half because 95% of the powder is actually applied to the pole, compared to 35-40% of the liquid paint. Very little cleanup is required since almost all of the powder coating adheres to the light standard. The powder coating contains no solvent, so there are no toxic fumes.

A Railroad Signal Maker utilized an ultraviolet (UV) curing technology to replace a water-based urethane coating process. This change was prompted by a need to comply with Southern California's stringent air emission standards for volatile organic compounds (VOCs). The new UV technology enabled safer, special coatings to dry much faster and maintained cleaner air. The result was an increase in production, improved process flow and handling, better compliance with Clean Air laws, and a $12,796 annual savings.

1.3.7 Substitutes for Solvent Cleaning

Small Electric Appliance Manufacturer

The Hamilton Beach Division of Scovill, Inc., manufactures small electric appliances. Scovill tested a water-soluble synthetic cleaner as a possible substitute for the 1,1,1-trichloroethane organic solvent degreaser at one of its plants. The cleaner is manufactured by the Cincinnati Milacron Company of Cincinnati, Ohio. They found the cleaner suitable for some of their applications, and have been able to reduce their 1,1,1-trichloroethane use by 30%. The Scovill plant reports a $12,000 annual savings from this substitution.

Solvent Recycling in Paint Manufacturing

In the 1980s, PPG introduced a family of new resins for industrial coatings with lower volatile organic compound (VOC) emissions. However, the distillation step to lower the VOC content produced a low-quality by-product solvent that was difficult to use or recycle. Initially, PPG consumed most of the recycled solvent in low-value applications such as plant cleaning and fuel blending.

PPG increased the solvent's value and recyclability by reformulating the resin products to eliminate extraneous solvents, and by modifying plant equipment and processes. The higher quality made purification easy. To eliminate technical and marketing objections, the purified by-product solvent was processed so it would meet or exceed the quality of the original solvent. PPG developed and tested a large number of products made from the recycled solvent. Since 1990, more than 3.4 million pounds of solvent have been recycled annually, for a net savings in excess of $900,000.

Paint Thinner On-site Distillation & Reuse

An office furniture manufacturer now saves $100 per week in solvent costs by reusing about 85% of its waste lacquer thinner. The company invested in a small solvent recovery unit, which paid for itself in about 1 year. The other 15% of the waste lacquer thinner which is not suitable for reuse is used as fuel.

Electronic Circuit Board Manufacturer

ITT Telecom reduced the quantity of waste solvents they generate by replacing a solvent based, photo resist system with an aqueous-based system. Previously, organic solvents such as 1,1,1-trichloroethane and methylene chloride were used to develop and strip the photo resist from the circuit board. The aqueous-based system uses water-miscible solvents from the glycol-ether family. The new system reduces hazardous waste generation and also improves product quality while reducing production time.
1.3.8 OTHER SOLVENT POLLUTION PREVENTION EXAMPLES

Solvent Cleaning & Paint Application

Improvements in sandblasting, cleaning, plating, and painting operations at the Tobyhanna Army Depot in Pennsylvania have reduced hazardous waste generation by 82% (751 tons per year) since 1985. Annually, avoided costs total over $550,000 for disposal, almost $7 million for environmental liability, and $400,000 for material purchases and handling. The Depot's waste minimization efforts include the following:

- Use of nonhazardous cleaners to replace hazardous ones in the ultrasonics cleaning shop.
- Use of spray gun cleaners and HVLP spraying equipment to reduce paint wastes, and recycling used thinner for reuse.

On-site Segregation & Reuse in Printing

At a label printing company, waste toluene from printing press cleanup has been eliminated by segregating the solvent according to the color and type of ink cleaned from the press. Each segregated batch of toluene is then reused for thinning the same color ink.

On-site Distillation & Reuse

The Rexham Corporation facility in Greensboro, North Carolina, is involved in the manufacture and printing of specialized product labels. Rexham installed a Cardinal distillation unit to reclaim n-propyl alcohol from their waste solvent for a total installed cost of $16,000. The distillation unit recovers 85% of the solvent in the waste stream, resulting in a savings of $15,000 per year in virgin solvent costs, and in a $22,800 savings in hazardous waste disposal costs.

Process Equipment Cleaning

The Clairol Plant in Camarillo, California, which produces hair care products, previously flushed their pipes with large quantities of water, wasting the materials inside the pipe. By installing a $50,000 system using a foam ball propelled through the pipe by air to collect the product, waste was reduced by 395 gallons per day and $240,000 was saved each year.

1.3.9 EMPLOYEE INVOLVEMENT

Mill Raises Pollution Awareness Of Workers

For 34 years, Don Alderson has worked at the USX Clairton Coke Works. Last week, for the first time, he learned how coke is made at the plant. Alderson, an electrical repair worker, is among 100 of the 1,600 employees at the coke works who have undergone a 40-hour training program to teach them the responsibilities of each worker and how their performance contributes to the coke-making process.

The course, which may be unprecedented in the steel industry, is designed to reduce plant emissions by making workers aware of the emission problems that can result if their jobs aren't done properly.

Workers are shown how improperly mixing oil and coal, or failing to close an oven door affects the process and plant emissions down the line.

Elmer Bloom, United Steel Workers of America grievance manager for the coking plant at Clairton, said the program has met with great success among the workers and has created pride and enthusiasm. "The bottom line is if we don't pay attention to the environment, who will? We care as much as the people around us. We live and work here. A smoking cap or lid or door can be prevented," Bloom said.

The program has also created considerable savings at the Clairton Plant. In 1987 the plant experienced 28 venting problems which stopped all operations at the plant. At $100 per ton and a daily output of 12,500 tons, each shutdown is costly. In 1990 with the program in place, Clairton experienced no venting accidents which required shutdown.

Employee Incentive Program Brings Savings

A plant operator at a cumene production facility discovered uncontrolled cumene vapors escaping from a pressure control vent. At the plant operators suggestion, the company installed a surplus condenser in order to return these emissions to the process.

This action resulted in the annual recovery of 400,000 pounds of cumene. Although such recovery represents less than 1/10 of 1% of total cumene production, it nevertheless translates into an annual savings to the company of over $100,000 worth of cumene.

The employee's idea arose through a corporate incentive program which provides direct financial incentives for non-management employees to identify cost reduction opportunities.
# CHAPTER 2

## POLLUTION PREVENTION PRACTICES

### Metal Parts Cleaning

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2.1 INTRODUCTION

The recommended strategy for developing effective solvent pollution prevention options for metal parts cleaning operations relies on a systematic exploration of the following sequence of steps:

1. Avoid the need to clean.
2. Select the least hazardous solvent.
3. Maximize cleaning efficiency.
4. Segregate cleaning wastes.
5. Maximize recycling and reuse.

Figure 2-1 provides a brief description of the most common metal parts cleaning methods currently used.

Figure 2-2 provides a list of the most common waste minimization practices which can be applied to solvent wastes from metal parts cleaning.

---

**Figure 2-1**

*Common Metal Parts Cleaning Methods*

**Wipe cleaning**

Wipe cleaning consists of soaking a clean rag with solvent or cleaning solution and then wiping the part clean. Usually it is associated with maintenance operations or processes that fabricate parts on a single item basis.

**Soak cleaning**

Soak cleaning consists of soaking parts in a tank of cold solvent or cleaning solution. Small parts are usually handled in a barrel or wire-mesh basket while larger parts are placed on racks. Usually used in maintenance or manufacturing operations.

- Solvent may be heated when a higher degree of cleaning efficiency is required.
- Ultrasonic cleaning is used for parts that have many crevices or hidden surfaces.

**Vapor Degreasing**

Vapor degreasing relies on hot solvent vapor condensing directly on cold parts that are inserted into the vapor space of a degreaser. When solvent vapors condense on dirty parts, the contamination is dissolved and then rinsed away.

**Diphasic cleaning**

Diphasic cleaning combines into one operation a water rinse both before and after the solvent cleaning step. Halogenated solvents and water are relatively insoluble so that when they are placed together in a tank, they will separate. The water, being less dense than the solvent, will float on top.

Therefore, the parts to be cleaned must pass through the water bath before reaching the solvent below. Upon removing the parts, they are again rinsed by the same water.

**Steam Gun Stripping**

The steam gun stripping method uses a mixture of solvents which are passed through a steam gun onto the parts to be cleaned. The soaked parts are then steamed with pure steam. This process is usually used for the removal of paint from a metal surface.

**Precision Cleaning**

Precision cleaning of instruments and electronic components requires solvents of high purity, and rapid evaporation rates. Freon compounds are customarily used for these applications.
## Pollution Prevention Practices For Metal Parts Cleaning Solvents

| Avoid or Reduce Need To Clean | Re-examine Important Cleaning Considerations | • Composition of the part | • Characteristics of the contaminant | • Source of the contaminant | • Degree of required cleanliness |
| Convert Upstream Manufacturing Processes | • Employ "low-waste" fabrication technologies | • Substitute chemicals used in upstream presses | • Upgrade deburring operation |
| Materials Substitution | Substitute Less Toxic Media For Solvents | • Replace with high pressure-hot water, steam | • Use cryogenic stripping | • Use bead blasting | • Replace with aqueous cleaners | • Use less toxic organic solvents (terpenes, aliphatic hydrocarbons, alcohols, esters, amines) |
| Extend Solution Life | Re-examine Operating Procedures | • Pre-clean parts before solvent cleaning | • Prevent contamination of cleaning solvent | • Prevent "drag-in" of water | • Use appropriate make-up solution | • Promptly remove solids | • Use two-stage cleaning | • Use ultrasonic or mechanical agitation | • Monitor solvent quality & composition |
| Reduce Drag-out Losses | • Reduce the concentration of bath constituents | • Reduce speed of workpiece withdrawal | • Properly position the workpiece on the cleaning rack | • Use air knife to blow-off drag-out | • Recover & recycle drag-out |
| Reduce Evaporative Losses | • Install lids on tanks | • Increase freeboard height | • Avoid draft over the degreaser | • Control amount of heat supplied to vapor degreaser | • Adjust cooling | • Check water jacket for proper flow & temperature | • Install freeboard chillers in addition to cooling jackets | • Avoid spraying parts above vapor zone or cooling jacket | • Reduce exhaust velocities | • Eliminate wind tunnels | • Move the work slowly | • Allow proper drainage before removing item | • Bring parts up to temperature before removal | • Dewater the solvent | • Avoid overloading or inserting oversized items into tank | • Routinely inspect for and repair leaks | • Consolidate cold cleaning into centralized degreaser | • Locate cold cleaning tanks away from heat sources |
| Recycle Spent Solvents | • Downgrading | • Reduce the number of different solvents used | • Segregate | • Solids removal | • Emulsion or dispersion breaking | • Dissolved & emulsified organics recovery | • Use industrial heat pumps for solvents recovery | • Other distillation, condensation & membrane separation |
| Solvent Air Emissions | • Activated Carbon Recovery | • Actuated Carbon Fiber Recovery | • Liquid Absorption | • Condensation | • Industrial Heat Pumps |
2.2 RE-EXAMINE CLEANING REQUIREMENTS

The first priority in efforts to reduce solvent waste from metal parts cleaning is to carefully re-examine the need for cleaning. This may seem unnecessary, but many metal cleaning operations have developed cleaning procedures which far exceed the actual cleaning requirements -- procedures which generate excessive waste.

Such examination may also serve to identify upstream manufacturing processes which can be modified in order to reduce, or even eliminate the need for cleaning.

2.2.1 UNDERSTAND THE CLEANING PROCESS & CLEANING REQUIREMENTS

Prior to making a choice about cleaning chemistry and equipment, it is necessary to understand four important cleaning considerations, namely:

- The composition of the part
- The characteristics of the contaminant
- The source of the contaminant
- The degree of required cleanliness

Composition Of The Part

The composition of the part relates to its configuration, size, weight, function, porosity, substrate and quantity. The size and shape of the work pieces seldom influence the type of cleaning chemistry used, but may determine the method of cleaning and handling. For example:

- Parts with excessive porosity, rough surfaces, permanent overlapping joints, blind holes can retain solution which can cause corrosion.
- Some metals such as aluminum and alloys containing magnesium, lithium and zinc require special consideration because of their sensitivity to attack by certain chemicals.

Contaminant Characteristics

The efficiency of cleaning is highest when the chemistry has an affinity for the contaminant to be removed. Typical contaminants which must be removed by metal parts cleaning processes can be classified into seven groups:

- Particulate Contamination - microscopic contaminant, usually effects only high quality cleaning.
- Thin Film Chemical Contamination - contaminant sources include outgassing from lubricants, adhesives, coatings, and polymeric and elastomeric materials. Contamination also occurs from finger prints, machining fluids, coolants, and packaging.
- Pigmented Compounds - these may require removal from substances such as: whiting, lithophone, mica, zinc oxide, bentonite, flour, graphite, and soap-like materials.
- Unpigmented Oil and Grease - such as drawing lubricants, rust preventative oils and quenching oils.
- Forming Lubricants and Machining Fluids - include: mineral and fatty oils; conventional or heavy duty soluble oils with sulfur or other compound added; chemical cutting fluids.
- Polishing and Buffing Compounds - can be classified into three subgroups:
  - Liquids -- mineral oils and oil-in-water emulsions, or animal and vegetable oils with abrasive materials.
  - Semi-Solids -- oil based materials containing abrasive and emulsions, or water-based materials containing abrasive and dispersing agents.
  - Solids -- grease containing stearic acid, hydrogenated fatty acids, tallow, petroleum waxes and abrasive materials etc.
- Miscellaneous Surface Contaminants - hand oils, shop dirt, airborne dust, finger grease and metal pieces, lapping compounds etc.

Contaminant Source

The source of the contaminant needs to be determined. This will help in determining when to begin to modify the need for cleaning. The following should be checked:

- Are the soils
  - Received as raw materials?
  - Produced in general machining operations?
  - Produced in forming/stamping operations?
  - Produced in subassembly?
  - Received with vendor parts?
In many cases, the answers to these questions will help identify upstream manufacturing steps which contribute the most to your cleaning requirements. The following section (Section 2.2.2) provides some example suggestions for converting upstream manufacturing processes in order to reduce subsequent solvent cleaning requirements.

**Degree of Required Cleanliness**

Once the contaminants and their sources are determined the required degree of cleanliness has to be re-examined. The goal is to achieve the minimum level of cleanliness acceptable to meet performance requirements. Several standard tests can be used to determine the cleaning ability of any alternative cleaning process. They are the following:

- Visual Inspection
- Electron or Optical Microscopy
- Microchemistry Characterization
- Tissue Paper Test
- Acid Copper Test
- Residue Level Test
- Atomizer Test
- Surface Energy Test
- Kerosene Viewing of Water Break
- Radioactive Tracers & Fluorescent Dyes
- Gravimetric Testing
- Particulate Contamination Evaluation

(source: WRITAR)

### 2.2.2 Convert Upstream Manufacturing Processes To Reduce Subsequent Solvent Cleaning Steps

Perhaps the most effective method of source reduction and solvent waste elimination is the conversion of manufacturing processes to reduce or eliminate solvent cleaning steps.

The following process changes reduce post-finishing steps, such as solvent cleaning, which generate waste in the metal shaping operations.

**Employ "Low-waste" Metal Cutting, Forming, & Bonding Technologies**

In the manufacture of a variety of materials, both metals and non-metals, new machining, cutting, forming, and bonding technologies which provide source reduction benefits include:

- Electrical discharge machining
- Waterjet cutting
- Plasma arc cutting
- Laser cutting
- Electrochemical machining
- Electromagnetic forming
- Induction bonding

In many cases, these technologies can reduce or eliminate the need for coolants, and reduce or eliminate subsequent metals parts cleaning requirements.

**Substitute Materials Used in Metal Cutting, Forming, & Bonding**

Substituting materials used in metal cutting, forming & bonding processes can not only reduce waste generated from these manufacturing steps, but may also reduce subsequent cleaning requirements. Examples include:

- Use high quality metalworking fluid
- Use synthetic metalworking fluids
- Use lime or borax soap
- Use gases for cooling

**Upgrade Deburring Operation**

In one facility, the TCA vapor degreasing process was replaced by upgrading the existing deburring operation and rescheduling the parts processing so that abrasive deburring was the final cleaning step for the vast majority of parts produced. Upgrading consisted of:

- Adding a wet sander and modifying the existing vibratory tumbling machines.
- The oil-based lubricant used in the old system was replaced with a water-based lubricant to make removal of the forming lubricants easier.
- The new water-based system now cleans and deburrs parts simultaneously.

Using a vibratory tumbler with a water-based cleaner to both clean and deburr parts simultaneously should work in other stamping and machining operations where deburring is done and precision cleaning is not necessary.

Section 6.2.1 provides a list of vendors of technologies which can reduce subsequent solvent cleaning steps.
2.3 MATERIALS SUBSTITUTION

Many firms have been successful in substituting less toxic cleaning media for toxic solvents. The alternatives include:

- Hot water or steam
- Mechanical or thermal methods
- Aqueous cleaners
- Less toxic organic solvents

Sections 6.2.2 and 6.2.3 provide a list of vendors of solvent substitutes and metal parts cleaning equipment.

Discussion of each substitution approach is provided in the following sections.

2.3.1 REPLACE WITH HIGH-PRESSURE HOT-WATER, STEAM

The simplest aqueous cleaner is water, which can be used combined with mechanical or ultrasonic agitation. Hot water high pressure spray systems are quite effective at removing caked-on dirt and grime, and have been successfully tested for certain critical cleaning requirements. Similarly, steam cleaning can also be used to clean grease and oils from metal parts.

Critical Cleaning Example: Electronic Industry

For critical cleaning where hard water deposits may result in staining, use of demineralized water is recommended. For example, hot deionized water has been successfully tested as a replacement for CFC-113 in certain critical cleaning applications in the manufacture of disk drives in the electronic industry.

Vehicle Maintenance Case Study

At Fort Lewis, Washington, the old procedure of cleaning engine compartments with solvents, steam, and detergents was replaced with high-pressure hot-water washers.

With the old procedure, cleaning with solvents, steam, and detergents:

- It was impossible to separate the oil/water emulsion in a simple oil/water separator.
- Solvents contaminated both the water and the oil, rendering both a hazardous waste.
- Disposal of this mixed waste cost $0.80 per gallon F.O.B. the disposal site in 1985, for a cost of $84,000 per year plus shipping.

With the new high-pressure, hot-water system:

- The need for detergents or solvents has been eliminated.
- Both water usage and maintenance have been reduced.
- Since the oil and grease were no longer emulsified, a simple oil/water separator was sufficient to treat this wastewater.
- In 1984, an additional 46,000 gal of used oil was recovered and sold to a recycler for $10,800.

2.3.2 REPLACE WITH MECHANICAL OR THERMAL ALTERNATIVES

Air blast systems utilizing a high velocity air jet can be used instead of solvents to dry parts following a water rinse operation.

Dry stripping and cleaning using plastic or sand blast media to clean and strip parts can reduce disposal costs and water usage and has been shown to significantly reduce labor costs. The blasting media can also be recycled.

- Hill Air Force Base in Ogden, Utah, has successfully employed plastic beads propelled by high pressure air jets to remove paint from aircraft exteriors. Besides reducing hazardous waste, the use of bead blasting improved working conditions, was easier to perform than solvent paint stripping, cost less and used less raw material.

Other abrasive blasting materials, such as carbon dioxide pellets, are also used for metal parts cleaning and paint stripping.

2.3.3 USE AQUEOUS CLEANERS

Aqueous cleaning has traditionally been used to remove inorganic-based materials from metals. Recently however, aqueous systems have been developed that remove organic contaminants. Numerous examples exist of successful substitution of aqueous cleaners for solvents:

- A company originally used trichloroethylene to wash their small parts prior to assembly. The company replaced the trichlor wash unit with a modified Hobart dishwasher, which uses hot water sprays and aqueous cleaners to remove the machine oils. The company used hot air to dry the parts immediately after they were cleaned.
The cleaning action of aqueous cleaners relies mainly on displacement of soils rather than dissolving them as is the case with organic solvents. Examples of some common chemicals used in aqueous cleaners include:

- Ammonium hydroxide; potassium hydroxide; sodium hydroxide
- Mineral acids (nitric, sulfuric, phosphoric, or hydrochloric)
- Organic acids (sulfamic, acetic, or citric)
- Dodecanedioic acid
- EDTA and its tetrasodium salt
- Mono-, di-, or tri-ethanolamine
- Borax
- Sodium carbonate; sodium gluconate
- Sodium silicate; sodium metasilicate
- Sodium tripolyphosphate; trisodium phosphate
- Tetrasodium pyrophosphate; tetrapotassium pyrophosphate
- Sodium xylene sulfonate

Many "safe substitutes" employ the use of additives to accomplish cleaning requirements. Some of these additives may present health & safety concerns of their own.

- Review Material Safety Data Sheets (MSDSs) and demand full answers, particularly the hazardous constituents, BOD and COD of solutions with additives.

Many suppliers can formulate to meet your needs to reduce bad side effects such as corrosion, flammability, health effects, etc.

**Determine If Organic Solvents Are A Component of Your Aqueous Cleaner**

Some aqueous cleaners include small concentrations of organic solvents to enhance cleaning performance. Again, carefully review the MSDSs, identify any organic solvents used, and compare to those listed in section 2.3.4.

**Contact Your Suppliers & Test Aqueous Cleaning Alternatives**

Solvent cleaning is often used because an attempt to utilize an aqueous cleaner was unsuccessful. Before committing to solvent, one should investigate the compounds requiring removal. Suppliers of metal processing chemicals can recommend substitutes that can be cleaned with aqueous cleaners. Testing of a number of substitutes is recommended. A suggested testing method follows, however you should also contact the aqueous cleaner manufacturers for specific recommendations.

**Evaluate Wastewater Quality Issues**

It is very important to evaluate the wastewater quality issues and recyclability aspects when selecting an aqueous cleaner.

**Figure 2-3**

**How to Select An Aqueous Cleaner**

1. Review cleaner composition. Hazardous or undesirable components are identified on material safety data sheets. Many candidate cleaners can be eliminated on this basis.
2. Identify contaminants to be cleaned from parts, and obtain samples of each.
3. Apply each contaminant to representative metal panels and immerse in each candidate cleaner in laboratory scale cleaning tanks. Use manufacturer's recommendations for concentration and temperature, and provide mechanical agitation. After periods of 5, 10, and 15 minutes, remove panels from bath, rinse, and evaluate cleanliness. Cleanliness can be ascertained by (a) water break, (b) fluorescence under UV light (applicable for soils that fluoresce), and (c) by immersing in a cupric chloride solution and observing uniformity of copper deposited.
4. If a contaminant was cleaned (from Step 3), lower the temperature and re-test until the minimum effective temperature is identified. Also determine the minimum effective cleaner concentration in a similar manner. If the contaminant from Step 3 was not cleaned, increase temperatures and concentrations to identify minimum effective parameters. These data will permit selecting the optimum operating conditions for any contaminant or mixtures of any of the cleaners evaluated.
5. Using a series of standard tests, determine etch rates, staining characteristics, effects on coatings' adhesion, and corrosion characteristics.
6. Evaluate cleaner performance including tank maintenance, recyclability, and disposal requirements in a pilot plant-scale tank prior to full scale implementation.

*Selection process developed by General Dynamics/Fort Worth Division (Evans et al 1987)*
### 2.3.4 Use Less Toxic Organic Solvents

Toxic solvents can often be replaced with safer alternatives. Prerequisites include:
- Low toxicity
- Low flammability
- Low vapor pressure
- High solvency
- Low cost

**Figure 2-4** provides some suggested alternatives for hazardous industrial solvents and cleaning agents currently in use (source: Pollution Prevention Review/Summer 1991)

**Figure 1-1** in Chapter 1.0 provides a suggested toxicity rating for a comprehensive list of common organic solvents.

<table>
<thead>
<tr>
<th>SOLVENT</th>
<th>APPLICATION</th>
<th>POSSIBLE SUBSTITUTE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CFCs &amp; TCA</strong></td>
<td>Industrial degreasing &amp; cleaning, and removal of flux from electronic circuit boards</td>
<td>- Semiaqueous emulsions: surfactants in organic solvents followed by water rinse</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Aqueous emulsions: organic or inorganic surfactants in water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Heavy aliphatic hydrocarbons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- N-methyl pyrrolidinone (NMP) and its derivatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Terpenes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- N-butyl butyrate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Alcohols, ethers, esters</td>
</tr>
<tr>
<td><strong>Aromatic Hydrocarbons</strong></td>
<td>Solvents in agricultural, chemical, coatings, adhesives, &amp; polymers</td>
<td>- N-alkyl pyrrolidinones (NAP)</td>
</tr>
<tr>
<td>(benzene, toluene, xylene)</td>
<td></td>
<td>- Terpenes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Aliphatic hydrocarbons</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Amines, ethers, esters, alcohols</td>
</tr>
<tr>
<td><strong>Ketones</strong></td>
<td>Cleaning agents in electronic, painting, coating, chemicals &amp; printing</td>
<td>- Surfactants in water, combined with mechanical scrubbing</td>
</tr>
<tr>
<td>(acetone, methyl ethyl ketone, methyl isobutyl ketone, and halogenated hydrocarbons)</td>
<td></td>
<td>- Diabasic esters (DBE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- N-methyl pyrrolidinone (NMP) and its derivatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Terpenes</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>- Alcohols</td>
</tr>
<tr>
<td><strong>Ethylene glycol ethers</strong></td>
<td>Photoresist thinner for integrated circuit manufacture</td>
<td>- Propylene glycol mono-methyl ether acetate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ethyl-3-ethoxypropionate (from propionic acid)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Ethyl lactate (from lactic acid)</td>
</tr>
</tbody>
</table>
Surfactants added to terpenes forms emulsified cleaning compounds that are water rinseable. Reported disadvantages of terpenes include difficulty in separating oily wastes in order to recycle the cleaning solution. Ultrafiltration is being tested as one means to recover the cleaning solution. In addition, because of their low volatility, terpenes are not usable in vapor degreasing operations.

Aliphatic Hydrocarbon

Aliphatic solvents include a wide range of solvents used for all sorts of hard surface cleaning. Most are not listed "hazardous air pollutants" or HAPs, and therefore generally preferred over many ketones, aromatic hydrocarbons, and halogenated hydrocarbons. Aliphatic hydrocarbons, however have flashpoints lower than 140 degrees fahrenheit, which classifies them as EPA hazardous. Their emissions are also regulated because of their volatile organic carbon (VOC) content. VOC's contribute to smog problems in many industrial areas. Common aliphatic carbon solvents (ranked from low to high hazard -- see Figure 1-1) include:

- Mineral spirits (petroleum distillates; petroleum naphtha)
- Stoddard solvent
- Turpentine
- Kerosene
- Heptane
- Hexane

Alcohols

Many common alcohols may also be used as cleaning solvents. As with aliphatic hydrocarbons, most are not listed "hazardous air pollutants" or HAPs, and therefore may be preferred over many ketones, aromatic hydrocarbons, and halogenated hydrocarbons for health safety reasons. However most alcohols are very flammable (even more so than many aliphatic hydrocarbons) with flashpoints in the 60 degree F range, which classifies them as EPA hazardous. Their emissions are also regulated because of their volatile organic carbon (VOC) content which contribute to smog. Common alcohol solvents (ranked from low to high hazard -- see Figure 1-1) include:

- Ethyl alcohol (ethanol; anhydrous alcohol)
- Isopropyl alcohol (isopropanol; rubbing alcohol)
- Sec-butyl alcohol (2-butanol)
- Isobutyl alcohol (isobutanol)
- N-butyl alcohol (n-butanol)
- Methyl alcohol (methanol)
- Ethylene glycol

Common organic solvents can be classified into the following general categories:

- Terpenes
- Aliphatic hydrocarbons
- Alcohols
- Esters
- Amines
- Glycol ethers
- Ketones and aldehydes
- Aromatic hydrocarbons
- Halogenated hydrocarbons
- Chlorofluorocarbons (CFCs)
- Hydrochlorofluorocarbons (HCFCs)
- Hydrofluorocarbons (HFCs), and
- Fluorocarbons (FCs)

Figure 1-1 in Chapter 1.0 provides a suggested toxicity rating for this comprehensive list of common solvents based on the following considerations:

- Atmospheric ozone depletion - phaseout
- Toxicity
  - Suspect or demonstrated carcinogen
  - Listed hazardous air pollutant (HAP)
  - Listed SARA 313 toxic chemical
  - Listed CERCLA hazardous substance
  - Volatile organic carbon (VOC) contributing to smog formation
- Flammability - RCRA hazardous

The following provides a brief description and example of common solvents for each category.

Terpenes

Terpenes, essentially oils isolated from plants through gentle heating or steam distillation, are especially promising as potential substitutes for many toxic solvents as well as aqueous cleaners. Terpenes are less toxic and more biodegradable than most solvents.

Limonene cleaners, commercially important terpenes made from oils of lemon or orange, are listed as GRAS (Generally Recognized As Safe) substances in the Code of Federal Regulation. Limonenes have tested favorably against solvents, solvent emulsions, and alkaline cleaners for removal of heavy greases, oils and oily deposits. Terpenes include:

- D-limonene
- Anethole
- Alpha-pinene
- Beta-pinene
- Alpha-p-terpinene
- Beta-terpinene
- Terpinolene
- Dipentene (di-limonene)
Esters

Esters are common organic solvents, also used as additives in aqueous cleaners. As with aliphatic hydrocarbons and alcohols, most are less toxic, and therefore may be preferred over many ketones, aromatic hydrocarbons, and halogenated hydrocarbons for health safety reasons. Common ester solvents include:

- Gamma-butryrolactone (BLO)
- Glyco ether acetate
- N-butyl butyrate
- Isobutyl isobutyrate
- Ethyl lactate
- Propylene glycol mono-methyl ether acetate
- Ethyl acetate
- Isopropyl acetate
- Butyl acetate

Ketones & Aldehydes

Often used in paint and resin related cleaning, these solvents pose both flashpoint and toxicity problems. Several are listed as "hazardous air pollutants", and their emissions are also regulated because of their volatile organic carbon (VOC) content. Common ketone or aldehyde solvents include:

- Acetone
- Methyl ethyl ketone
- Methyl isobutyl ketone
- Cyclohexanone
- Formaldehyde (formalin)

Aromatic Hydrocarbons

Although some may be used in specialized applications, aromatic hydrocarbons are rarely used for general cleaning due to their known toxicity and very low flashpoints. Most are listed as "hazardous air pollutants", and their emissions are also regulated because of their volatile organic carbon (VOC) content. Common aromatic hydrocarbon solvents include:

- Xylene
- Toluene (methyl benzene)
- Phenol
- Benzene

Glycol Ethers

Glycol ethers are common solvents used as an active ingredient in aqueous cleaners. This solvent group is being phased out since reproductive defects have been linked to their use, and some have been listed as hazardous air pollutants (HAPs) under the clean air act. Common glycol ethers include:

- Ethylene glycol monoethyl ether (cellosolve; 2-ethoxyethanol)
- Ethylene glycol monobutyl ether (butyl cellosolve)

Amines

Amines are common organic solvents which contain nitrogen. These compounds are also commonly used as additives in aqueous cleaners. Some amine solvents are less toxic, and therefore may be preferred over many ketones, aromatic hydrocarbons, and halogenated hydrocarbons for health safety reasons. These include:

- N-ethyl pyrrolidine (NAP) (pyrrolidinone)
- N-methyl-2-pyrrolidine (NMP)

Some amine solvents are highly toxic however, and care must be used in selecting the appropriate solvent. In addition, high nitrogen concentrations can cause problems with wastewater discharges. Common toxic amine solvents include:

- Morpholine (diethyleneimide)
- Pyridine

Halogenated Hydrocarbons

Halogenated (chlorinated) hydrocarbons have been widely used for a variety of industrial solvent applications. These are being phased out for numerous health and environmental protection reasons, including:

- Toxicity & carcinogenicity -- most have been listed as "hazardous air pollutants"
- High VOC emissions contributing to smog formation
- Contribute to atmospheric ozone depletion

Common halogenated hydrocarbons include:

- Methylene chloride (dichloromethane)
- 1,1,1 - trichloroethane (methyl chloroform; TCA)
- Chlorobenzene
- Trichloroethylene
- Tetrachloroethylene (perchloroethylene)
- 1,1,2 - trichloroethane
- Carbon tetrachloride (tetrachloromethane)
- Chloroform
- 1,1,2,2 - tetrachloroethane
Propylene glycol mono-methyl ether acetate has only a slightly different atomic structure than the ethylene glycol ethers, and appears to be metabolized differently in animals.

Ethyl-3-ethoxypropionate is derived from propionic acid, similar to acetic acid.

Ethyl lactate is a derivative of a lactic acid produced in mammals during normal respiration.

n-butyl butyrate, a substance that occurs naturally in cantaloupes, other melons, peaches, and plums but is formulated chemically by Dow Chemical Co.

These substances have been studied in animals and have demonstrably less toxicity than ethylene glycol ethers and many of the chlorinated solvents commonly used in precision cleaning.

The following provides a brief description of the substitutes that may be used for high quality precision cleaning, namely:

- Aqueous Cleaning
- Semi-Aqueous Cleaning
- Hydrocarbon Cleaning
- Abrasive Cleaning
- Non-Chelated Cleaners
- No Clean System
- Low Solids Fluxes
- Inert Gas Wave Soldering

Aqueous Cleaning

Industry has traditionally used aqueous cleaning to remove inorganic-based materials from metals. Recently however, aqueous systems have been developed that remove organic contaminants. These systems use saponifiers and emulsifiers as additives to enhance the cleaning capabilities of the solution. Use of water-based flux may be necessary to use this technology with electronic assemblies.

For critical cleaning applications where hard water deposits may result in staining, use of demineralized or deionized water is recommended. For example, hot deionized water has been successfully tested as a replacement for CFC-113 in certain critical cleaning applications in the manufacture of disk drives in the electronic industry.

2.3.5 High Quality Cleaning Applications

High quality precision cleaning is most commonly applied in the following industries:

- Printed circuit boards manufacturing
- Semiconductor industry
- Capacitors and electronic components manufacturing
- Medical equipment manufacturing
- Small diameter tubing manufacturing
- Instruments

These operations typically required cleaning solvents of high purity and rapid evaporation rates with low residuals.

The traditional cleaning chemicals which were suitable for high precision cleaning such as chlorofluorocarbons (CFCs) and chlorinated solvents are being phased-out because of their toxicity and ozone depletion potential. Another group of common solvents used in precision cleaning, ethylene glycol ethers, is being phased out since reproductive defects have been linked to their use.

A few specific examples of successful substitutes for precision cleaning requirements include (also see Figure 2-4):

- Chlorofluorocarbons (CFCs)
  - Chlorofluorocarbons (CFCs) offer good solvency and rapid evaporation. They are widely used in vapor degreasing and critical cleaning as they dry with no detectable residue. These solvents are being phased out because of their contribution to atmospheric ozone depletion.

- Hydrochlorofluorocarbons (HCFCs)
  - Hydrochlorofluorocarbons (HCFCs) are considered "interim" substitutes for CFCs because they nevertheless contribute to atmospheric ozone depletion -- but at a lower rate than CFCs.

- Hydrofluorocarbons (HFCs) & Fluorocarbons (FCs)
  - Hydrofluorocarbons (HFCs) & Fluorocarbons (FCs) do not deplete the ozone layer because they do not contain chlorine, and probably do not contribute to smog formation either. However these compounds have long atmospheric lifetimes and therefore would be expected to contribute significantly to global warming. Although there are currently no regulations on global warming gases, there may be in the future.

These substances have been studied in animals and have demonstrably less toxicity than ethylene glycol ethers and many of the chlorinated solvents commonly used in precision cleaning.

The following provides a brief description of the substitutes that may be used for high quality precision cleaning, namely:

- Aqueous Cleaning
- Semi-Aqueous Cleaning
- Hydrocarbon Cleaning
- Abrasive Cleaning
- Non-Chelated Cleaners
- No Clean System
- Low Solids Fluxes
- Inert Gas Wave Soldering
There is no drop-in substitute aqueous cleaning solution for all precision cleaning applications. However, many alternative cleaning technologies are ready and available and waiting to be evaluated. The best way to find the right aqueous-based cleaner for your operation is to work with vendors of aqueous cleaners and equipment.

See section 2.3.3 for further information on aqueous cleaners. A list of vendors of solvent substitutes compiled using information available to CHRM is provided in Section 6.2.2.

Semi-Aqueous Cleaning

Semi-aqueous cleaning solutions combine terpenes or hydrocarbon with other additives. These cleaners effectively remove heavy grease, heavy manufacturing soils, adhesives, organics, and water-soluble soils. These cleaners work well with all common flux types and penetrate into narrow spaces making them effective in cleaning surface mount assemblies. See section 2.3.4 for further information on terpenes and other semi-aqueous cleaning hydrocarbons.

Hydrocarbon Cleaning

Hydrocarbon cleaning includes oxygenated hydrocarbon formulations, usually aliphatic esters, or hydrocarbon-rich formulations. These cleaners have applications in electronics and precision cleaning and are commonly used to clean material on which water cannot be used due to corrosivity. These cleaners are combustible and require longer drying times. See section 2.3.4 for further information on hydrocarbon cleaning alternatives, including esters, alcohols, and others.

Use Abrasive Cleaning

Mechanical cleaning methods generate less waste than other techniques. However, these methods can only be used before electronic components have been added to the boards. Abrasive blast uses plastic, ceramic, carbon dioxide, or harder media such as aluminum oxide to remove oxidation layers, old plating, paint and burrs from workpieces, and to create a smooth surface. See section 2.3.2 for further information on abrasive cleaning.

Non-Chelated Cleaning

The use of non-chelate process chemicals instead of chelated chemical baths can reduce hazardous waste generation. Chelators are employed in chemical process baths to allow metal ions to remain in solution beyond their normal solubility limit. This enhances cleaning, metal etching, and selective electroless plating. However, once the chelating compounds enter the waste stream, more chemicals must be used for waste treatment, and more sludge is produced. Ferrous sulfate is a common reducing agent used to treat wastewaters that contain chelators, but one facility discovered that the iron present in the resultant sludge contributed approximately 32 percent to the total dry weight of the sludge.

Non-chelate alkaline cleaners are available. In addition, if chelators is required, the use of mild chelators can reduce the need for additional treatment of wastewaters. For example, EDTA is a mild chelator that only requires lowering the pH to below 3.0 to allow metals to precipitate.

Continuous filtration may be required to remove solids that form in the bath. Filter systems are available that can filter the tank contents once or twice each hour.

No Clean Systems

Several processes have been developed that, if implemented, would eliminate the need for cleaning fluxes applied prior to soldering printed circuit boards. Two of these processes are low solids fluxes and inert gas wave soldering.

- **Low Solids Fluxes** - The electronics industry has traditionally used rosin fluxes containing 15 to 35% solids for soldering of electronics assemblies. Low solids (1 to 10% rosin and/or resin) fluxes are available that, with proper application, leave little or no visible residue and may not need to be removed.

- **Inert Gas Wave Soldering** - This soldering operation is performed under a nitrogen atmosphere, applying carboxylic acid activators through ultrasonic injection. Since the system does not use conventional rosin or resin fluxes, oxide formation is reduced and post-solder cleaning is eliminated.
2.4 EXTEND SOLUTION LIFE

Anything you do to extend the useful life of a cleaning solvent will reduce the quantity of solvent wasted, and reduce the quantity (and cost) of replacement solvents. Three significant operational areas should be evaluated, including:

- Implementing operating procedures to maximize solution life
- Reduce drag-out losses
- Reduce evaporative losses

Each of these areas of operations are discussed more fully in the following sections.

Section 6.2.3 provides a list of vendors of metals parts cleaning equipment.

2.4.1 IMPLEMENT OPERATING PROCEDURES TO MAXIMIZE SOLUTION LIFE

Several pollution prevention practices can be implemented during the operation of your solvent cleaning system to maximize solution life and minimize losses. Suggestions include:

- Pre-clean parts before solvent cleaning.
- Prevent contamination of the solvent.
- Prevent "drag-in" of water.
- Use appropriate make-up solution.
- Promptly remove solids.
- Use two-stage cleaning.
- Use ultrasonic or mechanical agitation.
- Monitor solvent quality & composition.

Pre-clean parts before solvent cleaning

- Use dry pre-cleaning methods such as manually cleaning the part with a wire brush prior to solvent cleaning to remove the bulk of the dirt.
- Use high velocity, low volume spray wand to dislodge solids -- but be careful about water "drag-in."

Prevent contamination of cleaning solvent

- Reduce number of different solvents used.
- Prevent drag-in from other processes -- very small quantities of one solvent (less than ¼ of 1%) added to a second solvent can create acid conditions.
- Cover tanks when not in use.

Prevent "drag-in of water"

- Contamination of chlorinated solvents with water can cause acid formation.
- Acid acceptance test indicates that the solvent is close to the point of becoming acidic, and specific stabilizers should be added.
- Water contamination increases diffusion of solvents increasing evaporative loss.
- The water separator should be cleaned and checked frequently for proper drainage.
- The temperature of the water exiting the condenser coils should be maintained at 90 to 100°F.
- Parts should be checked to see that they do not enter the degreaser while wet. This may call for using oil-based abrasives and cutting oils in production steps prior to cleaning.

Use appropriate makeup solution

- The solution can be tested, and reactivated by adding appropriate agents. Usually, the expense of analysis will be offset by the savings in solvent.
- Adding fresh solvent to boost the level of stabilizers is poor practice; rather the solvent should be analyzed and specific compounds added as required.
- Some leasing services will provide this maintenance service for the tanks you own.

Promptly remove solids

- Contaminants can dissolve into, or absorb useful solvent -- promptly removing solids can extend solvent life by 4-13 weeks.
- Remove solids from tank bottom if tank does not have heating elements.
- Install solids filter on slipstream.
- Organic soil contamination should not be allowed to exceed 10 percent for cold cleaning operations, and 25 percent for vapor degreasers -- acid formation can occur.
Use two-stage cleaning

- Allows the use of dirtier solvents to achieve the same degree of cleaning.
- Use the first tank to pre-soak parts in used "dirty" solvent.
- Use the second tank with fresh solvent to accomplish cleaning requirements.
- When solvent in second tank no longer achieves cleaning requirements, use that solvent to replenish the "dirty" solvent used in the first tank.
- Add fresh solvent to the second tank.

Use ultrasonic or mechanical agitation

This will allow you to use your "dirty" solvent longer, and yet achieve the same cleaning effectiveness. May make possible use of some cleaner which has reduced toxicity compared to current solvent.

Monitor solvent quality & composition

Decisions to replace dirty solvent are often made arbitrarily, and therefore, much solvent is disposed of prematurely.

- Solvents are typically replaced when the sludge concentration reaches 2 to 3 percent, although most solvents are still effective with up to 10 percent solids in them.
- Use solvent to the maximum. Refrain from having solvent replaced on a periodic basis, rather only when absolutely necessary to achieve the cleaning power required.
- Solvent monitoring may be performed to ensure that the solvent is only replaced when it is truly dirty.
- Measuring the amount of light transmitted through a sample of dirty solvent is a reliable indicator of contamination. Such solvent "testers" are available from some solvent suppliers.

2.4.2 Reduce Drag-out Losses

Minimizing the drag-out reduces the amount of rinse water needed. Also, less of the cleaning solution leaves the process, which ultimately produces savings in raw materials and treatment/disposal costs. The amount of drag-out depends on the:

- Surface tension of the cleaning solution
- Viscosity of the cleaning solution
- Physical shape and surface area of the workpiece and rack
- Speed of workpiece withdrawal and drainage time

Generally, drag-out minimization techniques include the following practices:

- Reduce the concentration of bath constituents.
- Reduce speed of workpiece withdrawal.
- Properly position the workpiece on the cleaning rack.
- Use air knife to blow-off drag-out.
- Recover & recycle drag-out.

Lower the concentration of bath constituents

Controlling the concentration of the solvent bath can reduce drag-out losses in two ways. Reducing chemical concentrations in a process solution reduces the quantity of chemicals and the toxicity in any drag-out that occurs.

Also, greater concentrations of some of the chemicals in a solution increase the viscosity. As a result, the film that adheres to the work piece as it is removed from the process bath is thicker and will not drain as easily. Lowering the concentration will result in:

- Lower solution viscosity
- Reduced rinsing requirement

Reducing speed of workpiece withdrawal

In many cases the cleaning process is not the limiting factor for overall production capacity, and a few more minutes can be spent cleaning parts without affecting production. In such cases, the speed of workpiece withdrawal should be reduced, and ample drainage time allowed. For example:

- 30 seconds usually allows most drag-out to drain back to the tank.
- 10 seconds still permits good drag-out recovery in applications where quick drying is a problem.

Properly position workpiece on the rack

Proper positioning of the workpiece on a rack will facilitate the dripping of the drag-out back into the bath. This is best determined experimentally, although the following guidelines were found effective.

- Orient the surface as close to vertical as possible.
- Situate the longer dimension of the workpiece horizontally.
• Position the workpiece with the lower edge tilted from the horizontal so that the runoff is from a corner rather than an entire edge.

**Use Air Knife**

High pressure air knife can be installed to blow-off cleaning solution clinging to the workpiece.

**Improved drag-out recovery**

A drain board or empty tank positioned between a cleaning bath and rinse bath can capture the dripping solution and route it back to the bath.

2.4.3 **REDUCE EVAPORATIVE LOSSES**

Pollution prevention practices to reduce solvent air emissions through equipment and/or operating procedure modifications include:

- Install lids on tanks.
- Increase freeboard height.
- Avoid drafts over the degreaser.
- Control amount of heat supplied to vapor degreaser.
- Adjust cooling.
- Check the water jacket for proper water flow & temperature.
- Install freeboard chillers in addition to cooling jackets.
- Avoid spraying parts above vapor zone or cooling jacket.
- Reduce exhaust velocities.
- Eliminate wind tunnels.
- Move the work slowly.
- Allow proper drainage before removing item.
- Bring parts up to temperature before removal.
- Dewater the solvent.
- Avoid overloading or inserting oversized items into tank.
- Routinely inspect for and repair leaks.
- Consolidate cold cleaning into centralized degreaser.
- Locate cold cleaning tanks away from heat sources.

**Install lids/silhouettes on tanks**

All tanks should be covered when not in use. Covers that can be used during the cleaning process (known as "silhouette entries") are available and allow for even greater reduction in vapor loss. All covers should be designed to slide horizontally over the top of the tank, since this disturbs the vapor zone less than hinged covers. Covers can reduce solvent loss up to 55%.

**Increase the freeboard space on tanks**

An increased freeboard has been proven to decrease emissions. Early degreasers had a freeboard equal to one-half the tank width. When the U.S. EPA in the mid-1970s recommended a 75% freeboard, emissions were decreased up to 46%. Increasing the freeboard to 100% can provide an additional 39% reduction when air turbulence is present.

**Avoid drafts over the degreaser**

Fans, air conditioners, heaters, windows, doors, general plant air movement, and equipment movement can blow the vapor-air mixture out of the degreaser.

Locate the degreaser to minimize natural drafts or use baffles to prevent the vapors from being upset. Solvent loss reductions up to 30% can be realized.

**Control the amount of heat supplied to vapor degreasers**

Use the least amount of heat required to keep the solvent at a slow boil and to give adequate vapor production. Install thermostatic heating controls.

**Adjust cooling**

Regulate the cooling level either by adjusting the temperature of the cooling water or by altering its flow rate. The vapor level should balance at the midpoint of the condensing coil; a fluctuating vapor level pumps the vapor-air mixture out of the unit.

**Check the water jacket for proper water flow and temperature**

To prevent migration of hot vapor up the side walls and by preventing convection currents.

**Install freeboard chillers in addition to cooling jackets**

A second set of refrigerated coils is installed above the condenser coils. These coils chill the air above the vapor zone and create a second barrier to vapor loss. Reductions in solvent use of up to 60% have been realized. However, water contamination of the solvent can occur due to condensation buildup on the coils, so air inside the tank vapor zone should be dehumidified, or special water collection equipment is also necessary.
Avoid spraying parts above the vapor zone or cooling jacket

Spraying above the vapor zone not only generates a vapor-air mixture directly, which is immediately lost, but falling droplets of solvent also disrupt the vapor interface causing more vapor-air mixing.

Reduce exhaust velocities

Vapor control with lip-vent hood exhausts may be too forceful. Use the minimum exhaust velocity that provides proper vapor control in the work area.

Eliminate wind tunnels

Some semi-enclosed machine designs tend to channel and reinforce air current through the machine, especially if power-exhausted. Rearranging the air movement in the room can help to eliminate this wind tunnel effect.

Move the work slowly

Rapid parts or basket movement disrupts the vapor zone and causes mixing with air. Control the hoist speed to less than 11 feet per minute of vertical travel and ensure the proper conveyor speed. Consider installing programmable transporters.

Avoid solvent carry-out

Solvent not allowed to drain properly from parts is lost immediately to evaporation outside the degreaser. Adjust the positioning of baskets or racks to allow easy drainage. Rotate parts if necessary to promote drainage.

Bring parts up to temperature before removal

The cleaning cycle isn't complete until the parts have reached the temperature of the vapor, so that condensation has ceased. If condensation is still forming, solvent drag-out will increase.

Dewater the solvent

A water separator should be able to reduce dissolved water in the solvent. Skim water off the surface of the solvent to maintain a reduced water content. Water and solvent form a complex at boiling temperatures which has a lower boiling density than dry solvent vapors and is harder to contain.

Don't overload the degreaser

Avoid inserting oversized items or large baskets into tank. If the space between the wall of the tank and the work piece is too narrow, then a piston effect will force solvent vapor out of the tank. As a general measure, the cross-sectional area of the work load should not exceed 50 percent of the tank's open area.

Repair leaks

Leaks are difficult to detect because of the rapid evaporation of liquid solvent seepage. Careful inspection should be performed routinely, especially in hidden spots.

Consolidate cold cleaning operations into a centralized vapor degreasing operation

While cold cleaning solvents must usually be discarded when the level of contamination exceeds 10 percent, vapor degreasers can operate up to a level of 25 to 30 percent contamination. In addition, vapor degreasers provide much better cleaning, and the parts leave the unit dry.

Locate cold cleaning tanks away from heat sources

Additional heat will substantially increase vapor loss.
2.5 RECLAIM & REUSE

Numerous recycling technologies exist, and even more are becoming available. These are typically characterized in terms of recycling technologies for:

- Spent Solvents
- Solvent Air Emissions

The following sections provide more information on these solvent recycling technologies.

2.5.1 SPENT SOLVENTS

Common pollution prevention practices to reclaim and reuse spent solvents include:

- Downgrading.
- Reduce the number of different solvents used & segregate.
- Solids removal.
- Emulsion or dispersion breaking.
- Dissolved & emulsified organics recovery.
- Use industrial heat pumps for solvents recovery.
- Other distillation, condensation & membrane separation technologies.

Section 6.2.4 provides a list of vendors of spent solvent recycling equipment.

Downgrading

In some cases, waste solvent no longer useful for high quality cleaning operations can be reused for a process where the cleaning requirements are less rigorous.

*Reduce the number of different solvents used and Segregate*

Use of the same type of cleaning solvent for as many different operations as possible will facilitate reuse/recycling activities.

Also, be sure to segregate waste solvent from other process wastes. Segregating certain solvents from other non-compatible solvents may also be necessary for recycling.

Solids removal

In some cases, extensive distillation is not needed to regenerate solvent for reuse. Simple removal of suspended particles is sufficient to reduce fouling. You may be able to install in-line filters to prevent particulate buildup in the degreaser.

- One electronics controls manufacturer purchased a dozen super-fine filter units to remove particulates from parts cleaning solvents at a cost of $19,000. As a result, the facility reduced the amount of waste solvent generated from 24 to 4 drums per year, and saved $96,000 in the first year!

- Waterloo Industries, Inc. of Waterloo, Iowa, installed a separator unit designed to continuously remove sludge and particulate matter from the alkaline bath. Since installation, replacement chemical costs have decreased by 20%, the time interval between dumping and total clean-out of the system has increased from 4 to 13 weeks, and maintenance has been reduced—a pump is the only moving part in the cleaning process. This system can also be applied to solvent cleaning operations.

**Emulsion or dispersion breaking**

Emulsion or dispersion breaking chemicals are available to promote the separation of solvent from other solutions, such as oil or water.

**Dissolved and emulsified organics recovery**

Organics separation techniques can be used which concentrate the organics so they can be recovered.

**Industrial Heat Pumps for Recovery**

Industrial heat pumps take heat rejected at some point in the process, raise its temperature, and transfer it to another portion of the process. Industrial heat pumps have recently developed into a commercially viable, energy efficient option for recovery and recycling of waste solvents.

**Other distillation, condensation & membrane separation technologies**

Due to recent developments, small solvent recycling units are now commercially available for businesses generating low volumes of waste solvents. The simple heating and condensing systems remove impurities from the solvent waste streams, returning the solvent or the solvent blend to the process which generated it.
• A solvent recovery system was used by a laboratory at Toronto General Hospital. The distillation unit cleaned xylene and chloroform to 100% purity and isopropyl alcohol to 99.7%. The lab recovered $180 per week of solvents which would otherwise have required costly off-site disposal.

Some companies have been able to scale down their equipment considerably since the equipment was first marketed. They now manufacture units with capacities as small as 5 gallons of solvent treated per hour.

There are numerous manufacturers of solvent recovery equipment in a variety of sizes. The smallest of these units recovers solvents having a boiling point of 160°C or less. The waste solvent is reclaimed in 15-gallon batches, although clean solvent can be drawn off during operation. Recovery levels range from 80 to 99%, depending on the amount and type of contamination.

Contract With A Service Company To Maintain Solvent Baths

There are solvent service companies that will come in on a regular basis to replace old solvent and perform routine maintenance on solvent baths and solvent sinks. In the case of small solvent sink units, some companies allow for the shop to either own or lease the sink. Either way, for such small units the cost of having a contractor is often less than the cost for purchasing solvent, performing maintenance, and waste disposal combined.

Section 7.1 provides a list of waste solvent recycling facilities and contractors.

2.5.2 Solvent Air Emissions

In many cases, solvents found in air emissions from solvent cleaning operations can be recovered and reused economically. The systems required for this purpose should be able to recover the solvents in their original form, that means solvents of high quality. A wide variety of processes are applied for this purpose which are demonstrated in Figure 2-5.

The most widely used solvent air emission recovery systems include:

- Activated Carbon Recovery
- Actuated Carbon Fiber Recovery
- Liquid Absorption
- Condensation
- Industrial Heat Pumps

Section 6.2.5 provides a list of vendors of solvent air emissions recovery/recycling equipment.

Activated Carbon Recovery System

In this process solvent-laden air is passed through a bed for activated carbon which acts as the adsorption medium. In the next step the solvent is desorbed or stripped from the carbon. Desorption can be accomplished by several method including:

Steam is most often used in the desorption/reaction stage of the carbon bed because it is relatively inexpensive, inert and easily condensed back to the liquid state. In the final step the solvents may be recovered from the mixture through distillation or decantation.

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CHAPTER 3
POLLUTION PREVENTION PRACTICES
Paint Coating Operations

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3.1 INTRODUCTION

Waste and emissions from paint operations is a common concern of many metal manufacturers & finishers. This section discusses some general routines of good operation, and some specific waste minimization practices for industrial coating (paint) operations.

Wastes from parts cleaning, application, stripping, and equipment cleaning are the most common wastes from coating operations. The industry is extremely diverse, so the quantity of each waste produced varies greatly from operation to operation.

Many of the procedures outlined below fall under the category of housekeeping procedures. The proper operation of equipment and training of personnel, and improved scheduling require minimal capital outlays and no additional equipment, only a company-wide commitment to waste minimization.

The most common waste minimization practices which can be applied to these wastes are provided in Figure 3-1.

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<td>Operator training to improve transfer efficiency</td>
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<td>Keep spray gun perpendicular to surface</td>
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<td>Properly train operators</td>
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<td>Implement good operating procedures</td>
<td>Locate paint drums close to painting operations</td>
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<td>Use tight fitting lids &amp; spigots</td>
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<th>Paint Equipment Cleaning Solvent Wastes</th>
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<tr>
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<td>Substitute with less toxic solvents</td>
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<td>Implement good operating procedures</td>
<td>Reduce cleaning frequency</td>
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<td></td>
<td>Mix paints right before application</td>
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<td>Use proper cleaning methods</td>
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<td></td>
<td>- use enclosed gun cleaner</td>
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<td>Reuse to thin next batch of compatible paint</td>
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<td>Reduce rejects</td>
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</table>
3.2 SOLVENTS IN PAINTS & COATINGS

Numerous pollution prevention opportunities can be implemented to reduce waste generated from the application of paint coatings on metal parts. These include:

- Materials substitution
- Convert to "low-waste" curing technologies
- Convert to "low-waste" application technologies
- Improved operator training
- Implement good operating procedures

The following sections provide more detailed information on these pollution prevention practices for spent plating solutions.

3.2.1 MATERIAL SUBSTITUTION

In some cases, a toxic paint coating material can be replaced with a less toxic one. Examples include:

- Water-based coatings
- Radiation-curable coatings
- Powder coatings

Section 6.3.1 provides vendors of low VOC paints and coatings.

Water-based Coatings

One feature which makes water-based coatings attractive is that no major equipment changes are necessary to apply water-based coatings with solvent-based coating equipment. Besides eliminating solvent emissions, overspray from water-based coatings can be easily collected or captured for recovery with water in the spray booth. The solution can subsequently be concentrated and reused as paint again.

Radiation-curable Coatings

These coatings also do not contain or use organic solvents. Reactive monomers are applied as a liquid to a surface which is then exposed to high energy radiation such as UV or IR light. Radiation-curable coatings account for a substantial fraction of the curable coating market. The advantages of using this coating technique include the reduction in waste from solvent loss and a decrease in energy and maintenance requirements.

Powder Coatings

Use of powder coatings has been referred to as a "dry painting process." With this process, the powder is sprayed on the object and the overspray is readily retrieved and recycled, something that is very difficult to do with liquid paints. The ability to recycle the coating material provides a very high efficiency-use ratio. In a well-designed spray system, the coating powder remains clean at all times and the potential for waste generation (contaminated powder) is nearly zero.

3.2.2 CONVERT TO "LOW-WASTE" CURING TECHNOLOGIES

In some cases, new curing technologies are required in order to use some of the less toxic paint coating substitutes discussed previously in Section 3.2.1.

New curing devices have been developed which directly heat the product, and have been successfully applied to the curing of coatings for a variety of materials including metal, wood, paper, glass, plastic, and textiles. These include:

- Infrared drying
- Ultraviolet curing
- Indirect resistance heating

Section 6.3.3 provides vendors of "low waste" curing technologies.

Waste reduction advantages of such curing technologies include:

- Eliminates the need to blow hot air (with entrained dust), and eliminates or reduces air emissions, air pollution control requirements, and byproduct wastes (emission control sludges) associated with alternative technologies using fossil fuels.
- Facilitates use of less-toxic coating materials and adhesives (e.g., powder coatings, water-based coatings, UV-curable materials) as substitutes for toxic materials (e.g., solvent-based coatings).

3.2.3 CONVERT TO "LOW-WASTE" APPLICATION TECHNOLOGIES

Converting to "low-waste" application technologies can substantially reduce waste solvent generated from paint coating operations. Examples include:

- Use equipment with low overspray
- Use supercritical carbon dioxide spray delivery system
Section 6.3.2 provides vendors of "low-waste" application technologies.

Use equipment with low overspray

Paint waste can be reduced by using high efficiency transfer equipment that produces lower overspray. The standard method of applying paint is the air spray gun with a typical transfer efficiency of 20 - 40 percent.

Many of the newer spray application systems have shown much promise, with transfer efficiencies greater than 65 percent. These include:

- High volume, low pressure (HVLP) turbine
- High volume, stepped down low pressure (HVSDLP)
- Low pressure, low volume (LPLV)
- Thin film atomization (TFA)
- Electrostatic air-atomized spray
- Electrostatic centrifugal-atomized spray
- Roller/flow coating machines
- Electrocoating systems

Use Supercritical Carbon Dioxide Spray Delivery Systems

Supercritical carbon dioxide can be used in the spray application of coatings to replace the volatile organic solvent fraction that is used to obtain atomization viscosity. This enables applicators to reduce VOC emissions by 30 to 70 percent while continuing to use higher-molecular-weight polymer systems that give superior coating performance.

3.2.4 OPERATOR TRAINING TO IMPROVE TRANSFER EFFICIENCY

The transfer efficiency is also a function of operator skill and training. Implementing better operating practices can reduce paint waste and paint costs.

- Regulate the air pressure on spray guns. Air pressure is often set too high and more overspray is produced.
- Keep the spray gun perpendicular to the surface and at the correct distance from the surface.

3.2.5 GOOD OPERATING PROCEDURES TO MINIMIZE SOLVENT Wastes

Several simple operating procedures can help reduce solvent emissions from paint coating operations. Examples include:

- Locate paint drums close to painting operations to reduce needless transport of the drums, and reduce the chance of spillage.
- Use tight fitting lids and spigots to transfer materials. Never pour paint or thinner from large containers to small ones. This will reduce losses due to evaporation and spillage.
3.3 SOLVENT WASTES FROM PAINT EQUIPMENT CLEANING

Pollution prevention practices to reduce waste generated from cleaning paint application equipment include the following:

- Material substitution
- Improved operating procedures
- Recover & Reuse

3.3.1 MATERIAL SUBSTITUTION

The toxicity of equipment cleaning wastes can be reduced by replacing organic solvents with less toxic or nontoxic solutions. Also, replacing solvent usage with high-pressure alkaline solutions reduces the release. See section 2.3 for more information on solvent substitutes.

3.3.2 GOOD OPERATING PROCEDURES TO MINIMIZE SOLVENT WASTES

The following provides a brief description of good operating procedures which can reduce solvent wastes from paint equipment cleaning.

Reduce cleaning frequency

By revising production schedules to consolidate production runs or dedicating application equipment to a single type of paint can reduce equipment cleaning waste.

Mix paints right before application

The quantity of cleaning waste is also reduced by utilizing proportional mixing of paints at the point of paint application; this eliminates the need to clean paint mixing tanks.

Use proper cleaning methods

Suggested improved cleaning methods include:

- Paint cups should be scraped of all dry residual paint before cleaning them with thinner. Cups should never be cleaned by filling them with thinner and stirring them until the paint dissolves.
- Spray guns should be cleaned in an enclosed gun cleaner. Thinner is sprayed into the cleaner where it is condensed for later recovery. This reduces VOC emissions produced by cleaning guns outdoors.

3.3.3 RECOVER & REUSE EQUIPMENT CLEANING SOLVENTS

Paint application equipment - spray guns, hoses, as well as brushes and rollers - is often cleaned with solvents. Solvent cleaning wastes can sometimes be recycled in ways such as:

- Separating out the paint sludge through filtration, centrifugation, or decantation, and reusing the solvent.
- Collecting the cleaning wastes and reusing for cleaning - perhaps in another application - until the solvent is too contaminated for further use.
- Some paints require thinning before use. Segregating solvents generated from cleaning according to color will allow you to then use that solvent to thin the next batch of same color paint.

Recycle solvents on-site

Purchase of an on-site solvent recovery system may be a viable pollution prevention option for solvent wastes. Due to recent developments, small (5 to 15 gallon) solvent recycling units are now commercially available for businesses generating low volumes of waste solvents. (See section 2.5 for more information on solvent recycling.)

Section 6.2.4 provides a list of vendors which supply on-site solvent recovery equipment.

Recycle solvents off site

The sludge produced from drum, spray gun, and paint cup cleaning may contain as much as 50% organic thinners. There are solvent service companies that will come in on a regular basis to replace old solvent generated from parts cleaners. Many of these companies will also accept solvent waste generated from painting operations.

Section 7.1 provides a list of waste solvent recycling facilities and contractors.
3.4 SOLVENT WASTES FROM PAINT STRIPPING OPERATIONS

Solvent wastes from paint stripping operations can be reduced by using waste reduction practices such as the following:

- Implement good operating procedures
- Use alternative stripping systems
- Reduce number of rejects

### 3.4.1 GOOD OPERATING PROCEDURES TO MINIMIZE SOLVENT WASTES

Bad finishes require paint stripping more frequently than well applied paint coatings. The likelihood of producing a bad finish is reduced when application equipment is operating properly. Therefore, preventive maintenance is extremely important. All parts should be cleaned and, if necessary, lubricated regularly.

**Spray Guns**

Spray guns should be cleaned after use or whenever there will be an appreciable interval between use. For hand-held units, a solvent rinse with occasional blow-back (accomplished by covering the fluid tip and operating the trigger; this blows the paint back into its container) is adequate. All moving parts should be lubricated frequently and properly adjusted.

**Roller coating and flow coating machines**

Roller coating and flow coating machines must also be properly maintained if they are to produce good finishes. Rollers on roller coating machines should be cleaned regularly to remove dried paint and inspected for swelling of the material. If swelling is evident, the rollers should be replaced immediately.

**Curtain or flow coating machines**

Curtain or flow coating machines have a curtain head that must be kept clear at all times. If this aperture becomes blocked, the curtain will break and give an uneven finish. To clean the machine, solvent should first be circulated through the machine. After this, the aperture should be fully opened and cleaned with a soft rag or brush. Metal instruments should never be used for cleaning the curtain head.

### 3.4.2 USE ALTERNATIVE STRIPPING SYSTEMS

Alternate stripping systems can substantially reduce solvent wastes from paint stripping operations. Examples include:

- Mechanical paint stripping
- Cryogenic stripping
- Non-phenolic strippers

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Section 6.3.5 provides a list of vendors of alternative stripping systems.

**Use mechanical paint stripping methods**

Facilities handling items made of soft metals which are inappropriate for sandblasting or glass bead blasting have had great success at plastic bead blasting. High pressure air is used to propel the plastic beads against the paint surface, where they dislodge the paint. The beads and paint are then recovered and separated, with the beads being re-fed into the pressure gun. The dry waste, composed of the paint and any beads broken down due to attrition, are then removed for proper disposal.

- Systems have been developed which allow sandblasters to convert their existing blast generators to deliver plastic media and to recover and recycle the material.

**Use cryogenic stripping**

The use of carbon dioxide pellets have been demonstrated to substantially reduce solvent wastes from paint stripping operations.

**Use non-phenolic strippers**

These were developed in response to the need to reduce toxicity associated with phenol and acid additives.

### 3.4.3 REDUCE NUMBER OF REJECTS

Paint stripping wastes are generated when a bad finish has been produced and the coating must be removed to be reapplied. Many paint stripping wastes are generated due to failure of part of the system. Waste reduction methods are aimed at reducing the number of poor quality products produced.

- Inspect parts before painting -- This will avoid painting potential rejects. Be sure surfaces are clean, dry, and rust free.

**Decrease generation of off-spec coatings that require stripping**

This can be accomplished primarily through the application of better operating practices, paying particular attention to process quality control measures, and employee training.

- Locate solvent soak tanks away from paint curing ovens -- This will minimize the adverse effect of solvent on a painted surface or item.
# CHAPTER 4

POLLUTION PREVENTION PRACTICES
Process Equipment Cleaning

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### 4.1 INTRODUCTION

The use of solvents and solvent wastes generated from process equipment cleaning is a common concern of many industries.

This chapter details some general routines of good operation and some specific waste reduction practices for solvent wastes from process equipment cleaning.

Figure 4-1 provides a summary of the most common pollution prevention practices to reduce solvent wastes from process equipment cleaning.

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<thead>
<tr>
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<td></td>
<td>Schedule batches from light to dark colors</td>
<td>Use minimum surface area to volume ratio</td>
<td>Minimize residues</td>
<td>See section 2.4</td>
<td>Carefully choose the cleaning medium</td>
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<tr>
<td></td>
<td>Schedule longer production runs</td>
<td>Minimize undrainable pockets</td>
<td>Minimize amount of cleaning solution</td>
<td></td>
<td>Plan cleaning solution reuse</td>
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<td></td>
<td>Record cleaning costs separate</td>
<td>Use equipment with non-stick surfaces, prevent clings</td>
<td>Use high-pressure spray nozzles</td>
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<td>Rework cleanup solvent into useful products</td>
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<td></td>
<td>Convert batch to continuous process</td>
<td>Use smooth heat exchange surfaces</td>
<td>Clean equipment immediately after use</td>
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<td>Segregate wastes by solvent type</td>
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<td></td>
<td>Maximize dedication of equipment</td>
<td>Use squeegees to recover product prior to rinsing</td>
<td>Use less toxic cleaning chemicals</td>
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<td>Standardize solvent usage</td>
</tr>
<tr>
<td></td>
<td>Avoid unnecessary cleaning</td>
<td>Install mechanical wipers</td>
<td>Keep storage &amp; transfer systems closed to reduce drying</td>
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</tr>
</tbody>
</table>
4.2 PROCESS EQUIPMENT CLEANING WASTES

Numerous pollution prevention opportunities can be implemented to reduce process equipment cleaning wastes. These include:

- Reduce cleaning frequency
- Reduce material adhering to equipment
- Reduce quantity and/or toxicity of cleanup waste
- Extend cleaning solution life
- Recycle & reuse cleaning wastes

The following sections provide more detailed information on these pollution prevention practices for spent plating solutions.

4.2.1 REDUCE CLEANING FREQUENCY

Reducing or eliminating the need for cleanup begins by identifying the causes of undesirable deposit formation, followed by identifying and implementing the following suggested means to prevent or limit it.

- Schedule batches from light to dark colors
- Schedule longer production runs
- Record cleaning costs separate
- Convert batch to continuous process
- Maximize dedication of equipment
- Avoid unnecessary cleaning
- Inhibit fouling deposit formation

Record the cleaning costs as a separate item

If cleanup costs are not separated from other maintenance costs, proper analysis of these costs and the relative worth of different alternatives cannot be determined.

Convert from batch to continuous process

Continuous processes have many advantages over batch processes. These include:

- Lower labor requirements
- Ease of automation and control
- Elimination of the need for manual material transfer operations which tend to have a high probability of a spill
- Less cleanup waste since continuous processes are cleaned at regular intervals while batch processes must be cleaned between different batches

Maximize dedication of process equipment

Producing large quantities of a product at one time through proper scheduling can decrease the cleaning frequency and equipment down time. In many industries, manufacturers produce a year’s supply at one time.

Avoid unnecessary cleanup

If a piece of equipment is dedicated, it should not stay on the same cleaning schedule as undedicated equipment.

Inhibit fouling deposit formation

Fouling rates are usually attributed to:

- Crystallization
- Sedimentation
- Chemical reactions and polymerization
- High temperature cooking
- Corrosion
- Bacterial growth

Fouling most closely associated with heat transfer will reduce the overall efficiency of equipment while increasing the need for cleaning. Fouling can be inhibited by:

- Using smooth heat transfer surfaces
- Lower film temperatures
- Increased turbulence
- Control of steam composition
- Careful choice of heat exchanger type
- Prior removal of deposit precursors
- Better design or control of fired heaters
- The application of less corrosive and more thermally stable heat transfer fluids

In closed cooling water systems, the fouling rate can be inhibited through proper water treatment, by using a lower number of concentration cycles in the cooling tower, and by using make-up water with low total solids content.

4.2.2 REDUCE MATERIAL ADHERING TO EQUIPMENT

Reducing material adhering to equipment will substantially reduce cleanup wastes. Practices include:

- Use minimum surface area to volume ratio
- Minimize undrainable pockets
- Lining equipment with non-stick surfaces to prevent cling
- Use smooth heat exchange surfaces
- Use squeegees to recover product prior to rinsing
- Install mechanical wipers
- Provide sufficient drain time for liquids
- "Pigging" process lines

The plant should be designed to minimize the equipment surface exposed to the process fluid. Undrainable pockets should be kept to a minimum.
4.2.3 REDUCE QUANTITY AND/OR TOXICITY OF CLEANUP WASTE

When equipment must be cleaned, the cleanup should be performed efficiently with the minimum production of additional hazardous wastes. Practices include:

- Minimize residues
- Minimize amount of cleaning solution
- Use high-pressure spray nozzles
- Clean equipment immediately after use
- Use less toxic cleaning chemicals
- Keep storage & transfer systems closed to reduce drying

**Minimize residue**

Since the ultimate amount of sludge produced depends on the residue left after the process, minimizing the residue will decrease the amount of waste produced. This can be done by:

- Providing adequate batch drainage time
- Using non-stick surfaces
- Using mechanical or manual wall wipers
- Using cylindrical tanks with height-to-diameter ratios close to one (1) to minimize wetted surface
- Rotating agitator after batch dump
- Maximizing batch size

**Minimize the amount of cleaning solution**

Mechanical cleaning should be used over chemical cleaning whenever possible. When chemical cleaning solutions are used, the four parameters to control are time, temperature, concentration, and turbulence. Less cleaning solution is necessary as these parameters are increased. Cleaning solution used can be minimized by the:

- Use of high pressure spray nozzles
- Use of "flow-over" techniques
- Use of on-stream mechanical cleaning
- Use of clean-in-place (CIP) system with staged rinses
- Use of additives such as defoamers, suspending agents, emulsifiers, and wetting agents

The elimination of cleaning solutions altogether is possible by cleaning equipment with mechanical devices. One such device is a system which uses steel brushes fitted inside heat exchanger tubes which are propelled by process fluid and reversed periodically by a flow diverter.

**Use less toxic cleaning solvents**

Section 2.3 provides extensive discussion of recommended less toxic substitutes for toxic solvent cleaners.

4.2.4 EXTEND CLEANING SOLUTION LIFE

Anything you do to extend the useful life of a cleaning solvent will reduce the quantity of solvent wasted, and reduce the quantity (and cost) of replacement solvents. Section 2.4 provides extensive discussion of recommended pollution prevention practices to extend solution life.

4.2.5 RECYCLE & REUSE CLEANING WASTES

With proper planning, many cleaning wastes can be processed for recycle or reuse. Practices include:

- Carefully choose the cleaning medium and plan cleaning solution reuse
- Rework cleanup solvent into useful products
- Segregate wastes by solvent type
- Standardize solvent usage

**Choose cleaning medium and plan cleaning solution reuse**

From a waste minimization standpoint, the preferred order to select a cleaning medium is:

1. Process fluid rather than water
2. Water rather than chemical solutions

By employing a simple filtration to remove the solids, process-based cleaning solutions can be reused as part of the formulation or process make-up stream. Also, water and water-based cleaners are usually non-toxic or at least less toxic than most chemical solutions.
# CHAPTER 5

## SOURCES FOR INFORMATION

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</tbody>
</table>
5.1 FEDERAL TECHNICAL ASSISTANCE RESOURCES

5.1.1 The U.S. Environmental Protection Agency (U.S. EPA)

Region III Pollution Prevention Contacts

<table>
<thead>
<tr>
<th>Pollution Prevention Coordinator</th>
<th>Bill Reilly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Assessment Branch</td>
<td>333/50 Program Special Assistant</td>
</tr>
<tr>
<td>Environmental Services Division</td>
<td>Air, Radiation &amp; Toxics Division</td>
</tr>
<tr>
<td>U.S. EPA Region III</td>
<td>U.S. EPA Region III</td>
</tr>
<tr>
<td>841 Chestnut Building (3ES43)</td>
<td>841 Chestnut Building (3AT01)</td>
</tr>
<tr>
<td>Philadelphia, PA 19107</td>
<td>Philadelphia, PA 19107</td>
</tr>
<tr>
<td>(215) 597-8327/6289</td>
<td>(215) 597-3302</td>
</tr>
</tbody>
</table>

Pollution Prevention Information Clearinghouse (PPIC)

The EPA's Pollution Prevention Information Clearinghouse (PPIC) contains technical, policy, programmatic, legislative, and financial information concerning source reduction and recycling efforts. It is a free, nonregulatory service of the U.S. EPA and is accessible by personal computer, telephone hotline, or mail.

Pollution Prevention Information Clearinghouse
c/o SAIC
7600-A Leesburg Pike
Falls Church, VA 22043
(703) 821-4800 (for questions on computer access)
(703) 821-4775 (fax)
(202) 260-1963 (for ordering documents)

Source Reduction Review Project (SRRP)

The Source Reduction Review Project is a new initiative of the U.S. EPA to evaluate pollution prevention alternatives during the regulatory development process. Initially, the project focus is to ensure that source reduction measures and multi-media issues are considered during the development of air, water, and hazardous waste standards affecting certain industrial categories. The SRRP Coordinators for each participating EPA Office are as follows:

Office of Air & Radiation  
Jack Edwordson, (919) 541-5573  
Tim Mohin, (919) 541-5349

Office of Enforcement  
Charlie Garlow, (202) 260-1088

Office of Solid Waste  
Ed Abrams, (202) 260-4800  
Donna Perla, (703) 308-8402

Office of Policy, Planning, & Evaluation  
Wendy Cleland-Hamnet, (202) 260-4001

Office of P2 & Toxics  
Julie Shannon, (202) 260-2736  
Ward Penberthy, (202) 260-1664

Office of R&D  
Paul Shapiro, (202) 260-3547

Office of Water  
Vivian Daub, (202) 260-6790

Region 9  
Dan Reich, (415) 744-1336

The following chart presents a detailed listing of proposed regulation dates and EPA contacts for each industry/process category.
<table>
<thead>
<tr>
<th>Industrial/Process Category</th>
<th>Date</th>
<th>Air ¹</th>
<th>Date</th>
<th>Water²</th>
<th>Date</th>
<th>Hazardous Waste³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Products and Machinery</td>
<td>1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plywood Particle Board Mfg.</td>
<td>1999</td>
<td>Jim Berry 919-541-5605</td>
<td>1994</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced Plastic Composite Prod.</td>
<td>1993</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Air rules refer to MACT standards under the Clean Air Act. Dates were proposed in the Federal Register in February 1992.

² Waste rules refer to effluent limitations guidelines.

³ Hazardous Waste refers to RCRA listings of specific wastestreams: (A) Dioxin; (B) Solvents II/III; (C) Carbamates; (D) Paint Wastes. The solvent listing determination may indirectly affect many uses of solvents.

⁴ May or may not occur depending on outcome of Office of Water regulations.
5.1.2 U.S. Department of Energy (U.S. DOE)

The U.S. Department of Energy offers several services to assist individuals and companies in making good decisions concerning energy related issues, which include the following: (The main telephone number at the Department of Energy is 202-586-5000)

Energy Analysis & Diagnostic Center (EADC). Program Office of Industrial Technologies, CE-223, (202) 586-2098 -- The EADC program trains university engineering students to conduct energy efficiency audits for small and medium-sized manufacturing firms within a 150 mile radius of their school campus. The program provides "hands-on" experience in industrial energy management for young engineering professionals.

National Appropriate Technology Assistance Service (NATAS). Conservation and Renewable Energy, CE-34, (800) 428-2525 -- NATAS provides engineering, scientific, and technical information regarding the implementation of energy conservation techniques and renewable energy technologies in response to inquiries from individuals, businesses, and State or local governments.

Conservation & Renewable Energy Inquiry and Referral Service (CAREIRS), Conservation and Renewable Energy, CE-54, (800) 523-2929 -- The purpose of CAREIRS is to respond to public inquiries and transfer research and development results to energy decision makers in public and private sectors for improved energy development and use.

Innovative Concepts Program (InnCon)

The InnCon program was first funded in 1983 by the U.S. Department of Energy's (DOE) Conservation and Renewal Energy Division. Pacific Northwest Laboratory (PNL) operates InnCon for DOE. The InnCon program provides "seed money" in amounts of up to $20,000 to innovators who are finding new ways to save energy and increase industrial productivity. The InnCon program also provides nonfinancial support by helping the innovators publicize their concepts and by introducing them to potential sponsors.

Elliott Levine
Program Manager
CE-521, Forrestal Building
1000 Independence Ave., S.W.
Washington, D.C. 20585
(202) 586-1478

Research & Development in Waste Materials Management

The Department of Energy (DOE), Office of Industrial Technologies (OIT) funds numerous research and development activities leading to improvements in energy efficiency and fuel flexibility in industry. The Waste Materials Management Division, which is within the Office of Waste Reduction at OIT, undertakes a broad range of activities to reduce energy use and increase fuel flexibility in industry through better management of waste materials. For example:

Brayton-Cycle Solvent Recovery -- Under a DOE contract, Garrett AlResearch has developed a Brayton-Cycle heat pump to recover volatile organic solvent emissions from processes in the petroleum, organic-chemicals, paint, adhesives, printing, and dry-cleaning industries. The inherent cooling and heating capabilities of a Brayton-cycle heat pump provide a means to recover solvent economically and efficiently.

DOE Regional Contacts For Technical Assistance

For more information on specific projects listed previously, or other waste management research and development sponsored by the DOE Office of Industrial Technologies, contact:

<table>
<thead>
<tr>
<th>Location</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Department of Energy</td>
<td>Philadelphia Support Office</td>
</tr>
<tr>
<td>Office of Industrial Technologies Conserves and Renewable Energy</td>
<td>U.S. Department of Energy</td>
</tr>
<tr>
<td>CE-221 1000 Independence Avenue, S.W. Washington, D.C. 20585</td>
<td>1421 Cherry Street Philadelphia, PA 19102</td>
</tr>
<tr>
<td>(800) 523-2929</td>
<td>(215) 597-3890</td>
</tr>
</tbody>
</table>
5.1.3 President’s Commission On Environmental Quality (PCEQ)

On July 23, 1991, the President of the United States named 25 environmental, business, academic, and foundation leaders to serve as members of the President’s Commission on Environmental Quality (PCEQ). The Commission’s mission is to develop and promote an action agenda to improve the environment in a way that integrates environmental, economic, and quality of life goals, and to encourage innovative private sector initiatives.

The goals of the Commission will be implemented by establishing a leadership network of individuals who will devote time and resources to voluntary action and education programs; identifying successful models of what the private sector can accomplish on a cooperative voluntary basis; stimulating further action through information programs and technical assistance; and continuously improving performance through evaluation of such programs.

One of four Subcommittees formed by PCEQ was the Quality Environmental Management Subcommittee. Its aim was to demonstrate the various environmental improvements that can be achieved as a result of the increasing integration of environmental considerations into overall corporate settings through application of the Quality Management principles that both U.S. and Japanese companies have used to improve customer service, product quality, and employee satisfaction.

In January, 1993, the OEM Subcommittee completed an 18 month study which shows the significant pollution prevention and economic savings that have resulted from a dozen demonstration projects conducted in the facilities of eleven large, but very different, U.S. corporations. The subcommittee’s report entitled "Total Quality Management -- A Framework For Pollution Prevention," articulates the key Quality Management principles that were vital to achieving these results. The successes are described and the principles explained with the aim of stimulating and aiding a broad voluntary pollution prevention effort throughout the private sector.

For a copy of the report, contact:

President’s Commission on Environmental Quality
Executive Office of the President
722 Jackson Place, N.W.
Washington, DC 20503
(202) 395-5750
(202) 395-3745 (fax)
5.2 REGIONAL TECHNICAL ASSISTANCE RESOURCES

5.2.1 Center For Hazardous Materials Research (CHMR)

CHMR is a non-profit subsidiary of the University of Pittsburgh Trust and is a non-regulatory organization. Its mission is to assist in developing and implementing practical solutions to the technical, environmental, economic, and health problems associated with hazardous materials and waste. CHMR's Technical Assistance Program is a one-stop source for environmental information and assistance, including:

- **Seminars and Workshops** -- CHMR routinely conducts a broad range of seminars and workshops addressing priority environmental issues of concern to industry. These training programs are designed to increase communication and awareness of environmental issues, and provide information on techniques and approaches to manage them.

- **Environmental Services** -- CHMR conducts broadly based interdisciplinary applied research, technical assistance, education, and public policy programs on issues involving hazardous materials and waste. Services performed are tailored to meet specific needs of the client. Fees may be charged for these services based on the size and scope of the project. Typical examples include: pollution prevention assessments, regulatory compliance assessments, facility permitting guidance, community right-to-know, contamination investigations, risk assessments.

- **Publications** -- The Center For Hazardous Materials Research (CHMR) offers a variety of documents which provide useful additional information and guidance on pollution prevention and control. Publications on specific waste reduction and environmental compliance issues are available.

- **On-Site Consultations** -- CHMR can also perform on-site consultation services to provide clients with a general assessment of their hazardous waste management needs and compliance requirements, as well as identification of opportunities for minimizing waste generation.

For information on CHMR's pollution prevention services call (412) 826-5320.

5.2.2 National Environmental Technology Applications Corporation (NETAC)

NETAC's mission is to facilitate commercialization of promising environmental technologies. NETAC is a non-profit subsidiary of the University of Pittsburgh Trust, created through a cooperative agreement between the U.S. Environmental Protection Agency and the University. 

**Environmental Technology Commercialization Assistance Services**

NETAC services which provide environmental technology commercialization assistance include:

- Technical & commercial assessments
- Technology development assistance
- Testing & demonstration
- Market analysis & business development
- Permitting & regulatory assistance
- Patent, royalty, licensing agreements
- Identification of financial sources

**Environmental Technology & Product Profiles**

"Environmental Technology and Product Profiles" is a subscription service providing summary descriptions of a wide variety of innovative environmental technologies and products covering several environmental areas.

For more technology assistance information call (412) 826-5511.
5.3 STATE POLLUTION PREVENTION TECHNICAL ASSISTANCE RESOURCES

5.3.1 Delaware

Philip J. Cherry
Andrea K. Farrell
Pollution Prevention Program
Department of Natural Resources and Environmental Control
P.O. Box 1401
89 Kings Highway
Dover, DE 19903
(302) 739-5071/3822
(302) 739-5060 (fax)

Herbert E. Allen
Fred Hurlock
DELWRAP - Delaware Waste Reduction Assistance Program
Department of Civil Engineering
University of Delaware
Newark, DE 19716
(302) 831-8522/8449

5.3.2 District of Columbia

Mr. Nick Kaufman
District of Columbia
DC Gov’t Env. Reg. Admin.
Department of Consumer and Regulatory Affairs
Hazardous Waste Management Branch
2100 Martin Luther King, Jr., Avenue, S.E., Suite 203
Washington, D.C. 20020
(202) 939-8115
(202) 939-7185 (fax)

Mr. Kenneth Laden
District of Columbia Department of Public Works
Office of Policy Planning and Planning
2000 14th Street, NW.
Washington, D.C. 20009
(202) 939-8115
(202) 939-7185 (fax)

Ms. Evelyn Shields
Recycling Coordinator
DC Department of Public Works
65 K Street, N.E.
Washington, D.C. 20002
(202) 727-5887
(202) 727-5872 (fax)

5.3.3 Metropolitan Washington Area

Mr. George L. Nichols
Pollution Prevention Manager
Metropolitan Washington Council of Governments
777 North Capitol Street, NE., Suite 300
Washington, D.C. 20002
(202) 962-3201 (fax)

5.3.4 Maryland

Mitch McCalmon
Pollution Prevention Coordinator
Maryland Department of the Environment - OSPSC
2500 Broening Highway
Baltimore, MD 21224
(301) 631-3114

Maryland Hazardous Waste Facilities Siting Board
60 West Street, Suite 200A
Annapolis, MD 21401

Travis Walton, Director
Technical Extension Service
Engineering Research Center
University of Maryland
College Park, MD 20742
(301) 454-1941

George G. Perdikakis, Director
Maryland Environmental Services
2020 Industrial Drive
Annapolis, MD 21401
(301) 974-7281

5.3.5 Pennsylvania

Meredith Hill, Acting Chief
Source Reduction Program
Pennsylvania Department of Environmental Resources
P.O. Box 8472
Harrisburg, PA 17105-8472
(717) 787-7382

Roger Price
Center for Hazardous Materials Research
University of Pittsburgh Applied Research Center
320 William Pitt Way
Pittsburgh, PA 15238
(412) 825-5320
5.3.6  Virginia

Sharon Kenneally-Baxter, Director
Waste Reduction Assistance Program
Virginia Department of Waste Management
Monroe Building, 11 Floor
101 N. 14th Street
Richmond, VA 23219
(804) 371-8716

Dr. W. David Conn, Professor
Associate Director
University Center for Environmental and Hazardous Materials Studies
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0113
(703) 231-7508

5.3.7  West Virginia

Richard (Whitey) A. Ferrell, Jr.
Pollution Prevention and Open Dump Program (PPOD)
Waste Management Section
West Virginia Division of Environmental Protection
1356 Hansford Street
Charleston, WV 25301
(304) 558-4000
5.4 INDUSTRY TECHNICAL ASSISTANCE RESOURCES

5.4.1 The Industry Cooperative for Ozone Layer Protection (ICOLP)

In 1989, The Industry Cooperative for Ozone Layer Protection (ICOLP) was formed with the aim of collecting and disseminating information on alternative technologies to replace CFCs. The corporate members of ICOLP -- AT&T, Boeing Company, British Aerospace, Compaq Computer Corporation, Digital Equipment Corporation, Ford Motor Company, General Electric, Hitachi, Honeywell, IBM, Matsushita Electric, Mitsubishi Electric, Motorola, Northern Telecom, Sundstrand, Texas Instruments, and Toshiba -- are sharing their own internally developed information on CFC alternatives with other companies worldwide.

Industry Cooperative for Ozone Layer Protection
Suite 300
1440 New York Ave, N.W.
Washington D.C. 20005
(202) 737-1419

This and other alternative processes and technologies are available through OZONET, an interactive database funded by ICOLP. (See 5.5.1)

5.4.2 Industry & Trade Associations

Numerous industry and trade associations can provide information and direction relating to solvent pollution prevention. Some national associations include:

Chemical Coaters Association (CCA)
Box 241
Wheaton, IL 60187
(312) 668-0949

Chemical Manufacturers Association
2501 M Street, N.W.
Washington, D.C. 20037
Ms. Suzanne Wills
Manager, Waste & Release Reduction
(202) 887-1100

Chemical Producers & Dist. Assn.
1220 - 19th Street, N.W., Suite 202
Washington, D.C. 20036
(202) 785-2732
Mr. Hunter Hanshaw, Manager
Regulatory Affairs

Chemical Specialties Manufacturers Association
1001 Connecticut Avenue, NW
Washington, D.C. 20036
(202) 872-8110

Federation of Societies for Coatings Technology (FSCT)
1315 Walnut
Philadelphia, PA 19107
(215) 545-1508

Independent Lubricant Manufacturers Association
1055 Thomas Jefferson Street, NW. #302
Washington, DC 20007
(202) 337-3470
(703) 684-5575 (VA Office)

Industrial Specialty Chemical Association
1520 Locust Street
Philadelphia, PA 19102
(215) 546-9608

National Association of Solvent Recyclers
1333 New Hampshire Avenue, NW
Suite 1100
Washington, DC 20036
(202) 463-6956

National Association of Chemical Recyclers
1875 Connecticut Avenue, NW
Suite 1200
Washington, DC 20009
(202) 986-8150

National Lubricating Grease Institute
4635 Wyandotte Street
Kansas City, MO 64112
(816) 931-9480

National Paint and Coatings Association
1500 Rhode Island Avenue, NW
Washington, DC 20005
(202) 462-6272

Powder Coating Institute
1800 Diagonal Road, #600
Alexandria, VA 22314
(703) 684-4409

Synthetic Organic Chemical Manufacturers Association
1330 Connecticut Avenue, NW
Washington, DC 20036
(202) 659-0060

Industrial Heating Equipment Association
1901 N. Moore Street, Suite 509
Arlington, VA 22209
(703) 525-2513
Mr. James J. Houston, CAE
Executive Vice President
5.5 INTERACTIVE COMPUTERIZED INFORMATION DATABASES & BULLETIN BOARDS

5.5.1 Industry Cooperative for Ozone Layer Protection OZONET

In 1989, The Industry Cooperative for Ozone Layer Protection (ICOLP) was formed with the aim of collecting and disseminating information on alternative technologies to replace CFCs. This and other alternative processes and technologies are available through OZONET, an interactive database funded by ICOLP. Access to OZONET costs $42 per hour, and requires a computer and a modem. For information about becoming a user of OZONET, contact

David Bergman
IPC
7380 Lincoln Ave
Lincolnwood, IL 60646
(708) 677-2850

5.5.2 EPA’s Pollution Prevention Information Clearinghouse (PPIC)

The EPA’s Pollution Prevention Information Clearinghouse (PPIC) contains technical, policy, programmatic, legislative, and financial information concerning source reduction and recycling efforts. It is a free, nonregulatory service of the U.S. EPA and is accessible by personal computer, telephone hotline, or mail.

Pollution Prevention Information Clearinghouse
c/o SAIC
7600-A Leesburg Pike
Falls Church, VA 22043
(703) 821-4800 (for questions on computer access)
(703) 821-4775 (fax)
(202) 260-1963 (for ordering documents)

5.5.3 EPA’s Office of Air Quality Planning & Standards Bulletin Board

The EPA’s Office of Air Quality Planning & Standards (OAQPS) computer bulletin board system (BBS) provides access to information regarding federal air quality regulatory programs, databases, documents, and software. The Technology Transfer Network BBS gives access to the following bulletin boards:

1. Clean Air Act Amendments (CAAA): provides on-line summaries and full text files of each 1990 CAAA title, project status reports and policy documents, and the Title IV Acid Deposition Allowance.

2. Clearinghouse for Inventory and Emission Factors (CHIEF): the primary information clearinghouse on air emission inventories, emission factors, and inventory guidance.

3. Control Technology Center (CTC): information on control technology projects.

4. Emission Measurement Technology Information Center (EMTIC): provides technical information on regulations, source test methods, and agency contacts. Also includes measurement utility programs.

For information on accessing the OAQPS Technology Transfer Network Bulletin board, contact:

Office of Air Quality Planning & Standards
U.S. EPA
(919) 541-5384
5.6 OTHER USEFUL RESOURCES

Other useful resources are available to help businesses establish and implement their waste reduction programs. These include:

- Mailing Lists
- Computer Software Systems
- Chemical & Equipment Buyers’ Guides
- CFC Information
- Directories of Commercial Hazardous Waste Recovery, Treatment, and Disposal Facilities
- Northeast Industrial Waste Exchange (NIWE)

Information on each of these other useful resources for pollution prevention are provided in the remainder of this section.

5.6.1 Mailing Lists

Subject-specific mailing lists are available to help businesses keep up to date with changes and information on specific regulatory and waste reduction subjects. Some of these are listed as follows:

National Environmental Technology Applications Corporation (NETAC)
615 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5511

Center for Environmental Research Information (CERII)
Technology Transfer
U.S. Environmental Protection Agency
P. O. Box 12505
Cincinnati, OH 45212

The 33/50 Program
EPA TS-792a
401 M Street SW
Washington, DC 20460
(202) 554-1404

U.S. Environmental Protection Agency
Office of Underground Storage Tanks
Box 6044
Rockville, MD 20850

“Information For Small Business”
Small Business Ombudsman
U.S. Environmental Protection Agency
401 M Street, SW (A-149C)
Washington, DC 20460
(800) 368-5888

5.6.2 Computer Software Systems

Numerous computer software systems are available to provide direct access to the full text of current federal and state environmental regulations using a personal computer. These systems are convenient, powerful, and current with periodic updates provided as part of the service. In addition, several software packages have also been developed specifically to assist with performing waste reduction assessments and identifying waste reduction resources.

Directories of Computer Software Systems

Donley Technology
Box 335, Department E99
Garrisonville, VA 22433
(703) 859-1954

Pollution Engineering
P.O. Box 173377
Denver, CO 80217-3377
(800) 323-4958 (for reprints of “Selecting Software” Vol. 23, No. 1, Jan. 1991)

Software Packages of Environmental Regulations

ENELEX INFO, available from:
ERM Computer Services, Inc.
855 Springdale Drive
Exton, PA 19341
(215) 524-3600

Regulation Scanning Technology Corp.
333 Market St.
Williamsport, PA 17701
(717) 323-1010

Environmental Compliance Support
P.O. Box 1654
Colorado Springs, CO 80901
(719) 593-9699
Software Packages For Waste Reduction

Available from:
Center for Environmental Research Information (CERI)
Technology Transfer
U.S. Environmental Protection Agency
P. O. Box 12505
Cincinnati, OH 45212
(513) 569-7361

Waste Reduction Advisory System (WRAIS) & Users Guide - includes both the Waste Reduction Audit Checklist & the Waste Reduction Information Bibliography.
Available for $95 from:
Hazardous Waste Research & Information Center (HWRC)
One East Hazelwood Dr.
Champaign, Illinois 61820
(217) 244-8905

Great Lakes Technical Resource Library
(GLTRL) Equipment & Vendor database.
Available from:
Solid & Hazardous Waste Education Center
610 Langdon Street, Rm. 529
Madison, WI 53703
(608) 262-0385

5.6.3 Chemical & Equipment Buyers' Guides

Numerous buyers’ guides are available which provide the names of manufacturers and vendors of chemicals and equipment for waste reduction and/or recycling. Subscriptions to equipment buyers' guides are usually free. Some useful guides and subscriptions are provided as follows.

Directory of Equipment Buyers Guides

Pollution Equipment News
Rimbach Publishing Inc.
8650 Babcock Boulevard
Pittsburgh, PA 15237
(412) 364-5366

Water & Wastes Digest
Scranton Gillette Communications, Inc.
380 Northwest Highway
Des Plaines, IL 60016
(312) 298-5622

Products Finishing Directory
Gardner Publications, Inc.
Cincinnati, Ohio
(513) 231-0020

National Environmental Technology Applications Corporation (NETAC)
615 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5511

Gordon Publications, Inc.
301 Gibraltar Drive
Box 650,
Morris Plains, NJ 07950-0650
(201) 361-9060

Industrial Product Bulletin
Metalworking Digest
Powder/Bulk solids
Chemical Equipment
Food Products & Equipment
Material Handling Product News
Pharmaceutical Processing
Aerospace Products

Chemical Engineering Equipment Buyers Guide
Published by Chemical Engineering Magazine, A McGraw-Hill Publication
1221 Avenue of the Americas
New York, NY 10020
(212) 512-2000

Regional Industrial Buying Guide
Thomas Regional Directory Company Inc.
Five Penn Plaza
New York, NY 10117-0266
(212) 624-2100

Directory of Chemical Manufacturers

“OPD Chemical Buyers Directory”
Annual issue of Chemical Marketing Reporter
Schnell Publishing Co., Inc.
100 Church Street
New York, NY 10007-2694
(202) 732-9820

“Chemical Week Buyers’ Guide”
Published by Chemical Week Magazine, A McGraw-Hill Publication
1221 Avenue of the Americas
New York, NY 10020
(212) 512-2000

National Environmental Technology Applications Corporation (NETAC)
615 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5511
5.6.4 CFC Information

Information on options to CFCs is available from your local utility (CFCs used in refrigeration and cooling) or one of the following sources:

- Industry Cooperative for Ozone Layer Protection (ICOLP)
  1440 New York Ave., SW, Suite 300
  Washington, D.C. 20005
  (202) 737-1419

- CFC Alternatives, a quarterly newsletter available from:
  City of Irvine Environmental Program Office
  P.O. Box 19575
  Irvine, CA 92713

- National Institute of Standards & Technology (NIST)
  (301) 975-5851

5.6.5 Directories of Commercial Hazardous Waste Recovery, Treatment, and Disposal Facilities

There are several publications which provide comprehensive listings of commercial hazardous waste recovery, treatment and disposal facilities.

- Hazardous Waste Services Directory
  J. J. Keller & Associates, Inc.
  145 West Wisconsin Avenue
  P.O. Box 368
  Neenah, WI 54957
  (414) 722-2848
  (800) 558-5011

- Hazardous Wastes Management Reference Directory
  Rimbach Publishing Inc.
  8650 Babcock Boulevard
  Pittsburgh, PA 15237
  (412) 364-5366

- Directory of Waste Recycling Companies, Services & Equipment
  Waste Recyclers Council
  National Solid Waste Management Association
  (202) 659-4613

- El Environmental Services Directory
  Environmental Information, Ltd.
  4801 West 81st Street
  Suite 119
  Minneapolis, MN 55437
  (612) 831-2473

- National Environmental Technology Applications Corporation (NETAC)
  815 William Pitt Way
  Pittsburgh, PA 15238
  (412) 826-5320

- Directory of Resource Recovery Projects & Services
  Institute of Resource Recovery
  National Solid Waste Management Association
  (202) 659-4613

5.6.6 Northeast Industrial Waste Exchange

The Northeast Industrial Waste Exchange (NIWE) functions as an information clearinghouse. NIWE was established in 1981 by the Manufacturers Association of Central New York in cooperation with the Central New York Regional Planning and Development Board. NIWE's information is widely circulated but used primarily in the northeastern United States.

Information is distributed in two ways—a Listings Catalog is published quarterly, and a computerized waste materials listings service is available. Each February, May, August, and November, a list of "Materials Available" and "Materials Wanted" is printed and distributed as widely as possible, with current circulation numbering 10,500. A company wishing to have information included in a list may do so for $25 for three issues. The information is also made available on the computerized listings for the same period of time.

The computerized service is provided free of charge and is available to anyone having access to a microcomputer and modem. The service is designed to allow immediate access to current information. For more information contact:

Northeast Industrial Waste Exchange
90 Presidential Plaza
Suite 122
Syracuse, NY 13202
(315) 422-8572
# CHAPTER 6

CHEMICAL & EQUIPMENT MANUFACTURERS & VENDORS

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<td></td>
<td>Technologies Which Reduce Subsequent Solvent Cleaning</td>
<td>6-11</td>
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</table>
The following list of chemical & equipment suppliers is provided solely as a service to the user. Equipment and vendor information was extracted from product literature available to CHMR. IT IS NOT NECESSARILY A COMPLETE LIST OF ALL EQUIPMENT SUPPLIERS AND SHOULD NOT BE VIEWED AS AN ENDORSEMENT BY CHMR OF THE SUPPLIERS LISTED. Others are coming available or are already available but not known to CHMR.

CHMR in no way endorses any of the goods or services described. CHMR also does not warrant that the information is accurate or complete or that it constitutes a complete description of all the goods and services of this type which are available. CHMR welcomes receipt of information from equipment suppliers for our information clearinghouse.

YOU ARE STRONGLY ENCOURAGED TO CONSULT OTHER SOURCES, SUCH AS YOUR TRADE ASSOCIATION, STATE TECHNICAL ASSISTANCE PROGRAM, AND EQUIPMENT BUYERS' GUIDES, FOR A MORE INFORMATION.

6.1 CHEMICAL & EQUIPMENT BUYERS' GUIDES

Numerous buyers' guides are available which provide the names of manufacturers and vendors of chemicals and equipment for waste reduction and/or recycling. Subscriptions to equipment buyers guides' are usually free. Some useful guides and subscriptions are provided as follows.

**Directory of Equipment Buyers Guides**

Gordon Publications, Inc.
301 Gibraltar Drive
Box 650,
Morris Plains, NJ 07950-0650
(201) 361-9060
Industrial Product Bulletin
Metalworking Digest
Powder/Bulk solids
Chemical Equipment
Food Products & Equipment
Material Handling Product News
Pharmaceutical Processing
Aerospace Products

Rimbach Publishing Inc.
8650 Babcock Boulevard
Pittsburgh, PA 15237
(412) 364-5366

Water & Wastes Digest
Scranton Gillette Communications, Inc.
380 Northwest Highway
Des Plaines, IL 60016
(312) 298-6622

**Directory of Chemical Manufacturers**

"OPD Chemical Buyers Directory"
Annual issue of Chemical Marketing Reporter
Schnell Publishing Co., Inc.
100 Church Street
New York, NY 10007-2694
(202) 732-9820

SRI International
Directory of Chemical Producers:
USA/SRI International
Menlo Park, CA

Products Finishing Directory
Gardner Publications, Inc.
Cincinnati, Ohio
(513) 231-8020

National Environmental Technology Applications Corporation (NETAC)
615 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5511

Chemical Engineering Equipment Buyers Guide
Published by Chemical Engineering Magazine, A McGraw-Hill Publication
1221 Avenue of the Americas
New York, NY 10020
(212) 512-2000

Regional Industrial Buying Guide
Thomas Regional Directory Company Inc.
Five Penn Plaza
New York, NY 10117-0266
(212) 624-2100

Chemical Week Buyers' Guide
Published by Chemical Week Magazine, A McGraw-Hill Publication
1221 Avenue of the Americas
New York, NY 10020
(212) 512-2000

National Environmental Technology Applications Corporation (NETAC)
615 William Pitt Way
Pittsburgh, PA 15238
(412) 826-5511
6.2 METAL PARTS CLEANING

This section summarizes existing equipment and cleaners to permit users to begin a realistic look at metal parts cleaning alternatives. CHMR does not recommend a specific alternate cleaner, equipment or treatment methodology as the "best" approach. The tables provide a cross section of products available and identifies where additional information can be obtained. The user must identify the best combination of cleaners and equipment that meet your needs.

6.2.1 Techniques Which Reduce Subsequent Solvent Cleaning

Upstream metal machining, cutting, welding, and bonding technologies can reduce the need for subsequent solvent cleaning. These include: electrical discharge machining, waterjet cutting, electromagnetic forming, and air cooling. For more information on these technologies, and technology vendors, contact your local electric utility or the EPRI Industry Coordination Office listed below.

Graphel Inc.
6115 Centre Park Dr.
P.O. Box 369
West Chester, OH 45071
(513) 779-6166
(800) 255-1104
(electrical discharge machining)

Vortec Corporation
10125 Carver Road
Cincinnati, OH 45242
(513) 891-7474
(800) 441-7475
(substitute air cooling for liquid coolants)

EPRI Industry Coordination Office
Room 7-136
3412 Hillview Ave
Palo Alto, CA 94303
(415) 855-2899

6.2.2 Solvent Substitutes

Semi-Aqueous, Aqueous, & Hydrocarbon Solvent Substitutes

The following provides a list of solvent substitutes with information extracted from product literature available to CHMR. In some cases the type of solvent offered by the vendor is indicated as follows:

A - Aquous
T - Terpine-based (semi-aqueous)
H - Hydrocarbon
E - Suitable for electronic or other high quality cleaning applications
P - Suitable for paint stripping

As stated, these notations are provided solely as a service to the user, and are based on information currently available at CHMR. This list is not necessarily complete - some vendors may offer other solvent types than those indicated. Others are coming available or are already available but not known to CHMR.

Action Products, Inc.
2401 W. 1st Street
Tempe, AZ 85281
(602) 894-0100
(A)

Alconox, Inc.
215 Park Avenue South
New York, NY 10003
(212) 473-1300
(E)

Alko America
106 Elm Street
Lancaster, SC 29720
803-286-8181
(A,P)

Arco Chemical
3801 West Chester Pike
Newtown Square, PA 19073
(800) 321-7000
(H)

Atochem - NA
3 Parkway
Philadelphia, PA
(215) 587-7000
(A)

BASF Performance Chemicals
100 Cherry Hill Road
 Parsippany, NJ 07154
(201) 263-3400

BAU, Inc.
P.O. Box 190
Alton, NH 03809
(603) 364-2400

Chemical Solvents, Inc.
3751 Jennings Road
Cleveland, OH 44109
(216) 741-9310

Chesterton Technical Products
Middlesex Industrial Park
Route 93
Stoneham, MA 02180
(617) 438-7000

Chute Chemical Company
233 Bomarc Rd.
Bangor, ME 04401
(207) 942-5228
(P)

C. M. Laboratories, Inc.
P.O. Box 8002
Portland, ME 04101
(207) 883-8395
(800) 698-8830

3D Inc.
2053 Plaza Dr.
Benton Harbor, MI 49022
(616) 925-5644
(800) 272-5326
(A)
### Solvent Substitutes (Cont.)

#### Semi-Aqueous, Aqueous, & Hydrocarbon Solvent Substitutes (Cont.)

<table>
<thead>
<tr>
<th>Company</th>
<th>Address 1</th>
<th>Address 2</th>
<th>Phone 1</th>
<th>Phone 2</th>
</tr>
</thead>
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<tr>
<td>Delta Foremost Chemical</td>
<td>P. O. Box 30310</td>
<td>Memphis, TN 38130</td>
<td>(800) 238-5150</td>
<td></td>
</tr>
<tr>
<td>DuPont Chemicals</td>
<td>P. O. Box 80010</td>
<td>Wilmington, DE 19885-1010</td>
<td>(800) 453-8527</td>
<td></td>
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<tr>
<td>Engleside Products, Inc.</td>
<td>Lancaster, PA</td>
<td>(717) 397-9497</td>
<td>&quot;Orange Citra Solve&quot;</td>
<td>(T)</td>
</tr>
<tr>
<td>Environmental Specialties</td>
<td>860 Eddy Street</td>
<td>Providence, RI 02905</td>
<td>(401) 781-6770</td>
<td></td>
</tr>
<tr>
<td>Environmental Technology</td>
<td>Sanford, FL 32771</td>
<td>(407) 321-7910</td>
<td>(A)</td>
<td></td>
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<tr>
<td>Ethone, Inc.</td>
<td>P. O. Box 1900</td>
<td>New Haven, CT 06508</td>
<td>(203) 934-8611</td>
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<tr>
<td>ETUS, Inc.</td>
<td>1511 Kastner Place</td>
<td>Sanford, FL 32771</td>
<td>(407) 321-7910</td>
<td></td>
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<tr>
<td>EZE Products, Inc</td>
<td>P. O. Box 5744</td>
<td>Greenville, SC 29606</td>
<td>(A)</td>
<td></td>
</tr>
<tr>
<td>FPPF Chemical Co.</td>
<td>117 W. Tupper Street</td>
<td>Buffalo, NY 14201</td>
<td>(800) 735-3773</td>
<td></td>
</tr>
<tr>
<td>Fresh-Chemco</td>
<td>P. O. Box 18044</td>
<td>Pittsburgh, PA 15235</td>
<td>(412) 655-4004</td>
<td></td>
</tr>
<tr>
<td>Gravmills Corporation</td>
<td>3705 North Lincoln Avenue</td>
<td>Chicago, IL 60613-3594</td>
<td>(312) 248-6825</td>
<td></td>
</tr>
<tr>
<td>Hubbard-Hall, Inc</td>
<td>P.O. Box 790</td>
<td>Waterbury, CT 06725-0790</td>
<td>(203) 756-5521</td>
<td></td>
</tr>
<tr>
<td>Hurri-Clean Corporation</td>
<td>6000 Southern Industrial Dr.</td>
<td>Birmingham, AL 35235</td>
<td>(205) 655-8808</td>
<td></td>
</tr>
<tr>
<td>Inland Technology</td>
<td>2612 Pacific Hwy, E.</td>
<td>Tacoma, WA 98424</td>
<td>206-922-8932</td>
<td></td>
</tr>
<tr>
<td>International Specialty Products</td>
<td>1361 Alps Road</td>
<td>Wayne, NJ 07470</td>
<td>(800) 622-4423</td>
<td></td>
</tr>
<tr>
<td>JHM, Inc.</td>
<td>314 Straight Street</td>
<td>Grand Rapids, MI 49504</td>
<td>(616) 458-1981</td>
<td></td>
</tr>
<tr>
<td>Kester</td>
<td>515 E. Touhy Avenue</td>
<td>Des Plaines, IL 60018-2675</td>
<td>(A,E)</td>
<td></td>
</tr>
<tr>
<td>Kleer-Flo Company</td>
<td>15151 Technology Drive</td>
<td>Eden Prairie, MN 55344</td>
<td>(612) 934-2555</td>
<td></td>
</tr>
<tr>
<td>KYZEN Corporation</td>
<td>413 Harding Industrial Dr.</td>
<td>Nashville, TN 37211</td>
<td>(615) 831-0888</td>
<td></td>
</tr>
<tr>
<td>Love Company</td>
<td>(717) 273-1023</td>
<td>&quot;Orange-Solvents&quot;</td>
<td>(T)</td>
<td></td>
</tr>
<tr>
<td>LPS Laboratories</td>
<td>4647 Hugh Howell Road</td>
<td>Tucker, GA 30085-5052</td>
<td>(800) 241-8334</td>
<td></td>
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<tr>
<td>Mid Brook Products</td>
<td>2080 Brooklyn Road</td>
<td>Box 887</td>
<td>Jackson, MI 49204</td>
<td>(517) 787-3481</td>
</tr>
<tr>
<td>Noble Technologies</td>
<td>Suite 270</td>
<td>33 Boston Post Road West</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NuTech Environmental Corp</td>
<td>5350 North Washington St.</td>
<td>Denver, CO 80216</td>
<td>(800) 321-8824</td>
<td></td>
</tr>
<tr>
<td>Oakite Products, Inc.</td>
<td>50 Valley Road</td>
<td>Berkley Heights, NJ 07922</td>
<td>(201) 464-6900</td>
<td></td>
</tr>
<tr>
<td>Parker Amchen</td>
<td>32100 Stephenson Hwy</td>
<td>Madison Heights, MI 48071</td>
<td>(800) 222-2600</td>
<td></td>
</tr>
<tr>
<td>Penetone Corporation</td>
<td>74 Hudson Avenue</td>
<td>Tenafly, NJ 07670</td>
<td>(201) 567-3000</td>
<td></td>
</tr>
<tr>
<td>Petrofirm, Inc.</td>
<td>5400 1st Coast Highway</td>
<td>Fernandina Beach, FL 32034</td>
<td>(904) 261-8286</td>
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6.2.2 Solvent Substitutes (Cont.)

Semi-Aqueous, Aqueous, & Hydrocarbon Solvent Substitutes (Cont.)

Plant Chemistry
1365 Rufina Circle
Santa Fe, NM 87501
(505) 438-3448

Power-Tel Products Group, Suite 200
800 N. Belcher Road
Clearwater, FL 34625
(813) 442-2876
(T)

PT Technologies, Inc.
108 4th Avenue South
Safety Harbor, FL 34695
(813) 726-4644
(T)

Quaker Chemical Co.
Elm & Lee Streets
Comshohocken, PA 19428
(215) 832-4000
(A)

Quail Tech Enterprises, Inc.
1485 Bayshore Blvd.
San Francisco, CA 94124
(415) 467-7887
(A)

RAASM USA
P.O. Box 150146
Nashville, TN 37215
(615) 255-7434
(A)

Research Chemicals, Inc.
P.O. Box 1492
Fort Worth, TX 76101
(817) 451-7565
(P)

Rochester Midland Corp.
Rochester, NY
(716) 266-2250
(T)

Safety-Kleen
777 Big Timber Road
Elgin, IL 60120
(312) 697-8460

Sea Corporation
75 Sanger Street
P.O. Box 5098
Peoria, IL 61601
(800) 322-6145

Sentry Chemical Company
(404) 834-4242
(800) 877-3339
(E)

Sherwin-Williams Co.
101 Prospect Avenue, NW
Cleveland, OH 44115-1075
(216) 831-0400
(A)

Simple Green
P.O. Box 880135
El Paso, TX 88588-0135
(A,T)

Solvent Systems International
339 W. River Road
Elgin, IL 60123
(312) 931-5315

Spectro-Chemical Lab Division
Coors Porcelain Company
600 9th Street
Golden, CO 80401
(303) 277-4254
(A,T)

Starlite Chemicals, Inc.
1319 West North Avenue
Chicago, IL 60622
(312) 772-4830

Titan Laboratories
1240 Mtn. View-Alviso Road
Sunnyvale, CA 94089
(408) 734-2200

Total Systems Technology
65 Terrace Drive
Pittsburgh, PA 15236
(412) 653-7690
(800) 245-4828
(A)

V & A Cleaning Systems, Inc.
P.O. Box 555
Rindge, NH 03461
(603) 899-6490

Witco Corporation
Allied-Kellite Division
2701 Lake Street
Melrose Park, IL 60160-3041
(800) 942-9767

W. R. Grace
55 Hayden Avenue
Lexington, MA 62173
(404) 691-8646
(800) 232-6100
(A,E)

ZEP Manufacturing Company
(301) 776-8910
("ZEP Big-Orange") (T)

Carbon Dioxide Cleaning

Airco Gases
Murray Hill, NJ
(908) 771-1491

Alpheus Cleaning Technologies Corporation
9105 Millikan Avenue
Rancho Cucamonga, CA
91730
(714) 944-0055
CFC (Refrigerant) Alternatives

DuPont Company
C&P Department
Chestnut Run - 709
Wilmington, DE 19898
(302) 999-3018

EXAIR Corporation
1250 Century Circle North
Cincinnati, OH 45246-9913
(800) 398-3223
(Vortex tube cabinet cooler)

Flexible Products Company
P. O. Box 3190
Marietta, GA 30061
(404) 428-2684

6.2.3 Metal Parts Cleaning Equipment

Parts washers, solvent

Black Rhino Recycling
P.O. Box 18044
Pittsburgh, PA 15236
(412) 257-8503

Kleer-Flo Company
15151 Technology Drive
Eden Prairie, MN 55344
(800) 328-7942

Pure-Flow International
9617 Wallisville Road
Houston, TX 77014
(800) 833-3801

Petroform, Inc.
5400 1st Coast Highway
Fernandina Beach, FL 32034
(904) 261-8286

Vortec Corporation
10125 Carver Road
Cincinnati, OH 45242
(513) 891-7474
(800) 441-7475
(vortex tube cabinet cooling)

Dawson-MacDonald Co., Inc.
845 Worburn Street
Wilmington, MA 01887
(617) 944-4710

Graymills Corporation
3705 North Lincoln Avenue
Chicago, IL 60613-3594
(312) 248-6825

Safety Kleen Corp.
Box 1419
Elgin, IL 60120

Finishing Equipment, Inc.
3640 Kennebec Drive
St. Paul, MN 55122

Mart Corporation
24568 Adie Road
Maryland Heights, MO 63043
(314) 451-2775

Uni-Wash, Inc.
880 Fralick
Plymouth, MI 48170
(313) 451-2775

Fresh Chemco
P.O. Box 18044
Pittsburgh, PA 15236
(412) 655-4004

Progressive Recovery, Inc.
1020 N. Main Street
Columbia, IL 62236
6.2.3 Metal Parts Cleaning Equipment (Cont.)

Parts washers, aqueous

Action Products, Inc.
2401 W. 1st Street
Tempe, AZ 85281
(602) 894-0100

Digital Equipment Corp
Maynard, MA
(207) 626-3939
(Precision & Electronics)

Electronic Controls Des.
4287-A SE International Way
Milwaukee, WI 53228-8825
(800) 323-4548
(Precision & Electronics)

Advanced Deburring & Finishing
P.O. Box 1004
Statesville, NC 28677
(800) 553-7060

Equipment Systems Technology
P.O. Box 550
Findlay, OH 45840
(419) 424-4239

American Metal Wash Inc.
P.O. Box 265-N
Canonsburg, PA 15317
(412) 746-4203

Final Phase
23540 Pinewood
Warren, MI 48091
(large units)

ATCOR
150 Great Oaks Blvd.
San Jose, CA 95119-1367
(800) 827-6080

GOFF Corp.
P.O. Box 1607
Seminole, OK 74868
(800) 654-4633

Atochem Turco Products, Inc.
7300 Bolsa Avenue
Westminster, CA 92684
(714) 890-3600

Hotsy Corporation
21 Inverness Way East
Englewood, Colorado
80112-5796
(800) 525-1976

Autop North America
P.O. Box 150146
Nashville, TN 37215
(615) 255-7434

Hydro Systems Co.
3798 Round Bottom Rd.
Cincinnati, OH 45244
(513) 271-8800

Better Engineering Mfg. Inc.
7101 Belair Road
Baltimore, MD 21206
(800) 638-3380

Jet Edge Inc.
825 Rhode Island Ave.
Minneapolis, MN 55426
(800) 538-3343

Bowden Industries, Inc.
1004 Oster Drive, N.W.
Huntsville, AL 35816
(800) KLEENER

Kleer-Flo Company
15151 Technology Drive
Eden Prairie, MN 55344
(800) 328-7942

Cleanomat
654 Mendelsohn Avenue
Golden Valley, MN 55427

Lewis Corporation
Oxford, CO 80433
(203) 264-3100

ManGill Chemical, Magnus Division
23000 St. Clair Avenue
Cleveland, OH 44117
(800) 627-6422

New Pac, USA
P.O. Box 1461
Palatine, IL 60067
(312) 541-3961
(large units)

Peterson Machine Tool
5425 Antioch Drive
Shawnee Mission, KS 66202
(800) 255-6308

Proceco, Inc.
1020 East 8th St
Jacksonville, FL 32206
(904) 355-2888

Ransohoff
N. 5th St.,
Hamilton, OH 45011
(513) 863-5813
(large units)

Roto-Jet of America Co., Inc.
2819 San Fernando Blvd.
Burbank, CA 91504
(818) 841-1520

Sioux Steam Cleaner Co.
Sioux Plaza
Berkeley, CA 57004
(515) 763-2776

Sonicor
100 Wartburg Avenue
Copiague, NY 11726
(516) 842-3344

Speedam Corporation
508 Third Avenue
Des Plaines, IL 60016
(312) 803-3200

U.S. Polychemical Corp.
P.O. Box 268
Spring Valley, N.Y. 10997
### 6.2.3 Metal Parts Cleaning Equipment (Cont.)

**Parts washers, ultrasonic**

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<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Contact Information</th>
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<tr>
<td>Black Rhino Recycling</td>
<td>P.O. Box 18044</td>
<td>Pittsburgh, PA 15236</td>
</tr>
<tr>
<td></td>
<td>(412) 257-8503</td>
<td></td>
</tr>
<tr>
<td>Blackstone</td>
<td>P.O. Box 220</td>
<td>Jamestown, NY 14702</td>
</tr>
<tr>
<td></td>
<td>(800) 766-6606</td>
<td></td>
</tr>
<tr>
<td>Branson Ultrasonics</td>
<td>41 Eagle Road, Box 1961</td>
<td>Danbury, CT 06813-1961</td>
</tr>
<tr>
<td></td>
<td>(203) 796-0400</td>
<td></td>
</tr>
<tr>
<td>Crest Ultrasonics</td>
<td>P.O. Box 7266</td>
<td>Trenton, NJ 08628</td>
</tr>
<tr>
<td></td>
<td>(800) 441-9675</td>
<td></td>
</tr>
<tr>
<td>EZE Products, Inc</td>
<td>P.O. Box 5744</td>
<td>Greenville, SC 29606</td>
</tr>
<tr>
<td></td>
<td>(803) 879-7100</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(800) 255-1739</td>
<td></td>
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<tr>
<td>Magna sonic Systems</td>
<td>788 Industrial Blvd.</td>
<td>Xenia, OH 45385</td>
</tr>
<tr>
<td></td>
<td>P.O. Box G</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(513) 372-4811</td>
<td></td>
</tr>
<tr>
<td>Tiyoda Mfg. USA</td>
<td>1613 Lockness Place</td>
<td>Torrance, CA 90501</td>
</tr>
<tr>
<td></td>
<td>(213) 539-5471</td>
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**Parts washers, vapor (low emissions)**

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<thead>
<tr>
<th>Company</th>
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<tr>
<td>Durr Industries, Inc.</td>
<td>40600 Plymouth Road</td>
<td>Plymouth Road</td>
</tr>
<tr>
<td></td>
<td>P.O. Box 2129</td>
<td>Plymouth, MI 48170</td>
</tr>
<tr>
<td></td>
<td>(313) 459-6800</td>
<td></td>
</tr>
<tr>
<td>Petrofim, Inc.</td>
<td>5400 First Coast Highway</td>
<td>Fernandian Beach, FL</td>
</tr>
<tr>
<td></td>
<td>(904)261-9288</td>
<td>32034</td>
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### 6.2.4 Solvent Recycling

#### Distillation Units

<table>
<thead>
<tr>
<th>Company</th>
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<th>Phone</th>
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<tr>
<td>Acra Electric Corp</td>
<td>3801 N 25th Ave, Schiller Park, IL 60176</td>
<td>(312) 678-8870</td>
</tr>
<tr>
<td>AMPRO Technologies</td>
<td>3888 Commerce Street, Riverside, CA 92507</td>
<td>(714) 788-0510</td>
</tr>
<tr>
<td>B/R Instrument Corp.</td>
<td>P.O. Box 7, Pasadena, MD 21121</td>
<td>(612) 452-5695</td>
</tr>
<tr>
<td>Chemical Management Technology, Inc.</td>
<td>P.O. Box 300, Neptune Beach, FL 32233</td>
<td>(904) 247-3247</td>
</tr>
<tr>
<td>Corning Process Systems</td>
<td>Corning Glass Works Big Flats Plant, Corning, NY 14830</td>
<td>(607) 974-0299</td>
</tr>
<tr>
<td>DCI International</td>
<td>1229 Country Club Rd., Indianapolis, IN 46234</td>
<td>(317) 271-4001</td>
</tr>
<tr>
<td>Distillation Environmental Systems, Inc.</td>
<td>525 Boulevard, Kenilworth, NJ 07033</td>
<td>201 272-7600</td>
</tr>
<tr>
<td>Dove Equipment Co.</td>
<td>1110 North Main St, East Peoria, IL 61611</td>
<td>(309) 694-6228</td>
</tr>
<tr>
<td>Ecology Equipment, Inc.</td>
<td>4126 Library Road, Pittsburgh, PA 15234</td>
<td>(800) 852-0094</td>
</tr>
<tr>
<td>Finish Engineering Company</td>
<td>921 Greengarden Road, Erie, PA 16501</td>
<td>(814) 455-4478</td>
</tr>
<tr>
<td>Giant Distillation &amp; Recovery</td>
<td>900 N. Westwood Avenue, Toledo, OH 43607</td>
<td>(419) 531-4600</td>
</tr>
<tr>
<td>HOYT Corporation</td>
<td>Forge Road, Westport, MA 02790</td>
<td>(617) 636-8811</td>
</tr>
<tr>
<td>Interel Corporation</td>
<td>P.O. Box 4676, Englewood, CA 90155</td>
<td>(303) 773-0753</td>
</tr>
<tr>
<td>Jodan Technology</td>
<td>P.O. Box 362, 133 Massachusetts Ave, Lexington, MA 02173</td>
<td>(617) 863-8898</td>
</tr>
<tr>
<td>Kleer-Flo Company</td>
<td>1511 Technology Drive, Eden Prairie, MN 55344</td>
<td>(612) 934-2555</td>
</tr>
<tr>
<td>Lenan Corporation</td>
<td>615 North Parker Drive, Janesville, WI 53545</td>
<td>(800) 356-9424</td>
</tr>
<tr>
<td>Lenape Sales &amp; Service, Inc.</td>
<td>P.O. Box 285, Manasquan, NJ 08736</td>
<td>(201) 681-2442</td>
</tr>
<tr>
<td>Mac Associates</td>
<td>25 E Dudley Street, Marlboro, MA 01752</td>
<td></td>
</tr>
<tr>
<td>Morehouse Industries, Inc.</td>
<td>1600 W Commonwealth Avenue, P.O. Box 3620, Fullerton, CA 92633</td>
<td>(714) 738-5000</td>
</tr>
<tr>
<td>PBR Industries, Inc.</td>
<td>400 Farmingdale Rd, West Babylon, NY 11704</td>
<td>(516) 422-0057</td>
</tr>
<tr>
<td>Pittsburgh Spray Equipment</td>
<td>3601 Library Road, Pittsburgh, PA 15234</td>
<td>(412) 882-4550</td>
</tr>
<tr>
<td>Pope Scientific Inc.</td>
<td>N90 W14337 Commerce Dr., P.O. Box 495, Menomonee Falls, WI 53051</td>
<td>(414) 251-3300</td>
</tr>
<tr>
<td>Progressive Recovery, Inc.</td>
<td>1020 North Main Street, Columbia, IL 62236</td>
<td>(618) 281-7196</td>
</tr>
<tr>
<td>Pure-Flow International</td>
<td>9817 Wallisville Road, Houston, TX 77013</td>
<td>(800) 833-3801</td>
</tr>
<tr>
<td>Recyclene Products, Inc.</td>
<td>405 Eccles Avenue, South San Francisco, CA 94080</td>
<td>(415) 589-9600</td>
</tr>
<tr>
<td>Renzmann, Inc.</td>
<td>310 Oser Avenue, Hauppauge, NY 11788</td>
<td>(516) 231-3030</td>
</tr>
<tr>
<td>Siva International, Inc.</td>
<td>405 Eccles Avenue, S. San Francisco, CA 94080</td>
<td>(415) 589-9600</td>
</tr>
<tr>
<td>Solvent Klean, Inc.</td>
<td>131 1/2 Lynnfield Street, Peabody, MA 01960</td>
<td>(508) 531-2279</td>
</tr>
<tr>
<td>SRS Industrial Engineering</td>
<td>711 Foxwood Dr, Oceanside, CA 92057</td>
<td>(619) 722-8835</td>
</tr>
<tr>
<td>Thomas Equipment Co.</td>
<td>901 Tonne Road, Elk Grove Village, IL 60007</td>
<td></td>
</tr>
<tr>
<td>V &amp; A Cleaning Systems, Inc.</td>
<td>P.O. 555, Rindge, NH 03461</td>
<td>(603) 899-6490</td>
</tr>
<tr>
<td>Waste Recovery Designed Products, Inc.</td>
<td>Bridgeville, PA 15017</td>
<td>(412) 833-2956</td>
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### Filtration Units

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Phone</th>
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</thead>
<tbody>
<tr>
<td>Allen Filters, Inc.</td>
<td>Box 747, Springfield, MO 65801</td>
<td>(417) 865-2844</td>
</tr>
<tr>
<td>Fresh Chemco</td>
<td>P.O. Box 18044, Pittsburgh, PA 15236</td>
<td>(412) 655-4004</td>
</tr>
<tr>
<td>Harvard Filtration Systems</td>
<td>R.D. #2, Box 388, Eighty-Four, PA 15330</td>
<td>(412) 225-3650</td>
</tr>
<tr>
<td>Micropure Filtration</td>
<td>P.O. Box 7007, 2323 Sixth Street, Rockford, IL 61125-9901</td>
<td>(815) 962-8867</td>
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### 6.2.5 Solvent Emissions Recovery and Recycling

### Activated Carbon Absorption/Regeneration Systems

<table>
<thead>
<tr>
<th>Company</th>
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<tbody>
<tr>
<td>Baron Blakeslee Inc.</td>
<td>2001 N. Janice Ave., Melrose Park, IL 60160</td>
<td>(312) 450-3900</td>
</tr>
<tr>
<td>Dedert Corporation</td>
<td>20000 Governors Drive, Olympia Fields, IL 60461-1074</td>
<td>(708) 747-7000</td>
</tr>
<tr>
<td>HOYT</td>
<td>The Clean Air Co., 251 Forge Rd., Westport, MA 02790-0217</td>
<td>(617) 636-8811</td>
</tr>
<tr>
<td>Met-Pro Corporation Systems Division</td>
<td>180 Cassell Rd., Box 144, Harleysville, PA 19438 (215) 723-6751</td>
<td></td>
</tr>
<tr>
<td>RaySolv Inc.</td>
<td>225 Old New Brunswick Rd., Piscataway, NJ 08854 (201) 981-0500</td>
<td></td>
</tr>
<tr>
<td>VARA International Inc.</td>
<td>1201 19th Place, Vero Beach, FL 32960 (305) 567-1320</td>
<td></td>
</tr>
<tr>
<td>Vic Manufacturing Co.</td>
<td>152 Main St., Nantucket, MA 02554 (617) 228-3464 (800) 824-7888</td>
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### Condensation Systems

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
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<tr>
<td>Alloy Fab, Inc.</td>
<td>200 Ryan St., P.O. Box 898, S. Plainfield, NJ 07080 (201) 753-9393</td>
<td></td>
</tr>
<tr>
<td>Croll-Reynolds Co., Inc.</td>
<td>751 Central Ave., P.O. Box 668, Westfield, NJ 07901 (201) 232-4200</td>
<td></td>
</tr>
<tr>
<td>Edwards Engineering</td>
<td>101 Alexander Ave., Pompton Plains, NJ 07444 (201) 835-2800</td>
<td></td>
</tr>
<tr>
<td>Pfaudler Co.</td>
<td>1000 West Ave., Box 1800, Rochester, NY 14692 (716) 235-1000</td>
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---

**Note:** The text is formatted as a table with company names, addresses, and phone numbers.
6.3 PAINT APPLICATION AND STRIPPING

6.3.1 Low VOC Paints and Coatings

The Sherwin-Williams Co.
101 Prospect Avenue, NW
Cleveland, OH 44115-1075
(216) 831-0400

General Magnaplate Corp.
1331 Route 1
Linden, NJ 07036
(908) 862-6200

6.3.2 Low-waste Paint Application Technologies

Painting equipment

AccuSpray
Box 391525
Cleveland, OH 44139

Pratt Lambert
4 Sonwil Industrial Park
Buffalo, NY 14225
(716) 683-8631

Spraylat Corporation
716 South Columbus Avenue
Mt. Vernon, NY 10550
(914) 699-3030

Becker Powders, Inc.
4150 Lyman Drive
Hillark, OH 43206
(614) 771-7901

Protech Chemicals Ltd.
7600 Henri-Bourassa O.
Saint-Laurent, QU H4S 1W3
Canada
(800) 361-5783

Teknikote, Inc.
336 Roosevelt Avenue
Central Falls, RI 02863
(401) 274-2230

Modean Corporation
907 Bridgeport Avenue
Sheiton, CT 06484
(203) 925-1136

R-K Industries Inc.
c/o New England Oven & Furance
385 Boston Post Road
Orange, CT 06477
(203) 799-2005

Volstatic, Inc.
P.O. Box 6150
7960 Kentucky Drive
Florence, KY 41042
(606) 371-2557

Nordson Corporation
P.O. Box 151
555 Jackson Street
Amherst, OH 44001-0151
(216) 988-9411

Spray nozzles

Spraying Systems Co.
P.O. Box 7900
Wheaton, IL 60189-7900
(708) 665-5000

Vortec Corporation
10125 Carber Rd.
Cincinnati, OH 45242-9976
(513) 891-7474
(800) 441-7475

6.3.3 Paint Curing Technologies

Certain paint curing technologies (e.g., infrared drying) can facilitate use of less-toxic coating materials as substitutes for solvent-based coatings. For more information on these technologies, and technology vendors, contact your local electric utility or the EPRI Industry Coordination Office listed below.

Aitken Products, Inc
P.O. Box 151
Geneva, OH 44041
(216) 466-5711

Inductoheat
32251 North Avis Dr.
Madison Heights, MI 48071
(313) 585-9393
(800) 624-6297

Wellman Thermal Systems
One Progress Road
Shelbyville, IN 46176
(317) 398-4411

Alpha 1
Induction Service Center
1525 Old Alum Creek Dr.
Columbus, OH 43209
(614) 253-8500

Radyne Corporation
12819 West Silver Spring Rd.
Butler, WI 53007-1098
(414) 781-8160

EPRI Industry Coordination
Office
Room 7-136
3412 Hillview Ave
Palo Alto, CA 94303
(415) 855-2899
6.3.4 Paint Gun Cleaning Technologies

Black Rhino Recycling, Inc.  
P.O. Box 18044  
Pittsburgh, PA 15236  
(412) 257-8503

Ecology Equipment, Inc.  
4162 Library Road  
Pittsburgh, PA 15234  
(800) 852-0094

6.3.5 Paint Stripping

Abrasive cleaning

Black Rhino Recycling, Inc.  
P.O. Box 18044  
Pittsburgh, PA 15236  
(412) 257-8503

Hunter Products, Inc.  
Box 6795  
792 Partridge Drive  
Bridgewater, NJ 08807  
(800) 524-0692

Paint stripping solvent alternatives

Chute Chemical Company  
233 Bomarc Rd.  
Bangor, ME 04401  
(207) 942-5228

ETUS, Inc.  
1511 Kastner Place  
Sanford, FL 32771  
(407) 321-7910

Fresh Chemco  
P.O. Box 18044  
Pittsburgh, PA 15236  
(412) 655-4004

Research Chemicals, Inc.  
P.O. Box 1492  
Fort Worth, TX 76101  
(817) 451-7565

Other chemical suppliers listed under "Solvent Alternatives" may also provide substitutes for paint stripping.

Paint waste recycling

Agglo Recovery Inc.  
34 Leading Road  
Rexdale, Ontario  
Canada M9V 3S9  
(416) 740-0188

Environmental Purification Industries (EPI)  
2111 Champlain Street  
Toledo, OH 43611  
(419) 727-0495

6.4 PROCESS EQUIPMENT CLEANING

6.4.1 Technologies Which Reduce Subsequent Solvent Cleaning

TAH Industries, Inc.  
107 North Gold Drive  
Robbinsville, NJ 08691  
(609) 259-9222  
(Mixing equipment for dispensing two component adhesives)
## CHAPTER 7
WASTE RECYCLING FACILITIES & CONTRACTORS

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<td>7.1.6</td>
<td>Other States</td>
<td>7-2</td>
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7.1 WASTE SOLVENT RECYCLING FACILITIES & CONTRACTORS

7.1.1 Delaware

Boulden, Inc.
895 Nottingham Road
Elkton, MD 21921
(302) 368-2553

Engov Limited
490 Century Boulevard
Wilmington, DE
(302) 633-4480

Safety Kleen Corp.
777 Big Timber Road
Elgin, IL 60123
(708) 897-8460
Pick-up Service
(800) 265-2444

7.1.2 Maryland

Boulden, Inc.
895 Nottingham Road
Elkton, MD 21921
(410) 398-9060

Safety Kleen
1448 De Soto Boulevard
Baltimore, MD 21230
(410) 525-0001

7.1.3 Pennsylvania

Ashland Chemical, Inc
Branch Office
100 N. Commerce Dr (I-95)
Aston, PA 19014
(215) 494-5755

Chemcare
Coraopolis, PA
412-923-1100
Philadelphia, PA
(215) 365-7200
Dunceville, PA
(814) 695-7534
Hummelstown, PA
(717) 566-2521

Chemclene Corporation
258 North Phoenixville Pike
Malvern, PA 19355
(215) 644-2986

Delaware Container Company
West 11th Ave & Valley Rd
Coatesville, PA 19320
(215) 383-6600

Kleen-Line Service Company
411 Washington Ave
Dravosburg, PA 15034
(412) 466-6277

Capitol Parts Washer
570 Industrial Drive
Lewisberry, PA 17239
(717) 938-2284

7.1.4 Virginia

Ashland Chemical, Inc.
Branch Office
2410 Patterson Ave. S.W.
Roanoke, VA 24016
(703) 981-1251

Prillaman Chemical Corporation
Chester, VA 23831
(804) 748-8100
Suffolk, VA
(804) 539-7401

Safety-Kleen Corp
Chesapeake, VA
(804) 543-5907
Chester, VA
(804) 748-3767
Vinton, VA
(703) 890-4478
Safety-Kleen Pick-up Service
(800) 265-2444

7.1.5 West Virginia

Safety-Kleen Corp.
Cincinnati, OH
(513) 860-1507
Safety-Kleen Pick-up Service
(800) 265-2444

04/01/93
7-1
7.1 WASTE SOLVENT RECYCLING FACILITIES & CONTRACTORS (Cont.)

7.1.6 Other States

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>City</th>
<th>State</th>
<th>Zip Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashland Chemical, Inc.</td>
<td>Industrial Chemicals &amp; Solvents Division</td>
<td>P.O. Box 2219</td>
<td>Columbus, OH</td>
<td>43216</td>
</tr>
<tr>
<td>Klor Kleen Inc.</td>
<td>3118 Spring Grove Ave.</td>
<td>Cincinnati, OH</td>
<td>45225</td>
<td></td>
</tr>
<tr>
<td>Safety Kleen Corp.</td>
<td>777 Big Timber Road</td>
<td>Elgin, IL</td>
<td>60123</td>
<td></td>
</tr>
<tr>
<td>Sparkle Corp.</td>
<td>7013 Krick Rd.</td>
<td>Bedford, OH</td>
<td>44146</td>
<td></td>
</tr>
<tr>
<td>Tampa, FL</td>
<td></td>
<td></td>
<td></td>
<td></td>
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(800) 265-2444


**CHAPTER 8**

USEFUL REFERENCE DOCUMENTS

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8.1 ENVIRONMENTAL PROTECTION AGENCY (EPA)

8.1.1 Pollution Prevention Documents

The U.S. EPA is developing a series of documents for numerous industry specific categories which provide an overview of waste generating process and operations, and presents options for minimizing waste generation through source reduction and recycling. These documents, entitled "Guides To Pollution Prevention", and other useful pollution prevention documents are available free-of-charge from:

Center For Environmental Research Information (CERI) Technology Transfer U.S. Environmental Protection Agency P.O. Box 12505 Cincinnati, OH 45212 (513) 569-7562

OR

EPA's Pollution Prevention Information Clearinghouse
(202) 260-1963

The following provides a current list of those pollution prevention related documents available from the U.S. EPA.

Guides To Pollution Prevention

- The Pesticide Formulating Industry (625/7-90/004)
- The Paint Manufacturing Industry (625/7-90/005)
- The Fabricated Metal Products Industry (625/7-90/006)
- The Printed Circuit Board Manufacturing Industry (625/7-90/007)
- The Commercial Printing Industry (625/7-90/008)
- Research & Educational Institutions (625/7-90/009)
- Selected Hospital Waste Streams (625/7-90/010)
- The Photoprocessing Industry (625/7-91/012)
- The Automotive Repair Industry (625/7-91/013)
- The Fiberglass-Reinforced & Composite Plastics Industry (625/7-91/014)
- The Marine Maintenance & Repair Industry (625/7-91/015)
- The Automotive Refinishing Industry (625/7-91/016)
- The Pharmaceutical Industry (625/7-91/017)
- Mechanical Equipment Repair Industry (625/R-92/008)
- Metal Casting & Heat Treating Industry (625/R-92/009)
- Metal Finishing Industry (625/R-92/011)

EPA's 33/50 Program

- The 33/50 Program: Forging An Alliance For Pollution Prevention
- Guidance For Preparing 33/50 Program "Participation" Letters
- EPA's 33/50 Program Progress Report

Other Solvent Pollution Prevention Documents

- Waste Minimization Opportunity Assessment Manual (625/7-88/003)
- Case Studies for the Pollution Prevention Information Clearinghouse: Solvent Recovery, November 1989, (ISM-4)
- Waste Minimization in Metal Parts Cleaning (EPA/530-SW-89-049)
- Evaluation of Alternatives to Toxic Organic Paint Strippers (EPA/600/S2-86/063)
- Solvent Waste Reduction Alternatives Seminar Publication (EPA/625/4-89/021)
8.1.2 SARA Title III Documents

The U.S. EPA has developed a series of useful documents for the fabricated metal products industry regarding SARA Title III requirements and methods of estimating releases. These documents are available free-of-charge from:

U.S. Environmental Protection Agency
Emergency Planning & Community Right-to-Know
Document Distribution Center
P.O. Box 12505
Cincinnati, OH 45212
(800) 535-0202

The following provides a current list of those SARA Title III related documents available from the U.S. EPA.

SARA Title III Documents

- SARA Title III Fact Sheet
- Understanding Sections 311 & 312 of EPCRA
- Section 313 Release Reporting Requirements
- Toxic Chemical Release Inventory Reporting Form R & Instructions
- Section 313 Issue Paper: Clarification & Guidance For Metal Fabricators
- Common Synonyms
- Air Contaminants: Permissible Exposure Limits
- Title III, Section 313 Release Reporting Guidance: Estimating Releases From:
  - Electroplating Operations
  - Coating Oper., Roller, Knife, & Gravure
  - Coatings, Electrodeposition of Organic
  - Coatings, Spray Application of Organic
  - Leather Tanning & Finishing
  - Monofilament Fiber Manufacturing
  - Paper & Paperboard Production
  - Printing Operations
  - Rubber Production & Compounding
  - Semiconductor Manufacturing
  - Textile Dyeing
  - Wood Preserving Operations
  - Wood Products, Presswood & Laminated
8.2 ELECTRIC POWER RESEARCH INSTITUTE (EPRI) & LOCAL UTILITIES

The Electric Power Research Institute (EPRI) was founded by the nation's utilities to develop and manage an electric technology program with information on industrial processes, energy management, thermal control, waste reduction and pollution control technologies, and many other applications. EPRI operates several centers focused on the research and development of technologies with particular emphasis. These include:

- **Center For Materials Fabrication (CMF)** -- CMF is a research, development, and technology applications center established by EPRI. Member utilities have access to CMF's many technical services, free consultation on specific manufacturing problems and applications, and publications on various electrotechnologies.

- **Center For Metals Production (CMP)** -- CMP is a research and development center established by EPRI to provide advice on improving the productivity and energy efficiency of primary metals production businesses. Member utilities have access to the technical services and information available from CMP.

Member utilities have access to the extensive Electric Power database and EPRI Technical Library, which include numerous TechCommentary and TechApplication brochures and other useful documents available from EPRI.

Requests for copies of EPRI reports should be directed to:

Research Reports Center (RRC)
Box 50490
Palo Alto, CA 94303
(415) 965-4081

There is no charge for reports requested by EPRI member utilities and affiliates, U.S. utility associations, U.S. government agencies (federal, state, and local), media, and foreign organizations with which EPRI has an information exchange agreement. On request, RRC will send a catalog of EPRI reports.

**EPRI TechCommentary & TechApplication Brochures**

**Infrared Drying**
- Medium & Short Wave Infrared Curing, EPRI CMF TechApplication, Vol. 1, No. 3, 1987

**Ultraviolet Curing**
- Ultraviolet Curing Technology, EPRI CMF TechCommentary, Vol. 4, No. 4, 1987, 1990r
- UV Curing of Coatings on Metals, EPRI CMF TechApplication, Vol. 1, No. 16, 1987

**Electrical Discharge Machining**
- Electrical Discharge Machining, EPRI CMF TechCommentary, Vol. 3, No. 1, 1986
- Electrical Discharge Machining, EPRI CMF TechApplication, Vol. 1, No. 9, 1987

**Waterjet, Plasma Arc, & Laser Cutting**
- Waterjet Cutting, EPRI CMF TechCommentary, Vol. 5, No. 1, 1988
- Plasma Arc Cutting, EPRI CMF TechCommentary, Vol. 4, No. 5, 1987
- Laser Cutting, EPRI CMF TechCommentary, Vol. 3, No. 9, 1986
- Laser Cutting of Metal, EPRI CMF TechApplication, Vol. 1, No. 6, 1987

**Induction Bonding**
- Induction Heating of Thermoset Adhesives, EPRI CMF TechApplication, Vol. 1, No. 12, 1987

**Electromagnetic Forming**
- Electroforming, EPRI CMF TechCommentary, Vol. 3, No. 5, 1986

**Industrial Heat Pumps**
- Industrial Heat Pumps, EPRI TechCommentary Vol. 1, No.4, 1988
8.3 INDUSTRY ASSOCIATIONS

Numerous industry association periodicals which may contain useful pollution prevention information include:

American Paint and Coatings Journal
American Paint Journal Co.
2911 Washington Avenue
St. Louis, MO 63103

Assembly Engineering
Hitchcock Publishing Co.
Geneva Road
Wheaton, IL 60187

CMA Pollution Prevention Code
Documents
Chemical Manufacturers Association
Publications Fulfillment
2501 M Street, N.W.
Washington, DC 20037
(202) 887-1100

Cleaning - Finishing - Coating Digest
American Society for Metals
Metals Park, OH 44073

Electronic Packaging and Production
Milton S. River Publications, Inc.
222 W. Adams Street
Chicago, IL 60606

Industrial Finishing
Hitchcock Publishing Co.
Hitchcock Building
Wheaton, IL 60187

Journal of Coatings Technology
Fed. of Societies for Coating Tech.
1315 S. Walnut Street
Suite 830
Philadelphia, PA 19107

Journal of Protective Coatings & Linings
Steel Structures Painting Council
2100 Wharton Street, Suite 310
Pittsburgh, PA 15203
(412) 268-3327

Metal Finishing
Metal and Plastics Publications, Inc.
One University Plaza
Hackensack, NJ 07601

Metal Finishing Journal
Fuel and Metallurgical Journals, Ltd.
John Adam House
John Adam Street
London WC 2N 6JH, England

Metal Finishing Plants and Processes
Finishing Publications Ltd.
28 High Street
Teddington, Middlesex, England

Metal Progress
American Society for Metals
Metals Park, OH 44073

Plating and Surface Finishing
American Electroplaters Society, Inc.
1201 Louisiana Avenue
Winter Park, FL 32789

Pollution Prevention Resource Manual
Chemical Manufacturers Association
Publications Fulfillment
2501 M Street, N.W.
Washington, DC 20037

8.4 THE PRESIDENT'S COUNCIL ON ENVIRONMENTAL QUALITY (PCEQ)

The President's Council on Environmental Quality (PCEQ) has produced several useful pollution prevention documents including:

- Total Quality Management -- A Framework for Pollution Prevention
- Workplace Waste Reduction Guide

These documents are available from:

President's Commission on Environmental Quality
Executive Office of the President
722 Jackson Place, NW
Washington D.C. 20503
(202) 395-5750
(202) 395-3745 (fax)