On-site Reuse and Recycle of Halogenated Waste Solvents

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Session III
Reuse and Recycle
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INTRODUCTION

Numerous examples have shown that waste-reduction programs result in a cleaner environment, less worker exposure to chemicals, and significant savings in fuel, feedstock, and environmental-control costs.

The Dow Chemical Company has practiced waste reduction -- and shared its expertise with customers -- for more than two decades.

In order to illustrate some principles of waste management, this paper will describe internal and external efforts to reduce waste from the use of specialty chlorinated solvents -- including a description of in-house recycling -- factors influencing solvent consumption, and issues in solvent waste disposal.

WASTE REDUCTION: BACKGROUND

Dow has practiced waste reduction since the 1960s, when Chief Executive Officer Carl Gerstacker developed a pollution-control plan that called for employee involvement and rewards for achievement. He sought to improve yields, reduce waste, and find ways to use waste.

Significant dates in the regulatory and legislative history of waste reduction include: 1976, when the Environmental Protection Agency listed waste reduction at the top of a preferred hierarchy for waste management; and 1984, when Congress defined the desirability of waste reduction as a national policy.

In 1987, Dow grouped the internal efforts that grew from Gerstacker's plan under a program called WRAP -- Waste Reduction Always Pays. (The service provided to chlorinated solvents users is called the Waste Reduction Assistance Program. Details begin on Page 12).

The importance of a plan such as WRAP is that it is long-term, and formalizes past, present, and future waste-reduction efforts in order to track progress and chart a course (see Fig. 1). Goals are to:

- Reduce waste in all media.
- Create a disposition toward waste reduction.
- Provide incentives to reduce waste.
- Recognize excellence in waste-reduction efforts.
- Save money (including avoided costs).
- Lessen future liability.

Waste reduction can be defined as:

- Any in-plant practice or process that avoids, eliminates or reduces waste so as to reduce environmental risk to any media.
- The treatment, reuse or recycling of any material that reduces the volume and/or toxicity of waste prior to final disposition.

The Louisiana Operations Division -- a large, diversified manufacturing division -- provides excellent examples of success
Fig. 1
WRAP Flow Chart

1. Develop Historical Benchmark For Each Process
2. Inventory All Losses To Air, Water, Land (Quantity & Quality)
3. Identify Source Of Losses
4. Prioritize (Volume And Screening Method)
5. Set Goals
6. Determine Cost Effective Actions
7. Allocate Resources
8. Implement Actions
10. Communicate Internal & External
11. Plan For Future Reduction
in waste reduction. In the past decade, hydrocarbon emissions dropped 92% and chlorinated hydrocarbon discharges to water dropped 98% while production increased from about 8 billion pounds per year to 12 billion pounds per year.

The division utilized techniques such as improving the purity of raw materials, improving instrumentation, using on-stream analyzers, using process analysis by statistical methods, and improving maintenance.

**TRENDS IN CHLORINATED SOLVENTS USE**

Specialty chlorinated solvents include 1,1,1-trichloroethane, trichloroethylene, methylene chloride, and perchloroethylene. The diverse applications for these products include metal cleaning (by means of cold cleaning and vapor degreasing), dry cleaning, chemical processing, and production of fluorocarbons, aerosols, paint removers, adhesives, coatings/inks, and blowing agents.

The demand for metal-cleaning solvents far outweighs the demand for chlorinated solvents for any other application (see Fig. 2). It is more than twice the demand for dry cleaning solvents and three times the demand for fluorocarbons production solvents. Dry cleaning and fluorocarbons production are the second and third largest applications for chlorinated solvents, respectively.

Metal-cleaning solvents represented 38.2% of the total demand for chlorinated solvents in 1984 and 34.6% of the total in 1987. Although demand for metal-cleaning solvents dropped 139 million pounds in those three years -- a decline disproportionate to the 194-million-pound drop in total demand -- metal cleaning still is the most significant application for these four chlorinated solvents in the United States.

Conservation -- and efforts to encourage more efficient use of solvents -- have contributed to both the decline in demand for all virgin chlorinated solvents and the decline in use of virgin chlorinated solvents for metal-cleaning applications.
Applications/End Uses
For Specialty Chlorinated Solvents

![Bar Chart]

- Metal Cleaning: 754 MM LB
- Drycleaning: 344 MM LB
- Fluorocarbons Production: 208 MM LB
- Aerosols: 186 MM LB
- Chemical Processing Industry: 142 MM LB
- Paint Removers: 137 MM LB
- Other: 203 MM LB

Fig. 2
Many chlorinated solvents users hire companies with the technology to reclaim solvents from waste sludges. The following table illustrates the growth of contract reclamation.

**CONTRACT RECLAMATION INCREASING**

<table>
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<th>Year</th>
<th>Pounds reclaimed (in millions)</th>
<th>% of all solvents users buying reclaimed solvents</th>
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<tr>
<td>1977</td>
<td>69</td>
<td>20-25</td>
</tr>
<tr>
<td>1982</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>1986</td>
<td>268</td>
<td>75-80</td>
</tr>
<tr>
<td>1990</td>
<td>310 (estimate)</td>
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When recycled solvents enter the marketplace, the demand for virgin solvents drops correspondingly. And, reclaimed solvents come primarily from metal-cleaning applications.

The quality of recovered solvents may vary for reasons including stabilizer depletion and cross-contamination with other solvents or compounds.

Problems that can occur because of improperly stabilized solvent include:

- Dilution of fresh solvent, which can shorten solvent life.
- Reduced acid acceptor content. This can decrease the margin of safety before an acid condition develops in cases of stress.
- Reduced metal stabilizer content, which decreases or eliminates protection from corrosion. Corrosion produces acid that degrades solvent and consumes acid acceptor.
- Excess stabilizer content, a potential flammability hazard.
- Improper stabilizer ratio, which reduces the effectiveness of metal stabilizers.
- Contaminated solvent. Such contaminants as aromatics in methylene chloride and 1,1,1-trichloroethane in trichloroethylene can cause reactions that result in an acid condition, especially in the presence of aluminum.
- Excess water. This shortens solvent life, causes greater vapor loss, and creates corrosion and/or spotting on the work.

As Fig. 3 shows, the demand for virgin chlorinated solvents was sluggish between 1971 and 1980, and has fallen since 1980. That decline corresponds almost directly to the increase in total pounds of reclaimed solvents on the market since 1980.
U.S. Demand For Chlorinated Solvents

Fig. 3

MM LB

Total Virgin
Virgin MC
Reclaim

While the contract reclamation industry was growing, chlorinated solvents users also were finding ways to recover solvents in-house. In 1983, 52% of the customers that Dow knew were using chlorinated solvents, were recovering in-house. That figure was up to 64% in 1987.

The use of in-house stills to recover solvent and concentrate waste typically results in up to a 20% reduction in solvent use. In-house solvent recovery is tantamount to source reduction because it eliminates a need for virgin material.

Distillation recovery equipment falls into three categories: process stills, in-house solvent recovery equipment -- including units that are the same type of equipment as process stills, and semiportable ministills -- and thin-film evaporators. In addition, the vapor degreaser can be used as a quasi-still by means of the boil-down procedure (see Appendix A).

Process stills are used in conjunction with vapor degreasers. Dirty solvent from the sump of the degreaser is pumped to the still for distillation, then returned to the degreaser's offset clean solvent storage tank.

A degreaser with a still does not have to be shut down and cleaned to remove contaminants as often as a degreaser without a still. Periodically, the still is opened and the sludge removed while the degreaser continues operating. This process is called continuous distillation and can produce a waste that is approximately 25-50 percent solvent.

Process stills are often steam-heated, but can also be electrically heated or steam-fired. Their recovery rates are expressed in gallons per hour, and typically run from 30-200 gph. About 62% of Dow's larger customers recovering solvents on-site use process stills.

In-house solvent recovery equipment offers a specialty technique for minimizing solvent waste and eliminating the need to send spent solvent to an outside reclaimer.

To recover solvent, spent solvent is collected and stored until enough accumulates to fill a still. The contaminated solvent is pumped into the still, distilled, and recovered in drums or storage tanks. This is called batch distillation and removes 70-95% of the solvent in the waste.

Larger units are the same type of equipment as process stills, except that they are not necessarily used in conjunction with vapor degreasers.

Some newer, small-capacity units are electrically heated and recover solvent over a long period, typically about eight hours. Based on hundreds of calls on customers over the past four years, Dow estimates only about 1-2% of customers recovering solvents on-site use these ministills.

Thin-film evaporators are used for high-volume solvent recovery. Their application is primarily for continuous feed, and capacities range from 50-500 gph. Solvent recovery is 90-95%.
Recovered solvent fits into one of these three categories:
- Clean solvent.
- Clean solvent with the measured addition of acid acceptor.
- Clean solvent, analyzed for inhibitor content and restabilized with both acid acceptor and metal stabilizers as required.

The latter two categories usually are obtainable only through contract reclaimers.

The recovered solvents that are obtained from in-house distillation usually can be used directly in the cold cleaning or vapor degreasing process as a replacement for some virgin solvents. However, because the quality of recycled solvent can vary, it should be monitored by analysis and used only as a blend with virgin solvent.

Fortunately, in-house distillation is not often subject to cross-contamination, and blending with virgin solvents during reuse should keep stabilizers within satisfactory limits.

In some cases, however, it is necessary to restabilize recycled solvents in-house when inhibitor depletion is excessive and unavoidable. An example would be to add acid acceptor to trichloroethylene that has been depleted by carbon adsorption recovery. Some, not all, stabilizers are provided commercially in a safe and effective manner.

Depending on the equipment utilized and the nature of the production process, waste solvents and residues from in-house distillation are sent out for further reclamation or disposal (see Fig. 4). As a broad rule of thumb, solvent wastes containing up to 30% oil are forwarded to contract reclaimers. Solvent wastes containing 30-90% oil are sent to fuel blenders through a waste broker. Wastes with more than 90% oil are sent directly to disposal via thermal destruction. (A discussion of waste disposal issues starts on Page 18).

Some chlorinated solvents users enhance solvent recovery with steam sparging, stripping, or specialized collection systems such as double distillation. Such techniques, practiced on large quantities of waste, allow chlorinated solvents users to reduce their waste production substantially and fall more in the realm of waste management than waste reduction.

The major incentive to practice solvent reclamaton is to save money. For the same reason, solvents users are insisting on tighter machines, wasting less solvent, and looking for even more ways to use solvent more efficiently.
Fig. 4
Flow Diagram
Hazardous Waste Disposition

Any Generator (Customer)

In-House Recycling

Solvent  Sludge

Permitted Hazardous Waste Hauler

Landfill

Incinerator

Fuel Blender

Reclaimer

Sludge  Clean Solvent
WASTE REDUCTION: CUSTOMER ASSISTANCE

In 1976, the Environmental Protection Agency hired Dow to conduct a study to support new source performance standards for solvent metal-cleaning operations.

Under that contract, K.S. Surprenant and D.W. Richards identified and quantified emission control techniques being practiced at that time. They included use of covers, liquid absorption, carbon adsorption, use of refrigerated freeboard chillers, refrigeration condensation, and good operating techniques.

The study indicated that a large portion of the solvents emitted to the atmosphere and basically wasted resulted from inefficient cold cleaning and vapor degreasing. Since there were many techniques to improve efficiency and reduce waste during these operations, the study reinforced the commitment to assist solvents users.

The effort became the Waste Reduction Assistance Program, which has four elements: field support services, product stewardship, training and seminars, and literature.

Field support services. In 1986, 44% of the calls made by chlorinated solvents technical service personnel related to waste reduction. In 1987, 53% involved waste reduction. Waste reduction-related field support services include:

- Process troubleshooting, including visiting the plant to identify problems, as well as handling inquiries over the phone.
- Vapor degreaser inspections to determine if there are problems with the design or maintenance of the degreaser or associated equipment.
- Recommendations covering all phases of degreaser operation, including heat balance, water handling, and parts handling.
- Engineering consultations involving cleaning of metal and design of equipment.
- Waste- and emission-reduction recommendations.

Product stewardship. Examples of product stewardship as it relates to waste reduction are locating and monitoring vapor concentrations in the workplace and suggesting ways to reduce them. Monitoring includes taking halide meter readings and dosimeter readings, as well as conducting professional industrial hygiene surveys in some cases.

Training and seminars. Training is one of the most important facets of waste reduction. Topics include product application, maintenance, the theory of vapor cleaning, environmental and regulatory updates, and safety. Programs can take place in groups or one on one and are available to distributors of chlorinated solvents, distributors' customers, direct customers, and Dow's own field personnel.
Literature. Waste reduction is covered in solvent Material Safety Data Sheets, Product Stewardship Manuals, application brochures, newsletters (see Appendix B), and other publications.

These four elements, practiced together, constitute a formidable solvent-management program that is much stronger than any one of them practiced alone.

**FACTORS INFLUENCING SOLVENT CONSUMPTION**

Most of the techniques for reducing waste during cold cleaning and vapor degreasing are easy to follow and improve the efficiency with which the operations use solvents. Every pound of solvent conserved results in the equivalent pound of reduced demand for virgin solvents and reduces the volume of solvents requiring recycling or disposal.

**Cold cleaning**

Good operating practices are essential to curb solvent consumption during cold cleaning -- and they are mostly a matter of common sense.

To minimize evaporative losses:
- Use covers.
- Use a water layer on top of the solvent where acceptable.
- Use a coarse spray or solid stream of solvent instead of a fine spray.
- Control ventilation.
- Place wipe rags in a closed container and use them again wherever possible.
- Minimize open surface area.
- Use a deep tank with a high freeboard.
- Use specially designed containers with automatic lids and drains.
- Drain parts properly to capture as much of the solvent as possible.
- Don't use compressed air sprays to blow dry parts or to mix cleaning baths.

To reclaim solvent:
- Capture and distill any waste.
- Dispose of sludges at the proper time to avoid stressing the solvent.

**Vapor degreasing**

Reclamation of reusable solvent from waste sludges is important, but only about 15-30% of the solvent used for metal cleaning by vapor degreasing becomes waste. The other 70-85% is eventually lost to evaporation -- after multiple uses in the system -- through inefficient operation and maintenance of the
degreaser and associated equipment. Techniques to reduce overall emissions from a degreaser and to fine tune degreaser operation conserve some of that 70-85%.

Specific suggestions for minimizing solvent loss and reducing the cost of using solvent during vapor degreasing fit into seven general categories.

1. Ensure proper degreaser operation.

   Leave the unit on to maintain the vapor level unless it won't be in use for long periods of time.

   Don't expose heating coils to vapor. This could result in a breakdown of the solvent and corrosion problems in the unit, in addition to loss of solvent.

   Provide proper maintenance. Remove visible corrosion and repair leaks. Repairing leaks alone can result in up to a 50% reduction in solvent loss.

   Use and maintain appropriate design and safety devices. These devices include solvent level controls and vapor, condenser water, and boiling sump thermostats.


   Use the least amount of heat required to keep the solvent at a slow boil and to give adequate vapor production. High heat provides only rapid vapor recovery, not improved cleaning.

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


   Reduce exhaust velocities to provide adequate protection of workers, yet not draw vapors out of the degreaser. Adjusting exhaust velocities can achieve up to a 50% reduction in solvent loss.

   Cover open-top degreasers, especially during idle times. This is the most significant solvent conservation method; it can reduce solvent loss up to 55%. Sliding covers do not cause turbulence when moved, unlike hinged covers.

   Extend the freeboard. Units with freeboard heights that are 40% of the width of the degreaser can use up to 40% more solvent than units with ratios of 75-100%.
Use cold traps -- an upper set of very cold coils that cool the air above the vapors. Properly used, cold traps provide a dense air blanket that helps prevent vapor escape.

Cover the water separator to prevent any possible vapor loss.

Check the water jacket for proper water flow and temperature on the outside of the degreaser to prevent migration of hot vapor up the side walls.

Prevent 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 upset of the vapors and achieve up to a 30% reduction in solvent loss.

Also, vapor control with lip vent or hood exhaust may be too forceful, so reduce exhaust velocity to the minimum level that provides proper vapor control in the working area.

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

4. Minimize water contamination.

Avoid adding water. This is important to prevent depletion of stabilizers, which results in solvent decomposition and corrosion from acid formation by hydrolysis. Condenser coils, cold trap coils and the water jacket can be too cold, resulting in condensation of atmospheric moisture. Also, wet parts can introduce water, particularly as a component of water-soluble cutting oils.

Dewater the solvent. A water separator should be able to reduce dissolved water in the solvent. Also, skim floating water off the top of the solvent, since this represents excessive water content. Water and solvent form an azeotrope at boiling temperatures. The azeotrope has a lower density than dry solvent vapors and is harder to contain.

Install a separate water trough for refrigerated coils. Cold trap coils can build up a heavy dew. A separate discharge for this condensate is necessary to avoid introducing the water to the solvent at a common water
separator, which reduces the water separator's effectiveness and perhaps would overload its capacity.

5. Establish proper workload handling.

**Ensure parts are 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 carryout will increase.

When cleaning metal parts with spray, **spray below the vapor zone.** Spraying above the vapor zone generates a vapor-air mixture directly, which is immediately lost. Also, falling droplets of solvent disrupt vapor interface, causing more vapor-air mixing. Spraying below the vapor zone can achieve up to a 5% reduction in solvent loss.

**Move the work slowly.** (See Appendix C for instructions on using the stop-and-go technique). Control the hoist speed to less than 11 feet per minute of vertical travel and ensure the proper conveyor speed.

**Don't overload the degreaser.** Too large a mass of metal creates inefficient cleaning, excessive vapor drop, slow vapor recovery, and longer cleaning cycle, resulting in increased solvent consumption.

**Use properly sized baskets.** Large baskets that fill the area of the degreaser opening create a piston action when entering and leaving. This forces vapor out, which creates more solvent-vapor-air mixing. The basket should have an area of less than 50% of the degreaser opening.

**Drain the parts.** Solvent not allowed to drain properly from parts is lost immediately to evaporation outside the degreaser. Adjust the spacing in the baskets or the racks so drainage can occur.

6. Avoid solvent carriers and solvent-absorbent materials.

This includes such items as ropes, spacers, and wooden covers. Also, don't clean shop rags or gloves in the degreaser. Up to 5% savings in solvent are possible here.
7. Ensure proper solvent condition.

Remove metal fines and parts, sludge, and oil buildup.

Maintain inhibitor levels. Depletion of inhibitor levels could result in a catalytic breakdown of the solvent to form hydrochloric acid or metal chloride complexes, causing corrosion.

Use the boil-down procedure. (See Appendix A.)

Practice contract or in-house reclamation.

Modifications to existing degreasers

To improve the efficiency with which a degreaser uses solvent:

- Install automatic slide covers.
- Increase freeboard height.
- Install refrigerated freeboard chillers.
- Use carbon adsorption lip exhaust.
- Attach air refrigeration on the vent recycle.
- Install programmable transporters.

Case histories

Below are two examples of how waste reduction benefited chlorinated solvents users.

One user consumed 500,000 pounds of trichloroethylene per year in eight large cross-rod degreasers with process stills attached. Waste from the stills was dumped into a storage tank about every two days, then collected in drums for disposal. Waste amounting to about 20 drums a month was collected from each still.

To minimize waste and reclaim more solvent, thus reducing costs, the user now pumps the waste from each still into a holding tank. About every two weeks, the waste is redistilled, stirred, and steam sparged to remove as much solvent as possible.

This procedure reduces waste from 20 drums a month to five drums a month and reduces virgin solvent consumption by 15 drums a month.

The second user has a 3 foot-by-5 foot, open-top vapor degreaser to clean and finish parts from other companies. Investigation of why the degreaser was cleaning poorly turned up two problems.

First, the cleaning basket was too large. It was acting as a piston, pushing out vapors each time it was lowered into the degreaser. This increased the vapor-collapse amount and shortened the actual cleaning time.

Second, the disk-like metal parts were stacked too closely in the basket, resulting in inadequate cleaning and solvent entrapment.
Reducing the size of the cleaning basket and stacking parts differently allowed the user to improve cleaning and reduce solvent virgin consumption by up to 50%.

**WASTE DISPOSAL ISSUES**

Even with the most efficient waste-reduction efforts, waste disposal still is necessary. That means environmentally sound reclaimers, proper disposal, and fuel blending/burning -- usually in cement kilns or industrial furnaces -- are important.

Many commercial reclaimers manage their wastes as fuel. In 1981, 18% of the waste from commercial reclamation of chlorinated solvents was managed as fuel. By 1986, the total was 49%. Some experts would put today's figure at more than 90%. Disposing of this type of waste through fuel blending/burning has become even more significant as restrictions on disposal in landfills have increased.

Burning wastes that have been blended into fuel in cement kilns is particularly efficient. Not only are wastes used as energy, but the chloride ions from chlorinated-solvents waste are incorporated into the cement. Without fuel blending and subsequent burning in cement kilns, there would be inadequate commercial incineration capacity for the wastes that are being generated in the United States today.

**CONCLUSION: THE BENEFITS OF WASTE REDUCTION**

Reducing waste from the use of chlorinated solvents for metal cleaning means lower solvent costs and lower waste-disposal costs. The improved efficiency that helps reduce waste also means improved cleaning with no increase in solvent usage, another savings.

Dow hopes assisting chlorinated solvents users with waste reduction will attract new customers, maintain existing customers, reduce their liability exposure, and maintain the viability of the solvents marketplace -- all economic motives.

Other significant reasons for practicing waste reduction -- to lower worker exposure to vapors, to reduce solvent loss to the environment, and to comply with health and environmental laws -- also have economic benefits.

And the fact that so many reasons relate to costs is important. It gives credibility to the assertion that voluntary waste reduction will work.

Waste-reduction efforts and long-standing environmental and product stewardship programs demonstrate a commitment to protecting the environment. But waste reduction is just one part of waste management. So safe, permanent waste management and compliance with state and federal laws still are top priorities.

Yet the bottom line really is that electing to take a responsible approach to waste reduction makes good economic sense. Waste Reduction Always Pays.
APPENDIX A

Procedure for boil down of a still/degreaser

When the temperature in the boiling sump of the still reaches 194°F (using trichloroethylene as an example), concentrate the sludge in the still. Turn off the transfer pump and close the gate valve in the dirty solvent line. Continue to distill until the liquid level reaches the recommended minimum level of two inches above the heating element(s).

Turn off the heat in the boiling sump and allow the solvent sludge to cool to 90-100°F before draining. Drain the solvent into a 55-gallon drum(s). Remove parts, metallic fines and chips, or other insolubles by filtration or decantation. Give particular attention to the area under the heating elements.

Close the drain valve. Open the gate valve in the solvent line from the degreaser boiling sump to the still boiling sump. Turn on the transfer pump.

Once the liquid level reaches two inches above the heating element(s), turn on the heat. Add the necessary virgin solvent to the clean dip of the degreaser to properly maintain the needed liquid levels in all chambers of the degreaser and still.

Add the sludge solvent that was placed in the drum(s) back into the still boiling sump at the next boil down when the solvent reaches the minimum level of two inches above the heating coils.

After the third or fourth boil down, send a sample from the sludge drum to a laboratory for determination of nonvolatile content. When the oil concentration reaches 60-70%, dispose of the sludge material in compliance with regulations governing the disposal of waste products. Thermal destruction through fuel blending or incineration is recommended.
Prolong Solvent and Equipment Life By Controlling Water Contamination

Water in a degreaser can mean problems. Water in contact with boiling solvents can cause equipment corrosion. To have a longer equipment life, it is important to employ a water separator. Water separators are designed to purify the condenser water, reducing the amount of dissolved solids. Some separators are designed to remove the oil and water mixture. As the mixture drops into a trough or a settling basin, it is removed by gravity. The condenser coils and flow by gravity to the water separator. The water in the condenser water has a liquid level of degreaser. A water separator has a liquid level of one inch. If the degreaser has a liquid level of one inch, the water separator has a liquid level of one inch. The water separator has a liquid level of one inch. The water separator has a liquid level of one inch.

Conservation Techniques Due to Solvent Purchase

Use of In-House Solvent Reclamation Increasing for Good Reasons

Users of Dow solvents for metal cleaning are realizing increasingly significant benefits by using in-house solvent reclamation techniques. In addition to enhancing conservation, these techniques are generating similar manner except that the dirty solvent is generally concentrated in the degreaser and then transferred to a reclaiming still for final recovery.

NOTE: When handling distillation residues, follow plant and municipal regulations. Do not dump them into city sewers. Remember to use adequate protective equipment when using external distillation equipment. Monitor the temperature of the boiling contaminated solvent. Once it has reached the temperature listed above, it is time to concentrate the sludge in the still. Turn off the transfer pump and close the gate valve in the dirty solvent line. Continue to distill the dirty solvent until the liquid level drops to the recommended level of two inches above the bottom of the still. When using external distillation, monitor the temperature of the boiling contaminated solvent. Once it has reached the temperature listed above, it is time to concentrate the sludge in the still. Turn off the transfer pump and close the gate valve in the dirty solvent line. Continue to distill the dirty solvent until the liquid level drops to the recommended level of two inches above the bottom of the still. When using external distillation, monitor the temperature of the boiling contaminated solvent. Once it has reached the temperature listed above, it is time to concentrate the sludge in the still. Turn off the transfer pump and close the gate valve in the dirty solvent line. Continue to distill the dirty solvent until the liquid level drops to the recommended level of two inches above the bottom of the still.
APPENDIX C

Stop-and-go technique

The following procedure was developed to reduce solvent concentration in the ambient air near the degreaser. It also will reduce the solvent loss from a degreaser.

Lower the work load into the vapor zone at a slow speed. Otherwise, an excessive wave formation of the vapors will push an unnecessary amount of the vapors out of the degreaser.

The vapors will collapse as the work load enters the vapor zone. Whenever the vapors have dropped two to four inches, stop the load until the vapors stabilize or start to recover. At this point, lower the load further until the vapors have dropped another two to four inches.

This stop-and-go method of entry prevents solvent vapors from being pushed out of the degreaser by the plunger effect of the work load. It allows maximum vapor recovery with shorter cleaning cycles.

Once the work load is covered by the vapors, it need not be lowered further. Maximum area between the work load and the boiling sump gives optimum vapor recovery. The work load should never sit on top of the boiling sump.

Remove the work load in increments of two to four inches with pauses to allow the vapors to be entrapped in the freeboard area. This decreases vapor drag out. Once the work load has cleared the vapor zone, it should remain in the freeboard area until all parts are dry and no solvent drips from the work load.
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On-Site Reuse and Recycle of Petroleum Waste Solvents

Robert H. Salvesen
Waste Reduction At Dow And For Its Chlorinated Solvents Customers

1960s Gersticker plan for pollution control

- Enhance plant personnel attitude
- Minimize operating errors
- Enlist help of workforce
- Encourage pollution control program
- Reward achievement
- Inventory waste
- Improve yields, reduce waste - both profitable
- Use waste - disposal last resort
- Do a good job, let people know
- Establish scoring system for pollution control parallel to accident frequency rate in safety
Waste Reduction Always Pays

WRAP Flow Chart

Develop Historical Benchmark For Each Process
Inventory All Losses To Air, Water, Land (Quantity & Quality)
Identify Source Of Losses
Prioritize (Volume And Screening Method)
Set Goals
Determine Cost Effective Actions
Plan For Future Reduction
Communicate Internal & External
Document & Report Progress Routinely
Implement Actions
Allocate Resources
Internal WRAP Goals

- Reduce waste - all media
- Provide incentives
- Provide recognition for excellence
- Create waste reduction mentality
- Save money (including avoided cost)
- Lessen future liability

Specialty chlorinated solvents include:

- 1,1,1 - trichloroethane
- Trichloroethylene
- Methylene chloride
- Perchloroethylene
Applications/End Uses
For Specialty Chlorinated Solvents

1984 Volume (MM LB)

Metal Cleaning  344
Dry Cleaning  208
Fluorocarbons  186
Adsorbents  142
Chemical Processing  137
Paint Removal  203
Other  754

Significance of metal cleaning

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<tbody>
<tr>
<td>Total virgin chlorinated solvents</td>
<td>1700</td>
<td>615</td>
</tr>
<tr>
<td>Metal cleaning chlorinated virgin solvents</td>
<td>754</td>
<td>615</td>
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</table>
Trends in chlorinated solvents use

- Metal cleaning dropped 139 MM; total dropped 194 MM
- Metal cleaning dropped from 38.2% of total in 1984 to 34.6% in 1987
- But metal cleaning is still the major use for chlorinated solvents

Contract reclamation increasing

- 69 MM LB - 1977
- 147 MM LB - 1982
- 268 MM LB - 1986
- 310 MM LB - 1990 (estimate)
U.S. Demand For Chlorinated Solvents

- 52% of customers known to Dow in 1983 practiced it
- 64% of customers known to Dow in 1987 practiced it
Flow Diagram
Hazardous Waste Disposition

Any Generator (Customer) → Permitted Hazardous Waste Hauler

In-House Recycling

Solvent → Landfill → New Customer → Generator

Sludge → Fuel Blender → Broker → Reclaimer

Types of reclaimed solvent

- Clean solvent
- Clean solvent with the measured addition of acid acceptor
- Clean solvent restabilized with both acid acceptor and metal stabilizers as required
Problems related to improper stabilization

- Dilution of fresh solvent
- Reduced acid acceptor content
- Reduced metal stabilizer content
- Excess stabilizer content
- Improper stabilizer ratio
- Contaminated solvent
- Excess water

Disposition of solvent wastes

- Up to 30% oil - contract reclaimers
- 30-90% oil - fuel blenders
- More than 90% oil - disposal via thermal destruction
Economically driven cost reduction

- Solvents users practicing both in-house and contract reclamation
- Users insisting on tighter machines
- Users looking for more ways to conserve solvent
  - Waste less to reduce effect on environment
  - Use solvent more efficiently, effectively to reduce costs

Emission control techniques practiced in June 1976

- Use of covers
- Liquid absorption
- Carbon adsorption
- Use of refrigerated freeboard chillers
- Refrigeration condensation
- Good operating techniques
## Technical support to customers

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<th>Product Stewardship</th>
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</table>

## Calls related to waste reduction

- 44% in 1986
- 53% in 1987
Waste reduction-related field support services

- Process troubleshooting

Waste reduction-related field support services

- Process troubleshooting
- Vapor degreaser inspection
Waste reduction-related field support services

- Process troubleshooting
- Vapor degreaser inspection
- Degreaser operation recommendations

- Engineering consultation
Waste reduction-related field support services

- Process troubleshooting
- Vapor degreaser inspection
- Degreaser operation recommendations
- Engineering consultation
- Waste and emission reduction recommendations

Product stewardship assistance

- Workplace vapor concentration locating and monitoring
- Suggestions to reduce workplace vapor concentrations
Training and seminar topics

- Product application
- Environmental and regulatory updates
- Safety

Good cold cleaning operating practices

Do:
- Use covers
- Use water layer where acceptable
- Use coarse spray or solid stream
- Recover waste solvents by distillation
- Control ventilation
- Drain parts properly
- Capture draining solvent
- Place wipe rags in closed container
Good cold cleaning operating practices

Don’t:

- Use solvent in shallow pans
- Use compressed air sprays
- Blow dry parts with compressed air

Modifications to existing degreasers

- Install automatic slide covers
- Increase freeboard height
- Install refrigerated freeboard chillers
- Use carbon adsorption
- Attach air refrigeration on vent recycle
- Install programmable transporters
Redistillation reduced waste from 20 drums a month to 5 drums a month.

Reducing the size of the cleaning basket and improving the stacking of parts in the basket reduced solvent consumption by 40-50%.
More reclaimers managing wastes as fuel

1981 18%
1986 49%

How the customer benefits

Economic considerations
- Reduced solvent costs
- Reduced waste cost
- Improved cleaning operation

Compliance with regulations
Lower worker exposure
How Dow benefits

Product stewardship
  • Reduce solvent loss to environment
    - Reduce the need for regulation
    - Reduce overall liability exposure
Attracts new customers and maintains existing customers
Maintains viability of marketplace

How the public and the industry benefit

• Most efficient, effective cleaning method
• Safe cleaning method
• Environmental quality protected
Solvent Waste Reduction Alternatives Seminar

Speaker Papers