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On-Site Reuse and Recycle of Petroleum Waste Solvents

Robert H. Salvesen

TOPICS TO BE COVERED

TYPES OF SOLVENTS USED (NON-HALOGENATED)

HOW USED SOLVENTS ARE GENERATED

RECYCLING

- DEFINITION
- GENERAL GUIDELINES
- SPECIFIC DETAILS
- EXAMPLES

TYPES OF SOLVENTS USED

HYDROCARBONS	USAGE
VM&P NAPHTHA	PAINT THINNER
MINERAL SPIRITS	GENERAL CLEANING
AROMATIC NAPHTHA	PAINT THINNER/CLEANING
TOLUENE	PAINT THINNER
XYLENE	" "
ISOPARAFFINIC	" " (ODORLESS)
TURPENTINE	" "

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ABSTRACT

In-plant reuse and recycle of solvents is an accepted practice in many industries. This paper reviews practices and equipment which are appropriate for cleaners of parts and equipment.

Only non-halogenated solvents are discussed. The major types of solvents utilized are hydrocarbon (such as mineral spirits and naphthas) and oxygenated (i.e., MEK, MIBK, Ethyl Acetate and alcohols) materials. By proper segregation, labelling and management, essentially all solvents can be recycled.

Information is provided on the types of solvents which can be recycled, equipment available, economic factors for consideration and examples from industry on how recycling works.

Title

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IN-PLANT REUSE AND RECYCLE OF SOLVENTS

INTRODUCTION

Solvents used in most industrial operations serve as cleaning agents or reaction media. In most cases, the solvents are not consumed but are contaminated by other substances. The solvents are disposed when the contaminant level exceeds certain criteria limits. These limits can vary widely depending upon the particular process. For example, for engine parts cleaning, the solvent may contain up to 30-40% fuels, oils, water and solids before it needs to be replaced. In other cases, high purity is required and contamination exceeding a few parts per million signals a time to change solvents. Thus, while the composition of used solvents can vary considerably, the methods for reuse and recycling are applicable to many process operations.

This paper deals with non-halogenated solvents used in parts and equipment cleaning and will cover the following:

- Types of solvents used
- Generation and properties of used solvents
- Options for reuse/recycling
- Waste reduction practices and examples

TYPES OF SOLVENTS USED

Hydrocarbons

Hydrocarbon solvents used for parts and equipment cleaning may be derived from petroleum, coal tar or natural sources. Petroleum and coal tar products include the following:

- Aliphatic Naphtha such as
  - VM&P Naphtha
  - Mineral Spirits (low and high flash)
- Aromatic Naphtha
- Toluene
- Xylene
- Isoparaffinic Solvents

The most common natural hydrocarbon solvent is turpentine. Some proprietary solvents may contain mixtures of some of the above along with lanolin (to reduce skin irritation), detergents (for water rinsing), colorants, perfumes and other additives.

Paint Thinners

Paint thinners vary in composition to suit the specific paints used. These types of solvents can contain one or more of the following hydrocarbon or oxygenated materials:

- o Petroleum or Coal Tar Naphtha
- o Isoparaffinic (odorless) Solvents
- o Toluene
- o Xylene
- o Ketones
  - MEK (Methyl Ethyl Ketone)
  - MIBK (Methyl Isobutyl Ketone)
  - Others
- o Esters
  - Ethyl Acetate
  - Butyl Acetate
- o Alcohols
  - Methyl
  - Ethyl
  - Isopropyl
- o Glycol Ethers
  - Cellosolve (Butyl, etc.)

Paint thinners are included because cleaning of parts and equipment may often preceed painting and many of you might wish to recycle thinners along with other solvents.

Other Materials

For the sake of completeness, mention should be made of other organic and inorganic materials used for parts cleaning. These are heavy-duty cleaners and paint strippers, as noted below:

- o Organic Materials

These are generally mixtures of three or more of the following solvents:

- Methylene Chloride
- Mineral Spirits
- Toluene and/or Xylene
- Ketones
- Esters

- Alcohols
- Phenol or Cresols
- Glycol Ethers
- Wetting Agents

Suppliers produce proprietary mixtures which may also contain surfactants, colorants, perfumes, etc. Since the above are mixtures, it is not common practice to recycle these materials in-house, but there is no reason why large volume users could not do so. However, the recycled product should be reformulated and thus the recycler must be knowledgeable in this technology.

o Aqueous Systems

Acid and alkaline solutions have been used for heavy-duty cleaning for many years. Included in these categories are organic amines, which are alkaline ammonium type compounds. This paper will not cover recycle of these materials.

GENERATION AND PROPERTIES OF USED SOLVENTS

Generation Processes

Used solvent may be defined as any solvent contaminated with other liquids and/or solids which render it unsuitable for its intended purpose. Cleaning solvents are generally used in operations involving spraying, physical or vapor washing, dipping, hand brushing, etc. The major contaminants are fuels, oil, grease, water, dirt, metals, paint and other substances, depending upon the usage.

Cold Cleaning - The major non-vapor methods for cleaning parts and equipment involve the following:

o Wash Stations - in this operation, solvent is generally circulated by pump and the part washed continuously with a stream of liquid. Dissolved materials accumulate in the solvent, and solids are often removed with screens or filters.

o Spray Booth - solvent is aspirated from a container, mixed with air and impacts the part to be cleaned. The sprayed solvent is collected and recirculated. Soluble materials accumulate and solids are removed as noted above. Organic vapors are generally carried out the exhaust and may or may not be collected and recycled.

o Dip Tank - a large container of solvent is used for immersion of the part in solvent. Mixers may be added to accelerate cleaning. As above, soluble and insoluble materials accumulate. Some solids may settle out.

o Hand/Bucket Cleaning - this is the simplest operation, and commonly used by small operators. Brushes or rags are often used to remove tough dirt.

In all of the above processes, the solvent continuously degrades in quality because of accumulation of both soluble and insoluble materials. The amounts of various soluble and insoluble contaminants allowed to accumulate before changing solvent are a function of process requirements.

Vapor Degreasing - In vapor degreasing, the parts to be cleaned are suspended above the liquid and are cleansed by warm vapor condensing on the component. The condensed solvent and contaminants are returned to a reservoir where water, dirt, oils and other contaminants are collected. Clean vapors are continuously available to wash the parts. Solvent is changed only when contaminants and sludge build up enough to interfere with vapor cleaning. Many units have separate solvent distillation equipment as an integral part of the system. Other speakers will discuss this technology in detail.

Properties of Used Solvents

Typical properties of used and virgin (or recycled) hydrocarbon solvent (Mineral Spirits) are given in Table 1. This example would be typical of usage for cleaning gasoline engine parts. The major contaminants are as indicated below.

- Gasoline - this is indicated by the low flash point and low boiling (less than 320 F) compontents. The used solvent may contain 10-20% of gasoline.

- Water - water can be detected by various means. In the example given, it might show up as a separate fraction during the distillation. It would also be detected in the Water, Oil and Sediment Test.

- Oil and Sediment - dissolved lube and other oils would be detected in this test as well as sediment. By proper distillation, the contaminants can be removed and the reclaimed solvent will meet new or virgin product specifications.

Other pure organic materials which might be used as cleaners such as MEK, Ethyl Acetate and others, might have similar contaminants, and can be reclaimed to original specifications.

Paint thinners are a special case. Since thinners are blended products and formulated to meet specific volatility and solubility requirements, their reclamation for use as paint thinners is not generally recommended. However, used paint thinners are mainly generated from cleaning of brushes, spray guns and other application equipment. For these purposes, product specifications are not usually of significance.

Thus, used paint thinners can readily be reclaimed either by gravity settling, filtering, distillation or other means. Reclaimed paint thinner is usually sastisfactory for cleaning equipment, but is not recommended for thinning paints.

TABLE 1

PROPERTIES OF USED AND RECYCLED MINERAL SPIRITS

Test	Test Method	USED Solvent	Reclaimed Solvent
Flash Point,TCC, F	ASTM-D-56	<100-120	102-110
Distillation, F	" D-86		
IBP		150-330	315-330
10%		150-340	320-340
20%		170-340	
30%		300-345	
40%		320-350	
50%		325-350	325-350
60%		330-370	
70%		340-390	
80%		350-400	
90%		400-600	330-365
FBP		Above 500	350-400
Residue		30 Vol % (Max)	2-5 Vol %
Chlorine Content		<0.1	<0.1
Water, Oil & Sediment, %	ASTM D-95	2-20	<0.1
Appearance	Visual	Brown/Black	Clear/White

OPTIONS FOR REUSE AND RECYCLING

Consideration of options for reuse and recycling of solvents should include segregation practices, substitutes and down-grading, equipment requirements, costs and environmental regulations. These concerns are discussed below.

Increasing Reuse and Recyclability

Segregation - Segregation of solvents is one of the most important management steps impacting on reuse and recyclability. Past practices have often neglected segregation and changes are sometimes difficult to implement. What to segregate depends upon what downstream operations will be used. Generally, solvents need to be strictly segregated by each individual type. Mixing solvents often makes in-house recycling impossible. Proper labelling and/or color coding and adequate containers for collection of used solvents enhances segregation.

Substitutes - Replacement of one solvent for another is often easier said than done, but it needs to be considered and can lead to easier recycling. Several examples follow.

If chlorinated solvents are used for cleaning electrical parts and hydrocarbon solvents for machine parts, it may be appropriate to use a hydrocarbon solvent for both to simplify recycling. While hydrocarbons are often used for both, some may not prefer to use these solvents because they evaporate more slowly and are flammable.

Ethyl Acetate is sometimes used for cleaning purposes. Replacement with a hydrocarbon solvent can often provide similar results and simplifies reclamation.

Proprietary hydrocarbon solvents often contain emulsifiers, lanolin, colorants, odorants, etc., which may or may not be essential to the cleaning process. Recycling this type of mixture reclaims only the hydrocarbon fraction. Thus, the recovered material is not the same as the proprietary solvent. Reformulation of the solvent can be done by a knowledgeable person, if desired. The ingredients noted above may or may not be essential, as noted below.

Emulsifiers - are used to aid in solvent penetration of water-wet oil, grease or dirt. The emulsifiers also enable the solvent to be washed off with water. If these properties are not essential, emulsifiers are not needed.

Lanolin - is added to provide residual oil, thus reducing skin irritation and dryness caused by contact with the solvent. This ingredient is not essential to the cleaning process and solvent users should wear gloves or use a hand cream after contact.

Colorants, Odorants - and other ingredients are generally added for product identification and customer acceptance. While these

factors can be of some importance, they are not essential for cleaning purposes.

Aqueous Emulsion Systems - have been offered as substitutes for cleaning solvents and are claimed to be effective for cleaning engine and electrical parts. These systems may be satisfactory for a number of applications. However, there are two major concerns. One is that water-based systems may require drying to eliminate residues. A second problem is disposal of the dirty water. If significant quantities of oil, grease or other organic materials are carried off in the water, some treatment may be required prior to discharge.

Downgrading - In-plant reuse by downgrading is a common practice where a number of cleaning operations are conducted. Following are several examples:

- Cleaning of bearings often requires use of high purity, virgin solvent. Since these bearings are relatively clean to start with, the used solvent from this operation can readily be downgraded for use in cleaning dirtier engine components.

- Calibrating fluid used for fuel system components is often a special grade of mineral spirits. After usage, this material can be downgraded for other solvent purposes.

Economics - The economics of solvent recycling is dependent upon the following costs:

- Solvent
- Percent of recoverable solvent
- Collection and segregation
- Equipment and installation
- Operations
- Quality Assurance/Quality Control
- Disposal

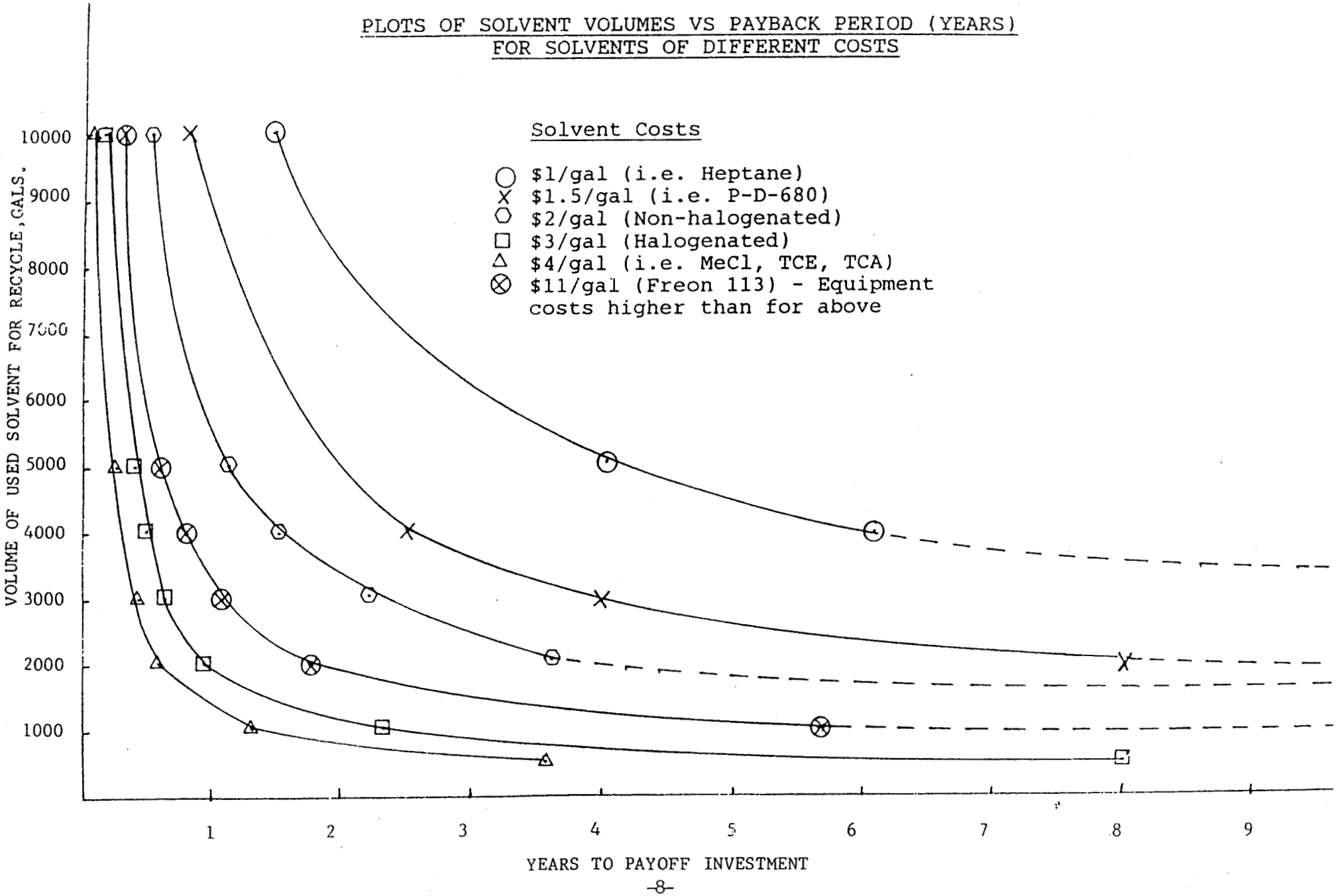
A generalized cost estimate for solvent recovery and payback of equipment costs is given in Figure 1 for solvents costing from $1-11/gallon. It may be seen that both solvent costs and volume have a significant impact on payback periods. More detailed cost studies are needed for specific cost/benefit analysis.

Processes and Equipment Used

There are a number of processes utilizing equipment for separating and recycling used solvents. Most operations for in-plant use are simple, but a wide range of options are

FIGURE 1

PLOTS OF SOLVENT VOLUMES VS PAYBACK PERIOD (YEARS)
FOR SOLVENTS OF DIFFERENT COSTS



available, where appropriate. These methods are discussed briefly in this section and another paper covers this subject in greater detail.

Gravity Separation - Simple settling of solids and water is often practiced for reuse of solvents. Paint thinners may be reused many times if solids are allowed to settle. The supernatent liquid can be removed for cleaning purposes. Centrifuges are also used to accelerate gravity separation.

Batch Stills - This type of equipment may be described as a flash, pot or single-plate batch still. The used solvent is heated, vaporized and the vapors condensed into a separate vessel. Solids or high-boiling liquids remain in the pot or distillation vessel as a residue. Liquids boiling up to about 400 F can be recovered. If mixed liquids are used they will not be separated unless the final boiling point of one solvent is about 50-60 F below the initial boiling point of the other solvent.

There are numerous suppliers of this type of equipment. Major design variations include the following:

- o Size - from 5-500 gallon capacity
- o Heating
  - Electrical
  - Steam jacked
  - Direct steam injection
  - Heat transfer fluids
- o With or without vacuum attachment
- o Materials of construction
- o Clean out
  - Bottom
  - Side
  - Top
  - Lift-out trays
  - Plastic bag liners
- o Controls

Costs range from $2-3,000 for 5-gallon units to well over $100,000 for the largest stills. These units are capable of reclaiming solvents to purity standards meeting or exceeding new product specifications.

Fractionation Units - For separation of solvent mixtures, fractionated units may be required. These are generally custom-made and can be provided to meet almost any separation requirement. Size, efficiency and design can be varied to suit

the needs. Costs generally range from $30,000 and up.

Thin Film Evaporators - This type of unit is a variation of flash stills in which a thin film of the used material is deposited on a rotating, hot metal surface. The solvent is flashed off, vaporized and either condensed or passed on to a fractionating unit for separation of specific solvents. These units are very versatile and specially suited for viscous liquids. Costs range from about $30,000 and up.

Vapor Degreasers With/Without Recycle - For continuous cleaning operations, and those desiring excellent solvent penetration, vapor degreasers are often preferred. Only the vapors contact the parts and condensate is returned to a sump. Some designs have condensers around the sides of the vessel and others at the top. Fresh, clean solvent is continuously vaporized to clean parts. In systems without internal recycle the solvent can become contaminated with components that vaporize with the solvent to reduce cleaning effectiveness. To avoid this, the dirty solvent may be recycled in a separate unit where the contaminants are removed. Generally, vapor degreasers are fairly large units containing from about 50 to several hundred gallons of solvent. Costs are also proportionately large ranging from $100,000 and upwards.

Toll Recyclers - A variation of in-plant recycling can be accomplished by toll recyclers. While the solvent is not recycled on-site, the solvent is replaced on-site. Solvent wash stations are often serviced by companies in this business. Service charges may vary from 50-90% of new solvent costs.

HAZARDOUS WASTE REDUCTION PRACTICES AND EXAMPLES

Audit

Any waste reduction program should start with an audit. This can be a do-it-yourself activity or larger facilities may wish to hire an outside consultant. The basic components of a waste audit are outlined in Table 2 and a format for actual use is given in Table 3. Audits should be conducted by personnel familiar with the solvents used, process operations, handling, treatment and disposal options. Several illustrative examples follow:

- Poor Material Selection

  - At a large shop, a decision was made to use a proprietary solvent when a less expensive non-proprietary solvent would have saved money and been easier to recycle.

  - A salesman recommended replacement of a chlorinated solvent by an odorless paint thinner for engine parts cleaning. The user did not realize that common mineral spirits would have done a better job and cost about 50% less.

TABLE 2

WASTE AUDIT OUTLINE

Step 1 - Collect Information

- o Tabulate existing data
- o Mass balance assessment
- o Check completeness of data

Step 2 - Evaluate Waste Handling

- o Raw materials
- o Housekeeping
- o Costs
- o Sources
- o Practices of personnel involved

Step 3 - Management Alternatives

- o Approach for each waste
- o Employee requirements and training
- o Housekeeping improvements
- o Segregation
- o Capital investments
- o Reformulation
- o Reuse
- o Technical, economic and liability assessments

Step 4 - Review and Update

- o Assess progress
- o Track and assess changes in
  - Raw materials
  - Processes
  - Products
  - Technology
  - Regulations

TABLE 3

STANDARD WASTE AUDIT FORMAT - AUTOMOTIVE REPAIRS

- Name and location of shop or business
- Name of audit personnel
- Date of audit
- Type of Shop
  - Automotive repair
  - New car dealer
  - Diesel repair
  - Transmission repair
  - Brake/muffler shop
  - Radiator service
  - Alignment
  - Suspension/chassis
  - Scheduled maintenance
  - Quick lube changes
  - Body/painting
- Size of shop
  - Vehicles serviced per week
  - Number of service bays available
- Services provided
- Number of employees
- Raw materials used
- Raw material storage (complete for each item)
  - Raw material (brand name/common name)
  - Item number
  - Volume in inventory
  - Describe usage
  - Describe disposal practice
  - Describe storage facilities
    (i.e.) 55-gal drum
    Containers (volume)
    Above or underground tank,
    Covered/open
    Indoor/outdoor
    Secured
  - Delivery system
    (i.e.) Gravity
    Funnel
    Pump
  - Material control practices
    (i.e.) Stockroom attendant
    Access (limited/unlimited)
    Signout sheet

TABLE 3 (Continued)

- Material usage (describe for each type)
  - Sink (size/description/location)
  - Dip tank (size/description/location)
  - Jet spray (size/description/location)
  - Spray hood (size/description/location)
- Waste material management
  - Segregation practiced (if yes, describe)
  - If no segregation, describe practice
  - Options available for segregation
  - Storage facilities (describe)
  - Disposal practices
    (i.e.) On-site recycling
    Serviced by equipment leasee/maintenance contractor
    Picked up by contractor
    Disposed in municipal solid waste
    Disposed to municipal sewer
  - Disposal costs
    (i.e.) Oils
    Solvents
    Residues/sludges
    Anti-freeze
    Aqueous materials
    Other
- Material losses
- Provide a schematic for waste management practices
- Prioritized sites of significant waste generation
- Waste management options
- Source reduction options
  - Material substitutions
  - Process changes
  - Housekeeping
- Regulatory compliance evaluation and needs
- Recommendations for improved management

Selection of the Best Option

After completion of an environmental audit and consideration of viable options, economics and applicable regulations, selection of the best option should be relatively easy. The major management practices which need to be selected are discussed below.

Segregation - Uncontrolled mixing of used solvents yields waste slops with little or no economic value and little chance of recycling. In addition, because waste mixtures are often designated as hazardous wastes, their disposal is becoming more costly. A summary of recommended options for a number of solvents is given in Table 4. Segregation by each individual solvent is generally the best means of optimizing recovery and minimizing costs. Alternate options are usually less desirable and not as cost effective.

o Example

We have all seen or heard of locations with vast numbers of drums of mixed solvents and other materials. These were accumulated because plant operators were not concerned about disposal or were not willing to pay disposal costs. My experience has been that many plant managers believed these drums contained valuable materials which should have been marketable, but realistically, were not.

Many superfund sites were created because of improper management and disposal. With a minimum of segregation, many of these waste drum fields could have been disposed to cement kiln operators who had capabilities for burning a variety of mixtures.

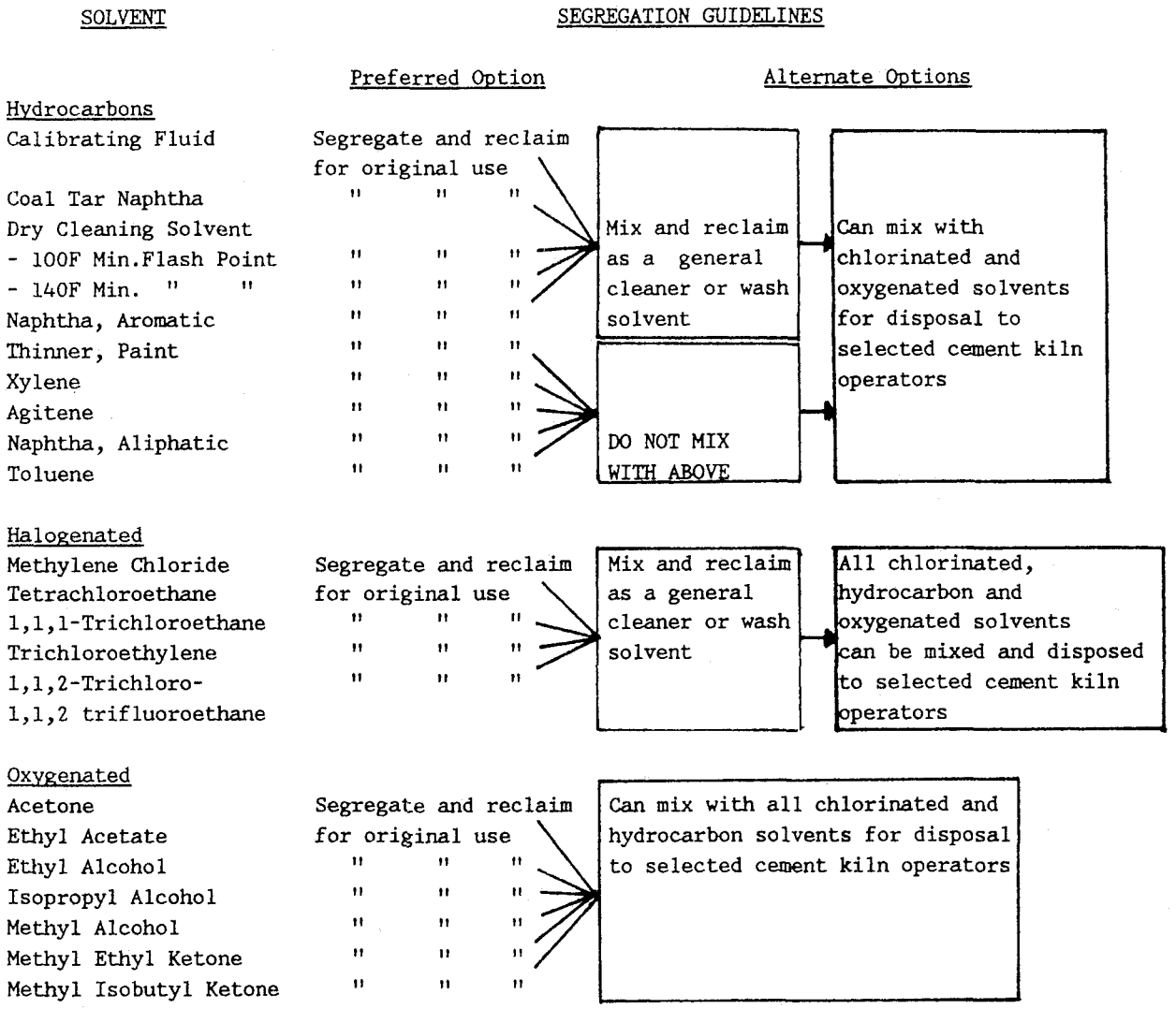
Collection - Adequately marked containers must be provided to encourage and ensure proper collection and segregation. Good practice includes color coding, visible and legible labels, and a manifest system. Color coding can simplify identification and is easy to implement. Labels can be hung on walls, placed on top of a container or stencilled on collection drums. Labels stencilled on both sides of a container work well, those only on top can be obliterated by a spill. A manifest should be used even for internal recycling. The generator should fill out a manifest form, attach it to the container, and have a copy sent to the recipient and to a central control person.

Recycling - Recycling or reclamation of used solvents can be accomplished with in-house equipment and facilities for almost all pure solvents, but is generally not practical for some mixed solvents. This discussion covers solvents segregated and collected after use as well as solvents recovered in vapor recovery units.

Recyclable and Non-Recyclable Solvents - Solvents which can be recycled readily are listed in Table 4. These materials can

TABLE 4

SUMMARY OF SEGREGATION RECOMMENDATIONS FOR RECLAMATION AND DISPOSAL OF SOLVENTS



generally be recycled to meet original solvent specifications.

In addition to those noted above, paint thinners can also be recycled. Since most thinners are mixtures and lose volatile solvents in use, the recycled solvent is not the same as virgin material. Thus, reclaimed thinner should not be used as a paint thinner but can be used to clean paint equipment.

Typical non-recyclable solvents are noted below, along with brief comments.

Carbon Removers and Paint Strippers

These mixtures are generally quite toxic since many contain phenolic compounds and thus in-house recycling is not recommended.

Proprietary Solvents

Many proprietary cleaning solvents contain additives (as noted above) which are not recovered in distillation. Therefore, the recycled material is not the same as the original solvent.

Processes and Equipment Used - The major processes and equipment used are discussed briefly below:

Gravity Separation - Used mainly for paint thinners.

Batch Stills - Many companies manufacture, sell and service batch stills for in-house recycling of solvents. A list of the major suppliers is given in Table 5 along with some general data on the types, ranges, features and costs of this equipment.

These units will not separate solvents and must be used for only one solvent at a time. They can be used for a variety of solvents with cleaning between batches.

- Examples

  NAVY-At the Naval Shipyard in Portsmouth, Va., a 15-gal/day batch still has been successfully used to recover mineral spirits and paint thinners. Savings amount to about $15,000 per year and the equipment was paid off in less than six months*.

  AIR FORCE-Robbins AFB has a number of different units for recycling over 50,000 gallons per year of various solvents. Total savings are reported to be over $600,000 per year.

* This information was obtained from an article dated 11/5/84 that appeared in the Virginia Pilot (a local Portsmouth, VA, newspaper).

TABLE 5

SUPPLIERS OF SOLVENT RECYCLING EQUIPMENT SUITABLE
FOR ON-SITE RECLAMATION - SINGLE-PLATE PACKAGED STILLS

Supplier	Thruput G/Hr(1	Solvent Capacity Gallons	Heating Options	Cooling Options	Explosion Proof	Cost $K	Solvent Types Designed for	Comments
Alternative Resource Management 7134 S. Yale(Suite 400) Tulsa, OK 74136 918-495-0535	1.5-100	5-100	Electric/ Steam	Refrig/ Water	Yes	2.5-100+	All	Atmospheric & Vacuum Models Available
Baron Blakeslee 2001 N. Janice Ave. Melrose Park, Il. 60160 312-450-3900	10-120	8-95	Electric/ Steam	Refrig/ Water	No	5-8	Halogenated	
Branson Cleaning Equip. Corp. P. O. Box 768 Shelton, Ct. 06484 203-796-0400	12-60	10-60	Electric/ Steam	Refrig/ Water	No	4-10	Halogenated	
BR Instrument Corp. P.O. Box 7 Pasadena, MD. 21122 301-647-2894	1-2	3-6	Electric	Water	Yes	9-12	All	For Lab Operations
DCI International 1229 Country Club Rd. Indianapolis, IN 46234 317-271-4001	250	250	Dir. Steam Injection	Water	Yes	N/A	All	For Removal of Solvents from Oils
Detrex Chemical Ind.Inc. P. O. Box 501 Detroit, Mi. 48232 313-358-5800	30-180	50-200	Electric/ Steam	Water	No	5-10	Halogenated	
Disti Inc. 131 Prince St. New York, N.Y. 10012 212-505-0611	2-70	10-50	Steam/ Hot Oil	Water	Yes	8-54	All	
Finnish Eng. Co. (Extratec) 921 Greengarden Rd. Erie, Pa. 16501-1591 814-455-4478	15-380	5-50	Electric/ Steam	Water	Yes	5-80	All	Make a Wide Range of ATM. & VAC. Models

TABLE 5(Continued)

Finishing Equip. Inc. 3640 Kenneber Dr. St. Paul, Mn. 55722 612-452-1860	N/A*	N/A	Electric/ Steam	Water	No	N/A	Halogenated	
Giant Distillation & Recovery Co. 3156 Bellevue Rd. Toledo, OH 43606	1.5- 10	5-60	Electric/ Oil	Water	Yes	5-100	All	Atmospheric & Vacuum Models Available
Hoyt Corp. Forge Rd. Westport, MA. 02990 617-636-8811	4-8	25-50	Oil	Water	No	N/A	Halogenated	Also Make Vapor Recovery Units
Lenape Equipment Co. P. O. Box 285 Manasquan, N.J. 08736 201-681-2442	4-45	5-30	Electric	Refrig/ Water	No	3-20	Halogenated	
National Ultrasonic Chicago, Il. 60626 312-465-6780	N/A (2)	N/A	N/A	N/A	N/A	N/A	Halogenated	
Phillips Mfg. Co. 7334 N. Clark St. Chicago, Il. 60626 312-338-6200	5-125	15-125	Electric/ Steam	Water	No	7-15	Halogenated	
Progressive Recovery Inc 1976 Congressional Dr. St. Louis, Mo. 63146 314-567-7963	5-35	5-25	Hot Oil	Water	Yes	8-30	All	
Ramco Equip. Co. 32 Montgomery St. Hillside, N.J. 07205 201-687-6700	25-200	30-135	Electric/ Steam	Water	No	7-20	Halogenated	Also Make Custom Designs
Recyclene 1910 Trade Zone Blvd. San Jose, Ca. 95131 408-945-8600	2-20	15-35	Electric/ Heated Oil	Water	Yes	4-21	All	
Vaco Solv Co. P.O. Box 26147 Cincinnati, OH. 45226 513-321-9178	1.6-10	5-60	Electric	Air	Yes	10-3	All	No Cooling Needed
Westinghouse Elec. Co. Box 300 Sykesville, Md. 21784 301-795-2800	15-30	18-50	Electric	Refrig/ Water	No	7-10	Halogenated	

* N/A = No Available Data

INDUSTRIES-Many industries have successfully recovered solvents with in-house units, thereby saving valuable resources, and eliminating or drastically reducing disposal requirements.

Fractionation Units

Custom-made fractionation units can be obtained from companies such as those noted in Table 6.

Thin Film Evaporators

To recover solvents from high viscosity fluids, thin film evaporators or wiped surface evaporators are generally recommended. In some cases, these units may be followed by fractional distillation units for better separation of solvents. Suppliers of this type equipment are noted in Table 5-6.

o Example

NAVY-The Navy has been recovering Freon 113 at Portsmouth, Virginia Naval Shipyard for many years and saving $20,000-30,000 per year.

Vapor Degreasers With and Without Recycle

Vapor degreasers are usually large units which generally have a freeboard area for condensing vapors above the vapor cleaning section. Some units contain internal solvent recycle systems, thereby minimizing the need for cleanout. Most vapor degreasers utilize halogenated solvents.

Disposal - Disposal of sludge bottoms from most distillation units is still necessary. Experience has shown that for solvents used in precision cleaning, only a small volume of fine solids is obtained. These solids can often be disposed as a non-hazardous solid waste. At the other extreme are sludges from paint thinners. These residues can be taken to dryness and disposed as a hazardous waste.

Interesting exceptions are still bottoms from mineral spirits used for engine cleaning. The residues are mainly oils and can often be blended in with waste oils for disposal.

In almost all cases where solvents are recycled, some residues remain which have to be disposed as hazardous wastes. Options include land filling, incineration, encapsulation, blending with asphalt and others.

CONCLUSIONS

In-plant recycle and reuse of solvents can be achieved for most solvents. The major concerns are:

- Quality and quantity of used solvents

TABLE 6

SUPPLIERS OF SOLVENT RECYCLING EQUIPMENT SUITABLE FOR ON-SITE RECLAMATION - CUSTOM BUILDERS OF FRACTIONAL DISTILLATION UNITS

	Type of Equipment Available			
Supplier	Thruput Gal/Hr (1)	Solvent Capacity Gallons	Explosion Proof	Price $K
Advanced Process Systems 10400 Linn Station Rd. Suite 310 Louisville, KY. 40223	5-100	5-100	Yes	20-50+
Artisan Ind. Inc. 73 Pond Rd. Waltham, Ma. 02154 617-893-6800	10-50	10-50	Yes	20-30+
Chem-Pro Equip. Co. 27 Daniel Rd. Fairfield, N.J. 07006 201-575-1924	5-50	10-50	Yes	20-30+
Distillation Eng. Co. 105 Dorsa Ave. Livingston, N.J. 07039 201-992-9620	5-50	10-50	Yes	20-30+
Ferguson Ind. Inc. 1900 West Northwest Hwy. Dallas, Tx. 75220 214-556-0010	N/A (2)	N/A	Yes	20-30+
Finish Eng. Co. 921 Greengardens Blvd. Erie, Pa. 16501 814-455-4478	5-50	10-50	Yes	20-30+
Progressive Recovery Inc. 1976 Congressional Dr. St. Louis, Mo. 63146 314-567-7963	3-30	10-50	Yes	20-40+

(1) For the lowest volatility solvent
(2) N/A = No data available

TABLE 7

SUPPLIERS OF SOLVENT RECYCLING EQUIPMENT SUITABLE FOR ON-SITE RECLAMATION - THIN-FILM EVAPORATORS

Supplier	Thrput Gal/Hr*	Solvent Capacity Gallons	Heating Options	Cooling Options	Price Range $K
Alpha Laval Inc. 2115 Linwood Ave. Ft. Lee, N.J. 07024 201-592-7800	-	-	Hot Oil	Refrig./ Water	50+
Artisan Ind. Inc. 73 Pond St. Waltham, Ma. 02154 617-893-6800	5-50	5-50	Steam/ Oil	Water	50-130
Brighton Corp. 11861 Mosteller Rd. Cincinnati, Oh. 45241 513-771-2300	7.5-200	5-200	Steam/ Hot Oil	Water	18-43
Luwa Corp. P. O. Box 16348 Charlotte, N. C. 28216 704-394-8341	50-1200	Cont.	Steam/ Hot Oil	Water	25-50+
Progressive Recov. Inc. 1976 Congressional Dr. St. Louis, Mo. 63146 314-567-7963	15-300	15-300	Steam/ Hot Oil	Water	40-120

* For the lowest volatility solvent

- Segregation and handling practices
- Selection of recycling equipment
- Management practices
- Costs for operation and maintenance

After completion of an environmental audit and review of the above, experience has shown that in-house recycling is often the most cost-effective and environmentally-preferred option.

On–Site Reuse and Recycle of Petroleum Waste Solvents

Robert H. Salvesen

TYPES OF SOLVENTS USED

HYDROCARBONS	USAGE
VM&P NAPHTHA	PAINT THINNER
MINERAL SPIRITS	GENERAL CLEANING
AROMATIC NAPHTHA	PAINT THINNER/CLEANING
TOLUENE	PAINT THINNER
XYLENE	" "
ISOPARAFFINIC	" " (ODORLESS)
TURPENTINE	" "

TYPES OF SOLVENTS USED (CONTINUED)

ALCOHOLS	
METHYL	" " /CLEANING
ETHYL	" "
ISOPROPYL	" "
KETONES	
MEK	PAINT THINNER
MIBK	" "
ESTERS	
ETHYL ACETATE	PAINT THINNER/CLEANING
BUTYL ACETATE	" "
GLYCOL ETHER	
CELLOSOLVES	" "

TYPES OF SOLVENTS USED (CONTINUED)

MIXTURES	
METHYLENE CHLORIDE	PAINT STRIPPERS
MINERAL SPIRITS	HEAVY-DUTY CLEANERS
TOLUENE/XYLENE	PAINT THINNER & STRIPPER
KETONES	" " "
ESTERS	" " "
ALCOHOLS	" " "
PHENOLS	" " "
ADDITIVES	
ODORANTS	PROPRIETARY CLEANERS
COLORANTS	" "
SURFACTANTS	" "
LANOLIN	" "

GENERATION PROCESSES

COLD CLEANING

WASH STATION

SPRAY BOOTH

DIP TANK

HAND/BUCKET

VAPOR DEGREASING

PAINTING

CLEANING SURFACES

CLEANING EQUIPMENT

WHAT IS RECLAIMING?

REMOVAL OF CONTAMINATING SUBSTANCES FROM SOLVENT TO RENEW THE SOLVENT TO THE ORIGINAL CONDITION FOR REUSE

PROPERTIES OF USED AND RECYCLED MINERAL SPIRITS

TEST	TEST METHOD	USED SOLVENT	RECLAIMED SOLVENT
FLASH POINT,TCC, F	ASTM-D-56	<100-120	102-110
DISTILLATION, F	" D-86		
IBP		150-330	315-330
10%		150-340	320-340
20%		170-340	
30%		300-345	
40%		320-350	
50%		325-350	325-350
60%		330-370	
70%		340-390	
80%		350-400	
90%		400-600	330-365
FBP		ABOVE 500	350-400
RESIDUE		30 VOL % (MAX)	2-5 VOL %
CHLORINE CONTENT		<0.1	<0.1
WATER, OIL & SEDIMENT, %	ASTM D-95	2-20	<0.1
APPEARANCE	VISUAL	BROWN/BLACK	CLEAR/WHITE

INCREASING REUSE & RECYCLING OF SOLVENTS

SEGREGATION

SUBSTITUTES

NEAT VS FORMULATED PRODUCTS

EMULSIONS

DOWNGRADING

ECONOMICS

PROCESSES & EQUIPMENT USED

- GRAVITY SEPARATION
- BATCH STILLS
  - CAPACITY 5-500 GALS
  - HEATING OPTIONS
  - VACUUM OPTIONS
  - MATERIALS OF CONSTRUCTION
  - CONFIGURATIONS
  - CONTROLS
- FRACTIONATION UNITS
- THIN FILM EVAPORATORS
- VAPOR DEGREASERS WITH/WITHOUT RECYCLE
- TOLL RECYCLERS

WASTE AUDIT OUTLINE

STEP 1 - COLLECT INFORMATION

STEP 2 - EVALUATE WASTE HANDLING

STEP 3 - MANAGEMENT ALTERNATIVES

STEP 4 - REVIEW AND UPDATE

SOLVENT RECOVERY DISTILLATION EQUIPMENT

HEAT TRANSFER METHOD	KEY CHARACTERISTIC
POT-COILS	MANUAL CLEANING
STEAM INJECTION	WATER CONTAMINATION (3 PRODUCTS)
THIN FILM (CONTINUOUS)	HIGH RATE/INVESTMENT/ OPERATOR TIME
WIPED SURFACE	VERY HIGH RATE OF INVESTMENT
CONDUCTIVITY HEAT TRANSFER	LOW COST/MINIMAL OPERATOR TIME

DESIGN AND SAFETY FEATURES

CLASS I, GROUP D, DIVISION 1 ELECTRICALS

PRESSURE RELIEF SYSTEM

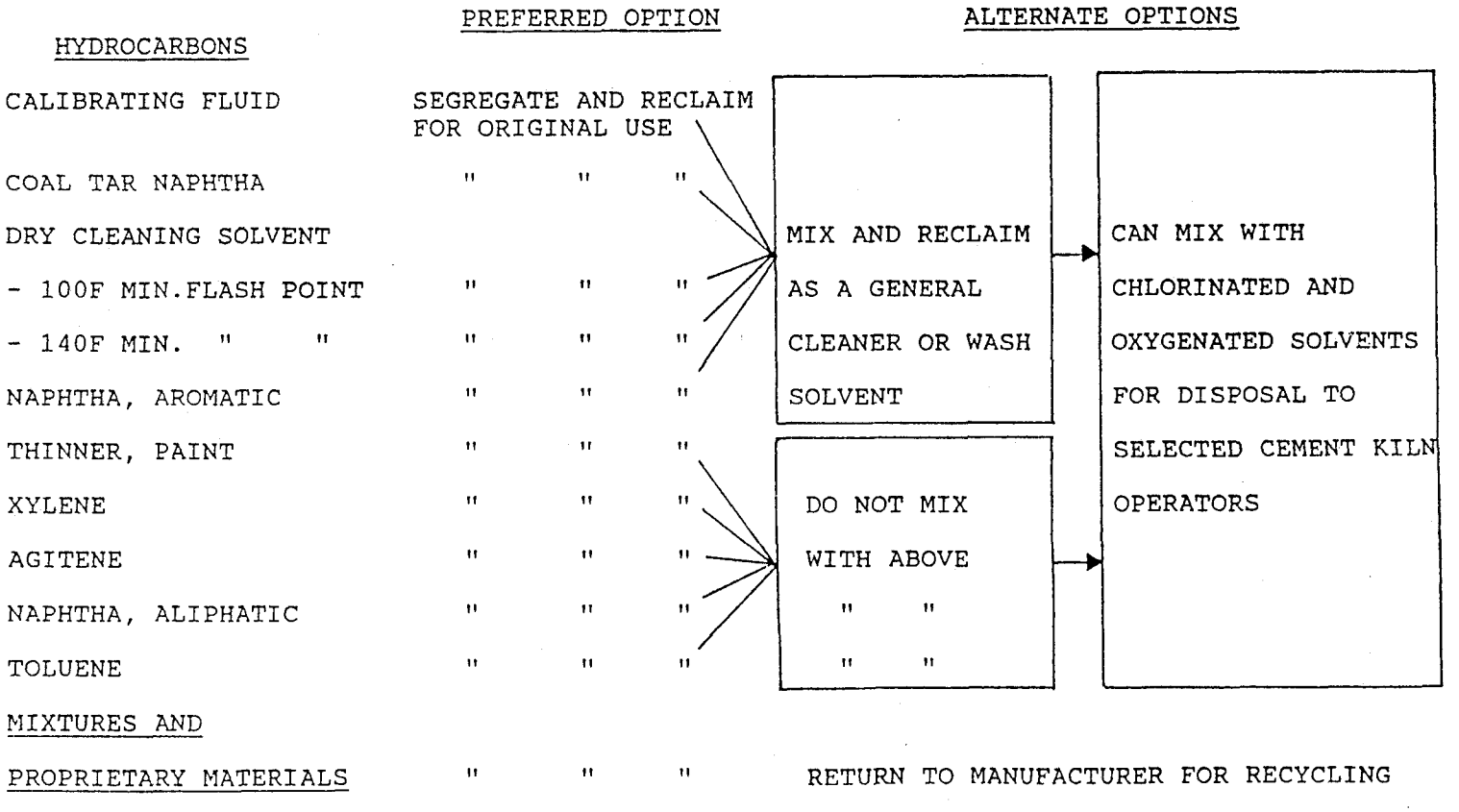
EASY CLEAN-OUT

TEMPERATURE CONTROLS

INTERNAL VISCOSITY MONITORING

UC RATED COMPONENTS

SEGREGATION GUIDELINES



SEGREGATION GUIDELINES

	PREFERRED OPTION	ALTERNATE OPTIONS
HALOGENATED		
METHYLENE CHLORIDE	SEGREGATE AND RECLAIM	ALL CHLORINATED, HYDROCARBON AND OXYGENATED SOLVENTS CAN BE MIXED AND DISPOSED TO SELECTED CEMENT KILN OPERATORS
TETRACHLOROETHANE	FOR ORIGINAL USE	
1,1,1-TRICHLOROETHANE	" " "	
TRICHLOROETHYLENE	" " "	
1,1,2-TRICHLORO-1,1,2 TRIFLUOROETHANE	" " "	
OXYGENATED		
ACETONE	SEGREGATE AND RECLAIM	CAN MIX WITH ALL CHLORINATED AND HYDROCARBON SOLVENTS FOR DISPOSAL TO SELECTED CEMENT KILN OPERATORS
ETHYL ACETATE	FOR ORIGINAL USE	
ETHYL ALCOHOL	" " "	
ISOPROPYL ALCOHOL	" " "	
METHYL ALCOHOL	" " "	
METHYL ETHYL KETONE	" " "	
METHYL ISOBUTYL KETONE	" " "	

VOLUME RANGE

5 GALLONS PER SHIFT

15 GALLONS PER SHIFT

55 GALLONS PER SHIFT

250 GALLONS PER SHIFT

500 GALLONS PER SHIFT

DISTILLATION RANGE

STANDARD DISTILLATION - 100-320 F

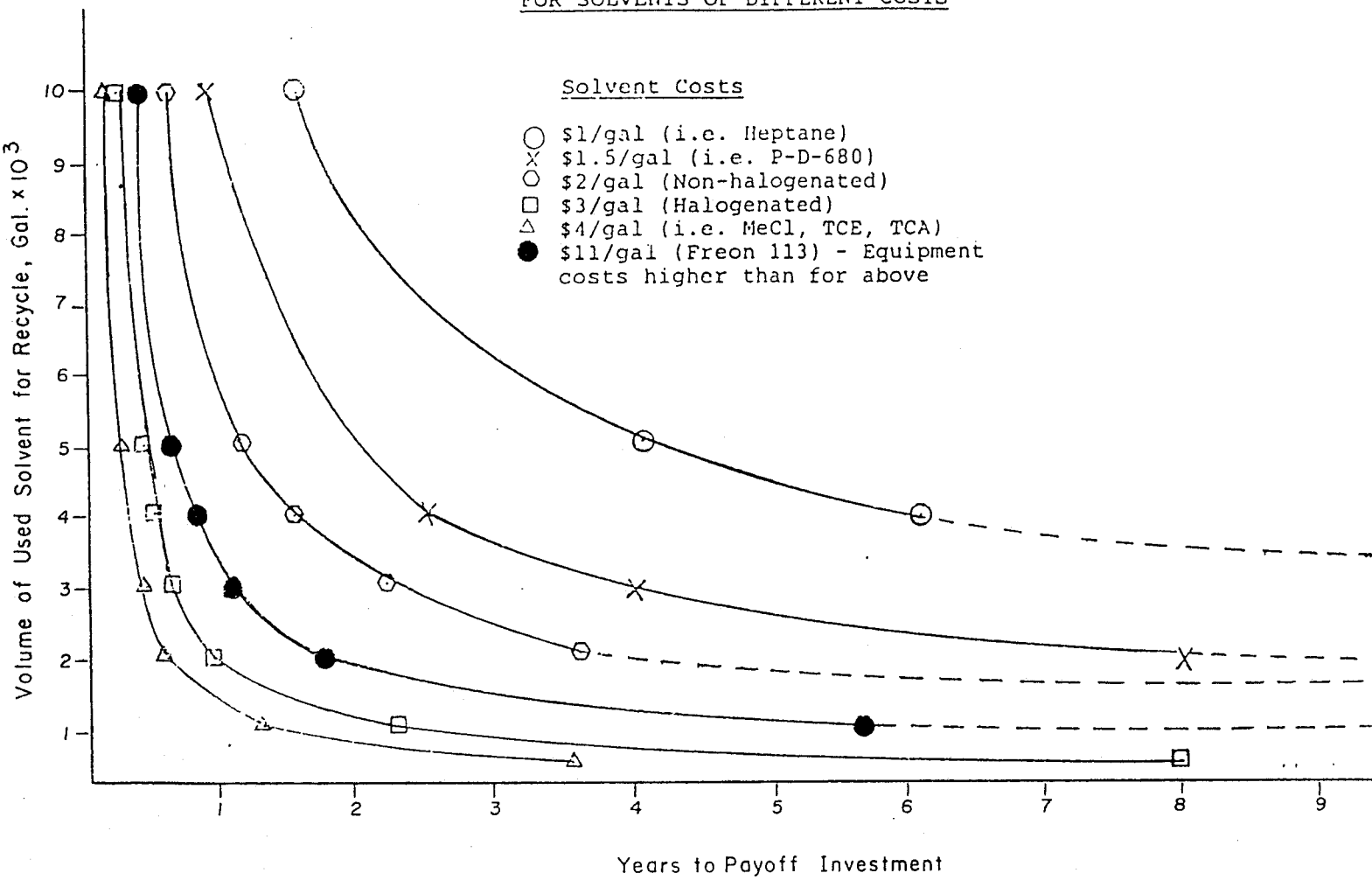
VACUUM DISTILLATION - 320-500 F

OPERATING COST (IN-PLANT)

- UTILITY (ELECTRIC 34 KW) 0.04-0.08 CENTS/GALLON
- LABOR 0.07-0.12 CENTS/GALLON

FIGURE 1

PLOTS OF SOLVENT VOLUMES VS PAYBACK PERIOD (YEARS)
FOR SOLVENTS OF DIFFERENT COSTS



CASE STUDY #8101-380

INDUSTRY	- PLASTICS
PROCESS	- MOLDER & DECORATOR OF INJECTOR THERMO-PLASTIC PARTS
SOLVENT	- ACETONE
SOLVENT USAGE	- 12 DRUMS PER DAY
SOLVENT COST	- $2.10/GALLON
AFTER IN-HOUSE DISTILLATION	- ROI, 8 MONTHS

CASE STUDY #8006-380

INDUSTRY	- ELECTRICAL EQUIPMENT
PROCESS	- FINAL COATING OF FIRE-RETARDANT PAINT
SOLVENT	- METHYLENE CHLORIDE
SOLVENT USAGE	- 4 DRUMS/DAY
SOLVENT COST	- $ 3.35/GALLON $35.00/DRUM DISPOSAL
AFTER IN-HOUSE DISTILLATION	- ROI, 1.2 YEARS

CASE STUDY #8210-LS

INDUSTRY	- CONTRACT PAINTING
PROCESS	- CLEAN, COAT AND CURE ALUMINUM EXTRUSIONS
SOLVENT	- KETONE-AROMATIC MIXTURE FOR FLUSH-OUT
SOLVENT USAGE	- 1-1.5 DRUMS/WEEK
SOLVENT COST	- $ 2.60/GALLON $78/DRUM DISPOSAL
AFTER IN-HOUSE DISTILLATION	- ROI, 1.5 MONTHS

CASE STUDY ROBBINS AF BASE

INDUSTRY	- AIRCRAFT REWORK FACILITY
PROCESS	- INDUSTRIAL OPERATIONS PAINTING
SOLVENT	- VARIOUS
SOLVENT USAGE	- 50,000 GALLONS/YEAR
SOLVENT COST	- VARIED
SAVINGS	- $600,000/YEAR

CASE STUDY NSY PORTSMOUTH, VA

INDUSTRY	- NAVAL SHIPYARD
PROCESS	- PAINT SHOP
SOLVENT	- ACETONE
SOLVENT USAGE	- 15-30 GALLONS/DAY
SOLVENT COST	- $4-5/GALLON
SAVINGS	- $15,000/YEAR

CASE STUDY NSY CHARLESTON, SC

INDUSTRY	- NAVAL SHIPYARD
PROCESS	- CLEANING ELECTRONICS
SOLVENT	- ACETONE
SOLVENT USAGE	- 3 DRUMS/DAY
SOLVENT COST	- $11.00/DRUM
SAVINGS	- $300,000/YEAR

CONCLUSIONS

- IN-PLANT RECYCLING POSSIBLE FOR MOST SOLVENTS
- NEED
  - AUDIT
  - ECONOMIC EVALUATION
  - QUALITY CONTROL
  - TRAINING
  - MANAGEMENT PRACTICES

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Solvent Waste Reduction Alternatives Seminar

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