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SOURCE ASSESSMENT:

SOLVENT EVAPORATION - DEGREASING

Industrial Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Research Triangle Park, North Carolina 27711

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SOLVENT EVAPORATION - DEGREASING

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PREFACE

The Industrial Environmental Research Laboratory (IERL) of EPA has the responsibility for insuring that pollution control technology is available for stationary sources to meet the requirements of the Clean Air Act, the Water Act and the Solid Waste legislation. If control technology is unavailable, inadequate, uneconomical or socially unacceptable, then financial support is provided for the development of the needed control techniques for industrial and extractive process industries. Approaches considered include: process modifications, feedstock modifications, add-on control devices, and complete process substitution. The scale of the control technology programs ranges from bench to full scale demonstration plants.

The Chemical Processes Branch of the Industrial Processes Division of IERL has the responsibility for investing tax dollars in programs to develop control technology for a large number (>500) of operations in the chemical industries. As in any technical program, the first question to answer is, "Where are the unsolved problems?" This is a determination which should not be made on superficial information; consequently, each of the industries is being evaluated in detail to determine if there is, in EPA's judgment, sufficient environmental risk associated with the process to invest in the development of control technology. This report contains the data necessary to make that decision for the air emissions from solvent evaporation-degreasing.

Monsanto Research Corporation has contracted with EPA to investigate the environmental impact of various industries which represent sources of pollution in accordance with EPA's responsibility as outlined above. Dr. Robert C. Binning serves as Program Manager in this overall program entitled, "Source Assessment," which includes the investigation of sources in each of four categories: combustion, organic materials, inorganic materials and open sources.

This study was initiated by IERL-RTP in November 1974 with Mr. Kenneth Baker of the Industrial Processes Division serving as EPA Project Leader. Project responsibility was transferred to IERL-Cincinnati in October 1975 and Mr. George S. Thompson, Jr. of the Industrial Pollution Control Division served as EPA Project Leader until the study was completed.

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SECTION I

INTRODUCTION

The removal of grease, wax, soil and other undesirable matter from various items ranging from metals to textiles, is a widespread practice in many industries, from gas stations to automotive production plants. The emissions from the organic solvents used in these degreasing processes can be a major source of air pollution. The objective of this study is to examine the environmental impact of degreasing operations and present this information in a source assessment document for use by the EPA in determining the need for control technology development.

This document was prepared by investigating the literature concerning degreasing operations and analyzing the information gathered. It describes: (1) degreasing processes and solvents, (2) types of degreasers and fabric scourers, (3) the source sites, (4) emissions characteristics, (5) the effects on air quality, (6) current state of the art and future plans for control technology, and (7) the outlook for the growth of degreasing operations.

Where data were lacking on the nature of the severity of emissions, simulated data were used and estimates made to evaluate the environmental impact.

SECTION II

SUMMARY

Solvent degreasing is a physical method of removing grease, wax, soil, or other undesirable matter from various metal, glass, plastic, or textile items with an organic solvent. It is estimated that 311,200 plants perform degreasing operations such as vapor degreasing, cold cleaning, and/or fabric scouring. The following solvents are discussed in this report:

- butanol
- acetone
- hexane
- toluene
- xylene
- benzene
- ethers
- cyclohexane
- fluorocarbons
- methyl ethyl ketone
- mineral spirits
- carbon tetrachloride
- methylene chloride
- perchloroethylene
- trichloroethylene
- 1,1,1-trichloroethane
- naphthas (petroleum distillates, Stoddard solvents)

It is estimated that the total emissions from the above 17 solvents equal 943,160 metric tons/yr[a] (1.04×10^6 tons/yr) and account for $\sim$4% of the total U.S. hydrocarbon emissions. One of the 17 solvents is considered carcinogenic, namely

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[a] 1 metric ton = 10^6 grams = 2205 pounds = 1.1 short tons; (short tons are designated "tons" in this document); other conversion factors and metric system prefixes are presented in Section IX.

trichloroethylene of which 1.72×10^5 metric tons/yr (1.89×10^5 tons/yr) is emitted from an estimated 5,200 plants.

A representative source was defined for each solvent type listed above to permit evaluation of the individual hazard potentials. The factors considered (summarized in Table 1) were: (1) the number of plants using each solvent; (2) the mean source severity, S, based on the time-averaged ground level concentration, $\overline{\chi}_{max}$, and on F which is the primary ambient air quality standard (AAQS) or a "corrected" threshold limit value (TLV® x 8/24 x 1/100) depending on the type and composition of the pollutant, these quantities for which are related in the form $S = \frac{\chi_{max}}{F}$; (3) the mass emissions of each solvent and their contribution to the total hydrocarbon emissions in the United States; and (4) the affected population determined by the number of people exposed in the area within the boundaries of $0.1 < S < 1$ from the center of the representative source site.

The representative source in each case considered the average plant size, average stack height, population density, frequency of operation, and mean emission rate corresponding to the consumption. The population density, 109 persons/km^2 (273 persons/mi^2) was the average density of the states which together consumed >50% of the solvent.

Overall degreasing operations are increasing at a rate of 3% to 5% per year. However, since degreasing is closely connected to basic economy related industries, production levels and air pollution regulations have considerable impact on solvent usage.

Organic solvent emissions are relatively easy to control in that high efficiency devices are not complex systems.

Table 1. Hazard Characterization of Solvent Types

Solvent type	Estimated number of plants using solvent	Mean source severity based on		National emissions burden			Affected population based on AAQS	Affected population based on TLV
				Mass emissions		Contribution to U.S. total, %		
		AAQS	TLV	10^3 metric tons/yr	10^3 tons/yr			
Butanol	300	4.241	0.112	3.3	3.6	0.012	98	9
Acetone	200	4.241	0.014	10	11	0.038	98	0
Methyl ethyl ketone	200	4.241	0.057	7.5	8.3	0.028	98	0
Hexane	400	4.241	0.019	7	7.7	0.026	98	0
Naphthas (petroleum distillates, Stoddard solvents)	235,000	4.241	0.036	188	207	0.707	98	0
Mineral spirits	1,000	4.241	0.060	30	33	0.113	98	0
Toluene	15,000	4.241	0.090	14	15.4	0.053	98	9
Xylene	11,000	4.241	0.077	112	12.1	0.421	98	2
Cyclohexane	4,000	4.241	0.032	1	1.1	0.004	98	0
Benzene	3,000	4.241	0.421	42	46.3	0.158	98	55
Ethers	1,000	4.241	0.028	6	6.6	0.023	98	0
Carbon tetrachloride	30	4.241	0.518	0.7	0.77	0.003	98	70
Fluorocarbons	1,000	4.241	0.018	17.1	18.7	0.064	98	0
Methylene chloride	2,400	0.879	0.013	56.2	562	0.211	39	0
Perchloroethylene	3,000	5.641	0.059	109	120.2	0.410	119	0
Trichloroethylene	5,200	5.338	0.066	171.5	189.1	0.645	133	12,400,000
1,1,1-Trichloroethane	28,000	2.955	0.003	167.8	185	0.631	23	0

SECTION III

SOURCE DESCRIPTION

A. SOURCE DEFINITION

The Solvent Evaporation - Degreasing Operations source includes hydrocarbon (organic materials) emissions from industrial degreasing operations, auto repair shops, auto service shops, garages, auto dealers, gasoline stations, maintenance shops, and textile plant operations. Emissions considered include halogenated hydrocarbons, acetone, alcohols, ethers, methyl-ethyl ketone, naphthas (petroleum distillates, Stoddard solvents), and toluene.

B. PROCESS DESCRIPTION

Solvent degreasing is a physical method of removing grease, wax, or soil from metal, glass, plastic surfaces or fabric by contacting the material to be removed with an organic solvent. Five major types of sources use solvent degreasing in their operations. These are listed in Table 2[1] together with the estimated number of plants of each type.

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[1]Statistical Abstract of the United States: 1973 (94th Edition). Washington, U.S. Bureau of the Census, 1973. 1014 p.

Table 2. SOLVENT DEGREASING SOURCE TYPES[1]

Source	SIC[a] major group	Number of plants	
Industrial degreasing			
Metal furniture	25	10,008	
Primary metals	33	6,837	
Fabricated products	34	27,418	
Nonelectric machinery	35	37,982	
Electric equipment	36	10,706	
Transportation equipment	37	7,483	
Instruments and clocks	38	4,453	
Miscellaneous	39	14,489	
SUBTOTAL			119,376
Automotive			
Auto repair, auto service, garages	--	125,229	
Automotive dealers	--	93,885	
SUBTOTAL			219,114
Gasoline stations	--		206,755
Maintenance shops	--		305,680
Textile plants (fabric scouring)	22		7,080
TOTAL			858,005

[a]Standard industrial classification of the Office of Management and Budget.

The solvents used in degreasing operations are listed below:

Butanol	Methyl ethyl ketone
Acetone	Mineral spirits
Hexane	Carbon tetrachloride
Toluene	Methylene chloride
Xylene	Perchloroethylene
Benzene	Trichloroethylene
Ethers	1,1,1-Trichloroethane
Cyclohexane	Naphthas (petroleum distillates,
Fluorocarbons	Stoddard solvents)

Further classification of the source is difficult since, as an integral part of the manufacturing or service process, emission frequency and composition depend upon the overall operation. Size of operation ranges from single proprietor garages and self-service cleaners to large industrial operations (an emission range from kilograms to metric tons of solvent emitted per year).

Auto repair and service shops, garages, automotive dealers, gasoline stations, and maintenance shops are not manufacturing plants but establishments of the retail and wholesale trades and service industries. Therefore, Table 3 lists SIC definitions only for major industrial groups that perform degreasing operations and for textile plants.[2]

[2]Standard Industrial Classification Manual, 1972. Washington, U.S. Government Printing Office (Stock No. 4101-0066), 1972. 649 p.

Table 3. SIC MAJOR GROUPS AND DEFINITIONS FOR SOLVENT USES[2]

SIC major group	Definition
25	Metal furniture - This major group includes establishments engaged in manufacturing household, office, public building, and restaurant furniture; and office and store fixtures. Establishments primarily engaged in the production of millwork are classified in Industry 2431; wood kitchen cabinets in Industry 2434; cut stone and concrete furniture in Major Group 32; laboratory and hospital furniture in Major Group 38; beauty and barber shop furniture in Major Group 39; and woodworking to individual order or in the nature of reconditioning and repair in nonmanufacturing industries.
33	Primary metals - This major group includes establishments engaged in the smelting and refining of ferrous and and nonferrous metals from ore, pig, or scrap; in the rolling, drawing, and alloying of ferrous and nonferrous metals; in the manufacture of castings and other basic products of ferrous and nonferrous metals; and in the manufacture of nails, spikes, and insulated wire and cable. This major group also includes the production of coke. Establishments primarily engaged in manufacturing metal forgings or stampings are classified in Group 346.
34	Fabricated products - This major group includes establishments engaged in fabricating ferrous and nonferrous metal products such as metal cans, tinware, hand tools, cutlery, general hardware, nonelectric heating apparatus, fabricated structural metal products, metal forgings, metal stampings, ordnance (except vehicles and guided missiles), and a variety of metal and wire products not elsewhere classified. Certain important segments of the metal fabricating industries are classified in other major groups, such as machinery in Major Groups 35 and 36; transportation equipment, including tanks, in Major Group 37; professional scientific and controlling instruments, watches and clocks in Major Group 38; and jewelry and silverware are in Major Group 39. Establishments primarily engaged in producing ferrous and nonferrous metals and their alloys are classified in Major Group 33.
35	Nonelectric machinery - This major group includes establishments engaged in manufacturing machinery and equipment, other than electrical equipment (Major Group 36) and transportation equipment (Major Group 37). Machines powered by built-in or detachable motors ordinarily are included in this major group, with the exception of electrical household appliances (Major Group 36). Portable tools, both electric and pneumatic powered, are included in this major group, but hand tools are classified in Major Group 34.
36	Electric equipment - This major group includes establishments engaged in manufacturing machinery, apparatus and supplies for the generation, storage, transmission, transformation, and utilization of electrical energy. The manufacture of household appliances is included in this group, but industrial machinery and equipment powered by built-in or detachable electric motors is classified in Major Group 35. Establishments primarily engaged in manufacturing instruments for indicating, measuring, and recording electrical quantities are classified in Industry 3825.

Table 3 (Continued). SIC MAJOR GROUPS AND DEFINITIONS FOR SOLVENT USES[2]

SIC major group	Definition
37	Transportation equipment - This major group includes establishments engaged in manufacturing equipment for transportation of passengers and cargo by land, air, and water. Important products produced by establishments classified in this major group include motor vehicles, aircraft, guided missiles and space vehicles, ships, boats, railroad equipment, and miscellaneous transportation equipment such as motorcycles, bicycles and snowmobiles. Establishments primarily engaged in manufacturing mobile homes are classified in Industry 2451.
38	Instruments and clocks- This major group includes establishments engaged in manufacturing instruments (including professional and scientific) for measuring, testing, analyzing, and controlling, and their associated sensors and accessories; optical instruments and lenses; surveying and drafting instruments; surgical, medical, and dental instruments, equipment, and supplies; ophthalmic goods; photographic equipment and supplies, and watches and clocks.
39	Miscellaneous - This major group includes establishments primarily engaged in manufacturing products not classified in any other manufacturing major group. Industries in this group fall into the following categories: jewelry, silverware and plated ware; musical instruments; toys, sporting and athletic goods; pens, pencils, and other office and artists' materials; buttons, costume novelties, miscellaneous notions; brooms and brushes; caskets; and other miscellaneous manufacturing industries.
22	Textile plants (fabric scouring) - This major group includes establishments engaged in performing any of the following operations: (1) preparation of fiber and subsequent manufacturing of yarn, thread, braids, twine, and other cordage; (2) manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn; (3) dyeing and finishing fiber, yarn, fabric, and knit apparel; (4) coating, waterproofing, or otherwise treating fabric; (5) the integrated manufacture of knit apparel and other finished articles from yarn; and (6) the manufacture of felt goods, lace goods, nonwoven fabrics, and miscellaneous textiles. This classification makes no distinction between the two types of organizations which operate in the textile industry: (1) the "integrated" mill which purchases materials, produces textiles and related articles within the establishment, and sells the finished products; and (2) the "contract" or "commission" mill which processes materials owned by others. Converters or other nonmanufacturing establishments which assign materials to contract mills for processing (other than knitting) are classified in nonmanufacturing industries; establishments which assign yarns to outside contractors or commission knitters for the production of knit products are classified in Group 225.

Degreasing operations are classified into two categories, degreasing and fabric scouring (see Figure 1).

1. Degreasers

Degreasers are used to clean all of the common industrial metals, including: malleable, ductile, and gray cast iron; carbon and alloy steel; stainless steel; copper; brass; bronze; zinc; aluminum; magnesium; tin; lead; nickel; and titanium. Glass is also cleaned by degreasing as are plastics which are not affected by the solvent.[3]

Degreasing operating conditions vary with the application and depend largely upon the delicacy of the item being cleaned. Degreasing is performed at atmospheric pressure and at temperatures ranging from 10°C to 120°C (vapor degreasers operate at temperatures greater than 40°C). Where useful, mechanical agitation is used to remove soils.

The degreasing process is adaptable to items of a wide range of sizes and shapes, from transistor components to aircraft sections. The process is also used to clean metal strip and wire at speeds up to 45 m to 60 m per min.[3]

A flow diagram for degreasers is shown in Figure 2. The work to be cleaned is conveyed either manually or automatically (stream 1) into the degreaser. After degreasing is completed, the part is withdrawn and conveyed to the next step in the manufacturing process (stream 2). Solvent is heated in the degreaser by either steam, gas, or electricity (stream 3) depending upon availability. Solvent leaves the

[3]Handbook of Vapor Degreasing. Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication No. 310), 1962. 33 p.

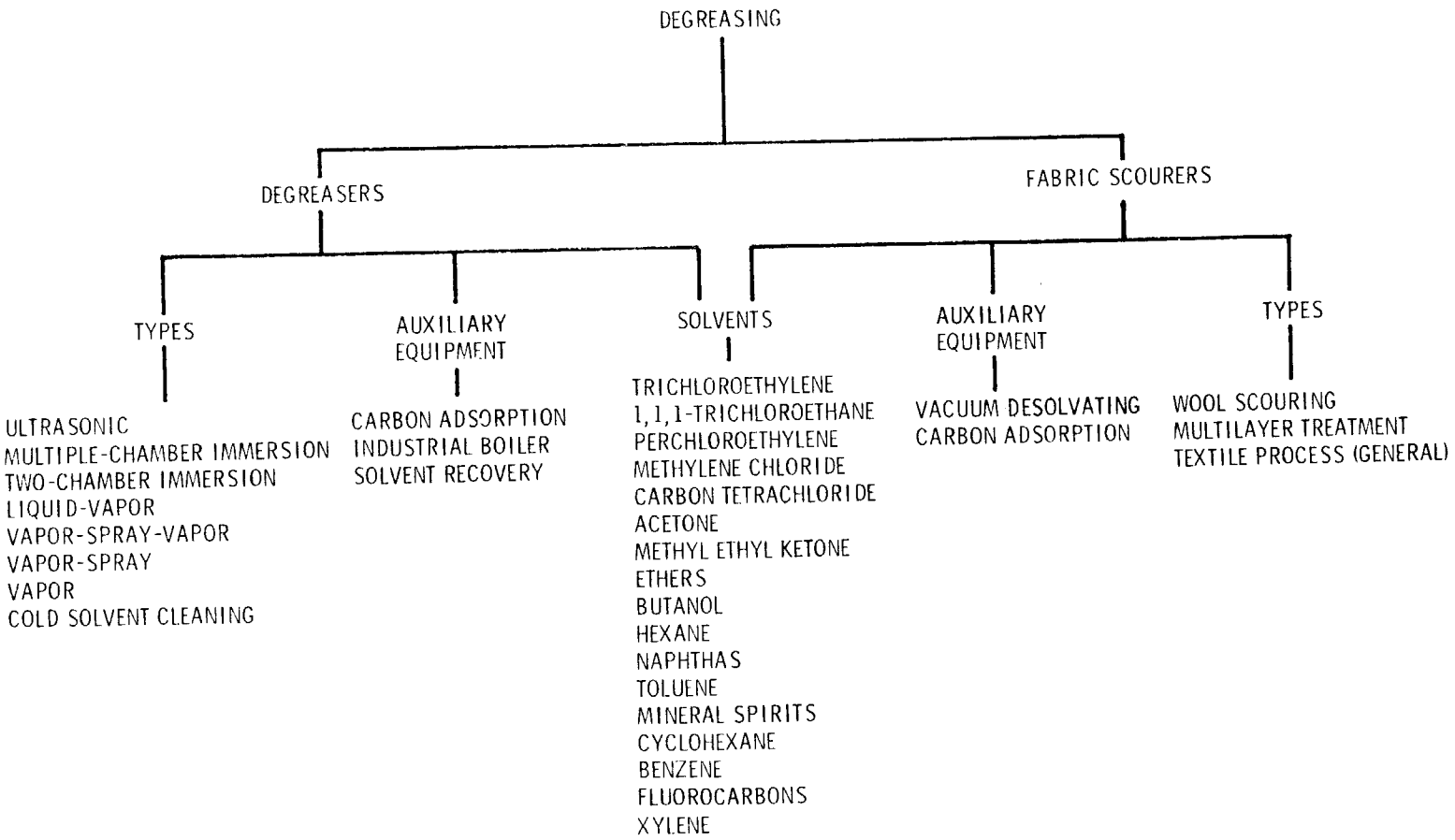

Figure 1. Degreasing operations breakdown

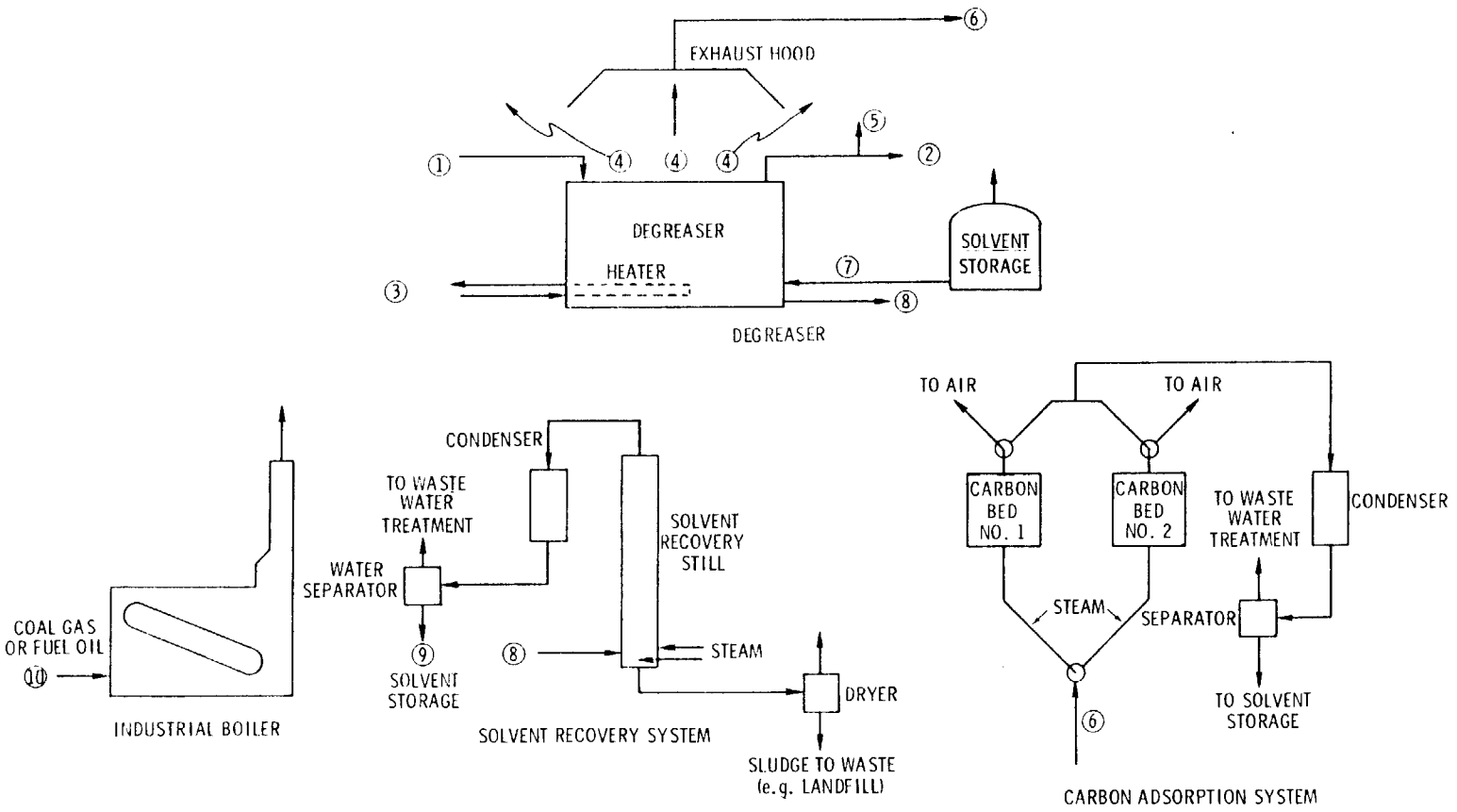

Figure 2. Degreaser flow diagrams

degreaser either by diffusion into the atmosphere (steam 4) or by entrainment with the work, so-called "dragout" (stream 5). Diffused solvent (stream 4) may be collected by an exhaust hood and vented to either the atmosphere or a carbon adsorption system (stream 6). Solvent loss is compensated for by the periodic addition of solvent (stream 7) from storage tanks or drums. Finally, "dirty" solvent, which is solvent contaminated with grease or oil, is removed from the system as necessary and sent to the solvent recovery system (stream 8). The distillate is condensed, sent through a water separator, and finally placed in solvent storage (stream 9). The boiler, which may be fired with coal, gas, or fuel oil (stream 10), provides steam if it is required.

a. Types - The eight basic types of degreaser units[3-7] are discussed individually below.

(1) Vapor degreaser - The simplest degreaser is the vapor degreaser (Figure 3).[3] The unit is comprised of a body containing a sump that holds the solvent and a heater that boils the solvent to generate solvent vapors. Vapor level

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[4]Kearney, T. J. OSHA and EPA as They Apply to Solvent Vapor Degreasing. Detrex Chemical Industries, Inc. Detroit. September 1974. 16 p.

[5]Kearney, T. J., and C. E. Kircher. How to Get the Most from Solvent-Vapor Degreasing, Part I. Metal Progress 77:87-92, April 1960.

[6]Kearney, T. J. and C. E. Kircher. How to Get the Most from Solvent-Vapor Degreasing, Part II. Metal Progress. 77:93-96, 162, 164, May 1960.

[7]Heinz, D. Study to Support Standards of Performance for Organic Solvent Metal Cleaning Operations, Survey of Emission Sources. Dow Chemical. Midland. Environmental Protection Agency, Contract No. 68-02-1329. 87 p.

[8]Today's Concepts of Solvent Degreasing. Detroit, Detrex Chemical Industries, Inc., 22 p.

is maintained by a water jacket which encircles the machine. The body of the degreaser extends above the water jacket to minimize the escape of solvent vapors. The height of this "freeboard" is equal to one-half the tank width, or at least 0.91 m, whichever is shorter.[3-5]

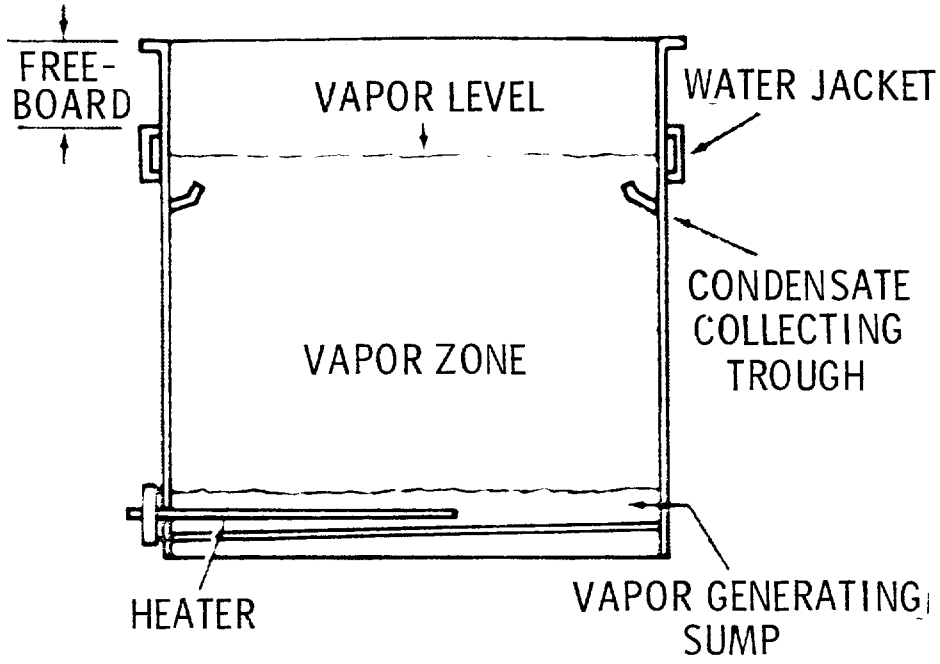

Figure 3. Basic vapor degreaser[8]

Vapor degreasers are satisfactory for removing oils and greases that are completely or almost completely soluble in the degreasing solvent. Work to be cleaned is immersed in the vapor zone. The cleaning results from the condensation of the solvent vapor on the exposed surfaces of the part. The condensed solvent dissolves the grease or oil and carries it to the sump. This action continues until the part is heated to the vapor temperature. The amount of condensation depends upon the mass of the part, its amount

thickness, and its specific heat. For example, aluminum will condense twice as much solvent vapor as the same weight of steel.[3,5,9]

(2) Vapor-distillate spray machine - Vapor-distillate spray machines combine the basic vapor degreaser with a spray system (Figure 4). The work is suspended in the vapor zone for degreasing. While still in the vapor zone, parts are flushed with a clean distillate spray which also cools the work surface so further condensation can take place.[3,5,9]

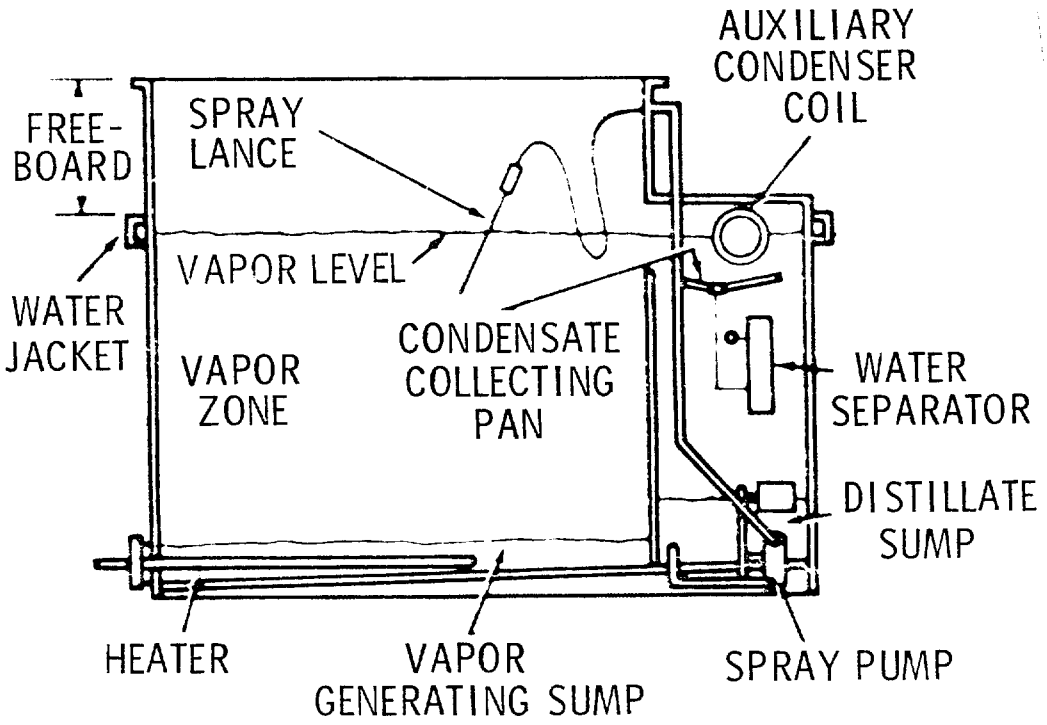

Figure 4. Vapor-distillate spray machine[8]

[9]Payne, H. F. Organic Coating Technology, Volume II. New York, John Wiley and Sons, Inc., 1961. p. 1019-1020.

As shown in Figure 4, condensed solvent is collected in a separate sump to one side of the work zone where it cannot be contaminated by soil from parts. Distillate flows into the solvent sump and then overflows into the boiling sump. The condensate collection system is equipped with a separator for removal of extraneous water. (Water enters the system from the atmosphere and with the work.) All solvent spraying takes place in the vapor zone.[3,5,9]

Vapor-distillate spraying removes soils which are partially insoluble in the solvent (e.g., polishing, buffing, and honing compounds). The mechanical action of the spray helps dislodge and remove the insoluble portion. The spray also helps remove the deposits of soluble materials, assists in cleaning the interior of parts that have cavities containing trapped air, and flushes out passageways.[5]

(3) Vapor-spray-vapor degreaser - The vapor-spray-vapor cycle (Figure 5) is similar to the vapor-distillate spray cycle. In the vapor-spray-vapor cycle, work is passed through the vapors and into the spray zone before the soluble portion of the gross soil, such as the carrier in a lapping compound, is completely removed. The solvent spray then dislodges the heavy soil and cools the parts enough for a final vapor rinse.[5]

(4) Liquid-vapor degreaser - A liquid-vapor degreaser (Figure 6) consists of two chambers. The first chamber contains boiling solvent which generates vapors. The second chamber is a warm solvent bath in which the parts are immersed. The condensate collection system returns the condensate to the warm solvent bath thereby constantly diluting it. Solvent overflows from the inversion chamber into the vapor operating sump.[5]

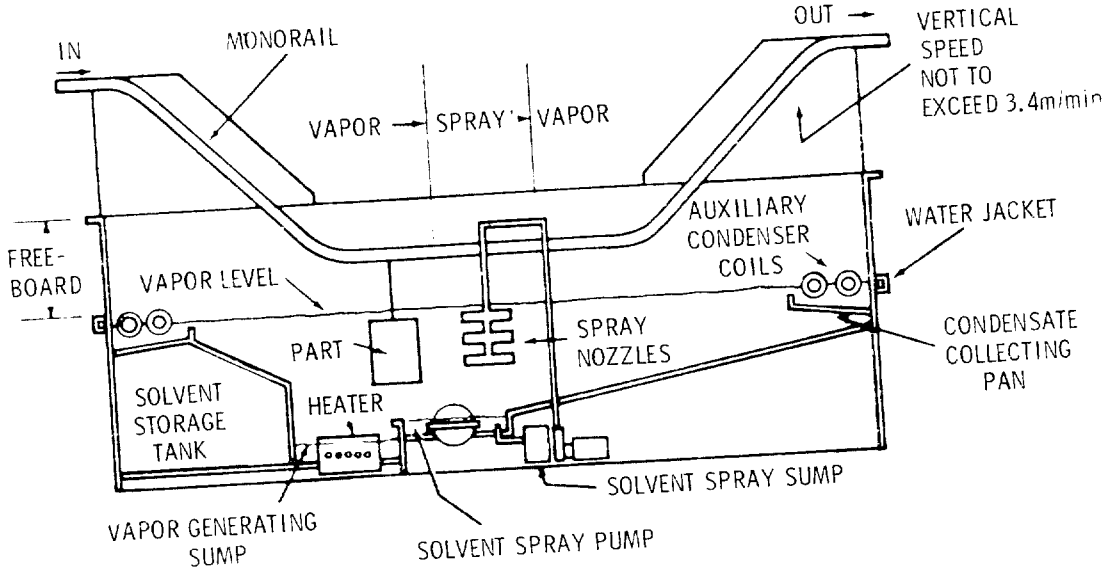

Figure 5. Vapor-spray-vapor degreasing unit[8]

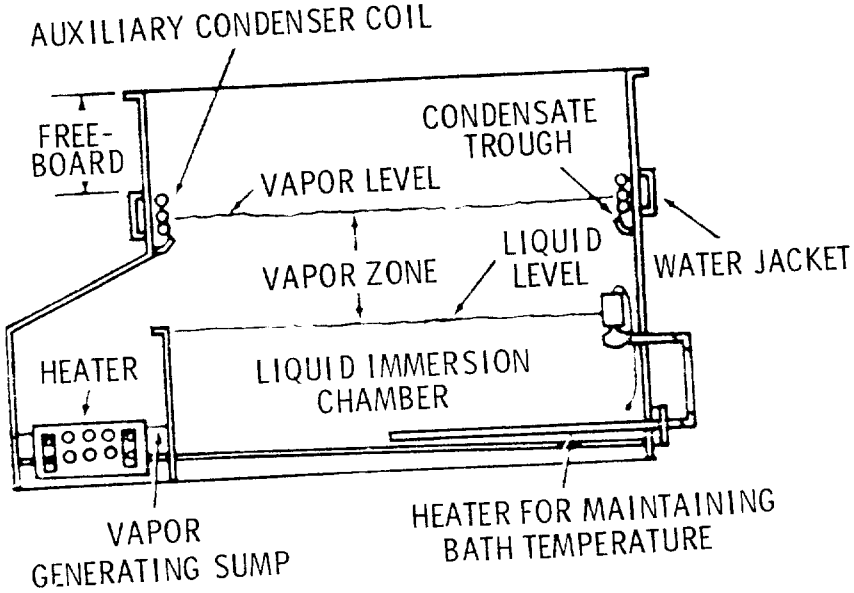

Figure 6. Liquid-vapor-degreaser[8]

Parts to be cleaned are lowered through the vapors into the inversion chamber where they are washed by the warm solvent. The parts are then withdrawn and held in the vapor to permit complete drainage and to undergo a vapor rinse. The solvent bath temperature is maintained below the solvent boiling point so that enough condensation will occur as the part moves through the vapor zone to effect a vapor rinse.[5] The vertical speed through the vapor zone should not exceed 3.4 m/min to maintain the air-vapor interface. Excessive speed causes solvent loss.

(5) Two-chamber immersion degreaser - Two-chamber immersion degreasers (Figure 7) are similar to liquid-vapor degreasers in that they consist of a boiling sump and a warm solvent bath. In the two-chamber immersion degreaser, however, cleaning is accomplished by immersing the parts in boiling solvent where the mechanical scrubbing action of the agitated liquid removes insolubles, heavy oils, and greases. From here the part is transferred to a rinse compartment, where the warm solvent rinses the part and also lowers the temperature of the work to permit a final vapor rinse.[5]

(6) Multiple immersion degreaser - The multiple immersion degreaser (Figure 8) is a two-chamber immersion degreaser with a third chamber added. The additional chamber contains solvent vapor that provides a final vapor rinse. This type of degreaser allows straight line production capability.[5]

(7) Ultrasonic degreaser - Ultrasonic degreasing combines a precleaning cycle, such as vapor-spray-vapor or immersion cleaning, with a subsequent treatment by immersion in an ultrasonically agitated liquid bath of the degreasing solvent

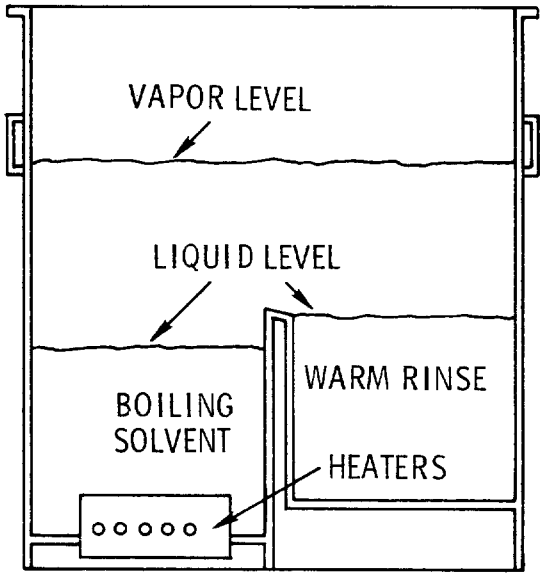

Figure 7. Two-chamber immersion degreaser[8]

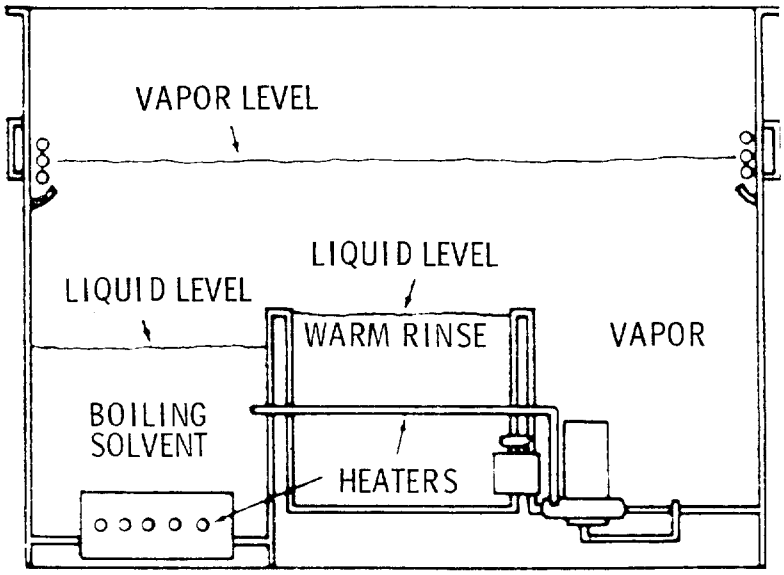

Figure 8. Multiple immersion degreaser[8]

(Figure 9).[10] Transducers, which convert electrical energy to mechanical energy, are placed in the bath either at the bottom or on the sides to supply the power for agitation. Filtration down to 2 μm, 5 μm, or 10 μm, depending upon the type of soil, is provided. The frequency and intensity of the ultrasonic energy are selected on the basis of tests. An example is the removal of residual oil from roller bearing cones. The cones were ultrasonically cleaned in trichloroethylene at 60°C with the immersed transducers operating at a frequency of 400 kHz (400 kilocycles). The average power intensity at the transducer was 2.5×10^4 W/m^2.[5]

(8) Cold solvent cleaning - When solvents are used at room temperature rather than in a vapor state, the process is usually called cold cleaning. These processes include wiping the area to be cleaned, spraying, or dipping in a tank of solvent.[7] It is estimated that 74% of plants using solvents use some cold solvent cleaning, while 54% of the total plants use cold solvent cleaning only. The percentage of plants using cold cleaning varies inversely with the size of the plant. Of the plants using solvents 76% do not use vapor recovery or control systems.[7] Refrigeration systems are used 8% of the time.

b. Auxiliary Equipment - In addition to the degreaser unit, auxiliary equipment of the types described below may be associated with each degreasing process.

(1) Solvent recovery system - As parts are degreased, the degreasing solvent becomes contaminated. The contaminated solvent is purified when the contaminant level approaches 30%. This level is determined by changes in physical properties

[10]Bransons FD & UD Series Ultransonic Vapor Degreasers. Stamford, Branson Cleaning Equipment Co., April 1974. 6 p.

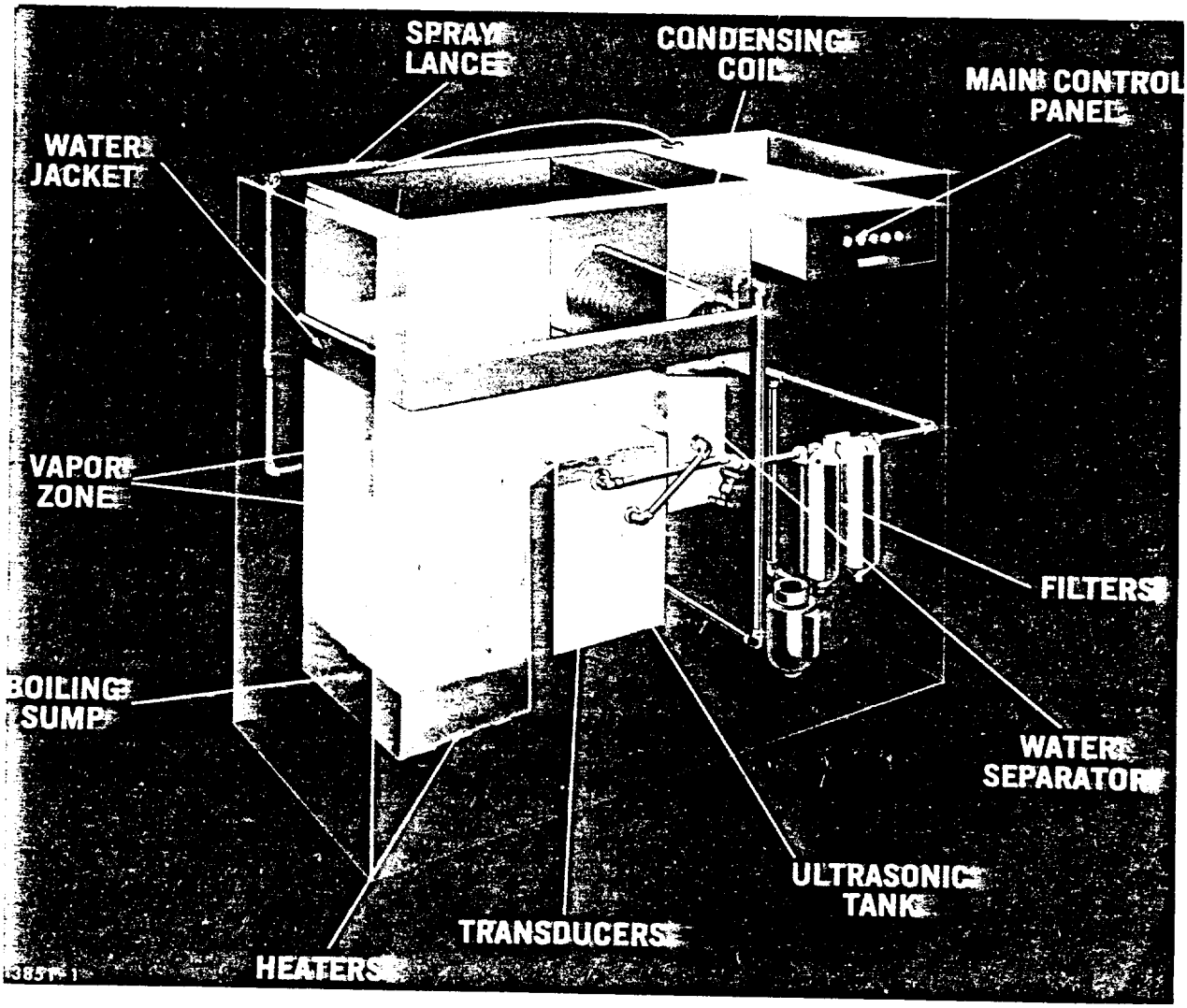

Figure 9. Ultrasonic degreaser[10]

such as the solvent boiling point (Table 4). The solvent is purified in one of two types of solvent recovery systems.[11]

One type of recovery system utilizes the degreaser itself as a solvent still (Figure 2). The condensate is collected in the condensate collecting trough and sent first to a water separator and then to reclaimed solvent storage. The contaminants are thus concentrated in the bottom of the degreaser, and they are cleaned out manually. There are two disadvantages to this system. First, production time is lost, since the degreaser must be off-line during the process. Second, this method of concentrating contaminants in the degreaser is not very efficient. As much as 50% of the sludge removed is solvent.[3,11]

Another type of solvent recovery system (Figure 2) contains a batch-type distillation column. This column may be fed directly from one degreaser or may be located to serve multiple degreasers. The contaminated solvent (stream 8) is placed in the bottom of the still where it is heated with steam to evaporate the solvent, leaving the contaminants in the bottom. The distillate is condensed, sent through a water separator, and finally placed in solvent storage (stream 9). Using a separate column for solvent recovery is more efficient than using the degreaser itself as a still, since only 10% of the sludge from the column is solvent. Furthermore, most solvents can be stripped from the sludge using steam injection to reduce the solvent level in the sludge to less than 1%.[3,11]

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[11]Vapor Degreasers. Clark, New Jersey, Branson Equipment Company. 11 p.

Table 4. BOILING POINTS OF CLEAN AND CONTAMINATED SOLVENTS[11]

Solvent	Boiling point, °C	
	Clean	30% contaminated
Trichloroethylene	87.2	90.5
Perchloroethylene	121.1	126.7
1,1,1-Trichloroethane	74.1	85.0
Methylene chloride	40.0	48.9
Carbon tetrachloride	76.8	
Acetone	56.5	
Butanol	117.2	
Ethers	35.0	
Methyl ethyl ketone	80.0	
Naphthas (petroleum distillates, Stoddard solvents)	150 - 200	
Fluorocarbons	0 - 50	
Hexane	68.9	
Toluene	111.1	
Mineral spirits	40 - 80	
Xylene	143.9	
Cyclohexane	80.0	
Benzene	80.1	

(2) Carbon adsorption system - Degreasers can be fitted with carbon adsorption beds to collect and recycle escaped solvent vapors (Figure 2, stream 6). Carbon adsorption systems are discussed in general in Section V.A.2.

(3) Industrial boiler - An industrial boiler (Figure 2) provides steam for degreasing processes that require it (e.g., processes with steam-heated degreasers or solvent stills). The boiler may be fired with coal, gas, or fuel oil (stream 10). The environmental impact of industrial boilers is being assessed in other contract studies and will not be discussed further in this report.

2. Fabric Scouring[a]

As shown in Figure 1, degreasing operations are accomplished using degreasers as described above and using fabric scouring. Fabric scouring is used to remove waxes, pectins, soil, lubricants, warp sizing, and other foreign substances remaining on the fibers or picked up in the fabrication of a fabric. Fabrics are scoured with detergents and water, with organic solvents, by kier boiling, or by enzyme treatment.[12] This report discusses only the organic solvent method of fabric scouring.

a. Types - Fabric scouring processes involving organic solvents include textile scouring, wool scouring, and multilayer treatment.

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[a] As used in this report, "scouring" is synonymous with "cleaning." In some literature sources, "scouring" means specifically "cleaning with detergent and water."

[12] Stout, E. E. Introduction to Textiles. New York, John Wiley and Sons, Inc., 1960. p. 283-284.

(1) Textile scouring process - Figure 10 is a typical flowsheet for a textile process. Scouring is accomplished prior to the dyeing step. Figure 11 depicts a scouring machine used for fabric scouring. The fabric is fed into the scouring section via the inlet conveyor. It then moves through the scouring section where it is sprayed with solvent. The fabric is supported and tensionless as it is scoured. Still tensionless, it is fed onto the dryer conveyors, traveling from bottom to top. The fabric is then cooled as it leaves the machine. It may be folded, rolled, or fed into the next machine after being scoured.[13,14]

Solvent is collected at two points in the machine. Excess solvent spray is collected beneath the conveyor and sent to a solvent holding tank. Solvent vapors collect at the bottom of the dryer, since this is the coolest point, and are condensed by the solvent condensers. The condensed solvent is then sent either to the solvent holding tank or directly to the solvent recovery system.[13,14]

(2) Wool scouring - In this process, wool is treated with a dry cleaning agent such as trichloroethylene or perchloroethylene. The used cleaning agent is then separated from the wool with a mixture of water and alcohol. The cleaning agent containing wool grease is separated from the water and alcohol mixture and recovered in a low pressure, low temperature distillation plant. See Figure 12.[15]

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[13]Mathews, J. C., et al. Screening Study on the Justification of Developing New Source Performance Standards for Various Textile Processing Operations. Research Triangle Park, North Carolina. Environmental Protection Agency, EPA Contract No. 68-02-0607-11. August 1974. 106 p.

[14]Solvent Scouring. Springfield, Riggs and Lombard, Inc. (Circular No. 721122), September 1973. 4 p.

[15]Saville, N. Method of Scouring Wool. U.S. Patent 3,619,116 (to Thomas Burley & Sons Limited, England), November 9, 1971.

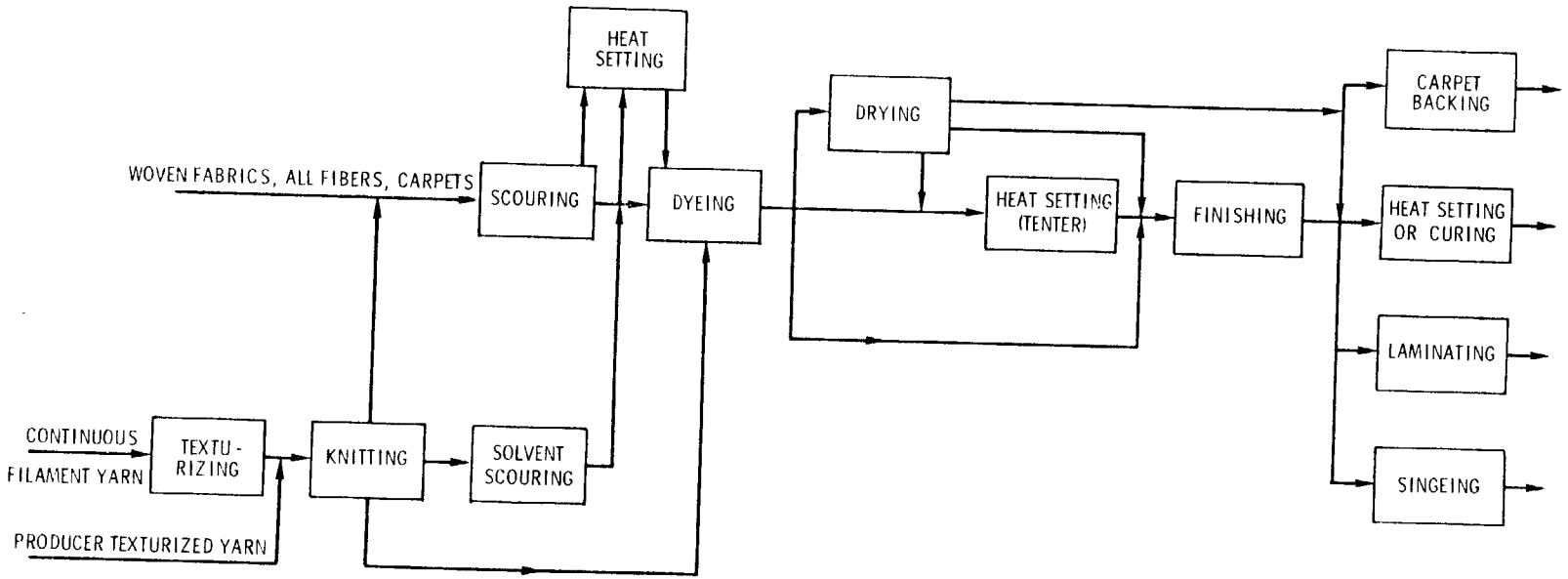

Figure 10. Textile process flowsheet[13]

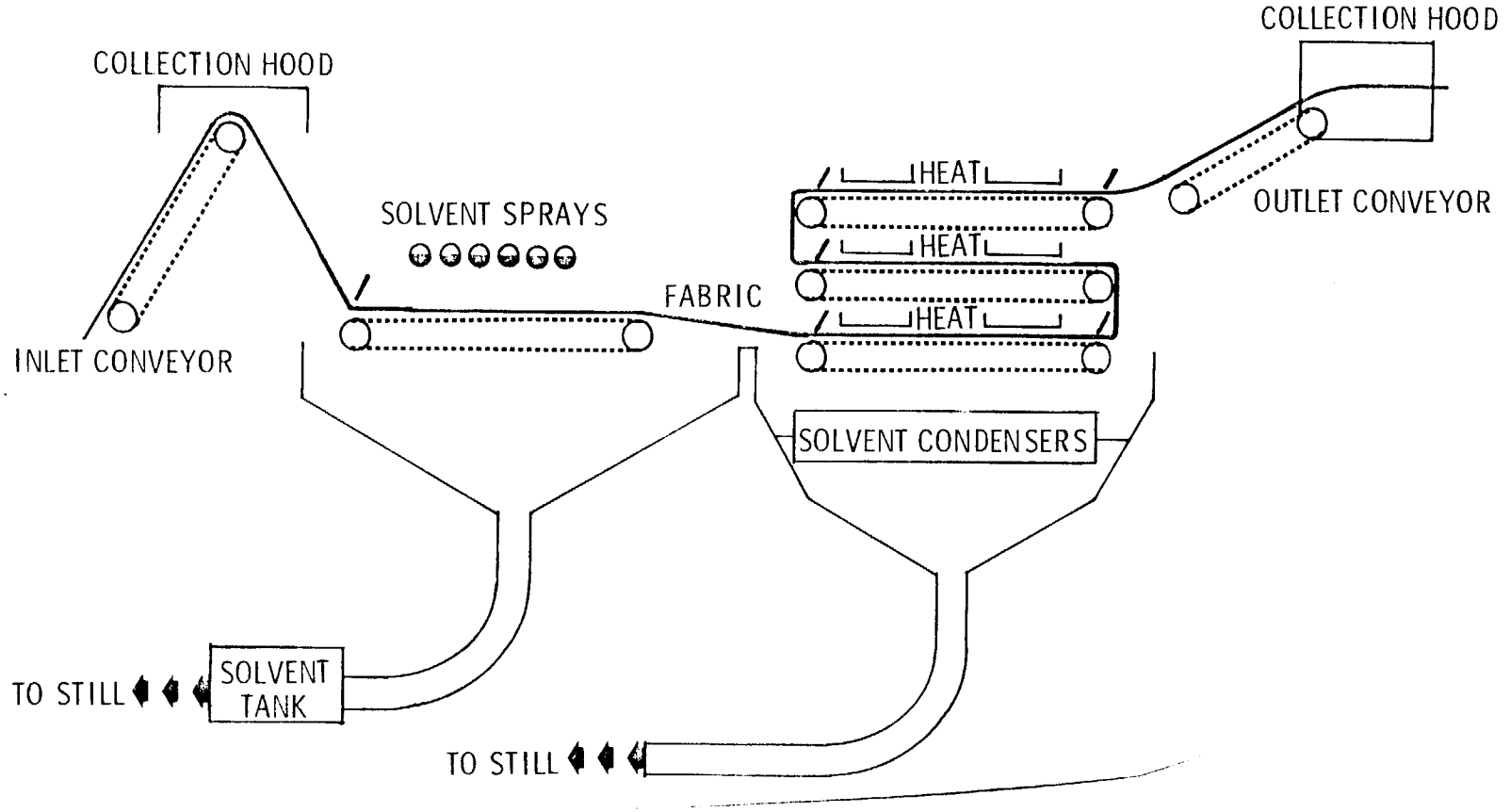

Figure 11. Continuous knit fabric scouring[13]

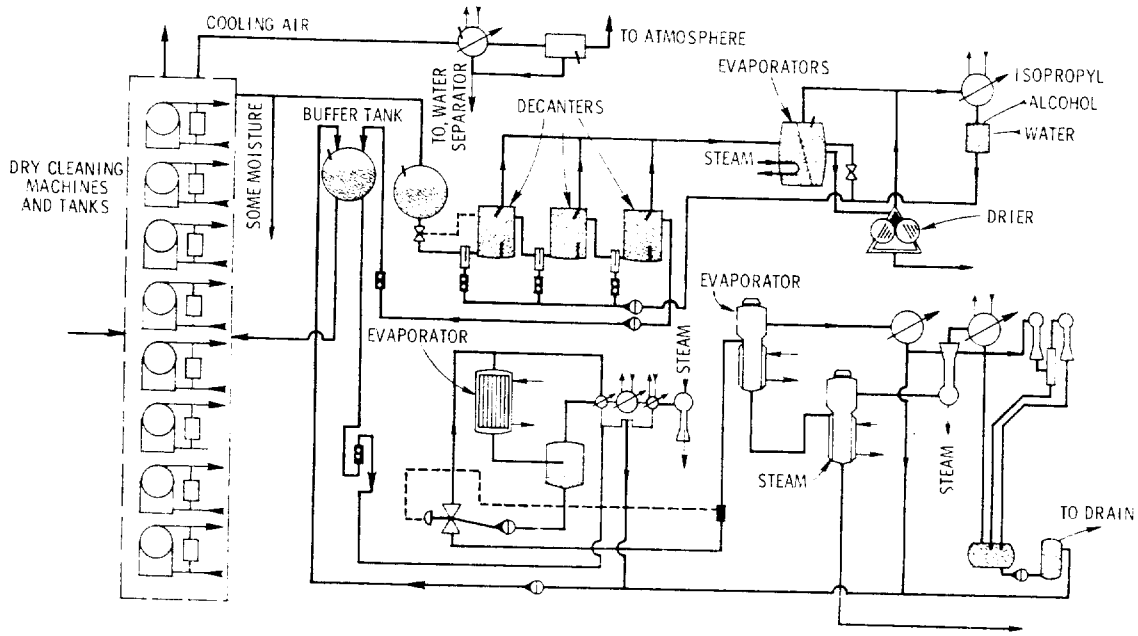

Figure 12. Wool scouring process[15]

(3) Multilayer treatment - This is a process whereby textiles are put through solvent scouring in several layers to increase throughput. The organic solvent bath penetrates these layers, removing both the grease and the adhering solvent. Solvents normally used are trichloroethylene, perchloroethylene, 1,1,2-trichloro-1,2,2-trifluoroethane, or mixtures of these. This process is essentially the same as that already discussed for textiles except that the material is put through in multilayer form.[16]

[16]Case, J. W., N. F. Crowder, and W. A. S. White. Treatment of Textiles. U.S. Patent 3,458,273 (to Imperial Chemical Industries Ltd., England), July 29, 1969.

b. Auxiliary Equipment -

(1) Vacuum desolvating process - This process involves passing a textile or other similar weblike material that is holding solvent through a vacuum chamber to remove the solvent. The time, vacuum, and temperature can be varied as required. Figure 13[17] shows the apparatus for this process.

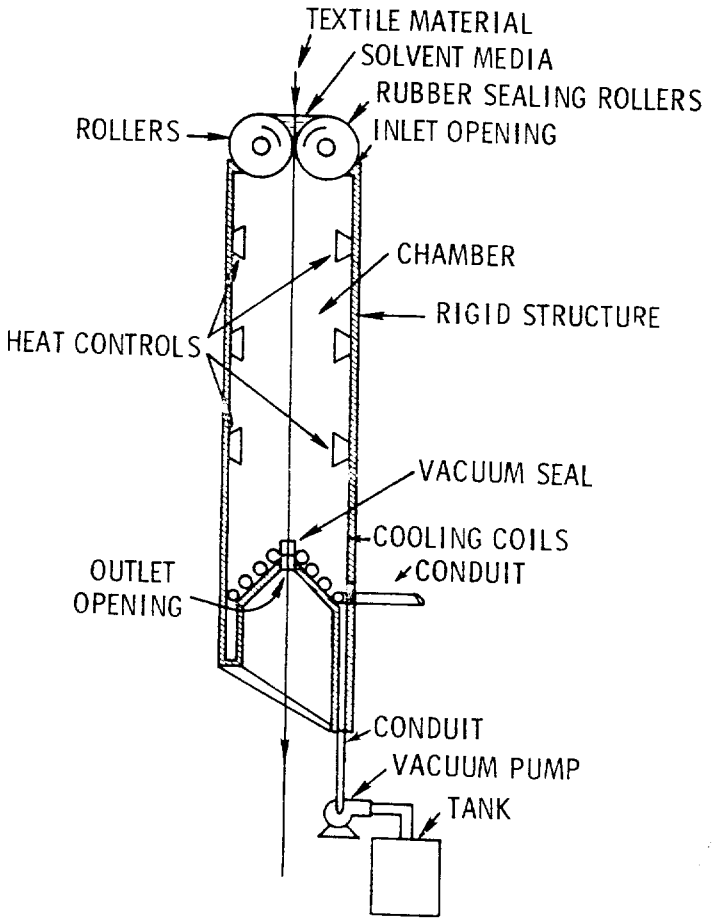

Figure 13. Vacuum process for the removal of moisture and solvents from textiles[17]

[17]Wedler, F. C. Process for Removal of Moisture and/or Solvents from Textile Materials. U.S. Patent 3,630,660 (to Burlington Industries), December 28, 1971.

(2) Carbon adsorption system - This system is basically the same as that described in Section V.A.2.

3. Solvents

Ten characteristics are required of solvent used in degreasing processes.[3] They must:

- Have high solvent power for the removal of oils, greases, and other contaminants
- Be nonflammable and nonexplosive under normal operating conditions
- Have a low latent heat of vaporization and a low specific heat so that a maximum amount of solvent will condense on a given weight of metal and keep heat requirements to a minimum
- Have a high vapor density by comparison with air and a low rate of diffusion into the air so that solvent losses are minimized
- Retain chemical stability under conditions of use
- Be noncorrosive to common materials of construction
- Have a boiling point low enough to permit the solvent to be easily separated from oil, grease, and other contaminants by simple distillation
- Have a boiling point high enough so that sufficient solvent vapors will be condensed on the work to insure adequate cleaning
- Be available at reasonable cost
- Remain safe under the operating conditions of vapor degreasing

Table 5[18-21] lists the physical properties of commercially available solvents. Table 6[7,19,22-27] gives the consumption of the estimated 17 solvents used in degreasing operations by industry category. A discussion of each of these solvents follows.

a. Halogenated Solvents-

(1) Trichloroethylene - Trichloroethylene ($ClCH=CCl_2$) is a stable, colorless liquid with a chloroform-like odor.[28] It has been used because of its high solvency power (kauri-butanol value of 129) and its low cost. From 1961 to 1972, trichloroethylene sold for $0.276/kg (in drums) while the next cheapest degreasing solvent, perchloroethylene, sold for

[18]Lange, N. A. and Forker, G. M. Handbook of Chemistry, Eighth Edition. Sandusky, Handbook Publishers, Inc., 1952. 1998 p.

[19]Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition. Vols. 7 and 13. New York, John Wiley and Sons, Inc., 1965 and 1967. p. 307-26 and p. 284-92.

[20]Modern Plastics Encyclopedia. Vol. 50, No. 10A. McGraw-Hill, New York. 1973-1974. p. 744-757.

[21]Heat Exchanger Tube Manual. Waterbury, Scovill Manufacturing Co., 1957. 171 p.

[22]Chemical Marketing Reporter. 208:9, September 22, 1975.

[23]Chemical Marketing Reporter. 208:9, September 1, 1975.

[24]Redksted, G. M. Upheaval in Vapor Degreasing. Factory. 27-32, January 1974.

[25]Personal Communication. J. S. Gunnin, Shell Chemical Company. Houston, Texas. October 1976.

[26]Personal Communication. K. S. Surprenant, Dow Chemical Company. Midland, Michigan. October 1976.

[27]Richards, D. W. and K. S. Surprenant. Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations. Research Triangle Park, North Carolina. Environmental Protection Agency, EPA Contract No. 68-02-1329, Task No. 9. June 1976.

[28]Sax, N. I. Dangerous Properties of Industrial Materials, Second Edition. New York, Reinhold Publishing Corporation, 1963. p. 1203.

Table 5. PROPERTIES OF COMMERCIALLY AVAILABLE SOLVENTS[a]

Solvent	Boiling point,[18] °C	Latent heat of vaporization,[18] J/g	Latent heat of vaporization,[18] cal/g	Specific heat,[18] J/g°C	Specific heat,[18] cal/g°C	Specific gravity[18] Liquid (water = 1)	Specific gravity[18] Vapor (air = 1)	Evaporation rate[20] (CCl_4 = 100)	Water solubility in solvent,[20] (@ 20°C, g/100 g)
Toluene	110.6[19]	363.4	(86.8)	1.76	(0.42)	0.87	3.14	12	0.05
Methyl ethyl ketone	79.6[19]	443.8	(106.0)	2.30	(0.55)	0.81	2.41	45	13.4
Acetone	56.7	521.3	(124.5)	2.22	(0.53	0.79	2.00	91	Complete
Carbon tetrachloride	76.7	218.1	(52.1)	0.84	(0.20)	1.58	5.3[b]	100	0.08
n-Butanol	117.2	591.6	(141.3)	2.34	(0.56)	0.81	2.55	3.5	25.8
Sec-Butanol	107.2	578.2	(138.1)	2.34	(0.56)	0.81	2.55	9.4	57.0
Naphtha, coal tar	150 - 200	326	(78)[21]	1.30	(0.31)[21]	0.90[b]	4.3[b]	1.5 - 12	<0.05
Naphtha, safety (Stoddard)	150 - 200	301.5	(72)[21]	1.34	(0.32)[21]	0.86[b]	4.3[b]	1.5 - 12	<0.05
Mineral spirits	155 - 175	326.6	(78)[21]	1.34	(0.32)[21]	0.87[b]	4.1[b]	0.63	<0.05
Ethers (petroleum)	40 - 70	288.9	(69)[21]	1.17	(0.28)[21]	0.60[b]	2.9[b]	100[b]	<0.05
Benzene	80.1[19]	394	(94.1)	1.72	(0.41)	0.88	2.77	49	0.05
o-Xylene	143.9[19]	347	(82.9)	1.72	(0.41)	0.88	3.66	5.5	0.04
Cyclohexane	80.7[19]	358.4	(85.6)	1.80	(0.43)	0.78	2.90	2[b]	<0.01
Hexane	66.7	337.0	(80.5)	1.55	(0.37)	0.66	2.97	113	<0.01
Trichlorotrifluoroethane	74.1	146.5	(35.0)	0.88	(0.21)	1.514	6.75	280	$0.01^{24°C}$
Methylene chloride	40.0	330.4	(78.9)	1.17	(0.28)	1.326	2.93	147	0.15
Perchloroethylene	121.1	209.4	(50.0)	0.88	(0.21)	1.623	5.73	27	0.01
Trichloroethylene	87.2	239.5	(57.2)	0.96	(0.23)	1.464	4.54	69	0.02
1,1,1-Trichloroethane	74.1	221.1	(52.8)	1.09	(0.26)	1.327	4.50	139	$0.05^{25°C}$

[a] Specific gravity of vapor phase was calculated using the ideal gas law.

Assuming boiling points for naphtha coal tar, Stoddard, mineral spirits, and ethers of 175°C, 175°C, 165°C, and 55°C, respectively, along with the densities shown, the molecular weights estimated from Reference 21 are 124, 125, 120, and 85, respectively; the density of air is assumed to be 1.293 kg/m^3.

Latent heats of vaporization were estimated from Reference 21; conversion factor is Btu/lb x 0.556 = cal/gram.

Specific heats were estimated from Reference 21 for the temperature range of 0 to 250°C, where applicable; conversion factor is Btu/lb °F x 0.778 = cal/g °C.

API gravities were assumed for the various petroleum fractions, respective to the list above, to be 25°, 33°C, 31°C, and 100°API.

[b] Estimated value.

Table 6. ESTIMATED SOLVENT USAGE IN DEGREASING OPERATIONS[a] [7,19,22-27]

(metric tons/yr)

Operation	Butanol	Acetone	Methyl ethyl ketone	Hexane	Naphthas	Mineral spirits	Toluene	Xylene	Cyclo-hexane	Benzene
Industrial degreasing										
Metal furniture	280	833	633	2,318	1,032	778	1,104	1,385	44	184
Primary metals	190	571	422	2,318	700	778	751	1,385		184
Fabricated products	760	2,309	1,758		2,765	778	3,047		44	184
Nonelectric machinery	1,047	3,190	2,344		3,834	778	4,240			
Electric equipment	298	905	703		1,106		1,192			
Transportation equipment	210	620	469		774	444	839			
Instruments and clocks	115	382	234		442		486			
Other miscellaneous	400	1,190	937	2,364	1,474	26,444	2,341	9,230	912	6,447
Automotive uses										
Repair, service garages					30,117					
Dealers					22,634					
Gasoline stations					49,765					
Maintenance shops					73,357					
Textile plants								100,000		35,000
TOTAL CONSUMPTION	3,300	10,000	7,500	7,000	188,000	30,000	14,000	112,000	1,000	42,000

[a] Blanks indicate not applicable.

Table 6 (continued). ESTIMATED SOLVENT USAGE IN DEGREASING OPERATIONS[a] [7,19,22-27]

(metric tons/yr)

Operation	Ethers	Carbon tetra-chloride	Fluoro-carbons	Methylene chloride	Perchloro-ethylene	Trichloro-ethylene	1,1,1-Trichloro-ethane	Totals
Industrial degreasing								
Metal furniture	667	52	233	4,500	4,650	13,215	12,585	44,493
Primary metals	667	38	155	2,925	3,022	8,926	8,483	31,515
Fabricated products	667	156	700	11,923	12,321	35,937	34,306	107,649
Nonelectric machinery	667	210	1,010	16,422	16,971	49,848	47,450	148,011
Electrical equipment	667	60	312	4,500	4,650	14,027	13,425	41,845
Transportation equipment	667	45	155	3,150	3,255	9,855	9,415	29,898
Instruments and clocks	667	22	78	2,025	2,092	5,796	5,593	17,932
Other miscellaneous	1,331	143	14,457	10,795	7,439	18,896	36,543	141,343
Automotive uses								
Repair, service garages								30,117
Dealers								22,634
Gasoline stations								49,765
Maintenance shops								73,357
Textile plants					54,600	15,000		204,600
TOTAL CONSUMPTION	6,000	720	17,100	56,240	109,000	171,500	167,800	943,160

[a] Blanks indicate not applicable.

$0.298/kg (same basis).[29] Trichloroethylene can be vaporized using gas, electric, or steam heaters.[3] Because its boiling point is 87.2°C, trichloroethylene can be vaporized with low pressure (135.7 kPa to 204.6 kPa) steam.[3] Stabilized trichloroethylene is used for degreasing applications. Trichloroethylene at $0.435/kg is now (1976) the most expensive of the fabric scouring solvents.[29]

(2) Fluorocarbons - In addition to trichlorotrifluoroethane, trichlorofluoromethane and tetrachlorodifluoroethane are also used in solvent cleaning processes on a small, specialized scale. All three display the high density (1.5 times that of water), low boiling point (0°C to 50°C), low viscosity, low surface tension, low toxicity, and good stability characteristics of halogenated hydrocarbons. Their principal use is as propellants in aerosols. Trichlorotrifluoroethane is also used as a solvent in dry cleaning operations.

(3) Methylene chloride - Methylene chloride (CH_2Cl_2) is a colorless, volatile liquid.[28] It is a low volume degreasing solvent with an estimated annual consumption of 5.6×10^4 metric tons. Methylene chloride is the most active of the degreasing solvents (kauri-butanol value of 136).[30] It also has the lowest boiling point (40.0°C) and the highest latent heat of vaporization (330.2 J/g) of these solvents.[31] The high solvency power means that methylene chloride is too harsh for some applications such as degreasing plastics and elastomers.[30] The low boiling point requires refrigerated

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[29]Chemical Marketing Reporter. 209(12):46-56. September 1976.

[30]The United States Environmental Protection Agency and How Its Regulations will Affect Vapor Degreasing. Chicago, Baron-Blakeslee, 1971. 19 p.

[31]Perry, J. H. (ed.). Chemical Engineers' Handbook, Fourth Edition. New York, McGraw-Hill Book Co., 1963. p. 3-23 to 3-42.

water (12.7°C to 15.5°C) on the degreaser condensing coils, and the high latent heat of vaporization requires more heat to be removed than for the other solvents.[4,30] Methylene chloride degreasers can be heated with gas, electricity, or steam (135.7 kPa to 204.6 kPa). Methylene chloride is stable under degreasing conditions. In 1976, the cost is estimated to be $0.435/kg.[29] Methylene chloride consumption in metal vapor degreasing has more than doubled since 1972, indicating a switch from other solvents such as trichloroethylene.

(4) 1,1,1-Trichloroethane - 1,1,1-Trichloroethane (methyl chloroform, CH_3CCl_3) is a colorless liquid. It is the second largest volume vapor degreasing solvent, with 1.68×10^5 metric tons/yr being consumed. 1,1,1-Trichloroethane is the degreasing solvent most like trichloroethylene in its degreasing properties. It has a boiling point of 74.1°C and a kauri-butanol value of 124 compared to corresponding properties in trichloroethylene of 87.2°C and 129.[32] 1,1,1-Trichloroethane also has a low toxicity rating (TLV = 1.900 g/m^3).[32] Because of its boiling point, this solvent can be heated with gas, electricity, or steam (135.7 kPa to 204.6 kPa),[3,30] but it must be stabilized for degreasing applications. It decomposes in the presence of water to form hydrochloric and acetic acids.[3,30] Improperly stabilized, 1,1,1-trichloroethane can also decompose in the presence of aluminum or magnesium.[3,30] Stabilizers for 1,1,1-trichloroethane (0.05 g/100 g @ 25°C) require a special separator and a desiccant to remove water from the system.[30] In 1976, the cost was estimated to be $0.467/kg.[29]

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[32]TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1973. American Conference of Governmental Industrial Hygienists. 1973. 94 p.

(5) Perchloroethylene - Perchloroethylene ($Cl_2C=CCl_2$) is a colorless liquid with a chloroform-like odor.[28] It is the third largest volume vapor degreasing solvent, with 1.1×10^5 metric tons consumed each year. Perchloroethylene's relatively high boiling point (121.1°C) allows the removal of high melting wax and grease and also allows the solvent to condense on the work for a longer period of time, thus giving a longer cleaning cycle. Perchloroethylene degreasers may be heated by using gas, steam, or electricity.[3] If steam is used, high pressures (344.7 kPa to 413.6 kPa) are required because of the boiling point.[3,30] The high temperature can also cause damage to materials that cannot stand it, such as plastics.[30] Perchloroethylene is also stabilized for degreasing use. In 1976, the cost was estimated to be $0.377/kg.[29]

(6) Carbon tetrachloride - Carbon tetrachloride (CCl_4) is a heavy, colorless liquid with an ethereal odor. It is used extensively as a solvent and diluent, dry cleaning agent, degreaser, etc. It is miscible in all proportions with alcohol, benzene, chloroform, ether, petroleum ether, etc. Carbon tetrachloride has a boiling point of 76.8°C and a vapor pressure of 133.3 Pa at 230°C. If ingested or inhaled, it can cause injury to the extent of death from prolonged exposure to high concentrations. It is similar to but not as strong as chloroform in its narcotic action.[28] The cost in 1976 was estimated to be $0.372/kg.[29]

b. Nonhalogenated Solvents -

(1) Acetone - Acetone (CH_3COCH_3) is a colorless liquid with a fragrant, mintlike odor. Its molecular weight is 58.08 and its boiling point is 56.48°C. Acetone generally is rated moderately toxic in that it may produce reversible or irreversible changes in the human body but not to the extent of threatening life or producing serious permanent physical impairment.

In industry, no injurious effects from its use have been reported other than the occurrence of skin irritations resulting from its defatting action.[28] It is widely used in industry as a solvent for fats, oils, waxes, nitrocellulose, and other cellulose derivations. The cost in 1976 was estimated to be $0.110/kg.[29]

(2) Butanol - Butyl alcohol ($CH_3CH_2CH_2CH_2OH$) is a colorless liquid with an odor resembling that of isoamyl alcohol. It boils in the range of 115°C to 118°C. It is used as a solvent in the manufacture and preparation of various materials such as airplane dopes, lacquers, and plastics. In industry it is used primarily because of its ability to make substances soluble in each other.[33] For example, a mixture of acetone, butyl alcohol, methyl or ethyl alcohol, and methyl ethyl ketone in methylene chloride is used as a paint stripper. The 1976 cost of butanol was estimated to be $0.485/kg.[29]

(3) Ethers - Ethers are organic compounds in which an oxygen atom is interposed between two carbon atoms in the structure of the molecule.[28] The simpler ethers such as ethyl ether, isopropyl ether, etc. are powerful narcotics which in larger doses can cause death.[28] Most ethers have low flash points; therefore, great care must be exercised when handling them. Also included under the term "ethers" are low-boiling petroleum fractions with properties similar to those of 'true' ethers. Isopropyl ether in 1976 was estimated to cost $0.310/kg and diethyl ether was estimated to cost $0.175/kg.[29]

(4) Methyl ethyl ketone (butanone) - Methyl ethyl ketone, $CH_3COCH_2CH_3$, is a colorless liquid with an odor like that of

[33]Jacobs, M. B., and L. Scheflan. Chemical Analysis of Industrial Solvents. New York, Interscience Publishers, Inc., 1953. 501 p.

acetone. It has a boiling point of 79.57°C and a flash point of -5.5°C. Methyl ethyl ketone is only slight to moderate in toxicity rating. Maximum allowable concentration is 250 ppm in air or 735 mg/m^3 of air.[28] It was estimated to cost $0.440/kg in 1976.[29] It is used as a solvent in the artificial leather industries.

(5) Naphthas (petroleum distillates, Stoddard solvents) - When hydrocarbons that are the primary component of industrial naphtha consist of paraffin and/or naphtha, the naphtha is classified as an aliphatic, following the practice of classifying industrial naphthas based on their solvency, as determined by the kauri-butanol laboratory test.[34]

Petroleum naphthas are approximately 65% hydrocarbons of five to eight carbon atoms and 35% hydrocarbons of nine or more carbon atoms. Approximately 2% of naphtha is toluene, less than 0.5% is benzene. Naphthas consist of approximately 10% aromatics and from 20% to 60% naphthenes and 70% to 30% paraffins, depending upon whether the naphtha is low naphthenic or high naphthenic.[35] According to ASTM Standard D 838, the boiling point range of refined solvent naphthas is 130°C to 145°C and the specific gravity range is from 0.85 to 0.87.[36] This would give naphtha an average molecular weight of 105.[21] Table 7 lists more specifications of naphthas.

(6) Toluene - Toluene ($C_6H_5CH_3$), or methylbenzene phenylmethane or toluol, is a colorless liquid with a benzol-like odor. Its boiling point is 110.4°C and its flash point is

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[34]American Society for Testing and Materials. 1972 Annual Book of ASTM Standards. Parts 17-20. Philadelphia. 1972.

[35]Boer, H., and P. Van Arkel. Better Gasoline Chromatography. Hydrocarbon Processing. 51:80-84, February, 1972.

[36]American Society for Testing and Materials. 1974 Annual Book of ASTM Standards. Parts 23-25 and 30. Philadelphia. 1974.

Table 7. SPECIFICATIONS OF SOME SOLVENTS[19]

Property	Solvent naphtha			Stod-dard solvent	Petro-leum spirits
	Refined	Crude, light	Crude, heavy		
ASTM designation	D 838	D 839	D 840	D 484	D 235
Specific gravity at 60°F	0.850-0.870	0.860-0.885	0.885-0.970		
Distillation, °C					
5% recovered	130 min	130 min	150-165		
50% recovered, max				176	176
90% recovered, max	145	160	200	190	190
end pt, max	155	180	220		
Flash pt, min, °F				100	100

4.4°C. It is moderately harmful to humans. Very serious effects due to exposure are rare. The maximum allowable concentration is 200 ppm in air.[28] Toluene is derived from coal tar, and commercial grades usually contain small amounts of benzene as an impurity. Its cost in 1976 was estimated to be $0.187/kg.[29] It is used as a solvent for the extraction of various materials, as a diluent in cellulose ether lacquers, and in the manufacture of benzoic acid, benzaldehyde, explosives, dyes, and other organic compounds.[33]

(7) Hexane - Hexane [$CH_3(CH_2)_4CH_3$] is a colorless liquid with a boiling point of 68.7°C, vapor pressure of 133.3 Pa at 15.8°C, and a primarily slight toxic hazard rating. Maximum acceptable concentration is 500 ppm in air and 1,760 mg/m^3 of air. As a volatile paraffin hydrocarbon, hexane is used in the manufacture of gasoline.[28] Its cost in 1976 was estimated to be $0.167/kg.[29]

(8) Mineral spirits - Mineral spirit is also called turpentine substitute, white spirit, or petroleum spirit. It is a clear, water-white refined hydrocarbon solvent and diluent petroleum distillate with a minimum flash point of 21°C. It has a boiling point in the range of 150°C to 190°C and a

density of 0.80. Its toxic hazard rating is considered to be slight to moderate.[33]

(9) Xylene - Xylene [$C_6H_4(CH_3)_2$] is a colorless liquid with a boiling point of 138°C to 144°C. It is only slightly hazardous to persons in contact with it during a normal working day. The maximum allowable concentration of xylene is 200 ppm in air.[28] It is used as a solvent for gums and oils and in the manufacture of dyes and other organic substances.[33] Xylene cost was estimated to be approximately $0.182/kg in 1976.[29] It is only very slightly soluble in water and is miscible with absolute alcohol and other common organic solvents.[33]

(10) Cyclohexane - Cyclohexane (C_6H_{12}), also known as hexahydrobenzene or hexamethylene, is a colorless mobile liquid with a pungent odor. Its boiling point is 80.7°C and its vapor pressure is 133.3 Pa at 60.8°C. The toxic hazard rating is relatively unknown, but the inhalation of concentrated amounts does cause moderate harm. Maximum allowable concentration is 400 mg/m^3 of air. Cyclohexane is a solvent for resins and rubber. It is also used as a degreasing agent and a paint thinner. It is insoluble in water but is completely miscible with alcohol, ethers, hydrocarbons, chlorinated hydrocarbons, and most other organic solvents.[33] Its cost was estimated to be $0.288/kg in 1976.[29]

(11) Benzene - Benzene (C_6H_6) is also called benzol. It is a colorless, clear liquid having a pleasant odor in low concentrations but unpleasant at higher concentrations. Its boiling point is 80.1°C. Since benzene evaporates at room temperature, it is used in industrial processes where the dissolved substances are to be left unchanged. Benzene is used in oil extraction, dyes, and dye intermediates, and in the manufacture of paints, varnishes, and stains as well as

paint and varnish removers. It is also used in the blending of motor fuel.[33] In 1976 its cost was estimated to be $0.286/kg.[29] The toxic hazard rating is slight to high, depending on the length of exposure and on the concentration.

c. Stabilizers - Suitable stabilizers are added to solvents that are not chemically stable under some conditions to which they are exposed in vapor degreasing. These stabilizers make the solvent resistant to conditions such as heat, oxygen, active metal chips and fines, acidic salts, alkaline and acidic metal working lubricants, and moisture that may occur. A list of stabilizers used with halogenated solvents is provided in Appendix B.

C. GEOGRAPHIC DISTRIBUTION

1. Degreasers

Since there is no degreasing industry *per se*, degreaser sites have been located by identifying the industries with which they are associated.

a. Vapor Degreasers - In 1972 there were approximately 13,400 plants with vapor degreasers. More than 62% of these plants were located in eight states (California, Illinois, Massachusetts, Michigan, New Jersey, New York, Ohio, and Pennsylvania). The other 38% of the plants were located in 41 of the remaining 42 states.

Figure 14 is a graphical presentation of the geographic distribution of plants operating vapor degreasers. Table 8[37-42] summarizes the number of plants by state.

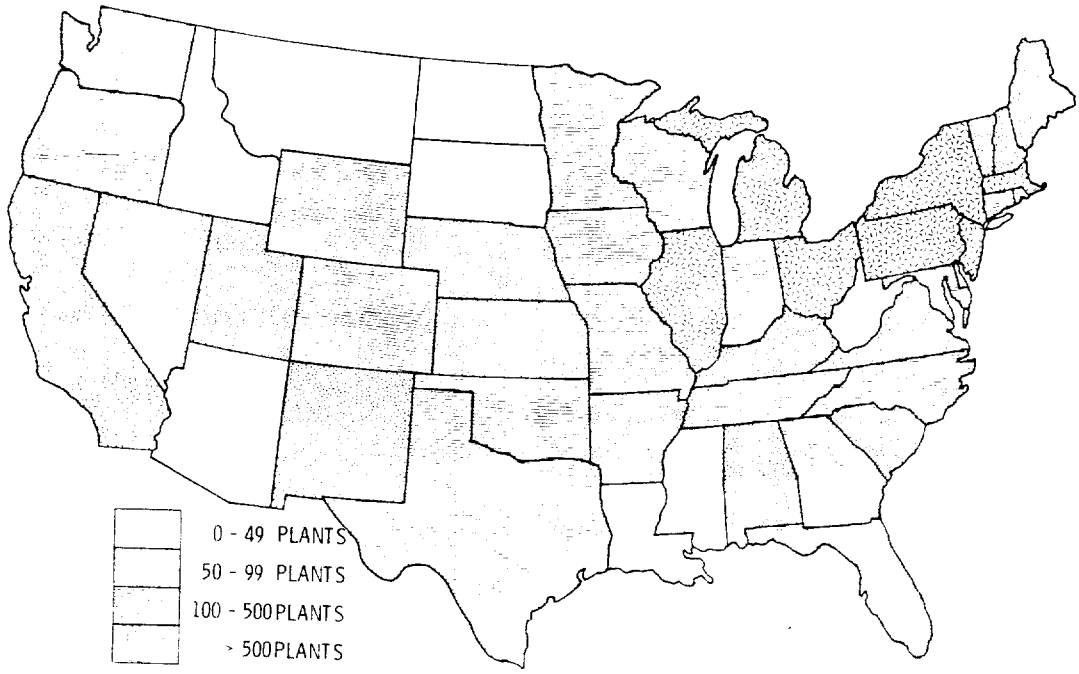

Figure 14. Geographic distribution of vapor degreaser sites

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[37] Hughes, T. W., et al. Source Assessment: Prioritization of Air Pollution for Industrial Surface Coating Operations. Environmental Protection Agency, Raleigh, N.C. EPA-650/2-75-019-a. February, 1975. 303 p.

[38] Automotive Stampings, SIC 3465. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34D-5. December 1973. 6 p.

[39] Plating and Polishing, SIC 3471. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34D-8. January 1974. 6 p.

[40] Metal Coating and Allied Services, SIC 3479. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34D-9, March 1974. 7 p.

[41] Valves and Pipe Fittings, SIC 3498. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34F-2. March 1972. 10 p.

[42] Fabricated Pipe and Fittings, SIC 3498. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34F-6. February 1974. 7 p.

Table 8. GEOGRAPHIC DISTRIBUTION OF VAPOR DEGREASERS[37-42]

State	Number of plants	State	Number of plants
Alabama	67	Nebraska	62
Alaska	0	Nevada	63
Arizona	40	New Hampshire	70
Arkansas	95	New Jersey	770
California	865	New Mexico	60
Colorado	121	New York	1,398
Connecticut	389	North Carolina	180
Delaware	25	North Dakota	21
Florida	156	Ohio	1,375
Georgia	100	Oklahoma	116
Hawaii	2	Oregon	244
Idaho	30	Pennsylvania	975
Illinois	1,394	Rhode Island	78
Indiana	367	South Carolina	55
Iowa	208	South Dakota	8
Kansas	68	Tennessee	129
Kentucky	94	Texas	372
Louisiana	26	Utah	63
Maine	66	Vermont	66
Maryland	104	Virginia	58
Massachusetts	510	Washington	153
Michigan	1,158	West Virginia	31
Minnesota	294	Wisconsin	433
Mississippi	26	Wyoming	105
Missouri	263		
Montana	9	TOTAL	13,362

b. Cold Cleaning - Of the 311,200 plants that performed degreasing operations in 1972, almost 300.000 used cold cleaning methods. More than half of these plants were located in nine states: California, Florida, Illinois, Michigan, New Jersey, New York, Ohio, Pennsylvania, and Texas. The rest of the plants were located in the other states.

Figure 15 is a graphical presentation of the geographic distribution of cold cleaning sites. Table 9[37-42] summarizes the number of plants by state.

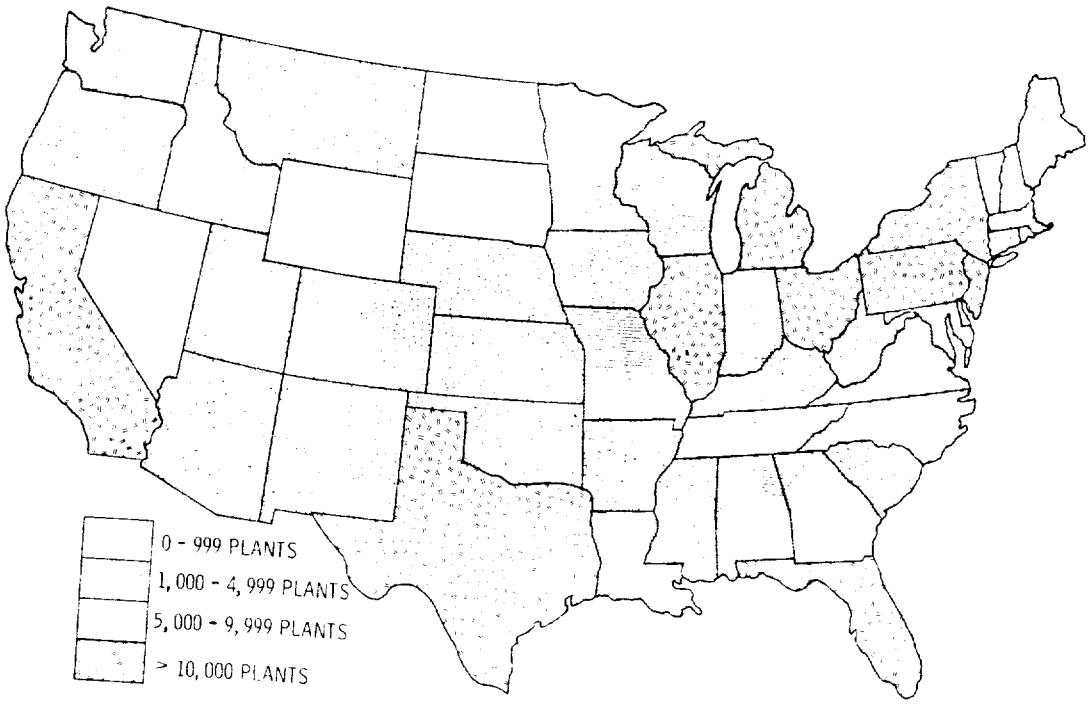

Figure 15. Geographical distribution of cold cleaning sites

Table 9. GEOGRAPHIC DISTRIBUTION OF INDUSTRIES USING COLD CLEANING[37-42]

State	Number of plants	State	Number of plants
Alabama	5,333	Nebraska	2,238
Alaska	500	Nevada	737
Arizona	2,660	New Hampshire	1,030
Arkansas	2,905	New Jersey	10,330
California	30,035	New Mexico	1,540
Colorado	3,279	New York	26,902
Connecticut	4,311	North Carolina	7,720
Delaware	875	North Dakota	979
Florida	10,344	Ohio	15,125
Georgia	7,000	Oklahoma	3,884
Hawaii	1,198	Oregon	2,956
Idaho	1,070	Pennsylvania	17,325
Illinois	15,806	Rhode Island	1,422
Indiana	7,733	South Carolina	3,945
Iowa	4,192	South Dakota	992
Kansas	3,432	Tennessee	5,971
Kentucky	4,906	Texas	16,228
Louisiana	5,674	Utah	1,537
Maine	1,434	Vermont	634
Maryland	5,996	Virginia	7,142
Massachusetts	6,090	Washington	5,147
Michigan	12,642	West Virginia	2,669
Minnesota	5,606	Wisconsin	6,467
Mississippi	3,374	Wyoming	395
Missouri	7,037		
Montana	1,091	TOTAL	297,838

2. Fabric Scourers

In 1972 there were approximately 5,150 plants with fabric scourers. More than 92% of these plants were located in 15 states: Connecticut, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Tennessee, and Virginia. The remaining 8% of the plants were located in the other 35 states.

Figure 16 is a graphical presentation of the location of fabric scouring plants by state. Table 10[43-59] summarizes this information.

Figure 16. Geographic distribution of fabric scouring sites

[43] Weaving Mills, Manmade Fiber and Silk, SIC 2221. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22A-2, March 1974. 7 p.

[44] Weaving and Finishing Mills, Wool, SIC 2231. U.S. Department of Commerce. Washington. Preliminary Report, 1972

Census of Manufactures, MC(P)-22A-3, March 1974. 7 p.

[45]Narrow Fabric Mills, SIC 2241. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC(P)-22A-4, December 1973. 7 p.

[46]Weaving Mills, Cotton, SIC 2211. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22A-1, March 1974. 10 p.

[47]Women's Hosiery, Except Socks, SIC 2251. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-1, January 1974 7 p.

[48]Hosiery, N.E.C., SIC 2252. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-2, February 1974. 7 p.

[49]Knit Outerwear Mills, SIC 2253. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-3, March 1974. 7 p.

[50]Knit Underwear Mills, SIC 2254. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-4, January 1974. 6 p.

[51]Circular Knit Fabric Mills, SIC 2257. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-5, January 1974. 7 p.

[52]Warp Knit Fabric Mills, SIC 2258. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-6, January 1974. 7 p.

[53]Knitting Mills, N.E.C., SIC 2259. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-7, December 1973. 6 p.

[54]Finishing Plants, Cotton, SIC 2261. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22C-1, March 1974. 7 p.

[55]Finishing Plants, Man-Made Fiber and Silk Fabric, SIC 2261. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22C-2, March 1974. 7 p.

[56]Finishing Plants, N.E.C., SIC 2269. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22C-5, March 1974. 6 p.

[57]Tufted Carpets and Rugs, SIC 2272. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22D-2, December 1973. 6 p.

[58]Yarn Mills, Except Wool, SIC 2281. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of

Table 10. GEOGRAPHIC DISTRIBUTION OF FABRIC SCOURING PLANTS[43-59]

State	Number of plants	State	Number of plants
Alabama	46	Montana	0
Alaska	0	Nebraska	6
Arizona	7	Nevada	7
Arkansas	17	New Hampshire	60
California	38	New Jersey	446
Colorado	11	New Mexico	1
Connecticut	52	New York	1,044
Delaware	14	North Carolina	1,260
Florida	63	North Dakota	0
Georgia	412	Ohio	12
Hawaii	0	Oklahoma	12
Idaho	1	Oregon	23
Illinois	14	Pennsylvania	447
Indiana	11	Rhode Island	144
Iowa	7	South Carolina	321
Kansas	6	South Dakota	0
Kentucky	15	Tennessee	72
Louisiana	11	Texas	19
Maine	52	Utah	7
Maryland	60	Vermont	39
Massachusetts	199	Virginia	94
Michigan	12	Washington	23
Minnesota	6	West Virginia	12
Mississippi	26	Wisconsin	13
Missouri	7	Wyoming	1
		TOTAL	5,150

Manufactures, MC72(P)-22E-1, March 1974. 7 p.

[59]Throwing and Winding Mills, SIC 2282. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22E-2, March 1974. 6 p.

SECTION IV

EMISSIONS

A. LOCATION AND DESCRIPTION

1. Degreasers

Degreasing processes generally have the eight emission points described in Table 11 and located on the flow diagram (Figure 17). Each emission point is discussed below.

Table 11. IDENTIFICATION OF EMISSION POINTS IN A DEGREASING OPERATION

Emission point	Description
A	Vapor loss from degreaser top
B	Solvent "dragout"
C	Exhaust from ventilator
D	Exhaust from gas burner
E	Tank loss
F	Solvent evaporation from sludge
G	Solvent evaporation from waste water
H	Adsorption bed exhaust

a. Vapor Loss from Degreaser (Emission Point A) - As the degreaser operates, solvent vapor is lost into the atmosphere. In addition to diffusion, such losses are dependent upon four factors. First, drafts across the degreaser top increase

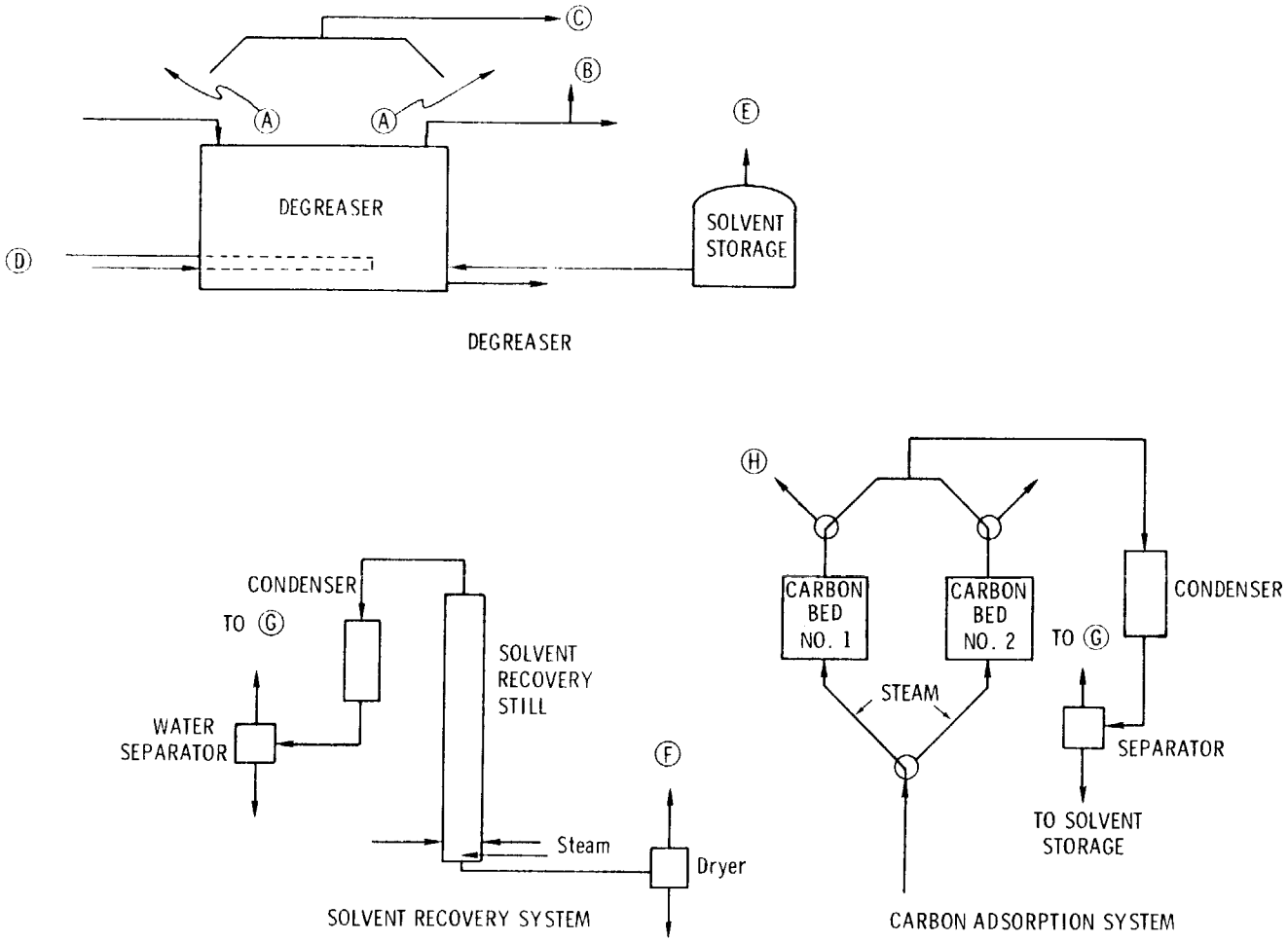

Figure 17. Location of degreaser emission points (shown as circled letters)

solvent loss, since the solvent vapor mixes with strong drafts or forced movement of air across or into a degreaser, and the diluted vapor is more easily swept out of the machine. An increase in air velocity over the top of a degreaser from 0 to 1.2 m/s can increase the solvent loss by a factor of eight. Second, degreasing of oversize parts results in excessive displacement of vapors - a so-called "piston" effect. Manufacturers of degreasers recommend that part size be limited to 50% of the degreaser area. Third, excessive speed of work leaving the vapor zone disturbs the air-vapor interface and results in increased solvent loss. Degreaser manufacturers recommend 3.4 m/min as the maximum part vertical speed. Finally, an improper heat balance can result in increased solvent loss. Solvent vapors should be generated at the same rate at which they are condensed by work entering the vapor zone and by the water condensers. If too little vapor is generated, the vapor level will drop and air will be drawn into the degreaser. The resulting air-vapor mixture is more easily swept from the machine by drafts. If too much vapor is generated, the vapor level will rise above the condensing coils and vapor will escape from the machine.[3,8,60]

Emissions from the degreaser top include the solvent, solvent stabilizers, and the grease or oil removed from the parts being degreased. Emissions from a degreaser top occur whenever the degreaser is "on," regardless of whether or not parts are being degreased.

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[60] Air Pollution Engineering Manual, Second Edition, Danielson, J. A. (ed.). Environmental Protection Agency. Research Triangle Park. Publication No. AP-40. May 1973. 987 p.

b. Solvent Dragout (Emission Point B) - Solvent dragout is the removal of solvent from the degreaser via entrainment with the parts being degreased. Dragout occurs through two mechanisms. First, if the work is removed before the temperature of the part reaches the vapor temperature, the part will leave the degreaser wet with condensate. Second, if the part contains cavities, the part shape itself can catch condensate and carry it from the machine. This condensate then evaporates into the atmosphere.[3,8,60]

Emissions from solvent dragout consist of solvent, solvent stabilizers, and grease or oil. The amount of emissions is dependent upon operating technique and the geometry of the part.

c. Ventilator Exhaust (Emission Point C) - Degreasers with larger than 0.46 m^2 of open area are equipped with ventilators. Suction slots run the length of the opposite longer sides and have a connecting chamber at one end. Exhaust rates are of the magnitude of 0.16 m^3/min per m^2 of evaporative area with velocities at the slot of 150 to 370 m/min. The exhaust is sent outside the building or, if collection equipment (e.g., carbon adsorption beds) is used, to the collector.[3] Emissions from the exhaust are the same as from the degreaser top: solvent, solvent stabilizer, and grease or oil.

d. Gas Burner Exhaust (Emission Point D) - Degreasers are heated by either steam, electricity, or natural gas. Electrical heaters produce no on-site emissions. The exhaust from natural gas heaters does occur at the degreaser site and includes emissions of sulfur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons.

e. Tank Loss (Emission Point E) - Solvent can be stored either in drums or in tanks. The degreasing processes using open tanks for solvent storage can emit solvent vapor to the atmosphere. Emissions from the tank storage vent consist of solvent and solvent stabilizers.

f. Solvent Evaporation from Sludge (Emission Point F) - When the degreasing solvent becomes contaminated, it must be purified with the use of a solvent recovery system. As discussed previously, either the degreaser itself is used as a still or a separate solvent still is used. In either case, the by-product is a sludge consisting of oil, grease, solvent, and inhibitor. The volatile portion of this sludge (i.e., solvent and solvent stabilizer) eventually is emitted to the atmosphere. For example, one method of sludge disposal is to spread the sludge out in pans to allow the solvent to evaporate. The solid residue is then landfilled.

The amount of emissions is dependent upon the solvent concentration in the sludge and the rate of disposal. Disposal rate depends upon production rate and part contamination level.

g. Solvent Evaporation from Waste Water (Emission Point G)- Water collected is saturated with solvent. Table 12 lists the solubility of degreasing solvents in water. Degreasing plants can dispose of their waste water through the local sewage system or other enclosed systems.

h. Adsorption Bed Exhaust (Emission Point H) - Some degreasers have carbon adsorption systems to collect fumes. The exhaust from the adsorption beds is vented to the atmosphere.

Table 12. SOLUBILITY OF DEGREASING SOLVENTS IN WATER[19,31]

Solvent	Solubility, g solvent/100 g water	Temperature, °C
Trichloroethylene	0.10	25
Perchloroethylene	0.04	20
1,1-Trichloroethane	Insoluble	--
Methylene chloride	2.0	20
Trichlorotrifluoroethane	Insoluble	--
Acetone	∞	--
Butanol	25.8	20
Carbon tetrachloride	0.03	20
Ethers	1.22/0.56	20
Methyl ethyl ketone	26.8	20
Naphthas (petroleum distillates, Stoddard solvents)	0.05	20
Toluene	0.06	20
Mineral spirits	0.05	20
Hexane	0.01	20
Xylene	0.02	20
Benzene	0.07	20
Cyclohexane	Insoluble	20

[a] Estimated.

2. Fabric Scouring

Fabric scouring processes have seven points of emissions. Figure 18 is a sketch of a fabric scourer with four of these points identified. The remaining three emission points are analogous to emission points in degreaser processes, namely: evaporation from sludge disposal, evaporation from waste water, and carbon adsorption bed exhaust. Table 13 lists all seven emission points. Each is discussed separately.

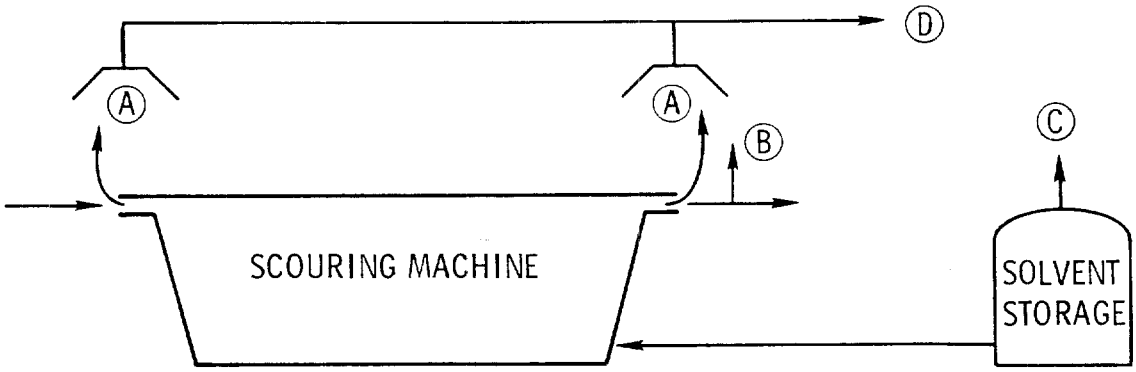
a. Inlet and Outlet Losses (Emission Point A) - Fabric scouring machines are enclosed, so that the only sources of emissions from the machine itself are the inlet and outlet openings.

b. Solvent Dragout (Emission Point B) - The fabric leaving the dryer section of the scouring machine contains unevaporated solvent. All of this solvent eventually is emitted to the atmosphere.

c. Solvent Storage Tank Vent (Emission Point C) - Solvent storage tanks for fabric scourers are similar to those used for degreasers. Emissions from the storage tank vent consist of solvent and solvent stabilizers.

d. Ventilator Exhaust (Emission Point D) - The emissions from the scourer inlet and outlet may be collected by a ventilation system. The exhaust from this system is sent either directly to the atmosphere or to a carbon adsorption system.

e. Evaporation from Sludge Disposal - This emission point is analagous to evaporation from sludge in degreaser operations.



FABRIC SCOURING

Figure 18. Emission points on fabric scourers

Table 13. FABRIC SCOURER EMISSION POINTS

Inlet and outlet losses (A)
Dragout (B)
Solvent storage tank vents (C)
Ventilator exhaust (D)
Evaporation from sludge disposal
Evaporation from waste water
Carbon adsorption bed exhaust

f. Evaporation from Waste Water - Table 12, shown earlier, lists the solubilities of solvents in water. Fabric scouring plants can dispose of their waste water through the local sewage system or other enclosed systems.

g. Carbon Adsorption Bed Exhaust - Some fabric scourers have a carbon absorption system to collect fumes. The exhaust from the adsorption beds is emitted to the atmosphere.

B. EMISSION FACTORS

Solvents used for degreasing operations are used up, i.e., the solvent consumed equals the solvent emitted. Therefore, the emission factors for degreasing solvents are 1,000 g/kg except for those (the halogenated solvents) that require stabilizers. Since the stabilizer is part of the solvent volume, its emission is subtracted from the solvent when considering emission factors. Tables 14 and 15 are compilations of emissions information for the nonhalogenated and halogenated solvents, respectively.[19,22-27,61-63]

C. DEFINITION OF A REPRESENTATIVE SOURCE

To determine a representative source for degreasing operations, each solvent type was taken separately and an average plant size, average stack height, population density, frequency of operation, and mean emission rate corresponding to consumption were established for each as follows:

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[61] Chemical Marketing Reporter, Chemical Profiles. November 18, April 1, January 14, 1974.

[62] Cooper, W. J. et al. Hydrocarbon Pollutant Systems Study, Volume 1, Stationary Sources, Effects and Control. Evans City. MSA Research Corporation. Report No. MSAR 72 233 (PB 219073). October 1972. 377 p.

[63] Staheli, A. H. Control Methods for Reducing Chlorinated Hydrocarbon Emissions from Vapor Degreasers. Western

Table 14. EMISSION FACTORS FOR NONHALOGENATED SOLVENTS[a] 19,22-27

Solvent type	Consumption rate, 10^3 metric tons/yr	Weight percent total consumption					
		Metal cleaning and degreasing	Protective coating	Miscellaneous use solvent	Chemical intermediate	Other	Degreasing emission factor, g/kg
Butanol	3.3	2.1		22.0	54.9	21	1,000
Acetone	10	1.1	10.0	10	64	15	1,000
Methyl ethyl ketone	7.5	3.1	72	8.0	8	8.9	1,000
Hexanes	7	5	10	15	20	50	1,000
Naphthas (petroleum distillates, Stoddard solvents)	188	4.2	42	12	2	40	1,000
Mineral spirits	30	14				86	1,000
Toluene	14	0.5	13	2	19.7	65.1	1,000
Xylene	12	0.5	9	2		80	1,000
Cyclohexane	1	0.1				99.9	1,000
Benzene	7	0.1			94.2	5	1,000
Ethers	6	11		60	25	4	1,000

[a] Blanks indicate not applicable.

Table 15. EMISSION FACTORS FOR HALOGENATED SOLVENTS[d,11,12,13,14,15]

Solvent type/ stabilizer	Metal cleaning/ fabric scouring consumption rate, 10^3 metric tons/g	Weight percent total consumption					Emission factor, g/kg
		Metal cleaning and degreasing	Fabric scouring	Misc. use solvent	Chemical intermediate	Other	
Trichloroethylene/	171.5	90	9			1	999 to 999.96
5-Methyl-2-isopropyl phenol							0.50
Triethylamine							0.04
Diisopropylamine							0.04
Propylene oxide							1.0
Methyl butynol							1.0
1,1,1-Trichloroethane/	167.8	71		6		23	970 to 999.96
2-Ethoxy-2,3-dihydropyran							5.0
Dimethylaminobenzaldehyde							20.0
Butylene oxide							2.5
p-t-Butylphenol							1.0
Morpholine							30.0
Diisopropylamine							0.04
Dimethylaniline							0.5
1,4-Dioxane							25.0
Nonylphenol							20.0
Furfural alcohol, furfural mercaptan							1.0
Nitromethane							7.5
2,6-di-t-Butyl-p-cresol							0.5
Glycidol							20.0
Carbon tetrachloride/	0.72	0.13			80.0	20	995 to 999.96
Butyndiol							5.0
Methyl butynol							5.0
Methyl pentynol							5.0
Ethylenediamine							0.04
Diethylenetriamine							0.04
Tetraethylenepentamine							0.04
Aniline							0.5
Caprolactam							5.0
Fluorocarbons/ (see Carbon tetrachloride)	17.1	4			10.0	86	995 to 999.96
Methylene chloride/ (see Carbon tetrachloride)	56.24	24		43	12	28.7	995 to 999.96
Perchloroethylene/ (See Carbon tetrachloride)	109	16	16	53	12	3	995 to 999.96

[d] Blanks indicate not applicable.

- Average plant size is the total consumption divided by the estimated number of plants.
- The population density is the average of the population densities of the states which together consumed at least 50% of the solvent.
- For the mean emission rate a log normal distribution is assumed for most of the material consumed. The emission rate, Q, is therefore determined by the relationship:

$$Q = \exp\left(\frac{\sum_{i=1}^{n} \ln X_i}{n}\right) \qquad (1)$$

where X_i = the ith observation

The confidence interval in this case is that interval within which the mean lies 95% of the time. This interval is one which is found by multiplying and dividing the mean by the factor, f:

$$f = \exp\left[t'_{\left(1-\frac{0.95}{2}\right)} \frac{\ln s_{GEO}}{\sqrt{n}} \left(1 - \frac{n}{N}\right)^{1/2}\right] \qquad (2)$$

where N = total number of plants
n = sample size
t' = "t" value from Student t-test
s_{GEO} = geometric standard deviation

The calculations were performed with the NEDS input data for all parameters. MRC's data base is contained in a computer memory and is updated as new information is obtained.

Electric Co., Inc. (Presented at Plant Engineering and Maintenance Conference, American Society of Mechanical Engineers. Baton Rouge. October 15-18, 1972). 5 p.

Table 16 summarizes the data used to define a hypothetical representative source for each solvent studied in this source assessment.

D. CRITERIA FOR AIR EMISSIONS

1. Maximum Ground Level Concentration

The maximum ground level concentration (χ_{max}) of each material emitted from degreasing operations was estimated by Gaussian plume dispersion modeling. χ_{max} values for the representative source are shown in Table 17. For comparison, the mass emissions and TLV's are also listed.

The following formula was used for the calculation of χ_{max}:

$$\chi_{max} = \frac{2Q_m}{\pi e h^2 \bar{u}} \qquad (3)$$

where Q_m = mass emission rate, g/s

$\bar{u}$ = average wind speed = 4.5 m/s

h = average height of the solvent emissions, m

e = 2.72

π = 3.1416

2. Source Severity

a. Simulation Methodology - To obtain an indication of the hazard potential of the emission source, the source severity, S, was defined as:

$$S = \frac{\bar{\chi}_{max}}{F} \qquad (4)$$

Table 16. REPRESENTATIVE SOURCE PER SOLVENT[a]

Solvent	Average plant size, metric tons	Average height, m	Population density, persons/km^2	Frequency of operation, %	Emission rate, g/s	
					Range	Mean
Butanol	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Acetone	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Methyl ethyl ketone	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Hexane	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Naphthas (petroleum distillates, Stoddard)	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Mineral spirits	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Toluene	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Xylene	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Cyclohexane	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Benzene	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Ethers	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Carbon tetrachloride	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Fluorocarbons	21.7	10.6 ± 7.1	109	65 ± 15	1.788 to 0.265	0.688
Methylene chloride	10.4	12.1 ± 5.4	109	80 ± 37	2.144 to 0.005	0.320
Perchloroethylene	26.0	10.7 ± 3.1	109	78 ± 10	1.813 to 0.375	0.824
Trichloroethane	5.4	14.1 ± 0.5	109	96 ± 2	0.240 to 0.167	0.200
Trichloroethylene	34.6	12.0 ± 4.9	109	78 ± 12	1.938 to 0.440	0.923

[a]Information obtained from MRC's NEDS computer data banks.

where $\overline{\chi}_{max}$ = time-averaged maximum ground level concentration

F = hazard factor; equal to the primary ambient air quality standard (AAQS) for particulate, sulfur oxides, nitrogen oxides, carbon monoxide and hydrocarbons, and equal to TLV x 8/24 x 1/100 for all other chemical substances

The source severity represents the ratio of the time-averaged maximum ground level exposure to the potential hazard level of exposure for an emitted material.

$\overline{\chi}_{max}$ was calculated using the formula:

$$\overline{\chi}_{max} = \chi_{max} \left(\frac{t_0}{t} \right)^{0.17} \qquad (5)$$

where t_0 = short-term averaging time, min

t = average time, min

For particulate, sulfur oxides, nitrogen oxides, carbon monoxide and hydrocarbons, the averaging times were the same as those used in the primary ambient air quality standards. The appropriate averaging time was 24 hours for all other pollutants.

χ_{max} for each material emitted from the representative plant performing degreasing operations are presented in Table 17. These calculations were based on emission factors obtained from the literature and do not necessarily represent the values that might be obtained from a sampling program.

Table 17. MAXIMUM GROUND LEVEL CONCENTRATIONS FOR DIFFERENT SOLVENT EMISSIONS

Solvent	Mass emissions, g/s	TLV, g/m^3	χ_{max}, g/m^3
Butanol	105	0.30	3.2×10^{-4}
Acetone	317	2.40	3.2×10^{-4}
Methyl ethyl ketone	238	0.59	3.2×10^{-4}
Hexane	222	1.80	3.2×10^{-4}
Naphthas	5,968	0.94	3.2×10^{-4}
Mineral spirits	952	0.56	3.2×10^{-4}
Toluene	444	0.375	3.2×10^{-4}
Xylene	3,555	0.436	3.2×10^{-4}
Cyclohexane	32	1.05	3.2×10^{-4}
Benzene	1,333	0.08	3.2×10^{-4}
Ether	190	1.20	3.2×10^{-4}
Carbon tetrachloride	22	0.065	3.2×10^{-4}
Fluorocarbons	543	1.90	3.2×10^{-4}
Methylene chloride	1,784	0.89	1.1×10^{-4}
Perchloroethylene	3,460	0.67	3.7×10^{-4}
Trichloroethylene	5,444	0.535	3.3×10^{-4}
Trichloroethane	5,327	1.90	5.2×10^{-4}

b. Source Severity Distribution - As discussed in this document, the 17 solvent types listed below are of concern as individual sources of air pollution.

1. Butanol
2. Acetone
3. Methyl ethyl ketone
4. Hexane
5. Naphthas (Petroleum distillates, Stoddard solvents)
6. Mineral spirits
7. Toluene
8. Xylene
9. Cyclohexane
10. Benzene
11. Ethers
12. Carbon tetrachloride
13. Fluorocarbons
14. Methylene chloride
15. Perchloroethylene
16. Trichloroethylene
17. 1,1,1-Trichloroethane

To examine the severity distribution, several graphs were drawn showing the severities calculated as described in the previous section vs percentage of plants. Severity distributions based on TLV's for each solvent were simulated where data were lacking. Deterministic distributions are presented for for solvents numbered 14 through 17 above. Trichloroethane was plotted both deterministicially and by simulation on one graph for comparison of the two methods.

Severity distributions were also plotted for all 17 solvents based upon hydrocarbon AAQS which is the same value for solvents numbered 1 through 13 above. Their distributions are therefore identical and are shown as one line.

Figure 19 shows the relationship of simulated data to deterministic data for trichloroethane. Figures 20 through 23 exhibit TLV severity distributions and Figure 24 shows severity based upon hydrocarbon AAQS.

3. Contribution to Total U.S. Emissions

The contribution of the emissions from degreasing operations was determined for total solvent consumed on a per state basis. The solvent consumed was compared to the total hydrocarbon emissions for each state to determine the percentage contributed by solvents to total emissions for that state. Table 18 lists the results. It is estimated that 24% of the hydrocarbon emissions in the U.S. come from solvent emissions.

4. Population Exposed to Pollutant Concentrations

A quantitative evaluation of the population affected by a representative source of emissions for each solvent was determined by comparing the severity based on TLV's with the severity based on AAQS, each versus population. Severity is $\overline{\chi}_{max}/F$, where $\overline{\chi}$ is the time averaged maximum ground level concentration and F is the "corrected" threshold limit value (TLV x 8/24 x 1/100) or the primary ambient air quality standard (AAQS). The population affected is determined by calculating the area that is exposed to the $\overline{\chi}$ for which $\overline{\chi}/F > 1$ and $\overline{\chi}/F > 0.1$. The population density of 109 persons/km^2, determined as discussed in Section IV.C, is then used to calculate the number of persons affected. Table 19 summarizes these calculations.

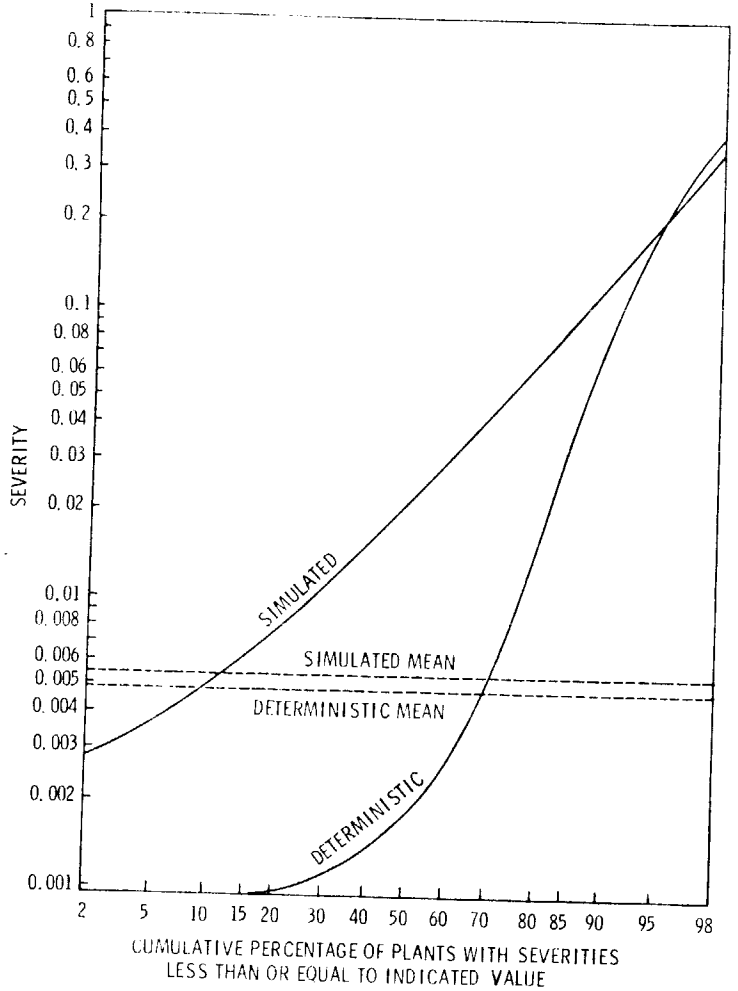

Figure 19. Trichloroethane TLV severity distribution

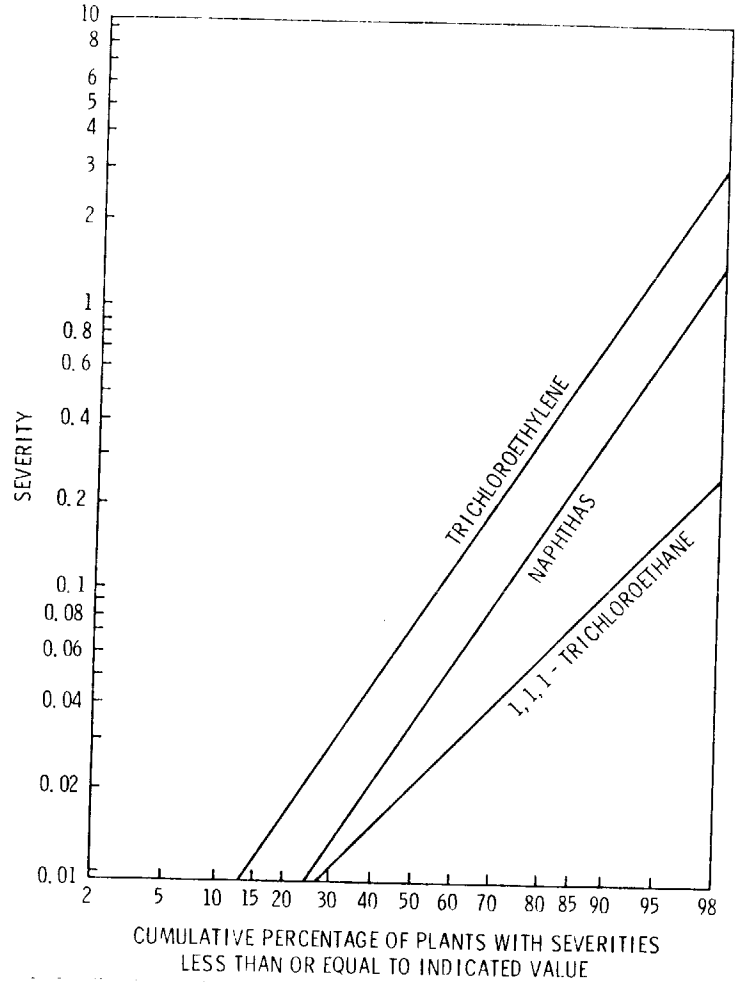

Figure 20. Simulated solvent severity distribution for specific TLVs of solvents with consumption over 150,000 metric tons/yr

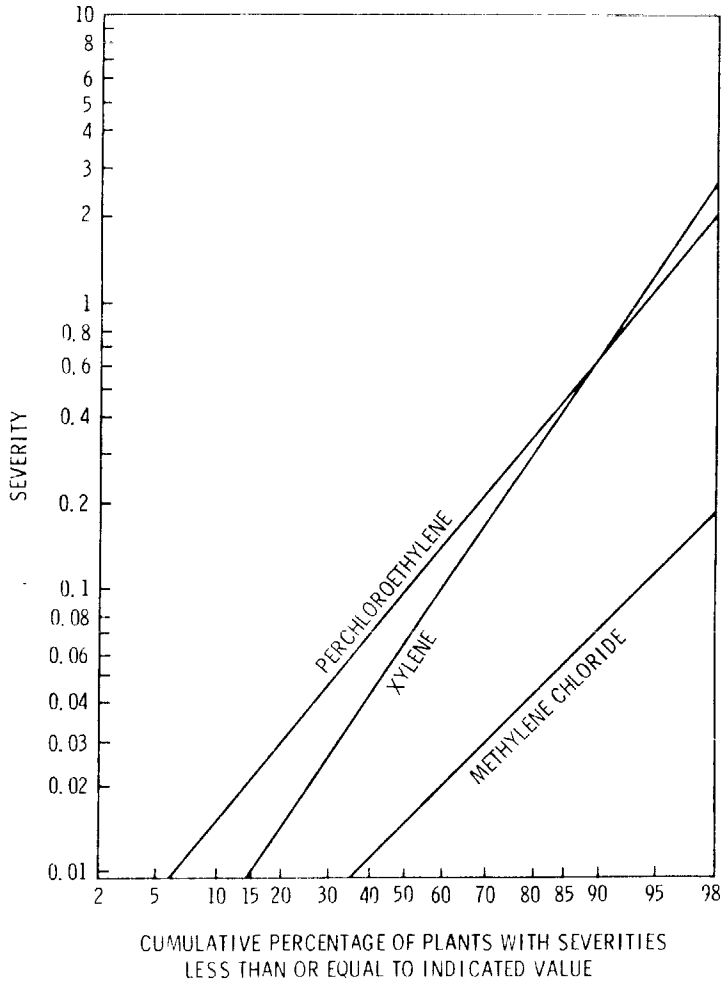

Figure 21. Simulated solvent severity distribution for specific TLVs of solvents with consumption between 50,000 and 150,000 metric tons/yr

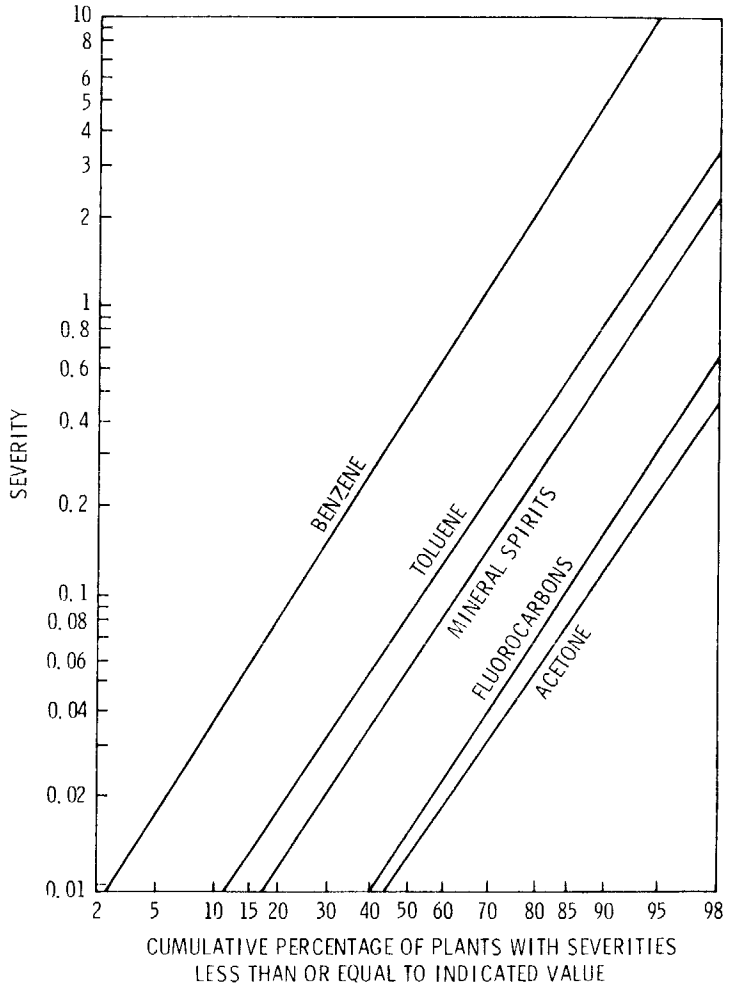

Figure 22. Simulated solvent severity distribution for specific TLVs of solvents with consumption between 10,000 and 50,000 metric tons/yr

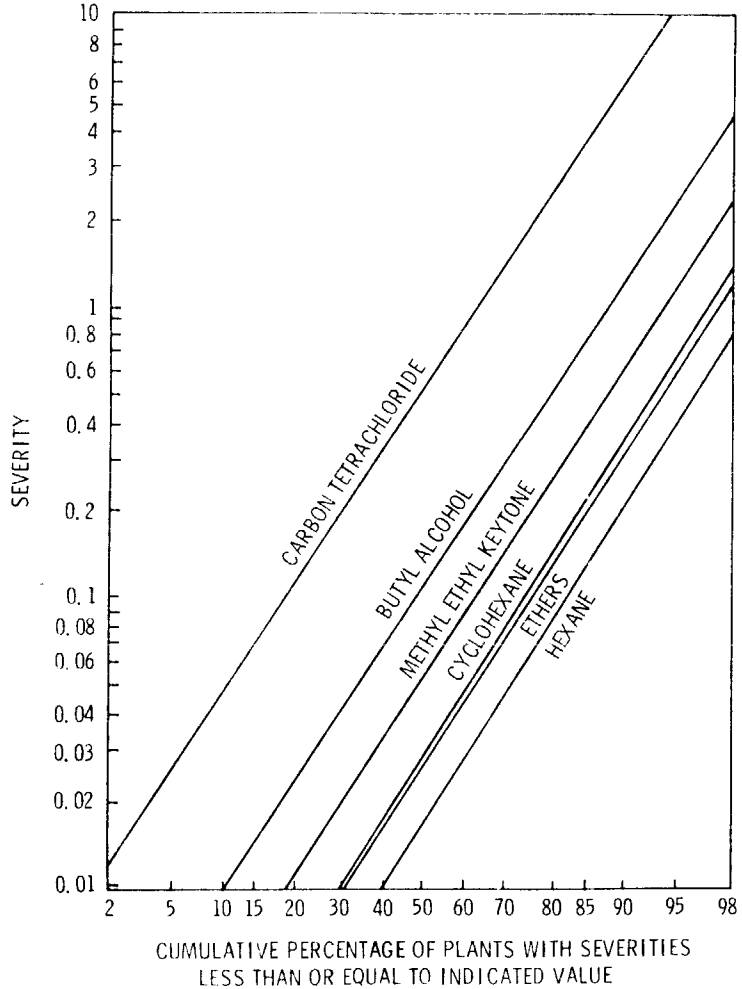

Figure 23. Simulated solvent severity distribution for specific TLVs of solvents with consumption less than 10,000 metric tons/yr

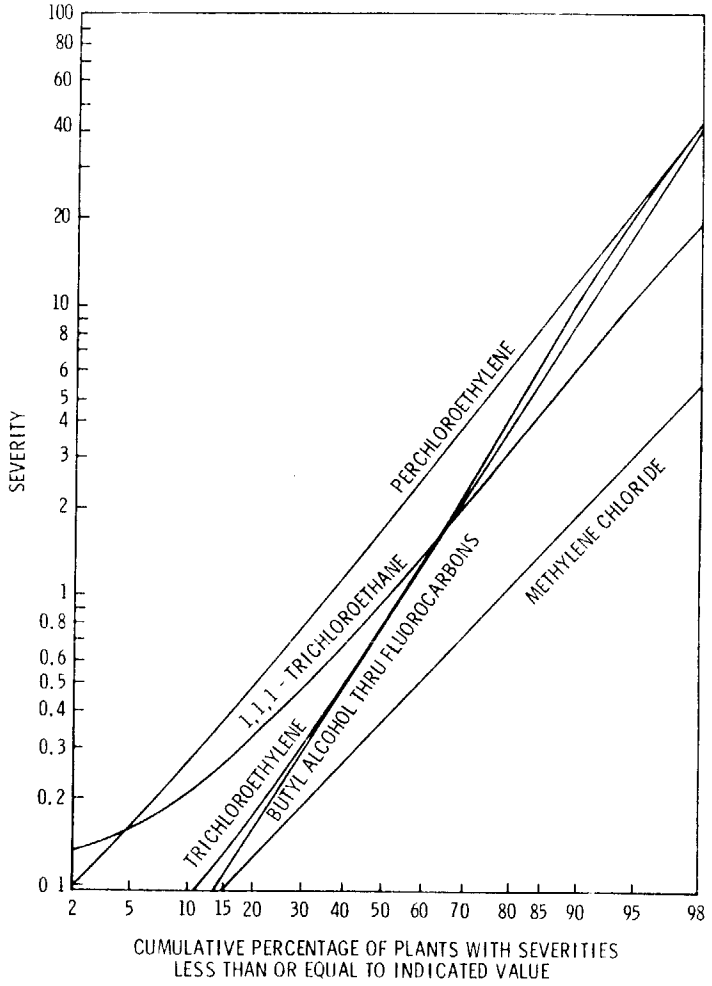

Figure 24. Simulated hydrocarbon severity distributions

Table 18. SOLVENT CONTRIBUTION TO HYDROCARBON EMISSIONS IN EACH STATE

State	Solvent cons. rate, 10^3 metric tons/yr	Total state hydrocarbon emissions, 10^3 metric tons/yr	Number of plants	Percent of total state hydrocarbon emissions
Alabama	16.2	324.1	5,400	5.0
Alaska	1.5	140.8	500	1.1
Arizona	8.3	171.1	2,700	4.8
Arkansas	9.1	281.7	3,000	3.2
California	93.8	1,914.0	30,900	4.9
Colorado	10.4	294.4	3,400	3.5
Connecticut	14.3	259.4	4,700	5.5
Delaware	2.5	775.1	900	0.3
Florida	32.0	536.2	10,500	6.0
Georgia	21.6	526.7	7,100	4.1
Hawaii	3.6	62.7	1,200	5.7
Idaho	3.4	163.6	1,100	2.1
Illinois	52.2	1,343.0	17,200	3.9
Indiana	24.4	675.1	8,100	3.6
Iowa	13.2	400.8	4,400	3.3
Kansas	10.6	742.8	3,500	1.4
Kentucky	15.2	274.6	5,000	5.5
Louisiana	17.1	1,741.0	5,700	1.0
Maine	4.6	72.0	1,500	6.4
Maryland	18.4	302.3	6,100	6.1
Massachusetts	19.9	463.1	6,600	4.3
Michigan	41.8	734.0	13,800	5.7
Minnesota	17.8	388.0	5,900	4.6
Mississippi	10.4	350.2	3,400	3.0
Missouri	22	588.4	7,300	3.7
Montana	3.3	174.2	1,100	1.9

Table 18 (Continued). SOLVENT CONTRIBUTION TO HYDROCARBON EMISSIONS IN EACH STATE

State	Solvent cons. rate, 10^3 metric tons/yr	Total state hydrocarbon emissions, 10^3 metric tons/yr	Number of plants	Percent of total state hydrocarbon emissions
Nebraska	7	255.6	2,300	2.7
Nevada	2.2	36.1	800	6.1
New Hampshire	3.4	44.4	1,100	7.7
New Jersey	33.8	786.6	11,100	4.3
New Mexico	4.8	310.2	1,600	1.5
New York	85.8	1,353.0	28,300	6.3
North Carolina	23.9	465.1	7,900	5.1
North Dakota	3	73.9	1,000	4.1
Ohio	50.1	1,244.0	16,500	4.0
Oklahoma	12	674.7	4,000	1.8
Oregon	9.8	204.8	3,200	4.8
Pennsylvania	55.5	1,331.0	18,300	4.2
Rhode Island	4.5	93.7	1,500	4.8
South Carolina	12.2	260.5	4,000	4.7
South Dakota	3.1	91.1	1,000	3.4
Tennessee	18.4	340.9	6,100	5.4
Texas	50.4	4,139.0	16,600	1.2
Utah	4.9	112.8	1,600	4.3
Vermont	2.1	25.5	700	8.2
Virginia	21.9	415.2	7,200	5.3
Washington	16.1	361.8	5,300	4.4
West Virginia	8.2	172.8	2,700	4.7
Wisconsin	20.8	362.6	6,900	5.7
Wyoming	1.6	275.2	500	0.6
TOTAL U.S.	943.1	27,129.8	311,200	

Table 19. POPULATION EXPOSED TO SOLVENT EMISSION FROM REPRESENTATIVE SOURCES[a]

Source type	Affected population based on AAQS	Affected population based on TLV	Estimated number of plants
Butanol	98	9	300
Acetone	98	0	200
Methyl ethyl ketone	98	0	200
Hexane	98	0	400
Naphthas (petroleum distillates, Stoddard solvents)	98	0	235,000
Mineral spirits	98	0	1,000
Toluene	98	9	15,000
Xylene	98	2	11,000
Cyclohexane	98	0	4,000
Benzene	98	55	3,000
Ethers	98	0	1,000
Carbon tetrachloride	98	70	30
Fluorocarbons	98	0	1,000
Methylene chloride	39	0	2,400
Perchloroethylene	119	0	3,000
Trichloroethylene	133	12.4×10^6	5,200
1,1,1-Trichloroethane	23	0	28,000

[a] Information obtained from MRC and NEDS computer data banks.

SECTION V

CONTROL TECHNOLOGY

A. STATE OF THE ART

Solvent vapors can be recovered from air and/or controlled in air by the use of systems based on refrigeration (freeboard chillers), carbon adsorption, and incineration (for non-chlorinated solvents). The percentage of industrial plants utilizing these systems is shown in Table 20. Approximately 25% of the vapor recovery and control systems is used by plants in SIC Groups 36 and 38. It is also noted that the larger the plant, the greater the use of vapor recovery and control systems. In plants employing from 20 to 100 people, only 0.8% use carbon adsorption, while 4.6% of plants employing over 500 people use carbon adsorption for solvent recovery.

Table 20. USE OF VAPOR RECOVERY AND CONTROL SYSTEMS[7]

Type of system	Percentage of plants
Carbon adsorption	1.5
Refrigeration	12.0
Incineration	2.0
Other	8.5
None	76.0

1. Freeboard Chiller (Refrigeration)

A freeboard chiller is a device used in open-top vapor degreasers to create a cold-air blanket above the solvent vapor layer. Prevention of vapor overflow in normal degreasing is achieved by means of condenser coils and a freeboard water jacket. Refrigerated freeboard chillers are actually a second set of condenser coils located slightly above the primary coils, as shown in Figure 25.[64] These coils effectively limit the diffusion of solvent vapors from the vapor zone into the work atmosphere.

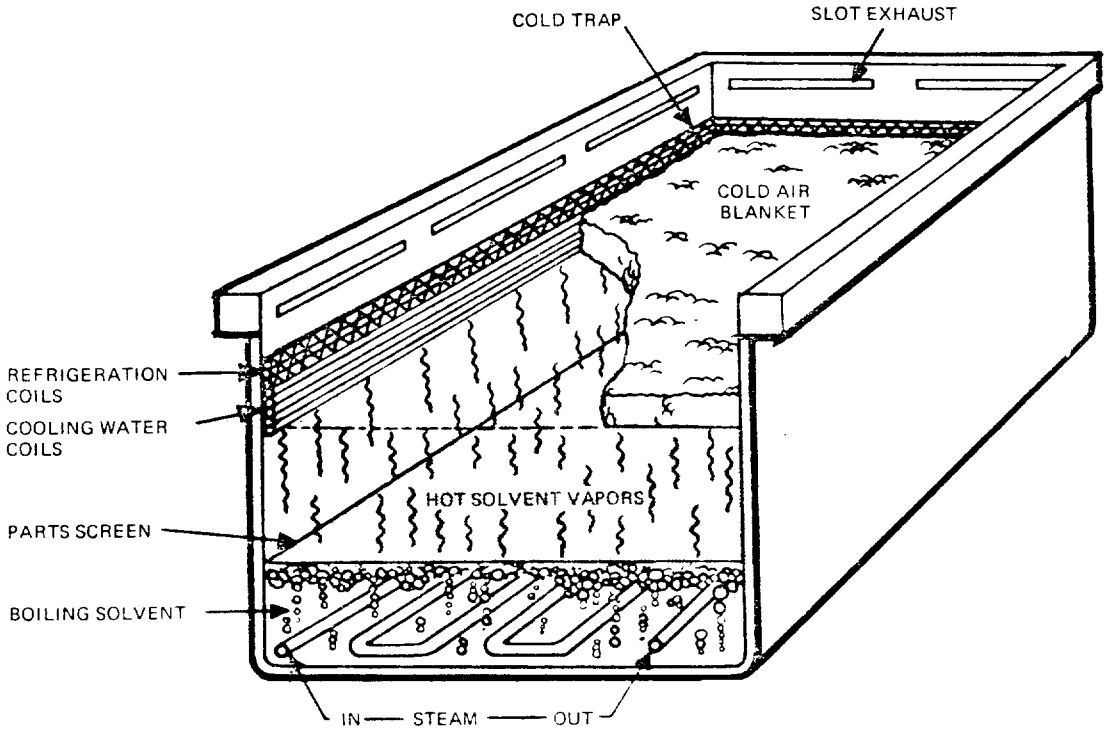

Figure 25. Schematic representation of degreaser with cold trap installed[64]

[64] Perry, J. H., and G. H. Chilton. Chemical Engineers' Handbook, Fifth Edition. New York, McGraw-Hill Book Co., 1973. Part 3. 250 p.

Freeboard chillers are divided into two classifications based upon the operating temperature of the refrigeration coils. Chillers operating below freezing fall in the first classification, and those operating above freezing fall in the second. The division at 0°C is created by patent rights. The principle of operation for both classifications is that the chilled, dehumidified air, being denser than ambient air, settles onto the solvent vapor layer and acts as a blanket to prevent diffusion of the solvent vapor into the ambient air.[24,63]

Freeboard chillers can cause condensation of moisture in the degreaser. This extra moisture, however, can be removed with larger water separators on the solvent condensate line or with the addition of a second water separator in series with the first. Although water contamination of vapor degreasing solvents has an adverse effect on the stabilizer systems, major stabilizer depletions from this source are uncommon.[24,27]

Eight companies that have installed chillers on their degreasers have reported solvent loss reductions ranging from 35% to 77%, with an average of 57%.[24] The manufacturer of chillers operating below freezing guarantees a 40% savings in slvent. It is estimated that 12% of the plants with degreasers use control systems based on the refrigeration principle.[7]

Field testing of chiller control technology was conducted by Dow Chemical at three locations to support their study of metal cleaning operations.[27] Conclusions from the work were concerned with the chiller operation and the vapor degreaser construction for maximum emission control: (a) larger and more square vapor degreasers will operate at a more favorable savings-to-cost ratio than small and narrow equipment; (b) the use of a refrigerated freeboard chiller is more profitable to the user when installed on equipment using more

costly vapor degreasing solvents; and (c) existing technology does not suggest that more expensive refrigeration designs, such as more coils or lower refrigeration temperatures, would improve the efficiency of emission control.

2. Adsorption

Adsorption is the process of removing molecules from a stream by contacting them with a solid. Gases, liquids, or solids can be selectively removed from air streams with materials known as adsorbents. The material which adheres to the adsorbent is called the adsorbate.

The mechanism by which components are adsorbed is complex, and although adsorption occurs at all solid interfaces, it is minimal unless the adsorbent has a large surface area, is porous, and possesses capillaries. The important characteristics of solid adsorbents are their large surface-to-volume ratios and preferential affinity for individual components.

The adsorption process includes three steps. The adsorbent is first contacted with the fluid, and a separation by adsorption results. Second, the unadsorbed portion of the fluid is separated from the adsorbent. For gases, this operation is completed when the gases leave the adsorbent bed. Third, the adsorbent is regenerated by removing the adsorbate from the adsorbent. For solvent recovery, low pressure steam is used to regenerate the adsorbent, and the condensed vapors are separated from the water by decantation, distillation, or both.

Activated carbon is capable of adsorbing 95% to 98% of the organic vapors from air at ambient temperature in the presence of water in the gas stream.[62] Because the adsorbed compounds have low vapor pressure at ambient temperatures,

the recovery of solvents present in air in small concentrations is low.

When a solvent vapor in air mixture is passed over activated carbon, the adsorption of the solvent vapor is complete at the beginning, but as the adsorptive capacity of the activated carbon is approached, traces of vapor appear in the exit air. When this situation occurs, it is said that breakthrough of the activated carbon has been reached. As the air flow is continued, and although additional amounts of solvent are adsorbed, the concentration of solvent vapor in the exit air increases until it equals that in the inlet air. The adsorbent is saturated under these operating conditions.

The adsorption of a mixture of adsorbable organic vapors in air is not uniform, and the more easily adsorbed components are those which have higher boiling points. When air containing a mixture of organic vapors is passed over activated carbon, the vapors are equally adsorbed at the start. However, as the amount of the higher boiling component in the adsorbent increases, the more volatile component revaporizes. The exit vapor consists primarily of the more volatile component after breakthrough has been reached. This process continues for each organic mixture component, until the highest boiling component is present in the exit gas. In the control of organic vapor mixtures, the adsorption cycle should be stopped when the first breakthrough occurs as determined by detection of vapors in the exit gas. Many theories have been advanced to explain the selective adsorption of certain vapors or gases. These theories are discussed by Perry and Chilton[64] and will not be repeated here.

The quantity of organic vapors adsorbed by activated carbon is a function of the particular vapor in question, the

adsorbent, the adsorbent temperature, and the vapor concentration. Removal of gaseous vapors by physical adsorption is practical for gases with a molecular weight over 45.[64] Each type of activated carbon has its own adsorbent properties for a given vapor, and the quantity of vapor adsorbed for a particular vapor concentration in the gas and at a particular temperature is best determined experimentally. The quantity of vapor adsorbed increases when the vapor concentration increases and the adsorbent temperature decreases.

After breakthrough has occurred, the adsorbent is regenerated by heating the solids until the adsorbate has been removed. A carrier gas must also be used to remove the vapors released. Low pressure saturated steam is used for activated carbon as both the heat source and carrier gas. Superheated steam (343°C) may be necessary to remove high boiling compounds and return the carbon to its original condition when high boiling compounds have reduced the carbon capacity to the point where complete regeneration is necessary.

Steam requirements for regeneration are a function of external heat losses and the nature of the solvent. The amount of steam adsorbed per kg of solvent as a function of elapsed time passes through a minimum. The carbon should be regenerated for this length of time to permit the minimum use of steam.[64] After regeneration the carbon is hot and saturated with water. Cooling and drying are done by blowing solvent-free air through the carbon bed. Evaporation of the water aids cooling of the carbon. If high temperature steam has been used, other means of cooling the carbon are required.

Fixed bed adsorbers arrayed in two or more parallel bed arrangements are used to remove solvent vapors from air. These are batch-type arrangements, where a bed is used until

breakthrough occurs and is then regenerated. The simplest adsorber design of this type is a two-bed system where one carbon bed is being regenerated as the other is adsorbing organic vapors (see Figure 26).[62] A three-bed arrangement permits a greater quantity of solvent to be adsorbed per unit of carbon because the effluent passes through two beds in series while the third bed is regenerated. This permits the activated carbon to be used after breakthrough since the second bed in the series removes solvent vapors from the first bed exit gas. When the first bed is saturated, it is removed from the stream for regeneration; the bed which was used to remove final traces of solvent vapors from the effluent becomes the new first bed; and the bed which has been regenerated becomes the new second bed.

Heat is released in the adsorption process, which causes the temperature of the adsorbent to increase. If the concentration of solvent vapors is not high, as in the case of degreasing operations, the temperature rise is typically 10°C.[60]

The pressure drop through a carbon bed is a function of the gas velocity, bed depth, and the carbon particle size. Activated carbon manufacturers supply empirical correlations for pressure drop in terms of these quantities. These correlations usually include pressure drop resulting from directional change of the gas stream at inlet and outlet.

Control of solvent vapor emissions by adsorption on activated carbon is applied when recovery of the adsorbate is economically desirable.

The greatest influence in determining whether a given adsorber can be operated profitably is the price of the solvent itself. Based on the 1975 price of trichloroethylene,

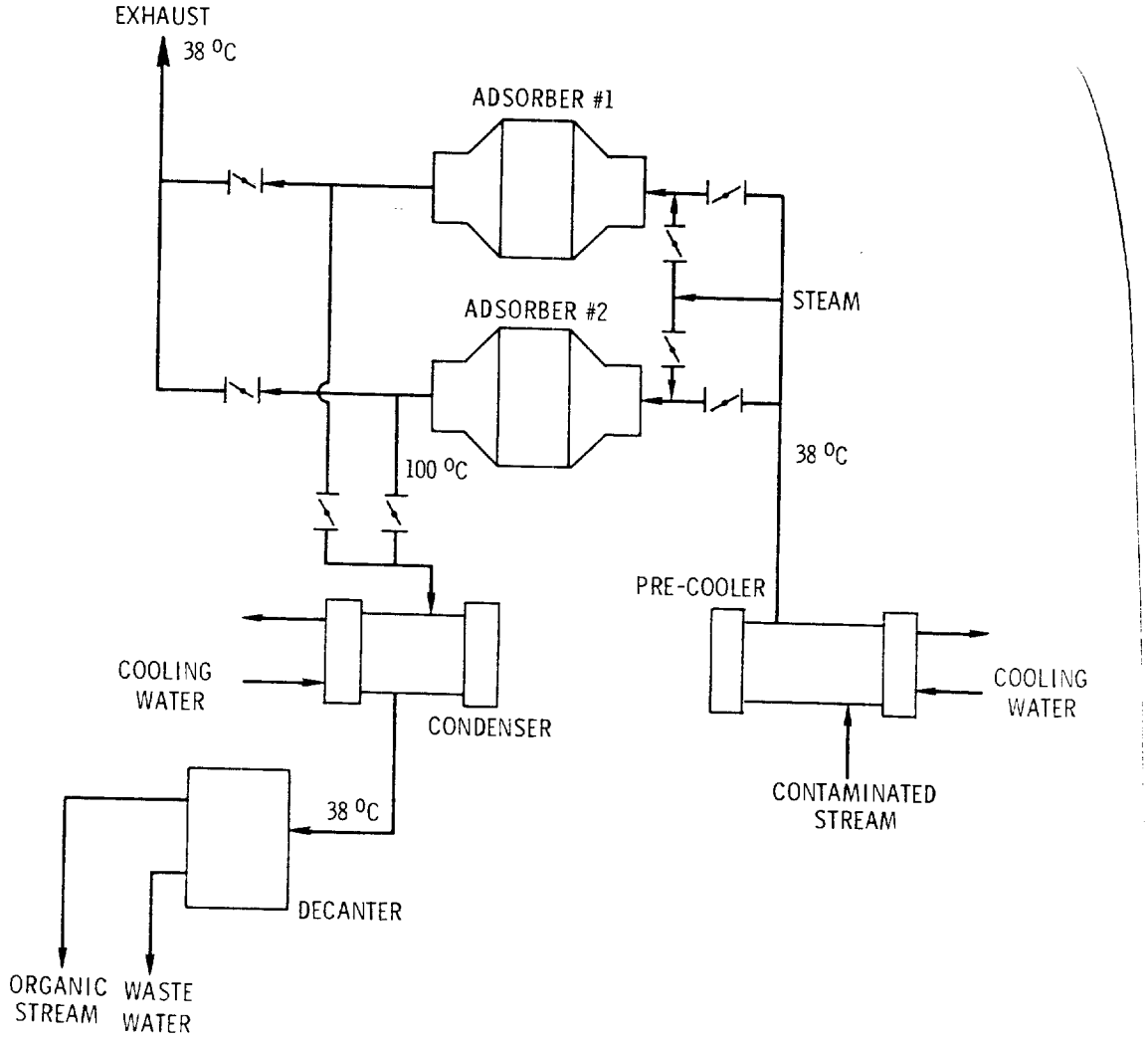

Figure 26. Carbon adsorption system[62]

it has been determined that a constant flow of at least 200 ppm is required to break even on a cost basis for the recovery of this chemical by carbon adsorption.

As discussed previously, carbon adsorption systems remove 95% to 98% of the solvent vapors in the air stream. However, the vapor collection system for degreasers and the system for fabric scourers are not 100% efficient. Accounting for solvent which cannot be reclaimed by the adsorber (that lost by drag-out on parts, leaks, and disposal of degreaser sludges and spill residues), adsorbers will reduce overall system emissions from 20% to 60%. The difference between this range and the 95% bed efficiencies can be attributed to the ability of the ventilation apparatus of the cleaning system to capture the solvent vapors. The percentage capture of solvent vapors by the vent system is the critical parameter controlling the overall system efficiency. Improved ventilation design for new systems might significantly increase the overall emission control efficiency of the carbon adsorber.

In general, however, modern technology will permit emission control from solvent metal cleaning operations up to a level of about 35% or a maximum of 40% with little or no operating cost penalty. Under particularly ideal conditions, an emission control efficiency of about 60% is possible. No known technology is available to control solvent emissions from solvent metal cleaning operations by 85% or greater with the exception of solvent substitution or total process change.[27]

3. Incineration

Incineration (thermal and catalytic) is a method of control for many kinds of solvents lost through evaporation.[37] However, since vapor degreasing processes use chlorinated solvents, incineration is not feasible. Chlorinated solvents

are converted during combustion to phosgene, hydrogen chloride, etc.[60]

4. Solvent Disposal

Solvents can be disposed of by burning, flushing, landfill, and disposal service; solvents can also be reclaimed. Table 21 shows the estimated percentages of plants that dispose of solvents by these various means or reclaim them.

Table 21. DISPOSAL ROUTES FOR SOLVENTS[7]

Disposal route	Percent of industrial plants
Burning	5
Flushing	15
Landfill	20
Disposal service	40
Reclamation	20

B. FUTURE CONSIDERATIONS

The literature contains no current reports of control technology under development for degreasing processes.

SECTION VI

GROWTH AND NATURE OF THE INDUSTRY

A. PRESENT TECHNOLOGY

The current technology for degreasing operations (both degreasers and fabric scourers) is discussed in Section III of this report.

B. EMERGING TECHNOLOGY

The technology for degreasing processes is presently static. The recent patent literature reveals no new processes for either degreasers or fabric scourers.[65]

C. INDUSTRY PRODUCTION TRENDS

1. Degreasers

The overall metals cleaning industry is growing at a rate of 3% to 5% per year. However, metal cleaning is closely connected to the overall economy. Production cutbacks in basic industries, particularly in automotive-related industries, could reduce the overall growth rate.

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[65] Johnson, K. Dry Cleaning and Degreasing Chemicals and Processes. Park Ridge, N. J., Noyes Data Corporation, 1973. 312 p.

The distribution of solvent usage may also change in the next several years, depending upon air pollution regulations. Presently, the 32 states listed in Table 22 have no restrictions on the use of trichloroethylene. Los Angeles Rule 66 restricts the use of trichloroethylene but exempts perchloroethylene and 1,1,1-trichloroethane from controls. Therefore, in states with Rule 66-type legislation, the trend has been to exempt solvents rather than add-on control equipment. Thus, if more states adopt Rule 66-type legislation, the consumption of trichloroethylene will further decline. However, if states or the federal government legislate restrictions of hydrocarbon emissions across the board, trichloroethylene usage will grow, since this solvent is as easy to control as are the other solvents. The trend in solvent usage is thus dependent upon legislation.[4]

2. Fabric Scourers

As a whole, the textile industry has been growing at a 4% to 5% rate since 1970.[1] Fabric scouring, however, has been growing and should continue to grow more rapidly than this in the foreseeable future.

Table 22. STATES WITHOUT RESTRICTIONS ON TRICHLOROETHYLENE USAGE[4]

Alabama	Missouri
Alaska	Montana
Arkansas	Nebraska
Delaware	Nevada
Florida	New Hampshire
Georgia	New Mexico
Hawaii	North Dakota
Idaho	Oregon
Illinois[a]	South Carolina
Iowa	South Dakota
Kansas	Utah
Maine	Vermont
Maryland[b]	Washington
Michigan	West Virginia
Minnesota	Wisconsin
Mississippi	Wyoming

[a] Illinois APC Board installation permit required if exhausted.
[b] Stack exhaust permit required.

SECTION VII

APPENDIXES

A. Distribution of U.S. Solvent Consumption
B. Stabilizers Used in Halogenated Hydrocarbons
C. NEDS Emission Data
D. Source Severity Distribution Input Data
E. Affected Population Calculation Data

APPENDIX A

DISTRIBUTION OF U.S. SOLVENT CONSUMPTION

Table A-1. DISTRIBUTION OF U.S. SOLVENT CONSUMPTION[a] [illegible]

Chemical	1974 Apparent U.S. consumption, 10³ metric tons	1974 Apparent solvent/degreasing consumption, 10³ metric tons	1974 Apparent fabric scouring consumption, 10³ metric tons	Total consumption, weight percent[b]: Metal cleaning and degreasing	Fabric scouring	Protective coating solvent	Miscellaneous use solvent	Chemical intermediate	Other	Comments
Halogenated hydrocarbons										
Carbon tetrachloride	531.8	0.72		0.13				80	13	6.8 Fumigant
Fluorocarbons	428.6	17.1		4				10	50 Aerosol	28 Refrigerant 8 Blowing agents
Methylene chloride	235.4	56.24		24			43 Paint remover	12	21	17.7 Aerosol
Perchloroethylene	339.2	54.4	54.6	16	16		53 Drycleaning	12	3	
Trichloroethylene	173.7	156.5	15	93	4		1			
1,1,1 Trichloroethane	216.3	167.8		71			6	23		
Hydrocarbons										
Hexane	135	7		5		10	15	20	50	
Benzene	5,307	7	35	0.1	0.7			94.2	5	
Toluene	3,085	14		0.5		13	2	19.7	58.3 Fuel	6.8 Nonfuel uses
Xylene	2,635	12	100	0.5	3.8	9	2		70 Isomer	10 Fuel
Cyclohexane	1,066.7	1		0.1						
Ethers	56.3	6		11			60	25	4 Anesthetic	
Mineral spirits	210	30		14					86	
Napthas	4,450	188		4.2		42	12	2	40	
Ketones										
Acetone	882.5	10		1.1		10	10	64	15	
Methyl ethyl ketone	237.2	7.5		3.1		72	8	8	8.9	
Methyl isobuthyl ketone	70.2					100				
Cyclohexanone	290									
Alcohols										
Methanol	3,233						8	76	16	
Ethanol	1,105					16	7	48	2	27 Toiletries and disinfectants
Isopropanol	802.9					6		55	39	
Buthyl alcohol	159.6	3.3		2.1			22	54.9	21	
Amyl alcohol	20.4									
Esters										
Amyl, buthyl, ethyl acetates	137					60			40	
Glycol ethers										
Ethylene glycol monomethyl	39.1					12	13	12	63	
Ethylene glycol monoethyl	86.3					3	9	49	9	
Ethylene glycol monobuthyl	62.5					41	32	10	17	
Diethylene glycol	30.3					36			64	
Triethylene glycol	35.5									

[a] Blanks indicate not applicable.
[b] MRC estimate.

[illegible] Encyclopedia of Chemical Technology, Second Edition. Vol. [illegible]. New York, John Wiley and Sons, Inc., 1965. pp. 376-377.

[illegible] Stationary Source Effects and Control, M[illegible] Corporation, October, 1972, PB 219 073.

APPENDIX B

STABILIZERS USED IN HALOGENATED HYDROCARBONS

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent[b] issued to
Organic mercaptans and disulfides (nonyl mercaptan, 2-mercaptoethyl methyl ether, bis(di-alkoxyphosphinothionyl) disulfide, bis(1-piperazinylthiocarbonyl) disulfide, cyclohexyl mercaptan, 2-mercaptoethanol, 2,3-dimercapto-1-propanol, dimethyl disulfide, di-*tert*-butyl disulfide, 4,4'-dithiodimorpholine, 2,2'-dithiobis(benzothiazole), dibenzyl disulfide, decamethylene dithiol, furfuryl mercaptan)	MC	0.1			3,641,169	DOW
with butylene oxide		0.3			"	"
Diakyl sulfoxides (glycidol(2,3-epoxy-1-propanol), dimethyl sulfoxide, 3-(methylamino)propionitrile, 3-(dimethylamino)propionitrile, methylethanolamine, morpholine, acetonitrile, butylene oxide)	MC		0.05 - 6		3,535,392	PPG
1,3,5-Cycloheptatriene	PERC, TCENE	0.05			3,642,645	WCGG
1,3,5-Cycloheptatriene	PERC, TCENE	0.1			"	"
with 1-(dimethylamino)propene-2		0.05			"	"
Dipentene (terpene)	AER	0.5			3,352,789	ALL
Indene	AER	0.30		0.450	"	"
p-Mentha-1,5-diene	AER	0.30			"	"
α-Metylstyrene	AER	0.30			"	"
Trimethyl orthoformate (TMOF)	MC	0.75		0.250	3,564,061	PCPSG
with nitromethane		0.75			"	"
TMOF	MC	0.5			"	"
with acetonitrile		0.5		0.070	"	"
TMOF	MC	1.0			"	"
with trioxane		1.0			"	"
TMOF	MC	0.75			"	"
with 1,4-dioxane		0.75		0.180[c]	"	"
TMOF	MC	0.50			"	"
with acetonitrile		0.25		0.070	"	"
and *tert*-butyl alcohol		0.25		0.300	"	"
TMOF	MC	2.10			"	"
with methanol		0.60		0.260	"	"
and methylformate		0.30		0.250	"	"

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent issued to
Benzotriazole	PERC	0.5	0.1 - 2.5		3,337,471	DOW
Oxazole	MC	2	1 - 4		3,676,355	UKF
Polyamines (ethylenediamine, triethylenediamine, 4,4'-ethylenedimorpholine, pyrrole, 1,1'-ethylenedipiperidine, diisopropylamine, diethylenetriamine, tetraethylenepentamine, n-methylpyrrole	PERC, TCENE, CH	0.004	0.001 - 0.02		3,424,805	WCGG
N,N-Dimethyl-p-phenylenediamine	MC	0.13			3,546,125	DOW
N,N,N',N'-Tetramethyl-o-phenylenediamine	MC	1.1			"	"
N,N,N',N-Tetramethylbenzidine	MC	0.22			"	"
Quaterniary ammonium compounds with volatile epoxy compounds and organic amines (pyridine, picoline, triethylamine, aniline, dimethylaniline, nalkylmorpholines, diisopropylamine, N-methylpyrrole)	MC, TCENE, CH		0.005 - 0.2 0.01 - 1.0 0.005 - 0.2		3,314,892 " "	CI " "
2-Methyl-2-oxazoline	MC	0.44			3,494,968	DOW
2-Phenyl-2-oxazoline	MC	0.65			"	"
2-(1-Aziridinyl)-2-oxazoline	MC	0.25				
Diaziridine compounds and N-ethylpyrrole (1,2-diethyldiaziridine, N-methylpyrrole)	TCENE, CH	6.8			3,551,505	SCB
α-Methyl-1-aziridineethanol	MC		1.0 - 4.0		3,328,474	DOW
2-(1-Aziridinyl)ethyl acetate						
Lactams (Caprolactam) with glycidol (2,3-epoxy-1-propanol)	MC, CH	0.5 0.25	0.05 - 5		3,496,241 "	FMC "
(2,3, and 4)-Pyridinecarboxaldehyde	MC	0.25			3,444,248	DOW
(2,3, and 4)-Acetylpyridine	MC	0.50	0.36 - 0.54		3,444,248	DOW
(2,3, and 4)-Cyanopyridine	MC	0.35	0.31 - 0.39		3,452,108	DOW

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent issued to
p-Nitrobenzonitrile	MC	0.33			3,454,659	DOW
o-Nitrobenzonitrile (2-nitro-p-tolunitrile, 4-nitro-m-tolunitrile, 2,3-dimethyl-4-nitrobenzonitrile)	MC	0.77			"	"
(3 and 8)-Aminoquinoline	MC	0.32			3,472,903	DOW
Acetaldehyde dimethylhydrazone	TCENE, CH	0.025			3,417,152	MES
with butylene oxide		0.2			"	"
with butylene oxide and propylene oxide		0.1			"	"
and thymol		0.1		0.240	"	"
(or formaldehyde dimethylhydrazone)		0.05			"	"
Crotonaldehyde dimethylhydrazone	TCENE	0.025			3,403,190	MES
with butylene oxide and nitromethane		0.2			"	"
with p-*tert*-pentylphenol		0.05		0.240	"	"
		0.002			"	"
p-(dimethylamino)benzaldehyde	MC		0.11 - 11.1		3,444,247	DOW
Methoxyacetonitrile	MC	2.9			3,565,811	DOW
and butylene oxide and nitromethane		0.32			"	"
or propargyl alcohol		0.44			"	"
		0.35		0.002[c]	"	"
Acetonitrile	MC	1.0		0.070	3,590,088	DNAG
and *tert*-butyl alcohol		5.0		0.300	3,445,532	
and 1,4-dioxane		0.7		0.180[c]	"	"
Acetonitrile	MC	3.0		0.070	"	"
and nitromethane		1.0		0.250	"	"
and 1,4-dioxane		0.8		0.180[c]	"	"
Acetonitrile	MC	0.5		0.070	"	"
and *tert*-butyl alcohol		3.0		0.300	"	"
and nitromethane		0.7		0.250	"	"
Nitromethane	MC	3.0		0.250	3,549,715	PPG
with butylene oxide		1.0			"	"
with 2-propanol		3.0		0.980	"	"

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent issued to
3-Methoxy-1,2-epoxypropane	MC	0.5			3,536,766	DOW
with 1,4-dioxane		2.5		0.180[c]	"	"
and nitromethane		0.5		0.250	"	"
and methyl glycidyl ether		0.5			"	"
Propylene oxide	CFA	0.5	0.5 - 3.0		3,445,527	DKKK
with nitromethane		0.05		0.250	"	"
3-Methoxyoxetane	MC	3.0			3,532,761	PPG
1,2-Dimethoxyethylene	MC	2.0	1 - 5		3,549,547	DOW
2-Methoxy-2,3-dihydropyran	MC	1.4			3,661,788	ICI
or 2-ethoxy-2,3,-dihydropyran		0.5	0.5 - 2		"	"
and isopropyl nitrate		2			"	"
4,7-Dihydro-1,3-dioxepin	MC	4	2 - 10		3,518,202	DOW
and nitromethane		1	0.25 - 2	0.250	"	"
or propargyl alcohol		0.5	0.25 - 0.5	0.002[c]	"	"
and butylene oxide		0.5	0.25 - 1.0		"	"
or epichlorhydrin		0.5	0.25 - 1.0	0.019[c]	"	"
Furfuryl alcohol	MC	0.066		0.020	3,475,503	DOW
Furfuryl mercaptan	MC	0.11			"	"
5-Formylfurfuryl alcohol	MC	0.19			"	"
2-Thiophenemethanol	MC	0.47			"	"
2,5-Tetrahydrofurandimethanol	MC	0.29			"	"
2-(2 and 3)-Pyridyl)ethanol	MC	0.32	0.28 - 0.35		"	"
o-Aminobenzyl alcohol	MC	0.37			"	"
p-methoxybenzyl alcohol	MC	0.21			"	"
3-Methyl-2-thiophenemethanol	MC	0.33			"	"
1,3-Dioxolane	MC		1 - 3		Reissue	AR
with phenolic antioxidants p-*tert*-butylphenol, 2,6-di-*tert*-butyl-p-cresol, nonylphenol, 4,4'-thiobis(6-*tert*-butyl)m-cresol			0.01 - 0.1		26,025	

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent issued to
1,4-Dioxane	MC	2.84		0.180[c]	3,629,128	ETH
with nitromethane		0.3921		0.250	"	"
butylene oxide		0.2601			"	"
N-methylpyrrole		0.005			"	"
diisopropylamine		0.003			"	"
3-Methylpropionaldehyde	MC	2			3,505,415	DNAG
4-Methyl-2-butanone	MC	2			"	"
Isobutyric acid, methyl ester	MC	1			"	"
and nitromethane		1		0.250	"	"
4-Methyl-4-methoxy-2-pentanone	MC	1			"	"
with acetonitrile		0.5		0.070	"	"
and *tert*-butyl alcohol		0.5		0.300	"	"
with *tert*-butyl alcohol		1		0.300	"	"
and methyl ethyl ketone		1		0.590	"	"
1,4-Cyclohexanedione	MC	0.25			3,546,305	DOW
1,2-Cyclohexanedione	MC	0.33			"	"
2,5-Butanedione	MC	0.17			"	"
2,3-Butanedione	MC	0.28			"	"
p-Benzoquinone	MC	0.24		0.0004	"	"
2,3-Dihydro-1,4-dithiin (also 5-methyl-2,3-dihydro-1,4-dithiin)	MC,TCENE		0.2 - 4.5		3,439,051	ICI
Polysulfones	PERC	0.092			3,396,115	DOW
Trimethylene sulfide	MC	0.17			3,467,722	DOW
3-Hydroxytrimethylene sulfide	MC	0.20			"	"

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent issued to
Isopropyl nitrate	MC	2	2 - 4		3,609,091	ICI
with acetonitrile		2			"	"
and nitromethane		1	0.75 - 1		"	"
and butylene oxide		0.25	0.1 - 1		"	"
with acrylonitrile		2	0.5 - 4		"	"
and butylene oxide		0.25	0.1 - 1	0.045[c]	"	"
Iron benzoate	TCENE, PERC	12	10.2 - 14.3		3,527,703	DOW
Sodium benzoate	TCENE, PERC	0.025	0.020 - 0.027		"	"
Zinc benzoate	TCENE, PERC	10	0.41 - 38.3		"	"
Sodium didecyl phosphate (or sodium dioctyl phosphate)	PERC	1.5			3,441,620	STA
Benzyl fluoride	MC	0.14	0.82 - 8.2		3,681,469	DOW
Benzotrifluoride	MC	4.9			"	"
Ethyl propargyl ether	PERC	0.25			Brit. 773,447	DIA
Propargyl benzoate	PERC	0.25			"	"
2-Butyne-1,4-diol-dibenzoate	PERC	0.25			"	"
with isoeugenol		0.01			"	"
Propargyl alcohol	AERO	0.01		0.002[c]	2,892,725	
Nitromethane	AER	2	0.1 - 5		3,085,116	DUP
Nitroethane	AER	1	0.1 - 5		"	"
2-Nitropropane	AER	2	0.1 - 5		"	"
Propargyl alcohol	TCENE	0.1	0.05 - 0.5	0.002[c]	2,803,676	DOW
with pyrrole		0.05	0.01 - 0.05		"	"
and diisopropylamine		0.001	0.0005 - 0.01		"	"
Methylbutynol (and 2 prior)	TCENE	0.1	0.05 - 0.5		"	"

APPENDIX B STABILIZERS USED IN HALOGENATED HYDROCARBONS

Stabilizing compound	Solvent[a]	Typical solute conc., wt %	Range of concentration, wt %	TLV, g/m^3	U.S. patent number	Patent issued to
1,4-Dioxane	CH	1			2,923,747	DOW
Nitromethane		1			"	"
Vinylidene chloride		0.5			"	"
2-Butyn-1,4-diol	AERO, CH	0.5			2,892,725	CEL
3-Methyl-1-butyn-3-ol	CH		0.1 - 0.5		2,542,551	RH
3-Methyl-1-butyn-3-ol (with thymol, di-*tert*-butyl-p-cresol, epichlorohydrin, butylene oxide, amines, dioxane)	CH		0.005 - 0.3		2,911,449	AIR

[a] PERC - Perchloroethylene
MC - Methyl chloroform; 1,1,1-trichloroethane
TCENE - Trichloroethylene
CH - Chlorinated hydrocarbons
CFA - Chloro-fluoro alkanes
AER - Aerosols; trichlorofluoromethane and ethanol
AERO - Methylene chloride and methanol (aerosols)

[b] UKF - Ugine Kuhlmann, France
WCGG - Wacker-Chemie GMBH, Germany
CI - Canadian Industries, Limited, Canada
SCB - Solvay ANC Cie, Belgium
FMC - FMC Corporation
DOW - Dow Chemical Corporation
MES - Montecatini Edison Spa, Italy
DNAG - Dynamit Nobel AG, Germany
DKKK - Daikin Kogyo K. K., Japan
ICI - Imperial Chemical Industries, Limited, Great Britain
AR - Argus Chemical Corporation
ETH - Ethyl Corporation
ALL - Allied Chemical Corporation
PCPSG - Produits Chimiques Peciney-Saint-Gobain, France
STA - Stauffer Chemical Corporation
DIA - Diamond Alkali Company
CEL - Celanese Corporation
DUP - E. I. Du Pont de Nemours and Company
RH - Rohm & Haas Co.
AIR - Air Reduction Corporation
PPG - PPG Industries, Inc.

[c] TLV for skin contact.

APPENDIX C

NEDS EMISSION DATA

Table C-1. SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR STODDARD SOLVENT

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
6	100	160	2	Guess
7	67	21	281	_[b]
16	33	10	_[a]	_[c]
19	_[a]	0	_[a]	_[c]
19	_[a]	0	1	_[c]
22	67	0	137	Material balance
22	67	100	144	_[c]
22	67	0	66	_[d]
24	33	20	_[a]	_[c]
27	33	20	8	Guess
29	33	10	4	Material balance
29	100	40	75	Material balance
33	67	30	10	Guess
35	33	_[a]	15	_[d]
36	33	0	21	_[d]
45	67	0	18	Guess
47	100	30	168	Material balance
48	33	10	28	Guess

[a] No data.

[b] NADA-approved non-EPA emission factor.

[c] Not applicable.

[d] Emission factor (AP-42 or pending).

Table C-2. SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR METHYLENE CHLORIDE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	33	-[a]	32	Guess
21	100	20	6	Material balance
45	67	-[a]	39	Emission test measurement
45	100	-[a]	23	Material balance
47	100	30	1	Material balance

[a]No data.

Table C-3. SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR PERCHLOROETHYLENE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	67	-[a]	250	-[b]
5	67	-[a]	190	-[b]
5	67	-[a]	60	-[b]
5	67	-[a]	16	-[b]
5	67	58	270	-[c]
5	100	0	91	-[d]
14	67	62	201	Emission test measurement
14	100	30	336	Material balance
14	67	25	236	Material balance
19	100	0	8	-[b]
19	100	0	9	-[d]
21	-[a]	90	4	Material balance
21	33	20	6	Material balance
21	67	20	5	Material balance
21	100	20	11	Material balance
29	67	10	35	Material balance
45	100	-[a]	7	Guess
47	100	30	6	Material balance
47	100	35	8	Material balance
47	33	25	7	-[d]

[a] No data.

[b] Not applicable.

[c] NADA-approved non-EPA emission factor.

[d] Emission factor (AP-42 or pending).

Table C-4. SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHYLENE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	33	-[a]	246	-[b]
5	33	-[a]	125	Guess
5	100	0	8	-[c]
6	100	160	113	Guess
6	33	140	20	Guess
16	-[a]	-[a]	74	Emission test measurement
16	-[a]	90	309	Material balance
16	67	30	8	Material balance
16	100	20	13	Material balance
21	67	20	95	Material balance
21	100	0	2	Material balance
21	100	20	107	Material balance
21	-[a]	20	1	Material balance
21	67	20	2	Material balance
21	100	20	13	Material balance
21	33	20	62	Material balance
47	100	30	218	Material balance
47	100	20	69	Material balance
47	100	35	422	Material balance
47	100	35	3	Material balance
47	100	30	27	Material balance
47	33	0	17	Material balance
47	33	25	33	-[b]
47	67	30	116	Material balance

[a] No data.

[b] Emission factor (AP-42 or pending).

[c] NADA-approved non-EPA emission factor.

Table C-5. SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
3	100	10	308	Material balance
3	100	10	209	Material balance
3	100	20	14	Material balance
5	_[a]	_[a]	4	_[b]
5	_[a]	_[a]	3	_[b]
5	_[a]	_[a]	17	_[b]
5	_[a]	_[a]	2	_[b]
5	_[a]	_[a]	3	_[b]
5	_[a]	_[a]	2	_[b]
5	_[a]	_[a]	3	_[b]
5	_[a]	_[a]	7	_[b]
5	_[a]	_[a]	87	_[b]
5	_[a]	_[a]	2	_[b]
5	_[a]	_[a]	3	_[b]
5	_[a]	_[a]	3	_[b]
5	_[a]	_[a]	8	_[b]
5	_[a]	_[a]	4	_[b]
5	_[a]	_[a]	1	_[b]
5	_[a]	_[a]	1	_[b]
5	_[a]	_[a]	4	_[b]
5	_[a]	_[a]	44	_[b]
5	_[a]	_[a]	55	_[b]
5	_[a]	_[a]	10	_[b]
5	_[a]	_[a]	4	_[b]
5	_[a]	_[a]	5	_[b]
5	_[a]	_[a]	2	_[b]
5	_[a]	_[a]	11	_[b]
5	_[a]	_[a]	5	_[b]

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	3	_b
5	_a	_a	4	_b
5	_a	_a	3	_b
5	_a	_a	28	_b
5	_a	_a	2	_b
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	9	_b
5	_a	_a	10	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	5	_b
5	_a	_a	5	_b
5	_a	_a	8	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	9	_b
5	_a	_a	3	_b
5	_a	_a	2	_b
5	_a	_a	14	_b
5	_a	_a	5	_b
5	_a	_a	21	_b
5	_a	_a	4	_b
5	_a	_a	8	_b
5	_a	_a	13	_b
5	_a	_a	5	_b
5	_a	_a	8	_b

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	7	_b
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	5	_b
5	_a	_a	7	_b
5	_a	_a	10	_b
5	_a	_a	6	_b
5	_a	_a	23	_b
5	_a	_a	31	_b
5	_a	_a	2	_b
5	_a	_a	17	_b
5	_a	_a	7	_b
5	_a	_a	297	_b
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	6	_b
5	_a	_a	4	_b
5	_a	_a	9	_b
5	_a	_a	6	_b
5	_a	_a	1	_b
5	_a	_a	5	_b
5	_a	_a	4	_b
5	_a	_a	1	_b
5	_a	_a	5	_b
5	_a	_a	4	_b
5	_a	_a	7	_b
5	_a	_a	23	_b
5	_a	_a	2	_b
5	_a	_a	2	_b

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	4	_b
5	_a	_a	4	_b
5	_a	_a	3	_b
5	_a	_a	31	_b
5	_a	_a	4	_b
5	_a	_a	3	_b
5	_a	_a	60	_b
5	_a	_a	3	_b
5	_a	_a	3	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	11	_b
5	_a	_a	11	_b
5	_a	_a	181	_b
5	_a	_a	2	_b
5	_a	_a	6	_b
5	_a	_a	9	_b
5	_a	_a	1	_b
5	_a	_a	3	_b
5	_a	_a	1	_b
5	_a	_a	5	_b
5	_a	_a	2	_b
5	_a	_a	4	_b
5	_a	_a	3	_b
5	_a	_a	3	_b
5	_a	_a	3	_b
5	_a	_a	5	_b
5	_a	_a	2	_b
5	_a	_a	4	_b

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	7	_b
5	_a	_a	1	_b
5	_a	_a	2	_b
5	_a	_a	3	_b
5	_a	_a	3	_b
5	_a	_a	2	_b
5	_a	_a	1	_b
5	_a	_a	37	_b
5	_a	_a	14	_b
5	_a	_a	2	_b
5	_a	_a	3	_b
5	_a	_a	8	_b
5	_a	_a	1	_b
5	_a	_a	2	_b
5	_a	_a	6	_b
5	_a	_a	2	_b
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	3	_b
5	_a	_a	4	_b
5	_a	_a	5	_b
5	_a	_a	24	_b
5	_a	_a	2	_b
5	_a	_a	10	_b
5	_a	_a	1	_b
5	_a	_a	4	_b
5	_a	_a	36	_b
5	_a	_a	2	_b
5	_a	_a	27	_b

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	57	_b
5	_a	_a	133	_b
5	_a	_a	8	_b
5	_a	_a	1	_b
5	_a	_a	10	_b
5	_a	_a	3	_b
5	_a	_a	4	_b
5	_a	_a	4	_b
5	_a	_a	5	_b
5	_a	_a	4	_b
5	_a	_a	3	_b
5	_a	_a	11	_b
5	_a	_a	6	_b
5	_a	_a	5	_b
5	_a	_a	14	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	7	_b
5	_a	_a	1	_b
5	_a	_a	3	_b
5	_a	_a	5	_b
5	_a	_a	3	_b
5	_a	_a	1	_b
5	_a	_a	14	_b
5	_a	_a	11	_b
5	_a	_a	138	_b
5	_a	_a	3	_b
5	_a	_a	2	_b
5	_a	_a	18	_b

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	1	_b
5	_a	_a	5	_b
5	_a	_a	12	_b
5	_a	_a	16	_b
5	_a	_a	22	_b
5	_a	_a	3	_b
5	_a	_a	45	_b
5	_a	_a	4	_b
5	_a	_a	4	_b
5	_a	_a	7	_b
5	_a	_a	18	_b
5	_a	_a	21	_b
5	_a	_a	4	_b
5	_a	_a	1	_b
5	_a	_a	27	_b
5	_a	_a	3	_b
5	_a	_a	11	_b
5	_a	_a	18	_b
5	_a	_a	2	_b
5	_a	_a	9	_b
5	_a	_a	2	_b
5	_a	_a	5	_b
5	_a	_a	2	_b
5	_a	_a	5	_b
5	_a	_a	2	_b
5	_a	_a	6	_b
5	_a	_a	9	_b
5	_a	_a	3	_b
5	_a	_a	6	_b

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	-[a]	-[a]	21	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	3	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	3	-[b]
5	-[a]	-[a]	6	-[b]
5	-[a]	-[a]	1	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	10	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	21	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	3	-[b]
5	-[a]	-[a]	19	-[b]
5	33	-[a]	170	-[c]
14	67	30	32	Emission test measurement
14	33	28	38	Material balance
14	33	28	38	Material balance
14	33	28	38	Material balance
14	33	28	38	Material balance
14	100	30	61	Material balance
14	67	26	13	-[c]
14	-[a]	50	585	-[c]
14	100	20	149	Material balance
14	67	20	43	Material balance
14	67	35	323	Material balance
14	100	25	11	Material balance

Table C-5 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR TRICHLOROETHANE

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
14	100	20	57	Material balance
14	67	30	21	Emission test measurement
14	100	25	28	Material balance
14	33	23	60	Material balance
14	100	46	55	Material balance
14	33	30	36	Material balance
14	67	25	133	Material balance
14	100	10	48	Material balance
15	100	44	0	[d]
15	33	35	0	[d]
19	100	20	45	[c]
19	100	0	3	[d]
19	100	0	24	[c]
21	67	20	10	Material balance
21	67	20	141	Material balance
21	100	20	153	Material balance
21	67	20	26	Material balance
22	[a]	[a]	[a]	[d]
29	100	10	51	Guess
33	33	20	53	Material balance
33	33	30	7	[d]
33	67	40	16	[b]
45	[a]	0	16	Material balance
45	100	[a]	16	Material balance
45	100	0	65	Material balance

[a] No data.

[b] NADA-approved non-EPA emission factor.

[c] Emission factor (AP-42 or pending).

[d] Not applicable.

Table C-6. SUMMARY OF EMISSIONS DATA CONTAINED IN NATIONAL EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
3	67	35	373	Material balance
3	100	35	2,540	Material balance
5	-[a]	-[a]	4	-[b]
5	-[a]	-[a]	3	-[b]
5	-[a]	-[a]	4	-[b]
5	-[a]	-[a]	13	-[b]
5	-[a]	-[a]	9	-[b]
5	-[a]	-[a]	11	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	12	-[b]
5	-[a]	-[a]	1	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	1	-[b]
5	-[a]	-[a]	6	-[b]
5	-[a]	-[a]	59	-[b]
5	-[a]	-[a]	25	-[b]
5	-[a]	-[a]	22	-[b]
5	-[a]	-[a]	17	-[b]
5	-[a]	-[a]	131	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	31	-[b]
5	-[a]	-[a]	1	-[b]
5	-[a]	-[a]	13	-[b]
5	-[a]	-[a]	4	-[b]
5	-[a]	-[a]	76	-[b]
5	-[a]	-[a]	4	-[b]
5	-[a]	-[a]	46	-[b]

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	12	_b
5	_a	_a	17	_b
5	_a	_a	11	_b
5	_a	_a	5	_b
5	_a	_a	23	_b
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	17	_b
5	_a	_a	1	_b
5	_a	_a	8	_b
5	_a	_a	64	_b
5	_a	_a	25	_b
5	_a	_a	7	_b
5	_a	_a	6	_b
5	_a	_a	21	_b
5	_a	_a	9	_b
5	_a	_a	19	_b
5	_a	_a	1	_b
5	_a	_a	81	_b
5	_a	_a	37	_b
5	_a	_a	4	_b
5	_a	_a	4	_b
5	_a	_a	1	_b
5	_a	_a	11	_b
5	_a	_a	3	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	32	_b

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	4	_b
5	_a	_a	2	_b
5	_a	_a	61	_b
5	_a	_a	6	_b
5	_a	_a	2	_b
5	_a	_a	13	_b
5	_a	_a	6	_b
5	_a	_a	5	_b
5	_a	_a	10	_b
5	_a	_a	9	_b
5	_a	_a	29	_b
5	_a	_a	4	_b
5	_a	_a	552	_b
5	_a	_a	37	_b
5	_a	_a	36	_b
5	_a	_a	28	_b
5	_a	_a	3	_b
5	_a	_a	5	_b
5	_a	_a	43	_b
5	_a	_a	417	_b
5	_a	_a	1	_b
5	_a	_a	63	_b
5	_a	_a	3	_b
5	_a	_a	3	_b
5	_a	_a	16	_b
5	_a	_a	5	_b
5	_a	_a	13	_b
5	_a	_a	17	_b
5	_a	_a	29	_b

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	242	_b
5	_a	_a	7	_b
5	_a	_a	27	_b
5	_a	_a	6	_b
5	_a	_a	6	_b
5	_a	_a	5	_b
5	_a	_a	4	_b
5	_a	_a	13	_b
5	_a	_a	2	_b
5	_a	_a	19	_b
5	_a	_a	9	_b
5	_a	_a	34	_b
5	_a	_a	4	_b
5	_a	_a	118	_b
5	_a	_a	4	_b
5	_a	_a	16	_b
5	_a	_a	7	_b
5	_a	_a	3	_b
5	_a	_a	4	_b
5	_a	_a	1	_b
5	_a	_a	5	_b
5	_a	_a	3	_b
5	_a	_a	1	_b
5	_a	_a	40	_b
5	_a	_a	2	_b
5	_a	_a	9	_b
5	_a	_a	31	_b
5	_a	_a	1	_b
5	_a	_a	72	_b

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	10	_b
5	_a	_a	5	_b
5	_a	_a	4	_b
5	_a	_a	15	_b
5	_a	_a	64	_b
5	_a	_a	9	_b
5	_a	_a	2	_b
5	_a	_a	16	_b
5	_a	_a	1	_b
5	_a	_a	8	_b
5	_a	_a	21	_b
5	_a	_a	9	_b
5	_a	_a	71	_b
5	_a	_a	1	_b
5	_a	_a	5	_b
5	_a	_a	17	_b
5	_a	_a	26	_b
5	_a	_a	2	_b
5	_a	_a	10	_b
5	_a	_a	5	_b
5	_a	_a	67	_b
5	_a	_a	2	_b
5	_a	_a	6	_b
5	_a	_a	17	_b
5	_a	_a	8	_b
5	_a	_a	2	_b
5	_a	_a	6	_b
5	_a	_a	20	_b
5	_a	_a	8	_b

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	5	_b
5	_a	_a	7	_b
5	_a	_a	8	_b
5	_a	_a	7	_b
5	_a	_a	8	_b
5	_a	_a	2	_b
5	_a	_a	7	_b
5	_a	_a	11	_b
5	_a	_a	23	_b
5	_a	_a	2	_b
5	_a	_a	14	_b
5	_a	_a	16	_b
5	_a	_a	5	_b
5	_a	_a	38	_b
5	_a	_a	39	_b
5	_a	_a	4	_b
5	_a	_a	4	_b
5	_a	_a	4	_b
5	_a	_a	7	_b
5	_a	_a	103	_b
5	_a	_a	7	_b
5	_a	_a	73	_b
5	_a	_a	9	_b
5	_a	_a	20	_b
5	_a	_a	61	_b
5	_a	_a	28	_b
5	_a	_a	1	_b
5	_a	_a	85	_b
5	_a	_a	5	_b

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	_a	_a	6	_b
5	_a	_a	9	_b
5	_a	_a	39	_b
5	_a	_a	124	_b
5	_a	_a	6	_b
5	_a	_a	34	_b
5	_a	_a	233	_b
5	_a	_a	131	_b
5	_a	_a	10	_b
5	_a	_a	4	_b
5	_a	_a	19	_b
5	_a	_a	11	_b
5	_a	_a	4	_b
5	_a	_a	33	_b
5	_a	_a	5	_b
5	_a	_a	2	_b
5	_a	_a	9	_b
5	_a	_a	56	_b
5	_a	_a	6	_b
5	_a	_a	9	_b
5	_a	_a	2	_b
5	_a	_a	2	_b
5	_a	_a	30	_b
5	_a	_a	11	_b
5	_a	_a	177	_b
5	_a	_a	10	_b
5	_a	_a	10	_b
5	_a	_a	42	_b
5	_a	_a	4	_b

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	10	-[b]
5	-[a]	-[a]	2	-[b]
5	-[a]	-[a]	1	-[b]
5	-[a]	-[a]	1	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	13	-[b]
5	-[a]	-[a]	12	-[b]
5	-[a]	-[a]	12	-[b]
5	-[a]	-[a]	9	-[b]
5	-[a]	-[a]	56	-[b]
5	-[a]	-[a]	26	-[b]
5	-[a]	-[a]	99	-[b]
5	-[a]	-[a]	96	-[b]
5	-[a]	-[a]	15	-[b]
5	-[a]	-[a]	77	-[b]
5	-[a]	-[a]	20	-[b]
5	-[a]	-[a]	205	-[b]
5	-[a]	-[a]	3	-[b]
5	-[a]	-[a]	5	-[b]
5	-[a]	-[a]	21	-[b]
5	-[a]	-[a]	75	-[b]
5	33	0	49	Material balance
5	33	0	72	Material balance
5	-[a]	0	42	Material balance
5	-[a]	0	30	Material balance
5	67	0	60	Material balance
5	-[a]	-[a]	43	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
5	67	-[a]	154	Material balance
5	67	-[a]	400	Material balance
5	100	0	1,370	Guess
5	-[a]	-[a]	940	-[b]
5	33	0	8	-[b]
5	-[a]	10	-[a]	-[c]
5	67	5	2	Material balance
6	-[a]	35	30	Material balance
13	67	30	13,100	Guess
13	100	50	350	-[d]
13	100	28	9	Guess
13	100	24	112	Guess
13	67	20	88	Guess
13	33	22	263	Guess
13	33	25	16	Guess
13	67	23	48	Guess
13	33	20	679	Material balance
13	67	35	81	-[d]
13	67	35	263	Guess
13	-[a]	50	1	Guess
13	67	-[a]	-[a]	-[c]
13	-[a]	25	18	Guess
13	33	36	96	-[b]
13	33	36	96	-[b]
13	33	10	175	Guess
14	100	0	297	Guess
14	33	14	117	Material balance
14	67	10	302	Material balance
14	100	30	356	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
14	33	10	48	Material balance
14	100	28	419	Material balance
14	67	0	168	Material balance
14	100	60	10	Material balance
14	67	25	82	Material balance
14	67	46	106	Material balance
14	67	32	60	Material balance
14	33	25	18	Material balance
15	67	12	0	[c]
15	33	33	0	[c]
15	33	24	0	[c]
15	33	6	0	[c]
15	33	27	0	[c]
16	100	[a]	[a]	[c]
16	[a]	10	[a]	[c]
16	[a]	[a]	[a]	[a]
16	67	0	125	Guess
16	67	0	4	Guess
16	100	0	31	Guess
17	33	25	2	Material balance
17	67	16	5	Emission test measurement
17	67	2	18	Emission test measurement
17	67	62	149	Material balance
17	33	20	300	[d]
17	67	30	245	Material balance
17	33	10	17	[b]
17	33	10	13	[b]
17	100	30	66	Material balance
17	33	30	19	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
17	67	26	13	Material balance
17	67	20	18	Material balance
17	67	37	1	Material balance
17	67	64	0	-[c]
19	67	5	40	-[c]
21	33	20	14	Material balance
21	100	20	4	Material balance
21	67	20	3	Material balance
21	33	20	193	Material balance
21	100	40	336	Guess
21	67	20	5	Material balance
21	33	20	11	Material balance
21	33	20	1	Material balance
21	67	20	20	Material balance
21	67	20	3	Material balance
21	33	20	21	Material balance
21	33	20	8	Material balance
21	33	20	7	Material balance
21	33	20	24	Material balance
21	67	0	17	Material balance
21	33	20	22	Material balance
21	33	20	21	Material balance
21	33	20	8	Material balance
21	33	15	15	Material balance
21	33	20	1	Material balance
21	67	20	10	Material balance
21	33	20	8	Material balance
21	33	20	6	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
21	33	20	8	Material balance
21	33	20	5	Material balance
21	67	20	11	Material balance
21	67	20	8	Material balance
21	33	20	60	Material balance
21	100	20	27	Material balance
21	33	20	13	Material balance
21	67	20	6	Material balance
21	33	20	8	Material balance
21	33	20	77	Material balance
21	33	20	6	Material balance
21	33	20	5	Material balance
21	33	20	7	Material balance
21	33	20	5	Material balance
21	67	20	47	Material balance
21	67	20	36	Material balance
21	33	15	6	Material balance
21	33	20	10	Material balance
21	67	20	20	Material balance
21	-[a]	20	18	Material balance
21	33	20	2	Material balance
21	33	20	4	Material balance
21	33	20	11	Material balance
21	67	20	25	Material balance
21	33	20	40	Material balance
21	33	20	5	Material balance
21	33	20	5	Material balance
21	33	20	20	Material balance
21	67	20	6	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
21	33	20	7	Material balance
21	67	20	39	Material balance
21	67	15	6	Material balance
21	33	20	22	Material balance
21	33	20	116	Material balance
21	33	20	20	Material balance
21	33	20	27	Material balance
21	33	20	4	Material balance
21	67	22	41	Material balance
21	33	20	7	Material balance
21	33	20	15	Material balance
21	33	20	7	Material balance
21	-[a]	20	11	Material balance
21	33	20	9	Material balance
21	33	20	12	Material balance
22	67	-[a]	180	Guess
22	100	0	390	-[c]
22	67	0	530	-[d]
22	-[a]	-[a]	-[a]	-[c]
22	33	-[a]	616	Guess
24	33	0	1	Guess
24	-[a]	-[a]	-[a]	-[c]
24	100	-[a]	123	Material balance
24	100	30	10	Material balance
24	33	30	-[a]	-[c]
24	67	8	66	Guess
24	67	20	-[a]	-[c]
27	33	20	12	Guess
29	33	10	52	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
29	67	16	78	Material balance
29	100	10	4	Guess
29	100	10	79	Guess
29	67	10	114	Material balance
29	33	10	21	Material balance
29	33	10	16	Material balance
29	100	10	49	Material balance
29	33	10	1	Material balance
30	100	45	21	Emission test measurement
30	100	41	7	[c]
32	33	40	5	Material balance
33	67	50	14,600	Emission test measurement
33	67	40	13	Guess
33	67	25	30	Material balance
33	100	35	42	[b]
33	100	30	161	Guess
33	67	30	25	[b]
33	33	0	2	[d]
33	67	0	104	[d]
33	67	20	3	[b]
33	100	30	8	[b]
33	67	20	12	[c]
33	33	20	6	[c]
33	67	40	29	Material balance
33	67	40	15	Material balance
33	67	40	93	Guess
35	67	0	2,700	Material balance
35	67	[a]	966	Guess
35	100	103	21,000	[c]

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
35	67	50	402	Material balance
35	100	148	1,160	Guess
35	33	4	99	Guess
35	67	-[a]	387	Guess
35	67	24	149	-[b]
35	33	7	19	Material balance
36	33	43	24	Emission test measurement
36	67	29	7	Emission test measurement
36	67	29	4	Emission test measurement
36	67	38	5	Emission test measurement
36	33	43	7	Emission test measurement
36	67	29	34	Emission test measurement
36	33	42	21	Emission test measurement
36	67	42	31	Emission test measurement
38	100	36	50	Material balance
38	33	123	12	Material balance
38	33	88	34	Material balance
38	100	0	78	Material balance
38	33	0	13	Material balance
38	33	36	26	-[d]
38	33	25	10	Material balance
38	33	33	17	Material balance
38	33	0	3	-[d]
38	33	0	7	-[d]
38	67	0	9	Material balance
38	33	20	8	Material balance
38	33	35	5	Material balance
38	33	0	3	-[d]
38	33	10	49	Material balance

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
38	33	30	1	-[d]
38	33	0	3	-[d]
38	33	0	2	Material balance
38	33	35	5	-[d]
38	33	22	13	-[d]
38	33	0	3	Material balance
40	100	6	120	Material balance
40	67	15	7	-[d]
40	100	25	180	Material balance
40	100	30	82	Material balance
40	33	30	36	Material balance
42	33	9	8	Material balance
42	33	9	-[a]	-[c]
42	33	10	10	Material balance
45	67	-[a]	115	-[c]
46	33	-[a]	218	-[d]
47	100	30	137	Material balance
47	67	20	45	Material balance
47	100	20	108	Material balance
47	100	20	85	-[d]
47	100	35	120	Material balance
47	100	35	4	Material balance
47	100	30	3	Material balance
47	67	30	95	Material balance
49	33	25	167	-[b]
49	33	28	9	-[b]
49	33	45	0	-[c]

Table C-6 (continued). SUMMARY OF EMISSIONS DATA CONTAINED IN EMISSIONS DATA SYSTEM (NEDS) FOR OTHER/NONCLASSIFIED SOLVENTS

State code	Frequency of operation, % of yr	Stack height, ft	Emission rate, tons/yr	Type of calculation
49	33	26	79	-[b]
49	33	55	32	

[a] No data.

[b] NADA-approved non-EPA emission factor.

[c] Not applicable.

[d] Emission factor (AP-42 or pending).

APPENDIX D

SOURCE SEVERITY DISTRIBUTION INPUT DATA

The following pages comprise the input data used to develop source severity distributions for these source types.

TLV SEV. DIST. (METHYLENE CHLORIDE)

THE SAMPLE MEAN IS 0.3344515E-01

THE SAMPLE STANDARD DEVIATION IS 0.6152499E-01

PROB(S.LE..1) = 0.9338000E+00
PROB(.1.LT.S.LE.1.0) = 0.6580000E-01
PROB(S.GT.1.0) = 0.4000000E-03

XSAMP = 0.5000000E+01
SNUM(1) = 0.4669000E+01
SNUM(2) = 0.3290000E+00
SNUM(3) = 0.2000000E-02

XPOP = 0.2400000E+04
PNUM(1) = 0.2241120E+04
PNUM(2) = 0.1579200E+03
PNUM(3) = 0.9600000E+00

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.4671E-03	TO	0.1521E-02	0.1420000E+03	0.2840000E-01
FROM	0.1521E-02	TO	0.1468E-01	0.2308000E+04	0.4900000E+00
FROM	0.1468E-01	TO	0.2784E-01	0.9640000E+03	0.6828000E+00
FROM	0.2784E-01	TO	0.4099E-01	0.5180000E+03	0.7864000E+00
FROM	0.4099E-01	TO	0.5415E-01	0.2950000E+03	0.8454000E+00
FROM	0.5415E-01	TO	0.6731E-01	0.1940000E+03	0.8842000E+00
FROM	0.6731E-01	TO	0.8047E-01	0.1230000E+03	0.9088001E+00
FROM	0.8047E-01	TO	0.9362E-01	0.1020000E+03	0.9292001E+00
FROM	0.9362E-01	TO	0.1068E+00	0.4400000E+02	0.9380001E+00
FROM	0.1068E+00	TO	0.1199E+00	0.5100000E+02	0.9482001E+00
FROM	0.1199E+00	TO	0.1331E+00	0.4400000E+02	0.9570001E+00
FROM	0.1331E+00	TO	0.1463E+00	0.3000000E+02	0.9630001E+00
FROM	0.1463E+00	TO	0.1594E+00	0.2200000E+02	0.9674001E+00
FROM	0.1594E+00	TO	0.1726E+00	0.1700000E+02	0.9708002E+00
FROM	0.1726E+00	TO	0.1187E+01	0.1460000E+03	0.1000000E+01

$CC=TY

TLV SEV. DIST. (PERCHLOROETHYLENE)

THE SAMPLE MEAN IS 0.2849864E+00

THE SAMPLE STANDARD DEVIATION IS 0.7035956E+00

PROB(S.LE..1) = 0.5386000E+00
PROB(.1.LT.S.LE.1.0) = 0.4028000E+00
PROB(S.GT.1.0) = 0.5860000E-01

XSAMP = 0.2000000E+02
SNUM(1) = 0.1077200E+02
SNUM(2) = 0.8056000E+01
SNUM(3) = 0.1172000E+01

XPOP = 0.3000000E+04
PNUM(1) = 0.1615800E+04
PNUM(2) = 0.1208400E+04
PNUM(3) = 0.1758000E+03

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.1373E-02	TO	0.5471E-02	0.1250000E+03	0.2500000E-01
FROM 0.5471E-02	TO	0.3085E+00	0.3809000E+04	0.7868000E+00
FROM 0.3085E+00	TO	0.6116E+00	0.5350000E+03	0.8938000E+00
FROM 0.6116E+00	TO	0.9147E+00	0.1950000E+03	0.9327999E+00
FROM 0.9147E+00	TO	0.1218E+01	0.1120000E+03	0.9552000E+00
FROM 0.1218E+01	TO	0.1521E+01	0.5500000E+02	0.9661999E+00
FROM 0.1521E+01	TO	0.1824E+01	0.4300000E+02	0.9747999E+00
FROM 0.1824E+01	TO	0.2127E+01	0.2300000E+02	0.9793999E+00
FROM 0.2127E+01	TO	0.2430E+01	0.1600000E+02	0.9825999E+00
FROM 0.2430E+01	TO	0.2733E+01	0.1200000E+02	0.9849999E+00
FROM 0.2733E+01	TO	0.3036E+01	0.1800000E+02	0.9885999E+00
FROM 0.3036E+01	TO	0.3339E+01	0.1600000E+02	0.9917999E+00
FROM 0.3339E+01	TO	0.3642E+01	0.6000000E+01	0.9929999E+00
FROM 0.3642E+01	TO	0.3945E+01	0.9000000E+01	0.9947999E+00
FROM 0.3945E+01	TO	0.1301E+02	0.2600000E+02	0.9999999E+00

```
$CC=TY
$CC=CR
$JOB
$LO=NO
$F16
      END
  **ERROR 0039     KAF
$F16
$F16
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$F16
$F16
$F16
$EOD
$JOB
$CLOS
*BUILD.OL
$JOB
$LOAD
```

TLV SEV. DIST.(BUTYL ALCOHOL)

THE SAMPLE MEAN IS 0.4878709E+00

THE SAMPLE STANDARD DEVIATION IS 0.1449097E+01

PROB(S.LE..1) = 0.5206000E+00
PROB(.1.LT.S.LE.1.0) = 0.3716000E+00
PROB(S.GT.1.0) = 0.1078000E+00

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.3000000E+03
PNUM(1) = 0.1561800E+03
PNUM(2) = 0.1114800E+03
PNUM(3) = 0.3234000E+02

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.5727E-03	TO	0.3034E-02	0.1460000E+03	0.2920000E-01
FROM 0.3034E-02	TO	0.3382E+00	0.3602000E+04	0.7496000E+00
FROM 0.3382E+00	TO	0.6734E+00	0.5180000E+03	0.8532000E+00
FROM 0.6734E+00	TO	0.1009E+01	0.2000000E+03	0.8932000E+00
FROM 0.1009E+01	TO	0.1344E+01	0.1240000E+03	0.9180000E+00
FROM 0.1344E+01	TO	0.1679E+01	0.7600000E+02	0.9332001E+00
FROM 0.1679E+01	TO	0.2014E+01	0.6200000E+02	0.9456000E+00
FROM 0.2014E+01	TO	0.2349E+01	0.4400000E+02	0.9544001E+00
FROM 0.2349E+01	TO	0.2685E+01	0.2700000E+02	0.9598001E+00
FROM 0.2685E+01	TO	0.3020E+01	0.3100000E+02	0.9660001E+00
FROM 0.3020E+01	TO	0.3355E+01	0.2300000E+02	0.9706001E+00
FROM 0.3355E+01	TO	0.3690E+01	0.1900000E+02	0.9744000E+00
FROM 0.3690E+01	TO	0.4025E+01	0.1600000E+02	0.9780000E+00
FROM 0.4025E+01	TO	0.4361E+01	0.1100000E+02	0.9802001E+00
FROM 0.4361E+01	TO	0.2830E+02	0.9900000E+02	0.1000000E+01

TRICHLOROETHANE TLV SEVERITY DIST.

THE SAMPLE MEAN IS 0.5264653E-01

THE SAMPLE STANDARD DEVIATION IS 0.1164178E+00

PROB(S.LE..1) = 0.8771999E+00
PROB(.1.LT.S.LE.1.0) = 0.1202000E+00
PROB(S.GT.1.0) = 0.2600000E-02

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.2800000E+05
PNUM(1) = 0.2456160E+05
PNUM(2) = 0.3365600E+04
PNUM(3) = 0.7280000E+02

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.1959E-02	TO	0.2467E-02	0.3200000E+02	0.6400000E-02
FROM	0.2467E-02	TO	0.3179E-01	0.3189000E+04	0.6442000E+00
FROM	0.3179E-01	TO	0.6111E-01	0.7870000E+03	0.8016000E+00
FROM	0.6111E-01	TO	0.9042E-01	0.2980000E+03	0.8612000E+00
FROM	0.9042E-01	TO	0.1197E+00	0.1810000E+03	0.8974000E+00
FROM	0.1197E+00	TO	0.1491E+00	0.1090000E+03	0.9191999E+00
FROM	0.1491E+00	TO	0.1784E+00	0.9300000E+02	0.9377999E+00
FROM	0.1784E+00	TO	0.2077E+00	0.7200000E+02	0.9521999E+00
FROM	0.2077E+00	TO	0.2370E+00	0.4100000E+02	0.9603999E+00
FROM	0.2370E+00	TO	0.2663E+00	0.3600000E+02	0.9675999E+00
FROM	0.2663E+00	TO	0.2957E+00	0.2800000E+02	0.9731999E+00
FROM	0.2957E+00	TO	0.3250E+00	0.1400000E+02	0.9759999E+00
FROM	0.3250E+00	TO	0.3543E+00	0.2400000E+02	0.9807999E+00
FROM	0.3543E+00	TO	0.3836E+00	0.1300000E+02	0.9833999E+00
FROM	0.3836E+00	TO	0.1847E+01	0.8300000E+02	0.9999999E+00

$CC=TY

TLV SEV. DIST. (TRICHLOROETHYLENE)

THE SAMPLE MEAN IS 0.3376922E+00

THE SAMPLE STANDARD DEVIATION IS 0.1073781E+01

PROB(S.LE..1) = 0.6020000E+00
PROB(.1.LT.S.LE.1.0) = 0.3220000E+00
PROB(S.GT.1.0) = 0.7600000E-01

XSAMP = 0.2400000E+02
SNUM(1) = 0.1444800E+02
SNUM(2) = 0.7728000E+01
SNUM(3) = 0.1824000E+01

XPOP = 0.5200000E+04
PNUM(1) = 0.3130400E+04
PNUM(2) = 0.1674400E+04
PNUM(3) = 0.3952000E+03

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.3294E-03	TO	0.2523E-02	0.2000000E+03	0.4000000E-01
FROM 0.2523E-02	TO	0.1892E+00	0.3405000E+04	0.7210000E+00
FROM 0.1892E+00	TO	0.3759E+00	0.5390000E+03	0.8288000E+00
FROM 0.3759E+00	TO	0.5625E+00	0.2230000E+03	0.8734000E+00
FROM 0.5625E+00	TO	0.7492E+00	0.1330000E+03	0.9000000E+00
FROM 0.7492E+00	TO	0.9359E+00	0.8600000E+02	0.9172000E+00
FROM 0.9359E+00	TO	0.1123E+01	0.7000000E+02	0.9312000E+00
FROM 0.1123E+01	TO	0.1309E+01	0.4600000E+02	0.9404000E+00
FROM 0.1309E+01	TO	0.1496E+01	0.3800000E+02	0.9480000E+00
FROM 0.1496E+01	TO	0.1683E+01	0.3000000E+02	0.9540000E+00
FROM 0.1683E+01	TO	0.1869E+01	0.2900000E+02	0.9598000E+00
FROM 0.1869E+01	TO	0.2056E+01	0.2200000E+02	0.9642000E+00
FROM 0.2056E+01	TO	0.2243E+01	0.1600000E+02	0.9674000E+00
FROM 0.2243E+01	TO	0.2429E+01	0.1800000E+02	0.9710000E+00
FROM 0.2429E+01	TO	0.2891E+02	0.1450000E+03	0.1000000E+01

$CC=TY
$JOB
$F16

TLV SEV. DIST.(FLUOROCARBONS)

THE SAMPLE MEAN IS 0.7703228E-01

THE SAMPLE STANDARD DEVIATION IS 0.2288047E+00

PROB(S.LE..1) = 0.8444000E+00
PROB(.1.LT.S.LE.1.0) = 0.1440000E+00
PROB(S.GT.1.0) = 0.1160000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.1000000E+04
PNUM(1) = 0.8444000E+03
PNUM(2) = 0.1440000E+03
PNUM(3) = 0.1160000E+02

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.9043E-04	TO	0.4790E-03	0.1460000E+03	0.2920000E-01
FROM	0.4790E-03	TO	0.5340E-01	0.3602000E+04	0.7496000E+00
FROM	0.5340E-01	TO	0.1063E+00	0.5180000E+03	0.8532000E+00
FROM	0.1063E+00	TO	0.1593E+00	0.2000000E+03	0.8932000E+00
FROM	0.1593E+00	TO	0.2122E+00	0.1240000E+03	0.9180000E+00
FROM	0.2122E+00	TO	0.2651E+00	0.7600000E+02	0.9332001E+00
FROM	0.2651E+00	TO	0.3180E+00	0.6200000E+02	0.9456000E+00
FROM	0.3180E+00	TO	0.3710E+00	0.4400000E+02	0.9544001E+00
FROM	0.3710E+00	TO	0.4239E+00	0.2700000E+02	0.9598001E+00
FROM	0.4239E+00	TO	0.4768E+00	0.3100000E+02	0.9660001E+00
FROM	0.4768E+00	TO	0.5297E+00	0.2300000E+02	0.9706001E+00
FROM	0.5297E+00	TO	0.5827E+00	0.1900000E+02	0.9744000E+00
FROM	0.5827E+00	TO	0.6356E+00	0.1800000E+02	0.9780000E+00
FROM	0.6356E+00	TO	0.6885E+00	0.1100000E+02	0.9802001E+00
FROM	0.6885E+00	TO	0.4468E+01	0.9900000E+02	0.1000000E+01

$CC=TY

TLV SEV. DIST.(CARBON TET)

THE SAMPLE MEAN IS 0.2251709E+01

THE SAMPLE STANDARD DEVIATION IS 0.6688141E+01

PROB(S.LE..1) = 0.2264000E+00
PROB(.1.LT.S.LE.1.0) = 0.4484000E+00
PROB(S.GT.1.0) = 0.3252000E+00

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.3000000E+02
PNUM(1) = 0.6792000E+01
PNUM(2) = 0.1345200E+02
PNUM(3) = 0.9756000E+01

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.2643E-02	TO	0.1400E-01	0.1460000E+03	0.2920000E-01
FROM 0.1400E-01	TO	0.1561E+01	0.3602000E+04	0.7496000E+00
FROM 0.1561E+01	TO	0.3108E+01	0.5180000E+03	0.8532000E+00
FROM 0.3108E+01	TO	0.4655E+01	0.2000000E+03	0.8932000E+00
FROM 0.4655E+01	TO	0.6202E+01	0.1240000E+03	0.9180000E+00
FROM 0.6202E+01	TO	0.7749E+01	0.7600000E+02	0.9332001E+00
FROM 0.7749E+01	TO	0.9296E+01	0.6200000E+02	0.9456000E+00
FROM 0.9296E+01	TO	0.1084E+02	0.4400000E+02	0.9544001E+00
FROM 0.1084E+02	TO	0.1239E+02	0.2700000E+02	0.9598001E+00
FROM 0.1239E+02	TO	0.1394E+02	0.3100000E+02	0.9660001E+00
FROM 0.1394E+02	TO	0.1548E+02	0.2300000E+02	0.9706001E+00
FROM 0.1548E+02	TO	0.1703E+02	0.1900000E+02	0.9744000E+00
FROM 0.1703E+02	TO	0.1858E+02	0.1800000E+02	0.9780000E+00
FROM 0.1858E+02	TO	0.2013E+02	0.1100000E+02	0.9802001E+00
FROM 0.2013E+02	TO	0.1306E+03	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(ETHERS)

THE SAMPLE MEAN IS 0.1219677E+00

THE SAMPLE STANDARD DEVIATION IS 0.3622741E+00

PROB(S.LE..1) = 0.7758000E+00
PROB(.1.LT.S.LE.1.0) = 0.2016000E+00
PROB(S.GT.1.0) = 0.2260000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.1000000E+04
PNUM(1) = 0.7758000E+03
PNUM(2) = 0.2016000E+03
PNUM(3) = 0.2260000E+02

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.1432E-03	TO	0.7584E-03	0.1460000E+03	0.2920000E-01
FROM 0.7584E-03	TO	0.8456E-01	0.3602000E+04	0.7496000E+00
FROM 0.8456E-01	TO	0.1684E+00	0.5180000E+03	0.8532000E+00
FROM 0.1684E+00	TO	0.2522E+00	0.2000000E+03	0.8932000E+00
FROM 0.2522E+00	TO	0.3359E+00	0.1240000E+03	0.9180000E+00
FROM 0.3359E+00	TO	0.4197E+00	0.7600000E+02	0.9332001E+00
FROM 0.4197E+00	TO	0.5035E+00	0.6200000E+02	0.9456000E+00
FROM 0.5035E+00	TO	0.5873E+00	0.4400000E+02	0.9544001E+00
FROM 0.5873E+00	TO	0.6711E+00	0.2700000E+02	0.9598001E+00
FROM 0.6711E+00	TO	0.7549E+00	0.3100000E+02	0.9660001E+00
FROM 0.7549E+00	TO	0.8387E+00	0.2300000E+02	0.9706001E+00
FROM 0.8387E+00	TO	0.9225E+00	0.1900000E+02	0.9744000E+00
FROM 0.9225E+00	TO	0.1006E+01	0.1800000E+02	0.9780000E+00
FROM 0.1006E+01	TO	0.1090E+01	0.1100000E+02	0.9802001E+00
FROM 0.1090E+01	TO	0.7074E+01	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(CYCLOHEXANE)

THE SAMPLE MEAN IS 0.1393917E+00

THE SAMPLE STANDARD DEVIATION IS 0.4140277E+00

PROB(S.LE..1) = 0.7548000E+00
PROB(.1.LT.S.LE.1.0) = 0.2184000E+00
PROB(S.GT.1.0) = 0.2680000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.4000000E+04
PNUM(1) = 0.3019200E+04
PNUM(2) = 0.8736000E+03
PNUM(3) = 0.1072000E+03

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.1636E-03	TO	0.8667E-03	0.1460000E+03	0.2920000E-01
FROM	0.8667E-03	TO	0.9664E-01	0.3602000E+04	0.7496000E+00
FROM	0.9664E-01	TO	0.1924E+00	0.5180000E+03	0.8532000E+00
FROM	0.1924E+00	TO	0.2882E+00	0.2000000E+03	0.8932000E+00
FROM	0.2882E+00	TO	0.3839E+00	0.1240000E+03	0.9180000E+00
FROM	0.3839E+00	TO	0.4797E+00	0.7600000E+02	0.9332001E+00
FROM	0.4797E+00	TO	0.5755E+00	0.6200000E+02	0.9456000E+00
FROM	0.5755E+00	TO	0.6712E+00	0.4400000E+02	0.9544001E+00
FROM	0.6712E+00	TO	0.7670E+00	0.2700000E+02	0.9598001E+00
FROM	0.7670E+00	TO	0.8628E+00	0.3100000E+02	0.9660001E+00
FROM	0.8628E+00	TO	0.9586E+00	0.2300000E+02	0.9706001E+00
FROM	0.9586E+00	TO	0.1054E+01	0.1900000E+02	0.9744000E+00
FROM	0.1054E+01	TO	0.1150E+01	0.1800000E+02	0.9780000E+00
FROM	0.1150E+01	TO	0.1246E+01	0.1100000E+02	0.9802001E+00
FROM	0.1246E+01	TO	0.8084E+01	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(XYLENE)

THE SAMPLE MEAN IS 0.3364618E+00

THE SAMPLE STANDARD DEVIATION IS 0.9993767E+00

PROB(S.LE..1) = 0.5988000E+00
PROB(.1.LT.S.LE.1.0) = 0.3246000E+00
PROB(S.GT.1.0) = 0.7660000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.1100000E+05
PNUM(1) = 0.6586800E+04
PNUM(2) = 0.3570600E+04
PNUM(3) = 0.8426000E+03

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.3950E-03	TO	0.2092E-02	0.1460000E+03	0.2920000E-01
FROM 0.2092E-02	TO	0.2333E+00	0.3602000E+04	0.7496000E+00
FROM 0.2333E+00	TO	0.4644E+00	0.5180000E+03	0.8532000E+00
FROM 0.4644E+00	TO	0.6956E+00	0.2000000E+03	0.8932000E+00
FROM 0.6956E+00	TO	0.9268E+00	0.1240000E+03	0.9180000E+00
FROM 0.9268E+00	TO	0.1158E+01	0.7600000E+02	0.9332001E+00
FROM 0.1158E+01	TO	0.1389E+01	0.6200000E+02	0.9456000E+00
FROM 0.1389E+01	TO	0.1620E+01	0.4400000E+02	0.9544001E+00
FROM 0.1620E+01	TO	0.1851E+01	0.2700000E+02	0.9598001E+00
FROM 0.1851E+01	TO	0.2083E+01	0.3100000E+02	0.9660001E+00
FROM 0.2083E+01	TO	0.2314E+01	0.2300000E+02	0.9706001E+00
FROM 0.2314E+01	TO	0.2545E+01	0.1900000E+02	0.9744000E+00
FROM 0.2545E+01	TO	0.2776E+01	0.1800000E+02	0.9780000E+00
FROM 0.2776E+01	TO	0.3007E+01	0.1100000E+02	0.9802001E+00
FROM 0.3007E+01	TO	0.1951E+02	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(TOLUENE)

THE SAMPLE MEAN IS 0.3902962E+00

THE SAMPLE STANDARD DEVIATION IS 0.1159277E+01

PROB(S.LE..1) = 0.5648000E+00
PROB(.1.LT.S.LE.1.0) = 0.3472000E+00
PROB(S.GT.1.0) = 0.8800000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.1500000E+05
PNUM(1) = 0.8472000E+04
PNUM(2) = 0.5208000E+04
PNUM(3) = 0.1320000E+04

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.4582E-05	TO	0.2427E-02	0.1460000E+03	0.2920000E-01
FROM 0.2427E-02	TO	0.2706E+00	0.3602000E+04	0.7496000E+00
FROM 0.2706E+00	TO	0.5387E+00	0.5180000E+03	0.8532000E+00
FROM 0.5387E+00	TO	0.8069E+00	0.2000000E+03	0.8932000E+00
FROM 0.8069E+00	TO	0.1075E+01	0.1240000E+03	0.9180000E+00
FROM 0.1075E+01	TO	0.1343E+01	0.7600000E+02	0.9332001E+00
FROM 0.1343E+01	TO	0.1611E+01	0.6200000E+02	0.9456000E+00
FROM 0.1611E+01	TO	0.1879E+01	0.4400000E+02	0.9544001E+00
FROM 0.1879E+01	TO	0.2148E+01	0.2700000E+02	0.9598001E+00
FROM 0.2148E+01	TO	0.2416E+01	0.3100000E+02	0.9660001E+00
FROM 0.2416E+01	TO	0.2684E+01	0.2300000E+02	0.9706001E+00
FROM 0.2684E+01	TO	0.2952E+01	0.1900000E+02	0.9744000E+00
FROM 0.2952E+01	TO	0.3220E+01	0.1800000E+02	0.9780000E+00
FROM 0.3220E+01	TO	0.3488E+01	0.1100000E+02	0.9802001E+00
FROM 0.3488E+01	TO	0.2264E+02	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(BENZENE)

THE SAMPLE MEAN IS 0.1829513E+01

THE SAMPLE STANDARD DEVIATION IS 0.5434116E+01

PROB(S.LE..1) = 0.2698000E+00
PROB(.1.LT.S.LE.1.0) = 0.4504000E+00
PROB(S.GT.1.0) = 0.2888000E+00

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.3000000E+04
PNUM(1) = 0.7824000E+03
PNUM(2) = 0.1351200E+04
PNUM(3) = 0.8664000E+03

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.2148E-02	TO	0.1138E-01	0.1460000E+03	0.2920000E-01
FROM	0.1138E-01	TO	0.1268E+01	0.3602000E+04	0.7496000E+00
FROM	0.1268E+01	TO	0.2525E+01	0.5180000E+03	0.8532000E+00
FROM	0.2525E+01	TO	0.3782E+01	0.2000000E+03	0.8932000E+00
FROM	0.3782E+01	TO	0.5039E+01	0.1240000E+03	0.9180000E+00
FROM	0.5039E+01	TO	0.6296E+01	0.7600000E+02	0.9332001E+00
FROM	0.6296E+01	TO	0.7553E+01	0.6200000E+02	0.9456000E+00
FROM	0.7553E+01	TO	0.8810E+01	0.4400000E+02	0.9544001E+00
FROM	0.8810E+01	TO	0.1007E+02	0.2700000E+02	0.9598001E+00
FROM	0.1007E+02	TO	0.1132E+02	0.3100000E+02	0.9660001E+00
FROM	0.1132E+02	TO	0.1258E+02	0.2300000E+02	0.9706001E+00
FROM	0.1258E+02	TO	0.1384E+02	0.1900000E+02	0.9744000E+00
FROM	0.1384E+02	TO	0.1509E+02	0.1800000E+02	0.9780000E+00
FROM	0.1509E+02	TO	0.1635E+02	0.1100000E+02	0.9802001E+00
FROM	0.1635E+02	TO	0.1061E+03	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(MINERAL SPIRITS)

THE SAMPLE MEAN IS 0.2613592E+00

THE SAMPLE STANDARD DEVIATION IS 0.7763018E+00

PROB(S.LE..1) = 0.6478000E+00
PROB(.1.LT.S.LE.1.0) = 0.2918000E+00
PROB(S.GT.1.0) = 0.6040000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.1000000E+04
PNUM(1) = 0.6478000E+03
PNUM(2) = 0.2918000E+03
PNUM(3) = 0.6040000E+02

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.3068E-03	TO	0.1625E-02	0.1460000E+03	0.2920000E-01
FROM 0.1625E-02	TO	0.1812E+00	0.3602000E+04	0.7496000E+00
FROM 0.1812E+00	TO	0.3608E+00	0.5180000E+03	0.8532000E+00
FROM 0.3608E+00	TO	0.5403E+00	0.2000000E+03	0.8932000E+00
FROM 0.5403E+00	TO	0.7199E+00	0.1240000E+03	0.9180000E+00
FROM 0.7199E+00	TO	0.8995E+00	0.7600000E+02	0.9332001E+00
FROM 0.8995E+00	TO	0.1079E+01	0.6200000E+02	0.9456000E+00
FROM 0.1079E+01	TO	0.1259E+01	0.4400000E+02	0.9544001E+00
FROM 0.1259E+01	TO	0.1438E+01	0.2700000E+02	0.9598001E+00
FROM 0.1438E+01	TO	0.1618E+01	0.3100000E+02	0.9660001E+00
FROM 0.1618E+01	TO	0.1797E+01	0.2300000E+02	0.9706001E+00
FROM 0.1797E+01	TO	0.1977E+01	0.1900000E+02	0.9744000E+00
FROM 0.1977E+01	TO	0.2156E+01	0.1800000E+02	0.9780000E+00
FROM 0.2156E+01	TO	0.2336E+01	0.1100000E+02	0.9802001E+00
FROM 0.2336E+01	TO	0.1516E+02	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(NAPTHAS)

THE SAMPLE MEAN IS 0.1557035E+00

THE SAMPLE STANDARD DEVIATION IS 0.4624780E+00

PROB(S.LE..1) = 0.7376000E+00
PROB(.1.LT.S.LE.1.0) = 0.2298000E+00
PROB(S.GT.1.0) = 0.3260000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.2350000E+06
PNUM(1) = 0.1733360E+06
PNUM(2) = 0.5400300E+05
PNUM(3) = 0.7661000E+04

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.1828E-03	TO	0.9682E-03	0.1460000E+03	0.2920000E-01
FROM 0.9682E-03	TO	0.1079E+00	0.3602000E+04	0.7496000E+00
FROM 0.1079E+00	TO	0.2149E+00	0.5180000E+03	0.8532000E+00
FROM 0.2149E+00	TO	0.3219E+00	0.2000000E+03	0.8932000E+00
FROM 0.3219E+00	TO	0.4289E+00	0.1240000E+03	0.9180000E+00
FROM 0.4289E+00	TO	0.5358E+00	0.7600000E+02	0.9332001E+00
FROM 0.5358E+00	TO	0.6428E+00	0.6200000E+02	0.9456000E+00
FROM 0.6428E+00	TO	0.7498E+00	0.4400000E+02	0.9544001E+00
FROM 0.7498E+00	TO	0.8568E+00	0.2700000E+02	0.9598001E+00
FROM 0.8568E+00	TO	0.9637E+00	0.3100000E+02	0.9660001E+00
FROM 0.9637E+00	TO	0.1071E+01	0.2300000E+02	0.9706001E+00
FROM 0.1071E+01	TO	0.1178E+01	0.1900000E+02	0.9744000E+00
FROM 0.1178E+01	TO	0.1285E+01	0.1800000E+02	0.9780000E+00
FROM 0.1285E+01	TO	0.1392E+01	0.1100000E+02	0.9802001E+00
FROM 0.1392E+01	TO	0.9030E+01	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(HEXANE)

THE SAMPLE MEAN IS 0.8131162E-01

THE SAMPLE STANDARD DEVIATION IS 0.2415161E+00

PROB(S.LE..1) = 0.8372000E+00
PROB(.1.LT.S.LE.1.0) = 0.1504000E+00
PROB(S.GT.1.0) = 0.1240000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.4000000E+04
PNUM(1) = 0.3348800E+04
PNUM(2) = 0.6016000E+03
PNUM(3) = 0.4960000E+02

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.9545E-04	TO	0.5056E-03	0.1460000E+03	0.2920000E-01
FROM	0.5056E-03	TO	0.5637E-01	0.3602000E+04	0.7496000E+00
FROM	0.5637E-01	TO	0.1122E+00	0.5180000E+03	0.8532000E+00
FROM	0.1122E+00	TO	0.1681E+00	0.2000000E+03	0.8932000E+00
FROM	0.1681E+00	TO	0.2240E+00	0.1240000E+03	0.9180000E+00
FROM	0.2240E+00	TO	0.2798E+00	0.7600000E+02	0.9332001E+00
FROM	0.2798E+00	TO	0.3357E+00	0.6200000E+02	0.9456000E+00
FROM	0.3357E+00	TO	0.3916E+00	0.4400000E+02	0.9544001E+00
FROM	0.3916E+00	TO	0.4474E+00	0.2700000E+02	0.9598001E+00
FROM	0.4474E+00	TO	0.5033E+00	0.3100000E+02	0.9660001E+00
FROM	0.5033E+00	TO	0.5592E+00	0.2300000E+02	0.9706001E+00
FROM	0.5592E+00	TO	0.6150E+00	0.1900000E+02	0.9744000E+00
FROM	0.6150E+00	TO	0.6709E+00	0.1800000E+02	0.9780000E+00
FROM	0.6709E+00	TO	0.7268E+00	0.1100000E+02	0.9802001E+00
FROM	0.7268E+00	TO	0.4716E+01	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(METHYL ETHYL KETONE)

THE SAMPLE MEAN IS 0.2480694E+00

THE SAMPLE STANDARD DEVIATION IS 0.7368291E+00

PROB(S.LE..1) = 0.6568000E+00
PROB(.1.LT.S.LE.1.0) = 0.2870000E+00
PROB(S.GT.1.0) = 0.5620000E-01

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.2000000E+03
PNUM(1) = 0.1313600E+03
PNUM(2) = 0.5740000E+02
PNUM(3) = 0.1124000E+02

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.2912E-03	TO	0.1543E-02	0.1460000E+03	0.2920000E-01
FROM	0.1543E-02	TO	0.1720E+00	0.3602000E+04	0.7496000E+00
FROM	0.1720E+00	TO	0.3424E+00	0.5180000E+03	0.8532000E+00
FROM	0.3424E+00	TO	0.5128E+00	0.2000000E+03	0.8932000E+00
FROM	0.5128E+00	TO	0.6833E+00	0.1240000E+03	0.9180000E+00
FROM	0.6833E+00	TO	0.8537E+00	0.7600000E+02	0.9332001E+00
FROM	0.8537E+00	TO	0.1024E+01	0.6200000E+02	0.9456000E+00
FROM	0.1024E+01	TO	0.1195E+01	0.4400000E+02	0.9544001E+00
FROM	0.1195E+01	TO	0.1365E+01	0.2700000E+02	0.9598001E+00
FROM	0.1365E+01	TO	0.1535E+01	0.3100000E+02	0.9660001E+00
FROM	0.1535E+01	TO	0.1706E+01	0.2300000E+02	0.9706001E+00
FROM	0.1706E+01	TO	0.1876E+01	0.1900000E+02	0.9744000E+00
FROM	0.1876E+01	TO	0.2047E+01	0.1800000E+02	0.9780000E+00
FROM	0.2047E+01	TO	0.2217E+01	0.1100000E+02	0.9802001E+00
FROM	0.2217E+01	TO	0.1439E+02	0.9900000E+02	0.1000000E+01

TLV SEV. DIST.(ACETONE)

THE SAMPLE MEAN IS 0.6098386E-01

THE SAMPLE STANDARD DEVIATION IS 0.1811371E+00

PROB(S.LE..1) = 0.8699999E+00
PROB(.1.LT.S.LE.1.0) = 0.1230000E+00
PROB(S.GT.1.0) = 0.7000000E-02

XSAMP = 0.0000000E+00
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.0000000E+00
SNUM(3) = 0.0000000E+00

XPOP = 0.2000000E+03
PNUM(1) = 0.1740000E+03
PNUM(2) = 0.2460000E+02
PNUM(3) = 0.1400000E+01

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.7159E-04	TO	0.3792E-03	0.1460000E+03	0.2920000E-01
FROM 0.3792E-03	TO	0.4228E-01	0.3602000E+04	0.7496000E+00
FROM 0.4228E-01	TO	0.8418E-01	0.5180000E+03	0.8532000E+00
FROM 0.8418E-01	TO	0.1261E+00	0.2000000E+03	0.8932000E+00
FROM 0.1261E+00	TO	0.1680E+00	0.1240000E+03	0.9180000E+00
FROM 0.1680E+00	TO	0.2099E+00	0.7600000E+02	0.9332001E+00
FROM 0.2099E+00	TO	0.2518E+00	0.6200000E+02	0.9456000E+00
FROM 0.2518E+00	TO	0.2937E+00	0.4400000E+02	0.9544001E+00
FROM 0.2937E+00	TO	0.3356E+00	0.2700000E+02	0.9598001E+00
FROM 0.3356E+00	TO	0.3775E+00	0.3100000E+02	0.9660001E+00
FROM 0.3775E+00	TO	0.4194E+00	0.2300000E+02	0.9706001E+00
FROM 0.4194E+00	TO	0.4613E+00	0.1900000E+02	0.9744000E+00
FROM 0.4613E+00	TO	0.5032E+00	0.1800000E+02	0.9780000E+00
FROM 0.5032E+00	TO	0.5451E+00	0.1100000E+02	0.9802001E+00
FROM 0.5451E+00	TO	0.3537E+01	0.9900000E+02	0.1000000E+01

NE SEV. DIST. (BUTYL ALCOHOL-FLUOROCAR.)

THE SAMPLE MEAN IS 0.4241069E+01

THE SAMPLE STANDARD DEVIATION IS 0.1192542E+02

PROB(S.LE..1) = 0.1324000E+00
PROB(.1.LT.S.LE.1.0) = 0.4100000E+00
PROB(S.GT.1.0) = 0.4576000E+00

XSAMP = 0.1500000E+02
SNUM(1) = 0.1986000E+01
SNUM(2) = 0.6150000E+01
SNUM(3) = 0.6864000E+01

XPOP = 0.3000000E+03
PNUM(1) = 0.3972000E+02
PNUM(2) = 0.1230000E+03
PNUM(3) = 0.1372800E+03

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.5116E-02	TO	0.2702E-01	0.1420000E+03	0.2840000E-01
FROM 0.2702E-01	TO	0.2990E+01	0.3609000E+04	0.7502000E+00
FROM 0.2990E+01	TO	0.5954E+01	0.5160000E+03	0.8534001E+00
FROM 0.5954E+01	TO	0.8917E+01	0.2020000E+03	0.8938001E+00
FROM 0.8917E+01	TO	0.1188E+02	0.1210000E+03	0.9180001E+00
FROM 0.1188E+02	TO	0.1484E+02	0.7300000E+02	0.9326001E+00
FROM 0.1484E+02	TO	0.1781E+02	0.6200000E+02	0.9450001E+00
FROM 0.1781E+02	TO	0.2077E+02	0.3900000E+02	0.9528000E+00
FROM 0.2077E+02	TO	0.2373E+02	0.2800000E+02	0.9584000E+00
FROM 0.2373E+02	TO	0.2670E+02	0.3500000E+02	0.9654000E+00
FROM 0.2670E+02	TO	0.2966E+02	0.2400000E+02	0.9702001E+00
FROM 0.2966E+02	TO	0.3262E+02	0.2000000E+02	0.9742001E+00
FROM 0.3262E+02	TO	0.3559E+02	0.1900000E+02	0.9780000E+00
FROM 0.3559E+02	TO	0.3855E+02	0.1200000E+02	0.9804000E+00
FROM 0.3855E+02	TO	0.1926E+03	0.9800000E+02	0.1000000E+01

HC SEV. DIST. (METHYLENE CHLORIDE)

THE SAMPLE MEAN IS 0.8794234E+00

THE SAMPLE STANDARD DEVIATION IS 0.1617758E+01

PROB(S.LE.-1) = 0.1414000E+00
PROB(-1.LT.S.LE.1.0) = 0.6286000E+00
PROB(S.GT.1.0) = 0.2300000E+00

XSAMP = 0.5000000E+01
SNUM(1) = 0.7070000E+00
SNUM(2) = 0.3143000E+01
SNUM(3) = 0.1150000E+01

XPOP = 0.2400000E+04
PNUM(1) = 0.3393600E+03
PNUM(2) = 0.1508640E+04
PNUM(3) = 0.5520000E+03

CLASS INTERVALS				ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM	0.1228E-01	TO	0.4000E-01	0.1420000E+03	0.2840000E-01
FROM	0.4000E-01	TO	0.3860E+00	0.2308000E+04	0.4900000E+00
FROM	0.3860E+00	TO	0.7319E+00	0.9640000E+03	0.6828000E+00
FROM	0.7319E+00	TO	0.1078E+01	0.5180000E+03	0.7864000E+00
FROM	0.1078E+01	TO	0.1424E+01	0.2950000E+03	0.8454000E+00
FROM	0.1424E+01	TO	0.1770E+01	0.1940000E+03	0.8842000E+00
FROM	0.1770E+01	TO	0.2116E+01	0.1230000E+03	0.9088001E+00
FROM	0.2116E+01	TO	0.2462E+01	0.1020000E+03	0.9292001E+00
FROM	0.2462E+01	TO	0.2808E+01	0.4400000E+02	0.9380001E+00
FROM	0.2808E+01	TO	0.3154E+01	0.5100000E+02	0.9482001E+00
FROM	0.3154E+01	TO	0.3500E+01	0.4400000E+02	0.9570001E+00
FROM	0.3500E+01	TO	0.3846E+01	0.3000000E+02	0.9630001E+00
FROM	0.3846E+01	TO	0.4192E+01	0.2200000E+02	0.9674001E+00
FROM	0.4192E+01	TO	0.4538E+01	0.1700000E+02	0.9708002E+00
FROM	0.4538E+01	TO	0.3120E+02	0.1460000E+03	0.1000000E+01

HC SEV. DIST. (PERCHLOROETHYLENE)

THE SAMPLE MEAN IS 0.5641367E+01

THE SAMPLE STANDARD DEVIATION IS 0.1392793E+02

PROB(S.LE..1) = 0.2180000E-01
PROB(.1.LT.S.LE.1.0) = 0.3514000E+00
PROB(S.GT.1.0) = 0.6268000E+00

XSAMP = 0.2000000E+02
SNUM(1) = 0.4360000E+00
SNUM(2) = 0.7028000E+01
SNUM(3) = 0.1253600E+02

XPOP = 0.3000000E+04
PNUM(1) = 0.6540000E+02
PNUM(2) = 0.1054200E+04
PNUM(3) = 0.1880400E+04

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.2718E-01	TO	0.1083E+00	0.1250000E+03	0.2500000E-01
FROM 0.1083E+00	TO	0.3947E+01	0.3348000E+04	0.6946000E+00
FROM 0.3947E+01	TO	0.7785E+01	0.6890000E+03	0.8324000E+00
FROM 0.7785E+01	TO	0.1162E+02	0.2780000E+03	0.8880000E+00
FROM 0.1162E+02	TO	0.1546E+02	0.1680000E+03	0.9215999E+00
FROM 0.1546E+02	TO	0.1930E+02	0.8400000E+02	0.9383999E+00
FROM 0.1930E+02	TO	0.2314E+02	0.7100000E+02	0.9525999E+00
FROM 0.2314E+02	TO	0.2698E+02	0.3800000E+02	0.9601999E+00
FROM 0.2698E+02	TO	0.3081E+02	0.3400000E+02	0.9669999E+00
FROM 0.3081E+02	TO	0.3465E+02	0.3000000E+02	0.9729999E+00
FROM 0.3465E+02	TO	0.3849E+02	0.1900000E+02	0.9767998E+00
FROM 0.3849E+02	TO	0.4233E+02	0.1300000E+02	0.9793999E+00
FROM 0.4233E+02	TO	0.4617E+02	0.1400000E+02	0.9821998E+00
FROM 0.4617E+02	TO	0.5000E+02	0.5000000E+01	0.9831998E+00
FROM 0.5000E+02	TO	0.2575E+03	0.8400000E+02	0.9999998E+00

HC SEV. DIST. (TRICHLOROETHANE)

THE SAMPLE MEAN IS 0.2955117E+01

THE SAMPLE STANDARD DEVIATION IS 0.6534678E+01

PROB(S.LE..1) = 0.0000000E+00
PROB(.1.LT.S.LE.1.0) = 0.4800000E+00
PROB(S.GT.1.0) = 0.5200000E+00

XSAMP = 0.2530000E+03
SNUM(1) = 0.0000000E+00
SNUM(2) = 0.1214400E+03
SNUM(3) = 0.1315600E+03

XPOP = 0.2800000E+05
PNUM(1) = 0.0000000E+00
PNUM(2) = 0.1344000E+05
PNUM(3) = 0.1456000E+05

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.1100E+00	TO	0.1385E+00	0.3200000E+02	0.6400000E-02
FROM 0.1385E+00	TO	0.1784E+01	0.3189000E+04	0.6442000E+00
FROM 0.1784E+01	TO	0.3430E+01	0.7870000E+03	0.8016000E+00
FROM 0.3430E+01	TO	0.5076E+01	0.2980000E+03	0.8612000E+00
FROM 0.5076E+01	TO	0.6721E+01	0.1810000E+03	0.8974000E+00
FROM 0.6721E+01	TO	0.8367E+01	0.1090000E+03	0.9191999E+00
FROM 0.8367E+01	TO	0.1001E+02	0.9300000E+02	0.9377999E+00
FROM 0.1001E+02	TO	0.1166E+02	0.7200000E+02	0.9521999E+00
FROM 0.1166E+02	TO	0.1330E+02	0.4100000E+02	0.9603999E+00
FROM 0.1330E+02	TO	0.1495E+02	0.3600000E+02	0.9675999E+00
FROM 0.1495E+02	TO	0.1660E+02	0.2800000E+02	0.9731999E+00
FROM 0.1660E+02	TO	0.1824E+02	0.1400000E+02	0.9759999E+00
FROM 0.1824E+02	TO	0.1989E+02	0.2400000E+02	0.9807999E+00
FROM 0.1989E+02	TO	0.2153E+02	0.1300000E+02	0.9833999E+00
FROM 0.2153E+02	TO	0.1037E+03	0.8300000E+02	0.9999999E+00

HC SEV. DIST. (TRICHLOROETHYLENE)

THE SAMPLE MEAN IS 0.5338023E+01

THE SAMPLE STANDARD DEVIATION IS 0.1697368E+02

PROB(S.LE..1) = 0.1098000E+00
PROB(.1.LT.S.LE.1.0) = 0.4030000E+00
PROB(S.GT.1.0) = 0.4872000E+00

XSAMP = 0.2400000E+02
SNUM(1) = 0.2635200E+01
SNUM(2) = 0.9672000E+01
SNUM(3) = 0.1169280E+02

XPOP = 0.5200000E+04
PNUM(1) = 0.5709600E+03
PNUM(2) = 0.2095600E+04
PNUM(3) = 0.2533440E+04

CLASS INTERVALS			ACTUAL FREQUENCY	CUMULATIVE FREQUENCY
FROM 0.5207E-02	TO	0.3989E-01	0.2000000E+03	0.4000000E-01
FROM 0.3989E-01	TO	0.2991E+01	0.3405000E+04	0.7210000E+00
FROM 0.2991E+01	TO	0.5941E+01	0.5390000E+03	0.8288000E+00
FROM 0.5941E+01	TO	0.8892E+01	0.2230000E+03	0.8734000E+00
FROM 0.8892E+01	TO	0.1184E+02	0.1330000E+03	0.9000000E+00
FROM 0.1184E+02	TO	0.1479E+02	0.8600000E+02	0.9172000E+00
FROM 0.1479E+02	TO	0.1774E+02	0.7000000E+02	0.9312000E+00
FROM 0.1774E+02	TO	0.2069E+02	0.4600000E+02	0.9404000E+00
FROM 0.2069E+02	TO	0.2365E+02	0.3800000E+02	0.9480000E+00
FROM 0.2365E+02	TO	0.2660E+02	0.3000000E+02	0.9540000E+00
FROM 0.2660E+02	TO	0.2955E+02	0.2900000E+02	0.9598000E+00
FROM 0.2955E+02	TO	0.3250E+02	0.2200000E+02	0.9642000E+00
FROM 0.3250E+02	TO	0.3545E+02	0.1600000E+02	0.9674000E+00
FROM 0.3545E+02	TO	0.3840E+02	0.1800000E+02	0.9710000E+00
FROM 0.3840E+02	TO	0.4570E+03	0.1450000E+03	0.1000000E+01

$CC=TY

SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE

THE THRESHOLD LIMIT VALUE IS 1.900000 GRAMS PER CUBIC METER

STATE CODE	FREQUENCY OF OPERATION (PERCENT)	STACK HEIGHT (METERS)	EMISSION RATE (MG/YR)	COMMENTS TYPE OF CALCULATION	SEVERITY
3	100	3.0	279.4	MB	2.763894
3	100	3.0	189.6	MB	1.875500
3	100	6.1	12.7	MB	0.3140789E-01
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	15.4	EF-1	0.6102105E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	78.9	EF-1	0.3122842E-01
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	7.3	EF-1	0.2871579E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	39.9	EF-1	0.1579368E-01
5	100	15.2	49.9	EF-1	0.1974210E-01
5	100	15.2	9.1	EF-1	0.3589473E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	10.0	EF-1	0.3948421E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	25.4	EF-1	0.1005053E-01
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	8.2	EF-1	0.3230526E-02
5	100	15.2	9.1	EF-1	0.3589473E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	7.3	EF-1	0.2871579E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	8.2	EF-1	0.3230526E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	12.7	EF-1	0.5025263E-02

SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE

THE THRESHOLD LIMIT VALUE IS 1.900000 GRAMS PER CUBIC METER

STATE CODE	FREQUENCY OF OPERATION (PERCENT)	STACK HEIGHT (METERS)	EMISSION RATE (MG/YR)	COMMENTS TYPE OF CALCULATION	SEVERITY
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	19.1	EF-1	0.7537894E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	7.3	EF-1	0.2871579E-02
5	100	15.2	11.8	EF-1	0.4666315E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	7.3	EF-1	0.2871579E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	9.1	EF-1	0.3589473E-02
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	20.9	EF-1	0.8255789E-02
5	100	15.2	28.1	EF-1	0.1112737E-01
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	15.4	EF-1	0.6102105E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	269.4	EF-1	.1066074
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	8.2	EF-1	0.3230526E-02
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	20.9	EF-1	0.8255789E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	28.1	EF-1	0.1112737E-01
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	54.4	EF-1	0.2153684E-01
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	10.0	EF-1	0.3948421E-02
5	100	15.2	10.0	EF-1	0.3948421E-02
5	100	15.2	164.2	EF-1	0.6496947E-01

SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE

THE THRESHOLD LIMIT VALUE IS 1.900000 GRAMS PER CUBIC METER

STATE CODE	FREQUENCY OF OPERATION (PERCENT)	STACK HEIGHT (METERS)	EMISSION RATE (MG/YR)	COMMENTS TYPE OF CALCULATION	SEVERITY
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	8.2	EF-1	0.3230526E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	33.6	EF-1	0.1328105E-01
5	100	15.2	12.7	EF-1	0.5025263E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	7.3	EF-1	0.2871579E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	21.8	EF-1	0.8614737E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	9.1	EF-1	0.3589473E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	32.7	EF-1	0.1292210E-01
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	24.5	EF-1	0.9691579E-02
5	100	15.2	51.7	EF-1	0.2046000E-01
5	100	15.2	120.7	EF-1	0.4774000E-01
5	100	15.2	7.3	EF-1	0.2871579E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	9.1	EF-1	0.3589473E-02
5	100	15.2	2.7	EF-1	0.1076842E-02

SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE

THE THRESHOLD LIMIT VALUE IS 1.900000 GRAMS PER CUBIC METER

STATE CODE	FREQUENCY OF OPERATION (PERCENT)	STACK HEIGHT (METERS)	EMISSION RATE (MG/YR)	COMMENTS TYPE OF CALCULATION	SEVERITY
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	10.0	EF-1	0.3948421E-02
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	12.7	EF-1	0.5025263E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	12.7	EF-1	0.5025263E-02
5	100	15.2	10.0	EF-1	0.3948421E-02
5	100	15.2	125.2	EF-1	0.4953473E-01
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	16.3	EF-1	0.6461052E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	10.9	EF-1	0.4307368E-02
5	100	15.2	14.5	EF-1	0.5743158E-02
5	100	15.2	20.0	EF-1	0.7896842E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	40.8	EF-1	0.1615263E-01
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	6.4	EF-1	0.2512631E-02
5	100	15.2	16.3	EF-1	0.6461052E-02
5	100	15.2	19.1	EF-1	0.7537894E-02
5	100	15.2	3.6	EF-1	0.1435789E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	24.5	EF-1	0.9691579E-02
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	10.0	EF-1	0.3948421E-02
5	100	15.2	16.3	EF-1	0.6461052E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	8.2	EF-1	0.3230526E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	8.2	EF-1	0.3230526E-02

SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE

THE THRESHOLD LIMIT VALUE IS 1.900000 GRAMS PER CUBIC METER

STATE CODE	FREQUENCY OF OPERATION (PERCENT)	STACK HEIGHT (METERS)	EMISSION RATE (MG/YR)	COMMENTS TYPE OF CALCULATION	SEVERITY
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	19.1	EF-1	0.7537894E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	100	15.2	5.4	EF-1	0.2153684E-02
5	100	15.2	0.9	EF-1	0.3589473E-03
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	9.1	EF-1	0.3589473E-02
5	100	15.2	4.5	EF-1	0.1794737E-02
5	100	15.2	19.1	EF-1	0.7537894E-02
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	1.8	EF-1	0.7178947E-03
5	100	15.2	2.7	EF-1	0.1076842E-02
5	33	15.2	17.2	EF-1	0.6820000E-02
14	67	9.1	154.2	EF-2	.1849123
14	33	8.5	29.0	EM	0.4762155E-01
14	33	8.5	34.5	MB	.1318027
14	33	8.5	34.5	MB	.1318027
14	33	8.5	34.5	MB	.1318027
14	100	9.1	34.5	MB	.1318027
14	67	7.9	55.3	MB	0.6082163E-01
14	100	15.2	11.8	EF-2	0.2575684E-01
14	100	6.1	530.7	EF-2	.2099842
14	67	6.1	135.2	MB	.3342697
14	67	10.7	39.0	MB	.1439808
14	100	7.6	293.0	MB	.3531526
14	100	6.1	10.0	MB	0.1579368E-01
14	67	9.1	51.7	MB	.1278750
14	100	7.6	19.1	EM	0.3125164E-01
14	33	7.0	25.4	MB	0.4020210E-01
14	100	14.0	54.4	MB	.3084270
14	33	9.1	49.9	MB	0.2332479E-01
14	67	7.6	32.7	MB	.1087719
14	100	3.0	120.7	MB	.2850149
19	100	6.1	43.5	MB	.4307368
19	100	3.0	40.8	EF-2	.1009539
19	100	3.0	2.7	NA	0.2692105E-01
21	67	6.1	21.8	EF-2	.2153684
21	67	6.1	9.1	MB	0.3348390E-01
21	100	6.1	127.9	MB	.4721229
21	67	6.1	138.8	MB	.3432434
29	100	3.0	23.6	MB	0.8705813E-01
33	33	6.1	46.3	GU	.4576578
33	33	9.1	48.1	MB	.3603070
33	67	12.2	6.4	NA	0.2115010E-01
			14.5	EF-1	0.1339356E-01

SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE

THE THRESHOLD LIMIT VALUE IS 1.900000 GRAMS PER CUBIC METER

STATE CODE	FREQUENCY OF OPERATION (PERCENT)	STACK HEIGHT (METERS)	EMISSION RATE (MG/YR)	COMMENTS TYPE OF CALCULATION	SEVERITY
45	100	3.0	14.5	MB	.1435769
45	100	15.2	14.5	MB	0.5743158E-02
45	100	3.0	59.0	MB	.5832894

SOURCE ASSESSMENT STANDARD STATISTICAL CALCULATIONS
SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE
STATISTICS FOR FREQUENCY OF OPERATION
NATURAL LOGS TAKEN ON DATA

SAMPLE SIZE= 253 POPULATION SIZE= 29000.00

EST POPULATION MEAN= 94.62314 EST POP STD DEV= 1.242643

EST STD ERROR OF MEAN= 1.013691 95 PERCENT CONF LIM= 1.027011

MINIMUM= 32.99999 MAXIMUM= 99.99992 RANGE= 66.99993

LOWER LIMIT= 93.59612 MEAN= 94.62314 UPPER LIMIT= 95.65015

ARRAY OF CLASS LIMITS

33.0 37.3 42.2 47.8 54.0 61.1 69.1 78.2

88.4 100.

ARRAY OF CLASS FREQUENCIES

9 0 0 0 0 10 0 0 234

SOURCE ASSESSMENT STANDARD STATISTICAL CALCULATIONS
SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE
STATISTICS FOR STACK HEIGHT
NATURAL LOGS TAKEN ON DATA

SAMPLE SIZE= 253 POPULATION SIZE= 29000.00

EST POPULATION MEAN= 13.47804 EST POP STD DEV= 1.416919

EST STD ERROR OF MEAN= 1.022053 95 PERCENT CONF LIM= 1.043682

MINIMUM= 3.048009 MAXIMUM= 15.24004 RANGE= 12.19203

LOWER LIMIT= 12.43435 MEAN= 13.47804 UPPER LIMIT= 14.52172

ARRAY OF CLASS LIMITS

3.05 3.64 4.36 5.21 6.23 7.45 8.91 10.7

12.7 15.2

ARRAY OF CLASS FREQUENCIES

8 0 0 10 1 8 5 2 219

SOURCE ASSESSMENT STANDARD STATISTICAL CALCULATIONS
SUMMARY OF EMISSIONS DATA CONTAINED IN NEDS FOR TRICHLOROETHANE
STATISTICS FOR EMISSION RATE
NATURAL LOGS TAKEN ON DATA

SAMPLE SIZE= 253 POPULATION SIZE= 29000.00

EST POPULATION MEAN= 6.324903 EST POP STD DEV= 3.750227

EST STD ERROR OF MEAN= 1.086259 95 PERCENT CONF LIM= 1.176061

MINIMUM= .9071850 MAXIMUM= 530.7026 RANGE= 529.7954

LOWER LIMIT= 5.148843 MEAN= 6.324903 UPPER LIMIT= 7.500964

ARRAY OF CLASS LIMITS

.907 1.84 3.74 7.59 15.4 31.3 63.5 129.

262. 531.

ARRAY OF CLASS FREQUENCIES

58 59 44 32 24 22 5 5 4

APPENDIX E

AFFECTED POPULATION CALCULATION DATA

```
EMISSION TYPE IS      BUTANOL

Q =  0.68800E+00    F =  0.16000E-03    H =  0.10600E+02    POP. DEN. =  0.10900E+03    WIND SPEED =  0.45000E+01
XMAX =      97.358                      MAX. SEVERITY =      0.954

CONVERGED AT STEP     8

CONVERGED AT STEP    54

ROOT ONE =            0.04165     ROOT TWO =            0.53527

AFFECTED AREA =            0.89467     AFFECTED POPULATION =           97.51863
```

```
EMISSION TYPE IS      ACETONE

Q =  0.68800E+00    F =  0.16000E-03    H =  0.10600E+02    POP. DEN. =  0.10900E+03    WIND SPEED =  0.45000E+01
XMAX =      97.358                      MAX. SEVERITY =      0.954

CONVERGED AT STEP     8

CONVERGED AT STEP    54

ROOT ONE =            0.04165     ROOT TWO =            0.53527

AFFECTED AREA =            0.89467     AFFECTED POPULATION =           97.51863
```

```
EMISSION TYPE IS      METHYL ETHYL KETONE

Q =  0.68800E+00    F =  0.16000E-03    H =  0.10600E+02    POP. DEN. =  0.10900E+03    WIND SPEED =  0.45000E+01
XMAX =      97.358                      MAX. SEVERITY =      0.954

CONVERGED AT STEP     8

CONVERGED AT STEP    54

ROOT ONE =            0.04165     ROOT TWO =            0.53527

AFFECTED AREA =            0.89467     AFFECTED POPULATION =           97.51863
```

EMISSION TYPE IS HEXANE

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS NAPHTHAS

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS MINERAL SPIRITS

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS 1,1,1-TRICHLOROETHANE

Q = 0.20000E+00 F = 0.63330E-02 H = 0.10100E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 92.328 MAX. SEVERITY = 0.008

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS BENZENE

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01

XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS ETHERS

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01

XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS CARBON TETRACHLORIDE

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01

XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS FLUOROCARBONS

Q = 0.68800E+00 F = 0.16000E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.954

CONVERGED AT STEP 8

CONVERGED AT STEP 54

ROOT ONE = 0.04165 ROOT TWO = 0.53527

AFFECTED AREA = 0.89467 AFFECTED POPULATION = 97.51863

EMISSION TYPE IS METHYLENE CHLORIDE

Q = 0.32000E+00 F = 0.16000E-03 H = 0.12100E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 112.611 MAX. SEVERITY = 0.336

CONVERGED AT STEP 5

CONVERGED AT STEP 18

ROOT ONE = 0.05778 ROOT TWO = 0.34181

AFFECTED AREA = 0.35657 AFFECTED POPULATION = 38.86596

EMISSION TYPE IS PERCHLOROETHYLENE

Q = 0.82400E+00 F = 0.16000E-03 H = 0.10700E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 98.336 MAX. SEVERITY = 1.120

CONVERGED AT STEP 8

CONVERGED AT STEP 62

ROOT ONE = 0.04116 ROOT TWO = 0.59040

AFFECTED AREA = 1.08975 AFFECTED POPULATION = 118.78240

EMISSION TYPE IS TRICHLOROETHYLENE

Q = 0.92300E+00 F = 0.16000E-03 H = 0.12000E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 111.574 MAX. SEVERITY = 0.986

CONVERGED AT STEP 8

CONVERGED AT STEP 53

ROOT ONE = 0.04750 ROOT TWO = 0.62475

AFFECTED AREA = 1.21913 AFFECTED POPULATION = 132.88470

EMISSION TYPE IS 1,1,1-TRICHLOROETHANE

Q = 0.20000E+00 F = 0.16000E-03 H = 0.10100E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 92.328 MAX. SEVERITY = 0.307

CONVERGED AT STEP 5

CONVERGED AT STEP 17

ROOT ONE = 0.04837 ROOT TWO = 0.26524

AFFECTED AREA = 0.21366 AFFECTED POPULATION = 23.28896

EMISSION TYPE IS BUTANOL

Q = 0.68800E+00 F = 0.10000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.329 MAX. SEVERITY = 0.153

CONVERGED AT STEP 4

CONVERGED AT STEP 5

ROOT ONE = 0.06340 ROOT TWO = 0.17360

AFFECTED AREA = 0.08214 AFFECTED POPULATION = 8.95345

EMISSION TYPE IS ACETONE

Q = 0.68800E+00 F = 0.80000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.329 MAX. SEVERITY = 0.019

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS METHYL ETHYL KETONE

Q = 0.68800E+00 F = 0.19600E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.329 MAX. SEVERITY = 0.078

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS HEXANE

Q = 0.68800E+00 F = 0.60000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.025

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS NAPHTHAS

Q = 0.68800E+00 F = 0.30000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.051

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS MINERAL SPIRITS

Q = 0.68800E+00 F = 0.18600E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.082

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS TOLUENE

Q = 0.68800E+00 F = 0.10000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.329 MAX. SEVERITY = 0.153

CONVERGED AT STEP 4

CONVERGED AT STEP 5

ROOT ONE = 0.06340 ROOT TWO = 0.17368

AFFECTED AREA = 0.08214 AFFECTED POPULATION = 8.95345

EMISSION TYPE IS XYLENE

Q = 0.68800E+00 F = 0.14500E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.105

CONVERGED AT STEP 9

CONVERGED AT STEP 6

ROOT ONE = 0.08271 ROOT TWO = 0.11665

AFFECTED AREA = 0.02126 AFFECTED POPULATION = 2.31683

EMISSION TYPE IS CYCLOHEXANE

Q = 0.68800E+00 F = 0.35000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.044

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS BENZENE

Q = 0.68800E+00 F = 0.26600E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.329 MAX. SEVERITY = 0.574

CONVERGED AT STEP 7

CONVERGED AT STEP 33

ROOT ONE = 0.04506 ROOT TWO = 0.40352

AFFECTED AREA = 0.50516 AFFECTED POPULATION = 55.06234

EMISSION TYPE IS ETHERS

Q = 0.68800E+00 F = 0.40000E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.329 MAX. SEVERITY = 0.038

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS CARBON TETRACHLORIDE

Q = 0.68800E+00 F = 0.21600E-03 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.707

CONVERGED AT STEP 7

CONVERGED AT STEP 41

ROOT ONE = 0.04355 ROOT TWO = 0.45353

AFFECTED AREA = 0.64024 AFFECTED POPULATION = 69.78596

EMISSION TYPE IS FLUOROCARBONS

Q = 0.68800E+00 F = 0.63330E-02 H = 0.10600E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 97.358 MAX. SEVERITY = 0.024

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS METHYLENE CHLORIDE

Q = 0.32000E+00 F = 0.29660E-02 H = 0.12100E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 112.611 MAX. SEVERITY = 0.018

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS PERCHLOROETHYLENE

Q = 0.82400E+00 F = 0.22330E-02 H = 0.10700E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 98.336 MAX. SEVERITY = 0.080

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

EMISSION TYPE IS TRICHLOROETHYLENE

Q = 0.92300E+00 F = 0.30000E-08 H = 0.12000E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 111.574 MAX. SEVERITY = 52612.609

FAILED TO CONVERGE AFTER 10000ITERATIONS

CONVERGED AT STEP 10000

CONVERGED AT STEP 1

ROOT ONE = 0.00210 ROOT TWO = 190.36534

AFFECTED AREA = 113847.96875 AFFECTED POPULATION = 12409429.00000

EMISSION TYPE IS 1,1,1-TRICHLOROETHANE

Q = 0.20000E+00 F = 0.63330E-02 H = 0.10100E+02 POP. DEN. = 0.10900E+03 WIND SPEED = 0.45000E+01
XMAX = 92.328 MAX. SEVERITY = 0.008

NO ROOTS, HENCE AFFECTED AREA AND POPULATION = 0

SECTION VIII

GLOSSARY OF TERMS

AFFECTED POPULATION - Number of people around a typical plant utilizing degreasing operations who are exposed to a source severity greater than 0.1 or 1.0, as specified.

COLD CLEANING - Removal of undesirable matter from various metals, glass, etc., with an organic solvent in a liquid rathern than a vapor state.

DRAGOUT - In metal degreasing, the solvent entrained with or contained on the piece of work as it leaves the degreaser.

EMISSION FACTOR - Quantity of a species that is emitted per unit weight of final product.

MINERAL SPIRIT - Clear, water-white refined hydrocarbon solvent and dilvent petroleum distillate with a minimum flash point of 21°C.

NAPTHAS - Petroleum distillates used as solvents or fuels containing hydrocarbon chains beginning with pentanes. This may include small concentrations of heptane, hexane, benzene, xylene, toluene, kerosene, and heavy aromatics. In this report, the term includes both high-flash and low-flash napthas.

SOLVENT DEGREASING - Physical method of removing grease, wax, soil, or other undesirable matter from various metal, glass, plastic, or textile items with an organic solvent.

SOURCE SEVERITY - Ratio of the ground level concentration of each emission species to its corresponding ambient air quality standard (for criteria pollutants) or to a reduced TLV (for noncriteria emission species).

SECTION IX

CONVERSION FACTORS AND METRIC PREFIXES[68]

CONVERSION FACTORS

To convert from	to	Multiply by
degree Celsius (°C)	degree Fahrenheit	$t_F^\circ = 1.8\ t_C^\circ + 32$
joule (J)	calorie	2.388×10^{-1}
kilogram (kg)	pound-mass (lb mass avoirdupois)	2.204
kilometer^2 (km^2)	mile^2	2.591
meter (m)	foot	3.281
meter^2 (m^2)	foot^2	1.076×10^{1}
meter^3 (m^3)	foot^3	3.531×10^{1}
meter^3 (m^3)	gallon (U.S. liquid)	2.642×10^{2}
metric ton	pound	2.205×10^{3}
paschal (Pa)	pound-force/inch^2 (psi)	1.450×10^{-4}
watt/meter^2 (W/m^2)	watt/centimeter	1.000×10^{-4}

METRIC PREFIXES

Prefix	Symbol	Multiplication factor	Example
kilo	k	10^3	1 kPa = 1×10^3 paschals
milli	m	10^{-3}	1 mg = 1×10^{-3} grams
micro	μ	10^{-6}	1 μm = 1×10^{-6} meter

[68] Metric Practices Guide. American Society for Testing and Materials. Philadelphia. ASTM Designation: E380-74. November 1974. 34 p.

SECTION X

REFERENCES

1. Statistical Abstract of the United States: 1973 (94th Edition). Washington, U.S. Bureau of the Census, 1973. 1014 p.

2. Standard Industrial Classification Manual, 1972. Washington, U.S. Government Printing Office (Stock No. 4101-0066), 1972. 649 p.

3. Handbook of Vapor Degreasing. Philadelphia, American Society for Testing and Materials (ASTM Special Technical Publication No. 310), 1962. 33 p.

4. Kearney, T. J. OSHA and EPA as They Apply to Solvent Vapor Degreasing. Detrex Chemical Industries, Inc. Detroit. September 1974. 16 p.

5. Kearney, T. J., and C. E. Kircher. How to Get the Most from Solvent-Vapor Degreasing, Part I. Metal Progress 77:87-02, April 1960.

6. Kearney, T. J. and C. E. Kircher. How to Get the Most from Solvent-Vapor Degreasing, Part II. Metal Progress. 77:93-96, 162, 164, May 1960.

7. Heinz, D. Study to Support Standards of Performance for Organic Solvent Metal Cleaning Operations, Survey of Emission Sources. Dow Chemical Company. Midland. Environmental Protection Agency, Contract No. 68-02-1329. 87 p.

8. Today's Concepts of Solvent Degreasing. Detroit, Detrex Chemical Industries, Inc., 22 p.

9. Payne, H. F. Organic Coating Technology, Volume II. New York, John Wiley and Sons, Inc., 1961. p. 1019-1020.

10. Bransons FD & UD Series Ultrasonic Vapor Degreasers. Stamford, Branson Cleaning Equipment Company, April 1974. 6 p.

11. Vapor Degreasers. Clark, New Jersey, Branson Equipment Company. 11 p.

12. Stout, E. E. Introduction to Textiles. New York, John Wiley and Sons, Inc., 1960. p. 283-284.

13. Mathews, J. C., et al. Screening Study on the Justification of Developing New Source Performance Standards for Various Textile Processing Operations. Research Triangle Park, North Carolina. Environmental Protection Agency, EPA Contract No. 68-02-0607-11. August 1974. 106 p.

14. Solvent Scouring. Springfield, Riggs and Lombard, Inc. (Circular No. 721122), September 1973. 4 p.

15. Saville, N. Method of Scouring Wool. U.S. Patent 3,619,116 (to Thomas Burnley & Sons Limited, England), November 9, 1971.

16. Case, J. W., N. F. Crowder, and W. A. S. White. Treatment of Textiles. U.S. Patent 3,458,273 (to Imperial Chemical Industries Ltd., England), July 29, 1969.

17. Wedler, F. C. Process for Removal of Moisture and/or Solvents from Textile Materials. U.S. Patent 3,630,660 (to Burlington Industries), December 28, 1971.

18. Lange, N. A. and Forker, G. M. Handbook of Chemistry, Eighth Edition. Sandusky, Handbook Publishers, Inc., 1952. 1998 p.

19. Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition. Vols. 7 and 13. New York, John Wiley and Sons, Inc., 1965 and 1967. p. 307-26 and p. 284-92.

20. Modern Plastics Encyclopedia. Vol. 50, No. 10A. McGraw-Hill, New York. 1973-1974. p. 744-757.

21. Heat Exchanger Tube Manual. Waterbury, Scovill Manufacturing Co., 1957. 171 p.

22. Chemical Marketing Reporter. 208:9, September 22, 1975.

23. Chemical Marketing Reporter. 208:9, September 1, 1975.

24. Redksted, G. M. Upheaval in Vapor Degreasing. Factory. 27-32, January 1974.

25. Personal Communication. J. S. Gunnin, Shell Chemical Company. Houston, Texas. October 1976.

26. Personal Communication. K. S. Surprenant, Dow Chemical Company. Midland, Michigan. October 1976.

27. Richards, D. W. and K. S. Surprenant. Study to Support New Source Performance Standards for Solvent Metal Cleaning Operations. Research Triangle Park, North Carolina. Environmental Protection Agency, EPA Contract No. 68-02-1329, Task No. 9. June 1976.

28. Sax, N. I. Dangerous Properties of Industrial Materials, Second Edition. New York, Reinhold Publishing Corporation, 1963. p. 1203.

29. Chemical Marketing Reporter. 209(12):46-56. September 1976.

30. The United States Environmental Protection Agency and How Its Regulations will Affect Vapor Degreasing. Chicago, Baron-Blakeslee, 1971. 19 p.

31. Perry, J. H. (ed.). Chemical Engineers' Handbook, Fourth Edition. New York, McGraw-Hill Book Co., 1963. 3-23 to 3-42 p.

32. TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1973. American Conference of Governmental Industrial Hygienists. 1973. 94 p.

33. Jacobs, M. B., and L. Scheflan. Chemical Analysis of Industrial Solvents. New York, Interscience Publishers, Inc., 1953. 501 p.

34. American Society for Testing and Materials. 1972 Annual Book of ASTM Standards. Parts 17-20. Philadelphia. 1972.

35. Boer, H., and P. Van Arkel. Better Gasoline Chromatography. Hydrocarbon Processing. 51:80-84, February 1972.

36. American Society for Testing and Materials. 1974 Annual Book of ASTM Standards. Parts 23-25 and 30. Philadelphia. 1974.

37. Hughes, T. W., et al. Source Assessment: Prioritization of Air Pollution for Industrial Surface Coating Operations. Environmental Protection Agency, Raleigh, N.C. EPA-650/2-75-019-a. February 1975. 303 p.

38. Automotive Stampings, SIC 3465. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufacturers, MC72(P)-34D-5. December 1973. 6 p.

39. Plating and Polishing, SIC 4371. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufacturers, MC72(P)-34D-8. January 1974. 6 p.

40. Metal Coating and Allied Services, SIC 3479. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34D-9, March 1974. 7 p.

41. Valves and Pipe Fittings, SIC 3498. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34F-2. March 1972. 10 p.

42. Fabricated Pipe and Fittings, SIC 3498. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-34F-6. February 1974. 7 p.

43. Weaving Mills, Manmade Fiber and Silk, SIC 2221. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22A-2, March 1974. 7 p.

44. Weaving and Finishing Mills, Wool, SIC 2231. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC(P)-22A-3, March 1974. 7 p.

45. Narrow Fabric Mills, SIC 2241. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC(P)-22A-4, December 1973. 7 p.

46. Weaving Mills, Cotton, SIC 2211. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22A-1, March 1974. 10 p.

47. Women's Hosiery, Except Socks, SIC 2251. U.S. Department Of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-1, January 1974. 7 p.

48. Hosiery, N.E.C., SIC 2252. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-2, February 1974. 7 p.

61. Chemical Marketing Reporter, Chemical Profiles. November 18, April 1, January 14, 1974.

62. Cooper, W. J. et al. Hydrocarbon Pollutant Systems Study, Volume I, Stationary Sources, Effects and Control. Evans City. MSA Research Corporation. Report No. MSAR 72 233 (PB 219073). October 1972. 377 p.

63. Staheli, A. H. Control Methods for Reducing Chlorinated Hydrocarbon Emissions from Vapor Degreasers. Western Electric Co., Inc. (Presented at Plant Engineering and Maintenance Conference, American Society of Mechanical Engineers. Baton Rouge. October 15-18, 1972). 5 p.

64. Perry, J. H., and G. H. Chilton. Chemical Engineers' Handbook, Fifth Edition. New York, McGraw-Hill Book Co., 1973. Part 3. 250 p.

65. Johnson, K. Dry Cleaning and Degreasing Chemicals and Processes. Park Ridge, N. J., Noyes Data Corporation, 1973. 312 p.

66. Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition. Vol. 8. New York, John Wiley and Sons, Inc., 1965. p. 376-377.

67. Hydrocarbon Pollutant Systems Study, Vol. I, Stationary Sources, Effects and Control, MSA Research Corporation, October, 1972, PB-219 073.

68. Metric Practices Guide. American Society for Testing and Materials. Philadelphia. ASTM Designation: E380-74. November 1974. 34 p.

49. Knit Outerwear Mills, SIC 2253. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-3, March 1974. 7 p.

50. Knit Underwear Mills, SIC 2254. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-B-4, January 1974. 7 p.

51. Circular Knit Fabric Mills, SIC 2257. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-5, January 1974. 7 p.

52. Warp Knit Fabric Mills, SIC 2258. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-6, January 1974. 7 p.

53. Knitting Mills, N.E.C., SIC 2259. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22B-7, December 1973. 6 p.

54. Finishing Plants, Cotton, SIC 2261. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22C-1, March 1974. 7 p.

55. Finishing Plants, Man-Made Fiber and Silk Fabric, SIC 2261. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22C-2, March 1974. 7 p.

56. Finishing Plants, N.E.C., SIC 2269. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22C-5, March 1974. 6 p.

57. Tufted Carpets and Rugs, SIC 2272. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22D-2, December 1973. 6 p.

58. Yarn Mills, Except Wool, SIC 2281. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22E-1, March 1974. 7 p.

59. Throwing and Winding Mills, SIC 2282. U.S. Department of Commerce. Washington. Preliminary Report, 1972 Census of Manufactures, MC72(P)-22E-2, March 1974. 6 p.

60. Air Pollution Engineering Manual, Second Edition, Danielson, J. A. (ed.). Environmental Protection Agency. Research Triangle Park. Publication No. AP-40. May 1973. 987 p.

61. Chemical Marketing Reporter, Chemical Profiles. November 18, April 1, January 14, 1974.

62. Cooper, W. J. et al. Hydrocarbon Pollutant Systems Study, Volume I, Stationary Sources, Effects and Control. Evans City. MSA Research Corporation. Report No. MSAR 72 233 (PB 219073). October 1972. 377 p.

63. Staheli, A. H. Control Methods for Reducing Chlorinated Hydrocarbon Emissions from Vapor Degreasers. Western Electric Co., Inc. (Presented at Plant Engineering and Maintenance Conference, American Society of Mechanical Engineers. Baton Rouge. October 15-18, 1972). 5 p.

64. Perry, J. H., and G. H. Chilton. Chemical Engineers' Handbook, Fifth Edition. New York, McGraw-Hill Book Co., 1973. Part 3. 250 p.

65. Johnson, K. Dry Cleaning and Degreasing Chemicals and Processes. Park Ridge, N. J., Noyes Data Corporation, 1973. 312 p.

66. Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition. Vol. 8. New York, John Wiley and Sons, Inc., 1965. p. 376-377.

67. Hydrocarbon Pollutant Systems Study, Vol. I, Stationary Sources, Effects and Control, MSA Research Corporation, October, 1972, PB-219 073.

68. Metric Practices Guide. American Society for Testing and Materials. Philadelphia. ASTM Designation: E380-74. November 1974. 34 p.

61. Chemical Marketing Reporter, Chemical Profiles. November 18, April 1, January 14, 1974.

62. Cooper, W. J. et al. Hydrocarbon Pollutant Systems Study, Volume I, Stationary Sources, Effects and Control. Evans City. MSA Research Corporation. Report No. MSAR 72 233 (PB 219073). October 1972. 377 p.

63. Staheli, A. H. Control Methods for Reducing Chlorinated Hydrocarbon Emissions from Vapor Degreasers. Western Electric Co., Inc. (Presented at Plant Engineering and Maintenance Conference, American Society of Mechanical Engineers. Baton Rouge. October 15-18, 1972). 5 p.

64. Perry, J. H., and G. H. Chilton. Chemical Engineers' Handbook, Fifth Edition. New York, McGraw-Hill Book Co., 1973. Part 3. 250 p.

65. Johnson, K. Dry Cleaning and Degreasing Chemicals and Processes. Park Ridge, N. J., Noyes Data Corporation, 1973. 312 p.

66. Kirk-Othmer Encyclopedia of Chemical Technology, Second Edition. Vol. 8. New York, John Wiley and Sons, Inc., 1965. p. 376-377.

67. Hydrocarbon Pollutant Systems Study, Vol. I, Stationary Sources, Effects and Control, MSA Research Corporation, October, 1972, PB-219 073.

68. Metric Practices Guide. American Society for Testing and Materials. Philadelphia. ASTM Designation: E380-74. November 1974. 34 p.