United States
Environmental Protection
Agency

Industrial Environmental
Research Laboratory
Cincinnati OH 45268

EPA-600/2-78-004g
April 1978

Research and Development

EPA

Source Assessment: Rail Tank Car, Tank Truck, and Drum Cleaning, State of the Art

Environmental Protection Technology Series

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SOURCE ASSESSMENT:
RAIL TANK CAR, TANK TRUCK, AND DRUM CLEANING
State of the Art

by

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Contract No. 68-02-1874

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report contains an assessment of air emissions and water pollutants from the rail tank car, tank truck, and drum cleaning industry. This study was conducted to provide a better understanding of the distribution and characteristics of pollutants from this industry. Further information on this subject may be obtained from the Organic Chemicals and Products Branch, Industrial Pollution Control Division.

David G. Stephan
Director
Industrial Environmental Research Laboratory
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PREFACE

The Industrial Environmental Research Laboratory (IERL) of the U.S. Environmental Protection Agency (EPA) has the responsibility for insuring that pollution control technology is available for stationary sources to meet requirements of the Clean Air Act, the Federal Water Pollution Control Act, and solid waste legislation. If control technology is unavailable, inadequate, or uneconomical, financial support is provided for the development of control techniques needed 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.

IERL has the responsibility for developing control technology for a large number (>500) of operations in the chemical and related industries. As in any technical program, identifying the unsolved problems is the first step. Each industry is to be examined in detail to determine if there is sufficient potential environmental risk to justify the development of control technology by IERL.

Monsanto Research Corporation (MRC) has contracted with EPA to investigate the environmental impact of various industries that represent sources of pollutants in accordance with EPA's responsibility, as outlined above. Dr. Robert C. Binning serves as MRC Program Manager in this overall program, entitled "Source Assessment," which includes investigating sources in each of four categories: combustion, organic materials, inorganic materials, and open sources. Dr. Dale A. Denny of the Industrial Processes Division at Research Triangle Park serves as EPA Project Officer for this series. Reports prepared in this program are of two types: Source Assessment Documents and State-of-the-Art Reports.

Source Assessment Documents contain data on pollutants from specific industries. Such data are gathered from literature, government agencies, and cooperating companies. Sampling and analysis are also performed by the contractor when available information does not adequately characterize the source pollutants. These documents contain all the information necessary for IERL to decide whether a need exists to develop additional control technology for specific industries.

State-of-the-Art Reports include data on pollutants from specific industries which are also gathered from literature, government agencies, and cooperating companies. However, no extensive sampling is conducted by the contractor for such industries. Results from such studies are published as State-of-the-Art Reports for potential utility by government, industry, and others having specific needs and interests.

This study was undertaken to provide information on air emissions and water pollutants from cleaning rail tank cars, tank trucks, and drums. The work was performed for the Organic Chemicals and Products Branch of the Industrial Pollution Control Division at Cincinnati under Mr. David L. Becker. Mr. Ronald J. Turner of IPCD served as EPA Project Leader.

ABSTRACT

This document reviews the state of the art of air emissions and water pollutants from cleaning rail tank cars, tank trucks, and drums. The composition, quantity, and rate of emissions and pollutants are described.

Rail tank cars, tank trucks, and drums are used to transport a wide variety of chemical and petroleum commodities from producer to consumer. Steaming, washing and/or flushing of such units result in air emissions and wastewater effluents. Air emissions are predominantly organic chemical vapors. Water pollutants common to these operations are primarily oil and grease, COD, BOD, suspended solids, and many other organic and inorganic materials. Because of the latter, there is a high degree of variability in the wastewater constituents. Representative sources were defined for rail tank car cleaning, tank truck cleaning, and drum cleaning, the latter with washing and burning and with washing only. To evaluate the hazard potential of the representative sources, source severity was defined and evaluated for air emissions and for wastewater effluents. Control methods used to reduce emissions from rail tank car and tank truck cleaning are flaring, absorption, or product recovery of flushed gases. All other emissions are vented. No practical control methods exist for drum washing. Emissions from drum burning furnaces are controlled by maintaining proper operating conditions. Wastewater treatments consist of a variety of physical, chemical, and biological processes. By EPA estimates, two-thirds of the tank truck industry discharges to municipal systems with little or no pretreatment. Where it has been provided, treatment has generally been limited to sedimentation, neutralization, evaporation ponds, and lagoons.

This report was submitted in partial fulfillment of Contract No. 68-02-1874 by Monsanto Research Corporation under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period August 1976 to June 1977, and the work was completed as of September 1977.

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TABLES

TABLES (continued)

ABBREVIATIONS AND SYMBOLS

AAQS	--	ambient air quality standard
BOD	--	biochemical oxygen demand
BOD_5	--	amount of dissolved oxygen consumed in five days by biological processes breaking down organic matter in an effluent
C	--	exposure level concentration
C_D	--	raw effluent concentration
CM	--	combustible material
COD	--	chemical oxygen demand
C_S	--	saturated dissolved oxygen concentration at 10°C
$(DO)_{WQC}$	--	dissolved oxygen fresh water quality criteria
e	--	2.72
F	--	hazard factor
H	--	emission height
LC_{50}	--	lethal concentration of a pollutant to 50% of an aquatic life exposed to the pollutant
LD_{50}	--	lethal dose of a pollutant to 50% of a male rat population
pH	--	measure of acidity or alkalinity of a material
Q	--	mass emission rate
S	--	source severity
S_{TOD}	--	severity of total oxygen demand potential
TOD	--	total effluent oxygen demand
TSS	--	total suspended solids
TLV	--	threshold limit value
$\bar{u}$	--	average wind speed
V_D	--	volumetric flow rate of discharge
V_R	--	volumetric flow rate of receiving waters
VSS	--	volatile suspended solids
χ_{max}	--	maximum ground level concentration of pollutant
$\bar{\chi}_{max}$	--	time-averaged maximum ground level concentration of pollutant
π	--	3.14

CONVERSION FACTORS AND METRIC PREFIXES[a]

CONVERSION FACTORS

To convert from	To	Multiply by
Degree Celsius (°C)	Degree Fahrenheit (°F)	$t^{\circ}_{F} = 1.8\ t^{\circ}_{C} + 32$
Gram/meter^3 (g/m^3)	Pound/gallon	8.344×10^{-6}
Gram/second (g/s)	Pound/hour	7.936
Kilogram (kg)	Pound-mass (pound mass avoirdupois)	2.205
Kilogram/meter^3 (kg/m^3)	Pound/gallon	8.344×10^{-3}
Meter (m)	Foot	3.281
Meter/second (m/s)	Foot/minute	1.181×10^{4}
Meter^3 (m^3)	Barrel (42 gallon)	6.293
Meter^3 (m^3)	Foot^3	3.531×10^{1}
Meter^3 (m^3)	Gallon (U.S. liquid)	2.642×10^{2}
Meter^3 (m^3)	Liter (ℓ)	1.000×10^{3}
Meter^3/second (m^3/s)	Gallon/minute	1.585×10^{-4}
Metric ton	Ton (short, 2,000 pound mass)	1.102
Milligram/liter (mg/ℓ)	Pound/gallon	8.344×10^{-6}
Pascal (Pa)	Torr (mm Hg, 0°C)	7.501×10^{-3}
Pascal (Pa)	Pounds-force/in.^{2} (psi)	1.450×10^{-4}
Second (s)	Minute	1.667×10^{-2}

METRIC PREFIXES

Prefix	Symbol	Multiplication factor	Example
Kilo	k	10^{3}	1 kPa = 1×10^{3} pascals
Milli	m	10^{-3}	1 mg = 1×10^{-3} gram
Micro	μ	10^{-6}	1 μm = 1×10^{-6} meter

[a] Standard for Metric Practice. ANSI/ASTM Designation: E 380-76$^{\varepsilon}$, IEEE Std 268-1976, American Society for Testing and Materials, Philadelphia, Pennsylvania, February 1976. 37 pp.

SECTION 1

INTRODUCTION

Various chemical and petroleum products are transported by rail tank cars, tank trucks, and drums. These shipping containers must be cleaned before being used to ship a different material in order to prevent contamination of the new material. Cleaning prior to repair or testing is also necessary.

This report presents an assessment of the environmental impact from the cleaning of rail tank cars, tank trucks, and drums which have carried organic chemicals and petroleum products (not including gasoline, diesel oil, fuel oil, jet fuels, or motor oils). Types of air emissions and wastewater effluents, pollutant masses, ground level concentrations, source severities, and affected population are discussed and analyzed. Control technology and the growth of this source are described.

SECTION 2

SUMMARY

Rail tank cars, tank trucks, and drums are used to transport a wide variety of chemical and petroleum commodities from producer to consumer. Industry officials estimate that as many as 700 different commodities are handled by these carriers. This report does not address such commodities as gasoline, diesel oil, fuel oil, jet fuels or motor oils. Rail tank cars, and most tank trucks and drums, are in dedicated service (carrying one commodity only) and, unless contaminated, are cleaned only prior to repair or testing. Nondedicated tank trucks (approximately 20,000 or 22% of the total tank trucks in service) and drums (approximately 5.6 million or 12.5% of the total) are cleaned after every trip to prevent cross contamination. The approximate total number of units cleaned per year are 37,200 rail tank cars, 5,010,000 tank trucks, and 24,680,000 drums.

Steaming, washing and/or flushing of rail tank cars, tank trucks, and drums result in air emissions and wastewater effluents. These cleaning operations are partially enclosed. Residual material is washed to the wastewater stream and only small amounts of material escape through the vents to the atmosphere. Burning of drums (as an alternative cleaning operation) is a more economical cleaning method for large companies but can result in increased air emissions.

Air emissions from cleaning of rail tank cars and tank trucks are predominantly organic chemical vapors. If these are all considered as hydrocarbon emissions, the total emissions from each of these industries contribute less than 0.0022% of the national emissions of hydrocarbons. Washing of drums falls into this same class (very low emission of noncriteria pollutants), but some drum burning can produce some criteria pollutants such as hydrocarbons, and nitrogen oxides (NO_x). These contribute less than 0.0001% and negligible amounts, respectively, to the national emissions burdens of these pollutants. Water pollutants from cleaning of rail tank cars, tank trucks, and drums are primarily oil and grease, total effluent oxygen demand (TOD), suspended solids, and phenol.

Since TOD values were not available, they were estimated from the chemical oxygen demand. Quantities of water pollutants from this source in the United States (shown for individual states in Tables 20-22) are summarized in Table 1.

TABLE 1. WATER POLLUTANTS FROM RAIL TANK CARS, TANK TRUCKS, AND DRUMS (metric tons/yr)

Source type (basis)	Oil and grease	Suspended solids	COD	Phenol
Rail tank car cleaning (37,220 cars/yr)	830	4,100	8,300	31
Tank truck cleaning (5,010,000 trucks/yr)	1,745	6,070	48,500	986
Drum cleaning (24,680,000 drums/yr)	101	353	2,824	57

For use in assessing the environmental impact of rail tank cars, tank trucks, and drums used for transporting various chemical and petroleum products, representative sources were defined for each of the cleaning types. A representative rail tank car cleaning station cleans 575 cars per year. The mix of commodities handled is: 35% petroleum products, 20% organic chemicals, 25% inorganic chemicals, 15% compressed gases, and 5% food products. A representative large tank truck cleaning terminal cleans 10,000 tank truck trailers per year. The commodity mix hauled is: 15% petroleum products, 35% organic chemicals, 35% inorganic chemicals, 5% food products, and 10% others (e.g., paints, inks, navel stores, etc.). A representative drum cleaner, washing only, cleans 83,780 drums per year. A representative drum cleaner, washing and burning, cleans 400,000 drums per year, 65% by burning and 35% by washing.

To evaluate the hazard potential of the representative sources, the source severity was defined for air emissions and for wastewater effluents. For air emissions, source severity was defined as the ratio of the time-averaged maximum ground level concentration of a pollutant emitted from a representative source to a hazard factor, F. For criteria pollutants, the hazard factor is the primary ambient air quality standard; for noncriteria pollutants, it is a "corrected" threshold limit value. For wastewater effluents, the source severity was defined as the ratio of the exposure level concentration to a hazard factor. For oil and grease, phenol, and suspended solids in each of the representative sources, the hazard factor was the EPA fresh water quality criteria for these pollutants. The exposure level concentration was defined as the ratio of the product of the volumetric discharge flow rate and the raw effluent concentration, to the volumetric flow rate of the receiving waters.

The source severity of the total oxygen demand potential of a discharge was defined as the ratio of the potential total oxygen deficit to the permissible total oxygen deficit. Total oxygen deficit was based on the discharge water volumetric flow rate, the receiving water volumetric flow rate, and the chemical oxygen demand; the permissible total oxygen deficit was the difference between the saturated dissolved oxygen concentration and the dissolved oxygen fresh water quality criteria. The source severity values calculated for air emissions and wastewater effluents from each type of representative cleaning source are summarized in Tables 2 and 3.

TABLE 2. SOURCE SEVERITIES FOR AIR EMISSIONS FROM A REPRESENTATIVE CLEANING SOURCE FOR RAIL TANK CARS, TANK TRUCKS, AND DRUMS

Type of cleaning	Emissions	Air source severity
Rail tank car	Ethylene glycol	0.00017[a]
	Creosote	3.6[a,b]
	Chlorobenzene	0.0061[a]
	o-Dichlorobenzene	0.034[a]
Tank truck	Acetone	0.045[a]
	Perchloroethylene	0.11[a]
	Methyl methacrylate	0.027[a]
	Phenol	0.100[a]
	Propylene glycol	0.0014[a]
Drum washing	Organics	-[c]
Drum burning	Particulates	0.28
	Hydrocarbons	-[c]
	Carbon monoxide	-[c]
	Nitrogen oxide	0.012

[a]These source severities, due to the intermittent nature of emissions, are for worst case conditions since the maximum ground level concentration was not time averaged.

[b]The sample was taken during the first 45 minutes of an 8-hr cleaning operation; hence the severity value is suspected of being artificially high.

[c]Negligible.

Unlike most manufacturing industries, the tank truck industry (which is service-oriented) produces wastewater whole volume and characteristics may vary widely at each terminal. Therefore, extensive data would be required for meaningful definition of the raw waste loads generated at truck terminals (1).

TABLE 3. SOURCE SEVERITIES FOR WATER POLLUTANTS FROM A REPRESENTATIVE CLEANING SOURCE FOR RAIL TANK CARS, TANK TRUCKS, AND DRUMS[a]

Type of cleaning	Pollutant	Water source severity
Rail tank car	Oil and grease	0.16
	TOD[b]	0.0034
	Suspended solids	0.00033
	Phenol	0.062
Tank truck	Oil and grease	0.014
	TOD	0.00081
	Suspended solids	0.00002
	Phenol	0.080
Drums (with burning facilities)	Oil and grease	0.0094
	TOD	0.00054
	Suspended solids	0.000013
	Phenol	0.053
Drums (washing only)	Oil and grease	0.0030
	TOD	0.00017
	Suspended solids	0.000004
	Phenol	0.017

[a]See Appendix B for detailed explanation of source severity.

[b]Total oxygen demand.

The population affected by the average ground level concentration, $\overline{\chi}$, for which $\overline{\chi}/F>1.0$ was determined from the affected area and a representative population density. For emissions from rail tank car and tank truck cleaning, the affected population is zero. For drum cleaning (both washing and burning), the affected population is also zero.

Control methods used to reduce emissions from rail tank car and tank truck cleaning are flaring, absorption, or product recovery of the gases flushed from cars or trucks that carry compressed, combustible gases. There are also no practical control methods

(1) Analysis of Proposed EPA Effluent Limitations on the For-Hire Tank Truck Industry. National Tank Truck Carriers, Inc., Washington, D.C., June 1974. 31 pp.

for emission reduction from drum washing at the present time. Emissions from drum burning furnaces can be controlled by maintaining proper operating conditions. Control technology for the treatment of wastewaters from these cleaning operations consists of increasing use of a variety of physical, chemical, and biological processes.

Unless more stringent controls are placed on the cleaning of rail tank cars, tank trucks, and drums, the increase in air emissions from these operations should equal the 30% increase in chemical production which is forecast through 1980. Increased implementation of wastewater treatment processes will lead to an estimated 50% decrease in discharged water pollutants by 1980.

SECTION 3

SOURCE DESCRIPTION

CLEANING OPERATIONS DESCRIPTION

The transportation of organic chemicals from point of production to point of consumption is accomplished in rail tank cars, tank trucks, drums, barges, and pipelines. This report does not cover barge or pipeline transport. Contamination of successive shipments can be avoided only by careful cleaning of containers prior to refilling with a different or fresh material.

All rail tank cars and most tank trucks and drums are used in dedicated service, which means that they are used repeatedly to transport one kind of material. In this service they are rarely or never cleaned unless they become contaminated. Some materials require periodic cleaning even with dedicated service. For example, styrene cars and trucks must be cleaned after every fifth trip because of slight polymerization of the styrene building up on the sides of the container (personal communications with F. Bonham, Monsanto Company).

Tank trucks and drums not in dedicated service must be cleaned after each trip before another material can be put into them for shipping. These shipping containers must also be cleaned prior to repairs or testing.

Rail transportation is the principal mode for long-distance movement of bulk chemicals. Truck transportation is used for moving bulk chemicals for distances up to a few hundred miles. Drums are used for transporting smaller quantities of chemicals and are carried by either rail or truck, depending on distance.

Rail Tank Car Cleaning

There were 177,878 rail tank cars in use in 1972, of which 3,970 were owned by railroads and 173,908 were privately owned. Car owners operating in private carriage of their own products or raw materials (chemical intermediates) account for approximately 10% of the private ownership. The rest are owned by car leasing and operating companies and, along with the railroad-owned cars, are operated on a for-hire basis (2).

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(2) Yearbook of Railroad Facts, 1973. Association of American Railroads, Washington, D.C., 1973.

Tank car cleaning is conducted largely at shipping and receiving terminals of manufacturers or producers where the wastes are compatible with and directed to the treatment systems of the individual companies. However, a significant amount (30% to 40%) of tank car cleaning is carried out at maintenance and service stations operated or contracted by owner-lessors. These installations must clean out wastes derived from a wide variety of commodities, many of which require specific cleaning methods. Wastewaters from these installations are partly or wholly treated on site. The extreme variety of commodities cleaned yields wastewaters which are highly variable, complex, and difficult to treat.

A typical tank car cleaning facility cleans from 4 to 10 cars per day. The tank cars cleaned in such facilities are used to haul liquid commodities such as petroleum products (excluding gasoline, fuel oils, and lubricating oils), vegetable and animal oils, organic and inorganic chemicals, beverages, and liquefied gases. Capacity per car varies from 38 m^3 to 129 m^3 (10,000 gal to 34,000 gal).

Cleaning agents used on tank cars are steam, water, detergents, and solvents. These agents are applied using steam hoses, pressure wands, or rotating spray heads placed through the opening in the top of the car. Chipping and scraping of hardened or crystallized products is frequently required. Cars carrying gases and volatile materials and those that are being pressure tested have to be filled or flushed out with water. The amount of liquid used per car varies from 0.23 m^3 (60 gal) for steam cleaning to 129 m^3 (34,000 gal) for total flushing of a large tank car. Table 4 presents tank car cleaning facilities data for several stations (3). The average amount of residual material cleaned from each car is estimated to be 250 kg (3).

Vapors from cleaning cars used to haul volatile materials are sent to flares at some cleaning facilities. Vapors of materials such as anhydrous ammonia and chlorine are dissolved in water and become wastewater constituents. Vapors not flared or dissolved in water are dissipated to the atmosphere.

Tank Truck Cleaning

An estimated 90,000 tank trucks are in service in the United States, of which 30,000 are used exclusively by the owners to haul their own products and 60,000 are operated on a for-hire basis.

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(3) Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Railroad Segment of the Transportation Industry Point Source Category. Office of Enforcement and General Counsel, National Field Investigations Center, Cincinnati, Ohio, February 1975.

Approximately 20% of the for-hire trucks are used to haul bulk dry freight and 80% are used to haul bulk liquids. Most companies operate fleets of five trucks or less; these constitute about 90% of the fleets in operation. The largest operating company has 3,600 trucks in its fleet. Wherever possible, these trucks are consigned to dedicated service, hauling one product for long periods of time. The interiors of dedicated trucks are cleaned infrequently, usually in connection with testing or repair.

Interior washing of for-hire tank trucks is conducted at many tank truck dispatch terminals. Each year trucks operating from a single large terminal commonly haul 50 or more organic and inorganic chemicals, salts, acids, bases, agricultural and food products, petroleum products, paint, glue, plastics, soap, liquefied gas, and latex. Table 5 shows the mix of commodities hauled at a midwest terminal (4). Cleaning tank trucks which have been used for such a wide variety of materials requires great flexibility in the selection of cleaning methods. Agents available at most terminals include water, steam, detergents, caustic, acid, and solvents. Tables 6 and 7 show cleaning methods, commodities and number of tank trucks cleaned at one terminal in one month as supplied by the terminal manager (4). Cleaning agents can be applied with hand-held pressure wands or by Turco or Butterworth rotating spray nozzles. Detergent, caustic, and acid solutions are usually recycled until spent and then sent to the treatment facilities. Solvents are recycled in a closed system, and sludges that accumulate are either incinerated or landfilled. Quantities of liquid used per tank truck vary from approximately 0.23 m^3 (60 gal) for steam operations to 20.9 m^3 (5,500 gal) for full flushing, with 2 m^3 (500 gal) being considered the average. The average amount of material cleaned from each trailer is estimated to be 100 kg (4).

Vapors from volatile materials are flared at a few terminals, but the most common practice is to allow them to dissipate in the atmosphere.

Drum Cleaning

Steel drums used in shipping organic and inorganic chemicals and other products are manufactured in three categories: 0.2-m^3 (55-gal) drums made with 18-gauge steel, 0.2-m^3 (55-gal) drums with 20-gauge bodies and 18-gauge heads, and 0.11-m^3 (30-gal) drums in 20-/18-gauge. Production of these drums for 1972-1975 is shown in Table 8.

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(4) Development Document for Proposed Effluent Limitations Guidelines and Source Performance Standards for the Trucking Segment of the Transportation Industry Point Source Category. Office of Enforcement and General Counsel, National Field Investigations Center, Cincinnati, Ohio, 1975.

TABLE 4. TANK CAR CLEANING FACILITIES DATA (3)

Site no.	Cars washed/ day	Wastewater flow m^3/day	Wastewater flow gpd	Commodities cleaned Type	Commodities cleaned Percent of total	Cleaning methods	Waste treatment
118	5.5	61	16,000	Oils, greases	29	Steam, detergent, solvent	Segregation, primary settling; skimming; batch treatment for CN, phenol, Cr:pH adjustment, pond settling
				Acids, bases	10	Dilute with water	
				Solids, foodstuffs	31	Water, steam	
				Organic liquids	13	Steam, water	
				Compressed gases	17	Water purge	
119	5.1	19	5,000	Approximately same as above		Same as above but less water due to warmer climate	Primary settling; oil skimming evaporation; no discharge
120	1.4	53	7,000 +7,000 tank test water	Approximately same as above		Generally same but higher, lower volume than above	Collection of excess residual; primary settling; gravity oil separation; equalization pond
121	5.0	53	14,000	Approximately same as above		Generally same with more solvents (recycled)	Primary settling; oil separation in 3 ponds in series
122	2.5	30	8,000	Generally same, more vegetable oils, nitrogen fertilizer		Generally same as Site 118, but more low pressure high volume water	Limited collection excess residual; primary settling; gravity oil separation; 3 ponds in series
123	7	40	10,600	Organic liquids	45.5	Manual removal of solids; steam; caustic; kerosene; detergent; purging	Gravity separation segregation; chemical coagulation; clarification
				Inorganic liquids	19.5		
				Organic gases	4.5		
				Inorganic gases	15.5		
				Organic solids	9.5		
				Inorganic solids	0.5		
				Unknown	5.0		
124	11	193	51,000	Same as Site 123		Same as Site 123	Same as Site 123 to city
125	5	72	19,000	Same as Site 123		Same as Site 123	Same as Site 123 to city
126	11	170	45,000	Same as Site 123		Same as Site 123	Pond, no outlet
127	4	17	4,500	Same as Site 123		Same as Site 123	Pond, spray, irrigation; to city
128	5	33	8,600	Same as Site 123		Same as Site 123	Gravity separation; chemical coagulation; evaporation pond
129	1.6	38	10,000	Oil	20.5	Steam, caustic	Primary settling; oil separation; to Sanitary District
				Chemicals	38.5	Water, detergents, steam	
				Compressed gas	31.2	Flaring, steam	
				Food	9.8	Water, detergent, steam	
130	1.1	19	5,000	Oil	32.0	Same as Site 129	Oil separator; pH adjustment
				Chemicals	21.3		
				Compressed gases	38.5		
				Food	8.2		
131	4.4	627	165,600 (includes tank test and cooling water)	LPG	34	Purge steam, water	Solvent recycled; landfill fuel oil and asphalt; primary settling skimmer; secondary pond
				Anhydrous ammonia	19	Purge steam, water	
				Acid and caustic	19	Neutralize, purge	
				Volatile hydrocarbons	5	Steam, water, chemicals	
				Fuel oil and asphalt	11	Purge steam, water, solvent	
				Food products	3	Purge steam, water, solvent	
				Unknown	9		
132	9	95	25,000 (includes sanitary cooling water)			Steam, fuel oil, detergent, water	API separatory and closed system; to city
133	9	57	15,000	Petroleum products	60	Venting, steaming, and detergent	Containment and floating skimmers; evaporation
				Acid and caustic	3		
				Anhydrous ammonia and LPG	37		
134	2			Petroleum products	90	Steam, detergents	None for tank test water and cooling water to city sewer; closed system and incineration
				Gases		Venting	

NOTE: Blanks indicate no data reported.

(continued)

TABLE 4 (continued)
(g/m^3, for columns listed below)

Site no.	Oil Raw	Oil Effluent	Suspended solids Raw	Suspended solids Effluent	BOD_5 Raw	BOD_5 Effluent	COD Raw	COD Effluent	Cyanide Raw	Cyanide Effluent	Chromium Raw	Chromium Effluent	Phenols Raw	Phenols Effluent	pH Units Raw	pH Units Effluent
118	10-4,000	20-150	50-20,000	15-50			200-40,000	200-5,000	0-1	0-0.02	0-10	0-0.05	0-150	0	1.5-12.5	6.5-8.5
119		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]
120	much less concentrated than Site 118 in all constituents															
121																
122																
123		6-19		64				474				0.04		0.24		6.8-7.6
124																
125																
126		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]
127		10		252				835				0.11		0.002		
128																
129		high		510		60										7.2
130		21		100		128				0.002		high		0.007		7.6
131	52.5	23	16	18	11	30	81	135					0.011	0.035	7.5	8.8
132	20-645	27-171	50-107	30-49											4.1-4.3	6.3-6.5
133		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]
134		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]		–[a]

[a] No discharge. NOTE: Blanks indicate no data reported.

TABLE 5. PRODUCTS HANDLED AND PERCENT OF TOTAL HAULAGE (4)

Product	Percent of total hauled 1971	1972
Rhoplex-latex	32.5	31.1
Glycols	10.9	21.1
Resin	10.4	10.6
Plastics (bulkers)	8.1	9.0
Poly glycols		4.7
Lacquer	3.1	3.0
Paint and enamel		2.4
MMA (acrylate monomer)		2.4
Molasses	1.3	1.7
Unidentified		1.4
Acryloids		1.3
Toluene		1.1
Toluenediamine		0.9
Vinyl acetate		0.8
Wax	1.2	0.8
Formaldehyde		0.8
Plasticizers		0.8
Jet fuel	2.5	0.8
Lube oil	5.3	0.6
Tar		0.6
Whiskey		0.5
Miscellaneous	24.5	3.0

NOTE: Blanks indicate these commodities were not cleaned in 1971.

TABLE 6. TRAILER INTERNAL CLEANING GENERATION RATES FOR ONE TERMINAL DURING ONE MONTH OF OPERATION (4)

Number	Cleaning method	Water use, m^3/trailer	Number of trailers	Total water use, m^3
1	Cold water flush	0.57	84	47.6
2	Cold water flush--caustic/acid tank	8.3	321	2,666.0
3	Cold water flush--steam--cold water rinse	3.0	316	954.5
4	Cold water flush--spin/detergent--cold water rinse	1.1	123	139.3
5	MEK, MIBK,[a] or acetone solvent--cold water rinse	0.57	0	0
6	Styrene solvent--cold water rinse	0.57	0	0
7	Cold water flush--steam--cold water rinse--spin w/detergent--cold water rinse	3.6	68	243.9
8	Cold water flush w/Butterworth for dry bulk trailer	5.7	78	441.7
TOTALS			990	4,493.3

[a]MEK - methyl ethyl ketone; MIBK - methyl isobutyl ketone.

TABLE 7. COMMODITY/TANK TRUCK DATA FOR ONE TERMINAL DURING ONE MONTH OF OPERATION (4)

Cleaning method number[a]	Commodity	No. of trailers cleaned
1	Uran fertilizer	16
	PAPI--isozylate	2
	Ethyl chloride	10
	Alum	53
	Water for glue	2
	Water softener	1
2	Caustic soda (50%)	123
	Silicate soda	2
	Acetic acid	22
	Phosphoric acid	1
	Spent acid	47
	Sulfuric acid	87
	Hydrochloric acid	38
	Corrosive liquid	1
3	Solvent	18
	Toluene	26
	Xylene	2
	IPA--isopropyl alcohol	23
	Sodium MBT	1
	EDA--ethylene diamine	15
	DTA--diethylene triamine	8
	Poly amines	7
	Vinyl acetate	23
	Cyescal	3
	Phenol	32
	Alcohol	22
	Petroleum chemicals	1
	Peroxide	4
	Biphenyl	2
	Sodium bichromate	9
	Sodium methylate	3
	PA-phthalic anhydride	6
	Acetone	9
	Adaline	4
	Ferric chloride	3
	TTA--Amine 220	3
	AN--acrylonitrile	8
	Protein feed supplement	2
	Calcium chloride	1
	Styrene	2
	Methyl acrylate	1

(continued)

TABLE 7 (continued).

Cleaning method number[a]	Commodity	No. of trailers cleaned
3 (cont.)	Weed killer	4
	Shell pan	1
	DMK--dimethyl ketone	4
	Benzene	1
	Pentylamine	1
	Ethylene glycol	3
	MEK--methyl ethyl ketone	14
	ITA	2
	Mineral spirits	3
	DAA--diacetone acrylonitrile	4
	NBA--normal butyl alcohol	1
	Methanol	3
	Butyl cellosolve	1
	Formaldehyde	24
	Oxylene	1
	Naphtha	1
	MIBK--methyl isobutyl ketone	4
	Demineralized water	1
	Turpentine	2
	Oxital--ethylene glycol mono-ethane ether	1
	TRI Clean D	2
4	Glue	72
	Paint	2
	Resin	30
	Water treating compound	5
	Coastal pale oil	7
	Petroleum oil	3
	Cotton oil	2
	Script set	2
7	Diesel oil	21
	Petrolatum	16
	Ink oil	2
	Strip oil	13
	Hi Boiler Oil	2
	Tall Oil	5
	Insulator oil (new)	1
	CPTIC--crude petroleum	8
8	Potash and fertilizers	
	Plastic pellets	78

[a]Cleaning method numbers correspond to those tested in Table 6.

TABLE 8. PRODUCTION OF STEEL DRUMS[a]

Drum			Production, thousands			
Size	Gauge	Type	1972	1973	1974	1975
0.2-m^3 (55-gal)	18	Tight head	10,851	12,032	12,357	8,352
0.2-m^3 (55-gal)	18	Open head	3,231	3,426	3,083	2,066
0.2-m^3 (55-gal)	20/18	Tight head	9,359	9,917	12,349	8,419
0.2-m^3 (55-gal)	20/18	Open head	2,044	2,234	2,484	1,956
0.11-m^3 (30-gal)	20/18	Tight head and open head	2,757	-[b]	-[b]	-[b]

[a] Personal communication from the National Barrel and Drum Association, 1976.
[b] Not available.

Drums constructed of 18-gauge steel have an average life with total cleaning of eight trips. Drums constructed with 20-gauge bodies and 18-gauge heads have an average life of three trips (private communication; estimated by M. Hershon, National Barrel and Drum Association). Not all drums are cleaned, especially those of thinner construction. If all 0.2-m^3 (55-gal) drums were cleaned for their average life, 121 million drums would be cleaned each year.

Tight-head drums which have carried materials that are easy to clean are steamed or washed with caustic. Drums used to carry materials which are difficult to clean are burned out either in a furnace or in the open. Tight-head drums have the head cut out before burning and are reconditioned as open-head drums. Steam cleaning is accomplished by inserting a steam nozzle into the drum, with vapors going to the atmosphere and condensed water going either to a sewer or onto the ground. Caustic washing is done by tumbling the drum with a charge of hot caustic solution and some pieces of chain. The caustic solution is recycled until spent and then neutralized and sent to the sewer. Some cleaners pond the spent caustic to allow sludge settling before sending the liquid to the sewer. The sludge is periodically removed from the pond and landfilled. There are few, if any, air emissions from caustic cleaning.

Fiber drums are lined with disposable plastic bags. Old bags are disposed of in an industrial trash container.

Drum burning furnaces are of two basic types; batch and continuous. A batch-type furnace is designed to hold one 0.2-m^3 (55-gal) drum at a time. The same chamber is used to process 0.11-m^3 (30-gal) drums. Several gas burners are arranged to completely bathe the drum in flame. The contents, lining, and outside paint of the drum are completely burned away within a nominal 4-minute period with the drum reaching a temperature of at least 480°C (5).

Continuous-type furnaces accomplish the same combustion process on each drum but are designed with a conveyor to pass a continuous stream of drums through a preheat zone, a combustion zone, and a postcombustion zone. The drums are given the same 4-minute combustion period at a temperature of at least 480°C. The temperature of the drums must not exceed 540°C since this would cause excessive scale and warping (5).

After the combustibles are consumed, the drums are allowed to cool. They are then shot-peened to remove ash and char. Dents are removed, the drums are tested hydraulically, and protective coatings are applied (5).

Emissions from the combustion process are vented to an afterburner or secondary combustion chamber where the gases are raised to at least 760°C for a minimum of 0.5 second. These conditions should ensure complete combustion of elemental carbon and organic combustion contaminants in the primary effluent (5).

Open air burning is far less efficient than furnace burning because there is no way to control combustion air and temperatures. Since there is no feasible way of controlling emissions from open burning, incompletely burned combustion products can be released to the atmosphere. The average amount of material removed from each drum is approximately 2 kg (5).

GEOGRAPHICAL DISTRIBUTION

Rail Tank Cars

Information on rail tank car cleaning racks from the Railway Progress Institute (personal communication with A. M. Skogsberg, 16 December 1976) and Railway Age Magazine (6) is shown by state in Table 9.

Rail tank cars operated by chemical manufacturing companies to haul their own products or raw materials account for about 10% of car ownership (3). All such cars are in dedicated service and are rarely cleaned. Therefore, the cleaning of tank cars by these companies is estimated to represent less than 5% of the total cleaning nationwide. The cleaning conducted by each of these companies is governed by the waste treatment regulations applicable to its industry.

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(5) Air Pollution Engineering Manual, Second Edition, J. A. Danielson, ed. Publication No. AP-40, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, May 1973. 987 pp.

(6) Railway Age Directory of Contract Car Repair Facilities. Railway Age, 177(13):44-49, 1976.

TABLE 9. RAIL CAR CLEANING BY STATE

State	No. of cleaning racks	No. of cars cleaned/yr
Alabama	2	500
Arkansas	3	3,000
California	5	2,000
Delaware	1	100
Georgia	3	2,000
Illinois	2	2,000
Indiana	2	4,750
Iowa	1	100
Kansas	5	5,000
Kentucky	2	200
Louisiana	3	2,500
Maryland	1	500
Mississippi	1	750
Missouri	2	600
Montana	1	500
Nebraska	2	200
New York	2	1,000
North Carolina	1	75
Ohio	1	1,750
Oklahoma	1	500
Oregon	1	375
Pennsylvania	5	1,850
Tennessee	1	75
Texas	12	5,500
Virginia	1	75
West Virginia	3	1,300
Wyoming	1	20
TOTALS	65	37,220

Tank Trucks

Interior washing of tank trucks in conducted at tank truck dispatch terminals, which are distributed throughout the states, but they are heavily concentrated in areas such as Chicago, Northern New Jersey, the Kanawha and Ohio River Valleys, and the Louisiana-Texas Gulf Coast area where large chemical manufacturing complexes are located (7). There is no adequate data base on how

(7) Final Report on Cost of Implementation and Capabilities of Available Technology to Comply with P.L. 92-500; Volume IV: Industry Categories 29-38. Prepared for the National Commission on Water Quality by Battelle Columbus Laboratories, Columbus, Ohio, July 3, 1975.

many tank truck dispatch terminals actually perform cleaning operations. Many truck fleets are too small to have their own cleaning racks and must have their cleaning done for them at larger terminals. Even the National Tank Truck Carriers organization does not have data that they consider adequate. Based on a limited study of the transportation segment, Battelle/Columbus has estimated that there are about 500 terminals involved in tank truck cleaning (7). Table 10 shows, by state, the distribution of tank truck cleaning, based on Battelle's estimates and other information obtained from conversations with industry members.

Drum Cleaning and Burning

The National Barrel and Drum Association (NBADA) is made up of 133 member companies, 35 of whom have burning facilities. NBADA estimates that the membership comprises at least 90% of the total business and approximately 33.3% of the total number of companies involved in the industry (personal communication with Pamela Terry, NBADA, September 24, 1976). Examination of manufacturing indexes and the yellow pages for several cities indicates that the 1/3 to 2/3 ratio holds fairly well for distribution of locations also. Table 11 shows NBADA member drum cleaning facilities by state. From this information, it is estimated that there are 24,680,000 drums cleaned per year with 10,100,000 of these burned clean. The total number of companies in the United States is estimated at 399 with 39 having burning facilities.

TABLE 10. TANK TRUCK CLEANING BY STATE (7)

State	No. of cleaning terminals	No. of tank trucks cleaned/yr
Alabama	10	81,000
Arizona	3	25,000
Arkansas	10	90,000
California	23	240,000
Colorado	5	55,000
Connecticut	10	82,000
Delaware	3	35,000
Florida	5	50,000
Georgia	6	45,000
Idaho	2	20,000
Illinois	30	290,000
Indiana	25	220,000
Iowa	7	70,000
Kansas	19	172,000
Kentucky	20	195,000
Louisiana	25	250,000
Maine	1	6,500
Maryland	15	110,000
Massachusetts	15	150,000
Michigan	15	160,000
Minnesota	11	120,000
Mississippi	3	30,000
Missouri	10	125,000
Montana	5	45,000
Nebraska	5	40,000
Nevada	1	6,900
New Hampshire	3	15,000
New Jersey	25	300,000
New Mexico	2	19,000
New York	20	190,000
North Carolina	3	35,000
North Dakota	2	19,000
Ohio	20	200,000
Oklahoma	15	150,000
Oregon	2	21,000
Pennsylvania	15	155,000
Rhode Island	2	10,000
South Carolina	5	50,000
South Dakota	3	29,000
Tennessee	8	90,000
Texas	30	400,000
Utah	2	20,000
Vermont	1	8,800
Virginia	15	125,000

(continued)

TABLE 10 (continued)

State	No. of cleaning terminals	No. of tank trucks cleaned/yr
Washington	10	91,000
West Virginia	18	200,000
Wisconsin	10	121,000
Wyoming	5	48,000
TOTALS	500	5,010,000

TABLE 11. NBADA MEMBER DRUM CLEANING AND BURNING BY STATE

State	No. of cleaning facilities	No. of burning facilities	10^3 Drums washed	10^3 Drums burned
Alabama	1	0	84	0
California	14	5	1,454	1,300
Colorado	3	0	251	0
Connecticut	2	0	168	0
Florida	3	0	240	0
Georgia	4	2	450	500
Illinois	7	2	708	530
Indiana	2	0	168	0
Iowa	1	0	83	0
Kansas	1	0	85	0
Kentucky	2	2	280	525
Louisiana	2	0	180	0
Maryland	4	1	392	265
Massachusetts	2	1	225	250
Michigan	5	3	580	785
Minnesota	4	3	508	750
Missouri	2	0	169	0
Nebraska	1	0	85	0
New Hampshire	1	0	80	0
New Jersey	10	2	920	525
New York	10	2	890	500
North Carolina	4	1	380	260
Ohio	15	2	1,390	700
Oklahoma	1	0	100	0
Oregon	1	0	80	0
Pennsylvania	12	3	1,160	720
Rhode Island	1	1	140	230
South Carolina	2	1	225	250
Tennessee	2	0	150	0
Texas	3	1	328	300
Virginia	3	0	240	0
Washington	2	1	224	220
Wisconsin	5	2	531	480
Wyoming	1	0	85	0
TOTAL NBADA members	133	35	13,123	9,090
TOTAL estimate of all drum cleaners	399	39	14,580	10,100

SECTION 4

EMISSIONS

SELECTED POLLUTANTS AND EMISSIONS

The great diversity of commodities (>700 chemicals) carried by rail tank cars, tank trucks, and drums makes it nearly impossible to sample and obtain emission factors for every possible material. In the drum cleaning and burning industry, only composite estimates are possible for a wide mixture of materials.

Sampling of emissions from the cleaning of representative indiviual commodities is practical with tank cars and tank trucks. In order to achieve a practical, but representative, picture of these emissions, the organic chemicals hauled by the carriers were broken down into classes characterized by high, medium, and low viscosities and by high, medium, and low vapor pressures. Viscosity affects the quantity of material remaining in the tank; low viscosity materials drain readily while high viscosity materials do not. Vapor pressure affects the air emissions since high vapor-pressure materials volatilize more readily during cleaning and tend to lead to higher emission rates.

After the classes of chemicals had been established, the selection of the particular chemical to be sampled for was dictated by the specific materials which were being cleaned during the sampling visits. Table 12 presents the chemicals sampled, the total of each per truck or car, and the TLV® (8, 9) (threshold limit value) of each.

Virtually all of the air and water pollutants are removed from the tank during the first washing cycle. This takes 45 minutes to 1 hour for tank trucks and 1 hour to 2 hours for rail tank cars. Subsequent rinsing adds only small (<2% est.) quantities of washing solution to the wastewaters.

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(8) TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1975. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1975. 97 pp.

(9) Sax, N. I. Dangerous Properties of Industrial Materials, Third Edition. Reinhold Book Corporation, New York, New York, 1968. 1251 pp.

TABLE 12. MEASURED EMISSIONS FROM TANK CAR AND TANK TRUCK CLEANING

Compound	Chemical class: Vapor pressure	Chemical class: Viscosity	Total emissions, g[a]	Measured emission concentration, mg/m^3	TLV: mg/m^3	TLV: Ref.
Acetone	High	Low	311/truck	654	2,400	8
Perchloroethylene	High	Low	215/truck	526	670	8
Methyl methacrylate	Medium	Medium	32.4/truck	79.1	410	8
Phenol	Low	Low	5.5/truck	14.0	19	8
Propylene glycol	Low	High	1.07/truck	4.3	260	–[b]
Ethylene glycol	Low	High	<0.32/car	<0.2	260	8
Chlorobenzene	Medium	Medium	15.7/car	8.8	350	8
o-Dichlorobenzene	Low	Medium	75.4/car	94.3	300	8
Creosote	Low	High	2,350/car (8-hr)	118	22	9

[a]Total emissions = (emission rate) x (emission volume).

[b]No TLV listed; assumed to be same as that for ethylene glycol based on comments in Sax (9).

Wastewater is subject to great variability and, even with a good treatment system, is difficult to treat to consistently acceptable levels. Table 13 presents waste treatment plant effluent data (API separator, pH adjustment, aeration basin, sedimentation) for one month of operation supplied by one tank truck terminal official (4). This terminal is adding more treatment process (equalization, air flotation, filtration, biological) to improve their treatment capability.

Another tank truck terminal official reports the treatment plant influent and effluent data shown in Table 14 which represent the results of tests taken over a 6-month operating period (10). This treatment facility (Figure 1) (10) is a 45-m^3/day (12,000-gal/day) demonstration plant funded by the U.S. Environmental Protection Agency.

Reported wastewater treatment data for several rail tank car cleaning stations are shown in Table 4 in Section 3 (3).

Samples taken from the stack of a drum burning furnace were analyzed for unburned organic materials and for organic products from incomplete combustion. Analysis showed no detectable levels (<5 x 10^{-6} g/m^3) of organic materials. This indicates

(10) O'Brien, J. E. A Demonstration Plant for the Treatment of Waste Waters from Tank Truck Cleanings. Presented at the American Institute of Chemical Engineers National Meeting, Atlantic City, New Jersey, September 1, 1976. 8 pp.

TABLE 13. WASTE TREATMENT PLANT EFFLUENT DATA, JUNE 1973 (4)[a]

Date	pH	Total residue, mg/ℓ	TSS, mg/ℓ	VSS, mg/ℓ	BOD, mg/ℓ	COD, mg/ℓ	Temperature, °C	Settleable solids, mg/ℓ
6/1	7.72	1,315	478	120	1,364	3,274	25	96
6/4	6.73	1,199	442	148	460	1,431		30
6/5--2.9" rain	6.94	1,196	342	122	475	1,373		24
6/6	7.45	1,469	1,168	238	61	269	21	548
6/7	7.47	499	175	36	185	268		9
6/8	7.12	548	242	42	40	110	27	12
6/11	8.08	755	49.2	14.8	11.4	66.5	30	0.4
6/12	7.62	677	584	90	8.3	64.8	23	70
6/13	8.06	448	131	20	10.1	30.1		10
6/14	8.90	409	85.6	16.4	13.3	42.2	24	
6/15	7.68	686	262	49	24	94.5	28	15.6
6/18	8.23	573	24	12.8	13.2	69.3	28	12
6/19	8.11	692	32.6	12.4	28	144	28	9.2
6/20	7.92	815	131	33	63	215	28	12.4
6/21	7.95	880	247	44	73	254	26	112
6/22	7.51	4,602	61.2	21.2	25	251	25	13.6
6/25	8.12	2,788	94	29		183	25	8.4
6/26	8.02	2,402	22	26.8		169	23	5.6
6/27	8.36	2,060	73.2	26.8		235	31	4.4
6/28	8.24	1,744	76	20.8		139	26	11.2
Monthly average	7.81	1,288	186	56	17.8	434	26	53

[a]TSS = total suspended solids, VSS = volatile suspended solids, BOD = biochemical oxygen demand, COD = chemical oxygen demand.

NOTE: Some of the quantities in Table 13 are shown per liter (ℓ), which is the system of units used in Reference 4. These values can be converted to the SI metric system using the equality, 1 ℓ = 0.001 m^3. Blanks indicate data not reported.

TABLE 14. TREATMENT PLANT OPERATING RESULTS--
MATLACK, INC., SWEDESBORO, N.J. (10)

Parameter	Raw feed	Effluent
pH	10.5 to 12.5	6.5 to 8.5
Color units	Over 500	10 to 50
Turbidity, FTU[a]	Over 500	-[b]
COD, g/m^3	1,800 to 11,000	125 to 300
BOD_5, g/m^3	600 to 2,000	20 to 100
Oil and grease, g/m^3	110 to 350	0 to 1
Phenols, g/m^3	1 to 250	0.1
Suspended solids, g/m^3	300 to 1,300	-[b]

[a]Formazin turbidity units; a standard unit of turbidity based upon a known chemical reaction.
[b]Data not reported.

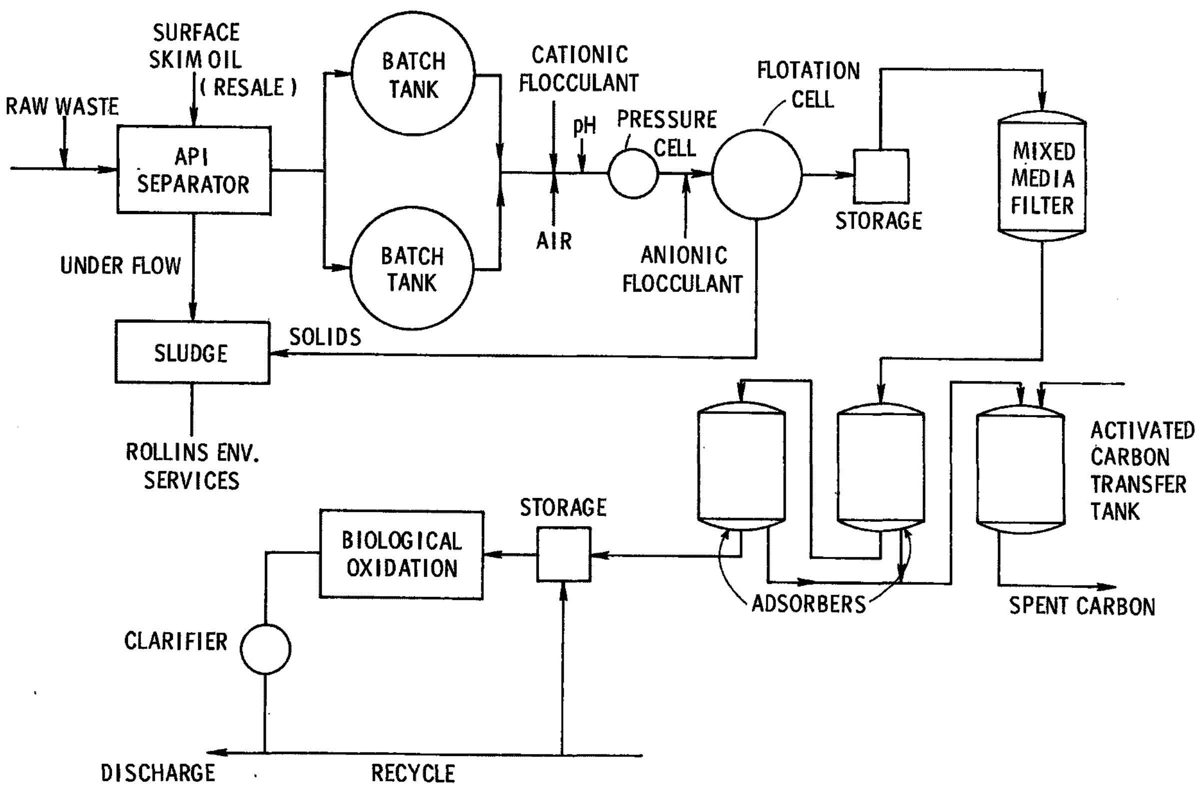

Figure 1. Wastewater treatment system, Matlack, Inc., Swedesboro, New Jersey (10).

that a properly operated furnace is capable of essentially total destruction of waste organic materials encountered in drum burning.

The drum cleaning companies visited had closed drum washing systems with no discharge of wastewaters. It is reasonable to assume that wastewaters from drum washing would present the same treatment problems as those from tank truck and rail tank car cleaning and would be treatable by use of the same basic treatment technology.

DEFINITIONS OF REPRESENTATIVE SOURCES

Four representative sources are defined for use in determining the source severity for each type of cleaning; i.e., rail tank car, tank truck, drum burning and washing, and drum washing only. Due to the lack of adequate published data, these definitions are based on estimates made by several officials of companies in the industry and by the industrial organizations (Railway Progress Institute, and National Barrel and Drum Association).

Representative Rail Tank Car Cleaning

The representative rail tank car cleaner cleans 575 cars/yr (5.5 cars/day). The commodities hauled and cleaned are 35% petroleum products (excluding gasoline, fuel oils, and lubricating oils), 20% organic chemicals, 25% inorganic chemicals, 15% compressed gases, and 5% food products. The emission height (height of car) is 4 m.

Representative Tank Truck Cleaner

The representative tank truck cleaner cleans 10,000 tank truck trailers per year. This is equivalent to 20,000 nondedicated tank trucks cleaned 5 times per week, 50 weeks per year at the 500 cleaning sites (Section 3.). The commodities hauled and cleaned are 15% petroleum products (excluding gasoline, fuel oils and lubricating oils), 35% organic chemicals, 35% inorganic chemicals, 5% food products, and 10% others (paints, inks, naval stores, plastic pellets, etc.) The emission height (height of truck is 3.55 m.

Representative Drum Cleaners

Drum Cleaner with Burning Equipment (Type a)--
The representative drum cleaner with burning equipment cleans approximately 400,000 drums/yr (assuming 260 days/yr, 1,540 drums/day), of which 65% are burned and 35% are washed. Emission heights are 10 m for burning and 1 m for washing.

Drum Cleaner with Washing Only (Type b)--
The representative drum cleaner, with washing only, cleans 83,800 drums per year. Emission height (top of drum) is 1 m.

Both categories of drum cleaners clean drums used to carry a vast variety of commodities, with organic chemicals (including solvents) accounting for 50%. The remaining 50% includes inorganic chemicals, asphaltic materials, elastomeric materials, printing inks, paints, food additives, fuel oils, etc.

ENVIRONMENTAL EFFECTS OF AIR EMISSIONS

Maximum Ground Level Concentrations

The maximum ground level concentration, χ_{max}, of each pollutant resulting from rail tank car and tank truck cleaning and from drum burning and washing was estimated by Gaussian plume dispersion meteorology. χ_{max} values for each type of cleaning are shown in Table 15. For comparison, the TLV's and ambient air quality standards (AAQS) are also listed. Air emissions from drum washing are negligible since each drum is washed by charging with cleaning solution, putting in some chain, closing the drum, and tumbling it. During this cycle, no vapors can escape except during charging and dumping. Emission rates would therefore be less than in rail car and tank truck cleaning, and these are shown in Table 15 to be extremely low.

Sampling and analysis for organic materials in the stack gases from drum furnaces show no detectable organics present (detection limit 5 x 10^{-6} g/m^3). The primary combustion chamber operates at less than 530°C with 200% excess air. Secondary combustion is accomplished at approximately 700°C with 100% excess air. These conditions are conducive to complete combustion of the organic materials in the drums, but the temperatures are low enough to prevent the formation of large quantities of nitrogen oxides (NO_x). Also, the concentrations of carbon monoxide (CO) and particulates would be small. Automobile body incinerators operate at conditions analagous to drum furnace conditions but with less excess air. Using emission factors for particulates and NO_2 from auto body incinerators (11), the emission factors from drum burning are estimated (see Appendix A). Maximum ground level concentrations are not given for organics, carbon monoxide, or hydrocarbons since the stack concentrations are below detection.

The following equation was used for the calculation of χ_{max} (12):

$$\chi_{max} = \frac{2\,Q}{\pi H^2 e \bar{u}} \qquad (1)$$

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(11) Compilation of Air Pollutant Emission Factors, Second Edition. Publication No. AP-42, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, April 1973. p. 2.2.-1.

where Q = mass emission rate, g/s
$\bar{u}$ = U.S. average wind speed, 4.47 m/s
H = emission height, m
e = 2.72
π = 3.14

Environmental Effects

To obtain an indication of the hazard potential of the emission source, the source severity, S, is defined as (12):

$$S = \frac{\bar{\chi}_{max}}{F} \qquad (2)$$

where $\bar{\chi}_{max}$ is the time-averaged maximum ground level concentration of each pollutant emitted from a representative source of tank or for criteria pollutants and "a corrected" threshold limit value (TLV • 8/24 • 1/100) for noncriteria pollutants. The source severity represents the ratio of time-averaged maximum ground level exposure to the hazard level of exposure for a particular pollutant.

$\bar{\chi}_{max}$ is the maximum ground level concentration (χ_{max}) averaged over a given period of time. The averaging time is 24 hours for noncriteria pollutants. For criteria pollutants, averaging times are the same as those used in the primary ambient air quality standards.

For the tank truck and rail tank car cleaning operations, the time periods during which emissions occur are approximately 1 hr for tank trucks and 2 hr for rail tank cars. These times correspond to the initial wash cycle of each carrier. Since it is rare for more than one truck or car containing a particular material to be cleaned in any one day, time-averaging of χ_{max} for that particular pollutant over a 24-hr period would result in an extremely low $\bar{\chi}_{max}$ and S. Using χ_{max} in place of $\bar{\chi}_{max}$ in Equation 1 gives a worst case source severity which represents the maximum hazard level of exposure for a particular pollutant at any time during a normal 24-hr period.

The values for $\bar{\chi}_{max}$ and S for each pollutant from each type of cleaning are given in Table 15. The worst case source severity factors for the pollutants from tank truck cleaning are <0.1 for

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(12) Serth, R. W., and T. W. Hughes. Source Assessment: Phthalic Anhydride (Air Emissions). EPA-600/2-76-032d, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, December 1976. 154 pp.

most classes of materials and just over 0.1 for the high vapor-pressure, low viscosity class. For rail tank car cleaning, the worst case source severity factors are <0.1 with the materials sampled except for one creosote car which was exceptionally dirty.

TABLE 15. MAXIMUM GROUND LEVEL CONCENTRATIONS AND SEVERITY FACTORS FOR DIFFERENT EMISSIONS

Type of cleaning	Emission	χ_{max}, µg/m³	TLV, g/m³	AAQS, (13) g/m³	Source severity
Tank truck	Acetone	359	2.4	-[a]	0.045
	Perchloroethylene	248	0.67	-[a]	0.11
	Methyl methacrylate	37	0.41	-[a]	0.027
	Phenol	6.35	0.019	-[a]	0.100
	Propylene glycol	1.24	0.26	-[a]	0.0014
Rail tank car	Ethylene glycol	<0.14	0.26	-[a]	0.00017
	Chlorobenzene	7.14	0.35	-[a]	0.0061
	o-Dichlorobenzene	34.3	0.3	-[a]	0.034
	Creosote	267	0.022	-[a]	3.6
Drum burning	Particulates	73	-[b]	0.00026[c]	0.28
	NO_x	1.2	-[b]	0.0001[d]	0.012

[a]AAQS not defined for these materials.

[b]Not applicable.

[c]24-hr average.

[d]Annual average.

For drum burning, the source severity factors are very low with particulates accounting for the highest severity of 0.56. Severity distributions for air emissions are not presented since estimates were used to define the representative source. A survey of the industry would be required to define ranges or limits on source size and this would necessitate an extensive effort.

Contribution to Total Air Emissions

The total air emissions from a particular source for each state and the nation are determined by multiplying the emission factor

(13) Code of Federal Regulations, Title 42 - Public Health, Chapter IV - Environmental Protection Agency, Part 410 - National Primary and Secondary Ambient Air Quality Standards, April 28, 1971. 16 pp.

of a pollutant by the source production. For tank truck and rail tank car cleaning, since the exact distribution of the representative chemical classes in total cleaning is unavailable, the emission factor for acetone (the highest measured) was used to calculate state and national burdens for tank truck cleaning; the emission factor for creosote was used for rail tank car cleaning. The total organic emissions from tank truck and rail tank car cleaning in each state were compared with the reported total hydrocarbon emission burden for that state (14), and these are shown in Table 16. Tank truck and rail tank car cleaning contribute <0.02% to the organic pollutant burden of the states or nation. Total hydrocarbon emissions from drum washing or burning are negligible. Total particulate emissions from drum burning contribute <0.023% of any state emission burden and 0.0007% of national emissions burden (Table 17).

Affected Population

To obtain a quantitative evaluation of the population influenced by a concentration of emissions from a source, the area exposed to the time-averaged ground level concentration, $\overline{\chi}$, for which $\overline{\chi}/F \geq 1.0$ is obtained by determining the area within the isopleth for $\overline{\chi}$ (15), and the number of people within the exposed area is then calculated by using a proper population density.

As shown in Table 15, the source severities (except for creosote) from rail tank car and tank truck cleaning, and from drum washing and burning are below 1.0, even though these are worst case calculations. When no area is exposed to a severity ≥1.0, the affected population for these operations is zero. The creosote emission was from an exceptionally dirty car and is not considered to be typical of the industry.

ENVIRONMENTAL EFFECTS OF WATER POLLUTANTS

Effluent Concentration

The effluent concentrations, C_D, are defined as the total mass of suspended or dissolved material in a unit volume of effluent at

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(14) Eimutis, E. C., and R. P. Quill. Source Assessment: State-by-State Listing of Criteria Pollutant Emissions. EPA-600/2-77-107b, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, July 1977. 146 pp.

(15) Turner, D. B. Workbook of Atmospheric Dispersion Estimates. Public Health Service Publication No. 999-AP-26, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio, 1969. 64 pp.

TABLE 16. MASS OF EMISSIONS FROM TANK TRUCK AND RAIL TANK CAR CLEANING AND COMPARISON WITH STATE AND NATIONAL HYDROCARBON EMISSION BURDENS

State	Carriers hauling organics, no. cleaned		Total emissions, metric tons/yr		Percent of state (14) hydrocarbon burden	
	Trucks	Rail cars	Trucks	Rail cars	Trucks	Rail cars
Alabama	28,350	100	8.82	0.24	0.0014	0.00004
Arizona	8,750	0	2.72	0	0.0014	0
Arkansas	31,500	600	9.80	1.41	0.0050	0.00072
California	84,000	400	26.12	0.94	0.0012	0.00004
Colorado	19,250	0	6.00	0	0.0031	0
Connecticut	28,700	0	8.93	0	0.0041	0
Delaware	12,250	20	3.81	0.05	0.0060	0.00008
Florida	17,500	0	5.44	0	0.0009	0
Georgia	15,750	400	4.90	0.94	0.0011	0.00021
Idaho	7,000	0	2.18	0	0.0026	0
Illinois	101,500	400	31.57	0.94	0.0017	0.00005
Indiana	77,000	950	23.95	2.23	0.0040	0.00037
Iowa	24,500	20	7.62	0.05	0.0024	0.00002
Kansas	60,200	1,000	18.72	2.35	0.0060	0.00076
Kentucky	68,250	40	21.23	0.09	0.0065	0.00003
Louisiana	87,500	500	27.21	1.18	0.0014	0.00006
Maine	2,275	0	0.71	0	0.0006	0
Maryland	38,500	100	11.97	0.24	0.0040	0.00008
Massachusetts	52,500	0	16.33	0	0.0037	0
Michigan	56,000	0	17.42	0	0.0024	0
Minnesota	42,000	0	13.06	0	0.0032	0
Mississippi	10,500	150	3.27	0.35	0.0017	0.00018
Missouri	43,750	120	13.61	0.28	0.0033	0.00007
Montana	15,750	100	4.90	0.24	0.0018	0.00009
Nebraska	14,000	40	4.35	0.09	0.0034	0.00007
Nevada	2,415	0	0.75	0	0.0014	0

(continued)

TABLE 16 (continued)

State	Carriers hauling organics, no. cleaned		Total emissions, metric tons/yr		Percent of state (14) hydrocarbon burden	
	Trucks	Rail cars	Trucks	Rail cars	Trucks	Rail cars
New Hampshire	5,250	0	1.63	0	0.0018	0
New Jersey	105,000	0	32.66	0	0.0040	0
New Mexico	6,650	0	2.07	0	0.0014	0
New York	66,500	200	20.68	0.47	0.0016	0.0004
North Carolina	12,250	25	3.81	0.06	0.0009	0.0001
North Dakota	6,650	0	2.07	0	0.0029	0
Ohio	70,000	0	21.77	0	0.0019	0
Oklahoma	52,500	100	16.33	0.24	0.0048	0.00007
Oregon	7,350	55	2.29	0.13	0.0010	0.00006
Pennsylvania	54,250	720	16.87	1.69	0.0019	0.00019
Rhode Island	3,500	0	1.09	0	0.0017	0
South Carolina	17,500	0	5.44	0	0.0006	0
South Dakota	10,150	0	3.16	0	0.0035	0
Tennessee	31,500	25	9.80	0.06	0.0027	0.00002
Texas	140,000	1,100	43.54	2.59	0.0020	0.00012
Utah	7,000	0	2.18	0	0.0022	0
Vermont	3,080	0	0.96	0	0.0023	0
Virginia	43,750	25	13.61	0.06	0.0037	0.00002
Washington	31,850	0	9.91	0	0.0029	0
West Virginia	70,000	220	21.77	0.52	0.0187	0.00045
Wisconsin	42,350	0	13.17	0	0.0025	0
Wyoming	16,800	4	5.22	0.01	0.0094	0.00002
NATIONAL	1,730,000	7,440	538.05	87.47	0.0022	0.00037

TABLE 17. MASS OF EMISSIONS FROM DRUM BURNING AND COMPARISONS WITH STATE AND NATIONAL PARTICULATE EMISSION BURDENS

State	No. of barrels burned	Total emissions, metric ton/yr	Percent of state particulate burden
California	1,400,000	16.8	0.0017
Georgia	550,000	6.6	0.0017
Illinois	590,000	7.0	0.0007
Kentucky	580,000	7.0	0.0013
Maryland	290,000	3.5	0.0007
Massachusetts	280,000	3.3	0.0034
Michigan	870,000	10.3	0.0014
Minnesota	830,000	9.9	0.0037
New Jersey	580,000	7.0	0.0046
New York	550,000	6.6	0.0041
North Carolina	290,000	3.5	0.0007
Ohio	780,000	9.2	0.0006
Pennsylvania	800,000	9.5	0.0005
Rhode Island	260,000	3.0	0.023
South Carolina	280,000	3.3	0.0017
Texas	330,000	4.0	0.0008
Washington	240,000	2.9	0.0018
Wisconsin	530,000	6.4	0.0015
TOTAL	10,100,000	119.6	0.0007

a given temperature and pressure. In the raw effluent from representative cleaning operations, C_D was estimated on the basis of available information. Concentrations for rail tank car cleaning were taken as the average of the values shown for the first site in Table 4. This site, except for cleaning more cars, closely approximate the representative source. For tank truck cleaning, the raw effluent averages shown in Table 14 were used since this terminal's cleaning operation is similar to the representative source (30 trucks/day versus 40/day for the representative plant). No effluent concentration data were available for drum washing operations. The assumption was made, therefore, that the total material cleaned from drums was distributed in the same percentage ratios as the effluents from tank trucks with no allowance made for removal of settleable solids (see Appendix A). The C_D values for all of these representative cleaning operations along with effluent flow rates are shown in Table 18.

Source Severity

Determination of the source severity for the representative sources gives a measure of the effluent species concentration relative to a potentially hazardous or permissible concentration. The source severity (defined in Appendix B) is calculated as follows (16):

$$S = \frac{C}{F} = \frac{\left(\frac{V_D}{V_R}\right)C_D}{F} \qquad (3)$$

where C = exposure level concentration, g/m^3[a]
F = hazard factor (Table 18)
V_D = volumetric flow rate of discharge, m^3/s
V_R = volumetric flow rate of receiving waters, m^3/s (national average river flow rate = 856 m^3/s)
C_D = concentration in raw effluent, g/m^3

Severity values were calculated using Equation 3 for oil and grease, phenol, and suspended solids for each of the representative sources, and these are shown in Table 19. The severity of the total oxygen demand potential (S_{TOD}) of a discharge is the ratio of the potential total oxygen deficit divided by a permissible total oxygen deficit. Thus, Equation 3 was modified as follows to permit calculation of the severity of the total oxygen demand of a discharge (17):

$$S_{(TOD)} = \frac{\frac{V_D}{V_R}(TOD)}{C_S - (DO)_{WQC}} \qquad (4)$$

where TOD = total effluent oxygen demand, g/m^3
C_S = saturated dissolved oxygen concentration at 10°C (= 11.3 g/m^3)
$(DO)_{WQC}$ = dissolved oxygen fresh water quality criteria (= 5.0 g/m^3)

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[a] g/m^3 is equivalent to mg/ℓ, which is the normal nonmetric unit used for concentration.

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(16) Decision Criteria for Water Discharges. Draft prepared for EPA review under Contract 68-02-1874 by Monsanto Research Corporation, Dayton, Ohio, 1976. 4 pp.

(17) Eimutis, E. C., T. J. Hoogheem, and T. W. Hughes. Briefing Document: Water Source Severity and Initial Water Prioritization Structures. Draft prepared under EPA Contract 68-02-1874 by Monsanto Research Corporation, Dayton, Ohio, September 21, 1976. 12 pp.

TABLE 18. EFFLUENT CONCENTRATIONS (C_D) AND HAZARD FACTORS (F) FOR REPRESENTATIVE SOURCES

Source	Effluent concentrations, g/m^3 Oil and grease	COD	Phenol	Suspended solids	Flow, m^3/day
Rail tank cars	2,005	20,100	75	10,025	61
Tank trucks	230	6,400	130	800	45
Drums, type a	148	4,130	84	517	25
Drums, type b	148	4,130	89	517	15
Hazard factor, F[a]	0.01 (18)	6.3[b]	0.001 (18)	25 (18)	

[a] EPA fresh water criteria or equivalent.

[b] $[C_S - (DO)_{WQC}]$ factor in Equation 4, allowable dissolved oxygen depletion.

TABLE 19. SOURCE SEVERITIES FOR REPRESENTATIVE SOURCES

Source type[a]	Source severity Oil and grease	TOD	Suspended solids	Phenol
Rail tank car	0.16	0.0034	0.00033	0.062
Tank truck	0.014	0.00081	0.000020	0.080
Drums, type a,b	0.0030	0.00017	0.000004	0.017

[a] The representative sources have been defined in Section 4.

Since TOD values are not available, Equation 4 was modified to (17):

$$S_{TOD} = \frac{\frac{V_D}{V_R} \, 1.3 \, (COD)}{[C_S - (DO)_{WQC}]} \qquad (5)$$

where COD = chemical oxygen demand, g/m^3

Severity values for TOD are shown in Table 19 for each of the representative sources. In all of the source severity determinations, the assumption was made that the raw effluent was

(18) Quality Criteria for Water. EPA-440/9-76-023, U.S. Environmental Protection Agency, Washington, D.C. 501 pp.

discharged with no treatment, thus giving a worst case determination. In practice, oil and grease separation and batch treatment of phenol provide a lower actual impact than the calculations indicate. Reductions in oxygen demand and suspended solids are also accomplished in the treatment processes used by the different cleaning facilities so these impacts are in practice, lower than the calculations indicate. Severities are low in all cases with the highest value being 0.16. Severity distributions for effluent species are not presented since estimates were used to define the representative source. A survey of the industry would be required to define ranges or limits on source size and this would necessitate an extensive effort.

Contribution to State and National Burdens

The total discharge quantities of oil and grease, COD, phenol, and suspended solids, assuming no treatment, were calculated by dividing the production of the representative source into state production totals and multiplying this by the discharge per representative source. These quantities are shown, by state and nation, for each type of cleaning operation in Tables 20, 21, and 22.

TABLE 20. RAIL TANK CAR CLEANING CONTRIBUTIONS TO STATE EMISSION BURDENS

State	Cars/yr	Oil and grease, metric tons/yr	COD, metric tons/yr	Suspended solids, metric tons/yr	Phenol, metric tons/yr
Alabama	500	11	110	56	0.42
Arkansas	3,000	67	670	330	2.5
California	2,000	44	440	220	1.7
Delaware	100	2.2	22	11	0.083
Georgia	2,000	44	440	220	1.7
Illinois	2,000	44	440	220	1.7
Indiana	4,750	106	1,100	530	3.9
Iowa	100	2.2	22	11	0.083
Kansas	5,000	110	1,100	560	4.2
Kentucky	200	4.4	44	22	0.17
Louisiana	2,500	56	550	280	2.1
Maryland	500	11	110	56	0.42
Mississippi	750	17	170	83	0.62
Missouri	600	13	130	67	0.50
Montana	500	11	110	56	0.42
Nebraska	200	4.4	44	22	0.17
New York	1,000	22	220	110	0.83
North Carolina	75	1.7	17	18.3	0.062
Ohio	1,750	39	389	194	1.5
Oklahoma	500	11	110	56	0.42
Oregon	375	8.3	83	42	0.31
Pennsylvania	1,850	41	410	206	1.5
Tennessee	75	1.7	17	8.3	0.062
Texas	5,500	120	1,200	610	4.6
Virginia	75	1.7	17	8.3	0.062
West Virginia	1,300	29	290	140	1.1
Wyoming	20	0.4	4.4	2.2	0.017
TOTALS	37,220	830	8,300	4,100	31

TABLE 21. TANK TRUCK CLEANING CONTRIBUTIONS TO STATE EMISSION BURDENS

State	Cars/yr	Oil and grease, metric tons/yr	COD metric tons/yr	Suspended solids, metric tons/yr	Phenol, metric tons/yr
Alabama	81,000	28	785	98	16
Arizona	25,000	8.7	242	30	4.9
Arkansas	90,000	31	872	109	18
California	240,000	84	2,326	291	47
Colorado	55,000	19	533	67	11
Connecticut	82,000	29	794	99	16
Delaware	35,000	12	339	42	6.9
Florida	50,000	17	484	61	9.8
Georgia	45,000	16	436	54	8.9
Idaho	20,000	7	194	24	3.9
Illinois	290,000	101	2,810	351	57
Indiana	220,000	77	2,131	266	43
Iowa	70,000	24	678	85	14
Kansas	172,000	60	1,667	208	34
Kentucky	195,000	68	1,890	236	38
Louisiana	250,000	87	2,422	303	49
Maine	6,500	2.3	63	7.9	1.3
Maryland	110,000	38	1,066	133	22
Massachusetts	150,000	52	1,453	182	30
Michigan	160,000	56	1,550	194	32
Minnesota	120,000	42	1,163	145	24
Mississippi	30,000	10	291	36	5.9
Missouri	125,000	44	1,211	151	25
Montana	45,000	16	436	54	8.9
Nebraska	40,000	14	388	48	7.9
Nevada	6,900	2.4	67	8.4	1.4
New Hampshire	15,000	5.2	145	18	3
New Jersey	300,000	104	2,907	363	59
New Mexico	19,000	6.6	184	23	3.7
New York	190,000	66	1,841	230	37
North Carolina	35,000	12	339	42	6.9
North Dakota	19,000	6.6	184	23	3.7
Ohio	200,000	70	1,938	242	39
Oklahoma	150,000	52	1,453	182	30
Oregon	21,000	7.3	204	25	4
Pennsylvania	155,000	54	1,502	188	30
Rhode Island	10,000	3.5	97	12	2
South Carolina	50,000	17	484	61	9.6
South Dakota	29,000	10	281	35	5.7
Tennessee	90,000	31	872	109	18
Texas	400,000	139	3,876	484	79
Utah	20,000	7	194	24	3.9
Vermont	8,800	3.1	85	11	1.7
Virginia	125,000	44	1,211	151	25
Washington	91,000	32	882	110	18
West Virginia	200,000	70	1,938	242	39
Wisconsin	121,000	42	1,172	147	24
Wyoming	48,000	17	465	58	9.4
TOTALS	5,010,000	1,745	48,545	6,068	986

TABLE 22. DRUM WASHING CONTRIBUTION TO STATE EMISSION BURDENS

State	10^3 Drums/yr	Oil and grease, metric tons/yr	Suspended solids, metric tons/yr	COD, metric tons/yr	Phenol, metric tons/yr
Alabama	93	0.65	2.2	18	0.37
California	1,616	11.2	39.1	313	6.36
Colorado	279	1.9	6.8	54	1.1
Connecticut	187	1.3	4.5	36	0.74
Florida	267	1.9	6.5	52	1.0
Georgia	500	3.5	12	97	2.0
Illinois	787	5.5	19	152	3.1
Indiana	187	1.3	4.5	36	0.74
Iowa	92	0.64	2.2	18	0.36
Kansas	94	0.65	2.3	18	0.37
Kentucky	311	2.2	7.5	60	1.2
Louisiana	200	1.4	4.8	39	0.79
Maryland	436	3.0	10	84	1.7
Massachusetts	250	1.7	6.0	48	0.98
Michigan	644	4.5	16	125	2.5
Minnesota	564	3.9	14	109	2.2
Missouri	188	1.3	4.6	36	0.74
Nebraska	94	0.65	2.3	18	0.37
New Hampshire	89	0.62	2.2	17	0.35
New Jersey	1,022	7.1	24.8	198	4.02
New York	989	6.9	24	192	3.9
North Carolina	422	2.9	10	82	1.7
Ohio	1,544	10.8	37.4	299	6.08
Oklahoma	111	0.77	2.7	21	0.44
Oregon	89	0.62	2.2	17	0.35
Pennsylvania	1,289	8.97	31.2	250	5.07
Rhode Island	156	1.1	3.8	30	0.61
South Carolina	250	1.7	6.1	48	0.98
Tennessee	167	1.2	4.0	32	0.66
Texas	361	2.5	8.7	70	1.4
Virginia	267	1.9	6.5	52	1.1
Washington	249	1.7	6.0	48	0.98
Wisconsin	590	4.1	14	114	2.3
Wyoming	94	0.65	2.3	18	0.37
TOTALS	14,580	101	353	2,824	57

SECTION 5

CONTROL TECHNOLOGY

PRESENT TECHNOLOGY

Practical and economically feasible control of air emissions from the cleaning of rail tank cars and tank trucks does not exist at present except for combustible gases and for water-soluble vapors such as ammonia and chlorine. Tanks carrying combustible gases are filled completely. The displaced gases from the tank are sent to a flare and burned. Vapors of materials such as ammonia and chlorine are absorbed in water and sent to the wastewater stream.

Air emissions from drum burning furnaces are controlled by proper operation of the afterburner or secondary combustion chamber of the furnace. There is no feasible control for emissions from open burning of drums. Solution washing of drums yields no air emissions since the drum is closed during the wash cycle. There is currently no control used for emissions from steaming of drums. Most of the material from the drums is carried off with the condensate water, and the air emission is dissipated to the atmosphere.

Until the late 1960's little attention was given to wastewater treatment in the rail tank car, tank truck, and drum reclaiming industries. This inattention resulted because the wastewaters were generally low in volume, installations were small, and environmental impacts were considered relatively small in comparison to those of other industrial pollution sources. Wastewater from an estimated two-thirds of the installations was directed to municipal treatment systems. The rest were discharged directly to surface water streams with only some oil separation.

In recent years, both the rail and truck industries have been making a serious effort to improve their wastewater treatment capabilities. No installation is known to have a completely satisfactory treatment system. State-of-the-art treatment technology applicable to rail and truck wastewaters is, for the most part, well known and has been used by manufacturing industries for several years. Wide diversity in the materials entering the wastewaters prevents the use of a single specific treatment system by all companies. For this reason, tank car and tank truck cleaning companies are approaching their individual problems by using one or more combinations of the methods described below in a building block approach to develop alternate treatment schemes.

Gravity Separation

Free oil enters the wastewaters from tank contents, exterior washing of tanks, and from leaks or spills. This is removed by gravity separation and incinerated or given to a contracting waste scavenger. The American Petroleum Institute (API) separator design is the most widely used. This separator is a long, rectangular basin which provides enough retention time for the oil to float to the surface for removal. API separators are divided into bays to maintain laminar flow and prevent short circuiting. They are equipped with skimmers that move the oil to the downstream end where it is collected in a slotted pipe or drum. When returning to the upstream end, the skimmers travel along the bottom and move settled solids into a collection trough. The sludge is dewatered and then incinerated or disposed of in a landfill, with the water going to the next treatment step.

There are several other designs of gravity separators but the differences only amount to different geometries.

Gravity separation is only effective for nonemulsified free oil; emulsified oil is not removed. Other factors affecting the efficiency of gravity separation are temperature, oil density, and suspended solids content. Oil removal also takes out some phenols, BOD, and COD since some organics are miscible with oil.

Equalization

For ease of operation and for a more constant quality of wastewater, the flow and waste concentration to mixed chemical treatment systems should be as uniform as possible. Large fluctuation should be dampened in equalization facilities.

Equalization is provided in holding tanks or ponds with a retention capacity of 1 day or longer. Baffles and mixers are used to improve equalization. Holding ponds are sometimes used to provide final treatment, relying on long retention times (several days) for settling and biological oxidation. Removal efficiencies vary widely: 5% to 40% for BOD_5, 5% to 30% for COD, 20% to 90% for oil, 10% to 80% for suspended solids, 0% to 70% for phenol, and 30% to 70% for odor (19).

Wastewater is directed from the holding basin to an emulsion-breaking and dissolved air-flotation chamber to remove emulsified oils and suspended solids.

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(19) Manual on Disposal of Refinery Wastes. American Petroleum Institute, Washington, D.C., 1969.

Emulsion Breaking

This operation can employ either chemical or physical methods. Physical methods include electrolysis, coalescence, filtration, centrifugation, distillation, and temperature change. Chemical methods, aimed at breaking down the stabilizing agent in the emulsion, are more satisfactory.

The most practical method of chemically breaking emulsions involves the addition of an acid or acid salt such as sulfuric acid, alum, ferrous sulfate, or ferric chloride. Soda ash may then be used to neutralize the separated water. The resulting free oil and alum or iron floc can be separated by sedimentation or air flotation.

Dissolved Air Flotation

This process consists of saturating a portion of the wastewater feed, or some of the recirculated effluent from the flotation unit, with air at a gage pressure of 275 kPa to 415 kPa (40 psi to 60 psi). The wastewater or recycled effluent is held at this pressure for 1 minute to 5 minutes in a retention tank and then released at atmospheric pressure to the flotation chamber. The sudden reduction in pressure releases air bubbles less than 100 µm in diameter which attach themselves to the oil and suspended particles in the wastewater. The resulting agglomerates are then buoyed to the surface to form a froth layer which is removed by skimming devices. The retention time in the flotation chamber is usually 15 minutes to 40 minutes. The addition of flocculating agents, such as polyelectrolytes, often improves the effectiveness of the air flotation process and clarification.

Coagulation

Coagulation consists of adding chemicals to the wastewater to create fast-settling agglomerates or floes from finely divided and slow-settling particles. Chemical coagulation and sedimentation can be used to treat the effluent from a gravity separator prior to biological treatment.

The chemical coagulation-sedimentation process has three essential steps. First, chemicals and/or polyelectrolytes are added in a flash mix tank for 1 minute to 3 minutes. Next, the wastewater is gently stirred in a flocculation basin for 10 minutes to 30 minutes so that flocs grow large enough to settle readily. Finally, the agglomerated sludge is separated in a clarifier or settling basin. This process is capable of giving results comparable to those of dissolved air flotation in removing oils, solids, BOD, and COD.

When operated properly, dissolved air flotation with chemical coagulation can produce an effluent having an oil content of less than 10 g/m^3. The reduction of organic pollutants may be incidental to the removal of oil and suspended solids. BOD_5 reduction can range from 20% to 70% (4).

The effluent from flotation-coagulation systems or from primary settling may be further treated biologically in aerated lagoons, or by trickling filters, or by activated sludge. Some tank truck cleaners are trying biological treatment at the present time. Activated carbon adsorption is being used as an alternative to biological treatment.

Aerated Lagoon

Aerated biological treatment is achieved by mixing dilute concentrations of microorganisms with wastewater in a large basin. The oxygen necessary to aerobically degrade the organic matter is supplied by mechanical or diffused aeration units, or by induced surface aeration. The turbulence normally maintained distributes the oxygen and biological solids throughout the basin.

An aerated lagoon differs from an activated sludge unit in that the effluent from the aerated lagoon may not be settled prior to discharge, and the biological solids are not recirculated. The low rate of organic removal resulting from the low concentration of biological solids maintained in the lagoon requires a greater retention time for an equivalent reduction in BOD than is the case with activated sludge. An aerated lagoon is capable of removing 50% to 95+% of BOD_5, depending on temperature and pollutant treatability (4). The removal efficiencies may be improved by further treating the lagoon effluent using chemical coagulation, sedimentation, filtration, or an effluent polishing pond.

Trickling Filter

In this process, wastewater is passed through a porous bed (stones or plastic) that contains a fixed growth of microorganisms. A microbial film develops on the surface of the filtering medium and removes organic materials from the wastewater by adsorption, bioflocculation, and sedimentation. Oxygen is very important in this system (as it is in any aerobic biological system) for rapid metabolism of the removed organic matter. Since the filter medium has a large surface area, oxygen can move readily by simple diffusion from the void spaces into the liquid layer. Treatment rates of trickling filters are controlled by both hydraulic and organic loading rates. Stone trickling filters are limited, due to the low flow rates involved, to depths between 1 m and 3 m. Those using plastic generally have high hydraulic and organic loadings, and their bed depths range from 5 m to 12 m. A modification of the trickling filter, used at one treatment system visited, consists of a large, rotating, cylindrical cage, mounted horizontally and partially submerged, carrying plastic rings. The rotation of the cage constantly renews the oxygen and maintains a high trickle rate.

As the microbial film ages and dies on the medium, it drops off and is washed away. With high organic and hydraulic loadings, the film growth is more rapid. However, the lack of oxygen in the medium interface coupled with greater hydraulic shearing action causes the microbial film to wash from the media surface continuously. A final clarifier is normally used to remove these solids from the filter effluent to maintain minimum effluent BOD and suspended solids concentration.

Activated Sludge

In this process, high concentrations (1.5 kg/m^3 to 3 kg/m^3) of newly grown and recycled microorganisms are suspended uniformly throughout a holding tank to which raw wastewaters are added. Oxygen is introduced by mechanical aerators, diffused air systems, or other means. The organic materials in the waste are removed from the aqueous phase by the microbiological growths and stabilized by biochemical synthesis and oxidation reactions. The basic activated sludge process involves the use of an aeration tank followed by a sedimentation tank. The flocculant microbial growths removed in the sedimentation tank are recycled to the aeration tank to maintain a high concentration of active microorganisms. Although the microorganisms remove almost all of the organic matter from the waste being treated, much of the converted organic matter remains in the system in the form of microbial cells. These cells have a relatively high rate of oxygen demand and must be removed from the treated wastewater before it is discharged.

Activated Carbon Adsorption

This is one of the most effective methods for removing from wastewaters countless dissolved organic materials (both biodegradable and refractory) which contribute to BOD, COD, and taste and odor problems. In a few existing units, biologically treated effluent is passed through vessels filled with granular, activated carbon. In another unit visited, powdered activated carbon is added along with coagulation chemicals into a tank following biological treatment. It has been demonstrated in pilot units that raw wastes, which have been given chemical coagulation (with sedimentation or filtration) to remove suspended solids, can be processed by carbon adsorption to provide almost any level of treatment (20). The carbon gradually loses its adsorptive capacity as it accumulates organic materials from the wastewater and must be eventually replaced. To make the process more economi-

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(20) Process Design Manual for Upgrading Existing Wastewater Treatment Plants. Contract 14-12-933, U.S. Environmental Protection Agency, October 1971.

cal the spent carbon is usually reactivated and the bed replenished with new carbon. Frequently multiple adsorption colums are utilized in series or in parallel so that at least one unit may be pulled out of service for replenishment. Moving bed carbon filters are sometimes used to eliminate the spare colums required for regeneration and to produce more consistent effluent, but there seem to be problems involved in the countercurrent movement of the carbon particles. Unlike biological treatment processes, the efficiency of carbon treatment is not very sensitive to seasonal temperature changes. In most cases, the combined use of coagulation, filtration, and carbon adsorption is more reliable and controllable than biological treatment.

Granular Media Filtration

The media used in granular filters, either pressurized or gravity, may consist of 1) sand, 2) sand and coal, or 3) sand, coal, and a heavy fine material such as garnet. When the medium is sand, a relatively uniform grade of sand rests on a layer of coarser sand or fine gravel. When the medium is sand and coal, a layer of fine sand rests on a layer of medium coal. These two types of filters present the problem of keeping the fine sand from moving through the coarse layer to the bottom. This problem can usually be solved by placing a layer of garnet between the fine and coarse layers. This comprises the third medium listed above. Periodically, the top sand layer is removed for landfilling and is replaced with fresh sand.

Granular media filters are capable of producing an effluent which consistently shows extremely low suspended solids and oil content on the order of 5 g/m^3 to 10 g/m^3 for each (4).

Batch Treatment of Individual Waste Streams

Sometimes, wastes are encountered which are not effectively treated by the above processes or even interfere with them. Metals and cyanide wastes are examples. Normally they occur intermittently and in relatively small quantities, making them amenable to batch treatment prior to discharge to surface waters or before mixing with other wastes for further treatment. Chromium wastes, for example, can be treated with sulfuric acid and sulfur dioxide to reduce hexavalent chromium to trivalent, which can then be discharged for precipitation in the coagulation-sedimentation system described previously. Cyanides can be subjected to alkaline chlorination destruction. At one facility, phenol wastewaters are segregated and treated with ozone before discharge to the regular wastewater treatment system. Phenol concentrations are reduced from as high as 30 kg/m^3 to less than 5 g/m^3 (4).

Ponds or Lagoons

Wastewater treatment in ponds or lagoons is a common practice in the railroad industry and, to some degree, in the trucking industry. It may be preceded by any one of the above described methods although it most often follows gravity separation. Where practiced, ponding is ordinarily the final step in treatment.

Ponds may be used for further gravity separation, for evaporation, or for aerobic digestion. Ponds are also used simply for equalization to eliminate slug discharges of pollutants to surface waters or to treatment facilities. The relatively long retention times provided assist in further oil separation and sedimentation, both of which are time dependent. Oil-skimming devices are used at the effluent outlet.

Evaporation ponds which have no discharge are used effectively where the rate of evaporation exceeds the rate of precipitation by an amount equal to or greater than the rate at which wastewater is sent to the pond. Evaporation ponds are inadequate if some of the wastewater dissipates through ground seepage and contaminates groundwaters. Ponds have actually been designed to leak where the soil is porous but, generally, this is not considered acceptable practice because of groundwater contamination possibilities.

Ponds or lagoons may be used to provide for aerobic digestion of oxygen-demanding wastes. Atmospheric aeration may be sufficient if the pond has a large surface area and volume compared with waste concentration. If atmospheric aeration is not adequate, mechanical aeration may be used. Ponds may also be used for anaerobic decomposition of organic wastes, but grossly unpleasant odors and putrid conditions frequently result.

Adequately designed ponds are capable of removing up to 95% of oil, suspended solids, BOD, and other constituents, depending on retention time, temperature, and treatability. Under ideal conditions, evaporation ponds can remove virtually 100% of all waste materials, leaving just solids to be incinerated or landfilled (4).

Neutralization

Neutralization, or pH adjustment to near the neutral value of 7.0, can be provided at any stage of treatment. Some microorganisms and treatment chemicals are somewhat pH sensitive, in which case pH control becomes mandatory. The adjustment of pH is accomplished by the addition of either acidic or basic chemicals, depending on the condition to be corrected. The hauling of acids and caustics, and the use of caustic or acid wash solutions, frequently necessitate pH control, even if only to meet regulatory limits on effluents.

Table 23 summarizes reported effluent concentrations from various combinations of the above described systems for petroleum

TABLE 23. LOWEST EFFLUENT CONCENTRATIONS EXPECTED USING VARIOUS TREATMENT PROCESS COMBINATIONS FOR PETROLEUM REFINERIES (21)

Process	Effluent concentration, g/m^3				
	BOD_5	COD	Suspended solids	Oil	Phenol
API separator	250	260	50	20	6
API separator and clarifier	45	130	25	5	10
API separator and dissolved air flotation	45	130	25	5	10
API separator and granular media filter	40	100	5	6	3
API separator and oxidation pond	10	50	20	2	0.01
API separator and clarifier, dissolved air flotation, granular media filter, aerated lagoon	10		10	5	0.1
API separator and trickling filter	25	80	2,010	0.5	
API separator and clarifier, dissolved air flotation, granular media filter, activated carbon	5	30	10	2	0.1

Note: Blanks indicate data not available.

refiners (21). Wastewater composition could affect the effluents achieved. In general, a system which includes gravity separation, dissolved air flotation, granular media filtration, and activated carbon adsorption is capable of producing a high quality effluent. However, carbon treatment is relatively costly and is not a cure-all for effluents.

The above treatment systems are available to the drum cleaning industry, and some companies are attempting to use some of the processes for wastewater treatment. Ponds are used by some com-

(21) Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for Petroleum Refineries. Office of Enforcement and General Counsel, National Field Investigations Center, Cincinnati, Ohio, 1973.

panies for sedimentation before sending the effluent to a municipal treatment system. Several companies have begun using closed systems for their washing cycles. In such systems, suspended solids are removed for landfilling, and the caustic liquor is regenerated and reused for long periods. When necessary, the liquid can be neutralized and discharged to the municipal system.

Solid waste materials are universally either incinerated or landfilled. In some cases, it is possible for undesirable materials to be landfilled in such a condition as to be hazardous because of soil percolation. This should be prevented by careful control of landfill operations involving these wastes.

FUTURE CONSIDERATIONS

Air

Closed, recycled washing systems for tank cars, tank trucks, and drums have very low, if any, air emissions. Drum burning furnaces, when afterburners are operated properly, are capable of being controlled to meet most standards. Vapors from complete water flushing of tank cars and tank trucks used to haul volatile, combustible materials can be, and often are, sent to flares.

Open cleaning operations, such as steaming of tank cars, tank trucks, and drums, and open air burning of drums are sources of uncontrolled air emissions. There are no feasible, or readily available, control methods known for these operations at the present time. Converting open cleaning operations to closed-cycle cleaning, and eliminating open air drum burning, seem to be the only alternatives for the immediate future.

Water

Existing control technology for wastewater treatment available to all three types of cleaning operations appears to be capable of providing adequate control of effluents (10). Further development in the area of effective strains of microorganisms for biological treatment of organic materials would be desirable. Economic considerations are a key factor in future applications of treatment technology. The development of standardized, building-block process units could lead to greater economy in capital costs for treatment facilities.

Solid

Incineration and landfilling of solid wastes are in fairly common usage at the present time. When properly done, these methods may be adequate for the future needs of tank car, tank truck, and drum cleaning.

SECTION 6

GROWTH POTENTIAL

At present there is no practical, economical method for effectively reducing the emissions from rail tank car, tank truck, and drum cleaning. It is expected that the volume of chemical materials transported will increase in parallel with the increase in chemical production. It has been forecast that chemical production will increase 9% in 1977, 7% in 1978, 5% in 1979, and 6% in 1980 for a total increase of 30% through 1980 (22). Therefore, emissions from these cleaning operations will increase by 30% also, unless some control methods are developed.

Continued efforts by the cleaning companies to install and/or optimize wastewater treatment systems should result in a decrease (estimated 50%) in the amount of discharged water pollutants through 1980.

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(22) Outlook is Optimistic for Chemicals in 1977. Chemical and Engineering News, 54(48):6-7, 1976.

REFERENCES

1. Analysis of Proposed EPA Effluent Limitations on the For-Hire Tank Truck Industry. National Tank Truck Carriers, Inc., Washington, D.C., June 1974. 31 pp.

2. Yearbook of Railroad Facts, 1973. Association of American Railroads, Washington, D.C., 1973.

3. Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for the Railroad Segment of the Transportation Industry Point Source Category. Office of Enforcement and General Counsel, National Field Investigations Center, Cincinnati, Ohio, February 1975.

4. Development Document for Proposed Effluent Limitations Guidelines and Source Performance Standards for the Trucking Segment of the Transportation Industry Point Source Category. Office of Enforcement and General Counsel, National Field Investigations Center, Cincinnati, Ohio, 1975.

5. Air Pollution Engineering Manual, Second Edition, J. A. Danielson, ed. Publication No. AP-40, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, May 1973. 987 pp.

6. Railway Age Directory of Contract Car Repair Facilities. Railway Age, 177(13):44-49, 1976.

7. Final Report on Cost of Implementation and Capabilities of Available Technology to Comply with P.L. 92-500; Volume IV: Industry Categories 29-38. Prepared for the National Commission on Water Quality by Battelle Columbus Laboratories, Columbus, Ohio, July 3, 1975.

8. TLVs® Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1975. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio, 1975. 97 pp.

9. Sax, N. I. Dangerous Properties of Industrial Materials, Third Edition. Reinhold Book Corporation, New York, New York, 1968. 1251 pp.

10. O'Brien, J. E. A Demonstration Plant for the Treatment of Waste Waters from Tank Truck Cleanings. Presented at the American Institute of Chemical Engineers National Meeting, Atlantic City, New Jersey, September 1, 1976. 8 pp.

11. Compilation of Air Pollutant Emission Factors, Second Edition. Publication No. AP-42, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, April 1973. p. 2.2-1.

12. Serth, R. W., and T. W. Hughes. Source Assessment: Phthalic Anhydride (Air Emissions). EPA-600/2-76-032d, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, December 1976. 154 pp.

13. Code of Federal Regulations, Title 42 - Public Health, Chapter IV - Environmental Protection Agency, Part 410 - National Primary and Secondary Ambient Air Quality Standards, April 28, 1971. 16 pp.

14. Eimutis, E. C., and R. P. Quill. Source Assessment: State-by-State Listing of Criteria Pollutant Emissions, EPA-600/2-77-107b, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, July 1977. 146 pp.

15. Turner, D. B. Workbook of Atmospheric Dispersion Estimates Public Health Service Publication No. 999-AP-26, U.S. Department of Health, Education, and Welfare, Cincinnati, Ohio, 1969. 64 pp.

16. Decision Criteria for Water Discharges. Draft prepared for EPA review under Contract 68-02-1874 by Monsanto Research Corporation, Dayton, Ohio, 1976. 4 pp.

17. Eimutis, E. C., T. J. Hoogheem, and T. W. Hughes. Briefing Document: Water Source Severity and Initial Water Prioritization Structures. Draft prepared under EPA Contract 68-02-1874 by Monsanto Research Corporation, Dayton, Ohio, September 21, 1976. 12 pp.

18. Quality Criteria for Water. EPA-440/9-76-023, U.S. Environmental Protection Agency, Washington, D.C. 501 pp.

19. Manual on Disposal of Refinery Wastes. American Petroleum Institute, Washington, D.C., 1969.

20. Process Design Manual for Upgrading Existing Waste Water Treatment Plants. Contract 14-12-933, U.S. Environmental Protection Agency, October 1971.

21. Development Document for Proposed Effluent Limitations Guidelines and New Source Performance Standards for Petroleum Refineries. Office of Enforcement and General Counsel, National Field Investigations Center, Cincinnati, Ohio, 1973.

22. Outlook is Optimistic for Chemicals in 1977. Chemical and Engineering News, 54(48):6-7, 1976.

APPENDIX A

ESTIMATES OF DRUM BURNING EMISSIONS

PARTICULATES

The particulate emission factor for auto incineration is 0.68 kg/car, based on 112 kg of combustible material (CM) on a stripped car body (11).

Assuming 2 kg of combustible material per drum gives:

$$E_p = \frac{0.68 \text{ kg}}{\text{car}} \cdot \frac{\text{car}}{112 \text{ kg CM}} \cdot \frac{2 \text{ kg CM}}{\text{drum}}$$

$$= 0.012 \text{ kg/drum}$$

A large representative plant cleans 400,000 drums/yr of which 65% are burned. Thus, 260,000 drums/yr are burned, and assuming 260 days/yr of operation, 24 hr/day gives:

$$260{,}000 \frac{\text{drum}}{\text{yr}} \cdot \frac{\text{yr}}{260 \text{ day}} \cdot \frac{\text{day}}{24 \text{ hr}} \cdot \frac{\text{hr}}{3{,}600 \text{ s}} = 0.012 \text{ drum/s}$$

Therefore,

$$Q_p = 0.012 \frac{\text{kg}}{\text{drum}} \cdot 0.012 \frac{\text{drum}}{\text{s}}$$

$$= 0.00014 \text{ kg/s or } 0.14 \text{ g/s}$$

where Q_p = mass particulate emission rate, g/s

NITROGEN OXIDES (NO_x)

Following the same logic as above:

$$E_{NO_x} = 0.01 \frac{\text{kg}}{\text{car}} \cdot \frac{\text{car}}{112 \text{ kg CM}} \cdot \frac{2 \text{ kg CM}}{\text{drum}} = 1.8 \times 10^{-4} \text{ kg/drum}$$

A large representative plant burns 0.012 drum/s; therefore

$$Q_{NO_x} = 1.8 \times 10^{-4} \text{ kg/drum} \cdot 0.012 \text{ drum/s}$$

$$= 2.2 \times 10^{-6} \text{ kg/s or } 2.2 \times 10^{-3} \text{ g/s}$$

DERIVATION OF REPRESENTATIVE DRUM CLEANING PLANTS

There are two types of plants: those which wash and burn drums clean and those which only wash drums clean. Using NBADA data on drums burned and washed (Table 11), the average size of the two types of plants can be derived.

There are 9,090,000 drums burned clean at 35 facilities, for an average of 260,000 drums per facility. Assuming that 65% of the drums handled by these facilities require burning and that the remaining 35% can be cleaned by washing, the average facility handles 400,000 drums per year. The remaining 98 facilities wash drums only and handle the remaining 8,200,000 drums per year.

The facilities which wash clean only are much smaller with an average of 84,000 drums per year for NBADA members. A representative plant which washes only would be even smaller if the total number of facilities were considered. For purposes of this report, the larger size is chosen. Thus, the representative plants are:

Burning and washing - 400,000 drums/yr
Washing only - 84,000 drums/yr

ESTIMATION OF DRUM CLEANING EFFLUENTS

Using tank truck cleaning effluent data, drum cleaning was estimated as follows. For 30 tank trucks per day, 45.4 m^3/day (12,000 gal/day) of effluent are produced when removing 100 kg of material per truck. For oil and grease, this gives 230 g/m^3 in the effluent, or 10.4 kg/day. This is 3.48 g of oil and grease per kilogram of material removed. Since each drum contains 2 kg of waste, the oil and grease are estimated as 6.96 g per drum washed. For the representative plants, this means:

35% of Type a plants - 0.97 metric tons/yr
100% of Type b plants - 0.585 metric tons/yr

Assuming 260 days of operation per year gives:

Type a plant - 3.75 kg/day
Type b plant - 2.25 kg/day

Estimated flow rates (from plant personnel) of 25 m^3/day (6,600 gal/day) and 15 m^3/day (4,000 gal/day) for Type a and Type b plants, respectively, gives effluent concentrations as follows:

Type a plant - 148 g/m^3
Type b plant - 148 g/m^3

Other effluents are calculated in a similar manner.

APPENDIX B

DEFINITION OF SOURCE SEVERITY FOR WATER DISCHARGES AND CALCULATION OF RIVER OR END-OF-PIPE CONCENTRATIONS

Source severity is defined as the pollutant concentration to which aquatic life is exposed divided by an acceptable concentration. The "exposure" concentration is the fully diluted receiving water concentration resulting from the effluent of the specific discharge of concern. The "acceptable" concentration (F) is defined as that concentration at which it is assumed that an incipient adverse environmental impact occurs. For most pollutants, it is the water quality criteria. For pollutants without water quality criteria, F is the lowest value of the following concentrations:

0.01 LC_{50} (LC_{50} is the lethal concentration of a pollutant to 50% of an aquatic life exposed to the pollutant)

0.00225 LD_{50} (LD_{50} is the lethal dose of a pollutant to 50% of a male rat population)

Mathematically, source severity (S) is:

$$S = \frac{\left(V_D/V_R\ C_D\right)}{F}$$

where V_D, V_R = volume of discharge and river flow, respectively
C_D = concentration of discharge
F = acceptable concentration as defined above

The oxygen source severity is defined as the maximum mass of oxygen that can potentially be consumed by a specific discharge divided by the mass of oxygen in the receiving water that can be consumed without exceeding the minimum water quality criteria for dissolved oxygen. The maximum mass of oxygen potentially consumable by the discharge is defined as the total oxygen demand (TOD) concentration multiplied by the discharge flow rate. The "allowable" mass is defined as the receiving water volumetric flow rate of mixing zone volume multiplied by the difference between the saturation concentration (C_S) at 10°C and the minimum water quality criteria for dissolved oxygen (DO_{WQC}).

Hence, the source severity can be defined mathematically as:

$$S = \frac{\left(\frac{V_D}{V_R}\right)TOD}{C_S - DO_{(WQC)}}$$

The receiving water is assumed to be initially at saturation and the discharge is assumed to be fully diluted and mixed upon entering the receiving water. It is also assumed that all of the total oxygen demand occurs instantaneously with no reaearation of the receiving body of water.

If it is desired to evaluate the severity at any other river flow rate, severity can be calculated as follows:

$$S_2 = S_1\left(\frac{V_{R_1}}{V_{R_2}}\right)$$

where S_1 = standard source severity as shown in Table 19
S_2 = source severity at river flow rate, V_{R_2}
V_{R_1}, V_{R_2} = river flow rates corresponding to the source severities S_1 and S_2, respectively

In addition, the concentration expected in the river can be determined by multiplying the source severity and the hazard factor (Table 18). The concentration expected from the discharge, C_D (no dilution in the river, can be calculated using the following set of equations:

$$C_D = S_D \; F$$

where

$$S_D = S\left(\frac{V_R}{V_D}\right)$$

and S = severity from Table 19
V_R = river flow in Equation 3, 856 m^3/s
V_D = volumetric discharge, m^3/s
F = hazard factor from Table 18

GLOSSARY

affected population: Number of nonplant persons exposed to concentrations of airborne materials which are present in concentrations greater than a determined hazard potential factor.

biochemical oxygen demand: A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water.

chemical oxygen demand: A measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water.

criteria pollutants: Emission species for which ambient air quality standards have been established; these include particulates, sulfur oxides, nitrogen oxides, carbon monoxide, and nonmethane hydrocarbons.

dedicated: Type of car, truck or drum used for carrying one commodity only and, unless contaminated, cleaned only prior to repair or testing.

emulsion: A heterogeneous liquid mixture not normally miscible, held in suspension by agitation or certain additives.

hazard factor: The ambient air quality standard of a criteria pollutant or a "corrected" TLV for noncriteria pollutants.

national emissions burden: The total quantity of specific pollutants generated in the U.S.

noncriteria pollutants: Emission species for which no ambient air quality standards have been established.

nondedicated: Type of car, truck or drum which is cleaned after every use to prevent cross contamination.

pollutant: Any introduced gas, liquid, or solid that makes a resource unfit for a specific purpose.

representative source: A source whose performance characteristics are representative of those of a large number of actual sources of similar type and function.

source severity: An indication of the hazard potential of a pollution source.

state emission burden: The total quantity of specific pollutants generated in a specific state.

threshold limit value: Airborne concentrations of substances that represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect.

total oxygen demand: A quantitative measure of all oxidizable material in water or wastewater as determined by measuring the depletion of oxygen in a known gas stream.

turbidity: A cloudy condition in water due to the suspension of silt or finely divided organic matter.

water quality criteria: The level of pollutants that affect the suitability of water for a given use.

water quality standard: A plan for water quality management containing four major elements: the use to be made of the water; criteria to protect those uses; implementation plans and enforcement plans; and an antidegradation statement to protect existing high quality waters.

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-600/2-78-004g		

4. TITLE AND SUBTITLE	5. REPORT DATE
SOURCE ASSESSMENT: RAIL TANK CAR, TANK TRUCK, AND DRUM CLEANING, State of the Art	April 1978 issuing date
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
D. E. Earley, K. M. Tackett and T. R. Blackwood	MRC-DA-713
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
Monsanto Research Corporation 1515 Nicholas Road Dayton, Ohio 45407	1AB604
	11. CONTRACT/GRANT NO.
	68-02-1874
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Industrial Environmental Research Laboratory-Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268	Task Final 8/76-9/77
	14. SPONSORING AGENCY CODE
	EPA/600/12

15. SUPPLEMENTARY NOTES

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16. ABSTRACT

This document reviews the state of the art of air emissions and water pollutants from cleaning rail tank cars, tank trucks, and drums. Composition, quantity, and rate of emissions and pollutants are described. Rail tank cars, tank trucks, and drums are used to transport chemical and petroleum commodities from producer to consumer. Steaming, washing and/or flushing of such units result in air emissions and wastewater effluents. Air emissions are predominantly organic chemical vapors. Water pollutants common to these operations are primarily oil and grease, COD, BOD, suspended solids and many other organic and inorganic materials. Representative sources were defined in order to evaluate the hazard potential. Source severity was defined and evaluated for air emissions and for wastewater effluents. Control methods used to reduce emissions from rail tank car and tank truck cleaning consist only of flaring flushed gases. By EPA estimates, two-thirds of the tank truck industry discharges into municipal systems with little or no pretreatment. This treatment has generally been limited to sedimentation, neutralization, evaporation ponds, and lagoons.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Water Pollution Assessments	Air Pollution Control Water Pollution Control Source Assessment	68A

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release to Public	Unclassified	68
	20. SECURITY CLASS (This page)	22. PRICE
	Unclassified	

EPA Form 2220-1 (9-73)

☆ U.S. GOVERNMENT PRINTING OFFICE: 1978—260-880/38