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Truck Transport of Hazardous Chemicals: Isopropylamine

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The transport of hazardous materials by all modes is a major concern of the U.S. Department of Transportation. Estimates place the total amount of hazardous materials transported in the United States in excess of 1.5 billion tons per year. Highway, water, and rail account for nearly all hazardous materials shipments; air shipments are negligible. Fuels, such as gasoline and diesel, account for about half of all hazardous materials transported. Chemicals account for most of the remainder.

The principal purpose of this report is to present estimates of truck shipments of isopropylamine, one of 147 large-volume chemicals that account for at least 80 percent of U.S. truck shipments of hazardous chemicals.

All of the reports in this series are based on the best available information at the time the research was conducted. The U.S. chemical industry, however, operates in an environment in which markets, production processes, and distribution requirements can change substantially from year to year. The information in this report on (a) chemical producers and their plant locations, (b) consuming plants and their locations, and (c) the estimated traffic flow from producers to consuners, is thus subject to change.

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PREFACE

The transport of hazardous materials by all modes is a major concern of the U.S. Department of Transportation (U.S. DOT). Estimates place the' total amount of hazardous materials transported in the United States in excess of 1.5 billion tons per year.' Highways, water, and rail account for nearly all hazardous materials shipments; air shipments are negligible. Fuels, such as gasoline and diesel, account for about half of all hazardous materials transported. Chemicals account for most of the remainder.

Because of the intermixture of freight and passenger vehicles on the Nation's roads and highways, and because hazardous materials are frequently transported through residential and commercial areas, incidents involving truck movements of hazardous materials may pose a risk to the general population. The U.S. DOT has extensive data on highway incidents involving particular hazardous materials, but does not have comparable volume data with which to establish failure rates (i.e., the percentage of shipments involved in incidents). Moreover, little is known about the routes over which particular hazardous materials are transported. Consequently, Federal and state authorities lack critical information that they need to formulate hazardous materials policies and programs regarding enforcement of regulations, training for dealing with hazardous materials incidents, etc.

This document is one of a series of reports being prepared on the transport of large-volume manufactured or processed non-fuel substances that together account for at least 80 percent of U.S. truck shipments of hazardous chemicals. It was sponsored by the Office of Hazardous Materials Safety, Research and Special Programs Administration (RSPA), U.S. DOT. The report was prepared by the Environmental Engineering Division, Volpe National Transportation Systems Center, U.S. DOT, and TDS Economics, Menlo Park, California.

It should be emphasized that all of the reports in this series are based on the best available information at the time the research was conducted. The U.S. chemical industry, however, operates in a dynamic economic and technological environment in which markets, production processes, and distribution requirements can change substantially from year to year. The information in this report on (a) chemical producers and their plant locations, (b) consuming plants and their locations, and (c) the estimated traffic flows from producers to consumers is thus subject to change.

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[1] Office of Technology Assessment, Congress of the United States, ***Transportation of Hazardous Materials,*** 1986, and Research and Special Programs Administration, U.S. Department of Transportation, ***Truck Transportation of Hazardous Materials, A National Overview,*** 1987.

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1. INTRODUCTION

The principal purpose of this report is to present estimates of bulk shipments by truck of isopropylamine, one of the 147 large-volume chemicals that account for at least 80 percent of U.S. truck shipments of hazardous chemicals. Appendix A lists these chemicals.

The following sections of this report describe the physical characteristics of isopropylamine, its uses, and domestic producers and users. Because there is so little direct evidence on the specific routes over which isopropylamine is shipped, and in what quantities, those routes are estimated. General descriptions of the routes are provided.

Unfortunately, there are insufficient data on actual flows of isopropylamine to test the estimation results for accuracy. It is shown, however, that the estimation results are consistent with Research and Special Programs Administration (RSPA) data on incidents involving truck shipments of isopropylamine.

2. CHARACTERISTICS OF ISOPROPYLAMINE

Isopropylamine is a colorless, flammable, low-boiling point liquid. It can irritate skin and eyes in the case of exposure. The *1996 North American Emergency Response Guidebook* recommends that emergency responders use its Guide No. 132 (UN 1221) in the case of a spill involving isopropylamine. Additional information about isopropylamine is given in Table 1.

3. USES OF ISOPROPYLAMINE

Almost all isopropylamine is used for the synthesis of herbicides (particularly the heterocyclic triazines, such as atrazine and related compounds, and the isopropylamine salt of the organophosphate, glyphosate). Small amounts are also used to produce detergents, isopropylaminoethanol, and other compounds.

4. PRODUCTION

Total U.S. production capacity for isopropylamine in 1992 was estimated to be 32.5 thousand short tons, of which 32.2 thousand short tons were available for shipment to off-site consumers. Isopropylamine is produced by three companies, each with one plant. These plants are located in Alabama, Louisiana, and Michigan. The plant in Louisiana is estimated to have accounted for over 60 percent of the total U.S. production in 1992.

TABLE 1. ADDITIONAL INFORMATION ON ISOPROPYLAMINE

Common Synonyms	2-Aminopropane Monoisopropylamine 2-Propanamine set-Propylamine 2-Propylamine
Formula	$(CH_3)_2CH\ NH_2$
UN Number	1221
DOT Hazard Class	Class 3 (Flammable and Combustible Liquids)
CAS Number	75-31-o
Description	Colorless, volatile liquid Strong ammonia odor

Sources: ***CHRIS Manual, Vol 1, A Condensed Guide to Chemical Hazards,*** 1992; National Tank Truck Carriers, Inc., ***Hazardous Commodity Handbook,*** Tenth Edition, 1994; and Gale Research Inc., ***Hazardous Substances Resource Guide,*** 1993

Isopropylamine is used in the manufacture of other chemicals at some of its producing plants. The quantities of isopropylamine used for this purpose are not available for shipment elsewhere. Production for intraplant use is termed "captive production." To calculate captive production, downstream chemicals produced within the same plant as isopropylamine are identified and the amount of isopropylamine needed in their production is estimated. The difference between total capacity and captive production defines the amount available for off-site shipments. It is the potential amount of production available for off-site consumption that is of interest to this study. Table 2 shows net production capacity available for off-site consumption, by producing plant, in 1992. Producers may ship to plants at other locations owned by the same parent company. These shipments are termed "captive shipments." As indicated in Table 2, no producers of isopropylamine make captive shipments.

TABLE 2. MAJOR PRODUCERS OF ISOPROPYLAMINE, 1992

Company	**Plant Location**	**Offsite Availability-f** (Thousands of Short Tons)	**Captive Shipments+**
Air Products	St. Gabriel, LA	19.8	No
Elf Atochem	Riverview, MI	3.9	No
Hoechst Celanese	Bucks, AL	8.5	No
Total Offsite Availability		32.2	

†**Offsite** availability is the amount of the product available for shipment after intraplant consumption is accounted for.

‡**Captive** shipments are shipments of the chemical from a producing plant to a consuming plant owned by the same company.

Sources: Based on information from industry sources.

5. CONSUMPTION

Eleven plants are identified as net consumers of isopropylamine. None of those plants produces isopropylamine. Consumption estimates for the plants consuming isopropylamine are listed in Table 3. Note that total net product requirement, 25.34 thousand short tons, is less than total off-site availability, 32.2 thousand short tons (see Table 2), because production capacity exceeds demand for the chemical. For each of the consuming plants, the chemical derivatives produced using isopropylamine are identified in Table 3.

As can be seen in Table 3, consumption of isopropylamine is concentrated in Alabama and Louisiana. Three consuming plants are located in those two states. Plants in eight other states consume the chemical in much smaller quantities. There are other, very small volume consumers that are not covered in this report.

6. INTERNATIONAL TRADE

U.S. imports of isopropylamine are negligible. In 1992, 7.8 thousand short tons of isopropylamine were exported.[2] Eighty-five percent of this tonnage went to countries in Latin America or Asia, and most of this was probably shipped directly from plants in Louisiana and Alabama. It is unlikely that any of the exported isopropylamine was transported by truck to port areas.

7. TRANSPORT AND DISTRIBUTION

Isopropylamine is shipped from producing plants to consumers by truck and rail. Of the eleven plants at which isopropylamine is consumed, nine are likely to receive product primarily by truck and two are likely to receive product primarily by rail. Rail is by far the most important mode for the shipment of bulk quantities of isopropylamine, as can be seen in Table 3. Water transport is used only for exports.

Because it is a liquid, large volume shipments are moved in rail tankcars and in tank trucks. Large volume, truckload shipments also move in drums. Small volume shipments (not investigated in this study) are transported in drums or similar containers capable of holding liquids.

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[2] Chemical industry sources.

TABLE 3. MAJOR CONSUMERS OF ISOPROPYLAMINE, 1992

Company	Plant Location	Estimated Net Product Requirement (Thousands of Short Tons)	Derivatives?
Consumers Receiving Shipments by Truck			
Union Carbide‡	Institute, WV	0.40	IPAE
Rhone-Poulenc§	Baltimore, MD	0.06	IDBSA
Witco§	Houston, TX	0.06	IDBSA
Stepan§	Fieldsboro, NJ	0.02	IDBSA
Stepan§	Millsdale, IL	0.02	IDBSA
Stepan§	Winder, GA	0.02	IDBSA
Pilot Chemical§	Lockland, OH	0.02	IDBSA
Pilot Chemical§	Middleton, OH	0.02	IDBSA
Pilot Chemical§	Santa Fe Springs, CA	0.02	IDBSA
Total Truck Shipments		0.64	
Consumers Receiving Shipments by Rail			
Ciba-Geigy	McIntosh, AL	16.0	TRIAZ
Monsanto	Luling, LA	8.7	GLYP
Total Rail Shipments		24.7	
Total, All Modes		25.34	

† Derivatives using isopropylamine in their manufacture:

GLYP--Glyphosate, isopropylamine salt
IPAE--1sopropylaminoethanol
IDBSA--1sopropylamine salt of dodecylbenzene sulfonic acid
TRIAZ--Triazine herbicides

‡ This isopropylamine is all supplied by Air Products, which toll manufactures it for Union Carbide at its St. Gabriel, LA, plant.

§ The estimated annual consumption is sufficiently small that it is unlikely that this consumer receives truck load or tank truck shipments of the product. Rather, it receives less than truck load shipments in drums.

Sources: Based on information from industry sources and U.S. Department of Transportation, HMIS database.

Of the nine consumer plants receiving shipments by truck, only one is large enough to receive tank truck shipments. The other eight receive shipments by truck in filled drums. These eight receive estimated annual shipments amounting to about 120 to 400 filled drums per year, or 10 to 33 filled drums per month. About 65 filled drums are required to meet the minimum shipment size for the definition of a large volume shipment used in this report. Given the close proximity of either a terminal or a producer to each of these eight consumers, and consumer preferences for flexible and quick delivery, it is likely that less-than-truckload (LTL) shipments are used.

Producers use public and private terminals located near consuming plants to facilitate the distribution of isopropylamine. Table 4 lists the terminals used for isopropylamine. The use of terminals helps to minimize road transport, with the consequence that truck movements from distribution points to final consumers are generally LTL in volume.

Terminals do not store quantities of isopropylamine in bulk. Rather, they store quantities of the chemical in drums. Filled drums are usually shipped by truck to the terminals. Truck movements, therefore, tend to be either truckload shipments of filled drums from a producing plant to a terminal, or short-haul LTL shipments of a few filled drums from terminals or producers to end-users. Exceptions to this include tank truck shipments from Air Product’s production plant in St. Gabriel, LA, to Union Carbide’s consuming plant in Institute, WV, and tank truck shipments from Air Product’s production plant in St. Gabriel, LA, to its drumming plant in Pace, FL.

Because of the small volume purchased by most of the isopropylamine consumers, average annual net consumption of the chemical at plants receiving truck shipments is only 70 short tons per year, compared with over 12 thousand short tons per year for plants receiving rail shipments.

8. METHODOLOGY TO ESTIMATE TRUCK FLOWS

The major producers of isopropylamine and their plant locations are identified in Table 2, along with the amounts of the chemical that each potentially has available for consumers. Table 3 lists consuming companies, their plant locations, and the estimated amounts of isopropylamine that each received by truck delivery in 1992. The terminals used in the distribution of isopropylamine are listed in Table 4. This section explains how this information is used to (1) identify the routes over which bulk shipments of isopropylamine are expected to move from producers to users, and (2) estimate the quantities of product moving in bulk over those routes.

TABLE 4. TERMINALS USED BY ISOPROPYLAMINE PRODUCERS

Producing Company	Terminal Location
Air Products	Duluth, GA-/-
	Pace, FL‡
Elf Atochem	Edison, NJ†
	La Porte, TX†
	Santa Fe Springs, CA†
Hoechst Celanese	Harvey, LA§

† These are public terminals. Public terminals are available to all producers on an as-needed basis. Use may change from year to year.

‡ Air Products ships isopropylamine in bulk in tank trucks from its St. Gabriel, LA production plant to its terminal in Pace, FL where it is put into drums for direct shipment by truck to consumers or for shipment by truck, sometimes in bulk, to the public terminal in Duluth, GA. No bulk shipments are made from the public terminal in Duluth, GA.

§ Hoechst Celanese ships isopropylamine in bulk by rail from its production plant in Bucks, AL to its drumming facility in Harvey, LA, where it is put into drums for direct shipment to customers. Bulk shipments are made only from Bucks, AL and drum shipments only from Harvey, LA.

Sources: Based on information from industry sources.

Because there is so little readily available direct information on the flows of isopropylamine over the Nation's highways, those flows must be estimated. For other chemicals studied, linear programming or gravity models were used to estimate the flows. For isopropylamine, the use of these models was unnecessary, since direct estimates of flows and routes can be easily and simply derived.

Only the isopropylamine consumer directly receiving tank truck or truckload shipments has a known relationship with a producer. The origin-destination pair for this producer-consumer connection is known, and the flow volume for the connection can be directly estimated, as can the projected route. All other tank truck or truckload shipments of isopropylamine involve movements from producers to terminals. Although rail and barge shipments are commonly used to transport chemicals from producers to terminals, most shipments of isopropylamine from producers to terminals are made in truckload quantities of filled drums. Based on the geographical location of terminals and LTL consumers, direct estimates of the quantities of isopropylamine being shipped from producers to terminals can be derived by assigning end-consumers to the appropriate terminals. Projected routes from producers to terminals can be estimated using the locations of the producing plants and of the corresponding terminals.

9. ESTIMATION RESULTS

Estimates of the quantities of isopropylamine being shipped in bulk by tank truck or truckload from producers to consumers and terminals are shown in Table 5. The estimation results for the flows of isopropylamine are summarized by state in Table 6.

As can be seen in Table 6, due to the small number of plants producing isopropylamine and the relatively wide geographic distribution of consuming plants (and terminals serving them), ton-miles tend to be spread across many states. Overall, bulk truck flows of isopropylamine are estimated at 580 thousand ton-miles per year. The state with the greatest number of ton-miles is Kentucky, located between the Louisiana producing plant and the West Virginia consuming plant. Alabama has the second largest number of ton-miles. Other states with relatively large numbers of ton-miles are Mississippi, Louisiana, and Tennessee. The average length of haul is 900 to 1,000 miles. This relatively long length of haul (compared to that for other, larger volume chemicals) is due primarily to the long distances between producers and terminals.

As indicated in Table 5, a relatively small amount of isopropylamine is trucked from the production plant in Michigan to a public terminal in Southern California. This is the only bulk movement by truck in the West. Bulk movements by truck from Michigan to California are expected to pass through Indiana, Illinois, Missouri, Oklahoma, Texas, New Mexico, and Arizona. The other bulk truck movements originating at the production plant in Michigan consist of flows of isopropylamine to terminals in Texas and New Jersey. The flows from Michigan to Texas are expected to pass through Ohio, Kentucky, Tennessee, Mississippi, and Louisiana; those from Michigan to New Jersey are expected to pass through Ohio and Pennsylvania.

TABLE 5. ESTIMATED QUANTITIES OF ISOPROPYLAMINE MOVING IN BULK BY TRUCK TO CONSUMERS OR TERMINALS, 1992

Producer	**Plant Location**	**Consumer or Terminal Location**	**Amount Shipped-f** (Thousands of Short Tons)
Air Products	St. Gabriel, LA	Institute, WV	0.40
Air Products+	St. Gabriel, LA	Pace, FL	0.08
Air Products Terminal 1‡	Pace, FL	Duluth, GA	0.02
Elf Atochem	Riverview, MI	Edison, NJ	0.08
Elf Atochem	Riverview, MI	La Porte, TX	0.06
Elf Atochem	Riverview, MI	Santa Fe Springs, CA	0.02

† Estimated amount of product shipped to terminal or consumer, including product for subsequent shipments to consumers identified in this report and to other consumers that are too small for inclusion in the list of consumers.

‡ Air Products ships in tank trucks from its St. Gabriel, LA production plant to its terminal in Pace, FL for drumming. The Pace, FL terminal ships the product in drums to the public terminal in Duluth, GA.

TABLE 6. ESTIMATES OF BULK TRUCK SHIPMENTS OF ISOPROPYLAMINE BY STATE, 1992

State	Producer, Terminal, or Consumer	Ton-Miles (Thousands)	Truck-miles-t (Thousands)
Alabama	‡	116.2	5.8
Arizona		7.3	0.4
California	Terminal	5.4	0.3
Florida	Terminal	1.9	0.1
Georgia	Terminal	2.1	0.1
Illinois		5.5	0.3
Indiana		0.9	0.0
Kentucky		124.9	6.2
Louisiana	Producer§	67.4	3.4
Michigan	Producer	10.3	0.5
Mississippi		73.3	3.7
Missouri		6.1	0.3
New Jersey	Terminal	4.1	0.2
New Mexico		7.4	0.4
Ohio		27.8	1.4
Oklahoma		7.4	0.4
Pennsylvania		27.2	1.4
Tennessee		54.1	2.7
Texas	Terminal	9.4	0.5
West Virginia	Consumer	20.8	1.0
Total		579.4	29.0

† Truck-miles are calculated by dividing the number of ton-miles by 20 short tons, which is the average size of a tanktruck load.

‡ While there is a producer of isopropylamine in Alabama, no significant bulk shipments by truck move from that producer to consumers or terminals. Thus, all bulk shipments by truck in Alabama are pass-through shipments.

§ While there is also a terminal in Louisiana, no significant bulk shipments by truck move into that facility from producers or other terminals, nor do any significant bulk shipments by truck move from that terminal to consumers.

The production plant in Louisiana is the origin of all other flows of isopropylamine in bulk by highway. The largest of the flows from Louisiana goes to the consuming plant in West Virginia. This flow is expected to pass through Mississippi, Alabama, Tennessee, and Kentucky. A lesser flow from Louisiana goes to the company terminal in Florida. This flow is expected to pass through Mississippi and Alabama. The company terminal, located in the Florida Panhandle, ships part of the product that it receives from Louisiana to a public terminal in Georgia. This flow is expected to pass through Alabama.

10. COMPARISON OF RESULTS WITH INCIDENTS DATA

Table 7 shows estimates of the expected annual number of highway truck accidents involving isopropylamine. These estimates are based on 1992 truck-miles and assume that there is one accident for every million truck-miles. The table also shows estimates of the expected number of years between spills resulting from highway accidents for each state. These latter estimates assume that about 15 percent of highway truck accidents result in a release or spill.

The estimates in Table 7 indicate that, as of 1992, the states with the highest risk of both highway truck accidents and isopropylamine spills resulting from such accidents were, in descending order, Kentucky, Alabama, Mississippi, Louisiana, and Tennessee. These states also rank highest in ton-miles and truck-miles of isopropylamine (see Table 6). The expected annual number of highway truck accidents involving isopropylamine for the nation as a whole was about 0.029 and the expected number of years between spills resulting from highway truck accidents was 230.

Table 8 indicates that, from 1985 to 1993, there were no spills of isopropylamine in the U.S. caused by highway accidents. This is consistent with the expected 230 years between spills caused by highway accidents in the U.S. The two spills of isopropylamine that did occur from 1985 to 1993 were caused by packaging failure. One of these spills, which occurred in Texas, was from a truckload shipment of isopropylamine in drums moving from the producing plant in Michigan to the terminal in Southern California. The other spill, which occurred in Kentucky, was from a tank truck moving product from the Louisiana producer to the West Virginia consumer. Both spills occurred in states identified in the analysis as having flows of isopropylamine. The origins of the two shipments that had the spills were producing plants identified in the analysis as shipping isopropylamine in bulk via truck. Likewise, the destinations of the two shipments were a consuming plant and a terminal identified in the analysis as receiving isopropylamine in bulk via truck.

TABLE 7. ESTIMATED NUMBER OF HIGHWAY ACCIDENTS INVOLVING ISOPROPYLAMINE, BY STATE, 1992

State	Estimated Accidents†	Estimated Years/Spill†	State	Estimated Accidents†	Estimated Years/Spill†
Alabama	0.006	1,147	Mississippi	0.004	1,818
Arizona	0.000	18,290	Missouri	0.000	22,002
California	0.000	24,876	New Jersey	0.000	32,680
Florida	0.000	68,729	New Mexico	0.000	18,067
Georgia	0.000	63,796	Ohio	0.001	4,801
Illinois	0.000	24,242	Oklahoma	0.000	18,116
Indiana	0.000	155,039	Pennsylvania	0.001	4,900
Kentucky	0.006	1,067	Tennessee	0.003	2,465
Louisiana	0.003	1,979	Texas	0.000	14,200
Michigan	0.001	12,920	West Virginia	0.001	6,410
			U.S.	0.029	230

† The number of accidents per year is calculated at one accident per one million truck-miles; about 15 percent of these accidents result in a release or spill. These rules of thumb were suggested by RSPA's Office of Hazardous Materials Safety.

TABLE 8. DATA ON ISOPROPYLAMINE BULK-SHIPMENT INCIDENTS, 1985 TO 1993

Incident State	Origin State	Destination State (gallons)	Release Quantity	Cause-f	Capacity (gallons)	Shipper Type‡
KY	LA	WV	1	20	6,500§	Plant
TX	MI	CA	40	20	5,335”	Plant

† Cause 20 indicates packaging failure (other causes listed in the HMIS data are 10, indicating human failure, 30, indicating a highway accident, and 40, indicating other cause).

‡ Both incidents involved shipments from a plant rather than a terminal.

§ In tank truck

* In drums

Source: U.S. Department of Transportation HMIS Database

APPENDIX A. LIST OF 147 LARGE-VOLUME CHEMICALS

Chemical	1994 Production (Thousands of Short Tons)
Acetaldehyde	174
Acetic Acid, Synthetic	1,992
Acetic Anhydride	na
Acetone	1,331
Acetylene	>140
Acrylamide	58
Acrylic Acid	575
Acrylonitrile	1,491
Activated Carbon	158
Adipic Acid	900
Aluminum Chloride	na
Aluminum Sulfate (w/17% Al_2O_3)	1,316
Ammonia	17,256
Ammonium Nitrate	8,517
Amyl Alcohol	23
Aniline	632
Argon	800
Atrazine	na
Barite	643
Barium Sulfide	na
Benzene	>7,110
Benzoic Acid	60
Benzyl Chloride	na
Bromine	215
1,3-Butadiene	1,689
1-Butanol	739
Butene- 1	483
n-Butyl Acetate	155
n-Butyl Acrylate	412
Butyraldehyde	1,097
Calcium Carbide	244
Calcium Hypochlorite	92
Calcium Oxide	>16,314
Carbon Black	1,625
Carbon Dioxide	12,547
Carbon Disulfide	na
Carbon Tetrachloride	124
Chlorinated Isocyanurates	68
Chlorine Gas	12,187
Chlorobenzene, Mono	109
Chlorodifluoromethane (F22)	153
Chloroform	565
Chloronitrobenzene	65
Copper Sulfate	53
Cyclohexane	982
Cyclohexanone	552
p-Dichlorobenzene	39
Dichlorodifluoromethane (F12)	63
Dicyclopentadiene	na
Dimethylamine	na
Epichlorohydrin	253
Ethanol (Synthetic)	324
Ethyl Acetate	163
Ethyl Acrylate	182
Ethylbenzene	5,378
Ethyl Chloride	na
Ethylenediamine	45
Ethylenediamine Tetraacetic Acid	6
Ethylene Dibromide	13
Ethylene Dichloride	8,380
Ethylene Glycol Monobutyl Ether	195
Ethylene Glycol Monoethyl Ether	29
Ethylene Glycol Monoethyl Ether Acetate	23
Ethylene Glycol Monomethyl Ether	20
Ethylene Oxide	2,928
Ferric Chloride (100%)	225
Formaldehyde (37%)	4,082
Furfural	43
n-Heptane	60
Hexamethylenediamine	626
Hexane	170
Hexene- 1	na
Hydrochloric Acid (100%)	3,734
Hydrofluoric Acid	200
Hydrofluosilicic Acid	55
Hydrogen	862
Hydrogen Cyanide	514
Hydrogen Peroxide	318
Isobu tanol	70
Isobutyl Acetate	42
Isobutylene	1,539

APPENDIX A. LIST OF 147 LARGE-VOLUME CHEMICALS (Continued)

Chemical	1994 Production (Thousands of Short Tons)
Isobutyraldehyde	264
Isoprene	310
Isopropanol	726
Isopropyl Acetate	28
Isopropylamine, Mono	na
Linear Alkylate Sulfonate	305
Maleic Anhydride	239
Methanol	5,387
Methylamine	na
Methyl t-Butyl Ether	5,515
Methyl Chloride	500
Methylchloroform	335
Methylene Dichloride	na
Methylene Diphenlyene Diisocyanate	535
Methyl Ethyl Ketone	600
Methyl Isobutyl Ketone	70
Methyl Methacrylate	659
Monoethanolamine	198
Naphthalene	101
Nitric Acid (100% HNO, Basis)	8,611
Nitrobenzene	720
Nitrogen	31,515
Nonylphenol	na
Oxygen	25,045
n-Pentane	na
Perchloroethylene	123
Phenol	2,065
Phosgene	na
Phosphoric Acid (P_2O_5 Basis)	12,792
Phosphorus	255
Phosphorus Oxychloride	36
Phosphorus Pentasulfide	61
Phosphorus Trichloride	158
Phthalic Anhydride	480
Pinene	na
Potassium Hydroxide (100%)	27
Propane	3 1,492
n-Propanol	625
Propionaldehyde	182
Propionic Acid	94
n-Propyl Acetate	44
Propylene Oxide	1,850
Propylene Tetramer (Dodecene)	155
Sodium (Metal)	na
Sodium Chlorate (100%)	559
Sodium Chromate/Dichromate	132
Sodium Cyanide	142
Sodium Hydrosulfide	117
Sodium Hydrosulfite	90
Sodium Hydroxide	12,555
Sodium Phosphate, Tribasic	22
S tyrene	5,455
Sulfur	12,677
Sulfur Dioxide	229
Sulfuric Acid	44,813
Tetrahydrofuran	126
Toluene	>2,895
Toluene Diisocyanate	419
Trichloroethylene	na
Tripropylene (Nonene)	328
Vinyl Acetate	1,518
Vinyl Chloride	6,924
o-Xylene	457
p-Xylene	3,114
Zinc Chloride	<10
Zinc Sulfate	43
Total	>349,004

Notes:

(1) The Acetylene production numbers include production for chemical use only.
(2) The Calcium Oxide, Benzene, and Toluene production numbers do not include production from all sources;
(3) The Zinc Chloride production number includes the zinc content of zinc ammonium chloride.

APPENDIX A. LIST OF 147 LARGE-VOLUME CHEMICALS (Concluded)

Sources:

(1) List of Chemicals: C. Starry, K. McCaleb, and W. Stock, "Study of Truck Transportation of Hazardous Chemicals," Prepared by SRI International for the U.S. Department of Transportation, 1993.
(2) 1994 Production Numbers: U.S. International Trade Commission, Synthetic ***Organic Chemicals, United States Production and Sales, 1994,*** USTIC Publication 2933, June 1995; U.S. Geological Survey, ***Minerals Yearbook, 1994; Chemical & Engineering*** News, June 24, 1996, pp. 41-43; U.S. DOE/EIA, ***Petroleum Supply Annual, 1995,*** Vol. 1; other industry sources; and Volpe estimates based on industry source projections of chemical production or consumption, or on the relationships between the quantities of selected inputs and the quantities of finished chemical product outputs.