# 4. PRODUCTION, IMPORT/EXPORT, USE, AND DISPOSAL

## 4.1 PRODUCTION

Normal hexane (*n*-hexane) is both an anthropogenic and naturally occurring chemical. *n*-Hexane is a minor constituent of crude oil and natural gas. Its inclusion in a variety of petroleum products is a consequence of refining operations that separate hydrocarbons within specific ranges of boiling points for such uses as heating oils or automotive fuels. It may also be a metabolic byproduct from certain types of fungi (Ahearn et al.1996). Such sources of natural releases are discussed in Chapter 5. In commercial products prepared from the distillation of petroleum, *n*-hexane has many uses as a special-purpose solvent and oil extractant. In a highly purified form, *n*-hexane is used in chemical laboratories as an extractant for a wide range of hydrocarbons and nonpolar organic compounds.

Virtually all *n*-hexane is obtained from petroleum mixtures through controlled fractional distillation and other refinery-based processes (Speight 1991). *n*-Hexane can also be synthesized from sugar cane wastes using special catalysts (SUCRON 1996). This type of synthesis is relatively new and the volume produced is still very limited. The presence of many types of hydrocarbon impurities in many commercial grades of *n*-hexane, combined with the intentional denaturing of *n*-hexane preparations to discourage substance abuse, make it difficult to establish odor thresholds for many products containing *n*-hexane.

Table 4-1 lists the facilities in each state that manufacture or process *n*-hexane, the intended use, and the range of maximum amounts of *n*-hexane that are stored on site. The data listed in Table 4-1 are derived from the Toxics Release Inventory (TRI96 1998). Only certain types of facilities were required to report. Therefore, this is not an exhaustive list. Based on the most current TRI information, there are currently 534 facilities that produce or process *n*-hexane in the United States.

The dual role of *n*-hexane as a component of refined petroleum fuels and as a highly refined, specialized product for other end uses lead to complications in making estimates of actual production levels. For instance, no formal production statistics could be identified associated with the *n*-hexane contained in heating or motor fuels. Since the late 1980s no quantitative production figures have been available for those companies documented as producing appreciable amounts of *n*-hexane for commercial use (SRI 1988, 1990, 1992, 1994, 1995, 1996). The following six facilities are currently documented as producers

## Table 4-1. Facilities That Manufacture or Process *n*-Hexane

| STATE [a] | NUMBER OF FACILITIES | RANGE OF MAXIMUM AMOUNTS ON SITE IN POUNDS [b] | ACTIVITIES AND USES [c] |
|---|---|---|---|
| AK | 2 | 1,000,000 - 9,999,999 | 1, 3, 4, 8 |
| AL | 15 | 1,000 - 49,999,999 | 1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13 |
| AR | 11 | 1,000 - 49,999,999 | 1, 2, 3, 7, 11, 12, 13 |
| AZ | 5 | 1,000 - 999,999 | 8, 11, 12 |
| CA | 39 | 100 - 99,999,999 | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 |
| CO | 8 | 1,000 - 9,999,999 | 1, 4, 6, 8, 10, 11, 13 |
| CT | 4 | 1,000 - 99,999 | 8, 11, 13 |
| DE | 5 | 10,000 - 49,999,999 | 1, 2, 3, 7, 8, 11 |
| FL | 8 | 1,000 - 999,999 | 8, 11, 12 |
| GA | 21 | 1,000 - 9,999,999 | 1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13 |
| HI | 2 | 100,000 - 9,999,999 | 1, 2, 6, 11 |
| IA | 20 | 1,000 - 999,999 | 11, 12, 13 |
| IL | 39 | 0 - 99,999,999 | 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13 |
| IN | 27 | 0 - 99,999,999 | 1, 3, 4, 7, 8, 9, 10, 11, 12, 13 |
| KS | 10 | 100 - 49,999,999 | 1, 3, 4, 8, 9, 10, 11, 12 |
| KY | 11 | 100 - 9,999,999 | 1, 3, 4, 6, 7, 9, 10, 11, 12, 13 |
| LA | 40 | 1,000 - 1E12 | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 |
| MA | 16 | 1,000 - 999,999 | 2, 3, 8, 10, 11, 12 |
| MD | 3 | 10,000 - 99,999 | 8, 11, 13 |
| ME | 2 | 1,000 - 999,999 | 1, 6, 12 |
| MI | 28 | 100 - 9,999,999 | 1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13 |
| MN | 20 | 1,000 - 49,999,999 | 1, 4, 5, 7, 8, 10, 11, 12, 13 |
| MO | 17 | 1,000 - 999,999 | 8, 9, 10, 11, 12, 13 |
| MS | 14 | 0 - 9,999,999 | 1, 3, 6, 7, 8, 11, 12, 13 |
| MT | 6 | 10,000 - 49,999,999 | 1, 2, 3, 4, 6, 7, 8, 9, 11 |
| NC | 15 | 100 - 999,999 | 1, 5, 8, 9, 11, 12, 13 |
| ND | 4 | 100,000 - 49,999,999 | 1, 2, 3, 4, 7, 11 |
| NE | 9 | 1,000 - 999,999 | 11, 12 |
| NJ | 17 | 1,000 - 99,999,999 | 1, 2, 3, 4, 7, 8, 9, 10, 11, 12 |
| NM | 4 | 100,000 - 9,999,999 | 1, 3, 4, 6, 7, 8, 9, 13 |
| NV | 2 | 10,000 - 999,999 | 8, 11 |
| NY | 7 | 1,000 - 999,999 | 1, 5, 8, 11, 12, 13 |
| OH | 58 | 0 - 49,999,999 | 1, 2, 3, 6, 7, 8, 9, 10, 11, 12, 13 |
| OK | 9 | 1,000 - 99,999,999 | 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13 |
| OR | 1 | 10,000,000 - 49,999,999 | 10 |
| PA | 20 | 1,000 - 49,999,999 | 1, 2, 3, 5, 6, 7, 8, 9, 11, 12, 13 |
| PR | 15 | 1,000 - 499,999,999 | 1, 2, 4, 5, 6, 8, 10, 11, 12, 13 |
| RI | 1 | 1,000 - 9,999 | 2, 3, 8, 13 |
| SC | 11 | 0 - 999,999 | 1, 5, 6, 8, 9, 11, 12, 13 |
| SD | 2 | 10,000 - 999,999 | 11, 12 |
| TN | 18 | 1,000 - 9,999,999 | 1, 2, 5, 6, 8, 9, 11, 12, 13 |
| TX | 121 | 0 - 1E12 | 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 |
| UT | 10 | 0 - 49,999,999 | 1, 2, 3, 4, 7, 8, 9, 11, 12, 13 |
| VA | 16 | 1,000 - 999,999 | 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13 |
| VI | 1 | 50,000,000 - 99,999,999 | 1, 2, 3, 4, 7, 11 |
| WA | 9 | 1,000 - 99,999,999 | 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13 |
| WI | 10 | 1,000 - 99,999 | 1, 6, 8, 10, 11, 12, 13 |
| WV | 5 | 1,000 - 99,999 | 11, 12, 13 |
| WY | 5 | 100,000 - 49,999,999 | 1, 3, 4, 5, 6, 7, 8 |

*Source: TRI96 1998*

[a] Post office state abbreviations used

[b] Range represents maximum amounts on site reported by facilities in each state

[c] Activities/Uses:

1. Produce
2. Import
3. Onsite use/processing
4. Sale/Distribution
5. Byproduct
6. Impurity
7. Reactant
8. Formulation Component
9. Article Component
10. Repackaging
11. Chemical Processing Aid
12. Manufacturing Aid
13. Ancillary/Other Uses

of *n*-hexane: Exxon Chemical Company, Baytown, Texas; Humphrey Chemical Company, Inc. (formerly the Cambrex Corporation), North Haven, Connecticut; Phibro Energy USA, Inc., Houston Texas; Phillips Petroleum Company's Olefins and Cyclics Branch, Sweeny, Texas; Phillips Petroleum Company's Specialty Chemicals Branch, Borger, Texas; and the UNI-VEN Company (formerly the Unocal Corporation), Lemont, Texas (SRI 1996). During the period 1988 to 95, the following five additional facilities were also documented as producing *n*-hexane: Independent Refining Company, Winnie, Texas; Pennzoil Company Atlas Refinery, Shreveport, Louisiana; Unocal Corporation, Beaumont, Texas; Texaco, Inc., El Dorado, Kansas; and South Hampton Refining Company, Silsbee, Texas (SRI 1990, 1992, 1994, 1995). The available information suggests that many facilities are capable of entering the market for *n*-hexane production through minor alterations in their refining operations when there is strong demand. Information from the mid-1970s suggests commercial production levels for *n*-hexane were approximately 358,341,000 pounds (143 million kg) (Marks et al.1980). For 1992, production was estimated at approximately 151 million kg (USITC 1994).

## 4.2 IMPORT/EXPORT

No current information concerning the import or export of *n*-hexane in the United States was located in the Literature.

## 4.3 USE

*n*-Hexane is used mainly as an edible-oil extractant for a variety of seed crops such as soybeans, cottonseed, rape seed (canola), flax (linseed), mustard seed, peanuts, safflower seed, and corn germ, which are then processed into foods for humans or livestock (Bhagya and Srinivas 1992; Conkerton et al.1995; Dominquez et al.1995; Kim and Yoon 1990; Lawson 1995; Srinivas et al.1992; Wanasundara and Shahidi 1994). While other petroleum-derived solvents (e.g., pentane) or other organic solvents (e.g., chloroform, methanol, ethanol, or ammonia-alcohol mixtures) are currently being studied or are used for certain processes, *n*-hexane has been widely used since the early part of this century, especially with soybeans, cottonseed, and linseed (Conkerton et al.1995). Part of *n*-hexane's appeal relates to aesthetic properties such as preserving the colors of the original plant materials. Different extractant mixtures can also have significant effects on the levels of materials that can cause bitter tastes (e.g., tannins) and on the degree to which certain flatulence-causing sugars are removed. While other solvents could be used in the initial oil extraction phases, several decades of experience in combining the oil-extraction steps with other

procedures to preserve desirable colors and eliminate unwanted tastes or other undesirable food properties have worked to maintain a heavy reliance on *n*-hexane for edible-oil extraction (Lawson 1995). In the 1970s it was estimated that soybean oil extraction alone accounted for approximately 30% of all uses of *n*-hexane in the United States (HSDB 1996).

*n*-Hexane has other major uses as a special-purpose solvent and cleaning agent (degreaser) in such industries as textile manufacture, shoe and leather making, and furniture manufacturing (Jorgensen and Chor 1981). It is used in the printing industry as a cleaner and as a component of some inks (EPA 1996c; Wadden et al.1995). Facilities that use rotogravure printers (facilities that produce catalogues, magazines, *"*glossy*"* newspaper inserts, or telephone directories) or similar rotogravure or flexographic technologies (for labels, gift wrap, metal foils, flexible packaging materials, and some floor coverings) also use *n*-hexane (EPA 1996c). While not used in most glues or epoxy cements (Rastogi 1993), *n*-hexane is the solvent used in *"*rubber*"* cement (also known as gum adhesive) widely used in schools and libraries and by artists (McCann 1992). Various glues, adhesives, and leather-dressing preparations, especially those used in assembling shoes, may contain *n*-hexane (Cardona et al.1993; Periago et al.1993; Takeuchi et al.1993). In bookbinding and leather working, *n*-hexane, often mixed with other hydrocarbon solvents, is used as a carrier for cedar oil, beeswax, or lanolin dressings (Jorgensen and Chor 1981; Roberts and Etherington 1996). *n*-Hexane is used in some typeover correction (*"*white-out*"*) fluids (Ong et al.1993). It has been used in many types of non-mercury thermometers, especially for thermometers used in low temperature ranges (EPA 19948). It has been used as a denaturing agent in some alcohol preparations (HSDB 1996). New roofing materials using rubber or plastic films and membranes held together by adhesives, sealants, or hardening agents may contain *n*-hexane (Herbert et al.1995). It may be used as a carrier or aerosol (propellant) agent in some perfumes (Bouhamra 1995; Jorgensen and Chor 1981). It is used in the pharmaceutical industry to help shape pills and tablets, which are then dried to vent off the *n*-hexane before packaging (Jorgensen and Chor 1981). In the petrochemical industry, lighter alkane fractions including *n*-hexane may be used as feedstocks in the manufacture of polyethylene or polypropylene (Jorgensen and Chor 1981). In canning operations, the ends of tin cans are held in place with adhesives that commonly contain *n*-hexane (Bachmann et al.1993). The balls used in several sports (e.g., baseball) have cores wrapped with strings or yarns, which are often held in place with adhesives containing *n*-hexane (Huang et al.1991). In the manufacture of truck and automobile tires, *n*-hexane is a solvent in mixtures (called *"*thinners*"*) used to adjust the viscosity of the rubber while it is being polymerized and formed into tires (Jorgensen and Chor 1981; Van Ert et al.1980). *n*-Hexane is apparently in the adhesives for certain types of tapes, bandages, and dressings used in hospitals (Jorgensen and Chor 198I). Adhesives, cleaners, or

lacquers containing *n*-hexane are also used to prepare the veneers used in making many types of furniture or ornamental boxes (Graham et al.1995).

Pure *n*-hexane is widely used in laboratories as an extractant for nonpolar compounds and in calibrating instruments for analyses of volatile organic compounds (VOC) or total petroleum hydrocarbons (TPH) (Kanatharana et al.1993). Since such analyses may require very high levels of purity, laboratories sometimes carry out their own fractional distillation or other pretreatment-purification procedures to remove petroleum hydrocarbon impurities found in commercially available grades of *n*-hexane (Kanatharana et al.1993). See Chapter 6 for more information about testing for *n*-hexane.

Finally, *n*-hexane may be a component of many types of commercial preparations or in mixtures produced in small batches o*n*-site such as paint thinners, general-purpose solvents, degreasing agents, or cleaners. For instance, until the 1970s naphtha, a mixture with a high *n*-hexane content, was widely used as a dry cleaning agent. Since the early 1900s construction workers, metal workers, janitors, furniture workers, motor-vehicle mechanics, and print-shop workers have used these general-purpose mixtures. Such mixtures have also been used extensively for home repair and hobby projects. These mixtures have wide variations in their compositions but often contain up to 20% *n*-hexane even when the main components are other petroleum alkane fractions (e.g., kerosene), aromatic hydrocarbons (e.g., toluene), chlorinated hydrocarbon solvents, or other organic liquids (Farmer 1996; Veulemans et al.1987).

## 4.4 DISPOSAL

Limited information was located in the literature concerning the disposal of *n*-hexane. Since it is highly flammable, *n*-hexane, or mixtures with significant amounts of *n*-hexane, are regulated under the Resource Conservation and Recovery Act (RCRA) disposal procedures covering D001 wastes for ignitable wastes and petroleum solvents. For printing operations it could also be considered under the K086 ink sludges designation (EPA 1996c). *n*-Hexane is listed as a toxic substance under Section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) under Title III of the Superfund Amendments and Reauthorization Act (SARA) (EPA 1993a). It is also listed as a Hazardous Air Pollutant (HAP) in the Clean Air Act Amendments of 1990 (EPA 1994g). Disposal of wastes containing *n*-hexane is controlled by a number of federal regulations (see Chapter 7).