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

4.1 PRODUCTION

Jet fuels are produced from refined crude petroleum to meet specifications for particular uses (Air Force 1989b; IARC 1989). These specifications are designated by the American Society for Testing and Materials (ASTM) (IARC 1989). Light jet fuels such as jet fuel no. 1 (kerosene) are refined from straight distillation of crude oil or distillation of crude oil in the presence of a catalyst. Fuels such as JP-5 and JP-8 are then chemically enhanced with antioxidants, dispersants, or corrosion inhibitors to meet the requirements for a specific application. Jet fuel no. 1 is a product of the straight-run distillation of crude petroleum (HSDB 1998). It consists of a mixture of petroleum hydrocarbons, chiefly of the methane series, which typically have from 10 to 16 carbon atoms per molecule (HSDB 1998; IARC 1989). The typical components of the end product of jet fuel no. 1 include paraffins (*n*-, iso-, monocycle-, bicycle- and tricycle-), olefins, aromatics, and nitrogen and sulfur impurities (Air Force 1989b; IARC 1989).

Although most facilities that refine crude petroleum in the United States produce a jet fuel no. 1 fraction (HSDB 1998), only producers that market jet fuel no. 1 as an end product are listed as commercial manufacturers. These manufacturers are Claibome Gasoline Company (Claibome and Union Parish, Louisiana), Continental Oil Company (Acadia Parish, Louisiana), Sun Production Company (Starr County, Texas), Exxon Corporation (Pledger County, Texas), Atlantic Richfield Company (New York, New York), and Shell Oil Company (Houston, Texas) (HSDB 1998). Because JP-5 and JP-8 are not required to be reported under SARA Section 313, there are no data for JP-5 and JP-8 in the 1992 Toxics Release Inventory (TRI) (TR192 1994).

Production of kerosene has steadily decreased since 1970 (API 1991). The supply of kerosene produced in 1970 was 95,600,000 barrels. By 1975, production volume had dropped to 55,500,000 barrels. As of 1990, only 16,400,000 barrels of kerosene were produced. While the demand for kerosene has gradually declined with time, that for jet fuels has steadily increased. As a result, many refiners have recently chosen to produce Jet A-l (a commercial jet fuel very similar to JP-8) as their basic product and to simply divert a portion of the product for marketing as kerosene (IARC 1989). In the United States, production of jet fuels, including both kerosene-type (JP-5 and JP-8) and wide-cut fuels, increased from 268,452,000O barrels (37,636,000 tons) in 1970 to 406,137,000 barrels (56,939,000 tons) in 1985 (IARC 1989). In the countries of the Organization for Economic Cooperation and Development (OECD), production increased from 411,282,000 barrels (57,659,000 tons) to 643,967,000 barrels (90,280,000 tons) during the same time (IARC 1989).

4.2 IMPORT/EXPORT

Imports of distillate fuels have varied from year to year since the 1970s. Since 1975, imports of distillate jet fuels such as jet fuel no. 1 into the United States have been low compared to the amount of distillate jet fuels produced in the United States (API 1991). Imports of kerosene fluctuated between 1975 and 1984 and then showed a steady increase from 1985 to 1987, attaining an annual maximum of 6,935,000 barrels in 1987. Between 1988 and 1990, imports of kerosene decreased to a low of 1,825,000 barrels (API 1991).

During the five-year period from 1990 to 1994, kerosene-type jet motor fuel imports into the U.S. have been steady, averaging approximately 27.3 million barrels annually. In 199 1, however, the year of the Persian Gulf War, imports reached a low of 19.7 million barrels. Imports rose to a peak of 29.4 million barrels in 1994 and declined slightly to 28.0 million barrels in 1996 (NTDB 1997). Import data for 1995 is not available.

Exports of jet fuel no. 1 between 1972 and 1975 ranged from 100,000 barrels (14,000 tons) in 1972 to 699,000 barrels (98,000 tons) in 1975 (HSDB 1998). Exports of distillate jet fuels increased almost 1 00-fold between 1975 and 1990 (API 1991). Little kerosene has been exported from the United States since the 1970s. In 1971, approximately 365,000 barrels were exported from the United States. The next 2 years for which export volumes were reported for kerosene were 1983 and 1984, when 365,000 barrels were exported each year. However, export volumes doubled from 730,000 barrels in 1986 to 1,820,000 barrels in 1990 (API 1991). Comprehensive export data for kerosene prior to 1986 are not available. Kerosene exportation between 1987 and 1989 remained relatively constant with a yearly export average of approximately 547,500 barrels. However, by 1990, the annual export of kerosene was 2,190,000 barrels (API 1991), an increase of approximately 400%. U.S. exports of kerosene-type jet motor fuels declined during the 5-year period between 1991 and 1995, from 14.1 to 9.4 million barrels annually NTDB 1997). The largest decrease occurred in 1994 when the quantity dropped 8.9 million barrels from the previous year, from 15.3 in 1993 to 6.4 million barrels in 1994 (NTDB 1997).

4.3 USE

Aviation turbine fuels were not used until the 1930s when the first turbojet engine was developed (IARC 1989). Jet-powered aircraft had only limited use in World War II, but further military and commercial developments allowed jet engines to dominate as power sources for aircraft in the 1960s. JP-1, a mixture of gasoline and kerosene, was the first jet fuel used by the U.S. Army Air Corps in 1944 (Army 1989). A military specification for JP-4, also a mixture of gasoline and kerosene, was first issued in 195 1 (Army 1989). JP-5 was developed by the U.S. Navy in the early 1950s for aircraft use aboard aircraft carriers. Its lower volatility and higher minimum flashpoint (140°F) compared to JP-4 made it safer in the event of a shipboard spill or crash (Army 1989). During the Vietnam War, the Navy's JP-5 proved to be a superior fuel for combat aircraft, as compared to the Air Force's JP-4; the Navy had lower loss rates as a result of fewer gunfire-initiated and post-crash fires and explosions (Air Force 1989a). Statistics showed that the probability of post-crash fires with JP4-fueled aircraft was 83%, but for kerosene (JP5)-fueled aircraft, the probability was only 35% (Air Force 1987). The Navy has also used JP-5 as an alternative fuel on surface ships (Risher 1995). As a result, the Air Force initiated a program to replace JP-4 with a safer, kerosene-based fuel. After extensive tests, Commercial Jet A-1, a low-freezing-point kerosene fuel used by commercial airlines, was determined to be a suitable replacement, and a military specification for JP-8 was prepared and published in 1976 (Air Force 1987). JP-8 is identical to Jet A-l, except for the addition of a fuel system icing inhibitor, a corrosion inhibitor, and a lubricity additive. For continental U.S. flights, U.S. commercial airlines use Jet A, which is basically the same as Jet A-l with a higher freeze point, making it unsuitable for military use (Air Force 1987). Properties of JP-8 were chosen to provide: (1) low volatility, as measured by flashpoint (in order to minimize in-flight and post-crash aircraft fires); (2) low freezing point (needed for high-altitude and worldwide operations); (3) high availability in wartime and low cost in peacetime; and (4) compatibility with existing aircraft (Air Force 1989a). In 1979, the U.S. Air Force switched from JP-4 to JP-8 for its operations in Great Britain (Air Force 1987). NATO has begun the process of switching to JP-8 as the single fuel for land-based air and ground forces. This conversion to one fuel for use by NATO ground and air forces is expected to result in substantial logistics and operations benefits (Army 1989). The U.S. Air Force is currently planning a domestic conversion from naphtha-based JP-4 jet fuel to distillate-based JP-8 jet fuel (Salthouse 1992).

4.4 DISPOSAL

Vapors generated in tank truck loading of jet fuels can be disposed of by the installation of a vapor recovery system (NIOSH 1989). Runoff of jet fuels from loading and unloading aircraft operations can be separated by an on-site oil/water separation system.

Several methods have been investigated for the disposal of jet fuels spilled onto soil from normal aircraft operations or from accidental spills. One method, *in situ* soil venting, involves using vacuum blowers to pull large amounts of air through soil contaminated with jet fuels (Elliot and DePaoli 1990). The vacuum pulls out the soil gas, and the jet fuel contaminants volatilize as a result of disrupted equilibrium. Incineration of free-product extracted from contaminated media is another method of disposal proposed for soils and water contaminated with jet fuels (OHM/TADS 1985). Incineration of soils contaminated with jet fuels has also been investigated (OHM/TADS 1985). Other methods include absorption (straw, polyurethane foam, activated carbon, and peat have been used as absorbents), gelling agents, combustion promoters, dispersants, and mechanical systems (OHM/TADS 1985). Biodegradation has also been suggested as a means of disposal for spills onto soil (OHM/TADS 1985). Hydrocarbon-degrading bacteria have been shown to degrade petroleum products into smaller units and eventually into nonseparable particles (Butt et al. 1988). Soil contaminated with jet fuel no. 1 was found to have a growth response of 10^6 colony-forming units per mL in 7 out of 21 types of bacteria isolated for sample study (Butt et al. 1988). For more information on biodegradation, refer to Chapter 5.

Wastes containing JP-5 and JP-8 are considered hazardous if they meet certain criteria specified by law. Hazardous wastes are subject to the handling, transport, treatment, storage, and disposal regulations as promulgated under the Resource Conservation and Recovery Act (HSDB 1998; IRPTC 1985). Regulations governing the treatment and disposal of wastes containing JP-5 and JP-8 are detailed in Chapter 7.