4. PRODUCTION, IMPORT, USE, AND DISPOSAL

4.1 PRODUCTION

Fuel oils are produced from refined crude petroleum to meet specifications for a particular use (Air Force 1989; IARC 1989). These specifications are designated by the American Society for Testing and Materials (ASTM) (IARC 1989). Light fuel oils such as fuel oil no. 1 and no. 2 are manufactured from straight distillation of crude oil, or distillation of crude oil in the presence of a catalyst, and are chemically enhanced with antioxidants, dispersants, or corrosion inhibitors to meet the requirements for a specific application. Fuel oil no. 1 is a product of the straight-run distillation of crude petroleum (HSDB 1991). 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 1991; IARC 1989). The typical components of the end product of fuel oil no. 1 include paraffins (*n*-, iso-, monocycle-, bicycle- and tricycle-), olefins, aromatics, and nitrogen and sulfur impurities (Air Force 1989; IARC 1989). Fuel oil no. 2 is manufactured from the blending of straight-run and catalytically cracked distillates (IARC 1989). The types of each stream and the proportioned amounts in the resulting fuel oil depend on the quality of the crude petroleum used for the distillations.

The distillate manufacturing processes of diesel fuel oils, such as fuel oil 1-D and fuel oil 2-D, are similar to those of fuel oil no. 1 and fuel oil no. 2, respectively (IARC 1989). Fuel oil no. 1-D is manufactured from a straight-run distillate process. Diesel fuel oil (l-D, 2-D) is defined as the fraction of petroleum that distills after kerosene (Air Force 1989). Fuel oil no. 2-D is also made from mixing of straight-run and catalytically cracked distillates (IARC 1989).

Residual fuel oils, such as fuel oil no. 4, are manufactured by the addition of blending stocks to distillation residues in order to meet viscosity specifications set by ASTM (IARC 1989). No data were located for the manufacturing process of fuel oil UNSP.

Although most facilities that refine crude petroleum in the United States produce a fuel oil. no. 1 fraction (HSDB 1991), only producers that market fuel oil no. 1 as an end product are listed as commercial manufacturers. These manufacturers include Claiborne Gasoline Company (Claiborne 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 1991). Since fuel oils nos. 1, 1D, 2, 2-D, and 4, and fuel oil UNSP are not required to be reported under SARA Section 313, there are no data for these fuel oils in the 1990 Toxics Release Inventory (TRI90 1992).

Between 1970 and 1980, distillate fuel production, which includes the production of diesel fuels, increased steadily (IARC 1989). The total production volume in 1970 was 2,460,000 barrels, which increased to 3,167,000 barrels in 1979; however, between 1980 and 1986, distillate fuel production volumes fluctuated. After 1986, production volume of distillate fuels steadily increased to a maximum to 3,167,000 barrels in 1990 (API 1991).

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. Production volumes of residual fuel oils showed a sharp increase between 1970 and 1980 and a sharp decline between 1980 and 1985 (IARC 1989). The total production volume of residual fuels in 1970 was 262,000,000 barrels, which increased to 456,000,000 barrels in 1975, 605,000,000 barrels in 1980, decreased to 321,000,000 barrels in 1985, and increased slightly to 346,000,000 barrels in 1990 (API 1991). No data were located for production volumes of fuel oil UNSP.

4.2 IMPORT/EXPORT

Imports of distillate fuels have varied from year to year since the 1970s. Since 1975, imports of distillate fuel oils such as fuel oils no. 1 and no. 2 into the United States have been low compared to the amount of distillate fuel oils produced in the United States (API 1991). Annual import volumes fluctuated between 57,000,000 barrels in 1975 and 64,000,000 barrels in 1983 with a maximum of 91,250,000 barrels in 1977. From 1984 to 1989, imports of distillate fuels steadily increased from 99,439,000 barrels in 1984 to 111,000,000 barrels in 1989. 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. From 1988 to 1990, imports of kerosene deceased to a low of 1,825,000 barrels in 1990 (API 1991).

Imports of residual fuel oils such as fuel oil no. 4 generally decreased in the period between 1975 and 1989 (API 1991). In 1975, total imports of residual fuel oil were 447,000,000 barrels; however, imports gradually decreased over this 15-year period to 230,000,000 barrels in 1985. No information was located regarding diesel fuel imports or unspecified fuel oil imports.

Exports of fuel oil no. 1 between 1972 and 1975 ranged from 14,000 tons in 1972 to 98,000 tons in 1975 (HSDB 1991). Exports of distillate fuel oils (which include fuel oil no. 1, fuel oil no. 2, diesel fuel, and fuel oil no. 4) increased almost 100-fold between 1975 and 1990 (API 1991). In 1975, a yearly average of 365,000 barrels of distillate fuel oils were exported out of the United States. By 1990, exports had increased to an average of 3,900,000 barrels. 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, between 1986 and 1990, 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%. Residual fuel oil exports also increased, from a daily average of 15,000 barrels in 1975 to 215,000 barrels in 1989 (API 1990).

4.3 USE

Fuel oils have many commercial and military uses. Kerosene, a type of fuel oil no. 1, was chosen as a jet fuel during the development of the first jet engines, largely because gasoline was in short supply during wartime (IARC 1989). Fuels that are used currently in jet engines, such as JP-5, are very similar to kerosene, and are also included in the fuel oil no. 1 designation. At present, fuel oil no. 1 is used almost exclusively for domestic heating (Air Force 1989) with burners of the vaporizing type (IARC 1989); although fuel oil no. 1 was used as a jet fuel in the first jet engines (IARC 1989). In the petroleum industry, fuel oil no. 1 has also been used as an illuminating fuel, a motor fuel, and a heating fuel (HSDB 1991). In the pesticide industry, fuel oil no. 1 has been used as a vehicle for insecticides and fungicides (HSDB 1991). Fuel oil no. 1 is also used in kerosene lamps, flares, and stoves. Fuel oil no. 2 has been primarily used as a home heating oil and as an industrial heating oil

(IARC 1989). Fuel oil no. 2 is also reported to be used in atomizing-type burners (Air Force 1989; IARC 1989).

Diesel fuels are most commonly used as transportation fuels for diesel engines (Air Force 1989; IARC 1989). Fuel oil no. 1-D is used in engines that require frequent load and speed changes (Air Force 1989). Fuel oil no. 2-D has been used for engines that are in industrial or heavy mobile service (Air Force 1989). Diesel fuels have been used in stationary gas turbines to generate electric power (IARC 1989).

In electric utilities, residual fuel oils, such as no. 4, have been used to process steam for electric plants (IARC 1989). Fuel oil no. 4 has been used in commercial and industrial burner installations that are not equipped with preheating facilities (Air Force 1989). In other industries, such as the maritime industry, plants and factories, and the petroleum industry, residual fuel oils have been used for space and water heating, pipeline pumping, and gas compression, as well as in road oils, and in the manufacture.

U.S. consumption of distillate fuels used for heating decreased gradually between 1979 and 1983 (IARC 1989). The annual domestic demand for distillate fuel oils was approximately 1,214,355,000 barrels in 1979, decreasing to 981,850,000 barrels in 1983. The U.S. demand for distillate fuels subsequently rose from 1984 to 1989, reaching an annual maximum of 1,248,700,000 barrels in 1989 (API 1991). The annual domestic demand for residual fuel oils also decreased between 1979 (1,034,800,000 barrels) and 1985 (475,600,000 barrels). After 1985, the demand varied from an annual average of 561,000,000 barrels in 1986 to 486,180,000 barrels in 1990 (API 1991). Finally, the average annual domestic demand for kerosene decreased from 68,990,000 barrels in 1979 to 16,790,000 barrels in 1990 (API 1991).

4.4 DISPOSAL

Incineration is one method of disposal proposed for fuel oils no. 1 and no. 2 (OHM/TADS 1985). Other methods may be used to disposal of oil spills, including 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 fuel oil no. 1 was found to have a growth response of 10 E+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.