

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

### 4.1 PRODUCTION

Originally, “straight-run” gasoline was produced by simple distillation of crude oil without the use of chemical conversion processes (Lane 1980; Sax and Lewis 1987). Shortly after 1900, motor vehicles began to appear in growing numbers, and gasoline began to have a marketable value as a refinery product. Around 1912, distillation of crude oil alone could not satisfy the rapidly growing demand for gasoline. At this time, gasoline-range hydrocarbons were recovered from “wet” natural gas. However, only a limited amount of natural gasoline could be included in finished gasoline because of its high volatility and its relatively low anti-knock quality (Lane 1980). Since then, petroleum refineries have developed several processes to contribute to the production of gasoline.

In general, gasolines are blended from several petroleum refinery process streams that are derived by the following methods: direct distillation of crude oil, catalytic and thermal cracking, hydrocracking, catalytic reforming, alkylation, and polymerization. Modern petroleum refining begins with the distillation of crude oil into the following fractions: light naphtha (used as a component of finished gasoline without additional refining), heavy naphtha (catalytically reformed to a higher-octane blending stock), kerosene and light gas-oil (used in the production of kerosene, jet fuel, diesel fuel, and furnace oils), heavy gas-oil (used in heavy diesel fuel, industrial fuel oil, and bunker oil), and reduced crude. The heavy gas-oil and other heavy oils recovered from the reduced crude can be cracked into gasolines (Lane 1980). The use of cracking to produce gasoline began in 1913. Cracking breaks down higher-boiling hydrocarbons into lower-boiling ones. The two general types of cracking used are catalytic and thermal. Catalysts may consist of naturally occurring clays or synthetic compounds. Catalytic cracking produces blending components for high-octane gasoline. Therefore, in addition to serving as a gasoline-production process, catalytic cracking also serves to improve octane (Hood 1973; Lane 1980). Hydrocracking, which consists of cracking in the presence of added hydrogen, permits wide variations in yields of gasoline and furnace oils to meet seasonal demand changes and can effectively process hard-to-crack stocks. However, since hydrocracked stocks lack the high-octane olefins present

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in catalytically cracked stocks, they must be reformed (Lane 1980). Reforming processes convert lowoctane gasoline-range hydrocarbons into higher-octane ones. Thermal reforming has been almost completely replaced by catalytic reforming. Most reforming catalysts are bimetallic catalysts consisting of platinum with another promoting metal, such as rhenium (Hood 1973; Lane 1980). Alkylation converts refinery gases into gasoline-range liquids of exceptionally high anti-knock quality. However, the process is costly and is not commonly used in gasoline production (Domask 1984; Lane 1980). Polymerization combines two or more low molecular weight olefin gases into higher molecular weight olefin liquids suitable for gasoline blending or for use as chemical feed stocks. However, because olefinic liquids have low anti-knock quality and the reactants, olefin gases, are valuable chemical feeds, the polymerization process is no longer widely used to produce gasoline blend streams (Domask 1984; Lane 1980).

After the various gasoline streams have been blended, foul-smelling, corrosive, sulfur compounds are removed by hydrogenation (Lane 1980). Additives and blending agents are added to improve the performance and stability of gasoline. These compounds include anti-knock agents, anti-oxidants, metal deactivators, lead scavengers, anti-rust agents, anti-icing agents, upper-cylinder lubricants, detergents, and dyes (IARC 1989; Lane 1980). At the end of the refining process, finished gasoline typically contains more than 150 separate compounds although as many as 1,000 compounds have been identified in some blends (Domask 1984; Mehlman 1990). At present, the only commercial source of gasoline is petroleum, but it has been produced from shale oil, Athabasca tar sands, and by hydrogenation or gasification of coal (Hood 1973; Sax and Lewis 1987).

Gasoline is available in the United States in leaded and unleaded grades. In the past, organic lead compounds were widely used as anti-knock agents in gasoline; however, methyl-tertiary-butyl ether has almost completely replaced tetraethyllead as an anti-knock agent and is now widely used in the production of unleaded gasoline (Sax and Lewis 1987). Now, EPA regulations do not permit intentional addition of lead or phosphorous to unleaded gasoline and limits their maximum concentrations to 0.013 g lead/L and 0.0013 g phosphorus/l. Leaded gasoline is produced in much smaller quantities for use in engines not equipped with catalytic converters. According to EPA regulations, leaded gasoline can contain any lead additive at a concentration higher than 0.013 g lead/L but no more than 1.1 g lead/L. The two common grades of both leaded and unleaded gasoline,

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premium and regular, differ in their anti-knock quality. Better anti-knock quality is indicated by a higher octane number (IARC 1989). Gasoline is marketed as several products and, within each product line, in various grades (IARC 1989).

The U.S. production volume of motor gasoline has steadily increased between 1983 and 1989 from 277.2 million gallons/day to 306.6 million gallons/day (DOE 1989a). During the month of January 1989, U.S. production of unleaded gasoline was nearly six times as high as U.S. production of leaded gasoline (DOE 1989b). The states leading production of unleaded gasoline were Texas, California, and New Jersey and the states leading production of leaded gasoline were Texas, California, and Illinois (DOE 1989b). In 1989, the 10 U.S. companies leading gasoline sales were the following (in descending order of sales): Shell, Amoco, Exxon, Mobil, Chevron, Texaco, Unocal, BP America, Sun, and Phillips (API 1991).

Since gasoline releases are not required to be reported under SARA Section 313, there are no data on gasoline in the Toxics Release Inventory (TR188 1990).

#### **4.2 IMPORT/EXPORT**

Between 1988 and 1989, net U.S. imports of gasoline declined by 14% to an average of 13.0 million gallons/day. By 1990, imports were up to an average of 14.3 million gallons/day (DOE 1990).

Typically net U.S. imports of gasoline account for 4-5% of demand (DOE 1989a). During the month of January 1989, the primary countries exporting gasoline to the United States were (in order of decreasing volume) Saudi Arabia, Venezuela, Brazil, Canada, France, Spain, and the United Kingdom (DOE 1989b).

Between 1988 and 1989, U.S. exports of finished motor gasoline increased from 924,000 gallons/day to 1.6 million gallons/day. Exports reached the highest point ever in 1989 at 2.4 million gallons/day (DOE 1990). During the month of January 1989, the United States exported primarily to Guatemala, Japan, and Mexico (DOE 1989b).

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##### 4.3 USE

Gasoline is used almost exclusively to fuel internal combustion engines (IARC 1989). Consumption of gasoline decreased slightly in 1982 and then again in 1989. In 1989, 306.6 million gallons of gasoline were consumed in the United States. During 1989, the use of unleaded gasoline continued to rise, accounting for 88.8% of the total gasoline demand in that year (DOE 1989a).

##### 4.4 DISPOSAL

Most gasoline is burned in internal combustion engines. Limited data are available on the disposal of gasoline. A suggested method is to spray it into an incinerator (OHM/TADS 1991).