Oil Products

1- Gaseous Fuels.

Natural gas, which is predominantly methane, occurs in underground reservoirs separately or in association with crude oil. The principal types of gaseous fuels are oil (distillation) gas, reformed natural gas, and reformed propane or liquefied petroleum gas (LPG).
LPG is the term applied to certain specific hydrocarbons and their mixtures, which exist in the gaseous state under atmospheric ambient conditions but can be converted to the liquid state under conditions of moderate pressure at ambient temperature. The most common commercial products are propane, butane, or a mixture of the two, and are generally extracted from natural gas or crude petroleum. Mixed gas is a gas prepared by adding natural gas or LPG to a manufactured gas, giving a product of better utility and higher heat content.

1.1 Compositions

The principal constituent of natural gas is methane. Other constituents are paraffinic hydrocarbons such as ethane, propane, and the butanes.

1.2 Manufacture

Unless produced specifically as a product (e.g., LPG), the gaseous products of refinery operations are mixtures of various gases. Each gas is a by-product of a refining process. Thus, the compositions of natural, manufactured, and mixed gases can vary so widely, no single set of specifications could cover all situations.

1.2 Properties and Uses

As already noted, the compositions of natural, manufactured, and mixed gases can vary so widely, no single set of specifications could cover all situations. The requirements are usually based on performances in burners and equipment, on mini mum heat content, and on maxi mum sulfur content. Gas utilities in most states come under the supervision of state commissions or regulatory bodies an d the utilities must provide a gas that is acceptable to all types of consumers and that will give satisfactory performance in all kinds of consuming equipment.

2- Gasoline

Gasoline, also called gas (United States and Canada), or petrol (Great Britain) or benzene (Europe) is a mixture of volatile, flammable liquid hydrocarbons derived from petroleum and used as fuel for internal-combustion engines. It is also used as a solvent for oils and fats. Gasoline became the preferred automobile fuel because of its high energy of combustion and capacity to mix readily with air in a carburetor. Gasoline is a mixture of hydrocarbons that usually boil below 180°C or, at most, below 200°C. B.p (35 – 180°C) and sp.gr (0.7 – 0.78).

2.1 Compositions

Gasoline is manufactured to meet specifications and regulations and not to achieve a specific distribution of hydrocarbons by class and size. Automotive gasoline typically contains about almost 200 (if not several hundred) hydrocarbon compounds. The relative concentrations of the compounds vary considerably depending on the source of crude oil, refinery process, and product specifications. Typical hydrocarbon chain lengths range from C_4 through C_{12} with a general hydrocarbon distribution consisting of alkanes (4–8%), alkenes (2–5%), iso-alkanes 25–40%, cycloalkanes (3–7%), cycloalkenes (l–4%), and aromatics (20–50%). However, these proportions vary greatly. The majority of the members of the paraffin, olefin, and

aromatic series (of which there are about 500) boiling below 200°C have been found in the gasoline fraction of petroleum.

2.2 Manufacture

- Gasoline produced by distillation (light straight run (LSR)), simply separating the volatile, more valuable fractions of crude petroleum (O.N ≈ 65).
- Catalytic reforming (O.N = 90)
- Thermal racking of heavy cuts higher than kerosene.
- Catalytic cracking (O.N > 90).
- Alkylation process (O.N > 95).
- Haydrocracking.

2.2 Properties

2.3.1 **Octane Number**

In a spark-ignition engine, some compounds start to burn before they reach the spark plug. This premature ignition causes knocking, which reduces the power of the engine, increases engine wear, and in some cases causes serious damage. Octane number is a measure of the propensity of fuels to knock in gasoline engines. It is based on an arbitrary scale in which the octane number of n-heptane is zero and the octane number of isooctane (2,2,4-trimethylpentane) is 100. When a fuel is tested in a standard single-cylinder engine, mixtures of isooctane and n-heptane are used as standards. ASTM D2699 and ASTM D2700 describe methods for measuring research octane number (RON) and motor octane number (MON), respectively. The engine speed for the RON test is 600 rpm, while 900 rpm is used for the MON test. RONC and MONC are sometimes used instead to RON and MON. Aromatics, olefins, and branched isomers have higher octane numbers than straight-chain isomers with similar carbon numbers. Octane numbers for naphthenes are substantially lower than those for aromatics.

2.3.2 **Reid vapor pressure**

Reid vapor pressure (RVP) is a common measure of the volatility of gasoline. It is defined as the absolute vapor pressure exerted by a liquid at 100 °F (37.8 °C) as determined by the test method ASTM-D-323. The test method applies to volatile crude oil and volatile nonviscous petroleum liquids, except liquified petroleum gases. The matter of vapor pressure is important relating to the function and operation of gasoline powered, especially carbureted, vehicles. High levels of vaporization are desirable for winter starting and operation and lower levels are desirable in avoiding vapor lock during summer heat. Fuel cannot be pumped when there is vapor in the fuel line (summer) and winter starting will be more difficult when liquid gasoline in the combustion chambers has not vaporized. Thus, oil refineries manipulate the Reid Vapor Pressure seasonally specifically to maintain gasoline engine reliability. The Reid vapor pressure (RVP) differs slightly from the true vapor pressure (TVP) of a liquid due to small sample vaporization and the presence of water vapor and air in the confined space of the test equipment. RVP various from winter to summer.

2.3.3 **Low - Sulfur Gasoline**

In recent years, the U.S. Environmental Protection Agency (EPA) and the European Parliament promulgated clean-fuel regulations that are lowering the sulfur content of gasoline

and diesel fuel. New sulfur-content standards for several developed countries are shown in Table below, which also shows the target dates for implementation.

Country	Fuel Sulfur Content, wppm		
	2004 Level	Target Level	Target Date
US[34-36]			
Gasoline	>300	30	2004 – 2008
Diesel, on-road	500	15	July 1, 2006
	-	-	July 1, 2010
Diesel, off-road	2000 – 3500	500	2007
	-	15	2010
Canada[37]			
Gasoline	150	30	2005
Diesel	500	15	2006
Germany[38]			
Gasoline	10	10	2003
Diesel	10	10	2003
Sweden[39]			
Diesel	10	10	1995
Other EU[38]			
Gasoline	150	50	2005
	-	10	2008
Diesel	350	50	2005
	-	10	2008
Australia[40]			
Gasoline	500	150	2005
Diesel	500	30	2008
Korea (South)[41]			
Gasoline	100	30	2006
Diesel	300	50	2006
Japan[42]			
Gasoline	100	10	2008
Diesel	500	50	2004
	-	10	2008

2.4 Gasoline Additives

Table below lists the kinds of additives used to prepare finished gasoline. Additive packages vary from season-to-season, region-to-region, and retailer usually are more concentrated. They are packaged so that they can be added b consumers to the fuel tanks of individual automobiles.

Additives Used in Gasoline

Additive Type	Function
Anti-oxidation	Minimize oxidation and gum formation during storage
Metal passivation	Deactivate trace metals that can accelerate oxidation
Corrosion inhibition	Minimize rust throughout the gasoline supply chain
Anti-icing	Minimize ice in carburetors during cold weather
IVD control (detergent)	Control deposition of carbon on intake valves
CCD control	Control deposition of carbon in combustion chambers
Anti-knock	Methylcyclopentadienyl manganese tricarbonyl (MMT)

3- Kerosene and Jet Fuel

Kerosene is a flammable pale-yellow or colorless oily liquid with a characteristic odor. It is obtained from petroleum and used for burning in lamps and domestic heaters or furnaces, as a fuel or fuel component for jet engines, and as a solvent for greases and insecticides. Kerosene is intermediate in volatility between gasoline and gas=diesel oil. It is a medium oil distilling between 150°C and 300°C. Kerosene is widely used to power jet engines of aircraft (jet fuel) and some rocket engines, but is also commonly used as a cooking and lighting fuel and for fire toys.

Jet fuel is a light petroleum distillate that is available in several forms suitable to use in various types of jet engines. Jet fuel comprises both gasoline and kerosene type jet fuels meeting specifications for using in aviation turbine power units and is often referred to as gasoline-type jet fuel and kerosene-type jet fuel.

3.1 Compositions

Chemically, kerosene is a mixture of hydrocarbons; the chemical composition depends on its source, but it usually consists of about 10 different hydrocarbons, each containing from 10 to 16 carbon atoms per molecule; the constituents include n-dodecane (n-$C_{12}H_{26}$), alkyl benzenes, and naphthalene and its derivatives. Kerosene is less volatile than gasoline; it boils between about 140°C and 320°C.

3.2 Manufacture

- Distillation of petroleum.
- Cracking process.

3.3 Properties

The key product properties are:

- Flash point
- Freezing point
- Sulfur content
- Smoke point

The flash point is the lowest temperature at which a liquid gives off enough vapor to ignite when an ignition source is present.

The freezing point is especially important for jet aircraft, which fly at high altitudes where the outside temperature is very low. Sulfur content is a measure of corrosiveness.

The measurement of smoke point goes back to the days when the primary use for kerosene was to fuel lamps. To get more light from a kerosene lamp, you could turn a little knob to adjust the wick. But if the flame got too high, it gave off smoke. Even today, per ASTM D1322, smoke point is the maximum height of flame that can be achieved with calibrated wick-fed lamp. The smoke point of a test fuel is compared to reference blends. A standard 40%/60% (volume/volume) mixture of toluene with 2,2,4-trimethylpentane has a smoke point of 14.7, while pure 2,2,4-trimethylpentane has a smoke point of 42.8. Clearly, isoparaffins have better smoke points than aromatics. Table below shows specifications for five grades of jet fuel, otherwise known as aviation turbine fuel. The JP fuels are for military aircraft.

Specification	Jet A	Jet B	JP-4	JP-5	JP-8
Flash point, °C (min)	38	-	-	60	38
Freeze point, °C (max)	-40 (Jet A) -47 (Jet A-1)	-50	-58	-46	-47
API Gravity	37 – 51	45 – 57	45 – 57	36 – 48	37 – 51
Distillation, °C					
10% max	205	-		205	205
20% max	-	145	145	-	-
50% max	-	190	190	-	-
90% max	-	245	245	-	-
EP	300	-	270	290	300
Sulfur, wt% max	0.3	0.3	0.4	0.4	0.3
Aromatics, vol% max	22	22	25	25	25
Olefins, vol% max	-	-	5	5	5

4- Diesel Oil

Diesel fuel oil is also a distillate fuel oil that distills between 180°C and 380°C. Several grades are available depending on their uses: diesel oil for diesel compression ignition (cars, trucks, and marine engines) and light heating oil for industrial and commercial uses.
Diesel fuel, many possible combinations of characteristics (such as volatility, ignition quality, viscosity, gravity, stability, and other properties) exist. To characterize diesel fuels and thereby establish a framework of definition and reference, various classifications are used in different countries.

4.1 Compositions

Petroleum-derived diesel is composed of about 75% saturated hydrocarbons (primarily paraffins including n, iso, and cycloparaffins), and 25% aromatic hydrocarbons (including naphthalenes and alkylbenzenes). The average chemical formula for common diesel fuel is $C_{12}H_{23}$, ranging approximately from $C_{10}H_{20}$ to $C_{15}H_{28}$.

4.2 Properties

Sulfur, cetane number, and (in some countries) aromatics and density are regulated for environmental reasons. Sulfur contributes heavily to particulate emissions from diesel engines, and cetane number is a measure of burning quality in a diesel engine. As with octane number, cetane number measures the tendency of fuels to auto-ignite in a standard test engine. It is easier to start a diesel engine when the cetane number of the fuel is high.
Diesel index is a simpler calculation based on density and aniline point. The streams listed in Table belows are typical candidates for making diesel fuel.

Properties of U.S. Diesel Blend Stocks, Year 2000 (California Excluded)

Blend Stock	Percent of Total U.S. Pool	Sulfur (wt%)	API Gravity	Cetane (no additives)
Straight-run gas oil	12.4	0.222	30.3 – 42.2	40.3 – 45.0
Hydrotreated straight-run	51.9	0.036	29.9 – 42.9	44.5 – 50.4
FCC light cycle oil	3.1	0.532	22.3 – 33.1	<<30
Hydrotreated light cycle oil	19.4	0.087	30.7 – 45.0	42.7 – 44.1
Coker gas oil	1.0	0.342	32.3 – 42.4	<<30
Hydrotreated coker gas oil	8.2	0.026	29.9 – 34.8	36.1 – 45.3
Hydrocrackate	4.0	0.008	32.9 – 41.8	50.2

Catalytic converters led to the elimination of lead from gasoline, because lead poisons the converter catalyst. Similarly, sulfur poisons catalysts that may be used on future vehicles. Hence, the reduction of sulfur in gasoline and diesel fuel to ultra-low levels is a key requirement of Auto Oil. Around the world, the transportation and fungibility of ultra-clean fuels is a major concern. For common-carrier pipelines, which transport various products made by different refiners, cross-contamination is a major concern.
Other important diesel-fuel properties include flash point, cloud point, pour point, kinematic viscosity, and lubricity. Cloud point and pour point indicate the temperature at which the fuel tends to thicken and then gel in cold weather. In addition to providing energy, diesel fuel also serves as a lubricant for fuel pumps and injectors, which prolongs the life of the engine. Viscosity measures the tendency of a fluid to flow. In a diesel engine, viscosity indicates how well a fuel atomizes in spray injectors. It also measures its quality as a lubricant for the fuel system. Lubricity measures the fuel's ability to reduce friction between solid surfaces in relative motion. It indicates how the engine will perform when loaded.

4.3 Diesel Additives

Chemical additives improve the performance and extend the tank-life of diesel fuels. Typical types of additives are shown in Table bellows.

Additives Used in Diesel Fuel

Additive Type	Function
Anti-oxidation	Minimize oxidation and gum formation during storage
Cetane improvement	Increase cetane number
Dispersion	Improve behavior in fuel injectors
Anti-icing	Minimize ice formation during cold weather
Detergent	Control deposition of carbon in the engine
Metal passivation	Deactivate trace metals that can accelerate oxidation
Corrosion inhibition	Minimize rust throughout the diesel fuel supply chain
Cold-flow improvement	Improve flow characteristics in cold weather

5. Fuel Oil

Fuel oil is classified in several ways but generally may be divided into two main types: distillate fuel oil and residual fuel oil. Distillate fuel oil is vaporized and condensed during a distillation process and thus has a definite boiling range and does not contain high-boiling constituents. A fuel oil that contains any amount of the residue from crude distillation of thermal cracking is a residual fuel oil. The terms distillate fuel oil and residual fuel oil are losing their significance, as fuel oil is now made for specific uses and may be either distillates or residuals or mixtures of the two. The terms domestic fuel oil, diesel fuel oil, and heavy fuel oil are more indicative of the uses of fuel oils.

Domestic fuel oil is fuel oil that is used primarily in the home. This category of fuel oil includes kerosene, stove oil, and furnace fuel oil; they are distillate fuel oils. Heavy fuel oil comprises all residual fuel oils (including those obtained by blending). Heavy fuel oil constituents range from distillable constituents to residual (nondistillable) constituents that must be heated to 260°C or more before they can be used. The kinematic viscosity is above 10 cst at 80°C. The flash point is always above 50°C and the density is always higher than 0.900. In general, heavy fuel oil usually contains cracked residua, reduced crude, or cracking coil heavy product, which is mixed (cut back) to a specified viscosity with cracked gas oils and fractionator bottoms.

6. Asphalt/ Bitumen

It is a sticky, black and highly viscous liquid or semi-solid form of petroleum. It may be found in natural deposits or may be a refined product; it is a substance classed as a pitch. Until the 20th century. The primary use of asphalt/bitumen is in road construction, where it is used as the glue or binder mixed with aggregate particles to create asphalt concrete. Its other main uses are for waterproofing products, including production of roofing felt and for sealing flat roofs.

Asphalt (or asphalt cement) is the carefully refined residue from the fractional distillation of crude oil boiling at 525°C.

6.1 Compositions

Asphalt is the residue of mixed-base and asphalt-bas e cru de oils. It can not be distilled even under the highest vacuum, because the temperatures required to do this promote formation of coke. Asphalt have complex chemical and physical compositions that usually vary with the

source of the crude oil and are considered dispersions of particles, called asphaltenes, in a high-boiling fluid composed of oil and resins.
Asphalt/bitumen can be separated from the other components in crude oil (such as naphtha, gasoline and diesel) by the process of fractional distillation, usually under vacuum conditions. A better separation can be achieved by further processing of the heavier fractions of the crude oil in a de-asphalting unit, which uses either propane or butane in a supercritical phase to dissolve the lighter molecules which are then separated.

6.2 Properties and uses

Nowadays, a good portion of the asphalt produced from petroleum is consumed in paving roads; the remainder is employ ed for roofing, paints , varnishes, insulating, rust-protective compositions, battery boxes, and compounding material s that go into rubber products, brake linings, and fuel briquettes. How ever, asphalt use s can be more popularly divided into use as road oils, cutback asphalt, asphalt emulsions, and solid asphalt. The properties of asphalt are defined by a variety of standard tests that can be used to define quality and viscosity specifications.