Fuel Sources

The fuel sources encountered in the upstream oil and gas industry come in a variety of forms from the obvious hydrocarbon fluids to the not-so-obvious substances such as grease for bearings or o-rings. They may be broken down into these different categories: gases, liquids/vapours, chemicals, and solids.

Gases
Liquids/vapours
Chemicals and Solids

Gases

For a gas to be explosive, it must mix with air or oxygen. The strength of a gas-air explosion depends on where the mixture lies within the flammability envelope, with the greatest energy release occurring at or near stoichiometric mixtures. The explosive properties of some gases typically found in the oil and gas industry are summarized in the following table.

Legend
MIE – Minimum Ignition Energy
AIT – Auto Ignition Temperature
LFL – Lower Flammability Limit
UFL – Upper Flammability Limit

Explosive Properties of Some Common Gases [34]

substances	MIE (mJ) in air	AIT(°C) in air	LFL (%vol)	UFL (%vol)
Methane	0.3	640	5	15
Ethane	0.26	506	3	12.4
Hydrogen Sulphide	0.077	260	4	55.7
Butane	0.26	408	1.8	8.4
Propane	0.26	500	2.1	9.5
Acetelyne	0.017	296	2.5	100

Note: The values reported in the two tables in this section may differ slightly from other sources as results depend on the laboratory procedures and apparatus used. Most values were taken from reference 34.

The following are special considerations for hydrocarbon gases commonly encountered in the upstream oil and gas industry:

Natural Gas
Natural gases vary in composition. The methane content can range from 87% to 96% with ethane, propane and other hydrocarbon gases making up the remainder. If natural gas contains any hydrogen sulphide, it is considered sour. Due to the large methane content of natural gas, its properties are very similar. Sometimes it is assumed to behave as methane. [34]

Hydrogen Sulphide (H_2S)
Hydrogen sulphide is a very toxic and explosive gas. At atmospheric conditions, the flammability range for H_2S is approximately 4 % - 55.7 % by volume in air. This wide range calls for increased caution. Constant monitoring is essential and safety procedures must be strictly followed when dealing with H_2S. Many jurisdictions require specialized safety training for anyone handling H_2S.

Some other important characteristics of H_2S include:

- Corrosiveness - H_2S can destroy steel and rubber seals increasing the possibility for its release.

- Heavier than Air - Because H_2S is heavier than air, it's possible for the gas to migrate to distant ignition sources. However, it is important to note that small percentages of H_2S in natural gas will tend to behave similarly to natural gas.

LPG Gases (including Propane and Butane)
Liquefied Petroleum Gases (LPGs) are largely composed of propane and butane, with propylene, butylenes, ethane and other gases found in small amounts. The ratio of propane and butane found in LPGs depends mainly upon where it was produced. In the United States, LPGs largely contain propane while in some European locations butane is the main constituent.

Storing LPGs: 80% Rule
Containers with LPGs should never be filled more than 80%. This allows for the expansion of vapours with temperature increases. Fires and explosions have resulted from overfilling LPG containers or from filling them in a cold environment and then moving them to a warmer one. [34]

Acetylene

Acetylene is a highly combustible gas. At atmospheric conditions, its flammability range extends from 2.5% - 100% by volume. The upper flammability limit will be achieved if the acetylene decomposes to around 80%. Liquid acetylene is rarely used; it is very unstable and considered a sensitive explosive. [34]

Hydrogen
Hydrogen is one of the easiest fuels to detonate because of its very wide flammability limit (Hydrogen LEL 4.0% in air; UEL 74% in air) and low minimum ignition energy. These characteristics make hydrogen extremely susceptible to electric sparks and arcs.

Liquids/Vapours
With the exception of a few reactive or unstable substances, liquids do not ignite. It is the vapours given off from the surface of the liquids that ignite. Liquids will give off vapours at a rate that is proportional to their temperature. The ability to give off vapours and the rate at which this occurs defines the volatility of the liquid.

The flash point of a liquid is defined as the lowest temperature at which that liquid gives off vapours at a sufficient rate to support a momentary flame across its surface. The flash point is also related to the vapour pressure of the liquid. A low vapour pressure corresponds to a high flash point, and a high vapour pressure corresponds to a low flash point. [16]. **It is important to remember that flash points are measured at atmospheric pressure; if the pressure is higher, the information relevant at atmospheric pressure is no longer accurate.**

The flash point should only be used as an approximate reference. The liquid may behave differently in the field than in laboratory tests performed to determine flash points. It is possible for an explosive atmosphere to exist even if the temperature of the environment is below the flash point of the liquid. The auto-ignition temperature for the liquid vapours is similar to that of gases.

Aerosols
A very fine mist from a hydrocarbon liquid may act as a pure gaseous substance. These aerosols may become an explosive mixture at temperatures that are far below the liquid's flash point. The droplets have to become vapourized but because of the small volume of the drops the energy required to do this is lowered significantly.

The properties of some liquids typically found in the upstream oil and gas industry are summarized in the table below.

Substances	MIE (mJ) in air	AIT(°C) in air	LFL (%vol)	UFL (%vol)	Flash Point(°C)
Crude oil condensates	-	-	-	-	-23 to +32
Liquified Natural Gas (LNG)	-	-	-	-	-
Gasoline	-	300-350	1	7	-43
Diesel	-	230	1	6	40 to 55
Methanol	0.14	470	6.7	36	-188
Superfrac	-	-	1	7	20
PWC 150 Frac Fluid	-	-	1.05	7.8	13
Edson Frac Oil 200	-	-	-	-	29.5
Ultra Stim C732	-	-	1.1	7	7
Distilate 822	-	-	0.7	6	77
C2000 Frac Oil	-	as low as 232.2	15	0.6	16 to >93

Explosive Properties of Some Common Liquids [34]

Crude Oil / Condensates

The category of crude oils and condensates includes liquids with a very wide range of properties. Crude oils are defined as unrefined petroleum liquids. Different crude oils will have different material properties depending on what they contain. They can range in density from very light to very heavy. Flash points may vary greatly. These potential differences underline the need for workers to always be familiar with the properties of the fluids they are working with so that they can accurately assess the hazards at hand.[34]

Hydrocarbons that are gases in the reservoir may turn into liquids called gas condensates at surface. These condensates tend to be largely composed of the C_5 to C_6 hydrocarbon chains. They are usually an oily liquid and may cause problems in gas distribution lines. They tend to have a low flash point and therefore are extremely flammable.

Hydrocarbon Based Frac Fluids

Hydrocarbon based frac fluids come in many different varieties. They can be as simple as diesel fuel or made up of many different admixtures. The characteristics of the reservoir determine what frac fluids will be used. Each frac fluid should have a material safety data sheet (MSDS) outlining its explosive nature. These sheets should always be reviewed before the frac fluid is used.

Gasoline, Diesel & Other Liquid Fuels

Gasoline mostly contains hydrocarbons in the C_4 to C_{10} range and many additives. If gasoline is exposed to air, it weathers. This means that certain parts of the gas vaporize faster than others, resulting in a change to the composition of the mixture. Gasoline is a

very volatile substance and has been the cause of many incidental fires. Its vapours are easily ignited. [34]

Methanol
Methanol is known as methyl alcohol, methyl hydrate, carbinol, wood alcohol or wood spirit. It forms vapours quite readily that have a fairly wide explosive range. The vapours are heavier then air so they can travel along the ground to an ignition source and flash back.

LNG
Liquefied Natural Gas mostly contains methane, however, it can contain other heavier hydrocarbons. It is usually stored at -160°C and atmospheric pressure.

Methane gas is usually lighter then air, however, the cool gas released from a LNG spill tends to be heavier then air. When such spills occur, the ground is immediately frozen and brought close to the temperature of the LNG. The heating of the gas then releases vapours while the moisture in the air condenses to give off a visible vapour cloud. This cloud will linger near ground level until further heat is supplied and the methane gas rises, or a wind blows it away. The initial vapour cloud can drift and stay within an ignitable range for some time. The frozen ground acts as an insulator allowing the LNG to stay in its liquid form until ambient temperatures provide sufficient heat to vaporize it. [39]

Chemicals & Solids
The chemicals and hydrocarbon-based liquids typically used by the oil and gas industry also have the potential to create explosive mixtures. These include:

- Chemicals used for well servicing and stimulations
- Solvents and cleaning agents
- Specially formulated hydraulic fluids and lubricants

In unique circumstances, some ‘solids’ used by the oil and gas industry may create explosive mixtures. As the solid is heated it can undergo pyrolysis, a chemical degrading that occurs resulting in a release of vapours. The vapours released have the ability to form an explosive atmosphere and can ignite. These solids can include:

- Lubricants
- Sealants
- Packings, “O” rings, diaphragms and valve seats
- Paints and Coatings