

## SECTION 1

# General Information

The General Information section includes a brief description of the technical activities of the GPA Midstream Association and GPSA. It includes a compilation of current GPA Midstream Association standards, publications, and Research Reports, a glossary of terms used in the natural gas industry and several tables of common conversion factors and equivalents. At the end of the Section is a listing of other technical associations and societies that publish codes, standards and other information pertinent to the natural gas processing industry.

### GPA MIDSTREAM ASSOCIATION TECHNICAL ACTIVITIES

The GPA Midstream Association is an international organization with a membership of about 100 companies, each of which is engaged in one or more functions of the natural gas and gas processing industry, including: natural gas production, gathering and processing; production of natural gas liquids (NGLs); volume transport or further processing of natural gas or gas liquids; or other commerce in natural gas or gas liquids. Its principal functions include the advancement of gas processing technology through development and promulgation of international standards for NGL product specifications, test methods, measurement, and handling. In addition, GPA Midstream Association sponsors basic research in thermodynamic and transport properties of natural gases, gas liquids, synthetic gases, and related process stream components. The dissemination of GPA Midstream Association technology is accomplished through publication of industry standards, research reports, and computer programs. This technology is developed in response to industry needs by a technical committee organization with the following structure and responsibilities:

#### Technical Committee

The parent body responsible for assessing the technological needs of the natural gas industry, establishing priorities, assigning problems to appropriate working sections, and reviewing results and recommendations of sections as needed.

The seven working sections of the Technical Committee are:

**Section A, Facilities Design and Optimization** — Maintains a continuing study of all phases of gas processing design (process, mechanical, electrical, instrumentation) of broad industry interest; this responsibility does not include analytical methods nor basic data on product properties, but does include onstream process and plant control instrumentation.

**Section B, Analysis** — Studies and develops analytical procedures and methods to improve accuracy and reliability of test methods and data to meet the needs of the natural gas industry. All of the industry's sampling procedures, specification test methods, and analytical standards have issued from this section.

**Section C, Specifications** — Maintains existing product specifications, and generates new and revised specifications in

response to changing industry and market needs. All U.S. and many international specifications for LP-gas and other NGL products are based on the work of this section.

**Section F, Technical Data Development** — Monitors the status, availability, and reliability of thermodynamic and physical property data needed for design and operation of natural gas and gas processing facilities. This section identifies industry needs for pertinent data, develops research projects to provide needed data, and supervises research to meet those needs. The section also evaluates new correlations and computer models for calculation and application of thermodynamic and physical properties applicable to natural gas processing and transport.

Primary responsibility for initiation and supervision of thermodynamic and physical properties research is vested in two steering committees comprised of highly qualified and experienced specialists.

**Section H, Product Measurement and Handling** — Monitors measurement data and correlations for both natural gas and natural gas liquids, and reviews handling procedures for gas liquids, including underground storage technology. The section initiates improvements in standards for accurate measurement and safe handling of both natural gas and gas liquids.

**Section M, Operations and Maintenance** — This Section was formed to assist member companies in addressing and resolving their operations and maintenance issues, and to be a forum where such issues on gas gathering and processing can be discussed. It is anticipated that the results of this committee can supplement the programs of the GPA Midstream Association Regional Meetings.

### GPSA TECHNICAL ACTIVITIES

GPSA is an affiliated organization of approximately 350 companies that cater to the supply and service needs of the natural gas producing and processing industry. The principal technical function of GPSA is to publish GPA Midstream Association and other technical information through the GPSA Engineering Data Book. In addition, technical experts from GPSA companies participate in GPA Midstream Association technical committee activities described above, and also provide valuable support and counsel in directing thermodynamic research and technical data development for the advancement of the industry's technology.

#### Editorial Review Board

The Editorial Review Board for the Engineering Data Book is the single GPSA technical committee. The Board is composed of recognized experts from both GPA Midstream Association and GPSA member companies, and is responsible for the continuing review and revision of the Engineering Data Book to assure that it meets the needs of the natural gas processing industry with the latest data and technology.

**FIG. 1-1**  
**Example Components of Industry Streams**

|                         | Components      |                  |                |                |                |                |                 |                 |                 |                 |                |                  |
|-------------------------|-----------------|------------------|----------------|----------------|----------------|----------------|-----------------|-----------------|-----------------|-----------------|----------------|------------------|
|                         | CO <sub>2</sub> | H <sub>2</sub> S | N <sub>2</sub> | C <sub>1</sub> | C <sub>2</sub> | C <sub>3</sub> | iC <sub>4</sub> | nC <sub>4</sub> | iC <sub>5</sub> | nC <sub>5</sub> | C <sub>6</sub> | C <sub>7</sub> + |
| Inert Gas               | •               |                  | •              |                |                |                |                 |                 |                 |                 |                |                  |
| Acid Gas                | •               | •                |                |                |                |                |                 |                 |                 |                 |                |                  |
| LNG                     |                 |                  | •              | •              | •              | •              | •               | •               |                 |                 |                |                  |
| Natural Gas             | •               | •                | •              | •              | •              | •              | •               | •               | •               | •               | •              | •                |
| LPG                     |                 |                  |                |                |                | •              | •               | •               |                 |                 |                |                  |
| Natural Gasoline        |                 |                  |                |                |                | •              | •               | •               | •               | •               | •              | •                |
| NGL                     |                 |                  |                |                | •              | •              | •               | •               | •               | •               | •              | •                |
| Condensate (Stabilized) |                 |                  |                |                |                |                | •               | •               | •               | •               | •              | •                |

## DEFINITIONS OF WORDS AND TERMS USED IN THE NATURAL GAS INDUSTRY

### Absorber

A tower or column that provides contact between natural gas, being processed and a liquid solvent.

### Absorption

The operation in which one or more components in the gas phase are transferred to (absorbed into) a liquid solvent.

### Absorption factor

A factor which is an indication of the tendency for a given gas phase component to be transferred to the liquid solvent. It is generally expressed as  $A = L/KV$  where L and V are the molar flows of liquid and vapor, and K is the average value of the vapor-liquid equilibrium constant for the component of concern.

### Absorption oil

A hydrocarbon liquid used to absorb and recover components from the natural gas being processed.

### Acid gas

The hydrogen sulfide and/or carbon dioxide contained in, or extracted from, gas or other streams.

### Adiabatic expansion

The expansion of a gas, vapor, or liquid stream from a higher pressure to a lower pressure in which there is no heat transfer between the gas, vapor, or liquid and the surroundings.

### Adsorbent

A solid substance used to remove components from natural gas being processed.

### Adsorption

The process by which gaseous components are adsorbed on solids because of their molecular attraction to the solid surface.

### Amine (alkanolamine)

Any of several liquid compounds containing amino nitrogen generally used in water solution to remove, by reversible chemical reaction, hydrogen sulfide and/or carbon dioxide from gas and liquid hydrocarbon streams.

### API Gravity

An arbitrary scale expressing the relative density of liquid petroleum products. The scale is calibrated in degrees API, calculated by the following formula:

$$\text{Deg API} = \left[ \frac{141.5}{\gamma(60^\circ\text{F}/60^\circ\text{F})} \right] - 131.5$$

$\gamma$  = relative density

### Associated gas

Gaseous hydrocarbons occurring as a free-gas phase under original oil-reservoir conditions of temperature and pressure.

### Atmospheric pressure

The pressure exerted on the earth by the earth's atmosphere. A pressure of 760 mm of mercury, 29.92 inches of mercury, or 14.696 psia is used as a standard for some measurements. State regulatory bodies have set other standards for use in measuring the legal volume of gas. Atmospheric pressure may also refer to the absolute ambient pressure at any given location.

### Barrel

A common FPS-unit measure of liquid volume which, in the petroleum industry, equals 42 U.S. liquid gallons for petroleum or natural gas liquid products measured at 60 °F and equilibrium vapor pressure. One barrel equals 0.159 cubic meters, or 6.29 barrels per cubic meter (See Fig. 1-2).

### Blanket gas

A gas phase maintained in a vessel containing liquid to protect the liquid against air contamination, to reduce the hazard of explosion, or to maintain pressure of the liquid. The source of the gas is external to the vessel.

### Blow case

A small vessel in which liquid is accumulated and then forced from the vessel by applying gas or air pressure above the liquid level.

### Blowdown

The act of emptying or depressurizing a vessel. This may also refer to discarded material, such as blowdown water from a boiler or cooling tower.

### Boilaway test

Sometimes used to describe the GPA weathering test for LP-gas. Refer to definition for "weathering test".

### Bottoms

The liquid or residual matter which is withdrawn from the bottom of a fractionator or other vessel during processing or while in storage.

### B-P mix

A liquefied hydrocarbon product composed chiefly of butanes and propane. If it originates in a refinery, it may also contain butylenes and propylene. More specifically, it conforms to the GPA specifications for commercial B-P mixes as described in GPA Standard 2140.

### Breathing

The movement of vapor in or out of an atmospheric pressure storage tank because of a change of level of the stored liquid, a change in the temperature of the vapor space above the liquid, or a change of atmospheric pressure.

### BS&W (basic sediment and water)

Waste that collects in the bottom of vessels and tanks containing petroleum or petroleum products.

### Bubble point

The temperature at a specified pressure at which the first stable vapor forms above a liquid.

### Butane, commercial

A liquefied hydrocarbon consisting predominately of butane and/or butylene and which conforms to the GPA specification for commercial butane defined in GPA Standard 2140.

### Butane, normal

In commercial transactions, a product meeting the GPA specifications for commercial butane and, in addition, containing a minimum of 95 liquid volume percent normal butane. Chemically, normal butane is an aliphatic compound of the paraffin series having the chemical formula  $C_4H_{10}$  and having all of its carbon atoms joined in a straight chain.

### Calorific Value

See Heating Value.

### Calorimeter

An apparatus which is used to determine the heating value of a combustible material.

### Carbonyl sulfide

A chemical compound of the aldehyde group containing a carbonyl group and sulfur (COS). Sometimes a contaminant in natural gas and NGL. It may need to be removed in order to meet sulfur specifications.

### Casinghead gas

Unprocessed natural gas produced from a reservoir containing oil. It contains heavier hydrocarbon vapors and is usually produced under low pressure from a casing head on the well.

### CFD (Computational fluid dynamics)

A computational fluid dynamic model based on finite element analysis of a system or piece of equipment. The model uses numerical analysis and algorithms to solve and analyze problems that involve fluid flows. These models are frequently referred to as a CFD model.

### Charcoal test

A test standardized by the GPA Midstream Association and the American Gas Association for determining the natural gasoline content of a given natural gas. The gasoline is adsorbed from the gas on activated charcoal and then recovered by distillation. The test is prescribed in Testing Code 101-43, a joint publication of AGA and GPA.

### Chromatography

A technique for separating a mixture into individual components by repeated adsorption and desorption on a confined solid bed. It is used for analysis of natural gas and NGL.

### Claus process

A process to convert hydrogen sulfide into elemental sulfur by selective oxidation.

### Compressibility factor

A factor, usually expressed as "Z," which gives the ratio of the actual volume of gas at a given temperature and pressure to the volume of gas when calculated by the ideal gas law.

### Compression ratio

The ratio of the absolute discharge pressure from a compressor to the absolute intake pressure. Also applies to one cylinder of a reciprocating compressor and one or more stages of a rotating compressor.

### Condensate

The liquid formed by the condensation of a vapor or gas; specifically, the hydrocarbon liquid separated from natural gas because of changes in temperature and pressure when the gas from the reservoir was delivered to the surface separators. In a steam system it may be water that is condensed and returned to the boilers.

### Convergence pressure

The pressure at a given temperature for a hydrocarbon system of fixed composition at which the vapor-liquid equilibrium K-values of the various components in the system become, or tend to become, unity. The convergence pressure is used to adjust vapor-liquid equilibrium K-values to the particular system under consideration. (See Section 25 of this Data Book)

### Copper strip test

A test using a small strip of pure copper to determine qualitatively the hydrogen sulfide corrosivity of a product. Refer to GPA LP-gas copper strip test (Copper Strip Method), ASTM D-1838 test procedure.

### Cricondenbar

The highest pressure at which liquid and vapor phases can exist at equilibrium in a multicomponent system.

### Cricodentherm

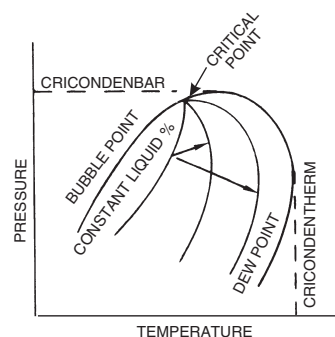
The highest temperature at which liquid and vapor phases can exist at equilibrium in a multicomponent system.

### Critical density

The density of a substance at its critical temperature and critical pressure.

### Critical pressure

The vapor pressure of a substance at its critical temperature.



**Critical temperature**

For a pure component, the maximum temperature at which the component can exist as a liquid.

**Cryogenic plant**

A gas processing plant which is capable of producing natural gas liquid products at very low operating temperatures, usually below minus 50 °F.

**Cubic meter**

A unit of volume measurement commonly used in international commerce for petroleum, petroleum products and natural gas. One cubic meter measured at 60 °F = 264.172 U.S. gallons = 6.29 barrels = 35.315 cubic feet measured at 60 °F.

**Deaerator**

An item of equipment used for removing air or other non-condensable gases from a process stream or from steam condensate or boiler feed water.

**Debutanizer**

A fractionator designed to separate butane (and more volatile components if present) from a hydrocarbon mixture.

**Deethanizer**

A fractionator designed to separate ethane (and more volatile components if present) from a hydrocarbon mixture.

**Dehydration**

The act or process of removing water from gases or liquids.

**Demethanized product**

A product from which essentially all methane and lighter materials have been removed.

**Demethanizer**

A fractionator designed to separate methane (and more volatile components if present) from a hydrocarbon mixture.

**Depropanizer**

A fractionator designed to separate propane (and more volatile components if present) from a hydrocarbon mixture.

**Desiccant**

A substance used in a dehydrator to remove water and moisture. Also a material used to remove moisture from the air.

**Desulfurization**

A process by which sulfur and sulfur compounds are removed from gases or liquid hydrocarbon mixtures.

**Dew point**

The temperature at any given pressure, or the pressure at any given temperature, at which liquid initially condenses from a gas or vapor. It is specifically applied to the temperature at which water vapor starts to condense from a gas mixture (water dew point), or at which hydrocarbons start to condense (hydrocarbon dew point).

**Distillation**

The process of separating materials by successively heating to vaporize a portion and then cooling to liquefy a part of the vapor. Materials to be separated must differ in boiling point and/or relative volatility.

**DMR (dual mixed refrigerant) process**

LNG process that utilizes two separate mixed refrigerant loops. The warm mixed refrigerant is a mixture of ethane, propane, mixed butanes and/or iso-pentane. The cold refrigerant is much lighter containing nitrogen and methane as prime components. Also referred to as "Double Mixed Refrigerant." (See Section 16 of this Data Book).

**Doctor test**

A qualitative method for detecting hydrogen sulfide and mercaptans in NGL. The test distinguishes between "sour" and "sweet" products.

**Dry gas**

(1) Gas whose water content has been reduced by a dehydration process. (2) Gas containing little or no hydrocarbons commercially recoverable as liquid product. Gas in the second definition preferably should be called lean gas.

**End point**

The maximum temperature observed on the thermometer during an ASTM distillation test.

**EOR (enhanced oil recovery)**

Technology employed to increase the recoverable oil-in-place in a petroleum reservoir.

**EP-mix (ethane-propane mix)**

A product consisting of a mixture of essentially ethane and propane.

**Expansion turbine**

A device which converts part of the energy content of a gas or liquid stream into mechanical work by expanding the gas or liquid through a turbine from which work is extracted.

**Extraction**

The process of transferring one or more components from one liquid phase to another by virtue of different solubility in the two liquids. It is also used to indicate removal of one or more constituents from a stream.

**Field separator**

A vessel in the oil or gas field for separating gas, hydrocarbon liquid, and water from each other.

**Flash point**

The lowest temperature at which vapors from a hydrocarbon liquid will ignite. See ASTM D-56.

**FLNG (floating LNG)**

LNG facilities that are installed on a floating vessel.

**Fractionation**

See definition of "distillation." Generally used to describe separation of a mixture of hydrocarbons into individual products based on difference in boiling point and/or relative volatility.

**Freeze valve**

A specially constructed and calibrated valve designed and used solely for determining the water content in propane product. See ASTM D-2713.

**Gas constant (R)**

The constant multiplier in the Ideal Gas Law. Numerically,  $R = PV/T$ , if V is the volume of one mole of an ideal gas at temperature T and pressure P.

**Gas hydrate**

Refer to definition of "hydrate".

**Gas injection**

The injection of natural gas into a reservoir to maintain or increase the reservoir pressure or reduce the rate of decline of the reservoir pressure.

**Gas lift**

A method for bringing crude oil or water to the surface by injecting gas into the producing well bore.

**Gas-oil ratio (GOR)**

The ratio of gas to liquid hydrocarbon produced from a well. This may be expressed as standard cubic feet of gas per barrel of stock tank liquid.

**Gas processing**

The separation of constituents from natural gas for the purpose of making salable products and also for treating the residue gas to meet required specifications.

**Gas processing plant**

A plant which processes natural gas for recovery of natural gas liquids and sometimes other substances such as sulfur.

**Gas-well gas**

The gas produced or separated at surface conditions from the full well stream produced from a gas reservoir.

**Gas-well liquids**

The liquid separated at surface conditions from the full well stream produced from a gas reservoir.

**Gathering system**

The network of pipelines which carry gas from the wells to the processing plant or other separation equipment.

**gpm/GPM**

(1) gpm (gallons per minute): The term used to describe the rate of flowing fluid in gallons per minute. (2) GPM — Preferably Gal/Mcf (gallons per thousand cubic feet): GPM refers to the content in natural gas of components which are recoverable or recovered as liquid products.

**Heat medium (heating medium)**

A material, whether flowing or static, used to transport heat from a primary source such as combustion of fuel to another material. Heating oil, steam, and an eutectic salt mixture are examples of heat mediums.

**Heating value (heat of combustion)**

The amount of heat obtained by the complete combustion of a unit quantity of material. The gross, or higher, heating value (HHV) is the amount of heat obtained when the water produced in the combustion is condensed. The net, or lower, heating value (LHV) is the amount of heat obtained when the water produced in the combustion is not condensed.

**Heavy ends**

The portion of a hydrocarbon mixture having the highest boiling point. Usually hexanes or heptanes and all heavier hydrocarbons are the heavy ends in a natural gas stream.

**Hexanes plus (or heptanes plus)**

The portion of a hydrocarbon fluid mixture or the last component of a hydrocarbon analysis which contains the hexanes (or heptanes) and all hydrocarbons heavier than the hexanes (or heptanes).

**Hydrate**

A solid material resulting from the combination of a hydrocarbon with water under pressure.

**Ideal gas (also called “perfect” gas)**

A gas that obeys the ideal gas law expressed as  $PV=RT$ , see Fig. 1-7.

**Immiscible**

Liquids that will not mix nor blend to give homogeneity are said to be immiscible.

**Inerts**

Elements or compounds not acted upon chemically by the surrounding environment. Nitrogen and helium are examples of inert constituents of natural gases.

**Iso-butane**

In commercial transactions, a product meeting the GPA specification for commercial butane and, in addition, containing a minimum of 95 liquid volume percent iso-butane. Chemically, a hydrocarbon of the paraffin series with the formula  $C_4H_{10}$  and having its carbon atoms branched.

**Jacket water**

Water which fills, or is circulated through, a casing which partially or wholly surrounds a vessel or machine element in order to remove, add, or distribute heat in order to control the temperature within the vessel or element.

**Joule-Thomson effect**

The change in gas temperature which occurs when the gas is expanded at constant enthalpy from a higher pressure to a lower pressure. The effect for most gases at normal pressure, except hydrogen and helium, is a cooling of the gas.

**Lead acetate test**

A method for detecting the presence of hydrogen sulfide by discoloration of paper which has been moistened with lead acetate solution. See ASTM D-2420.

**Lean gas**

(1) The residue gas remaining after recovery of natural gas liquids in a gas processing plant. (2) Unprocessed gas containing little or no recoverable natural gas liquids.

**Lean oil**

Absorption oil as purchased or recovered by the plant, or oil from which the absorbed constituents have been removed.

**Lift gas**

Gas used in a gas lift operation.

**Light ends**

The low-boiling, easily evaporated components of a hydrocarbon liquid mixture.

**Light hydrocarbons**

The low molecular weight hydrocarbons such as methane, ethane, propane and butanes.

**LNG (liquefied natural gas)**

The light hydrocarbon portion of natural gas, predominately methane, which has been liquefied. (See Section 16 of this Data Book)

**Loading rack**

A structural and piping installation alongside a railroad track or roadway used for the purpose of filling railroad tank cars or transport trucks.

**LPG (liquefied petroleum gas)**

Predominately propane or butane, either separately or in mixtures, which is maintained in a liquid state under pressure within the confining vessel.

**LTS (low temperature separation)**

A unit which uses cooling to remove liquids (NGL) from raw natural gas streams. Cooling is usually by refrigeration, expander, or J-T (Joule-Thomson) effect. LTS units generally use inhibitors for hydrate inhibition of the condensed water phase.

An LTS process is thermodynamically characterized as constant enthalpy when using a J-T valve. Also called a J-T process.

**LP-gas (liquefied petroleum gas)**

Refer to definition of "LPG".

**LRG (liquefied refinery gas)**

Liquid propane or butane produced by a crude oil refinery. It may differ from LP-gas in that propylene and butylene may be present.

**LTX (low temperature extraction unit)**

A unit which uses the cooling of a constant enthalpy expansion, i.e. J-T effect, for liquid recovery from a high-pressure raw natural gas stream without the use of inhibitors. (See Section 16 of this Data Book).

**Mcf**

An abbreviation for one thousand cubic feet of gas.

**MMcf**

An abbreviation for one million cubic feet of gas.

**Methane Number**

Parameter used to quantify the knock resistance of a natural gas fuel in an internal combustion engine. Refer to Section 15 for additional information.

**Mercaptan**

Any of a homologous series of compounds of the general formula RSH. All mercaptans possess a foul odor.

**Miscible flood**

A method of secondary recovery of fluids from a reservoir by injection of fluids that are miscible with the reservoir fluids.

**Mixed fluid cascade process (MFC)**

An LNG liquefaction process that incorporates three separate mixed refrigeration cycles. (See Section 16 of this Data Book).

**Natural gas**

Gaseous form of petroleum. Consisting predominately of mixtures of hydrocarbon gases. The most common component is methane.

**Natural gasoline**

A mixture of hydrocarbons, mostly pentanes and heavier, extracted from natural gas, which meets vapor pressure, end point, and other specifications for natural gasoline as adopted by the GPA. See GPA Standard 3132.

**Natural gas processing plant**

Term used for gas processing plant, natural gasoline plant, gasoline plant, etc.

**NGL recovery**

The removal of natural gas liquids from a gas stream to either meet a sales gas hydrocarbon dewpoint specification, or deep recovery when components have a higher value as liquid products than as gas products.

**NGL (natural gas liquids)**

Natural gas liquids are those hydrocarbons liquefied at the surface in field facilities or in gas processing plants. Natural gas liquids include ethane, propane, butanes, and natural gasoline.

**NRU (nitrogen rejection unit)**

Process to remove excess nitrogen from produced gas. (See Section 16 of this Data Book).

**Odorant**

An odoriferous compound added to natural or LP-gas to impart a distinctive odor for detection of fugitive vapors. Ethyl mercaptan is the most widely used odorant for LP-gas, while tertiary butyl mercaptan, usually mixed with small amounts of other compounds, is the predominant odorant for natural gas.

**Oil-well gas**

Gas that is produced from an oil well.

**Open Art**

Process technology that does not require licensing from a vendor, i.e., it is not or no longer patented technology.

**Operating factor**

The percentage of time a unit is performing the function for which it was designed.

**Outage**

The vapor volume in a liquid vessel left for liquid expansion. Sometimes referred to as ullage.

**Packaged unit**

A shop-assembled group of equipment and accessories which needs only foundations, inlet and outlet piping, and utility connections to make an operating unit.

**Packed column**

A fractionation or absorption column filled with packing designed to give the required contact between the rising vapors and the descending liquid.

**Peak shaving**

The use of non-conventional fuels to supplement the normal supply of pipeline gas during periods of extremely high demand.

**Pentane-plus**

A hydrocarbon mixture consisting of iso-pentane ( $C_5H_{12}$ ) and heavier components with higher boiling points.

**Pigging**

A procedure for forcing a device through a pipeline for cleaning purposes, separating products, or inspecting the line.

**Pipeline gas**

Gas which meets a transmission company's minimum specifications.

**Pressure Swing Adsorption (PSA)**

Process which selectively adsorbs different gases. The adsorption occurs at high pressures, and the adsorbent is regenerated at low pressures.

**Propane**

A normally gaseous paraffinic compound ( $C_3H_8$ ). The term includes all products covered by GPA specifications for commercial and HD-5 propane. See GPA Standard 2140.

**Propane, commercial**

A liquefied hydrocarbon product consisting predominately of propane and/or propylene and which conforms to the GPA specification for commercial propane as defined in GPA Standard 2140.

**Propane HD-5**

A special grade of propane consisting predominately of propane and which conforms to the GPA specification for HD-5 propane

**Pure component cascade (PCC)**

Cascade refrigeration system used for LNG production. Three refrigeration systems utilized: propane, ethylene and methane. (See Section 16 of this Data Book).

**Raw gas**

Unprocessed gas, or the inlet gas to a gas processing plant.

**Raw mix liquids**

A mixture of natural gas liquids prior to fractionation. Also called "raw make".

**Real gas**

A gas that does not obey the ideal gas law. Instead its behavior is expressed as  $PV = zRT$  where  $z$  is the compressibility factor and  $z \neq 1.0$ . For an ideal gas  $z = 1.0$ , see [Fig. 1-7](#).

**Recovery**

That percent or fraction of a given component in the plant feed which is recovered as plant product.

**Recycle**

Return of part of a process stream to a point upstream from where it was removed to enhance recovery or control.

**Reflux**

In fractionation, the portion of condensed overhead returned to the column to enhance achievable purity of the overhead product.

**Reflux ratio**

A way of giving a relative measurement to the volume of reflux. Usually referred either to the feed or overhead product.

**Relative density (See specific gravity)****Relief system**

The system for safely relieving excess pressure to avoid exceeding equipment design pressure.

**Residue**

The material which remains after a separation process. (1) Residue gas is that gas remaining after the recovery of liquid products. (2) Residue may also be the heaviest liquid or solid remaining after distillation or reclaiming process.

**Retrograde condensation (vaporization)**

Condensation or vaporization that is the reverse of expected behavior. Condensation caused by a decrease in pressure or an increase in temperature. Vaporization caused by an increase in pressure or a decrease in temperature.

**Rich gas**

Gas feed to a gas processing plant for liquid recovery.

**Rich oil**

The oil leaving the bottom of an absorber. It is the lean oil plus the absorbed constituents.

**RVP (Reid Vapor Pressure)**

The vapor pressure of a material measured by the Reid Method and apparatus as detailed in ASTM Test Procedure D-323.

**S & W (See BS&W)****Saturated compounds**

Hydrocarbon compounds having no unsaturated carbon valence bonds. Natural gas and natural gas liquids are mixtures of saturated compounds.

**Saturated liquid**

Liquid which is at its boiling point or is in equilibrium with a vapor phase in its containing vessel.

**Saturated vapor**

Vapor at its dew point.

**scf (standard cubic feet)**

Gas volume at standard temperature and pressure.

**Single mixed refrigerant (SMR)**

Refrigerant composed of some or all of the following components: nitrogen, methane, ethane, ethylene, propane, butanes and pentanes. The refrigerant composition is selected so that the refrigerant boiling curve closely matches the cooling curve of the gas being liquefied. (See Section 16 of this Data Book).

**Shrinkage**

The reduction in volume of a gas stream by removal of some of its constituents such as for recovered products, fuel, or losses.

**SNG (Synthetic or Substitute Natural Gas)**

The gas product resulting from the gasification of coal and/or gas liquids or heavier hydrocarbons.

**Solution gas**

Gas which originates from the liquid phase in an oil reservoir.

**Sour**

Liquids and gases are said to be "sour" if they contain hydrogen sulfide, carbon dioxide, and/or mercaptans above a specified level. It also is used to refer to the feed stream to a sweetening unit.

**Sour gas**

Gas containing undesirable quantities of hydrogen sulfide, mercaptans, and/or carbon dioxide. It also is used to refer to the feed stream to a sweetening unit.

**Specific gravity**

The ratio of the mass of a given volume of a substance to that of another equal volume of another substance used as standard. Unless otherwise stated, air is used as the standard for gases and water for liquids, with the volumes measured at 60 °F and standard atmospheric pressure.

**Splitter**

A name applied to fractionators, particularly those separating isomers (e.g., butane splitter refers to a tower producing most of the iso-butane in the feed as overhead and most of the normal butane in the feed as bottoms).

**Sponge absorbent**

An absorbent for recovering vapors of a lighter absorbent that is used in the main absorption process of a gas processing plant.

**Stabilized condensate**

Condensate that has been stabilized to a definite vapor pressure in a fractionation system.

**Stabilizer**

A fractionation column designed to reduce the vapor pressure of a liquid stream.

**Stage separation system**

A system of separators where the liquid portion of the well effluent is separated from formation gas and flash vapors.

**Still**

The column where the absorbed product is recovered from the lean absorption oil. In plants using a low molecular weight absorption oil, the still is designed as a fractionation column. In plants using a high molecular weight absorption oil, the still may use steam or other fluids as stripping medium. Also used to refer to regenerators in amine treating and glycol dehydration systems.

**Strapping**

A term applied to the process of calibrating liquid storage capacity of storage tanks in increments of depth.

**Stream day**

A continuous 24 hour period of plant operation.

**Stripper**

A column wherein absorbed constituents are stripped from the absorption oil. The term is applicable to columns using a stripping medium, such as steam or gas.

**Stripping factor**

An expression used to describe the degree of stripping. Mathematically, it is KV/L, the reciprocal of the absorption factor.

**Stripping medium**

As stated under “stripper”, the medium may be steam, gas, or other material that will increase the driving force for stripping.

**Sulfur**

A yellow, non-metallic chemical element. In its elemental state, it exists in both crystalline and amorphous forms. In many gas streams, sulfur may be found as volatile sulfur compounds, such as hydrogen sulfide, sulfur oxides, mercaptans, and carbonyl sulfide. Reduction of the concentration of these gaseous sulfur compounds is often necessary for corrosion control and possibly for health and safety reasons.

**Sulfur dioxide (SO<sub>2</sub>)**

A heavy, colorless, suffocating gas that is chemically an oxide of sulfur. Conversion of the gaseous sulfur oxides to sulfur is necessary for corrosion control, for health and safety reasons, and for complying with governmental standards.

**Sweet**

Gas containing essentially no objectionable sulfur compounds. Also, treated gas leaving a sweetening unit.

**Sweet gas**

Gas which has no more than the maximum sulfur and/or CO<sub>2</sub> content defined by (1) the specifications for the sales gas from a plant; (2) the definition by a legal body. Also, the treated gas leaving a sweetening unit.

**Temperature correction factor**

A factor for correcting volume at a given temperature to that at a specific reference temperature. Reference temperature most commonly used in the petroleum industry is 60 °F.

**Therm**

A unit of gross heating value equivalent to 100,000 Btu.

**Tonne**

A unit of mass measurement, commonly used in international petroleum commerce; an expression for the metric ton, or 1000 kilograms.

**Trayed column**

A vessel wherein gas and liquid, or two essentially immiscible liquids, are contacted, usually counter-currently on trays. Also refer to packed column.

**Turboexpander**

Refer to definition of “expansion turbine.”

**Ullage (See outage)****Unsaturated compounds**

Hydrocarbon compounds having one or more unsaturated valence bonds, i.e., ethylene, propylene. These compounds are not found in natural gas streams or gas liquids because of their relatively high chemical reactivity. Unsaturates are produced by a thermal cracking or chemical reaction and can be found in synthetic gas (SNG) or light refinery gases (LRG).

**Vapor pressure (true vapor pressure)**

The pressure exerted by the equilibrium vapor of a liquid when confined in a closed previously evacuated tank or test apparatus.

**Vapor pressure gasoline**

A descriptive phrase for natural gasoline meeting a specified vapor pressure.

**Vapor pressure, GPA**

Vapor pressure as specified by GPA procedures.

**Vapor recovery**

Equipment or process for the recovery of desired components from stock tank vapors or vapors from some other source.

**Volatile sulfur**

An obsolete term referring to sulfur compounds that will vaporize readily (See sulfur).

**Weathering**

The evaporation of liquid caused by exposing it to the conditions of atmospheric temperature and pressure. Partial evaporation of liquid by use of heat may also be called weathering.

**Weathering test**

A GPA test for LP-gas for the determination of heavy components in a sample by evaporation under specified conditions.

**Weight in air**

Weight compared to a standard with no correction for air buoyancy.

**Wellhead**

The assembly of fittings, valves, and controls located at the surface and connected to the flow lines, tubing, and casing of the well so as to control the flow from the reservoir.

**Wet gas**

(1) A gas containing water, or a gas which has not been dehydrated. (2) A term synonymous with rich gas. Refer to definition of “rich gas”.

**Wobbe number**

A number proportional to the heat input to a burner at constant pressure. In British practice, it is the gross heating value of a gas divided by the square root of its gravity. Widely used in Europe, together with a measured or calculated flame speed, to determine interchangeability of gaseous fuels.

$$\text{Wobbe No.} = \frac{\text{HHV}}{\sqrt{(\text{MW}/28.9625)}}$$

## CONVERSION FACTORS

### Energy Units Conversion

In these tables, factors for conversion, including conversions to the International System of Units (SI), are based on ASTM Standard for Metric Practice, E380-91. The latest edition of the Engineering Data Book should be studied for more detail on the SI system, including definitions and symbols. (See Tables 1-2, 1-3, and 1-4)

In calculating derived factors in the tables that follow, exact conversions were used, when available, rather than the 7-digit round-offs listed in ASTM E380 conversion tables. Derived factors given below are rounded to the same number of significant digits as the source factors.

In any conversion of fundamental measurement units, some confusion may result due to redefinition of units used in earlier tables. For example, in 1959 a small refinement was made in the definition of the yard, which changed its length from 3600/3937 meter (or 1 inch = 25.4000508 mm) to 0.9144 m exactly (or 1 inch = 25.4 mm exactly). The tables below are based on the new definition, but one should be aware that where U.S. land measurements are concerned, the old relationship applies. Refer to ASTM E380-91, note 13, for more detail.

Confusion may arise in the definition of units for heat or energy. In the tables below, the Btu (IT) and calorie (IT) are used. These are the heat units recommended by the International Conference on the Properties of Steam, as defined:

1 Btu (IT) = 1055.055 852 62 joule (exactly)  
1 Calorie (IT) = 4.186 800 joule (exactly)

**For information only**, other definitions that may be used elsewhere:

1 Btu (Mean) = 1055.87 joule  
1 Btu (39 °F) = 1059.67 joule  
1 Btu (60 °F) = 1054.68 joule  
1 Btu (Thermochemical) = 1054.350 joule  
1 calorie (Mean) = 4.190 02 joule  
1 calorie (15 °C) = 4.185 80 joule  
1 calorie (20 °C) = 4.181 90 joule  
1 calorie (Thermochemical) = 4.184 000 joule

The fundamental relationship between the Btu and the calorie:

$$\text{Btu} \times \frac{\text{gram-pound relationship}}{\text{Fahrenheit-Celsius scale relationship}} = \text{calorie (IT, mean, or other)}$$

$$\text{Btu} \times \frac{453.592\,29\,\text{g/lb}}{1.8} = \text{calorie (IT, mean, or other)}$$

Temperature difference — 1.8 °F/°C

1 therm = 100,000 Btu =  $105.5056 \times 10^6$  J  
= 105,505.6 kJ =  $1.055\,056 \times 10^5$  kJ.  
(Btu denotes British Thermal Units)  
(ref: Physical Properties of Natural Gases,  
Gas Unie, 1988 p. 23)

1 decatherm = 1,000,000 Btu = 1 MMBtu =  $10^6$  Btu

1 thermie = 1 Mcal (15 °C) =  $4.1858 \times 10_6$  J

1 terajoule = 1 TJ =  $1 \times 10^{12}$  Joule

## Gas Volume Relationships

Gas volume are commonly referred to in “standard” or “normal” units.

Standard conditions commonly refers to gas volumes measured at:

15 °C and 101.3250 kPa

60 °F and 14.696 psia

For the purposes of these Data Books, the metric unit system will be used. M (mega) is used to denote  $10^6$  for SI units.

These P & T conditions are often indicated as Standard Temperature and Pressure, abbreviated to STP. However standard conditions can refer to other combinations of pressure and temperature as might be agreed between gas buyer and seller. There is no internationally accepted standard for STP. In 1980 GPA adopted 15 °C, 101.3250 kPa (abs) as standard conditions for SI units. Thus standard molar volumes are:

23.645 std m<sup>3</sup>/kmol at 15 °C (288.15 K), 101.3250 kPa.  
GPA FPS standard conditions.

379.49 std ft<sup>3</sup>/lb mole at 60 °F (519.67 °R), 14.696 psia.

Other standard conditions sometimes used are:

| P                      | T     |
|------------------------|-------|
| 101.3250 kPa           | 20 °C |
| 100.0 kPa              | 15 °C |
| 14.73 psia             | 60 °F |
| 14.40 psia (99.28 kPa) | 60 °F |
| and others             |       |

Normal conditions refers to gas volumes measured at 0 °C and 101.3250 kPa (760 mm Hg), often abbreviated to NTP (Normal Temperature and Pressure). In SI systems, both the normal and standard conditions are used. The normal molar volume is:

22.414 Nm<sup>3</sup>/kmol at 0 °C (273.15 K), 101.3250 kPa

**Example 1-1** — Consider 100 kg of 16 mole weight gas.

$$(100\,\text{kg}) \left( \frac{\text{kmol}}{16\,\text{kg}} \right) = 6.25\,\text{kmol gas}$$

$$(100\,\text{kg}) \left( \frac{2.205\,\text{lb}}{1\,\text{kg}} \right) \left( \frac{\text{lb mol}}{16\,\text{lb}} \right) = 13.78\,\text{lb mol gas}$$

The volume occupied by this mass can be found by using the relationships presented above:

$$(6.25\,\text{kmol}) \left( \frac{23.645\,\text{m}^3}{\text{kmol}} \right) = 147.8\,\text{std m}^3 \text{ @ } 15^\circ\text{C}, 101.325\,\text{kPa}$$

$$(6.25\,\text{kmol}) \left( \frac{22.414\,\text{m}^3}{\text{kmol}} \right) = 140.1\,\text{Nm}^3 \text{ @ } 0^\circ\text{C}, 101.325\,\text{kPa}$$

$$(13.78\,\text{lb mol}) \left( \frac{379.5\,\text{std ft}^3}{\text{lb mol}} \right) = 5299\,\text{std ft}^3 \text{ (scf) @ } 60^\circ\text{F}, 14.696\,\text{psia}$$

Thus the following volume conversions individually represent the same mass (kg, kmol or lb, lb-mol) of gas assuming either constant z or ideal gas behavior.

1 Nm<sup>3</sup> = 37.33 scf. Same mass on either side of this equation.

1 std m<sup>3</sup> = 35.38 scf. Again, same mass on either side of this equation, but 1 std m<sup>3</sup> (15 °C) contains slightly smaller mass than in 1 Nm<sup>3</sup> (0 °C). Gas is less dense at 15 °C than at 0 °C.

## Other Useful Relationships

Real Gas Law  
PV = ZRT

Gas Density

$$\rho = \frac{(P)(MW)}{(Z)(R)(T)}$$

Standard Volumetric Flow to “In-situ” or actual volumetric flow

$$\text{MMscfd} \left( \frac{P_{\text{std}}}{P} \right) \left( \frac{T}{T_{\text{std}}} \right) \left( \frac{Z_a}{Z_{\text{std}}} \right) \left( \frac{1\,\text{d}}{86\,400\,\text{s}} \right) = \frac{\text{ft}^3}{\text{sec}}$$