

Appendix

ASTM DEFINITIONS OF TERMS

ASTM DICTIONARY OF SCIENCE AND TECHNOLOGY¹ defines various engineering terms in standard terminology. ASTM provides several definitions for most properties by its different committees. The closest definitions to the properties used in the book are given below. The identifier provided includes the standard designation in which the term appears followed by the committee having jurisdiction of that standard. For example, D02 represents the ASTM Committee on Petroleum Products and Lubricants.

Additive—Any substance added in small quantities to another substance, usually to improve properties; sometimes called a modifier. **D 16, D01**

Aniline point—The minimum equilibrium solution temperature for equal volumes of aniline (aminobenzene) and sample. **D 4175, D02**

API gravity—An arbitrary scale developed by the American Petroleum Institute and frequently used in reference to petroleum insulating oil. The relationship between API gravity and specific gravity 60/60°F is defined by the following: Degree API gravity at 60°F = 141.5/(SG 60/60°F) – 131.5. [Note: For definition see Eq. (2.4) in this book.] **D 2864, D27**

Ash—Residue after the combustion of a substance under specified conditions. **D 2652, D28**

Assay—Analysis of a mixture to determine the presence or concentration of a particular component. **F 1494, F23**

Autoignition—The ignition of material caused by the application of pressure, heat, or radiation, rather than by an external ignition source, such as a spark, flame, or incandescent surface. **D 4175, D02**

Autoignition temperature—The minimum temperature at which autoignition occurs. **D 4175, D02**

Average (for a series of observations)—The total divided by the number of observations. **D123, D13**

Bar—Unit of pressure; 14.5 lb/in², 1.020 kg/cm², 0.987 atm, 0.1 MPa. **D 6161, D19**

Bitumen—A class of black or dark-colored (solid, semisolid, or viscous) cementitious substances, natural or manufactured, composed principally of high-molecular-weight hydrocarbons, of which asphalts, tars, pitches, and asphaltites are typical. **D 8, D04**

Boiling point—The temperature at which the vapor pressure of an engine coolant reaches atmospheric pressure under equilibrium boiling conditions. [Note: This definition is applicable to all types of liquids.] **D 4725, D15**

Boiling pressure—At a specified temperature, the pressure at which a liquid and its vapor are in equilibrium. **E 7, E04**

¹ ASTM Dictionary of Engineering Science and Technology, 9th ed., ASTM International, West Conshohocken, PA, 2000.

BTU—One British thermal unit is the amount of heat required to raise 1 lb of water 1°F. **E 1705, E48**

Carbon black—A material consisting essentially of elemental carbon in the form of near-spherical colloidal particles and coalesced particle aggregates of colloidal size, obtained by partial combustion or thermal decomposition of hydrocarbons. **D 1566, D11**

Carbon residue—The residue formed by evaporation and thermal degradation of a carbon-containing material. **D 4175, D02**

Catalyst—A substance whose presence initiates or changes the rate of a chemical reaction, but does not itself enter into the reaction. **C 904, C03**

Cetane number (cn)—A measure of the ignition performance of a diesel fuel obtained by comparing it to reference fuels in a standardized engine test. **D 4175, D02**

Chemical potential (μ_i or \bar{G}_i)—The partial molar free energy of component i , that is, the change in the free energy of a solution upon adding 1 mol of component i to an infinite amount of solution of given composition, $(\delta G/\delta n_i)_{T,P,n_i} = \bar{G}_i = \mu_i$, where G = Gibbs free energy and n_i = number of moles of the i th component. **E 7, E04**

Cloud point—The temperature at which a defined liquid mixture, under controlled cooling, produces perceptible haze or cloudiness due to the formation of fine particles of an incompatible material. **D 6440, D01**

Coal—A brown to black combustible sedimentary rock (in the geological sense) composed principally of consolidated and chemically altered plant remains. **D 121, D05**

Coke—A carbonaceous solid produced from coal, petroleum, or other materials by thermal decomposition with passage through a plastic state. **C 709, D02**

Combustion—A chemical process of oxidation that occurs at a rate fast enough to produce heat and usually light either as glow or flames. **D 123, D13**

Compressed natural gas (CNG)—Natural gas that is typically pressurized to 3600 psi. CNG is primarily used as a vehicular fuel. **D 4150, D03**

Concentration—Quantity of substance in a unit quantity of sample. **E 1605, E06**

Critical point—In a phase diagram, that specific value of composition, temperature, pressure, or combinations thereof at which the phases of a heterogeneous equilibrium become identical. **E 7, E04**

Critical pressure—Pressure at the critical point. **E 1142, E37**

Critical temperature—(1) Temperature above which the vapor phase cannot be condensed to liquid by an increase in pressure. **E 7, E04**

(2) Temperature at the critical point. **E 1142, E37**

Degradation—Damage by weakening or loss of some property, quality, or capability. **E 1749, E 06**

- Degree Celsius (°C)**—Derived unit of temperature in the International System of Units (SI). **E 344, E20**
- Density**—The mass per unit volume of a substrate at a specified temperature and pressure; usually expressed in g/mL, kg/L, g/cm³, g/L, kg/m³, or lb/gal. **D 16, D01**
- Deposition**—The chemical, mechanical, or biological processes through which sediments accumulate in a resting place. **D 4410, D19**
- Dew point**—The temperature at any given pressure 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). **D 4150, D03**
- Diffusion**—(1) Spreading of a constituent in a gas, liquid, or solid tending to make the composition of all parts uniform. (2) The spontaneous movement of atoms or molecules to new sites within a material. **B 374, B08**
- Distillation**—The act of vaporizing and condensing a liquid in sequential steps to effect separation from a liquid mixture. **E 1705, E 48**
- Distillation temperature (in a column distillation)**—The temperature of the saturated vapor measured just above the top of the fractionating column. **D 4175, D02**
- Endothermic reaction**—A chemical reaction in which heat is absorbed. **C 1145, C 28**
- Enthalpy**—A thermodynamic *function* defined by the equation $H = U + PV$, where H is the enthalpy, U is the *internal* energy, P is the pressure, and V the volume of the system. [Note: Also see Eq. (6.1) of this book.] **E 1142, E37**
- Equilibrium**—A state of dynamic balance between the opposing actions, reactions, or velocities of a reversible process. **E 7, E04**
- Evaporation**—Process where a liquid (water) passes from a liquid to a gaseous state. **D 6161, D19**
- Fire point**—The lowest temperature at which a liquid or solid specimen will sustain burning for 5 s. **D 4175, D02**
- Flammable liquid**—A liquid having a flash point below 37.8°C (100°F) and having a vapor pressure not exceeding 40 psi (absolute) at 37.8°C and known as a Class I liquid. **E 772, E44**
- Flash point**—The lowest temperature of a specimen corrected to a pressure of 760 mm Hg (101.3 kPa), at which application of an ignition source causes any vapor from the specimen to ignite under specified conditions of test. **D 1711, D09**
- Fluidity**—The reciprocal of viscosity. **D 1695, D01**
- Freezing point**—The temperature at which the liquid and solid states of a substance are in equilibrium at a given pressure (usually atmospheric). For pure substances it is identical with the melting point of the solid form. **D 4790, D16**
- Gas**—One of the states of matter, having neither independent shape nor volume and tending to expand indefinitely. **D 1356, D22**
- Gasification**—Any chemical or heat process used to convert a feedstock to a gaseous fuel. **E 1126, E 48**
- Gasoline**—A volatile mixture of liquid hydrocarbons, normally containing small amounts of additives, suitable for use as a fuel in spark-ignition internal combustion engines. **D 4175, D02**
- Gibbs free energy**—The maximum useful work that can be obtained from a chemical system without net change in temperature or pressure, $\Delta F = \Delta H - T\Delta S$. [Note: For definition see Eq. (6.6) in this book; the author has used G for Gibbs free energy.] **E 7, E04**
- Grain**—Unit of weight; 0.648 g, 0.000143 lb. **D 6161, D19**
- Gross calorific value (synonym: higher heating value, HHV)**—The energy released by combustion of a unit quantity of refuse-derived fuel at constant volume or constant pressure in a suitable calorimeter under specified conditions such that all water in the products is in liquid form. This the measure of calorific value is predominately used in the United States. **E 856, D34**
- Heat capacity**—The quantity of heat required to raise a system 1° in temperature either at constant volume or constant pressure. **D 5681, D34**
- Heat flux (q)**—The heat flow rate through a surface of unit area perpendicular to the direction of heat flow (q in SI units: W/m²; q in inch-pound units: Btu/h/ft² = Btu/h · ft²) **C 168, C16**
- Henry's law**—The principle that the mass of a gas dissolved in a liquid is proportional to the pressure of the gas above the liquid. **D 4175, D02**
- Higher heating value (HHV)**—A synonym for gross calorific value. **D 5681, D34**
- Inert components**—Those elements or components of natural gas (fuel gas) that do not contribute to the heating value. **D 4150, D03**
- Inhibitor**—A substance added to a material to retard or prevent deterioration. **D 4790, D16**
- Initial boiling point**—The temperature observed immediately after the first drop of distillate falls into the receiving cylinder during a distillation test. **D 4790, D 16**
- Interface**—A boundary between two phases with different chemical or physical properties. **E 673, E 42**
- Interfacial tension (IFT)**—The force existing in a liquid-liquid phase interface that tends to diminish the area of the interface. This force, which is analogous to the surface tension of liquid-vapor interfaces, acts at each point on the interface in the plane tangent at that point. **D 459, D12**
- International System of Units, SI**—A complete coherent system of units whose base units are the meter, kilogram, second, ampere, kelvin, mole, and candela. Other units are derived as combinations of the base units or are supplementary units. **A 340, A06**
- Interphase**—The region between two distinct phases over which there is a variation of a property. **E 673, E42**
- ISO**—Abbreviation for International Organization for Standards: An organization that develops and publishes international standards for a variety of technical applications, including data processing and communications. **E 1457, F05**
- Jet fuel**—Any liquid suitable for the generation of power by combustion in aircraft gas turbine engines. **D 4175, D02**
- Joule (J)**—The unit of energy in the SI system of units. One joule is 1 W · s. **A 340, A06**
- Kelvin (K)**—The unit of thermodynamic temperature; the SI unit of temperature for which an interval of 1 kelvin (K) equals exactly an interval of 1°C and for which a level of 273.15 K equals exactly 0°C. **D 123, D13**

Liquefied petroleum gas (LPG)—A mixture of normally gaseous hydrocarbons, predominantly propane or butane or both, that has been liquefied by compression or cooling, or both, to facilitate storage, transport, and handling.

D 4175, D02

Liquid—A substance that has a definite volume but no definite form, except such given by its container. It has a viscosity of 1×10^{-3} to 1×10^3 St (1×10^{-7} to 1×10^{-1} $\text{m}^2 \cdot \text{s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at agreed upon temperature. (This does not include powders and granular materials.) Liquids are divided into two classes:

- (1) Class A, low viscosity—A liquid having a viscosity of 1×10^{-3} to 25.00 St (1×10^{-7} to 25.00×10^{-4} $\text{m}^2 \cdot \text{s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at agreed upon temperature.
- (2) Class B, high viscosity—A liquid having a viscosity of 25.01 to 1×10^3 St (25.01×10^{-4} to 1×10^{-1} $\text{m}^2 \cdot \text{s}^{-1}$) at 104°F (40°C) or an equivalent viscosity at agreed upon temperature.

D 16, D01

Lower heating value (LHV)—A synonym for net calorific value.

D 5681, D34

Lubricant—Any material interposed between two surfaces that reduces the friction or wear between them.

D 4175, D02

Mass—The quantity of matter in a body (also see weight).

D 123, D13

Melting point—In a phase diagram, the temperature at which the liquids and solids coincide at an invariant point.

E 7, E04

Micron (μm , micrometer)—A metric unit of measurement equivalent to 10^{-6} m, 10^{-4} cm.

D 6161, D19

Molality—Moles (gram molecular weight) of solute per 1000 g of solvent.

D 6161, D19

Molarity—Moles (gram molecular weight) of solute per liter of total solution

D 6161, D19

Molecular diffusion—A process of spontaneous intermixing of different substances, attributable to molecular motion, and tending to produce uniformity of concentration.

D1356, D22

Mole fraction—The ratio of the number of molecules (or moles) of a compound or element to the total number of molecules (or moles) present.

D 4023, D22

Naphtha, aromatic solvent—A concentrate of aromatic hydrocarbons including C_8 , C_9 , and C_{10} homologs.

D 4790, D 16

Napthenic oil—An hydrocarbon process oil containing more than 30%, by mass, of naphthenic hydrocarbons.

D 1566, D11

Natural gas—A naturally occurring mixture of hydrocarbon and nonhydrocarbon gases found in porous geological formations (reservoirs) beneath the earth's surface, often in association with petroleum. The principal constituent of natural gas is methane.

D 4150, D03

Net calorific value (Net heat of combustion at constant pressure)—The heat produced by combustion of unit quantity of a solid or liquid fuel when burned, at constant pressure of 1 atm (0.1 MPa), under the conditions such

that all the water in the products remains in the form of vapor.

D 121, D05

Net heat of combustion—The oxygen bomb (see Test Method D 3286) value for the heat of combustion, corrected for gaseous state of product water.

E 176, E05

Octane number (for spark ignition engine fuel)—Any one of several numerical indicators of resistance to knock obtained by comparison with reference fuels in standardized engine or vehicle tests.

D 4175, D02

Oxygenate—An oxygen-containing ashless organic compound, such as an alcohol or ether, which may be used as a fuel or fuel supplement.

D 4175, D02

Paraffinic oil—A petroleum oil (derived from paraffin crude oil) whose paraffinic carbon type content is typically greater than 60%.

E 1519, E35

Partial pressure—The contribution of one component of a system to the total pressure of its vapor at a specified temperature and gross composition.

E 7, E04

Porosity—The percentage of the total volume of a material occupied by both open and closed pores. [Note: In this book porosity represented by ϕ (see Eq. 8.72) is the fraction of total volume of a material occupied by *open pores* and is not identical to this definition.]

C 709, D02

Pour point—The lowest temperature at which a liquid can be observed to flow under specified conditions.

D 2864, D27

Precipitation—Separation of new phase from solid, liquid, or gaseous solutions, usually with changing conditions or temperature or pressure, or both.

E 7, E04

Pressure—The internal force per unit area exerted by any material. Since the pressure is directly dependent on the temperature, the latter must be specified.

D 3064, D10

Pressure, saturation—The pressure, for a pure substance at any given temperature, at which vapor and liquid, or vapor and solid, coexist in stable equilibrium. [Note: This is the definition of vapor pressure used in this book.]

E 41, G03

Quality—Collection of features and characteristics of a product, process, or service that confers its ability to satisfy stated or implied needs.

E 253, E18

Range—The region between the limits within which a quantity is measured and is expressed by stating the lower and upper range values.

E 344, E20

Refractive index—The ratio of the velocity of light (of specified wavelength) in air to its velocity in the substance under examination. This is relative refractive index of refraction. If absolute refractive index (that is, referred to vacuum) is desired, this value should be multiplied by the factor 1.00027, the absolute refractive index of air. [Note: In this book absolute refractive index is used.]

D 4175, D02

Saturation—The condition of coexistence in stable equilibrium of a vapor and a liquid or a vapor and solid phase of the same substance at the same temperature.

E 41, G03

Smoke point—The maximum height of a smokeless flame of fuel burned in a wick-fed lamp.

D 4175, D02

Solid—A state of matter in which the relative motion of molecules is restricted and in which molecules tend to retain a definite fixed position relative to each other. A solid may be said to have a definite shape and volume.

E 1547, E 15

Solubility—The extent that one material will dissolve in another, generally expressed as mass percent, or as volume percent, or parts per 100 parts of solvent by mass or volume. The temperature should be specified. **D 3064, D10**

Solubility parameter (of liquids)—The square root of the heat of vaporization minus work of vaporization (cohesive energy density) per unit volume of liquid at 298 K.

D 4175, D02

Solutes—Matter dissolved in a solvent. **D 6161, D19**

Specific gravity (deprecated term of liquids)—The ratio of density of a substance to that of a reference substance such as water (for solids and liquids) or hydrogen (for gases) under specified conditions. Also called relative density. [Note: In this book the reference substance for definition of gas specific gravity is air].

D 4175, D02

Surface tension—Property that exists due to molecular forces in the surface film of all liquids and tends to prevent the liquid from spreading. **B 374, B08**

Temperature—The thermal state of matter as measured on a definite scale. **B 713, B01**

Thermal conductivity (λ)—Time rate of heat flow, under steady conditions, through unit area, per unit temperature gradient in the direction perpendicular to the area.

E 1142, E37

Thermal diffusivity—Ratio of thermal conductivity of a substance to the product of its density and specific heat capacity. **E1142, E37**

Vapor—The gaseous phase of matter that normally exists in a liquid or solid state. **D 1356, D22**

Vapor pressure—The pressure exerted by the vapor of a liquid when in equilibrium with the liquid. **D 4175, D02**

Viscosity, absolute (η)—The ratio of shear stress to shear rate. It is the property of internal resistance of a fluid that opposes the relative motion of adjacent layers [Note: See Eq. (8.1) in this book.] The unit most commonly used for insulating fluids is centipoise. **D 2864, D27**

Viscosity, kinematic—The quotient of the absolute (dynamic) viscosity divided by the density, η/ρ both at the same temperature. For insulating liquids, the unit most commonly unit is the centistokes (100 cSt = 1 St). [Note: See Eq. (8.1) in this book.] **D 2864, D27**

Viscosity, Saybolt Universal—The efflux time in seconds of 60 mL of sample flowing through a calibrated Saybolt Universal orifice under specified conditions. **D 2864, D27**

Wax appearance point—The temperature at which wax or other solid substances first begin to separate from the liquid oil when it is cooled under prescribed conditions (refer to D 3117, Test Method for Wax Appearance Point of Distillate Fuels). **D 2864, D27**

Weight (synonymous with mass)—The mass of a body is a measure of its inertia, or resistance to change in motion. **E 867, E17**

Greek Alphabet

α	Alpha
β	Beta
Γ	Gamma (Uppercase)
γ	Gamma
Δ	Delta (Uppercase)
δ	Delta
ϵ	Epsilon
ζ	Zeta
η	Eta
Θ	Theta (Uppercase)
θ	Theta
K	Kappa (Uppercase)
κ	Kappa
Λ	Lambda (Uppercase)
λ	Lambda
μ	Mu
ν	Nu
ξ	Xi
Π	Pi (Uppercase)
π	Pi
ρ	Rho
Σ	Sigma (Uppercase)
σ	Sigma
τ	Tau
υ	Upsilon
Φ	Phi (Uppercase)
ϕ	Phi
φ	Phi
χ	Chi
Ψ	Psi (Uppercase)
Ω	Omega (Upper case)
ω	Omega