Manual of Petroleum Measurement Standards Chapter 1—Vocabulary

SECOND EDITION, JULY 1994

American Petroleum Institute
1220 L Street, Northwest
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Measurement Coordination

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FOREWORD

The definitions included in this document are derived from standards published as of December 31, 1992. New definitions or revised definitions as a result of standards developed and published after this date will appear in the next edition.

The definitions presented in this document support the petroleum industry's terminology requirements associated with the custody transfer, loss control, and environmental measurement activities addressed within API's *Manual of Petroleum Measurement Standards*. Some of the definitions will be specific to these applications and may conflict with usage of the terms in other contexts, while others may be applied more broadly.

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Suggested revisions are invited and should be submitted to Measurement Coordination, Industry Services Department, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005.

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Chapter 1—Vocabulary

1.0 Scope

The words and terms contained in this vocabulary are defined and described to assist in understanding their use throughout the entire API *Manual of Petroleum Measurement Standards* (MPMS).

Additional sections have been included that are based on the definitions found in the vocabulary. Useful facts and information not found elsewhere in the API *Manual of Petroleum Measurement Standards* are also included.

1.1 Vocabulary

A

Absolute temperature: (See temperature, absolute.)

Absolute viscosity: (See viscosity, absolute.)

Accessory equipment: Any device that enhances the utility of a measurement system, including readouts, registers, monitors, and liquid- or flow-conditioning equipment.

Accuracy: The ability of a measuring instrument to indicate values closely approximating the true value of the quantity measured.

Accuracy curve of a volume meter: A plot of meter factor or K factor or error as a function of flow rate used to evaluate the meter's performance.

Adjustment (of meter registration): The operation of bringing a measuring instrument (meter) into a satisfactory state of performance and accuracy.

Air (gas) vapor eliminator (separator): A device used to separate and remove gases (air, gas, or vapor) from a liquid to be measured to prevent an error in liquid measurement from having gas included in the measurement as liquid.

Air-jacketed thermometer: A glass stem thermometer totally encased in a glass sheath that provides air space between the thermometer and the liquid in which the unit is immersed.

All-levels sample: A sample obtained by submerging a stoppered beaker or bottle to a point as near as possible to the draw-off level, then opening the sampler and raising it at a rate such that it is approximately three-fourths full as it emerges from the liquid. An all-levels sample is not necessarily a representative sample because the tank volume may not be proportional to the depth and because the operator may not be able to raise the sampler at the variable rate required for proportional filling. The rate of filling is proportional to the square root of the depth of immersion.

Allowable: The amount of crude oil that can be taken from an oil field as set by regulation, having the effect of law.

Ambient conditions: The conditions (pressure, temperature, humidity, etc.) of the medium surrounding an object such as the case of a meter, instrument, transducer, etc.

Amplifier: A device for increasing the magnitude of a quantity such as an electrical measurement signal. An amplifier use includes increasing a transmitted or received measurement signal for purposes that include operation of indicating, counting, recording, and controlling devices or other instrument that receives the transmitted signal; (also see preamplifier).

Analog output: Transducer output that is a continuous function of the measurand.

Analog signal: A signal that varies continuously in amplitude rather than in discrete steps.

Anchor weight: A weight installed in a tank to which the guide wires or cables for an automatic tank gauge float are attached to hold them taut and plumb.

Angle-stem thermometer: A glass stem thermometer in which the tail is bent at an angle to the stem so that the tail can be mounted in a horizontally disposed thermowell, leaving the scale vertical for greater ease of reading.

API gravity: A term used by the petroleum industry to express the relative density of petroleum liquids (also see density, relative). API gravity is measured by a hydrometer instrument having a scale graduated in degrees API. The relationship between API gravity and relative density (formerly called specific gravity) is as follows:

$$\text{API Gravity at } 60°\text{F} = \frac{141.5}{\text{Relative density } 60/60°\text{F}} - 131.5$$

See 1.7 for the relationship between API gravity, relative density 60/60°F, and density at 15°C.

Apparent compressibility: (See compressibility, apparent.)

Argument, mathematic: The independent variable X for a function $F(X)$ and also the values of the independent variable in a numerical table, such as for angles in a table of trigonometric functions or the numbers in a table of logarithms; (also see function).

Armored case (thermometer): A sturdy metal case in which a glass stem thermometer can be placed in order to minimize the risk of breakage of the thermometer in use.

Atmosphere; abbreviated **atm**: A standard unit of pressure equivalent to a column of mercury 760 millimeters high at 0°C under a gravitational acceleration of 980.665 centimeter-gram-second (cgs) units. The pressure exerted by 101.325 kilopascals of 0°C (32°F) mercury (equivalent to 14.696 pounds per square inch absolute).

Atmospheric pressure: (See pressure, atmospheric.)

Automatic gauging tape: The flexible measuring or connecting element that is used to measure the liquid level in tanks by the automatic gauge method.

Automatic sampler: A device used to extract a representative sample from the liquid flowing in a pipe. The automatic sampler generally consists of a probe, a sample extractor, an associated controller, a flow measuring device, and a sample receiver.

Automatic sampling system: A system that consists of stream conditioning, an automatic sampler, and sample mixing and handling.

Automatic tank gauge: An instrument that automatically measures and displays liquid levels or ullages in one or more tanks either continuously, periodically, or on demand.

Automatic temperature compensator: A meter accessory device enabling a meter that is measuring volume at stream temperature to register the equivalent volume at a reference or base temperature.

Automatic vessel tank gauging system: A system that automatically measures and displays liquid levels or ullage in one or more vessel tanks on a continuous, periodic, or on-demand basis.

Auxiliary meter equipment: Equipment (such as a strainer, air separator, or flow conditioner) installed in conjunction with a meter to protect or improve the performance of the meter. Auxiliary equipment does not include instrumentation and accessories driven by the meter's output rotation or pulses.

B

Back pressure: The operating pressure level measured downstream from a measuring device.

Back pressure valve: (See valve, back pressure.)

Ballast: Water taken on when a vessel is empty or partially loaded to increase draft so that the propeller is properly submerged and stability and trim are maintained.

Barrel; abbreviated **bbl**: A unit of quantity for oil equal to 42 U.S. gallons or 9702.0 cubic inches.

Baseline: The fore and aft reference line at the upper surface of the flat plate keel at the centerline for flush shell plate vessels, or the thickness of the garboard strake above that level for vessels having lap seam shell plating.

Basic sediment and water; abbreviated **BS&W**: (Archaic, see sediment and water.)

Batch: A parcel of a single petroleum liquid consigned separately in a pipeline; (see tender and delivery, meter).

Battery or bank of meters: An installation of meters having two or more meters connected in parallel.

Bellows: A pressure sensing element of cylindrical shape whose walls contain deep convolutions that cause the length of the bellows to change when pressure is applied.

Bias: Any influence on a result that produces an incorrect approximation of the true value of the variable being measured. Bias is the result of a predictable systematic error.

Bi-directional meter: A meter that can measure flow from either direction.

Bilge radius: The radius of the rounded portion of the vessel's shell that connects the bottom to the sides.

Bill of lading; abbreviated **BOL**: A document by which a carrier acknowledges having received in good order and condition (or the reverse) certain specified goods consigned to him by some particular shipper and binds himself to deliver those goods in similar condition, unless the perils of the sea, fire, or enemies prevent him, to the consignees of the shippers at the point of destination on their paying him the stipulated freight.

Blind (blanking device): A circular metal disc that is installed in a pipeline by fastening it between flanges to prevent flow in the pipeline.

Boring sample: A sample of the material contained in a barrel, case, bag, or cake that is obtained from the chips created by boring holes into the material with a ship auger.

Bottom guide wire anchor: A bar welded to the bottom of a tank to which guide wires or cables for the float of an automatic tank gauge are attached.

Bottom sample: A spot sample collected from the material at the bottom of the tank, container, or line at its lowest point. In practice, the term has a variety of meanings. As a result, it is recommended that the specific sampling location [for example, 6 inches (15 centimeters) from the bottom] should be specified when using this term.

Bottom water sample: A spot sample of free water taken from beneath the petroleum contained in a ship or barge compartment or a storage tank.

Bourdon tube: A pressure sensing element consisting of a twisted or curved tube of noncircular cross section that tends to be straightened by the application of internal pressure.

Breadth, extreme: The maximum breadth of the hull measured to the outside surfaces of the side shell plating or to the outside of the guards, if fitted.

Bubble point: When the pressure is lowered on a liquid held at a constant temperature, the pressure at which the first bubble of vapor forms is the bubble point. Bubble point pressures are higher at high temperatures.

Bulb: The temperature sensing (detecting) element of a temperature measuring device.

Bulkhead: The vertical partition walls that subdivide the interior of a vessel into compartments or rooms.

C

Calibration (of a container): The process or procedure of determining the exact volume capacity or partial capacities of a standard capacity measure, a tank prover, or a pipe prover.

Calibration (of an instrument): The process or procedure of adjusting an instrument, such as a meter, so that its indication or registration is in satisfactorily close agreement with a reference standard. Meter proving data may be used either to calibrate the meter or to calculate a meter factor.

Calibration (of a prover): The procedure for determining the volume of a prover.

Calibration adjuster (meter): (See meter calibration adjuster.)

Calibration curve (meter): A curve or graph that expresses the relationship between the true values of the quantity measured and corresponding values indicated by the meter.

Calibration table (tank): (See capacity table.)

Calibration, tank: Bottom calibration of a tank is either:

a. The determination of the tank volume below the strike plate, which is considered to be zero on the tank gauge table.

b. The quantity of liquid contained in a tank below the gauge point.

The following terms are related to tank calibration:

> ***Measurement calibration method, tank:*** The method of tank calibration in which volume capacities are calculated from external and/or internal measurements of the tank dimensions.
>
> ***Liquid calibration, tank:*** The method of tank calibration in which the capacities are determined by filling into (or withdrawing from) the tank accurately determined volumes of liquid.
>
> ***Over-calibration, tank:*** A tank is said to be over-calibrated when its actual capacity is less than that shown on its calibration table or by its capacity indicator.
>
> ***Under-calibration, tank:*** A tank is said to be under-calibrated when its actual capacity is greater than that shown by its calibration table or capacity indicator.

Camber: The arching or rounding up transversely of the vessel's deck.

Capacitance probe: A device that senses the different dielectric constants of oil and water or oil and air.

Capacity: The volume of a container or tank filled to a specified level.

Capacity indicator (on a proving tank): A device fitted to a proving tank that indicates

the position of the liquid surface in relation to the reference mark corresponding to the nominal capacity of the proving tank, thus enabling the determination of its liquid contents.

Capacity, nominal (of a tank): The nominal capacity is the designated volume of a container.

Capacity table: A table often referred to as a tank capacity table or calibration table, showing the capacities of or volumes in a tank for various liquid levels measured from the reference gauge point.

Capsule: A pressure sensing element consisting of two metallic diaphragms (usually circular) that are joined around their peripheries.

Cargo quantity option certificate: A certificate signed by vessel and shore representatives acknowledging the amount of cargo intended to load. Generally, most product cargoes have a tolerance based on either supplier, receiver, or vessel capabilities. Each party involved with the loading shall agree to the quantity amount to be loaded.

Cavitation: The formation and collapse of vapor cavities (bubbles) in a liquid that result from a sudden decrease and increase of pressure. Collapse of the cavities causes large impulsive pressures in the vicinity of the cavity. Cavitation can occur and cause mechanical damage to adjacent surfaces in meters, valves, pumps, and pipes at locations where flowing liquid encounters a restriction or change in direction.

Check valve: (See valve, check.)

Choke: A device that is placed in a pipe to restrict flow.

Clearance sample: A spot sample taken with the inlet opening of the sampling apparatus 4 inches (10 centimeters) [some regulatory agencies require 6 inches (15 centimeters)] below the bottom of the tank outlet. This term is normally associated with small tanks (100 barrels or less), commonly referred to as lease tanks.

Clingage: The liquid film that adheres to the inside surface of a container after it has been emptied.

Closing gauge: The measurement in a tank after a delivery or receipt.

Coalescer: A device that is used to cause the separation and removal of one fluid from another, such as removal of water from a petroleum liquid.

Coefficient of expansion adjuster (meter): An accessory device for a meter that is used with an automatic temperature compensator. The coefficient of expansion adjuster regulates the magnitude of temperature compensation consistent with the coefficient of thermal expansion of the liquid being metered.

Commercial gauger: Commercial organizations and individuals who measure, gauge, or sample merchandise. "Public Gauger" has been used to denote a type of commercial gauger dealing mainly with petroleum and petroleum products. "Public gaugers" are commercial gaugers and are subject to the regulations in 19 *Code of Federal Regulations* Part 151.

Commercial laboratory: Commercial organizations and individuals who analyze merchandise, i.e., determine its composition and/or characteristics through laboratory analysis.

Compensation: Provision of a supplemental device, circuit, or special materials to counteract known sources of error.

Composite spot sample: A blend of spot samples mixed in proportion to the volumes of material from which the spot samples were obtained.

Compressibility (liquid): The change in volume per unit of volume of a liquid caused by a unit change in pressure at constant temperature.

Compressibility, apparent: The algebraic sum of the actual compressibility of a liquid and the volume change per unit of volume of the confining container caused by a unit change in pressure at constant temperature.

Compressibility factor: 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.

Condensate reservoir, automatic tank gauge: A device situated at the base of an automatic tank gauge to collect and drain off condensate from within the tape conduit.

Conductor, shielded: Single or multiple conductors surrounded by a flexible metal shield for the purpose of preventing spurious signals from being carried on the shielded conductors.

Contain: A standard capacity measure is calibrated "to contain" by a procedure that begins with the internal surfaces of the vessel dry and free of the calibrating liquid; (see deliver).

Continuous sample: A sample obtained from a pipeline in such a manner as to give a representative average of a moving stream. This sample may be collected on a continuous basis or intermittently and proportional to time or flow.

Control chart: A chart of successive meter factors (or relative meter errors) generally plotted as a function of time. It is used to evaluate meter stability and to determine when meter performance has departed from its normal range.

Conventional tank: A tank of a shape commonly used in the petroleum industry that is not constructed to withstand any appreciable pressure or vacuum in the vapor space.

Core sample: A spot sample of uniform cross sectional area taken at a given height in a tank.

Counter, factoring: An electronic counter (register) capable of expressing metered volume. The counter includes selective means for automatically applying the meter factor.

Counter, meter: A counting device, electrical or mechanical, coupled to the meter measuring element to register the indicated volume passed through the meter.

Counter-printer, computing: A counter-printer with selective means for setting the price per standard unit of measurement and to compute the total price for a quantity of product delivered.

Counterweight: A device that exerts force or tension on the tape or cable to hold connecting elements tight.

Course, tank: One circumferential ring of plates in a tank; (see storage tank).

Crude oil: A mixture of hydrocarbons that existed in liquid phase in underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.

Crude oil truck driver; abbreviated **COTD**: Assumes the driver is also the gauger. However, it should be recognized that these duties may be separated between two individuals, such as a person who only drives the tank truck and a gauger who is responsible for measurement and testing.

Crude oil washing; abbreviated **COW**: (See washing, crude oil.)

Cup case thermometer: A holder for a mercury-in-glass thermometer incorporating a small metal container in which the bulb of the thermometer is inserted and that serves to take a small sample of the liquid.

Custody transfer measurement: Provides quantity and quality information used for the physical and fiscal documentation of a change in ownership and/or a change in responsibility for commodities.

D

Datum plate: A level metal plate located directly under the reference gauge point to provide a fixed contact surface from which liquid depth measurement can be made.

Dead legs: Sections of pipe that, by design, do not allow for the flow of material through them.

Deadrise: The transverse rise of the vessel's bottom from the keel to the bilge.

Deadwood: Any tank fitting, appurtenance, or structural member that affects the capacity of the tank. Deadwood is positive if it increases tank capacity or negative if it decreases capacity.

Degrees of freedom: The number of independent results used in estimating standard deviation.

Deliver: A standard capacity measure is calibrated "to deliver" by a procedure that begins with the internal surfaces of the vessel wetted with the calibrating liquid; (see contain).

Delivery: The volume delivered through a meter during a metering operation or upon completing fluid movement into or out of a tank. A "batch" or tender may also be called a delivery (see batch).

Delivery, meter: A volume of delivered liquid that is measured by a meter.

Delivery, over- or under-: The amount by which the true volume that has passed through the meter exceeds or is less than the indicated volume registered by a meter; (see error, absolute).

Density: The density of a quantity of a homogeneous substance is the ratio of its mass to its volume. The density varies as the temperature changes and is therefore generally expressed as the mass per unit of volume at a specified temperature.

Density, absolute: The density of a solid or liquid substance at a specified temperature is the mass of the substance occupying unit volume at the specified temperature. Density as so defined is sometimes referred to as "true density" or as "density in vacuo." When reporting density, the units of mass and volume used and the temperature of the determination must be stated (for example, grams per milliliter at t °C).

Density, relative: The ratio of the mass of given volume of liquid at 15°C (or other standard temperature, such as 60°F) to the mass of an equal volume of pure water at the same temperature. When reporting results, explicitly state the standard reference temperature (for example, relative density 15/15°C).

Depth, molded: The vertical distance from the baseline to the underside of the deck plating at the side, measured at the mid-length of the vessel.

Detector, prover: A device that indicates the passage of a displacer in a prover; (also see transducer).

Detector signal: A contact closure change, or other signal, that starts or stops a prover counter/timer and defines the calibrated volume of the prover.

Deviation: Any departure from a reference value.

Dial: The part of an indicating device, such as a meter counter, that contains the scale or scales.

Dial indicator: A pointer and fixed number dial reading in calibrated increments.

Diaphragm: A sensing element consisting of a thin, usually circular, plate that is deformed by pressure applied across the plate.

Differential pressure: (See pressure, differential.)

Differential pressure valve: (See valve, differential pressure.)

Digit: A numerical character used to represent one of the integers smaller than the radix or base (for example, in decimal notation, one of the characters 0 to 9).

Digital: Numerical data existing in the form of digits.

Digital signal: A signal that varies in discrete steps rather than continuously.

Dimension: A geometric element in a design, such as length, angle, etc., or the magnitude of such a quantity.

Dip: A term that designates the depth of liquid in a storage tank; [see innage and outage (ullage)].

Dip hatch, tank: (See gauge hatch, tank.)

Dip point, tank: (See gauge point, tank.)

Dip rod, stick: (See gauge rod.)

Dip weight, bob: (See gauge weight, bob.)

Dipper sample: A sample obtained by placing a dipper or other collecting vessel in the path of a free-flowing stream to collect a definite volume from the full cross section of the stream at regular time intervals for a constant time rate or at time intervals varied in proportion to the flow rate.

Dipping reference point, tank: (See gauging reference point, tank.)

Discrimination: The ability to sense and record a value of a parameter to the specified increments.

Displacement meter: A meter in which the measuring element measures a volume of liquid by mechanically separating the liquid into discrete quantities of fixed volume and counting the quantities in volume units.

Displacer, prover: A spherical or cylindrical object that is a component part of a pipe prover that moves through the prover pipe. The displacer has an elastic seal that contacts the inner pipe wall of a prover to prevent leakage. The displacer is caused to move through the prover pipe by the flowing fluid and displaces a known measured volume of fluid between two fixed detecting devices.

Dissolved water: Water in solution in petroleum and petroleum products.

Draft: The depth of a vessel below the waterline measured from the surface of the water to the bottom of the vessel's keel.

Draft, extreme: The depth of the vessel below the waterline measured vertically from the waterline to the lowest projecting portion of the vessel.

Draft, molded: The depth of the vessel below the waterline measured vertically from the baseline to the waterline.

Draft marks: The vertical column of numbers on each side of the vessel at each end and sometimes amidships to indicate the distance from the lower edge of the number to the bottom of the keel.

Drain sample: A sample obtained from the draw-off or discharge valve on a storage tank. Occasionally, a drain sample may be the same as a bottom sample, as in the case of a tank car.

Drainage time for a capacity standard: A fixed time period for completing the draining of a field standard test measure that is calibrated on a "to deliver" basis, as described on the Report of Calibration by the calibrating agency.

Drift: An observed change, usually uncontrolled, in meter performance, meter factor, etc., that occurs over a period of time.

Dual meter counter shifter: An arrangement for connecting two (or more) meter counters to enable shifting the registration from one counter to another.

E

Electromechanical: Refers to equipment comprising both mechanical and electrical components such as electromechanical valves, electromechanical counters, etc.

Eliminator: An air, gas-vapor eliminator device used in a pipeline in conjunction with a meter to separate and remove air or vapor entrained in liquid to prevent its entry into the meter and erroneous measurement as liquid.

Emergent stem correction, thermometer: (See total immersion thermometer.)

Emulsion: An oil/water mixture that does not readily separate.

Entrained water: Water suspended in the oil. Entrained water includes emulsions but does not include dissolved water.

Environmental conditions: External conditions (such as, shock, vibration, and temperature) to which a meter, transducer, instrument, etc., may be exposed during shipping, storage, handling, and operation.

Environmental measurement: Identifies and quantifies releases into the environment by actual testing and modeling.

Equatorial circumference of a spherical tank: The circumference of the horizontal great circle at the equator of a spherical tank.

Equilibrium pressure (saturated vapor pressure): (See pressure, equilibrium.)

Equilibrium vapor pressure: (See pressure, equilibrium.)

Equivalent dip/innage (gauge), tank: The equivalent dip is the depth of liquid in a tank corresponding to a given ullage. It is obtained by subtracting the observed ullage from the height of the ullage reference point above the dip point on the bottom of the tank.

Error: Various terms related to error are as follows:

Error, absolute: The difference between the result of a measurement and the true value of the measured quantity as determined by means of a suitable standard device.

Error curve: A curve or graph that represents the error of a measuring device such as a pressure gauge as a function either of the quantity measured or of any other quantity that has an influence on the error.

Error, measurement: The discrepancy between the result of the measurement and the value of the quantity measured. The value of the quantity measured is a comparison value equal, according to the particular case, to the following:

a. The true value of the quantity.
b. The accepted true value.

c. The arithmetic mean of the results of a series measurements.

Error observation: The error committed by the observer when reading the indication of an instrument (meter), graduated scale, etc. It is sometimes called an experimental error.

Error, precision of measurement: The degree of conformity to each other of measurements repeated under specified conditions irrespective of whether they are close or far from the true value.

Error, random: An error that varies in an unpredictable manner in absolute value and in algebraic sign when a large number of measurements of the same value of a quantity are made under effectively identical conditions.

Notes:
1. It is not possible to take account of random error by the application of a correction to the uncorrected result of the measurement; it is only possible to fix limits within which, with a stated probability, this error will lie on completion of a series of measurements made under effectively identical conditions (using the same measuring instrument, with the same observer, and under the same environmental conditions, etc.).
2. The terms "dispersion error" and "statistical error" are also used.

Error, relative: The quotient of the absolute error divided by the true value of the measured quantity. This fraction multiplied by 100 gives the relative error as a percentage.

Error and repeatability of measurements: The closeness of the agreement between the results of successive measurements of the same quantity carried out by the same method, under the same environment, by the same observer, with the same measuring instruments, in the same laboratory, and at short intervals of time.

Error and reproducibility of measurements: The closeness of the agreement between the results of measurements of the same quantity where the individual measurements are made as follows:

a. By different methods with different measuring instruments.
b. By different observers in different laboratories.
c. With the same instruments used under different conditions after intervals of time that are long compared with the duration of a single measurement.

Notes:
1. The term reproducibility is also used when only some of the factors listed above are different in the individual measurements; these factors should be specified in detail in each particular case.
2. Reproducibility of measurement is most frequently estimated on the basis of the uncertainty of measurement. Owing to the larger number of sources of random errors, this uncertainty is, in general, greater than for the repeatability of a measurement; reproducibility is therefore inferior to repeatability.
3. The results of individual measurements should be corrected for systematic errors.

Error, systematic: An error that, in the course of a number of measurements, made under the same conditions, and of the same value of a given quantity, either remains constant in absolute value and sign or varies according to a definite law when the conditions change. Thus, it causes a bias. (See notes that follow.)

Examples:

Constant systematic error: error that results from a weighing by means of a weight whose mass is taken to be equal to its nominal mass of 1 kilogram, whereas its true mass is 1.010 kilogram.

Error that results from using, at an ambient temperature of 20°C, a rule gauged at 0°C without introducing a suitable correction.

Error that results from the use of a thermoelectric thermometer whose circuit suffers from parasitic thermoelectric effects.

Variable systematic error: indication error of a measuring instrument arising from a systematic variation of temperature during a number of consecutive measurements of the same value.

Notes:
1. The causes of systematic errors can be known or unknown.
2. A systematic error that can be determined by calculation or by experiment should be eliminated by an appropriate correction.
3. Systematic errors that cannot be determined but whose values are considered to be small compared with the inaccuracy of measurement are treated as random errors when calculating the uncertainty of measurement.
4. Systematic errors that cannot be determined but whose values are considered to be sufficiently large compared with the inaccuracy of measurement should be valued approximately and taken into consideration when calculating the uncertainty of the measurement.

Excess flow valve: (See valve, excess flow.)

Expansion (expansibility) factor: A multiplying factor used to correct the calculated flow rate for the reduction in fluid density that a compressible fluid experiences when it passes through an orifice as a result of the increased fluid velocity and the decreased static pressure.

Expansion thermometer: A type of thermometer using a known third order coefficient of expansion of either a solid, a liquid, or a gas to provide indication in terms of degrees of temperature.

Expansion trunk (dome): A trunk extending above a space used for the storage of liquid cargo and providing space for the thermal expansion of the liquid without overflowing.

Externally actuated sampler: A device that is operated by a power source other than the fluid being sampled (for example, an electric or pneumatic motor).

Extrapolation: Any process by which the value of a function is estimated for a value of the independent variable outside of the range in which the function has been determined; (also see function, argument).

F

Feature: An individual characteristic of a part, such as screw-thread, taper, slot, etc.

Figure, numerical: An arithmetic value expressed by one or more digits.

Filling density: The percent ratio of the weight of the liquid in a tank to the weight of water that the tank will hold.

Filter: (See strainer.)

Filter, electrical: A circuit used to eliminate or reduce certain waves or frequencies while leaving others relatively unchanged.

Filter, separator: (See coalescer.)

Flange taps: The position of a pair of tapholes. The upstream tap center is located 1 inch (2.54 centimeters) upstream of the nearest plate face, and the downstream tap center is located 1 inch (2.54 centimeters) downstream of the nearest plate face.

Flash: The sudden vaporization of a liquid caused by rapid decrease in pressure and/or increase in temperature.

Flash point: The minimum temperature to which a product must be heated for the vapors emitted to ignite momentarily in the presence of a flame when operating under standardized conditions.

Flashing: The continuing process by which a liquid is caused to flash.

Float, automatic tank gauge: A liquid level detecting element floating at the liquid surface in a tank that moves in a vertical direction to follow the change in liquid level.

Float guide wires, automatic tank gauge: Solid wires or flexible cables used to

guide the travel of an automatic gauge float.

Float well, tank: An enclosure built into the roof of a floating-roof tank to contain and guide the float of an automatic tank gauge.

Floating cover: A lightweight covering of either metal or plastic material designed to float on the surface of the liquid in a tank. Alternatively, a floating cover may be supported by a float system so that it is just above the free-liquid surface. The device is used to minimize the evaporation of volatile products in a container.

Floating-roof sample: A spot sample taken just below the surface to determine the API gravity of the liquid on which the roof is floating.

Floating-roof tank: A tank in which the roof floats freely on the surface of the liquid contents except at low levels when the weight of the roof is transmitted by its supporting legs to the tank bottom.

Floating screen: A lightweight metal or plastic covering that is arranged to float on the surface of a liquid in a container to retard its evaporation.

Flotation level: The depth of submergence of a buoyant automatic gauge float in a liquid of known density or weight.

Flow meter discrimination: A measure of the smallest increment of change in the pulse output of a flow meter as it relates to the actual volume being measured.

Flow proportional sample: A sample taken from a pipe such that the rate of sampling is proportional, throughout the sampling period, to the flow rate of the liquid in the pipe.

Flow range: The range between the maximum and the minimum flow rates of a meter, generally determined by the limits of acceptable error; (see meter flow rate, maximum and minimum).

Flow rate: The quotient of a volume or mass of liquid passing a point in a line per unit of time.

Flow straightener: A length of straight pipe containing straightening vanes or the equivalent that is installed at the inlet of a flow meter to eliminate swirl from the liquid from entering the meter and causing measurement errors.

Fluid: Gas or liquid, or a mixture of gas and liquid.

Free water; abbreviated **FW**: The water that exists as a separate phase.

Frequency: The number of repetitions of a periodic process in a unit of time.

Frequency converter: An electronic instrument for converting frequency (pulse train) to a proportionate analog signal.

Frequency, electrical: The number of repetitions (cycles) of a periodic signal (for example, pulses, alternating voltage, current, etc.) occurring in a time period of one second. The number of repetitions (cycles) that occur in a one-second period is expressed as hertz (for example, 60 Hz).

Frequency output: An output in the form of frequency, which varies as a function of the applied measurand (for example, angular speed and flow rate).

Frequency range: The measured values over which a meter or other measuring instrument is intended to measure. The range is specified by its upper and lower limits.

Function, mathematic: A mathematical expression describing the relationship between variables. The function takes on a definite value or values when special values are assigned to certain other quantities, called the arguments, or independent variables of the function; (also see argument).

G

Gage: An alternate spelling of gauge.

Garboard: The strake or shell plating adjacent to the keel plate on a vessel.

Gas eliminator (separator): (See air eliminator.)

Gas lock (pressure), tank: A device fitted to the gauge hatch on a pressure tank that enables manual gauging and sampling without loss of vapor.

Gathering: The process of transferring the custody of crude oil or gas in the field from one party to another by performing various measurements and quality tests.

Gauge glass: A glass tube or metal housing with a glass window that is connected to a container to indicate the level of the liquid contents.

Gauge hatch, tank: The opening in the top of a container through which gauging and sampling operations are carried out [see dip (gauge) hatch].

Gauge head, automatic tank gauge: The housing of the automatic tank gauge that may include the indicator and transmitter.

Gauge point, tank: The point on the bottom of a container that the gauge weight touches during the gauging and from which the measurements of the oil and water depths are taken. The gauge point usually corresponds with the datum point; but, if not, the difference in level between the datum point and the gauge point must be designated in the capacity table.

Gauge pressure: (See pressure, gauge.)

Gauge rod, stick: A rigid length of wood or metal that is provided with a scale for measurement and usually graduated in units of volume.

Gauge tape: A graduated metal tape used for measuring the depth of liquid in a tank.

Gauge tester (automatic tank gauge): (See operation checker, automatic tank gauge.)

Gauge weight (bob): A weight (plumb bob) that is attached to a metal gauge tape and is of sufficient weight to keep the tape taut and of such shape as to facilitate the penetration of any sludge that might be present on the datum plate of a tank.

Gauging: A process of measuring the height of a liquid in a container.

Gauging (innaging, dipping, sounding): A process to determine the depth of liquid in a tank, which is measured from the surface of the liquid to the tank bottom or to a fixed datum plate.

Gauging (outaging, ullaging): A process to determine the volume of available space in a container unoccupied by contents. Hence, ullaging is a method of gauging the contents of a tank by measuring the distance from the surface of the liquid to the reference gauge point.

Grab: The volume of sample extracted from a pipeline by a single actuation of the sample extractor.

Grab sample: (a) Solid—A sample obtained by collecting equal quantities from parts or packages of a shipment of loose solids so that the sample is representative of the entire shipment. (b) Liquid—A sample collected at a specific location in a tank or from a flowing stream in a pipe at a specific time.

Graduate, laboratory: A glass measuring cylinder, usually graduated in milliliters.

Graduated neck (prover): The section of reduced cross-sectional area at the top and/or bot-

tom of a prover tank having visible graduations to enable measuring small incremental volumes.

Gravity compensator: A double index scale against which a fixed reference pointer may be moved to correct for variations in relative density from a base point computed for water at 60°F (15°C). The compensator is marked in both relative density and API gravity units.

Gravity selector, meter: (See coefficient of expansion adjuster, meter.)

Grease sample: A sample obtained by scooping or dipping a quantity of soft or semiliquid material from a package in a representative manner.

Great circle: The path on the surface of a sphere-type tank defined by the intersection of a plane surface that includes the center of the sphere.

Gross heating value: The number of kilojoules (BTU's) evolved by the complete combustion, at constant pressure, of one standard cubic meter (foot) of gas [the temperature of the gas, air, and products of combustion being at 60°F (15°C)] and all of the water formed by the combustion reaction being condensed to the liquid state.

Gross observed volume; abbreviated **GOV**: (See volume, gross observed.)

Gross standard volume; abbreviated **GSV**: (See volume, gross standard.)

Guards: Heavy round pipes running longitudinally and welded to the outside of the side shell plating of a vessel to act as fenders.

Guide pole: A device, usually in the form of a cylindrical vertical tube, used in floating-roof tanks to prevent rotation of the roof.

Gunwale: The intersection of the deck plating with the side shell plating of a vessel. A gunwale may be a tee connection or a radius connection.

H

Half siding: The flat, horizontal section of the bottom shell plating measured from the centerline of the vessel to the edge of the flat keel plate.

Hatch: An opening in the top of a tank providing access for gauging, cleaning, or other purposes.

Headlog (in river craft of a rectangular shape): The structural member at the extreme end between the rake shell plating and the deck.

High vapor pressure liquid: (See pressure.)

Hog: The distortion of a ship's form due to stresses in which the bow and stern drop below their normal positions relative to the midship portion of the vessel.

Homogenous: When a fluid composition is the same at all points.

Hysteresis: The difference between the indications of a measuring instrument when the same value of the quantity measured is reached by increasing or decreasing the quantity.

I

Identification inscriptions of a measuring instrument: All the words, letters, and marks carried by a measuring instrument indicating its origin, destination, operation, characteristics, method of use, etc.

Impact pressure: (See pressure, impact.)

Independent inspector: A person or organization of persons, acting independently of, but on behalf of, one or more parties involved in the transfer, storage, inventory, or analysis of a commodity or the calibration of land or marine vessels, for purposes of determining the quantity, capacity, and/or the quality of a commodity; (also see commercial gauger).

Independent surveyor: Often synonymous with "independent inspector" but usually implying a person or organization capable of total quantity and quality inspection, in addition to being capable of providing calibration of shore, truck, rail, and marine vessels; meter proving; and physical properties determinations.

Independent tank: A tank whose boundaries are not part of the hull structure of a barge.

Index: A fixed or movable part of a measuring instrument's indicating device (such as, pointer, liquid surface, recording stylus, etc.) whose position with reference to the scale marks indicates the value of the measured quantity.

Indicated volume: (See volume, indicated.)

Indicating instrument: A measuring instrument in which the value of the measured quantity is visually indicated but is not recorded.

Inert gas: A gas that does not react with the surroundings.

Inerting: (a) The process of pressurizing the vapor space of a vessel with an inert gas blanket (usually exhaust gas) to prevent the formation of an explosive mixture; (b) a procedure used to reduce the oxygen content of a vessel's cargo spaces to sufficiently low concentrations at which combustion cannot be sustained by contained gases or vapors. For inerting, nitrogen, carbon dioxide, or the ship's exhaust are often used.

Innage: (See gauging, innage.)

Innage bob: [See gauge weight (bob).]

Input: A signal received by a device.

Integral hull tank: A tank whose boundaries are the bottom, side, deck, or bulkhead of the vessel hull.

Instrument, measuring: An instrument that serves to transform the quantity measured or a related quantity into an indication of equivalent information.

Integrating: Providing an output that is a time integral function of the measurand.

Interface: (a) The contact surface between two boundaries of liquids or the commingling of products adjacent to each other in a pipeline; (b) a means for coupling unlike equipment or functions so that they may communicate and work in unison.

Intermediate container: The vessel into which all or part of the sample from a primary container/receiver is transferred for transport, storage, or ease of handling.

Intermediate gears: A system of gears that transmits rotary motion.

Intermittent sample: A pipeline sample withdrawn by equal increments at a rate of less than one increment per minute.

International System of Units (SI): A coherent system of units of measurement founded on the following seven base units: the metre, unit of length; the kilogram, unit of mass; the second, unit of time; the ampere, unit of electric current; the kelvin, unit of thermodynamic temperature; the candela, unit of luminous intensity; and the mole, amount of substance.

Interpolation: A process by which an appropriate value is placed between tabulated values of a function.

Interpulse spacing: Variations in meter pulse width/space, normally expressed in percent.

Isentropic exponent: A thermodynamic state property that establishes the relationship between an expanding fluid's pressure and density as the fluid flows through an orifice plate bore.

Isokinetic sample: Sampling in such a manner that the linear velocity of the liquid through the opening of the sampling probe is equal to the linear velocity of the liquid in the pipeline at the sampling location and is in the same direction as the bulk of the liquid in the pipeline approaching the sampling probe.

L

Lagging edge: The positive-to-negative transition of an electric signal.

Laminar flow: A smooth flow of fluid in which no cross flow of fluid particles occurs between adjacent stream lines. The transition from smooth uniform laminar flow to turbulent flow generally occurs as the Reynolds number increases from about 2300 to 4000 or more.

Leading edge: The negative-to-positive transition of an electric signal.

Lease automatic custody transfer system; abbreviated **LACT**: An arrangement of equipment designed for the unattended custody transfer of liquid hydrocarbons from producing leases to the transporting carrier.

Length (of a tank barge): The distance measured on the centerline between the headlog plates at each end of a barge tank.

Length between perpendiculars: The distance on the summer load waterline from the fore side of the stern to the aft side of the rudder post or stern post. On vessels without a rudder or stern post, the length is measured to the centerline of the rudder stock.

Letter of protest (notice of apparent discrepancy): A letter issued by any participant in a custody transfer citing any condition with which issue is taken. This serves as a written record that a particular action or finding was questioned at the time of occurrence.

Line circulation: Petroleum or other liquid delivered through a pipeline system into a receiving vessel or tank to ensure that the section of pipeline from the source tank to the receiving tank is full in order to minimize the amount of air in the pipeline.

Line displacement: An operation to replace previous material in a pipeline.

Line drop: Opening (venting to atmosphere) a vessel's piping system so as to allow, to the extent possible, its drainage into a tank or tanks where the material may be gauged and accounted for.

Line press (pack): The recorded difference in a tank's gauges taken both while the tank's valve or valves are closed (off line) and while they are open (on line) into a closed system. All downstream valves of the line section to be pressed are open while the terminating valves remain closed. The term also refers to the act of performing this operation.

Linear meter range: The flow range over which the meter factor does not deviate from specified limits.

Linearity of a meter: The ideal accuracy curve of a volume meter is a straight line denoting a constant meter factor. Meter linearity is expressed as the total range of deviation of the accuracy curve from such a straight line between the minimum and maximum recommended flow rates.

Liquid: (See fluid.)

Liquefied petroleum gas (LP-gas); abbreviated **LPG**: Gas that is predominantly butane and propane separated from natural gasoline or natural gas and sold in liquid form as fuel—commonly known as bottled gas, tank gas, or LP-gas.

List (heel): (a) The leaning or inclination of a vessel, expressed in degrees port or degrees starboard; (b) the transverse deviation of a vessel from the upright position, expressed in degrees.

List correction: The correction applied to the volume or gauge observed in a vessel's tank when the vessel is listing, provided that liquid is in contact with all bulkheads in the tank. List correction may be accomplished by referring to the list correction tables for each of the vessel's tanks or by mathematical calculation.

Load on top; abbreviated **LOT**: Defined as both a procedure and a practice as follows:

Procedure: The shipboard procedure of collecting and settling water and oil mixtures resulting from ballasting and tank cleaning operations (usually in a special slop tank or tanks) and subsequently loading cargo on top of and pumping the mixture ashore at the discharge port.

Practice: The act of commingling onboard quantity with cargo being loaded.

Lock-in thermometer: A dial indicating temperature instrument having an automatic locking device for the indicator. This feature ensures that the indication cannot change until the reading has been taken and the instrument reset.

Loss control measurement: The systematic review and analysis of all measurements that provide for inventory control by establishing baseline measurements against which to judge loss control efforts.

Low vapor pressure liquid: (See pressure, low vapor pressure liquid.)

Lower sample: A spot sample from the mid-point of the lower one-third of the tank contents (a distance of five-sixths of the liquid depth below the top surface).

M

Mass: An absolute measure of a particular quantity of matter. Mass is defined in terms of a standard mass, and therefore the mass of an object is simply a multiple of the mass standard. The mass of an object remains constant regardless of its location. The metric unit of mass is the kilogram (kg).

Mass, apparent: The weight of an object in air, compared with a mass standard.

Mass standard: A precise standard whose volume, density, cubical coefficient of thermal expansion, and mass have been determined by the National Institute of Standards and Technology (NIST).

Mass standard, apparent: A precise standard whose density and apparent mass have been determined by a high-precision commercial laboratory, as compared with it's primary standards. Apparent mass standards are calibrated by primary mass or primary apparent mass standards, which in turn have been certified by National Institute of Standards and Technology (NIST).

Master meter: A meter that is proved using a certified prover and then used to calibrate other provers or prove other meters.

Maximum loading gauge (stop gauge): The maximum permissible gauge measurement to which a rail tank car shall be loaded [according to Interstate Commerce Commission (ICC) regulations].

Measurand: A physical quantity, property, or condition that has been or is to be measured.

Note: The term measurand is preferred to input, parameter to be measured, physical phenomenon, stimulus, and variable.

Measured variable: The physical quantity, property, or condition that is to be measured. Common measured variables are temperature, pressure, rate of flow, thickness, velocity, etc.

Measurement: The following terms pertain to different categories of measurement:

Measurement, base unit of: A unit of measurement of one of the base quantities (see note).

Example: The metre is the base unit of length in the International System of Units. The derived units of this system, such as units of velocity, force, electric potential, etc., originate from the metre, together with other base units.

Note: The derived units of measurement in a system of measurement originate from the base units of measurement.

Measurement, reference conditions of: The temperature and pressure conditions to which a measured volume is to be corrected. The temperature to which the volume measurements are to be corrected is 60°F or 15°C. The reference pressure should be designated and can be atmospheric pressure, the absolute vapor pressure of the liquid being measured at 60°F or 15°C, or some other pressure that has been agreed upon by parties involved with the measurement.

Measurement, standard condition of: The standard pressure and temperature to which measurements should be referred. These are 1 bar (101.325 kPa)/cm^2 and 15°C for the SI metric system, and 14.73 lb/in.^{2} and 60°F for the United States' and British systems.

Measurement, standard units of volume: The standard units of volume are the cubic metre, U.S. gallon and the British imperial gallon.

Measurement, system of units of: A set of base and derived units corresponding to a particular group of quantities.

Example: centimetre-gram-second (cgs) system, metre-kilogram-second-ampere (MKSA) system, International System of Units (SI).

Measurement, unit of: The value of a quantity conventionally accepted as having a numerical value of one. The unit of measurement of a quantity is fixed in order to make quantitative comparison possible between different values of this same quantity.

Measurement, unit symbol: A conventional sign designating the unit of measurement.

Examples:

m = symbol of metre
g = symbol of gram
A = symbol of ampere

Measuring chamber: The portion of a displacement meter that contains the measuring element.

Measuring element: (a) The portion of a displacement meter that moves within the measuring chamber so as to divide the liquid into measured segments as the liquid passes through the meter; (b) The rotating member of a turbine meter commonly referred to as the rotor.

Measuring range: The range of values of the quantity to be measured for which the indications of a measuring instrument, obtained under the normal conditions of use and in a single measurement, should not be affected by an error exceeding the maximum permissible error.

Merchantable oil: A term applied to liquid hydrocarbons that are judged to be acceptable for custody transfer to a carrier. The oil is settled and contains no more than a set amount of suspended sediment and water (S&W) and other impurities.

Meter flow: A device used to measure fluid volume under dynamic conditions.

Meter accuracy factor: When applied to volume meter proving results, this term means specifically the number obtained by dividing the volume registered by the meter by the actual proving volume. It is thus the reciprocal of the meter factor.

Meter bank: Fluid meters coupled in parallel, the sum of which represents the total fluid measured. .

Meter calibration adjuster: A device to enable adjusting the meter register to indicate true volume within acceptable tolerance.

Meter case: The outer portion of a meter that encloses the measuring chamber and other working parts.

Meter characteristic: An expression of the relationship between the volume of a given liquid indicated by a meter register and the actual volume of that liquid that passed through the meter for the corresponding period.

Meter combinator (accumulator): A device or system for accumulating the registration of two or more meters in order that their total may be shown on a single readout device.

Meter factor: A dimensionless term obtained by dividing the gross standard volume of liquid passed through the meter (as measured by a prover during proving) by the corresponding meter indicated volume at standard conditions. For subsequent metering operations, the throughput or gross measured volume is determined by multiplying the indicated volume registered by the meter times the meter factor.

Meter flow rate, maximum: The maximum rate of flow recommended by the meter manufacturer or authorized by a regulatory body. The maximum rate is determined by considerations of accuracy, durability, pressure drop, repeatability, and linearity.

Meter flow rate, minimum: The minimum rate of flow recommended by the meter manufacturer or authorized by a regulatory body. The minimum rate is determined by considerations of accuracy, repeatability, and linearity.

Meter, nonrotating: Any metering device for which the meter pulse output is not derived from mechanical rotation as driven by the flowing stream.

Meter performance: A general expression for the relationship between the volume registered by a meter and the true volume that passed through the meter. The term may refer to meter error, meter factor, meter accuracy, etc.

Meter proof: (a) The multiple passes or round-trips of the displacer in a prover for purposes of determining a meter factor; (b) to establish a meter factor by comparing meter throughput to a prover of known volume.

Meter proving: The procedure required to determine the relationship between the volume of liquid passing through a meter at one set of conditions and the indicated volume at those same conditions.

Meter pulse continuity: The deviation of the interpulse period of a flow meter, expressed as a percentage of a full pulse period.

Meter readings: The instantaneous display of the number of units of volume or equivalent thereof, read directly from a meter register.

Meter slippage: (See slippage, meter.)

Meter tube: The straight sections of pipe, including all segments that are integral to the orifice plate holder, upstream and downstream of an orifice plate.

Meter, turbine (with electrical output): A flow measuring device in which the action of the fluid stream passing through the device turns a bladed turbine and produces an electrical output signal having a frequency proportional to the turbine speed.

Middle sample: A spot sample collected from the middle of the tank contents halfway between the bottom and liquid level of the tank (a distance of one-half of the depth of liquid below the liquid's surface).

Minimum pipeline velocity: The velocity that exists at the lowest operating flow rate, excluding those rates that occur infrequently or for short time periods (less than 5 minutes).

Molded dimensions: The dimensions of a vessel to the molded lines.

Molded lines: The lines defining the geometry of a hull as a surface without thickness.

Molded volume: The volume of a compartment without deduction for internal structure or fittings.

Multiple tank composite sample: A mixture of individual samples or composites of samples that have been obtained from several tanks or ship/barge compartments containing the same grade of material. The mixture is blended in proportion to the volume of material contained in the respective tanks or compartments.

N

Negator motor: The negator is a strip of flat spring stainless steel that has been given a curvature by continuous heavy forming at a constant radius so that, in its relaxed or unstressed condition, it remains in the form of a tightly wound spiral. This form permits a compact mounting within the gauge head. The stainless steel negator motor eliminates counterweight and cable assembly.

Net standard volume; abbreviated **NSV**: (See volume, net standard.)

Newtonian fluid: A liquid whose viscosity is unaffected by the kind of magnitude of motion or agitation to which it may be subject as long as the temperature remains constant.

Noise (electrical): An unwanted component of a signal that obscures the information content; any spurious voltage or current arising from external sources and appearing in the circuits of a device.

Nominal: Describes a value assigned for the purpose of convenient designation; existing in name only.

Nonpressure tank: A tank of conventional shape intended primarily for the storage of liquids at or near atmospheric pressure.

Nozzle sample: A sample obtained from a gasoline pump nozzle that dispenses product from a storage tank at a retail outlet or a wholesale purchaser-consumer facility.

O

Observed reference height: The distance actually measured from the tank bottom or datum plate to the established reference point.

Observed values: Hydrometer readings observed at temperatures other than the specified reference temperature. These values are only hydrometer readings and not density, relative density, or API gravity at that temperature.

Offset: When using the optical reference line method for calibrating tanks, the measure-

ment observed through the optical device on the horizontal scale of the traversing magnetic slide at each vertical station.

Onboard quantity; abbreviated **OBQ**: Refers to materials present in a vessel's cargo tanks, void spaces, and/or pipelines before the vessel is loaded. Onboard quantity includes a combination of water, oil, slops, oil residue, oil/water emulsions, sludge, and sediment.

Opening gauge: The measurement in a tank before a delivery or receipt.

Operating conditions: (See environmental conditions.)

Operation checker (automatic tank gauge): A device used to check for free movement of the gauge mechanism.

Orifice plate: A thin plate in which a circular concentric aperture (bore) has been machined.

Orifice plate coefficient of discharge: The ratio of the true flow to the theoretical flow, which is applied to the theoretical flow equation to obtain the actual (true) flow of an orifice meter.

Orifice plate holder: A pressure-containing piping element, such as a set of orifice flanges or an orifice fitting, used to contain and position the orifice plate in the piping system.

Oscillator: An electronic device that generates a signal at a preset frequency determined by the values of certain constants in its circuits.

Outage (ullage): The volume of available space in a container unoccupied by contents. Ullaging is a method of gauging the contents of a tank by measuring the distance from the surface of the liquid to the top of the tank; see gauging (outage, ullage).

Outage bob: (See gauge weight.)

Outlet sample: A spot sample taken with the inlet opening of the sampling apparatus at the level of the bottom of the tank outlet (fixed or floating).

Outlier: A result that differs considerably from the main body of results in a set.

Output: A signal transmitted from a device.

Over-ranging: A term, when applied to metering, indicating that the maximum permitted flow rate of the meter is being exceeded.

P

Parameters: The values that characterize and summarize the essential features of measurements.

Partial immersion thermometer: A thermometer that is used for measurement with a specific length of the bulb and stem immersed in the liquid, thus leaving the scale above the surface for ease of reading.

Partial pressure: (See pressure, partial.)

Performance curve: (See accuracy curve and error curve.)

Petroleum: A substance, generally liquid, occurring naturally in the earth and composed mainly of mixtures of chemical compounds of carbon and hydrogen with or without other nonmetallic elements such as sulfur, oxygen, and nitrogen. The compounds that compose petroleum may be in the gaseous, liquid, or solid state, depending on their nature and on the existent conditions of temperature and pressure.

Pickup, meter: A device for converting meter rotor movement into an electrical output signal; (also see transducer).

Pipe taps: The position of a pair of tapholes to measure flow rate via differential pressure across an orifice plate. The upstream tap center is located at a distance of two and one-half times the published inside pipe diameter upstream of the nearest plate face, and the downstream tap center is located at a distance eight times the published inside pipe diameter downstream of the nearest plate face.

Pipeline: A section of pipe used for the transfer of fluid.

Polar circumference of a spherical tank: A circumference measured through the north and south poles of a sphere.

Positioning wire or cable: Solid or stranded wire or cable that connects the float to the tape or that drives the dial indicator or transmitter.

Power mixer: A device that uses an external source of power to achieve stream conditioning.

Preamplifier: A device used to increase the amplitude of faint signals so they may be transmitted effectively.

Precision: (a) Possessing high resolution and good repeatability; (b) the degree to which data within a set cluster together.

Pre-set instrument (for measuring): A measuring instrument fitted with a device that automatically terminates the measurement when it reaches a value fixed in advance.

Pressure: The following terms pertain to different categories of pressure:

Ambient pressure: The pressure of the surrounding medium, such as of the liquid in a pipeline or of the atmosphere.

Atmospheric pressure: The pressure exerted by the weight of the atmosphere. At sea level, the pressure is approximately 14.7 pounds per square inch (101 kilopascals), often referred to as 1 atmosphere, atmospheric pressure, or pressure of one atmosphere.

Back pressure, turbine meter: The pressure that is measured four pipe diameters downstream from the turbine flow-meter under operating conditions, expressed in N/m^2.

Differential: The static pressure difference determined in orifice measurement typically measured between the upstream and downstream flange, pipe, or other taps of an orifice meter.

High vapor pressure liquid: A liquid that, at the measurement or proving temperature of the meter, has a vapor pressure equal to or higher than atmospheric pressure; (see low vapor pressure liquid).

Low vapor pressure liquid: A liquid that, at the measurement or proving temperature of the meter, has a vapor pressure less than atmospheric pressure; (see high vapor pressure liquid).

Pressure, equilibrium: The pressure at which a liquid and its vapor are in equilibrium at a given temperature.

Pressure, dry method vapor: The vapor pressure of a liquid at 100°F (37.8°C, 311°K) as determined by ASTM D 4953, *Method for Vapor Pressure of Gasoline and Gasoline-Oxygenate Blends (Dry Method).*[1]

Pressure, gauge: Pressure measured relative to atmospheric pressure taken as zero.

[1]American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.

Pressure, impact: Pressure exerted by a moving fluid on a plane perpendicular to its direction of flow. It is measured in the direction of flow.

Pressure lock: A manually operated semiautomatic gauging device that is self-enclosed and used for the prevention of vapor losses in the gauging of atmospheric pressure, variable vapor space, and high-pressure tanks.

Pressure loss (drop): The differential pressure in the flowing fluid stream (which will vary with flow rate) between the inlet and outlet of a meter, flow straightener, valve, strainer, lengths of pipe, etc.

Pressure, partial: The pressure that is exerted by a single gaseous component of a mixture of fluids.

Pressure, Reid vapor: The vapor pressure of a liquid at 100°F (37.8°C, 311°K) as determined by ASTM D 323, *Test Method for Vapor Pressure of Petroleum Products (Reid Method).*

Pressure, static: Pressure in a fluid or system that is exerted perpendicular to the surface on which it acts. In a moving fluid, the static pressure is measured at right angles to the direction of flow.

Pressure, velocity: The component of the pressure of the moving fluid that is due to its velocity and is commonly equal to the difference between the impact pressure and the static pressure (see pressure, impact, and pressure, static).

Pressure actuated thermometer: A thermometer in which the pressure developed by thermal changes in the thermometric filling medium actuates an indicating or recording device calibrated in terms of degrees of temperature.

Pressure-type tank: A tank specially constructed for the storage of volatile liquids under pressure. Such tanks are spheroidal, spherical, hemispherically ended, or of other special shapes.

Primary container/receiver: A vessel in which all samples are initially collected. Examples of primary sample containers include glass and plastic bottles, cans, core-type thief, and fixed and portable sample receivers.

Primary element (primary detector): (See sensing element.)

Primary sample receiver (receptacle): A fixed or portable container into which all sample grabs are collected.

Probe: That portion of the sampling system that extends into the pipeline and directs a portion of the fluid to the extractor.

Profile testing: A procedure for simultaneously sampling at several points across the diameter of a pipe to identify the extent of stratification.

Prover, conventional pipe: A meter prover having a volume between detectors that permits a minimum accumulation of 10,000 direct (unaltered) pulses from the meter. A conventional pipe prover may be of either the bidirectional or unidirectional type.

Prover, master-meter: A meter used as a reference for the proving of another meter. A comparison of the two meter outputs is the basis of the master-meter method. Displacement or turbine meters may serve as master meters.

Prover, meter: An open or closed vessel of known volume utilized as a volumetric reference standard for the calibration of meters in liquid petroleum service. Such provers are designed, fabricated, and operated according to the recommendations of API MPMS Chapter 4.

Prover pass: (a) One movement of the displacer between the detectors in a prover; (b) The volume determined by a displacer traveling between detector switches in a single direction.

Prover round-trip: (a) The forward and reverse passes in a bidirectional prover; (b) the volumes determined by a bidirectional displacer traveling between detector switches in one direction and the return direction.

Prover, small volume: Meter prover having a volume between detectors that does not permit a minimum accumulation of 10,000 direct (unaltered) pulses from the meter. Small volume provers require meter pulse discrimination by pulse interpolation counter or other techniques to increase the resolution.

Prover, tank: An open or closed vessel of known capacity designed for the accurate determination of the volume of liquid delivered into or out of it during a meter proving operation.

Proving: The procedure used to determine a meter factor.

Proving counter, meter: A counter in which a special gating circuit in the counter is triggered by switches in the proving system to start and stop the counter.

Pulse generator: A displacement meter accessory coupled to the measuring element and designed to produce a series of electrical pulses whose number is proportional to the volume measured and whose frequency is proportional to the flow rate.

Pulse interpolation: Any of the various techniques by which the whole number of meter pulses is counted between two events (such as detector switch closures) and any remaining fraction of a pulse between those two events is calculated.

Pulser: (See pulse generator.)

Q

Quantity measured (metered): The gross volume metered corrected to agreed reference conditions of pressure and temperature; (also see measurement).

R

Ramp/sweep generator: A device that changes a frequency at a constant rate and incorporates an oscillator that can be programmed to provide an output over a specified frequency range.

Range: The region between the limits within which a quantity is measured, received, or transmitted. The range is expressed by stating the lower and upper range values, such as 0°C to 150°C and 50 m^3/s to 500 m^3/s.

Range of uncertainty: The range or interval within which the true value is expected to lie with a stated degree of confidence.

Rangeability: The capability of a meter or flow measuring device to operate between the minimum and maximum flow range within an acceptable tolerance. Rangeability is generally expressed as ratio of a maximum flow to the minimum flow.

Reading: (See meter reading.)

Readout: A device that displays numbers or symbols and incorporates electric or electronic features.

Readout device: A device that indicates or registers the value measured by an instrument in practical units.

Real gas specific gravity: The ratio of the density of the gas, under the observed conditions of temperature and pressure, to the density of dry air at the same temperature and pressure. It follows that the ideal gas specific gravity is the ratio of the molecular weight of the gaseous mixture to the molecular weight of air.

Receiver instrument, meter: An instrument that receives signals from a transmitter.

Record chart: A strip, disc, or sheet on which the indications of the measuring instrument are marked by a pen in the form of a graph.

Recording instrument: A measuring instrument that records the value of the measured variable by marking or printing on a removable paper chart, tape, or other suitable recording material.

Reference circumference: The circumference of a tank measured by the manual tank strapping method (MTSM) on the bottom ring.

Reference conditions: The conditions of temperature and pressure to which measured volumes are to be corrected.

Reference depth: The distance from the reference point to the bottom of the tank. Preferably, this distance should be stamped on the fixed benchmark plate or stenciled on the tank roof near the gauging hatch.

Reference gauging point: (a) The point where the reference height is determined and from which the ullages/innages are taken. (b) On pressure tank cars, the reference point is a fixed pointer located in the tank car manway housing adjacent to the gauge tube, a point to which all subsequent measurements are related.

Reference height: The distance from the datum plate or tank bottom to the reference gauge point.

Reference measuring instrument (tank): A device calibrated to hold or deliver a known volume of liquid.

Reference offset: When using the optical reference line method for calibrating tanks, the measurement observed on the horizontal scale of the traversing magnetic slide at the vertical station on the bottom plate.

Register: A mechanical device that displays numbers.

Register, meter: A device that accumulates and displays the indicated volume passed through a meter; (also see counter, meter).

Register, multimeter: A register that indicates the combined registration of two or more meters.

Registration, over- or under-: The amount by which the indicated volume registered by a meter exceeds or is less than the true volume that passed through the meter as determined by means of a suitable standard device; (also see error, absolute).

Reid vapor pressure; abbreviated **RVP**: (See pressure, Reid vapor.)

Relative density: (See density, relative.)

Reliability: The ability of an item to operate as specified for an indicated time period, often expressed as mean time between failures (MTBF) or mean time to failure (MTTF).

Relief lines: Sections of pipe that lead to a pressure/vacuum relief valve.

Remaining on board; abbreviated ROB: Refers to material remaining in a vessel's cargo tanks, void spaces, and/or pipelines after the cargo is discharged. ROB includes any combination of water, oil, slops, oil residue, oil water emulsions, sludge, and sediment.

Remote transmission and telemetering: A separate or integral instrument system, used in conjunction with some other basic measuring means (such as an automatic tank gauge), which transmits the basic reading to some place other than the point of measurement.

Repeatability: (a) Metering—The closeness of the agreement between the results of successive measurement of the same quantity carried out by the same method, by the same person, with the same measuring instrument at the same location, over a short period of time. More specifically, the ability of a meter and prover system to repeat its registered volume during a series of consecutive proving runs under constant operating conditions. (b) Laboratory Test Method—The difference between successive test results obtained by the same operator, with the same apparatus, under certain operating conditions, on identical test material using the same test method.

Representative sample: A portion extracted from a total volume that contains the constituents in the same proportions as are present in the total volume.

Reproducibility: (a) Metering—The closeness of the agreement between the results of measurements of the same quantity where the individual measurements are made by different methods, with different measuring instruments, by different observers, at different locations after a long period of time; or where only some of the factors listed are different. More specifically, the ability of a meter and prover system to reproduce results over a long period of time in service where the range of variation of pressure, temperature, flow rate, and physical properties of the metered liquid is negligibly small. (b) Laboratory Test Method— The difference between two single and independent results obtained by different operators, working in different laboratories, on identical test material using the same test method.

Resistance thermometer: A thermometer that uses an electrical resistor to detect temperature and electrical means to measure and indicate temperature.

Resolution: The smallest change in the quantity measured to which the instrument will react with an observable change in an analog or digital indication.

Response time, thermometer (thermal time constant): The time required for a thermometer to indicate 63.2 percent of the magnitude of a change in the measured temperature.

Reynolds number; abbreviated **Re**: The ratio of inertial forces to viscous forces; a measure of turbulence. A parameter that correlates the actual flow profile with the fully developed flow profile established under steady flow of a homogeneous, newtonian fluid. It is a dimensionless number defined as follows:

$$Re = Du\rho/\mu$$

Where: D = inside diameter of the pipe
u = mean flow velocity
ρ = fluid density
μ = fluid viscosity, all in consistent units

Run, meter proving: Any single prover volume measurement in a set of prover volume measurements required to prove a meter.

Run ticket: The document customarily used to record lease or facility name, location, crude oil quantity and quality test data, destination, gauger/witness signatures, etc., applicable to a particular gathering or transfer of custody transaction; (also see ticket, measurement).

Running sample: A sample obtained by lowering a beaker or bottle to the level of the bottom of the outlet connection or swing line and returning it to the top of the oil at a rate such that the beaker or bottle is about three-fourths full when withdrawn from the oil.

Running start-and-stop method (meter proving): A meter proving method wherein the opening and closing meter readings of the test run are determined at flowing conditions.

S

Sag: The distortion of a barge, or vessel, form due to stresses in which the midship portion of the vessel drops below its normal position relative to the bow and stern.

Sample: A portion extracted from a total volume that may or may not contain the constituents in the same proportions that are present in that total volume.

Sample container: Receptacle used for storage and transport of the sample.

Sample controller: A device that governs the operation of the sample extractor.

Sample extractor: A device that extracts a sample from a pipeline, sample loop, or tank.

Sample handling and mixing: The conditioning, transferring, and transporting of a sample.

Sample loop; also called a **fast loop** or **slip stream**: A low volume bypass diverted from the main pipeline.

Sample system proving: A procedure used to validate an automatic sampling system.

Sampling : All the steps required to obtain a sample that is representative of the contents of any pipe, tank, or other vessel and to place that sample in a container from which a representative test specimen can be taken for analysis.

Scale: An ordered set of gauge or scale marks together with their defining figures, words, or symbols in relation to which the position of the index is observed when reading an instrument.

Scale base: The line, actual or implied, that passes through the midpoints of the shortest marks on the scale.

Scale division: The interval between any two successive scale marks of the scale.

Scale length: The linear or curvilinear length measured along the scale base between the centers of the terminal scale marks.

Scale mark: A line or other mark on the scale of an indicating device corresponding to one or more defined values of the quantity measured.

Scale numbering: The set of numbers marked on a scale either corresponding to the values of the quantity measured, defined by the scale marks, or indicating only the numerical order of the scale marks.

Scale range: (a) The zone included between the scale marks corresponding to the maximum and minimum values of the scale; (b) the difference between the maximum and minimum values of the scale.

Seal, capillary, meter: The liquid seal that reduces slippage between moving parts of a meter.

Seal unit (automatic tank gauge): An assembly used to seal the gauge assembly from tank vapors.

Sediment: Solid materials that may include a combination of sand, rust, and scale.

Sediment and water; abbreviated **S&W**: A material, coexisting with yet foreign to a petroleum liquid, that requires a separate measurement for reasons that include sales accounting. This foreign material may include free water and sediment (FW&S) and emulsified or suspended water and sediment (SW&S). The quantity of suspended material (SW&S) present is determined by a centrifuge or laboratory testing of a sample of petroleum liquid; (also see free water).

Selective tank remote gauge: A single receiver used with a remote transmission system that permits the use of one or more tank transmitters so that selective readings can be obtained by switching from one tank to another.

Sensing element: The part of the sensor (or detector) that is responsive to the magnitude of the measured quantity.

Sensing element (thermometer): That portion of a thermometer that senses and responds to changes of temperature (for example, the bulb of a liquid-in-glass thermometer).

Sensitivity: The ratio of a change in output magnitude to the change of input that causes it after equilibrium has been reached. Sensitivity is expressed as a ratio with the units of measurement of the two quantities stated. The ratio is constant over the range of a linear device. For a nonlinear device, the applicable input level must be stated.

Servo-mechanism: An externally powered mechanism activated by the sensing element to provide sufficient power to position the indicator. It generally includes a corrective feedback arrangement.

Settling tank: A tank or system of piping wherein the velocity of the liquid stream is sufficiently reduced to enable foreign particles or water to settle from the oil.

Sheer: The longitudinal curve of a vessel's decking in a vertical plane. As a result of sheer, a vessel's deck height above the baseline is higher (or lower) at the ends than amidships.

Shell: The plating forming the outer side and bottom skin of the hull.

Shell full: Designates that a tank is filled to its shell capacity.

Signal: Information about a variable that can be transmitted.

Signal, input: A signal applied to a device, element, or system.

Signal, measured: The electrical, mechanical, pneumatic or other variable applied to the input of a device. It is the analog of the measured variable produced by a transducer.

Signal-to-noise ratio; abbreviated **SNR**: The ratio of the magnitude of the electrical signal to that of the electrical noise.

Single-tank composite sample: A blend of the upper, middle, and lower samples. For a tank of uniform cross section, such as an upright cylindrical tank, the blend consists of equal parts of the three samples. For a horizontal cylindrical tank, the blend consists of the three samples in the proportions shown in Table 2 of API MPMS Chapter 8.1.

Slippage, meter: The volume of liquid that passes through a meter without causing registration. Meter slippage varies with flow rate, viscosity, and dimensional changes in the meter that result from variations in temperature and pressure of the measured liquid.

Slops: Oil, oil/water/sediment, and emulsions contained in slop tanks or designated cargo tanks. The mixture usually results from tank stripping, tank washing, or dirty ballast phase separation.

Sludge: A highly viscous mixture that may include oil, water, sediment, and residue.

Small tank: A crude oil storage tank with a 1,000-barrel or less capacity.

Specific gravity; abbreviated **sp gr**: Archaic (see density, relative).

Spot (grab) sample: A sample taken at a specific location in a tank or from a flowing stream in a pipeline at a specific time.

Stability: The ability of a measuring instrument to maintain its accuracy over a long period of time.

Stand pipes; also called **still pipes** or **stilling wells**: Vertical sections of pipe or tubing extending from the gauging platform to near the bottom of tanks that are equipped with external or internal floating roofs. Stand pipes may also be found on ships and barges.

Standard: The following terms pertain to the category of measurement standards:

Standard: A measuring instrument intended to define, to represent physically, or to reproduce the unit of measurement of a quantity (or a multiple or submultiple of that unit), in order to transmit it to other measuring instruments by comparison.

International standard: A standard recognized by an international agreement to serve internationally as the basis for fixing the value of all other standards of the given quantity.

National standard: A standard recognized by an official national decision as the basis for fixing the value, in a country, of all other standards of the given quantity. In general, the national standard in a country is also the primary standard.

Primary standard: A standard of a particular measure that has the highest metrological qualities in a given field (see notes).

Notes:
1. The concept of a primary standard is equally valid for base units and for derived units.
2. The primary standard is never used directly for measurement other than for comparison with duplicate standards or reference standards.

Secondary standard: A standard, the value of which is fixed by direct or indirect comparison with a primary standard or by means of a reference-value standard.

Working standard: A standard that, calibrated against a reference standard, is intended to verify working measuring instruments of lower accuracy.

Standard, API: As per API Policy 104, a prescribed set of voluntary rules, conditions, or requirements concerned with the definition of terms; classification of components; delineation of procedures; specification of dimensions; construction criteria, materials, performance, design, or operations; measurement of quality and quantity in describing materials, products, systems, services, or practices; or descriptions of fit and measurement of size (see note).

Note: This definition includes all API publications that are or have been designated standards, specifications, recommended practices, bulletins, guides, and manuals. The actual title is optional to the department developing the publication.

Standard air: The accepted density of standard air varies between the U.S., British, and metric systems of measurement. The correct densities have been incorporated in API MPMS Chapter 11.1, "Volume Correction Factors" (also ASTM D 1250 and IP 200[2]).

Standard brass: Brass of a specified density used in fabricating precision balance weights.

Standard conditions of measurement: (See reference conditions.)

Standing start-and-stop method, meter proving: A meter-proving method wherein the opening and closing meter readings of the test run are determined at no-flow conditions.

[2]Institute of Petroleum, 61 New Cavendish Street, London W1M8AR, England.

Static mixer: A device that utilizes the kinetic energy of the moving fluid to achieve stream conditioning.

Static pressure: (See pressure, static.)

Stepper-drive: A drive means for remotely located meter accessories.

Step-over (tank strapping): A device used in tank strapping for measuring the distance apart along the arc of two points on a tank shell where it is not possible to use a strapping tape directly because of an intervening obstruction, such as a protruding fitting.

Strainer: A device placed upstream of a meter or other equipment to remove from the stream foreign material that is likely to damage or interfere with operation. The strainer element is generally coarser than that of a filter designed to remove solid contaminants.

Strake: A course or row of shell, deck, bulkhead, or other plating.

Strapping (tanks): The measurement of the external circumference of a vertical or horizontal cylindrical tank by stretching a steel tape around each course of the tank's plates and recording the measurement.

Strapping tape (tank strapping): A measuring tape graduated in units of length and used for taking the measurements for producing a tank calibration or tank gauge table.

Stream conditioning: The mixing of a flowing stream so that a representative sample may be extracted.

Streamline flow: Flow having a Reynolds number less than 4000; (also see Reynolds number, laminar flow, and turbulent flow).

Surface sample: A spot sample skimmed from the surface of liquid in a tank.

Surface sensing element: The detecting element of a surface sensing automatic tank gauge.

Surge tank: A vessel used to smooth out the flow in a flowing stream.

Swirl: A qualitative term describing tangential motions of liquid flow in a pipe, tube, or tank.

T

Tail, thermometer: The ungraduated lower portion of a mercury-in-glass direct-reading thermometer, which does not contain the sensing element.

Tank capacity table: (See capacity table.)

Tank composite sample: A blend created from the upper, middle, and lower samples from a single tank. For a tank of uniform cross section, such as an upright cylindrical tank, the blend consists of equal parts of the three samples. For a horizontal cylindrical tank, the blend consists of three samples in the proportions shown in Table 2 of API MPMS Chapter 8.1.

Tank table: (See capacity table.)

Tap sample (tank-side sample): A spot sample taken from a sample tap on the side of a tank. It may also be referred to as a tank-side sample.

Tape, automatic tank gauge: A metal tape used to connect the liquid level detecting element and the gauge-head mechanism.

Tape clamp (tank strapping tape): A quick-release clamp that may be fitted around a strapping tape at any convenient position throughout its length.

Tape positioner (tank strapping tape): A guide sliding freely along the strapping tape and used to pull and hold the tape in the correct position for taking measurements.

Taphole: A hole radially drilled in the wall of the meter tube or orifice plate holder, the inside edge of which is flush and without any burrs.

Temperature, absolute: The temperature measured from the absolute zero (–273.15°C); degrees Celsius + 273.15° = degrees absolute in Kelvin.

Temperature error: The measuring error caused by the temperature of a measurement differing from the pertinent reference value.

Temperature measurement device: Consists of a sensor, transmission medium, and readout equipment in an operating configuration used to determine the temperature of a liquid for measurement purposes.

Temperature range, operating: The range of ambient temperatures, given by their extremes, within which the transducer is intended to operate.

Temperature sensor: Consists of a sensing element and its housing, if any, and is defined as the part of a temperature device that is positioned in a liquid the temperature of which is being measured.

Tender: (See batch.)

Test measures, field standard: A vessel fabricated to meet specific design criteria and calibrated by an official agency such as the National Institute of Standards and Technology (NIST) or another NIST-certified, competent laboratory.

Test run, meter proving: (See run, meter proving.)

Test specimen: The representative sample taken from the primary or immediate sample container for analysis.

Thermistor (thermal sensitive resistor): A temperature-sensitive element consisting of a semiconductor such as germanium oxide, whose conductance changes with its temperature. Thermistors are used to make temperature measurements electrically.

Thermocouple: A temperature-sensitive element consisting of a pair of dissimilar metals so arranged that the electromotive force produced by the couple depends upon the difference in temperature between the hot and cold junctions of the metals. The output is measured on a millivoltmeter calibrated in terms of degrees of temperature.

Thermometer: The following terms refer to different types of thermometers:

Complete (full) immersion thermometer: A thermometer that indicates temperature correctly when completely immersed in the material being tested.

Partial immersion thermometer: A thermometer that indicates temperature eratone correctly when immersed to a specified depth. A mark and/or written distance on the back of each thermometer indicates the proper immersion level.

Reversible thermometer: A device containing a mercury-in-glass thermometer, which may be inverted after the thermometer has reached thermal equilibrium with the oil in which it is immersed. The inversion of the device breaks the mercury thread, which being disconnected from the sensing element (the bulb) runs down to the other end of the thermometer stem. The instrument is then drawn to the surface and the recorded temperature, which remains unchanged until the instrument is reset, can then be read off the scale.

Total immersion thermometer: A thermometer that indicates correctly when immersed to just barely below the reading.

Thermowell: A metal protective socket installed in the well or shell of a liquid container into which the sensing element of a temperature sensing device is inserted.

Thief: An industry term for a bottom closure, core-type sampler used to secure samples from storage tanks.

Thread, thermometer: A term given to the length of mercury in the capillary of a mercury-in-glass thermometer that indicates the temperature.

Ticket, measurement: The term used to include expressions such as run ticket and receipt and delivery ticket. It is also used to mean the paper or readouts in a meter station that is automated, remotely controlled, and/or computerized.

Time proportional sample: A sample composed of equal volume grabs taken from a pipeline at uniform time intervals during the entire transfer.

Tolerance: The amount of measurement error that will be allowed. It is a plus or minus value.

Top sample: A spot sample taken from a tank obtained 6 inches (15 centimeters) below the top surface of the liquid.

Total calculated volume; abbreviated **TCV**: (See volume, total calculated.)

Total observed volume; abbreviated **TOV**: (See volume, total observed.)

Totalizer: Meter register as pertains to total; for example, the summation of several independent quantities are contained in the totalizer.

Traceability: The relation of a prover or a transducer calibration, through a step-by-step process, to an instrument or group of instruments calibrated and certified by a national or international primary standard.

Transducer: A device that provides a usable output signal in response to a measurement.

Transmitter: That portion of a remote transmission system that constitutes the sending element.

Trim: Refers to the condition of a vessel in terms of its longitudinal position in the water. Trim is the difference between the forward draft and the aft draft and is expressed by the head or by the stern to indicate the end of the vessel that is deeper in the water.

Trim correction: The correction applied to the volumes or gauge observed in a vessel's tank when the vessel is out of trim, provided that the liquid is in contact with all bulkheads in the tank. Trim correction may be accomplished by referring to the trim correction tables for each of the vessel's tanks or by calculation.

True value: The theoretically correct amount. In practice, it is represented by the standard being used for comparison, such as a prover.

True vapor pressure: (See pressure, true vapor.)

Tube (thief) sample: A sample obtained with a sampling tube or special thief, either as a core sample or a spot sample from a specific point in the tank or container.

Turbine: A bladed rotor flowmeter component that turns at a speed that is proportional to the mean velocity of the stream and therefore to the volume rate of flow.

Turbine meter: A meter in which the measuring element is a multibladed rotor to which the metered stream imparts a rotational velocity that is proportional to the mean velocity of the stream. Measured volume is registered by rotor revolutions.

Turbulent flow: In turbulent flow, random eddying flow patterns are superimposed upon the general flow progressing in a given direction. The transition from smooth uniform laminar flow to turbulent flow generally occurs as the Reynolds number increases from about 2300 to 4000 or more.

Turndown: Field terminology for rejecting a tank's contents on the basis of the gauger's evaluation and analysis.

Two-phase: A fluid state consisting of a mixture of liquid with gas or solids. Also a mixture of a gas with solids or with liquid droplets.

U

Ullage: (See gauging, outage.)

Ullage hatch, marine vessel: (See gauge hatch, tank.)

Ullage paste: A paste that is applied to a ullage rule or dip tape and weight to indicate the level at which the liquid meniscus cuts the graduated portion.

Units of volume: The usual units of volume for petroleum measurement are cubic metre, litre, imperial gallon, U.S. gallon or barrel (42 U.S. gallons), or cubic feet.

Upper sample: A spot sample taken at the middle of the upper one-third of the tank contents (a distance of one-sixth of the liquid depth below the liquid's surface).

V

Vacuum breaker: A device used to prevent vacuum from occurring in a tank, vessel, piping, etc.

Valve: The following terms pertain to the category of valve:

Valve, back pressure: A valve used to automatically regulate a uniform pressure on the inlet side of such valve.

Valve, block and bleed: A high integrity valve with double seals and provision for determining if either seal leaks.

Valve, check: A valve used to control a selected direction of flow and prevent the liquid flow from reversing in direction.

Valve, differential pressure: A valve used to automatically regulate a uniform difference in pressure between two separate locations in a pipeline.

Valve, excess flow: A valve used to automatically prevent the liquid flow rate in a pipeline from exceeding a high limit.

Vapor point: (See bubble point.)

Vapor pressure, absolute or **true**: (See pressure, equilibrium.)

Vapor-tight tank: A tank of conventional shape intended primarily for the storage of volatile liquids, such as gasoline, and so constructed that it will withstand pressures differing only slightly from atmospheric. Such tanks are equipped with special devices that permit gauging without opening the tank to the atmosphere.

Variable: (See measurand.)

Velocity pressure: (See pressure, velocity.)

Vessel experience factor; abbreviated **VEF**: A compilation of the history of the total calculated volume (TCV) vessel measurements, adjusted for onboard quantity (OBQ) or remaining onboard (ROB), to the TCV shore measurements. Separate VEF's should be developed for both load and discharge terminals. Preferably, information used in calculating a VEF should be based on documents that follow accepted industry standards and practices, such as inspection company reports.

Vessel ratio, discharge; abbreviated **DVR**: The total calculated volume (TCV) by vessel measurement on arrival, less remaining on board (ROB), divided by the TCV by shore measurement at discharge [DVR = (TCV arrival volume – ROB)/TCV received on shore at discharge].

Vessel ratio, load; abbreviated **LVR**: The total calculated volume (TCV) by vessel measurement on sailing, less onboard quantity (OBQ), divided by the TCV by shore measurement at loading [LVR = (TCV sailing volume – OBQ)/TCV received from shore at loading].

Vibration error: The maximum change in operating output, at any measurand value within a specified range, when vibration levels of specified amplitude and range of frequencies are applied to the transducer along specified axes.

Viscosity, absolute: The measure of resistance to shear per unit of time of a fluid's intermolecular cohesive force.

Viscosity, kinematic: The ratio of absolute viscosity to density. The SI unit is the square metre per second (m^2/s).

Viscosity, Saybolt second furol; abbreviated **SSF**: The efflux time in seconds of 60 milliliters of sample flowing through a calibrated furol orifice under specified conditions. The furol viscosity is approximately one-tenth the universal viscosity and is recommended for those petroleum products having viscosities greater than 1000 sec (Saybolt second universal), such as fuel oils and other residual materials. The word "furol" is a contraction of fuel and road oils.

Viscosity, Saybolt second universal; abbreviated **SSU**: The efflux time in seconds of 60 milliliters of sample flowing through a calibrated universal orifice under specified conditions.

Viscous hydrocarbon: Any liquid hydrocarbon that requires special treatment or equipment in its handling or storage because of its resistance to flow.

Volume, gross: The indicated volume multiplied by the meter factor (*MF*) for the particular liquid and flow rate under which the meter was proved.

Volume, gross observed; abbreviated **GOV**: The total volume of all petroleum liquids and sediment and water, excluding free water, at observed temperature and pressure.

Volume, gross standard; abbreviated **GSV**: (a) The total volume of all petroleum liquids and sediment and water, excluding free water, corrected by the appropriate volume correction factor (C_{tl}) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure correction factor (C_{pl}) and meter factor; (b) the gross volume at standard temperature corrected to standard pressure. Gross standard volume = closed meter reading – open meter reading × $MF \times C_{tl} \times C_{pl}$.

Volume indicated: The change in meter reading that occurs during a receipt or delivery.

Volume meter: A device that when installed in a pipe in which liquid is flowing indicates the volume of liquid that passes through it.

Volume, net standard; abbreviated **NSV**: The total volume of all petroleum liquids, excluding sediment and water and free water, corrected by the appropriate volume correction factor (C_{tl}) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure correction factor (C_{pl}) and meter factor.

Volume, total calculated; abbreviated **TCV**: The total volume of all petroleum liquids and sediment and water, corrected by the appropriate volume correction factor (C_{tl}) for the observed temperature and API gravity, relative density, or density to a standard temperature such as 60°F or 15°C and also corrected by the applicable pressure correction factor (C_{pl}) and meter factor, plus all free water measured at observed temperature and pressure (gross standard volume plus free water).

Volume, total observed; abbreviated **TOV**: The total measured volume of all petroleum liquids, sludges, sediment and water, and free water at observed temperature and pressure.

Vortex: The swirling motion of liquid often encountered as it enters the outlet opening of a container (tank). The vortex (swirl) causes entrainment of considerable quantities of air or vapor with the liquid.

W

Washing, crude oil; abbreviated **COW**: The use of a high-pressure stream of the crude oil cargo to dislodge or dissolve clingage and sediment from the bulkheads, bottom, and internal tank structures of a vessel during the discharge operation.

Washing, water: The use of a high-pressure water stream to dislodge clingage and sediment from the bulkheads, bottoms, and internal structures of a vessel's cargo tanks.

Water, bottom: Water accumulated at (or sometimes added to) the bottom of the oil in a storage tank.

Water/cut measurement: The procedure of locating the oil/water interface for the purpose of determining the volume of free water in a shore tank or vessel compartment. It is also used to refer to the line of demarcation of the oil/water interface.

Water dip: The depth of free water in a container over and above the dip plate.

Water equivalent (pyknometer): The water equivalent of a pyknometer at a temperature "*t*" is the weight in air of pure water contained by the pyknometer at the temperature "*t*."

Water finder (water finding rule): A graduated rod, usually of metal, to which water-finding paste can be applied. This paste or paper is discolored on contact with water and thus affords a ready means of measuring the depth of water in a tank when the water finder is lowered to the tank bottom.

Water-finding paste: A paste containing a chemical that changes color in contact with water. The paste, when applied to a water-finding rule, gives an indication of the level of free water in a container.

Water washing: (See washing, water.)

Wedge formula: A mathematical means of approximating the small quantities of liquid and solid cargo and free water onboard before a vessel is loaded and after its cargo is discharged. The formula is based on cargo compartment dimensions and vessel trim. The

wedge formula shall be used only when a wedge exists and when the liquid does not touch all bulkheads of the vessel's tank.

Wedge tables: Precalculated vessel tables based on the wedge formula and displayed in much the same way as the vessel innage/ullage tables. Wedge tables are used for small quantities [for example, onboard quantity (OBQ) and remaining onboard (ROB)] when the liquid does not touch all bulkheads of the vessel's tank.

Weigh scale: A device for determining either the mass or the weight of a body, depending upon the apparatus and procedure employed.

Weigh tank: A tank used with a weigh scale that is used for measurement of the liquid contents of the tank.

Weighing: Measuring the net force acting on an object's mass.

Weight; abbreviated **wt**: The net force exerted on an object's mass compared with a reference standard.

Weight in air: The weight in air of a substance is its weight in vacuum, reduced by its buoyancy (in air).

Weight of a measurement: A number that expresses the degree of confidence in the result of a measurement of a certain quantity in comparison with the result of another measurement of the same quantity.

Worst-case conditions (sampling): The operating conditions for the sampler that represent the most uneven and unstable concentration profile at the sampling location.

Z

Zero measurand output: The output of a transducer with zero measurand applied.

1.2 Abbreviations

Abbreviation	Description
A, AMP	ampere
AAR	Association of American Railroads (see section 1.9)
abs	absolute
ABS	American Bureau of Shipping (see section 1.9)
AC	alternating current
AGA	American Gas Association (see section 1.9)
AIChE	American Institute of Chemical Engineers (see section 1.9)
AIME	American Institute of Mining, Metallurgical, and Petroleum Engineers (see Section 1.9)
AM	amplitude modulation
ANMC	American National Metric Council (see section 1.9)
ANSI	American National Standards Institute (see section 1.9)
AOPL	Association of Oil Pipelines (see section 1.9)
API	American Petroleum Institute (see section 1.9)
approx	approximately
ASME	American Society of Mechanical Engineers (see section 1.9)
ASTM	American Society for Testing Materials (see section 1.9)
atm	atmosphere
avg	average
bbl, bbls	barrel, barrels
Be	Baume
BLM	Bureau of Land Management (see section 1.9)
bp	boiling point
bbl/d, BPD	barrels per day
bbl/h, BPH	barrels per hour
BSI	British Standards Institute (see section 1.9)
BS&W	archaic [see sediment and water (S&W)]
Btu	British thermal unit
C	Celsius
cc	cubic centimetre
cfh	cubic feet per hour
cfm	cubic feet per minute
CFR	*Code of Federal Regulations*
cfs	cubic feet per second

Abbreviation	Description
cg	center of gravity
cgs	centimetre-gram-second
cm	centimetre
CMA	Chemical Manufacturers Association (see section 1.9)
coef	coefficient
col	column
COW	crude oil washing
cpe	pressure correction factor for liquid
cpm	cycles per minute
cps	cycles per second (new definition is hertz)
cte	volume correction factor for liquid
cyl	cylinder
DC	direct current
deg	degree
dia	diameter
DOC	Department of Commerce (see section 1.9)
DOD	Department of Defense (see section 1.9)
DOE	Department of Energy (see section 1.9)
DOI	Department of the Interior (see section 1.9)
DOT	Department of Transportation (see section 1.9)
DVR	discharge vessel ratio; see vessel ratio, discharge
EC	European Community (see section 1.9)
emf	electromotive force
Entelec	Energy Telecommunications and Electrical Association (see section 1.9)
EPA	Environmental Protection Agency (see section 1.9)
F	Fahrenheit
FM	frequency modulation
fpm	feet per minute
fps	(a) feet per second; (b) foot-pound-second
FR	*Federal Register*
ft	feet
FW	(a) free water; (b) fresh water
g	(a) acceleration due to gravity; (b) gram
g-cal	gram-calorie
gal, gals	gallon, gallons

Abbreviation	Description
gm	gram (alternate abbreviation); see g
GOV	gross observed volume (see volume, gross observed)
GPA	Gas Processors Association (see section 1.9)
gpm	gallons per minute
GRI	Gas Research Institute (see section 1.9)
GSV	gross standard volume (see volume, gross standard)
GSW	gross standard weight
hr	hour
Hz	hertz (new term for cycles per second)
ICS	International Chamber of Shipping (see section 1.9)
ID	inside diameter
IEEE	Institute of Electrical and Electronic Engineers (see section 1.9)
IGS	inert gas system
IMO	International Maritime Organization (see section 1.9)
in	inches
in-lb	inch-pound
IP	Institute of Petroleum (see section 1.9)
ISA	Instrument Society of America (see section 1.9)
ISGOTT	*International Safety Guide for Oil Tankers and Terminals*
ISO	International Organization for Standardization (see section 1.9)
K	kelvin
kg	kilogram
kg-cal, KCAL	kilogram calories
kg-m, KGF-M	kilogram (-force)-metre
km	kilometre
L	litre
LACT	lease automatic custody transfer
lb, lbs	pound, pounds
LNG	liquified natural gas
log	logarithm
LOT	load on top
LPG	liquified petroleum gas
LVR	load vessel ratio (see vessel ratio, load)

Abbreviation	Description
m	metre
ma	milliampere
max	maximum
mcf	thousand cubic feet
MF	meter factor
mHz	megahertz (one million hertz)
min	minimum
mm	millimetres
mmf	magnetomotive force
MMS	Minerals Management Service (see section 1.9)
mp	melting point
MPMS	*Manual of Petroleum Measurement Standards*, API
NCWM	National Conference on Weights and Measures (see section 1.9)
NIST	National Institute of Standards and Technology (see section 1.9)
NFPA	National Fire Protection Association (see section 1.9)
NGL	natural gas liquids
NSV	net standard volume (see volume, net standard
NSW	net standard weight
OBQ	onboard quantity
OCIMF	Oil Companies International Marine Forum (see section 1.9)
OD	outside diameter
OIML	International Organization of Legal Metrology (see section 1.9)
OSHA	Occupational Safety and Health Administration (see section 1.9)
oz	ounces
p, pp	page, pages
ppm	parts per million
psi	pounds per square inch
psia	pounds per square inch absolute
psig	pounds per square inch gauge
R	(a) degrees Rankine (Fahrenheit absolute); (b) radius
Re	Reynolds number
rev	revolution
rms	root mean square
ROB	remaining onboard
rpm	revolutions per minute

Abbreviation	Description
rps	revolutions per second
RVP	Reid vapor pressure
S&W	sediment and water
SGA	Southern Gas Association (see section 1.9)
SI	International System of Units (see section 1.5)
SNR	signal-to-noise ratio
sp gr	specific gravity, archaic (see density, relative)
sp ht	specific heat
SPE	Society of Petroleum Engineers (see section 1.9)
sq	square
SSF	viscosity, Saybolt second furol
SSU	viscosity, Saybolt second universal
std	standard
sw	saltwater
TCV	total calculated volume (see volume, total calculated)
TDV	total delivered volume (see volume, total delivered)
temp	temperature
TOV	total observed volume (see volume, total observed)
TRV	total received volume (see volume, total received)
USCG	United States Coast Guard (see section 1.9)
USCS	United States Custom Service (see section 1.9)
VCF	volume correction factor
VEF	vessel experience factor
vel	velocity
vert	vertical
vis	viscosity
vol	volume
vs	versus
wg	water gauge
wt	weight
yd	yard
yr	year

1.3 Manual of Petroleum Measurement Standards Table of Contents

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	8.2	Automatic Sampling of Petroleum and Petroleum Products
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CELM	19	Evaporation Loss Measurement
	19.1	Evaporative Loss from Fixed-Roof Tanks
	Publ 2514A	Atmospheric Hydrocarbon Emissions from Marine Vessel Transfer Operations
	Bul 2516	Evaporation Loss from Low-Pressure Tanks
	Bul 2517	Evaporation Loss from External Floating-Roof Tanks
	Publ 2519	Evaporation Loss from Internal Floating-Roof Tanks

Committee	Chapter	Title
CELM (cont.)	Bul 2521	Use of Pressure-Vacuum Vent Valves for Atmospheric Loss
	Publ 2524	Impact Assessment of New Data on the Validity of American Petroleum Institute Marine Transfer Operation Emission Factors
	Publ 2525	Review of Air Toxics Emission Calculations from Storage Tanks (Phase I), Air Toxic Emissions Calculation Validation Program: Analysis of Crude Oil and Refined Product Samples and Comparison of Vapor Composition to Model Predictions (Phase II)
	Publ 2557	Vapor Collection and Control Options for Storage and Transfer Operations in the Petroleum Industry
	Publ 2558	Wind Tunnel Testing of External Floating-Roof Storage Tanks
CODM	20	Allocation Measurement of Oil and Natural Gas
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1.4 Mathematical Signs and Symbols

1.4.1 SIGNS AND SYMBOLS

+	plus (sign of addition)
+	positive
–	minus (sign of subtraction)
–	negative
(±)	plus or minus (minus or plus)
×	times, by (multiplication sign)
•	multiplied by
÷	sign of division
/	divided by
()[]{}	parentheses, brackets, and braces; quantities enclosed by them to be taken together in multiplying, dividing, etc.
:	ratio sign
: :	equals, as (proportion)
<	less than
>	greater than
=	equals
≈	approximately equals
≤	equal to or less than
≥	equal to or greater than
≠	not equal to
→≐	approaches
≡	identical with
∝	varies as
∞	infinity
$\sqrt[3]{}$	cube root of
||	parallel to
$\overline{AB}$	length of line from A to B
π	pi (= 3.14159+)
°	degrees
'	minutes
"	seconds
∠	angle
dx	differential of x
Δ	(delta) difference
Δx	increment of x
$\partial u/\partial x$	partial derivative of u with respect to x
$\int$	integral of
$\int_a^b$	integral of, between limits a and b
$f(x), F(x)$	functions of x
$\|x\|$	absolute value of x
σ	standard deviation
σ_2	variance
Σ	(sigma) summation of
$\bar{x}$	(bar x) the mean value of a set of values $x_1, x_2, \ldots x_n$
$\sqrt{}$	square root of
$\therefore$	therefore

1.4.2 NUMERICAL PREFIXES

The following numerical prefixes are standard in the scientific, engineering, and mathematics community. There are instances, in common practice, where usage of these terms conflicts.

Value	Prefix	Symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

1.5 International System of Units (SI)

Quantity	Unit	SI Symbol	Formula
	BASE UNITS		
length	metre	m	—
mass	kilogram	kg	—
time	second	s	—
electric current	ampere	A	—
thermodynamic temperature	kelvin	K	—
amount of substance	mole	mol	—
luminous intensity	candela	cd	—
	SUPPLEMENTARY UNITS		
plane angle	radian	rad	—
solid angle	steradian	sr	—
	DERIVED UNITS		
acceleration	metre per second squared	—	m/s^2
activity (of a radioactive source)	disintegration per second	—	(disintegration)/s
angular acceleration	radian per second squared	—	rad/s^2
angular velocity	radian per second	—	rad/s
area	square metre	—	m^2
density	kilogram per cubic metre	—	kg/m^3
electric capacitance	farad	F	A • s/V
electrical conductance	siemens	S	A/V
electric field strength	volt per metre	—	V/m
electric inductance	henry	H	V • s/A
electric potential difference	volt	V	W/A
electric resistance	ohm		V/A
electromotive force	volt	V	W/A
energy	joule	J	N • m
entropy	joule per kelvin	—	J/K
force	newton	N	$kg • m/s^2$
frequency	hertz	Hz	(cycle)/s
illuminance	lux	lx	lm/m^2
luminance	candela per square metre	—	cd/m^2

Quantity	Unit	SI Symbol	Formula
	DERIVED UNITS (CONTINUED)		
luminous flux	lumen	lm	cd • sr
magnetic field strength	ampere per metre	—	A/m
magnetic flux	weber	Wb	V • s
magnetic flux density	tesla	T	Wb/m^2
magnetomotive force	ampere	A	—
power	watt	W	J/s
pressure	pascal	Pa	N/m^2
quantity of electricity	coulomb	C	A • s
quantity of heat	joule	J	N • m
radiant intensity	watt per steradian	—	W/sr
specific heat	joule per kilogram-kelvin	—	J/kg • K
stress	pascal	Pa	N/m^2
thermal conductivity	watt per metre-kelvin	—	W/m • K
velocity	metre per second	—	m/s
viscosity, dynamic	pascal-second	—	Pa • s
viscosity, kinematic	square metre per second	—	N • m
voltage	volt	V	W/A
volume	cubic metre	—	m^3
wave number	reciprocal metre	—	(wave)/m
work	joule	J	N • m

Note: See Chapter 15, "Guidelines for the Use of the International System of Units (SI) in Petroleum and Allied Industries."

1.6 Interrelation of Units of Measurement

To Convert	To	Multiply by
	LENGTH	
Metres	Yards	1.0936
	Feet	3.2808
	Inches	39.370
Yards	Metres	0.9144†
Feet	Metres	0.3048†
Inches	Centimetres	2.54†
	WEIGHT	
Long tons	Pounds (avoirdupois)	2240.†
	Short tons	1.12†
	Metric tons (tonnes)	1.01605
Short tons	Pounds (avoirdupois)	2000.†
	Long tons	0.892857
	Metric tons (tonnes)	0.907185
Metric tons (tonnes)	Long tons	0.984206
	Short tons	1.10231
Pounds (avoirdupois)	Kilograms	0.453592
Kilograms	Pounds (avoirdupois)	2.20462
	VOLUME AND CAPACITY*	
U.S. gallons	Cubic inches	231.†
	Cubic feet	0.133681
	Imperial gallons	0.832674
	U.S. barrels	0.0238095
	Litres	3.78541
U.S. barrels	U.S. gallons	42†
	Cubic inches	9702†
	Cubic feet	5.61458
	Imperial gallons	34.9723
	Litres	158.987
Imperial gallons	Cubic inches	277.42
	Cubic feet	0.160544
	U.S. gallons	1.20095
	U.S. barrels	0.0285941
	Litres	4.54596
Cubic feet	Imperial gallons	6.22883
	U.S. gallons	7.48052
	U.S. barrels	0.178108
	Litres	28.3169
	Cubic metres	0.0283169

†This relationship is exact by definition. *These factors are solely for conversion at the same temperature.

To Convert	To	Multiply by
VOLUME AND CAPACITY* (CONTINUED)		
Cubic inches	Imperial gallons	0.00360465
	U.S. gallons	0.0043290
	Litres	0.0163871
Litres	Cubic inches	61.0238
	Cubic feet	0.0353147
	Imperial gallons	0.219969
	U.S. gallons	0.264172
	U.S. barrels	0.00628981
Cubic metres	Imperial gallons	219.969
	U.S. gallons	264.172
	U.S. barrels	6.28981
	Cubic feet	35.3147

1.7 API Gravity at 60°F to Relative Density 60/60°F and to Density at 15°C

Table 1 gives the values for relative density 60/60°F and density at 15°C equivalent to values of API gravity at 60°F in the range from 0° to 85° API. The relation between API gravity and relative density is purely mathematical and is given by the following equation:

$$\text{API gravity at } 60°\text{F} = \frac{141.5}{\text{relative density } 60/60°\text{F}} - 131.5$$

This table must be entered with API gravity at 60°F. It is emphasized that the equivalent density is at 15°C (59°F) and not at 60°F.

Table 1—API Gravity to Relative Density and to Density

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
0.0	1.0760	1075.3	3.5	1.0481	1047.5
0.1	1.0752	1074.5	3.6	1.0474	1046.7
0.2	1.0744	1073.7	3.7	1.0466	1045.9
0.3	1.0736	1072.9	3.8	1.0458	1045.2
0.4	1.0728	1072.1	3.9	1.0451	1044.4
0.5	1.0720	1071.3	4.0	1.0443	1043.6
0.6	1.0712	1070.5	4.1	1.0435	1042.8
0.7	1.0703	1069.7	4.2	1.0427	1042.1
0.8	1.0695	1068.8	4.3	1.0420	1041.3
0.9	1.0687	1068.0	4.4	1.0412	1040.5
1.0	1.0679	1067.2	4.5	1.0404	1039.8
1.1	1.0671	1066.4	4.6	1.0397	1039.0
1.2	1.0663	1065.6	4.7	1.0389	1038.3
1.3	1.0655	1064.8	4.8	1.0382	1037.5
1.4	1.0647	1064.0	4.9	1.0374	1036.7
1.5	1.0639	1063.2	5.0	1.0366	1036.0
1.6	1.0631	1062.4	5.1	1.0359	1035.2
1.7	1.0623	1061.6	5.2	1.0351	1034.5
1.8	1.0615	1060.8	5.3	1.0344	1033.7
1.9	1.0607	1060.0	5.4	1.0336	1033.0
2.0	1.0599	1059.2	5.5	1.0328	1032.2
2.1	1.0591	1058.5	5.6	1.0321	1031.4
2.2	1.0583	1057.7	5.7	1.0313	1030.7
2.3	1.0575	1056.9	5.8	1.0306	1029.9
2.4	1.0568	1056.1	5.9	1.0298	1029.2
2.5	1.0560	1055.3	6.0	1.0291	1028.4
2.6	1.0552	1054.5	6.1	1.0283	1027.7
2.7	1.0544	1053.7	6.2	1.0276	1027.0
2.8	1.0536	1052.2	6.3	1.0269	1026.2
2.9	1.0528	1052.2	6.4	1.0261	1025.5
3.0	1.0520	1051.4	6.5	1.0254	1024.7
3.1	1.0513	1050.6	6.6	1.0246	1024.0
3.2	1.0505	1049.8	6.7	1.0239	1023.2
3.3	1.0497	1049.0	6.8	1.0231	1022.5
3.4	1.0489	1048.3	6.9	1.0224	1021.8

Note: Density in this table is mass per unit volume at 15°C expressed in kilograms per cubic metre.

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
7.0	1.0217	1021.0	12.0	0.9861	985.5
7.1	1.0209	1020.3	12.1	0.9854	984.8
7.2	1.0202	1019.6	12.2	0.9847	984.1
7.3	1.0195	1018.8	12.3	0.9840	983.4
7.4	1.0187	1018.1	12.4	0.9833	982.7
7.5	1.0180	1017.4	12.5	0.9826	982.0
7.6	1.0173	1016.6	12.6	0.9820	981.4
7.7	1.0165	1015.9	12.7	0.9813	980.7
7.8	1.0158	1015.2	12.8	0.9806	980.0
7.9	1.0151	1014.4	12.9	0.9799	979.3
8.0	1.0143	1013.7	13.0	0.9792	978.6
8.1	1.0136	1013.0	13.1	0.9786	978.0
8.2	1.0129	1012.3	13.2	0.9779	977.3
8.3	1.0122	1011.5	13.3	0.9772	976.6
8.4	1.0114	1010.8	13.4	0.9765	975.9
8.5	1.0107	1010.1	13.5	0.9759	975.3
8.6	1.0100	1009.4	13.6	0.9752	974.6
8.7	1.0093	1008.6	13.7	0.9745	973.9
8.8	1.0086	1007.9	13.8	0.9738	973.3
8.9	1.0078	1007.2	13.9	0.9732	972.6
9.0	1.0071	1006.5	14.0	0.9725	971.9
9.1	1.0064	1005.8	14.1	0.9718	971.3
9.2	1.0057	1005.1	14.2	0.9712	970.6
9.3	1.0050	1004.4	14.3	0.9705	969.9
9.4	1.0043	1003.6	14.4	0.9698	969.3
9.5	1.0035	1002.9	14.5	0.9692	968.6
9.6	1.0028	1002.2	14.6	0.9685	967.9
9.7	1.0021	1001.5	14.7	0.9679	967.3
9.8	1.0014	1000.8	14.8	0.9672	966.6
9.9	1.0007	1000.1	14.9	0.9665	966.0
10.0	1.0000	999.4	15.0	0.9659	965.3
10.1	0.9993	998.7	15.1	0.9652	964.6
10.2	0.9986	998.0	15.2	0.9646	964.0
10.3	0.9979	997.3	15.3	0.9639	963.3
10.4	0.9972	996.6	15.4	0.9632	962.7
10.5	0.9965	995.9	15.5	0.9626	962.0
10.6	0.9958	995.2	15.6	0.9619	961.4
10.7	0.9951	994.5	15.7	0.9613	960.7
10.8	0.9944	993.8	15.8	0.9606	960.1
10.9	0.9937	993.1	15.9	0.9600	959.4
11.0	0.9930	992.4	16.0	0.9593	958.8
11.1	0.9923	991.7	16.1	0.9587	958.1
11.2	0.9916	991.0	16.2	0.9580	957.5
11.3	0.9909	990.3	16.3	0.9574	956.8
11.4	0.9902	989.6	16.4	0.9567	956.2
11.5	0.9895	988.9	16.5	0.9561	955.5
11.6	0.9888	988.2	16.6	0.9554	954.9
11.7	0.9881	987.5	16.7	0.9548	954.2
11.8	0.9874	986.8	16.8	0.9541	953.6
11.9	0.9868	986.2	16.9	0.9535	952.9

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
17.0	0.9529	952.3	22.0	0.9218	921.3
17.1	0.9522	951.7	22.1	0.9212	920.7
17.2	0.9516	951.0	22.2	0.9206	920.1
17.3	0.9509	950.4	22.3	0.9200	919.5
17.4	0.9503	949.7	22.4	0.9194	918.9
17.5	0.9497	949.1	22.5	0.9188	918.3
17.6	0.9490	948.5	22.6	0.9182	917.7
17.7	0.9484	947.8	22.7	0.9176	917.1
17.8	0.9478	947.2	22.8	0.9170	916.5
17.9	0.9471	946.6	22.9	0.9165	915.9
18.0	0.9465	945.9	23.0	0.9159	915.3
18.1	0.9459	945.3	23.1	0.9153	914.7
18.2	0.9452	944.7	23.2	0.9147	914.2
18.3	0.9446	944.0	23.3	0.9141	913.6
18.4	0.9440	943.4	23.4	0.9135	913.0
18.5	0.9433	942.8	23.5	0.9129	912.4
18.6	0.9427	942.2	23.6	0.9123	911.8
18.7	0.9421	941.5	23.7	0.9117	911.2
18.8	0.9415	940.9	23.8	0.9111	910.6
18.9	0.9408	940.3	23.9	0.9106	910.0
19.0	0.9402	939.7	24.0	0.9100	909.5
19.1	0.9396	939.0	24.1	0.9094	908.9
19.2	0.9390	938.4	24.2	0.9088	908.3
19.3	0.9383	937.8	24.3	0.9082	907.7
19.4	0.9377	937.2	24.4	0.9076	907.1
19.5	0.9371	936.5	24.5	0.9071	906.5
19.6	0.9365	935.9	24.6	0.9065	906.0
19.7	0.9358	935.3	24.7	0.9059	905.4
19.8	0.9352	934.7	24.8	0.9053	904.8
19.9	0.9346	934.1	24.9	0.9047	904.2
20.0	0.9340	933.5	25.0	0.9042	903.6
20.1	0.9334	932.8	25.1	0.9036	903.1
20.2	0.9328	932.2	25.2	0.9030	902.5
20.3	0.9321	931.6	25.3	0.9024	901.9
20.4	0.9315	931.0	25.4	0.9018	901.3
20.5	0.9309	930.4	25.5	0.9013	900.8
20.6	0.9303	929.8	25.6	0.9007	900.2
20.7	0.9297	929.2	25.7	0.9001	899.6
20.8	0.9291	928.6	25.8	0.8996	899.1
20.9	0.9285	927.9	25.9	0.8990	898.5
21.0	0.9279	927.3	26.0	0.8984	897.9
21.1	0.9273	926.7	26.1	0.8978	897.3
21.2	0.9267	926.1	26.2	0.8973	896.8
21.3	0.9260	925.5	26.3	0.8967	896.2
21.4	0.9254	924.9	26.4	0.8961	895.6
21.5	0.9248	924.3	26.5	0.8956	895.1
21.6	0.9242	923.7	26.6	0.8950	894.5
21.7	0.9236	923.1	26.7	0.8944	893.9
21.8	0.9230	922.5	26.8	0.8939	893.4
21.9	0.9224	921.9	26.9	0.8933	892.8

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
27.0	0.8927	892.2	32.0	0.8654	865.0
27.1	0.8922	891.7	32.1	0.8649	864.5
27.2	0.8916	891.1	32.2	0.8644	863.9
27.3	0.8911	890.6	32.3	0.8639	863.4
27.4	0.8905	890.0	32.4	0.8633	862.9
27.5	0.8899	889.4	32.5	0.8628	862.3
27.6	0.8894	888.9	32.6	0.8623	861.8
27.7	0.8888	888.3	32.7	0.8618	861.3
27.8	0.8883	887.8	32.8	0.8612	860.8
27.9	0.8877	887.2	32.9	0.8607	860.2
28.0	0.8871	886.7	33.0	0.8602	854.7
28.1	0.8866	886.1	33.1	0.8597	859.2
28.2	0.8860	885.5	33.2	0.8591	858.7
28.3	0.8855	885.0	33.3	0.8586	858.2
28.4	0.8849	884.4	33.4	0.8581	857.6
28.5	0.8844	883.9	33.5	0.8576	857.1
28.6	0.8838	883.3	33.6	0.8571	856.6
28.7	0.8833	882.8	33.7	0.8565	856.1
28.8	0.8827	882.2	33.8	0.8560	855.6
28.9	0.8822	881.7	33.9	0.8555	855.0
29.0	0.8816	881.1	34.0	0.8550	854.5
29.1	0.8811	880.6	34.1	0.8545	854.0
29.2	0.8805	880.0	34.2	0.8540	853.5
29.3	0.8800	879.5	34.3	0.8534	853.0
29.4	0.8794	878.9	34.4	0.8529	852.5
29.5	0.8789	878.4	34.5	0.8524	852.0
29.6	0.8783	877.9	34.6	0.8519	851.4
29.7	0.8778	877.3	34.7	0.8514	850.9
29.8	0.8772	876.8	34.8	0.8509	850.4
29.9	0.8767	876.2	34.9	0.8504	849.9
30.0	0.8762	875.7	35.0	0.8498	849.4
30.1	0.8756	875.1	35.1	0.8493	848.9
30.2	0.8751	874.6	35.2	0.8488	848.4
30.3	0.8745	874.1	35.3	0.8483	847.9
30.4	0.8740	873.5	35.4	0.8478	847.4
30.5	0.8735	873.0	35.5	0.8473	846.9
30.6	0.8729	872.4	35.6	0.8468	846.4
30.7	0.8724	871.9	35.7	0.8463	845.8
30.8	0.8718	871.4	35.8	0.8458	845.3
30.9	0.8713	870.8	35.9	0.8453	844.8
31.0	0.8708	870.3	36.0	0.8448	844.3
31.1	0.8702	869.8	36.1	0.8443	843.8
31.2	0.8697	869.2	36.2	0.8438	843.3
31.3	0.8692	868.7	36.3	0.8433	842.8
31.4	0.8686	868.2	36.4	0.8428	842.3
31.5	0.8681	867.6	36.5	0.8423	841.8
31.6	0.8676	867.1	36.6	0.8418	841.3
31.7	0.8670	866.6	36.7	0.8413	840.8
31.8	0.8665	866.0	36.8	0.8408	840.3
31.9	0.8660	865.5	36.9	0.8403	839.8

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
37.0	0.8398	839.3	42.0	0.8156	815.2
37.1	0.8393	838.8	42.1	0.8151	814.7
37.2	0.8388	838.3	42.2	0.8146	814.2
37.3	0.8383	837.8	42.3	0.8142	813.8
37.4	0.8378	837.3	42.4	0.8137	813.3
37.5	0.8373	836.8	42.5	0.8132	812.8
37.6	0.8368	836.4	42.6	0.8128	812.4
37.7	0.8363	835.9	42.7	0.8123	811.9
37.8	0.8358	835.4	42.8	0.8118	811.4
37.9	0.8353	834.9	42.9	0.8114	811.0
38.0	0.8348	834.4	43.0	0.8109	810.5
38.1	0.8343	833.9	43.1	0.8104	810.0
38.2	0.8338	833.4	43.2	0.8100	809.6
38.3	0.8333	832.9	43.3	0.8095	809.1
38.4	0.8328	832.4	43.4	0.8090	808.6
38.5	0.8324	831.9	43.5	0.8086	808.2
38.6	0.8319	831.4	43.6	0.8081	807.7
38.7	0.8314	831.0	43.7	0.8076	807.3
38.8	0.8309	830.5	43.8	0.8072	806.8
38.9	0.8304	830.0	43.9	0.8067	806.3
39.0	0.8299	829.5	44.0	0.8063	805.9
39.1	0.8294	829.0	44.1	0.8058	805.4
39.2	0.8289	828.5	44.2	0.8054	805.0
39.3	0.8285	828.0	44.3	0.8049	804.5
39.4	0.8280	827.6	44.4	0.8044	804.1
39.5	0.8275	827.1	44.5	0.8040	803.6
39.6	0.8270	826.6	44.6	0.8035	803.1
39.7	0.8265	826.1	44.7	0.8031	802.7
39.8	0.8260	825.6	44.8	0.8026	802.2
39.9	0.8256	825.1	44.9	0.8022	801.8
40.0	0.8251	824.7	45.0	0.8017	801.3
40.1	0.8246	824.2	45.1	0.8012	800.9
40.2	0.8241	823.7	45.2	0.8008	800.4
40.3	0.8236	823.2	45.3	0.8003	800.0
40.4	0.8232	822.7	45.4	0.7999	799.5
40.5	0.8227	822.3	45.5	0.7994	799.1
40.6	0.8222	821.8	45.6	0.7990	798.6
40.7	0.8217	821.3	45.7	0.7985	798.2
40.8	0.8212	820.8	45.8	0.7981	797.7
40.9	0.8208	820.4	45.9	0.7976	797.3
41.0	0.8203	819.9	46.0	0.7972	796.8
41.1	0.8198	819.4	46.1	0.7967	796.4
41.2	0.8193	818.9	46.2	0.7963	795.9
41.3	0.8189	818.5	46.3	0.7958	795.5
41.4	0.8184	818.0	46.4	0.7954	795.0
41.5	0.8179	817.5	46.5	0.7949	794.6
41.6	0.8174	817.0	46.6	0.7945	794.1
41.7	0.8170	816.6	46.7	0.7941	793.7
41.8	0.8165	816.1	46.8	0.7936	793.2
41.9	0.8160	815.6	46.9	0.7932	792.8

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
47.0	0.7927	792.4	52.0	0.7711	770.8
47.1	0.7923	791.9	52.1	0.7707	770.4
47.2	0.7918	791.5	52.2	0.7703	770.0
47.3	0.7914	791.0	52.3	0.7699	769.6
47.4	0.7909	790.6	52.4	0.7694	769.2
47.5	0.7905	790.1	52.5	0.7690	768.8
47.6	0.7901	789.7	52.6	0.7686	768.3
47.7	0.7896	789.3	52.7	0.7682	767.9
47.8	0.7892	788.8	52.8	0.7678	767.5
47.9	0.7887	788.4	52.9	0.7674	767.1
48.0	0.7883	787.9	53.0	0.7669	766.7
48.1	0.7879	787.5	53.1	0.7665	766.3
48.2	0.7874	787.1	53.2	0.7661	765.8
48.3	0.7870	786.6	53.3	0.7657	765.4
48.4	0.7865	786.2	53.4	0.7653	765.0
48.5	0.7861	785.8	53.5	0.7649	764.6
48.6	0.7857	785.3	53.6	0.7645	764.2
48.7	0.7852	784.9	53.7	0.7640	763.8
48.8	0.7848	784.5	53.8	0.7636	763.4
48.9	0.7844	784.0	53.9	0.7632	763.0
49.0	0.7839	783.6	54.0	0.7628	762.5
49.1	0.7835	783.2	54.1	0.7624	762.1
49.2	0.7831	782.7	54.2	0.7620	761.7
49.3	0.7826	782.3	54.3	0.7616	761.3
49.4	0.7822	781.9	54.4	0.7612	760.9
49.5	0.7818	781.4	54.5	0.7608	760.5
49.6	0.7813	781.0	54.6	0.7603	760.1
49.7	0.7809	780.6	54.7	0.7599	759.7
49.8	0.7805	780.2	54.8	0.7595	759.3
49.9	0.7800	779.7	54.9	0.7591	758.9
50.0	0.7796	779.3	55.0	0.7587	758.5
50.1	0.7792	778.9	55.1	0.7583	758.1
50.2	0.7788	778.4	55.2	0.7579	757.6
50.3	0.7783	778.0	55.3	0.7575	757.2
50.4	0.7779	777.6	55.4	0.7571	756.8
50.5	0.7775	777.2	55.5	0.7567	756.4
50.6	0.7770	776.7	55.6	0.7563	756.0
50.7	0.7766	776.3	55.7	0.7559	755.6
50.8	0.7762	775.9	55.8	0.7555	755.2
50.9	0.7758	775.5	55.9	0.7551	754.8
51.0	0.7753	775.1	56.0	0.7547	754.4
51.1	0.7749	774.6	56.1	0.7543	754.0
51.2	0.7745	774.2	56.2	0.7539	753.6
51.3	0.7741	773.8	56.3	0.7535	753.2
51.4	0.7736	773.4	56.4	0.7531	752.8
51.5	0.7732	772.9	56.5	0.7527	752.4
51.6	0.7728	772.5	56.6	0.7523	752.0
51.7	0.7724	772.1	56.7	0.7519	751.6
51.8	0.7720	771.7	56.8	0.7515	751.2
51.9	0.7715	771.3	56.9	0.7511	750.8

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
57.0	0.7507	750.4	62.0	0.7313	731.1
57.1	0.7503	750.0	62.1	0.7309	730.7
57.2	0.7499	749.6	62.2	0.7305	730.3
57.3	0.7495	749.2	62.3	0.7301	729.9
57.4	0.7491	748.8	62.4	0.7298	729.5
57.5	0.7487	748.4	62.5	0.7294	729.2
57.6	0.7483	748.0	62.6	0.7290	728.8
57.7	0.7479	747.6	62.7	0.7286	728.4
57.8	0.7475	747.3	62.8	0.7283	728.0
57.9	0.7471	746.9	62.9	0.7279	727.7
58.0	0.7467	746.5	63.0	0.7275	727.3
58.1	0.7463	746.1	63.1	0.7271	726.9
58.2	0.7459	745.7	63.2	0.7268	726.5
58.3	0.7455	745.3	63.3	0.7264	726.2
58.4	0.7451	744.9	63.4	0.7260	725.8
58.5	0.7447	744.5	63.5	0.7256	725.4
58.6	0.7443	744.1	63.6	0.7253	725.1
58.7	0.7440	743.7	63.7	0.7249	724.7
58.8	0.7436	743.3	63.8	0.7245	724.3
58.9	0.7432	742.9	63.9	0.7242	723.9
59.0	0.7428	742.6	64.0	0.7239	723.6
59.1	0.7424	742.2	64.1	0.7234	723.2
59.2	0.7420	741.8	64.2	0.7230	722.8
59.3	0.7416	741.4	64.3	0.7227	722.5
59.4	0.7412	741.0	64.4	0.7223	722.1
59.5	0.7408	740.6	64.5	0.7219	721.7
59.6	0.7405	740.2	64.6	0.7216	721.4
59.7	0.7401	739.8	64.7	0.7212	721.0
59.8	0.7397	739.4	64.8	0.7208	720.6
59.9	0.7393	739.1	64.9	0.7205	720.3
60.0	0.7389	738.7	65.0	0.7201	719.9
60.1	0.7385	738.3	65.1	0.7197	719.5
60.2	0.7381	737.9	65.2	0.7194	719.2
60.3	0.7377	737.5	65.3	0.7190	718.8
60.4	0.7374	737.1	65.4	0.7186	718.4
60.5	0.7370	736.8	65.5	0.7183	718.1
60.6	0.7366	736.4	65.6	0.7179	717.7
60.7	0.7362	736.0	65.7	0.7175	717.3
60.8	0.7358	735.6	65.8	0.7172	717.0
60.9	0.7354	735.2	65.9	0.7168	716.6
61.0	0.7351	734.8	66.0	0.7165	716.3
61.1	0.7347	734.5	66.1	0.7161	715.9
61.2	0.7343	734.1	66.2	0.7157	715.5
61.3	0.7339	733.7	66.3	0.7154	715.2
61.4	0.7335	733.3	66.4	0.7150	714.8
61.5	0.7332	732.9	66.5	0.7146	714.5
61.6	0.7328	732.6	66.6	0.7143	714.1
61.7	0.7324	732.2	66.7	0.7139	713.7
61.8	0.7320	731.8	66.8	0.7136	713.4
61.9	0.7316	731.4	66.9	0.7132	713.0

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
67.0	0.7128	712.7	72.0	0.6953	695.2
67.1	0.7125	712.3	72.1	0.6950	694.8
67.2	0.7121	711.9	72.2	0.6946	694.5
67.3	0.7118	711.6	72.3	0.6943	694.1
67.4	0.7114	711.2	72.4	0.6940	693.8
67.5	0.7111	710.9	72.5	0.6936	693.5
67.6	0.7107	710.5	72.6	0.6933	693.1
67.7	0.7103	710.2	72.7	0.6929	692.8
67.8	0.7100	709.8	72.8	0.6926	692.4
67.9	0.7096	709.4	72.9	0.6923	692.1
68.0	0.7093	709.1	73.0	0.6919	691.8
68.1	0.7089	708.7	73.1	0.6916	691.4
68.2	0.7086	708.4	73.2	0.6913	691.1
68.3	0.7082	708.0	73.3	0.6909	690.8
68.4	0.7079	707.7	73.4	0.6906	690.4
68.5	0.7075	707.3	73.5	0.6902	690.1
68.6	0.7071	707.0	73.6	0.6899	689.7
68.7	0.7068	706.6	73.7	0.6896	689.4
68.8	0.7064	706.3	73.8	0.6892	689.1
68.9	0.7061	705.9	73.9	0.6889	688.7
69.0	0.7057	705.6	74.0	0.6886	688.4
69.1	0.7054	705.2	74.1	0.6882	688.1
69.2	0.7050	704.9	74.2	0.6879	687.7
69.3	0.7047	704.5	74.3	0.6876	687.4
69.4	0.7043	704.2	74.4	0.6872	687.1
69.5	0.7040	703.8	74.5	0.6869	686.7
69.6	0.7036	703.5	74.6	0.6866	686.4
69.7	0.7033	703.1	74.7	0.6862	686.1
69.8	0.7029	702.8	74.8	0.6859	685.7
69.9	0.7026	702.4	74.9	0.6856	685.4
70.0	0.7022	702.1	75.0	0.6852	685.1
70.1	0.7019	701.7	75.1	0.6849	684.7
70.2	0.7015	701.4	75.2	0.6846	684.4
70.3	0.7012	701.0	75.3	0.6842	684.1
70.4	0.7008	700.7	75.4	0.6839	683.8
70.5	0.7005	700.3	75.5	0.6836	683.4
70.6	0.7001	700.0	75.6	0.6832	683.1
70.7	0.6998	699.6	75.7	0.6829	682.8
70.8	0.6995	699.3	75.8	0.6826	682.4
70.9	0.6991	698.9	75.9	0.6823	682.1
71.0	0.6988	698.6	76.0	0.6819	681.8
71.1	0.6984	698.2	76.1	0.6816	681.5
71.2	0.6981	697.9	76.2	0.6813	681.1
71.3	0.6977	697.6	76.3	0.6809	680.8
71.4	0.6974	697.2	76.4	0.6806	680.5
71.5	0.6970	696.9	76.5	0.6803	680.1
71.6	0.6967	696.5	76.6	0.6800	679.8
71.7	0.6964	696.2	76.7	0.6796	679.5
71.8	0.6960	695.8	76.8	0.6793	679.2
71.9	0.6957	695.5	76.9	0.6790	678.8

Table 1—API Gravity to Relative Density and to Density (Continued)

API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)	API Gravity (60°F)	Relative Density (60/60°F)	Density (15°C)
77.0	0.6787	678.5	81.0	0.6659	665.8
77.1	0.6783	678.2	81.1	0.6656	665.4
77.2	0.6780	677.9	81.2	0.6653	665.1
77.3	0.6777	677.5	81.3	0.6649	664.8
77.4	0.6774	677.2	81.4	0.6646	646.5
77.5	0.6770	676.9	81.5	0.6643	664.2
77.6	0.6767	676.6	81.6	0.6640	663.9
77.7	0.6764	676.2	81.7	0.6637	663.6
77.8	0.6761	675.9	81.8	0.6634	663.3
77.9	0.6757	675.6	81.9	0.6631	663.0
78.0	0.6754	675.3	82.0	0.6628	662.6
78.1	0.6751	675.0	82.1	0.6625	662.3
78.2	0.6748	674.6	82.2	0.6621	662.0
78.3	0.6745	674.3	82.3	0.6618	661.7
78.4	0.6741	674.0	82.4	0.6615	661.4
78.5	0.6738	673.7	82.5	0.6612	661.1
78.6	0.6735	673.4	82.6	0.6609	660.8
78.7	0.6732	673.0	82.7	0.6606	660.5
78.8	0.6728	672.7	82.8	0.6603	660.2
78.9	0.6725	672.4	82.9	0.6600	659.9
79.0	0.6722	672.1	83.0	0.6597	659.6
79.1	0.6719	671.8	83.1	0.6594	659.3
79.2	0.6716	671.4	83.2	0.6591	658.9
79.3	0.6713	671.1	83.3	0.6588	658.6
79.4	0.6709	670.8	83.4	0.6584	658.3
79.5	0.6706	670.5	83.5	0.6581	658.0
79.6	0.6703	670.2	83.6	0.6578	657.7
79.7	0.6700	669.9	83.7	0.6575	657.4
79.8	0.6697	669.5	83.8	0.6572	657.1
79.9	0.6693	669.2	83.9	0.6569	656.8
80.0	0.6690	668.9	84.0	0.6566	656.5
80.1	0.6687	668.6	84.1	0.6563	656.2
80.2	0.6684	668.3	84.2	0.6560	655.9
80.3	0.6681	668.0	84.3	0.6557	655.6
80.4	0.6678	667.6	84.4	0.6554	655.3
80.5	0.6675	667.3	84.5	0.6551	655.0
80.6	0.6671	667.0	84.6	0.6548	654.7
80.7	0.6668	666.7	84.7	0.6545	654.4
80.8	0.6665	666.4	84.8	0.6542	654.1
80.9	0.6662	666.1	84.9	0.6539	653.8
			85.0	0.6536	653.5

1.8 Temperature Conversions

1.8.1 CONVERSION FORMULAS

Use the following formulas to convert temperatures to and from SI units:

$$°C = 5/9\ (°F - 32)$$

$$°F = 9/5\ (°C + 32)$$

Where:

$°F$ = Degree Fahrenheit
$°C$ = Degree Celsius

1.8.2 CONVERSION VALUES

Table 2 provides conversion values for temperatures in degrees Fahrenheit and degrees Celsius for each whole degree from –50° to +250°. The temperature to be converted is found in the center "temperature to be converted" column. If the temperature to be converted is in degrees Fahrenheit, its equivalent in degrees Celsius is found in the "degrees Celsius" column to the left. If the temperature to be converted is in degrees Celsius, its equivalent in degrees Fahrenheit is found in the "degrees Fahrenheit" column to the right.

Table 2—Temperature Conversions

Degrees Celsius	Temperature to Be Converted	Degrees Fahrenheit	Degrees Celsius	Temperature to Be Converted	Degrees Fahrenheit
–45.6	–50	–58.0	–24.4	–12	10.4
–45.0	–49	–56.2	–23.9	–11	12.2
–44.4	–48	–54.4	–23.3	–10	14.0
–43.9	–47	–52.6	–22.8	–9	15.8
–43.3	–46	–50.8	–22.2	–8	17.6
–42.8	–45	–49.0	–21.7	–7	19.4
–42.2	–44	–47.2	–21.1	–6	21.2
–41.7	–43	–45.4	–20.6	–5	23.0
–41.1	–42	–43.6	–20.0	–4	24.8
–40.6	–41	–41.8	–19.4	–3	26.6
–40.0	–40	–40.0	–18.9	–2	28.4
–39.4	–39	–38.2	–18.3	–1	30.2
–38.9	–38	–36.4	–17.8	0	32.0
–38.3	–37	–34.6	–17.2	1	33.8
–37.8	–36	–32.8	–16.7	2	35.6
–37.2	–35	–31.0	–16.1	3	37.4
–36.7	–34	–29.2	–15.6	4	39.2
–36.1	–33	–27.4	–15.0	5	41.0
–35.6	–32	–25.6	–14.4	6	42.8
–35.0	–31	–23.8	–13.9	7	44.6
–34.4	–30	–22.0	–13.3	8	46.4
–33.9	–29	–20.2	–12.8	9	48.2
–33.3	–28	–18.4	–12.2	10	50.0
–32.8	–27	–16.6	–11.7	11	51.8
–32.2	–26	–14.8	–11.1	12	53.6
–31.7	–25	–13.0	–10.6	13	55.4
–31.1	–24	–11.2	–10.0	14	57.2
–30.6	–23	–9.4	–9.4	15	59.0
–30.0	–22	–7.6	–8.9	16	60.8
–29.4	–21	–5.8	–8.3	17	62.6
–28.9	–20	–4.0	–7.8	18	64.4
–28.3	–19	–2.2	–7.2	19	66.2
–27.8	–18	–0.4	–6.7	20	68.0
–27.2	–17	1.4	–6.1	21	69.8
–26.7	–16	3.2	–5.6	22	71.6
–26.1	–15	5.0	–5.0	23	73.4
–25.6	–14	6.8	–4.4	24	75.2
–25.0	–13	8.6	–3.9	25	77.0

Table 2—Temperature Conversions (Continued)

Degrees Celsius	Temperature to Be Converted	Degrees Fahrenheit	Degrees Celsius	Temperature to Be Converted	Degrees Fahrenheit
–3.3	26	78.8	33.3	92	197.6
–2.8	27	80.6	33.9	93	199.4
–2.2	28	82.4	34.4	94	201.2
–1.7	29	84.2	35.0	95	203.0
–1.1	30	86.0	35.6	96	204.8
–0.6	31	87.8	36.1	97	206.6
0.0	32	89.6	36.7	98	208.4
0.6	33	91.4	37.2	99	210.2
1.1	34	93.2	37.8	100	212.0
1.7	35	95.0	38.3	101	213.8
2.2	36	96.8	38.9	102	215.6
2.8	37	98.6	39.4	103	217.4
3.3	38	100.4	40.0	104	219.2
3.9	39	102.2	40.6	105	221.0
4.4	40	104.0	41.1	106	222.8
5.0	41	105.8	41.7	107	224.6
5.6	42	107.6	42.2	108	226.4
6.1	43	109.4	42.8	109	228.2
6.7	44	111.2	43.3	110	230.0
7.2	45	113.0	43.9	111	231.8
7.8	46	114.8	44.4	112	233.6
8.3	47	116.6	45.0	113	235.4
8.9	48	118.4	45.6	114	237.2
9.4	49	120.2	46.1	115	239.0
10.0	50	122.0	46.7	116	240.8
10.6	51	123.8	47.2	117	242.6
11.1	52	125.6	47.8	118	244.4
11.7	53	127.4	48.3	119	246.2
12.2	54	129.2	48.9	120	248.0
12.8	55	131.0	49.4	121	249.8
13.3	56	132.8	50.0	122	251.6
13.9	57	134.6	50.6	123	253.4
14.4	58	136.4	51.1	124	255.2
15.0	59	138.2	51.7	125	257.0
15.6	60	140.0	52.2	126	258.8
16.1	61	141.8	52.8	127	260.6
16.7	62	143.6	53.3	128	262.4
17.2	63	145.4	53.9	129	264.2
17.8	64	147.2	54.4	130	266.0
18.3	65	149.0	55.0	131	267.8
18.9	66	150.8	55.6	132	269.6
19.4	67	152.6	56.1	133	271.4
20.0	68	154.4	56.7	134	273.2
20.6	69	156.2	57.2	135	275.0
21.1	70	158.0	57.8	136	276.8
21.7	71	159.8	58.3	137	278.6
22.2	72	161.6	58.9	138	280.4
22.8	73	163.4	59.4	139	282.2
23.3	74	165.2	60.0	140	284.0
23.9	75	167.0	60.6	141	285.8
24.4	76	168.8	61.1	142	287.6
25.0	77	170.6	61.7	143	289.4
25.6	78	172.4	62.2	144	291.2
26.1	79	174.2	62.8	145	293.0
26.7	80	176.0	63.3	146	294.8
27.2	81	177.8	63.9	147	296.6
27.8	82	179.6	64.4	148	298.4
28.3	83	181.4	65.0	149	300.2
28.9	84	183.2	65.6	150	302.0
29.4	85	185.0	66.1	151	303.8
30.0	86	186.8	66.7	152	305.6
30.6	87	188.6	67.2	153	307.4
31.1	88	190.4	67.8	154	309.2
31.7	89	192.2	68.3	155	311.0
32.2	90	194.0	68.9	156	312.8
32.8	91	195.8	69.4	157	314.6

Table 2—Temperature Conversions (Continued)

Degrees Celsius	Temperature to Be Converted	Degrees Fahrenheit	Degrees Celsius	Temperature to Be Converted	Degrees Fahrenheit
70.0	158	316.4	96.1	205	401.0
70.6	159	318.2	96.7	206	402.8
71.1	160	320.0	97.2	207	404.6
71.7	161	321.8	97.8	208	406.4
72.2	162	323.6	98.3	209	408.2
72.8	163	325.4	98.9	210	410.0
73.3	164	327.2	99.4	211	411.8
73.9	165	329.0	100.0	212	413.6
74.4	166	330.8	100.6	213	415.4
75.0	167	332.6	101.1	214	417.2
75.6	168	334.4	101.7	215	419.0
76.1	169	336.2	102.2	216	420.8
76.7	170	338.0	102.8	217	422.6
77.2	171	339.8	103.3	218	424.4
77.8	172	341.6	103.9	219	426.2
78.3	173	343.4	104.4	220	428.0
78.9	174	345.2	105.0	221	429.8
79.4	175	347.0	105.6	222	431.6
80.0	176	348.8	106.1	223	433.4
80.6	177	350.6	106.7	224	435.2
81.1	178	352.4	107.2	225	437.0
81.7	179	354.2	107.8	226	438.8
82.2	180	356.0	108.3	227	440.6
82.8	181	357.8	108.9	228	442.4
83.3	182	359.6	109.4	229	444.2
83.9	183	361.4	110.0	230	446.0
84.4	184	363.2	110.6	231	447.8
85.0	185	365.0	111.1	232	449.6
85.6	186	366.8	111.7	233	451.4
86.1	187	368.6	112.2	234	453.2
86.7	188	370.4	112.8	235	455.0
87.2	189	372.2	113.3	236	456.8
87.8	190	374.0	113.9	237	458.6
88.3	191	375.8	114.4	238	460.4
88.9	192	377.6	115.0	239	462.2
89.4	193	379.4	115.6	240	464.0
90.0	194	381.2	116.1	241	465.8
90.6	195	383.0	116.7	242	467.6
91.1	196	384.8	117.2	243	469.4
91.7	197	386.6	117.8	244	471.2
92.2	198	388.4	118.3	245	473.0
92.8	199	390.2	118.9	246	474.8
93.3	200	392.0	119.4	247	476.6
93.9	201	393.8	120.0	248	478.4
94.4	202	395.6	120.6	249	480.2
95.0	203	397.4	121.1	250	482.0
95.6	204	399.2			

Note: °Kelvin = °centigrade + 273.16.

1.9 Government Agencies, Standards Organizations, Professional Societies, and Trade Associations

American Bureau of Shipping (ABS)

Paramus, New Jersey
201-368-9100
founded 1862

The American Bureau of Shipping establishes universal standards by which ships, mobile offshore drilling units, and other marine structures are built and maintained.

American Gas Association (AGA)

Arlington, Virginia
703-841-8400
founded 1919

The American Gas Association provides services to natural gas utilities in fields of technical operation, finance, communications, and legal activities.

American Institute of Chemical Engineers (AIChE)

New York, New York
212-705-7338
founded 1908

The American Institute of Chemical Engineers is a technical society whose main function is to inform its members of new developments in the field of chemical engineering.

American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME)

New York, New York
212-705-7695
founded 1871

The American Institute of Mining, Metallurgical, and Petroleum Engineers is a separate corporation controlled by its four member societies: the Society of Mining Engineers, the Metallurgical Society, the Iron and Steel Society, and the Society of Petroleum Engineers. It promotes knowledge involved in the production and use of minerals, metals, and energy resources.

American National Metric Council (ANMC)

Washington, D.C.
202-628-5757
founded 1973

The American National Metric Council is involved with the metric activities of commerce and industry.

American National Standards Institute (ANSI)

New York, New York
212-354-3300
founded 1918

The American National Standards Institute provides information on and approves American National Standards for industry, engineering, safety, design, and other applications.

American Petroleum Institute (API)

Washington, D.C.
202-682-8000
founded 1919

The American Petroleum Institute serves the petroleum industry by sponsoring research, developing technical standards, formulating policies, and providing information to the public.

American Society of Mechanical Engineers (ASME)

Dallas, Texas
214-437-1194
founded 1880

The American Society of Mechanical Engineers is an educational and technical society that sponsors international and national meetings, develops standards, and conducts a technical publishing operation.

American Society for Testing and Materials (ASTM)

Philadelphia, Pennsylvania
215-299-5400
founded 1898

The American Society for Testing and Materials develops consensus standards for materials, products, systems, and services, and promotes related knowledge.

Association of American Railroads (AAR)

Washington, D.C.
202-639-2100
founded 1872

The Association of American Railroads represents the freight railroad industry before the government and the public and provides research and development for the industry.

Association of Oil Pipelines (AOPL)

Washington, D.C.
202-331-0771
founded 1947

The Association of Oil Pipelines is a trade association that represents liquid petroleum pipeline companies. It prepares testimony on legal and economic regulatory issues and appeals of government actions, and it lobbies on behalf of the companies. AOPL generally handles legal and economic issues, while the Manufacturing, Distribution and Marketing Department of API handles technical ones.

British Standards Institute (BSI)

London, England
01 636 1004

The British Standards Institute is similar to the American National Standards Institute, except that it both produces and coordinates British national standards. BSI is the United Kingdom's representative to ISO.

Bureau of Explosives

founded 1907

The Bureau of Explosives became the Hazardous Material division of the Association of American Railroads in 1985.

Bureau of Land Management (BLM)

Washington, D.C.
202-343-5717

The Bureau of Land Management, a division of the U.S. Department of the Interior, manages public lands for multiple use. Its goal is to find the combination of uses for the more than 500 million acres it manages that will best meet the long-term needs of the public.

Chemical Manufacturers Association (CMA)

Washington, D.C.
202-887-1100
founded 1872

The Chemical Manufacturers Association represents the manufacturers of basic industrial chemicals and coordinates their legislative, regulatory, and legal efforts on international, national, state, and local issues.

Department of Commerce (DOC)

Washington, D.C.
202-377-2000
established 1913

The Department of Commerce is concerned with U.S. international trade, economic growth, and technological advancement. It also promotes the national interest and encourages the free enterprise system.

Department of Defense (DOD)

Washington, D.C.
202-545-6700
established 1949

The Department of Defense uses its four divisions—the Army, Navy, Marine Corps, and Air Force—to provide the military services needed to deter war and provide for the security of the U.S.

Department of Energy (DOE)

Washington, D.C.
202-252-5000
founded 1977

The Department of Energy develops a national energy plan that includes research in the development of energy technology, energy conservation, the nuclear weapons program, and energy regulatory problems.

Department of the Interior (DOI)

Washington, D.C.
202-343-7720
established 1849

The Department of the Interior manages federal lands and national resources, including the assessment and development of energy and mineral resources on public lands.

Department of Transportation (DOT)
Washington, D.C.
202-426-4000
established 1967

The Department of Transportation establishes the transportation policy of the U.S., which includes highway planning, development, and construction; urban mass transit; railroads; and safety of waterways, ports, and oil and gas pipelines.

Energy Telecommunications and Electrical Association (Entelec)
Dallas, Texas
214-578-1900
founded 1928

Entelec is an association of companies and corporations with personnel who are involved in the electrical, electronics, communications, and related fields. Entelec sponsors a conference once a year, which is also called Entelec.

Environmental Protection Agency (EPA)
Washington, D.C.
202-382-2090
established 1970 as an independent agency

The Environmental Protection Agency enforces federal laws intended to protect the environment. These laws cover air and water pollution, solid wastes, pesticides, radiation, and toxic substances.

European Community (EC)
Brussels, Belgium

The European Community consists of four institutions: the European parliament, the Council, the Commission, and the Court of Justice. It is responsible for administering the Paris and the Rome treaties.

Gas Processors Association (GPA)
Tulsa, Oklahoma
918-493-3872
founded 1921

The Gas Processors Association is composed of firms that handle natural gas and other hydrocarbons at gas-processing plants.

Gas Research Institute (GRI)
Chicago, Illinois
312-399-8100
founded 1976

The Gas Research Institute is a scientific research organization that plans, finances, and manages basic research and technological development programs dealing with natural gas.

Institute of Electrical and Electronics Engineers, Inc. (IEEE)
New York, New York
212-705-7900
founded 1963

The Institute of Electrical and Electronics Engineers is a scientific, educational, and professional organization concerned with all areas of electronics and electric technology.

Instrument Society of America (ISA)

Research Triangle Park, North Carolina
919-549-8411
founded 1945

The Instrument Society of America develops and distributes knowledge relating to the design, manufacture, and use of instruments in industry, laboratory, marine, and space environments.

International Chamber of Shipping (ICS)

London, England
01 735 7696

The International Chamber of Shipping is a marine trade association that represents the interests of its members (major oil companies) at the International Maritime Organization.

International Maritime Organization (IMO)

London, England
01 735 7611

The International Maritime Organization is a branch of the United Nations. It helps governments cooperate in matters concerning the regulation and practice of technical matters that affect shipping engaged in international trade. IMO also promotes standards affecting maritime safety and the prevention and control of marine pollution from ships.

International Organization of Legal Metrology (OIML)

Paris, France
878 12 82
created 1955

The International Organization of Legal Metrology is an intergovernmental organization that handles the administrative and technical regulation of measurements and measuring instruments to facilitate commerce between countries.

International Organization for Standardization (ISO)

Geneva, Switzerland
34 12 40

The International Organization for Standardization seeks international agreement on standards and develops international standards to increase trade and to improve quality and productivity.

Institute of Petroleum (IP)

London, England
01 636 1009
founded 1913

The Institute of Petroleum promotes, encourages, and coordinates scientific research on petroleum and its products and develops standards for their use.

Minerals Management Service (MMS)

Washington, D.C.
202-343-3983

The Minerals Management Service is a division of the Department of the Interior. It is re-

sponsible for establishing effective means of collecting revenues from mineral leases for both offshore and onshore federal and Indian lands and for developing offshore energy and mineral resources.

National Conference on Weighs and Measures (NCWM)

Gaithersburg, Maryland
301-921-3677
founded 1905

The National Conference on Weights and Measures is composed of officials of weights and measures enforcement agencies from state, county, and local governments, and associate members from industry. NCWM develops model laws and regulations for state adoption.

National Fire Protection Association (NFPA)

Quincy, Massachusetts
617-984-7450
founded 1896

The National Fire Protection Association is active in methodological development and analysis in areas of fire risk assessment, probabilistic models of fire protection, and fire experience statistics.

National Institute of Standards and Technology (NIST)

Gaithersburg, Maryland
301-975-2000
established 1901

The National Institute of Standards and Technology (formerly the National Bureau of Standards) promotes U.S. science and technology by conducting research, providing the basis for the U.S. physical measurement system, developing a technical basis for trade, and establishing technical services to advance public safety.

Occupational Safety and Health Administration (OSHA)

Washington, D.C.
202-634-7943
established 1970

The Occupational Safety and Health Administration is concerned with providing safe and healthful working conditions.

Oil Companies International Marine Forum (OCIMF)

London, England
01 283 2922

The Oil Companies International Marine Forum is a marine trade organization whose members are representatives of national trade associations of maritime nations. It represents shipowners before regulatory bodies and regulates world shipping.

Society of Petroleum Engineers (SPE)

Richardson, Texas
214-669-3377
founded 1922

The Society of Petroleum Engineers is an international technical and professional association that provides information on petroleum engineering technology and the petroleum engineering profession.

Southern Gas Association (SGA)

Dallas, Texas
214-387-8505
founded 1908

The Southern Gas Association encourages the development of the gas industry through scientific research and the cooperation of organizations with related interests.

United States Coast Guard (USCG)

Washington, D.C.
202-426-2158

The United States Coast Guard is the branch of the Armed Forces that enforces maritime laws. These laws encompass search and rescue, commercial vessel safety, marine and environmental safety, and waterways management.

United States Customs Service (USCS)

Washington, D.C.
202-566-8195
established 1927 as a separate agency

The U.S. Customs Service collects duty on imports and implements U.S. customs laws.

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