Manual of Petroleum Measurement Standards
Chapter 15—Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries

FORMERLY API PUBLICATION 2564
THIRD EDITION, DECEMBER 2001

REAFFIRMED, FEBRUARY 2015

AMERICAN PETROLEUM INSTITUTE

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Measurement Coordination

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Chapter 15—Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries

15.0 Introduction

The general purpose of this publication is to encourage and facilitate uniformity of metric practice within the petroleum industry. The specific purposes are as follows:

1. To define metric practice for the petroleum industry;
2. To encourage uniformity of metric practice and nomenclature within the petroleum industry and
3. To facilitate the use of SI in all aspects of the petroleum industry. Use of this publication by the American Petroleum Institute, its divisions, and its members implements API's policy and also implements recommendations in ISO 1000—1992, *SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units* [I][1].

Production of the first edition of API's Publication 2564 in 1973 was encouraged by API member companies either operating internationally or participating in the activities of the International Organization for Standardization (ISO). The Institute of Petroleum, Great Britain, (IP) and the Canadian Petroleum Association (CPA) both offered their full endorsement and accompanied it with valuable technical support and assistance.

The transition to the International System of Units (SI) has advanced considerably since 1973. The Metric Conversion Act of 1975 (Public Law 94—168) has been enacted, declaring the coordination and planning of increasing use of the metric system (SI) in the United States to be government policy. A notice by the Assistant Secretary of Commerce for Science and Technology in the *Federal Register* of October 26, 1977 (Volume 42, Number 206, pages 56513 and 56514) interprets and modifies SI for the United States. The act also provided for establishing a U.S. Metric Board to coordinate voluntary conversion. In 1982, the U.S. Metric Board was disbanded. Responsibility for metric coordination was transferred to the Office of Metric Programs in the Department of Commerce. The Omnibus Trade and Competitiveness Act of 1988 amended the Metric Conversion Act of 1975, designating the SI system as the preferred measurement system for the United States. In 1991, Federal Agencies were directed to use the Metric System to the extent economically feasible and practicable by Executive Order 12770, Metric Usage in the Federal government. In addition to the increased activity of the federal government in this field, the interpretation of SI also has been dealt with extensively in metric practice guides of various standards associations, technical and trade societies, and individual industries [1 – 16]. The International System of Units (SI) is the dominate measurement used with the exception of the United States. With the arrival of the global market place, it is imperative for US petroleum industry to extend its use of SI and for personnel in the petroleum industry to gain a working knowledge of SI.

The API Metric Transition Committee was formed in 1976 to coordinate internal API metric policy and to formulate API's policy with regard to government and non government bodies. One of the Metric Transition Committee's first actions was the creation of the Subcommittee on Units to review and revise Chapter 15, Sections I and 2, of the *Manual of Petroleum Measurement Standards*. Sections I and 2 had been published as API Publications 2563 *Metric Practice Guide*, and 2564 *Conversion of Operational and Process Measurement Units to the Metric (SI) System*.

At the recommendation of the Subcommittee on Units, the Metric Transition Committee discontinued API Publication 2563 and adopted ASTM (American Society for Testing and Materials) E 380–76 [3] and ANSI (American National Standards Institute) Z210.1–1976 [2] as the authoritative metric practice guide. ASTM E 380 has been replaced by IEEE/ASTM SI 10-1997, *Standard for use of the International System of units (SI): The Modern Metric System* [14]. Because of special interpretations and applications of SI with the petroleum industry, API will continue publishing API *MPMS* Chapter 15. In preparing Chapter 15, the working group has tried to keep consistent with metric practice as defined by the General Conference on Weights and Measures (abbreviated CGPM from the official French name), the federal government, and significant standards organizations (such as the American Society for Testing and Materials, the American National Standards Institute, and related technical societies). However, even among these sources, agreement is not absolute on all details of metric practice. Where feasible, Chapter 15 has adhered to the policies of the voluntary standards associations ASTM and ANSI on all unresolved issues. Where no clear policy has been evident or where the policy was not acceptable to the petroleum industry, this publication has recognized the particular needs of the petroleum industry. All such cases have been specific interpretations of SI, not repudiation of the system. Emphasis has been placed on the application of SI in practice, which has necessitated some departures from rigorous adherence to the idealized, "pure" SI.

15.1 Scope and Field of Application

This publication specifies the API preferred units for quantities involved in petroleum industry measurements and indicates factors for conversion of quantities expressed in customary units to the API preferred metric units. The quanti-

[1]Numbers in brackets pertain to the references in Appendix C.

ties that comprise the tables are grouped into convenient categories related to their use. They were chosen to meet the needs of the many and varied aspects of the petroleum industry but also should be useful in other, similar process industries.

15.2 References

This publication emphasizes the practical application of SI. For a complete, detailed presentation of SI and the metric practice on which this publication is based, the reader should consult references 2, 3, or 4.

15.3 The International System of Units (SI)

15.3.1 GENERAL

SI is the official abbreviation, in all languages, for the International System of Units (Le Système International d'Units). The International System is not the old centimeter-gram-second (cgs) system of metric units but is based on the meter, kilogram, and second as the fundamental quantities. SI is considered to be an improvement over the centimeter-gram-second metric system and is used currently or is being adopted by most nations of the world.

There are two classes of units in SI. The first consists of base units which, by convention, are dimensionally independent. The second class consists of derived units that are formed by combining base units according to the algebraic relations linking the corresponding quantities. Special names and symbols have been assigned to the commonly used units in this class.

The coherent nature of SI is preserved by defining all derived combination in terms of unity, thus eliminating conversion factors within the system. As an example, the derived unit of power, with its special name, watt, is defined as 1 joule of work completed in 1 second of time.

15.3.2 SI BASE UNITS

There are seven base units in SI. These units are considered to be dimensionally independent and are precisely defined. The definitions are shown below:

Quantity	Name	Symbol	Definition
length	meter	m	The meter is the length of the path traveled by light in vacuum during a time interval of 1/299 792 458 of a second. (17th GGPM 1983).
mass	kilogram	kg	The kilogram is the unit of mass (not force); it is equal to the mass of the international prototype of the kilogram. (1st and 3rd CGPM, 1889 and 1901). This international prototype, made of platinum-iridium, is kept at the International Bureau of Weights and Measures. A copy of the international prototype is maintained by the national standards agency of each major country. The kilogram is the only base unit defined by an artifact and is the only base unit having a prefix.
time	second	s	The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom. (13th CGPM, 1967)
electric current	ampere	A	The ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length. (CIPM, 1946, Resolution 2 approved by the 9th CGPM, 1948)

Quantity	Name	Symbol	Definition
temperature	kelvin	K	The kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. (13th CGPM, 1967) The unit kelvin and its symbol K are used to express an interval of difference of temperature. (Thirteenth CGPM, 1967, Resolution 3) In addition to the thermodynamic temperature, Celsius temperature (formerly called Centigrade) is widely used. The degree Celsius (ºC), a derived unit, is the unit for expressing Celsius temperatures and temperature intervals. Celsius temperature t is related to thermodynamic temperature T by following equation: $t = T - T_o$ *where* T_o = 273.15 by definition. The temperature interval 1°C equals 1 K exactly.
amount of substance	mole	mol	The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles. (14th CGPM, 1971)
luminous intensity	candela	cd	The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radian intensity in that direction of 1/683 watt per steradian. (16th CGPM, 1979)

15.3.3 SI SUPPLEMENTARY UNITS

The General Conference has not yet classified certain units either as base units or derived units. These SI units are assigned to a third class called “supplementary units” and may be regarded either as base units or as derived units. They are the unit of plane angle, the radian and the unit of solid angle, the steradian. Both are purely geometric.

The radian is the plane angle between two radii of a circle that cut off, on the circumference, an arc equal in length to the radius. (Figure 1)

The steradian is the solid angle that, having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere. (Figure 2)

15.3.4 DERIVED UNITS

Derived units are expressed algebraically in terms of base units with the mathematical symbols for multiplication and division. Several derived units have been give special names and symbols which may themselves be used to express other derived units in a simpler way than in terms of the base units. Examples of derived units are given in Table 1. Examples of derived units with special names are given in Table 2.

15.3.5 OTHER ALLOWABLE UNITS

There are a number of other units which, while not a part of SI, are nevertheless important and widely used and which will often be used along with SI units. Examples are the minute, hour, day and year as units of time (in addition to the second); degree, minute and second of arc (in addition to radian); the metric ton (which equals 1000 kilograms); the liter (which equals 1 cubic decimeter); the nautical mile; and the knot. All “other allowable” units given in the accompanying tables (15.5) of conversion factors are listed and defined in 15.4.13.

15.3.6 DECIMAL MULTIPLES AND SUBMULTIPLES OF SI UNIT

The prefixes listed in Table 3 are used with SI units. Depending on the magnitude of the quantity to be measured, use of the appropriate prefixes (those representing powers divisible by 3 are preferred) makes it possible to keep the numbers to be handled within a convenient range. Prefixes generally should be chosen so that the range will be from 0.1 to 1 000.

Table 1—Examples of SI Derived Units

Quantity	SI Unit Name	SI Unit Symbol
area	square meter	m^2
volume	cubic meter	m^3
speed, velocity	meter per second	m/s
acceleration	meter per second squared	m/s^2
wave number	reciprocal meter	m^{-1}
mass density (density)	kilogram per cubic meter	kg/m^3
specific volume	cubic meter per kilogram	m^3/kg
current density	ampere per square meter	A/m^2
magnetic field strength	ampere per meter	A/m
concentration (of amount of substance)	mole per cubic meter	mol/m^3
luminance	candela per square meter	cd/m^2
mass fraction	kilogram per kilogram, which may be represented by the number 1	kg/kg = 1
catalytic (activity) concentration	katal per cubic meter	kat/m^3

Table 2—SI Derived Units with Special Names

Quantity	SI Unit Name	Symbol	Expression in Terms of Other SI Units	Expression in Terms of SI Base Units
plane angle	radian	rad		$m \cdot m^{-1} = 1$
solid angle	steradian	sr		$m^2 \cdot m^2 = 1$
frequency	hertz	Hz		s^{-1}
force	newton	N		$m \cdot kg \cdot s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1} \cdot kg \cdot s^{-2}$
energy, work, quantity of heat	joule	J	$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$
power, radiant flux	watt	W	J/s	$m^2 \cdot kg \cdot s^{-3}$
electric charge, quantity of electricity	coulomb	C		$s \cdot A$
electric potential, potential differences, electromotive force	volt	V	W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
capacitance	farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$
electric resistance	ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$
electric conductance	siemens	S	A/V	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$
magnetic flux	webber	Wb	$V \cdot s$	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$
inductance	henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$
Celsius temperature	degree Celsius	°C		K
luminous flux	lumen	lm	$cd \cdot sr$	$m^2 \cdot m^{-2} \cdot cd = cd$
illuminance	lux	lx	lm/m^2	$m^2 \cdot m^{-4} \cdot cd = m^{-2} \cdot cd$
activity (of a radionuclide)	becquerel	Bq		s^{-1}
absorbed dose, specific energy (imparted), kerma	gray	Gy	J/kg	$m^2 \cdot s^{-2}$
dose equivalent, ambient dose equivalent, directional dose equivalent, personal dose equivalent, equivalent dose	sievert	Sv	J/kg	$m^2 \cdot s^{-2}$
catalytic activity	katal	kat	$s^{-1} \cdot mol$	$m^3 \cdot s^{-1} \cdot mol$

Table 3—SI Prefixes

Factor	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}	deka	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

15.3.7 USE OF LETTER SYMBOLS

The distinction between upper case and lower case symbols is very important. For instance:

K = kelvin

k = kilo = 10^3

M = mega = 10^6

m = milli = 10^{-3} (when m is used as a prefix)

m = meter (when m is used alone)

N = newton

n = nano = 10^{-9}

The problem of how to handle situations where both upper case and lower case characters are not available (computers, for instance) has been studied by API and others. Recommendations have been agreed upon and are documented in ISO 2955 [11]. Where a compound units includes a unit symbol that is also a symbol for a prefix, special care must be taken to avoid confusion. For example, the unit newton meter for torque should be written N · m to avoid confusion with mN, the millinewton.

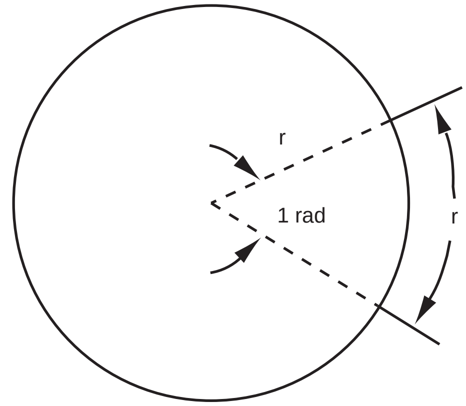


Figure 1—Radian

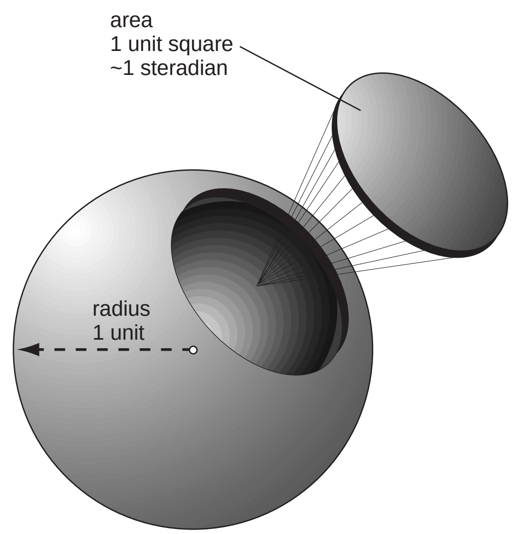


Figure 2—Steradian

15.4 Use of Conversion Tables in Section 15.5

15.4.1 CATEGORIES

The tables of units and conversion factors in 15.5 have been grouped into the following categories:

1. Space, Time
2. Mass, Amount of Substance
3. Heating Valve, Entropy, Heat Capacity
4. Temperature, Pressure, Vacuum
5. Density, Specific Volume, Concentration, Dosage
6. Facility Throughput, Capacity
7. Flow Rate
8. Energy, Work, Quantity of Heat, Power
9. Mechanics
10. Transport Properties
11. Electricity, Magnetism
12. Acoustics, Light, Radiation

15.4.2 CORRECTIONS

The tables of 15.5 have been reviewed and edited by API and are distributed for general API use. Any mathematical or typographical error should be brought to the attention of the API Standardization Manager at standards@api.org.

15.4.3 PREFERRED UNITS

The metric units recommended for general use are shown under heading “API preferred metric unit.” In most but not all cases, these conform to SI practice. The major exceptions are listed in 15.4.12. Where conversion factors for the quantity expressed in inch-pound units are shown with more than one metric unit, the unit in the “preferred” column is expected to have more general application; other units that also may be needed are shown in the other “other allowable” column. *Preferred units do not preclude the use of other multiples or submultiples, as the choice of such unit-multiple is governed by the magnitude of the numerical value.*

15.4.4 EQUIVALENT UNITS

Where units appear side-by-side in the “preferred and “other allowable” columns, they are equivalent and the latter unit is an acceptable alternative designation.

15.4.5 NOTATION

Notation conforms to SI practice; that is, groups of three digits to the left or right of the decimal marker are separated by spaces—no commas or other triad spacers are used. Exponential (E) notation was chosen for convenience because it is a standard method of display in may calculators, because of the inability of computers to print out or transmit superscripts, and because this notation already is used widely in standards. An asterisk (*) indicates that all of the succeeding digits are zeros. If a conversion factor happens to end in a zero but does not have an asterisk, then any subsequent digits would not necessarily be zeros.

Thus,

$3.048\ 0 \text{ E} + 00 = 3.048\ 0 \times 10^0 = 3.048\ 0$

$3.048^* \text{ E} - 01 = 3.048\ 000 \times 10^{-1} = 0.304\ 800\ 0$

$9.290\ 304 \text{ E} + 02 = 9.290\ 304 \times 10^2 = 929.030\ 4$

Conversion factors are derived by using exact values of the following:

1 lb = 4.535 923 7 E – 01 kg

1 ft = 3.048 E – 01 m

1 Fahrenheit degree = ($^5/_9$) kelvin

1 cal_{th} = 4.184 E + 00 J

1 Btu_{IT} = 1.055 055 852 62 E + 03 J

1 a = 365 d = 3.153 6 E + 07 s

g_n = 9.806 65 E + 00 m/s^2

15.4.6 SIGNIFICANT DIGITS

Most of the conversion factors are shown to six or seven significant digits, which are more than adequate for most applications. Those shown to fewer than six significant figures are limited by the precision of the known or determinable value of a physical property. The subjects of precision and round-off procedures are covered in references 2, 3, and 15.

15.4.7 HORSEPOWER, CALORIE & BTU

The quantity horsepower, unless noted otherwise, refers to the mechanical horsepower of 550 ft-lbf/s; calorie refers to the thermochemical calorie; British thermal unit (Btu) refers to the International Steam Tables (IT) Btu.

Thermochemical Unit × 0.999 331 2 = IT Unit
(Btu or Calorie)

15.4.8 REFERENCE CONDITIONS

The standard reference conditions of pressure and temperature for use in measurements of petroleum and its products (both liquid and gaseous) are 101.325 kilopascals and 15°C. Exceptions are liquid hydrocarbons with vapor pressure greater than atmospheric at 15°C, in which case the standard pressure is the equilibrium pressure at 15°C. For specialized applications in the gas industry, see reference 7.

15.4.9 AMOUNT OF SUBSTANCE

When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such participles. This definition is essentially identical to the old definition of the gram mole. However, since the kilogram is the SI unit of mass, it is recommended that the Kilomole (which is equal to 1 000 mole) be the unit for the amount of substance in those applications where gram mole has been conventionally used. Some commercial applications continue to use non-SI approaches to indicate amount of substance. For example, fuel gas measurements may be expressed in cubic meters of dry gas at a specified temperature and pressure.

15.4.10 DENSITY

The preferred measure of density in SI units is absolute density (kilograms per cubic meter) at 15°C and 101.325 kilopascals (standard atmospheric pressure). API gravity is not used within the SI system. The term ‘specific gravity’ is replaced by ‘relative density’. While relative density is used as a measure of density in both the SI and U.S. Customary systems, the reference conditions are different. The preferred reference conditions in SI units are 15°C and 101.325 kilopascals for the fluid being measured and the reference fluid (water or air for liquids and gases respectively) and is represented as (15°C/15°C).

Watson (UOP) characterization factor is to be redefined so that present numerical values are retained for correlation usage as follows:

$$K_W = \frac{1000\sqrt[3]{1.8BP}}{\text{density at } 15°\text{C}}$$

where

K_W = Watson Characterization factor,

BP = mean average boiling point in kelvins.

Specific gravity is to be replaced by relative density at 15°C and 101.325 kilopascals, where the reference fluids for liquids and gases are water and air, respectively.

15.4.11 ATTACHMENTS TO UNITS

Section 3.5.5 of references 2, 3, and 4 prohibits attaching letters to a unit symbol to give information about the quantity under consideration. For this reason, no attempt should be made to construct SI equivalents of the abbreviations "psia" and "psig," which traditionally have been used to distinguish between absolute and gage pressure. If the context leaves any doubt which type of pressure is meant, the word pressure should be qualified appropriately. For example, "… a gage pressure of 19 kilopascals" or "… an absolute pressure of 120 kilopascals." In instances where space does not permit writing out "gage pressure" or "absolute pressure," for example, on instrument faces, the notation kPa (ga) and kPa (abs) may be used.

15.4.12 EXCEPTIONS

The major exceptions to SI practice are as follows:

1. Length—The nautical mile is permitted for marine and aeronautical applications.
2. Time— Along with the second, the units hour, day, and year are allowable.
3. Velocity— The knot is permitted for marine and aeronautical applications.
4. Plane angle—In surveying, navigation, drafting, and so forth, angles may continue to be express in degree, minute, and second (°, ′, ″) or in decimalized degrees and need not be converted to radians. For calculations involving rotational motion, radians are preferred.
5. Pressure—The bar (which equals 10^5 pascals) is an allowable unit. Prefixes should not be used with the bar.
6. Volume—The special name liter (L) has been approved for the cubic decimeter (dm^3) but its use is restricted to the measurement of liquids and gases. The only prefixes that may be used with the liter are milli and micro. Thus, mL and μL.
7. Viscosity—Centipoise (cP) and centistokes (cSt) are acceptable as names for millipascal seconds (mPa · s) and square millimeters per second (mm^2/s), respectively.

15.4.13 NOMENCLATURE

			Definition		
Symbol	Name	Quantity	In Terms of Other Units	In Terms of Base Units	Type of Unit
A	ampere	electric current	—	—	base
a	annum (year)	time (see 15.5, note 5)	365 d	$3.153\,600 \times 10^7$s	allowable
bar	bar	pressure	10^5Pa	10^5 kg/(m · s^2)	allowable
Bq	becquerel	activity (of a radionuclide)	—	1 s^{-1}	derived
C	coulomb	quantity of electricity, electric charge	—	1 A · s	derived
°C	degree Celsius	Celsius temperature	(see 15.3.2)	—	derived
cd	candela	luminous intensity	—	—	base
cP	centipoise	dynamic viscosity	1 mPa · s	10^{-3}(kg/(m · s)	allowable
cSt	centistokes	kinematic viscosity	1 mm^2/s	10^{-6} m^2/s	allowable
D	darcy	permeability (of porous media)	—	1μm^2	allowable
d	day	time (see 15.5, note 5)	24 h	8.640×10^4s	allowable
F	Farad	capacitance	1 C/V	1 s^4 A^2/(m^2 · kg)	derived
g	gram	mass	—	10^{-3} kg	allowable (submultiple of base unit)
Gy	gray	absorbed dose, specific energy imparted, kerma, absorbed dose index	1 J/kg	1 m^2/s^2	derived

Symbol	Name	Quantity	Definition: In Terms of Other Units	Definition: In Terms of Base Units	Type of Unit
h	hour	time (see 15.5, note 5)	60 min	3.6×10^3 s	allowable
H	henry	inductance	1 Wb /A	1 $m^2 \cdot kg/(s^2 \cdot A^2)$	derived
ha	hectare	area	—	10^4 m^2	allowable
Hz	hertz	frequency (of periodic phenomenon)	—	1 s^{-2}	derived
J	joule	work, energy, quantity of heat	1 N · m	1 $m^2 \cdot kg/s^2$	derived
K	kelvin	thermodynamic temperature	—	—	base
Kat	katl	catalytic activity	—	$s^{-1} \cdot$ mol	derived
kg	kilogram	mass	—	—	base
kn	knot	velocity	1.852 km/h	5.144 444 m/s	allowable
L	liter	volume	1 dm^3	10^{-3} m^3	allowable
lm	lumen	luminous flux	—	1 cd · sr	derived
lx	lux	illumination	1 lm/m^2	1 cd · sr/m^2	derived
m	meter	length	—	—	base
min	minute	time (see 15.5, note 5)	—	60 s	allowable
mol	mole	amount of substance	(see 15.4.9)	—	base
N	newton	force	—	1 m · kg/s^2	derived
naut. mi.	nautical mile	distance	1.852 km	1.852×10^3 m	allowable
Pa	pascal	pressure	1 N/m^2	1 $kg/(m \cdot s^2)$	derived
r	revolution	angular displacement	360°	2π rad	allowable
rad	radian	plane angle	—	—	supplementary
S	siemens	conductance	1 A/V	1 $s^3 \cdot A^2/(m^2 \cdot kg)$	derived
s	second	time	—	—	base
sr	steradian	solid angle	—	—	supplementary
Sv	sievert	dose equivalent	1 J/kg	1 m^2/s^2	derived
t	metric ton	mass	1 Mg	10^3 kg	allowable
T	tesla	magnetic flux density	1 Wb/m^2	1 $kg/(s^2 \cdot A)$	derived
V	volt	electric potential, potential difference, electromotive force	1 W/A	1 $m^2 \cdot kg/(s^3 \cdot A)$	derived
W	watt	power, radiant flux	1 J/s	1 $m^2 \cdot kg/s^3$	derived
Wb	weber	magnetic flux	1 V · s	1 $m^2 \cdot kg/(s^3 \cdot A)$	derived
Ω	ohm	electric resistance	1 V/A	1 $m^2 \cdot kg/(s^3 \cdot A^2)$	derived
°	degree	plane angle	—	π/180 rad	allowable
′	minute	plane angle	(1/60)°	$2.908\,882 \times 10^{-4}$ rad	allowable
″	second	plane angle	(1/60)′	$4.848\,137 \times 10^{-6}$ rad	allowable

Notes to Section 15.5

1. Based on U.S. survey foot rather than the international foot

   1 U.S. survey foot = $\frac{1200}{3937}$ meter (exactly)
   1 international foot = 0.3048 meter (exactly)
   1 U.S. statute mile = 2580 U.S. survey feet

2. The cubem (cubic mile) is used in the measurement of very large volumes, such as the content of a sedimentary basin.

3. In surveying, navigation, and so forth, angles will, no doubt, continue to be measured with instruments that read in degrees, minutes, and seconds and need not be converted into radians; for calculations involving rotational energy, radians are preferred.

4. The unit of a million years is used in geochronology. At the present time, abbreviations such as MY or mmy are used. The mega-annum is the preferred unit, but as many simply prefer to use mathematical notation (that is, $\times 10^6$).

5. The year as defined in these tables is the calendar year, equivalent to exactly 365 mean solar days. For some purposes, the use of other years such as the sidereal year or the tropical year may be more appropriate. The conversion factors for years to seconds are as follows:

Calendar year	3.153 600*	E+07
Sidereal year	3.155 815	E+07
Tropical year	3.155 693	E+07

6. The conversion factor is for an ideal gas, calculated by using a value of 8.314 41 J/(mol · K), which has a standard deviation of 0.000 26 J/(mol · K), for the molar gas constant [13]. The converted quantity, therefore, should be rounded to an appropriate number of significant digits commensurate with the precision of the original measurement, but in no case to more than five.

7. The special name liter (symbol L) has been approved for the cubic decimeter (symbol dm^3) but use of this unit is restricted to the measurement of liquids and gases.

8. The use of the bar should be limited to physical measurement (for example, pressure gages); however, the kilopascal is preferred. It is recommended that only the pascal or standard multiples (kPa, MPa) be used in calculations.

9. Subsurface pressures can be measured in megapascals or as freshwater heads in meters. If the latter approach is adopted, the hydrostatic gradient becomes dimensionless.

10. See Table 3 of the ASTM-IP Petroleum Measurement Tables (ASTM D 1250, IP 200, API Standard 2540, ANSI Z11.83, ISO R91). The 1952 edition of the ASTM-IP tables converts API gravity at 60°F to density (kg/L) at 15°C, and an additional conversion kg/L to kg/m^3 is necessary. The 1980 edition of the ASTM-IP tables uses density in kg/m^3.

11. Quantities listed under "Facility Throughput, Capacity" are to be used only for characterizing the size or capacity of a plant or piece of equipment. Quantities listed under "Flow Rate" are for use in design calculation.

12. 1 therm = 100 000 Btu (IT). However, consumption of natural gas in the United States normally is expressed in therms based on the value of the Btu (59°F) (*Federal Register*, Vol. 33, No. 146, July 27, 1968). In this case, the conversion factor from therm to megajoule is 1.054 804 E+02.

13. Based on 550 ft · lbf/s horsepower.

14. ch · h or CV · h = cheval vapeur-hour ("metric" horsepower-hour).

15. Chu (Centigrade heat unit) is the quantity of heat required to raise 1 pound of water 1 degree Celsius.

16. ch or CV = cheval vapeur or "metric" horsepower; 1 ch = 1 CV = 75 kgf · m/s.

17. Seismic velocities will be expressed in m/ms (which has the same value as km/s) because the records are calibrated in milliseconds.

18. The reciprocal velocity unit is used in sonic logging work.

19. The centipoise (cP) is an acceptable name for the millipascal second (mPa · s), and

$$1 \text{ cP} = 1 \text{ mPa} \cdot \text{s}$$

   The centistokes (cSt) is an acceptable name for the square millimeter per second (mm^2/s), and

$$1 \text{ cSt} = 1 \text{ mm}^2/\text{s}$$

   The following special names for non-SI viscosity units are not acceptable SI practice.

   poise (P), where 1 P = 1 dyn · s/cm^2
   stokes (St), where 1 St = 1 cm^2/s
   reyn, where 1 reyn = 1 lbf · s/in^2

20. The SI unit for intrinsic permeability (of porous media to fluids) is the m^2. In practice, the μm^2 is a more convenient unit. This working unit is called the darcy (D). In 1978, the API redefined the darcy as being exactly equal to 1 μm^2. Previously, it had the value of $0.986\,923 \times 10^{-12}$ m^2. The full definition of the darcy is as follows:

   > The darcy is a unit of permeability in fluid flow through a porous medium, having the dimensions of dynamic viscosity multiplied by volume flow rate per unit area and divided by pressure gradient,

which simplifies to a dimension of area. A darcy is defined as being exactly equal to 1μm^2.

A permeability of one darcy will permit a flow of 1 m^3/s of fluid of 1 Pa · s viscosity through an area of 1 m^2 under a pressure gradient of 10^{12} Pa/m:

$$1\ \text{D} = 10^{-12}\ \text{Pa} \cdot \text{s}\ [\text{m}^3/(\text{s} \cdot \text{m2})]\ (\text{m/Pa})$$
$$= 10^{-12}\ \text{Pa} \cdot \text{s}\ (\text{m/s})\ (\text{m/Pa})$$
$$= 10^{-12}\ \text{m}^2 = 1\ \mu\text{m}^2$$

21. The ohm meter is used in borehole geophysical devices.

22. Reference level for sound power (acoustical power is 1 pW.

$$L_w = 10 \log_{10} \left(\frac{\text{actual power in W}}{10^{-12}}\right)$$

where

L_w = sound power level expressed in decibels (dB).

23. Reference level for sound pressure is 20 μ Pa. Sound pressure is shown in decibels (dB) based upon a logarithmic scale.

$$L_p = 20 \log_{10} \left(\frac{\text{actual power in Pa}}{20 \times 10^{-6}}\right)$$

15.5 Tables of Recommended SI Units and Conversion Factors

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
SPACE, TIME							
Length	m	naut. mi	km		1.852*	E + 00	
				naut.mi	1		
		mi	km		1.609 344*	E + 00	
		mi (U.S. statute)	km		1.609 347	E + 00	1
		chain	m		2.011 684	E + 01	1
		rod	m		5.029 210	E + 00	1
		fathom	m		1.828 804	E + 00	1
		m	m		1		
		yard	m		9.144*	E – 01	
		ft	m		3.048*	E – 01	
		ft (U.S. survey)	m		3.048 006	E – 01	1
		link	m		2.011 684	E – 01	1
		in.	mm		2.54*	E + 01	
				cm	2.54*	E + 00	
		cm	mm		1.0*	E + 01	
				cm	1		
		mm	mm		1		
		mil	µm		2.54*	E + 01	
		micron (µ)	µm		1		
Surface Texture	m	min	µm		2.54*	E – 02	
		nm	µm		1.0*	E – 03	
Length/Length	m/m	ft/mi	m/km		1.893 939	E – 01	
Length/Volume	m/m^3	ft/U.S. gal	m/m^3		8.051 964	E + 01	
		ft/ft^3	m/m^3		1.076 391	E + 01	
		ft/bbl	m/m^3		1.917 134	E + 00	
Length/Temperature	m/K	See "Temperature, Pressure, Vacuum"					
Area	m^2	mi^2	km^2		2.589 988	E + 00	
		mi^2 (U.S. statute)	km^2		2.589 998	E + 00	1
		ha	m^2		1.0*	E + 04	
		acre	ha		4.046 873	E – 01	1
				m^2	4.046 873	E + 03	1
		sq chain	m^2		4.046 873	E + 02	1
		sq rod	m^2		2.529 295	E + 01	1
		yd^2	m^2		8.361 274	E – 01	
		ft^2	m^2		9.290 304*	E – 02	
		ft^2 (U.S. survey)	m^2		9.290 341	E – 02	1
		in^2	mm^2		6.451 6*	E + 02	
				cm^2	6.451 6*	E +00	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
SPACE, TIME (CONTINUED)							
Area (continued)		cm^2	mm^2		1.0*	E + 02	
				cm^2	1		
		mm^2	mm^2		1		
Area/Volume	m^2/m^3	$ft^2/in.^3$	m^2/cm^3		5.669 291	E–03	
Area/Mass	m^2/kg	cm^2/g	m^2/kg		1.0*	E–03	
Volume, Capacity	m^3	cubem	km^3		4.168 182	E+00	2
		acre · ft	m^3		1.233 489	E+03	1
				ha · m	1.233 489	E–01	1
		m^3	m^3		1		
		yd^3	m^3		7.645 549	E–01	
		bbl (42 U.S. gal)	m^3		1.589 873	E–01	
		ft^3	m^3		2.831 685	E–02	
			dm^3	L	2.831 685	E+01	
Volume, Capacity	m^3	Can. gal	m^3		4.546 09*	E–03	
			dm^3	L	4.546 09*	E+00	
		U.K. gal	m^3		4.546 092	E–03	
			dm^3	L	4.546 092	E+00	
		U.S. gal	m^3		3.785 412	E–03	
			dm^3	L	3.785 412	E+00	
		L	dm^3	L	1		
		U.K. qt	dm^3	L	1.136 523	E+00	
		U.S. qt	dm^3	L	9.463 529	E–01	
		U.K. pt	dm^3	L	5.682 615	E–01	
		U.S. pt	dm^3	L	4.731 765	E–01	
		U.K. fl oz	cm^3		2.841 306	E+01	
		U.S. fl oz	cm^3		2.957 353	E+01	
		$in.^3$	cm^3		1.638 706	E+01	
		mL	cm^3		1		
Volume/Length	m^3/m	bbl/in.	m^3/m		6.259 342	E+00	
		bbl/ft	m^3/m		5.216 119	E–01	
		ft^3/ft	m^2/m		9.290 304*	E–02	
		U.S. gal/ft	dm^3/m	L/m	1.241 933	E+01	
Volume/Mass	m^3/kg	See “Density, Specific Volume, Concentration, Dosage”					
Plane Angle	rad	Rad	rad		1		
		deg (°)	rad		1.745 329	E–02	3
				°	1		3
		min (′)	rad		2.908 822	E–04	3
				′	1		3
		sec (″)	rad		4.848 137	E–06	3
				″	1		3

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
SPACE, TIME (CONTINUED)							
Solid Angle	sr	sr	sr		1		
Time	s	million years (MY)	Ma		1		4
		yr	a		1		5
		wk	d		7.0*	E+00	
		d	d		1		
		h	h		1		
				min	6.0*	E+01	
		min	s		6.0*	E+01	
				h	1.666 66	E–02	
				min	1		
		s	s		1		
		millimicrosecond	ns		1		

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent	Notes See p. 9
MASS, AMOUNT OF SUBSTANCE						
Mass	kg	U.K. ton (long ton)	Mg	t	1.016 047 E+00	
		U.S. ton (short ton)	Mg	t	9.071 847 E–01	
		U.K. cwt	kg		5.080 235 E+01	
		U.S. cwt	kg		4.535 924 E+01	
		kg	kg		1	
		lb	kg		4.535 924 E–01	
		oz (troy)	g		3.011 348 E+01	
		oz (avdp)	g		2.834 952 E+01	
		g	g		1	
		grain	mg		6.479 891 E+01	
		mg	mg		1	
		µg	µg		1	
Mass/Length	kg/m	See “Mechanics”				
Mass/Area	kg/m^2	See “Mechanics”				
Mass/Volume	kg/m^3	See “Density, Specific Volume, Concentration, Dosage”				
Mass/Mass	kg/kg	See “Density, Specific Volume, Concentration, Dosage”				
Amount of Substance	mol	ft^3 (60°F, 1 atm.)	kmol		1.195 29 E–03	6
		ft^3 (60°F, 14.73 $lbf/in.^2$	kmol		1.198 06 E–03	6
		m^3 (0°C, 1 atm)	kmol		4.461 53 E–02	6
		m^3 (15°C, 1 atm)	kmol		4.229 28 E–02	6
		m^3 (20°C, 1 atm)	kmol		4.157 15 E–02	6
		m^3 (25°C, 1 atm)	kmol		4.087 43 E–02	6

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
HEATING VALUE, ENTROPY, HEAT CAPACITY							
Heating Value	J/kg	Btu/lb	MJ/kg		2.326 000	E–03	
			kJ/kg	J/g	2.326 000	E+00	
				kW · h/kg	6.461 112	E–04	
		cal/g	kJ/kg	J/g	4.184*	E+00	
		cal/lb	J/kg		9.224 141	E+00	
Heating Value (Mole Basis)	J/mol	kcal/g mol	kJ/kmol		4.184*	E+03	
		Btu/lb mol	MJ/kmol		2.326 000	E–03	
			kJ/kmol		2.326 000	E+00	
Heating Value (Volume Basis—Solids and Liquids)	J/m^3	Therm/U.S. gal	MJ/m^3	kJ/dm^3	2.787 163	E+04	7, 12
			kJ/m^3		2.787 163	E+07	
				kW · h/dm^3	7.742 119	E+00	7
		Therm/U.K. gal	MJ/m^3	kJ/dm^3	2.320 798	E+04	
			kJ/m^3		2.320 798	E+07	
				kW · h/dm^3	6.466 660	E+00	
		Therm/Can. gal	MJ/m^3	kJ/dm^3	2.320 799	E+04	7, 12
			kJ/m^3		2.320 799	E+07	
				kW · h/dm^3	6.466 663	E+00	7
		Btu/U.S. gal	MJ/m^3	kJ/dm^3	2.787 163	E–01	7
			kJ/m^3		2.787 163	E+02	
				kW · h/m^3	7.742 119	E–02	
		Btu/U.K. gal	MJ/m^3	kJ/dm^3	2.320 800	E–01	7
			kJ/m^3		2.320 800	E+02	
				kW · h/m^3	6.446 660	E–02	
		Btu/Can. gal	MJ/m^3	kJ/dm^3	2.320 799	E–01	7
			kJ/m^3		2.320 799	E+02	
				kW · h/m^3	6.446 663	E–02	
		Btu/ft^3	MJ/m^3	kJ/dm^3	3.725 895	E–01	7
			kKJ/m^3		3.725 895	E+02	
				kW · h/m^3	1.034 971	E–02	
		kcal/m^3	MJ/m^3		4.184*	E–03	7
			kJ/m^3		4.184*	E+00	
		cal/mL	MJ/m^3		4.184*	E+00	
		ft · lbf/U.S. gal	kJ/m^3		3.581 692	E–01	
Heating Value (Volume Basis—Gases)	J/m^3	cal/mL	kJ/m^3	J/dm^3	4.184*	E+03	7
		kcal/m	kJ/m^3	J/dm^3	4.184*	E+00	7
		Btu/ft^3	kJ/m^3	J/dm^3	3.725 895	E+01	7

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
HEATING VALUE, ENTROPY, HEAT CAPACITY (CONTINUED)							
Specific Entropy	J/(kg·K)	Btu/(lb · °R)	kJ/(kg · K)	J/(g · K)	4.186 8*	E+00	
		cal/(g · K)	kJ/(kg · K)	J/(g · K)	4.184*	E+00	
		kcal/(kg · °C)	kJ/(kg · K)	J/(g · K)	4.184*	E+00	
Specific Heat Capacity (Mass Basis)	J/(kg·K)	kW·h/(kg · °C)	kJ/(kg · K)	J/(g · C)	3.6*	E+03	
		Btu/(lb · °F)	kJ/(kg · K)	J/(g · C)	4.186 8*	E+00	
		kcal/(kg · °C)	kJ/(kg · K)	J/(g · C)	4.184*	E+00	
Molar Heat Capacity	J/(mol·K)	Btu/(lb mol · °F)	kJ/(kmol·K)	J/(g · C)	4.186 8*	E+00	
		cal/(g mol · °C)	kJ/(kmol·K)	J/(g · C)	4.184*	E+00	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
TEMPERATURE, PRESSURE, VACUUM							
Temperature (Absolute)	K	°R K	K K		5/9 1		
Temperature (Traditional)	K	°F °C	°C °C		(°F–32)/1.8 1		
Temperature (Difference)	K	°F °C	K K	°C °C	5/9 1		
Temperature/Length (Geothermal Gradient)	K/m	°F/100 ft	mK/m		1.822 689	E+01	
Length/ Temperature (Geothermal Step)	m/K	ft/°F	m/K		5.486 4*	E–01	
Pressure	Pa	atm (14.696 lbf/in.^{2} or 760 mmHg at 0°C)	Mpa kPa	 bar	1.013 250* 1.013 250* 1.013 250*	E–01 E+02 E+00	
		bar	Mpa kPa	 bar	1.0* 1.0* 1	E–01 E+02	8
		at (kgt/cm^2) (technical atmosphere)	Mpa kPa	 bar	9.806 650* 9.806 650* 9.806 650*	E–02 E+01 E–01	
		lbf/in.^{2} (psi)	mPa kPa	 bar	6.894 757 6.894 757 6.894 757	E–03 E+00 E–02	
		inHg at 60°F inHg at 32°F inH$_2$0 at 39.2°F inH$_2$0 at 60°F	kPa kPa kPa kPa		3.376 85 3.386 38 2.490 82 2.488 4	E+00 E+00 E–01 E–01	
		mmHg at 0°C (torr) cmH$_2$0 at 4°C	kPa kPa		1.333 22 9.806 38	E–01 E–02	
		lbf/ft^2 (psf) µmHg at 0°C	kPa Pa		4.788 026 1.333 22	E–02 E–01	
		µbar dyn/cm^2	Pa Pa		1.0* 1.0*	E–01 E–01	
Vacuum, Draft	Pa	inHg at 60°F inH$_2$0 at 39.2°F inH$_2$0 at 60°F	kPa kPa kPa		3.376 85 2.490 82 2.488 4	E+00 E–01 E–01	
		mmHg at°C (torr) cmH$_2$0 at 4°C	kPa kPa		1.333 22 9.806 38	E–01 E–02	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
TEMPERATURE, PRESSURE, VACUUM (CONTINUED)							
Liquid Head	m	ft	m		3.048*	E–01	
		in.	mm		2.54*	E+01	
Pressure Drop/Length	Pa/m	psi/ft	kPa/m		2.262 059	E+01	9
		psi/100 ft	kPa/m		2.262 059	E–01	
		psi/mi	kPa/km		4.284 203	E+00	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
DENSITY, SPECIFIC VOLUME, CONCENTRATION, DOSAGE							
Density (Gases)	kg/m^3	lb/ft^3	kg/m^3		1.601 846	E+01	
Density (Liquids)	kg/m^3	lb/U.S. gal	kg/m^3		1.198 264	E+02	
				kg/dm^3	1.198 264	E–01	7
		lb/U.K. gal	kg/m3		9.977 633	E+01	
				kg/dm^3	9.977 633	E–02	7
		lb/ft^3	kg/m^3		1.601 846	E+01	
				kg/dm^3	1.601 846	E–02	7
		g/cm^3	kg/m^3		1.0*	E+03	
				kg/dm^3	1		7
		kg/L	kg/m^3		1.0*	E+03	
		°API	kg/m^3		Use tables		10
Density (Solids)	kg/m^3	lb/ft^3	kg/m^3		1.601 846	E+01	
				kg/dm^3	1.601 846	E–02	
Specific Volume (Gases)	m^3/kg	ft^3/lb	m^3/kg	dm^3/kg	6.242 796	E–02	
					6.242 796	E+01	7
Specific Volume (Liquid)	m^3/kg	ft^3/lb	m^3/kg		6.242 796	E–02	
				dm^3/kg	6.242 796	E+01	7
		U.K. gal/lb	m^3/kg		1.002 242	E–02	
				dm^3/kg	1.002 242	E+01	7
		U.S. gal/lb	m^3/kg		8.345 404	E–03	
				dm^3/kg	8.345 404	E+00	7
Molar Volume (Clay Yield)	m^3/kg	L/g mol	$m^3/kmol$		1		
		ft^3/lb mol	$m^3/kmol$		6.242 796	E–02	
Specific Volume (Clay Yield)	m^3/kg	bbl/U.S. ton	m^3/Mg	m^3/t	1.752 535	E–01	7
		bbl/U.K. ton	m^3/Mg	m^3/t	1.564 763	E–01	7
Yield (Shale Distillation)	m^3/kg	bbl/U.S. ton	dm^3/Mg	dm^3/t	1.752 535	E+02	7
		bbl/U.K. ton	dm^3/Mg	dm^3/t	1.564 763	E+02	7
		U.S. bbl/U.S. ton	dm^3/Mg	dm^3/t	4/172 702	E+00	7
		U.K. bbl/U.K. ton	dm^3/Mg	dm^3/t	3.725 627	E+00	7
Concentration (Mass/Mass)	kg/kg	wt %	kg/kg		1.0*	E–02	
			g/kg		1.0*	E+01	
		wt ppm	mg/kg		1		
Concentration (Mass/Volume)	kg/m^3	lb/bbl	kg/m^3	g/dm^3	2.853 010	E+00	7
		g/U.S. gal	kg/m^3		2.641 720	E–01	
		g/U.K. gal	kg/m^3		2.199 692	E–01	
		lb/1000 U.S. gal	g/m^3	mg/dm^3	1.198 264	E+02	7
		lb/1000 U.K. gal	g/m^3	mg/dm^3	9.977 633	E+01	7
		grains/U.S. gal	g/m^3	mg/dm^3	1.711 806	E+01	7

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
DENSITY, SPECIFIC VOLUME, CONCENTRATION, DOSAGE (CONTINUED)							
Concentration (continued) (Mass/Volume)		lb/1000 bbl	g/m^3	mg/dm^3	2.853 010	E+00	7
		mg/U.S. gal	g/m^3	mg/dm^3	2.641 720	E–01	7
		grains/100 ft^3	mg/m^3		2.288 342	E+01	
		grains/ft^3	mg/m^3		2.288 352	E+03	
Concentration (Volume/Volume)	m^3/m^3	bbl/bbl	m^3/m^3		1		
		ft^3/ft^3	m^3/m^3		1		
		bbl/(acre·ft)	dm^3/m^3	L/m^3	1.288 923	E–01	1
		U.K. gal/ft^3	dm^3/m^3	L/m^3	1.605 437	E+02	
		U.S. gal/ft^3	dm^3/m^3	L/m^3	1.336 806	E+02	
		mL/U.S. gal	dm^3/m^3	L/m^3	2.641 720	E–01	
		mL/U.K. gal	dm^3/m^3	L/m^3	2.199 692	E–01	
		Vol %	m^3/m^3		1.0*	E–01	
		Vol ppm	cm^3/m^3		1		
			dm^3/m^3	L/m^3	1.0*	E–03	
		U.K. gal/1000 bbl	cm^3/m^3		2.859 406	E+01	
		U.S. gal/1000bbl	cm^3/m^3		2.380 952	E+02	
Concentration (Mole/Volume)	mol/m^3	lb mol/U.S. gal	$kmol/m^3$		1.198 406	E+02	
		lb mol/U.K. gal	$kmol/m^3$		9.977 633	E+01	
		1lb mol/ft^3	$kmol/m^3$		1.601 846	E+01	
		std. ft^3 (60°F, 1 atm)/bbl	$kmol/m^3$		7.518 18	E–03	6
Concentration (Volume/Mole)	m^3/mol	U.S. gal/1000 std. ft^3 (60°F/60°F)	$dm^3/kmol$	L/kmol	3.166 93	E+00	6
		bbl/million std. ft^3 (60°F/60°F)	$dm^3/kmol$	L/kmol	1.330 11	E–01	6

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
FACILITY THROUGHPUT, CAPACITY							
Throughput (Mass Basis)	kg/s	Million lb/yr	Mg/a	t/a	4.535 924	E+02	
		U.K. ton/yr	Mg/a	t/a	1.016 047	E+00	
		U.S. ton/yr	Mg/a	t/a	9.071 847	E–01	
		U.K. ton/d	Mg/d	t/d	1.016 047	E+00	
				t/h,Mg/h	4.233 529	E–02	
		U.S. ton/d	Mg/d	t/d	9.071 847	E–01	
				t/h, Mg/h	3.779 936	E–02	
		U.K. ton/h	Mg/h	t/h	1.016 047	E+00	
		U.S. ton/h	Mg/h	t/h	9.071 847	E–01	
		lb/h	kg/h		4.535 924	E–01	
Throughput (Volume Basis)	m^3/s	bbl/d	m^3/a		5.803 036	E+01	
			m^3/d		1.589 873	E–01	
			m^3/h		6.624 471	E–03	
		ft^3/d	m^3/h		1.179 869	E–03	
			m^3/d		2.831 685	E–02	
		bbl/h	m^3/h		1.859 873	E–01	
		ft^3/h	m^3/h		2.831 685	E–02	
		U.K. gal/h	m^3/h		4.546 092	E–03	
				L/h	4.546 092	E+00	
		U.S. gal/h	m^3/h		3.785 412	E–03	
				L/h	3.785 412	E+00	
		U.K. gal/min	m^3/h		2.727 655	E–01	
				L/min	4.546 092	E+00	
		U.S. gal/min	m^3/h		2.271 247	E–01	
				L/min	3.785 412	E+00	
Throughput (Mole Basis)	mol/s	lb mol/h	kmol/h		4.535 92	E–01	
				kmol/s	1.259 979	E–04	
Pipeline Capacity	m^3/m	bbl/mi	m^3/km		9.879 013	E–02	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent	Notes See p. 9
FLOW RATE						
Flow Rate (Mass Basis)	kg/s	U.K. ton/min	kg/s		1.693 412 E+01	
		U.S. ton/min	kg/s		1.511 975 E+01	
		U.K. ton/h	kg/s		2.822 353 E–01	
		U.S. ton/h	kg/s		2.519 958 E–01	
		million lb/d	kg/s		5.249 912 E+00	
		U.K. ton/d	kg/s		1.175 980 E–02	
		U.S. ton/d	kg/s		1.049 982 E–02	
		million lb/yr	kg/s		1.438 332 E–02	
		U.K. ton/yr	kg/s		3.221 864 E–05	
		U.S. ton/yr	kg/s		2.876 664 E–05	
		lb/s	kg/s		4.535 924 E–01	
		lb/min	kg/s		7.559 973 E–03	
		lb/h	kg/s		1.259 979 E–04	
Flow Rage (Volume Basis)	m^3/s	bbl/d	dm^3/s		1.840 131 E–03	
		ft^3/d	dm^3/s		3.277 413 E–04	
		bbl/h	dm^3/s		4.416 314 E–02	
		ft^3/h	dm^3/s		7.865 791 E–03	
		U.K. gal/h	dm^3/s		1.262 803 E–03	
		U.S. gal/h	dm^3/s		1.051 503 E–03	
		U.K. gal/min	dm^3/s		7.576 820 E–02	
		U.S. gal/min	dm^3/s		6.309 020 E–02	
		ft^3/min	dm^3/s		4.719 474 E–01	
		ft^3/s	dm^3/s		2.831 685 E+01	
Flow Rate (Mole Basis)	mol/s	lb mol/s	kmol/s		4.535 924 E–01	
		lb/mol/h	kmol/s		1.259 979 E–04	
		million SCF/SD*	kmol/s		1.383 449 E–02	
Flow Rate/Length (Mass Basis)	kg/(s · m)	lb/(s · m)	kg/(s · m)		1.488 164 E+00	
		lb/(h · m)	kg/(s · m)		4.133 789 E–04	
Flow Rate/Length (Volume Basis)	m^2/s	U.K. gal/(min · ft)	m^2/s	$m^3/(s \cdot m)$	2.485 833 E–04	
		U.S. gal/(min · ft)	m^2/s	$m^3/(s \cdot m)$	2.069 888 E–04	
		U.K. gal/(h · in.)	m^2/s	$m^3/(s \cdot m)$	4.971 667 E–05	
		U.S. gal/(h · in.)	m^2/s	$m^3/(s \cdot m)$	4.139 776 E–05	
		U.K. gal/(h · ft)	m^2/s	$m^3/(s \cdot m)$	4.143 055 E–06	
		U.S. gal/(h · ft)	m^2/s	$m^3/(s \cdot m)$	3.449 814 E–06	
Flow Rate/Area (Mass Basis)	$kg/(s \cdot m^2)$	$lb/(s \cdot ft^2)$	$kg/(s \cdot m^2)$		4.822 428 E+00	
		$lb/(h \cdot ft^2)$	$kg/(s \cdot m^2)$		1.356 230 E–03	
Flow Rate/Area (Volume Basis)	m/s	$ft^3/(s \cdot ft^2)$	m/s	$m^3/(s \cdot m^2)$	3.048* E+00	
		$ft^3/(min \cdot ft^2)$	m/s	$m^3/(s \cdot m^2)$	5.08* E–03	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
FLOW RATE (CONTINUED)							
Flow Rate/Area (continued) (Volume Basis)		U.K. gal/(h · in.^{2})	m/s	m^3/(s · m^2)	1.957 349	E–03	
		U.S. gal/(h · in.^{2})	m/s	m^3/(s · m^2)	1.629 833	E–03	
		U.K. gal/(min · ft^2)	m/s	m^3/(s · m^2)	8.155 621	E–04	
		U.S. gal/(min · ft^2)	m/s	m^3/(s · m^2)	6.790 972	E–04	
		U.K. gal/(h · ft^2)	m/s	m^3/(s · m^2)	1.359 270	E–05	
		U.S. gal/(h · ft^2)	m/s	m^3/(s · m^2)	1.131 829	E–05	
Flow Rate/ Pressure Drop (Productivity Rate)	m^3/ (s · Pa)	bbl/(d · psi)	m^3/(d · kPa)		2.305 916	E–02	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
ENERGY, WORK, QUANTITY OF HEAT, POWER							
Energy, Work, Quantity of heat	J	quad	EJ		1.055 056	E+00	
			TW · h		2.930 711	E+02	
		therm	MJ		1.055 056	E+02	12
			kJ		1.055 056	E+05	
				kW · h	2.930 711	E+01	
		U.S. tonf · mi	MJ		1.431 744	E+01	
		hp · h	MJ		2.684 520	E+00	13
			kJ		2.684 520	E+03	
				kW · h	7.456 999	E–01	
		ch · h or CV · h	MJ		2.647 796	E+00	14
			kJ		2.647 796	E+03	
				kW · h	7.354 99	E–01	
		kW · h	MJ		3.6*	E+00	
			kJ		3.6*	E+03	
		Chu	kJ		1.899 101	E+00	15
				kW · h	5.275 280	E–04	
		Btu	kJ		1.055 056	E+00	
				kW · h	2.930 711	E–04	
		kcal	kJ		4.184*	E+00	
		cal	kJ		4.184*	E–03	
		ft · lbf	kJ		1.355 818	E–03	
		J	kJ		1.0*	E–03	
		lb · ft^2/s^2(f · pdl)	kJ		4.214 011	E–05	
		erg	J		1.0*	E–07	
Impact Energy	J	kgf · m	J		9.806 650*	E+00	
		ft · lbf	J		1.355 818	E+00	
Work/Length	J/m	U.S. tonf · mi/ft	MJ/m		4.697 322	E+01	
Surface Energy	J/m^2	erg/cm^2	mJ/m^2		1.0*	E+00	
Power	W	quad/yr	EJ/a		1.055 056	E+00	
				GW	3.345 561	E+01	
		erg/a	TW		3.170 979	E–27	
			GW		3.170 979	E–24	
		million Btu/h	MW		2.930 711	E–01	
		ton of refrigeration	kW		3.516 853	E+00	
		Btu/s	kW		1.055 056	E+00	
		kW	kW		1		

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
ENERGY, WORK, QUANTITY OF HEAT, POWER (CONTINUTED)							
Power (continued)		hydraulic horse-power—hhp	kW		7.460 43	E–01	
		hp (electric)	kW		7.46*	E–01	
		hp (550 ft · lbf/s)	kW		7.456 999	E–01	
		ch or CV	kW		7.354 99	E–01	6
		Btu/min	kW		1.758 427	E–02	
		ft · lbf/s	kW		1.355 818	E–03	
		kcal/h	W		1.162 222	E+00	
		Btu/h	W		2.930 711	E–01	
		ft · lbf/min	W		2.259 697	E–02	
Power/Area	W/m^2	$Btu/(s \cdot ft^2)$	kW/m^2		1.135 653	E+01	
		$cal/(h \cdot cm^2)$	kW/m^2		1.162 222	E–02	
		Btu/(h · ft2)	kW/m^2		3.154 591	E–03	
Heat Flow Unit-hfu (Geothermics)		$\mu cal/(s \cdot cm^2)$	mW/m^2		4.184*	E+01	
Heat Release Rate, Mixing Power	W/m^3	hp/ft^3	kW/m^3		2.633 414	E+01	13
		$cal/(h \cdot cm^3)$	kW/m^3		1.162 222	E+00	
		$Btu/(s \cdot ft^3)$	kW/m^3		3.725 895	E+01	
		$Btu/(h \cdot ft^3)$	kW/m^3		1.034 971	E–02	
Heat Generation Unit—hgu (Radioactive Rocks)		$cal/(s \cdot cm^3)$	$\mu W/m^3$		4.184*	E+12	
Cooling Duty (Machinery)	W/W	Btu/(bhp · h)	W/kW		3.930 148	E–01	13
Mass Fuel Consumption	kg/J	lb/(hp · h)	mg/J	kg/MJ	1.689 659	E–01	13
				kg/(kW · h)	6.082 774	E–01	
Volume Fuel Consumption	m^3/J	$m^3/(kW \cdot h)$	dm^3/MJ	mm^3/J	2.777 778	E+02	7
				$dm^3/(kW \cdot h)$	1.0*	E+03	7
		U.S. gal/(hp · h)	dm^3/MJ	mm^3/J	1.410 089	E+00	7, 13
				$dm^3(kW \cdot h)$	5.076 321	E+00	7
		U.K. pt/(hp · h)	dm^3/MJ	mm^3/J	2.116 809	E–01	7, 13
				$dm^3/(kW \cdot H)$	7.620 512	E–01	7
Fuel Consumption (Automotive)	m^3/m	U.K. gal/mi	$dm^3/100km$	L/100km	2.284 811	E+02	7
		U.S. gal/mi	$dm^3/100km$	L/100km	2.352 146	E+02	
		mi/U.S. gal	km/dm^3	km/L	4.251 437	E–01	
		mi/UK gal	km/dm^3	km/L	3.540 060	E–01	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
MECHANICS							
Velocity (Linear) Speed	m/s	knot	km/h		1.852*	E+00	
				knot	1		
		mi/h	km/h		1.609 433*	E+00	
		m/s	m/s		1		
		ft/s	m/s		3.048*	E–01	
				cm/s	3.048*	E+01	
				m/ms	3.048*	E–04	17
		ft/min	m/s		5.08*	E–03	
				cm/s	5.08*	E–01	
		ft/h	mm/s		8.466 667	E–02	
				cm/s	8.466 667	E–03	
		ft/d	mm/s		3.527 778	E–03	
				m/d	3.048*	E–01	
		in./s	mm/s		2.54*	E+01	
				cm/s	2.54*	E+01	
		in./min	mm/s		4.233 333	E–01	
				cm/s	4.233 333	E–02	
Velocity (Angular)	rad/s	r/min	rad/s		1.047 198	E–01	
		r/min		r/min	1		
		r/s	rad/s		6.283 185	E+00	
		r/s		r/s	1		
		deg/min	rad/s		2.909 882	E–04	
		deg/s	rad/s		1.745 329	E–02	
Reciprocal Velocity	s/m	ms/ft	s/m		3.280 840	E+00	18
Acceleration (Linear)	m/s^2	ft/s^2	m/s^2		3.048*	E–01	
		gal (cm/s^2)	m/s^2		1.0*	E–02	
Acceleration (Angular)	rad/s^2	rad/s^2	rad/s^2		1		
		rpm/s s^2	rad/s^2		1.047 198	E–01	
Corrosion Rate	mm/a	in./yr (ipy)	mm/a		2.54*	E+01	
Momentum	kg · m/s	lb · ft/s	kg · m/s		1.382 550	E–01	
Force	N	U.K. tonf	kN		9.964 016	E+00	
		U.S. tonf	kN		8.896 443	E+00	
		kgf (kp)	N		9.806 650*	E+00	
		lbf	N		4.448 222	E+00	
		N	N		1		
		pdl	mN		1.382 550	E+02	
		dyn	mN		1.0*	E–02	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
MECHANICS (CONTINUED)							
Bending Moment, Torque	N · m	U.S. tonf · f kgf · m lbf · ft	kN · m N · m N · m		2.711 636 9.806 650* 1.355 818	E+00 E+00 E+00	
		lbf · in. pdl · ft	N · m N · m		1.129 848 4.214 011	E–01 E–02	
Bending Moment, Length	N · m/m	lbf · ft/in. kgf · m/m lbf · in./in.	N · m/m N · m/m N · m/m		5.337 866 9.806 650* 4.448 222	E+01 E+00 E+00	
Moment of Inertia	$kg·m^2$	$lb·ft^2$ $in.^4$	$kg · m^2$ cm^4		4.214 011 4.162 314	E–02 E+01	
Stress	Pa	U.S. $tonf/in^2$ $kgf/in.^2$ (psi)	MPa MPa	N/mm^2 N/mm^2	1.378 951 9.806 650*	E+01 E+00	
		U.S. $tonf/ft^2$ $lbf/in.^2$ (psi)	MPa MPa	N/mm^2 N/mm^2	9.576 052 6.894 757	E–02 E–03	
		$lbf/in.^2$(psf) dyn/cm^2	kPa Pa		4.788 026 1.0*	E–02 E–01	
Yield Point, Gel Strength (Drilling Fluid)		$lbf/100ft^2$	Pa		4.788 026	E+01	
Mass/Length	kg/m	lb/ft	kg/m		1.488 164	E+00	
Mass/Area Structural Loading, Bearing Capacity (Mass Basis)	kg/m^2	U.S. ton/ft^2 lb/ft^2	Mg/m^2 kg/m^2	t/m^2	9.764 855 4.882 428	E+00 E+00	
Modulus of Elasticity	Pa	$lbf/in.^2$ (psi)	MPa	N/mm^2	6.894 757	E–03	
Sesction Modulus	m^3	$in.^3$	cm^3		1.638 706	E+01	
Coefficient of Thermal Expansion	m/(m · k)	in./(in. · °F)	mm/(mm · K)	mm/(mm · °C)	5.555 556	E–01	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 9
TRANSPORT PROPERTIES							
Diffusivity	m^2/s	ft^2/s	mm^2/s		9.920 304*	E+04	
		cm^2/s	mm^2/s		1.0*	E+02	
		ft^2/h	mm^2/s		2.580 64*	E+01	
Thermal Resistance	$K \cdot m^2/W$	$°C \cdot m^2 \cdot h/kcal$	$K \cdot m^2/kW$		8.604 208	E+02	
		$°F \cdot ft^2 \cdot h/Btu$	$K \cdot m^2/kW$		1.761 102	E+02	
Heat Flux	W/m^2	$Btu/(h \cdot ft^2)$	kW/m^2		3.154 591	E–03	
Thermal Conductivity	$W/(m \cdot K)$	$cal/(s \cdot cm^2 \cdot °C/cm)$	$W/(m \cdot K)$	$W/(m^2 \cdot °C/m)$	4.184*	E+01	
		$Btu/(h \cdot ft^2 \cdot °F/ft)$	$W/(m \cdot K)$	$W/(m^2 \cdot °C/m)$	1.730 735	E+00	
		$kcal/(h \cdot m^2 \cdot °C/m)$	$W/(m \cdot K)$	$W/(m^2 \cdot °C/m)$	1.162 222	E+00	
		$Btu(h \cdot ft^2 \cdot °F/in)$	$W/(m \cdot K)$	$W/(m^2 \cdot °C/m)$	1.442 279	E–01	
		$cal/h \cdot cm^2 \cdot °C/cm)$	$W/(m \cdot K)$	$W/(m^2 \cdot °C/m)$	1.622 222	E–01	
Heat Transfer Coefficient	$W/(m^2 \cdot K)$	$cal/(s \cdot cm^3 \cdot °C)$	$kW/(m^2 \cdot K)$		4.184*		
		$Btu/(s \cdot ft^2 \cdot °F)$	$kW/(m^2 \cdot K)$		2.044 175		
		$cal/(h \cdot cm^2 \cdot °C)$	$kW/(m^2 \cdot K)$		1.162 222		
		$Btu/(h \cdot ft^2 \cdot °F)$	$kW/(m^2 \cdot K)$		5.678 263		
		$Btu/(h \cdot ft^2 \cdot °R)$	$kW/(m^2 \cdot K)$		5.678 263		
		$kcal/(h \cdot m^2 \cdot °C)$	$kW/(m^2 \cdot K)$		1.162 222		
Volumetric Heat Transfer Coefficient	$W/(m^3 \cdot K)$	$Btu/(s \cdot ft^3 \cdot °F)$	$kW/(m^3 \cdot K)$		6.706 611		
		$Btu/(h \cdot ft^3 \cdot °F)$	$kW/(m^3 \cdot K)$		1.862 947		
Surface Tension	N/M	dyn/cm	mN/m		1.0*	E+00	
Viscosity (Dynamic)	$Pa \cdot s$	$lbf \cdot s/in.^2$	$mPa \cdot s$	cP	6.894 757	E+06	19
		$lbf \cdot s/ft^2$	$mPa \cdot s$	cP	4.788 026	E+04	19
		$kgf \cdot s/m^2$	$mPa \cdot s$	cP	9.806 650*	E+03	19
		$dyn \cdot s/cm^2$	$Pa \cdot s$		1.0*	E–01	19
			$mPa \cdot s$	cP	1.0*	E+02	19
		P	$Pa \cdot s$		1.0*	E–01	19
			$mPa \cdot s$	cP	1.0*	E+02	19
		cP	$mPa \cdot s$	cP	1.0*	E+00	19
Viscosity (Kinematic)	m^2/s	ft^2/s	mm^2/s	cSt	9.290 304*	E+04	19
		in^2/s	mm^2/s	cSt	6.451 6*	E+02	19
		ft^2/h	mm^2/s	cSt	2.580 64*	E+01	19
		m^2/h	mm^2/s	cSt	2.77 777 778	E+02	19
		cm^2/s	mm^2/s	cSt	1.0*	E+02	19
		St	mm^2/s	cSt	1.0*	E+02	19
		cSt	mm^2/s	cSt	1.0*	E+00	19
Permeability	m^2	D	μm^2	D	1.0*	E+00	20
		mD	μm^2	D	1.0*	E–03	20

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent	Notes See p. 10
ELECTRICITY, MAGNETISM						
Admittance	S	S	S		1	
Capacitance	F	µF	µF		1	
Capacity, Storage Battery	C	A · h	kC		3.6* E+00	
Charge Density	C/m³	C/mm³	C/mm³		1	
Couductance	S	S ʋ	S S		1 1	
Conductivity	S/m	S/m mʋ/m	S/m mS/m		1 1	
Current Density	A/m²	A/mm² A/in²	A/mm² A/mm²		1 E–03 1.550 003	
Displacement	C/m²	C/cm²	C/cm²		1	
Electric Charge	C	C	C		1	
Electric Current Electric Dipole Moment	A C · m	A C · m	A C · m		1 1	
Electric Field Strength	V/m	V/m	V/m		1	
Electric Flux	C	C	C		1	
Electric Polarization	C/m²	C/m²	C/m²		1	
Electric Potential	V	V mB	V mV		1 1	
Electromagnetic Moment	A · m²	A · m²	A · m²		1 1	
Electromotive Force	V	V	V		1	
Flux of Displacement	C	C	C		1	
Frequency	Hz	cycles/s	Hz		1	
Impedance	Ω	Ω	Ω		1	
Linear Current Density	A/m	A/mm	A/mm		1	
Magnetic Dipole Moment	Wb · m	Wb · m	Wb · m		1	
Magnetic Field Strength	A/m	A/mm oersted	A/mm A/m		1 7.957 747 E+01	
Magnetic Flux	Wb	mWb maxwell	mWb nWb		1 1.0* E+01	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent	Notes See p. 10
ELECTRICITY, MAGNETISM (CONTINUED)						
Magnetic Flux Density	T	mT gauss gamma	mT T nT		1 1.0* E–04 1	
Magnetic Induction	T	mT	mT		1	
Magnetic Moment	$A \cdot m^2$	$A \cdot m^2$	$A \cdot m^2$		1	
Magnetic Polarization	T	mT	mT		1	
Magnetic Potential Difference	A	A	A		1	
Magnetic Vector Potential	Wb/m	Wb/mm	Wb/mm		1	
Magnetization	A/m	A/mm	A/mm		1	
Modulus of Admittance	S	S	S		1	
Modulus of Impedance	Ω	Ω	Ω		1	
Mutual Inductance	H	H	H		1	
Permeability	H/m	mH/m	mH/m		1	
Permeance	H	H	H		1	
Permittivity	F/m	mF/m	mF/m		1	
Potential Difference	V	V	V		1	
Quantity of Electricity	C	C	C		1	
Reactance	Ω	Ω	Ω		1	
Reluctance	H^{-1}	H^{-1}	H^{-1}		1	
Resistance	Ω	Ω	Ω		1	
Resistivity	Ω · m	Ω · cm Ω · m	Ω · cm Ω · m		1 1	 21
Self Inductance	H	mH	MH		1	
Surface Density of Charge	C/m^2	mC/m^2	mC/m^2		1	
Susceptance	S	S	S		1	
Volume Density of Charge	C/m^3	C/mm^3	Cmm^3		1	

Quantity	SI Unit	Customary Unit	Metric Unit: API Preferred	Metric Unit: Other Allowable	Conversion Factor (Multiply Quantity) Expressed in Customary Units by Factor to Get Metric Equivalent		Notes See p. 10
ACOUSTICS, LIGHT, RADIATION							
Acoustical Energy	J	J	J		1		
Acoustical Intensity	W/m^2	W/cm^2	W/m^2		1.0*	E+04	
Acoustical Power	W	W	W		1		22
Activity (of a radionuclide)	Bq	curie	Bq		3.7*	E+10	
Illuminance, Illumination	lx	footcandle (fc)	lx		1.076 391	E+01	
		lm/ft^2	lx		1.076 391	E+01	
Irradiance	W/m^2	W/m^2	W/m^2		1		
Light Exposure	lx · s	fc · s	lx · s		1.076 391	E+01	
Luminance	cd/m^2	cd/m^2	cd/m^2		1		
		footlambert (fL)	cd/m^2		3.426 259	E+00	
Luminous Efficacy	lm/W	lm/W	lm/W		1		
Luminous Exitance	lm/m^2	lm/m^2	lm/m^2		1		
		lm/ft^2	lm/m^2		1.076 391	E+01	
Luminous Flux	lm	lm	lm		1		
Luminous Intensity	cd	cd	cd		1		
Quantity of Light	lm · s	Talbot	lm · s		1		
Radiance	$W/(m^2 \cdot sr)$	$W/(m^2 \cdot sr)$	$W/(m^2 \cdot sr)$		1		
Radiant Energy	J	J	J		1		
Radiantflux	W	W	W		1		
Radiant Intensity	W/sr	W/sr	W/sr		1		
Radiant Power	W	W	W		1		
Sound Pressure	Pa	Pa	Pa		1		23
Wavelength	m	Å	nm		1.0*	E–01	

15.6 Examples

Conversions from Customary Units to SI Units are given in Appendix A and Appendix B.

15.7 Acknowledgments

The Subcommittee on Units acknowledges the valuable contributions and inspiration it received from its first chairman, Karl Linn, who died in 1977. Mr. Linn's dedication, leadership, and knowledge set examples of excellence for his colleagues to emulate in the preparation of this publication.

The subcommittee also acknowledges the support it received from the American Gas Association, the Gas Processors Association, and the Society of Petroleum Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Representatives of these organizations served as members of the Subcommittee on Units, thereby making direct contributions to the revision of API Publication 2564 in addition to the liaison they provided with their sponsoring organizations.

APPENDIX A—METRIC CONVERSION OF LIQUIDS

A.1 Conversion Procedures

A.1.1 GENERAL

A.1.1.1 This appendix includes procedures for the systematic conversion of volumes of liquids at standard conditions of 60°F and 14.696 psia to volumes at standard conditions at temperature of 15°C (288.15K) and absolute pressure of 101.325 kPa. It includes values of commonly used constants. It is not within the scope of this document to address significant decimal places.

A.1.2 SOFT CONVERSION

A.1.2.1 The "Soft Conversion" of volumes at standard conditions of 60°F and 14.696 psia to volumes at standard conditions at a temperature of 15°C (288.15K) and an absolute pressure of 101.325 kPa requires a standard conversion policy. The lack of such policy has restricted and at times offered confusion as to the proper method of conversion. Soft conversion normally involves only the use of conversion factors, and may be carried out by either converting all basic values, or by measuring quantity in conventional unit of measurement and converting the results to SI.

A.1.2.2 The official symbol (not abbreviation; hence no period) in all languages for the International System of Units is:

SI

Note: SI is the International System of Units established by the General Conference of Weights and Measures. It is a practical system of units of measurement intended for adoption by all signatories the Metric Convention. The United States is a member of this signatory group.

A.1.2.3 Units written out in full, whether or not they are the names of persons, do not have an initial upper case letter except at the beginning of a sentence. However, the symbols for units named after persons are written in upper case.

Example: The SI unit of pressure is pascal. The SI symbol for pascal is Pa.
Exception: Celsius is always written with a capital letter.

A.1.2.4 Idioms should not be used.

Example: kilo to mean kilogram (use kg)
cc to mean cubic centimeter (use cm^3or mL)

A.1.3 SYMBOLS

A.1.3.1 A symbol represents a unit and is the same in all languages. It is not an abbreviation.

A.1.3.2 Symbols shall be written in Roman (upright) type irrespective of the type used in the rest of the text

Example: "He ordered 40 kg of cement."

A.1.3.3 Symbols do not change in the plural.

Example: 142 kg, not 142 kgs.

A.1.3.4 Symbols are never followed by a decimal point or period except at the end of a sentence.

A.1.4 NUMERALS

A.1.4.1 In text, tables and on engineering drawings, if a numerical value is less than one, a 0 shall precede the decimal point.

Example: 0.134, not .134.

A.1.5 RECOMMENDED UNITS

A.1.5.1 Chapter 15 *Guidelines for the Use of the International System of Units (SI) in the Petroleum and Allied Industries* indicates the SI multiple to be used for each application.

A.1.6 STANDARD REFERENCE CONDITIONS

A.1.6.1 Whenever the physical quantity "volume" is used in precise measurements, the temperature (T) and pressure (P) should be specified.

A.1.6.1.1 SI Standard reference conditions agreed by ISO and adopted by API are:

15°C (288.15 K) (K stands for kelvin)
101.325 kPa absolute 9

A.1.6.1.2 US Standard reference conditions currently used in the US by the API are:

60°F
14.696 psia

A.2 Metric Conversion

A.2.1 PROCEDURE FOR THE CONVERSION OF API GRAVITY AT 60°F TO DENSITY AT 15°C

A.2.1.1 Convert API Gravity to Relative Density at 60°F.

$$\rho_{60} = 999.102 \times \frac{141.5}{131.5 + °API}$$

A.2.1.2 Calculate the coefficient of thermal expansion; dependent on type of liquid. i.e.: crude oil or general products

a. Set $\rho_\tau = \rho_{\tau'}$, rounded to the nearest 0.1 kg/m^3.
b. Select the values of K_0, K_1 and K_2 according to API gravity and applicable table.
c. Calculate the value of at according to the formula:

$$\alpha_\tau = (K_0 + K_1\,\rho_{\tau'} + K_2\,\rho_\tau^{\,2}) / \rho_\tau^{\,2}$$

d. Round the value of at to the nearest 10^{-7}.

A.2.1.3 Calculate the Corrected Density at 15°C according to the formula:

$$\rho_{15} = \rho_{60}\,(1 + \alpha_\tau)$$

Round the final density to the nearest 0.1 kg/m^3.

A.2.2 PROCEDURE FOR THE CONVERSION FROM RELATIVE DENSITY AT 60°F/60°F TO RELATIVE DENSITY AT 15°C

a. Convert the Relative Density (60°F/60°F), G, to Relative Density at 60°F

$$\rho 60 = 999.012 \times G$$

b. Calculate coefficient of thermal expansion; dependent on type of liquid. i.e.: crude oil or general products

1. Set rt = ρ60, rounded to the nearest 0.1 kg/m^3.
2. Select the values of K_0, K_1 and K_2 according to the relative density and applicable table.
3. Calculate the value of at to the nearest 10^{-7}.
4. Calculate the corrected Density at 15°C according to the formula:

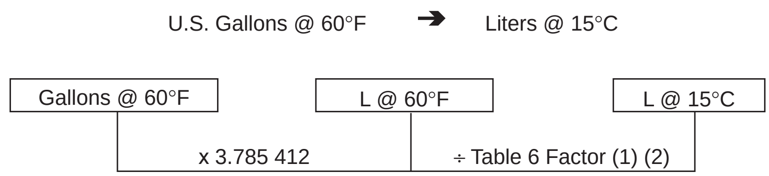
$$\rho_\tau 15 = \rho 60\,(1 + \alpha_\tau)$$

5. Round the final density to the nearest 0.1 kg/m^3.

Table A-1—Coefficients

Table	API Gravity Range		Relative Density Range				
	Min	Max	Min	Max	K_0	K_1	K_2
A	0	100	0.6110	1.0760	341.0957	0.0	0.0
B	52	85	0.6530	0.7705	192.4571	0.2438	0.0
B	48	52	0.7710	0.7885	1489.0670	0.0	–0.00186840
B	37	48	07890	0.8395	330.3010	0.0	0.0
B	0	37	0.8400	1.0750	103.8720	0.2701	0.0
D	–10	45	0.8000	1.1640	0.0	0.3488	0.0

15.7.1 CONVERSION OF U.S. GALLONS AT 60°F TO LITERS (L) AT 15°C



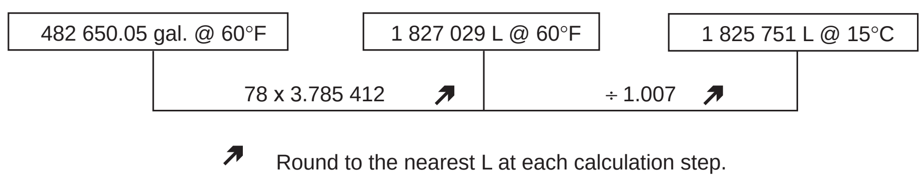
Example

Convert 482 650.05 gallons of gasoline having an API gravity of 55.1 @ 60°F to 15°C

1. Factor for volume correction due to temperature change from 60°F to 15°C (59°F) is obtained from appropriate volume correction tables:
   - 6A - Crude Oils
   - 6B - Applicable Petroleum Products
   - 6C - Individual and Special Applications
   - 6D - Lubricating Oils
   - 24 - Liquid Petroleum Gases

Factors for other chemicals must be obtained from specialty tables. The factors in the tables are for volume correction from 59°F to 60°F. Dividing the factors into the volume gives the correction from 60°F to 59°F. (15°C).

2. The API Gravity must be used to determine the correction factor from the temperature tables.



15.7.2 CONVERSION OF U.S. BARRELS AT 60°F TO CUBIC METERS (M^3) AT 15°C

U.S. Barrels @ 60°F ➔ Cubic Meters (m^3) @ 15°C

Barrels @ 60°F		m^3 @ 60°F		m^3 @ 15°C
	x 0.1589873		÷ Table 6 Factor (1) (2)	

Example

Convert 1 000 000.55 barrels of crude oil having an API gravity of
35.0 @ 60°F to cubic meters @ 15°C

1. Factor for volume correction due to temperature change from 60°F to 15°C (59°F) is obtained from appropriate volume correction tables:
   - 6A - Crude Oils
   - 6B - Applicable Petroleum Products
   - 6C - Individual and Special Applications
   - 6D - Lubricating Oils
   - 24 - Liquid Petroleum Gases

Factors for other chemicals must be obtained from specialty tables. The factors in the tables are for volume correction from 59°F to 60°F. Dividing the factors into the volume gives the correction from 60°F to 59°F. (15°C).

2. The API Gravity must be used to determine the correction factor from the temperature tables.

1 000 000.55 bbl @ 60°F		158 987.4 m^3 @ 60°F		158 907.9 m^3 @ 15°C
	x 0.1589873 ↗		÷ 1.005 ↗	

↗ Round to the nearest 0.001m^3 at each calculation step.

APPENDIX B—METRIC CONVERSION OF NATURAL GAS

B.1 General

This appendix includes procedures for the systematic conversion of volumes, energy and heating values at standard conditions of 60°F and 14.696 psia to volumes at standard conditions at a temperature of 15°C (288.15K) and at an absolute pressure of 101.325 kPa. It includes values of commonly used constants.

B.1.1 HARD VS. SOFT CONVERSION

Hard conversion is generally defined as the conversion that involves replacement or modification of hardware (e.g., gauging tape, thermometers, pressure gauges, etc.), or the rationalization of numerical values (e.g., quality control specifications). Soft conversion normally involves only the use of conversion factors, and may be carried out by either converting all basic values, or by measuring quantity on conventional units of measurement and converting the results to SI (i.e., volumetric tank tables from gallons to liters).

B.1.2 VOLUME

In SI, all volumes of natural gas shall be expressed at the standard reference temperature and pressure conditions at 15°C and an absolute pressure of 101.325 kPa respectively. No other reference conditions shall be used.

The natural gas volume reporting unit for production and large volume gas streams will be thousands of cubic meters and will normally be reported to $0.1 \times 10^{1/4}$ $m^{1/4}$. However, small commercial and residential sales volumes may require reporting to 0.01 or $0.001 \times 10^{1/4} m^{1/4}$ in which case, a more appropriate unit would be the cubic meter ($m^{1/4}$).

B.1.3 ENERGY AND HEATING VALUE

The unit for energy in SI is the joule (J) and appropriate multiples thereof.

Natural gas heating value will be measured and reported in megajoules per cubic meter (MJ/m^3) at the standard reference conditions of 15°C, 101.325 kPa and free of water vapor and should be reported to four significant figures e.g., 37.45 MJ/m^3).

The amount of energy (volume times heating value) should be reported to the nearest whole gigajoule (GJ). However, small commercial and residential sales may be to the nearest 0.1 GJ.

In order to maintain consistency in determining the amount of energy, the following calculation procedure is recommended:

a. Determine volume in cubic meters to the nearest $0.1 \times 10^3 m^3$ (for small volume sales, to the nearest cubic meter).
b. Determine heating value in megajoules per cubic meter to four significant figures. Ensure that the heating value is stated for the same reference conditions used for volume.
c. Determine the amount of energy by multiplying the above two values, rounding to the nearest whole gigajoule (or, 0.1 GJ, if more appropriate).

B.1.4 METERING EQUIPMENT—ORIFICE METERS

The calculation of volumes measured by orifice meters is generally based upon API *MPMS* Chapter 14.3. Until such time as this report has been converted to SI, it is recommended that measurement in traditional units be continued, with the results being soft converted to the appropriate SI units of measurement.

B.1.5 METERING EQUIPMENT—OTHER

As with orifice metering, the soft conversion to measurement with SI units is recommended, except where hard converted equipment is available for new or replacement installations.

B.1.6 EQUIVALENT VOLUME

The current practice of specifying a volume as the equivalent volume of 1,000 Btu gas, will have no useful SI equal, and attempts to develop one should be discouraged.

B.1.7 CONTRACTS

Soft conversion of existing gas purchase, sale and transportation contracts can be achieved with an appended list of conversion factors. New contracts should incorporate rationalization of numerical values, such as maximum sulfur content, dew point specifications, minimum heating value, etc. The following rationalized values for selected specifications are suggested (see top of page 38).

B.1.8 CONVERSION FACTORS

Conversion factors should normally be carried to more significant figures than can be justified by the precision of the value. Once a measurement has been made and accepted by all parties involved in the custody transfer, that measurement becomes a precise value. The factor used to convert that value to SI units should not introduce any computational bias to the value. The technique used for developing and using conversion factors in section 3 of this report, and recommended for use throughout the natural gas industry, is as follows:

Using the data provided, and any conversion factors that are obtained or developed, carry as many significant figures as practical into the final results. Then round the results to the appropriate number of significant figures that can be justified by the data available, or by the precision of the measurement.

Description	Existing Specification		Rationalized SI Specification
	Traditional Units	**SI Units**	
H_2S	1/4 grain/100 ft^3	5.6 – 5.8 mg/m^3	6 mg/m^3
	1 grain/100 ft^3	22.4 – 23.4 mg/m^3	23 mg/m^3
	5 grains/100 ft^3	112 – 117 mg/m^3	115 mg/m^3
Water	1 lb/MMcf	16 –17 mg/m^3	16 mg/m^3
	4 lb/MMcf	63 – 66 mg/m^3	65 mg/m^3
	7 lb/MMcf	110 – 115 mg/m^3	110 mg/m^3
Liquefiable Hydrocarbons	0.25 Can. gal. Mcf	39 – 41 mL/m^3	40 mL/m^3
	0.50 Can. gal. Mcf	79 – 82 mL/m^3	80 mL/m^3
	1.00 Can. gal. Mcf	158 – 164 mL/m^3	160 mL/m^3
Hydrocarbon dew point	15°F at 800 psia	-9.4°C at 5516 kPa	–10°C at an absolute pressure at 5500 kPa

B.2 Discussion and Tables of Conversion Factors

B.2.1 VOLUME

A cubic meter of natural gas is defined as that quantity of gas which, at the stated condition of temperature and pressure, will fill a space of one cubic meter.

The standard cubic meter of natural gas which will be used is specified to be the standard reference temperature of 15°C and at an absolute pressure of 101.325 kPa.

When converting volumes of natural gas from cubic feet to cubic meters in standard conditions, the conditions of pressure and temperature used to define a "standard" cubic foot must be considered. A standard cubic foot of gas is normally specified at 60°F; no uniform pressure base has evolved.

The following Table B-1 is a summary of conversion factors from cubic feet at 60°F and various pressure conditions to cubic meters at 15°C and 101.325 kPa. For other pressure bases, the reader is directed to the conversion formula in section 4.1. It should be noted that this table is not intended to provide conversion factors from the observed conditions of pressure and temperature, but only from the "standard" pressure and temperature conditions.

Table B-1—Volume Conversion Factors (ft^3 to m^3) For standard Cubic Foot at Various Reference Conditions to Cubic Meter at Standard Reference Conditions

Cubic Foot Reference Conditions		Conversion Factor
Pressure (psia)	Temperature (°F)	($ft^3 \times$ Factor = m^3)
14.4	60	0.027 693 20
14.65	60	0.028 173 99
14.696	60	0.028 262 45
14.7	60	0.028 270 15
14.73*	60	0.028 327 84
14.9	60	0.028 654 78
15.025	60	0.028 895 17

*Standard reference conditions for the cubic meter are specified as a temperature of 15°C and an absolute pressure of 101.325 kPa.

B.2.2 ENERGY

The SI unit for energy in natural gas will normally be specified in gigajoules (GJ).

The energy content of natural gas has traditionally been stated in British thermal units (Btu). One Btu is defined as the amount of heat required to raise the temperature of one pound of pure water one degree Fahrenheit under a pressure of one standard atmosphere. The specific heat capacity of water varies slightly with temperature but unfortunately, there is no unanimous agreement as to the temperature range over which the one degree temperature rise should take place. Neither is there international agreement on the specific heat capacity of water at any given temperature.

The Btu 60/61, as more fully defined on Table B-2. One Btu 60/61 is equivalent to 1 054.615 J. This is based on acceptance of the National Institute for Standards & Technology (NIST) value for the specific heat capacity of water.

Table B-2 also lists several other definitions of Btu that are utilized within the natural gas industry, and provided the conversion factors to convert each of the Btu's to joules. Before using Table B-2, one should ascertain which definition of Btu has been used. If unspecified, then the Btu 60/61 should be assumed.

Should a different definition of Btu be encountered for which a conversion factor must be calculated, the reader is directed to the National Bureau of Standards Res. NBS 23, 197 (1939) by Osborne, Stimson and Ginnings in which the specific heat capacity of water at various temperature is provided. A sample calculation of the conversion factor from Btu to joules forms Section 15, 7.13.2 of this report. The conversion factors in Table B-2 can only be used directly if the energy content (measured in Btu) has been correctly determined. Energy is normally determined as the product of volume and heating value. On occasion, the reference conditions for volume differ from those at which the heating value is determined. In this case, the heating value must be calculated for the identical reference conditions as those specified for volume.

Table B-2—Energy Unit Conversion Factors (Btu to J)

Btu	Used by	Definition	Conversion Factor (Btu × Factor = Joules)
Btu 60/61	Consumer and Corporate Affairs Gas Inspection Act National Energy Board	Heat to raise temperature from 60°F to 61°F	1 054.615
Btu 58.5/59.5	American Gas Association ASTM D 1826-64 Calif. to Pub Util. Comm.	Heat to raise temperature from 58.5°F to 59.5°F	1 054.804
Btu 60*	Many export contracts	Heat to raise temperature from 59.5°F to 60.5°F	1 054 678
Btu IT	International Steam Tables ASTM D 1826-77	1 Btu/lb = 2 326 j/kg	1 055.056**
Btu UK	U.K. Gas Industry	Based on 15°C calorie	1 054.76**

**CAUTION:* The term sixty degree Btu has been used to mean either Btu 60 or Btu 61. The confusion surrounding the use of this term should be clarified for each particular case before using the conversion factors contained in this table.
**These conversion factors have been defined rather than calculated.

B.2.3 HEATING VALUE

The heating value of natural gas has traditionally been expressed as Btu/ft$^{1/4}$. In SI, it will be expressed as megajoules per cubic meter (MJ/m$^{1/4}$). In both systems of measurement, the term "heating value", as used in the natural gas industry, refers to the gross or higher heating value. Irrespective of the units used, Btu/ft$^{1/4}$ or megajoules per cubic meter, it is necessary to specify the pressure, temperature and humidity conditions for which the heating value is expressed. No agreement concerning humidity conditions exists for the heating value in the Imperial system, but when using SI units, heating value is determined for gas that is specified to be free of water vapor.

The gross or higher heating value is defined as the total heat, measured in joules, obtained by complete combustion at constant pressure of one cubic meter of gas with air, the gas to be free of all water vapor and the temperature of the gas, air and products of combustion to be at standard temperature and all water formed by combustion reaction to be condensed to the liquid state.

B.3 Example Calculations of Conversion Factors

B.3.1 VOLUME

Following is the development of a formula to convert from a "standard" cubic foot to a cubic meter at standard reference conditions

The ideal Gas Law:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

or

$$V_2 = V_1 \frac{P_1 T_2}{P_2 T_1}$$

Rewriting the equation to include allowance for the water content of the gas:

$$V_2 = V_1 \frac{(P_1 - VT_1) T_2}{(P_2 - VT_2) T_1}$$

V_1 = 0.028 316 846 6m^3/ft^3

P_1 = pressure base for the cubic foot (psi)

P_2 = pressure base for the cubic meter

$= \frac{101.325 \text{ kPa}}{6.894\ 757 \text{ kPa/psi}}$

= 14.695 949 40 psia

T_1 = temperature base for the cubic foot

= 60°F

= 15.555.556°C

= 288.705 556 K

T_2 = temperature base for the cubic meter

= 15°C

= 288.15 K

B.3.2 HEATING VALUE

Determine the conversion factor to convert from Btu/ft^3 to the equivalent SI unit MJ/m^3

$$V_2 = 0.028\ 316\ 846\ 6\frac{\text{m}^3}{\text{ft}^3} \times \frac{P^1\text{psi} \times 288.15\text{K}}{14.695\ 949\ 40\ \text{psi} \times 288.705\ 556\ \text{K}}$$

$$V_2 = 0.001\ 923\ 139\ 21 \times P_1\text{m}^3\text{ft}^3$$

B.3.3 ENERGY

Determine the conversion factor to convert from the Btu defined by the American Gas Association, to the SI unit, Joule (J).

AGA definition of Btu: The amount of heat required to heat one pound of pure water from 58.5°F to 59.5°F at a pressure of one atmosphere.

Mean temperature: 59°F = 15°C

Specific heat capacity of water at 15°C (from Chemical Rubber Company Handbook of Chemistry and Physics):

4.185 8 J/(g.°C)

$$1\ \text{lb.} = 453.592\ 37\ \text{g (exactly)}$$

$$1°\text{F} = \frac{5°\text{C}}{9}$$

$$\frac{1\ \text{Btu}}{\text{lb. °F}} = \frac{4.185\ 8\ \text{J}}{\text{g. °C}} \times \frac{453.592\ 37\ \text{q}}{\text{lb.}} \times \frac{5°\text{C}}{9°\text{F}}$$

1 Btu 58.5/59.5 = 1 054.803 86 J

Rounding 1 054.804 J

B.3.4 EXAMPLE CALCULATIONS

Example 1

Determine the conversion factor for the Btu as defined in the federal Gas Inspection Act and cubic foot measured at 60°F and 14.73 psia and under dry conditions.

Btu definition: Btu 60/61

From Table B-1, 1 ft^3 = 0.028 327 84 m^3

From Table B-2, 1 Btu 60/61 = 1 054.615 J

= 0.001 054 615 MJ

$$1\ \text{Btu/ft}^3 = \frac{1\ \text{ft}^3}{0.028\ 327\ 84\ \text{m}^3} \times \frac{0.001\ 054\ 615\ \text{MJ}}{1\ \text{Btu 60/61}}$$

1 Btu/ft^3 = 0.037 228 918 MJ/m^3

Rounding 0.037 228 92 MJ/m^3

Example 2

Determine the conversion factor to convert from the following definitions of energy and standard cubic foot.

Reference conditions for cubic foot: 60°F
14.73 psia saturated

Btu definition: Btu 60/61

In this example, the pressure of water vapor in the gas must be subtracted from the pressure at which the cubic foot is specified. A conversion factor from cubic foot to cubic meter is then calculated, and then used as in Example 1, above.

The ideal Gas Law:

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

or

$$V_2 = V_1\frac{P_1T_2}{P_2T_1}$$

Rewriting the equation to include allowance for the water content of the gas:

$$V_2 = V_1\frac{(P_1 - VT_1)T_2}{(P_2 - VT_2)T_1}$$

V_1 = 0.028 316 846 6 m^3/ft^3

P_1 = pressure base for the cubic foot (psi)

P_2 = pressure base for the cubic meter

$= \dfrac{101.325\ \text{kPa}}{6.894\ 757\ \text{kPa/psi}}$

= 14.695 949 40 psia

T_1 = temperature base for the cubic foot

= 60°F

= 288.705 55 K

T_2 = temperature base for the cubic meter

= 15°C

= 288.15 K

VT_1 = vapor pressure of water at T_1 (60°F)

= 0.256 11 psia

VT_2 = Vapor pressure of water at T_2

Because the standard metric conditions are defined dry.

$$VT_2 = 0.0 \text{ psia}$$

$$V_2 = 0.028\,316\,846\,6 \times \frac{m^3}{ft^3} \times \frac{(14.73 - 0.256\,11) \times 288.15 \text{ K}}{14.695\,949\,40 \times 288.705\,556}$$

$$V_2 = 0.027\,835\,305 \text{ m}^3/\text{ft}^3$$

From Table B-2, $1 \text{ Btu } 60/61 = 1.054\,615 \text{ J} = 0.001\,054\,615 \text{ MJ}$

$$1 \text{ Btu/ft}^3 = \frac{1 \text{ ft}^3}{0.027\,835\,305 \text{ m}^3} \times \frac{0.001\,054\,615 \text{ MJ}}{1 \text{ Btu } 60/61}$$

$$1 \text{ Btu/ft}^3 = 0.037\,887\,670 \text{ MJ/m}^3$$

Rounding 0.037 887 67

Table B-3—Heating Value Conversion Factors (Btu/ft^3 to MJ/m^3)
For Various Definitions of British Thermal Unit and Cubic Foot SI Standard Reference Conditions.

Difference Conditions for the ft^3			Conversion Factor (Btu/ft^3 × Factor = MJ/m^3)				
Pressure (psia)	Temp. (°F)	Humidity	Btu 60/61	Btu 58.5/59.5	Btu 60	Btu (IT)	Btu (UK)
14.4	60	Saturated**	0.038 771 66	0.038 778 60	0.038 773 97	0.038 787 87	0.038 776 99
14.65	60	Saturated	0.038 098 25	0.038 105 08	0.038 100 53	0.038 114 18	0.038 103 49
14.696	60	Saturated	0.037 976 88	0.037 983 69	0.037 979 15	0.037 992 76	0.037 982 11
14.7	60	Saturated	0.037 996 37	0.037 973 17	0.037 968 64	0.037 982 24	0.037 971 59
14.73	60	Saturated	0.037 887 67	0.037 894 46	0.037 889 94	0.037 903 52	0.037 892 88
14.9	60	Saturated	0.037 447 84	0.037 454 55	0.037 450 08	0.037 463 50	0.037 452 99
15.025	60	Saturated	0.037 130 89	0.037 137 54	0.037 133 11	0.037 146 42	0.037 136 00
14.4	60	Dry	0.038 082 09	0.038 088 91	0.038 084 36	0.038 098 01	0.038 087 32
14.65	60	Dry	0.037 432 22	0.037 438 93	0.037 434 46	0.037 447 87	0.037 437 37
14.696	60	Dry	0.037 315 05	0.037 321 74	0.037 317 28	0.037 330 66	0.037 320 18
14.7	60	Dry	0.037 304 90	0.037 311 59	0.037 307 13	0.037 320 50	0.037 310 03
14.73	60	Dry	0.037 228 92	0.037 235 60	0.037 231 15	0.037 244 49	0.037 234 04
14.9	60	Dry	0.036 804 16	0.036 810 76	0.036 806 36	0.036 819 55	0.036 809 22
15.025	60	Dry	0.036 497 79	0.036 504 51	0.036 500 15	0.036 513 23	0.036 502 99

*SI standard reference conditions are specified as a temperature of 15°C an absolute pressure of 101.325 kPa and free water pour.
**Vapor pressure of water taken to be 0.256 11 psi; reference—ASME Steam Tables.

APPENDIX C—BIBLIOGRAPHY

Note: Metric practice guides are revised frequently. The following references were current at the time this publication was prepared.

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APPENDIX D—ORGANIZATION NAMES, ABBREVIATIONS, AND FUNCTIONS

As a consequence of the metrication program and the establishment of metric standards, there will be an increasing number of contacts with, and reference to, a variety of national and international organizations active in this field. The most important of these organizations, with their initials or abbreviations, are listed below.

D.1 Standards Organizations

ANSI — American National Standards Institute—Founded in 1918. Members include industrial firms, trade associations, technical societies, consumer organizations, and government agencies. Serves as a clearinghouse for nationally coordinated safety, engineering, and industrial standards. U.S. representative in ISO.

ASTM — American Society for Testing and Materials—Founded in 1898 and incorporated in 1902, ASTM develops voluntary consensus standards for materials, products, systems, and services. Membership includes producers, users, and general interest/ultimate consumers from around the globe.

BSI — British Standards Institution—United Kingdom national standards body.

CAPP — Canadian Association of Petroleum Producers—Trade association representing oil and gas companies engaged in exploration, production, and pipelining. The companies within the CPA are responsible for 85% of Canada's oil and gas production.

COPANT — Pan American Standards Commission—Founded in 1961. Consists of national standards bodies of thirteen Latin American countries and of Trinidad and Tobago and two associate members: South Africa and the Dominican Republic. A coordinating organization concerned with the regional implementation of ISO and IEC Standards.

IEC — International Electrotechnical Commission—Founded in 1906. The electrotechnical counterpart to ISO. Consists of national electrotechnical committees of more than 40 countries. Publishes more than 1000 international standards.

ISO — International Organization for Standardization—Founded in 1947. Consists of national standards bodies of more than 87 countries. Publishes more than 4000 international standards.

D.2 Trade Associations and Technical Societies

AGA — American Gas Association—Founded in 1918. Trade association consisting of distributors and transporters of natural, manufactured, and mixed gas. Provides information on sales, finance, utilization, research, management, safety, accounting, and all phases of gas transmission and distribution.

AIME — American Institute of Mining, Metallurgical and Petroleum Engineers, Inc.—Founded in 1871 to promote (through meetings, publications, and other activities) the arts and sciences connected with economic production of useful minerals and metals for the ultimate benefit of mankind.

ANMC — American National Metric Council—Formed in 1973 as a division of ANSI; incorporated as a separate organization in 1976. Established to help guide metric conversion in a manner that promotes consistent application of metric units. Responsibility for this is vested in its Metric Practice Committee that was established in the fall of 1973.

GPA — Gas Processors Association—Established to develop more fully the gas producing and processing industry; to advance the technology of production, measurement, and handling of natural and synthetic gases and liquid products from them; and to publicize the valuable inherent qualities of these materials with a view to improve their uses.

IEEE — Institute of Electrical and Electronics Engineers—Founded in 1884. Membership society established to advance the theory and practice of its field through meetings, publications, standards, and related activities and to advance the professional standing of its members.

IP — Institute of Petroleum—Founded in 1913. British organization, with both individual and company members, established to promote, encourage, and coordinate the study of petroleum and its products and to accumulate and disseminate related information and knowledge. Maintains close contact with the American Petroleum Institute, particularly on matters related to petroleum measurement.

MTC — Metric Transition Committee—Founded in 1976. API committee created to assist in the implementation of the API metric conversion policy.

SPE Society of Petroleum Engineers of AIME—An international professional and technical organization of individuals engaged primarily in producing hydrocarbons and related energy resources. Its parent organization is AIME.

D.3 Intergovernmental Agencies

BIPM International Bureau of Weights and Measures—The metrological laboratory under the responsibility of the CIPM which can arrange for the measurement standards of any country to be compared with internationally agreed-upon standards.

CIPM International Committee for Weights and Measures—Responsible for implementing decisions of the CGPM and preparing for each conference.

CGPM General Conference on Weights and Measures—Membership drawn from those 41 nations who are signatories to the Metre Convention. The conference meets approximately every 4 years.

Additional copies are available through Global Engineering Documents at (800) 854-7179 or (303) 397-7956

Information about API Publications, Programs and Services is available on the World Wide Web at: http://www.api.org

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