Designation: F 1332 – 99

An American National Standard

Standard Practice for Use of SI (Metric) Units in Maritime Applications (Committee F-25 Supplement to IEEE/ASTM SI 10)[1]

This standard is issued under the fixed designation F 1332; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

INTRODUCTION

The International System of Units (SI) was developed by the General Conference on Weights and Measures (CGPM), which is an international treaty organization. The abbreviation *SI*, derived from the French "Le Système International d'Unités," is used in all languages.

On Dec. 23, 1975, Public Law 94-168, "The Metric Conversion Act of 1975," was signed by President Ford, committing the United States to a coordinated voluntary conversion to the metric system of measurement. The Act specifically defines the "metric system of measurement" as "the International System of Units as established by the General Conference on Weights and Measures in 1960, and as interpreted or modified for the United States by the Secretary of Commerce."

On Aug. 23, 1988, President Reagan signed into law P.L. 100-576, the Omnibus Trade and Competitiveness Act of 1988. The Act specifies that "metric" means the modernized metric system (SI). The Act then amended the Metric Conversion Act of 1975 to designate the metric system of measurement as the preferred system of weights and measures for United States trade and commerce.

This practice will help obtain uniform SI practice in the marine industry by providing a technical reference for the International System of Units (SI). The practice is not intended to cover all aspects of SI usage, but to serve as a ready reference especially tailored to the operating needs of the industry. For further information on SI usage and conversion factors for units not found herein, refer to IEEE/ASTM SI 10, upon which this practice is based.[2] In the event of a conflict, IEEE/ASTM SI 10 shall take precedence. (See also NIST Special Publication 811.)[3] Hardware and other standards in SI are currently being developed.

1. Scope

1.1 This practice covers the use of SI, which is comprised of base and derived SI units. Also discussed are non-SI units that have been accepted and recognized by the CGPM as appropriate for limited use or time. Basic rules for style and usage of SI are set forth, as well as methods for conversion from non-SI units to SI units. Tables of quantities used by the marine industry are included, with present units and conversion factors given.

2. Referenced Documents

2.1 *ASTM Standards:*

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modernized Metric System[2]

2.2 *NIST Publications:*

NIST Special Publication 811 Guide for the Use of the International System of Units (SI)[3]

NIST Special Publication 330 The International System of Units (SI)[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *quantity*, *n*—measurable attribute of a physical phenomenon.

3.1.2 *SI*, *n*—The universally accepted abbreviation for the International System of Units as defined in the document *Le Système International d'Unités*, 6th Edition, published by the International Bureau of Weights and Measures (BIPM), Sevres, France, 1991, and as interpreted and modified for the United

[1] This practice is under the jurisdiction of ASTM Committee F-25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.07 on General Requirements.

Current edition approved April 10, 1999. Published July 1999. Originally published as F 1332 – 91. Last previous edition F 1332 – 93.

[2] *Annual Book of ASTM Standards*, Vol 14.04 (Excerpts in Related Materials section of all other volumes).

[3] Available from National Institute for Standards and Technology (NIST), Gaithersburg, MD 20899.

States by the U.S. Department of Commerce. The U.S. version of the defining document is published by the National Institute of Standards and Technology as NIST Special Publication 330.[3,4]

3.1.3 *unit*, *n*—reference value of a given quantity as defined by CGPM Resolution or ISO standards. There is only one unit for each quantity in SI.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *coherent system of units*—a system of units of measurement in which a small number of base units, defined as dimensionally independent, are used to derive all other units in the system by rules of multiplication and division with no numerical factors other than unity.

4. The Concept of SI

4.1 The International System of Units (SI) was developed to provide a universal, coherent, and preferred system of units for world-wide use and appropriate to the needs of modern science, technology, and international commerce.

4.2 The principal features of SI are:

4.2.1 There is one and only one unit for each quantity.

4.2.2 The system is fully coherent.

4.2.3 Designated prefixes can be attached to units to form multiples and submultiples of ten raised to a power. Use of the prefixes provides for convenient numerical values when the magnitude of a quantity is stated, and avoids the need for many insignificant zeroes. The system is decimal, the same as the commonly used numerical system.

4.2.4 Units and prefixes are represented by standardized and internationally recognized symbols.

4.3 A few specifically accepted non-SI units are permitted in conjunction with SI.

4.4 SI units, acceptable non-SI units, and prefixes are discussed in Sections 5 and 6.

5. SI Units

5.1 SI includes two classes of units:

5.1.1 Base units and

5.1.2 Derived units.

5.2 *Base Units*—The International System of Units is based on seven base units, listed in Table 1, which by convention are regarded as dimensionally independent.

5.3 *Derived Units*—Derived units are formed by the algebraic combination of base units and derived units. Derived units with special names are listed in Table 2.

5.4 *Temperature*—The SI unit of thermodynamic temperature is the kelvin, and this unit is properly used for expressing thermodynamic temperature and temperature intervals. The degree Celsius is equivalent to kelvin with a different zero point on the scale. Celsius temperature t equals kelvin temperature minus 273.15 ($t = T - T_o$ where T = Kelvin and T_o = 273.15).

TABLE 1 SI Base Units

Quantity	Base SI Unit	Symbol
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

TABLE 2 SI Derived Units with Special Names

Quantity	Name of Derived SI unit	Symbol	Expressed in Terms of Base and Derived SI Units
Angle, plane	radian	rad	mm = 1
Angle, solid	steradian	Sr	$m^2/m^2 = 1$
Frequency	hertz	Hz	s^{-1}
Force	newton	N	$kg·m/s^2$
Pressure, stress	pascal	Pa	N/m^2
Energy, work, quantity of heat	joule	J	N·m
Power, radiant flux	watt	W	J/s
Electric charge, quantity of electricity	coulomb	C	A·s
Electric potential, potential difference, electromotive force	volt	V	W/A
Electric capacitance	farad	F	C/V
Electric resistance	ohm	Ω	V/A
Electric conductance	siemens	s	A/V
Magnetic flux	weber	Wb	V·s
Magnetic flux density	tesla	T	Wb/m^2
Inductance	henry	H	Wb/A
Luminous flux	lumen	lm	cd·sr
Illuminance	lux	lx	lm/m^2
Celsius temperature[A]	degree Celsius	°C	K
Activity (of a radionuclide)	becquerel	Bq	s^{-1}
Absorbed dose	gray	Gy	J/kg
Dose equivalent	sievert	Sv	J/kg

[A] See 5.4.

5.5 *SI Prefixes*—The prefixes and symbols shown in Table 3 are used to form decimal multiples and submultiples of SI units.

5.6 *Selection of Prefixes*:

5.6.1 A prefix should be selected so that the numerical value of the unit expressed will fall between 0.1 and 1000. An exception to this rule arises in the preparation of tables of values of the same quantity and in discussion of such values within a given context, when it is better to use the same unit multiple. Also, for certain applications, one particular multiple will customarily be used; for example, use of the millimetre for linear dimensions in engineering drawings.

5.6.2 Compound prefixes should not be used; for example, use GJ, not kMJ.

5.6.3 Prefixes should preferably not be used in the denominator of compound units. Example, use V/m not mV/mm. The exception is the kilogram as it is the base unit: J/kg, not kJ/g.

5.6.4 Errors in calculation may be avoided by using powers of ten with the units rather than prefixes.

[4] The U.S. edition of the English translation of the BIPM SI publication differs from the translation in the BIPM SI publication only in the following usage: (1) The dot is used as the decimal marker and (2) the spelling of English-language words, for example, "meter,' liter," and "deka" are used instead of "metre," "litre," and "deca" in accordance with the *U.S. Government Printing Office Style Manual*, which follows *Webster's Third New International Dictionary* rather than the *Oxford Dictionary* used in many English-speaking countries.

The spelling of "meter" and "liter" in preference to "metre" and "litre" is recommended by the U.S. Department of Commerce as preferred for U.S. use and is mandated by the Department of Commerce for use by all agencies of the Federal government.

TABLE 3 SI Prefixes

exa	E	10^{18}	1 000 000 000 000 000 000
peta	P	10^{15}	1 000 000 000 000 000
tera	T	10^{12}	1 000 000 000 000
giga	G	10^{9}	1 000 000 000
mega	M	10^{6}	1 000 000
kilo	k	10^{3}	1 000
hecto[A]	h	10^{2}	100
deka[A]	da	10^{1}	10
deci[A]	d	10^{-1}	0.1
centi[B]	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	µ	10^{-6}	0.000 001
nano	n	10^{-9}	0.000 000 001
pico	p	10^{-12}	0.000 000 000 001
femto	f	10^{-15}	0.000 000 000 000 001
atto	a	10^{-18}	0.000 000 000 000 000 001

[A]To be avoided where practical.
[B]Usually avoided, but used in some disciplines.

6. Non-SI Units in Use with SI

6.1 *Units in Use with SI*—Certain units that are not SI have been accepted for use with SI units. Some of these units, currently recognized as acceptable for use with SI, are listed in Table 4 and Table 5.

6.2 *Time*—The SI unit of time is the second. This unit is preferred and should be used when practical, particularly in technical calculations.

6.3 *Plane Angle*—The SI unit of plane angle is the radian. When the radian is not a convenient unit, the degree should be used with decimal submultiples. Minutes and seconds should be used only when required (as in navigation).

6.4 *Area*—The SI unit of area is the square metre. The hectare (ha) is a special name for square hectometre (hm^2). Large land or water areas are generally expressed in hectares or in square kilometres.

6.5 *Volume*—The SI unit of volume is the cubic metre. The cubic metre, or one of its multiples or submultiples, is preferred for all applications. The special name litre has been approved by the CGPM for the cubic decimetre.

6.6 *Mass*—The SI unit of mass is the kilogram. The kilogram, or one of the multiples or submultiples formed by attaching an SI prefix to gram, is preferred for all applications. For large masses (such as have been expressed in tons), the megagram is the appropriate unit. The term metric ton should be restricted to commercial and maritime usage, and no prefixes should be used with it. To avoid confusion, use of the term "tonne" to indicate metric ton is discouraged.

TABLE 4 Non-SI Units in Use with SI

Quantity	Unit	Symbol	Definition
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min = 3600 s
	day	d	1d = 24 h = 86 400 s
plane angle	degree	°	1° = (π/180) rad
	minute	′	1′ = (1/60)° π/10 800) rad
	second	″	1″= (1/60)′ = (π/648 000) rad
volume	litre	L	1 L = 1 dm^3= 10^{-3} m^3
mass	metric ton	t	1 t =10^3 kg

TABLE 5 Units in Use Temporarily with SI[A]

Name	Value in SI Unit (exact)
nautical mile (nmi)	1852 m
knot (kn)	nmi/h = (1852/3600 m/s)
Hectare (ha)	$10^4 m^2$
bar[B]	100 kPa
curie (Ci)	3.7×10^{10} Bq
roentgen (R)	2.58×10^{-4} C/kg
rad (rad)[C]	1×10^{-2} Gy
rem (rem)	1×10^{-2} Sv

[A]Because their usage is already well established, these units may be used subject to further review.
[B]Usage is restricted to meteorology.
[C]If there is risk of confusion with the symbol for radian, rd may be used as the symbol for rad.

7. Mass, Force, and Weight

7.1 SI, being coherent, is different from the older metric systems in the use of distinctly separate units for mass and force. In SI, the unit of force, the newton (N), is derived as the laws of physics dictate, instead of being related to gravity, and is defined as being equal to the force that imparts an acceleration of unit (1 m/s^2) to a unit mass, the kilogram (kg).

7.1.1 *Mass*—The mass of a body is a measure of its inertia, that is, its resistance to a change in its motion. In practical terms, mass represents the quantity of matter in a body (not to be confused with amount of substance expressed in moles). The SI unit of mass is the kilogram (kg).

7.1.2 *Force*—Force is the mechanical action on a body resulting from physical contact with another body or the action resulting from gravitational or electromagnetic fields. The SI unit of force is the newton (N).

7.1.3 *Weight*—The weight W of a body is the effective gravity force acting on it and equals the product of its mass m and the local acceleration of free fall, g, so that $W = mg$. In SI, weight is measured in newtons (N). Because the acceleration of gravity (the acceleration of free fall) varies slightly over the surface of the earth, the weight of a body varies accordingly, whereas its mass is a constant.

7.1.4 *Discussion*—The existence of clearly separate units for mass and force in SI contrasts with the widespread use of the units lb and kg for both mass and force. Whereas the word "weight" has been commonly used when mass is intended or implied, especially in commerce and everyday life, this use should in time disappear with growing acceptance and use of SI units, and the word *mass* (rather than *weight*) will be used when mass is meant. The use of weight for mass should be avoided altogether in scientific and technical communication.

8. Rules for Style and Usage of SI

8.1 *Rules for Writing Unit Symbols*:

8.1.1 Particular care must be taken to use the correct symbols for units and prefixes (for example, K for kelvin, k for kilo, M for mega, m for milli). When using systems with limited character sets, as in Telex transmission or computer printout, the standard symbols cannot be used. For these purposes, refer to ISO 2955 or ANSI X3.50.

8.1.2 Unit symbols are symbols and do not vary from singular to plural.

8.1.3 Unit symbols should be printed in roman (upright) type, regardless of the type style used in the surrounding text.

8.1.4 Unit symbols are not followed by a period except when used at the end of a sentence.

8.1.5 The numerical value associated with a symbol should be separated from that symbol by a space. For example, 25.4 mm, not 25.4mm. The only exception to this rule is that no space is left between the numerical value and the symbols of degree, minute, and second of plane angle and degree Celsius.

8.1.6 Unit symbols should be used in preference to the unit names except when a number written out in words precedes the unit; for example "seven metres" not "seven m."

8.2 *Rules for Writing Unit Names*:

8.2.1 The first letter of a unit name is not capitalized except at the beginning of a sentence or in capitalized material such as a title.

8.2.2 Plurals of unit names are formed in the ordinary manner, except for lux, hertz, and siemens, which remain the same.

8.2.3 No space or hyphen is used between a prefix and the unit name; for example, kilonewton.

8.3 *Product, Quotient, and Powers*:

8.3.1 To indicate the product of units when using their names, a space is left between the names (for example, newton metre). When using symbols, a centered dot should be placed between the symbols (for example, N·m).

8.3.2 To indicate the quotient of units when using their names use the word "per" (for example, metres per second). When using unit symbols, a solidus (/) or negative exponent should be used (for example, m/s or $m \cdot s^{-1}$). Do not use more than one solidus in the same expression. Use parentheses to avoid any ambiguity (consider m/s·A can mean m/(s·A) or (m/s)·A).

8.3.3 To indicate powers when using unit names, the words "square," "cubic," "squared," "cubed," and so forth should be used (for example, square metre, second squared). When using unit symbols, powers are indicated by the use of an exponent (for example, m^3).

8.4 *Numbers*:

8.4.1 At present, the period will be used for the decimal marker. For numbers of less than one, a zero should precede the decimal; for example, 0.964.

8.4.2 Recommended international practice calls for the use of a half space to separate large numbers into groups of three. Do not use a comma. The digits should be separated into groups of three counting from the decimal point toward the left and the right, and using a small space to separate the groups. In numbers of four digits, the space is usually not necessary except to provide uniformity in tables, columns, and so forth. For example, 16 390, 1.828 8 or 1.8288, 4 536 or 4536.

9. Conversion and Rounding Methods

9.1 *Soft Conversion*—Soft conversion is the process of changing the non-SI measurement language to equivalent SI units within acceptable measurement tolerances without changing the physical configuration. In other words, the item described is the same item both before and after conversion.

9.2 *Hard Conversion*—Hard conversion is the change of design and use of measures to SI as if non-SI units did not exist, namely the use of integers and round numbers, in SI, as the basis of design. Although the term is in general use, it is technically incorrect when applied to specific items because no "conversion" takes place; rather, a new item, designed in SI units (requiring a new identification), is created to replace the old item.

9.3 *Conversion Factors*—Table 6 contains conversion factors for units commonly used in the marine field.

9.4 *Precision*—When converting, care must be given to the precision desired. The number of significant digits retained in the answer should be such that accuracy is neither sacrificed nor exaggerated. Specified quantities should first be multiplied by the exact conversion factor and then rounded to the appropriate number of significant digits. Do not round either the conversion factor or the quantity before performing the multiplication, as accuracy would be reduced. Use appropriate prefixes to eliminate insignificant, leading, or trailing zeroes.

9.5 *Rounding*—The rounding required by conversion and computation in SI units should be done using the following rules for the three general cases:

9.5.1 Where the digit immediately following the last digit to be retained is less than 5, the last digit retained should not be changed.

9.5.2 Where the digit immediately following the last digit to be retained is greater than 5 (or it is a 5 followed by at least one digit other than 0), the last digit should be increased by one.

9.5.3 Where the digit immediately following the last digit to be retained is exactly 5 (or it is a 5 followed by only zeroes), the last digit retained is not changed if it is even, and if it is odd it should be increased by one. For example, 4.365 00 becomes 4.36 when rounded to three digits. 4.355 00 also becomes 4.36 when rounded to three digits.

9.5.4 The above rules provide an additional observation about significant digits. The least significant digit (the last digit retained in the rounding process) cannot be considered more precise than 0.5 of its place value.

10. Accuracy of Conversion

10.1 It is important, in any conversion, to determine the accuracy of the original value and the repeatability of the converted value. Where interchangeability of converted values is required, IEEE/ASTM SI 10 should be consulted for exact procedures which will establish limits to the errors resulting from conversion calculations.

11. Special Ratios

11.1 Two special ratios[5] are used in the maritime industry. These ratios are speed-length ratio, $V/\sqrt{L}$, and displacement-length ratio, $\Delta/(0.01\ L)^3$

where:
V = = speed in knots,
L = = length in feet, and
Δ = = displacement in long tons.

11.2 When using SI units, the speed-length ratio should be replaced by Froude number, $v\ /\ (gL)^{0.5}$, in coherent units,

where:
v = = velocity,
g = = gravitational acceleration, and
L = = the ship's length.

11.3 Similarly, the displacement-length ratio should be replaced by the volumetric coefficient,[6] ∇/L^3, in coherent units,

where:
∇ = the underwater volume of the hull and
L = the ship's length.

11.4 Speed-length ratio and displacement-length ratio are in common use because they have convenient values in their dimensional form. For example, $V/\sqrt{L} = 1$ is significant from a wave resistance viewpoint. Using SI units would cause the numerical values of speed-length ratio to be multiplied by 1.81 and displacement-length ratio by 35.9.

11.5 Froude number is a factor of 0.298 times speed-length ratio. Since using SI units in dimensional speed-length ratio will change the values used, it is logical to use the dimensionless ratio, that is, the Froude number. Thus, Froude number should be used in place of speed-length ratio when designing in the SI system.

[5] Taylor, D. W., *The Speed and Power of Ships*, third ed., Government Printing Office, Washington, DC, 1943, p. 59.

[6] Panel H-2, "Explanatory Notes for Resistance and Propulsion Data Sheets," *Society of Naval Architects and Marine Engineers Technical and Research Bulletin 1–13*, July 1953, p. 8.

12. Conversion Factors

12.1 Table 6 and Table 7 provide conversion factors to SI for those quantities commonly used in the marine industry.

12.2 The maritime industry is subject to a complexity of national and international laws, treaties, regulations, and long term safety and contractual obligations which in some instances prevent unilateral changes from customary maritime language and usage of SI basic and supplementary terms. Therefore, Table 6 provides, in addition to the recommended SI units, a number of non-SI units permitted for use until such time as the preferred SI units can be adopted without detriment.

12.3 To convert a present unit to its equivalent SI unit or unit permitted for use, multiply the present unit in column 3 by the multiplication factor shown in column 6. To convert to present units, divide the SI unit by the factor.

12.4 Conversion factors are presented for ready adaptation to computer readout and electronic data transmission. The factors are written as a number equal to or greater than one and less than ten with six or fewer decimal places. This number is followed by the letter *E* (for exponent), a plus or minus symbol, and two digits which indicate the power of 10 by which the number must be multiplied to obtain the correct value. For example:

$$3.523\,907\ E - 02 \text{ is } 3.523\,907 \times 10^{-2}$$
or
$$0.035\,239\,07$$

Similarly:

$$3.386\,389\ E + 03 \text{ is } 3.386\,389 \times 10^{3}$$
or
$$3386.389$$

13. Keywords

13.1 measurement; metric; metric for maritime applications

TABLE 6 Conversion Table

ISO No.[A]	Quantity/Areas of Use	Present Units	Preferred SI Units	Units Permitted for Use with SI[B]	Conversion Factors
1	2	3	4	5	6
1-1.1	*Plane angle:*				
	Machine design	radian	radian (rad)		1.0[C]
	Angle of entrance of hull, engine timing, navigation[D]	degree		degree (°)[C]	1.0[C]
		minute		degree (°)	1 min = 1.666 667 E − 02°
		second		degree (°)	1 s = 2.777 778 E − 04°
1-3.1	*Length:*				
	Distances	nautical mile[E]	kilometre (km)		1 nautical mile = 1.852 km[C]
				nautical mile	1.0[C]
		statute mile	kilometre (km)		1 statute mile = 1.609 347 km
		international mile	kilometre (km)		1 international mile = 1.609 344 km
	Depth of water, length of cables, wires, and ropes	fathom[F]	metre (m)		1 fathom = 1.828 804 E + 00 m

TABLE 6 *Continued*

ISO No.[A]	Quantity/Areas of Use	Present Units	Preferred SI Units	Units Permitted for Use with SI[B]	Conversion Factors
1	2	3	4	5	6
	Deck heights, draft, main hull dimensions, stability data, location of centers of gravity, buoyancy and flotation, KM, KG, GM, and GZ	foot and inch	metre (m)		1 foot = 3.048 000 E − 01 m[C]
	Draft marks on hull	foot	decimetre (dm)		1 foot = 3.048 000 E + 00 dm[C]
	Deck camber, frame scantlings and plate thickness, insulation thickness, machinery dimensions, pipe sizes	foot or inch, or both	millimetre (mm)		1 foot = 3.048 000 E + 02 mm 1 inch = 2.540 000 E + 01 mm
	Rope and cable diameters	inch	millimetre (mm)		1 inch = 2.540 000 E + 01 mm[C]
	Paint film thickness	mil (10^{-3} inch)	micrometre (µm)		1 mil = 2.540 000 E + 01 µm[C]
1-4.1	*Area:*				
	Deck areas, heating surface, panelling areas, propeller blade area, waterplane area, wetted hull surface, free surface	square yard square foot	square metre (m^2) square metre (m^2)		1 yd^2 = 8.361 274 E − 01 m^2 1 ft^2 = 9.290 304 E − 02 m^2[C]
	Sectional area of stressed parts	square inch	square millimetre (mm^2)		1 $in.^2$ = 6.451 600 E + 02 mm^2[C]
1-4.1a	*First moment of area:*				
	Structure design, midship section	$inch^2$ foot	cubic metre (m^3)		1 $in.^2$ ft = 1.966 448 E − 04 m^3
				metre $centimetre^2$ ($m \cdot cm^2$)	1 $in.^2$ ft = 1.966 448 E + 00 $m \cdot cm^2$
1-4.1b	*Section modulus:*				
	Frames and associated plating	$inch^3$ $inch^2$ foot	cubic millimetre (mm^3)	 metre $centimetre^2$ ($m \cdot cm^2$)	1 $in.^3$ = 1.638 706 E + 04 mm^3 1 $in.^2$ ft = 1.966 448 E + 00 $m \cdot cm^2$
1-4.1c	*Second moment of area:*				
	Structure design, midship section	$inch^2$ $foot^2$	$metre^4$(m^4)		1 $in.^2$ ft^2 = 5.993 733 E − 05 m^4
				$metre^2$ $centimetre^2$ ($m^2 \cdot cm^2$)	1 $in.^2$ ft^2 = 5.993 733 E − 01 $m^2 \cdot cm^2$
	Frames and associated plating	$inch^4$	$millimetre^4$ (mm^4)		1 $in.^4$ = 4.162 314 E + 05 mm^4
1-5.1	*Volume:*				
	Freight volume measurement[G]	ton of 40 ft^3	cubic metre (m^3)		1 freight ton = 1.132 674[C] E + 00 m^3
	Gross and net tonnage (measurement ton)	ton of 100 ft^3	cubic metre (m^3)		1 measurement ton = 2.831 685 E + 00 m^3
	Volume of displacement, volume of holds, large air receivers	cubic foot	cubic metre (m^3)		1 ft^3 = 2.831 685 E − 02 m^3
	Volume of large fuel tanks	barrel (42 gallons)	cubic metre (m^3)		1 bbl = 1.589 873 E − 01 m^3
	Volume of small tanks and small air receivers	U.S. gallon (liquid) U.S. gallon (liquid)	cubic metre (m^3)	 litre (L)	1 gal = 3.785 412 E − 03 m^3 1 gal = 3.785 412 E − 00 L
1-5.1a	*Specific volume:*				
	Stowage factors for solid and liquid cargo, fuel oil and water	$foot^3$ per ton	cubic metre per kilogram (m^3/kg)		1 ft^3/ton = 2.786 963 E − 05 m^3/kg
				cubic metre per metric ton (m^3/t)	1 ft^3/ton = 2.786 963 E − 02 m^3/t
	Gases and vapors	$foot^3$ per pound	cubic metre per kilogram (m^3/kg)		1 ft^3/lb = 6.242 796 E − 02 m^3/kg
				litre per kilogram (L/kg)	1 ft^3/lb = 6.242 796 E + 01 L/kg
1-5.1b	*Volume flow:*				
	Capacity of air compressors, fans, large pumps	$foot^3$ per minute	cubic metre per second (m^3/s)		1 ft^3/min = 4.719 474 E − 04 m^3/s
				cubic metre per hour (m^3/h)	1 ft^3/min = 1.699 011 E + 00 m^3/h
	Capacity of most pumps	gallon per minute	cubic metre per second (m^3/s)		1 gal/min = 6.309 020 E − 05 m^3/s
				litre per second (L/s)	1 gal/min = 6.309 020 E − 02 L/s
	Barrel per day	barrel per day	cubic metre per second (m^3/s)		1 bbl/d = 1.840 131 E − 06 m^3/s
				cubic metre per day (m^3/d)	1 bbl/d = 1.589 873 E − 01 m^3/d

TABLE 6 *Continued*

ISO No.[A]	Quantity/Areas of Use	Present Units	Preferred SI Units	Units Permitted for Use with SI[B]	Conversion Factors
1	2	3	4	5	6
	Barrel per nautical mile	barrel per nmi	cubic metre per metre (m^3/m)		1 bbl/nmi = 8.584 627 E − 05 m^3/m
				cubic metre per nmi (m^3/nmi)	1 bbl/nmi = 1.589 873 E − 01 m^3/nmi
1-6.1	*Time:*				
	As at present	day (d)		day (d)	1.0[C]
		hour (h)		hour (h)	1.0[C]
		minute (min)		minute (min)	1.0[C]
		second (s)	second (s)		1.0[C]
1-7.1	*Angular velocity:*				
	Machine design	radian per second	radian per second (rad/s)		1.0[C]
1-7.1a	*Angular acceleration:*				
	Machine design	radian per second^2	radian per second squared (rad/s^2)		1.0[C]
1-9.1	*Velocity:*				
	Ship speed	knot[E]	metre per second (m/s)		1 knot = 5.144 444 E − 01 m/s
				knot	1.0[C]
	Fluid velocity, linear velocity of machinery parts, speed of cables, ropes, wires	foot per second	metre per second (m/s)		1 ft/s = 3.048 000 E − 01 m/s[C]
1-10.1	*Acceleration:*				
	Machine design Vibration	foot per second^2	metre per second squared (m/s^2)		1 ft/s^2= 3.048 000 E − 01 m/s^2[C]
2-3.1	*Frequency:*				
	Electrical and Electronics	cycle per second	hertz (Hz)		1.0[C]
2-3.2	*Rotational speed:*				
	Rotational speed of machinery	revolutions per minute (r/min)	radian per second (rad/s)		1 rpm = 1.047 198 E − 01 rad/s
				r/min	1.0[C]
3-1.1	*Mass:*				
	Deadweight, displacement lightweight ballast, fresh water and fuel oil capacity	ton (long)[H]	megagram (Mg)		1 ton = 1.016 047 E + 00 Mg
				metric ton (t)	1 ton = 1.016 047 E + 00 t
	Lifting capacity, test load and SWL (safe working load, rated) of cranes, booms, and winches	ton		metric ton (t)	1 ton = 1.016 047 E + 00 t
		pound	kilogram (kg)		1 lb = 4.535 924 E − 01 kg
	General stores, pieces of equipment	pound (lb)	kilogram (kg)		1 lb = 4.535 924 E − 01 kg
		hundred weight (cwt)	kilogram (kg)		1 cwt = 5.080 235 E + 01 kg
	Engineering calculations	slug	kilogram (kg)		1.459 390 E + 1 kg
3-1.1a	*Moment of mass:*	pound foot	kilogram metre (kg·m)		1 lb-ft = 1.382 549 E − 01 kg·m
		ton foot	megagram metre (Mg·m)		1 ton foot = 3.096 911 E − 01 Mg·m
				metric ton metre (t·m)	1 ton·ft = 3.096 911 E − 01 t·m
	Trimming moments	ton foot	megagram metre (Mg·m)		1 ton foot = 3.096 911 E − 01 Mg·m
				metric ton metre (t·m)	1 ton·ft = 3.096 911 E − 01 t·m
3-1.1b	*Mass flow:*				
	Liquid flow rates	ton per hour	kilogram per second (kg/s)		1 ton/h = 2.822 352 E − 01 kg/s
				metric ton per hour (t/h)	1 ton/h = 1.016 047 E + 00 t/h
	Gas and steam flow rates	pound per hour	kilogram per second (kg/s)		1 lb/h = 1.259 979 E − 04 kg/s
				kilogram per hour (kg/h)	1 lb/h = 4.535 924 E − 01 kg/h
3-1.1c	*Unit displacement:*				
	Displacement per unit of immersion	ton per inch	kilogram per metre (kg/m)		1 ton/in. = 4.000 185 E + 04 kg/m
				metric ton per centimetre (t/cm)	1 ton/in. = 4.000 185 E − 01 t/cm
3-1.1d	*Moment to change trim by a unit amount:*	ton foot per inch	kilogram metre per metre (kg·m/m)		1 ton·ft/in. = 1.219 256 E + 00 kg·m/m
				metric ton metre per centimetre (t·m/cm)	1 ton·ft/in. = 1.219 256 E − 01 t·m/cm
3-1.1e	*Moment to change list by a unit amount:*	ton foot per degree	kilogram metre per radian (kg·m/rad)		1 ton·ft/deg = 1.774 400 E + 00 kg·m/rad
				ton metre per degree (t·m/degree)	1 ton·ft/deg = 3.096 911 E + 01 t·m/deg
3-2.1	*Density:*				
	Density of solids	pound per inch^3	kilogram per cubic metre (kg/m^3)		1 lb/in.^{3} = 2.767 990 E + 04 kg/m^3
	Density of solids			kilogram per cubic centimetre (kg/cm^3)	1 lb/in.^{3} = 2.767 991 E − 02 kg/cm^3

TABLE 6 *Continued*

ISO No.[A]	Quantity/Areas of Use	Present Units	Preferred SI Units	Units Permitted for Use with SI[B]	Conversion Factors
1	2	3	4	5	6
	Density of liquids	pound per gallon	kilogram per cubic metre (kg/m^3)		1 lb/gal = 1.198 264 E + 02 kg/m^3
				kilogram per litre (kg/L)	1 lb/gal = 1.198 264 E − 01 kg/L
	Density of gases	pound per $foot^3$	kilogram per cubic metre (kg/m^3)		1 lb/ft^3 = 1.601 846 E + 01 kg/m^3
3-2.1a	*Concentration:*				
	Salinity	grains per gallon	kilogram per cubic metre (kg/m^3)		1 grain/gal = 1.711 806 E − 02 kg/m^3
	Boiler feed water testing, potable water testing			grams per litre (g/L)	1 grain/gal = 1.711 806 E + 02 g/L
3-7.1	*Momentum:*				
	Machine design	pound foot per second	kilogram metre per second (kg·m/s)		1 lb·ft/s = 1.382 550 E − 01 kg·m/s
3-8.1	*Moment of momentum:*				
	(Angular momentum) machine design	pound $foot^2$ per second	kilogram metre squared per second ($kg·m^2/s$)		1 $lb·ft^2/s$ = 4.214 011 E − 02 $kg·m^2/s$
3-9.1	*Moment of inertia:*				
	Machine design	pound $foot^2$	kilogram $metre^2$($kg·m^2$)		1 $lb·ft^2$ = 4.214 011 E − 02 $kg·m^2$
		pound $inch^2$	kilogram $metre^2$($kg·m^2$)		1 $lb·in.^2$ = 2.926 397 E − 04 $kg·m^2$
3-10.1	*Force:*				
	Machine and structure design	ton-force	kilonewton (kN)		1 tonf = 9.964 017 E + 00 kN
		pound-force	newton (N)		1 lbf = 4.448 222 E + 00 N
3-12.1	*Moment of force (torque):*[I]				
	Machine and structure design, bending moments	foot ton-force	kilonewton metre (kN·m)		1 tonf·ft = 3.037 032 E + 00 kN·m
		foot pound-force	newton metre (N·m)		1 ft·lbf = 1.355 818 E + 00 N·m
		inch pound-force	newton metre (N·m)		1 in.·lbf = 1.129 848 E − 01 N·m
		foot poundal	newton metre (N·m)		1 pdl·lbf = 4.214 012 E − 02 N·m
3-13.1	*Pressure:*[J]				
	Normal fluid pressure, (for example, compressed air, oil, steam)	pound-force per $inch^2$	kilopascal (kPa) or MPa		1 $lbf/in.^2$ = 6.894 757 E + 00 kPa
	Bearing pressures	kilogram-force per $centimetre^2$	kilopascal (kPa) or MPa		1 kgf/cm^2 = 9.806 650 E + 01 kPa
	Barometric measurements and pressures of small magnitude	inch of mercury (60°F)	kilopascal (kPa)		1 in. H_2O = 3.376 850 E + 00 kPa
		inch of mercury (ISO)	kilopascal (kPa)		1 in. Hg = 3.386 39 E + 00 kPa
	Differential pressures	inch of water (60°F)	kilopascal (kPa)		1 in. H_2O = 2.488 400 E − 01 kPa
	Ventilation pressures	inch of water (ISO)	kilopascal (kPa)		1 in. H_2O = 2.490 89 E − 01 kPa
3-13.2	*Stress:*				
	Stresses in materials	pound-force per $inch^2$	megapascal (MPa) or GPa		1 $lbf/in.^2$ = 6.894 757 E − 03 MPa
		ton-force per $inch^2$	megapascal (MPa) or GPa		1 $tonf/in.^2$= 1.535 495 E − 04 MPa
		kip per $inch^2$	megapascal (MPa) or GPa		1 $kip/in.^2$ = 6.894 757 E + 00 MPa
3-21.1	*Dynamic viscosity:*				
	Viscosity of liquids and gases	centipoise (cP)	millipascal second (mPa·s)		1.0[C]
		pound force second per square foot	pascal second (Pa·s)		1 $lbf·s/ft^2$ = 4.788 026 E + 01 Pa·s
3-22.1	*Kinematic viscosity:*				
	Viscosity of liquids	centistokes (cSt)	square millimetre per second (mm^2/s)		1.0[C]
		square foot per second	square metre per second (m^2/s)		1 ft^2/s = 9.290 304 E − 02 m^2/s
3-24.1	*Energy, work:*				
	Thermodynamics	Btu	kilojoule (kJ)		1 Btu = 1.055 056 E + 00 kJ
		foot pound-force	joule (J) or any multiple		1 ft·lbf = 1.355 818 E + 00 J
		calorie (international)	joule (J) or any multiple		4.186 800* E + 00 J
3-25.1	*Power:*				

TABLE 6 *Continued*

ISO No.[A]	Quantity/Areas of Use	Present Units	Preferred SI Units	Units Permitted for Use with SI[B]	Conversion Factors
1	2	3	4	5	6
	Mechanical, electrical or hydraulic power of normal magnitude	horsepower (SHP, BHP, etc.)	kilowatt (kW)		1 hp = 7.457 000 E − 01 kW
	Small powers	foot pound force per second	watt (W)		1 ft·lbf/s = 1.355 818 E + 00 W
4-1.1	*Absolute temperature:*				
	Thermodynamic calculations	degree Rankine	kelvin (K)		$T_K = T_R/1.8$
4-2.1	*Temperature:*				
	All measured and specified temperature	degree Fahrenheit	degree Celsius (°C) or kelvin (K)		$t_{°C} = (t_{°F} - 32)/1.8$
4-2.1a	*Temperature interval:*				
	All temperature intervals	degree Fahrenheit	degree Celsius (°C) or kelvin (K)		1°F = 5/9°C[C] 1°F = 5/9 K[C]
4-3.1	*Linear expansion coefficient:*				
	All linear expansion coefficients	inch per inch per degree Fahrenheit	metre per metre per kelvin (m/m) k^{-1}		$1°F^{-1} = 1.8$[C]
4-6.1	*Heat, quantity of heat:*				
	Thermodynamics, refrigeration	Btu	joule (J) and its multiples		1 Btu = 1.055 056 E + 00 kJ
4-7.1	*Heat flow rate:*				
	Boiler and heat exchanger design	Btu per second	watt (W) and its multiples		1 Btu/s = 1.055 056 E + 00 kW
	Thermodynamics	Btu per hour	watt (W)		1 Btu/h = 2.930 711 E − 01 W
	Refrigeration and air conditioning	ton of refrigeration	kilowatt (kW)		1 ton (refrigeration) = 3.516 853 E + 00 kW
4-7.1a	*Density of heat flow rate:*				
	Boiler and heat exchanger design	Btu per foot^2 hour	watt per square metre (W/m^2)		1 Btu/(ft^2·h) = 3.154 591 E + 00 W/m^2
4-7.1b	*Volumetric heat release rate:*				
	Boiler design	Btu per foot^2 hour	watt per cubic metre (W/m^3)		1 Btu/(ft^3/h) = 1.034 971 E + 01 W/m^3
4-7.1c	*Fuel consumption rate:*				
	Specific fuel consumption	pound per horsepower hour	kilogram per joule (kg/J)		1 lb/hph = 1.689 659 E − 07 kg/J
4-9.1	*Thermal conductivity:*				
	Heat exchanger design, insulation	Btu inch per foot^2 hour degree Fahrenheit	watt per metre °C (W/(m·°C)) or W/(m·K)		1 Btu·in/(ft^2·h·°F) = 1.442 279 E − 01 W/(m·°C)
4-10.1	*Coefficient of heat transfer:*				
	Heat exchanger design, insulation	Btu per hour-foot^2 degree Fahrenheit	watt per square metre degree C (W/(m^2·°C)) or W/(m^2·K)		1 Btu/(h·ft^2·°F) = 5.678 263 E + 00 W/m^2·°C
4-14.1	*Specific heat capacity:*				
	Thermodynamics, applied heat, refrigeration	Btu per pound degree F	kilojoule per kilogram kelvin (kJ/(kg·K))		1 Btu/(lb·°F) = 4.186 800 E + 00 kJ/(kg·°K)[C]
4-18.1	*Specific entropy:*				
	Thermodynamics	Btu per pound degree R	kilojoule per kilogram kelvin (kJ/(kg·K))		1 Btu/(lb·°R) = 4.186 800 E + 00 kJ/(kg·K)[C]
4-20.1	*Specific internal energy:*				
	Calorific value, specific latent heat thermodynamics, refrigeration	Btu per pound	kilojoule per kilogram (kJ/kg)		1 Btu/lb = 2.326 000 E + 00 kJ/kg[C]
5-1.1	*Electric current:*	ampere	ampere (A)		1.0[C]
5-2.1	*Quantity of electricity:*				
	Electrical charge	coulomb	coulomb (C)		1.0[C]
	Battery rating	ampere hour	coulomb (C)		1.0[C]
				ampere hour (A·h)	1 A·h = 3.6 E + 3C[C]
5-6.3	*Electromotive force, potential:*				
	Difference	volt	volt (V)		1.0[C]
5-9.1	*Capacitance*	farad	farad (F)		1.0[C]
5-17.1	*Magnetic field intensity*	oersted	ampere per metre (A/m)		1 oersted = 7.957 747 E + 01 A/m
5-18.2	*Magnetomotive force*	gilbert	ampere (A)		1 gilbert = 7.957 747 E − 01 A
5-19.1	*Magnetic flux density*	gauss	tesla (T)		1 gauss = 1.000 000 E − 04 T[C]
5-20.1	*Magnetic flux*	maxwell	weber (Wb)		1 maxwell = 1.000 000 E − 08 Wb[C]
5-22.1	*Inductance*	henry	henry (H)		1.0[C]
5-24.1	*Permeability*	gauss/oersted	henry per metre (H/m)		1 gauss/oersted = 1.257 E − 06 H/m
5-33.1	*Resistance*	ohm	ohm (Ω)		1.0[C]
5-34.1	*Conductance*	mho	siemens (S)		1.0[C]

TABLE 6 *Continued*

ISO No.[A]	Quantity/Areas of Use	Present Units	Preferred SI Units	Units Permitted for Use with SI[B]	Conversion Factors
1	2	3	4	5	6
5-35.1	*Resistivity*	ohm-centimetre (Ω·cm)	ohm-metre (Ω·m)		1 Ω·cm = 1.000 000 E − 02 Ω·m[C]
		ohm circular-mil per foot	ohm millimetre^2 per metre (Ω·mm^2/m)		1 Ω·cmil/ft = 1.662 426 E − 03 Ω·mm^2/m
5-36.1	*Conductivity*	mho per centimetre	siemens per metre (S/m)		1 mho/cm = 1.000 000 E + 02 S/m[C]
5-44.1	*Electric power*	watt	watt (W)		1.0[C]
6-19.1	*Luminous intensity*	candlepower, candle	candela (cd)		1 candlepower = 1 cd[C]
6-20.1	*Luminous flux*	lumen	lumen (lm)		1.0[C]
6-22.1	*Luminance*	lambert	candela per metre^2 (cd/m^2)		1 lambert = 3.183 099 E + 03 cd/m^2
6-24.1	*Illuminance*	footcandle	lux (lx)		1 footcandle = 1.076 391 E + 01 Lx
6-50.1	*Activity (of a radionuclide):*	curie	becquerel (Bq)		1 curie = 3.700 000 E + 10 Bq[C]
	Absorbed dose	rad (rd)	gray (Gy)		1 rad = 1.000 000 E − 02 Gy[C]
	Dose equivalent	rem	sievert (Sv)		1 rem = 1.000 000 E − 02 Sv[C]
	Exposure (X and gamma rays)	roentgen (R)	coulomb per kilogram (C/kg)		1 R = 2.580 000 E − 04 C/kg[C]

[A]ISO number is from ISO 31 classification system.

[B]Units permitted for use with SI are in common use throughout the international maritime industry. The switch to preferred SI units should be made as conditions permit.

[C]Indicates exact conversion value.

[D]Minutes and seconds of plane angle may still be used for navigation purposes.

[E]For values of nautical mile and knot, see Table 6.

[F]Conversion based on the foot and one fathom equal to six feet.

[G]The volume measurement for those not using the metric system is generally 40 cubic feet, however, 50 cubic feet is used occasionally. It is recommended that the cubic metre (35.315 cubic feet) be used as the replacement unit. The conversion factor for one non-metric measurement ton (40 cubic feet) equals 1.132 67 cubic metres. One cubic metre of 35.315 cubic feet equals 0.883 non-metric measurement tons. The conversion of tariffs filed with the Federal Maritime Commission must be accomplished in accordance with their filing requirements.

[H]All tonnage measurements are long tons (2240 pounds). The short ton (2000 pounds) equals 0.907 185 t.

[I]An apparent anomaly exists in the case of the joule for work (J = N·m) and the use of N·m for torque or bending moment. These are, however, entirely different units. In the former, the unit of work results from unit force moving through unit distance. In the latter unit force acts at right angles to the lever arm of unit length. The distinction would be readily seen if vectors were incorporated in the unit symbols. For these reasons, it is important to express work or energy in joules and moment of force or torque in newton metres, not joules. The use of newton metre per radian as the unit of torque in rotational dynamics will result in dimensional integrity.

[J]It has been internationally recommended that pressure units themselves should not be modified to indicate whether pressure is "absolute" (that is above zero) or "gage" (that is, above atmospheric pressure). If, therefore, the context leaves any doubt as to which is meant, the word "pressure" must be qualified appropriately. (For example, ". . . at a gage pressure of 13 kPa" or ". . . at an absolute pressure of 13 kPa" or ". . . reached an absolute pressure of 13 kPa.")

TABLE 7 Alphabetical List of Units

Present Units	Preferred SI Units	Units Permitted for Use with SI	Conversion Factors
ampere	ampere (A)		1.0[A]
ampere hour		ampere hour (A·h)	1.0[A]
ampere hour	coulomb		1 A·h = 3.6 E + 3 C[A]
		ampere hour (A·h)	1.0[A]
barrel (42 gal)	cubic metre (m^3)		1 bbl = 1.589 873 E − 01 m^3
barrel/day	cubic metre per second (m^3/s)		1 bbl/d = 1.840 131 E − 06 m^3/s
barrel/day		cu metre/day (m^3/d)	1 bbl/d = 1.589 873 E − 01 m^3/d
barrel/nmi	cubic metre per metre (m^3/m)		1 bbl/nmi = 8.584 627 E − 05 m^3/m
barrel/nmi		cu metre/nmi (m^3/nmi)	1 bbl/nmi = 1.589 873 E − 01 m^3/nmi
Btu	joule (J) and its multiples		1 Btu = 1.055 056 E + 00 kJ
Btu per foot^2 hour	watt per square metre (W/m^2)		1 Btu/(ft^2·h) = 3.1544 59 E + 00 W/m^2
Btu per (foot^3 hour)	watt per cubic metre (W/m^3)		1 Btu/(ft^3/h) = 1.034 971 E + 01 W/m^3
Btu per hour	watt (W)		1 Btu/h = 2.930 711 E − 01 W
Btu per hour-foot^2 °F	watt per square metre degree C (W/(m^2·°C)) or W/(m^2·K)		1 Btu/(h·ft^2·°F) = 5.678 263 E + 00 W/m^2·°C
Btu inch per foot^2 hour °F	watt per metre °C (W/(m·°C)) or W/(m·K)		1 Btu·in./(ft^2·h·°F) = 1.442 279 E − 01 W/(m·°C)
Btu per pound	kilojoule per kilogram (kJ/kg)		1 Btu/lb = 2.326 000 E + 00 kJ/kg[A]
Btu per pound °F	kilojoule per (kilogram kelvin) (kJ/(kg·K))		1 Btu/(lb·°F) = 4.186 800 E + 00 kJ/(kg·°C)[A]
Btu per pound °R	kilojoule per kilogram		1 Btu/(lb·°R) = 4.186 800 E + 00 kJ/(kg·K)[A]
Btu per second	watt (W) and its multiples		1 Btu/s = 1.055 056 E + 00 kW
calorie (international)	joule (J)		1 calorie = 4.186 800 E + 00
candlepower, candle	candela (cd)		1 candlepower = 1 cd[A]
centipoise (cP)	millipascal second (mPa·s)		1.0[A]
centistokes (cSt)	square millimetre per second (mm^2/s)		1.0[A]
coulomb	coulomb (C)		1.0[A]
curie	becquerel (Bq)		1 curie = 3.700 000 E + 10 Bq[A]
cycle/second	hertz (Hz)		1.0[A]

TABLE 7 *Continued*

Present Units	Preferred SI Units	Units Permitted for Use with SI	Conversion Factors
degree Fahrenheit	degree Celsius (°C) or kelvin (K)		1°F = 5/9°C[A] 1°F = 5/9 K[A]
degree Rankine	kelvin (K)		$T_K = T_R/1.8$
farad	farad (F)		1.0[A]
fathom	metre (m)		1 fathom = 1.828 804 E + 00 m
foot	metre (m)		1 foot = 3.048 000 E − 01 m[A]
foot	millimetre (mm)		1 foot = 3.048 000 E + 02 mm[A]
foot	decimetre (dm)		1 foot = 3.048 000 E + 00 dm[A]
foot^2	square metre (m^2)		1 ft^2 = 9.290 304 E − 02 m^2
foot^3	cubic metre (m^3)		1 ft^3 = 2.831 685 E − 02 m^3
footcandle	lux (lx)		1 footcandle = 1.076 391 E + 01 lx
foot pound-force	joule (J) or any multiple		1 ft·lbf = 1.355 818 E + 00 J
foot pound force per second	watt (W)		1 ft·lbf/s = 1.355 818 E + 00 W
foot^3/minute	cubic metre per second (m^3/s)		1 ft^3/min = 4.719 474 E − 04 m^3/s
	liter per second (L/s)		1 ft^3/min = 4.719 474 E − 01 L/s
		cubic metre per hour (m^3/h)	1 ft^3/min = 1.699 011 E + 00 m^3/h
foot^3/pound	cubic metre per kilogram (m^3/kg)		1 ft^3/lb = 6.242 796 E − 02 m^3/kg
foot^3/ton	cubic metre per kilogram (m^3/kg)		1 ft^3/ton = 2.786 963 E − 05 m^3/kg
foot^3/ton		cubic metre per metric ton (m^3/t)	1 ft^3/ton = 2.786 963 E − 02 m^3/t
foot^3/pound		litre per kilogram (L/kg)	1 ft^3/lb = 6.242 796 E + 01 L/kg
foot pound-force (torque)	newton metre (N·m)		1 ft·lbf = 1.355 818 E + 00 N·m
foot pound-force (energy)	joule (J)		1 ft·lbf = 1.355 818 E + 00 N·m
foot poundal	newton metre (N·m)		1 pdl·ft = 4.214 012 E − 02 N·m
foot/second	metre per second (m/s)		1 ft/s = 3.048 000 E − 01 m/s[A]
foot/second^2	metre per second squared (m/s^2)		1 ft/s^2 = 3.048 000 E − 01 m/s^2[A]
foot ton-force	kilonewton metre (kN·m)		1 tonf·ft = 3.037 032 E + 00 kN·m
gallon U.S. (liquid)	cubic metre (m^3)		1 gal = 3.785 412 E − 03 m^3
gallon U.S. (liquid)		litre (L)	1 gal = 3.785 412 E − 00 L
gallon/minute	cubic metre per second (m^3/s)		1 gal/min = 6.309 020 E − 05 m^3/s
gallon/minute		litre per second (L/s)	1 gal/min = 6.309 020 E − 02 L/s
gauss	tesla (T)		1 gauss = 1.000 000 E − 04 T[A]
gauss/oersted	henry per metre (H/m)		1 gauss/oersted = 1.257 E − 06 H/m
gilbert	ampere (A)		1 gilbert = 7.957 747 E − 01 A
grains per gallon	kilogram per cubic metre (kg/m^3)		1 grain/gal = 1.711 806 E − 02 kg/m^3
grains per gallon		grams per litre (g/L)	1 grain/gal = 1.711 806 E − 02 g/L
henry	henry (H)		1.0[A]
horsepower (SHP, BHP, etc.)	kilowatt (kW)		1 hp = 7.457 000 E − 01 kW
hundred weight (cwt)	kilogram (kg)		1 cwt = 5.080 235 E + 01 kg
inch	millimetre (mm)		1 in. = 2.540 000 E + 01 mm[A]
inch^2	square millimetre (mm^2)		1 in.^{2} = 6.451 160 E + 02 mm[A]
inch^3	millimetre cubed (mm^3)		1 in.^{3} = 1.638 706 E + 04 mm^3
inch^4	millimetre^4 (mm^4)		1 in.^{4} = 4.162 314 E + 05 mm^4
inch^2 foot	cubic metre (m^3)		1 in.^{2} ft = 1.966 448 E − 04 m^3
inch^2 foot		metre centimetre^2 (m·cm^2)	1 in.^{2} ft = 1.966 448 E + 00 m·cm^2
inch^2 foot^2	metre^4(m^4)		1 in.^{2} ft^2 = 5.993 733 E − 05 m^4
inch^2 foot^2		metre^2 centimetre^2 (m^2·cm^2)	1 in.^{2} ft^2 = 5.993 733 E − 01 m^2·cm^2
inch per inch °F	metre per metre·kelvin (K^{-1}) m/(m·K)		1 in./in. °F = 1 + 00 mm · 1.8K
inch of water (60°F)	kilopascal (kPa)		1 in. H_2O = 2.488 400 E − 01 kPa
inch of water (ISO conv.)	kilopascal (kPa)		1 in. H_2O = 2.490 89 E − 01 kPa3
inch of mercury (60°F)	kilopascal (kPa)		1 in. Hg = 3.376 850 E + 00 kPa
inch of mercury (ISO conv.)	kilopascal (kPa)		1 in. H_2O = 3.386 39 E + 00 kPa
inch pound-force	newton metre (N·m)		1 lbf·in. = 1.129 848 E − 01 N·m
kilogram-force per centimetre	kilopascal (kPa) or MPa		1 kgf/cm^2= 9.806 650 E + 01 kPa
kip per inch^2	megapascal (MPa) or GPa		1 kip/in.^{2}= 6.894 757 E + 00 MPa
knot	metre per second (m/s)		1 knot = 5.144 444 E − 01 m/s
lambert	candela per metre^2 (cd/m^2)		1 lambert = 3.183 099 E + 03 cd/m^2
lumen	lumen (lm)		1.0[A]
maxwell	weber (Wb)		1 maxwell = 1.000 000 E − 08 Wb[A]
mho	siemens (S)		1.0[A]
mho/centimetre	siemens per metre (S/m)		1 mho/cm = 1.000 000 E + 02 S/m[A]
mil (10^{-3} inch)	micrometre (µm)		1 mil - 2.540 000 E + 01 µm[A]
mile (international)	kilometre (km)		1 international mile = 1.609 344 km
mile (nautical)	kilometre (km)		1 nautical mile = 1.852 km[A]
mile (statute)	kilometre (km)		1 statute mile = 1.609 347 km
minute	degree (°)		1 min = 1.666 667 E − 02 deg
ohm	ohm (Ω)		1.0[A]
ohm-centimetre (Ω·cm)	ohm-metre (Ω·m)		1 Ω·cm = 1.000 000 E − 02 Ω·m[A]
ohm circular-mil/foot	ohm millimetre^2 per metre (Ω·mm^2/m)		1 Ω·cmil/ft = 1.662 426 E − 03 Ω·mm^2/m
oersted	ampere per metre (A/m)		1 oersted = 7.957 747 E + 01 A/m
pound (avoirdupois)	kilogram (kg)		1 lb = 4.535 924 E − 01 kg
pound foot	kilogram metre (kg·m)		1 lb-ft = 1.382 549 E − 01 kg·m
pound foot^2	kilogram metre^2 (kg·m^2)		1 lb·ft^2 = 4.214 011 E − 02 kg·m^2
pound foot per second	kilogram metre per second (kg·m/s)		1 lb·ft/s = 1.382 550 E − 01 kg·m/s

TABLE 7 *Continued*

Present Units	Preferred SI Units	Units Permitted for Use with SI	Conversion Factors
pound foot^2 per second	kilogram metre squared per second ($kg·m^2/s$)		1 $lb·ft^2/s$ = 4.214 011 E − 02 $kg·m^2/s$
pound-force	newton (N)		1 lbf = 4.448 222 E + 00 N
pound force second per square foot	pascal second (Pa·s)		1 $lbf·s/ft^2$ = 4.788 026 E + 01 Pa·s
pound-force per inch^2	megapascal (MPa) or GPa		1 $lbf/in.^2$= 6.894 757 E − 03 MPa
pound-force per inch^2	kilopascal (kPa)		1 $lbf/in.^2$= 6.894 757 E + 00 kPa
pound inch^2	kilogram metre^2 ($kg·m^2$)		1 $lb·in.^2$ = 2.926 397 E − 04 $kg·m^2$
pound per foot^3	kilogram per cubic metre (kg/m^3)		1 lb/ft^3 = 1.601 846 E + 01 kg/m^3
pound per gallon	kilogram per cubic metre (kg/m^3)		1 lb/gal = 1.198 264 E + 02 kg/m^3
pound per gallon		kilogram per litre (kg/L)	1 lb/gal = 1.198 264 E − 01 kg/L
pound per horsepower hour	kilogram per joule (kg/J)		1 lb/hph = 1.689 659 E − 07 kg/J
pound per hour	kilogram per second (kg/s)		1 lb/h = 1.259 979 E − 04 kg/s
pound per hour		kilogram per hour (kg/h)	1 lb/h = 4.535 924 E − 01 kg/h
pound per inch^3	kilogram per cubic metre (kg/m^3)		1 $lb/in.^3$ = 2.767 990 E + 04 kg/m^3
pound per inch^3		kilogram per cubic centimetre (kg/cm^3)	1 $lb/in.^3$ = 2.767 991 E − 02 kg/cm^3
rad (rd)	gray (Gy)		1 rad = 1.000 000 E − 02 Gy^A
radian/second	radian per second (rad/s)		1.0^A
radian/second^2	radian per second squared (rad/s^2)		1.0^A
rem	sievert (Sv)		1 rem = 1.000 000 E − 02 Sv^A
revolutions per minute (r/min)	radian per second (rad/s)		1 r/min = 1.047 198 E − 01 rad/s
roentgen (R)	coulomb/kilogram (C/kg)		1 R = 2.580 000 E − 04 C/kg^A
second		degree (°)	1 s = 2.777 778 E − 04 deg
square foot per second	square metre per second (m^2/s)		1 ft^2/s = 9.290 304 E − 02 m^2/s^A
ton (long)^B	megagram (Mg)		1 ton = 1.016 047 E + 00 Mg
ton (long)		metric ton (t)	1 ton = 1.016 047 E + 00 t
ton of 40 ft^3	cubic metre (m^3)		1 freight ton = 1.132 674 E + 00 m^3
ton of 100 ft^3	cubic metre (m^3)		1 measurement ton = 2.831 685 E + 00 m^3
ton of refrigeration	kilowatt (kW)		1 ton (refrigeration) = 3.516 853 E + 00 kW
ton foot	megagram metre (Mg·m)		1 ton foot = 3.096 911 E − 01 Mg·m
ton foot		metric ton metre (t·m)	1 ton·ft = 3.096 911 E − 01 t·m
ton foot per inch	kilogram metre per metre (kg·m/m)		1 ton·ft/in. = 1.219 256 E + 00 kg·m/m
ton foot per inch		metric ton metre per metre (t·m/m)	1 ton·ft/in. = 1.219 256 E − 04 t·m/m
ton foot per degree	kilogram metre per radian (kg·m/rad)		1 ton·ft/deg = 1.774 400 E + 00 kg·m/rad
ton foot per degree		ton metre per degree (t·m/degree)	1 ton·ft/deg = 3.096 911 E + 00 t·m/deg
ton-force	kilonewton (kN)		1 tonf = 9.964 017 E + 00 kN
ton per hour	megagram per second (Mg/s)		1 ton/h = 2.822 352 E − 04 Mg/s
ton per hour		metric ton per hour (t/h)	1 ton/h = 1.016 047 E + 00 t/h
ton per inch	kilogram per metre (kg/m)		1 ton/in. = 4.000 185 E + 04 kg/m
ton per inch		metric ton per metre (t/m)	1 ton/in. = 4.000 185 E − 04 t/m
ton-force per inch^2	megapascal (MPa) or GPa		1 $tonf/in.^2$= 1.535 495 E − 04 MPa
volt	volt (V)		1.0^A
watt	watt (W)		1.0^A
yard^2	square metre (m^2)		1 yd^2 = 8.361 274 E − 01 m^2

^{A}Indicates exact conversion value.
^{B}Unless otherwise noted, all tons are long tons (2240 lbs).