

Engineering Procedure

SAEP-103

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Metric Units of Weights and Measures

Document Responsibility: Standards Coordinator

Saudi Aramco DeskTop Standards

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1 Scope

By Royal Decree of October 26, 1962, metric units for length, surface, volume, and mass have been prescribed for use throughout the Kingdom. The Saudi Arabia Standards Organization has issued Saudi Arabian Standards (SAS) 16, 17, and 18 which specify the use of the "International System of Units (SI)" for all physical quantities defined therein. In compliance with further recent Saudi Arab Government instructions, a Company-wide metrication program was announced by the Aramco President on September 10, 1980.

This Saudi Aramco Engineering Procedure (SAEP) provides guidelines for the use of metric units of weights and measures in written correspondence, documents, and data throughout the Company. This SAEP replaces all previously issued instructions, guidelines, and conversion tables related to metric units.

2 Applicable Documents

Saudi Arabian Standards Organization

SAS 16/1396 H, Part 1 The International System of Units (SI)

SAS 17/1396 H, Part 2 The International System of Units (SI)

SAS 18/1396 H, Part 3 The International System of Units (SI)

NBS SP330 The International System of Units (SI)

International Organization for Standardization

ISO 1000 SI Units and their Multiples

American National Standards Institute

ANSI X3.50 Representation of SI and Other Units

American Society for Testing and Materials

ASTM E380 American Standard for Metric Practice

American Petroleum Institute

API PUB 2564 Guidelines for the Use of SI

Guidelines for the Use of the Metric System

3 Instructions

3.1 General Rule

The metric units listed in this SAEP shall be used as the primary means to describe physical quantities in all written documents or data within the Company, both technical and non-technical, except where such usage would be impractical (excessively complicated) or be inaccurate or misleading. The conventional (English and US) units may be added within parentheses only in cases where some readers may not be familiar with the metric units used. However, the dual system of units should not be perpetuated indefinitely.

A clear distinction shall be maintained when referring to metric and non-metric materials, both of which may be in use within the company at one time. For example: a ¾-inch bolt must not be called a 19 mm bolt.

The conventional units only (without conversion) shall be used with reference to materials and events which are distinctly designed on the basis of English units and in expressions such as yardstick, 12-inch nominal pipe size, 6d nail, one-mile race. A hyphen is used between a number and the unit name in nominal designation except 1-½ inch NPS. Common commercial designations such as wire gauges, drill sizes, when used in a descriptive manner not involving calculations, may be expressed in the customary units until such designations will have become obsolete in the industry.

3.2 Transition Period

During the company metrication program, many working aids such as forms, charts, standards, specifications, computer programs and computer stored data are being converted to metric units by the responsible departments. The metricated documents shall be used as they become available.

The use of materials made to non-metric standards and the use of non-metric container sizes and purchase units will continue until such materials and containers will be replaced by metric equivalents.

Routine correspondence using a non-metric form will normally continue until a revised form has been approved and issued by the responsible department. Purchase orders and correspondence with vendors will normally continue to use the computer stored material descriptions. Each originator of correspondence shall only metricate in his own area of direct responsibility.

Exceptions to the above guidelines will be necessary to maintain coherence in the use of metric units within a new project. If it is decided that a project should be predominantly metric before all of the applicable company references have

been converted, the Project Management shall make the necessary conversions in line with this procedure SAEP-103.

When referring to existing facilities and using non-metric records in future correspondence, care shall be taken to avoid misunderstanding or error when units are converted.

In all written material containing numerical data, the emphasis should be on a clear communication of the content, but also on familiarizing readers with the metric system.

3.3 SI Metric System

SI (an abbreviation of "Le System International d'Unites") has been adopted by the International Bureau of Weights and Measures and by the Saudi Arabian Standards Organization. Other metric units formerly in use shall be avoided or abandoned, such as erg, dyne, micron, atmosphere (see Section 3.4), mm Hg, and metric horsepower.

3.3.1 Base Units

The SI system is based on the seven base units and two supplementary units, shown in Attachment A. Explicitly distinct units for mass and force are used. The kilogram is the unit for mass. The newton is the unit for force and is defined as kg.m/s^2 . Kilogram-force is an obsolete metric unit.

The term weight must be used only in a context where its meaning is completely clear, that is either as force of gravity or mass. Balances and scales may be calibrated in mass units although some types actually respond to force of gravity to measure mass indirectly. The term load means either mass or force, depending on its use. A load that produces a vertically downward force because of the influence of gravity acting on a mass may be expressed in mass units. A load that produces a force from anything other than the influence of gravity is expressed in force units. The ratings of lifting equipment (cranes, hoists) will be given in metric mass units, kg or ton. The metric ton is a convenient measure of mass for commercial use which, however, should be avoided in technical writing and be replaced by megagrams (Mg).

3.3.2 Derived Units with Special Names

Units for all other quantities are derived from the seven base and two supplementary units in ratios of the base units with a numerical factor of one. Attachment B provides 18 derived units which have special names

for convenience such as "pascal" for "newton per square meter"; either form is correct. Sometimes a compound phrase such as "volt-seconds" is more descriptive to the reader than the synonym "webers" for magnetic flux.

3.3.3 Derived Units Expressed in Base and Other SI Units

Attachment C lists some derived units which are expressed in terms of base units. Attachment D lists derived units expressed by means of units with special names. Either form is correct.

3.3.4 Prefixes

Decimal multiples and submultiples of the SI units may be indicated by the prefixes shown in Attachment E for convenience when expressing very large or small quantities so that numerical value will normally fall between 0.1 and 1000 in running text. A wider range is appropriate in special situations; for example, in tables and on drawings the same unit and prefix should be used consistently. Some of the prefixes are rarely used and may need clarification by adding the equivalent power of ten when addressing a reader who may be unfamiliar with the prefixes.

For mass the prefixes are applied to the gram instead of the base unit kilogram. Compound prefixes are not to be used; for example use Mg, but not kkg. Exponents refer to the compound prefix-unit, such as 1 km² equals 10⁶ m², not 10³ m². No prefix other than milli or micro should be used with liter.

3.4 Acceptable Non-SI Units

For practical reasons, certain units which are not part of SI are acceptable for continued use indefinitely or for a limited time. These are listed in Attachment E. The most important ones are degree Celsius (°C), degree angle (deg), minute, hour, day, liter, revolutions per minute (RPM).

Fundamental constants of nature or "natural units" may be used when practical, such as elementary charge (e), speed of light (c), speed of sound (Mach number), and Planck constant (h).

Logarithmic measures such as pH and dB are acceptable.

In the context of navigation and meteorology, the units nautical mile, knot, bar, and atmosphere may be continued temporarily. Likewise, in the special field of radiology the unit curie (Ci), rontgen (R), and rad (rd) are still permitted.

Also acceptable are technical units such as Brinell hardness, Rockwell "C" hardness, and Pyrometric Cone Equivalents (PCE).

3.5 Format and Writing Style

The following guidelines shall be used to promote uniformity of practice, to facilitate the familiarization, and to reduce risk of error.

3.5.1 Capitals

The following rules apply when using word processing apparatus which has both uppercase and lowercase letters:

- a) Units: When written in full, the names of all units start with a lowercase letter, except at the beginning of a sentence. The unit "degree" is lowercase but the modifier "Celsius" is capitalized. The "degree centigrade" is obsolete.
- b) Symbols: Use symbols, not abbreviations. For example, use "A" and not "amp" for ampere. Unit symbols are written with lowercase letters, except as follows: (1) the first letter is uppercase when the name of the unit is derived from the name of a person and (2) the symbol for liter is capital L.
- c) Prefixes: The symbol for numerical prefixes E,P,T,G, and M are written with uppercase letters, all others with lowercase letters. All prefixes are written in lowercase letters when written out in full, for example: mega.

3.5.2 Plurals

When written in full, the names of unit are made plural when appropriate. There is no plural for lux, hertz and siemens. Fractions are always followed by the singular form of the unit name. Symbols for units are always singular (no "s" may be added).

3.5.3 Periods

A period is not used after a symbol, except at the end of a sentence.

3.5.4 Degrees

The symbol K for temperature is used without the degree symbol. However, for degrees Celsius the degree symbol is used (°C).

3.5.5 Decimal Point

The dot is used as the decimal point and is placed on the line. In numbers less than one, a zero must be written before the decimal point.

3.5.6 Grouping of Digits

Digits shall be separated into groups of three, counting from the decimal sign. The comma should not be used; this is to avoid confusion with the decimal sign since many countries use the comma as decimal sign. Instead, a space is left. In numbers of four digits the space is not recommended except when in tabular form together with numbers of five or more digits.

For example: 1 234 567 instead of 1,234,567
0.528 75 instead of 0.52875

3.5.7 Spacing

No space shall be left between a prefix and unit name or the symbol; for example: kJ; kilojoule. A space must be left between a number and a symbol except for degree, minute and second of angle; for example: 500 MW, 20°C, 47 deg 15' 21". A hyphen is used between the number and symbol (except deg and °C) when the quantity is used as an adjective (35-mm film).

3.5.8 Powers

When unit names are written in full, the words "square" and "cubic" are used before a measure of length. For example: square meter. The words "squared" and "cubed" are placed after other units. For example: second squared.

3.5.9 Compound Units

Avoid mixtures of words and symbols. When names are written in full use "per" for a ratio.

Use a space or a hyphen (never a center dot) for a product. For example: meter per second (not meter/second), newton meter or newton-meter. In the case of watt hour the space may be omitted: watthour.

Use the center dot for a product in the symbols for compound units, if possible, otherwise use the dot on the line. For example N.m or N·m (not Nm or N-m).

When using symbols, the ratio is indicated by a slash or by negative exponents. Only one slash may be used in a compound unit. Do not use "p" such as kph nor k.p.h., but use km/h for kilometer per hour. Two or more units which follow the slash in the denominator shall be placed within parenthesis. For example: W/(m.K), not W/m/K. RPM and rpm are both acceptable.

3.5.10 Prefixes

Prefixes are written without a space between the prefix and the unit name or unit symbol.

In three cases the final vowel of the prefix is dropped: megohm, kilohm and hectare. In all other cases both vowels are retained without space or hyphen.

The use of prefixes (except in kg) in the denominator of a compound unit shall normally be avoided. For example: Mg/m³ or kg/L instead of kg/dm³ or g/cm³. An exception is m/ms for seismic velocities because the records are calibrated in milliseconds.

3.5.11 Attachments

No letters may be attached to SI unit symbols as was customary with some English units such as psig and psia. However, the word gauge or absolute or the abbreviations (ga or abs) should be added when needed for clarity. For example: kPa (abs) or kPa (ga).

3.6 Limited Character Sets

3.6.1 Typewriting

Most typewriters do not have a special type ball that contains Greek letters (such as $\emptyset$, Ω , and π), superscripts for powers, and the center dot. Numerals, the degree sign (lower case o), and the minus sign can be raised to the superscript position by rolling the platen half a space. The Greek letters may be spelled out or be hand written. The dot on the line may be used instead of the center dot.

3.6.2 Telex and Computer Printing

ANSI X3.50 provides a standard for representing SI and other units in word processing systems with limited character sets. Exponents may be printed on the line instead of in superscript position, for example: M³ for "cubic meter", M.S-1 for meter per second. Rules are given for representing the SI prefixes such as MA for mega, M for milli, U for

micro. Attachment G provides a list of all-capital-letter computer symbols for SI units and prefixes from ISO 2955 (E).

However, to ensure clear communications it is recommended to use the full names instead of symbols and abbreviations in systems which cannot represent them in the normal manner.

3.6.3 Arabic Translation

The use of symbols and abbreviations should be avoided in text which must be translated into Arabic in all cases where such use could result in error or transcription problems. In all such instances the SI units and prefixes should be spelled out in full.

3.7 Calculations

All future calculations will be carried out using the SI units where practical. However, during the transition period, the conventional methods and units may be used if the metric system would result in an excessive impact on cost and/or schedule of the work.

The practicality of using the metric system in calculations is governed by the circumstances in each case. Maximum use should be made of the guidance offered by professional societies such as SPE/AIME and AIChE who are promoting the effective use of the metric system in technical work.

When calculations are made in compliance with a Code, or using a computer program, which has not yet been metricated, the conventional units may be used. However, where metricated versions of the same exist, these should be used. The end results of conventional calculations should be converted to metric units.

3.8 Standard Conditions

The standard reference conditions for material properties will be 15°C (instead of 60°F = 15.56°C) and 101.325 kPa. A volume at standard reference conditions shall be expressed in standard cubic meters or m³ (std).

3.9 Drawing Practice

Conversion of the drawing practices from conventional to metric units shall be done in a rational manner. Consistency shall be maintained as far as possible on each drawing and on sets of related drawings and records per project or job.

3.9.1 Metric Projects

Metric designs will be made only after adequate preparation in the

Company metrication program; normally the initial feasibility studies, project development, topographical surveys, and other preliminaries will have been carried out in the metric system to facilitate metric design.

Metric design may still include the use of certain materials designed and designated in conventional units, for example: 24-inch pipe 2.15 m long.

Metric drawings are characterized by the use of meter or millimeter for most linear dimensions and by the use of a metric scale. English dimensions will not be added on metric drawings except in isolated cases for a specific purpose, for example to connect to non-metric equipment.

Permissible metric scales are the decimal multiples of 2, 5, 10 and 25 such as 1:200, 1:500, 1:250, 1:1000. The scales of 1:33 1/3 and 1:75 are also permitted.

Drawing sheet sizes are a matter of material standardization not governed by this SAEP.

3.9.2 Non-metric Projects

Designs which are predominantly in conventional units may be continued during the transition period of metrication as dictated by practical considerations such as in the case of plant modifications or extensions. Metric dimensions will not be added except in isolated cases. Non-metric projects may incorporate certain approved metric materials and equipment. Locally supplied materials cannot be rejected on the sole ground that they are made to a metric design or standard provided that any necessary adaptors are available. Such metric materials and equipment will be indicated on the drawings using metric dimensions and designations.

3.9.3 Vendor Drawings

When metricated materials and equipment have been accepted, the relevant vendor drawings, calculations and data shall use metric units only, except that for non-metricated projects certain dimensions, such as foundation anchor bolt locations, shall have the ft/inch dimension added between parentheses.

Vendor drawings for non-metric equipment, when used in a metricated project, shall have all overall and critical dimensions added in mm between parentheses.

3.10 Conversion

Seven-digit conversion factors are listed in ASTM E380. The most commonly used factors are given in Attachments H and I.

When the conversion is made, the numerical value of the SI unit should have the same number of significant figures as the original numerical value of the conventional unit. The precision of the original value must be established or estimated. For example: 1 ft may actually stand for 1.0 ft or 1.000 ft.

Accordingly, 1 ft converts to 0.3 m, 1.00 ft converts to 0.305 m and only 1.000 ft converts to 0.3048 m.

The converted value shall be rounded to the proper significant number of digits in the normal manner.

Copies of Attachment H and I should be kept handy for daily use and familiarization in the Company metrication program.

4 Responsibilities

4.1 Metrication in Correspondence

The responsibility for the orderly implementation of the metric system in Company correspondence rests with the managers of the departments in which the correspondence is originated. Conversion of Company forms, standards, specifications, programs and other printed work aids shall be done by the departments having responsibility for the development and maintenance of such material.

4.2 Chief Engineer

The Chief Engineer has been designated the corporate coordinator for the companywide metrication program.

4.3 Metrication Committee

Metrication Committee is a standing committee, chaired by a representative of the Technical Services Department, in which various other departments are represented as needed. The responsibilities of this committee include:

- a) Study the anticipated impact of metrication on the operation and practices within the various affected departments.
 - b) Promote and facilitate the understanding, acceptance, and regular usage of the metric system by organizations and individuals.
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- c) Investigate the needs and problems arising from metrication in the various operational areas.
- d) Provide information and assistance to facilitate the orderly and uniform implementation of metric practices.
- e) Make recommendations to resolve specific questions and problems regarding metrication in project work.
- f) Promote standardization and acceptance of metric equipment, materials, and container sizes.
- g) Develop and maintain a time schedule for milestones in the Company metrication program and make progress reports.
- h) Assist the Chief Engineer in the coordination of the overall metrication effort.

5 Notes

None.

Revision Summary

30 April 2005

Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with editorial changes.

Attachment A – SI Base and Supplementary Units

	Quantity	Unit Name	Unit Symbol
SI Base Units:	length	meter	m
	mass	kilogram	kg
	time	second	s
	electric current	ampere	A
	thermodynamic temperature	kelvin	K
	amount of substance	mole	mol
	luminous intensity	candela	cd
SI Supplementary Units:			
	plane angle	radian	rad
	solid angle	steradian	sr

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Attachment B – SI Derived Units with Special Names

Quantity	Name	Symbol	Expression in terms of other units	Expression in terms of SI base units
frequency	hertz	Hz		s^{-1}
force	newton	N		$m.kg.s^{-2}$
pressure, stress	pascal	Pa	N/m^2	$m^{-1}.kg.s^{-2}$
energy, work, quantity of heat	joule	J	$N.m$	$m^2.kg.s^{-2}$
power, radiant flux	watt	W	J/s	$m^2.kg.s^{-3}$
quantity of electricity, electric charge	coulomb	C	$A.s$	$s.A$
electric potential, potential differences, electromotive force	volt	V	W/A	$m^2.kg.s^{-3}.A^{-1}$
capacitance	farad	F	C/V	$m^{-2}.kg^{-1}.s^4.A^2$
electric resistance	ohm	Ω	V/A	$m^2.kg.s^{-3}.A^{-2}$
conductance	siemens	S	A/V	$m^{-2}.kg^{-1}.s^3.A^2$
magnetic flux	weber	Wb	$V.s$	$m^2.kg.s^{-2}.A^{-1}$
magnetic flux density	tesla	T	Wb/m^2	$kg.s^{-2}.A^{-1}$
inductance	henry	H	Wo/A	$m^2.kg.s^{-2}.A^{-2}$
Celsius temperature	degree Celsius	$^{\circ}C$		K
luminous flux	lumen	lm		cd.sr
illuminance	lux	lx	lm/m^2	$m^{-2}.cd.sr$
activity (of a radio-nuclide)	becquerel	Bq		s^{-1}
absorbed dose, specific energy imparted, kerma, absorbed dose index	gray	Gy	J/kg	$m^2.s^{-2}$

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Attachment C – Some SI Derived Units Expressed in Base Units

Quantity	SI Units	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	1 per meter	m^{-1}
density, mass density	kilogram per cubic meter	kg/m^3
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
specific volume	Cubic meter per kilogram	m^3/kg
luminance	candela per square meter	cd/m^2
kinematic viscosity	square meter per second	m^2/s
angular velocity	radian per second	rad/s
angular acceleration	radian per second squared	rad/s^2
rate of flow	cubic meter per second	m^3/s

Attachment D – SI Derived Units Expressed by Means of Special Names

Quantity	Name	Symbol	Expression in Terms of SI Base Units
dynamic viscosity	pascal second	Pa.s	$\text{m}^{-1}.\text{kg}.\text{s}^{-1}$
moment of force	newton meter	N.m	$\text{m}^2.\text{kg}.\text{s}^{-2}$
surface tension	newton per meter	N/m	$\text{kg}.\text{s}^{-2}$
power density, heat flux density, irradiance	watt per square meter	W/m^2	$\text{kg}.\text{s}^{-3}$
heat capacity, entropy	joule per kelvin	J/k	$\text{m}^2.\text{kg}.\text{s}^{-2}.\text{K}^{-1}$
specific heat capacity, specific entropy	joule per kilogram kelvin	J/(kg.K)	$\text{m}^2.\text{s}^{-2}.\text{K}^{-1}$
specific energy, enthalpy	joule per kilogram	J/kg	$\text{m}^2.\text{s}^{-2}$
thermal conductivity	watt per meter kelvin	$\text{W}/(\text{m}.\text{K})$	$\text{m}.\text{kg}.\text{s}^{-3}.\text{K}^{-1}$
energy density	joule per cubic meter	J/m^3	$\text{m}^{-1}.\text{kg}.\text{s}^{-2}$
electric field strength	volt per meter	V/m	$\text{m}.\text{kg}.\text{s}^{-3}.\text{A}^{-1}$
electric charge density	coulomb per cubic meter	C/m^3	$\text{m}^{-3}.\text{s}.\text{A}$
electric flux density	coulomb per square meter	C/m^2	$\text{m}^{-2}.\text{s}.\text{A}$
permittivity	farad per meter	F/m	$\text{m}^{-3}.\text{kg}^{-1}.\text{s}^4.\text{A}^2$
permeability	henry per meter	H/m	$\text{m}.\text{kg}.\text{s}^{-2}.\text{A}^{-2}$
molar energy	joule per mole	J/mol	$\text{m}^2.\text{kg}.\text{s}^{-2}.\text{mol}^{-1}$
molar entropy, molar heat capacity	joule per mole kelvin	J/(mol.K)	$\text{m}^2.\text{kg}.\text{s}^{-2}.\text{K}^{-1}.\text{mol}^{-1}$
exposure (X and rays)	coulomb per kilogram	C/kg	$\text{kg}^{-1}.\text{s}.\text{A}$
absorbed dose rate	gray per second	Gy/s	$\text{m}^2.\text{s}^{-3}$

Attachment E – 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	necto	n
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

Attachment F – Permissible Non-SI Units

Name	Symbol	Value in SI Units
degree Celsius *	°C	$T_C = T_K - 273.15$
minute	min	1 min = 60 s
hour	h	1 h = 3600 s
day	d	1 d = 86 400 s
year (calendar)	a	1 a = 31 536 000 s
degree	°	$1^\circ = (\pi/180) \text{ rad}$
minute	'	$1' = (\pi/10\,800) \text{ rad}$
second	"	$1'' = (\pi/648\,000) \text{ rad}$
liter	L	1 L = 0.000 m ³
hectare	ha	1 ha = 10 000 m ²
metric ton	t	1 t = 1000 kg
nautical mile	naut mi	= 1 852 m
knot		= 0.514 444 m/s
bar	bar	1 bar = 100 kPa
atmosphere, standard	atm	1 atm = 101.325 kPa
curie	Ci	1 Ci = $3.7 \times 10^{10} \text{ s}^{-1}$
röntgen	R	1 R = $2.58 \times 10^{-4} \text{ C/kg}$
rad	rd	1 rd = 0.01 J/kg
revolutions per minute	RPM or rpm	1 RPM = $(\pi/30) \text{ rad/s}$

* Refer to Section 3.5.4

Attachment G – Representations of SI Units Using Capitals

Base SI Units:

meter	M
kilogram	KG
second	S
ampere	A
kelvin	K
mole	MOL
candela	CD

Supplementary units:

radian	RAD
steradian	SR

Derived SI Units with special names:

hertz	HZ
newton	N
pascal	PA
joule	J
watt	W
coulomb	C
volt	V
ohm	OHM
siemens	SIE
farad	F
weber	WB
henry	H
tesla	T
lumen	LM
lux	LX

Attachment G – Representations of SI Units Using Capitals (Cont'd)

Other units from ISO 1000-1973:

grade (angle)	GON
degree (angle)	DEG
minute (angle)	MNT
second (angle)	SEC
litre (liter)	L
are	ARE
minute (time)	MIN
hour	HR
day	D
year	ANN
gram	G
tonne	TNE
bar	BAR
poise	P
stokes	ST
electronvolt	EV
degree Celsius	CEL
atomic mass unit	U

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Representations of Prefixes

tera	T
giga	G
mega	MA
kilo	K
hecto	H
deka (deca)	DA
deci	D
centi	C
milli	M
micro	
nano	N
pico	P
femto	F
atto	A

Attachment H – Metric Conversions - Common Single Units

To Convert From Customary Unit	To Preferred Unit Name	Symbol	Multiply By	
acre	square meter	m ²	4046.856	
atmosphere (std)	kilopascal	kPa	101.325	
barrel (42 gal)	cubic meter	m ³	0.158 987	
Btu (International Table)	kilojoule	kJ	1.055 056	
calorie (Thermochemical)	joule	J	4.184	
degree F	degree Celsius	°C	5/9 (°F -32)	
degree R	kelvin	K	5/9	
foot	meter	m	0.3048	
gallon (US liquid)	liter	L	3.785 412	
grain	milligram	mg	64.799	
horsepower (US)	kilowatt	kW	0.7457	
inch (US)	millimeter	mm	25.4	
inch of mercury (60 °F)	kilopascal	kPa	3.376 85	
inch of water (60 °F)	kilopascal	kPa	0.248 843	
lambert	candela per square meter	cd/m ²	3183	
mil	micrometer	μm	25.4	
mile (US Statute)	kilometer	km	1.609 344	
ounce (Avoirdupois)	gram	g	28.349 523	
ounce (US fluid)	milliliter	mL	29.573 53	
poise	pascal-second	Pa.s	0.1	
poundal	newton	N	0.138 254 95	
pound (Avoirdupois)	kilogram	kg	0.453 592 37	
pound force (lbf)	newton	N	4.448 222	
psi	kilopascal	kPa	6.894 757	
slug	kilogram	kg	14.593 903	
stokes	square centimeter per second	cm ² /S	1	
ton, long (2240 lbm)	ton	t	1.016 047	
ton, short (2000 lbm)	ton	t	0.907 184 74	
ton of refrigeration	kilowatt	kW	3.516 853	
yard (US)	meter	m	0.9144	

Multiply factors for compound units. For example: to convert lbs/ft³ to kg/m³ multiply by 0.4536/(0.3048)³.
Attachment I lists factors for some frequently used compound units.

Attachment I – Metric Conversions - Common Compound Units

To Convert From Customary Unit	To Preferred Unit Name	Symbol	Multiply By
barrel per hour	liters per second	L/s	0.044 163
barrel per day	cubic meters per day	m ³ /d	0.158 987
MMBOD	cubic meters per day	m ³ /d	0.158 987 x 10 ⁶
Btu/second (Int. Table)	kilowatt	kW	1.055 056
Btu/hour	watt	W	0.293 071
Btu/lbm	kilojoule per kilogram	kJ/kg	2.326
Btu/(lbm. °F)	kilojoule per kilogram-kelvin	kJ/(kg.K)	4.1868
Btu/(lbm.mole. °R)	joule per mole-kelvin	J/(mol.K)	4.1868
Btu/°R	kilojoule per kelvin	KJ/K	1.8991
Btu/(ft. ² ,hr)	watt per square meter	W/m ²	3.154 591
Btu/(ft.hr.°F)	watt per meter-kelvin	W/(m.K)	1.730 735
Btu/(ft. ² hr.°F)	watt per square meter-kelvin	W/(m ² K)	5.678 263
footcandle	lux	lx	10.763 910
foot pound force (ft. lbf)	joule	J	1.355 818
foot ²	square meter	m ²	0.092 903
foot ³	cubic meter	m ³	0.028 316 85
foot ³ /minute	liter per second	L/s	0.471 947
foot ³ /hour	cubic meter per day	m ³ /d	0.679 604
MMSCFD	cubic meter per second	m ³ /s (std)	0.327 741
gallon/minute (GPM)	liter per second	L/s	0.063 090
inch ²	square centimeter	cm ²	6.451 600
inch ³	cubic centimeter	cm ³	16.387 064
kilowatt hour (kWh)	megajoule	MJ	3.6
mile per hour	kilometer per hour	km/h	1.609 344
mile per hour	meter per second	m/s	0.4470
pound force/foot ² (psf)	pascal	Pa	47.880 258
pound mass/foot ³ (lbm/ft ³)	kilogram per cubic meter	kg/m ³	16.018 463
pound mass/gallon	kilogram per liter	kg/L	0.119 826
pound mass/hour	kilogram per hour	kg/h	0.453 592
million lbm/year	ton per annum	t/a	453.592
poundmole	mole	mol	453.592
psi/(lbf/inch ²)	kilopascal	kPa	6.894 757
psi/foot	kilopascal per meter	kPa/m	22.620 59
psi/mile	pascal per meter	Pa/m	4.284 203
Watt-hour	kilojoule	kJ	3.6
yard ²	square meter	m ²	0.836 127
yard ³	cubic meter	m ³	0.764 555