DEPARTMENT OF COMMERCE * NATIONAL BUREAU OF STANDARDS

NBS TECHNICAL NOTE 938

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction

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Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction

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RECOMMENDED PRACTICE FOR THE USE OF METRIC (SI) UNITS IN BUILDING DESIGN AND CONSTRUCTION

Hans J. Milton

Abstract: This Technical Note contains a comprehensive set of recommendations for the use of metric (SI) units in building design and construction.

It includes descriptive material dealing with the structure of the International System of Units (SI); rules and recommendations for the presentation of SI units and symbols, and of numerical values associated with SI; a set of tables showing working units and typical applications for SI units in building design and construction; and a section dealing with special considerations in the selection and use of SI units in design and construction. Appendixes show conversion factors for the most common units; superseded metric units not recommended for use with SI; an SI units and relationships chart; and appropriate references.

This document was prepared to provide the technical basis for an ASTM reference standard on recommended practice for the use of metric (SI) units in building design and construction.

Key Words: International System of Units (SI); metric design and construction; recommended SI practice.

PREFACE

This Technical Note has been prepared in response to requests from the American Society for Testing and Materials (ASTM Committee E6 - Performance of Building Constructions) and the American National Metric Council (Construction Industries Coordinating Committee) for the development of a "recommended practice for the use of metric (SI) units in building design and construction."

The first draft of this document was submitted to ASTM Subcommittee E6.62, Coordination of Dimensions for Building Materials and Systems, in November 1976, and has had a unanimous affirmative ballot with some editorial comment. This edited version has been submitted to the main committee of E6 for ballot.

In keeping with the "Metric Conversion Act of 1975" (Public Law 94-168), the metric units contained in this document are those found in the International System of Units (SI), as interpreted or modified for the United States by the Secretary of Commerce. It includes an extensive listing of SI units for use in design and construction, working ranges and typical applications, and relevant explanatory material relating to the use of SI units for specific quantities.

This report has the following objectives:

a. to share the information contained in the document more widely among all sectors associated with the construction community; and

b. to invite constructive comment from parties not affiliated with ASTM Committee E6.

The principal author of the document is Hans J. Milton, B. Arch., M. Bldg. Sc., M.B.A., FRAIA, technical consultant to the Center for Building Technology on metrication and coordination of dimensions in building. In the period from 1970 to 1974, Mr. Milton was a key figure in the Australian change to metric measurement in building design and construction. He is now the Assistant Secretary for Housing Research in the Australian Government Service, and has been made available to the National Bureau of Standards to assist in the research and planning for metrication in the U.S. building community.

Technical and editorial comments on earlier drafts were received from a number of experts on the International System of Units (SI). Major contributors of constructive comment were: Mr. Louis Barbrow, National Bureau of Standards; Mr. Andrew Lally, American Institute of Steel Construction, Inc.; Mr. Robert Lukens, American Society for Testing and Materials (editorial review); and Professor Cornelius Wandmacher, University of Cincinnati and Chairman of the ANMC/CICC Engineering Design Subsector Committee.

James G. Gross
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TABLE OF CONTENTS

INTRODUCTION

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

SI is a rational, coherent, international, and preferred measurement system which is derived from earlier decimal metric systems but supersedes all of them.

The use of the metric system in the United States was legalized by an Act of Congress in 1866, but was not made obligatory.
On December 23, 1975, Public Law 94-168, "The Metric Conversion Act of 1975," was signed by President Ford, declaring a national policy of coordinating the increasing use of the metric system in the United States, and establishing a United States Metric Board to coordinate the voluntary conversion to the metric system. The Act specifically defines the metric system of measurement as "the International System of Units as established by the General Conference of Weights and Measures in 1960, and as interpreted or modified for the United States by the Secretary of Commerce."

There have been some refinements of the system since 1960, and the United States has a special opportunity to change from the outdated customary system to the most up-to-date international system in one single step.

In the building design and construction community the application of SI units, together with preferred numerical values, is certain to simplify and speed up calculations and facilitate all measurement intensive activities. Because SI is a coherent system of units with only one unit for any physical quantity, there is no need to convert within the system - from one unit to another, as with feet and inches, ounces and pounds, or gallons and cubic feet. With the change to SI, the U.S. construction community can become a leader in the metric building world.

This document has been prepared to provide the technical basis for a single, comprehensive, and authoritative standard for SI units to be used in building design, product manufacture, or construction applications.

1. SCOPE

1.1 This document outlines a selection of SI units, with multiples and submultiples, for general use in building design and construction.

1.2 In addition, rules and recommendations are given for the presentation of SI units and symbols, and for numerical values shown in conjunction with SI.

1.3 A selection of conversion factors appropriate for use within the construction community is given in Appendix A.

1.4 The SI units included in this document comply with and augment the "American National Standard Metric Practice" ANSI Z 210.1 - 1976 (also identified as ASTM E 380 - 76 or IEEE Std 268 - 1976), and are generally consistent with ISO 1000 - 1973 (E) "SI Units and Recommendations for the Use of Their Multiples and Certain Other Units."

1.5 The official metric (SI) system of measurement for use in the United States is described in the Notice "THE METRIC SYSTEM OF MEASUREMENT - Interpretation and Modification of the International System of Units for the United States," issued in the Federal Register (Vol. 41, No. 239, pages 54 018 - 19) on Friday, December 10, 1976.

2. DEFINITIONS

2.1 SI - the International System of Units (abbreviation for " le Système International d'Unités) as defined by the General Conference of Weights and Measures (CGPM) - based upon seven (7) base units, two (2) supplementary units, and derived units, which together form a coherent system.

2.2 Quantity - measurable attribute of a physical phenomenon. There are base units for seven (7) quantities and supplementary units for two (2) quantities upon which units for all other quantities are founded.

2.3 Unit - reference value of a given quantity as defined by CGPM Resolution or set out in ISO standards. There is only one unit for each quantity in SI.

2.4 Coherent unit system - system in which relations between units contain as numerical factor only the number one (1) or unity, because all derived units have a unity relationship to the constituent base and supplementary units.

2.5 Numerical value of a quantity - magnitude of a quantity expressed by the product of a number and the unit in which the quantity is measured.

3. THE CONCEPT OF SI

3.1 The International System of Units (SI) represents a universal, coherent, and preferred system of measurement for worldwide use and appropriate to the needs of modern science and technology. SI is a live measurement system, under constant review and development by CGPM in line with practical developments and scientific advancement.

3.2 The principal features of SI are:

a. There is only one recognized unit for each physical quantity.

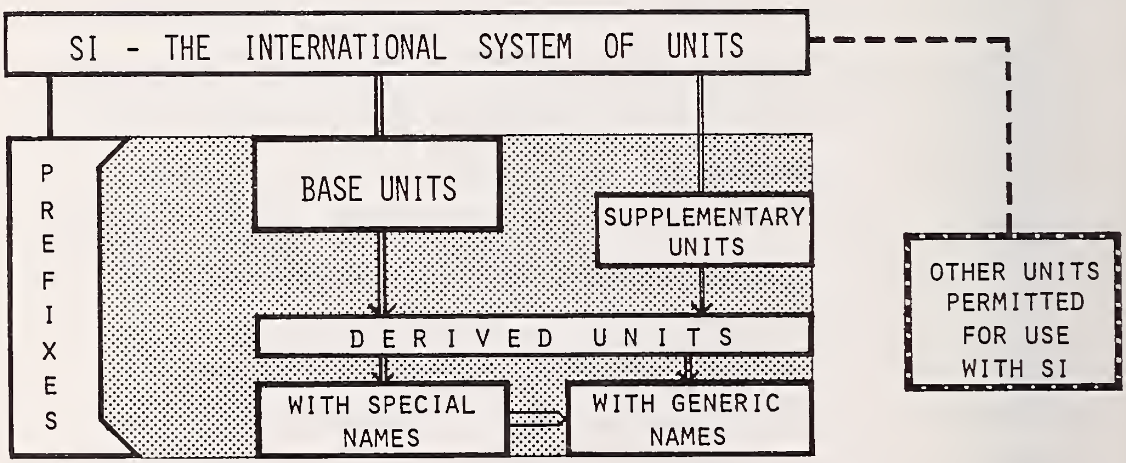
b. The system is fully coherent; this means that all units in the system relate to each other on a unity (one-to-one) basis.

c. A set of internationally agreed prefixes can be attached to units to form preferred multiples and submultiples in powers of 1000. This provides for convenient numerical values when the magnitude of a quantity is stated.

3.3 Because of their practical significance, the use of a specific group of non-SI units in conjunction with SI is permitted for some quantities.

3.4 SI units, permissible non-SI units, and prefixes are discussed in Sections 4, 5, and 6.

3.5 The diagram below shows graphically the types of units within SI or associated with SI.



4. SI UNITS

4.1 The International System of Units (SI) has three classes of units:

a. Base Units (7) - for independent quantities

b. Supplementary Units (2) - for plane angle and solid angle

c. Derived Units

4.2 The seven base units and two supplementary units are unique units which, except for the kilogram,[1] are defined in terms of reproducible phenomena.

4.3 Derived units can all be defined in terms of their derivation from base units and supplementary units. They fall into two categories:

a. Derived units with special names and symbols

b. Derived units with generic or complex names, expressed in terms of

i. one base unit

ii. two or more base units

iii. base units and/or derived units with special names

iv. supplementary units and base and/or derived units

4.4 Table A, on page 4, contains SI base, supplementary, and derived units of significance in design and construction, listing the following:

a. Quantity

b. Unit name

c. Unit symbol

d. Unit formula

e. Unit derivation (in terms of base and supplementary units)

f. Remarks

4.5 A chart, showing the relationship between the base units, supplementary units and derived units that have been given special names is set out in Appendix B.

5. NON-SI UNITS FOR USE WITH SI

5.1 There is an additional group of acceptable, but noncoherent, traditional units retained for use with SI because of their significance in general application.

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[1] *The primary standard for mass is the "international prototype kilogram maintained under specified conditions at the International Bureau of Weights and Measures (BIPM) near Paris, France.*

5.2 Non-SI units of significance to design and construction are shown in Table B, under two categories:

a. Units for general use

b. Units for limited application only

TABLE B: OTHER UNITS WHOSE USE IS PERMITTED WITH SI

QUANTITY	UNIT NAME	SYMBOL	RELATIONSHIP TO SI UNIT	REMARKS
UNITS FOR GENERAL USE:				
Volume	liter (1)	L	1 L = 0.001 m^3 = 10^6 mm^3	An alternate spelling is 'litre'. The liter can be used with the SI prefix 'milli'.
Mass	metric ton (2)	t	1 t = 1 Mg = 1000 kg	
Time	minute hour day (mean solar) year (calendar)	min h d a	1 min = 60 s 1 h = 3600 s = (60 min) 1 d = 86 400 s = (24 h) 1 a = 31 536 000 s = (365 d)	See also Section 9.6, page 26
Temperature Interval	degree Celsius	°C	1 °C = 1 K	The Celsius temperature 0 °C corresponds to 273.15 K exactly. ($t_{°C} = T_K - 273.15$)
Plane Angle	degree (of arc)	°	1° = 0.017 453 rad = 17.453 mrad	1° = (π/180) rad
Velocity	kilometer per hour	km/h	1 km/h = 0.278 m/s	1 m/s = 3.6 km/h
UNITS ACCEPTED FOR LIMITED APPLICATION ONLY:				
Area	hectare	ha	1 ha = 10 000 m^2	For use in land measurement.
Energy	kilowatthour	kWh	1 kWh = 3.6 MJ	For measurement of electrical energy consumption only.
Speed of Rotation	revolution per minute	r/min	1 r/min = $\frac{1}{60}$ r/s = $\frac{2\pi}{60}$ rad/s	To measure rotational speed in slow moving equipment only.

(1) The international symbol for liter is the lowercase "l", which can be easily confused with the numeral "1". Several English speaking countries have adopted the script "ℓ" as symbol for liter in order to avoid any misinterpretation. The symbol "L" (capital ell) is recommended for United States use to prevent confusion.

(2) The international name for metric ton is "tonne". The metric ton is equal to the "megagram" (Mg).

5.3 Appendix C, on page 40, shows a group of superseded metric units not recommended for use with SI in design and construction applications.

6. SI UNIT PREFIXES

6.1 SI is based on the decimal system of multiples and submultiples, and therefore the use of common fractions is minimized. Multiples are formed by attaching standard prefixes to SI units.

TABLE A

UNITS IN THE INTERNATIONAL SYSTEM - SI

UNIT GROUP / QUANTITY	UNIT NAME	SYMBOL	FORMULA	UNIT DERIVATION	REMARKS
BASE UNITS					
Length	meter	m			An alternative spelling is "metre".
Mass	kilogram	kg			
Time	second	s			Already in common use.
Electric Current	ampere	A			Already in common use.
Thermodynamic Temperature	kelvin	K			The customary unit for temperature is the degree Celsius (°C).
Heat Flux Density, Irradiance, Sound Intensity	watt per square meter		W/m^2	$kg \cdot s^{-3}$ (5)	(5) m^2 is cancelled out
Thermal Conductivity	watt per meter kelvin		$W/(m \cdot K)$	$m.kg.s^{-3}.K^{-1}$	
Coefficient of Heat Transfer	watt per square meter kelvin		$W/(m^2 \cdot K)$	$kg \cdot s^{-3} \cdot K^{-1}$ (6)	(6) m^2 is cancelled out
Thermal Resistance, Thermal Insulance	square meter kelvin per watt		$m^2 \cdot K/W$	$kg^{-1} \cdot s^3 \cdot K$ (7)	(7) m^2 is cancelled out
Electric Field Strength	volt per meter		V/m	$m \cdot kg \cdot s^{-3} \cdot A^{-1}$	
Electric Flux Density	coulomb per square meter		C/m^2	$m^{-2} \cdot s \cdot A$	
Electric Charge Density	coulomb per cubic meter		C/m^3	$m^{-3} \cdot s \cdot A$	
Electric Permittivity	farad per meter		F/m	$m^{-3} \cdot kg^{-1} \cdot s^4 \cdot A^2$	
Electric Permeability	henry per meter		H/m	$m \cdot kg \cdot s^{-2} \cdot A^{-2}$	
Electric Resistivity	ohm meter		$\Omega \cdot m$	$m^3 \cdot kg \cdot s^{-3} \cdot A^{-2}$	
Electric Conductivity	siemens per meter		S/m	$m^{-3} \cdot kg^{-1} \cdot s^3 \cdot A^2$	
Light Exposure	lux second		$lx \cdot s$	$m^{-2} \cdot s \cdot cd \cdot sr$	
Luminous Efficacy	lumen per watt		lm/W	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot cd \cdot sr$	
d. UNITS EXPRESSED IN TERMS OF SUPPLEMENTARY UNITS AND BASE AND/OR DERIVED UNITS					
Angular Velocity	radian per second		rad/s	$s^{-1} \cdot rad$	
Angular Acceleration	radian per second squared		rad/s^2	$s^{-2} \cdot rad$	
Radiant Intensity	watt per steradian		W/sr	$m^2 \cdot kg \cdot s^{-3} \cdot sr^{-1}$	
Radiance	watt per square meter steradian		$W/(m^2 \cdot sr)$	$kg \cdot s^{-3} \cdot sr^{-1}$ (8)	(8) m^2 is cancelled out

TABLE A

UNITS IN THE INTERNATIONAL SYSTEM - SI

UNIT GROUP QUANTITY	UNIT NAME	SYMBOL	FORMULA	UNIT DERIVATION	REMARKS
BASE UNITS					
Length	meter	m			An alternative spelling is "metre".
Mass	kilogram	kg			
Time	second	s			Already in common use.
Electric Current	ampere	A			Already in common use.
Thermodynamic Temperature	kelvin	K			The customary unit for temperature is the degree Celsius (°C).
Amount of Substance	mole	mol			The mol has no application in construction.
Luminous Intensity	candela	cd			Already in common use.
SUPPLEMENTARY UNITS					
Plane Angle	radian	rad			Already in common use.
Solid Angle	steradian	sr			Already in common use.
DERIVED UNITS WITH SPECIAL NAMES					
Frequency (of a periodic phenomenon)	hertz	Hz	1/s	s^{-1}	The hertz replaces "cycle per second".
Force	newton	N	$kg \cdot m/s^2$	$m \cdot kg \cdot s^{-2}$	
Pressure, Stress, Elastic Modulus	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	$m^2 \cdot kg \cdot s^{-3}$	Already in common use.
Quantity of Electricity, Electric Charge	coulomb	C	$A \cdot s$	$s \cdot A$	Already in common use.
Electric Potential, Potential Difference, Electromotive Force	volt	V	J/C or W/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$	Already in common use.
Electric Capacitance	farad	F	C/V	$m^{-2} \cdot kg^{-1} \cdot s^4 \cdot A^2$	Already in common use.
Electric Resistance	ohm	Ω	V/A	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-2}$	Already in common use.
Electric Conductance	siemens	S	A/V or 1/Ω	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot A^2$	The siemens was formerly referred to as "mho".
Magnetic Flux	weber	Wb	$V \cdot s$	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-1}$	Already in common use.
Magnetic Flux Density	tesla	T	Wb/m^2	$kg \cdot s^{-2} \cdot A^{-1}$	Already in common use.
Electric Inductance	henry	H	Wb/A	$m^2 \cdot kg \cdot s^{-2} \cdot A^{-2}$	Already in common use.
Luminous Flux	lumen	lm	$cd \cdot sr$	$cd \cdot sr$	Already in common use.
Illuminance	lux	lx	lm/m^2	$m^{-2} \cdot cd \cdot sr$	
Activity (of radionuclides)	becquerel	Bq	1/s	s^{-1}	No application in construction.
Absorbed Dose	gray	Gy	J/kg	$m^2 \cdot s^{-2}$ (*)	(*) kg is cancelled out. No application in construction.
DERIVED UNITS WITH GENERIC NAMES					
a. UNITS EXPRESSED IN TERMS OF ONE BASE UNIT					
Area	square meter	m^2		m^2	
Volume, Capacity	cubic meter	m^3		m^3	($1 m^3$ = 1000 L)
Section Modulus	meter to third power		m^3	m^3	
Second Moment of Area	meter to fourth power		m^4	m^4	
Curvature	reciprocal (of) meter		1/m	m^{-1}	
Rotational Frequency	reciprocal (of) second		1/s	s^{-1}	Revolution per second (r/s) is used in specifications for rotating machinery.
Coefficient of Linear Thermal Expansion	reciprocal (of) kelvin		1/K	K^{-1}	
b. UNITS EXPRESSED IN TERMS OF TWO OR MORE BASE UNITS					
Linear Velocity	meter per second		m/s	$m \cdot s^{-1}$	
Linear Acceleration	meter per second squared		m/s^2	$m \cdot s^{-2}$	
Kinematic Viscosity	square meter per second		m^2/s	$m^2 \cdot s^{-1}$	
Volume Rate of Flow	cubic meter per second		m^3/s	$m^3 \cdot s^{-1}$	
Specific Volume	cubic meter per kilogram		m^3/kg	$m^3 \cdot kg^{-1}$	
Mass per Unit Length	kilogram per meter		kg/m	$m^{-1} \cdot kg$	
Mass per Unit Area	kilogram per square meter		kg/m^2	$m^{-2} \cdot kg$	
Density (Mass per Unit Volume)	kilogram per cubic meter		kg/m^3	$m^{-3} \cdot kg$	In this SI form, mass density is conveniently 1000 times specific gravity.
Moment of Inertia	kilogram meter squared		$kg \cdot m^2$	$m^2 \cdot kg$	
Mass Flow Rate	kilogram per second		kg/s	$kg \cdot s^{-1}$	
Momentum	kilogram meter per second		$kg \cdot m/s$	$m \cdot kg \cdot s^{-1}$	
Angular Momentum	kilogram meter squared per second		$kg \cdot m^2/s$	$m^2 \cdot kg \cdot s^{-1}$	
Magnetic Field Strength	ampere per meter		A/m	$m^{-1} \cdot A$	
Current Density	ampere per square meter		A/m^2	$m^{-2} \cdot A$	
Luminance	candela per square meter		cd/m^2	$m^{-2} \cdot cd$	
c. UNITS EXPRESSED IN TERMS OF BASE UNITS AND/OR DERIVED UNITS WITH SPECIAL NAMES					
Moment of Force, Torque	newton meter		$N \cdot m$	$m^2 \cdot kg \cdot s^{-2}$	
Flexural Rigidity	newton square meter		$N \cdot m^2$	$m^3 \cdot kg \cdot s^{-2}$	
Force per Unit Length, Surface Tension	newton per meter		N/m	$kg \cdot s^{-2}$ (1)	(1) m is cancelled out
Dynamic Viscosity	pascal second		$Pa \cdot s$	$m^{-1} \cdot kg \cdot s^{-1}$	
Impact Ductility	joule per square meter		J/m^2	$kg \cdot s^{-2}$ (2)	(2) m^2 is cancelled out
Combustion Heat (per Unit Volume)	joule per cubic meter		J/m^3	$m^{-1} \cdot kg \cdot s^{-2}$	
Combustion Heat (per Unit Mass), Specific Energy, Specific Latent Heat	joule per kilogram		J/kg	$m^2 \cdot s^{-2}$ (3)	(3) kg is cancelled out
Heat Capacity, Entropy	joule per kelvin		J/K	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$	
Specific Heat Capacity, Specific Entropy	joule per kilogram kelvin		$J/(kg \cdot K)$	$m^2 \cdot s^{-2} \cdot K^{-1}$ (4)	(4) kg is cancelled out
Heat Flux Density, Irradiance, Sound Intensity	watt per square meter		W/m^2	$kg \cdot s^{-3}$ (5)	(5) m^2 is cancelled out
Thermal Conductivity	watt per meter kelvin		$W/(m \cdot K)$	$m \cdot kg \cdot s^{-3} \cdot K^{-1}$	
Coefficient of Heat Transfer	watt per square meter kelvin		$W/(m^2 \cdot K)$	$kg \cdot s^{-3} \cdot K^{-1}$ (6)	(6) m^2 is cancelled out
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Electric Resistivity	ohm meter		$\Omega \cdot m$	$m^3 \cdot kg \cdot s^{-3} \cdot A^{-2}$	
Electric Conductivity	siemens per meter		S/m	$m^{-3} \cdot kg^{-1} \cdot s^3 \cdot A^2$	
Light Exposure	lux second		$lx \cdot s$	$m^{-2} \cdot s \cdot cd \cdot sr$	
Luminous Efficacy	lumen per watt		lm/W	$m^{-2} \cdot kg^{-1} \cdot s^3 \cdot cd \cdot sr$	
d. UNITS EXPRESSED IN TERMS OF SUPPLEMENTARY UNITS AND BASE AND/OR DERIVED UNITS					
Angular Velocity	radian per second		rad/s	$s^{-1} \cdot rad$	
Angular Acceleration	radian per second squared		rad/s^2	$s^{-2} \cdot rad$	
Radiant Intensity	watt per steradian		W/sr	$m^2 \cdot kg \cdot s^{-3} \cdot sr^{-1}$	
Radiance	watt per square meter steradian		$W/(m^2 \cdot sr)$	$kg \cdot s^{-3} \cdot sr^{-1}$ (8)	(8) m^2 is cancelled out

6.2 Preferred multiples range in geometric steps of 1000 (10^3) up to 10^{18}, submultiples range in geometric steps of $\frac{1}{1000}$ (10^{-3}) down to 10^{-18}.

6.3 PREFERRED MULTIPLES AND SUBMULTIPLES: The following preferred prefixes, shown in Table C, are relevant in building design and construction. Prefixes outside the range 10^{-6} (micro) to 10^6 (mega) will only occur in rare instances.

TABLE C: PREFERRED MULTIPLES AND SUBMULTIPLES AND THEIR PREFIXES

MULTIPLICATION FACTOR		PREFIX NAME	PREFIX SYMBOL	PRONUNCIATION
10^{12} or	1 000 000 000 000	tera	T	as in *terrace*
10^9 or	1 000 000 000	giga	G	*jig'a*
10^6 or	1 000 000	mega	M	as in *megaphone*
10^3 or	1 000	kilo	k	as in *kilowatt*
10^{-3} or	0.001	milli	m	as in *military*
10^{-6}	0.000 001	micro	μ	as in *microphone*
10^{-9} or	0.000 000 001	nano	n	*nan'oh*
10^{-12} or	0.000 000 000 001	pico	p	*peek'oh*

6.4 OTHER MULTIPLES FOR LIMITED APPLICATION: SI includes a number of additional historically used multiples and submultiples, shown in Table D, but these should be avoided as far as possible.

TABLE D: OTHER NON-PREFERRED MULTIPLES AND THEIR PREFIXES

MULTIPLICATION FACTOR	PREFIX NAME	PREFIX SYMBOL	PRONUNCIATION
10^2 or 100	hecto	h	*heck'toe*
10^1 or 10	deka	da	*deck'a*
10^{-1} or 0.1	deci	d	as in *decimal*
10^{-2} or 0.01	centi	c	as in *sentiment*

7. RULES AND RECOMMENDATIONS FOR THE USE OF SI

7.1 Two tables of rules and recommendations have been prepared in order to facilitate the correct application of SI units and symbols; and the correct presentation of units, symbols, and numerical values shown in conjunction with units and symbols.

7.2 Table E, on pages 8 and 9, gives "Rules and Recommendations for the Presentation of SI Units and Symbols."

7.3 Table F, on pages 10 and 11, gives guidance on "Presentation of Numerical Values with SI."

7.4 The tables provide a convenient reference guide for the editorial checking of metric documents to ensure that the presentation of data is in line with accepted practice.

TABLE E

RULES AND RECOMMENDATIONS FOR THE PRESENTATION OF SI UNITS AND SYMBOLS

	TYPICAL EXAMPLES	REMARKS
A. GENERAL		
1. All unit names should either be denoted by correct symbols or be written in full. In the interest of simplification and to reduce the amount of writing use unit symbols rather than fully written forms.		
2. DO NOT USE mixtures of names and symbols.	USE: J/kg or joule per kilogram	NOT: joule per kg NOT: J/kilogram
B. SYMBOLS FOR UNIT QUANTITIES AND PREFIXES		
1. SI symbols are internationally agreed and there is only one symbol for each unit quantity. Multiples and submultiples are formed by using the unit symbol and attaching a prefix symbol in front of it.	m, kg, s, A, cd, K	See also B5 - B7
2. All unit symbols are shown in upright letters, and can be produced by a normal typewriter keyboard - with the exceptions of the symbols for the SI unit ohm and the prefix micro which are represented by Greek letters Ω and μ respectively.		EXCEPTIONS: Ω, μ
3. Unit symbols are NEVER followed by a period (full stop) except at the end of a sentence.	60 kg/m	NOT: 60 kg./m.
4. Unit symbols are normally written in lowercase, except for unit names derived from a proper name, in which case the initial is capitalized. Some units have symbols consisting of two letters from a proper name, of which only the first letter is capitalized. (The symbol for the unit name "ohm" is the capital Greek letter Ω).	m, kg, s, mol, cd etc. A, K, N, J, W, V etc. Pa, Hz, Wb, etc.	EXCEPTION: L
5. Prefixes for magnitudes from 10^6 to 10^{18} have capital upright letter symbols.	M, G, T etc.	See also C1
6. Prefixes for magnitudes from 10^{-18} through to 10^3 have lowercase upright letter symbols. (The symbol for 10^{-6} or micro is the lowercase Greek letter μ).	p, n, μ, m, k etc.	See also C1
7. Prefix symbols are directly attached to the unit symbol, without a space between them.	mm, kW, MN, etc.	NOT: m m, k W, M N
8. DO NOT USE compound prefixes to form a multiple or submultiple of a unit (e.g. USE nanometer, DO NOT USE micromillimeter or millimicrometer).	nm	NOT: μmm or mμm
9. In the case of the base unit kilogram, prefixes are attached to the 'gram' (e.g. milligram NOT microkilogram).	mg	NOT: μkg
10. USE ONLY ONE PREFIX when forming a multiple or a submultiple of a compound unit. Normally, the prefix should be attached to a unit in the numerator. An exception from this rule is made for the base unit kilogram.	km/s; mV/m	NOT: mm/μs; μV/mm EXCEPTION: MJ/kg NOT kJ/g
C. AREAS OF POSSIBLE CONFUSION REQUIRING SPECIAL CARE		
1. The symbols for SI units and the conventions that govern their use should be STRICTLY followed. A number of prefix and unit symbols use the same letter, but in different form. EXERCISE CARE to present the correct symbol for each quantity.	g (gram); G (giga) k (kilo); K (kelvin) m (milli); m (meter); M (mega) n (nano); N (newton)	OTHERS: c (centi); C (coulomb) °C (degree Celsius) s (second); S (siemens) t (metric ton); T (tera)
2. All prefix and unit symbols retain their prescribed form regardless of the surrounding typography. In printouts from limited character sets (telex, computer printers) special considerations apply to symbols for mega, micro, ohm and siemens. Where confusion is likely to arise, WRITE UNITS IN FULL.		

TABLE E (CONTINUED)

	TYPICAL EXAMPLES	REMARKS
D. UNIT NAMES WRITTEN OUT IN FULL		
1. Unit names, including prefixes are treated as common names and are not capitalized, except at the beginning of sentences or in titles. (The only exception is "Celsius" in "degree Celsius," where degree is considered as the unit name and is shown in lowercase, while Celsius represents an adjective and is capitalized).	meter, newton, etc.	NOT: Meter, Newton EXCEPTION: degree Celsius
2. Where a prefix is attached to an SI unit to form a multiple or submultiple, the combination is written as one word. (There are three cases where the final vowel of the prefix is omitted in the combination: megohm, kilohm, and hectare.)	millimeter; kilowatt	NOT: milli-meter NOT: kilo watt
3. Where a compound unit is formed by multiplication of two units, the use of a space between units is preferred, but a hyphen is acceptable and in some situations more appropriate, to avoid any risk of misinterpretation.	newton meter or newton-meter	NOT: newtonmeter
4. Where a compound unit is formed by division of two units, this is expressed by inserting per between the numerator and the denominator.	meter per second joule per kelvin	NOT: meter/second NOT: joule/kelvin
5. Where the numerical value of a unit is written in full, the unit should also be written in full.	seven meters	NOT: seven m
E. PLURALS		
1. Units written in full are subject to the normal rules of grammar. For any unit with a numerical value greater than one (1), an "s" is added to the written unit to denote the plural.	1.2 meters; 2.3 newtons; 33.2 kilograms	BUT: 0.8 meter
2. The following units have the same plural as singular when written out in full: hertz, lux, siemens.	350 kilohertz 12.5 lux	
3. Symbols NEVER change in the plural.	2.3 N; 33.2 kg	NOT: 2.3 Ns; 33.2 kgs
F. COMPOUND UNIT SYMBOLS - PRODUCTS AND QUOTIENTS		
1. The product of two units is indicated by a dot placed at mid-height between the unit symbols.	kN·m; Pa·s	NOT: kNm; Pas NOT: kN m; Pa s
2. To express a derived unit formed by division, any one of the following methods may be used:		See also F3 and F5
a. a solidus (slash, /)	kg/m^3; W/(m·K)	See also F3 and F5
b. a horizontal line between numerator and denominator	$\frac{kg}{m^3}$; $\frac{W}{m\cdot K}$	
c. a negative index (or negative power)	$kg\cdot m^{-3}$; $W\cdot m^{-1}\cdot K^{-1}$	
3. Only one solidus may be used in any combination.	m/s^2; $m\cdot kg/(s^3\cdot A)$	NOT: m/s/s NOT: $m\cdot kg/s^3/A$
4. DO NOT USE the abbreviation "p" for per in the expression of a division.	km/h	NOT: kph or k.p.h.
5. Where the denominator is a product, this should be shown in parentheses.	$W/(m^2\cdot K)$	

TABLE F

PRESENTATION OF NUMERICAL VALUES IN CONJUNCTION WITH SI

	TYPICAL EXAMPLES	REMARKS
A. DECIMAL MARKER		
1. Whereas most European countries use the comma on the line as the decimal marker and this practice is advocated by ISO, a special exception is made for documents in the English language which have traditionally used the point (dot) on the line, or period, as decimal marker.		See also under G.
2. The recommended decimal marker for use in the United States is the point on the line (period), and the comma should not be used.	9.9 ; 15.375	NOT: 9,9 ; 15,375
In handwritten documents the decimal marker may be shown slightly above the line for clear identification.	9·9; 15·375	
3. Always show a zero before the decimal point for all numbers smaller than 1.0 (one).	0.1 ; 0.725	NOT: .1 ; .725
B. SPACING		
1. Always leave a gap between the numerical value associated with a symbol and the symbol, of at least half a space in width.	900 MHz ; 200 mg ; 10^6 mm^2 or 10^6 mm^2	NOT: 900MHz ; 200mg NOT: 10^6mm^2
In the case of the symbol for the "degree Celsius" this space is optional, but the degree symbol must always be attached to Celsius.	20°C or 20 °C	NOT: 20° C
2. In non-SI expressions of plane angle (°, ', "), DO NOT LEAVE A SPACE between the numerical value and the symbol.	27°30' (of arc)	NOT: 27 ° 30 '
3. Always leave a space on each side of signs for multiplication, division, addition, and subtraction	100 mm x 100 mm ; 36 MPa + 8 MPa	NOT: 100 mmx100 mm NOT: 36 MPa+ 8 MPa
C. FRACTIONS		
1. Avoid common fractions in connection with SI units.	WRITE: 0.5 kPa	NOT: 1/2 kPa
2. Always use decimal notation to express fractions of any number larger than 1.0 (one).	1.5 ; 16.375	NOT: 1-1/2 ; 16-3/8
3. While the most common fractions such as half, third, quarter, and fifth will remain in speech, always show decimal notation in written, typed, or printed material.	0.5 ; 0.33 ; 0.25 ; 0.2	NOT: 1/2 ; 1/3 ; 1/4 ; 1/5
D. POWERS OF UNITS AND EXPONENTIAL NOTATION		
1. When writing unit names with a modifier 'squared' or 'cubed', the following rules should be applied:		
a. In the case of area and volume, the modifier is written before the unit name as "square" and "cubic".	cubic meter ; square millimeter	NOT: meter cubed ; millimeter squared
b. In all other cases, the modifier is shown after the unit name as "squared", "cubed", "to the fourth power", etc.	meter per second squared	NOT: meter per square second; (or 'meter per second per second')
c. The abbreviations "sq." for square, and "cu." for cubic should not be used.		NOT: sq. millimeter NOT: cu. meter
2. For unit symbols with modifiers (such as square, cubic, fourth power etc.) always show the superscript immediately after the symbol.	m^2 ; mm^3 ; s^4	NOT: m ^{2}; mm ^{3}; s ^{4}

	TYPICAL EXAMPLES	REMARKS
3. Show the superscript as a reduced size numeral raised half a line space. Where a typewriter without superscript numerals is used, the full size numeral should be raised half a line space, provided that this does not encroach on print in the line above.	mm^3, m/s^2	PERMITTED: mm^3, m/s^2
4. Where an exponent is attached to a prefixed symbol, it indicates that that multiple (or submultiple) is raised to the power expressed by the exponent.	$1\ mm^3 = (10^{-3}\ m)^3 = 10^{-9}\ m^3$ $1\ km^2 = (10^3\ m)^2 = 10^6\ m^2$	NOT: $1\ mm^3 = 10^{-3}\ m^3$
E. RATIOS		
1. Do not mix units in expressing a ratio of like unit quantities.	0.01 m/m $0.03\ m^2/m^2$	NOT: 10 mm/m NOT: $30\ 000\ mm^2/m^2$
2. Wherever possible, use a nonquantitative expression (ratio or percentage) to indicate measurement of slopes, deflections, etc.		PREFERRED: 1:100; 0.01; 1% 1:33; 0.03; 3%
F. RANGE		
1. The choice of the appropriate prefix to indicate a multiple or submultiple of an SI unit is governed by convenience to obtain numerical values within a practical range and to eliminate non-significant digits.		
2. In preference, use prefixes representing ternary powers of 10 (10 raised to a power which is a multiple of 3).	milli, kilo, mega	AVOID: centi, deci, deka, hecto
3. Select prefixes so that the numerical value or values occur in a common range between 0.1 and 1000.	120 kN 3.94 mm 14.5 MPa	IN LIEU OF: 120 000 N 0.003 94 m 14 500 kPa
4. Compatibility with the general range must be a consideration; e. g., if all dimensions on a drawing are shown in millimeters (mm), a range from 1 to 99 999 (a maximum of five numerals) would be acceptable to avoid mixing of units.		NOTE: Drawings should show "All dimensions in millimeters".
G. PRESENTATION AND TABULATION OF NUMBERS		
1. In numbers with many digits it has been common practice in the United State to separate digits into groups of three by means of commas. This practice must not be used with SI, to avoid confusion. It is recommended international practice to arrange digits in long numbers in groups of three from the decimal marker, with a gap of not less than half a space, and not more than a full space, separating each group.	54 375.260 55 54 375.260 55	NOT: 54,375.260,55 NOT: 53475.26055
2. For individual numbers with four digits before (or after) the decimal marker this space is not necessary.	4500; 0.0355	
3. In all tabulations of numbers with five or more digits before and/or after the decimal marker, group digits into groups of three: e.g., 12.5255; 5735; 98 300 ; 0.425 75	12.525 5 5 735 98 300 0.425 75 104 047.951 25	
H. USE OF UNPREFIXED UNITS IN CALCULATIONS		
Errors in calculations involving compound units can be minimized if all prefixed units are reverted back to coherent base or derived units, with numerical values expressed in powers-of-ten notation.	PREFERRED: $136\ kJ = 136 \times 10^3\ J$ $20\ MPa = 20 \times 10^6\ Pa$ $1.5\ t\ (Mg) = 1.5 \times 10^3\ kg$	ALSO ACCEPTABLE: (or 1.36×10^5 J) (or 2×10^7 Pa)

8. SI UNITS FOR USE IN DESIGN AND CONSTRUCTION

8.1 Correct selection of units for use in building design calculations and in documentation is essential to minimize errors and to optimize the coordination between the various sectors and groups within the construction community.

8.2 The following tables list SI units, and other units acceptable with SI as recommended, for use in building design and construction related activities. Where appropriate, working ranges are indicated for selected units, and typical examples provided of their field(s) of application. In addition, explanatory remarks are added to briefly deal with any special considerations. A subdivision, similar to that used for ISO 1000, has been adopted:

8.3 PREFERRED RANGES OF VALUES

The use of an appropriate unit or multiple of a unit depends upon the context in which it is used.

8.4.1 In printed or typed material it is preferable to use numbers between 1 and 1000, wherever possible, by selecting the appropriate prefix. For example:

- 725 m is preferred to 0.725 km or 725 000 mm.

8.4.2 If the numerical quantity is part of a group of numbers in a different range, select the prefix which most adequately covers the range, without unduly large or small numbers. For example:

- If 725 m is part of a group of numbers shown in kilometers, show it as 0.725 km.

8.4.3 Although physical data generally should be presented in the most condensed form possible – by using appropriate prefixes – it may be advantageous in calculations to use exponential notation, in lieu of prefixes. For example:

- $900\ \text{mm}^2 = 0.9 \times 10^{-3}\ \text{m}^2$; $36\ \text{MPa} = 36 \times 10^6\ \text{Pa} = 36 \times 10^6\ \text{N/m}^2$

8.4.4 In drawings it will be of advantage to show one measurement unit throughout, so that numerical values can be represented by numbers only, and the unit symbol can be deleted.

For example, in a drawing in which all dimensions are shown in millimeters, 5-digit numbers (indicating millimeters) are quite acceptable.

TABLE G

SPACE AND TIME: GEOMETRY, KINEMATICS AND PERIODIC PHENOMENA

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
LENGTH (m)	m		meter	*ARCHITECTURE AND GENERAL ENGINEERING* Levels, overall dimensions, spans, column heights, etc., in engineering computations. *ESTIMATING AND SPECIFICATION* Trenches, curbs, fences, lumber lengths, pipes and conduits; lengths of building materials generally. *LAND SURVEYING* Boundary and cadastral surveys; survey plans; heights, geodetic surveys, contours. *HYDRAULIC ENGINEERING* Pipe and channel lengths, depth of storage tanks or reservoirs, height of potentiometric head, hydraulic head, piezometric head.	USE meters on all drawings with scale ratios between 1:200 and 1:2000. Where required for purposes of accuracy, show dimensions to three decimal places. An alternative spelling is "metre".
	mm		millimeter	*ARCHITECTURE AND GENERAL ENGINEERING* Spans, dimensions in buildings, dimensions of building products; depth and width of sections; displacement, settlement, deflection, elongation; slump of concrete, size of aggregate; radius of gyration, eccentricity; detailed dimensions generally; rainfall. *ESTIMATING AND SPECIFICATION* Lumber cross sections; thicknesses, diameters, sheet metal gages, fasteners; all other building product dimensions. *HYDRAULIC ENGINEERING* Pipe diameters; radii of ground water wells; height of capillary rise; precipitation, evaporation.	USE millimeters on drawings with scale ratios between 1:1 and 1:200. AVOID the use of centimeters (cm). Where 'cm' is shown in documents, such as for snow depth, body dimensions, or carpet sizes, etc. CONVERT to 'mm' or 'm'.
	km		kilometer	Distances for transportation purposes geographical or statistical applications in surveying; long pipes and channels.	
	μm		micrometer	Thickness of coatings (paint, galvanizing etc.), thin sheet materials, size of fine aggregate.	
AREA (m^2)	m^2		square meter	*GENERAL APPLICATIONS* Small land areas; area of cross-section of earthworks, channels and larger pipes; surface area of tanks and small reservoirs; areas in general. *ESTIMATING AND SPECIFICATION* Site clearing; floor areas; paving, masonry construction, roofing, wall and floor finishes, plastering, paintwork, glass areas, membranes, lining materials, insulation, reinforcing mesh, formwork; areas of all building components.	($1\ m^2 = 10^6\ mm^2$) Replaces sq.ft.; sq.yd. and square. SPECIFY masonry construction by wall area x wall thickness.
	mm^2		square millimeter	Area of cross section for structural and other sections, bars, pipes, rolled and pressed shapes, etc.	AVOID the use of cm^2 (square centimeter) by conversion to mm^2. ($1\ cm^2 = 10^2\ mm^2 = 100\ mm^2$)
	km^2		square kilometer	Large catchment areas or land areas.	
		ha	hectare	Land areas; irrigation areas; areas on boundary and other survey plans.	($1\ ha = (10^2\ m)^2 = 10^4\ m^2 = 10\,000\ m^2$)

TABLE G (CONTINUED)

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
VOLUME, CAPACITY (m^3)	m^3		cubic meter	*GENERAL APPLICATIONS* Volume, capacity (large quantities); volume of earthworks, excavations, filling, waste removal; concrete, sand, all bulk materials supplied by volume, and large quantities of lumber. *HYDRAULIC ENGINEERING* Water distribution, irrigation, diversions, sewage, storage capacity, underground basins.	$1\ m^3 = 1000$ L As far as possible, USE the cubic meter as the preferred unit of volume for all engineering purposes.
	mm^3		cubic millimeter	Volume, capacity (small quantities)	
		L	liter	Volume of fluids and containers for fluids; liquid materials, domestic water supply, consumption; volume/capacity of fuel tanks	The liter and its multiples or submultiples may be used for domestic and industrial supplies of liquids
		mL	milliliter	Volume of fluids and containers for fluids (limited application only)	1 L = 1 dm^3 = 1000 cm^3 1 mL = 1 cm^3 See Section 9.3, p. 25/26
		cm^3	cubic centimeter	Limited application only (small quantities)	$1\ cm^3 = 1000\ mm^3 = 10^{-6}\ m^3$
MODULUS OF SECTION (m^3)	mm^3		millimeter to third power	Geometric properties of structural sections, such as plastic section modulus, elastic section modulus, etc.	See Section 9.4, p. 26
	m^3		meter to third power		
SECOND MOMENT OF AREA (m^4)	mm^4		millimeter to fourth power	Geometric properties of structural sections, such as moment of inertia of a section, torsional constant of a cross section.	See Section 9.4, p. 26
	m^4		meter to fourth power		
PLANE ANGLE (rad)	rad		radian	Generally used in calculations only to preserve coherence.	Slopes and gradients may be expressed as a ratio or as a percentage:
	mrad		milliradian		
		(_°)	degree (of arc)	*GENERAL APPLICATIONS* Angular measurement in construction (generally using decimalized degrees); angle of rotation, torsion, shear resistance, friction, internal friction, etc. *LAND SURVEYING* Bearings shown on boundary and cadastral survey plans; geodetic surveying	26.57° = 1 : 2 = 50 % = 0.4637 rad (1 rad = 57.2958°) See also Section 9.5, on pages 26 and 27
TIME, TIME INTERVAL (s)	s		second	Time used in methods of test; all calculations involving derived units with a time component, in order to preserve coherence.	AVOID the use of minute (min) as far as possible
		h	hour	Time used in methods of test; all calculations involving labor time, plant hire, maintenance periods, etc.	(1 h = 3600 s) (1 d = 86 400 s = 86.4 ks)
		d	day		
		a	annum (year)		
FREQUENCY (Hz)	Hz		hertz	Frequency of sound, vibration, shock; frequency of electro-magnetic waves	(1 Hz = 1/s = s^{-1}) Replaces cycle(s) per second (c/s or cps)
	kHz		kilohertz		
	MHz		megahertz		

TABLE G (CONTINUED)

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
ROTATIONAL FREQUENCY, SPEED OF ROTATION (s^{-1})		r/s	revolution per second	Widely used in the specification of rotational speed of machinery; Use r/min (revolutions per minute) only for slow moving machinery	(1 r/s = 2π rad/s = 60 r/min)
VELOCITY, SPEED (m/s)	m/s		meter per second	Calculations involving rectilinear motion, velocity and speed in general; wind velocity; velocity of fluids; pipe flow velocity	(1 m/s = 3.6 km/h)
		km/h	kilometer per hour	Wind speed; speed used in transportation; speed limits	
		mm/h	millimeter per hour	Rainfall intensity	
ANGULAR VELOCITY (rad/s)	rad/s		radian per second	Calculations involving rotational motion	
LINEAR ACCELERATION (m/s^2)	m/s^2		meter per second squared	Kinematics, and calculation of dynamic forces	Recommended value of acceleration of gravity for use in U.S: g_{us} = 9.8 m/s^2 See page 28
VOLUME RATE OF FLOW (m^3/s)	m^3/s		cubic meter per second	Volumetric flow in general; flow in pipes, ducts, channels, rivers; irrigation spray demand	(1 m^3/s = 1000 L/s) See also Section 9.6.3 on page 27
		m^3/h	cubic meter per hour		
		m^3/d	cubic meter per day		
		L/s	liter per second	Volumetric flow of fluids only	
		L/d	liter per day		

TABLE H

MECHANICS: STATICS AND DYNAMICS

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
MASS (kg)	kg		kilogram	Mass of materials in general, mass of structural elements and machinery	USE kilograms (kg) in calculations and specifications
	g		gram	Mass of samples of material for testing	Masses greater than 10^4 kg (10 000 kg) may be conveniently expressed in metric tons (t): 1 t = 10^3 kg = 1 Mg = 1000 kg
		t	metric ton	Mass of large quantities of materials, such as structural steel, reinforcement, aggregates, concrete, etc.; ratings of lifting equipment.	
MASS PER UNIT LENGTH (kg/m)	kg/m		kilogram per meter	Mass per unit length of sections, bars, and similar items of uniform cross section	Also known as "Linear Density"
		g/m	gram per meter	Mass per unit length of wire and similar material of uniform cross section	
MASS PER UNIT AREA (kg/m^2)	kg/m^2		kilogram per square meter	Mass per unit area of slabs, plates, and similar items of uniform thickness or depth; rating for load-carrying capacities on floors (display on notices only)*	*DO NOT USE in stress calculations
		g/m^2	gram per square meter	Mass per unit area of thin sheet materials, coatings, etc.	
MASS DENSITY, CONCENTRATION (kg/m^3)	kg/m^3		kilogram per cubic meter	Density of materials in general; mass per unit volume of materials in a concrete mix; evaluation of masses of structures and materials	Also known as "Mass per Unit Volume" (1 kg/m^3 = 1 g/L) (1 g/m^3 = 1 mg/L)
		g/m^3	gram per cubic meter	Mass per unit volume (concentration) in pollution control	
		$\mu g/m^3$	microgram per cubic meter		
MOMENTUM (kg·m/s)	kg·m/s		kilogram meter per second	Used in applied mechanics; evaluation of impact and dynamic forces	
MOMENT OF INERTIA ($kg \cdot m^2$)	$kg \cdot m^2$		kilogram square meter	Rotational dynamics. Evaluation of the restraining forces required for propellers, windmills, etc.	See also Section 9.11 on pages 29/30
MASS PER UNIT TIME (kg/s)	kg/s		kilogram per second	Rate of transport of material on conveyors and other materials handling equipment	1 kg/s = 3.6 t/h
		t/h	metric ton per hour		
FORCE (N)	N		newton	Unit of force for use in calculations	1 N = 1 $kg \cdot m/s^2$ See also Section 9.8 on page 28
	kN		kilonewton	Forces in structural elements, such as columns, piles, ties, pre-stressing tendons, etc.; concentrated forces; axial forces; reactions; shear force; gravitational force	
FORCE PER UNIT LENGTH (N/m)	N/m		newton per meter	Unit for use in calculations	
	kN/m		kilonewton per meter	Transverse force per unit length on a beam, column, etc.; force distribution in a linear direction	
MOMENT OF FORCE TORSIONAL OR BENDING MOMENT, (N·m)	N·m		newton meter	Bending moments (in structural sections), torsional moment; overturning moment; tightening tension for high strength bolts; torque in engine drive shafts, axles, etc.	See also Sections 9.10.4 and 9.11 on pages 29 and 30
	kN·m		kilonewton meter		
	MN·m		meganewton meter		

TABLE H (CONTINUED)

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
PRESSURE, STRESS, MODULUS OF ELASTICITY (Pa)	Pa		pascal	Unit for use in calculations; low differential pressure in fluids	(1 Pa = 1 N/m^2)
	kPa		kilopascal	Uniformly distributed pressure (loads) on floors; soil bearing pressure; wind pressure (loads), snow loads, dead and live loads; pressure in fluids; differential pressure (e.g., in ventilating systems)	Where wind pressure, snow loads, dead and live loads are shown in kN/m^2 CHANGE units to kPa
	MPa		megapascal	Modulus of elasticity; stress (ultimate, proof, yield, permissible, calculated, etc.) in structural materials; concrete and steel strength grades	1 MPa = 1 MN/m^2 = 1 N/mm^2
	GPa		gigapascal	Modulus of elasticity in high strength materials	
	μPa		micropascal	Sound pressure (20 μPa is the reference quantity for sound pressure level)	
COMPRESSIBILITY (Pa^{-1})	1/Pa		reciprocal (of) pascal	Settlement analysis, (coefficient of compressibility), bulk compressibility	(1/Pa = 1 m^2/N)
	1/kPa		reciprocal (of) kilopascal		
DYNAMIC VISCOSITY (Pa·s)	Pa·s		pascal second	Shear stresses in fluids	(1 Pa·s = 1 Ns/m^2) The centipoise (cP) = 10^{-3} Pa·s WILL NOT BE USED
	mPa·s		millipascal second		
KINEMATIC VISCOSITY (m^2/s)	m^2/s		square meter per second		The centistokes (cSt) = 10^{-6}m^2/s WILL NOT BE USED 1 cSt = 1 mm^2/s
	mm^2/s		square millimeter per second	Computation of Reynold's number, settlement analysis (coeff. of consolidation)	
WORK, ENERGY (J)	J		joule	Energy absorbed in impact testing of materials; energy in general; calculations involving mechanical and electrical energy	
	kJ		kilojoule		
	MJ		megajoule		
		kWh	kilowatthour	Electrical energy applications only	1 kWh = 3.6 MJ
IMPACT STRENGTH (J/m^2)	J/m^2		joule per square meter	Impact strength; impact ductility	
	kJ/m^2		kilojoule per square meter		
POWER (W)	W		watt	Power in general (mechanical, electrical, thermal); input/output rating, etc. of motors, engines, heating and ventilating plant and other equipment in general	
	kW		kilowatt		
	MW		megawatt	Power input/output rating etc. of heavy power plant	
	pW		picowatt	Sound power level (1 pW is the reference quantity for sound power level)	

TABLE J

HEAT: THERMAL EFFECTS, HEAT TRANSFER

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
TEMPERATURE VALUE (K)	K		kelvin	Expression of thermodynamic temperature; calculations involving units of temperature	($t_{°C} = T_K - 273.15$)
		°C	degree Celsius	Common temperature scale for use in meteorology and general applications; ambient temperature values	Temperature values will normally be measured in °C (degrees Celsius)
TEMPERATURE INTERVAL (K)	K		kelvin	Heat transfer calculations; temperature intervals in test methods, etc.	(1 K = 1°C) The use of K (kelvin) in compound units is recommended
		°C	degree Celsius		
COEFFICIENT OF LINEAR THERMAL EXPANSION (1/K)	1/K		reciprocal (of) kelvin	Expansion of materials subject to a change in temperature (generally expressed as a ratio per kelvin or degree Celsius)	
		1/°C	reciprocal (of) degree Celsius		
HEAT, QUANTITY OF HEAT (J)	J		joule	Thermal energy calculations. Enthalpy, latent heat, sensible heat	
	kJ		kilojoule		
	MJ		megajoule		
SPECIFIC ENERGY, SPECIFIC LATENT HEAT; COMBUSTION HEAT (mass basis) (J/kg)	J/kg		joule per kilogram	Heat of transition; heat and energy contained in materials; combustion heat per unit mass; calorific value of fuels (mass basis); specific sensible heat, specific latent heat in psychrometric calculations	
	kJ/kg		kilojoule per kilogram		
	MJ/kg		megajoule per kilogram		
ENERGY DENSITY, COMBUSTION HEAT (Volume basis) (J/m^3)	J/m^3		joule per cubic meter	Combustion heat per unit volume	
	kJ/m^3		kilojoule per cubic meter		($1\ kJ/m^3 = 1\ J/L$)
	MJ/m^3		megajoule per cubic meter	Calorific value of fuels (volume basis)	($1\ MJ/m^3 = 1\ kJ/L$)
HEAT CAPACITY, ENTROPY (J/K)	J/K		joule per kelvin	Thermal behavior of materials, heat transmission calculations, entropy	
	kJ/K		kilojoule per kelvin		
SPECIFIC HEAT CAPACITY, SPECIFIC ENTROPY (J/(kg·K))	J/(kg·K)		joule per kilogram kelvin	Thermal behavior of materials, heat transmission calculations	
	kJ/(kg·K)		kilojoule per kilogram kelvin		
HEAT FLOW RATE (W)	W		watt	Heat flow rate through walls, windows, etc.; heat demand	(1 W = 1 J/s)
	kW		kilowatt		
POWER DENSITY, HEAT FLUX DENSITY, IRRADIANCE (W/m^2)	W/m^2		watt per square meter	Density of power or heat flow through building walls and other heat transfer surfaces; heat transmission calculations	
	kW/m^2		kilowatt per square meter		

TABLE J (CONTINUED)

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
HEAT RELEASE RATE (W/m^3)	W/m^3		watt per cubic meter	Rate of heat release per unit volume over time (for gases and liquids)	($W/m^3 = J/(m^3 \cdot s)$)
	kW/m^3		kilowatt per cubic meter		
THERMAL CONDUCTIVITY, ($W/(m \cdot K)$)	$W/(m \cdot K)$		watt per meter kelvin	Estimation of thermal behavior of materials and systems; heat transmission calculations Thermal conductivity of structural and building materials in fire-resistance testing, insulation, etc.	$1\ W/(m \cdot K) = 1\ W/(m \cdot {}^\circ C)$ (k value)
COEFFICIENT OF HEAT TRANSFER, (THERMAL CONDUCTANCE) ($W/(m^2 \cdot K)$)	$W/(m^2 \cdot K)$		watt per square meter kelvin	Heat transfer calculations for buildings, building components and equipment. Transmittance of construction elements	(U value)
	$kW/(m^2 \cdot K)$		kilowatt per square meter kelvin		
THERMAL RESISTIVITY $(m \cdot K)/W$	$(m \cdot K)/W$		meter kelvin per watt	Heat transmission calculations (reciprocal of thermal conductivity)	
THERMAL INSULANCE, (THERMAL RESISTANCE) $(m^2 \cdot K)/W$	$(m^2 \cdot K)/W$		square meter kelvin per watt	Heat transmission calcuations (reciprocal of thermal conductance)	(R value)

TABLE K

ELECTRICITY AND MAGNETISM

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
ELECTRIC CURRENT (A)	A		ampere	Maintenance rating of an electrical installation. Leakage current	
	kA mA μA		kiloampere milliampere microampere		
MAGNETOMOTIVE FORCE, MAGNETIC POTENTIAL DIFFERENCE (A)				Used in the calculations involved in magnetic circuits	
MAGNETIC FIELD STRENGTH, MAGNETIZATION (A/m)	A/m		ampere per meter	Magnetic field strength used in calculation of magnetic circuitry such as transformers, magnetic amplifiers, and general cores	(1 kA/m = 1 A/mm)
	kA/m		kiloampere per meter		
CURRENT DENSITY (A/m^2)	A/m^2		ampere per square meter	Design of cross-sectional area of electrical conductor	
	kA/m^2		kiloampere per square meter		
		A/mm^2	ampere per square millimeter		($1\ A/mm^2 = 1\ MA/m^2$)
ELECTRIC CHARGE, QUANTITY OF ELECTRICITY (C)	C		coulomb	The voltage on a unit with capacitive type characteristics may be related to the amount of charge present (e.g. electrostatic precipitators). Storage battery capacities	1 C = 1 A·s DO NOT USE ampere hour: 1 A·h = 3.6 kC
	kC μC nC pC		kilocoulomb microcoulomb nanocoulomb picocoulomb		
ELECTRIC POTENTIAL, POTENTIAL DIFFERENCE, ELECTROMOTIVE FORCE (V)	V		volt		1 V = 1 W/A
	MV kV mV μV		megavolt kilovolt millivolt microvolt		
ELECTRIC FIELD STRENGTH (V/m)	V/m		volt per meter	The electric field strength gives the potential gradient at points in space. This may be used to calculate or test electrical parameters such as dielectric strength.	
	MV/m kV/m mV/m μV/m		megavolt per meter kilovolt per meter millivolt per meter microvolt per meter		
ACTIVE POWER (W)	W		watt	The useful power of an electrical circuit is expressed in 'watts' (W). (The apparent power in an electrical circuit is expressed in 'volt-amperes', (V·A)).	1 W = 1 V·A
	GW MW kW mW μW		gigawatt megawatt kilowatt milliwatt microwatt		
CAPACITANCE (F)	F		farad	Electronic components. Electrical design and performance calculators.	1 F = 1 C/V
	mF μF nF pF		millifarad microfarad nanofarad picofarad.		

TABLE K (CONTINUED)

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
RESISTANCE (Ω)	Ω GΩ MΩ kΩ mΩ		ohm gigaohm megohm kilohm milliohm	The design of electrical devices with resistance, such as motors, generators, heaters, electrical distribution systems, etc.	1 Ω = 1 V/A
CONDUCTANCE, ADMITTANCE SUSCEPTANCE (S)	S MS kS mS μS		siemens megasiemens kilosiemens millisiemens microsiemens		The siemens (S) was formerly known as mho
RESISTIVITY (Ω·m)	Ω·m GΩ·m MΩ·m kΩ·m mΩ·m μΩ·m nΩ·m		ohm meter gigaohm meter megohm meter kilohm meter milliohm meter microohm meter nanoohm meter		
(ELECTRICAL) CONDUCTIVITY (S/m)	S/m MS/m kS/m μS/m		siemens per meter megasiemens per meter kilosiemens per meter microsiemens per meter	A parameter for measuring water quality.	
MAGNETIC FLUX, FLUX OF MAGNETIC INDUCTION (Wb)	mWb		milliweber	Used in the calculations involved in magnetic circuits.	1 Wb = 1 V·s
MAGNETIC FLUX DENSITY, MAGNETIC INDUCTION (T)	T mT μT nT		tesla millitesla microtesla nanotesla	Used in the calculations involved in magnetic circuits.	1 T = 1 Wb/m^2
MAGNETIC VECTOR POTENTIAL (Wb/m^2)	kWb/m^2		kiloweber per square meter	Used in the calculations involved in magnetic circuits.	
SELF INDUCTANCE, MUTUAL INDUCTANCE, PERMEANCE (H)	H mH μH nH pH		henry millihenry microhenry nanohenry picohenry	Used in analysis and calculations involving transformers.	1 H = 1 Wb/A
RELUCTANCE (1/H)	1/H		reciprocal of henry	Design of motors and generators	
PERMEABILITY (H/m)	H/m μH/m nH/m		henry per meter microhenry per meter nanohenry per meter	Permeability gives the relationship between the magnetic flux density and the magnetic field strength.	

TABLE L

LIGHTING

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
LUMINOUS INTENSITY (cd)	cd		candela		
SOLID ANGLE (sr)	sr		steradian		
LUMINOUS FLUX (lm)	lm klm		lumen kilolumen	Luminous flux of light sources, lamps and light bulbs	1 lm = 1 cd·sr Already in general use
QUANTITY OF LIGHT (lm·s)	lm·s	lm·h	lumen second lumen hour		1 lm·h = 3600 lm/s
LUMINANCE (cd/m^2)	cd/m^2 kcd/m^2	cd/mm^2	candela per square meter kilocandela per square meter candela per square millimeter	Assessment of surface brightness; luminance of light sources, lamps and light bulbs; calculation of glare in lighting layouts	Replaces stilb (1 sb = 10^4 cd/m^2) and apostilb (1 apostilb = $cd/\pi m^2$)
ILLUMINANCE (lx)	lx klx		lux kilolux	Luminous flux per unit area used in determination of illumination levels and design/evaluation of interior lighting layouts. (Outdoor daylight illumination on a horizontal plane ranges up to 100 klx)	a) Formerly referred to as illumination 1 lx = 1 lm/m^2 b) Replaces (1 ph = 10^4 lx) c) Luminous exitance is described in lm/m^2
LIGHT EXPOSURE (lx·s)	lx·s klx·s		lux second kilolux second		
LUMINOUS EFFICACY (lm/W)	lm/W		lumen per watt	Rating of luminous efficacy of artificial light sources	

TABLE M
ACOUSTICS

QUANTITY AND SI UNIT SYMBOL	PREFERRED UNITS (SYMBOLS)	OTHER ACCEPTABLE UNITS	UNIT NAME	TYPICAL APPLICATIONS	REMARKS
WAVE LENGTH (m)	m mm		meter millimeter	Definition of sound wave pitch	
AREA OF ABSORPTIVE SURFACE (m^2)	m^2		square meter	Calculations of room absorption	
PERIOD, PERIODIC TIME (s)	s ms		second millisecond	Measurement of time and reverberation time	
FREQUENCY (Hz)	Hz kHz		hertz kilohertz	Frequency ranges in sound absorption calculations and sound pressure measurement	1 Hz = 1 cycle per second (cps)
(INSTANTANEOUS) SOUND PRESSURE (Pa)	Pa mPa μPa		pascal millipascal micropascal	Measurement of sound pressure; reference level for sound pressure is 20 μPa, but sound pressure is shown in decibels (dB) based upon a logarithmic scale Sound pressure level L_p = $= 20 \log_{10} \frac{\text{actual pressure (Pa)}}{20 \times 10^{-6} \text{ (Pa)}}$	Do NOT USE dyne (1 dyn = 10 μPa)
SOUND POWER, SOUND ENERGY FLUX (W)	W mW μW pW		watt milliwatt microwatt picowatt	Measurement of sound power; reference level for sound power is 1 pW Sound power level, L = $= 10 \log_{10} \frac{\text{actual power (W)}}{10^{-12} \text{ (W)}}$	
SOUND INTENSITY (W/m^2)	W/m^2 pW/m^2		watt per square meter picowatt per square meter	Measurement of sound intensity; reference level for sound intensity is 1 pW/m^2 Sound intensity level L_I = $= 10 \log_{10} \frac{\text{actual intensity } (W/m^2)}{10^{-12} \ (W/m^2)}$ dB	
SPECIFIC ACOUSTIC IMPEDANCE (Pa·s/m)	Pa·s/m		pascal second per meter	Sound impedance measurement	(1 Pa·s/m = 1 N s/m^3)
ACOUSTIC IMPEDANCE, RESISTANCE ($Pa{\cdot}s/m^3$)	$Pa{\cdot}s/m^3$		pascal second per cubic meter	Sound impedance measurement	

9. SPECIAL CONSIDERATIONS IN THE USE OF SI UNITS IN BUILDING DESIGN AND CONSTRUCTION

9.1 LINEAR MEASUREMENT (LENGTH)

9.1.1 The preferred units for measurement of length in building design, construction, and production are the millimeter (mm) and the meter (m).

9.1.2 In special applications, the kilometer (km) is used for the measurement of long distances, and the micrometer (μm) is used for precision measurements.

9.1.3 The centimeter (cm) is to be avoided in all building design and construction applications.

9.1.4 The arguments for the deletion of the centimeter are:

a. the centimeter is not consistent with the preferred use of multiples which represent ternary powers of 10 ;

b. the order of magnitude between the millimeter and centimeter is only 10, and the use of both units would lead to confusion ;

c. the millimeter (mm) provides integers within appropriate tolerances for all building dimensions and nearly all building product dimensions, so that decimal fractions are almost entirely eliminated from documents. In contrast, acceptance of the centimeter would inevitably lead to extensive use of decimal fractions, which is undesirable.

9.1.5 On drawings, unit symbols may be deleted if the following rules are applied:

a. the drawing is designated "all dimensions shown in millimeters," or "all dimensions shown in meters;"

b. whole numbers always indicate millimeters: e.g. 3600 ; 300 ; 25

i. any length up to 328 feet can be shown by a simple 5-digit number; for example: 327' - 10 $^{11}/16$" equals 99 941

ii. similarly, any length up to 32 feet and 9 inches can be shown by a 4-digit number ;

iii. any length up to 3 feet and 3 $^{5}/16$ inches can be shown by a 3-digit number.

c. decimalized expressions, taken to three decimal places, always indicate "meters" ; for example: 3.600 ; 0.300 ; 0.025

9.1.6 The use of millimeters and meters, as recommended, saves both space and time in drawing, typing, and computer applications. It also improves clarity in drawings with a lot of dimensions.

9.1.7 SURVEY MEASUREMENT

The change to SI units will also eliminate the discrepancies between the units "international foot" and U.S. survey foot," "international mile" and "U.S. survey mile" (the survey mile is approximately 3 millimeters longer), and corresponding derived units for area measurement. (1)

9.2 AREA

9.2.1 The preferred unit for area measurement is the square meter (m^2). Very large areas can be expressed in square kilometers (km^2), and small areas will be expressed in square millimeters (mm^2), or in square meters using exponential notation (e.g. $10^{-6}\ m^2$).

9.2.2 The hectare (ha), is used for surface measurement of land and water only ($1\ ha = (100\ m)^2 = 10\,000\ m^2 = 10^4\ m^2 = 0.01\ km^2$).

9.2.3 The square centimeter (cm^2) is to be avoided to minimize confusion. Any measurement of area given in square centimeters should be converted to square millimeters or square meters ($1\ cm^2 = 100\ mm^2 = 10^{-4}\ m^2$).

9.2.4 At times, it will be more appropriate to indicate the surface or cross-sectional area of building products by linear dimensions; e.g., 40 mm x 90 mm; 300 x 600. It is preferred practice to indicate the width dimension first and height second.

9.3 VOLUME AND FLUID CAPACITY

9.3.1 The preferred unit for measurement of volume in construction and for large storage tank capacities is the cubic meter (m^3).

9.3.2 The preferred units for measurement of fluid capacity (liquid volume) are the liter (L) and the milliliter (mL).

9.3.3 By international definition, in 1964, the liter is equal to one thousandth of a cubic meter, or equal to one cubic decimeter (dm^3).

9.3.4 Because the cubic meter contains one billion (10^3) cubic millimeters, the cubic decimeter (dm^3) and the cubic centimeter (cm^3) may find limited application in some industries, particularly as they represent preferred steps

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(1) *Since 1893, the U.S. basis of length measurement has been derived from metric standards. In 1959, the definition of length of the "foot" was changed from 1200/3937 m to 0.3048 m exactly, which resulted in the new value being shorter by two parts in a million.*
At the same time it was decided that any data derived from and published as a result of geodetic surveys within the United States would remain with the old standard. Thus all land measurements in U.S. customary units are based upon the "U.S. survey foot," which converts to 0.304 800 6 m (1200/3937 m).
The change to SI will eliminate this dual standard.

of 1000 in volume measurement. However, it is recommended that any such cases be converted to the preferred units for volume measurement in building design and construction applications, shown in Table N.

TABLE N: UNITS FOR VOLUME AND FLUID CAPACITY AND THEIR RELATIONSHIPS

PREFERRED UNITS		LIMITED APPLICATION	RELATIONSHIPS
ALL VOLUMES	FLUID VOLUME ONLY		
m^3			$1\ m^3 = 1000\ L = 1000\ dm^3$
	L	dm^3	$1\ L = 1\ dm^3 = 10^{-3}\ m^3$ $= 10^6\ mm^3$ $= 1000\ mL$
	mL	cm^3	$1\ mL = 1\ cm^3 = 10^{-6}\ m^3$ $= 10^3\ mm^3$
mm^3			$1\ mm^3 = 10^{-9}\ m^3$

9.4 GEOMETRICAL CROSS-SECTIONAL PROPERTIES

9.4.1 The expression of geometrical cross-sectional properties of structural sections involves raising the unit of length to the third, fourth or sixth power. Values can be shown either in mm^3, mm^4, or mm^6, with exponential notation, or else in m^3, m^4, or m^6, with exponential notation.

9.4.2 The following measurement units are suitable:

a. Modulus of Section — mm^3 or m^3 — ($1\ mm^3 = 10^{-9}\ m^3$)

b. Second Moment of Area, Torsional Constant) mm^4 or m^4 — ($1\ mm^4 = 10^{-12}\ m^4$)

c. Warping Constant — mm^6 or m^6 — ($1\ mm^6 = 10^{-18}\ m^6$)

9.4.3 Thus, the cross-sectional properties of a wide flange beam, 460 mm deep, and 82 kg/m mass per unit length, could be expressed as follows:

a. Plastic Modulus Z_x = $1.835 \times 10^6\ mm^3$ or $1.835 \times 10^{-3}\ m^3$

b. Second Moment of Area I_{x-x} = $0.371 \times 10^9\ mm^4$ or $0.371 \times 10^{-3}\ m^4$

c. Torsional Constant J = $0.691 \times 10^6\ mm^4$ or $0.691 \times 10^{-6}\ m^4$

d. Warping Constant C_w = $0.924 \times 10^{12}\ mm^6$ or $0.924 \times 10^{-6}\ m^6$

9.5 PLANE ANGLE

9.5.1 While the SI unit for plane angle, the radian (rad), should be used in calculations for reasons of its coherence, the customary units of angular measure, degree (°), minute ('), and second (") of arc will continue to be used in many applications in cartography and surveying.

9.5.2 The degree (°), with parts denoted by decimals (as in 27.25°), will continue to be utilized in engineering and in construction.

9.6 TIME INTERVAL

9.6.1 In general applications, the day (d), hour (h), and minute (min) are permitted non-SI alternatives to the SI base unit for time, the second (s).

9.6.2 It is recommended that the minute (min) be avoided as far as possible to minimize the number of units in which time is a dimension.

9.6.3 For instance, flow rates should be expressed in cubic meters per second, liters per second, or cubic meters per hour, rather than in cubic meters per minute or in liters per minute, so that the variety of units is reduced. For example:

1 m^3/s	=	1000 L/s	(DO NOT USE 60 m^3/min)
1 L/s	=	3.6 m^3/h	(DO NOT USE 60 L/min)
1 m^3/h	=	1000 L/h	(DO NOT USE 16.67 L/min)

9.6.4 Because of its variability, the month should not be used to indicate a time dimension, unless a specific calendar month is referred to.

9.6.5 Where the calendar year (symbol "a" for annum) is used as a measurement for time interval, it represents 365 days, or 31 536 000 seconds.

9.7 TEMPERATURE AND TEMPERATURE INTERVAL

9.7.1 The SI base unit of (thermodynamic) temperature is the kelvin (K), and this unit is used for expressing both thermodynamic temperature and temperature interval.

9.7.2 Wide use is also made of the degree Celsius (°C), for the expression of ambient temperature levels in Celsius temperature, and for temperature intervals.

9.7.3 The temperature interval of one kelvin equals exactly one degree Celsius. For this reason, the degree Celsius may be used in lieu of kelvin in calculations involving temperature interval, although the kelvin (K) is preferred.

9.7.4 A temperature expressed in degrees Celsius is equal to the temperature expressed in kelvins less 273.15 . There are no negative (minus) temperature values in the kelvin scale.

9.7.5 It is recommended that the kelvin (K) be used in compound units involving temperature or temperature interval.

9.8 MASS, WEIGHT, AND FORCE

9.8.1 The significant difference between SI and traditional metric or other measurement systems is the use of explicit and distinctly separate units for "mass" and for "force".

9.8.2 The SI base unit kilogram (kg) denotes the base unit of mass (the quantity of matter of an object which is constant and independent of gravitational attraction).

9.8.3 The derived SI unit newton (N) denotes the absolute derived unit of force (mass times acceleration : $kg \cdot m/s^2$).

9.8.4 The general use of the term "weight" should be avoided in technical practice for two reasons:

a. in common parlance "weight" is confused with "mass" ;

b. weight describes only a particular force that is related solely to gravitational acceleration, which varies on the surface of the earth.

9.8.5 As servicable as the customary gravitational system may seem in the area of "statics", the absolute and more universally useful concepts of the clear SI distinction between "mass" and "force" will become increasingly significant as engineering and construction become more and more involved in "dynamic" considerations.

9.8.6 In dynamic calculations, the value of a mass in kilograms (kg) is used directly with the appropriate acceleration. Thus the customary (frequently mystifying) expression $m = W/g$ is not applicable, and is indeed inconsistent with SI. Hence SI simplifies and clarifies dynamics.

9.8.7 For engineering design purposes, in United States locations (except perhaps Alaska), the following value is recommended for acceleration of gravity: $g = 9.8\ m/s^2$. (The standard international value is $9.806\,65\ m/s^2$).

9.8.8 The use of the factor 9.8 (m/s^2) is recommended for g because it:

a. provides adequate accuracy in nearly all instances ;

b. gives fewer decimal places than the use of 9.81, or even 9.806 65, which was advocated in Britain ;

c. provides a different number in the product than would be obtained with the use of a factor of 10 (advocated by some), which can be easily overlooked and cause errors, as well as introducing overdesign by 2% .

9.8.9. The newton extends through to derived quantities for pressure and stress; energy, work, and quantity of heat; power; and many of the electrical units.

9.8.10 The unit kilogram-force (kgf) is inconsistent with SI, and is in the process of being dropped and replaced by the newton in traditionally metric countries. The kilogram-force (kgf) SHOULD NOT BE USED in the United States.

9.9 PRESSURE, STRESS, AND ELASTIC MODULUS

9.9.1 The SI unit for both pressure and stress (force per unit area) is the pascal (Pa), which replaces a large number of customary units, and also supersedes a few traditional but non-SI metric units.

9.9.2 While it may be useful in some applications to read out test results in N/mm^2 (which is identical with MN/m^2), or in kN/m^2, it is preferable and recommended to always show computations and results in megapascals (MPa) or kilopascals (kPa).

9.9.3 The non-SI units, the "bar" (which equals 100 kPa or 0.1 MPa), and the "millibar" (which equals 100 Pa or 0.1 kPa), should not be used with SI in design or construction applications.

9.10 ENERGY, WORK, AND QUANTITY OF HEAT

9.10.1 The SI unit of energy, work, and quantity of heat is the joule (J), which is equal to a newton meter (N·m), and to a watt second (W·s).

9.10.2 The joule provides one coherent unit to supersede a large number of traditional units: Btu, therm, calorie, kilocalorie, foot pound-force, etc.

9.10.3 For many years, and since long before the joule was named, the kilowatthour (kWh)* has been used extensively as the unit of energy in electrical energy consumption. Most existing electricity meters show kWh, and recalibration in the SI unit megajoule (MJ) would be needlessly costly. For this reason, the kWh (kilowatthour) will be permitted as an alternative unit in electrical applications, but it should not be introduced in new areas. (* The accepted symbol in the United States is "kWh", but the correct SI symbol would be kW·h).

9.10.4 The joule should never be used for torque, which is widely designated as newton meter (N·m).

9.11 ROTATIONAL DYNAMICS

For dimensional consistency in calculations involving rotational dynamics, the units shown in Table O, on page 29, are recommended, because they contain the SI unit for angular displacement, the radian (rad), and thus provide dimensional integrity in equations.

TABLE O: UNITS RECOMMENDED FOR ROTATIONAL DYNAMICS

QUANTITY	RECOMMENDED SI UNIT	ALTERNATIVE UNIT WHICH DISREGARDS ANGULAR DISPLACEMENT
Torque	$N \cdot m / rad$	$N \cdot m$
Moment of Inertia	$kg \cdot m^2 / rad^2$	$kg \cdot m^2$
Moment of Momentum	$kg \cdot m^2 / (rad \cdot s)$	$kg \cdot m^2 / s$

9.12 POWER AND HEAT FLOW RATE

9.12.1 The SI unit for power and heat flow rate is the watt (W), which is already in worldwide use as the general unit for electrical power.

9.12.2 The watt, and its multiples, will now replace a number of traditional units of power and heat flow rate:

a. for general power: the horsepower (electric, boiler), and the foot pound-force per hour (or minute / or second)

b. for heat flow rate: the Btu per hour, the calorie per minute (or second), the kilocalorie per minute (or second), and the ton of refrigeration

9.13 ELECTRICAL UNITS

There are no changes in units used in electrical engineering, except:

a. the renaming of the unit of conductance to siemens (S) from "mho" ;

b. the use of the SI unit for frequency, hertz (Hz), in lieu of cycles per second (cps).

9.14 LIGHTING UNITS

9.14.1 The SI units for luminous intensity, candela (cd), and for luminous flux, lumen (lm), are already in common use.

9.14.2 The candela (cd) directly replaces the former units "candle" and "candlepower".

9.14.3 Illuminance will be expressed in the SI unit lux (lx), which is equal to the lumen per square meter (lm/m^2), and replaces lumen per square foot and the footcandle.

9.14.4 Luminance will be expressed in the SI unit candela per square meter (cd/m^2), which replaces candela per square foot, footlambert, and lambert.

9.15 <u>DIMENSIONLESS QUANTITIES</u>

Dimensionless quantities, or ratios, such as relative humidity, specific gravity, decibel (dB), pH, etc., remain unchanged when converting to SI.

9.16 <u>CONSTANTS FOR USE IN BUILDING DESIGN CALCULATIONS</u>

Table P shows a selection of internationally agreed values and empirical constants for use in design calculations.

TABLE P: DESIGN CONSTANTS (NAME, SYMBOL, VALUE AND UNIT)

NAME	SYMBOL	VALUE	UNIT
Standard atmosphere pressure (international value)	P_o	101.325	kPa
Absolute (zero) temperature	T	0.0 (-273.15)	K (°C)
Velocity of sound in air (P_o, 20°C, 50% R.H.)	M	344	m/s
Specific volume of perfect gas (P_o, 20°C)	V_o	22.414	m^3/kmol (L/mol)
Characteristic gas constant for air	R_a	287.045	J/(kg·K)
Characteristic gas constant for water vapor	R_v	461.52	J/(kg·K)
Natural logarithms	e	2.718 28	
Pi (π)	π	3.141 59	

10. APPENDIXES

APPENDIX A: Pages 34-37

CONVERSION FACTORS FOR THE MOST COMMON UNITS USED IN BUILDING DESIGN AND CONSTRUCTION (shown to six significant places)

METRIC TO CUSTOMARY CUSTOMARY TO METRIC

APPENDIX B: Page 38

SI UNITS AND RELATIONSHIPS CHART: CHART AND EXPLANATIONS

APPENDIX C: Page 40

SUPERSEDED METRIC UNITS NOT RECOMMENDED FOR USE WITH SI

APPENDIX A
CONVERSION FACTORS FOR THE MOST COMMON UNITS USED IN BUILDING DESIGN AND CONSTRUCTION

Conversion factors are taken to six significant figures, where appropriate. Underlined values denote exact conversions.

METRIC TO CUSTOMARY / CUSTOMARY TO METRIC

LENGTH

1 km	= 0.621 371	mile (international)	1 mile (international)	= 1.609 344	km
	= 49.7096	chain	1 chain	= 20.1168	m
1 m	= 1.093 61	yd	1 yd	= 0.9144	m
	= 3.280 84	ft	1 ft	= 0.3048	m
1 mm	= 0.039 370 1	in		= 304.8	mm
			1 in	= 25.4	mm
			(1 U.S. survey foot	= 0.304 800 6	m)*

* Section 9.1.7 on page 27 deals with US survey measurement

AREA

1 km^2	= 0.386 101	mile^2 (U.S. survey)	1 mile^2 (U.S. survey)	= 2.590 00	km^2
1 ha	= 2.471 04	acre (U.S. survey)	1 acre (U.S. survey)	= 0.404 687	ha
1 m^2	= 1.195 99	yd^2		= 4046.87	m^2
	= 10.7639	ft^2	1 yd^2	= 0.836 127	m^2
1 mm^2	= 0.001 550	in^2	1 ft^2	= 0.092 903	m^2
			1 in^2	= 645.16	mm^2

VOLUME, MODULUS OF SECTION

1 m^3	= 0.810 709 x 10^{-3}	acre feet	1 acre ft	= 1233.49	m^3
	= 1.307 95	yd^3	1 yd^3	= 0.764 555	m^3
	= 35.3147	ft^3	100 board ft	= 0.235 974	m^3
	= 423.776	board ft	1 ft^3	= 0.028 316 8	m^3
1 mm^3	= 61.0237 x 10^{-6}	in^3		= 28.3168	L (dm^3)
			1 in^3	= 16 387.1	mm^3
				= 16.3871	mL (cm^3)

(FLUID) CAPACITY

1 L	= 0.035 314 7	ft^3	1 gal (U.S. liquid)**	= 3.785 41	L
	= 0.264 172	gal (U.S.)	1 qt (U.S. liquid)	= 946.353	mL
	= 1.056 69	qt (U.S.)	1 pt (U.S. liquid)	= 473.177	mL
1 mL	= 0.061 023 7	in^3	1 fl oz (U.S.)	= 29.5735	mL
	= 0.033 814	fl oz (U.S.)			

** 1 gal(UK) approx. 1.2 gal(U.S.)

SECOND MOMENT OF AREA

1 mm^4	= 2.402 51 x 10^{-6}	in^4	1 in^4	= 416 231	mm^4
				= 0.416 231 x 10^{-6}	m^4

PLANE ANGLE

1 rad	= 57° 17' 45"	(degree)	1° (degree)	= 0.017 453 3	rad
	= 57.2958°	(degree)		= 17.4533	mrad
	= 3437.75'	(minute)	1' (minute)	= 290.888	µrad
	= 206 265"	(second)	1" (second)	= 4.848 14	µrad

VELOCITY, SPEED

1 m/s	= 3.280 84	ft/s	1 ft/s	= 0.3048	m/s
	= 2.236 94	mile/h	1 mile/h	= 1.609 344	km/h
1 km/h	= 0.621 371	mile/h		= 0.447 04	m/s

METRIC TO CUSTOMARY — CUSTOMARY TO METRIC

ACCELERATION

1 m/s^2	= 3.280 84	ft/s^2	1 ft/s^2	= <u>0.3048</u>	m/s^2

VOLUME RATE OF FLOW

1 m^3/s	= 35.3147	ft^3/s	1 ft^3/s	= 0.028 316 8	m^3/s
	= 22.8245	million gal/d	1 ft^3/min	= 0.471 947	L/s
	= 0.810 709 $\times 10^{-3}$	acre ft/s	1 gal/min	= 0.063 090 2	L/s
1 L/s	= 2.118 88	ft^3/min	1 gal/h	= 1.051 50	mL/s
	= 15.850 3	gal/min	1 million gal/d	= 43.8126	L/s
	= 951.022	gal/h	1 acre ft/s	= 1233.49	m^3/s

TEMPERATURE INTERVAL

1 °C	= <u>1 K</u> = <u>1.8</u>	°F	1 °F	= 0.555 556	°C or K
				= 5/9 °C	= 5/9 K

EQUIVALENT TEMPERATURE VALUE ($t_{°C} = T_K - 273.15$)

$t_{°C}$	= 5/9 (t_F - 32)	t_F	= 9/5 $t_{°C}$ + 32

M A S S

1 kg	= 2.204 62	lb (avoirdupois)	1 ton (short)***	= 0.907 185	metric ton
	= 35.2740	oz (avoirdupois)		= 907.185	kg
1 metric ton	= 1.102 31	ton (short, 2000 lb)	1 lb	= 0.453 592	kg
	= 2204.62	lb	1 oz	= 28.3495	g
1 g	= 0.035 274	oz	1 pennyweight	= 1.555 17	g
	= 0.643 015	pennyweight			

***(1 long ton (2240 lb) = 1016.05 kg)

MASS PER UNIT LENGTH

1 kg/m	= 0.671 969	lb/ft	1 lb/ft	= 1.488 16	kg/m
1 g/m	= 3.547 99	lb/mile	1 lb/mile	= 0.281 849	g/m

MASS PER UNIT AREA

1 kg/m^2	= 0.204 816	lb/ft^2	1 lb/ft^2	= 4.882 43	kg/m^2
1 g/m^2	= 0.029 494	oz/yd^2	1 oz/yd^2	= 33.9057	g/m^2
	= 3.277 06 $\times 10^{-3}$	oz/ft^2	1 oz/ft^2	= 305.152	g/m^2

DENSITY (MASS PER UNIT VOLUME)

1 kg/m^3	= 0.062 428	lb/ft^3	1 lb/ft^3	= 16.0185	kg/m^3
	= 1.685 56	lb/yd^3	1 lb/yd^3	= 0.593 276	kg/m^3
1 t/m^3	= 0.842 778	ton/yd^3	1 ton/yd^3	= 1.186 55	t/m^3

MOMENT OF INERTIA

1 $kg{\cdot}m^2$	= 23.7304	$lb{\cdot}ft^2$	1 $lb{\cdot}ft^2$	= 0.042 140 1	$kg{\cdot}m^2$
	=3417.17	$lb{\cdot}in^2$	1 $lb{\cdot}in^2$	= 292.640	$kg{\cdot}mm^2$

MASS PER UNIT TIME

1 kg/s	= 2.204 62	lb/s	1 lb/s	= 0.453 592	kg/s
1 t/h	= 0.984 207	ton/h	1 ton/h	= 1.016 05	t/h

APPENDIX A (CONTINUED)

METRIC TO CUSTOMARY			CUSTOMARY TO METRIC		
FORCE					
1 MN	= 112.404	tonf (ton-force)	1 tonf (ton-force)	= 8.896 44	kN
1 kN	= 0.112 404	tonf	1 kip (1000 lbf)	= 4.448 22	kN
	= 224.809	lbf (pound-force)	1 lbf (pound-force)	= 4.448 22	N
1 N	= 0.224 809	lbf			
MOMENT OF FORCE, TORQUE					
1 N·m	= 0.737 562	lbf·ft	1 lbf·ft	= 1.355 82	N·m
	= 8.850 75	lbf·in	1 lbf·in	= 0.112 985	N·m
1 kN·m	= 0.368 781	tonf·ft	1 tonf·ft	= 2.711 64	kN·m
	= 0.737 562	kip·ft	1 kip·ft	= 1.355 82	kN·m
FORCE PER UNIT LENGTH					
1 N/m	= 0.068 521 8	lbf/ft	1 lbf/ft	= 14.5939	N/m
1 kN/m	= 0.034 260 9	tonf/ft	1 lbf/in	= 175.127	N/m
			1 tonf/ft	= 29.187 8	kN/m
PRESSURE, STRESS, MODULUS OF ELASTICITY (FORCE PER UNIT AREA) (1 Pa = 1 N/m^2)					
1 MPa	= 0.072 518 8	tonf/in^2	1 tonf/in^2	= 13.7895	MPa
	= 10.4427	tonf/ft^2	1 tonf/ft^2	= 95.7605	kPa
	= 145.038	lbf/in^2	1 kip/in^2	= 6.894 76	MPa
1 kPa	= 20.8854	lbf/ft^2	1 lbf/in^2	= 6.894 76	kPa
			1 lbf/ft^2	= 47.8803	Pa
WORK, ENERGY, HEAT (1 J = 1 N·m = 1 W·s)					
1 MJ	= 0.277 778	kWh	1 kWh (550 ft·lbf/s)	= 3.6	MJ
1 kJ	= 0.947 817	Btu	1 Btu (Int. Table)	= 1.055 06	kJ
1 J	= 0.737 562	ft·lbf		= 1055.06	J
			1 ft·lbf	= 1.355 82	J
POWER, HEAT FLOW RATE					
1 kW	= 1.341 02	hp (horsepower)	1 hp	= 0.745 700	kW
1 W	= 3.412 14	Btu/h		= 745.700	W
	= 0.737 562	ft·lbf/s	1 Btu/h	= 0.293 071	W
			1 ft·lbf/s	= 1.355 82	W
HEAT FLUX DENSITY					
1 W/m^2	= 0.316 998	Btu/(ft^2·h)	1 Btu/(ft^2·h)	= 3.154 59	W/m^2
COEFFICIENT OF HEAT TRANSFER					
1 W/(m^2·K)	= 0.176 110	Btu/(ft^2·h·°F)	1 Btu/(ft^2·h·°F)	= 5.678 26	W/(m^2·K)
THERMAL CONDUCTIVITY					
1 W/(m·K)	= 0.577 789	Btu/(ft·h·°F)	1 Btu/(ft·h·°F)	= 1.730 73	W/(m·K)

APPENDIX A (CONTINUED)

METRIC TO CUSTOMARY			CUSTOMARY TO METRIC		
CALORIFIC VALUE (MASS AND VOLUME BASIS)					
1 kJ/kg (1 J/g)	= 0.429 923	Btu/lb	1 Btu/lb	= 2.326 (= 2.326	kJ/kg (J/g)
1 kJ/m³	= 0.026 839 2	Btu/ft³	1 Btu/ft³	= 37.2589	kJ/m³
THERMAL CAPACITY (MASS AND VOLUME BASIS)					
1 kJ/(kg·K)	= 0.238 846	Btu/(lb·°F)	1 Btu/(lb·°F)	= 4.1868	kJ/(kg·K)
1 kJ/(m³·K)	= 0.014 910 7	Btu/(ft³·°F)	1 Btu/(ft³·°F)	= 67.0661	kJ/(m³·K)
ILLUMINANCE					
1 lx (lux)	= 0.092 903	lm/ft² (footcandle)	1 lm/ft² (footcandle)	= 10.7639	lx (lux)
LUMINANCE					
1 cd/m²	= 0.092 903	cd/ft²	1 cd/ft²	= 10.7639	cd/m²
	= 0.291 864	footlambert	1 footlambert	= 3.426 26	cd/m²
1 kcd/m²	= 0.314 159	lambert	1 lambert	= 3.183 01	kcd/m²

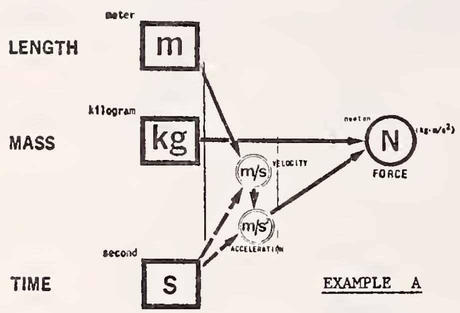
APPENDIX B

SI UNITS AND RELATIONSHIP CHART - EXPLANATIONS

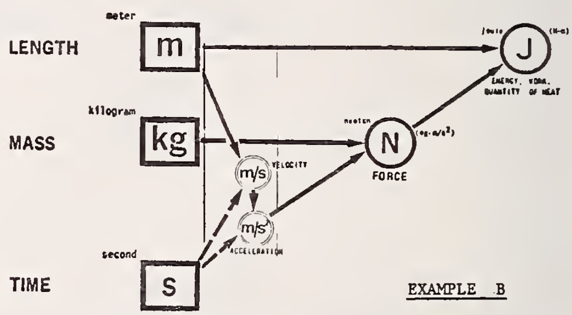
1. The SI CHART on page 38 shows graphically how the seventeen (17) derived SI units with special names are formed in a coherent manner from the base and supplementary units. Unit symbols are shown in rectangles for base units and supplementary units, and in circles for derived units. The unit name is spelled out in full toward the upper left, and the derivation is shown in parentheses toward the upper right. The name of the quantity (the measurable attribute) is stated in capital letters.

2. In the chart the derivation of each unit is indicated by arrows in the following manner:
   a. solid lines represent a relationship in which the derived unit is a product of the constituent units (J = N · m ; Wb = V · s ; C = A · s)
   b. a single broken line indicates that the derived unit is the reciprocal of the originating unit (Hz = 1/s ; Bq = 1/s ; S = 1/Ω)
   c. solid and broken lines indicate that the derived unit has both a numerator factor (solid line) and a denominator factor (broken line), as shown by the following examples: Pa = N / m^2 ; W = J / s ; Ω = V / A ; H = Wb / A ; lx = lm / m^2

3. The progressive linking of coherent SI units is illustrated by the two reduced size extracts from the SI Chart:



Three base units - meter (m), kilogram (kg) and second (s) combine to form the derived unit of FORCE (kg·m/s^2), which has been given the special name "newton" (N) .

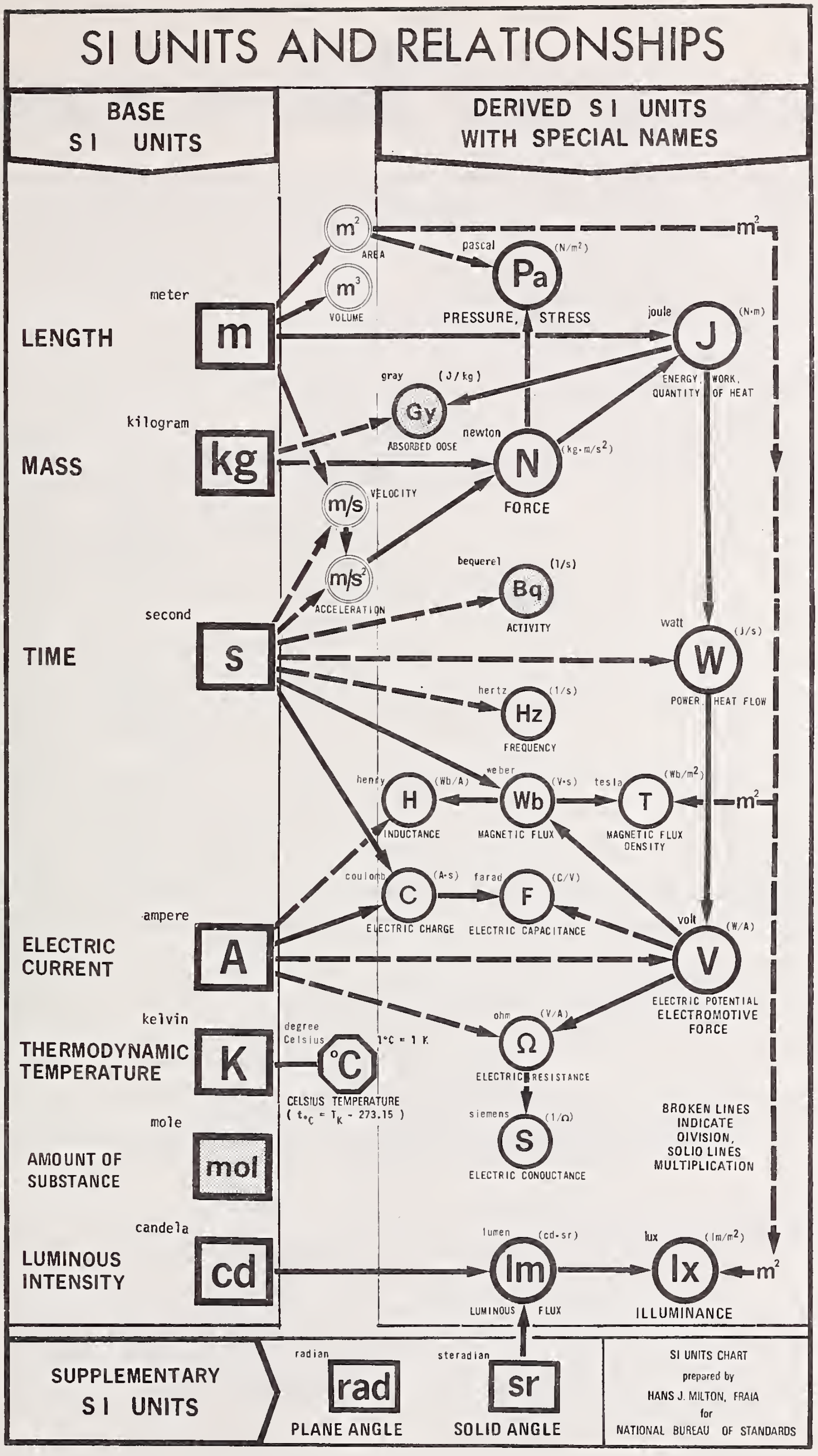


The newton (N) combines with the base unit meter (m) to form the derived unit of ENERGY, or WORK or QUANTITY OF HEAT (N·m), which has been given the special name "joule" (J).

4. There are a total of twenty-six (26) SI units with special names and symbols of the Chart. Of these:
   a. thirteen (13), one-half of the total, are already in general use now:
      s, A, cd, Hz, W, V, C, F, H, Ω, lm, rad, and sr
   b. one (1), the siemens (S), was previously referred to as "mho", so that its adoption involves a change in name only
   c. three (3) have almost no application in design and construction:
      mole (mol) - base unit for amount of substance
      becquerel (Bq) - derived unit for activity (of radionuclides)
      gray (Gy) - derived unit for absorbed dose

5. Thus, a maximum of nine (9) new units in SI will need to be learned:
   m, kg, K, N, Pa, J, Wb, T, and lx

6. The "degree Celsius" (°C) is a special name for the base unit kelvin (K), for use in expressing temperature interval or Celsius temperature, and is therefore shown directly related to kelvin.


SI UNITS AND RELATIONSHIPS
BASE SI UNITS
DERIVED SI UNITS WITH SPECIAL NAMES
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
m²
AREA
m³
VOLUME
m/s
VELOCITY
m/s²
ACCELERATION
pascal
(N/m²)
Pa
PRESSURE, STRESS
joule
(N·m)
J
ENERGY, WORK, QUANTITY OF HEAT
gray
(J/kg)
Gy
ABSORBED DOSE
newton
(kg·m/s²)
N
FORCE
bequerel
(1/s)
Bq
ACTIVITY
watt
(J/s)
W
POWER, HEAT FLOW
hertz
(1/s)
Hz
FREQUENCY
henry
(Wb/A)
H
INDUCTANCE
weber
(V·s)
Wb
MAGNETIC FLUX
tesla
(Wb/m²)
T
MAGNETIC FLUX DENSITY
coulomb
(A·s)
C
ELECTRIC CHARGE
farad
(C/V)
F
ELECTRIC CAPACITANCE
volt
(W/A)
V
ELECTRIC POTENTIAL
ELECTROMOTIVE FORCE
ohm
(V/A)
Ω
ELECTRIC RESISTANCE
siemens
(1/Ω)
S
ELECTRIC CONDUCTANCE
degree Celsius
1°C = 1 K
°C
CELSIUS TEMPERATURE
(t°C = TK - 273.15)
BROKEN LINES INDICATE DIVISION, SOLID LINES MULTIPLICATION
lumen
(cd·sr)
lm
LUMINOUS FLUX
lux
(lm/m²)
lx
ILLUMINANCE
SUPPLEMENTARY SI UNITS
radian
rad
PLANE ANGLE
steradian
sr
SOLID ANGLE
SI UNITS CHART
prepared by
HANS J. MILTON, FRAIA
for
NATIONAL BUREAU OF STANDARDS

APPENDIX C

SUPERSEDED METRIC UNITS NOT RECOMMENDED FOR USE WITH SI

It is strongly recommended that the traditional and "cgs" metric (non-SI) units listed in Table P be avoided in building design or construction applications. Any data showing these units should be converted to the appropriate SI units that supersede them.

TABLE P: UNITS OUTSIDE SI NOT RECOMMENDED FOR USE

Unit Name	Symbol	Value in SI Units
dyne	dyn	10^{-5} N (or 10 μN)
bar	bar	10^{5} Pa (or 100 kPa)
erg	erg	10^{-7} J (or 100 nJ)
poise	P	10^{-1} Pa·s (or 100 mPa·s)
stokes	St	10^{-4} m^2/s (or 100 mm^2/s)
gauss	Gs, (G)	10^{-4} T (or 100 μT)
maxwell	Mx	10^{-8} Wb (or 10 nWb)
stilb	sb	10^{4} cd/m^2 (or 10 kcd/m^2)
phot	ph	10^{4} lx (or 10 klx)
kilogram-force	kgf	9.806 65 N
calorie (int.)	cal	4.1868 J
kilocalorie (int.)	kcal	4.1868 kJ
torr	torr	133.322 Pa
oersted	Oe	79.5775 A/m

REFERENCES (AND THEIR AVAILABILITY)

1. American National Standard ANSI Z 210.1 - 1976 / ASTM E 380 - 76 / IEEE Std 268 - 1976 METRIC PRACTICE (1976 Revised Edition)

   Available from:

   - (ANSI Z 210.1) - *American National Standards Institute, 1430 Broadway, New York, N.Y. 10018*
   - (ASTM E 380) - *American Society for Testing and Materials 1916 Race Street, Philadelphia, Pa. 19013*
   - (IEEE Std 268) - *Institute of Electrical and Electronic Engineers, 345 East 47th Street, New York, N.Y. 10017*

2. ANMC METRIC EDITORIAL GUIDE, 2nd Edition, 1975

   Available from: *American National Metric Council, 1625 Massachusetts Avenue, N.W. Washington, D.C. 20036*

3. U.S. Department of Commerce / National Bureau of Standards NBS Special Publication 330, THE INTERNATIONAL SYSTEM OF UNITS (SI), 1974 Revised Edition

   Available from: *U.S. Government Printing Office, Washington, D.C. 20402*

4. U.S. Federal Register - The National Archives of the United States, Vol. 41, Number 239, pages 54018 - 19, THE METRIC SYSTEM OF MEASUREMENT (Interpretation and Modification of the International System of Units for the United States) - Issued December 10, 1976

   Available from: *Office of Technical Publications, National Bureau of Standards, Washington, D.C. 20234*

5. Public Law 94 - 168, METRIC CONVERSION ACT OF 1975 (December 23, 1975)

   Available from: *U.S. Government Printing Office, Washington, D.C. 20402*

6. International Standard ISO 1000 - 1973 (E) SI UNITS AND RECOMMENDATIONS FOR THE USE OF THEIR MULTIPLES AND CERTAIN OTHER UNITS (1973 Edition)

7. International Standard ISO 31/0 - 1974 (E), General Introduction to ISO 31 - GENERAL PRINCIPLES CONCERNING QUANTITIES, UNITS AND SYMBOLS

   6. and 7. available through: *American National Standards Institute, 1430 Broadway, New York, N.Y. 10018*

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15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This Technical Note contains a comprehensive set of recommendations for the use of metric (SI) units in building design and construction.

It includes descriptive material dealing with the structure of the International System of Units (SI); rules and recommendations for the presentation of SI units and symbols, and of numerical values associated with SI; a set of tables showing working units and typical applications for SI units in building design and construction; and a section dealing with special considerations in the selection and use of SI units in design and construction. Appendixes show conversion factors for the most common units; superseded metric units not recommended for use with SI; an SI units and relationships chart; and appropriate references.

This document was prepared to provide the technical basis for an ASTM reference standard on recommended practice for the use of metric (SI) units in building design and construction.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

International System of Units (SI); metric design and construction; recommended SI practice

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