Symbols and Abbreviations

For symbols of chemical elements, see Sec. 6; for abbreviations applying to metric weights
and measures and SI units, Sec. 1; SI unit prefixes are listed on p. 1-19.

Pairs of parentheses, brackets, etc., are frequently used in this work to indicate correspond-
ing values. For example, the statement that ''the cost per kW of a 30,000-kW plant is $86; of a
15,000-kW plant, $98; and of an 8,000-kW plant, $112,'' is condensed as follows: The cost
per kW of a 30,000 (15,000) [8,000]-kW plant is $86 (98) [112].

In the citation of references readers should always attempt to consult the latest edition of
referenced publications.

A or Å	Angstrom unit $= 10^{-10}$ m; 3.937×10^{-11} in	ANSI	American National Standards Institute
A	mass number $= N + Z$; ampere	antilog	antilogarithm of
AA	arithmetical average	API	Am. Petroleum Inst.
AAA	Am. Automobile Assoc.	approx	approximately
AAMA	American Automobile Manufacturers' Assoc.	APWA	Am. Public Works Assoc.
AAR	Assoc. of Am. Railroads	AREA	Am. Railroad Eng. Assoc.
AAS	Am. Astronautical Soc.	ARI	Air Conditioning and Refrigeration Inst.
ABAI	Am. Boiler & Affiliated Industries	ARS	Am. Rocket Soc.
abs	absolute	ASCE	Am. Soc. of Civil Engineers
a.c.	aerodynamic center	ASHRAE	Am. Soc. of Heating, Refrigerating, and Air Conditioning
a-c, ac	alternating current		Engineers
ACI	Am. Concrete Inst.	ASLE	Am. Soc. of Lubricating Engineers
ACM	Assoc. for Computing Machinery	ASM	Am. Soc. of Metals
ACRMA	Air Conditioning and Refrigerating Manufacturers Assoc.	ASME	Am. Soc. of Mechanical Engineers
ACS	Am. Chemical Soc.	ASST	Am. Soc. of Steel Treating
ACSR	aluminum cable steel-reinforced	ASTM	Am. Soc. for Testing and Materials
ACV	air cushion vehicle	ASTME	Am. Soc. of Tool & Manufacturing Engineers
A.D.	anno Domini (in the year of our Lord)	atm	atmosphere
AEC	Atomic Energy Commission (U.S.)	*Auto. Ind.*	Automotive Industries (New York)
a-f, af	audio frequency	avdp	avoirdupois
AFBMA	Anti-friction Bearings Manufacturers' Assoc.	avg, ave	average
AFS	Am. Foundrymen's Soc.	AWG	Am. Wire Gage
AGA	Am. Gas Assoc.	AWPA	Am. Wood Preservation Assoc.
AGMA	Am. Gear Manufacturers' Assoc.	AWS	American Welding Soc.
ahp	air horsepower	AWWA	American Water Works Assoc.
AlChE	Am. Inst. of Chemical Engineers	b	barns
AIEE	Am. Inst. of Electrical Engineers (see IEEE)	bar	barometer
AIME	Am. Inst. of Mining Engineers	B&S	Brown & Sharp (gage); Beams and Stringers
AIP	Am. Inst. of Physics	bbl	barrels
AISC	American Institute of Steel Construction, Inc.	B.C.	before Christ
AISE	Am. Iron & Steel Engineers	B.C.C.	body centered cubic
AISI	Am. Iron and Steel Inst.	Bé	Baumé (degrees)
a.m.	ante meridiem (before noon)	B.G.	Birmingham gage (hoop and sheet)
a-m, am	amplitude modulation	bgd	billions of gallons per day
Am. Mach.	Am. Machinist (New York)	BHN	Brinnell Hardness Number
AMA	Acoustical Materials Assoc.	bhp	brake horsepower
AMCA	Air Moving & Conditioning Assoc., Inc.	BLC	boundary layer control
amu	atomic mass unit	B.M.	board measure; bench mark
AN	ammonium nitrate (explosive); Army-Navy Specification	bmep	brake mean effective pressure
AN-FO	ammonium nitrate-fuel oil (explosive)	B of M,	Bureau of Mines
ANC	Army-Navy Civil Aeronautics Committee	BuMines	
ANS	Am. Nuclear Soc.	BOD	biochemical oxygen demand

xx SYMBOLS AND ABBREVIATIONS

bp	boiling point	d-c, dc	direct current
Bq	bequerel	def	definition
bsfc	brake specific fuel consumption	deg	degrees
BSI	British Standards Inst.	diam. (dia)	diameter
Btu	British thermal units	DO	dissolved oxygen
Btuh, Btu/h	Btu per hr	D_2O	deuterium (heavy water)
bu	bushels	d.p.	double pole
Bull.	Bulletin	DP	Diametral pitch
Buweaps	Bureau of Weapons, U.S. Navy	DPH	diamond pyramid hardness
BWG	Birmingham wire gage	DST	daylight saving time
c	velocity of light	d^2 tons	breaking strength, d = chain wire diam, in.
°C	degrees Celsius (centigrade)	DX	direct expansion
C	coulomb	*e*	base of Napierian logarithmic system (= 2.7182 +)
CAB	Civil Aeronautics Board	EAP	equivalent air pressure
CAGI	Compressed Air & Gas Inst.	EDR	equivalent direct radiation
cal	calories	EEI	Edison Electric Inst.
C-B-R	chemical, biological & radiological (filters)	eff	efficiency
CBS	Columbia Broadcasting System	e.g.	exempli gratia (for example)
cc, cm³	cubic centimeters	ehp	effective horsepower
CCR	critical compression ratio	EHV	extra high voltage
c to c	center to center	*El. Wld.*	Electrical World (New York)
cd	candela	elec	electric
c.f.	centrifugal force	elong	elongation
cf.	confer (compare)	emf	electromotive force
cfh, ft³/h	cubic feet per hour	*Engg.*	Engineering (London)
cfm, ft³/min	cubic feet per minute	*Engr.*	The Engineer (London)
C.F.R.	Cooperative Fuel Research	ENT	emergency negative thrust
cfs, ft³/s	cubic feet per second	EP	extreme pressure (lubricant)
cg	center of gravity	ERDA	Energy Research & Development Administration (successor to AEC; see also NRC)
cgs	centimeter-gram-second		
Chm. Eng.	Chemical Eng'g (New York)	Eq.	equation
chu	centigrade heat unit	est	estimated
C.I.	cast iron	etc.	et cetera (and so forth)
cir	circular	et seq.	et sequens (and the following)
cir mil	circular mils	eV	electron volts
cm	centimeters	evap	evaporation
CME	Chartered Mech. Engr. (IMechE)	exp	exponential function of
C.N.	cetane number	exsec	exterior secant of
coef	coefficient	ext	external
COESA	U.S. Committee on Extension to the Standard Atmosphere	°F	degrees Fahrenheit
col	column	F	farad
colog	cologarithm of	FAA	Federal Aviation Agency
const	constant	F.C.	fixed carbon, %
cos	cosine of	FCC	Federal Communications Commission; Federal Constructive Council
$\cos^{-1}$	angle whose cosine is, inverse cosine of		
cosh	hyperbolic cosine of	F.C.C.	face-centered-cubic (alloys)
$\cosh^{-1}$	inverse hyperbolic cosine of	ff.	following (pages)
cot	cotangent of	fhp	friction horsepower
$\cot^{-1}$	angle whose cotangent is (see $\cos^{-1}$)	Fig.	figure
coth	hyperbolic cotangent of	F.I.T.	Federal income tax
$\coth^{-1}$	inverse hyperbolic cotangent of	f-m, fm	frequency modulation
covers	coversed sine of	F.O.B.	free on board (cars)
c.p.	circular pitch; center of pressure	FP	fore perpendicular
cp	candle power	FPC	Federal Power Commission
cp	coef of performance	fpm, ft/min	feet per minute
CP	chemically pure	fps	foot-pound-second system
CPH	close packed hexagonal	ft/s	feet per second
cpm,	cycles per minute	F.S.	Federal Specifications
cycles/min		FSB	Federal Specifications Board
cps, cycles/s	cycles per second	fsp	fiber saturation point
CSA	Canadian Standards Assoc.	ft	feet
csc	cosecant of	fc	foot candles
$\csc^{-1}$	angle whose cosecant is (see $\cos^{-1}$)	fL	foot lamberts
csch	hyperbolic cosecant of	ft · lb	foot-pounds
csch^{-1}	inverse hyperbolic cosecant of	*g*	acceleration due to gravity
cu	cubic	g	grams
cyl	cylinder	gal	gallons
db, dB	decibel	gc	gigacycles per sec

GCA	ground-controlled approach		J&P	joists and planks
g · cal	gram-calories		*Jour.*	Journal
gd	Gudermannian of		JP	jet propulsion fuel
G.E.	General Electric Co.		*k*	isentropic exponent; conductivity
GEM	ground effect machine		K	degrees Kelvin (Celsius abs)
GFI	gullet feed index		K	Knudsen number
G.M.	General Motors Co.		kB	kilo Btu (1000 Btu)
GMT	Greenwich Mean Time		kc	kilocycles
GNP	gross national product		kcps	kilocycles per sec
gpcd	gallons per capita day		kg	kilograms
gpd	gallons per day; grams per denier		kg · cal	kilogram-calories
gpm, gal/min	gallons per minute		kg · m	kilogram-meters
gps, gal/s	gallons per second		kip	1000 lb or 1 kilo-pound
gpt	grams per tex		kips	thousands of pounds
H	henry		km	kilometers
h	Planck's constant = 6.624×10^{-27} erg-sec		kmc	kilomegacycles per sec
$\hbar$	Planck's constant, $\hbar = h/2\pi$		kmcps	kilomegacycles per sec
HEPA	high efficiency particulate matter		kpsi	thousands of pounds per sq in
h-f, hf	high frequency		ksi	one kip per sq in, 1000 psi (lb/in^2)
hhv	high heat value		kts	knots
horiz	horizontal		kVA	kilovolt-amperes
hp	horsepower		kW	kilowatts
h-p	high-pressure		kWh	kilowatt-hours
HPAC	Heating, Piping, & Air Conditioning (Chicago)		L	lamberts
hp · hr	horsepower-hour		l, L	litres
hr, h	hours		£	Laplace operational symbol
HSS	high speed steel		lb	pounds
H.T.	heat-treated		L.B.P.	length between perpendiculars
HTHW	high temperature hot water		lhv	low heat value
Hz	hertz = 1 cycle/s (cps)		lim	limit
IACS	International Annealed Copper Standard		lin	linear
IAeS	Institute of Aerospace Sciences		ln	Napierian logarithm of
ibid.	ibidem (in the same place)		loc. cit.	loco citato (place already cited)
ICAO	International Civil Aviation Organization		log	common logarithm of
ICC	Interstate Commerce Commission		LOX	liquid oxygen explosive
ICE	Inst. of Civil Engineers		l-p, lp	low pressure
ICI	International Commission on Illumination		LPG	liquified petroleum gas
I.C.T.	International Critical Tables		lpw, lm/W	lumens per watt
I.D., ID	inside diameter		lx	lux
i.e.	id est (that is)		L.W.L.	load water line
IEC	International Electrotechnical Commission		lm	lumen
IEEE	Inst. of Electrical & Electronics Engineers (successor to AIEE, *q.v.*)		m	metres
			M	thousand; Mach number; moisture, %
IES	Illuminating Engineering Soc.		mA	milliamperes
i-f, if	intermediate frequency		*Machy.*	Machinery (New York)
IGT	Inst. of Gas Technology		max	maximum
ihp	indicated horsepower		MBh	thousands of Btu per hr
IMechE	Inst. of Mechanical Engineers		mc	megacycles per sec
imep	indicated mean effective pressure		m.c.	moisture content
Imp	Imperial		Mcf	thousand cubic feet
in., in	inches		mcps	megacycles per sec
in. · lb,	inch-pounds		*Mech. Eng.*	Mechanical Eng'g (ASME)
in · lb			mep	mean effective pressure
INA	Inst. of Naval Architects		METO	maximum, except during take-off
Ind. & Eng.	Industrial & Eng'g Chemistry (Easton, PA)		me V	million electron volts
Chem.			MF	maintenance factor
int	internal		mhc	mean horizontal candles
i-p, ip	intermediate pressure		mi	mile
ipm, in/min	inches per minute		MIL-STD	U.S. Military Standard
ipr	inches per revolution		min	minutes; minimum
IPS	iron pipe size		mip	mean indicated pressure
IRE	Inst. of Radio Engineers (see IEEE)		MKS	meter-kilogram-second system
IRS	Internal Revenue Service		MKSA	meter-kilogram-second-ampere system
ISO	International Organization for Standardization		mL	millilamberts
isoth	isothermal		ml, mL	millilitre = 1.000027 cm³
ISTM	International Soc. for Testing Materials		mlhc	mean lower hemispherical candles
IUPAC	International Union of Pure & Applied Chemistry		mm	millimetres
J	joule		mm-free	mineral matter free

mmf	magnetomotive force	psi, lb/in^2	lb per sq in
mol	mole	psia	lb per sq in. abs
mp	melting point	psig	lb per sq in. gage
MPC	maximum permissible concentration	pt	point; pint
mph, mi/h	miles per hour	PVC	polyvinyl chloride
MRT	mean radiant temperature	Q	10^{18} Btu
ms	manuscript; milliseconds	qt	quarts
msc	mean spherical candles	q.v.	quod vide (which see)
MSS	Manufacturers Standardization Soc. of the Valve & Fittings Industry	r	roentgens
		R	gas constant
Mu	micron, micro	R	deg Rankine (Fahrenheit abs); Reynolds number
MW	megawatts	rad	radius; radiation absorbed dose; radian
MW day	megawatt day	RBE	see rem
MWT	mean water temperature	R-C	resistor-capacitor
n	polytropic exponent	RCA	Radio Corporation of America
N	number (in mathematical tables)	R&D	research & development
N	number of neutrons; newton	RDX	cyclonite, a military explosive
N$_s$	specific speed	rem	Roentgen equivalent man (formerly RBE)
NA	not available	rev	revolutions
NAA	National Assoc. of Accountants	r-f, rf	radio frequency
NACA	National Advisory Committee on Aeronautics (see NASA)	RMA	Rubber Manufacturers Assoc.
NACM	National Assoc. of Chain Manufacturers	rms	square root of mean square
NASA	National Aeronautics and Space Administration	rpm, r/min	revolutions per minute
nat.	natural	rps, r/s	revolutions per second
NBC	National Broadcasting Company	RSHF	room sensible heat factor
NBFU	National Board of Fire Underwriters	ry.	railway
NBS	National Bureau of Standards	*s*	entropy
NCN	nitrocarbonitrate (explosive)	s	seconds
NDHA	National District Hearing Assoc.	S	sulfur, %; siemens
NEC®	National Electric Code® (National Electrical Code® and NEC® are registered trademarks of the National Fire Protection Association, Inc., Quincy, MA.)	SAE	Soc. of Automotive Engineers
		sat	saturated
		SBI	steel Boiler Inst.
NEMA	National Electrical Manufacturers Assoc.	scfm	standard cu ft per min
NFPA	National Fire Protection Assoc.	SCR	silicon controlled rectifier
NLGI	National Lubricating Grease Institute	sec	secant of
nm	nautical miles	sec^{-1}	angle whose secant is (see cos^{-1})
No. (Nos.)	number(s)	Sec.	Section
NPSH	net positive suction head	sech	hyperbolic secant of
NRC	Nuclear Regulator Commission (successor to AEC; see also ERDA)	sech^{-1}	inverse hyperbolic secant of
		segm	segment
NTP	normal temperature and pressure	SE No.	steam emulsion number
O.D., OD	outside diameter (pipes)	sfc	specific fuel consumption, lb per hphr
O.H.	open-hearth (steel)	sfm, sfpm	surface feet per minute
O.N.	octane number	shp	shaft horsepower
op. cit.	opere citato (work already cited)	SI	International System of Units (Le Système International d'Unites)
OSHA	Occupational Safety & Health Administration		
OSW	Office of Saline Water	sin	sine of
OTS	Office of Technical Services, U.S. Dept. of Commerce	sin^{-1}	angle whose sine is (see cos^{-1})
oz	ounces	sinh	hyperbolic sine of
p. (pp.)	page (pages)	sinh^{-1}	inverse hyperbolic sine of
Pa	pascal	SME	Society of Manufacturing Engineers (successor to ASTME)
P.C.	propulsive coefficient		
PE	polyethylene	SNAME	Soc. of Naval Architects and Marine Engineers
PEG	polyethylene glycol	SP	static pressure
P.E.L.	proportional elastic limit	sp	specific
PETN	an explosive	specif	specification
pf	power factor	sp gr	specific gravity
PFI	Pipe Fabrication Inst.	sp ht	specific heat
PIV	peak inverse voltage	spp	species unspecified (botanical)
p.m.	post meridiem (after noon)	SPS	standard pipe size
PM	preventive maintenance	sq	square
P.N.	performance number	sr	steradian
ppb	parts per billion	SSF	sec Saybolt Furol
PPI	plan position indicator	SSU	seconds Saybolt Universal (same as SUS)
ppm	parts per million	std	standard
press	pressure	SUS	Saybolt Universal seconds (same as SSU)
Proc.	Proceedings	SWG	Standard (British) wire gage
PSD	power spectral density, g^2/cps	T	tesla

TAC	Technical Advisory Committee on Weather Design Conditions (ASHRAE)	USS	United States Standard
		USSG	U.S. Standard Gage
tan	tangent of	UTC	Coordinated Universal Time
$\tan^{-1}$	angle whose tangent is (see $\cos^{-1}$)	V	volt
tanh	hyperbolic tangent of	VCF	visual comfort factor
$\tanh^{-1}$	inverse hyperbolic tangent of	VCI	visual comfort index
TDH	total dynamic head	VDI	Verein Deutscher Ingenieure
TEL	tetraethyl lead	vel	velocity
temp	temperature	vers	versed sine of
THI	temperature-humidity (discomfort) index	vert	vertical
thp	thrust horsepower	VHF	very high frequency
TNT	trinitrotoluol (explosive)	VI	viscosity index
torr	$= 1$ mm Hg $= 1.332$ millibars (1/760) atm	viz.	videlicet (namely)
	$= (1.013250/760)$ dynes per cm^2	V.M.	volatile matter, %
TP	total pressure	vol	volume
tph	tons per hour	VP	velocity pressure
tpi	turns per in	vs.	versus
TR	transmitter-receiver	W	watt
Trans.	Transactions	Wb	weber
T.S.	tensile strength; tensile stress	W&M	Washburn & Moen wire gage
tsi	tons per sq in	w.g.	water gage
ttd	terminal temperature difference	WHO	World Health Organization
UHF	ultra high frequency	W.I.	wrought iron
UKAEA	United Kingdom Atomic Energy Authority	W.P.A.	Western Pine Assoc.
UL	Underwriters' Laboratory	wt	weight
ult	ultimate	yd	yards
UMS	universal maintenance standards	Y.P.	yield point
USAF	U.S. Air Force	yr	year(s)
USCG	U.S. Coast Guard	Y.S.	yield strength; yield stress
USCS	U.S. Commercial Standard; U.S. Customary System	*z*	atomic number; figure of merit
USDA	U.S. Dept. of Agriculture	*Zeit.*	Zeitschrift
USFPL	U.S. Forest Products Laboratory	Δ	mass defect
USGS	U.S. Geologic Survey	μc	microcurie
USHEW	U.S. Dept. of Health, Education & Welfare	σ, s	Boltzmann constant
USN	U.S. Navy	μ	micro (= 10^{-6}), as in μs
USP	U.S. Pharmacopoeia	μm	micrometer (micron) = 10^{-6} m (10^{-3} mm)
USPHS	U.S. Public Health Service	Ω	ohm

MATHEMATICAL SIGNS AND SYMBOLS

$+$	plus (sign of addition)	$\neq$	not equal to
$+$	positive	$\rightarrow \doteq$	approaches
$-$	minus (sign of subtraction)	$\propto$	varies as
$-$	negative	∞	infinity
$\pm (\mp)$	plus or minus (minus or plus)	$\sqrt{\ }$	square root of
$\times$	times, by (multiplication sign)	$\sqrt[3]{\ }$	cube root of
$\cdot$	multiplied by	$\therefore$	therefore
$\div$	sign of division	$\|$	parallel to
$/$	divided by	() [] {}	parentheses, brackets and braces; quantities enclosed by them
$:$	ratio sign, divided by, is to		to be taken together in multiplying, dividing, etc.
$::$	equals, as (proportion)	$\overline{AB}$	length of line from A to B
$<$	less than	π	pi (= 3.14159^+)
$>$	greater than	$°$	degrees
$\ll$	much less than	$'$	minutes
$\gg$	much greater than	$''$	seconds
$=$	equals	$\angle$	angle
$\equiv$	identical with	dx	differential of x
$\sim$	similar to	Δ	(delta) difference
$\approx$	approximately equals	Δx	increment of x
$\cong$	approximately equals, congruent	$\partial u / \partial x$	partial derivative of u with respect to x
$\leqq$	qual to or less than	$\int$	integral of
$\geqq$	equal to or greater than		

xxiv SYMBOLS AND ABBREVIATIONS

$\int_b^a$	integral of, between limits a and b
$\oint$	line integral around a closed path
Σ	(sigma) summation of
$f(x), F(x)$	functions of x
$\exp x = e^x$	[$e = 2.71828$ (base of natural, or Napierian, logarithms)]
∇	del or nabla, vector differential operator
∇^2	Laplacian operator
£	Laplace operational symbol

$4!$	factorial $4 = 4 \times 3 \times 2 \times 1$
$\lvert x \rvert$	absolute value of x
$\dot{x}$	first derivative of x with respect to time
$\ddot{x}$	second derivative of x with respect to time
$\mathbf{A} \times \mathbf{B}$	vector product; magnitude of $\mathbf{A}$ times magnitude of $\mathbf{B}$ times sine of the angle from $\mathbf{A}$ to $\mathbf{B}$; $AB \sin \overline{AB}$
$\mathbf{A} \cdot \mathbf{B}$	scalar product; magnitude of $\mathbf{A}$ times magnitude of $\mathbf{B}$ times cosine of the angle from $\mathbf{A}$ to $\mathbf{B}$; $AB \cos \overline{AB}$