

CHAPTER 37

ABBREVIATIONS AND SYMBOLS

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THIS chapter contains information about abbreviations and symbols for heating, ventilating, air-conditioning, and refrigerating (HVAC&R) engineers.

**Abbreviations** are shortened forms of names and expressions used in text, drawings, and computer programs. This chapter discusses conventional English-language abbreviations that may be different in other languages. A **letter symbol** represents a quantity or a unit, not its name, and is independent of language. Because of this, use of a letter symbol is preferred over abbreviations for unit or quantity terms. Letter symbols necessary for individual chapters are defined in the chapters where they occur.

Abbreviations are never used for mathematical signs, such as the equality sign (=) or division sign (/), except in computer programming, where the abbreviation functions as a letter symbol. Mathematical operations are performed only with symbols. Abbreviations should be used only where necessary to save time and space; avoid their usage in documents circulated in foreign countries.

Graphical symbols in this chapter of piping, ductwork, fittings, and in-line accessories can be used on scale drawings and diagrams.

Identifying piping by legend and color promotes greater safety and lessens the chance of error in emergencies. Piping identification is now required throughout the United States by the Occupational Safety and Health Administration (OSHA) for some industries and by many federal, state, and local codes.

**ABBREVIATIONS FOR TEXT, DRAWINGS, AND COMPUTER PROGRAMS**

Table 1 gives some abbreviations, as well as others commonly found on mechanical drawings and abbreviations (symbols) used in computer programming. Abbreviations specific to a single subject are defined in the chapters in which they appear. Additional abbreviations used on drawings can be found in the section on Graphical Symbols for Drawings.

**Computer Programs**

The abbreviations (symbols) used for computer programming for the HVAC&R industries have been developed by ASHRAE Technical Committee 1.5, Computer Applications. These symbols identify computer variables, subprograms, subroutines, and functions commonly applied in the industry. Using these symbols enhances comprehension of the program listings and provides a clearly defined nomenclature in applicable computer programs.

Certain programming languages differentiate between real numbers (numbers with decimals) and integers (numbers without decimals) by reserving certain initial letters of a variable for integer numbers. Many of the symbols listed in this chapter begin with these letters and, in order to make them real numbers, must be prefixed with a noninteger letter.

Some symbols have two or more options listed. The longest abbreviation is preferred and should be used if possible. However, it is sometimes necessary to shorten the symbol to further identify the variable. For instance, the area of a wall cannot be defined as WALLAREA because some computer languages restrict the number of letters in a variable name. Therefore, a shorter variable symbol is applied, and WALLAREA becomes WALLA or WAREA.

Many advanced computer programming languages such as Basic, C, and C++ do not have the limitations of older computer language compilers. It is good programming practice to include the complete name of each variable and to define any abbreviations in the comments section at the beginning of each module of code. Abbreviations should be used to help clarify the variables in an equation and not to obscure the readability of the code.

In Table 1, the same symbol is sometimes used for different terms. This liberty is taken because it is unlikely that the two terms would be used in the same program. If such were the case, one of the terms would require a suffix or prefix to differentiate it from the other.

**LETTER SYMBOLS**

Letter symbols include symbols for physical quantities (quantity symbols) and symbols for the units in which these quantities are measured (unit symbols). **Quantity symbols**, such as *I* for electric current, are listed in this chapter and are printed in italic type. A **unit symbol** is a letter or group of letters such as ft for foot or a special sign such as ° for degrees and is printed in Roman type. Subscripts and superscripts are governed by the same principles. Letter symbols are restricted mainly to the English and Greek alphabets.

Quantity symbols may be used in mathematical expressions in any way consistent with good mathematical usage. The product of two quantities, *a* and *b*, is indicated by *ab*. The quotient is *a/b*, or *ab<sup>-1</sup>*. To avoid misinterpretation, parentheses must be used if more than one slash (/) is used in an algebraic term; for example, (*a/b*)/*c* or *a/(b/c)* is correct, but not *a/b/c*.

Subscripts and superscripts, or several of them separated by commas, may be attached to a single basic letter (kernel), but not to other subscripts or superscripts. A symbol that has been modified by a superscript should be enclosed in parentheses before an exponent is added (*X<sub>a</sub>*)<sup>3</sup>. Symbols can also have alphanumeric marks such as ' (prime), + (plus), and \* (asterisk).

More detailed information on the general principles of letter symbol standardization are in standards listed at the end of this chapter. The letter symbols, in general, follow these standards, which are out of print:

Y10.3M	Letter Symbols for Mechanics and Time-Related Phenomena
Y10.4-82	Letter Symbols for Heat and Thermodynamics

Other symbols chosen by an author for a physical magnitude not appearing in any standard list should be ones that do not already have different meanings in the field of the text.

The preparation of this chapter is assigned to TC 1.6, Terminology.

**Table 1 Abbreviations for Text, Drawings, and Computer Programs**

Term	Text	Drawings	Program
above finished floor	—	AFF	—
absolute	abs	ABS	ABS
accumulat(e, -or)	acc	ACCUM	ACCUM
air condition(-ing, -ed)	—	AIR COND	—
air-conditioning unit(s)	—	ACU	ACU
air-handling unit	—	AHU	AHU
air horsepower	ahp	AHP	AHP
alteration	altrn	ALTRN	—
alternating current	ac	AC	AC
altitude	alt	ALT	ALT
ambient	amb	AMB	AMB
American National Standards Institute <sup>1</sup>	ANSI	ANSI	—
American wire gage	AWG	AWG	—
ampere (amp, amps)	amp	AMP	AMP, AMPS
angle	—	—	ANG
angle of incidence	—	—	ANGI
apparatus dew point	adp	ADP	ADP
approximate	approx.	APPROX	—
area	—	—	A
atmosphere	atm	ATM	—
average	avg	AVG	AVG
azimuth	az	AZ	AZ
azimuth, solar	—	—	SAZ
azimuth, wall	—	—	WAZ
barometer(-tric)	baro	BARO	—
bill of material	b/m	BOM	—
boiling point	bp	BP	BP
brake horsepower	bhp	BHP	BHP
Brown & Sharpe wire gage	B&S	B&S	—
British thermal unit	Btu	BTU	BTU
Celsius	°C	°C	°C
center to center	c to c	C TO C	—
circuit	ckt	CKT	CKT
clockwise	cw	CW	—
coefficient	coeff.	COEF	COEF
coefficient, valve flow	C <sub>v</sub>	C <sub>v</sub>	CV
coil	—	—	COIL
compressor	cprsr	CMPR	CMPR
condens(-er, -ing, -ation)	cond	COND	COND
conductance	—	—	C
conductivity	condct	CNDCT	K
conductors, number of (3)	3/c	3/c	—
contact factor	—	—	CF
cooling load	clg load	CLG LOAD	CLOAD
counterclockwise	ccw	CCW	—
cubic feet	ft <sup>3</sup>	CU FT	CUFT, CFT
cubic inch	in <sup>3</sup>	CU IN	CUIN, CIN
cubic feet per minute	cfm	CFM	CFM
cfm, standard conditions	scfm	SCFM	SCFM
cubic ft per sec, standard	sfcfs	SCFS	SCFS
decibel	dB	DB	DB
degree	deg. or °	DEG or °	DEG
density	dens	DENS	RHO
depth or deep	dp	DP	DPTH
dew-point temperature	dpt	DPT	DPT
diameter	dia.	DIA	DIA
diameter, inside	ID	ID	ID
diameter, outside	OD	OD	OD
difference or delta	diff., Δ	DIFF	D, DELTA
diffuse radiation	—	—	DFRAD
direct current	dc	DC	DC
direct radiation	dir radn	DIR RADN	DIRAD
dry	—	—	DRY
dry-bulb temperature	dbt	DBT	DB, DBT
effectiveness	—	—	EFT
effective temperature <sup>2</sup>	ET*	ET*	ET
efficiency	eff	EFF	EFF
efficiency, fin	—	—	FEFF
efficiency, surface	—	—	SEFF

Term	Text	Drawings	Program
electromotive force	emf	EMF	—
elevation	elev.	EL	ELEV
entering	entr	ENT	ENT
entering water temperature	EWT	EWT	EWT
entering air temperature	EAT	EAT	EAT
enthalpy	—	—	H
entropy	—	—	S
equivalent direct radiation	edr	EDR	—
equivalent feet	equiv ft	EQIV FT	EQFT
equivalent inches	equiv in	EQIV IN	EQIN
evaporat(-e, -ing, -cd, -or)	evap	EVAP	EVAP
expansion	exp	EXP	XPAN
face area	fa	FA	FA
face to face	f to f	F to F	—
face velocity	fvel	FVEL	FV
factor, correction	—	—	CFAC, CFACT
factor, friction	—	—	FFACT, FF
Fahrenheit	°F	°F	F
fan	—	—	FAN
feet per minute	fpm	FPM	FPM
feet per second	fps	FPS	FPS
film coefficient, <sup>3</sup> inside	—	—	FI, HI
film coefficient, <sup>3</sup> outside	—	—	FO, HO
flow rate, air	—	—	QAR, QAIR
flow rate, fluid	—	—	QFL
flow rate, gas	—	—	QGA, QGAS
foot or feet	ft	FT	FT
foot-pound	ft·lb	FT LB	—
freezing point	fp	FP	FP
frequency	Hz	HZ	—
gage or gauge	ga	GA	GA, GAGE
gallons	gal	GAL	GAL
gallons per hour	gph	GPH	GPH
gallons per minute	gpm	GPM	GPM
gallons per day	gpd	GPD	GPD
grains	gr	GR	GR
gravitational constant	G	G	G
greatest temp difference	GTD	GTD	GTD
head	hd	HD	HD
heat	—	—	HT
heater	—	—	HTR
heat gain	HG	HG	HG, HEATG
heat gain, latent	LHG	LHG	HGL
heat gain, sensible	SHG	SHG	HGS
heat loss	—	—	HL, HEATL
heat transfer	—	—	Q
heat transfer coefficient	U	U	U
height	hgt	HGT	HGT, HT
high-pressure steam	hps	HPS	HPS
high-temperature hot water	hthw	HTHW	HTHW
horsepower	hp	HP	HP
hour(s)	h	HR	HR
humidity, relative	rh	RH	RH
humidity ratio	W	W	W
inch	in.	IN.	IN
incident angle	—	—	INANG
indicated horsepower	ihp	IHP	—
International Pipe Std	IPS	IPS	—
iron pipe size	ips	IPS	—
kilowatt	kW	KW	KW
kilowatt hour	kWh	KWH	KWH
latent heat	LH	LH	LH, LHEAT
least mean temp. difference <sup>4</sup>	LMTD	LMTD	LMTD
least temp. difference <sup>4</sup>	LTD	LTD	LTD
leaving air temperature	lat	LAT	LAT
leaving water temperature	lwt	LWT	LWT
length	lg	LG	LG, L
linear feet	lin ft	LF	LF
liquid	liq	LIQ	LIQ
load-sharing (hybrid) HVAC system	LSHVAC	LSHVAC	LSHVAC
logarithm (natural)	ln	LN	LN
logarithm to base 10	log	LOG	LOG

Term	Text	Drawings	Program
low-pressure steam	lps	LPS	LPS
low-temp. hot water	lthw	LTHW	LTHW
Mach number	Mach	MACH	—
mass flow rate	mfr	MFR	MFR
maximum	max.	MAX	MAX
mean effective temp.	MET	MET	MET
mean temp. difference	MTD	MTD	MTD
medium-pressure steam	mps	MPS	MPS
medium-temp. hot water	mthw	MTHW	MTHW
mercury	Hg	HG	HG
miles per hour	mph	MPH	MPH
minimum	min.	MIN	MIN
minute	min	MIN	MIN
noise criteria	NC	NC	—
normally open	n o	N O	—
normally closed	n c	N C	—
not applicable	na	N/A	—
not in contract	n i c	N I C	—
not to scale	—	N T S	—
number	no.	NO	N, NO
number of circuits	—	—	NC
number of tubes	—	—	NT
ounce	oz	OZ	OZ
outside air	oa	OA	OA
parts per million	ppm	PPM	PPM
percent	%	%	PCT
phase (electrical)	ph	PH	—
pipe	—	—	PIPE
pounds	lb	LBS	LBS
pounds per square foot	psf	PSF	PSF
psf absolute	psfa	PSFA	PSFA
psf gage	psfg	PSFG	PSFG
pounds per square inch	psi	PSI	PSI
psi absolute	psia	PSIA	PSIA
psi gage	psig	PSIG	PSIG
pressure	—	PRESS	PRES, P
pressure, barometric	baro pr	BARO PR	—
pressure, critical	—	—	CRIP
pressure, dynamic (velocity)	vp	VP	VP
pressure drop or difference	PD	PD	PD, DELTP
pressure, static	sp	SP	SP
pressure, vapor	vap pr	VAP PR	VAP
primary	pri	PRI	PRIM
quart	qt	QT	QT
radian	—	—	RAD
radiat(-e, -or)	—	RAD	—
radiant panel	RP	RP	RP
radiation	—	RADN	RAD
radius	—	—	R
Rankine	°R	°R	R
receiver	rcvr	RCVR	REC
recirculate	recirc.	RECIRC	RCIR, RECIR
refrigerant (12, 22, etc.)	R-12, R-22	R12, R22	R12, R22
relative humidity	rh	RH	RH
resist(-ance, -ivity, -or)	res	RES	RES, OHMS
return air	ra	RA	RA
revolutions	rev	REV	REV
revolutions per minute	rpm	RPM	RPM
revolutions per second	rps	RPS	RPS
roughness	rgh	RGH	RGH, E
safety factor	sf	SF	SF
saturation	sat.	SAT	SAT
Saybolt seconds Furol	ssf	SSF	SSF
Saybolt seconds Universal	ssu	SSU	SSU
sea level	sl	SL	SE
second	s	S	SEC
sensible heat	SH	SH	SH
sensible heat gain	SHG	SHG	SHG
sensible heat ratio	SHR	SHR	SHR
shading coefficient	—	—	SC
shaft horsepower	sft hp	SFT HP	SHP
solar	—	—	SOL

Term	Text	Drawings	Program
specification	spec	SPEC	—
specific gravity	SG	SG	—
specific heat	sp ht	SP HT	C
sp ht at constant pressure	$c_p$	$c_p$	CP
sp ht at constant volume	$c_v$	$c_v$	CV
specific volume	sp vol	SP VOL	V, CVOL
square	sq.	SQ	SQ
standard	std	STD	STD
standard time meridian	—	—	STM
static pressure	SP	SP	SP
suction	suct.	SUCT	SUCT, SUC
summ(-er, -ary, -ation)	—	—	SUM
supply	sply	SPLY	SUP, SPLY
supply air	sa	SA	SA
surface	—	—	SUR, S
surface, dry	—	—	SURD
surface, wet	—	—	SURW
system	—	—	SYS
tabulat(-e, -ion)	tab	TAB	TAB
tee	—	—	TEE
temperature	temp.	TEMP	T, TEMP
temperature difference	TD, $\Delta t$	TD	TD, TDIF
temperature entering	TE	TE	TE, TENT
temperature leaving	TL	TL	TL, TLEA
thermal conductivity	$k$	K	K
thermal expansion coeff.	—	—	TXPC
thermal resistance	R	R	RES, R
thermocouple	tc	TC	TC, TCPL
thermostat	T STAT	T STAT	T STAT
thick(-ness)	thkns	THKNS	THK
thousand circular mils	Mcm	MCM	MCM
thousand cubic feet	Mcf	MCF	MCF
thousand foot-pounds	kip ft	KIP FT	KIPFT
thousand pounds	kip	KIP	KIP
time	—	T	T
ton	—	—	TON
tons of refrigeration	tons	TONS	TONS
total	—	—	TOT
total heat	tot ht	TOT HT	—
transmissivity	—	—	TAU
U-factor	—	—	U
unit	—	—	UNIT
vacuum	vac	VAC	VAC
valve	v	V	VLV
vapor proof	vap prf	VAP PRF	—
variable	var	VAR	VAR
variable air volume	VAV	VAV	VAV
velocity	vel.	VEL	VEL, V
velocity, wind	w vel.	W VEL	W VEL
ventilation, vent	vent	VENT	VENT
vertical	vert.	VERT	VERT
viscosity	visc	VISC	MU, VISC
volt	V	V	E, VOLTS
volt ampere	VA	VA	VA
volume	vol.	VOL	VOL
volumetric flow rate	—	—	VFR
wall	—	—	W, WAL
water	—	—	WTR
watt	W	W	WAT, W
watt-hour	Wh	WH	WHR
weight	wt	WT	WT
wet bulb	wb	WB	WB
wet-bulb temperature	wbt	WBT	WBT
width	—	—	WI
wind	—	—	WD
wind direction	wdir	WDIR	WDIR
wind pressure	wpr	WPR	WP, WPRES
yard	yd	YD	YD
year	yr	YR	YR
zone	z	Z	Z, ZN

<sup>1</sup>Abbreviations of most proper names use capital letters in both text and drawings.  
<sup>2</sup>The asterisk (\*) is used with ET\*, effective temperature, as in Chapter 9 of this volume.  
<sup>3</sup>These are surface heat transfer coefficients.  
<sup>4</sup>Letter L also used for *Logarithm* of these temperature differences in computer programming.

LETTER SYMBOLS

Symbol	Description of Item	Typical Units
<i>a</i>	acoustic velocity	fps or fpm
<i>A</i>	area	ft <sup>2</sup>
<i>b</i>	breadth or width	ft
<i>B</i>	barometric pressure	psia or in. Hg
<i>c</i>	concentration	lb/ft <sup>3</sup> , mol/ft <sup>3</sup>
<i>c</i>	specific heat	Btu/lb·°F
<i>c<sub>p</sub></i>	specific heat at constant pressure	Btu/lb·°F
<i>c<sub>v</sub></i>	specific heat at constant volume	Btu/lb·°F
<i>C</i>	coefficient	—
<i>C</i>	fluid capacity rate	Btu/h·°F
<i>C</i>	thermal conductance	Btu/h·ft <sup>2</sup> ·°F
<i>C<sub>L</sub></i>	loss coefficient	—
<i>C<sub>p</sub></i>	coefficient of performance	—
<i>d</i>	prefix meaning differential	—
<i>d</i> or <i>D</i>	diameter	ft
<i>D<sub>e</sub></i> or <i>D<sub>h</sub></i>	equivalent or hydraulic diameter	ft
<i>D<sub>v</sub></i>	mass diffusivity	ft <sup>2</sup> /s
<i>e</i>	base of natural logarithms	—
<i>E</i>	energy	Btu
<i>E</i>	electrical potential	V
<i>f</i>	film conductance (alternate for <i>h</i> )	Btu/h·ft <sup>2</sup> ·°F
<i>f</i>	frequency	Hz
<i>f<sub>D</sub></i>	friction factor, Darcy-Weisbach formulation	—
<i>f<sub>F</sub></i>	friction factor, Fanning formulation	—
<i>F</i>	force	lb <sub>f</sub>
<i>F<sub>ij</sub></i>	angle factor (radiation)	—
<i>g</i>	gravitational acceleration	ft/s <sup>2</sup>
<i>G</i>	mass velocity	lb/h·ft <sup>2</sup>
<i>h</i>	heat transfer coefficient	Btu/h·ft <sup>2</sup> ·°F
<i>h</i>	hydraulic head	ft
<i>h</i>	specific enthalpy	Btu/lb
<i>h<sub>a</sub></i>	enthalpy of dry air	Btu/lb
<i>h<sub>D</sub></i>	mass transfer coefficient	lb/h·ft <sup>2</sup> ·lb per ft <sup>3</sup>
<i>h<sub>s</sub></i>	enthalpy of moist air at saturation	Btu/lb
<i>H</i>	total enthalpy	Btu
<i>I</i>	electric current	A
<i>J</i>	mechanical equivalent of heat	ft·lb <sub>f</sub> /Btu
<i>k</i>	thermal conductivity	Btu/h·ft·°F
<i>k</i> (or <i>γ</i> )	ratio of specific heats, <i>c<sub>p</sub></i> / <i>c<sub>v</sub></i>	—
<i>K</i>	proportionality constant	—
<i>K<sub>D</sub></i>	mass transfer coefficient	lb/h·ft <sup>2</sup>
<i>l</i> or <i>L</i>	length	ft
<i>L<sub>p</sub></i>	sound pressure	dB
<i>L<sub>w</sub></i>	sound power	dB
<i>m</i> or <i>M</i>	mass	lb
<i>M</i>	molecular weight	lb/lb mol
<i>n</i> or <i>N</i>	number in general	—
<i>N</i>	rate of rotation	rpm
<i>p</i> or <i>P</i>	pressure	psi
<i>p<sub>a</sub></i>	partial pressure of dry air	psi
<i>p<sub>s</sub></i>	partial pressure of water vapor in moist air	psi
<i>p<sub>w</sub></i>	vapor pressure of water in saturated moist air	psi
<i>P</i>	power	hp, watts
<i>q</i>	time rate of heat transfer	Btu/h
<i>Q</i>	total heat transfer	Btu
<i>Q̇</i>	volumetric flow rate	cfm
<i>r</i>	radius	ft
<i>r</i> or <i>R</i>	thermal resistance	ft <sup>2</sup> ·h·°F/Btu
<i>R</i>	gas constant	ft·lb <sub>f</sub> /lb <sub>m</sub> ·°R
<i>s</i>	specific entropy	Btu/lb·°R
<i>S</i>	total entropy	Btu/°R
<i>t</i>	temperature	°F
<i>ΔT<sub>m</sub></i> or <i>ΔT<sub>m</sub></i>	mean temperature difference	°F
<i>T</i>	absolute temperature	°R
<i>u</i>	specific internal energy	Btu/lb
<i>U</i>	total internal energy	Btu
<i>U</i>	overall heat transfer coefficient	Btu/h·ft <sup>2</sup> ·°F
<i>v</i>	specific volume	ft <sup>3</sup> /lb

Symbol	Description of Item	Typical Units
<i>V</i>	total volume	ft <sup>3</sup>
<i>V</i>	linear velocity	fps
<i>w</i>	mass rate of flow	lb/h
<i>W</i>	weight	lb <sub>f</sub>
<i>W</i>	humidity ratio of moist air	lb(water)/lb(dry air)
<i>W</i>	work	ft·lb <sub>f</sub>
<i>W<sub>s</sub></i>	humidity ratio of moist air at saturation	lb(water)/lb(dry air)
<i>x</i>	mole fraction	—
<i>x</i>	quality, mass fraction of vapor	—
<i>x, y, z</i>	lengths along principal coordinate axes	ft
<i>Z</i>	figure of merit	—
<i>α</i>	absolute Seebeck coefficient	V/°C
<i>α</i>	absorptivity, absorptance radiation	—
<i>α</i>	linear coefficient of thermal expansion	per °F
<i>α</i>	thermal diffusivity	ft <sup>2</sup> /h
<i>β</i>	volume coefficient of thermal expansion	per °F
<i>γ</i> (or <i>k</i> )	ratio of specific heats, <i>c<sub>p</sub></i> / <i>c<sub>v</sub></i>	—
<i>γ</i>	specific weight	lb <sub>f</sub> /ft <sup>3</sup>
<i>Δ</i>	difference between values	—
<i>ε</i>	emissivity, emittance (radiation)	—
<i>θ</i>	time	s, h
<i>η</i>	efficiency or effectiveness	—
<i>λ</i>	wavelength	nm
<i>μ</i>	degree of saturation	—
<i>μ</i>	dynamic viscosity	lb/ft·h
<i>ν</i>	kinematic viscosity	ft <sup>2</sup> /h
<i>ρ</i>	density	lb/ft <sup>3</sup>
<i>ρ</i>	reflectivity, reflectance (radiation)	—
<i>ρ</i>	volume resistivity	Ω·cm
<i>σ</i>	Stefan-Boltzmann constant	Btu/h·ft <sup>2</sup> ·°R <sup>4</sup>
<i>σ</i>	surface tension	lb <sub>f</sub> /ft
<i>τ</i>	stress	lb <sub>f</sub> /ft <sup>2</sup>
<i>τ</i>	time	s, h
<i>τ</i>	transmissivity, transmittance (radiation)	—
<i>φ</i>	relative humidity	—

DIMENSIONLESS NUMBERS

Fo	Fourier number	$\alpha\tau/L^2$
Gr	Grashof number	$L^3\rho^2\beta g(\Delta t)/\mu^2$
Gz	Graetz number	$wc_p/kL$
<i>j<sub>D</sub></i>	Colburn mass transfer	$Sh/ReSc^{1/3}$
<i>j<sub>H</sub></i>	Colburn heat transfer	$Nu/RePr^{1/3}$
Le	Lewis number	$\alpha/D_v$
M	Mach number	$V/a$
Nu	Nusselt number	$hD/k$
Pe	Peclet number	$GDc_p/k$
Pr	Prandtl number	$c_p\mu/k$
Re	Reynolds number	$\rho VD/\mu$
Sc	Schmidt number	$\mu/\rho D_v$
Sh	Sherwood number	$h_D L/D_v$
St	Stanton number	$h/Gc_p$
Str	Strouhal number	$fd/V$

MATHEMATICAL SYMBOLS

equal to	=
not equal to	≠
approximately equal to	≈
greater than	>
less than	<
greater than or equal to	≥
less than or equal to	≤
plus	+
minus	−
plus or minus	±
<i>a</i> multiplied by <i>b</i>	<i>ab</i> , <i>a · b</i> , <i>a × b</i>
<i>a</i> divided by <i>b</i>	$\frac{a}{b}$ , <i>a/b</i> , <i>ab</i> <sup>-1</sup>
ratio of circumference of a circle to its diameter	π

$a$ raised to the power $n$	$a^n$
square root of $a$	$\sqrt{a}, a^{0.5}$
infinity	$\infty$
percent	%
summation of	$\Sigma$
natural log	ln
logarithm to base 10	log

**SUBSCRIPTS**

These are to be affixed to the appropriate symbols. Several subscripts may be used together to denote combinations of various states, points, or paths. Often the subscript indicates that a particular property is to be kept constant in a process.

$a, b, \dots$	referring to different phases, states or physical conditions of a substance, or to different substances
$a$	air
$a$	ambient
$b$	barometric (pressure)
$c$	referring to critical state or critical value
$c$	convection
$db$	dry bulb
$dp$	dew point
$e$	base of natural logarithms
$f$	referring to saturated liquid
$f$	film
$fg$	referring to evaporation or condensation
$F$	friction
$g$	referring to saturated vapor
$h$	referring to change of phase in evaporation
$H$	water vapor
$i$	referring to saturated solid
$i$	internal
$if$	referring to change of phase in melting
$ig$	referring to change of phase in sublimation
$k$	kinetic
$L$	latent
$m$	mean value
$M$	molar basis
$p$	referring to constant pressure conditions or processes
$p$	potential
$r$	refrigerant
$r$	radiant or radiation
$s$	referring to moist air at saturation
$s$	sensible
$s$	referring to isentropic conditions or processes
$s$	static (pressure)
$s$	surface
$t$	total (pressure)
$T$	referring to isothermal conditions or processes
$v$	referring to constant volume conditions or processes
$v$	vapor
$v$	velocity (pressure)
$w$	wall
$w$	water
$wb$	wet bulb
$0$	referring to initial or standard states or conditions
$1, 2, \dots$	different points in a process, or different instants of time

**GRAPHICAL SYMBOLS FOR DRAWINGS**

Graphical symbols have been extracted from ANSI/ASHRAE Standard 134-2005. Additional symbols are from current practice and extracted from ASME Standards Y32.2.3 and Y32.2.4.

**Piping**

**Heating**



High-pressure steam	———— HPS ————
Medium-pressure steam	———— MPS ————
Low-pressure steam	———— LPS ————
High-pressure steam condensate	———— HPC ————
Medium-pressure steam condensate	———— MPC ————

Low-pressure steam condensate	———— LPC ————
Boiler blowdown	———— BBD ————
Pumped condensate	———— PC ————
Vacuum pump discharge	———— VPD ————
Makeup water	———— MU ————
Atmospheric vent	———— ATV ————
Fuel oil	———— FO(NAME) ————
Low-temperature hot water supply	———— HWS ————
Medium-temperature hot water supply	———— MTWS ————
High-temperature hot water supply	———— HTWS ————
Low-temperature hot water return	———— HWR ————
Medium-temperature hot water return	———— MTWR ————
High-temperature hot water return	———— HTWR ————
Compressed air	———— A(NAME) ————
Vacuum (air)	———— VAC ————
Existing piping	———— (NAME)E ————
Pipe to be removed	—XX— (NAME) —XX—

**Air Conditioning and Refrigeration**

Refrigerant discharge	———— RD ————
Refrigerant suction	———— RS ————
Brine supply	———— B ————
Brine return	———— BR ————
Condenser water supply	———— CWS ————
Condenser water return	———— CWR ————
Chilled water supply	———— CHWS ————
Chilled water return	———— CHWR ————
Fill line	———— FILL ————
Humidification line	———— H ————
Drain	———— D ————
Hot/chilled water supply	———— H/C S ————
Hot/chilled water return	———— H/C R ————
Refrigerant liquid	———— RL ————
Heat pump water supply	———— HPWS ————
Heat pump water return	———— HPWR ————

**Plumbing**

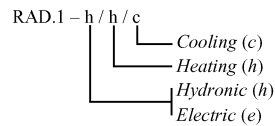
Sanitary drain above floor or grade	———— SAN ————
Sanitary drain below floor or grade	----- SAN -----
Storm drain above floor or grade	———— ST ————
Storm drain below floor or grade	----- ST -----
Condensate drain above floor or grade	———— CD ————
Condensate drain below floor or grade	----- CD -----
Vent	———— V ————
Cold water	———— CW ————
Hot water	———— HW ————
Hot water return	———— HWR ————
Gas	———— G ———— G ————
Acid waste	———— AW ————
Drinking water supply	———— DCW ————
Chemical supply pipes <sup>a</sup>	———— (NAME) ————
Floor drain	————  ————
Funnel drain, open	————  ————

**Fire Safety Devices<sup>b</sup>**

**Signal Initiating Detectors**

Heat (thermal)		Gas	
Smoke		Flame	

**Radiant Panels**

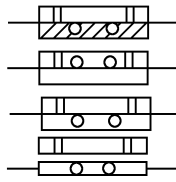
Hydronic heating element	○	
Electric heating element	●	

<sup>a</sup>See section on Piping Identification in this chapter.

<sup>b</sup>Refer to *Standard for Fire Safety Symbols*, 1999 edition (NFPA Standard 170).

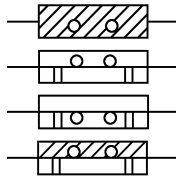
**Radiant Ceiling Panels**

- Embedded
- Above ceiling
- Surface mounted
- Suspended

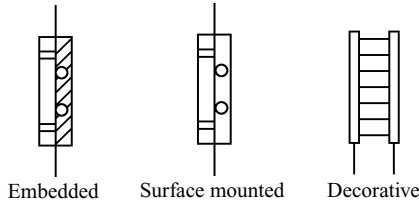


**Radiant Floor Panels**

- Slab on grade
- Above subfloor
- Below subfloor
- Slab above subfloor

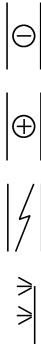


**Radiant Wall Panels**



**Coils**

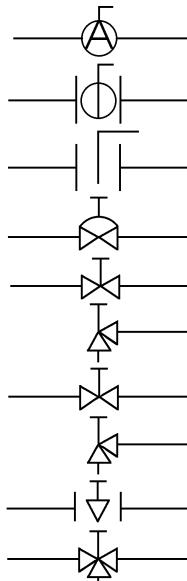
- Cooling coil
- Heating coil
- Electrical coil
- Humidifier



**Valves**

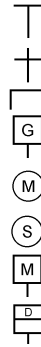
**Valves for Selective Actuators**

- Air line
- Ball
- Butterfly
- Diaphragm
- Gate
- Gate, angle
- Globe
- Globe, angle
- Plug valve
- Three way



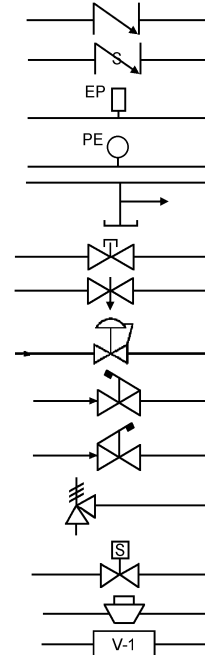
**Valves Actuators**

- Manual
- Non-rising stem
- Outside stem & yoke
- Lever
- Gear
- Electric Motor
- Solenoid
- Pneumatic Motor
- Diaphragm



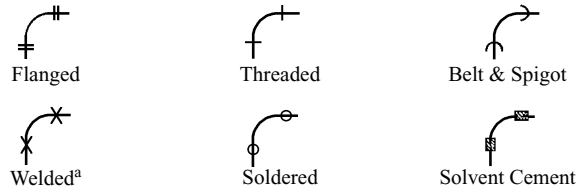
**Valves, Special Duty**

- Check, swing gate
- Check, spring
- Control, electric-pneumatic
- Control, pneumatic-electric
- Hose end drain
- Lock shield
- Needle
- Pressure-reducing regulator
- Quick-opening
- Quick-closing
- Safety or relief
- Solenoid
- Square-head cock
- Unclassified (number and specify)



**Fittings**

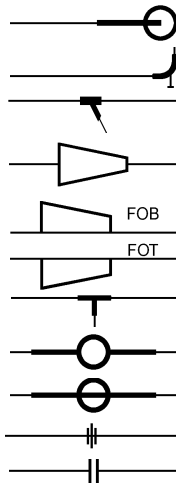
The following fittings are shown without connection notations. This reflects current practice. The symbol for the body of a fitting is the same for all types of connections, unless otherwise specified. The types of connections are often specified for a range of pipe sizes, but are shown with the fitting symbol where required. For example, an elbow would be:



Fitting	Symbol
Bushing	
Cap	
Cross	
Elbow, 90°	
Elbow, 45°	
Elbow, facing toward viewer	

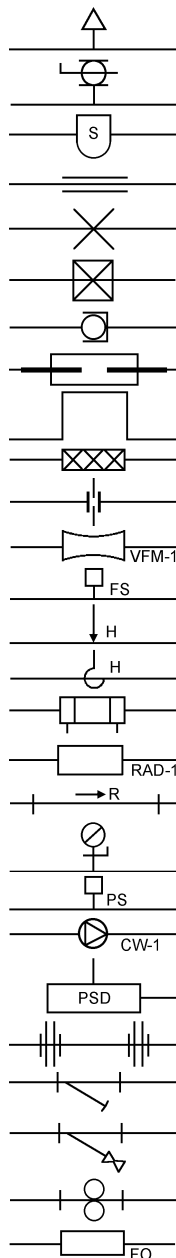
<sup>a</sup> Includes fusion; specify type.

Elbow, facing away from viewer  
 Elbow, base-supported  
 Lateral  
 Reducer, concentric  
 Reducer, eccentric, flat on bottom  
 Reducer, eccentric, flat on top  
 Tee  
 Tee, facing toward viewer  
 Tee, facing away from viewer  
 Union, screwed  
 Union, flanged

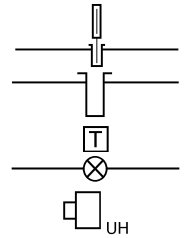


**Piping Specialties**

Air vent, automatic  
 Air vent, manual  
 Air separator  
 Pipe guide  
 Anchor, intermediate  
 Anchor, main  
 Ball joint  
 Expansion joint  
 Expansion loop  
 Flexible connector  
 Flowmeter, orifice plate with flanges  
 Flowmeter, venturi  
 Flow switch  
 Hanger rod  
 Hanger spring  
 Heat exchanger, liquid  
 Heat transfer surface (indicate type)  
 Pitch of pipe, rise (R) drop (D)  
 Pressure gage and cock  
 Pressure switch  
 Pump (indicate use)  
 Pump suction diffuser  
 Spool piece, flanged  
 Strainer  
 Strainer, blow off  
 Strainer, duplex  
 Tank (indicate use)



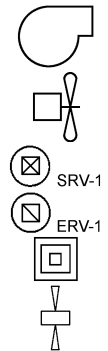
Thermometer  
 Thermometer well, only  
 Thermostat  
 Traps, steam (indicate type)  
 Unit heater (indicate type)



**Air-Moving Devices and Components**

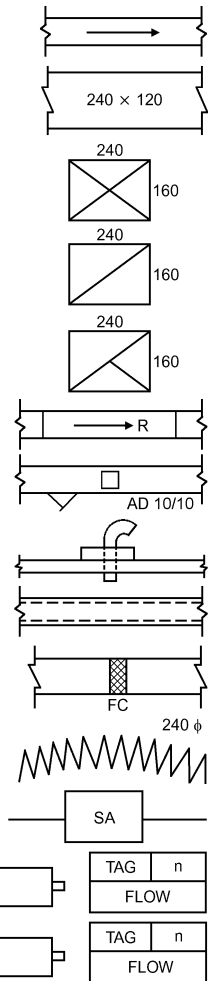
**Fans (indicate use)**

Centrifugal  
 Propeller  
 Roof ventilator, intake  
 Roof ventilator, exhaust  
 Roof ventilator, louvered  
 Vaneaxial



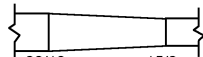
**Ductwork<sup>a,b</sup>**

Direction of flow  
 Duct size, where first dimension is visible duct  
 Duct section, supply  
 Duct section, return  
 Duct section, exhaust  
 Change of elevation rise (R) drop (D)  
 Access doors, vertical or horizontal  
 Cowl, (gooseneck) and flashing  
 Duct lining  
 Flexible connection  
 Flexible duct  
 Sound attenuator  
 Terminal unit, mixing  
 Terminal unit, variable volume

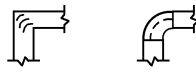


<sup>a</sup> Units of measurement are not shown here, but should be shown on drawings. The first dimension is visible duct dimension for duct size, top dimension for grilles, and horizontal dimension for registers.  
<sup>b</sup> Show volumetric flow rate at each device.

Transition<sup>a</sup>



Turning vanes

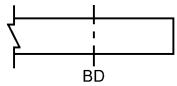


Smoke detectors

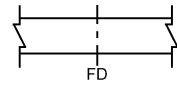


**Dampers**

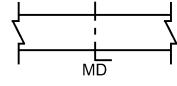
Backdraft damper



Fire damper



Manual volume

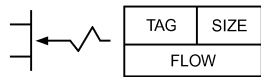


Smoke damper



**Grilles, Register and Diffusers<sup>b</sup>**

Sidewall inlet, (exhaust) outlet, registers, and grilles



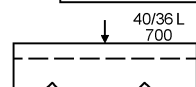
Sidewall outlet, registers, and grilles



Rectangular four-way outlet, supply



Louver and screen



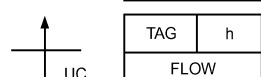
Transfer grille or louver



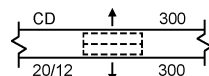
Door grille or louver



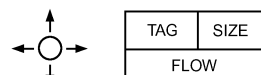
Undercut door



Ceiling diffuser, rectangular



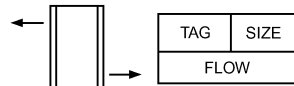
Round outlet



Linear outlet



Light troffer outlet



**Refrigeration**

**Compressors**

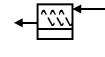
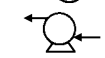
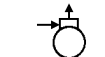
Centrifugal



Reciprocating

Rotary

Rotary screw

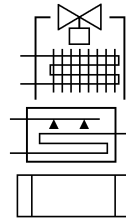


**Condensers**

Air cooled

Evaporative

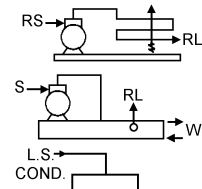
Water cooled, (specify type)



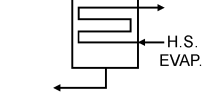
**Condensing Units**

Air cooled<sup>a</sup>

Water cooled<sup>a</sup>



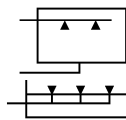
**Condenser-Evaporator (Cascade System)**



**Cooling Towers**

Cooling tower

Spray pond



**Evaporators<sup>b</sup>**

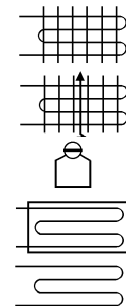
Finned coil

Forced convection

Immersion cooling unit

Plate coil

Pipe coil<sup>c</sup>



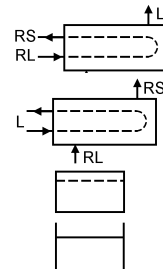
**Liquid Chillers (Chillers only)**

Direct expansion<sup>d</sup>

Flooded<sup>d</sup>

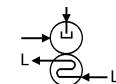
Tank, closed

Tank, open



**Chilling Units**

Absorption



<sup>a</sup>Indicate flat on bottom or top (FOB or FOT), if applicable.

<sup>b</sup>Show volumetric flow rate at each device.

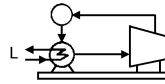
<sup>a</sup>L = Liquid being cooled, RL = Refrigerant liquid, RS = Refrigerant suction.

<sup>b</sup>Specify manifolding.

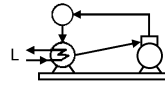
<sup>c</sup>Frequently used diagrammatically as evaporator and/or condenser with labeling name and type.

<sup>d</sup>L = Liquid being cooled, RL = Refrigerant liquid, RS = Refrigerant suction.

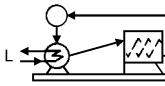
Centrifugal



Reciprocating



Rotary screw



**Controls**

**Refrigerant Controls**

Capillary tube



Expansion valve, hand



Expansion valve, automatic



Expansion valve, thermostatic



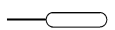
Float valve, high side, or liquid drain valve



Float valve, low side



Thermal bulb



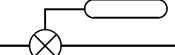
Solenoid valve



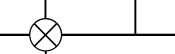
Constant pressure valve, suction



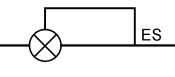
Evaporator pressure regulating valve, thermostatic, throttling



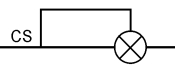
Evaporator pressure regulating valve, thermostatic, snap-action



Evaporator pressure regulating valve, throttling-type, evaporator side



Compressor suction valve, pressure-limiting, throttling-type, compressor side



Thermosuction valve



Snap-action valve



Refrigerant reversing valve

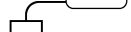


**Temperature or Temperature-Actuated Electrical or Flow Controls**

Thermostat, self-contained



Thermostat, remote bulb



Sensor, temperature



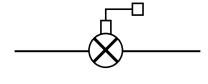
Pressure-reducing regulator



Pressure regulator



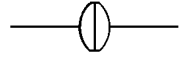
Valve, condenser water regulating



**Auxiliary Equipment**

**Refrigerant**

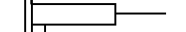
Filter



Strainer



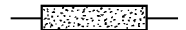
Filter and drier



Scale trap



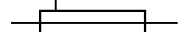
Drier



Vibration absorber



Heat exchanger



Oil separator



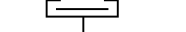
Sight glass



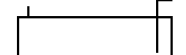
Fusible plug



Rupture disk



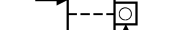
Receiver, high-pressure, horizontal



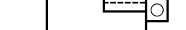
Receiver, high-pressure, vertical



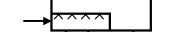
Receiver, low-pressure



Intercooler

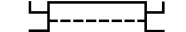


Intercooler/desuperheater



**Energy Recovery Equipment**

Condenser, double bundle

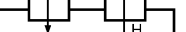


**Air to Air Energy Recovery**

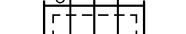
Rotary heat wheel



Coil loop



Heat pipe



Fixed plate

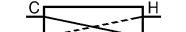
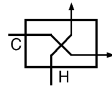


Plate fin, crossflow



**Power Sources**

Motor, electric (number for identification of description in specifications)



Engine (indicate fuel)



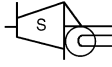
Gas turbine



Steam turbine



Steam turbine, condensing



**Electrical Equipment<sup>a</sup>**

Symbols for electrical equipment shown on mechanical drawings are usually geometric figures with an appropriate name or abbreviation, with details described in the specifications. The following are some common examples.<sup>b</sup>

Motor control



Disconnect switch, unfused



Disconnect switch, fused



Time clock



Automatic filter panel



Lighting panel



Power panel



<sup>a</sup> See ARI Standard 130 for preferred symbols of common electrical parts.  
<sup>b</sup> Number each symbol if more than one; see ASME Standard Y32.4.

**PIPING SYSTEM IDENTIFICATION**

The material in piping systems is identified to promote greater safety and lessen the chances of error, confusion, or inaction in times of emergency. Primary identification should be by means of a lettered legend naming the material conveyed by the piping. In addition to, but not instead of lettered identification, color can be used to identify the hazards or use of the material.

The data in this section have been extracted from ASME Standard A13.1.

**Definitions**

**Piping Systems.** Piping systems include pipes of any kind, fittings, valves, and pipe coverings. Supports, brackets, and other accessories are not included. Pipes are defined as conduits for the transport of gases, liquids, semiliquids, or fine particulate dust.

**Materials Inherently Hazardous to Life and Property.** There are four categories of hazardous materials:

- Flammable or explosive materials that are easily ignited, including materials known as fire producers or explosives
- Chemically active or toxic materials that are corrosive or are in themselves toxic or productive of poisonous gases
- Materials at extreme temperatures or pressures that, when released from the piping, cause a sudden outburst with the potential for inflicting injury or property damage by burns, impingement, or flashing to vapor state
- Radioactive materials that emit ionizing radiation

**Materials of Inherently Low Hazard.** All materials that are not hazardous by nature, and are near enough to ambient pressure and temperature that people working on systems carrying these materials run little risk through their release.

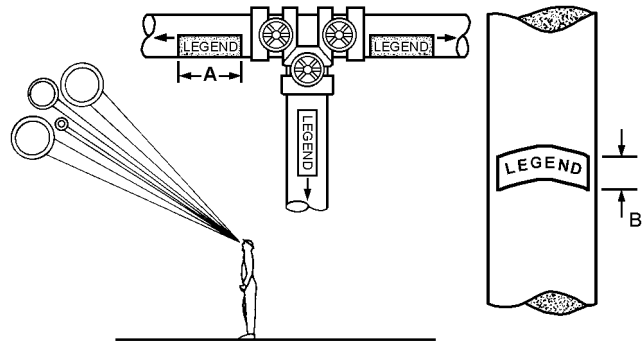
**Table 2 Examples of Legends**

HOT WATER
AIR 100 PSIG
H.P. RETURN
STEAM 100 PSIG

**Table 3 Classification of Hazardous Materials and Designation of Colors<sup>a</sup>**

Classification	Color Field	Colors of Letters for Legend
<b>Materials Inherently Hazardous</b>		
Flammable or explosive	Yellow	Black
Chemically active or toxic	Yellow	Black
Extreme temperatures or pressures	Yellow	Black
Radioactive <sup>b</sup>	Purple	Yellow
<b>Materials of Inherently Low Hazard</b>		
Liquid or liquid admixture <sup>c</sup>	Green	Black
Gas or gaseous admixture	Blue	White
<b>Fire Quenching Materials</b>		
Water, foam, CO <sub>2</sub> , Halon, etc.	Red	White

<sup>a</sup>When preceding color scheme is used, colors should be as recommended in latest revision of NEMA Standard Z535.1.  
<sup>b</sup>Previously specified radioactive markers using yellow or purple are acceptable if already installed and/or until existing supplies are depleted, subject to applicable federal regulations.  
<sup>c</sup>Markers with black letters on green field are acceptable if already installed and/or until existing supplies are depleted.



**Fig. 1 Visibility of Pipe Markings**

**Fire Quenching Materials.** This classification includes sprinkler systems and other piped fire fighting or fire protection equipment. This includes water (for fire fighting), chemical foam, CO<sub>2</sub>, Halon, and so forth.

**Method of Identification**

**Legend.** The legend is the primary and explicit identification of content. Positive identification of the content of the piping system is by lettered legend giving the name of the contents, in full or abbreviated form, as shown in Table 2. Arrows should be used to indicate the direction of flow. Use the legend to identify contents exactly and to provide temperature, pressure, and other details necessary to identify the hazard.

The legend shall be brief, informative, pointed, and simple. Legends should be applied close to valves and adjacent to changes in direction, branches, and where pipes pass through walls or floors, and as frequently as needed along straight runs to provide clear and positive identification. Identification may be applied by stenciling, tape, or markers (see Figure 1). The number and location of identification markers on a particular piping system is based on judgment.

**Color.** Colors listed in Table 3 are used to identify the characteristic properties of the contents. Color can be shown on or contiguous to the piping by any physical means, but it should be used

**Table 4 Size of Legend Letters**

<b>Outside Diameter of Pipe or Covering, in.</b>	<b>Length of Color Field A, in.</b>	<b>Size of Letters B, in.</b>
3/4 to 1 1/4	8	1/2
1 1/2 to 2	8	3/4
2 1/2 to 6	12	1-1/4
8 to 10	24	2-1/2
over 10	32	3-1/2

in combination with a legend. Color can be used in continuous total length coverage or in intermittent displays.

**Visibility.** Pipe markings should be highly visible. If pipe lines are above the normal line of vision, the lettering is placed below the horizontal centerline of the pipe (Figure 1).

**Type and Size of Letters.** Provide the maximum contrast between color field and legend (Table 3). Table 4 shows the size of letters recommended. Use of standard size letters of 1/2 in. or larger is recommended. For identifying materials in pipes of less than 3/4 in. in diameter and for valve and fitting identification, use a permanently legible tag.

**Unusual or Extreme Situations.** When the piping layout occurs in or creates an area of limited accessibility or is extremely complex, other identification techniques may be required. While a certain amount of imagination may be needed, the designer should always clearly identify the hazard and use the recommended color and legend guidelines.

**CODES AND STANDARDS**

ARI. 1988. Graphic electrical/electronic symbols for air-conditioning and refrigeration equipment. *Standard* 130-88.

ASHRAE. 2005. Graphic symbols for heating, ventilating, air-conditioning, and refrigeration systems. ANSI/ASHRAE *Standard* 134-2005.

ASME. 2007. Standard markers for pipe identification. ANSI/ASME *Standard* A13.1-2007. American Society of Mechanical Engineers, New York.

ASME. 1988. Letter symbols: Glossary of terms concerning letter symbols. *Standard* Y10.1-1972 (R1988). American Society of Mechanical Engineers, New York.

ASME. 1984. Letter symbols and abbreviations for quantities used in acoustics. *Standard* Y10.11-1984. American Society of Mechanical Engineers, New York.

ASME. 1987. Illuminating engineering. *Standard* Y10.18-1967 (R1977). American Society of Mechanical Engineers, New York.

ASME. 1999. Graphical symbols for pipe fittings, valves, and piping. *Standard* Y32.2.3. American Society of Mechanical Engineers, New York.

ASME. 1998. Graphical symbols for heating, ventilating, and air conditioning. *Standard* Y32.2.4. American Society of Mechanical Engineers, New York.

IEEE. 2004. Standard letter symbols for units of measurement. *Standard* 260.1-2004. Institute of Electrical and Electronics Engineers, Piscataway, NJ.

IEEE. 1996. Letter symbols and abbreviations used in acoustics. *Standard* 260.4-1996. Institute of Electrical and Electronics Engineers, Piscataway, NJ.

NEMA. 2002. Safety color code. *Standard* Z535-2002. National Electrical Manufacturers Association, Rosslyn, VA.

NFPA. 2006. Standard for fire safety and emergency symbols, 2006 edition. *Standard* 170. National Fire Protection Association, Quincy, MA.