Thermodynamics, Laws of: Two laws upon which rest the classical theory of thermodynamics. These laws have been stated in many different, but equivalent ways. *The First Law:* (1) When work is expended in generating heat, the quantity of heat produced is proportional to the work expended; and conversely, when heat is employed in the performance of work, the quantity of heat which disappears is proportional to the work done. (Joule)[a] (G.P.)[b]; (2) If a system is caused to change from an initial state to a final state by adiabatic means only, the work done is the same for all adiabatic paths connecting the two states. (Zemansky); (3) In any power cycle or refrigeration cycle the net heat absorbed by the working substance is exactly equal to the net work done. *The Second Law:* (1) It is impossible for a self-acting machine, unaided by any external agency, to convey heat from a body of lower to one of higher temperature. (Clausius) (G.P.); (2) It is impossible to derive mechanical work from heat taken from a body unless there is available a body of lower temperature into which the residue not so used may be discharged. (Kelvin) (G.P.); (3) It is impossible to construct an engine that, operating in a cycle, will produce no effect other than the extraction of heat from a reservoir and the performance of an equivalent amount of work (Zemansky).

Thermostat: An instrument which responds to changes in temperature, and which directly or indirectly controls temperature.

Transmittance, Thermal: The time rate of heat flow, from the fluid on the warm side to the fluid on the cold side, per (square foot) (degree temperature difference between the two fluids). Sometimes called *Overall Coefficient of Heat Transfer*.

Common unit is Btu per (hour) (square foot) (Fahrenheit degree). Symbol U.

Two-Pipe System (*Steam or Water*): A heating system in which one pipe is used for the supply of the heating medium to the heating unit, and another for the return of the heating medium to the source of heat supply. The essential feature of a two-pipe system is that each heating unit receives a direct supply of the heating medium, which medium cannot have served a preceding heating unit.

Up-Feed System: A heating system in which the supply mains are below the level of the heating units which they serve.

Vacuum Heating System: A two-pipe steam heating system equipped with the necessary accessory apparatus which will permit operating the system below atmospheric pressure when desired.

Vane Ratio: In air distributing devices the ratio of depth of vane to shortest opening width between two adjacent grille bars.

Vapor: The gaseous form of substances which are normally in the solid or liquid state, and which can be changed to these states either by increasing the pressure or decreasing the temperature. Vapors diffuse. (ASA definition.)

Vapor Heating System: A steam heating system which operates under pressures at or near atmospheric and which returns the condensate to the boiler or receiver by gravity. Vapor systems have thermostatic traps or other means of resistance on the return ends of the heating units for preventing steam from entering the return mains; they also have a pressure-equalizing and air-eliminating device at the end of the dry-return.

Velocity: A vector quantity which denotes at once the time rate and the direction of a linear motion. $V = \frac{ds}{dt}$. For uniform linear motion $V = \frac{s}{t}$. Common units are: feet per second.

Ventilation: The process of supplying or removing air, by natural or mechanical means, to or from any space. Such air may or may not have been conditioned. (See *Air Conditioning*.)

Viscosity: That property of semi-fluids, fluids, and gases by virtue of which they resist an instantaneous change of shape or arrangement of parts. It is the cause of fluid friction whenever adjacent layers of fluid move with relation to each other.

The coefficient of viscosity is the resistance offered by a layer of the fluid of unit area to the motion parallel to this area of another layer of the fluid at unit distance moving with unit velocity relative to the first layer. This coefficient is known as the *absolute viscosity*, and in cgs units is the force in dynes per square centimeter at a velocity of 1 cm per second at a distance of 1 cm. This unit of absolute viscosity is the poise. Values of absolute viscosity are frequently listed in centipoises, a centipoise being 1/100 of 1 *poise*.

In many formulas *absolute viscosity* is expressed in pounds per foot second or pounds per foot hour. Conversion from centipoises may be made as follows: viscosity in centipoises × 0.000672 = viscosity in pounds per foot second, or viscosity in centipoises × 2.42 = viscosity in pounds per foot hour.

Kinematic viscosity is the ratio of *absolute viscosity* to the density of a fluid. The unit is the stoke which equals one poise per cu cm per gram, or 1 sq cm per sec. For conversion to English units: kinematic viscosity in stokes × 0.001076 = kinematic viscosity in square feet per second.

Volume, Specific: The volume of a substance per unit mass; the reciprocal of density. Units: cubic feet per pound, cubic centimeters per gram, etc.

Warm Air Heating System: A warm air heating plant consists of a heating unit (fuel-burning furnace) enclosed in a casing, from which the heated air is distributed to various rooms of the building through ducts.

Warm Air Heating System, Forced: A warm air heating system in which circulation of air is effected by a fan. Such a system may include air cleaning devices.

Warm Air Heating System, Gravity: A warm air heating system in which the motive head producing flow depends on the difference in weight between the heated air leaving the casing and the cooler air entering the bottom of the casing.

Warm Air Heating System, Perimeter: A warm air heating system of the combination panel and convection type. Warm air ducts embedded in the concrete slab of a basementless house, around the perimeter, received heated air from a furnace and deliver it to the heated space through registers placed in or near the floor. Air is returned to the furnace from registers near the ceiling.

[a] Names of authors who first stated laws are given in parentheses.
[b] From *Glossary of Physics*, by LeRoy Dougherty Weld (McGraw-Hill, 1937).

THE GREEK ALPHABET

A α	Alpha	H η	Eta	N ν	Nu	T τ	Tau
B β	Beta	Θ ϑ θ	Theta	Ξ ξ	Xi	T υ	Upsilon
Γ γ	Gamma	I ι	Iota	O o	Omicron	Φ φ ϕ	Phi
Δ δ	Delta	K κ	Kappa	Π π	Pi	X χ	Chi
E ϵ	Epsilon	Λ λ	Lambda	P ρ	Rho	Ψ ψ	Psi
Z ζ	Zeta	M μ	Mu	Σ σ s	Sigma	Ω ω	Omega

CHAPTER 2

ABBREVIATIONS, SYMBOLS, CONVERSION FACTORS

Standard Abbreviations; Standard Symbols; Conversion Equations; Graphical Symbols for Piping, Ductwork, Heating and Ventilating, Refrigerating; Identification of Piping by Color

THIS chapter contains information regarding abbreviations, symbols, and conversion equations, which are of particular interest to the engineer engaged in heating, ventilating, and air conditioning.

ABBREVIATIONS

Abbreviations are shortened forms of names and expressions employed in texts and tabulations, and should not generally be used as symbols in equations. Most of the following abbreviations have been compiled from a list of approved standards.[1] In general, the period has been omitted in all abbreviations, except where the omission results in the formation of an English word.

Absolute	abs
Air horsepower	air hp
Alternating-current (as adjective)	a-c
Ampere	amp
Ampere-hour	amp-hr
Atmosphere	atm
Average	avg
Avoirdupois	avdp
Barometer	bar.
Boiling point	bp
Brake horsepower	bhp
Brake horsepower-hour	bhp-hr
British thermal unit	Btu
British thermal units per hour	Btuh
British thermal units per hour (thousands)	MBh
Calorie	cal
Centigram	cg
Centimeter	cm
Centimeter-gram-second (system)	cgs
Cubic	cu
Cubic centimeter	cu cm or cc
Cubic foot	cu ft
Cubic feet per minute	cfm
Cubic feet per second	cfs
Decibel	db
Degree[2]	deg or °
Degree, Centigrade	C
Degree, Fahrenheit	F
Degree, Kelvin	K
Degree, Rankine	R
Diameter	dia
Direct-current (as adjective)	d-c
Electromotive force	emf
Feet per minute	fpm
Feet per second	fps
Foot	ft
Foot-pound	ft-lb
Foot-pound-second (system)	fps
Freezing point	fp
Gallon	gal
Gallons per minute	gpm
Gallons per second	gps
Gram	g
Gram-calorie	g-cal
Horsepower	hp
Horsepower-hour	hp-hr
Hour	hr
Inch	in.
Inch-pound	in.-lb
Indicated horsepower	ihp
Indicated horsepower-hour	ihp-hr
Kilogram	kg
Kilowatt	kw
Kilowatt-hour	kwhr
Mass	mass
Melting point	mp
Meter	m
Micron	μ (mu)
Miles per hour	mph
Milinches	mi
Millimeter	mm
Minute	min
Molecular weight	mol wt
Mol	mol
Ounce	oz
Pound	lb
Pounds per square inch	psi
Pounds per square inch, gage	psig
Pounds per square inch, absolute	psia
Revolutions per minute	rpm
Revolutions per second	rps
Second	sec
Specific gravity	sp gr
Specific heat	sp ht
Square foot	sq ft
Square inch	sq in.
Watt	w
Watthour	whr

[1] Abbreviations for Scientific and Engineering Terms, Z10.1-1941 (American Standards Association).
[2] It is recommended that the abbreviation for the temperature scale, F, C, K, R, be included in expressions for numerical temperatures but, wherever feasible, the abbreviation for *degree* be omitted *e.g.*, 68 F.

SYMBOLS

A letter symbol is a single character, with subscript or superscript if required, used to designate a physical magnitude in mathematical equations and expressions. Two or more symbols together always represent a product. The following have been compiled from a selected list of approved standards.[3] Additional symbols and variations in the standard symbols found necessary in the individual chapters will be found in a list at the end of Chapters 3, 4, 13, and 53.

Acceleration, due to gravity	g
Acceleration, linear	a

[3] Letter Symbols for Mechanics of Solid Bodies, Z10.2-1948, and Letter Symbols for Heat and Thermodynamics, Y10.4-1957 (American Standards Association).