HVACR FORMULAS

TON OF REFRIGERATION - The amount of heat required to melt a ton (2000 lbs.) of ice at 32°F

288,000 BTU/24 hr.
12,000 BTU/hr.

APPROXIMATELY 2 inches Hg. (mercury) = **1 psi**

WORK = Force (energy exerted) X Distance
Example: A 150 lb. man climbs a flight of stairs 100 ft. high

Work = 150 lb. X 100 ft.
Work = 15,000 ft.-lb.

ONE HORSEPOWER = 33,000 ft.-lb. of work in 1 minute

ONE HORSEPOWER = 746 Watts

CONVERTING KW to BTU: 1 KW = 3413 BTU's

Example: A 20 KW heater (20 KW X 3413 BTU/KW = 68,260 BTU's

CONVERTING BTU to KW: 3413 BTU's = 1 KW
Example: A 100,000 BTU/hr. oil or gas furnace
(100,000 ÷ 3413 = 29.3 KW)

COULOMB = 6.24 X 10^{18} (1 Coulomb = 1 Amp)

E = voltage (emf)
I = Amperage (current)
R = Resistance (load)

WATTS (POWER) = volts x amps or P = E x I

$$P \text{ (in KW)} = \frac{E \times I}{1,000}$$

U FACTOR = reciprocal of R factor

Example: $\frac{1}{19}$ R = .05U

= BTU's transferred / 1 Sq.Ft. / 1°F / 1 Hour

VA (how the secondary of a transformer is rated) = volts X amps

Example: 24V x .41A = 10 VA

ONE FARAD CAPACITY = 1 amp. stored under 1 volt of pressure

MFD (microfarad) = $\frac{1}{1,000,000}$Farad

$\frac{LRA}{5}$ **(**Locked rotor amps) = FLA (Full Load Amps)

LRA = FLA x 5

TXV (shown in equilibrium)

	46.7	Bulb Pressure
Spring Pressure	9.7 37	Evaporator Pressure

Bulb Pressure = opening force
Spring and Evaporator Pressures = closing forces

RPM of motor =

$$\frac{60Hz\ x\ 120}{No.\ of\ Poles}$$

1800 RPM Motor – slippage makes it about 1750
3600 RPM Motor – slippage makes it about 3450

DRY AIR = 78.0% Nitrogen
21.0% Oxygen
1.0% Other Gases

WET AIR = Same as dry air **plus water vapor**

SPECIFIC DENSITY = $\frac{1}{Specific\,Volume}$

SPECIFIC DENSITY OF AIR = $\frac{1}{13.33}$ = .075 lbs./cu.ft.

STANDARD AIR = .24 Specific Heat (BTU's needed to raise 1 lb. 1 degree)

SENSIBLE HEAT FORMULA (Furnaces):

BTU/hr. – Specific Heat X Specific Density X 60 min./hr. **=** X CFM X ΔT

.24 X .075 X 60 X CFM X ΔT = 1.08 X CFM X ΔT

ENTHALPHY = Sensible heat and Latent heat

TOTAL HEAT FORMULA (for cooling, humidifying or dehumidifying)

BTU/hr. = Specific Density X 60 min./hr. X CFM X ΔH

= 0.75 x 60 x CFM x ΔH

= 4.5 x CFM x ΔH

RELATIVE HUMIDITY = $\frac{Moisture\ present}{Moisture\ air\ can\ hold}$

SPECIFIC HUMIDITY = grains of moisture per dry air

7000 GRAINS in 1 lb. of water

DEW POINT = when wet bulb equals dry bulb

TOTAL PRESSURE (Ductwork) = Static Pressure plus Velocity Pressure

CFM = Area (sq. ft.) X Velocity (ft. min.)

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HOW TO CALCULATE AREA

Rectangular Duct: $A = \underline{L \times W}$

Round Duct: $A = \frac{\pi D^2}{4}$ OR πr^2

RETURN AIR GRILLES – Net free area = about 75%

3 PHASE VOLTAGE UNBALANCE =

$$\frac{100\ x\ maximum\ deg.\ from\ average\ volts}{Average\ Volts}$$

NET OIL PRESSURE = Gross Oil Pressure – Suction Pressure

COMPRESSION RATIO =

$$\frac{Discharge\ Pressure\ Absolute}{Suction\ Pressure\ Absolute}$$

HEAT PUMP AUXILIARY HEAT – sized at 100% of load

ARI HEAT PUMP RATING POINTS (SEER Ratings) 47° 17°

NON-BLEND REFRIGERANTS:

Constant Pressure = Constant Temperature during Saturated Condition

BLENDS – Rising Temperature during Saturated Condition

28 INCHES OF WC = 1 psi

NATURAL GAS COMBUSTION:

Excess Air = 50%
15 ft^3 of air to burn 1 $ft.^3$ of methane produces:
- 16 $ft.^3$ of flue gases:
  - 1 $ft.^3$ of oxygen
  - 12 $ft.^3$ of nitrogen
  - 1 $ft.^3$ of carbon dioxide

2 $ft.^3$ of water vapor
Another 15 $ft.^3$ of air is added at the draft hood

GAS PIPING (Sizing – CF/hr.) = $\frac{Input\ BTU's}{Heating\ Value}$

Example: $\frac{80{,}000\ Input\ BTU's}{1000\ (Heating\ Value\ per\ CV\ of\ Natural\ Gas}$ = 80 CF/hr.

Example: $\frac{80{,}000\ Input\ BTU's}{2250\ (Heating\ Value\ per\ CV\ of\ Propane)}$ = 31 CF/hr.

FLAMMABILITY LIMITS	Propane	Butane	Natural Gas
	2.4 – 9.5	1.9 – 8.5	4 – 14

COMBUSTION AIR NEEDED	Propane	Natural Gas
(PC = Perfect Combustion)	23.5 $ft.^3$ (PC)	10 $ft.^3$ (PC)
(RC = Real Combustion)	36 $ft.^3$ (RC)	15 $ft.^3$ (RC)
ULTIMATE CO_2	13.7%	11.8%

CALCULATING OIL NOZZLE SIZE (GPH):

$\frac{BTU\ Input}{140{,}000\ BTUs}$ = Nozzle Size (GPH)

OR

$$\frac{BTU\ Output}{140{,}000\ x\ Efficiency\ of\ Furnace}$$

FURNACE EFFICIENCY:

% Efficiency = $\frac{energy\ output}{energy\ input}$

OIL BURNER STACK TEMPERATURE (Net) =

Highest Stack Temperature minus Room Temperature

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Example: 520° Stack Temp. – 70°Room Temp. = Net Stack Temperature of 450°

KELVIN TO CELSIUS: C = K – 273

CELSIUS TO KELVIN: K = C + 273

ABSOLUTE TEMPERATURE MEASURED IN KELVINS

SINE = side opposite / hypotenuse (sin) **COSINE =** side adjacent / hypotenuse (cos)

TANGENT = side opposite / side adjacent (tan)

PERIMETER OF SQUARE:	P = 4s	P = Perimeter
		s = side
PERIMETER OF RECTANGLE:	P = 2l + 2w	P = Perimeter
		l = length
		w = width
PERIMETER OF TRIANGLE:	P = a + b + c	P = Perimeter
		a = 1st side
		b = 2nd side
		c = 3rd side
PERIMETER OF CIRCLE:	C = πD	C = Circumference
	C = $2\pi r$	$\pi = 3.1416$
		D = Diameter
		r = radius

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AREA OF SQUARE:	$a = s^2$	A = Area
		s = side
AREA OF RECTANGLE:	A = lw	A = Area
		l = length
		w = width
AREA OF TRIANGLE:	A = 1/2bh	A = Area
		b = base
		h = height
AREA OF CIRCLE:	$A = \pi r^2$	A = Area
		$\pi = 3.1416$
	$A = \frac{\pi}{4} D^2$	r = radius
		D = Diameter
VOLUME OF RECTANGULAR SOLID:		
	V = l wh	V = Volume
		l = length
		w = width
		h = height
VOLUME OF CYLINDRICAL SOLID:		
	$V = \pi r^2 h$	V = Volume
		$\pi = 3.1416$
	$V = \frac{\pi}{4} D^2 h$	r = radius

D = Diameter

h = height

CAPACITANCE IN SERIES : $C = \frac{1}{\frac{1}{C1}+\frac{1}{C2}+\cdots}$

CAPACITANCE IN PARALLEL: $C = C_1 + C_2 + \ldots$

GAS LAWS:

Boyles Law: $P_1 V_1 = P_2 V_2$ P = Pressure (absolute)

V = Volume

Charles' Law: $\frac{P1}{T1} = \frac{P2}{T2}$ P = Pressure (absolute)

T = Temperature (absolute)

GENERAL GAS LAW: $\frac{P1\,V1}{T1} = \frac{P2\,V2}{T2}$ P = Pressuure (absolute)

V = Volume

T = Temperature (absolute)

PYTHAGOREAN THEOREM: $C^2 = a^2 + b^2$ c = hypotenuse

a & b = sides