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

\[
100,000 + 3413 = 29.3 \text{ KW}
\]

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

\[
E = \text{voltage (emf)}
I = \text{Amperage (current)}
R = \text{Resistance (load)}
\]

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

\[
P (\text{in KW}) = \frac{E \times I}{1,000}
\]
U FACTOR = reciprocal of R factor

Example: \( 1 \frac{R}{U} = \frac{.05}{U} \)

= 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

\[ MFD \text{ (microfarad)} = \frac{1}{1,000,000} \text{Farad} \]

\( LRA \) (Locked rotor amps) = FLA (Full Load Amps)

\[ LRA = FLA \times 5 \]

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 =

\[ \frac{60 \text{Hz} \times 120}{\text{No. of Poles}} \]

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 = \( \frac{1}{\text{Specific Volume}} \)

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 \( \Delta T \)

\[ .24 \times .075 \times 60 \times \text{CFM} \times \Delta T = 1.08 \times \text{CFM} \times \Delta T \]

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 \( \Delta H \)

= 0.75 x 60 x CFM x \( \Delta H \)

= 4.5 x CFM x \( \Delta H \)

RELATIVE HUMIDITY = \( \frac{\text{Moisture present}}{\text{Moisture air can hold}} \)

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.)
HOW TO CALCULATE AREA

Rectangular Duct: \[ A = L \times W \]

Round Duct: \[ A = \frac{\pi D^2}{4} \text{ OR } \pi r^2 \]

RETURN AIR GRILLES – Net free area = about 75%

3 PHASE VOLTAGE UNBALANCE =

\[
\frac{100 \times \text{maximum deg, from average volts}}{\text{Average Volts}}
\]

NET OIL PRESSURE = Gross Oil Pressure – Suction Pressure

COMPRESSION RATIO =

\[
\frac{\text{Discharge Pressure Absolute}}{\text{Suction Pressure Absolute}}
\]

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

BLEND – 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.) = \( \frac{\text{Input BTU’s}}{\text{Heating Value}} \)

Example:
\[
\frac{80,000 \text{ Input BTU’s}}{1000 (\text{Heating Value per CV of Natural Gas})} = 80 \text{ CF/hr.}
\]

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

FLAMMABILITY LIMITS

<table>
<thead>
<tr>
<th>Propane</th>
<th>Butane</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4 – 9.5</td>
<td>1.9 – 8.5</td>
<td>4 – 14</td>
</tr>
</tbody>
</table>

COMBUSTION AIR NEEDED (PC = Perfect Combustion)

<table>
<thead>
<tr>
<th>Propane</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.5 ft.³ (PC)</td>
<td>10 ft.³ (PC)</td>
</tr>
</tbody>
</table>

(RE = Real Combustion)

<table>
<thead>
<tr>
<th>Butane</th>
<th>Propane</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 ft.³ (RC)</td>
<td>15 ft.³ (RC)</td>
</tr>
</tbody>
</table>

ULTIMATE CO₂

<table>
<thead>
<tr>
<th>Propane</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.7%</td>
<td>11.8%</td>
</tr>
</tbody>
</table>

CALCULATING OIL NOZZLE SIZE (GPH):

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

OR

\[
\frac{\text{BTU Output}}{140,000 \times \text{Efficiency of Furnace}}
\]

FURNACE EFFICIENCY:

\[
\% \text{ Efficiency} = \frac{\text{energy output}}{\text{energy input}}
\]

OIL BURNER STACK TEMPERATURE (Net) =

Highest Stack Temperature minus Room Temperature
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**

<table>
<thead>
<tr>
<th>SINE = side opposite</th>
<th>COSINE = side adjacent</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sin )</td>
<td>( \cos )</td>
</tr>
<tr>
<td>hypotenuse</td>
<td>hypotenuse</td>
</tr>
</tbody>
</table>

**TANGENT = side opposite**

<table>
<thead>
<tr>
<th></th>
<th>tan side adjacent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \tan )</td>
</tr>
</tbody>
</table>

**PERIMETER OF SQUARE:**

\[ P = 4s \]

\( s \) = side

**PERIMETER OF RECTANGLE:**

\[ P = 2l + 2w \]

\( l \) = length

\( w \) = width

**PERIMETER OF TRIANGLE:**

\[ P = a + b + c \]

\( a \) = 1\textsuperscript{st} side

\( b \) = 2\textsuperscript{nd} side

\( c \) = 3\textsuperscript{rd} side

**PERIMETER OF CIRCLE:**

\[ C = \pi D \]

\[ C = 2\pi r \]

\( \pi = 3.1416 \)

\( D \) = Diameter

\( r \) = radius
AREA OF SQUARE: \[ a = s^2 \] \[ A = \text{Area} \]
\[ s = \text{side} \]

AREA OF RECTANGLE: \[ A = lw \] \[ A = \text{Area} \]
\[ l = \text{length} \]
\[ w = \text{width} \]

AREA OF TRIANGLE: \[ A = \frac{1}{2}bh \] \[ A = \text{Area} \]
\[ b = \text{base} \]
\[ h = \text{height} \]

AREA OF CIRCLE: \[ A = \pi r^2 \] \[ A = \text{Area} \]
\[ \pi = 3.1416 \]
\[ A = \frac{\pi}{4} D^2 \] \[ r = \text{radius} \]
\[ D = \text{Diameter} \]

VOLUME OF RECTANGULAR SOLID: \[ V = lwh \] \[ V = \text{Volume} \]
\[ l = \text{length} \]
\[ w = \text{width} \]
\[ h = \text{height} \]

VOLUME OF CYLINDRICAL SOLID: \[ V = \pi r^2 h \] \[ V = \text{Volume} \]
\[ \pi = 3.1416 \]
\[ V = \frac{\pi}{4} D^2 h \] \[ r = \text{radius} \]
D = Diameter

h = height

CAPACITANCE IN SERIES: \[ C = \frac{1}{C_1 + \frac{1}{C_2} + \ldots} \]

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: \( \frac{P_1}{T_1} = \frac{P_2}{T_2} \) \( P = \) Pressure (absolute)
\( T = \) Temperature (absolute)

GENERAL GAS LAW: \( \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \) \( P = \) Pressure (absolute)
\( V = \) Volume
\( T = \) Temperature (absolute)

PYTHAGOREAN THEOREM: \( c^2 = a^2 + b^2 \) \( c = \) hypotenuse
\( a & b = \) sides