2.0 KEY EQUATIONS

Evaporator Net Refrigeration Effect

$$Q_{net\ refrigeration\ effect}\ [Btu] = (H_1 - H_4)\left[\frac{Btu}{lb}\right] * (Refrig\ Flow\ Rate)\left[\frac{lb}{min}\right] * (60)\left[\frac{min}{hr}\right]$$

$$H_1 = leaving\ evaporator\ enthalpy\left[\frac{Btu}{lb}\right];\ H_4 = entering\ evaporator\ enthalpy\ [\frac{Btu}{lb}]$$

Compressor Work

$$W_{compressor}\ [Btu] = (H_2 - H_1)\left[\frac{Btu}{lb}\right] * (Refrig\ Flow\ Rate)\left[\frac{lb}{min}\right] * (60)\left[\frac{min}{hr}\right]$$

$$H_2 = leaving\ compressor\ enthalpy\left[\frac{Btu}{lb}\right];\ H_1 = entering\ condneser\ enthalpy\ [\frac{Btu}{lb}]$$

Net Condenser Effect

$$Q_{net\ condenser\ effect}\ [Btu] = (H_2 - H_4)\left[\frac{Btu}{lb}\right] * (Refrig\ Flow\ Rate)\left[\frac{lb}{min}\right] * (60)\left[\frac{min}{hr}\right]$$

$$H_2 = entering\ condenser\ enthalpy\left[\frac{Btu}{lb}\right];\ H_4 = leaving\ condneser\ enthalpy\ [\frac{Btu}{lb}]$$

Net Condenser Effect Function of Compressor Work and Net Refrigeration Effect

$$Q_{net\ condenser\ effect}\ [Btu] = W_{compressor}\ [Btu] + Q_{net\ refrigeration\ effect}\ [Btu]$$

Coefficient of Performance

$$COP = \frac{W_{out}}{W_{in}} = \frac{Q_{net\ refrigeration\ effect}\ [Btu]}{W_{compressor}\ [Btu]}$$

Refrigeration Room Ventilation Rate

$Q[CFM] = 100XG^{0.5}$, where G = lbs of refrigerant.

2.0 KEY EQUATIONS AND TERMS

◆ Relationship of Enthalpy of Vaporization, Enthalpy of Saturated Vapor and Liquid Water

$$h_g = h_f + h_{fg}$$
$$h_g = enthalpy\ of\ saturated\ vapor[\frac{Btu}{lbm}]$$
$$h_f = enthalpy\ of\ saturated\ liquid$$
$$h_{fg} = enthalpy\ of\ vaporization$$
$$*\ all\ enthalpies\ at\ constant\ temperature\ \&\ pressure$$

◆ Enthalpy of Wet Steam (Mixed Region) as a Function of Steam Quality

$$h_{mix} = h_f + x * h_{fg}$$
$$h_{mix} = enthalpy\ of\ wet\ steam\ (mix\ of\ liquid\ \&\ vapor)$$
$$x = steam\ quality, drnyess\ fraction, \%\ vapor$$

◆ Relationship of Entropy of Vaporization, Entropy of Saturated Vapor and Liquid Water

$$s_g = s_f + s_{fg}$$
$$s_g = entropy\ of\ saturated\ vapor[$$
$$s_f = entropy\ of\ saturated\ liquid$$
$$s_{fg} = entropy\ of\ vaporization$$

◆ Entropy of Wet Steam (Mixed Region) as a Function of Steam Quality

$$s_{mix} = s_f + x * s_{fg}$$
$$s_{mix} = entropy\ of\ wet\ steam\ (mix\ of\ liquid\ \&\ vapor)$$
$$x = steam\ quality, drnyess\ fraction, \%\ vapor$$

◆ Heat Available from Condensing Steam

$$Q = \dot{m} * h_{fg}$$
$$\dot{m} = mass\ flow\ rate\ [\frac{lbm}{hr}]$$
$$Q = energy\ [\frac{Btu}{hr}]$$

◆ Throttling: Irreversible Adiabatic [Constant Enthalpy] or Isenthalpic

$$h_{initial} = h_{final}$$

◆ Tank Heating/Cooling: Isometric [Constant Volume]

$$v_{initial} = v_{final}$$
$$v = specific\ volume\ [\frac{ft^3}{lb}]$$

◆ Turbine Expansion: Isentropic [Constant Entropy] or Reversible Adiabatic

$$s_{initial} = s_{final}$$

◆ Compressor: Isentropic [Constant Entropy] or Reversible Adiabatic

$$s_{initial} = s_{final}$$

◆ Boiler Heating: Isobaric [Constant Pressure]

$$P_{initial} = P_{final}$$
$$P = pressure\ [psia]$$

◆ Heat Exchanger (Boiling or Condensing): Isothermal [Constant Temperature]

$$T_{initial} = T_{final}$$

◆ Boiler Efficiency

$$\varepsilon_{boiler} = \frac{(\dot{m}_{feedwater}) * (H_{steam,out} - H_{feedwater,in)}}{\dot{m}_{fuel} * HHV}$$

◆ Convert Feed-Water Flowrate in GPM to Steam Flowrate in lbs/hr

$$1 \frac{gallon\ of\ water}{minute} * [\frac{1\ ft^3}{7.48\ gallon} * \frac{62.4\ lb}{ft^3} * \frac{60\ minute}{hour}] = 500 \frac{lbs}{hr}$$

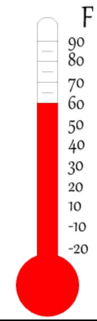
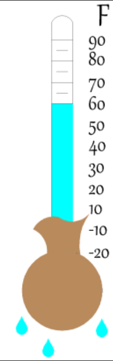
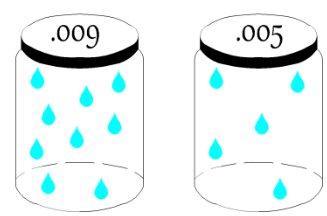
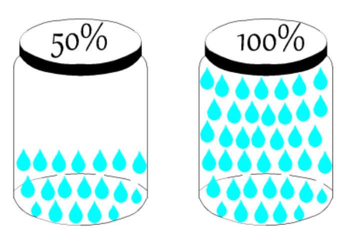
◆ Simplified Steam Heating Coil: Steam to Water Heat Transfer

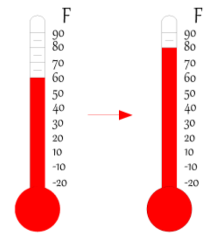
$$\dot{m}_{steam} * h_{fg} = 500 * GPM_{water} * \Delta T$$

◆ Simplified Steam Heating Coil: Steam to Air Heat Transfer

$$\dot{m}_{steam} * h_{fg} = 1.08 * CFM_{air} * \Delta T$$

2.0 KEY TERMS

1	**Dry Bulb Temperature**	Dry bulb temperature indicates the amount of energy independent of the amount of water in the air. *Measured with a thermometer.* $\boldsymbol{Units} = [°F]$	
2	**Wet Bulb Temperature**	Wet bulb temperature indicates the amount of water in the air. *Measured with a sling psychrometer or hygrometer*. $\boldsymbol{Units} = [°F]$	
3	**Dew Point**	The temperature at which moist air must be cooled to, in order for water to condense out of the air. $\boldsymbol{Units} = [°F]$	
4	**Humidity Ratio**	Humidity ratio or specific humidity is the measure of the amount of water in air. $Units = [\frac{\boldsymbol{lb\ of\ Water\ Varpor}}{\boldsymbol{lb\ of\ Dry\ Air}}]$	
5	**Relative Humidity**	Relative Humidity indicates the amount of water in the air relative to the total amount of water the air can hold. *Units = [%]*	

6	**Sensible Heat**	Sensible heat indicates the amount of dry heat. It indicates the amount of energy either absorbed or released to change the dry bulb temperature of the air. $Units = [\frac{Btu}{lb\ of\ air}]$	
7	**Latent Heat**	Latent heat indicates the amount of energy in the air due to moisture. It is the amount of heat released when water in the air condenses out or the amount of heat absorbed by water in order to vaporize the water. $Units = [\frac{Btu}{lb\ of\ air}]$	
8	**Enthalpy**	Enthalpy is an indication of the total amount of energy in the air, both sensible and latent. $Units = [\frac{Btu}{lb\ of\ air}]$	

Exam Tip #1: Do not spend enormous amounts of time trying to interpolate the exact value on the psychrometric chart.

The psychrometric chart is provided as part of the NCEES exam, but the chart is small and unclear compared to the ones typically used in practice. It is the opinion of the writer that this fact should indicate to the test taker that it is not important to get the values to the nearest 0.0001 (exaggeration) because it is impossible. In addition, the exam writer would not provide possible multiple choice answers that are fairly close together because of the confusion that would arise.

Exam Tip #2: During the exam, do not write on anything that is not part of the exam, including your own psychrometric chart. This may result in disqualification.

3.0 KEY EQUATIONS

◆ Sensible Heat Equation

$$Q_{sensible} = 1.08 * \Delta T_{DB} * CFM$$

$$Q_{sensible} = sensible\ heat\ [\frac{Btu}{hr}]$$

$$\Delta T_{DB} = difference\ in\ dry\ bulb\ temperature\ between\ entering\ and\ leaving$$

$$CFM = volumetric\ flow\ rate, cubic\ feet\ per\ minute$$

◆ Latent Heat Equation

$$\boldsymbol{Q_{latent} = 0.68 * \Delta W_{GR} * CFM}$$

$$Q_{latent} = latent\ heat\ [\frac{Btu}{hr}]$$

$$\Delta \boldsymbol{W_{GR}} = change\ in\ humidity\ ratio\ [\frac{gains\ of\ water\ vapor}{lb\ of\ dry\ air}]$$

$$CFM = volumetric\ flow\ rate, cubic\ feet\ per\ minute$$

◆ Latent Heat Equation

$$\boldsymbol{Q_{latent} = 4,840 * \Delta W_{LB} * CFM}$$

$$Q_{latent} = latent\ heat\ [\frac{Btu}{hr}]$$

$$\Delta \boldsymbol{W_{lb}} = change\ in\ humidity\ ratio\ [\frac{lbs\ of\ water\ vapor}{lb\ of\ dry\ air}]$$

$$CFM = volumetric\ flow\ rate, cubic\ feet\ per\ minute$$

◆ Total Heat Equation

$$\boldsymbol{Q_{total} = 4.5 * (\Delta h) * CFM}$$

$$Q_{total} = total\ heat\ [\frac{Btu}{hr}]$$

$$\Delta \boldsymbol{h} = change\ in\ enthalpy\ between\ entering\ and\ leaving$$

$$CFM = volumetric\ flow\ rate, cubic\ feet\ per\ minute$$

◆ Air Mixing Equation - Dry Bulb

$$\boldsymbol{T_{mix,DB} = T_{1,DB} * \%_1 + T_{2,DB} * \%_2}$$

$$\boldsymbol{T_{mix,DB}} = mixed\ air\ dry\ bulb\ temperature$$

$$\boldsymbol{T_{1,DB}} = air\ stream\ 1\ dry\ bulb\ temperature$$

$$\%_{\boldsymbol{1}} = air\ stream\ 1\ percent\ by\ mass$$

$$\boldsymbol{T_{2,DB}} = air\ stream\ 2\ dry\ bulb\ temperature$$

$$\%_{\boldsymbol{2}} = air\ stream\ 2\ percent\ by\ mass$$

◆ Air Mixing Equation - Dry Bulb

$$T_{mix,DB} = \frac{T_{1,DB} * CFM_1 + T_{2,DB} * CFM_2}{CFM_1 + CFM_2}$$

$$CFM_1 = air\ stream\ 1\ volumetric\ flow\ rate$$
$$CFM_2 = air\ stream\ 2\ volumetric\ flow\ rate$$

◆ Air Mixing Equation - Enthalpy

$$h_{mix} = h_{1,DB} * \%_1 + h_{2,DB} * \%_2$$
$$h_{mix} = mixed\ air\ enthalpy$$
$$h_1 = air\ stream\ 1\ enthalpy$$
$$\%_1 = air\ stream\ 1\ percent\ by\ mass$$
$$h_2 = air\ stream\ 2\ enthalpy$$
$$\%_2 = air\ stream\ 2\ percent\ by\ mass$$

◆ Air Mixing Equation - Enthalpy

$$h_{mix} = \frac{h_1 * CFM_1 + h_2 * CFM_2}{CFM_1 + CFM_2}$$

◆ Relative Humidity as a Function of Humidity Ratio and Partial Pressures

$$RH = \frac{p_w}{p_{SAT}} x\ 100\% \approx \frac{W_w}{W_{SAT}} x\ 100\%$$

$$RH = relative\ humidity$$
$$p_w = partial\ pressure\ of\ water\ vapor\ in\ the\ air\ stream$$
$$p_{SAT} = saturated\ vapor\ pressure\ of\ water\ at\ the\ temperature\ in\ question$$
$$W_w = humidity\ ratio\ of\ the\ air\ stream$$
$$W_{SAT} = humidity\ ratio\ of\ the\ air\ stream\ at\ saturation\ at\ the\ temperature\ in\ question$$

2.0 IMPORTANT TERMS & EQUATIONS

◆ Convert U-Factor to R-Value

$$U = \frac{1}{R}$$

$$U = heat\ transfer\ coefficient\ [\frac{Btu}{hr * ft^2 * °F}]$$

$$R = thermal\ resistance\ [\frac{hr * ft^2 * °F}{Btu}]$$

◆ Addition of R-Values

$$R_{total} = R_1 + R_2 + R_3 \ldots + R_n$$

◆ Addition of U-Factors

$$\frac{1}{U_{total}} = \frac{1}{U_1} + \frac{1}{U_2} + \frac{1}{U_3} \ldots + \frac{1}{U_n}$$

◆ Thermal Conductivity Units

$$k = \frac{Btu}{hr * ft * °F}$$

◆ Convert Thermal Conductivity to R-Value and U-Factor

$$R = \frac{t}{k}$$

$$t = thickness\ of\ material\ [ft]$$

$$k = thermal\ conductivity\ [\frac{Btu}{hr * ft * °F}$$

$$U = \frac{k}{t}$$

◆ Heat Transfer Equation

$$Q = U * A * \Delta T$$

$$U = overall\ heat\ transfer\ coefficient[\frac{Btu}{hr * ft^2 * °F}]$$

$$A = area\ of\ heat\ transfer\ [ft^2]$$

$$\Delta T = temperature\ difference\ between\ hot\ and\ cold\ areas\ of\ heat\ transfer\ [°F]$$

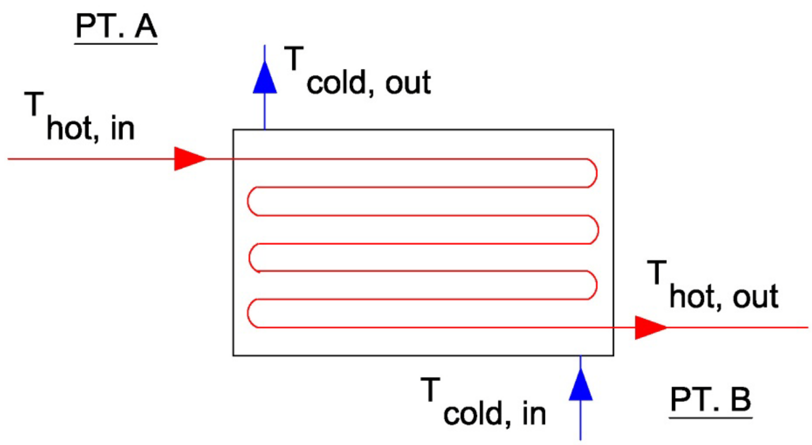
◆ Log Mean Temperature Difference (LMTD)

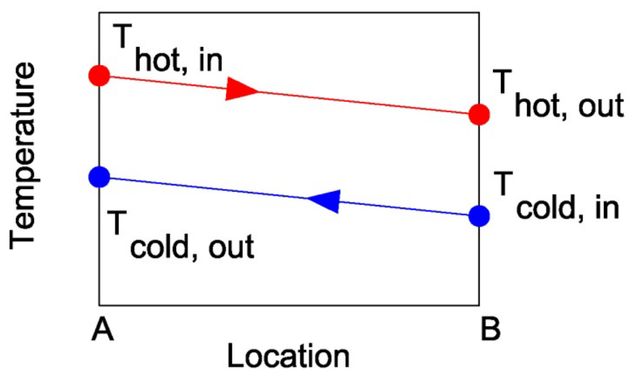
$$LMTD = \frac{\Delta T_a - \Delta T_b}{\ln\left(\frac{\Delta T_a}{\Delta T_b}\right)}$$

$$\Delta T_a = temperature\ difference\ at\ entrance$$

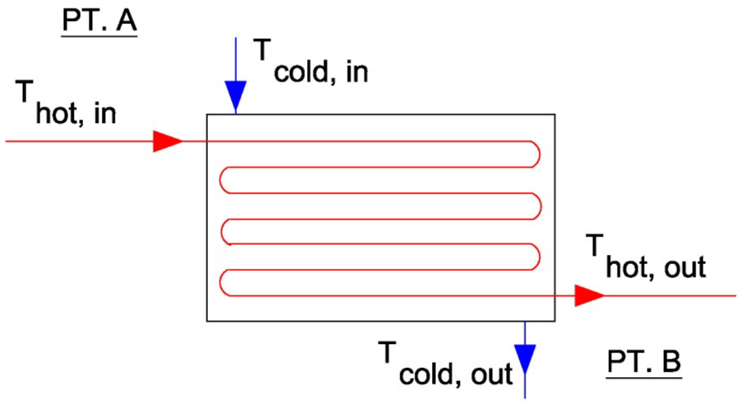
$$\Delta T_b = temperature\ difference\ at\ exit$$

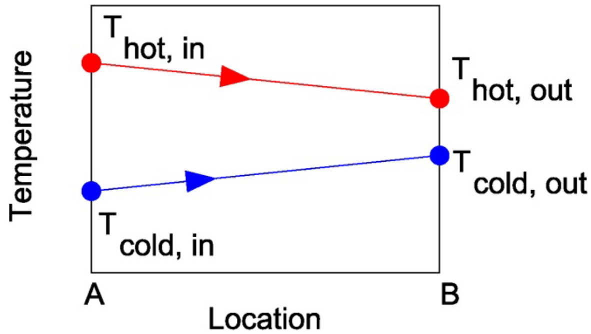
◆ Counter-flow Heat Exchanger





◆ Parallel-flow Heat Exchanger





◆ Conduction Heat Transfer Equation

$$Q = \frac{k * A * (T_{hot} - T_{cold})}{t}$$

$$where\ Q = quantity\ of\ heat\ transfered\ \left[\frac{Btu}{hr}\right]$$

$$k = thermal\ conductivity\ of\ material\ \left[\frac{Btu}{hr * ft * °F}\right]$$

$$T_{hot} - T_{cold} = temperature\ difference\ between\ indoors\ and\ outdoors\ [°F]$$

$$t = thickness\ of\ material\ [ft]$$

$$A = area\ of\ heat\ transfer\ [ft^2]$$

◆ Convective Heat Transfer Equation

$$Q = h * A * \Delta T$$

$$h = convective\ heat\ transfer\ coefficient[\frac{Btu}{hr * ft^2 * °F}]$$

$$A = area\ of\ heat\ transfer\ [ft^2]$$

$$\Delta T = temperature\ difference\ between\ hot\ and\ cold\ areas\ of\ heat\ transfer\ [°F]$$

◆ Radiative Heat Transfer Equation

$$Q = h_{rad} * A * \Delta T$$

$$h_{rad} = radiation\ heat\ transfer\ coefficient [\frac{Btu}{hr * ft^2 * °F}]$$

$$A = area\ of\ heat\ transfer\ [ft^2]$$

$$\Delta T = temperature\ difference\ between\ hot\ and\ cold\ areas\ of\ heat\ transfer\ [°F]$$

2.0 KEY EQUATIONS AND TERMS

◆ Mechanical Horsepower of a Fan

$$MHP = \frac{CFM * TSP[in.wg]}{6{,}356}$$

$$MHP = mechanical\ horse\ power\ [HP]$$
$$CFM = airflow$$
$$TSP = total\ static\ pressure\ [in.wg]$$

◆ Convert Mechanical Horsepower to Brake Horsepower

$$BHP = MHP * \left(\frac{1}{fan\ efficiency}\right)$$

◆ Convert Brake Horsepower to Electric Horsepower

$$HP = BHP * \left(\frac{1}{motor\ efficiency}\right)$$

◆ Velocity Pressure as a Function of Air Velocity

$$VP = \frac{FPM}{4005}\ [in.wg]$$

$$FPM = air\ velocity\ in\ feet\ per\ minute$$
$$VP = velocity\ pressure\ [in.wg]$$

◆ Simplified Sensible Heat Equation

$$Q\left[\frac{Btu}{h}\right] = 1.08 * CFM * \Delta T[°\mathrm{F}]$$
$$*\ air\ conditions\ at\ 70°\mathrm{F}\ and\ 1\ atm.$$

◆ Friction loss due to length of duct

$$F_{duct}[in.wg] = L[ft] * f\left[\frac{in.wg}{100\ ft}\right]$$

◆ Fan Affinity Laws

$$\textbf{CASE 1}: \ N_{old} = N_{new}$$
$$CFM_{new} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^1 CFM_{old}$$
$$P_{new} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^2 P_{old}$$
$$BHP_{new} = \left(\frac{RPM_{new}}{RPM_{old}}\right)^3 BHP_{old}$$

◆ Fan Affinity Laws

$$\textbf{CASE 2}: \ RPM_{old} = RPM_{new}$$
$$CFM_{new} = \left(\frac{N_{new}}{N_{old}}\right)^1 CFM_{old}$$
$$P_{new} = \left(\frac{N_{new}}{N_{old}}\right)^2 P_{old}$$
$$BHP_{new} = \left(\frac{N_{new}}{N_{old}}\right)^3 BHP_{old}$$

◆ Bypass Factor Equation for Coils

$$Bypas\ Factor = \frac{h_{entering\ coil} - h_{leaving\ coil}}{h_{entering\ coil} - h_{apparatus\ dew\ point}}$$

where h is equal to the enthalpy

◆ Bypass Factor Equation for Coils

$$Bypas\ Factor = \frac{T_{entering\ coil} - T_{leaving\ coil}}{T_{entering\ coil} - T_{apparatus\ dew\ point}}$$

where T is equal to the dry bulb temperature

◆ Bypass Factor Equation for Coils

$$Bypas\ Factor = \frac{W_{entering\ coil} - W_{leaving\ coil}}{W_{entering\ coil} - W_{apparatus\ dew\ point}}$$

where W is equal to the humidity ratio

Moisture Transfer Equation

$$H = 60 * \rho * Q * (W_{exit} - W_{enter})$$
$$W = the\ humidity\ ratio\ entering\ or\ leaving\ the\ system\ \frac{[lb\ of\ water]}{[lb\ of\ dry\ air]}$$
$$\rho = density\ of\ air\ [\frac{lb}{ft^3}]$$
$$Q = air\ flow\ rate\ [\frac{ft^3}{min}]$$
$$H = moisture\ transferred\ [\frac{lb}{hr}]$$

Energy Recovery Device Efficiency Equations

$$\varepsilon_{sensible} = \frac{q_{sensible,actual}}{q_{sensible,max}}$$
$$\varepsilon_{latent} = \frac{q_{latent,actual}}{q_{latent,max}}$$
$$\varepsilon_{total} = \frac{q_{total,actual}}{q_{total,max}}$$

Energy Recovery Device Determine Actual Sensible Heat Transferred

$$q_{sensible,actual} = 1.08 * CFM_{outdoor} * (T_{outdoor} - T_{supply})$$
$$q_{sensible,actual} = 1.08 * CFM_{return} * (T_{return} - T_{exhaust})$$

Energy Recovery Device Determine Maximum Possible Sensible Heat Transferred

$$q_{sensible,max} = 1.08 * CFM_{min} * (T_{outdoor} - T_{return})$$

Energy Recovery Device Determine Actual Latent Heat Transferred

$$q_{latent,actual} = 4{,}770 * CFM_{outdoor} * (W_{outdoor} - W_{supply})$$
$$q_{latent,actual} = 4{,}770 * CFM_{return} * (W_{return} - W_{exhaust})$$

Energy Recovery Device Determine Maximum Possible Latent Heat Transferred

$$q_{latent,max} = 4{,}770 * CFM_{return} * (W_{outdoor} - W_{return})$$

Energy Recovery Device Determine Actual Enthalpy Transferred

$$q_{total,actual} = 4.5 * CFM_{outdoor} * (h_{outdoor} - h_{supply})$$
$$q_{stotal,actual} = 4.5 * CFM_{return} * (h_{return} - h_{exhaust})$$

Energy Recovery Device Determine Maximum Possible Enthalpy Transferred

$$q_{total,max} = 4.5 * CFM_{outdoor} * (h_{outdoor} - h_{return})$$

Darcy Weisbach Equation

$$h = \frac{fLv^2}{2Dg} \; [Darcy\ Weisbach\ Equation]$$
$$where\ h = ft\ of\ head; f = Darcy\ friction\ factor; v = velocity\ \left[\frac{ft}{sec}\right],$$
$$D = inner\ diameter\ [ft], g = gravity\ [32.2 \frac{ft}{sec^2}]$$

Darcy Weisbach Equation

$$h = \frac{fLv^2}{2Dg} \; [Darcy\ Weisbach\ Equation]$$
$$where\ h = ft\ of\ head; f = Darcy\ friction\ factor; v = velocity\ \left[\frac{ft}{sec}\right],$$
$$D = inner\ diameter\ [ft], g = gravity\ [32.2 \frac{ft}{sec^2}]$$

Positive Suction Head Equation

$$\boldsymbol{P_{suct}} = \pm \boldsymbol{P_{elev}} - \boldsymbol{P_{fric}} + \boldsymbol{P_{vel}}$$

Pressure Drop due to Velocity Equation [Pump]

$$\frac{\boldsymbol{V^2}}{\boldsymbol{2g}} [ft\ of\ head]; velocity\ in \frac{ft}{sec};$$
$$gravity = 32.2 \frac{ft}{\mathrm{sec}^2}$$

◆ Pump Affinity Laws

$$\frac{Q_1}{Q_2} = \frac{D_1}{D_2}; if\ speed\ is\ held\ constant$$
$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}; if\ diameter\ is\ held\ constant$$

◆ Pump Affinity Laws

$$\frac{H_1}{H_2} = \frac{D_1^2}{D_2^2}; if\ speed\ is\ held\ constant$$
$$\frac{H_1}{H_2} = \frac{N_1^2}{N_2^2}; if\ diameter\ is\ held\ constant$$

◆ Pump Affinity Laws

$$\frac{P_1}{P_2} = \frac{D_1^3}{D_2^3}; if\ speed\ is\ held\ constant$$
$$\frac{P_1}{P_2} = \frac{N_1^3}{N_2^3}; if\ diameter\ is\ held\ constant$$

◆ Heat Transfer Between Pipe to Outer Surface

$$Q_{pipe\ to\ outer\ surface} = \frac{k[\frac{Btu * in}{h * ft^2 * °F}]}{X[in]} * A[ft^2] * (T_{outer\ surface} - T_{pipe})[°F]$$

Where k is equal to the conductivity of the insulation and X is equal to the thickness of the insulation. K can vary depending on the temperature of the pipe.

◆ Heat Transfer Between Pipe Surface and Air

$$Q_{outer\ surface\ to\ air} = h[\frac{Btu}{ft^2 * h * °F}] * A[ft^2] * (T_{ambient} - T_{outer\ surface})[°F]$$

Where h is equal to the surface coefficient of the insulation. This value is a measure of how well the surface of the material in question is at conducting heat to the ambient air. The value can increase for higher wind speeds and varying surface and air temperatures.

◆ Cooling Tower Range

$$Range = T_{water,in}\ [°F] - T_{water,out}\ [°F]$$

◆ Cooling Tower Apprach

$$Approach = T_{water,out}\ [°F] - T_{air\ in,WB}\ [°F]$$

◆ Cooling Tower Effectiveness

$$Effectiveness = \frac{Range}{Range + \ Approach}$$

◆ Cooling Tower Evaporation Rate

$$.000943 * cooling\ tower\ flow\ rate \left[\frac{gal}{min}\right] * \left(T_{water,In} - T_{water,out}\right) = evaporation\ rate \left[\frac{gal}{min}\right]$$

◆ Combining the Sound Levels of Multiple Sources

$$L_A = 10 * \log_{10}(10^{\frac{DB_1}{100}} + 10^{\frac{DB_2}{100}} + 10^{\frac{DB_3}{100}} + 10^{\frac{DB_4}{100}} + 10^{\frac{DB_5}{100}} + 10^{\frac{DB_6}{100}} + v10^{\frac{DB_7}{100}} + 10^{\frac{DB_8}{100}})$$

◆ Sound Level at a Distance from a Point Source (Spherical Propagation)

$$L_{db} = L_{equip} - 20 * \log_{10} x - 1$$
$$L_{db} = Sound\ level\ at\ a\ distance\ of\ x\ [DB]$$
$$L_{equip} = Sound\ level\ of\ equipment\ [DB]$$
$$x = distance\ from\ equipment\ [ft']$$

◆ Sound Level at a Distance from a Point Source (Half-Spherical Propagation)

$$L_{db} = L_{equip} - 20 * \log_{10} x + 2$$

◆ Sound Level at a Distance from a Point Source (Quarter-Spherical Propagation)

$$L_{db} = L_{equip} - 20 * \log_{10} x + 5$$

◆ Sound Level at a Distance from a Point Source (Eighth-Spherical Propagation)

$$L_{db} = L_{equip} - 20 * \log_{10} x + 8$$

2.0 EQUATIONS/TERMS

◆ Ohm's Law

$$I = \frac{V}{R}$$
$$I = current\ [amps]$$
$$V = voltage\ [volts]$$
$$R = resistantce\ [amps]$$

◆ Resistors in series

$$R_{eq,series} = R_1 + R_2 + R_3 + R_n$$

◆ Resistors in parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_n}$$

◆ Power Equations

$$P = I * V$$
$$P = \frac{V^2}{R}$$
$$P = I^2 * R$$

◆ Pump Water Horsepower Equations

$$P_{mech\ work,pump[HP]} = \frac{h_{ft} * Q_{gpm} * (SG)}{3956};$$

$$Q = volumetric\ flow\ rate\ [gallons\ per\ minute]$$
$$h = pressure\ [feet\ of\ head]$$
$$P = power\ [horesepower]$$
$$SG = specific\ gravity$$

$$P_{mech\ work,pump,[HP]} = \frac{p_{psi} * Q_{gpm} * (SG)}{1{,}714};$$
$$p = pressure\ [psi]$$

◆ Fan Mechanical Horsepower Equation

$$P_{mech\ work,fan[HP]} = \frac{Q_{cfm} * TP_{in\ wg}}{6356};$$
$$Q_{cfm} = volumetric\ flow\ rate\ of\ air\ [cubic\ feet\ per\ minute]$$
$$TP_{in\ wg} = total\ pressure\ [inches\ water\ gauge]$$
$$P_{mech\ work,fan[HP]} = fan\ mechanical\ horsepower$$

◆ Pump or Fan Brake Horsepower Equation

$$P_{fan/pump[HP]} = \frac{P_{mech\ work[HP]]}}{\varepsilon_{fan/pump}};$$

◆ Motor Horsepower Equation

$$P_{motor} = \frac{P_{mech\ work[HP]]}}{\varepsilon_{motor}};$$

◆ Electrical Power Supplied to Motor

$$P_{supplied\ to\ motor[HP]} = \frac{P_{motor[HP]}}{PF}$$

Conversion	Formula	Factor Value
Present Value to Future Value	$FV = PV\ x\ (1+i)^n$	Multiply PV by (F/P, i, n)
Future Value to Present Value	$PV\ = \frac{FV}{(1+i)^n}$	Multiply FV by (P/F, i, n)
Present Value to Annual Value	$A = PV * (\frac{i*(1+i)^n}{(1+i)^n - 1})$	Multiply PV by (A/P, i, n)
Annual Value to Present Value	$PV = A * (\frac{1-(1+i)^{-n}}{i})$	Multiply A by (P/A, i, n)
Future Value to Annual Value	$A = FV(\frac{i}{(1+i)^n - 1})$	Multiply FV by (A/F, i, n)
Annual Value to Future Value	$FV = A * (\frac{(1+i)^n - 1}{i})$	Multiply A by (F/A, i, n)