NEBB

ABBREVIATIONS			
A	Area	lx	Lux
ACH	Air Changes per Hour	M	Mass
A_k	Effective Area	ma	Mixed Air
AVG	Average	m	Meters / Metres
BHP	Brake Horsepower	m^3/s	Volumetric Flow: Cubic Meters Per Second
BP	Brake Power	mbh	1000 Btu/hr
Btu	British Thermal Unit	NLA	No Load Amperage
Btu/hr or Btuh	British Thermal Unit Per Hour	NPSHA	Net Positive Suction Head Available
CL	Center Distance (used in belt formula)	oa	Outside Air
°C	Degrees Celsius	$\%_{oa}$	% of Outside Air
C	Friction Loss Coefficient (For Duct Fittings)	Ω	Ohm
CCF	100 Cubic Foot	P	Pressure
CFM	Volumetric Flow: Cubic Feet Per Minute	P_a	Atmospheric Pressure
C_p	Specific Heat	P_{ab}	Absolute Pressure
C_v	Flow Constant (IP)	Pa	Pascals
ρ	Density	π	Pi = 3.14
d	Diameter	PD	Sheave Pitch Diameter
Δ	Difference or Change (Final - Initial)	$P_{℄}$	Pressure at Pump Centerline
d_{imp}	Impeller Diameter	ppm	Parts Per Million
E	Volts	psi	Pounds Per Square Inch
Eff	Efficiency	psia	Pounds Per Square Inch Absolute
EP	Pump Efficiency	psig	Pounds Per Square Inch Gauge
°F	Degrees Fahrenheit	P_{vp}	Absolute Vapor Pressure
f	Friction Factor	Q (flow)	Volumetric Fluid Flow Rate
fc	foot-candle	Q (heat)	Heat Flow Rate
FLA	Full Load Amps	°R	Degrees Rankin
FPM	Feet Per Minute	r	Radius
ft	Foot	$\%_{ra}$	% of Return Air
g	Acceleration of Gravity	R	Resistance
gal	Gallons	ra	Return Air
GPM	Gallons Per Minute	rad	Radians
h	Enthalpy	RH	Relative Humidity
H	Head	RPM	Revolutions Per Minute
Hg	Mercury	R_{value}	Thermal Resistance
h_{ma}	Mixed Air Enthalpy	s	Second
h_{oa}	Outside Air Enthalpy	SHR	Sensible Heat Ratio
HP	Horsepower	SME	Sash Movement Effect Performance Rating (SME-XX yyy)
hr	Hour	SP	Static Pressure
h_{ra}	Return Air Enthalpy	Sp Gr	Specific Gravity (for water use 1.00)
HT	Height	T	Temperature
in	Inch	Ta	Absolute Temperature (460˚ + T) or °R
I	Amps	T_{ma}	Mixed Air Temperature
J	Joules	T_{oa}	Outside Air Temperature
K	Kelvin	TP	Total Pressure
K_v	Flow constant (SI)	T_{ra}	Return Air Temperature
kcal	kilocalorie	TS	Tip Speed
kg	Kilogram	U	Heat Transfer Coefficient
kJ	Kilojoule	µ	Viscosity, Dynamic
kPa	Kilopascal	V	Velocity
kW	Kilowatt	VP	Velocity Pressure
l	Liter (Litre)	W	Watt or J/s
l/s	Volumetric Flow: Liters Per Second	WD	Width
lb	Pounds	wg or wc	water gauge or water column
lm	Lumens	WHP	Water Horsepower
ln	natural log	WP	Water Power
LG	Length	ω	Humidity Ratio

EQUATIONS				
TOPIC	**US Equation (IP)**	**US Unit (IP)**	**Metric Equation (SI)**	**Metric Unit (SI)**
AIRFLOW & VELOCITY	$Q = V \times A$	CFM, ft^3/min	$Q = V \times A$	m^3/s
	$\text{Duct Fitting Loss} = C \times VP$	in. wg	$\text{Duct Fitting Loss} = C \times VP$	Pa
	$TP_{(in\ wg)} = VP + SP$	in. wg	$TP_{(Pa)} = VP + SP$	Pa
	$V_{(\text{ std air})} = 4005 \times \sqrt{VP}$	FPM, ft/min in. wg	$V_{(\text{std air})} = \sqrt{(1.66 \times VP)}$	m/s, Pa
	$V = 1096 \times \sqrt{\left(\frac{VP}{\rho}\right)}$	in. wg	$V = 1.414 \times \sqrt{\left(\frac{VP}{\rho}\right)}$	Pa
	$ACH = \frac{Q \times 60}{(LG \text{ x } WD \text{ x } HT)}$	air changes/hr	$ACH = \frac{Q \times 3600}{(LG \text{ x } WD \text{ x } HT)}$	air changes/hr
	$Area_{Round} = \frac{\pi \times \left(\frac{d}{2}\right)^2}{144} = \frac{(\pi \times r^2)}{144}$	in^2, ft^2	$Area_{Round} = \pi \times \left(\frac{d}{2}\right)^2 = (\pi \times r^2)$	m^2
	$Area_{(square/rectangular)} = \frac{(HT \times WD)}{144}$	in^2, ft^2	$Area_{(square/rectangular)} = (HT \times WD)$	m^2
	$Area_{Oval} = \frac{\left(HT \text{ x } (WD - HT) + \left(\pi \times \left(\frac{HT}{2}\right)^2\right)\right)}{144}$	in^2, ft^2	$Area_{Oval} = \left(HT \text{ x } (WD - HT) + \left(\pi \times \left(\frac{HT}{2}\right)^2\right)\right)$	m^2
AIR TEMPERATURE	$°F = (1.8 \times °C) + 32°$	°F	$°C = (°F - 32) \div 1.8$	°C
	$°R = (°F + 460)$	°R	$K = (°C + 273)$	K
	$T_{ma} = (\%_{oa} \times T_{oa}) + (\%_{ra} \times T_{ra})$	°F, °R	$T_{ma} = (\%_{oa} \times T_{oa}) + (\%_{ra} \times T_{ra})$	°C, K
	$h_{ma} = (\%_{oa} \times h_{oa}) + (\%_{ra} \times h_{ra})$	$Btu/lb_{dry\ air}$	$h_{ma} = (\%_{oa} \times h_{oa}) + (\%_{ra} \times h_{ra})$	$kJ/kg_{dry\ air}$
	$\%_{oa} = \left(\frac{(h_{ra} - h_{ma})}{(h_{ra} - h_{oa})}\right) \times 100$	%	$\%_{oa} = \left(\frac{(h_{ra} - h_{ma})}{(h_{ra} - h_{oa})}\right) \times 100$	%
	$\%_{oa} = \left(\frac{(T_{ra} - T_{ma})}{(T_{ra} - T_{oa})}\right) \times 100$	%	$\%_{oa} = \left(\frac{(T_{ra} - T_{ma})}{(T_{ra} - T_{oa})}\right) \times 100$	%
HEAT TRANSFER (AIR)	$Q_{total} = 4.5 \times CFM \times \Delta h$ (Standard Air)	Btu/hr	$Q_{total} = 1.2 \times {}^{l}/_{s} \times \Delta h$ (Standard Air)	W
	$Q_{total} = 60 \times \rho \times CFM \times \Delta h$ (Non-Standard Air)	Btu/hr	$Q_{total} = \rho \times {}^{l}/_{s} \times \Delta h$ (Non-Standard Air)	W
	$Q_{sensible} = 1.08 \times CFM \times \Delta T_{air}$ (Standard Air)	Btu/hr	$Q_{sensible} = 1.23 \times {}^{l}/_{s} \times \Delta T_{air}$ (Standard Air)	W
	$Q_{sensible} = 60 \times Cp \times \rho \times CFM \times \Delta T_{air}$ (Non-Standard Air)	Btu/hr	$Q_{sensible} = Cp \times \rho \times {}^{l}/_{s} \times \Delta T_{air}$ (Non-Standard Air)	W
	$Q_{latent} = 0.69 \times CFM \times \Delta\omega_{\frac{gr\ of\ H_2O}{lb\ dry\ air}}$ (Standard Air)	Btu/hr	$Q_{latent} = 3.0 \times {}^{l}/_{s} \times \Delta\omega_{g\ H_2O}/_{kg\ dry\ air}$ (Standard Air)	W
	$Q_{latent} = 4840 \times CFM \times \Delta\omega_{\frac{lb\ of\ H_2O}{lb\ dry\ air}}$ (Standard Air)	Btu/hr		

EQUATIONS				
TOPIC	**US Equation (IP)**	**US Unit (IP)**	**Metric Equation (SI)**	**Metric Unit (SI)**
HEAT TRANSFER (AIR)	$Q_{latent} = \frac{1073}{7000} \times 60 \times \rho \times CFM \times \Delta\omega_{gr\ of\ H_2O / lb\ dry\ air}$ (Non-Standard Air)	Btu/hr	$Q_{latent} = 2.5x\ \rho\ x\ {}^{l}/_{s} \times \Delta\omega_{g\ H_2O} /_{kg\ dry\ air}$ (Non-Standard Air)	W
	$Q_{latent} = 1073 \times 60 \times \rho \times CFM \times \Delta\omega_{lb\ of\ H_2O / lb\ dry\ air}$ (Non-Standard Air)	Btu/hr		W
	$SHR = Q_{sensible} \div Q_{total}$	unitless	$SHR = Q_{sensible} \div Q_{total}$	unitless
	$Q_{total} = Q_{latent} + Q_{sensible}$	Btu/hr	$Q_{total} = Q_{latent} + Q_{sensible}$	W
	$Q_{Btuh} = A_{ft^2} \times U \times \Delta T$ (°F)	Btu/hr	$Q_{W} = A_{m^2} \times U \times \Delta T$ (°C)	W
FAN	$\frac{CFM_2}{CFM_1} = \frac{RPM_2}{RPM_1}$	ft^3/min, rev/min	$\frac{l/s_2}{l/s_1} = \frac{m^3/s_s}{m^3/s_1} = \frac{rad/s_2}{rad/s_1}$	l/s, m^3/s, rad/s
	$\frac{P_2}{P_1} = \left(\frac{CFM_2}{CFM_1}\right)^2$	in. wg, ft^3/min	$\frac{P_2}{P_1} = \left(\frac{l/s_2}{l/s_1}\right)^2 = \left(\frac{m^3/s_2}{m^3/s_1}\right)^2$	Pa, l/s, m^3/s
	$\frac{BHP_2}{BHP_1} = \left(\frac{CFM_2}{CFM_1}\right)^3$	HP	$\frac{kW_2}{kW_1} = \left(\frac{l/s_2}{l/s_1}\right)^3 = \left(\frac{m^3/s_2}{m^3/s_1}\right)^3$	kW, l/s, m^3/s
	$Tip\ Speed = TS = \frac{(\pi \times d \times rpm)}{12}$	FPM, ft/min	$Tip\ Speed = TS = \frac{(\pi \times d \times rpm)}{60}$	m/s
SHEAVE	$RPM_{fan} = \left(\frac{PD_{motor}}{PD_{fan}}\right) \times RPM_{motor}$	rev/min, in	$\frac{RPM_{fan}}{RPM_{motor}} = \frac{PD_{motor}}{PD_{fan}}$	rev/min, mm
	$Fan\ Belt\ Length = (CL \times 2) + \left(1.57 \times (PD_{large} + PD_{small})\right) + \left(\frac{(PD_{large} - PD_{small})^2}{4 \times CL}\right)$			in (IP), mm (SI)
ELECTRICAL	$E = I \times \Omega$			Volts
	$\Omega = E \div I$			Ohms
POWER	$W = E \times I$	W	$kW = \frac{(E \times I)}{1000}$	kW
	$BHP_{1\ phase} = \frac{(E \times I \times PF \times Eff)}{746}$ PF=Power Factor	HP	$kW_{1\ phase} = \frac{(E \times I \times PF\ x\ Eff)}{1000}$ PF=Power Factor	kW
	$BHP_{3\ phase} = \frac{(E \times I \times PF \times Eff \times 1.732)}{746}$ PF=Power Factor = 0.8 & Eff=0.9; if not given	HP	$kW_{3\ phase} = \frac{(E \times I \times PF \times Eff\ x\ 1.732)}{1000}$ PF=Power Factor	kW
	$BHP = HP \times \left(\frac{(I_{actual} - (NLA \times 0.5)}{(FLA_{actual} - (NLA \times 0.5)}\right)$	HP	$BkW = kW \times \left(\frac{(I_{actual} - (NLA \times 0.5)}{(FLA_{actual} - (NLA \times 0.5)}\right)$	kW
	$FLA_{actual} = \frac{(FLA_{tag} \times E_{tag})}{E_{actual}}$	Amps	$FLA_{actual} = \frac{(FLA_{tag} \times E_{tag})}{E_{actual}}$	Amps
	$Fan\ HP = \frac{(CFM \times TP \times SpGr)}{(6356 \times Eff)}$	HP	$Fan\ kW = \frac{(m^3/s \times TP \times SpGr)}{(1000 \times Eff)}$	kW
RESISTANCE	$\frac{1}{R_{Total_{Parallel}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$			Ohms
	$R_{Total_{Series}} = R_1 + R_2 + R_3 + \cdots + R_n$			Ohms

NEBB®

EQUATIONS				
TOPIC	**US Equation (IP)**	**US Unit (IP)**	**Metric Equation (SI)**	**Metric Unit (SI)**
RESISTANCE	$E_{primary} \times I_{primary} = E_{secondary} \times I_{secondary}$			Volts, Amps
	$\text{Voltage Drop} = I \times R_{Total}$			Volts
PUMP	$\frac{GPM_2}{GPM_1} = \frac{RPM_2}{RPM_1}$	gal/min, rev/min	$\frac{l/s_2}{l/s_1} = \frac{m^3/s_2}{m^3/s_1} = \frac{RPM_2}{RPM_1}$	l/s, m^3/s, RPM
	$\frac{GPM_2}{GPM_1} = \frac{d_{imp2}}{d_{imp1}}$	gal/min, in	$\frac{l/s_2}{l/s_1} = \frac{m^3/s_2}{m^3/s_1} = \frac{d_{imp2}}{d_{imp1}}$	l/s, m^3/s, mm
	$\frac{H_2}{H_1} = \left(\frac{GPM_2}{GPM_1}\right)^2$	in wc, ft wc, psi, gal/min	$\frac{H_2}{H_1} = \left(\frac{l/s_2}{l/s_1}\right)^2 = \left(\frac{RPM_2}{RPM_1}\right)^2$	kPa, l/s, RPM
	$\frac{BHP_2}{BHP_1} = \left(\frac{GPM_2}{GPM_1}\right)^3$	HP, gal/min	$\frac{BkW_2}{BkW_1} = \left(\frac{l/s_2}{l/s_1}\right)^3 = \left(\frac{RPM_2}{RPM_1}\right)^3$	BkW, L/s, RPM
	$WHP = \frac{(GPM \times H_{ft\,wg} \times SpGr)}{3960}$ SpGr = 1.0, unless given, EP use 0.7 if not given	HP	$WP_{kW} = 9.81 \times m^3/s \times H_m \times SpGr$ SpGr = 1.0, unless given, EP use 0.7 if not given	kW
			$WP_W = \frac{(l/s \times H_{Pa} \times SpGr)}{1000}$ SpGr = 1.0, unless given, EP use 0.7 if not given	W
	$BHP = \frac{(GPM \times H_{ft\,wg} \times SpGr)}{(3960 \times EP)}$	HP	$BP = \frac{WP}{EP}$ SpGr = 1.0, unless given, EP use 0.7 if not given	kW
	$EP_{in\,\%} = \frac{(WHP \times 100)}{BHP}$	%	$EP_{in\,\%} = \frac{(WP \times 100)}{BP}$	%
HYDRONIC	$\text{Coil } \Delta P\text{: } P_2 = P_1 \times \left(\frac{GPM_2}{GPM_1}\right)^2$	in wc, ft wc, psi	$\text{Coil } \Delta P\text{: } P_2 = P_1 \times \left(\frac{l/s_2}{l/s_1}\right)^2$	kPa, m wc
	$C_v = \frac{GPM \times \sqrt{SpGr}}{\sqrt{\Delta P_{psi}}}$	unitless	$K_v = \frac{m^3/h \times \sqrt{SpGr}}{\sqrt{\Delta P_{Bar}}}$	unitless
	$GPM = \frac{C_v \times \sqrt{\Delta P_{psi}}}{\sqrt{SpGr}}$	GPM, gal/min	$m^3/h = \frac{K_v \times \sqrt{\Delta P_{Bar}}}{\sqrt{SpGr}}$	m^3/h
	$\Delta P_{psi} = SpGr \times \left(\frac{GPM}{C_v}\right)^2$ SpGr = 1.0, unless given	psi	$\Delta P_{Bar} = SpGr \times \left(\frac{m^3/h}{K_v}\right)^2$	bar
	$NPSHA = P_a \pm P_s + \left(\frac{V^2}{2g}\right) - P_{vp} - P_f$	ft wc	$NPSHA = P_a \pm P_s + \left(\frac{V^2}{2g}\right) - P_{vp} - P_f$	m
HEAT TRANSFER (HYDRONIC)	$Q_{Btu} = 500 \times GPM \times \Delta T_{°F}$ (Standard Water)	Btu/hr	$Q_{kW} = 4.190 \times l/s \times \Delta T_{°C}$ (Standard Water)	kW
			$Q_W = 4190 \times l/s \times \Delta T_{°C}$ (Standard Water)	W
	$Q_{Btu} = C_p\ x\ 60 \times \rho \times GPM \times \Delta T_{°F}$ (Non-Standard Water)	Btu/hr	$Q_W = C_p \times \rho \times l/s \times \Delta T_{°C}$ (Non-Standard Water)	W
BOILER	$\text{Output Btu} = \text{Input Btu} \times \%\text{Eff}$	Btu	$\text{Output kW} = \text{Input kW} \times \%\text{Eff}$	kW
	Boiler Operating Cost $= \text{Fire Rate}_{gal/hr} \times \text{hrs Burned} \times \$Cost/gal$	\$	Boiler Operating Cost $= \text{Fire Rate}_{l/hr} \times \text{hrs Burned} \times \$Cost/l$	\$
	$\text{Fire Rate} = \frac{\text{Input Btu}}{\text{Fuel Btu}_{gal/hr}}$	gal/hr	$\text{Fire Rate} = \frac{\text{Input MJ}}{\text{Fuel MJ}_{l/hr}}$	l/hr

METRIC EQUIVALENTS		
Unit of	**Metric Unit (SI)**	**Equivalent US Unit (IP)**
acceleration	1 m/s^2	3.281 ft/sec^2
area	1 m^2	10.764 ft^2
area	1 mm^2	0.0016 in^2
energy	1 kcal	3.968 Btu/hr
energy	1 W	3.413 Btu/hr
energy	1 kW	3413 Btu/hr
length	1 m	3.281 ft
length	1 m	39.37 in
length	1 cm	0.39 in
length	1 mm	0.039 in
lighting intensity	1 lx	0.093 fc
lighting intensity	1 lm/m^2	0.0931 fc
mass	1 kg	2.2 lb
power (motor)	1 kW	1.34 HP
power (energy)	1 J/hr	0.000948 Btu/hr
pressure	1 Pa	0.004 in wg
pressure	1 kPa	0.145 psi
pressure	1 kPa	0.3345 ft wc
pressure	1 kPa	0.296 in Hg
velocity	1 m/s	196.9 fpm
velocity	1 m/s	3.28 fps
volume	1 m^3	35.31 ft^3
volumetric flow rate (air)	1 m^3/s	2118.88 cfm
volumetric flow rate (air)	1 l/s	2.12 cfm
volumetric flow rate (air)	1 m^3/hr	0.589 cfm
volumetric flow rate (water)	1 l/s	15.88 gpm
volumetric flow rate (water)	1 m^3/s	15880 gpm

ENGINEERING CONSTANTS		
Definition	**US Units (IP)**	**Metric Units (SI)**
Atmospheric Pressure @ Sea Level	1 atm = 29.92 in Hg = 14.7 psi	101.325 kPa
Atmospheric Pressure @ Sea Level (coll)	1 bar = 14.5 psi = 29.53 in Hg	100 kPa
Heat of Evaporation	970 Btu/lb	2257 kJ/kg
Heat of Condensation	970 Btu/lb	2257 kJ/kg
Heat of Fusion	144 Btu/lb	335 kJ/kg
Mass (1 lb of moisture)	7000 grains	N/A
Density of Air (Std)	0.075 lb/ft^3	1.204 kg/m^3
Density of Water (Std)	62.4 lb/ft^3	1000 kg/m^3
Density of Water (Std)	8.33 lb/gal	1000 kg/m^3
Specific Heat (Cp) of dry air	0.24 Btu/(lb x ˚F) @ 68°F	1.005 kJ/(kg x K) @ 20°C
Specific Heat (Cp) ice	0.50 Btu/(lb x ˚F) @ 32°F	2.05 kJ/(kg x K) @ 0°C
Specific Heat (Cp) vapor	0.45 Btu/lb x ˚F @ 68°F	1.996 kJ/(kg x K) @ 20°C
Specific Heat (Cp) water	1.00 Btu/lb x ˚F @ 68°F	4.187 kJ/(kg x K) @ 20°C
Standard Temperature & Pressure (STP)	68°F at Sea Level (14.7 psi)	20°C at Sea Level (101.325 kPa)
Standard Temperature & Pressure (STP)	68°F at Sea Level (29.92 in. Hg)	20°C at Sea Level (101.325 kPa)
Ton of refrigeration	12,000 Btu/hr	3.516 kW
Ton of refrigeration (evaporator)	12,000 Btu/hr	3.516 kW
Ton of refrigeration (condenser)	15,000 Btu/hr	4.395 kW
Volume	1 CF = 7.49 gallons	N/A

CONVERSIONS			
Unit of	**To Convert**	**Into**	**Multiply by**
energy	CCF	Btu	100,000
energy	mbh	Btu/hr	1,000
power	HP	Btu/hr	2545
power	HP	watts	746
pressure	ft.wc	psi	0.434
pressure	psi	ft. wc	2.31
pressure	psi	in. Hg	2.036