Psychrometric Formulae

A. AIR MIXING EQUATIONS (Outdoor and Return Air)

$$tm = \frac{(cfm_{oa} \times t_{oa}) + (cfm_{ra} \times h_{ra})}{cfm_{ga}}$$

$$hm = \frac{(cfmoa \times hoa) + (cfm_{ra} \times h_{ra})}{cfm_{sa}} \quad (2)$$

$$wm = \frac{(cfm_{oa} \times W_{oa}) + (cfm_{ra} \times h_{ra})}{cfm_{sa}} \quad (3)$$

B. COOLING LOAD EQUATIONS

ERSH	=	RSH + (BF) (OASH) + RSHS*	(4)
ERLH	=	RLH + (BF) (OALH) + RLHS*	
ERTH	=	ERLH + ERSH	(6)
TSH	=	RSH + OASH + RSHS*	(7)
TLH	=	RLH + OALH + RLHS*	(8)
GTH	=	TSH + TLH + GTHS*	(9)
RSH	=	$1.08 \times cfm_{sa} \times (t_{rm} - t_{sa})$	(10)
RLH	=	$0.68 \times cfm_{sa} \times (W_{rm} - W_{sa})$	(11)
RTH	=	$4.45 \times cfm_{sa} \times (h_{rm} - h_{sa})$	(12)
RTH	=	RSH + RLH	(13)
OASH	=	1 .08 X Cfmoa X (toa - trm)	(
OALH	=	0.68 x cfmoa x (Woa - Wrm)	(15)
OATH	=	4.45 x cfmoa x (hoa - hrm)	(1
OATH	=	OASH + OALH	(17
(BF)(OATH)	=	(BF) (OASH) + (BF) (OALH)	(18)
ERSH	=	$1.08 \times Cfm_{da} \times (t_{rm} - t_{adp})$ (1-BF)	(19)
ERLH	=	$0.68 \times Cfm_{da} \times (W_{rm} - W_{adp})$ (1-BF)	(20
ERTH	=	$4.45 \times Cfm_{da} \times (h_{rm} - h_{adp})$ (1-BF)	(21)
TSH	=	$1.08 \times Cfm_{da} \times (t_{edp} - t_{ldp})$**	(22)
TLH	=	$0.68 \times Cfm_{da} \times (W_{ea} - W_{la})$ **	(23)
GTH	=	$4.45 \times x \times Cfm_{da} \times$ (hea - h!a)**	(24)

C. SENSIBLE HEAT FACTOR EQUATIONS

$$RSHF = \frac{RSH}{RSH + RLH} = \frac{RSH}{RTH} \quad (25)$$

$$ESHF = \frac{ERSH}{RSH + ERLH} = \frac{ERSH}{RRTH} \quad (26$$

$$GSHF = \frac{RSH}{TSH + TLH} = \frac{TSH}{GTH} \quad (26)$$

D. BYPASS FACTOR EQUATIONS

$$BF = \frac{t_{ldb} - t_{adp}}{t_{edp} - t_{adp}} : (1 - BF) = \frac{t_{edb} - t_{ldp}}{t_{edb} - t_{adp}}$$

$$BF = \frac{W_{la} - W_{adp}}{W_{ea} - W_{adp}} : (1 - BF) = \frac{W_{ea} - W_{la}}{W_{ea} - W_{adp}} \quad (29)$$

$$BF = \frac{h_{la} - h_{adp}}{h_{ea} - h_{adp}} : (1 - BF) = \frac{h_{ea} - h_{la}}{h_{ea} - h_{adp}} \quad (30)$$

E. TEMPERATURE EQUATIONS AT APPARATUS

$$t_{edb}{}^{**} = \frac{(cfm_{oa} \times t_{oa}) + (cfm_{ra} \times t_{ra})}{cfm_{sa}\ \#} \quad (31)$$

$$tldb = t_{adp} + BF\,(t_{edb} - t_{adp}) \quad (32)$$

t_{edb}** and t_{lwb} correspond to the calculated values of h_{ea} and h_{la} on the psychrometric chart.

$$h_{ea}{}^{**} = \frac{(cfm_{oa} \times h_{oa}) + (cfm_{ra} \times h_{ra})}{cfm_{sa}\ \#} \quad (33$$

$$h_{ldb} = ht_{adp} + BF\,(h_{ea} - h_{adp}) \quad (34)$$

F. TEMPERATURE EQUATIONS FOR SUPPLY AIR

$$tsa = trm - \frac{RSH}{1.08\,(cfm_{sa}\ \#)} \quad (35)$$

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Psychrometric Formulae (Contd...)

G. AIR QUANTITY EQUATIONS

$$cfm_{da} = \frac{ERSH}{1.08 \times (1\text{-}BF)\ (t_{rm} - t_{adp})} \quad (36)$$

$$cfmda = \frac{ERLH}{0 \quad \times (1\text{-}BF)\ (W_{rm} - W_{adp})} \quad (37$$

$$cfm_{da} = \frac{ERTH}{4.45 \times (1\text{-}BF)\ (h_{rm} - h_{adp})} \quad (38$$

$$cfm_{da} = \frac{TSH}{1.08 \times (1\text{-}BF)\ (t_{edp} - t_{ldp})} \quad (39)$$

$$cfm_{da}\ ‡ = \frac{TLH}{0.68 \times (W_{ea} - W_{la})} \quad ($$

$$cfm_{da}\ ‡ = \frac{GTH}{4.45 \times (h_{ea} - h_{la})} \quad (41)$$

$$cfm_{sa}\ ‡ = \frac{RSH}{1.08 \times (t_{rm} - T_{sa})} \quad (42$$

$$cfm_{sa} = \frac{RLH}{0.68 \times (W_{rm} - W_{sa})} \quad (43)$$

$$cfm_{da} = \frac{RTH}{4.45 \times (h_{rm} - h_{sa})} \quad (44)$$

$$cfm_{ba} = cfm_{sa} - cfm_{da} \quad (44)$$

Note : cfm_{da} will be less than cfm_{sa} only when air is physically bypassd around the conditioning apparatus.

$$cfm_{sa} = cfm_{oa} - cfm_{ra} \quad (45)$$

$$1.08 = 0.244 \times \frac{60}{13.5}$$

Where 0.244 = Specific heat of moist air at 70 F db and 50% rh, Btu / (deg F) (lb dry air).

60 = min./hr

13. = specific volume of moist air at 70 F db and 50% rh

$$0.68 = \frac{60}{13.5} \times \frac{107}{700}$$

Where 60 = min./hr

13.5 = Specific volume of moist air at 7 F db and 50% rh

1076 = average heat removal required to condense one pound of water vapor from the room air

7000 = grains per pound

$$4.45 = \frac{60}{13.}$$

Where 60 = min./hr

13.5 = Specific volume of moist air at 70 F db and 50% rh

* RSHS, RLHS and GTHS are supplementary loads due to duct heat gain, duct leakage loss, fan and pump horsepower gains, etc. To simplify the various examples, these supplementary loads have not been used in the calculations. However, in actual practice, these supplementary loads should be used where appropriate.

Note : cfmda will be less than cfmsa only when air is physically bypassed around the conditioning apparatus.

‡ When no air is to be physically bypassed around the conditioning apparatus, $cfm_{da} = cfm_{sa}$.

** When t_m, Wm and hm are equal to the entering conditions at the cooling apparatus, they may be substituted for t_{edp} W_{ea} and h_{ea} respectively.

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ABBREVIATIONS

Adp	Apparatus Dewpoint
BF	Bypass Factor
(BF) (OALH)	Bypassed Outdoor Air Latent Heat
(BF) (OASH)	Bypassed Outdoor Air Sensible Heat
But/hr	British Thermal Units per hour
Cfm	cubic feet per minute
db	Dry-Bulb Temperature
dp	Dewpoint
ERLH	Effective Room Latent Heat
ERSH	Effective Room Sensible Heat
ERTH	Effective Room Total Heat
ESHF	Effective Sensible Heat Factor
F	Fahrenheit degrees
fpm	feet per minute
gpm	gallons per minute
gr/lb	grains per pound
GSHF	Grand Sensible Heat Factor
GTHS	Grand Total Heat Supplement
OALH	Outdoor Air Latent Heat
OASH	Outdoor Air Sensible Heat
OATH	Outdoor Air Total Heat
rh	relative humidity
RLH	Room Latent Heat
RLHS	Room Latent Heat Supplement
RSH	Room Sensible Heat
RSHF	Room sensible heat supplement
RSHS	Room Latent Heat supplement
RTH	Room Total Heat
Sat Eff	saturation efficency of spray
SHF	Sensible Heat Factor
TLH	Total Latent Heat
TSH	Total Sensible Heat
w b	wet bulb

SYMBOLS

cfm_{ba}	Bypassed Air Quantity around Apparatus
cfm_{da}	Dehumidified Air Quantity
cfm_{oa}	Outdoor Air Quantity
cfm_{ra}	Return Air Quantity
cfm_{sa}	Supply Air Quantity
h	Specific Enthalpy
h_{adp}	Apparatus Dewpoint Enthalpy
h_{es}	Effective Surface Temperature Enthalpy
h_{ea}	Entering Air Enthalpy
h_{ia}	Leaving Air Enthalpy
h_{m}	Mixture of Outdoor and Return Air Enthalpy
h_{oa}	Outdoor Air Enthalpy
h_{ra}	Room Air Enthalpy
h_{sa}	Supply Air Enthalpy
t	Temperature
t_{adp}	Apparatus Dewpoint Temperature
t_{edb}	Entering Dry-Bulb Temperature
t_{es}	Effective Surface Temperature
t_{ew}	Entering Water Temperature
t_{ewb}	Entering Wet-Bulb Temperature
t_{ldb}	Leaving Dry-Bulb Temperature
t_{iwb}	Leaving Wet-Bulb Temperature
t_{m}	Mixture of Outdoor and Return Air Dry-Bulb Temperature
t_{oa}	Outdoor Air Dry-Bulb Temperature
t_{im}	Room Dry-Bulb Temperature
t_{sa}	Supply Air Dry-Bulb Temperature
W	Moisture Content or Specific Humidity
W_{adp}	Apparatus Dewpoint Moisture Content
W_{ea}	Entering Air Moisture Content
W_{es}	Effective Surface Temperature Moisture Content
W_{la}	Leaving Air Moisture Content
W_{m}	Mixture of Outdoor and Return Dry Moisture Content
W_{oa}	Outdoor Air Moisture Content
W_{m}	Room Moisture Content
W_{sa}	Supply Air Moisture Content

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