1

$Tcal$

$Mean_*$

$$Mean_load/K = Trec + T_{load}$$

$$T_{load}$$

$Trec$

$$Mean_atm/K = Trec + T_{emi}$$

$T_B$

$$Mean_source/K = Trec + T_{emi} + B_s * e^{-\tau} * T_B$$

$B_S$

$\tau$

$$T_B = Tcal * \frac{(Mean_source - Mean_atm)}{(Mean_load - Mean_atm)}$$

$$Tcal = (T_{load} - T_{emi})\frac{e^{\tau}}{B_s}$$

$$Tsys = \frac{Tcal * Mean_atm}{Mean_load - Mean_atm}$$

$T_{emi}$

$$T_{emi} = \frac{(T_{load} + Trec) * Mean_atm}{Mean_load} - Trec$$

$$T_{sky} = \frac{T_{emi} - (1. - F_{eff}) * T_{cab}}{F_{eff}}$$

$F_{eff}$

$$T_{cab}$$

$T_{sky}$

$$T_{sky} = \frac{T_{sky_s} + T_{sky_i} * Gain_i}{(1. + Gain_i)}$$

$$P_{amb}$$

$$T_{amb}$$

$$Tcal = \frac{(T_{load} * (1. + Gain_i) - T_{emi_s} - Gain_i * T_{emi_i})}{B_s * e^{-Tau_s * Air_mass}}$$

$Tau_s$

$T_{rec}$

$Gain_i$

$$Air_mass$$

$$P_{amb}, T_{amb}$$

$$Humidity$$

$Tau$

$Water$

$$Trec = \frac{T_{load} * Mean_atm - T_{emi} * Mean_load}{Mean_load - Mean_atm}$$

$$Trec = \frac{T_{load} * Mean_cold - T_{cold} * Mean_load}{Mean_load - Mean_cold}$$

$T_{atm_s}$

$$T_{atm_i}$$

$Tau_i$

$$T_{sky_s} = T_{atm_s} * (1. - e^{-Tau_s * Air_mass})$$

$$T_{sky_i} = T_{atm_i} * (1. - e^{-Tau_i * Air_mass})$$

$Tsys$

$B_s$

$$B_{eff}$$

$T_A^*$

$$\frac{1}{1 + Gain_i * e^{(Tau_s - Tau_i) * Air_mass}}$$

$$e^{(Tau_i - Tau_s) * Air_mass} / Gain_i$$

$C_{eff}$

$$Mean_load/K = Trec + C_{eff} * T_{load} + (1 - C_{eff}) * T_{emi}$$

$$Tcal = C_{eff} * \frac{(T_{load} - T_{emi}) * (1. + Gain_i)}{B_s * e^{-Tau_s * Air_mass}}$$

$$T_{emi} = \frac{(T_{load} + Trec) * Mean_atm * C_{eff}}{Mean_load - (1 - C_{eff}) * Mean_atm} - Trec$$

$$Trec = \frac{C_{eff} * Mean_atm * T_{load} - (Mean_load - (1 - C_{eff}) * Mean_atm) * T_emi}{Mean_load - Mean_atm}$$

$\eta$

$$Mean_load/K = \eta * (Trec + T_{load})$$

$$T_{emi} = \frac{\eta * (Trec + T_{load}) * Mean_atm}{Mean_load} - Trec$$

$$Trec = \frac{Mean_cold * T_{load} - Mean_load * T_{cold}}{Mean_load - \eta * Mean_cold}$$

$$T_B = e^{\tau} \frac{\eta}{B_s} (T_{load} + Trec) \frac{Mean_sou - Mean_atm}{Mean_load}$$

$$T_{sky} = \tau * T_{atm}$$

$T_{atm}$

$$T_{emi} = F_{eff} * \tau * T_{atm} + (1 - F_{eff}) * T_{cab}$$

$$\tau = (T_{emi} - (1 - F_{eff}) * T_{cab})/(F_{eff} * T_{atm})$$

$$Tcal = C_{eff} * (T_{load} - T_{emi})(1 + Gain_i)/((1 - \tau) * B_s)$$

$$Tcal = C_{eff} \frac{(T_{load} - T_{emi}) * (1 + Gain_i) * T_{atm} * F_{eff}}{B_s * (F_{eff} * (T_{atm} - T_{cab}) + T_{cab} - T_{emi})}$$

$$Tcal = C_{eff} \frac{F_{eff} * (1 + Gain_i) * T_{atm}}{B_s * (1 - F_{eff} * \frac{T_{cab} - T_{atm}}{T_{cab} - T_{emi}})}$$

$$T_{cab} = 290K$$

$$T_{atm} = 240K$$

$$T_{emi} = 50K$$

$$C_{eff} = 1$$

$$Tcal = \frac{240 * (1 + Gain_i) * F_{eff}}{B_s * (1 - 0.2 * F_{eff})}$$

$$T_{emi} = (1. - F_{eff}) * T_{cab} + F_{eff} * C^{te} * Water * Air_mass$$

$$\frac{\partial Tcal}{\partial Trec} = \frac{\partial Tcal}{\partial T_{emi}} \frac{\partial T_{emi}}{\partial Trec} + \frac{\partial Tcal}{\partial Tau} \frac{\partial Tau}{\partial Trec}$$

$$\frac{\partial Tcal}{\partial T_{emi}} = \frac{Tcal}{T_{emi} - T_{load}}$$

$$\frac{\partial T_{emi}}{\partial Trec} = -1 + \frac{T_{emi} + Trec}{T_{load} + Trec}$$

$$\frac{\partial Tcal}{\partial T_{emi}} \frac{\partial T_{emi}}{\partial Trec} = \frac{Tcal}{T_{load} + Trec}$$

$$\frac{\partial Tcal}{\partial Tau} = Air_mass * Tcal$$

$$\frac{\partial Tau}{\partial Trec} = \frac{\partial Tau}{\partial T_{emi}} \frac{\partial T_{emi}}{\partial Trec}$$

$$\frac{\partial Tau}{\partial Trec} = \frac{1}{Air_mass * T_{atm} * F_{eff}} \frac{\partial T_{emi}}{\partial Trec}$$

$$\frac{\partial Tcal}{\partial Tau}\frac{\partial Tau}{\partial Trec} = \frac{Tcal}{T_{atm} * F_{eff}}\frac{T_{emi} - T_{load}}{T_{load} + Trec}$$

$$\frac{1}{Tcal}\frac{\partial Tcal}{\partial Trec} = \frac{T_{atm} * F_{eff} - T_{load} + T_{emi}}{F_{eff} * T_{atm} * (T_{load} + Trec)}$$

$$T_{load} = T_{cab}$$

$$\frac{1}{Tcal}\frac{\partial Tcal}{\partial Trec} = \frac{F_{eff} - 1}{F_{eff}}\frac{1}{T_{load} + Trec}$$

3

$10^{-4}$

$Tcab$

$$\frac{1}{Tcal}\frac{\partial Tcal}{\partial T_{cab}} = \frac{(T_{atm} - T_{emi}}{(T_{cab} - T_{emi}) * (T_{cab} - T_{emi} - F_{eff} * (T_{cab} - T_{atm})}$$

3.6

$10^{-3}$

$$\frac{1}{Tcal}\frac{\partial Tcal}{\partial F_{eff}} = \frac{1}{F_{eff}} + \frac{1}{\frac{T_{cab}-T_{emi}}{T_{cab}-T_{atm}} - F_{eff}}$$

$$\frac{\partial Tcal}{\partial C_{eff}} = \frac{Tcal}{C_{eff}} - \frac{Tcal}{T_{load} - T_{emi}} \frac{\partial T_{emi}}{\partial C_{eff}}$$

$$\frac{\partial T_{emi}}{\partial C_{eff}} = \frac{(T_{emi} + Trec)^2}{T_{load} + Trec}$$

$$\frac{1}{Tcal}\frac{\partial Tcal}{\partial C_{eff}} = \frac{1}{C_{eff}} - \frac{(T_{emi} + Trec)^2}{C_{eff}^2 * (T_{load} + Trec) * (T_{load} - T_{emi})}$$

$$\frac{\partial Tcal}{\partial \eta} = \frac{Tcal}{\eta} + \frac{\partial Tau}{\partial \eta}\frac{\partial Tcal}{\partial Tau} + \frac{\partial Trec}{\partial \eta}\frac{\partial Tcal}{\partial Trec}$$

$$\frac{\partial Tau}{\partial \eta} = \frac{1}{T_{atm} * F_{eff}} \frac{\partial Temi}{\partial \eta}$$

$$\frac{\partial Temi}{\partial \eta} = -\frac{T_{emi} + Trec}{\eta^2} + \frac{\partial Trec}{\partial \eta} \frac{T_{emi} - T_{load}}{T_{load} + Trec}$$

$$\frac{1}{Tcal}\frac{\partial Tcal}{\partial \eta} = \frac{\eta * T_{atm} * Feff - T_{emi} - Trec}{\eta^2}$$

$$\frac{\partial Trec}{\partial \eta} = Trec \frac{Trec - T_{cold}}{T_{load} - \eta * T_{cold} + (1 - \eta) * Trec}$$

$T_{cold}$

$II$