Kestrel Weather Calculations

Air Flow:

For a Square air space:

$$F = HWV$$

For a Round air space:

$$F = V\pi(D/2)^2$$

Where:
F is Air Flow in m^3/s
H is height of the enclosed space in Meters
W is width of the enclosed space in Meters
D is the diameter in Meters
V is velocity of wind speed in m/s

Altitude:

The formula for Altitude as a function of Pressure is:

$$Z(p) = A_0 \times (1 - \frac{p}{p_{msl}})^k$$

Z:	Altitude (Km)
p:	Pressure (mbars)
p_{msl}:	Pressure at sea level
A_0:	Constant: 44.3307
k:	Constant: 0.19026

Delta T:

Delta T is simply the difference in temperature between the measured Dry Bulb temp and Wet Bulb temp. By definition, dry bulb temperature is always bigger/equal to wet bulb temp, so the minimum Delta T is 0.

$$deltaT = T_{db} - T_{wb}$$

Where:
T_{db} = dry bulb temperature in Celsius
T_{wb} = wet bulb temperature in Celsius

Density Altitude:

Air Density

Air Density is calculated using the ideal gas law (PV = NRT) which can be reduced to the following formula:

$$D = \left(\frac{P}{R_d \times T}\right) \times \left(1 - \left(\frac{0.378 \times P_v}{P}\right)\right)$$

D = density, kg/m^3
P_v = pressure of water vapor in the air (Pascals)
P = measured air pressure (Pascals)
R_d = gas constant for dry air (J/kg*degK) = 287.05
T = temperature (deg K) = deg C + 273.15

Calculating Density Altitude from Air Density

Reference derives the following formula for Density Altitude as a function of Air Density:

$$DA = 44.3308 - 42.2665 \times D^{0.234969}$$

DA = Density Altitude (km)
D = Air Density as obtained above.
Reference

Dew Point:

Relative humidity relates ambient saturated water vapor pressure to saturated water vapor pressure to the dew point as follows:

$$e_{sd} = \frac{RH}{100} e_s \quad (3)$$

e_{sd}	- Saturated Water Vapor Pressure at the Dew Point Temperature
e_s	- Saturated Water Vapor Pressure ambient
RH	- Relative humidity as a percentage.

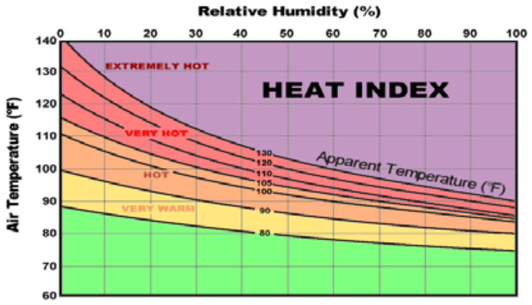
e_s can be found with by calculating the saturated water vapor pressure based on the measured temperature as described above. RH is measured directly. We can then calculate e_{sd} from (3). The dew point is then found by using a lookup table for saturated water vapor pressure.

Evaporation Rate:

NK uses a formula derived from *Estimating Evaporation Rates to Prevent Plastic Shrinkage Cracking* which can be found here.

Heat Index:

Heat Index is derived from obtaining a value in a lookup table based on the Weather.gov heat index chart: https://www.weather.gov/oun/safety-summer-heatindex



Moisture Content / Humidity Ratio:

$$MR = (621.97 * P_w)/(P - P_w)$$

Where:
MR is the mixing ratio in g/Kg
P_w is the actual water vapour pressure in mbar for a given temperature in mBar
P is the station pressure in mBar
P_s is the saturation water vapour pressure at a given temperature in mBar
RH is the relative humidity in percent / 100. Example 40% = .4

Naturally Aspirate Wet Bulb Temperature (NWB Temp):

Kestrel uses a calculation that is derived from the paper :
Bernard, T.E (1999). 'Prediction of Workplace Wet Bulb Global Temperature', Applied Occupational and Environmental Hygiene, 14:2, 126-134. For additional information, please contact NK.

Psychrometric Wet Bulb Temperature:

NK uses the Advanced Weather Interactive Processing System (AWIPS) method for calculating Wet Bulb. Wet Bulb temperature (T_w) is calculated as a function of station temperature (T_s), dew point temperature (T_d), and station pressure (P_s). The calculation is iterative and not provided here. For more information contact NK.

Relative Air Density (RAD):

RAD = AD / AD_o * 100

Where:
RAD = Relative Air Density
AD = Measured Air Density in kg/m^3
ADo = Air Density at sea level (1.225 kg/m^3)

Wet Bulb Globe Temperature (WBGT):

Outdoor WBGT = $f(t_{wna}, t_{g6}, t_d) = 0.7*t_{wna} + 0.2*T_{g6} + 0.1*t_d$

Indoor WBGT = $f(t_{wna}, t_{g6}) = 0.7*t_{wna} + 0.3*t_{g6}$

where all temperatures are measured in °C.

t_{wna} = Natural Wet Bulb Temp, t_{g6} = Globe Temp, t_d = Dry Bulb Temp

Wind Chill:

The Joint Action Group for Temperature Indices (JAG/TI) uses the following formula for calculating Wind Chill Factor.

$$T_{wcc} = 13.12 + 0.6215T_{ac} - 11.37V_{kph}^{0.16} + 0.3965T_aV_{kph}^{0.16}$$

T_{wcc} - Wind Chill (degrees C)
T_{ac} - Air Temperature (degrees C)
V_{kph} - Wind Speed at 10 meters (kph)

NOTE: NK then uses an adjustment based on the assumption that most users will take wind measurements lower than 10m above ground.