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.

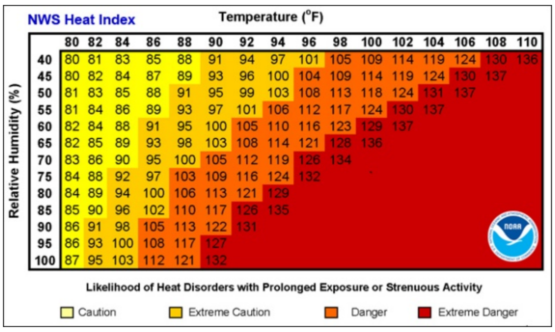
e_s can be found with by calculating the saturated water vapor pressure based on the measured temperature as described above. RH is measured directly. We can then calculate e_{sd} from (3). The dew point is then found by using a lookup table for saturated water vapor pressure.

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 NOAA heat index chart:
https://www.weather.gov/safety/heat-index



NWS Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

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.