THSW Index

Parameters Used: Temperature, Humidity, Solar Radiation, Wind Speed, Latitude & Longitude, Time and Date

What is it:
Like Heat Index, the THSW Index uses humidity and temperature to calculate an apparent temperature. In addition, THSW incorporates the heating effects of solar radiation and the cooling effects of wind (like wind chill) on our perception of temperature.

Formula:
The formula was developed by Steadman (1979). The following describes the series of formulas used to determine the THSW or Temperature-Humidity-Sun-Wind Index. Thus, this index indicates the level of thermal comfort including the effects of all these values.

This Index is calculated by adding a series of successive terms. Each term represents one of the three parameters: (Humidity, Sun & Wind). The humidity term serves as the base from which increments for sun and wind effects are added.

The Vantage Pro calculation is an improvement over the THSW Index in the Health EnviroMonitor because the Health system:

- only calculates THSW Index when air temperature is at or above 68°F.
- assumes the sky is clear.
- assumes the elevation is sea level.

Humidity

The first term is humidity. This term is determined in the same manner as the Heat Index. This term serves as a base number to which increments of wind and sun are added to come up with the final THSW Index temperature.

Note: Heat Index has also been referred to as "Temperature-Humidity Index" and "Thermal Index" in some Davis products

Wind

The second term is wind. This term is determined in part by a lookup table (for temperatures above 50°F) and in part by the wind chill calculation.

- At 0 mph, set this term equal to zero.
- For temperatures at or above 70°F and wind speeds above 40 mph, set the wind speed equal to 40 mph and use the table.
- For temperatures at or above 130°F, set this term equal to zero.
- For temperatures below 50°F:
  - For the display console: use the wind chill calculation as the base temperature.
  - For the WeatherLink software (version 5.2 and higher): use the new heat index formula (as described in the heat index section) as the base temperature and calculate the wind chill increment using the difference between the air temperature and wind chill (which is always a negative number).

The resulting value is the wind term, which will be added to the humidity term and subsequently the sun term as indicated below.
Note 1: older console versions of product that use the old wind chill formula (see wind chill section) have a different table for temperatures between 50°F and 70°F.
Note 2: The WeatherLink software (version 5.2) does not include the sun term in its calculation. It shows the result as the "THW Index" or Temperature-Humidity-Wind Index. This value indicates the "apparent" temperature in the shade due to these factors.

Increment (°F) for Wind in THSW Index									
Temp (°F)	Wind Speed (mph)								
	0	5	10	15	20	25	30	35	40
50	0	-2	-4	-5	-6	-7	-8	-9	-9
55	0	-1	-3	-5	-6	-7	-8	-9	-9
60	0	-1	-3	-5	-6	-7	-8	-9	-9
65	0	0	-3	-5	-6	-7	-8	-9	-9
70	0	0	-2	-4	-5	-6	-7	-8	-9
75	0	0	-2	-3	-4	-5	-6	-7	-7
80	0	0	-1	-2	-3	-5	-5	-6	-6
85	0	0	-1	-2	-3	-3	-4	-4	-4
90	0	0	0	-1	-2	-2	-2	-2	-2
95	0	0	0	0	0	0	1	1	1
100	0	0	0	0	1	2	3	3	3
105	0	0	0	1	2	3	4	5	5
110	0	0	0	2	3	4	5	5	6
115	0	0	0	1	2	3	4	6	6
120	0	0	0	1	1	2	3	4	4
125	0	0	0	0	0	1	1	1	1
130	0	0	0	0	0	0	0	0	0

Increment (°F) for Wind in THSW Index															
Temp (°F)	Wind Speed (mph)														
	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180
50	-9	-10	-11	-12	-12	-13	-13	-14	-14	-15	-15	-15	-16	-16	-16
55	-9	-10	-10	-11	-11	-12	-12	-13	-13	-13	-13	-14	-14	-14	-14
60	-9	-10	-10	-10	-11	-11	-11	-11	-12	-12	-12	-12	-12	-12	-12
65	-9	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-11	-11	-11
70	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9	-9

Sun

The third term is sun. This term, *Qg*, is actually a combination of four terms (direct incoming solar, indirect incoming solar, terrestrial, and sky radiation). The term depends upon wind speed to determine how strong an effect it is (discussed later).

It is assumed that a flat, fixed position sensor is being used as in the Vantage Pro Plus system.

$Qg = Q1 + Q2 + Q3 - Q4$

Direct Incoming Solar Radiation Term (*Q1*)

First, calculate what the solar radiation reading would be if the sensor were tilted normal to the sun. The following parameters are calculated in the same manner as for the ET formula (see ET section).

- Sky cover, *c*
- Solar Zenith Angle, θ

Solar radiation normal to the sun, $Q_n = (5E\text{-}06\theta^3 - 0.0002\theta^2 + 0.0029\theta + 1)*Q$,

Where Q is the measured solar radiation value and θ is the solar zenith angle in degrees (as determined above)
Otherwise, if the c is greater than 60%, $Q_n = Q$.

Next, direct incoming solar, Q_d, is determined from Q_n,

$Q_d = 0.9 * (1 - c^2) * Q_n$, where c is the cloud cover fraction calculated as before,

Finally, $Q1 = 0.56 * F * Q_d$

Where F is the projected area body factor.
If $70° >= \theta >= 2°$, $F = 0.386 - 0.0032*(90 - \theta)$, ($\theta$ is in degrees in the formula),
If $\theta < 2°$, $F = 0.110$
If $\theta > 70°$, $F = 0.325$

Indirect Incoming Solar Radiation Term (*Q2*)

$Q_i = 0.1 * (1 - c^2) * Q_n$, where Q_n is the normal solar radiation & c is the cloud cover fraction (as determined in *Q1* above)

$Q2 = 0.224 * Q_i$

Terrestrial Radiation (*Q3*)

$Q3 = 0.028 * Q$, where Q is the directly measured solar radiation and is used in this case.

Sky Radiation (*Q4*)

$Q4 = 150 [1 - c^2 (0.50 - 0.0043\phi)] * [1 - 0.62 *\exp (-0.108Z) - 0.16 * (vp\text{^}0.5)]$,

Where c is the cloud cover fraction calculated as before, ϕ is the station's latitude in degrees, Z is the station's elevation in **kilometers**, and vp is the vapor pressure (in kPa),

$vp = RH*0.01*0.6112 * \exp [(17.62*T)/(T + 243.12)]$, where RH is the outdoor relative humidity expressed as a percent & T the air temperature in **°C**.

From the resulting Q_g, if the wind speed is < 7 mph, then the sun term in THSWI (in ° F) is $0.101 * Q_g$,

Otherwise, the sun term is $(1.10Q_g)/(8 + 0.45v)$, where v is the wind speed in mph.

REFERENCES

Steadman, R.G., 1979: The Assessment of Sultriness, Part II: Effects of Wind, Extra Radiation and Barometric Pressure on Apparent Temperature. *Journal of Applied Meteorology, July 1979*.

"Media Guide to NWS Products and Services", National Weather Service Forecast Office, Monterey, CA, 1995.

Quayle, R.G. and Steadman, R.G., 1998: The Steadman Wind Chill: An Improvement over Present Scales. *Weather and Forecasting, December 1998*