CONVERTING THERMOANEMOMETER STANDARD VELOCITY TO ACTUAL VELOCITY

APPLICATION NOTE TSI-109 (A4)

Since thermal air velocity sensors are sensitive to changes in air density and air velocity, all thermal anemometers indicate velocities with reference to a set of standard conditions. For TSI® Incorporated instruments, standard conditions are defined as 21.1°C (70°F) and 101.4 kPa (14.7 psia) at 0% relative humidity. Other manufacturers may use different values.

The indicated velocity is called "Standard" or "Mass" velocity. This is the velocity that this mass of air would be moving if the temperature and pressure were at standard conditions. It is usually the most useful measure of airflow because it defines the heat-carrying capacity of the air.

In some applications it is desired to correct standard velocity readings to actual velocity. Actual velocity is the velocity at which a microscopic particle of dust would be traveling if it were in the air stream. To convert the velocity, you need to compensate for temperature, pressure and humidity. Below is a table showing the difference between standard and actual velocity at some typical conditions.

Measurement Conditions	Standard Velocity	Actual Velocity	% Difference
16°C (60.8°F), 30% rh, 760 mmHg	5 m/s (984 ft/min)	4.94 m/s (972 ft/min)	1.2
26°C (78.8°F), 70% rh, 740 mmHg	5 m/s (984 ft/min)	5.35 m/s (1053 ft/min)	7.0
34°C (93.2°F), 30% rh, 760 mmHg	5 m/s (984 ft/min)	5.30 m/s (1044 ft/min)	6.1
34°C (93.2°F), 80% rh, 760 mmHg	5 m/s (984 ft/min)	5.45 m/s (1073 ft/min)	9.0
34°C (93.2°F), 80% rh, 780 mmHg	5 m/s (984 ft/min)	5.30 m/s (1044 ft/min)	6.1

Correcting Mass Velocity Readings To Actual (Moist Air) Velocity

I) Correct for temperature and pressure

In Degrees Fahrenheit

$$V_{dry} = V_{std}\left[\frac{460 + T_{amb}}{460 + 70}\right]\left[\frac{760}{P_{barometric}}\right] \text{ or}$$

In degrees Celsius

$$V_{dry} = V_{std}\left[\frac{273 + T_{amb}}{273 + 21.1}\right]\left[\frac{760}{P_{barometric}}\right]$$

Where:

T_{amb}	=	Ambient temperature (°F or °C)
V_{dry}	=	Velocity of dry air (corrected for temperature and pressure)
V_{std}	=	Measured standard or mass velocity
$P_{barometric}$	=	Total air pressure (barometric pressure in mmHg)

II) Correct for Humidity Effects

When humidity is high a significant fraction of the air is composed of water vapor. In most cases, the effect of humidity on air density at room temperature and below is negligible. However, at higher temperature and relative humidity, the effect on the readings may be more of a concern.

1) Determine the dewpoint temperature of the air stream being measured.

   Some TSI® thermoanemometer models can calculate dewpoint. If your model can measure relative humidity and air temperature then it can also calculate dewpoint. Alternately, a psychometric chart can be used if the ambient temperature and relative humidity are known.

2) Look up the vapor pressure that coincides with the dewpoint temperature from Table 1.

3) Calculate the moist air mass flow velocity.

$$V_{act\ moist} = \frac{D_{dry} \times V_{dry}}{D_{total}} = \frac{P_{barometric} \times V_{dry}}{P_{barometric} - P_{vapor}}$$

Where:

$V_{act\ moist}$	=	Actual velocity of moist air corrected for humidity effects
V_{dry}	=	Velocity of dry air corrected for temperature and pressure
D_{dry}	=	Density of dry air
D_{total}	=	Total air density (density of moist air)
P_{vapor}	=	Vapor pressure in mmHg
$P_{barometric}$	=	Total air pressure (barometric pressure in mmHg)

Example 1:
You want to convert standard air velocity measurement to actual air velocities. The air temperature is 26°C, with relative humidity of 70%, dew point of 20°C and a pressure of 740 mmHg. The measured velocity is 5 standard m/s.

$$V_{dry} = 5.0\left[\frac{273 + 26}{273 + 21.1}\right]\frac{760}{740} = 5.22 \text{ m/s}$$

From Table 1: $P_{vapor} = 17.55$ mmHg

$$V_{act\ moist} = \frac{D_{dry} \times V_{dry}}{D_{total}} = \frac{740 \times 5.2 \text{ m/s}}{(740 - 17.55)} = 5.35 \text{ m/s}$$

Example 2:
You want to correct your standard air velocity measurement to units of actual velocity. The air temperature is 72°F, with relative humidity of 60%, dew point of 57.4°F (14.1°C) and a pressure of 780 mmHg. The measured velocity is 500 standard ft/min.

$$V_{dry} = 500\left[\frac{460 + 72}{460 + 70}\right]\frac{760}{780} = 489 \text{ ft/min}$$

From Table 1: $P_{vapor} = 12.07$ mmHg

$$V_{act\ moist} = \frac{D_{dry} \times V_{dry}}{D_{total}} = \frac{780 \times 489 \text{ ft/min}}{780 - 12.07} = 497 \text{ ft/min}$$

Table 1: Dew Point vs. Vapor Pressure

Dew Point °C	Vapor Press mmHg	Dew Point °C	Vapor Press mmHg	Dew Point °C	Vapor Press mmHg	Dew Point °C	Vapor Press mmHg
-50	0.029	-7	2.550	16	13.64	39	52.51
-45	0.054	-6	2.778	17	14.54	40	55.40
-40	0.096	-5	3.025	18	15.49	41	58.42
-35	0.169	-4	3.291	19	16.49	42	61.58
-30	0.288	-3	3.578	20	17.55	43	64.89
-25	0.480	-2	3.887	21	18.66	44	68.35
-24	0.530	-1	4.220	22	19.84	45	71.97
-23	0.585	0	4.580	23	21.09	46	75.75
-22	0.646	1	4.920	24	22.40	47	79.70
-21	0.712	2	5.290	25	23.78	48	83.83
-20	0.783	3	5.680	26	25.24	49	88.14
-19	0.862	4	6.100	27	26.77	50	92.6
-18	0.947	5	6.540	28	28.38	51	97.3
-17	1.041	6	7.010	29	30.08	52	102.2
-16	1.142	7	7.510	30	31.86	53	107.3
-15	1.252	8	8.040	31	33.74	54	112.7
-14	1.373	9	8.61	32	35.7	55	118.2
-13	1.503	10	9.21	33	37.78	56	124.0
-12	1.644	11	9.85	34	39.95	57	130.0
-11	1.798	12	10.52	35	42.23	58	136.3
-10	1.964	13	11.24	36	44.62	59	142.8
-9	2.144	14	11.99	37	47.13	60	149.6
-8	2.340	15	12.79	38	49.76		

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TSI-109-Rev. D (9/13/2021) A4 Printed in U.S.A.