Mass Flow Compensation

A gas flow rate of 650 SCFM develops a differential pressure of 90" H_2O across an orifice plate at reference conditions of 30 psig and 140°F. Compensate this gas flow for temperature and pressure variations.

$$\text{Flow} = K\sqrt{\frac{DP_f \times P_f}{T_f} \times \frac{T_{ref}}{P_{ref}}}$$

Where:
f = flowing conditions
ref = reference conditions (in absolute units)

Apply Multiplier/Divider Algorithm:

$$PV = K\sqrt{\frac{(\text{Input A} \times \text{Ratio A} + \text{Bias A}) \times (\text{Input C} \times \text{Ratio C} + \text{Bias C})}{(\text{Input B} \times \text{Ratio B} + \text{Bias B})}} \times (\text{Calc}_{HI} - \text{Calc}_{LO})$$

Assign inputs using Engineering units:

Let:

Input A = DP_f = IN1 (in H_2O)
Input B = T_f = IN2 + Bias2 = IN2°F + 460 (°R)
Input C = P_f = IN3 + Bias3 = IN3psig + 14.7(psia)
T_{ref} = 140°F + 460 = 600°R
P_{ref} = 30 psig + 14.7 = 44.7 psia
Calc_{Hi} = 650.0
Calc_{Lo} = 0.0 > Flow in SFCM at Reference Conditions
K = to be determined next

Note: If temperature and pressure signals are already ranged in absolute units, no Bias is required for inputs B and C.

$$PV = Q_{SCFM} = K\sqrt{\frac{DP_f \times (IN3 + 14.7)}{(IN2 + 460)}} \times K^2 \times (650.0 - 0.0)$$

Note: When IN2 and IN3 are at the reference conditions of 600°R (140°F) and 44.7psia (30 psig) respectively and DP_f = 90" H_2O, the equation must calculate 650 SCFM. To accomplish this, divide the DP value by "90" to normalize the equation.

$$Q_{SCFM} = K\sqrt{\frac{DP_f}{90} \times \frac{(IN3 + 14.7)}{(IN2 + 460)} \times \frac{T_{ref}}{P_{ref}}} \times 650$$

Rearranging terms:

$$Q_{SCFM} = K\sqrt{DP_f \times \underbrace{\frac{(IN3 + 14.7)}{(IN2 + 460)}}_{\text{Variable}} \times \underbrace{\frac{1}{90} \times \frac{T_{ref}}{P_{ref}}}_{\text{Constant} = K^2}} \times 650$$

Example continued on next page

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Determined value of K:

$$K^2 = \frac{1}{90} \times \frac{T_{ref}}{P_{ref}} = \frac{600}{(90)(44.7)} = 0.14914$$

Therefore K = 0.386

$$Q_{SCFM} = (0.386)(650)\sqrt{\frac{DP_f \text{ (in } H_2O) (IN3 + 14.7)}{(IN2 + 460)}}$$

K; $(\text{Calc}_{HI} - \text{Calc}_{LO})$

Summary of Flow Values At Values Conditions

	Temp (T_f) (°R)	Pressure (T_f) (psia)	Flow (SFCM)	
			DP_f = 45" H_2O (50%)	DP_f = 90" H_2O (100%)
Reference Conditions	140°F + 460	30 psi + 14.7	459	650
	170° F + 460	50 psi + 14.7	539	763
	170°F + 460	20 psi + 14.7	395	559
	110°F + 460	50 psi + 14.7	567	802
	110°F + 460	20 psi + 14.7	415	587