Pitot-Static Calibration Flow Chart, written by Al Lawless

Std Sea Level Conditions $T_o = 15^\circ\mathrm{C} = 288.15\ \mathrm{K} = 518.7\ \mathrm{R}$

$a_o = 1116.45\ \mathrm{ft/s} = 661\ \mathrm{KTAS} = 761.14\ \mathrm{mph} = 340.3\ \mathrm{m/s}$

$P_o = 2116.22\ \mathrm{lb/ft^2} = 29.92\ \mathrm{in.Hg} = 101325\ \mathrm{Pa}$

$\rho_o = .0023689\ \mathrm{slg/ft^3} = 1.225\ \mathrm{kg/m^3}$

$g = 32.17\ \mathrm{ft/sec^2} = 9.80665\ \mathrm{m/sec^2}$

Mach

$$M \equiv \frac{V_T}{a} = \frac{V_T}{a_o\sqrt{\theta}}$$

$$M(<1) = \sqrt{5\left[\left(\frac{q_c}{P_a}+1\right)^{2/7}-1\right]}$$

$q_c \equiv P_T - P_a$; $q_{cic} \equiv P_p - P_s$

$\Delta P_T \equiv P_P - P_T$; $\Delta P_s \equiv P_s - P_a$

$\Delta P_T, \Delta P_s$, = total & static **errors**

Common definitions:
P_a = true ambient pressure,
P_T = true total pressure,
P_s = instrument-corrected static press.
P_P = instrument-corrected pitot press.

Temperature

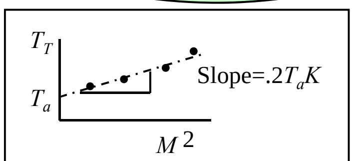
$K = {}^\circ C + 273.15$

$R = {}^\circ F + 459.67$

${}^\circ C = [{}^\circ F - 32]\frac{5}{9}$

${}^\circ F = \frac{9}{5}{}^\circ C + 32$

T_{Ti} → $+\Delta T_{ic}$ → T_T → $T_a = \dfrac{T_T}{1 + .2KM^2}$ → $\theta = \dfrac{T_a}{T_o}$



Note: Must use absolute temperatures (K or R) when calculating θ.

Calculations require consistent units (e.g. ft/s, lb/ft²) for all inputs & outputs.
ft/s = knots x 1.68781 = mph x 1.4666
m/s = knots x .51444 = ft/s x .30386
knots = .54 x Km/hr = mph x .869
Pa = lb/ft² x 47.88 = lb/in² x .3325

Altitude

H_i → $+\Delta H_{ic}$ → H_{ic} → $+\Delta H_{pc}$ → H_c

$\Delta H_{pc} = H_c - H_{ic}$

If using known pressure alt.

$\Delta H_{pc} = \dfrac{\Delta P_s}{\rho_a g}$

$\Delta H_c \approx \Delta H_G \dfrac{T_s}{T_a}$ H_G = geometric (tapeline) altitude; T_s = std temp at test altitude (abs.); T_a = test day ambient temp (abs.)

$$\delta = \frac{P_a}{P_o} = [1 - 6.876\times10^{-6} \times H_c]^{5.25}$$
<36,088 ft (<11,000 m)

$$\delta = .223358\, e^{-.00004806\,[H_c - 36,088]}$$
>36,088 ft (>11,000 m)

$$\sigma = \frac{\rho_a}{\rho_o} = \frac{\delta}{\theta}$$

Sign Convention

Note that SFTE sign convention stipulates ΔP_T and ΔP_s are errors to be subtracted while ΔH_{pc} and ΔV_{pc} are corrections to be added.

SUPERSONIC EQUATIONS

$$\frac{q_c}{P_a} = \frac{166.92\left[\dfrac{V_e}{a_o\sqrt{\delta}}\right]^7}{\left(7\left[\dfrac{V_e}{a_o\sqrt{\delta}}\right]^2 - 1\right)^{2.5}} - 1$$

Can replace $\dfrac{V_e}{a_o\sqrt{\delta}}$ with M

or replace $\dfrac{V_e}{\sqrt{\delta}}$ with V_c and

replace P_a with P_o

Airspeed

V_i → $+\Delta V_{ic}$ → V_{ic} → $+\Delta V_{pc}$ → V_c → $+\Delta V_c$ → V_e → $\div\sqrt{\sigma}$ → V_T → $-V_{headwind}$ → V_G

$$q_{cic} = P_o\left[\left(\frac{\rho_o}{P_o}\frac{V_{ic}^2}{7}+1\right)^{3.5} - 1\right]$$

$\Delta V_{pc} = V_c - V_{ic}$

$$V_c = \sqrt{7\frac{P_o}{\rho_o}\left([\frac{q_c}{P_o}+1]^{2/7} - 1\right)}$$

$q_{cic} + \Delta P_s - \Delta P_T = q_c$

ΔPs

If using known V_c

$$q_c = P_o\left[\left(\frac{\rho_o}{P_o}\frac{V_c^2}{7}+1\right)^{3.5} - 1\right]$$

ΔP_T often ≈ 0 for fixed-wing A/C in normal flight.
Exact solution requires multiple tests or noseboom with P_T reference.

Subsonic ΔV_c from scale altitude (a.k.a. compressibility) correction chart, or from $\Delta V_c = V_e - V_c$ where

$$V_e = \sqrt{7\frac{P_a}{\rho_o}\left([\frac{q_c}{P_a}+1]^{2/7} - 1\right)}$$

$$V_T = \sqrt{7\frac{P_a}{\rho_a}\left([\frac{q_c}{P_a}+1]^{2/7} - 1\right)}$$

If using known V_T

$$q_c = P_a\left[\left(\frac{\rho_a}{P_a}\frac{V_T^2}{7}+1\right)^{3.5} - 1\right]$$