Calibration and Uncertainty

Quick reference for instrumentation and control engineers

ib

instrumentationblog.in

Errors

Error % of span	**(reading − true) ÷ span × 100**
mA error % span	**(I − $I_{expected}$) ÷ 16 × 100**
Error % of reading	**(reading − true) ÷ true × 100**
Hysteresis	**$\lvert R_{up} - R_{down} \rvert$ ÷ span × 100**
Correction	**true − reading = −error**

5 point test (4 to 20 mA)

%	mA
0	4.000
25	8.000
50	12.000
75	16.000
100	20.000

Test rising then falling; never overshoot a point.

Uncertainty (GUM)

Combined	**$u_c = \sqrt{(\Sigma\, u_i^2)}$**
Expanded	**$U = k \times u_c$, k = 2 ≈ 95 %**
Type A (mean)	**$u = s \div \sqrt{n}$**
Std deviation	**$s = \sqrt{[\Sigma(x - \bar{x})^2 \div (n - 1)]}$**
TPE	**$\sqrt{(e_1^2 + e_2^2 + \ldots)}$**

Type B divisors

Distribution	u =
Normal (certificate, k given)	U ÷ k
Rectangular (spec, resolution)	a ÷ √3
Triangular	a ÷ √6
U shaped	a ÷ √2
Display resolution r	(r ÷ 2) ÷ √3

Decisions

TUR	**tolerance ÷ U_{95} (aim ≥ 4:1)**
Guard band	**acceptance = tolerance − U**
Pass	**|error| ≤ acceptance limit**

Sensor tolerances

Sensor	Tolerance
Pt100 class AA	± (0.1 + 0.0017 |t|) °C
Pt100 class A	± (0.15 + 0.002 |t|) °C
Pt100 class B	± (0.3 + 0.005 |t|) °C
Type K/N class 1	± 1.5 °C or 0.4 % |t|
Type K/N class 2	± 2.5 °C or 0.75 % |t|
Gauge class 1.0 (EN 837)	± 1 % of span

Deadweight tester

Pressure	**$p = m \times g_{local} \div A$**
Local gravity	**$g \approx 9.780327\,(1 + 0.0053024 \sin^2\varphi - 0.0000058 \sin^2 2\varphi) - 3.086 \times 10^{-6}\, h$**

Good practice

- Record as found before adjusting.
- Use traceable standards within due date.
- Let readings settle; note ambient temperature.
- Trend as found errors to set intervals (ILAC G24).