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STATIC AND DYNAMIC CHARACTERISTICS OF MEASUREMENT SYSTEMS

Document 1: Selected Derivations and Notes

Static Calibration Part 1: Derivation of the Thermistor Constants

Constant:	Value:
R_o	9647.88 Ω
β	3617.58

Derivation (From: *MATLAB Tools for ME 646 – 2017*)

$$R = R_o \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_o}\right)\right]$$

$$T_o = 298.15\,K$$

$$R = R_o \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_o}\right)\right] = R_o \exp\left[\frac{-\beta}{T_o}\right]\exp\left[\frac{\beta}{T}\right]$$

$$R = A\exp[\beta x]$$

$$where\ A = R_o \exp\left[\frac{-\beta}{T_o}\right]\ \ and\ \ x = \frac{1}{T}$$

$$R = R_o \exp\left[\beta\left(\frac{1}{T} - \frac{1}{T_o}\right)\right]$$

$$\ln R = \ln R_o + \beta\left(\frac{1}{T} - \frac{1}{T_o}\right)$$

$$\ln R = \left(\ln R_o - \frac{\beta}{T_o}\right) + \beta\left(\frac{1}{T}\right)$$

$$\equiv y' = a_o + a_1 x'$$

$$\text{where } \ y' = \ln R \text{ and } x' = \frac{1}{T}$$

$$and\ a_o = \ln R_o - \frac{\beta}{T_o}\ and\ a_1 = \beta$$

Static Calibration Part 4: Conversion of Thermocouple Voltage to Temperature

The thermocouple was calibrated assuming the values outputted by the thermistor were correct. A least squares regression best fit line was generated from Figure 1 in the published MATLAB document. The slope and y-intercept of the line generated from Figure 1 were used to calculate the temperature of the thermocouple.

$$Temperature = \frac{(Thermocouple\ Voltage) - b}{m}$$

Where

$$m = 10\ mV/°C,\ and\ b = 14.8\ mV$$

The sample mean temperature was found to be -0.3156 °C

A bare wire thermocouple was dipped in an ice bath 25 times. The standard deviation of this value was found to be 2.067. The sample size for this operation was 25, *v* was found to be 24.

See pages 3 through 5 in the published MATLAB code for more information.

Dynamic Calibration Part 6: Table Containing Time Constant Calculations and Standard Error of the Mean

Sheath Material	Transition	Method Of Event Start:	Time Constant	S_{yx}
Steel	Boiling Water To Icewater	5 σ		12.8
Steel	Ice Water To Boiling Water	5 σ		17
Aluminum	Boiling Water To Ice Water	5 σ		15.4
Aluminum	Ice Water To Boiling Water	5 σ		16.5
Bare Wire	Boiling Water To Ice Water	5 σ		16.4
Bare Wire	Ice Water To Boiling Water	5 σ		17.4
Steel	Boiling Water To Icewater	Max Slope		8.68
Steel	Ice Water To Boiling Water	Max Slope		17
Aluminum	Boiling Water To Ice Water	Max Slope		13.1
Aluminum	Ice Water To Boiling Water	Max Slope		10.9
Bare Wire	Boiling Water To Ice Water	Max Slope		16.4
Bare Wire	Ice Water To Boiling Water	Max Slope		7.61

Works Cited

Linear least squares (mathematics). (2017, February 21). Retrieved February 25, 2017, from https://en.wikipedia.org/wiki/Linear_least_squares_(mathematics)