Understanding Calibration Uncertainties
Reported by Burns Engineering

Abstract
This guide provides an abbreviated description of the methodology used to calculate the calibration uncertainties that are included on the calibration reports provided by Burns Engineering.

Overview of the Requirements

ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories* requires that the calibration laboratory have a procedure for estimating the uncertainty of measurements. It requires the laboratory to include all uncertainty components which are of importance in the given situation. Sources contributing to the uncertainty include but are not limited to reference standards, calibration methods, equipment, environmental conditions, properties and condition of the item being calibrated (the unit under test), and the operator.

Burns Engineering Measurement Uncertainty Analysis

Burns Engineering uses a method of uncertainty analysis that is consistent with the 1993 ISO Guide to the Expression of Uncertainty in Measurement, commonly referred to as the GUM. All known uncertainty components which are of importance are taken into account. The list of components which Burns has identified includes, but is not limited to items such as the uncertainty and drift of the SPRT used, the accuracy and resolution of the bridge or DMM, the uncertainty and drift of the standard resistor used, the calibration bath stability and uniformity, and the repeatability and reproducibility of measurement which includes short term behavior of the unit under test (UUT) and operator variation. The contribution to uncertainty for each of the identified components is determined as a 1 standard uncertainty magnitude and the components are then summed using an RSS method (squaring each component value, summing them all together and then taking the square root of the sum). This provides the standard uncertainty of the measurement, this value is then multiplied by 2 to give the expanded uncertainty which has a level of confidence of approximately 95%. The expanded uncertainty is the value that is included on the calibration report.

Short Term Behavior of the Unit Under Test

Burns has found that in many instances the short term behavior of the UUT is the most significant component in the uncertainty estimate. Take for example the calibration of an industrial grade PRT using the same equipment as that which is used for an SPRT, i.e. fixed point cell, bridge, etc. The equipment used may be capable of achieving very low uncertainties, however once the short term behavior of the UUT is added into the estimate, it can easily become the dominant component. For example an industrial PRT that is specified by the manufacturer to have a short term repeatability and Hysteresis of less than 10mK at the triple point of water (TPW) with a 3σ confidence level is calibrated using equipment and methods capable of 2mK expanded uncertainty (k=2) at the TPW, the resultant expanded uncertainty is calculated as follows.

Component	Expanded Uncertainty	Coverage Factor	1 standard uncertainty
All equipment and method combined	2 mK	2	1mK
UUT	10mK	3	3.33mK
		RSS Combined Standard Uncertainty:	3.48mK
		Expanded Uncertainty, k=2 (95%):	6.95mK

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