Evaluation of Measurement Uncertainty in Calibration of a 4 Ton Capacity Electronic Balance

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Abstract:

Electronic balances are essential instruments in both industrial and research laboratories for accurate and reliable mass measurements. Their performance depends on instrument design, environmental stability and systematic calibration. Measurement uncertainty, which represents the quantified doubt associated with a measurement result, forms the cornerstone for assessing conformity, traceability, and quality assurance in calibration processes. The evaluation of measurement uncertainty in this work follows the principles of the Guide to the Expression of Uncertainty in Measurement (GUM, ISO/IEC Guide 98-3:2008) and the requirements of ISO/IEC 17025:2017. This work presents the calibration and performance evaluation of a high-capacity electronic balance with maximum capacity of 4000 kg. Such balances are critical in industrial applications, including propellant processing, bulk material handling, and manufacturing quality control, where reliable mass determination directly affects process safety and product integrity. The calibration encompassed key metrological tests-repeatability, eccentricity, sensitivity, linearity, hysteresis, and reference weight accuracy-conducted in accordance with recognized procedures from OIML R76 [3] and relevant national metrology standards. Experimental data were acquired over multiple cycles, and uncertainty components were evaluated using both Type A (statistical) and Type B (systematic) methods. Each source of uncertainty was modelled using appropriate probability distributions, combined using the root-sum-square method, and expanded to a coverage factor k=2, corresponding to a 95% confidence level. The resulting combined expanded uncertainty at full load was ±0.709 kg, corresponding to 0.018% of full scale. This value lies well within the acceptable industrial tolerance for Class III balances, thereby confirming the balance's suitability for traceable, repeatable, and accurate industrial mass measurement.

Keywords:

Electronic balance calibration, Measurement Uncertainty, ISO/IEC 17025, GUM.