



# Introductory notes for the Acta IMEKO thematic issue on the 2023 SBM Metrology Conference – part 3

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Dear Readers,

This thematic issue of Acta IMEKO brings together selected contributions from the 2023 SBM Metrology Conference, highlighting recent advances and emerging challenges across a broad spectrum of metrological applications. The papers collected herein reflect the central role of metrology in supporting technological innovation, regulatory frameworks, industrial competitiveness, and sustainability. Topics span digital transformation in measurement systems, quantum-based electrical standards, radiation and environmental metrology, uncertainty-informed conformity assessment, non-destructive material characterisation, and advanced photovoltaic technologies. Together, these contributions illustrate how rigorous measurement science underpins reliable decision-making in increasingly complex technical and socio-economic contexts. This issue underscores the dynamic evolution of metrology and its growing relevance in addressing contemporary scientific and industrial demands.

The transition from analogue to digital communication in flow measurement systems has intensified with the growing adoption of smart meters in gas and oil applications. The paper [1] proposes and validates a testing methodology for assessing the metrological reliability of flow computers when operating with digital inputs. The approach is experimentally compared with conventional analogue-based tests by evaluating the Volume Conversion Factor. Results show that digital testing reduces measurement uncertainty, test complexity, and execution time, while maintaining metrological robustness. The proposed method supports the reliable integration of smart meters and provides a practical basis for updating regulatory and conformity assessment practices in legal metrology.

Paper [2] presents the development of a cyber-physical system for a radiation meter calibration laboratory, using air-kerma measurement as a pilot digital-twin application. A Monte Carlo-based virtual laboratory was implemented to replicate the

physical calibration setup and integrated into a digital twin workflow with bidirectional data exchange. The agreement between virtual and physical measurements demonstrates the feasibility of applying digital twin concepts in ionising radiation metrology. The proposed framework supports Metrology 4.0 by enhancing traceability, process understanding, and interoperability, and offers a foundation for future applications such as interlaboratory comparisons and advanced calibration strategies in radiation protection.

The application of the relative (comparative) method for radionuclide activity determination using high-purity germanium gamma spectrometry at the Brazilian National Laboratory for Ionizing Radiation Metrology is reported in [3]. Activities of <sup>22</sup>Na, <sup>60</sup>Co, <sup>133</sup>Ba, and <sup>137</sup>Cs were determined for liquid and solid sources with traceability to national standards. The methodology demonstrated high accuracy and efficiency, with total uncertainties below 2.2 % for liquid samples and 2.8 % for solid samples at a 95 % confidence level. The results confirm the robustness of the comparative method and support its continued use in radiation metrology, nuclear medicine, industry, and environmental monitoring.

Paper [4] presents the operating principles and preliminary implementation of an electric current primary standard based on Ohm's law, integrating Josephson voltage and quantum Hall resistance standards. The proposed system provides a direct realisation of the ampere in the nanoampere to milliampere range, addressing the current absence of a national DC current primary standard in Brazil. Experimental results obtained from the calibration of a multifunction calibrator demonstrate relative uncertainties comparable to the best Calibration and Measurement Capabilities recognised by the BIPM. This work represents a significant step toward strengthening quantum-based electrical metrology infrastructure and traceability within the revised SI framework.

A scoping review of methodological approaches for determining total oil and grease (TOG) in water is disclosed in

[5]. The paper analyses scientific publications from 1970 to 2023 in relation to the evolution of international environmental policies. The study reveals a strong correlation between regulatory milestones promoted by the United Nations and the growth of research on TOG measurement techniques. A pronounced increase in publications is observed over the last decade, reflecting heightened environmental awareness and regulatory demands. By mapping methodological trends and policy drivers, this work highlights the central role of metrology in supporting ecological monitoring, wastewater regulation, and evidence-based decision-making in the context of global sustainability challenges.

The assurance of validity in Zener DC voltage standard calibrations through the systematic use of historical calibration data is addressed in [6]. Aligned with ISO/IEC 17025:2017 requirements, it discusses practical approaches, including control charts, replicate calibrations, intralaboratory comparisons, and intermediate checks. The main contribution is the application of linear regression-based prediction techniques combined with the normalised error ( $E_n$ ) as an objective acceptance criterion. Experimental results demonstrate the method's effectiveness in identifying the preservation or loss of historical calibration behaviour, providing a robust and transferable framework for improving confidence in high-accuracy calibration results.

Paper [7] reviews the application of conformity assessment principles to custody transfer operations in the oil and gas industry, where measurement reliability is critical due to the high economic value involved. Emphasis is placed on the role of measurement uncertainty in managing producer and consumer risks and in supporting objective decision-making near specification limits. Through an extensive literature review, the authors identify a gap in the systematic use of uncertainty-based tools for custody transfer assessments. The study highlights the guard-band approach as a valuable methodological resource for reducing false conformity decisions, minimising commercial disputes, and enhancing confidence in compliance evaluations in high-stakes industrial transactions.

A metrological approach for determining the Poisson modulus of aluminium samples using nondestructive ultrasonic testing based on longitudinal and transverse wave velocities is presented in [8]. Emphasis is placed on rigorous evaluation of measurement uncertainty, ensuring traceable and reliable results that are consistent with international standards. The study demonstrates the feasibility, accuracy, and economic advantages of ultrasonic methods compared with destructive testing, highlighting their suitability for industrial quality control and material characterisation. The experimentally determined Poisson modulus agrees well with reference values, reinforcing the role of ultrasound-based metrology as a robust, efficient, and safe technique for assessing the mechanical properties of metallic materials.

A Si-GaAs double-junction solar cell combining experimental electrical characterisation of silicon devices with numerical simulation of a III-V top cell is proposed in [9]. Using the SCAPS software, the authors optimise the GaAs sub-cell structure, identifying the base-layer thickness and doping

conditions that maximise performance while maintaining compatibility with commercially available Si cells. An efficiency of 25.0 % is achieved for the simulated III-V device. The study highlights the complementary role of accurate electrical measurements and modelling in the development of high-efficiency tandem photovoltaic technologies, supporting metrology-driven design and performance assessment of advanced solar cells.

We hope you will enjoy your reading.

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Section Editors

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