BOOK OF ABSTRACTS

IMEKO JOINT CONFERENCE

TC8
TC11
TC24

TORINO, ITALY   **SEPTEMBER 14-17, 2025**

INRiM
ISTITUTO NAZIONALE
DI RICERCA METROLOGICA

Politecnico di Torino
1859

Welcome Message from the General Chairs

It is our great pleasure to welcome you to the 2025 IMEKO TC8-TC11-TC24 Joint Conference. This international event gathers experts both from industry and academia, covering different topics from the fields of '**Traceability in Metrology**' (IMEKO TC8), '**Measurement in Testing, Inspection and Certification**' (IMEKO TC11), and '**Chemical Measurements**' (IMEKO TC24). This **IMEKO** (International Measurement Confederation) conference has been organised by **INRiM** (Istituto Nazionale di Ricerca Metrologica, National Metrology Institute of Italy) and **Politecnico di Torino**, in collaboration with **EUROLAB** and **ASSOTIC**. Moreover, the Conference received the patronage of **Accredia** and **Eurachem**, which actively supported the promotion of the event and contributed to its scientific program.

The IMEKO TC8-TC11-TC24 Joint Conference has been constantly growing in the last years, attracting an increasing interest from academics and professionals working in the field of Instrumentation and Measurement. The scientific program is robust and diverse, featuring 3 keynote presentations, 13 technical oral sessions over three days, and an insightful poster session. We received 108 abstracts from around the world, each rigorously peer-reviewed by our dedicated International Program Committee. Based on quality, originality, and relevance, 88 contributions were selected for presentation. We extend our gratitude to all reviewers for their meticulous efforts in ensuring a high-quality program.

This year's keynote speeches will feature renowned experts:

- **Vito Fernicola** (INRIM Board of Directors and ACCREDIA Vice-President, Italy) will present on 'Measuring and adapting quality infrastructure in a changing world'
- **Eugenia Eftimie Totu** (Eurachem Chair - National University of Science and Technology POLITEHNICA Bucharest, Romania) will address 'Next-Generation of Chemical Sensors for Health: Precision Detection of Inorganic Ions in Periodontal Diagnostics Under Eurachem Guidelines'
- **Claudia Koch** (Head of Section "Digitalization of Quality Infrastructure", Bundesanstalt für Materialforschung und –prüfung (BAM), Germany) will present 'Towards a digital ecosystem for quality infrastructure: DCC, digital reference material documents and beyond'

Moreover, the technical program is enriched by 6 special sessions:

- '**Gas Analysis for Sustainable Energy and Climate Change Mitigation'**, organised by Zhechao Qu (PTB, Germany)
- '**Innovative Networks of Testing and Calibration Laboratories**' organised by Admer Rey Dablio (Industrial Technology Development Institute - Department of Science and Technology, Philippines)
- '**Traceability for Laboratory Medicine**' organised by Yuriy Kuzmenko (SE "UKRMETRTESTSTANDART", Ukraine)

- '**New Eurachem Guidance on Validation of Measurement Procedures that Include Sampling**', organised by Marina Patriarca (Chair of "Reference Materials" Eurachem Working Group), Mike Ramsey (Chair of "Uncertainty from Sampling" Eurachem Working Group) and Eugenia Eftimie Totu (Eurachem Chair)
- '**Chemico-physical measurements in Heritage Science**' organised by Laura Guidorzi (Università degli Studi di Torino, Italy), Marta Magalini (Istituto Nazionale di Fisica Nucleare (INFN), Italy), and Miriana Marabotto (Istituto Nazionale di Fisica Nucleare (INFN), Italy)
- '**Young metrologists from Ukraine**' organised by Moritz Ackermann (PTB, Germany)

We are confident that this Conference will be a unique opportunity to promote new collaborations, stimulate insightful discussions, and exchange knowledge and new ideas in the fields of traceability, TIC and chemical measurements.

With our warmest regards,
See you in Torino!

The General Chairs
Dr. Michela Sega
Dr. Leonardo Iannucci

IMEKO Torino 2025 Committee

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IMEKO Torino 2025 Keynote Speakers

Keynote Lecture - Monday September 15 - H 10:00

Measuring and adapting quality infrastructure in a changing world

Vito **Fernicola**

INRIM Board of Directors and ACCREDIA Vice-President

ABSTRACT

Quality, security and interoperability of products, services, processes and systems?
It is the result of teamwork. Standardisation, metrology, accreditation, conformity assessment and market surveillance form the backbone of the quality infrastructure (QI), a building block of our economic and social systems. By linking organisations, policies and practices, QI supports industrial development and competitiveness while ensuring global trust and wise use of resources.

Although its benefits are well known, there are still few instruments that measure its deployment and development globally. In particular, the Quality Infrastructure for Sustainable Development (QI4SD) index focuses mainly on the contribution of QI to the achievement of the SDGs, while the Global Quality Infrastructure Index (GQII) highlights the close relationship between QI and country development.

This talk will review the correlation between QI measures and economic performance (innovation, competitiveness, trade) with a focus on metrology and how its effectiveness is essential for providing sustainable services, traceable measures and making an impact. Accurate measurements and measuring instruments are necessary for the protection of health, safety, the environment and citizens.

Metrology's key role in ensuring trust is expanding to meet the challenges of the energy transition and to support clean technologies, services and products of the future in a competitiveness-oriented and climate-neutral approach to decarbonisation. Good practices of institutions that have been able to better respond to evolving traceability needs, adopting technological advances, promoting stakeholder engagement and improving the integration of QI components will be discussed.

In general, capacity building, skills development and the promotion of a quality culture remain central elements of these efforts, lest the rapid evolution of digital technologies prevent the inclusion of all segments of society. Metrology and QI are accepting the challenge to find new tools related to traceability to better serve the development of future-oriented quality policies that meet the needs of people, planet and prosperity.

Next-Generation of Chemical Sensors for Health: Precision Detection of Inorganic Ions in Periodontal Diagnostics Under Eurachem Guidelines

Eugenia Eftimie **Totu**

Eurachem Chair
National University of Science and Technology POLITEHNICA Bucharest, Romania
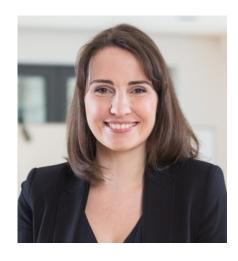
ABSTRACT

Periodontal disease is a chronic inflammatory condition affecting patients of all ages, leading to periodontium deterioration and potential tooth loss. Its diagnosis has traditionally depended on clinical and radiographic assessments, which may not fully reflect the underlying inflammatory response. Gingival crevicular fluid (GCF), a plasma-derived extravasate from the gingival sulcus, contains serum, periodontal tissues, bacteria, and various components such as electrolytes, proteins, glucose, enzymes, complement, leukocytes, and exfoliated epithelial cells, making it a valuable diagnostic indicator of periodontal destruction. Consequently, developing innovative, non-invasive techniques for early detection, severity assessment, treatment monitoring, and prognosis prediction remains a crucial challenge. Measuring sodium, potassium, and calcium ion concentrations in GCF provides a valuable indicator of periodontal tissue health and serves as a potential diagnostic marker for active disease states. This presentation aims to introduce a novel device capable of locally sensing inorganic ions, such as calcium ion, within the periodontal pocket. To enhance reliability, implantable device failure is expected to be minimized by leveraging the properties of the used nanoparticles. For a calcium ion detection sensor in periodontal diagnostics, Eurachem guidelines ensure calibration with certified calcium ion solutions (e.g., NIST-traceable standards), measurement uncertainty calculations (e.g., considering temperature, pH variations in biological samples); regular validation using control samples to check sensor drift and response accuracy, standardized reporting of results with clear traceability documentation. For the measurement uncertainty quantification it was followed the Eurachem Guides "Quantifying Uncertainty in Analytical Measurement", as well as "Assessment of performance and uncertainty in qualitative chemical analysis".

Towards a digital ecosystem for quality infrastructure: DCC, digital reference material documents and beyond

Claudia **Koch**

Head of Section "Digitalization of Quality Infrastructure"
Bundesanstalt für Materialforschung und –prüfung (BAM)

ABSTRACT

The transition from a document-based to a data-driven quality infrastructure (QI) that is networked, automated, and intelligent will significantly enhance efficiency and transparency. More importantly, the digitalization of QI strengthens trust in safety and quality. To achieve this, BAM together with Germany's central QI institutions partnered in the initiative QI-Digital to jointly establish a digital ecosystem for QI. This initiative leverages recognized standards and latest technologies to seamlessly integrate QI procedures, processes, and tools, facilitating cross-system networking among stakeholders in QI. Through concrete use cases and projects, the initiative develops, tests, and demonstrates practical solutions. This talk will provide insights into the comprehensive roadmap for the digital transformation of QI, illustrating diverse areas of action.

The talk specifically highlights the potential of data spaces for a digital QI. It further provides a deep dive into machine-readable quality documents, focusing on digital reference material documents (DRMDs): Based on the digital calibration certificate (DCC), the XML schema developed at BAM incorporates ISO 17034 requirements in a computer-readable format, offering significant process improvements. DRMDs enable direct integration into laboratory information systems, reduce manual data entry errors, and enhance traceability. Standardized data formats simplify information exchange between systems and refine quality control. To expedite market adoption, BAM has developed a software tool for creating DRMDs and an AI tool for converting existing PDF certificates into DRMDs. These demonstrators, along with the inclusion of DRMDs in the reference materials database COMAR, showcase their functionality and potential to a broader community.

IMEKO Torino 2025 Special Sessions

Special Session #1: Gas Analysis for Sustainable Energy and Climate Change Mitigation
Organized by: Zhechao Qu, *Physikalisch-Technische Bundesanstalt (PTB)*

Special Session #2: Innovative Networks of Testing and Calibration Laboratories
Organized by: Admer Rey Dablio, *Industrial Technology Development Institute*

Special Session #3: Traceability for Laboratory Medicine
Organized by: Yuriy Kuzmenko, *SE "UKRMETRTESTSTANDART"*

Special Session #4: Metrological Traceability, Method Validation, and Measurement Uncertainty in Analytical Sciences. Guidelines and Experiences from the Eurachem Community
Organized by: Marina Patriarca, Mike Ramsey, Eugenia Eftimie Totu, *Eurachem*

Special Session #5: Chemico-physical measurements in Heritage Science
Organized by: Laura Guidorzi, *Università degli Studi di Torino*, Marta Magalini, Miriana Marabotto, *Istituto Nazionale di Fisica Nucleare*

Contents

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Monitoring of Combinatorial Solution Deposition of Thin Films

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Optimization of thin film deposition is often the limiting step in discovery of new materials and device development. Over the years, high-throughput combinatorial methods were developed for deposition of thin films from the gas phase. However, very few reports focused on combinatorial thin film deposition from solution. We have introduced a new combinatorial approach for deposition of thin films from solution using a flow deposition reactor for simultaneously studying the effect of two key parameters, deposition time and deposition temperature, on a single sample. A novel temperature measurement sensor matrix was custom designed for monitoring the temperature gradient on the substrate in real time. As a proof of concept, we demonstrate solution deposition of PbS thin films which resulted in a library of 25 deposition condition combinations on a single GaAs(100) substrate. This approach paves the road towards cost-effective, rapid combinatorial studies of a large variety of solution-deposited thin film materials.

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Rapid Monitoring of Key Alloying Elements in Deformed Steel Bars Using Portable EDXRF and LIBS: A Strategy Against Substandard Quality

Authors: Gina Catalan[1]; Jo Marie Venus Agad[1]; Mary Joy Bautista[1]; Morris Pioquinto[1]

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Abstract:
This study investigates the effectiveness of combining portable analytical techniques—Energy Dispersive X-ray Fluorescence (EDXRF) and Laser-Induced Breakdown Spectroscopy (LIBS)—as alternatives to traditional Spark Optical Emission Spectroscopy (Spark-OES) for the rapid assessment of key alloying elements (C, Si, Mn, P, S) in deformed steel bars.
Both EDXRF and LIBS demonstrated strong accuracy and precision in analyzing these elements, with statistical analysis revealing significant correlations with the Spark-OES benchmark. The combination of these portable methods offers substantial advantages, including on-site testing capabilities and minimal sample preparation, enabling real-time monitoring and immediate quality control.
The findings underscore the potential of EDXRF and LIBS to enhance quality assurance processes in the steel industry, promoting safer construction practices through efficient, non-destructive testing methods.
Keywords: LIBS, EDXRF, Spark-OES, deformed steel bars, quality assurance

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Metrological traceability paths for stable isotope measurements of CO2 in air

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Measurements of carbon dioxide (CO2) stable isotopes in air and of the δ13C-CO2 ratio are indicators of the anthropogenic contribution to CO2 emissions. These measurements provide useful data to monitor the anthropogenic CO2 impact on climate change. To be reliable, the results have to be traceable to internationally recognized references, which enable data comparability in time and space. The Vienna Peedee Belemnite (VPDB) isotope reference defines the zero point of the carbon stable isotope scale describing the relative abundance of 13C and 12C. At present, the standard and associated VPDB scale for δ13CVPDB in CO2 are still artefact-based and rely on the CO2 production from carbonate material through its reaction with (over)saturated phosphoric acid. They are used to transfer the scale to CO2 in air measurements. However, the use of this method is limited to specialized laboratories and gaseous Certified Reference Materials (CRMs) are needed to meet increasing demand.
At INRiM, gravimetric mixtures of CO2 in air, candidate CRMs for isotopic composition, are under development. They are based on two different traceability paths, both linked to the VPDB scale. The first one rely on pure CO2 sources with different δ13C-CO2 values considered as references, diluted to ambient amount fraction to produce the candidate CRMs. The second one starts from certified reference mixtures, which are used to calibrate a cavity ring-down spectrometer used to assign the isotopic values to the same candidate CRMs. This work presents the two traceability paths and their application to three case studies at different δ13C-CO2 values.

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Cavity ring-down spectroscopy for the certification of the isotopic composition of CO2 in air CRMs

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The increase of greenhouse gases (GHGs) concentration in the atmosphere due to anthropogenic emissions has been the major driver of climate change since the mid-twentieth century. Carbon dioxide (CO_2) is the most important long-lived anthropogenic GHG. The study of its isotopic composition gives useful information for assessing and quantifying the uptake of CO_2 in the environmental compartments, as well as for distinguishing natural from anthropogenic carbon in the atmosphere. INRiM, the Italian National Metrology Institute, is deeply involved in supporting the efforts of the metrological community to achieve the comparability of results and to assure accuracy and metrological traceability to CO_2 stable isotope measurement results. In this framework, the realization of gaseous Certified Reference Materials (CRMs) of CO_2 in air at ambient level and known $\delta 13C$-CO_2 represents a fundamental and promising activity. The availability of sound and affordable CRMs for the measurement of the isotopic composition of CO_2 at ambient amount fraction can support the researchers using spectroscopic techniques in the isotope measurement field.
CRMs for the CO_2 amount fraction at atmospheric level in air are realized at INRiM by the gravimetric method following the International Standard ISO 6142-1. Cavity ring-down spectroscopy (CRDS) is used to assign also the $\delta 13C$-CO_2 value to the prepared CRMs, which spans in the range from +1.3 ‰ to -42 ‰, with expanded uncertainties of 0.2-0.3 ‰. This work describes the analytical procedure based on CRDS and the preliminary stability studies carried out in the assignment of the $\delta 13C$-CO_2 values.

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Implementation of traceability during interlaboratory comparisons of the measurement results of hematological characteristics of human blood processed together by the least squares method

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It is not difficult to imagine an experiment that has been performed many times in different laboratories around the world, when the characteristics of a blood sample taken from one person were measured on devices from the same or different manufacturers. In theory, the result should be the same on different devices. In practice, there has always been and will always be some difference. Did such experiments bring the great benefit that they could have? In fact, no, because there was no clear mathematical model for processing and optimal use of such comparative measurements, and there was no organizational structure for their performance.

The proposed measurement model allows to combine processing of any measurements combination of any human blood samples, certified and non-certified reference materials, manufacturer's control samples, etc. during international and interlaboratory comparisons of measurement results. Measurements are proposed to be performed in accordance with the scheme of the Metrological Measurement Network (MMN), which has significant advantages over the circular and radial scheme.

In the absence of certified reference materials (CRM) or reference methods, it is proposed to average the reference numerical axis based on the measurement results made by a large number of working devices of all manufacturers. This will give a local reference, relative to which the measurement biases of each device will be obtained. This is the main idea proposed in this publication on the example of processing the results of interlaboratory comparisons in the field of measurement of hematological characteristics of human blood.

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Ensuring metrological traceability by establishing the reference numerical axis using the Least Squares Method

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To establish unbiased measurement traceability a method for implementing a single reference numerical axis by adjustment arbitrary combinations of dependent non-equal measurements by the Least Squares Method (LSM) is proposed. The organization of comparisons according to the Metrological Measurement Network (MMN) scheme allows the involvement of a theoretically unlimited number of participants in implementing a single reference numerical axis.

While forming a single reference numerical axis, each set of certified reference materials (CRM), measurement standard or instrument receives an additive and multiplicative bias of its own working numerical axis relative to the jointly formed reference numerical axis. Each CRM or material measure also receives the assigned value relative to the single reference numerical axis formed with their participation.

Additive and multiplicative biases characterize the bias of zero and measurement unit of the scale of each measurement standard, instrument or set of CRMs relative to the zero and measurement unit of a single reference numerical axis calculated by the adjustment of all measurement results using the LSM.

The results of Comparison of Certified and Measured Values of Potassium in Human Serum CRMs provided in the Joint Committee for Traceability in Laboratory Medicine (JCTLM) document DBWG P-04A were re-evaluated using the proposed methodology. The new measurement biases differ from those in the DBWG P-04A. As a result, the conclusions on the equivalence of the CRMs were updated.

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Deep Learning in Surface Metrology: AI-Based Decision-Making and Surface Texture Parameter Prediction

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The work proposes a deep learning application for decision-making support in surface metrology. A large amount of collected data was used from measured surface topography using tactile and non-tactile systems. The proposed algorithm, with built-in AI models, is helpful for preparing metrological scenarios and predicting surface texture parameters. The deep learning application with optimisation approaches is presented with a defined loss function. The proposed approach shows the concept of future AI-based surface metrology with a predefined measurement scenario suggested as the AI-preliminary selected measurement tool capable of predicting surface texture parameters.

This work employs a preliminary developed and tested deep learning algorithm to predict the measurement system type or surface texture parameter based on other labels using models built from actual experimental data.

In this study, a prediction algorithm was used, incorporating the Keras and TensorFlow in Python language. The validated models incorporated numerous attributes and predicted measurement system type classes. Thousands of measurements were collected to train the algorithm, using various tactile and optical instruments, from reference roughness standards with known parameters and prepared machined surfaces with varied parameters. To expand and diversify the dataset, bootstrap resampling and conditional noise addition were applied. Hundred resampled datasets were generated by randomly sampling rows with replacements from the original dataset. This increased the size of the data set while preserving variability.

In this study, three Python scripts were developed to predict two different tasks in surface metrology: system type classification and regression of the roughness parameter Ra.

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Proficiency Testing Scheme for Toxic Elements in Milkfish (Chanos chanos) in the Philippines: Ensuring Food Safety and Quality Control

Author: Alleni Junsay[1]

Co-authors: Aaron Dacuya [1]; Clarissa Manguin [1]; Gian Ernest Dizon [1]; Ian Deniell Magsino [1]; Janesky Esplana [1]

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Milkfish (Chanos chanos) is a staple aquaculture product in the Philippines, making food safety and quality assurance essential for consumer protection. This study presents a Proficiency Testing (PT) scheme organized by the National Metrology Laboratory of the Philippines (NML) to assess the capability of local laboratories to detect toxic elements in milkfish, specifically arsenic (As), cadmium (Cd), lead (Pb), and mercury (Hg). Philippine Reference Material (PRM) 2002 –Toxic Elements in Milkfish, a certified homogeneous and stable reference material, was prepared and distributed to participating laboratories for independent analysis. Results were evaluated using z'-scores and other statistical performance metrics.

A total of 26 local testing laboratories participated in the PT scheme, with 23 submitting results. Among them, 42% of the 12 participants for total arsenic, 62% of the 21 participants for cadmium, 64% of the 14 participants for total mercury, and 82% of the 22 participants for lead achieved an "acceptable" z'-score performance. These findings suggest areas for improvement in laboratory proficiency, emphasizing the need for continuous enhancement of analytical testing capabilities.

The study underscores the importance of regular participation in accuracy-based PT programs conducted by NML to enhance the reliability and accuracy of toxic element analysis in Philippine laboratories.

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Validation of Analytical Methods for Assessing Heavy Metal in Green Mussels (Perna viridis) from Major Mussel-Producing Regions in the Philippines

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Green mussels (Perna viridis) are valuable marine resource in the Philippines, contributing significantly to the local economy and nutrition. These mussels, commonly farmed in the country's coastal waters, are filter feeders and may accumulate heavy metals like cadmium (Cd), mercury (Hg), and lead (Pb), which pose risks to both marine ecosystems and human health. This study focused on developing and validating gravimetric external calibration methods to quantify heavy metal levels in mussels from top mussel-producing regions in the Philippines. The analysis was performed using Graphite Furnace Atomic Absorption Spectrophotometry (GFAAS) for Cd and Pb, and Direct Mercury Analyzer (DMA) for Hg. The validation parameters, including linearity, precision, trueness, and detection limits, were evaluated. The validated methods demonstrated a linear range with correlation coefficients (r) > 0.995. The matrix limit of quantification (LOQ) for Hg, Cd, and Pb were determined to be 20.9, 175.9, and 208.7 µg/kg, respectively. Trueness for Cd and Hg (n=10) was assessed using NIST SRM 1566b Oyster Tissue, yielding recovery ranges of 85.9-91.7 % for Cd and 89.2-96.0 % for Hg. For Pb, trueness was evaluated through recovery by spiking at low and high concentrations (n=7), resulting in recovery ranges of 85.1-104.8 % and 87.9-100.1 %, respectively. The validated methods revealed that Hg and Pb levels in mussels were below the maximum residue limit (MRL), while Cd level in one of the regions exceeded the MRL. These validated methods support Philippine aquaculture sector by providing dependable testing laboratory results, informing food safety decisions, and fostering product quality.

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Development and Validation of Reliable Quantitative Methods for Ethoxyquin in Chicken by Fluorescence Detection (LC-FLD) and Isotope Dilution Tandem Mass Spectrometry (LC-IDMS/MS)

Author: Abigail Grace Bion[1]

Co-authors: Aaron Dacuya [2]; Alleni Junsay [2]; Benilda Ebarvia [1]

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Ethoxyquin (EQ) is a quinoline-based antioxidant widely used in food and feed applications. Its use as an animal feed additive often results in residues in food products of animal origin, such as fish, shrimp, poultry meat, and eggs, raising potential health concerns. This study developed and validated liquid chromatography methods with fluorescence detection (LC-FLD) and isotope dilution tandem mass spectrometry (LC-IDMS/MS) for quantifying EQ. Sample preparation utilized the Quick, Easy, Cheap, Effective, Rugged, and Safe (QuEChERS) technique with a novel dispersive solid-phase extraction enhanced matrix removal-lipid (dSPE EMR-lipid) approach. The limits of detection (LOD) and quantification (LOQ) were 0.0024 and 0.0036 mg/kg for LC-FLD, and 0.0018 and 0.0025 mg/kg for LC-IDMS/MS, respectively. Matrix-matched calibration curves demonstrated excellent linearity (R = 0.999) for both methods. Recoveries were satisfactory at three spiking levels (94–106%), while repeatability (RSD ≤ 4.2%, n = 10) and intermediate precision over one, two, and three month period (RSD ≤ 7.6%, n = 3) met acceptance criteria based on the Horwitz equation. The developed methods are fit for purpose and suitable for accurate monitoring of EQ in chicken and similar matrices. The methods were successfully implemented to assess and characterize a chicken-based reference material for ethoxyquin analysis.

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Efficient Strategies for Selecting Minimal Solute Sets in Linear Solvation Energy (LSER) Models

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Linear solvation energy relationship (LSER) models are used in adsorption and chromatography to describe how molecular interactions influence solute retention or adsorption. These models relate the partitioning coefficient of a solute to various molecular properties, enabling predictions based on solute descriptors, which can be looked up or calculated via quantum chemistry.

Mathematically, LSER models are expressed as linear equations, with coefficients obtained through multiple linear regression of experimental data from a set of solutes. Since obtaining data for solutes is labor-intensive, and solutes may have limitations (e.g., low solubility, high cost, or instability), selecting an optimal minimal set of solutes becomes important.

This study discusses strategies for selecting a chemically diverse minimal solute set that minimizes the standard error of the model's coefficients. Monte Carlo simulations (performed in JMP via Python integration) are used to explore potential solutes, considering cases where solute descriptors span a limited range. Theoretical upper and lower bounds for the standard error are presented. Both homoscedastic and heteroscedastic LSER models are considered. Finally, the impact of interdependencies among solute descriptors on the statistical robustness of these strategies is discussed.

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Towards Reliable Solubility Data in Supercritical CO_2: A Consistency Framework and Machine Learning Approach

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Supercritical extraction of solid solutes using carbon dioxide is widely popular due to its green nature, high dissolution capabilities, and ease of solute separation. The key parameter for designing such a process is the equilibrium solubility of solids in supercritical CO_2. However, solubility data from different studies often show inconsistencies, necessitating reliability checks.

Various correlations describe solubility in supercritical CO_2, with the Mendez-Santiago-Teja (MST) correlation being one of the most reliable. However, its applicability is limited by the lack of sublimation pressure and enthalpy data for many complex organic molecules.

This work explored how to approximate sublimation enthalpy from readily available properties of the solute. Another question we addressed is how sensitive the consistency tests to uncertainty of the sublimation pressure and sublimation enthalpy. The developed consistency test was successfully applied to published solubility data, identifying inconsistencies using statistical metrics, including those from robust statistic analysis.

After removing inconsistent data points, the refined dataset was used to train a supervised learning regression model for solubility prediction. The model demonstrated high accuracy when tested against experimental data. Finally, the model was applied to predict the solubility of a complex industrial mixture, leading to the development of a concept for its fractionation.

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Conformity assessment to metrological requirements in Legal Metrology

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This article explores the multifaceted challenges of conformity assessment for metrological requirements in legal metrology. Ensuring these requirements for measuring instruments is crucial for proportionate, modern, and effective regulation, yet the increasing complexity of both the requirements themselves and the measurement systems presents a major hurdle. This complexity is compounded by rapid technological advancements in measurement, which often outpace the development of corresponding conformity assessment procedures, potentially delaying assurance of new systems' reliability. The article delves into the practical difficulties faced by stakeholders, including the constant challenge of bridging the gap between theoretical metrological requirements and their real-world implementation. It examines the critical role of proper documentation in demonstrating traceability, highlighting the potential problems arising from incomplete, inaccurate, or missing records, as well as the impact of evolving reference standards. The article emphasizes the need for a multifaceted approach to address these problems, and to simplify regulatory frameworks. Furthermore, it discusses the inconsistencies in defining "metrological requirements" across different legal acts and the challenges in identifying and documenting technical requirements for measuring instrument type approval, contributing to difficulties in interpretation and application. The interconnected roles of accreditation and metrology within the quality infrastructure are also examined, emphasizing the importance of harmonized procedures, uniform terminology, and a shared understanding of metrological supervision concepts among industry, laboratories, and governments to foster trust in measurement results. Finally, the article considers how to adapt and innovate conformity assessment procedures to maintain confidence in metrological results in the face of rapid technological progress.

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Risk Assessment for Calibration: The Non-Linearized Case

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This study presents a model designed to evaluate risks in calibration processes. A probabilistic model was described for estimating the global producer's and consumer's risk with a non-linearized tolerance interval. The measurement uncertainty required to determine the risk for the explanatory variable at a given value of the response variable was determined based on the data obtained from the regression analysis. The model was tested on the example from industrial practice to evaluate the risks associated with calibrating the roundness measurement device within a moderate scale of -3 µm to 3 µm. The results indicate that global consumers' and producers' risks along a moderate scale are lower in the non-linearized model compared to the linear model. The calibration risk assessment model was evaluated using confusion matrix-based metrics.

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Metrological traceability for measuring Indoor Air Quality using low-cost sensors

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Indoor air quality (IAQ) monitoring has gained significant attention due to its impact on human health and well-being. Nowadays, there has been an increased development and use of low-cost sensors, particularly for the collection of indoor air quality data. While these sensors provide low-cost and widespread monitoring solutions, they are still poorly characterised and the lack of dedicated standardised validation methods is a significant obstacle to the quality of their measurements. The Italian project "MIRABLE - Measurement Infrastructure for Research on heAlthy and zero energy Buildings in novel Living lab Ecosystems", carried out in collaboration between the Italian National Metrology Institute, INRiM, and the Polytechnic University of Torino, aimed to develop a measurement infrastructure for monitoring multi-domain indoor environmental conditions and occupant interaction in a full-scale Living Laboratory (called "H-IEQ LL"), using low-cost sensors. In this framework, in order to obtain reliable results, INRiM started activities on the metrological characterization of low-cost sensors for CO2, CO, NOx. Particular attention was given to the set-up of a calibration system for low-cost CO_2 sensors, resorting to a reference mixture of CO_2 to ensure the metrological traceability of the measurement results. A primary reference analyser based on NDIR spectroscopy was employed in the calibration procedure. Preliminary results obtained with CO_2 sensors are presented in this work. A similar approach will be carried out for low-cost sensors of CO and NOx in the future.

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Evaluation of performance of chemical laboratories for sulfite mass fraction determination in Philippine export products by proficiency testing

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The Philippines is a top exporter of dried mangoes and desiccated coconut globally. These products are often fortified with sulfites due to its antioxidant, antimicrobial, and preservative properties. However, sulfite content in foods is regulated due to potential health risks, particularly for individuals with allergies and respiratory conditions. Accurate and reliable measurement results are essential for effective monitoring the presence of sulfites in food to ensure food safety, prevent trade issues, and sustain market acceptability. Participation in proficiency testing (PT) schemes is an essential laboratory quality assurance measure to achieve this. This study highlights the PT schemes organized by the National Metrology Laboratory of the Philippines for the local testing laboratories to determine sulfite in export products, dried mango (2020) and desiccated coconut (2023). Participants'performance were evaluated against assigned values obtained by using a validated liquid chromatography-isotope dilution mass spectrometry (LC-IDMS). Acceptable scores were achieved by 40% (2 of 5) and 75% (3 of 4) of the participating laboratories for the PT schemes on dried mango and desiccated coconut matrices, respectively. Participation in these PT schemes provided local laboratories with an effective way to assess their technical capabilities and enhance their measurement methods, supporting the accurate determination of sulfite levels in Philippine export products.

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The Impact of Data Quality on ML Diagnostic Models: Ensuring Reliability in Medical AI

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The application of artificial intelligence and machine learning algorithms in healthcare has grown exponentially in recent years, offering benefits such as improving diagnostic accuracy and efficiency and addressing challenges such as interpretative bias. Ensuring the reliability of such models requires robust evaluations of their sensitivity to data quality—the extent to which data meets required standards. This study explores how variations in data accuracy, precision, and completeness affect an algorithm's ability to correctly classify electrocardiogram results. The models analysed—K-Nearest Neighbours, Random Forest, Artificial Neural Networks, and Convolutional Neural Networks—were selected due to their prevalence in electrocardiogram classification tasks. Using the PhysioNet's MIT-BIH Arrhythmia Dataset, the study classifies five types of beats defined by the AAMI EC57. To simulate varying data quality, the dataset has undergone systematic degradation through the addition of noise, rounding of decimal places, and removing data features. The re-evaluation of model performance has highlighted the effects of data quality on diagnostic outcomes, providing insights into the robustness of models under suboptimal conditions. By examining these critical factors, the study aims to inform the development of more reliable machine learning diagnostic systems, raising awareness of the importance of data integrity in medical applications. The study has shown that model performance is most sensitive to accuracy, completeness, and precision in descending order, with accuracy showing the greatest reduction in model predictions. It has also been displayed that model sensitivity is correlated with class population, as low-represented classes have yielded greater deviation under the application of data degradation.

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UPGRADING HIGH-CAPACITY MANUAL MASS COMPARATORS BY DEVELOPMENT OF AN AUTOMATED ROTARY MULTI-POSITION WEIGHING SYSTEM

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High-capacity calibration of mass standards using manual mass comparators requires the repetitive loading and unloading of masses into the comparator. This routine lifting could pose a threat to the musculoskeletal health and overall well-being of the calibration staff. This study developed an automated rotary plate that served as an accessory for existing manual comparators in the laboratory. The plate could mimic the calibration process by alternately conveying the reference and sample masses to and from the comparator.

The plate, controlled by stepper motor and microcontroller, is capable of rotary and vertical motions. The rotary aligns the mass standard to the comparator's weighing pan, whereas, the vertical motion transfers the mass from the plate to the pan.

To evaluate the developed weighing system, repeatability tests were performed for 5 kg, 10 kg, and 20 kg masses, with ten (10) calibration cycles each. The standard deviation of the results s_w was compared to the comparator's pooled standard deviation s_p, as well as the standard deviations obtained from its manufacturer s_d and manual calibration s_m. The results showed that the weighing system can produce repeatability results that is up to 65% better than s_p, 75% better than s_d, and 18% better than s_m.

This demonstrates that the integration of the automatic rotary plate enhances the repeatability and precision of the manual mass comparators. Hence, implying that the system can potentially be used to calibrate mass standards of even higher accuracy class than the intended application of the manual mass comparator in the laboratory.

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Possibilities of calibrating the piezo actuator using the laser interferometer in Croatian National Laboratory for Length

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Only a few of the most advanced national metrology institutes have a Calibration and Measurement Capabilities calibration service in the BIPM Key Comparison Database to calibrate piezoelectric actuators. Given the importance of precise displacement measurements in various high-precision applications, research on the feasibility of calibrating a piezoelectric actuator using a laser interferometer was conducted at the Croatian National Laboratory for Length. In this research a displacement actuator P −621.ZCD, manufactured by Physik Instrumente has been calibrated using Renishaw ML10 laser interferometer equipped with an EC10 environmental compensation unit. The calibration was performed within a displacement range of up to 1 μm. The paper provides a detailed description of the measurement procedure, the obtained results, and the evaluation of measurement uncertainty.

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Optimization of Reference Instrument Selection for Verification and Calibration

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Accurate and reliable measurements are fundamental to testing, inspection, and certification processes. A critical element in ensuring measurement integrity is the appropriate selection and use of reference instruments for verification and calibration. This paper addresses the optimization of this selection process, focusing on increasing the reliability of calibration and verification results, while taking into account practical limitations related to the scope of application of the measuring instrument. We explore a systematic approach that moves beyond simple accuracy specifications to encompass a wider range of crucial factors.

This optimized approach considers the specific measurement task, including the measurand and its associated accuracy requirements. The paper discusses the importance of understanding the manufacturer's provided accuracy characteristics. Furthermore, we address the critical role of adhering to relevant regulatory requirements in reference instrument selection.

The optimized selection of a reference instrument for verification and calibration is based on the required error ratio, as specified by the relevant requirements. To meet this ratio, the manufacturer's stated measurement uncertainty (or error, where applicable) of the reference instrument is considered. Another case is also analyzed, where compliance with the requirements is assessed based on an analysis of the reference instrument's calibration data.

The paper presents a structured methodology for reference instrument selection, incorporating a decision-making framework that balances performance requirements with practical limitations. This framework enables metrology professionals to make informed decisions, minimizing measurement uncertainties and ensuring the long-term reliability of their measurement systems.

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Reactive power/energy instruments in harmonically distorted conditions –analysis of different measuring algorithms'response in relation to fundamental reactive power

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There are several issues when it comes down to measurement of reactive power/energy, in non-sinusoidal conditions. First, there is the fact that the term reactive power is not unambiguously defined in case of harmonically distorted voltages and currents. An effort for overcoming the specific issue was made with the publication of IEEE 1459 standard, in which the fundamental power components are stated to be of particular interest when it comes down to system parameters monitoring, even in harmonically polluted environment. Additional challenge are the different measuring algorithms, implemented in modern measurement solutions. They provide the same quantity response in case of pure sinusoidal waveforms, while the expectations are that the measurement result will differ in case of distorted voltages and currents, according to the a priori known algorithms'response. In this work, an experimental verification of the reading of different meters for reactive power/energy will be conducted in relation to the mathematically modelled instruments' output. The reference quantity, in relation to which the instruments'readings will be analyzed, is the fundamental reactive power, taking into account the remarks presented in IEEE 1459. For the purposes of experimental verification, both one harmonic component and randomly distorted signals will be utilized and the meters'errors will be analyzed from the perspective of the share of fundamental reactive power/energy in the system. In order for the measurements to be conducted at highest metrological level, reference standards of the highest accuracy class will be used, which are traceable to the intrinsic standards of BIPM.

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Microplastics detection in milkfish (Chanos chanos) from selected aquaculure farm in the Philippines

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Microplastics (MPs), due to their minute nature, are becoming a major concern globally. Their reliable detection and analysis are crucial for the development of solutions to mitigate their potential impacts on the environment, ecosystems, and human health. However, the removal of biological materials, as the microplastics can be trapped or obscured making isolation difficult, remains a significant challenge. This study optimized the digestion and extraction of microplastics from various milkfish tissues, including meat, fat, gastrointestinal tract (GIT), head, and gills, using 10-20% potassium hydroxide (KOH) combined with a dual-density separation method involving saturated sodium chloride (NaCl) and sodium iodide (NaI) salt solutions. Six reference plastic polymers—polyethylene (PE), polypropylene (PP), polystyrene (PS), polyamide (PA, Nylon), polyvinyl chloride (PVC), and polyethylene terephthalate (PET)—were spiked into the fish samples to assess recovery efficiency. Results revealed excellent digestion efficiencies (90.0% to 98.3%) and % recoveries (90.3% to 123.7%) in 10% KOH solution at 40℃ for 48 hours. Optical microscopy and Fourier Transform Infrared Spectroscopy revealed no significant structural/morphological changes in the recovered plastics. Furthermore, the optimized protocol was applied to milkfish samples collected from Southeastern Mindanao, Philippines, where cellulose fibers, PE, PP, Nylon, and PET polymers were detected. The average number of microplastics found in the meat, fat, GIT, head, and gills were 0.9 ± 0.2, 2.4 ± 2.6, 0.6 ± 1.2, 2.7 ± 2.0 and 0.2 ± 0.5. As microplastic contamination continues to proliferate, their analysis becomes increasingly crucial and could be incorporated into food safety and agricultural monitoring frameworks.

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Application of Intelligent Data Analysis System (IDAS) for Oxidation State Analysis of Copper (Cu) Leadframes using Auger Electron Microprobe

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The Semiconductor and Electronics (S&E) sector plays a critical role in the Philippine economy, with copper (Cu) being widely used in semiconductor packaging. However, copper's high affinity for oxidation can negatively impact the reliability of leadframes. This study establishes an Auger spectral profiling database to identify the oxidation states in copper alloy-based leadframes, utilizing the Intelligent Data Analysis System (IDAS) developed by the Industrial Technology Development Institute (ITDI) and Advanced Science and Technology Institute (ASTI) of the Department of Science and Technology (DOST-Philippines).

Oxidation was simulated through controlled heat treatment, followed by surface characterization using optical microscopy (OM), field emission scanning electron microscopy (FE-SEM), energy-dispersive X-ray spectroscopy (EDS), and Auger electron spectroscopy (AES). Optimized AES parameters (10.0 kV, 10.0 nA) were employed for chemical state analysis, with validation conducted using reference materials (Cu and Cu_2O). Results showed oxidation-induced color changes, increased surface textures, and elemental modifications, with AES confirming the conversion of elemental Cu to Cu_2O.

Principal Component Analysis (PCA) and k-means clustering facilitated the classification of oxidation states using IDAS. PCA and clustering analyses in IDAS effectively categorized oxidation states, distinguishing fresh from oxidized leadframes, with PC1 (42.22%) capturing the most variation, followed by PC2 (25.06%) and PC3 (6.94%).

This study demonstrates the successful use of IDAS in classifying copper oxidation in leadframes, offering an efficient alternative method for monitoring copper degradation in semiconductor packaging.

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Development of a research methodology for the analysis of the geometric surface structure of objects made from materials with varying reflectivity

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The paper addresses issues related to the metrology of the surface layer, with particular emphasis on the geometric structure of the surface in terms of topography, product quality, and quality verification methods. The aim of the research was to develop a methodology for analyzing technologically manufactured objects made of materials with different reflectivity. This will enable a comprehensive quality assessment using non-contact optical systems in comparison to contact methods. The study involved samples of materials used in medical technology, such as implant components and surgical instruments. The geometric structure of the surfaces was analyzed using contact methods, providing reference data for comparison with optical measurement results. These findings serve as a basis for further analysis, allowing for the assessment of how material reflectivity affects measurement accuracy. A quantitative (parametric) and qualitative (non-parametric) analysis of topography was conducted, considering surface characteristics and measurement conditions. The developed guidelines outline methods for surface topography testing and quality control, which are crucial in industrial applications. This will facilitate the rapid diagnosis of errors and the implementation of corrective measures. The collected data—including measurement conditions, filters, and key parameters—will support designers and technologists in establishing normative requirements for surface testing of implants and medical instruments.

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Method Validation of Total Reflection X-ray Fluorescence (TXRF) Analysis as a Screening Method for Mercury (Hg) in Philippine Milkfish

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Mercury (Hg), is a naturally occurring element that is released to bodies of water through anthropogenic activities, industrial discharges, or naturally occurring Hg in soils. Its inability to be degraded further can result in bioaccumulation in aquatic species and eventually lead to human consumption which pose potential health risks. Analysis of Hg content of milkfish using TXRF spectrometry was validated using Philippine Reference Material (PRM) 2002-As, Cd, Hg & Pb in Milkfish produced by the DOST-ITDI National Metrology Division with a recovery range of 93-104%. The relative standard deviation (RSD) percentages is less than 10%, which indicates the collected dataset is relatively precise and consistent. The expanded uncertainty was determined to be 0.08 ppm Hg using the Nordtest method for measurement uncertainty (MU) estimation. For confirmation, DORM-5 was analyzed using the method resulting to 98.885% Hg recovery. Overall, the study showed that the TXRF analysis is a cheaper alternative, reliable, and reliable method in detecting Hg content in milkfish samples even in low concentration; therefore, making it suitable for screening and evaluation of mercury in milkfish samples.

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Metrology for nitrogen / protein content measurements in food

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The Kjeldahl method is a widely used technique for determining the nitrogen content in organic and inorganic substances. This method is commonly used to estimate protein content in food, feed, soil, and other materials.

This work explains details of the Kjeldahl method for nitrogen and protein content determinations in food, in order to identify the way providing the best metrological features.

In any measurement, the key issue is ensuring metrological traceability. In the Kjedal method, metrological traceability is ensured through the using hydrochloric or sulfuric acids solutions, the concentrations of which were investigated with the primary method –constant current coulometry.

Constant current coulometry is one of the key electrochemical methods used in National Metrology Institutes (NMIs) and Designated Institutes (DIs), which are responsible for ensuring accurate measurements of substances at the highest metrological level for establishing primary national standards. This is a precise method based on Faraday's laws. Using Faraday's laws principles, was developed a measuring system for implementing constant current coulometry method at SE Ukrmetrteststandart (UMTS). The development was carried out as collaboration of the UMTS with the Institute of Electrodynamics of the National Academy of Science of Ukraine (IED) and the Scientific-Production Center "Energoimpuls". With the constant current coulometry in UMTS are determining following substances assays –hydrochloric acid, sulfuric acid, and disodium carbonate. All three of these substances can be used in support to the Kjeldahl method, particularly for the nitrogen / protein content measurements in food.

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Assessing Measurement Consistency of Reference Standards Through Intra-Laboratory En Criteria Analysis

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Adherence to MKC EN ISO/IEC 17025:2018 necessitates participation in inter-laboratory comparisons and proficiency testing for quality assurance in calibration and testing laboratories as well as application of other measures to ensure the validity of the test and calibration results. This study investigates an intra-laboratory comparison methodology as a supplementary quality assurance tool. Specifically, the accredited calibration Laboratory for Electrical Measurements (LEM) at Ss. Cyril and Methodius University in Skopje performed a comparative analysis of several reference standards used for high resistance measurement and reproduction of the particular quantity. These standards include, high voltage decade resistor, both 8 ½ digit and 6 ½ digit multimeters and a multifunction calibrator, with particular adapter for high resistance/ low currents measurement, all traceable to BIPM intrinsic standards. An advanced statistical methodology adhered to ISO/IEC 17043 guidelines, utilizing the calculation of En criteria at multiple measurement points is applied. Measurement uncertainty was determined through uncertainty propagation, conforming to the "Guide to the expression of uncertainty in measurement" (GUM). This intra-laboratory comparison provides a quantitative assessment of the consistency and reliability of the laboratory's standards, contributing to enhanced confidence in measurement results.

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Ensuring the validity of the calibration results of current transformers through intralaboratory comparison

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The calibration laboratories accredited according to the standard ISO/IEC 17025:2017 should continuously monitor the validity of measurement results. By ensuring the validity of calibration results, the laboratory also monitors its own performance. There are several different techniques for confirming the validity of results and they are the matter of choice and the capability of the accredited laboratory. The paper describes two different methods that the Calibration Laboratory of the Nikola Tesla Institute of Electrical Engineering uses in intralaboratory comparison as a technique for ensuring the validity of current transformer calibration results. Statistical processing of the obtained results shows that the En number at all measurement points is satisfactory, which confirms the competence of the Institute's Laboratory in the field of current transformer calibration.

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Analysis of Measurement Uncertainty in Experimental Methods Applied to Daylight in Buildings

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Lighting plays a critical role in ensuring both environmental comfort and energy efficiency in buildings, as it directly influences the creation of a suitable visual environment for performing visual tasks. The lighting of interior spaces can be achieved through natural light, artificial light, or preferably, whenever possible, a combination of both. Despite the existence of recent dynamic daylight metrics, the Daylight Factor (DF) still is a key metric for quantifying the daylighting conditions and is very useful in assessing the quality of the indoor luminous environment. Standardized guidelines for measuring indoor lighting conditions are provided by EN 12464-1, which addresses electric lighting, and EN 17037, which offers frameworks for daylighting in buildings, though its widespread use is still restricted for various real scenarios. While artificial lighting is commonly assessed based on these standards, daylighting conditions are less frequently measured, particularly due to challenges in accounting for external obstructions and for different sky nebulosity conditions. This paper is focused on the impact of the illuminance (both outdoor and indoor) measurement uncertainty by comparing distinct experimental methods, namely, regarding its accuracy and how it can be improved, providing a comparative analysis that serves as a valuable tool for validating measurement approaches and supporting informed decision-making processes in architectural and lighting design.

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INSTRUMENTAL METHODS OF ANALYTICAL CHEMISTRY APPLIED IN POWER TRANSFORMER CONDITION ASSESSMENT

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The application of instrumental methods of analytical chemistry in power transformer (PT) condition assessment enables the separation, identification and quantification of degradation products or contaminants, which are present in transformer oils in very low concentrations (ppm), and provide adequate evaluation of insulating system degradation. This paper presents a review of the most important instrumental methods applied in the laboratory of the Nikola Tesla Institute (NTI) and emphasizes the importance of their application during transformers life cycle. Gas chromatography (GC) is applied for assessment of PT operating condition and fault detection thought dissolved gas analysis (DGA) and cellulose degradation by measuring of light alcohols (methanol and ethanol) as cellulose ageing markers in early stage. On the other side, GC technique is used for quantification of contaminants (PCB) and corrosive sulphur compounds (DBDS, S8) in insulating liquids whose presence causes high operational risk due to the deposition of electroconductive metal sulfides (copper and silver) and consequent transformer failures. Liquid chromatography (HPLC) is applied for testing the presence of specific additives, such as metal passivators, and furanic compound (as cellulose insulation degradation products) in insulating liquids. The importance of applying infrared spectrophotometry to new oils is reflected in the analysis of the chemical composition (p/n/a composition) and antioxidant content (DBPC) and the monitoring of oil oxidation inhibitor consumption in operation. The paper presents the results of several Round Robin Tests (RRT) for certain test methods in which the NTI chemical laboratory anticipated thus improving the measurement uncertainty of test methods.

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Conformity Assessment of Impedance Parameters Meters by MonteCalc Uncertainty Toolkit

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In the paper the development of calibration procedure for impedance parameters meters in the Laboratory for Electrical Measurements at the Ss. Cyril and Methodius University in Skopje will be presented. The procedure encompasses evaluation of the measurement uncertainty in calibration of meters for electrical inductance and capacity by two approaches: the mainstream GUM methodology and the stochastic Monte Carlo technique. For the purposes of the Monte Carlo evaluation, an original software MonteCalc Uncertainty Toolkit, has been developed in LabViewTM by the authors. The software is universal and can be applied in various calibration procedures of different instruments for wide range of physical quantities. The algorithm of the MonteCalc Uncertainty Toolkit will be elaborated. The MonteCalc Uncertainty Toolkit has been applied on real experimental data derived by the process of laboratory calibration of a RLC meter. The gained outcomes are verified against the uncertainty results obtained by the GUM methodology and the evident discrepancies will be discussed. The MonteCalc Uncertainty Toolkit also encompasses an algorithm for decision making in the process of conformity assessment against different predefined acceptance criteria compliant with the ILAC G8:09/2019 Guidelines on Decision Rules and Statements of Conformity. This decision-making tool has been applied for evaluation of the RCL meter calibration conformity in comparison its predefined technical specifications.

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Calibration of High Frequency Instruments-Evaluation of Uncertainty by Monte Carlo Approach

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The calibration of high frequency instruments, like oscilloscopes or frequency counters is a metrologically very intensive task. These calibration activities are to some extent prescribed in the Euramet cg-7 Guideline "Calibration of Measuring Devices for Electrical Quantities Calibration of Oscilloscopes". However, it belongs to the category of extreme electrical metrology, due to several factors: the complex measurement procedure, which has to be validated, unestablished international measurement traceability chain for signals at high frequencies to the SI units, and the high number of influential factors in the uncertainty budget. In the paper, the measurement uncertainty model for the calibration of oscilloscopes developed by the Laboratory for Electrical Measurements at the Ss. Cyril and Methodius University will be presented. Also, the original software MonteCalc Uncertainty Toolkit, developed in LabViewTM based on the stochastic Monte Carlo approach for uncertainty evaluation will be applied. The results derived by the two methods will be compared and discussed by using experimental data from laboratory calibration of an oscilloscope with very high frequency range of over 500 MHz. Based on the uncertainty propagation distribution gained by the Monte Carlo algorithm, assessment of the conformity compliance of the artefact of calibration in particular measurement points will be made against prescribed decision-making rules embedded in the MonteCalc Uncertainty Toolkit.

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A study on the dimensional accuracy of a Qidi Tech X-Max 3d printer

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The world is filled with 3d printers and materials, allowing people to fulfil the fruits of their creative minds. However, certain projects require objects to be produced within tight tolerances, and this can be a challenge for the majority of 3d printers. This paper aims to present a study on the dimensional accuracy and precision of a Qidi Tech X-Max 3d printer, by means of producing a rectangular grid tool and measuring it on an optical CMM machine. This procedure makes it possible to calculate parameters at specific three-dimensional coordinates in the grid tool, permitting an exact characterization of the printing process. The flatness of the printer's hot bed will be analysed as these printers are known for having warp issues that significantly impact the accuracy of the X and Y axes. The effect of these flatness errors on axis calibration and printing of large objects will also be examined.

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Uncertainty of measurements of electric field strength and magnetic flux density in the vicinity of overhead power line

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Overhead power lines are one of the most important sources of low frequency electromagnetic field due to their number, length and proximity to residential areas. For that reason, measurements of electromagnetic fields in their vicinity are very important in order to assess the exposure of the general public to these fields and to check whether the field levels are within the limits prescribed by national and international legislation. Since the measurement results are compared with the prescribed reference levels, the measurement uncertainty should be evaluated and taken into account in the conformity assessment. The evaluation of measurement uncertainty is of particular importance when the measured values are close to the prescribed reference levels. The paper analyses the most relevant uncertainty components related to measurements of electric and magnetic field in the vicinity of overhead power line. The uncertainty components related to the calibration of the measurement system, proximity of the operator, repeatability and positioning of the measuring probe are analyzed in detail and evaluated for the real example of measurements in the vicinity of an overhead power line. For the selected example the expanded measurement uncertainty is calculated as well. In order to provide the validity of the measurement results the measurements are carried out with two measuring systems and they are also compared with the calculation results. The possibilities for reducing some of the aforementioned uncertainty components are analyzed and the recommendations for their reduction are given.

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Low frequency electromagnetic field measurements and conformity assessment

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The topic of the paper is focused on measurements of low frequency electromagnetic fields, i.e. power frequency (50 Hz) electric field strength and magnetic flux density. The measurements are carried out in order to check the compliance of the field levels with the reference levels prescribed by national or international legislation. The reference levels for power frequency electric field strength and magnetic flux density prescribed by the Recommendation 1999/519/EC, ICNIRP guidelines and Serbian legislation are presented. In order to provide the conformity assessment, it is necessary to adopt the decision rule and to evaluate the expanded measurement uncertainty for each particular case. In this paper, expanded uncertainty is evaluated for the case of measurements in the vicinity of overhead power lines and substations, taking into account the most important components of electric and magnetic field measurement uncertainty. It is analyzed how the evaluated expanded measurement uncertainty and the adopted decision rule affect the conformity assessment. The analysis is carried on the set of several hundred measurements carried out in residential areas near overhead power lines and substations. Different decision rules are applied on the analyzed set of measurement results in order to check how it affects the conformity assessment. The obtained results are compared with the reference levels prescribed by both national and international legislation. The percentage of cases in which the selection of different decision rule leads to different conclusion, i.e. conformity assessment is calculated.

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Traceability for medical measuring devices through optical absorbance liquid filters

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Many medical measuring devices (MMD), such as those used in clinical diagnostics, use optical absorbance as the measurand. Optical absorbance liquid filters (OALF) are used to calibrate optical absorbance equipment, but there is currently a capability gap across NMIs in the characterisation and use of such filters, which leads to a lack of traceability.

Many MMDs measure optical absorbance in micro volumes. The devices must be calibrated for absorbance according to pharmaceutical quality standards (detailed in European Pharmacopeia), but some instruments should also be calibrated for absorbance at required specific wavelengths due to their construction.

Currently, precise calibration methods of MMDs for absorbance at required specific wavelengths are not possible using commercially available liquid and solid traceable standards and the calibrations are performed at approximate wavelengths and absorbance levels. New OALF, covering the optical absorbance from 0.001 to 3.000 in the spectral range from 220 nm to 780 nm, developed within ETraceAbs project will help to improve the limited range of commercially available standards.

Almost all NMIs have optical absorption measurement capabilities, but not all of them have the necessary experience in the characterisation of OALF to support traceability of MMDs. The aim is to establish traceable measurement capabilities, allowing the dissemination of optical absorbance via Certified Reference Materials, targeting a low uncertainty of 0.010 at an absorbance level of 3.000 and at temperatures between 15 ℃ and 40 ℃, to ensure that testing and medical laboratories can link the optical absorbance quantity for their MMDs to SI units.

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Performance of Testing Laboratories in Proficiency Testing in Salmonella sp. Detection in Seafood

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The results of two proficiency testing (PT) schemes in *Salmonella* sp. detection in seafood, conducted in 2022 and 2023, were described. The PT schemes, *Salmonella* sp. detection in octopus powder (ICSM-2022-01) and *Salmonella* sp. detection in shrimp powder (ICSM-2023-01), were organized by the Metrology in Biology (MiB) Section, National Metrology Laboratory of the Philippines in accordance to ISO 17043. The PT samples used in these PT schemes were tested for homogeneity and stability prior to distribution. Each participant laboratories received two sets of samples: one set contained *Salmonella* sp. (as target organism) and *Proteus mirabilis* (as background flora), and the other set contained only *P. mirabilis*. The performance of the participants was assessed based on accurate determination of presence or absence of the target organism. Reported results from all 29 participants in ICSM-2022-01 achieved 93.10% sensitivity rate and 86.21% specificity rate. Out of 29 laboratories, 23 received satisfactory evaluation while six received unsatisfactory evaluation. In ICSM-2023-01, reported results from all 28 participants obtained 96.43% sensitivity rate and 78.57% specificity rate. Of the 28 laboratories, 21 received satisfactory rating while seven received unsatisfactory rating. In both PT rounds, three laboratories had repeatedly received unsatisfactory rating mainly due to false positive results. Sources of errors might be from cross-contamination and/ or confusion during confirmatory tests. Laboratories with unsatisfactory performance were advised to review their methods and observe proper aseptic techniques, conduct root cause analysis and corrective action, if necessary.

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MetCCUS: Advancing metrology for measurements of impurities in CO2 in CCUS

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To combat climate change, the European Green Deal targets a 55% reduction in greenhouse gas emissions by 2030 and net-zero emissions by 2050. Carbon dioxide (CO_2), the main greenhouse gas, is emitted largely from fuel combustion and industrial sectors such as cement, steel, and refineries. Carbon Capture, Utilisation, and Storage (CCUS) can significantly reduce emissions by capturing CO_2 at the source, transporting it, and permanently storing it underground.

A key challenge in CCUS is the accurate measurement of impurities in captured CO_2. Reliable quantification of these impurities is essential to ensure safe transport, prevent pipeline corrosion, and meet emerging specifications from initiatives such as Aramis and Northern Lights. Both storage sites and CO_2 utilisation processes require strict control over impurity levels. However, suitable primary reference materials (PRMs) for all relevant impurities at required concentrations are currently unavailable.

The MetCCUS project (21GRD06), part of the European Partnership on Metrology, addresses this gap by developing PRMs for key impurities in CO_2. These materials will enable the calibration of both online and offline measurement systems used to assess CO_2 purity. Alongside the development of these reference materials, the project establishes accurate gas analysis methods to help the CCUS industry and laboratories to obtain reliable measurement results for the composition of CO_2 and comply with specifications

The development and validation of the primary reference materials and calibration methods will be presented.

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Traceability Assurance Method for Photogrammetric Measurements Performed Using RealityScan Application

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RealityScan is a free, powerful, photogrammetry-based mobile application that allows users to create high-quality 3D models from real-world objects using just a smartphone or tablet. By capturing multiple photos from different angles, the application processes the images into detailed 3D models that can be used in game development, virtual reality, and other creative projects. RealityScan simplifies the process of photogrammetry, making it accessible to professionals and hobbyists alike.
In this paper, traceability assurance method for measurements performed using photogrammetric system built out of smartphone and RealityScan application is presented. It is based on measurements of material standards calibrated in accredited calibration laboratories or National Metrology Institutes, whose reference values are traceable to national measurement standards. The method allows also for assessing the task-specific maximum permissible errors of mentioned photogrammetric system. The paper shows procedures, example of measurements and result analysis. Limitations and possible fields of application of such metrologically traceable system, having in mind the values of maximum permissible errors that were determined, are also discussed.

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Interlaboratory comparison of categorical characteristics of a substance, material, or object

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Interlaboratory studies are widely used for evaluation of the proficiency (competence) of calibration and testing laboratories, characterization of certified reference materials, and other purposes. When a reference value for the measurand in the interlaboratory study is unknown, the laboratory results may be used to estimate (build) a consensus value instead of the reference value. Since no algebraic operations and mathematical functions exist among categorical –nominal and ordinal –values, a numerical consensus value (as a kind of mean) cannot be formulated in such a case. Consensus of responses of experts of different laboratories participating in an interlaboratory comparison, classifying a substance, material, or object according to its nominal and ordinal characteristics, could be interpreted as cohesiveness or closeness, i.e., the degree to which the experts agree. The two-way factorial analysis of variation of nominal variables CATANOVA and of ordinal variables ORDANOVA answers the question 'is a consensus of participating laboratories achieved or not?' The answer is based on testing hypotheses about homogeneity of the between-laboratory and within-laboratory variation components, as well as the components caused by other factors under study. The details and examples will be available in the new IUPAC/CITAC Guide for interlaboratory comparison of categorical characteristics, preparing for publication in Pure and Applied Chemistry 2025.

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Emission measurements and its role in Future Maritime Shipping sector

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In the coming years, the maritime shipping sector seeks to embrace alternative fuels such as green ammonia, hydrogen, synthetic fuels, and Power-to-X (PtX) solutions like methanol and biomethane to reduce their environmental impact. This transition demands the development of engine technologies to adapt to these new fuels and a growing need for accurate and traceable measurement systems to support these advancements and validate their performance. Accurate pressure, temperature, and emission concentration measurements are essential for research and development in this sector and, at the same time, benefit related sectors. Exploiting machine learning and modelling advances will significantly help optimize the power units and after-treatment systems. In this aspect, the project aims to develop new and improve existing traceable emission measurement methods for online and in-situ measurements of typical gaseous (e.g., NO, NO_2, N_2O, NH_3, CH_3OH, CO, CH_2O) and PM, black carbon (BC) emissions generated from PtX fuels. The methods and selected commercial low-cost sensors will also be validated and applied for dynamic measurements on test engines running on selected fuels. Sources of measurement uncertainties will be identified and quantified.

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Validation of Measurement Procedures that Include Sampling (VaMPIS) –a new Eurachem Guide

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The validation of measurement procedures (or methods) has traditionally focused on the a analytical procedures made (ex situ) on extracted samples within the laboratory [1]. However, it has been widely accepted that the measurement procedure actually begins at the moment that a sample is taken from the sampling target (e.g. [2], ISO 17025). The validation process therefore needs to be expanded to include the primary sampling procedure, and how to do this is explained in this new Eurachem Guide on Validation of Measurement Procedures that Include Sampling (VaMPIS, [3]). It is applicable to measurement procedures whether they are applied ex situ, or in situ, when no physical sample is extracted. It can also be applied either simultaneously to the whole measurement procedure, or sequentially when a previously validated analytical is used. Worked examples are given in the Guide [3] for each of these situations.
[1] Cantwell H. (ed.) Eurachem Guide: The Fitness for Purpose of Analytical Methods –A Laboratory Guide to Method Validation and Related Topics, Eurachem (3rd ed. 2025). http://www.eurachem.org. [2] Ramsey M. H., Ellison S. L. R. and Rostron P., (eds.) Eurachem/EUROLAB/CITAC/Nordtest/AMC Guide: Measurement Uncertainty Arising from Sampling: a Guide to Methods and Approaches. Eurachem (2nd ed. 2019) http://www.eurachem.org. [3] Ramsey M.H., Rostron P.D., and Raposo F.C. (eds.) Eurachem/EUROLAB/CITAC/Nordtest/AMC Guide: Validation of Measurement Procedures that Include Sampling, Eurachem (2024). http://www.eurachem.org.

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Economic Impact of Flowmeter Measurement Errors in Water Resources Management in Industry: Contributions to Decision-Making and Operational Efficiency

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The economic impact of flowmeter measurement errors is a critical issue in water resources management within the industrial sector. Accurate measurements are fundamental for decision-making processes, particularly in water scarcity, a growing global concern because of climate change.

These concerns and the economic implications of transactions between suppliers and industrial utilities highlight the importance of efficient water resource management. The calibration of measurement equipment in the laboratory and the field is essential for collecting statistically representative data under various measurement conditions. This process allows for the technical evaluation of metrological performance and identifying factors contributing to errors and sources of uncertainty, such as installation conditions.

The data analysis derived from this experimental work provides valuable insights for decision-making. It helps to reduce measurement errors through calibrated procedures aligned with reference standards, thus assuring low measuring uncertainty. These improvements enhance the quality and reliability of the services provided, positively influencing commercial transactions, operational management of installed instrumentation, technical knowledge of infrastructure, and overall water resources management. By providing more accurate measurements, all stakeholders benefit from improved efficiency and reduced costs in industrial water management.

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A Networking Success: The Role of the Philippines' DOST OneLab Network in Ensuring Food Safety for both the National and International Markets

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In 2014, the Philippines' Department of Science and Technology (DOST) has established the one-stop laboratory system for global competitiveness. Knowing the Philippines as an archipelagic country, with cities and communities separated by bodies of water, and with the fact that not one laboratory can cater into the wide variety of test and calibration requirements of various stakeholders, the Department decided to establish a network of testing and calibration laboratories, providing a linkage between stakeholders and the laboratories with capabilities. These laboratories are accredited by the Philippine Accreditation Bureau (PAB) of the Department of Trade and Industry (DTI), the country's accreditation body, based on Philippine National Standard (PNS) ISO/IEC 17025:2017. The standard sets general requirements for the competence of testing and calibration laboratories. For almost a decade now, the network has already grown into 68 network member laboratories in 2025, coming from both government and private sectors, even from laboratories located in Australia, Cambodia, Malaysia, Thailand, United Arab Emirates (UAE), and Vietnam. Many of these member laboratories come from testing laboratories which are being utilized to address the increasing needs from various stakeholders for testing of raw materials and products to ensure safety and quality, meeting national and international requirements and standards. Through the network, micro, small and medium enterprises (MSMEs) in remote areas of the Philippines can now have access to testing services to check if their raw materials and products are complying to quality requirements and are safe for consumption.

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Management issues of VaMPIS and ongoing IMQC

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To ensure the fit for purpose of measurement results in routine laboratory operation, quality control monitoring should be carried out throughout the overall measurement procedure according to an integrated measurement QC (IMCQ) approach which include all steps from sampling and transportation to measurement results. In an integrated approach the IMQC programme should include features that will cover all steps of the sampling procedure. IMQC data should be recorded in such a way that it is possible to detect deviation in the control results outside of the predefined criteria, which indicates that the method is no longer fit for purpose as well as trends that can potentially lead to non-compliant work.

In order to validate the whole measurement procedure, and apply ongoing QC, there needs to be an increased level of effective cooperation between all organisations responsible for these activities. So, the communication phase between parties (e.g. customer/inspection or regulatory body and laboratory) is one of the relevant management issues within the sampling operation. It is particularly useful when sampling and analysis are carried by several different organisations. Equally important are the aspects related to the identification of responsibilities before starting the entire process.

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Using electronic spreadsheets for different approaches of estimating uncertainty in electrometric pH measurements

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This paper explores uncertainty quantification in electrometric pH measurements using a Microsoft® Excel spreadsheet. The aim of this study is to simplify the process for analysts by providing a computational tool that calculates uncertainty based on pH calibration and measurement models. The provided layout allows immediate uncertainty calculation using the GUM, Kragten and Monte Carlo approaches. The GUM approach via partial derivatives confirms with relative uncertainty, while the Kragten approach evaluates the change in the result compared to the standard uncertainty, which reduces the risk of miscalculation. The Monte Carlo approach examines the distribution pattern of the input quantities to calculate the distribution of the result. The combination of these three approaches helps in developing effective strategies and understanding different aspects of the problem. The uncertainty calculator improves statistical management, improves the quality of laboratory results, saves computation time and reduces errors. It also has benefits for testing laboratories' quality systems, improves PT activities and supports the development of reference laboratories.

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Setting target uncertainty using the Optimised Uncertainty approach

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This presentation expands on previous talks that give an overview of the Validation of Measurement Procedures that Include Sampling (VaMPIS) approach. A crucial part of VaMPIS is the use of a 'target' level of measurement uncertainty (MU), including that from sampling. This can be compared with the actual MU obtained by experiment, thus establishing whether the latter is fit for its intended purpose. Consequently, a judgement can be made on whether the measurement procedure that includes sampling can be considered to have been validated.

Sometimes a target uncertainty level that includes sampling will have already been mandated by a regulator. Otherwise, the Optimised Uncertainty (OU) method can be used, as described in the VaMPIS guidance. The philosophy underpinning the OU method is the optimisation of a financial loss function. It is in essence a 'least-cost' approach, where the combined costs of both making the measurements, and the potential costs arising from misclassification of a sampling target, are minimized. Where the measured MU is found to deviate sufficiently from the target MU that the measurement procedure cannot be considered as validated, an optimal apportionment of expenditure between the sampling and analytical procedures can be calculated in order to achieve fitness for purpose.

Both of these functions can be easily performed using a computer program called OptiMU, freely available from the website of the British Royal Society of Chemistry, Analytical Methods Committee. This will be used to demonstrate the OU method in the context of Example A2 from the VaMPIS guidance.

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The Impact of Long-Term Standard Drift on Metrological Traceability

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The measurement result by a standard may become unreliable without regular calibration, which may disrupt the chain of metrological traceability. Different chains of metrological traceability led to different measurement uncertainties. The readings of any standard change between calibrations due to its drift. The standard drift affects metrological traceability at all levels of its hierarchy. Taking into account the drift of the standard in practice may include the following elements: determining the appropriate component of the total measurement uncertainty; establishing the frequency of calibration of the standard; using correction during calibration; documenting metrological traceability. A special procedure and software are proposed to simplify the consideration of the influence of time drift of standards on the provision of metrological traceability by calibration laboratories for calibration of standards and measuring instruments.

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Intra-pulse laser absorption spectroscopy for chemical process metrology

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This study aims at fast and accurate sensing in dynamic conditions using the intrapulse laser technique. Quantifying dynamic quantities such as speciation mole fraction and temperature is crucial in various scientific and industrial chemical reaction processes, which requires fast and accurate sensing techniques. The intrapulse laser is a powerful technique that enables simultaneous measurements of multiple species and temperature in dynamic environments. The intrapulse laser operated at a 900 kHz repetition rate with a 200 ns pulse width, achieving a time resolution comparable to the fixed-wavelength method. The chirp rate of the intrapulse laser is 250-400 MHz, providing a spectral resolution of 0.0156-0.0197 cm-1. To correct the rapid passage effect observed under low-pressure conditions, a novel method of symmetrically flipping half of the unaffected spectrum has been proposed and validated. Specific experiments were designed to validate the capability of the intrapulse laser in accurately quantifying NO, H_2O and temperature.

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Metrology to Support Ammonia Use in Emerging Applications

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The EU through its initiatives (REPowerEU, REFuelEU, and FuelEUmaritime) aims to reduce the EU's net greenhouse gas emissions. Green hydrogen is central to this context, but the demand will be met through import. Ammonia promises to be a suitable hydrogen energy carrier with its extended use in end-case applications (e.g., ammonia cracking, shipping, and power generation).

Ammonia's potential in decarbonizing industries like shipping (e.g., fuel) and power generation (e.g., cracking ammonia to produce hydrogen for fuel cell applications) highlights the importance of developing robust metrological frameworks. In the former case, impurity-based pollutants must be monitored for regulation and better design of after-treatment systems in stacks, as it may lead to catalyst poisoning. In the latter case, impurities in ammonia (e.g., CO, CO2, H2S, SO2) or remaining not converted NH3 can lead to the presence of those impurities in hydrogen degrading the hydrogen fuel cell performance, poisoning the anode and damaging the electrolyte membrane. There is a need for accurate, cost-effective techniques to be deployed at ports and at the point of usage to monitor the impurities in ammonia and subsequent value chains. Addressing these gaps is crucial for scaling ammonia's role in renewable energy, hydrogen storage, and global trade, and ensuring it can meet future demands for sustainable energy solutions. As demand increases, there is a need for precise monitoring, leak detection, and reliable flow measurement systems to prevent environmental risks and optimize performance.

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Validation of measurement procedures that include sampling of water intended for human consumption using sequential approach

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The sample is the beginning of every analytical work, it contains the information we want to obtain. The collected samples constitute only a fraction of the analyzed object, so to obtain reliable information about the object, the sample must be representative. For the information obtained to be useful, its quality must be known. Uncertainty is the most important parameter to describe the quality of measurements, and it influences the decisions that are made based on the results of analysis. Each step of the analytical procedure influences the final results in a significant way, so it is necessary to consider the uncertainties related to sampling, sample preparation and analysis. Otherwise, the measurement uncertainty could be underestimated, which in turn could result in financial, health and environmental consequences.

This work reports on the validation of sampling procedures for water intended for human consumption within measurement procedures using the sequential approach described in the recently published in Eurachem guide "Validation of Measurement Procedures that Include Sampling". This approach implies that the analytical procedures have been validated in isolation, followed by validation of the sampling procedure to obtain validation of the overall measurement procedure. A Duplicate Method was implemented with eight sample targets to obtain representative samples of water intended for human consumption. Each sample target was sampled twice by repeating the sampling procedure with a time delay. Each sample then analyzed for free chlorine, total trihalomethanes and anions using previously validated spectrophotometry, gas chromatography and ion chromatography methods.

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Comparing EN 17075 and VaMPIS approaches for in situ continuous monitoring of free chlorine in drinking water

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chlorine is one of the most common products used for the disinfection of drinking water worldwide. Real-time monitoring has long demonstrated its usefulness, providing benefits such as controlling the level of chlorine addition to ensure that the residual concentration is maintained constantly.

The performances of 8 commercially available on-line analysers for monitoring free chlorine in water under controlled and real conditions was carried out (Guigues et al.,2022), following protocols described in EN 17075. Measurement uncertainty was estimated under controlled conditions considering bias, repeatability, and deviation from linearity as well as key influential factors for amperometric chlorine measurement: pH and temperature. The performance under real conditions was calculated as the difference between the free chlorine concentration measured by the on-line analyser, and the reference value obtained using the DPD method (EN ISO 7393-2) with a portable spectrophotometer. The 90th percentile of the absolute differences was determined in accordance with the EN 17075 standard.

The VaMPIS simultaneous approach using the duplicate method was applied to data obtained in real conditions from two on-line amperometric analysers with 3 electrodes covered with a membrane, and using gel to compensate for pH. The duplicate method with a simplified balance design was then used to estimate the overall measurement uncertainty. Bias was estimated by comparing in situ measurements made by the on-line analyser with the DPD method (EN ISO 7393-2) on samples collected at the same time (and same location), following the approach described in Example A.2.

Measurement uncertainties obtained with both approaches will be compared.

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Resource Efficient On-Device Language Models in Legally Controlled Measuring Instruments

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The European Union's (EU) Artificial Intelligence (AI) Act represents a significant regulatory framework that governs the deployment of AI systems across various sectors, including critical infrastructure. A crucial challenge identified is the integration of AI in measuring instruments, especially utility meters used in critical infrastructures, as highlighted in the EU AI Act's Annex III. AI applications, especially language models, in legal metrology, are primarily server-based, requiring substantial resources, and continuous connectivity. This limits their use in on-device, resource-constrained environments. Incorporating AI, specifically small language models (SLM) and large language models (LLM), into these measuring instruments presents unique opportunities and challenges along their lifecycle, impacting manufacturers, notified bodies, market surveillance authorities, and consumers alike. Using language models on the measuring devices could enable real-time compliance checks, facilitate analytical natural language conversations, provide an instantaneous generation of legally admissible reports, enhance anomaly detection, and improve transparency through Explainable Artificial Intelligence (XAI) results.

Therefore, this paper explores the possibility of integrating resource-efficient language models directly into legally regulated measuring devices to determine greater operational accuracy, compliance verification, and improvement of user interactions. We also address significant computation, memory, and energy consumption challenges in measuring instruments while applying language models. Advanced techniques such as model optimization, quantization, pruning, knowledge distillation, and other existing methods will be explored regarding their potential to mitigate these limitations. Furthermore, the paper explores the EU AI Act to identify the additional obligations stemming from that regulation.

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Kinetic Modeling of Chemical Migration from Polyethylene Packaging Film: A Comparative Study of Regulatory Methods

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Abstract

An understanding of chemical migration kinetics from packaging in food is essential to be able to quantify consumer exposure and screen compliance against regulation. This work examines the migration kinetics of chemical residues from monolayer polyethylene packaging film using the developed protocols under US 21 CFR and JETRO 2009. Polyethylene (PE) film samples were extracted with n-heptane according to specified conditions: 21℃/30 minutes (US CFR) and 25℃/60 minutes (JETRO 2009). Migration data were modeled using zero-order, first-order, and second-order kinetic models to determine the best-fit model. The results showed that traditional kinetic models did not well describe migration behavior, with R^2 values below 0.1, indicating poor correlations between concentration and time. Low-level concentration samples had relatively improved model fits, with second-order kinetics giving the best R^2 values (~0.1). But high-concentration samples contained wide variability, suggesting that migration is governed by processes other than usual kinetic postulates. Residual analysis confirmed that zero- and first-order models consistently fell below the expected migration rates and second-order models revealed a somewhat improved fit. Despite these outcomes, no kinetic model fully duplicated observed migration performance, suggesting the complexity of chemical interaction in polyethylene matrices. These results emphasize the challenge of applying traditional kinetic models to real situations of migration and support the need for alternative modeling approaches to enhance prediction effectiveness in food safety assessments.

Keywords: Chemical migration, kinetics, polyethylene packaging, regulatory compliance, food contact materials

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Method Validation and Chemometric Analysis of UV-Absorbing Contaminant Migration from Low-density Polyethylene Packaging Materials into 8% Ethanol

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Ensuring the safety of food packaging materials is critical due to the potential migration of chemical contaminants into food. This study validated an extraction method using 8% ethanol, a food simulant for alcoholic products, following US 21 CFR Part 177, and assessed the impact of thickness on the migration of total UV-absorbing contaminants (TACs). A total of 22 LDPE samples collected from 13 locations across Mega Manila and ranging in thicknesses from 6 μm to 130 μm, were analyzed. Method validation demonstrated a limit of detection (LOD) of 0.010 Au and a limit of quantification (LOQ) of 0.025 Au. Repeatability and intermediate precision assessments confirmed method reliability, with %RSD values of 35.8% (low), 10.4% (mid), and 8.5% (high) for Analyst A, and 17.4%, 12.1%, and 10.4% for Analyst B. All sample absorbance values fell below the Philippine FDA regulatory threshold (0.300 Au) with notable samples PE-0008 and PE-0022, exhibiting the highest (0.154 Au and 0.123 Au, respectively). Chemometric analyses revealed a moderate positive correlation between sample thickness and TAC migration (Spearman's $\rho = 0.481$, $p = 0.0235$; Kendall's $\tau = 0.333$, $p = 0.0486$). However, Kruskal-Wallis results ($\chi^2 = 7.23$, $p = 0.2042$) and LOESS regression suggested that thickness alone is not a primary driver of migration behavior. K-means clustering and LOESS trends—showing absorbance peaking at 30–40 μm and declining thereafter—reinforce the need to consider multiple factors beyond thickness when assessing migration risks. Future studies should integrate chromatographic techniques for a more comprehensive understanding of LDPE food packaging safety.

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Real-Time Precipitation Measurement for Extreme Weather Monitoring.

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Climate change has led to more frequent and intense extreme weather events, highlighting the need for improved precipitation measurement systems. Classic methods lack sufficient time resolution, limiting decision-making and early warning capabilities. To address this issue, a new high-resolution meteorological research station was developed in 2023 and installed at the Portuguese National Laboratory for Civil Engineering. This station autonomously collects real-time meteorological data, providing critical insights and observations for extreme weather monitoring.

The station is designed as an off-grid, self-sustaining system powered by photovoltaic solar panels, making it environmentally friendly and suitable for deployment in remote locations. It includes a weighing precipitation gauge and a multiparametric station that samples data every 10 seconds, significantly improving time resolution compared to classic methods. Together with precipitation measurements, influence quantities are also measured, namely, wind intensity and direction, ambient temperature, atmospheric pressure, and relative humidity, enabling comprehensive meteorological research including correlation studies. All measurements are traceable to the SI.

The ultimate goal is to make the collected meteorological data available to scientists and stakeholders for applications in water resource management, urban planning, and disaster prevention. Future developments include real-time data accessibility, supported by a fully automated calibration process using Digital Calibration Certificates. This process integrates machine-to-machine communication to validate and correct measurements autonomously.

By providing high-resolution, real-time precipitation data, this meteorological research station represents a significant advancement in climate monitoring, contributing to better decision-making and providing a reliable support for early warning systems for extreme weather events.

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Proposed procedure for selecting and validating reference TOC meters based on their real performances

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In ultrapure water (UPW) production, maintaining low Total Organic Carbon (TOC) levels (below 5 µg/L) is essential. TOC levels are monitored using TOC meters integrated into the production systems. For high TOC levels, calibration typically involves a standard solution with a known concentration (500 µg/L, USP 643). However, for low TOC levels, standards cannot be used due to water instability and offline measurement challenges. Therefore, best practices recommend using TOC meters as references in a dedicated setup to calibrate within a selected range (up to 200/1000 µg/L). To assess the performance of TOC meters in Milli-Q® products, a review of the current calibration procedure was undertaken. This analysis emphasized the importance of reference repeatability for optimal performance, leading to a procedure for selecting TOC meters as future references.

The procedure involves: 1) selecting a pool of potential reference TOC meters using the 90th percentile of the deviations, 2) identifying the best-performing TOC meters based on precision and bias criteria, and 3) verifying conformity with known TOC levels using 500 ppb standard solutions of sucrose and 1,4-benzoquinone.

Extensive measurements demonstrated the ability to select between 6 to over 20 TOC meters based on performance criteria. The selection, validation, and characterization of reference TOC meters were repeated multiple times, confirming their reliability and interchangeability. This validated methodology can also be applied to other measurements lacking metrological references or standard solutions.

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Preliminary Assessment of Total UV-Absorbing Contaminants Migrating from Philippine-based Microwavable Containers to Fatty / Oily Food Simulant using Modified 21 CFR Part 177 Method

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Single-use microwavable containers are commonly employed to package takeaway and delivery food products because they are perceived to be convenient, durable and safe. In this study, a modification of 21 CFR Part 177 validated by Alejandro et al. to profile low-density polyethylene (LDPE) bags was used to assess selected rigid polypropylene (PP) food packaging present in Philippine markets. A paired t-test between LDPE and PP samples (n = 15) yielded tstat (7.86 x 10-9) < tcrit (2.145) and p (1.00) > 0.05, confirming method ruggedness and applicability. Twenty-one unique brands of microwavable containers were purchased from 16 different retailers, cut into 5 cm x 10 cm, and immersed in n-heptane at ambient conditions (25 ± 3 ℃, 50 ± 30 %RH) for 30 minutes. Spectral scanning resulted to a range of 0.008 to 0.199 Au, indicating large variability across brands. Of the samples analyzed, 23.8% were above the 0.1 Au maximum allowable limit set by FDA Philippines. This implies that approximately one-fourth of the commercially-available brands are likely demonstrating chemical migration when in contact with high-fat, low-moisture products, typical of food items sold in local eateries and quick-service restaurants. Further investigations include repeatability measurements for verification, migration studies at non-ambient conditions and using other food simulants, and targeted and quantitative analysis for exposure assessments.

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Multivariate Analysis on Samples from the 2024 Manila Bay Oil Spill

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The 2024 Manila Bay oil spill was an impact of the monsoon rains brought upon by Super Typhoon Carina. Investigations utilizing chemical forensics were conducted to evaluate the impact of the accident. In this study, the application of multivariate analysis to aid the assessment was also explored.

Samples were collected at different points around the spill site, including the suspected source, and nearby coastal areas. Sample preparation was performed by extraction with dichloromethane followed by drying over sodium sulfate, while analysis was accomplished using gas chromatography –mass spectrometry (GC-MS) in Scan and SIM modes.

Common diagnostic biomarkers (n-hopanes and tricyclic terpanes; steranes and diasteranes; triaromatic steranes; and sesquiterpanes) were used for comparison of the different oil samples, while n-alkanes were assessed to provide a general overview. Principal component analysis and K-means clustering were also performed.

The study aims to provide an alternate approach to gaining insights on the properties of oil spill samples. This also emphasizes the vital role of chemical measurements in making informed decisions and response efforts during environmental crises.

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Development of a Rapid and Cost-Effective Analytical Protocol for Quantifying Essential Oils Physisorbed on Mesoporous Silica Using AI-Enhanced NIR Spectroscopy

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This investigation aims to design a passive-release air-cleaning system comprising two essential elements: a biocide, represented by various essential oils as a sustainable alternative, and MCM-41, a widely recognized drug delivery system with a high analyte adsorption capacity.

Near-Infrared (NIR) spectroscopy has emerged as a leading process analytical technology due to its rapid, non-destructive nature. When combined with chemometrics, it has demonstrated significant potential for determining physical and chemical parameters in biological products, including phenolic compounds [1]. Essential oils contain bioactive phenolic compounds such as thymol, carvacrol, eugenol, caffeic acid, and rosmarinic acid, which exhibit strong antioxidant, antimicrobial, and anti-inflammatory properties.

This research leverages NIR spectroscopy to quantify the amount of essential oil physisorbed on mesoporous silica, aiming to eliminate the need for traditional, costly, and time-consuming analytical techniques such as liquid/gas chromatography and thermogravimetric analysis. However, due to the weak absorption intensity, broad spectral bands, and severe overlap inherent to NIR spectroscopy, advanced chemometric algorithms have been required for accurate analysis [2].

In addition, with its powerful data processing and pattern recognition capabilities, AI and machine learning have introduced novel chemometric approaches for NIR spectral analysis, particularly for complex systems. Although previous studies have primarily relied on Partial Least Squares Regression (PLSR), in this research we have systematically compared its performance with AI-based models to evaluate whether AI can improve predictive accuracy and potentially replace traditional chemometric methods as reported in literature [3].

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Quantitative Analysis of Hydroxyapatite in Previously Treated Archaeological Samples

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The use of infrared spectroscopy is fundamental for the study of archaeological sediment samples, as it provides valuable information regarding their mineralogical composition. Moreover, this technique offers additional advantages, such as rapid analysis execution, low cost and ease of implementation.

In this study, 11 loose sediment samples from Neolithic ash-rich layers of Riparo Gaban site, located near Trento, were analyzed. These samples had been previously treated with HCl and CH_3COOH to remove calcite and enhance the visibility of hydroxyapatite peaks. For the quantitative analysis, a database was first constructed containing hundreds of spectra obtained from standard samples of calcite, hydroxyapatite, quartz, and mixtures of these components treated with the two different acids. Infrared spectra were acquired using FT-IR on KBr pellets to ensure precisely weighed mixtures for each measurement.

Referring to quantitative analysis, one of the main issues is the overlapping of the absorption peaks of different target components.

Deep and machine learning methods combined with chemometrics enable the development of models that can overcome this difficulty. Although a few studies have explored the application of deep learning combined with traditional chemometrics to establish both qualitative and quantitative models. Our previous research has demonstrated that training neural networks requires thousands of spectra, and this would make the analysis process complicated and time-consuming. To address this limitation, an algorithm was developed to generate "synthetic" spectra, increasing the amount of available spectral data. This approach allowed us to feed the network with an extended dataset, obtaining reliable results in hydroxyapatite quantitative analysis.

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The relationship between the two Eurachem Guides on validation: FfP and VaMPIS

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Eurachem's main mission is to promote best practices in analytical measurement by publishing guides on the web. The Fitness for Purpose (FfP) Guide is one of Eurachem's oldest and most downloadable guides providing information on the validation of analytical methods. The third edition of the FfP Guide coincides with the first edition of the Validation of Measurement Procedures that Include Sampling (VaMPIS) Guide. The VaMPIS Guide is the first attempt to fill the gap in the validation of sampling procedures that has been discussed between organizations for many years. The purpose of this presentation is to outline the changes in the new edition of the FfP Guide, its relationship to the VaMPIS Guide, and to briefly point out the similarities and differences between the two validation schemes.

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Quantitative Analysis of Glass Artifacts from Mykolayiv and Zaporizhzhia Oblasts (southern Ukraine): a Multi-Scale Approach

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Glass is a common archaeological material, often found as ornamental beads and containers for oils and perfumes. Understanding its chemical composition provides insights into past populations, trade networks and manufacturing processes. This study adopts a multi-analytical approach combining quantitative and qualitative data to two assemblages from southern Ukraine: Hellenistic core-formed vessels from Olbia Pontica (Mykolayiv Oblast) and glass beads from a Scythian context on the Khortytsia island (Zaporizhzhia Oblast).

A crucial first step is visual inspection via optical microscopy to identify artifact components, including colours and alterations. SEM-EDS provides microscale quantitative analysis, allowing characterization of major and minor elements. This method enabled a preliminary classification of the Olbia Pontica vessels following Lu et al. (2021), identifying some of the samples as Type II glass, linked to Syro-Palestinian raw materials, and others as Type III glass, associated with Egyptian sources.

For provenance studies, LA-ICP-MS, with its lower detection limits, was applied to the Khortytsia beads. Both Type II and Type III glasses were identified, with differentiation refined by Ti content. The frequent coexistence of these types within the same artifact suggests interactions between primary and secondary production centres.

To further analyse opacifiers and colorants, XRD was employed to determine crystalline phases in the glass, identifying calcium antimonate and lead antimonate as opacifiers for white and yellow hues. Additionally, FORS analysis confirmed the presence of various chromophores, with cobalt ions (Co++) as the dominant colorant in most samples. This integrated methodology enhances our understanding of ancient glass production and trade networks.

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Performance Comparison of a Self-Cleaning and a Conventional pH Electrode in Wastewater Process Monitoring

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Reliable pH measurement is essential in wastewater treatment for effective process control and regulatory compliance. This study compares the performance of a self-cleaning pH electrode (HORIBA) and a conventional fixed pH electrode installed in parallel within a biological treatment process. A total of 2,324 paired pH readings were collected over a 97-day period. Statistical analysis revealed a significant difference in mean values (6.93 for HORIBA vs. 6.12 for the conventional electrode; $t(2323) = 56.88$, $p < 0.001$).

The HORIBA sensor recorded lower mean values and exhibited lower variability (standard deviation = 0.2335) compared to the conventional electrode (0.6461). The HORIBA data showed strong negative skewness and high kurtosis, suggesting its ability to detect occasional low pH events with higher sensitivity. In contrast, the conventional sensor displayed moderate positive skewness and a broader range of readings, likely due to delayed response or surface fouling over time.

From a Process Analytical Technology (PAT) standpoint, the self-cleaning HORIBA electrode demonstrated superior stability, consistent response, and minimal drift, making it suitable for real-time monitoring and early deviation detection. The absence of frequent manual maintenance further supports its integration into automated process control systems.

This comparison highlights the operational advantages of self-cleaning pH electrodes in high-load wastewater environments. Further studies are recommended to assess long-term performance across varying operational conditions, including solids concentration, temperature shifts, and chemical dosing. Life-cycle assessments and calibration stability evaluations will help determine cost-effectiveness and support broader PAT implementation.

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Minimizing the risks of making decisions on conformity assessment in the production of CRM for construction laboratories

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The risks of making decisions on conformity assessment based on the steel reinforcement of a large Uzbek manufacturer that has implemented a quality management system with metrological traceability of measurements and a representative of a small business are analyzed.

Using the capabilities of an accredited pproficiency testing providers, an interlaboratory comparison was organized with the participation of more than 10 accredited laboratories and tests were conducted according to the methodology of ГОСТ 12004-81 "Reinforcing steel. Tensile testing methods", which is in force in the CIS.

The quality and safety indicators of steel reinforcement, such as "tensile strength" and "yield strength", are determined by the initial cross-sectional area in accordance with clause 1.4 of GOST 12004-81 using the following formula:

$F = m/(p l)$

ρ is the density of steel, 7850 kg/m3.

It can be noted that the actual density of commercially available samples differs significantly from 7850 kg/m3. Accordingly, if the stability and homogeneity characteristics of samples are assessed based on the above method, it is impossible to ensure metrological traceability and reliability of test results.

We propose a hydrostatic method for measuring the cross-sectional area, by the following formula: $F = (m1 - m2)/(p l)$

Are also analyzed, with the sensitivity coefficient obtained through the derivative applied when assessing uncertainty.

A test method and procedure are proposed that primarily allow minimizing the risks of the reliability of the characteristics of standard samples that depend on an incomplete mathematical model and are associated with uncertainty due to the negative influence of the sensitivity coefficient estimate through the derivative.

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Multidisciplinary Studies of XVII century Shroud copies

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In the XVI-XVII centuries, several copies of Turin Shroud were manufactured across Europe, reflecting the growing devotion and political power of Savoia family, owner of the relic. They were painted on linen to resemble the original and to mimic the Turin Shroud's markings. Some of them were authenticated by contact with the "original"and certified by the writing "Ab Originalis". Some replica shows interesting peculiarities, related to both artistic quality and manufacturing process.
Currently CISS is cataloguing: about 120 copies. INRIM and ENEA got the chance to characterize the optical properties of two of them: the shroud of Arquata and that of Agliè. The shroud of Arquata has the front and back footprint which is not produced by drawings or painting as in the other copies. The shroud of Agliè has artistic peculiarity and author's signature.
Spectroradiometric and optical characterizations have been conducted on both copies to define proper long-term conservation, dyes (Agliè), and manufacturing procedure (Arquata).
Analyses of low-contrast images on ancient textiles are challenging due to fabric's irregular surface, illuminating spectrum and position which can impact on measurement accuracy and image rendition. The paper presents measurement procedures and results achieved by optical characterization, highlight the metrological peculiarities of the most suitable methods for ancient textiles based on the expertise achieved on the actual Turin Shroud and Arquata copy. Additionally, a comparison among the peculiarities of the two artefacts based on the measured spectral reflectance is provided with an explication on the manufactured method of Arquata copy.

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3D printed Reference Materials for optical properties

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The angular distribution of reflected light from a surface is described by the Luminance Coefficient q defined as the ratio between the reflected luminance L [cd/m²] in a given direction of observation and the illuminance E [lux] on the surface, provided by a source from a given direction of illumination. Usually, this quantity is measured by an absolute method with calibrated illuminance and luminancemeter, installed on specifically designed goniometers. The main application of luminance coefficient is road lighting: the knowledge of q values of the asphalt (for specific lighting and observation directions), allows the design of lighting systems able to ensure road safety and visibility by compliance to the normative road luminance requirements.

INRIM developed and patented special Reference Materials (RM) representative of the luminance coefficient quantity, digitally designed and manufactured by 3D printing. The full set include five different RMs with different specifications (spatial distribution of q) and have been used in the first Inter-Laboratory Comparison (ILC) on Luminance Coefficient carried out during the EURAMET funded project SURFACE. The measurement of q is challenging, as the ILC showed, and the availability of RMs can help laboratories in increasing their measurement accuracy. The paper presents the RMs, their usage in the ILC, and peculiarities as one of the firsts implementations of IoT technologies in metrology and RM.

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Long-term corrosion of archaeological bronze artefacts: the contribution of chemical measurements

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One major concern of curators and archaeologists is the preservation of archaeological objects taken out of excavations and kept in museums. In this context, the research is devoted to the study of the long-term corrosion mechanisms affecting archaeological artefacts during burial and after excavation.

The study was carried out some Cu-based reference alloys (binary, ternary, quaternary alloys) characterized by chemical composition and microstructure similar to real artefacts coming from the archaeological sites in the Mediterranean basin. The alloys were buried in soils coming from these sites, whose characteristics were assessed according to the international standard ISO11464. The reference alloys were characterised by means of Raman Spectroscopy, X-ray fluorescence, and Scanning Electron Microscopy, both at increasing times of burial and after a long-term exposure to atmospheric corrosion.

The use of combined chemical and microstructural analyses provides good insight into the nature of the corrosion structures. Generally, the chemical composition of the alloy can be regarded as a crucial parameter. Apart from soil minerals, such as calcite and quartz, cuprite and paratacamite were detected as the main corrosion products on binary Cu-Sn and ternary Cu-Sn-Zn alloys. Malachite is traced as micro-inclusions, mainly on samples exposed to marine environments. Eventually, the presence of nantokite affected the long-term stability of the copper-based alloys due to the reaction of the corrosion patina with water and air, inducing the active cyclic copper corrosion known as "bronze disease". The highest corrosion resistance was assessed on Cu-based reference alloys characterised by a high percentage of Pb.

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Electrochemical characterization of additively manufactured alloys

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Additive manufacturing techniques represent one of the main breakthroughs in materials engineering over the last decade. The possibility to produce metallic components layer by layer has introduced more flexibility in the design and has alloyed consistent weight reduction. Nonetheless, new challenges have arisen from the presence of peculiar features in the microstructure, such as porosity, metastable phases, and anisotropy due to directional solidification. For this reason, it is of paramount importance to understand the effect of these modified microstructures on the corrosion resistance of the materials.

This contribution presents the results from different studies carried out over the last years to assess the corrosion behaviour of different alloys produced by additive manufacturing technology. Specifically, the investigated materials are Ti6246 (6.0 wt% Al, 2.0 wt% Sn, 4.0 wt% Zr, 6.0 wt% Mo, balance Ti) and A20X (4.7 wt% Cu, 3.5 wt% Ti, 1.5 wt% B, 0.71 wt% Ag, 0.22 wt% Mg, balance Al). The effect of the orientation with respect to the building direction was assessed, to identify the possible effect of directional solidification on the electrochemical behaviour. Then, the effect of heat treatment, and the consequent changes in the alloy microstructure, was investigated.

The corrosion kinetics and the associated mechanism were investigated by means of potetiodynamic polarization and electrochemical impedance spectroscopy measurements. Then, the corrosion morphology and the composition of the superficial oxide layers were analysed using electron microscopy and X-ray photoelectron spectroscopy (XPS).

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Wearable electrochemical sensors for telemedicine

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Telemedicine is becoming increasingly important in healthcare thanks to the new potential disclosed by wearable sensors. Indeed, the possibility of monitoring the patient's health status in real-time, with warning messages sent directly to physicians guarantees effective health surveillance, especially for elderly patients, who often suffer from chronic pathologies and need dedicated solutions.

In order to address this issue, this study presents the characterization of flexible electrochemical sensors, produced by inkjet printing. The sensing performance was assessed in vitro for different target analytes (glucose, lactate, and potassium ions), which are relevant for monitoring the health conditions of a patient. Moreover, thanks to an interdigitated electrode design, the hydration level of a material mimicking the human skin was assessed.

Future work will design a dedicated portable instrumentation, in order to develop an independent device capable of acquiring the different measurements and then transmitting the data to an online platform.

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Restorative dentistry: new diagnostic approaches based on chemical measurements

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Dental caries refers to both the carious lesion and the caries process itself. The process starts on the external part of the dental crown, the enamel, mainly composed of hydroxyapatite, whose exposure to acid environments leads to demineralization through the precipitation of calcium and phosphate from the tightly packed hydroxyapatite lattice. Slowly, the process proceeds on the dentin and the cementum, up to irreversible damage. Demineralization removes essential mineral ions from tooth hard tissue, but it is a reversible process. Demineralization and remineralization continuously occur in dependence on the oral pH and the availability of mineral ions in the saliva.

The early detection of tooth demineralisation is a real challenge from the clinical point of view and the availability of effective non-invasive methods for early demineralization assessment is important for developing preventive healthcare strategies.

Chemical measurements, such as spectroscopic techniques and impedance spectroscopy, integrated with neural classifiers, can be the basis for the development of non-invasive diagnostic approaches for detecting and monitoring the demineralisation process at the very beginning. Results of in-vitro studies will be presented and discussed in detail.

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A multiband photogrammetry workflow using polarized light and Physically Based Rendering for capturing non-collaborative surfaces

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Non-invasive techniques like photogrammetry and multiband imaging are transforming the field of cultural heritage studies, enabling detailed analysis of artworks through low-cost digital tools. These methods allow experts to create precise digital twins, aiding in pigment analysis, technique identification, and artifact dating. Photogrammetry, widely adopted for its cost-effectiveness and ease of use, generates accurate 3D color and geometric models. However, challenges persist with reflective materials like metals, limiting its application. Recent advances, such as polarized light integration, hold great promise in overcoming these barriers, enhancing accuracy for non-collaborative surfaces. Combining polarized photogrammetry with multiband data (UV luminescence) enriches 3D models, thereby facilitating a more comprehensive understanding of surface features. This integration enables a better analysis, transforming complex datasets into accessible, interactive models.
This study presents a workflow addressing photogrammetry's limitations by merging polarized images and multiband data into a single, metrologically and visually accurate 3D model. A free web platform tool (Sketchfab) was used to ensure lightweight, user-friendly visualization of a 6th-century BCE Chinese gold Buddha statuette chosen as a case study. The artifact's reflective surfaces challenge traditional photogrammetry, but this methodology solved these issues.

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Nb2O5-based chemosensor for ethanol sensing

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Nowadays gas sensors are widely employed in several applications including industry, medicine and environmental monitoring. In this field, metal-oxide sensors represent a valid solution due to their good performance and low cost. With the aim of developing an ethanol gas sensor, the performance of a nano-structured thin film of Nb2O5 deposited by pulsed laser deposition on an alumina substrate (3 mm x 6 mm) was evaluated. Substrate features two Pt interdigitated electrodes for contacting the sensing film and a heater for maintaining a suitable working temperature. Film deposition was carried out in a vacuum chamber (P = 5·10-5 Pa) with a Nd:YAG UV pulsed laser (λ = 266 nm) focused over a Nb2O5 target. Subsequently, oxygen was introduced in the chamber till reaching a pressure of about 15 Pa. Thereafter, the sensing film was deposited on the substrate with 2000 laser pulses whose energy was 112 mJ.

The film was initially characterized electron microscopy. The film features a porous nano-structure composed of thin vertical pillars with an average diameter of about 70 nm and a thickness of about 500 nm.

Then, the sensor was characterized in terms of optimal working temperature, sensitivity and response times towards ethanol. Sensor response is almost linear with good repeatability in the range from 50 ppm to 100 ppm at the optimal working temperature of 420 ℃. Response and recovery times are in the order of 5 s and 100 s, respectively. Sensor performance is promising for developing an ethanol chemosensor.

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OCT measurements for in-situ monitoring of cleaning treatments

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Cleaning of historical artefacts has always represented a critical treatment in conservation. Nowadays, chemico-physical analyses provide preliminary insights on the material distribution and film forming on the artefact's surface, supporting the cleaning procedure. However, these characterisations are mainly carried out only ex-situ (i.e. before and after the treatment) and do not allow a continuous monitoring of the cleaning procedure.

Conservator's practice requires to perform the cleaning treatment under a microscope or by employing magnifying tools, delegating the assessment of its effectiveness and invasiveness to the technical competences and experience of the conservator.

In this contest, the research was focused with the development and metrological validation of an innovative approach based on Optical Coherence Tomography (OCT), for the in-situ monitoring of cleaning treatments. OCT measurements, coupled with fluorescence spectroscopy, were carried to measure the thickness of overlapped and unwanted layers, assessing their distribution and homogeneity on the artefact's surface. Moreover, the contribution of OCT in examining sub-superficial structural changes, at the interfaces between different layers, suggested an attempt to validate OCT measurements as a non-invasive methodology for the sub-superficial roughness profile measurements. The metrological approach developed gave an accurate assessment of the impact of intervention materials and procedures on the original matter.

The outcome of the experimental activity highlighted potentialities and limits of the analytical approach proposed, assessed both on mock-ups and complex real case studies.

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Integrating Photogrammetry and Multispectral Imaging for the Conservation of Artifacts

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This work presents a novel approach integrating multi-spectral imaging techniques and 3D modelling to address challenges in conservation and fruition of artworks. By combining 3D modelling, multispectral imaging, and photogrammetry, this method provides an advanced framework for monitoring the state of preservation of cultural artifacts and developing effective preservation strategies. The use of 3D digital twins enables tracking of the degradation processes, identifying damage and previous restoration interventions, and provides important insights into the artistic techniques used in the creation of the objects. These models not only work as valuable archival resources for museums but can also be employed for educational purposes in innovative exhibitions.

The case study presented involves the acquisition of visible and multi-spectral photogrammetry data of three polychrome wooden Buddhist sculptures of the Museo di Arte Orientale of Turin (Italy). The developed setup allows for the creation of a single geometric model, onto which different textures can be applied depending on the multispectral band being investigated.

This integrated approach highlights the potential of the proposed approach to improve the metrological assessment of cultural heritage artifacts, offering a comprehensive evaluation of their conservation state and supporting the development of tailored preservation strategies.

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Heritage 3D modelling: the case study of the scientific instrument collection of Politecnico di Torino

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A preservation campaign is underway at Politecnico di Torino, focusing on a collection of instruments for electrical measurements. The collection spans instruments used for didactic purposes and research from 1920 to 1960, including electrometers, voltmeters, amperometers, galvanometers, electrical analyzers, and more.

These multimaterial artefacts are in varying states of conservation, necessitating tailored conservation strategies that require a deep understanding of the chemical composition of the constituent materials and superficial layers, such as varnish, lacquers, and corrosion products. The preservation campaign employs in situ non-invasive analytical techniques, including X-ray fluorescence (XRF) spectroscopy and Raman spectroscopy.

The identification of the corrosion products was performed by Raman spectroscopy, without any preliminary cleaning of the artefacts, in areas with different exposure to atmospheric corrosion. Different corrosion morphologies related to the different metallic materials and to the different exposure conditions to indoor atmosphere have been found. The technique of photogrammetry was employed to create three-dimensional models representing the objects. The models integrate data from UV luminescence and visible light into a single 3D representation. This approach enabled the identification of certain deterio-rations highlighting the presence of residual materials onto the surface. In order to enhance the preci-sion of the models of shiny and reflective metal objects, the reproduction technique employed the polarised light, with the dual purpose of reducing errors due to three-dimensional reconstruction and obtaining a more realistic effect when sharing.

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Research on Intelligent Traceability Framework for Trusted Artificial Intelligence

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With the deep integration of artificial intelligence and big data technology, the self-learning ability of the system brings efficiency improvement, but problems such as data pollution, algorithm black box, and model drift exacerbate the difficulty of tracing. This article proposes a three-layer traceability framework (TVB Trace) that integrates blockchain metadata anchoring, dynamic verification mechanism, and trusted execution environment. By constructing a verifiable data lineage graph and algorithm decision chain throughout the entire lifecycle, it achieves transparent supervision of AI self-learning systems. Experiments have shown that this framework can improve data traceability accuracy to 99.2% and enhance model decision interpretability by over 40%.

Keywords: Artificial intelligence traceability, Blockchain, Trusted computing, Self-learning system.

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Research on Innovation of Chain Verification System for Intelligent Manufacturing

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In the context of digital reconstruction of the global industrial chain, traditional testing and calibration methods face systemic challenges such as data silos, low cross-border mutual recognition efficiency, and insufficient real-time performance. This article proposes a four-dimensional authentication framework (Q-FACT 2.0) that integrates quantum time benchmarks, blockchain forensics, and neural symbol verification. By constructing a cross-scale data trusted circulation mechanism and an adaptive calibration model, an intelligent verification system with full lifecycle traceability and millisecond-level response is achieved. The experiment shows that this system reduces the industrial detection error rate to 0.003 ‰ and compresses the certification cycle by 85%, providing theoretical support and technical path for the innovation of quality infrastructure in the era of intelligent manufacturing.

Keywords: quantum metrology, federated verification, blockchain forensics, neural symbol systems.

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Some Aspects of Metrological Traceability as a Consequence of Blending Low-carbon Hydrogen to Natural Gas Pipelines in Brazil

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Brazil has a natural gas (NG) network of about 45000 km that includes 9500 km of the high pressure main hub most of it near seashore and a 35500 km distribution network from city gates to points of use in the internal parts of cities. The main componentes of of the main hub are composed of ducts, flanges, valves, interconnections and sensors. These mentioned componentes have to attend the requirements of properties and characteristics according to national regulations, internal regional codes, as well as ISO, Brazilian (by way of The Brazilian Association of Techical Standards - ABNT), and US technical standards (from ASME, API, etc). There is an implicit concern on Traceability because: a) custody transfer is a must that is always present; b) the design and specifications of the components have to follow the established technical and metrological rules; c) the online measurements from upstream to downstream of the pipelines. In August of 2024 the National Hydrogen Program called PNH2 was established by two specific Federal Laws. Since then the five companies that own the main hub started a technical, logistic and economic discussion based on research studies in order to blend low-carbon hydrogen (LCH2), with Life Cycle Assessment (LCA) and established fontiers, to existing NG pipelines. This work shall discuss the needs of Traceability taking into account The Metrology and The Quality Infrastructure (QI) in the most relevant aspects of the pipelines in Brazil i.e. mechanical properties, hydrogen embrittlement, chemical composition of both NG and LCH2, etc.

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A digital QI for testing and calibration laboratories: from theory to practice

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From seamlessly connected labs, data-driven services, and AI-supported analyses to business models that turn laboratory services from a "compulsory exercise" into a driver of efficiency and product innovation: The digital transformation of laboratories and quality infrastructure (QI) at large promises efficiency gains, increased technical excellence, and innovation along the entire value chain. The tools and processes of a digital QI can enable laboratories, their customers, authorities and other stakeholders to jointly increase efficiency and trust, and create added value.

Our paper illustrates the vision of a digital QI in laboratories and substantiates it with realistic scenarios and practical examples. Presenting relevant digital QI tools and their role in this vision, we make the potential of machine-readable standards, certificates of conformity, calibration and reference material certificates, test reports, and eAttestations tangible. The integration of laboratories into a wider digital ecosystem for QI connected with further industry-used technologies, such as data spaces, hold tremendous potential for all actors.

We hereby draw from our comprehensive, structured stakeholder dialogue with representatives from laboratories and their ecosystem. This exercise allowed to derive concrete requirements and draw a profound vision how a digital QI can significantly alter the daily routines of laboratories enabling digital end-to-end processes for calibration and testing. The paper provides insights into these findings, and the next steps that are currently implemented based on the derived recommendations –aimed at facilitating the realization of this vision that not only requires the development of technology, but rather an inclusive engagement with the laboratory community.

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Test Bench for Gas Meter Calibration as a Key Element in Ensuring Metrological Traceability and Measurement Uncertainty Control

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Metrological traceability and measurement uncertainty assessment are key factors in ensuring the reliability of results and supporting decision-making in gas quality control and metering.

This abstract presents a developed test bench for the calibration and verification of gas meters, with a focus on ensuring metrological traceability and enabling uncertainty evaluation.

The bench is based on two reference gas meters —rotary and turbine —both with established traceability to national standards. Operating in the flow range from 0.8 to 650 m³/h, the system enables calibration and verification of gas meters of various types and sizes. It ensures the transfer of the gas volume unit from national standards to industrial gas meters, forming part of the metrological traceability chain.

Traceability connects measurement results to national standards via a series of calibrations, each contributing its own uncertainty. Proper estimation of measurement uncertainty allows the evaluation of whether the measured value meets specified tolerances, which is essential for conformity assessment and determining meter suitability.

By incorporating traceability and managing uncertainty, the bench ensures consistent and trustworthy measurements across various applications. The development and use of such systems help maintain the integrity of measurement data throughout the gas supply chain.

Although not innovative in design, the bench plays a crucial role in ensuring accurate and traceable gas measurements, directly contributing to quality assurance and conformity assessment procedures in the TIC sector.

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CALIBRATION OF TEST RIGS –WORKING STANDARDS FOR CALIBRATION AND VERIFICATION OF LIQUID METERS AND FLOWMETERS

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Considering the design features of the test rigs –working standards for calibration and verification of liquid meters and flowmeters, their calibration can be carried out in one of two ways - by calibrating of each component or directly at the installation site. Two calibration methods were developed by specialists of SE "UKRMETRTESTSTANDART", namely MKU 516-24/03 "Metrology. Test rigs for verification and calibration of flowmeters and liquid meters. Calibration method"and MKU 091-24/03 "Metrology. Test rigs - working standards for verification and calibration of water volume meters. Calibration method using a comparator".

According to the MKU 516-24/03 method, the calibration of the test rig consists of calibration of the measuring instruments included in it and evaluation the measurement uncertainty in the process of calibrating flow meters and liquid meters caused by the test rig.

The MKU 091-24/03 method applies to test rigs regardless of the measurement method. This method consists in calibrating the comparator meter with high stability on a reference test rig, on the test rig being calibrated, and further processing of the results obtained and estimating the measurement uncertainty.

Considering estimated values, probability distributions and sensitivity coefficients of each uncertainty source, the uncertainty contributions are obtained, and consequently the overall expanded uncertainty of test rig can be calculated.

Both methods are validated in accordance with the requirements of ISO/IEC 17025 including through systematic assessment of factors influencing the outcome. As a result, calibration methods MKU 516-24/03 and MKU 091-24/03 allow ensuring the validity and reliability of obtained results.

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CALIBRATION OF STEAM STERILIZERS

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The healthcare sector is a vital area of human activity. To ensure the traceability of measurement results, calibration of equipment is a critical factor. The primary task of calibration laboratories is to ensure the uniformity of measurements and the metrological traceability of measurement results during the calibration of measuring instruments, which, in turn, is not possible without the use of a calibration procedure.

A steam sterilizer is a medical device that uses saturated water vapor under pressure to sterilize medical instruments, equipment, and other items. Utilizing high pressure and saturated steam, this method has become the gold standard in hospitals, laboratories, dentistry, podiatry, facilities for personal hygiene and beauty care and also veterinary practice around the world due to its ability to destroy all types of microorganisms, including resistant bacterial spores.

According to EN 13060, the standardized characteristics of a steam sterilizer are the operating pressure inside the sterilizer and the sterilization temperature.

Calibration is carried out by placing high-temperature pressure and temperature data loggers inside the usable chamber space of the sterilizer. Each logger, through dedicated software, records data at least 10 times during the sterilization phase. Upon completion of the sterilization program, the data from the sensors are exported and used as primary data for processing the calibration results.

Based on the physical understanding of the process, we identified the main (significant) sources of uncertainty of measurement.

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Impact of High CO2 Content in Natural Gas on Hydrocarbon Dew Point Measurements

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The hydrocarbon dew point (HDP) is a critical quality parameter in natural gas metering and custody transfer. Exceeding
the HDP may result in condensation of hydrocarbons, leading to equipment damage, measurement inaccuracies, and
operational risks. The most widespread method for HDP determination is the condensation technique using chilled
mirrors. However, modern optical analyzers like the Zegaz Dewpoint Duo enable independent, simultaneous detection
of hydrocarbon and water dew points.
This study investigates the impact of elevated CO2 concentrations in natural gas on HDP measurements using both
traditional condensation-based and optical methods. Comparative measurements were performed on gas mixtures with
varying CO2 levels. When CO2 concentration was below 1%, the agreement between both methods remained within
acceptable uncertainty. However, as CO2 concentration exceeded 2%, significant discrepancies emerged. The traditional
condensation-based instrument began detecting the CO2 dew point instead of the hydrocarbon dew point, resulting in
systematic measurement errors.
To validate the findings, measurements were conducted using pure CO2. No water dew point was detected, and the
apparent hydrocarbon dew point matched the CO2 condensation curve precisely, confirming misinterpretation by
mirror-based techniques under such conditions.
The results emphasize a limitation of traditional dew point methods in CO2-rich gases and demonstrate the necessity of
using more selective optical analyzers to ensure traceable and accurate measurements. These findings are particularly
relevant for metrology in the gas sector, supporting safe operation, regulatory compliance, and alignment with digital
transformation in measurement systems.

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STUDY OF METROLOGICAL CHARACTERISTICS OF HOUSEHOLD MEMBRANE GAS METERS ON THE INFLUENCE OF HYDROGEN, HYDROGEN MIXTURES AND NATURAL GAS

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This research investigates how household membrane gas meters perform when used with hydrogen and hydrogen-gas mixtures, compared to traditional natural gas. With growing interest in hydrogen as a cleaner energy source, it's crucial to understand how existing gas infrastructure responds to these new fuels. The study was carried out at the State Enterprise "IVANO-FRANKIVSKSTANDARTMETROLOGY" and included five testing stages.

First, the tightness of each gas meter was verified to ensure no leaks. Then, baseline measurements were taken using air to assess initial performance. In the third stage, the meters were tested with pure hydrogen and two hydrogen-gas mixtures: 10% hydrogen/90% natural gas and 20% hydrogen/80% natural gas. These tests were done at different flow rates to analyze how gas composition affects accuracy. After testing, the meters were rechecked with air to evaluate any changes. Finally, after a full year of real-world use with natural gas, the meters were tested again to assess long-term effects. The results showed that most meters maintained acceptable accuracy. However, one meter out of five slightly exceeded the allowed error range after long-term use. Overall, hydrogen and its mixtures caused a small increase in measurement error (about ±2%) and some minor leaks were observed during hydrogen exposure.

In conclusion, the findings support the potential use of household membrane gas meters for hydrogen-gas mixtures, although ongoing monitoring and occasional recalibration may be necessary to ensure accuracy.

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Prism-based compensation of group delay dispersion in a femtosecond laser resonator and analysis of the influence of prism configuration on radiation parameters

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This paper presents a mathematical algorithm for calculating the minimum distance between prisms and the permissible insertion depth of prisms into the laser beam for compensating group delay dispersion (GDD) in a femtosecond laser resonator. GDD arises due to optical elements such as the Ti:Sa crystal and fused silica prisms. The developed method accounts for arbitrary angles of incidence on the prisms, including deviations from the Brewster angle, which is crucial for laser alignment.

It is shown that at a fixed prism separation distance (610 mm), varying the insertion depth (3–4 mm) allows tuning GDD compensation, affecting the central wavelength (808–850 nm) and spectral width (27–56 nm) of the output radiation. Experimental results confirm mode-locking regimes at different prism configurations, demonstrating good agreement with theoretical predictions.

The accuracy of the calculations was verified by geometric modeling, showing less than 1.1% deviation from the analytical model. The proposed approach provides a practical tool for optimizing femtosecond laser systems, particularly for applications in dielectric laser acceleration (DLA).

The study contributes to the precise control of ultrashort pulse generation, offering insights into resonator design for advanced laser technologies.

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FEATURES OF CALIBRATION AND EVALUATION OF EXPANDED UNCERTAINTY OF A WORKING STANDARD IN THE FLOW RATE RANGE UP TO 25000 M³/H

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The article presents the development, calibration methodology, and uncertainty evaluation of a newly established working standard designed for gas flow measurements up to 25,000 m³/h. Created by SE "Ivano-Frankivskstandardmetrology", it is the first such facility in Ukraine, enabling traceable calibration, testing, and verification of gas meters with nominal diameters up to DN 500.

The working standard consists of modular flow-generating units, equipped with frequency regulators, full-bore valves, and reference sections incorporating temperature and pressure sensors. The design minimizes flow resistance, vibration impact, and connection volume. Data from measurement and control units are processed digitally and transferred to a PC for real-time monitoring.

Calibration of the reference meters involves determining a conversion coefficient using nationally and internationally recognized standards (VETU 03-01-03-11 and UA4). Pulse counting forms the basis for volume calculation, with additional corrections for pulse omissions. Polynomial approximation using the least squares method is applied to derive flow-dependent coefficients.

Uncertainty analysis includes both Type A (statistical) and Type B (systematic) components, accounting for meter errors, pressure and temperature measurements, pulse omissions, and flow accumulation effects. Specific formulas are used to quantify each component, with separate treatment for single and combined reference meter configurations. The highest resulting value of expanded uncertainty is selected to define the system's performance.

This work introduces a structured and validated methodology to ensure high accuracy across a broad flow rate range. Its implementation marks a significant advancement in national metrological infrastructure, providing reliable support for industrial and regulatory gas metering needs.

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Approaches to enhancing the optical base of the length standard in Ukraine using high-precision alignment equipment

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The realization of the unit of length using interferometric methods remains one of the most accurate means of ensuring traceability in metrology. To improve the reliability and reproducibility of the reference system's operation, it is relevant to upgrade the optical element base without changing the fundamental principle of its operation. This work considers approaches to the modernization of structural elements of the optical part, in particular, holders, alignment mechanisms, and mounting units.

The potential use of modern alignment platforms is analyzed, such as high-precision optical mounting hardware from leading manufacturers like Thorlabs. These components can reduce mechanical play, improve the stability of optical element positioning, and ensure repeatable adjustment. A modular approach to the design of the optical system is proposed, enabling rapid reconfiguration of the interferometer for different calibration tasks.

The selection of materials and components with a low coefficient of thermal expansion is also considered, which helps reduce instability of the optical base during long-term use.

The proposed approach to upgrading the optical element base is aimed at enhancing the technical flexibility and operational reliability of the national length standard, as well as laying the groundwork for the future implementation of stabilized radiation sources and digital signal processing methods.