NACRW
NORTH AMERICAN
CHEMICAL RESIDUE WORKSHOP

SHORT COURSE ON QA/QC

Squeezing more out of Laboratory Analyses with QA/QC

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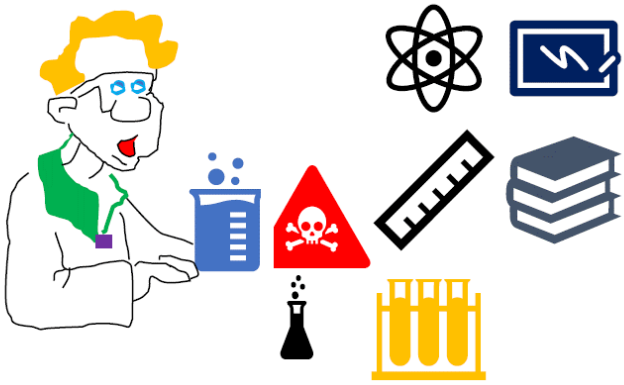
SUNDAY JULY 23, 2023

0800hrs – 1600hrs

Marriott Harbor Beach Resort

Fort Lauderdale, Florida USA



Philosophies of QA/QC in brief

The ISO-IUPAC-BIPM system

Scientific freedom prevails, and you are free to report your research results as you please, if they represent the overall meaning of the message or story that you are trying to tell. It is perfectly acceptable to extract the best possible results of your investigation where deviations between theory and experiments are given by confidence intervals or standard deviations of the mean. Any doubts about the validity of your results are expressed as errors of measurements and there are no requirements with respect to reporting the number of repetitions. The error of measurement should be as low as possible and methods to identify outliers are available and they may be applied to reduce the amount of redundant information to a minimum, which ensures the delivery of maximum precision. It is assumed that many replicates automatically produce excellent accuracy. A universal level of 5 % relative error of measurement is considered maximum acceptable levels for research investigations. The tools of QA/QC that are used in the industry do not have much impact on academia, owing predominantly to the high costs of purchasing the required guidelines and the lack of training in practices and procedures of QA/QC amongst academic staff.

The NIST-Eurachem-CITAC-BIPM system

Scientific publications, international surveys of reproducibility among accredited laboratories, bad press pertaining to the validity of research investigations and ensuing numbers of costly and embarrassing litigations prompts revision of the current system of QA/QC. Commissions and international organisations are established to review the state of QA/QC in industry and academia, and it is realised that new systems of QA/QC must be developed to serve the needs of all areas of industry and research. Moreover, all policies and guidelines must be available for download from the web free of charge. To increase the understanding of the fundamentals of QA/QC and its relation to metrology a new vocabulary is introduced. This causes revision of some of the current concepts such as error of measurement and trueness. The concept of error of measurement is renamed to uncertainty of measurement to express the level of doubt to the results rather than indicating that mistakes were made during the recording of measurement results. The guidelines of GUM, QUAM and VIM3 are in focus, as the corresponding methodologies are incorporated into recommendations and legislations around QA/QC. The main outcomes of the work of the committees are recommendations to perform full method validations, calculate the uncertainty of measurements and prepare uncertainty budgets with the aim of increasing the level of credibility and reliability in the process of decision making.

New methods and way ahead

Even with the development of a new system with recommendations to QA/QC spectacular shortcomings have been identified. Efforts to secure reproducibility are not always fruitful. Full correspondence between results of professional laboratories is not obtained, which to some extent delays the implementation of the new system of QA/QC in the working environment. Although the LEAN technology, as a spin-off to QA/QC, has proved efficient in the manufacturing process to improve the quality of products, it needs to be transformed to meet the academic environment. Productivity and quality can be improved, and it enables laboratories to deliver results with higher degrees of trueness. In the search for the truth in science some amendments to the new system are imminent. Scientific methodology must be followed, and the conditions of reproducibility must be fulfilled. Occasionally, it is revealed that established methods do not perform according to expectations, to a degree where uncertainties of measurements reach magnitudes that make the methods not fit for purpose. Therefore, the method validations should focus on making the predicted uncertainty of measurement correspond to the measured uncertainty of measurement that may be obtain by, for example, the principle of pooled calibrations (PoPC) that refers to the operational calibrations of apparatuses. Henceforth, it is recommended to focus on the method validation that, if performed successfully, will secure the delivery of results that are fully reproducible.

#	Time	Topic	Materials and resources
1	08:00 – 08:30	Welcome and registration. Introduction to program and overview of QA/QC	Leaflet, name tag, programme
2	08:30 – 09:00	A bit of statistics. ISO and IUPAC testing, Multilinear regression (MLR), Analysis of variance (ANOVA), F-testing, t-testing, distributions.	ISO 5725, IUPAC, Miller and Miller, notes with examples
3	09:00 – 09:30	Modeling of data with zero order and first order equations, error of measurement, connection between qualitative and quantitative analysis, linear range, lower and upper limits of analysis operational calibration and standard addition method (SAM).	Guidelines of AOAC, IUPAC, websites, textbook material, case studies and notes
4	09:30 – 10:00	Identification and handling of outliers. Good laboratory practice. Data management. Small and large data sets.	ISO 5725, IUPAC, Miller and Miller, WHO, OECD, FDA
5	10:00 – 10:30	Break	Tea, biscuits, and coffee
6	10:30 – 11:00	Introduction to contemporary QA/QC, QMS, QM, SOP, quality policy and definition of terms and explanation to the concepts of QA/QC. Purpose of QA/QC, survey of QA/QC (Alan J. Handley), uncertainty of measurement, precision, and accuracy	Eurachem, CITAC, ISO, NIST, BIPM, websites, case studies, and notes
7	11:00 – 11:30	International organisations ISO/NIST/BIPM/IUPAC/Eurachem/CITAC/BIPM/ILAC, Demonstration of limitations to the traditional methods of analysis. NIST/Eurachem/VIM3, new concepts, measurand, precision, trueness, and accuracy	Websites, NIST, IUPAC, ISO, BIPM, GUM, QUAM, VIM3, notes, examples
8	11:30 – 12:00	Method validation, SOP, fishbone diagram, uncertainty budget, standard uncertainty, combined uncertainty, expanded uncertainty, target uncertainty, fitness for purpose and compliance	NIST, ISO, BIPM, GUM, QUAM, VIM3, articles
9	12:00 – 13:00	Lunch	to be provided-sandwiches

10	13:00 – 13:30	QUAM testing and decision making, intra-laboratory testing, inter-laboratory testing, certified reference materials and metrology	Articles, FDA guidelines, IUPAC, NIST, BIPM, Eurachem/CITAC
11	13:30 – 14:00	Scientific methodology and uncertainty of measurement, standard reference materials, certified reference materials, fundamental constants, The International Measurement Evaluation Programme (IMEP)	NIST, BIPM, IUPAC, GUM, QUAM, VIM3. notes
12	14:00 – 14:30	Evaluation of results from the literature, PFAS, Pb in drinking water (Flint), CO_2 in the atmosphere, pesticides etc.	NIST, IUPAC, BIPM, GUM, QUAM, VIM3, websites, articles
13	14:30 – 15:00	Break	Tea, biscuits, and coffee
14	15:00 – 15:30	Horwitz's CV-value and consensus science. Principle of pooled calibrations, apparatuses' response functions, lower limit of analysis (LLA), upper limit of analysis (ULA), start of best range (SBR), linear range, correspondence between slope and result	NIST, Eurachem, EURAMET, PoPC, guidelines, articles and notes
15	15:30 – 16:00	Reporting, laboratory management system (LIMS), certification, accreditation, internal audit and external audit, proficiency testing, summary, and way ahead	ILAC, NIST, Eurachem, websites, cloud LIMS

Learning outcomes

After the presentations, the attendees should be able to:

Lesson 2

- Explain how testing is linked to statistical distributions
- Explain how to check if data are distributed according the normal distribution
- Test of data according to principles of the ISO, F-testing and t-testing
- Perform MLR with corresponding uncertainty
- Explain advantages and drawbacks of analysis of variance (ANOVA)
- Depict data in diagram of the canonical distribution
- Test if the results comply with regulatory limits

Lesson 3

- Explain when data may be described by either zero-order or first-order models
- Calculate the linear range of operational calibrations to chemical residue analysis
- Determine which model, zero-order or first-order, that most conveniently describes the data
- Explain the linkages between qualitative and quantitative analysis
- Explain how the linear range is established of operational calibrations
- Explain how to apply the standard addition method (SAM) to calibrations, calculation of uncertainty of measurement and correction for interferences
- Determine the lower limit of analysis, limit of detection (LOD), limit of quantitation (LOQ), method detection limit and method reporting limit (MRL) etc.

Lesson 4

- Identify outliers by statistical testing
- Distinguish between outliers, gross errors and mistakes
- Explain the meaning of GLP
- Organise the data for data processing
- Read and write data from/to computers

Lesson 6

- Explain new concepts of QA/QC according to the vocabulary in metrology (VIM3)
- Explain the differences between contemporary concepts of precision and accuracy and new concepts of precision, trueness and accuracy
- Apply new concepts of precision, trueness and accuracy to chemical residue analysis
- Explain the purpose of introducing QA/QC to chemical-residue analysis
- Explain why it is important to add QA/QC to university curricula
- Explain contemporary definitions of precision and accuracy
- Explain the concept of uncertainty according to the international standardization organization (ISO)
- Calculate uncertainty of measurement according to ISO standards

Lesson 7

- Explain the role, responsibility and resources of key international organizations of QA/QC
- Interpret data with examples from the literature
- Evaluate own data
- Explain the meaning of the concept of quality to analysis of chemical residues
- Explain the position and responsibility of laboratory staff in the quality-management system (QMS)
- Explain how to write the laboratory’s quality policy
- Prepare input to the quality manual (QM)

- Explain the concepts of quality assurance (QA) and quality control (QC) in terms of definitions and the application to the laboratory environment
- Apply principles of good laboratory practice to maintain quality to laboratory work
- Prepare input to the standard-operating procedure (SOP) with focus on uncertainty of measurement

Lesson 8

- Explain principles and purpose of the method validation
- Extract information of the SOP to prepare for calculation of the uncertainty budget
- Construct a fishbone diagram (Isikawa diagram/cause-and-effect diagram) to obtain an overview of contributions to the combined uncertainty of the uncertainty budget
- Calculate the uncertainty of measurement by means of the uncertainty budget
- Explain the concepts of standard uncertainty, combined uncertainty, expanded uncertainty and target uncertainty
- Explain the concepts of measurements' fitness for purpose
- Explain how to obtain compliance between results

Lesson 10

- Describe the application of coverage factor
- Participate in intra-laboratory testing
- Participate in inter-laboratory testing
- Explain the meaning and applications of certified reference materials

Lesson 11

- Explain the outcome of the IMEP
- Explain testing, comparison and compliance according to new practices and procedures of QA/QC
- Apply standard-reference materials (SRMs) and certified-reference materials (CRMs) to determination of accuracy and preparations for proficiency testing

- Explain the position of SRMs and CRMs in the metrology system
- Determination of trueness by means of recovery measurements and analysis of SRMs/CRMs
- Perform testing according to new methods of international organizations BIPM and IUPAC

Lesson 12

- Perform calculations according to literature results
- Evaluate data from the literature
- Perform decision making based on the calculations and testing
- Propose alternative interpretations

Lesson 14

- Explain why different methods of QA/QC are used in the industry and in science
- Explain the meaning of the concepts of scientific methodology
- Explain the applications of SRMs and CRMs in research
- Describe the uncertainty of fundamental constants of science
- Explain the concept of accuracy and the relation to consensus science
- Explain the meaning of Horwitz's formula and calculate the Horwitz CV-value
- Describe the apparatuses' response function
- Perform method validation according to the principles of pooled calibrations
- Determine the lower limit of analysis (LLA)
- Determine the upper limit of analysis (ULA)
- Determine the start of best range (SBR)
- Calculate the upper-limit of analysis
- Calculate the best relative uncertainty (BRU) of measurement
- Depict results of multiple determinations of sample concentrations versus slope of individual calibration lines

Lesson 15

- Explain the difference between certification and accreditation
- Explain the activities needed for the laboratory to have their methods certified
- Explain how the laboratory become accredited
- Explain how to perform lab documentation by the LIMS
- Apply QA/QC to prepare for audits
- Explain how to prepare for proficiency testing
- Explain how to prepare the reports for customers and authorities
- Explain how to prepare affidavits for litigations