Overview of Round Robin Testing

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What is Round Robin Testing?

General term used to describe a coordinated assessment of the ability of test laboratories to accurately and precisely measure the value of particular parameters (e.g. voltage, current, electrical power, luminous flux, colour temperature of a light source) under controlled conditions.

More specifically this relates to:

- **Interlaboratory Comparison** – organisation, performance and evaluation of measurements or tests on the same or similar items by two or more laboratories in accordance with pre-determined conditions.
- **Proficiency Testing** – evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons.

Objectives

- Evaluation of a laboratory's performance
- Identifying any problems in laboratories (operational or equipment)
- Establishing effectiveness and comparability of test or measurement methods
- Providing confidence to laboratory clientele
- Validating uncertainty claims of a laboratory
- Education/training of staff in participating laboratories

Process

Basic principle:

Organising body prepares and circulates samples (artefacts) with known properties to participating laboratories for measurement and determination of those properties, with stated uncertainty of measurement.

Complexity found in the Detail:

- Identifying stable artefacts (no drift in performance, robust for transport)
- Initial determination of the values of the known properties of the artefacts
- Protecting against loss of artefact integrity between participating laboratories
- Operational integrity, traceability and security of artefacts

Contributors

Organising body:

Takes responsibility for the development and operation of an Interlaboratory Comparison/Proficiency Test.

Known as the Proficiency Testing Provider or **Nucleus Laboratory**

Responsibility: to carry out its proficiency testing operations in such a way as to meet the requirements of ISO/IEC 17043 and to satisfy the needs of the participants, regulatory authorities and organizations providing recognition

Accreditation:

ISO/IEC 17043 - Conformity assessment — General requirements for proficiency testing

ISO/IEC 17025 - General requirements for the competence of testing and calibration laboratories

Contributors

Coordinator:

One or more individuals with responsibility for organizing and managing all of the activities involved in the operation of an Interlaboratory Comparison/Proficiency Test (may or may not be affiliated with the Nucleus Laboratory)

Participant:

Laboratory, organization or individual, that receives test items and submits results for review by the Nucleus Laboratory

Accreditation:

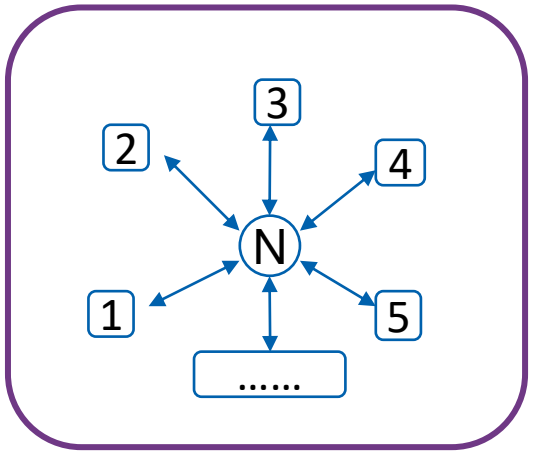
ISO/IEC 17025 - General requirements for the competence of testing and calibration laboratories

Interlaboratory Comparison Scheme Structure

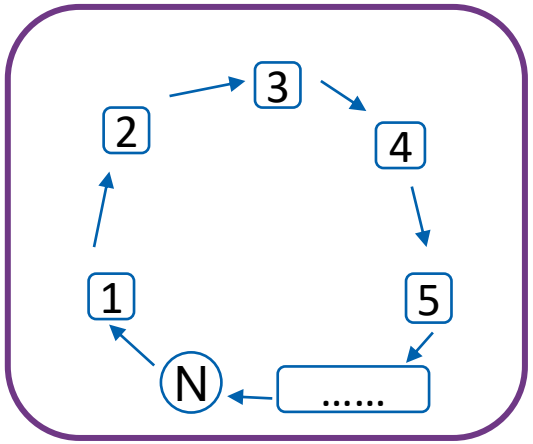
The type of scheme structure is dependent on:

- The number of participant laboratories
- Number of artefact sets that can be provided
- Available timeframe for completion
- Logistics

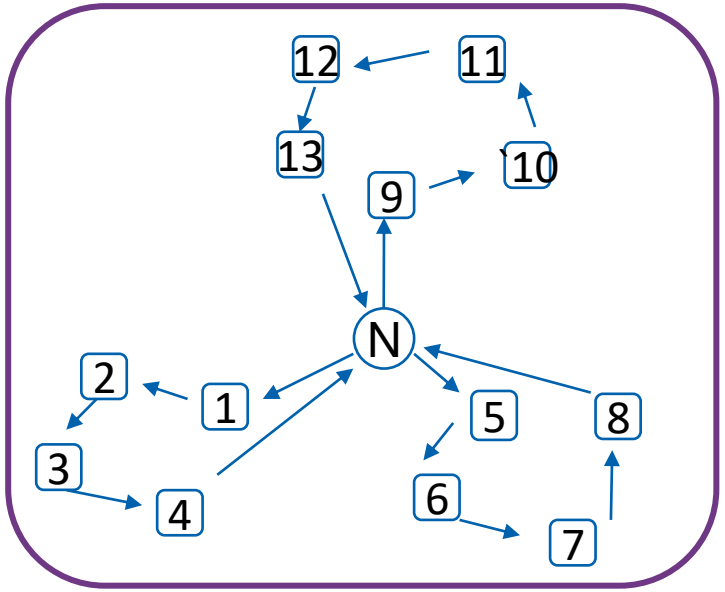
Interlaboratory Scheme Structure



Star



Round robin



Hybrid: Star + round robin

x Participant laboratory

N Nucleus Laboratory

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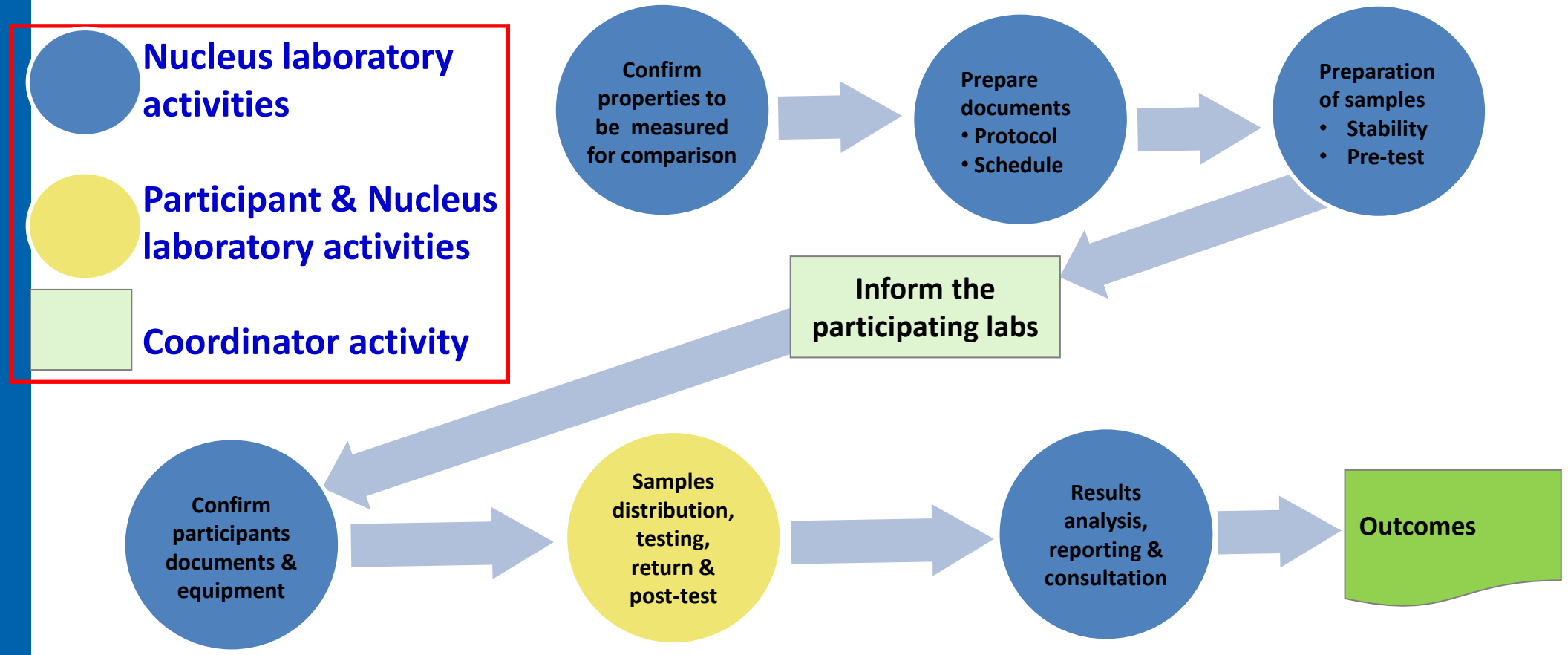
Interlaboratory Comparison Methodology



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Outcomes/Benefits of Round Robin Testing

- Identification and rectification of participant laboratory testing problems
- Proficiency test report is available to support request for test method accreditation
- Client confidence (local Regulator, regional Regulators, suppliers)
- Uncertainty claim validation or improvement
- Identification of training needs and other improvements
- Meets accreditation body's requirement for accredited laboratory's regular participation in proficiency testing activities

Questions

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ISO/IEC 17025

General requirement for the competence of testing and calibration laboratories

- Introduction to the technical requirements that a laboratory must do to become accredited

Clause 5: Technical requirements

5.1 General

5.2 Personnel

5.3 Accommodation

5.4 Test methods & validation

5.5 Equipment

5.6 Measurement traceability

5.7 Sampling

5.8 Test items

5.9 Quality control

5.10 Report

5.1 General

Many factors determine the correctness and reliability of the test and/or calibrations performed by a laboratory:

- Staff competency & diligence (5.2)
- Facility accommodation & environment (5.3)
- Test & calibration methods & validation (5.4)
- Equipment quality and maintenance (5.5)
- Measurement traceability (5.6)
- Sampling practices (5.7)
- Handling & storage of test & calibration items (5.8)

5.2 Personnel

The laboratory management shall ensure the competence of all who:

- Operate specific equipment
- Perform tests
- Evaluate results
- Sign test reports

Personnel shall be qualified on the basis of appropriate education, training and experience

The laboratory shall:

- Have a policy and procedures for identifying and providing training needs
- Maintain current job descriptions for managerial, technical and key personnel

5.2 Personnel – maintaining records and documented procedures

- A record of the qualifications and experience of staff, with objective evidence of their qualifications
- A clear record of scope of accreditation of tests and calibrations that members of staff are authorised to conduct
- Documented procedure for training staff in quality issues and technical procedures, including tests
- Documented procedure for conducting evaluation of the competence of staff after training and before authorising them for the procedures they were trained
- A recording of trainings, including objective evidence of competence
- A mechanism for recording (identifying) which staff conducted each procedure, test or calibration

5.3 Facility Accommodation & Environmental Conditions

Laboratory facilities and environmental conditions shall facilitate

- Correct performance of tests
- Monitoring, control and recording of environmental conditions
- Prevent cross-contamination (photometric testing: stray light)

Have procedures/instructions for staff on appropriate actions when environmental conditions move out of specification.

Also ensure good housekeeping!

5.4 Test & Calibration Methods and Method Validation

The laboratory shall:

- Use appropriate methods and procedures for all calibrations and tests within its scope
  - Where relevant, test procedures include details of sampling, handling, transport, storage and sample preparation.
- Have instructions on the use and operation of all relevant equipment
- Have and apply procedures for determining uncertainty of measurement for all calibrations and tests

(These documents should be maintained and contained in a Manual of Procedures)

- Determine the accuracy, precision and, where relevant, the limit of detection of the methods used, including standard published methods

5.4 Test & Calibration – Non-standard Methods

Full documentation required including:

- Unique identification (code)
- Scope
- Description of the type of item to be tested/calibrated
- Measurands and range of values to be determined
- Equipment & apparatus (including technical performance specifications)
  - Reference standards and/or reference materials required
- Environmental conditions required, any stabilisation period of reference/test item
- Description of procedure including,
  - data to be recorded, analysis method,
  - approval/rejection criteria,
  - reporting, determination of uncertainty

5.4 Test & Calibration – Validation of Non-standard Methods

Techniques for validation should be one or a combination of the following:

- Calibration using reference standards or reference materials
- Comparison of results achieved with other methods
- Interlaboratory comparisons
- Systematic assessment of the factors influencing the result
- Assessment of the uncertainty of the results based on scientific understanding of the theoretical principals of the method and practical experience

5.5 Equipment

The laboratory shall:

- Have a system for commissioning equipment and verifying its performance and calibration before it is used for test or calibration work
- Have a plan for periodic calibration and verification of the performance of all equipment which affects the validity of measurements
- Have records showing that this plan is followed and which enable the status of any equipment to be verified at any point in its history of use
- For equipment subject to regular checks or calibrations, be labelled with a calibration sticker so that its status immediately visible to users

5.5 Equipment – Records

Equipment records shall include the following:

- Identity of the item and its software (if applicable)
- Manufacturer’s name, type identification, serial number
- Confirmation that equipment complies with specification
- Manufacturer’s instructions
- Procedures for safe handling, transport and storage
- Historical reports & certificates of all calibrations, adjustments, acceptance criteria and due date of next calibration
- Maintenance plan and up to date maintenance log
- Incident log (damage, malfunction, modification, repair)

5.6 Measurement Traceability

The laboratory shall:

- Identify all the measuring equipment involved, directly or indirectly, in measurement or calibration (which, if not properly calibrated, would affect the validity of measurements) and have it calibrated in a manner which provides traceability to the international measurement system
- Have a management procedure to ensure that calibration is maintained at all times, i.e. recalibration is conducted as necessary and, where possible, equipment is monitored so that any drift away from calibration will be detected
- Have records which could be audited to confirm the calibration status of the equipment at any point in the past

5.8 Test Items

The Laboratory shall:

- Have procedure for logging samples upon entry to the laboratory
- Uniquely number samples as soon as practicable after receipt
- Ensure samples are stored securely and in a way that will preserve them against any changes which may affect measurement results
- Have a system for ensuring that the procedures required to be carried out on samples are clearly communicated to laboratory staff
- Have a procedure to ensure reports are checked to make sure they correspond to the raw data
- Have a clear policy on how long samples are retained before disposal.

5.9 Quality Control

- The laboratory shall have quality control procedures for monitoring the validity of tests and calibrations undertaken.
- Monitoring shall be planned & reviewed and may include:
  - Regular use of certified reference materials and/or secondary reference materials
  - Participation in interlaboratory comparison or proficiency testing programs
  - Retesting or recalibration of retained items
- Ensure that during a test or calibration, all observations are recorded at the time when they are made, and the person making the record is identified
- Always preserve the raw data in the record so that any problems can be investigated
- Have a policy on how amendments to entries on laboratory records are to be made

5.9 Quality Control

Where computers or automated equipment is used in tests and calibrations procedures for the control of data is necessary to ensure:

- Computer software developed by the laboratory is sufficiently documented and validated
- Integrity & confidentiality of data entry/collection, storage, transmission and processing is maintained
- Suitable environmental and operating conditions are maintained for proper functioning of the computers and equipment

5.10 Report

A test report shall include a minimum set of information

- Title
- Name, address & location of laboratory
- Laboratory's assigned accreditation number from Accreditation Body (if applicable)
- Unique identification of the test report (on each page)
- Name & address of customer
- Identification of test method used
- Unambiguous identification of the sample item(s), a description, stated condition and date of receipt
- test or calibration results, units of measurement, stated uncertainty of measurement
- Names, function and signature of authorised persons

Questions

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ISO 13528

Statistical methods for use in proficiency testing by interlaboratory comparison

- Provides support for the implementation of ISO/IEC 17043, particularly, on the requirements for the statistical design, validation of proficiency test items, review of results, and reporting summary statistics

Introduction

Purposes of Proficiency Testing

The use of interlaboratory comparisons to determine the performance of participants (which may be laboratories, inspection bodies, or individuals) for specific tests or measurements, and to monitor their continuing performance.

Rationale for Scoring in Proficiency Testing Schemes

Most proficiency testing schemes compare the participant's deviation from an assigned value for a test item with a numerical criterion which is used to decide whether or not the deviation represents cause for concern.

4.2 Basic Model

For a single measurand:

$$x_i = \mu + \varepsilon_i$$

where

x_i = proficiency test result from participant i

μ = true value for the measurand

ε_i = measurement error for participant i, distributed according to a relevant model

5.2 Basis of a statistical design

Proficiency testing schemes with different objectives and with different sources of error could have different designs

For Lighting products

Use a proficiency testing scheme that compares a participant's result with the assigned value, using the participant's own measurement uncertainty. The design will need to consider how the assigned value and its uncertainty are to be obtained and how participant measurement uncertainties are to be used in scoring.

6.1 Homogeneity and Stability of Proficiency Test Items

Proficiency testing provider shall ensure that batches of proficiency test items are sufficiently homogeneous and stable for the purposes of the proficiency testing scheme.

Where the same artefact is used by multiple participants, the proficiency testing provider shall assure stability throughout the round, or have procedures to identify and account for instability through the progression of a round of the proficiency testing scheme.

6.3 Blunder Removal

ISO/IEC 17043:2010, B.2.5 recommends removing obvious blunders from a data set at an early stage in an analysis, prior to use of any robust procedure or any test to identify statistical outliers.

These can be identified by:

- Visual review of data
- Robust statistical methods
- Outlier techniques for individual results

Generally, these results would be treated separately (such as contacting the participant). It can be possible to correct some blunders, but this should only be done according to an approved policy and procedure.

7 Determination of the Assigned Value and its Standard Uncertainty

Results from one laboratory

An assigned value can be determined by a single laboratory using a reference method with a Certified Reference Material (CRM) and with a complete uncertainty statement and documented metrological traceability that is appropriate for the proficiency testing scheme.

$$x_{pt} = x_{CRM} + \bar{d}$$

x_{CRM} is the assigned value for the CRM

x_{pt} is the assigned value for the proficiency test item

d_i is the difference between the average results for the proficiency test item and the CRM on the i^{th} samples

$\bar{d}$ is the average of the differences d_i

The standard uncertainty

$$U_{char} = \sqrt{u_{CRM}^2 + u_{\bar{d}}^2}$$

7 Determination of the Assigned Value and its Standard Uncertainty

Consensus value from expert laboratories

Assigned values can be determined using an interlaboratory comparison study with expert laboratories.

The proficiency testing provider shall establish a procedure for estimation of the assigned value and associated uncertainty. (e.g. weighted or un-weighted averages.

8 Determination of criteria for evaluation of performance

The basic approach for all purposes is to compare a result on a proficiency test item (x_i) with an assigned value (x_{pt}). For evaluation, the difference is compared to an allowance for measurement error.

This comparison is commonly made through a standardized performance statistic.

For lighting:

- z’ scores
- E_n scores

9.5 z’ scores

The z’ score is suitable for the purpose of testing laboratory accreditation, which examines a laboratory’s competence and compliance to a test method which is developed to limit measurement variations as is often required in product certification activities.

$$z'_i = \frac{x_i - x_{pt}}{\sqrt{\sigma_{pt}^2 + u^2(x_{pt})}}$$

where

- x_i is the laboratory’s proficiency test result
- x_{pt} is the assigned value
- σ_{pt} is the standard deviation for proficiency assessment
- $u(x_{pt})$ is the uncertainty of measurement of the assigned value

9.5 z’ scores

Interpretation of z’ scores:

- $|z'| \leq 2{,}0$ is considered to be acceptable
  - Expect approximately95% of scores to be within this range
- $2{,}0 < |z'| < 3{,}0$ is considered to give a warning signal
  - Expect approximately 5% of scores to be within this range
- $|z| \geq 3{,}0$ is considered to be unacceptable (or action signal)
  - Expect approximately 0.3% of scores to be within this range

9.7 E_n scores

E_n scores can be useful when an objective for the proficiency testing scheme is to evaluate a participant's ability to have results close to the assigned value within their claimed expanded uncertainty

$$\left(E_n\right)_i = \frac{x_i - x_{pt}}{\sqrt{U^2\left(x_i\right) + U^2\left(x_{pt}\right)}}$$

where

x_{pt} is the assigned value determined in a reference laboratory

$U(x_{pt})$ is the expanded uncertainty of the assigned value x_{pt}

$U(x_i)$ is the expanded uncertainty of a participant's result x_i

9.7 E_n scores

Interpretation of E_n scores:

- En ≤ -1.0 or En ≥ 1.0 could indicate a need to review the uncertainty estimates, or to correct a measurement issue

- -1.0 < En < 1.0 should be taken as an indicator of successful performance only if the uncertainties are valid and the deviation (xi-xpt) is smaller than needed by the participant's customers.

Questions

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