QuickStart Guide to Measurement Uncertainty

Measurement Uncertainty refers to the doubt or range of values associated with a measurement result. It's crucial for understanding the reliability of measurements. One approach that is used by calibration laboratories, and may be used for testing laboratories, includes these steps:

1. Identify the Measurement Process: Define the measurement process, including the instrument used, the quantity being measured, the measurement procedure, and any relevant environmental factors.
2. List Sources of Uncertainty: Identify all potential sources of uncertainty that can affect the measurement result. These can include instrument limitations, calibration errors, environmental conditions, operator skill, etc.
3. Classify Uncertainties: Categorize uncertainties into two main types: Type A and Type B.

   Type A: These are evaluated statistically based on a series of repeated measurements. Calculate the standard deviation or standard error of the mean to estimate uncertainty due to random fluctuations.

   Type B: These are assessed using other information sources like calibration certificates, manufacturer specifications, expert opinions, etc. They're typically evaluated using probability distributions.
4. Quantify Type A Uncertainties: Perform multiple measurements of the same quantity under similar conditions. Calculate the mean and standard deviation of these measurements. The standard deviation represents the Type A uncertainty.
5. Quantify Type B Uncertainties: For each identified source of uncertainty, gather relevant data or information. Estimate the uncertainty contribution from each source using appropriate statistical methods or available information.
6. Combine Uncertainties: Combine Type A and Type B uncertainties to calculate the combined standard uncertainty. This is often done using the root-sum-square (RSS) method. Square each uncertainty component, sum them up, and take the square root of the sum.
7. Coverage Factor: Introduce a coverage factor (usually denoted as k) to account for the confidence level. For a Gaussian distribution (which is often assumed), a coverage factor of 2 corresponds to a 95% confidence level.
8. Expanded Uncertainty: Multiply the combined standard uncertainty by the coverage factor to obtain the expanded uncertainty. This provides a range within which the true value is likely to lie.
9. Report Uncertainty: Present the measurement result along with the expanded uncertainty. This communicates the reliability of the measurement to others.
10. Iterative Process: Measurement uncertainty assessment is not a one-time task. It should be periodically reviewed and updated as new information or data becomes available, or if the measurement process changes.
11. Documentation: Keep comprehensive records of the measurement process, sources of uncertainty, calculations, and any assumptions made during the assessment. This documentation is crucial for traceability and repeatability.

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Testing laboratories often find this approach is not practical. Testing laboratories may choose to use a variety of data-driven approaches using laboratory data from calibrations, quality controls, or validation.

Some of the common approaches using laboratory data include:

- NORDTEST NT TR 537 – "Handbook for calculation of measurement uncertainty in environmental laboratories"
- ISO 21748 – "Guidance for the use of repeatability, reproducibility and trueness estimates in measurement uncertainty estimation"
- ISO 11352 – "Water quality – Estimation of measurement uncertainty based on validation and quality control data"

There are two points for testing laboratories to note: 1) These approaches do not identify the major sources of error, as required by the standard and 2) That single value may not define the uncertainty of a method when using one of these approaches. To address the first point, consider listing or using a fishbone diagram to identify the major sources or error. The considerations in addressing the second include the evaluating the impact over the range of the test and the understanding the impacts of different sample preparations of the items or matrices involved.

Remember that measurement uncertainty assessment is both a scientific and mathematical process. It requires a thorough understanding of the measurement process, statistical methods, and relevant data sources.

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