

# Traceability

## 1. Introduction

The concept of traceability to a national laboratory is fundamental to a unified system of metrology. Unfortunately, the term is often used in a very loose way without rigorous definition. The purpose of this document is to give the International Organization for Standardization (ISO) definition and various interpretive notes that have been accepted by all the members of the North American Metrology Cooperation (NORAMET). The document is intended to clarify, strengthen and standardize the use of the term within the measurement systems of the member countries.

## 2. Definition

Property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties.

### Notes

1. The concept is often expressed by the adjective traceable.
2. The unbroken chain of comparisons is often called a traceability chain.
3. (Applicable only to the French text.)
4. This definition and the above notes are taken verbatim from the International Vocabulary of Basic and General Terms in Metrology (ISO, 1993).

## 3. Interpretation

This definition applies both to physical and to chemical measurements.

Traceability only exists when metrological evidence, appropriate for the application, is collected to document the traceability chain and quantify its associated measurement uncertainties.

The values of standards, their uncertainties, and the corrections and uncertainties of associated measurement systems may have time-dependent components. Evidence must therefore be collected at appropriate intervals and used on a continuing basis to remove measurement biases and re-determine the associated uncertainties.

## 4. Stated References

In most cases, the ultimate reference for a measurement result is the SI definition of the appropriate unit. However, the stated reference is usually a national laboratory that maintains a realization of the unit. This is an appropriate and practical way of stating traceability and reflects the usual chain of measurement comparisons (calibrations) that exist in a country.

Certain quantities, such as refractive index, relative permeability, reflectance, etc. are defined as the ratio of two comparable quantities. These dimensionless quantities are

expressed as numbers. Nevertheless, the term "traceable to the national laboratory" can be used if there is a properly documented chain of comparisons to similar measurements at the national laboratory.

For some quantities that are not well-defined physical quantities (e.g. hardness), there are no SI units and traceability is referred to "consensus standards" which are artifacts and/or processes that are used as de facto standards by general agreement. Again, a proper chain of comparisons can justify the use of the term "traceable to the national laboratory".

## **5. Quantity of Matter**

In measurements of quantity of matter, traceability to the SI unit (the mole) cannot be achieved in practice through the comparison of physical artifacts because of the very large number of substances which would each have to be individually compared. Instead the Consultative Committee on the Quantity of Matter (CCQM) has stated that traceability to the SI can be established by making measurements using a primary method, correctly applied and with evaluated uncertainties.

A primary method of measurement is a method having the highest metrological qualities, whose operation can be completely described and understood, for which a complete uncertainty statement can be written down in terms of SI units, and whose results are, therefore, accepted without reference to a standard of the quantity being measured.

This satisfies the purpose of establishing traceability which is to ensure that measurements at the end of a traceability chain can be made in SI units having quantified uncertainties so that the measurements are accurate, comparable with measurements made by other methods and in other domains, and stable in the long term (see Resolutions 1, 2 and 7 of the 20th Conférence Générale des Poids et Mesures (CGPM), 1995).