

Validation of Test Methods

General principles and concepts

PURPOSE

The document is intended to give general views on certain issues related to the validation of test methods and should be seen as a common understanding and position of EAL and Eurolab.

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Authorship

This publication is a revision of the earlier guidance Publication ELA-G3, to cover the needs of testing and of calibration laboratories. It will henceforth be a responsibility of EAL Committee 4.

Official language

The text may be translated into other languages as required. The English language version remains the definitive version.

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Guidance Publications

This document represents a consensus of EAL member opinion and preferred practice on how the relevant clauses of the accreditation standards might be applied in the context of the subject matter of this document. The approaches taken are not mandatory and are for the guidance of accreditation bodies and their client laboratories. Nevertheless, the document has been produced as a means of promoting a consistent approach to laboratory accreditation amongst EAL member bodies, particularly those participating in the EAL Multilateral Agreement.

Further information

For further information about this publication, contact your National member of EAL:

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0 Foreword

- 0.1 EAL and Eurolab have a Permanent Liaison Group (PLG), which is a forum where EAL and Eurolab are discussing matters of mutual interest. The PLG consists of five members from each organisation.
- 0.2 This document has been prepared in the PLG and endorsed by both organisations.
- 0.3 The document is intended to give general views on certain issues related to the validation of test methods and should be seen as a common understanding and position of EAL and Eurolab. In order to define and describe the activities behind the concept 'Validation of test methods' more detailed guidance documents are needed. This document should be seen as a basis for such guidance document

1 Introduction

- 1.1 The definition used for 'validation' in the ISO standard 8402 is 'confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled'. This definition gives the impression of confined and well-defined (exact) operations. Test methods are normally developed for an intended application range. The reference to particular requirements must in many cases be interpreted in a flexible way as the requirements can be of general nature.
- 1.2 Both standardised and non-standardised test methods are covered. They can be exact or associated with large uncertainties. Even novel test methods will be considered. The validation of a test method becomes in this context a way of demonstrating that the method is fit for its intended purpose. The fitness for purpose includes an assessment and a balancing of technological possibilities, risks and costs.
- 1.3 There are very few papers in the open literature dealing with the general principles of test method validation. On the other hand, a lot of detailed descriptions of the validation of specific test methods are available. A brief overview of the concepts, aims and procedures in validation is given in this document.

2 General principles to be used in validation

- 2.1 In the validation process an estimate is made of the representativeness, repeatability and reproducibility of the test method. The definitions are given in Section 4.
- 2.2 In the validation process the ultimate aim is to secure that the test methods are good enough with respect to representativeness, reproducibility and

repeatability. How much effort should be spent on validation must be decided on a case by case basis. If large economic values as well as considerable health, safety and environmental issues are involved, much more emphasis must be paid to the validation of the test methods. The frequency of use of the test method should also be considered when determining the extent of validation. The total consequences of wrong results are of course larger for methods in extensive use than for test methods used occasionally.

- 2.3 The validation of test methods covers to a large extent the uncertainty, repeatability and reproducibility of the test method. As the factors affecting the results and contributing most to the uncertainty change from one technical sector to another or even from one test method to another, a universal solution cannot be given. Guidance on the expression of uncertainties can be found for example in the international *Guide to the expression of uncertainty in measurement* and EAL guidance document
EAL-G23: *Expression of uncertainty in quantitative testing*.
- 2.4 Standardised test methods should be considered validated for their intended application range and thus good enough for that purpose although their repeatability and reproducibility are not known in detail. The testing laboratory must, however, check that they apply the method correctly. For non-standardised test methods it is up to the testing laboratories to determine how far they go in defining the level of repeatability and reproducibility.
- 2.5 To develop a representative test method, adequate knowledge is required of the practical use of the test results and of the real service conditions of the object of the test. Based on such knowledge, the 'representative' properties to be determined by the test may be identified.

The factors affecting the test results and their uncertainty may be grouped into three main categories:

(a) Instrumental and technical factors:

- sampling;
- homogeneity;
- test method;
- equipment.

(b) Human factors.

(c) Environmental factors:

- testing environment.

- 2.7 **Instrumental and technical factors** are related to the constructional and functional characteristics of the test and measurement equipment, as well as to other technical operations involved in the test (e.g. sampling, preparation of

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samples, test object homogeneity). Their effect may be minimised and kept under control by the following provisions:

- define the equipment as precisely as necessary;
- provide a clear description of the test procedure as well as the equipment operation;
- establish procedures for operational control and calibration;
- ensure where applicable traceability of measurements to the SI units.

Whenever practical, the above provisions should be included in the description of the test method. References to internal procedures or applicable standards should be included.

2.8 **Human factors** are related to the competence of the staff and may be controlled through:

- education/basic knowledge;
- on job training/practical experience.

The qualification required for the personnel employed for a given test may be specified in the test method or reference can be made to the applicable internal procedures.

2.9 **Environmental factors** are associated to the environment where the test is performed. Among others the effect of the following parameters must be assessed and properly controlled:

- atmospheric conditions (temperature, pressure, humidity);
- pollution/contamination;
- other environmental characteristics (e.g. EMC).

2.10 The effect of the above parameters should be described in the test method or reference to other applicable documents should be made. However, for new test methods this information is often not available. In some cases the data base for method validation is so large that statistical methods should be applied.

2.11 The validation process must consider the expected or required uncertainty of the test results and their intended use.

2.12 Critical threshold values (e.g. in health and environment) cannot generally be technically justified with a small uncertainty. However, if a legal limit is set, there must be test methods suited for the purpose. Reference is made to a recent ILAC Guide.

2.13 The required depth of the validation process depends also on the maturity of the test method and the prevalence of its use. One can distinguish between the

following categories:

- novel methods;
- methods used by several laboratories;
- modification of established methods;
- standardised methods.

- 2.14 The ways, in which the validation is performed in the different cases, need not be clearly differentiated. If the fitness for purpose concept is maintained, it is often possible to validate at reasonable cost but with a higher degree of uncertainty.
- 2.15 The novel methods are first developed in one single laboratory, often on the basis of a special request from a customer or on ideas created in the laboratory. That customer cannot pay for a wide range validation nor can the laboratory itself. The aim of the validation of test methods must always be to demonstrate that the method is fit for the intended purpose and that the results have an acceptable uncertainty. It is important that the rules of validation of test methods do not prevent the natural technological development from taking place. The laboratory does not expect (although it does want) outside financial help for validation of novel methods and in many cases tries to protect its new development from going to its competitors or from becoming generally available to all.
- 2.16 When a certain number of laboratories work in the same area, cooperation and inter-laboratory comparisons can be arranged. The coordination of such activities is an extra economic burden. In order to speed up the process, external financing is needed.
- 2.17 The testing laboratories need to update their existing test methods. The flexible scope of accreditation as agreed between EAL and Eurolab was also intended to allow modifications to be made to accepted (accreditation covered) test methods. This requires validation procedures applicable to method modifications. It is up to the laboratories to describe their procedures for validating modified test methods.
- 2.18 The most thorough validation procedure is required for test method standardization purposes. The work needed is considerable and covers proficiency testing, the determination of factors affecting the uncertainty, measuring range, etc. The financial burden cannot be laid on the laboratories but on the standardization organisations. Standardised test methods must be considered sufficiently validated for their intended application ranges. If they are not, they should be withdrawn.

The validation of test methods consists of two interrelated steps:

- (a) suitability of the test to solve the problem (customer needs)
- (b) demonstration of the technical capability of the test method within the specified test range

i.e. measuring the right properties with a sufficiently reliable method.

2.20 The suitability or representativeness of a test method is in many cases an attribute which is difficult to define especially for tests related to product acceptance. The test methods must be such that the results obtained correlate with the performance characteristics and operational experience of the product.

3 Validation procedure

3.1 Both testing laboratories and accreditation bodies are looking for procedures and guidelines for planning and controlling the test method validation process. However, the discussion above has clearly indicated that one single procedure cannot be developed. Consequently, a palette of different choices of validation techniques has to be developed. How detailed the validation will be, depends on the circumstances (needs, costs, possibilities, risks, etc.).

3.2 The validation of the test methods is, of course, of interest also to the accreditation bodies. The principle to be applied should be that the laboratory describes the way it is validating the test methods and the accreditation body should make the judgement if the procedure used is acceptable in that case. The different validation possibilities are built up around:

- utilization of calibration;
- intercomparisons including the use of reference materials and reference methods;
- well qualified staff and their professional judgement;
- simulation and modelling;
- other approaches.

3.3 Method validation is often based on the combined use of validation procedures. The validation used can be 'direct' or comparative. The selection of the validation procedures should also be justified on a cost-benefit basis as long as the fitness-for-purpose is maintained. Focusing the effort on the most critical factors affecting the test method will lead to a different solution for the validation of 'exact' physical and chemical test methods as compared to that for product or subjective testing. For example, in the validation of ergonomics and sensory test methods not all possibilities are applicable.

3.4 As said above different validation procedures may be followed, their effectiveness and applicability depending on the type of test considered. They can be characterised as 'scientific' or 'comparative':

(a) **'Scientific approach'**

In the scientific approach the assessment of the representativeness, repeatability and reproducibility of the method is performed with reference to the different constitutive elements and features. Evidence should describe the representativeness of the selected properties and the associated uncertainty. This can be based on information published in the scientific

and technical literature or on ad hoc investigations performed by the laboratory developing the method. The laboratory shall demonstrate that relevant influencing factors (instrumental and technical, human, environmental) have been analysed and that they are under control within the uncertainty associated with the method.

(b) **'Comparative approach'**

The test method is assessed by comparing its results to those obtained by means of another already validated test method, which has been developed for the same purposes. If this is not possible, the performance characteristics of the method may be assessed through interlaboratory comparisons. The method is 'valid' if the results obtained by the different laboratories fall within the expected uncertainty limit. Deviations beyond such limits may indicate e.g. a lack of control of the influencing parameters. The causes of this behaviour should be clarified and the method is to be redefined accordingly. The interlaboratory comparison does not always provide a comprehensive validation of the representativeness of the method, which may be accurate and stable, though physically 'wrong'.

- 3.5 The acceptance procedure for new or modified test methods is either (a) determined internally in the laboratory (b) agreed upon between the customer and the laboratory or (c) accepted by the authorities and/or accreditation bodies. A higher degree of reliance is needed when safety, health and large economic values are involved. Calibration has been emphasised as an important element in the method validation process, but it is not necessarily the most dominating factor. The understanding of the testing method with its systematic and random errors is crucial. A scientific approach to analyse sources of error as well as the competence of the personnel doing that job is of great importance.
- 3.6 The laboratory should always describe the way the validation of test methods is done and this description should be a part of the quality system/manual when appropriate.
- 3.7 As simplified validation procedures ('fast' validation methods) must be used in many cases, the capability to use professional judgement in assessing whether the validation is comprehensive enough becomes pronounced. However, even when talking about simplified or fast validation procedures, the validation must be done with such a depth that the method is fit for the intended use and acceptable to the customer and/or authorities. It is clear that the definition of the use and scope of the method and assumption of uncertainty should not be misleading and too optimistic.
- 3.8 When the use of new test methods becomes more extensive, work describing the effect of changes in test parameters can be initiated in order to show the robustness of the method. Prenormative research should also be initiated.
- 3.9 The need for new or improved test methods arises when we lack methods or the existing ones are not complete, good or efficient enough. There is no need for the laboratory community to develop new methods if existing ones can be considered adequate.

4 Definitions

Repeatability (of results of measurements)

Closeness of the agreement between the results of successive measurements of the same measurand carried out under the same conditions of measurement. (VIM)

Notes

1. These conditions are called repeatability conditions
2. Repeatability conditions include:
 - the same measurement procedure;
 - the same observer;
 - the same measuring instrument, used under the same conditions;
 - the same location;
 - repetition over a short period of time.
3. Repeatability may be expressed quantitatively in terms of the dispersion characteristics of the results.

Reproducibility (of results of measurements)

Closeness of the agreement between the results of measurements of the same measurand carried out under changed conditions of measurement. (VIM)

Notes

1. A valid statement of reproducibility requires specification of the conditions changes.
2. The changes conditions may include:
 - principle of measurement;
 - method of measurement;
 - observer;
 - measuring instrument;
 - reference standard;
 - location;

- conditions of use;
- time.

3. Reproducibility may be expressed quantitatively in terms of the dispersion characteristics of the results.
4. Results are here usually understood to be corrected results.

Uncertainty (of measurement)

Parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand. (BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML).

Notes

1. The parameter may be, for example, a standard deviation (or a given multiple of it), or the width of a confidence interval.
2. Uncertainty of measurement comprises, in general, many components. Some of these components may be evaluated from the statistic distribution of the results of series of measurements and can be characterised by experimental standard deviations. The other components, which can also be characterised by standard deviations, are evaluated from assumed probability distributions based on experience or other information.
3. It is understood that the result of the measurement is the best estimate of the value of the measurand, and that all components of uncertainty, including those arising from systematic effects, such as components associated with corrections and reference standards, contribute to the dispersion.

Validation

Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled (ISO 8402).

Notes

1. In design and development, validation concerns the process of examining a product to determine conformity with user needs.

2. Validation is normally performed on the final product under defined operating conditions. It may be necessary in earlier stages.
3. The term 'validated' is used to designate the corresponding status.
4. Multiple validations may be carried out if there are different intended uses.

Verification

Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled.

Notes

1. In design and development, verification concerns the process of examining the result of a given activity to determine conformity with the stated requirements for that activity.
2. The term 'verified' is used to designate the corresponding status.

5 References and background material

ISO 5725 (1986): *Precision of test methods - Determination of repeatability and reproducibility for a standard test method by inter-laboratory tests.*

ISO 8402 (1994): *Quality management and quality assurance - vocabulary.*

BIPM/IEC/IFCC/ISO/IUPAC/IUPAP/OIML (1995): *Guide to the expression of uncertainty in measurement.*

EAL-G 23 (1997): *Expression on uncertainty in quantitative testing.*

EAL-G 12 (1995): *Traceability of measuring and test equipment to national standards.*

Forstén Jarl (1991): *A view on the assessment of the technical competence of testing laboratories.* Nordtest Technical Report 149, 46p.

ILAC (1996): *Guide an assessment and reporting of compliance with specification, based on measurements and tests in a laboratory.*

VIM (1993): *International vocabulary of basic and general terms in metrology.*