ORGANISATION INTERNATIONALE DE METROLOGIE LEGALE

COMMITTEE DRAFT OIML/2nd CD

Date: 2006-03-15 R e f e r e n c e number: OIML TC 4/N 5

Supersedes document: D 5

OIML/TC 4

Title: Measurement standards and calibration and verification devices

Secretariat: SLOVAKIA

Circulated to P- and O-members and liaison international bodies and external organisations for:

discussion at (date and place of meeting): .....

[X] Comments by:

P and O Members of TC 4.

[X] Vote (P-members only) and comments by: 2006.06.15.

TITLE OF THE CD (English): **Principles for the establishment of hierarchy schemes for measuring instruments**

TITLE OF THE CD (French): **Principles pour l´établissement des schémas de hiérarchie des instruments de mesure**

Contents

1. INTRODUCTION

Metrology in general, including legal metrology, nowadays is already quite different from what it was some twenty – thirty years ago, both at national and international levels. Metrology is facing multiply developments such as globalisation of economics and international trade, geopolitical changes, elimination of technical barriers to trade, liberalisation, privatisation and redefinition of the role of the state in metrology.

Metrology has changed also due to implementation of quality management systems in various organisations, accreditation of testing and calibration laboratories, and conformity assessment procedures based on quality system of production.

The quality of products and services is increasingly dependent on reliable measurements. The importance attached to measurements is reflected in relevant international standards by the requirement that measurements must be traceable to national or international standards. So, for example, according to ISO 9001:2000 *Quality management systems. Requirements*, in an organisation where it is necessary to ensure valid results, measuring equipment shall be calibrated or verified at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standard.

In line with another standard, ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories* [1], all equipment used in testing and/or calibration laboratories having significant effect on the accuracy or validity of the result of the test or calibration shall be calibrated before being put into service. The programme for calibration of equipment shall ensure that calibrations and measurements made by the laboratory are traceable to the SI units.

Traceability is based on the one hand on calibrations, traceable to national standards, particularly those that are primary standards and international standards, on the other hand on equivalence between national standards.

Traceability of measurements is essential if the results of these measurements are to be comparable and if uncertainty of measurements is to be meaningfully assigned. National measurement systems require that all measurements necessary for the proper performance of a calibration, testing or verification are traceable, where the concept is applicable, to national measurement standards or, when using reference materials, to national or international reference materials.

The objective of this Document is to give a clear and transparent picture of the principles of traceability and how the traceability may be achieved. It proposes also general rules for the establishment of hierarchy schemes for measuring instruments as a specification of chains of comparison for measuring instruments (including means and methods of comparisons), which serves to evidence their traceability.

This Document gives guidance and assistance to organisations on how to comply with the traceability requirements for relevant standards. It is intended for legal metrology laboratories where supervision of measuring and test equipment is an important part of quality assurance. It may be used by organisations involved in industrial production processes (development, manufacture, installation, final inspection) and by calibration and testing laboratories.

The quest for a better quality of measurements is the very reason for the existence of hierarchy schemes. This can be achieved in a number of ways, the classical scheme that is based on the direct calibration chain being the most widely used.

2. TERMINOLOGY

In this Document the terminology of the International Vocabulary of Basic and General Terms in Metrology (VIM) [2], the International Vocabulary of Terms in Legal Metrology (VIML) [3] and Guide to the Expression of Uncertainty in Measurement (GUM) [4] are used.

2.1 **Traceability of calibrations and measurements**

The property of the result of these calibrations and measurements whereby it can be related to the definition of units through an unbroken chain of comparisons all having stated uncertainties.
For the application of legal metrology control, traceability may be obtained either through evaluation of uncertainties or through compliance with stated maximum permissible errors.

2.2 **Hierarchy scheme**

Specification of chains of comparisons for given kind of measuring instrument which serves to evidence their traceability.

2.3 **National hierarchy scheme**

Hierarchy scheme containing specification of recommended (permissible) kinds of measuring instruments for individual levels of traceability, requirements for their metrological characteristics and recommended (permissible) methods and means of comparison valid for given kind of measuring instruments in the particular country.

2.4 **Local hierarchy scheme**

Hierarchy scheme containing specification of real reference and working standards, their metrological characteristics and methods and means of comparison for given kind of measuring instruments at a given location, in a given organisation or in a given laboratory.

2.5 **Means of comparison**

Technical devices, reference materials or material medium, in which comparison is carried out, necessary for transfer of values from standards to compared measuring instruments, which influence uncertainties of comparison.

2.6 **Calibration hierarchy**

Sequence of calibrations of measuring instruments between stated metrological reference and the final measuring instrument.

2.7 **National Metrology Institute (National Standard Laboratory)**

The institute in a country that is by law responsible for the conservation of one or more national standards.

2.8 **Legal metrology laboratory (Legal metrology services)**

Authorised body performing (responsible for) legal control of measuring instruments, e.g. type approval, verification, etc.

2.9 **Accredited calibration laboratory**

Laboratory that performs calibration of measuring instruments and is formally recognised by authority body and is competent to carry out calibration.

3. TRACEABILITY AND ITS ELEMENTS

3.1 Traceability of measuring and test equipment by means of calibration or verification is necessitated in order:

- to meet the requirements of growing national and international trade; guarantee the product quality and compatibility of manufactured parts,
- to protect the interests of individuals and enterprises, protect national interests and protect public health and safety, including environment and medical services in relation.

3.2 For the application of any laws and regulations prescribing requirements on measurements, on prepackages and on measuring instruments, traceability to SI units is required and may be obtained:

- either through the system of national measurement standards and certified reference materials, or
- through traceability to recognised national measurement standards or certified reference materials of other countries when system of national measurement standards is not sufficient.

3.3 The term *traceability* means that the indication of a measuring instrument (or a material measure) has been compared, in one or more stages, with a national standard for the measurand in question. In each of these stages, a calibration has been performed using a standard which value and uncertainty are already determined by calibration with a higher-level standard. Therefore there is a hierarchy of calibrations as shown in Fig. 1.

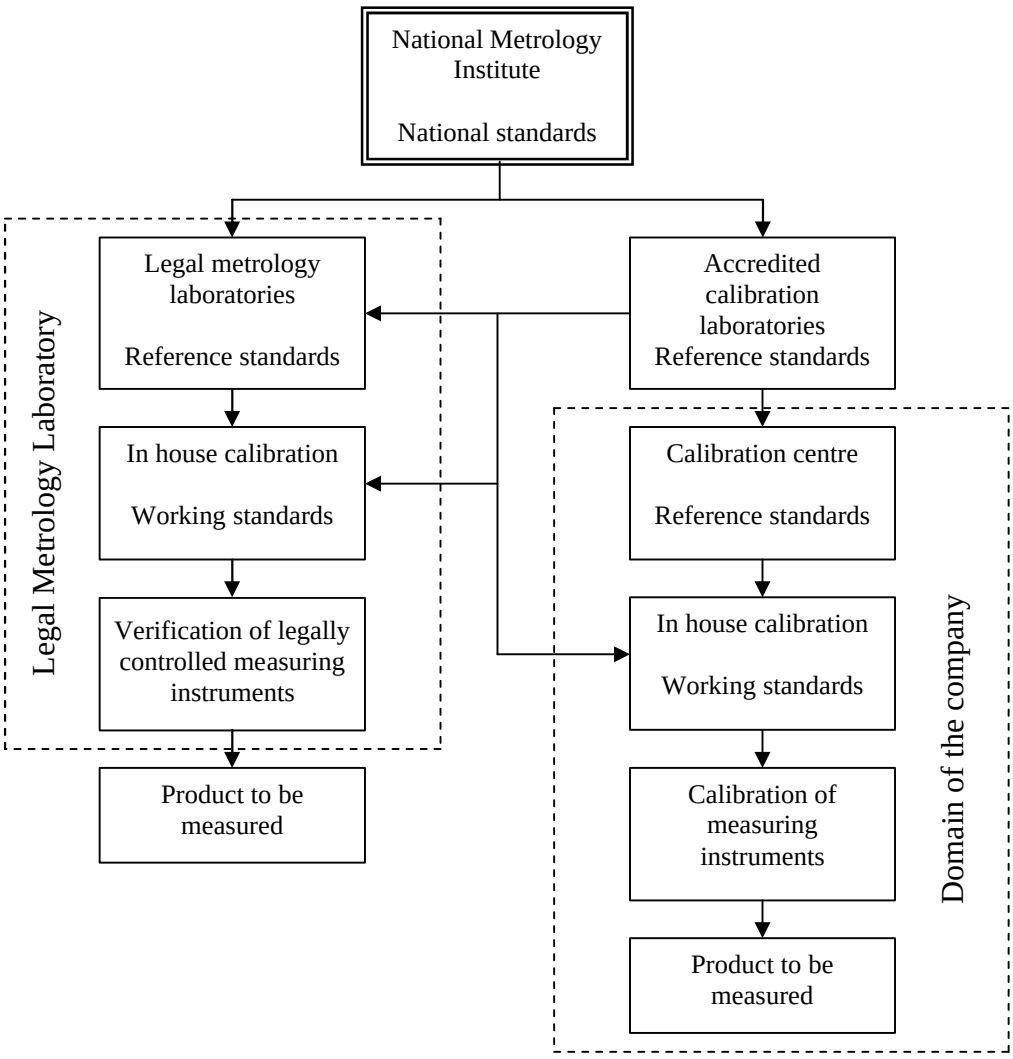

National Metrology Institute
National standards
Legal metrology laboratories
Reference standards
Accredited calibration laboratories
Reference standards
Legal Metrology Laboratory
In house calibration
Working standards
Calibration centre
Reference standards
Verification of legally controlled measuring instruments
In house calibration
Working standards
Domain of the company
Product to be measured
Calibration of measuring instruments
Product to be measured

Fig. 1

3.4 Traceability is characterised by a number of essential elements:

- ***an unbroken chain of comparisons*** going back to a standard acceptable to the parties, usually national standards;
- ***measurement uncertainty;*** the measurement uncertainty for each step in the traceability chain must be calculated according to (agreed methods, based on) the "Guide to the expression of uncertainty in measurement" [4] and must be stated in such a way that an overall uncertainty for each following stage of the chain may be calculated;
- ***documentation;*** each step in the chain must be performed according to documented and generally acknowledged procedures; the results must equally be documented;
- ***competence;*** the laboratories performing one or more steps in the chain must supply evidence for their technical competence (equipment, skills of personnel, environmental conditions, etc.);
- ***reference to SI units;*** the chain of comparisons must end at primary standards for the realisation of the SI units or at standards, which traceability to primary standard is demonstrable (as far as technical possible or applicable);
- ***re-calibrations;*** calibrations must be repeated at regular intervals depending upon a number of variables, e.g. uncertainty required, frequency of use, way of use, stability of equipment and it should be stated in the documentation of the standard;
- ***periodic verification;*** subsequent verification of a measuring instrument carried out periodically at specified intervals according to the procedure laid down by the regulations.

3.5 In many fields, reference materials take the position of physical reference standards. It is equally important that such reference materials are traceable to relevant SI units realised by national or international measurement standards. Certification of reference materials is a method that is often used to demonstrate traceability to national or international measurement standards.

Notes: 1) Reference and working standards and means of comparison have to be provided by documentation in accordance with valid regulations. The basic document for these standards and means of comparison is the valid calibration certificate issued either by accredited calibration laboratory or by laboratory demonstrating traceability to national standard.

2) The important parts of traceability documentation are calibration or verification methods and procedures. Calibration or verification procedures have to clearly describe traceability of measurements, e.g. have to clearly define, which standards and means of comparison are used for it. At the same time these procedures have to state the detailed procedure for the uncertainties evaluation of calibrated or verified measuring instruments.

4. LEVELS OF DISSEMINATION OF UNITS OF MEASUREMENT

4.1 **International level**

At the international level, decisions concerning the international System of Units (SI) and the realisation of the primary standards are taken by the Conférence Génerale des Poids et Mesures (CGPM). The Bureau International des Poids et Mesures (BIPM) is in charge with

coordinating the development and maintenance of primary standards and organises intercomparisons on the highest level.

4.2 **National metrology institutes**

The National Metrology Institutes are the highest authorities in metrology in almost all countries. In most cases they maintain the *"national standards"* of the country that are the sources of traceability for the associated physical quantity in that country. If the National Metrology Institute has facilities to realise the corresponding SI unit of measurement (the term SI unit includes all derived units), the national standard is identical to or directly traceable to the primary standard realising the unit. If the Institute does not have this facility, it has to ensure that the measurements are traceable to a primary standard maintained in another country. The National Metrology Institutes ensure that the primary standards themselves are internationally compared. They are responsible for dissemination of the units of measurement to users, scientists, public authorities, laboratories or industrial enterprises and are therefore at the top level of the metrological infrastructure in a country.

4.3 **Accredited calibration laboratories**

4.3.1 Calibration laboratories in industry and other organisations accredited by national accreditation bodies according to internationally established criteria shall be able to demonstrate that calibration of critical equipment and hence their measurement results, relevant to their scope of accreditation are traceable to SI units (as far as technical possible or as far as applicable).

4.3.2 Accredited calibration laboratories are often at the top of a firm's internal calibration hierarchy. Their task is then to compare, at appropriate intervals, the firm's own working standards with reference standards, which are calibrated by a National Metrology Institute or an accredited laboratory with suitable best measurement capability.

4.3.3 Many accredited laboratories carry out calibrations for the third parties, e.g. for organisations that are not equipped with calibration facilities and for private test laboratories as well, which work in the field of product certification. In this case the customer has to be assured that measurement uncertainty achieved in laboratory is suitable and sufficient for the intended use of the measuring instrument to be calibrated.

4.3.4 The calibration results are documented in a calibration certificate.

4.4 **Legal metrology laboratories**

4.4.1 Legal metrology laboratories are laboratories of the state legal metrology services or private metrology laboratories charged (authorised) by national (legal) metrology authority to carry out legal control of measuring instruments in defined scope.

4.4.2 Legal metrology laboratories according to national legislation shall be able to demonstrate that calibration of measurement standards and of verification devices and hence their measurement results, relevant to their scope of authorisation, are traceable to SI units. Their reference standards are calibrated by a National Metrology Institute or an accredited laboratory with suitable best measurement capability.

4.4.3 Legal metrology laboratories are in some countries accredited.

4.5 **In house calibration**

4.5.1 In-house calibration is regular calibration of working standards, measuring and test equipment used in a metrology laboratory or in a company against its own reference standards that are traceably calibrated at an accredited calibration laboratory or a National Metrology Institute.

4.5.2 The scope of in-house calibration is at the discretion of the laboratory or company concerned. The results obtained with the in house calibrated measuring and test equipment should be sufficiently accurate and reliable.

4.5.3 The hierarchy of standards and a resulting metrological organisation structure for tracing measurement and test results within a laboratory or a company to national standards in general is shown in Fig. 2.

Standard (measuring equipment)	**Responsible**	**Tasks**	**Basis** for the verification, calibration or measurements	**Documentation** of the verification, calibration and measurements
Nat. stds.	**National Metrology Institute (NMI)**	To maintain National – standards and disseminate the measuring units	Statutory duty to represent SI units and ensure international comparability	Calibration certificate for reference standard
Reference standards	**Accredited calibration laboratories and Legal metrology laboratories**	Calibration of working standards to safeguard the metrology infrastructure of country	Calibration certificate from NMI or other accredited laboratory	Calibration certificate for working standard
Working standards	**Legal metrology laboratories and in-house calibration**	Verification or calibration of measuring instruments	Calibration certificate from NMI or accredited laboratory or in – house calibration	Calibration or verification certificate. Verification or calibration mark
Ordinary instruments	**User**	Measurement and tests performed by legally controlled meas. instr. or as a part of quality assurance measures	Verification or calibration certificate or verification or calibration mark or the like	Measurement and test results

Fig. 2

5. GENERAL PRINCIPLES FOR THE ESTABLISHMENT OF HIERARCHY SCHEMES, THEIR STRUCTURE AND PRACTICAL REALISATION

Hierarchy scheme for measuring instruments is a graphically illustrated system of gradually arranged measuring instruments determining the uninterrupted chains of comparisons from the national standard up to measuring instruments, giving methods of comparison, important metrological characteristics and mutual links.

5.1 **General principles for the establishment of hierarchy schemes**

5.1.1 The hierarchy scheme may cover the overall field of measurements of particular quantity or only a defined part of it, which is characterised by one or more of the following data:

- range of values of measured quantity (e.g. high temperatures, low absolute pressures etc.),
- specification of certain field in the given quantity (e.g. DC voltage measurements as a part of electricity voltage measurements, power of AC current at certain range of frequencies or power of DC current etc.),
- kind of measuring instruments (e.g. line length measuring instruments etc.),
- measured medium (e.g. gas flow rate, liquid density etc.).

5.1.2 Each hierarchy scheme for measuring instruments is to be dealing with measuring instruments of one quantity or some interrelated quantities. If reference or working standards of another quantities have to be used in the hierarchy scheme of the given quantity, it is recommended to involve them into the scheme.

5.1.3 The hierarchy scheme for measuring instruments of certain quantity may be divided into a number of autonomous schemes if it leads to its more efficient arrangement and more rational use.

5.1.4 At establishment of the hierarchy scheme, it is necessary to specify especially:

- kinds of measuring instruments capable to fulfil the role of reference and working standards for different values or for different ranges of values of the given quantity,
- number of levels of reference and/or working standards,
- methods and means of comparison.

Note: At establishment of the hierarchy schemes the experiences from hitherto praxis and ways of solution (of hierarchy schemes) adopted by international organisations or internationally testified are taken into account. Even in such cases there is a necessity to consider extent and the way of application upon real conditions.

5.1.5 Choice of kinds of measuring instruments capable to fulfil the role of reference and working standards is determined by appropriate level of their metrological and technical characteristics in accordance with the specification stated in OIML D 8 „Measurement Standards. Choice, recognition, use, conservation and documentation“ [5].

5.1.6 Determination of the number of levels of reference and/or working standards is in the nature technically – economic optimising problem, at which it is considered, especially:

- overall number of measuring instruments of the given quantity as regards kinds of measuring instruments and their accuracy and their distribution,

- kinds of measuring instruments capable to fulfil the role of reference and working standards of different accuracy levels, their productivity and the mean values of intervals between calibrations and existence of proper methods and means of comparisons,
- costs of equipment, use and conservation of standards and means of comparison, etc.

5.1.7 Method of comparison indicated in the hierarchy scheme should correspond to one of the following general methods:

- direct measurements (used in verification or calibration of a measuring instrument against a measure or of a measure against a measuring instrument),
- direct comparison or comparison using a measure (standard of comparison) (used in verification or calibration of a measuring instrument against a measuring instrument),
- comparison with the help of a comparator (used in verification or calibration of a measure against a measure),
- indirect measurements (used in calibration or verification of standards or measuring instruments using standard calibrated in terms of other physical quantities connected with a measurand functionally).

5.1.8 In calibration of standards and measuring instruments or in verification of measuring instruments, the characteristics of their uncertainty indicated in the hierarchy scheme are defined by calculations with consideration of the characteristics of the total uncertainty of the higher-level standard and methods for transferring the unit.
In verification of measuring instruments involving determination of their compliance with the existing requirements, i. e. establishment of their suitability for application in accordance with the legislation, the value of ratio of uncertainty between working standards and measuring instruments should not be more than 1:2. It is recommended to choose this ratio from the range of values (1:3 – 1:10).

5.2 The structure of hierarchy schemes

5.2.1 Hierarchy scheme consists of the graphic part and of commentary of the scheme.

5.2.2 Graphic part provides visual preview on traceability of measuring instruments and only basic information on some, from the traceability view important characteristics. If the graphic part is wide and complicated, it is possible to divide it into sections, while the commentary remains common.

5.2.3 Commentary of hierarchy scheme contains all important specifications of hierarchy levels and traceability of measuring instruments and all information necessary for placing measuring instruments into hierarchy scheme, including explanations, recommendations or comments concerning traceability.

5.2.4 Hierarchy schemes are divided into three fields:

- field of reference standards,
- field of working standards,
- field of measuring instruments.

5.2.5 Field of working standards can be divided according to accuracy into a number of levels (levels of working standards may by indicated by Arabic numbers where 1st level mark belongs to the standards of highest level in the hierarchy).

5.2.6 In the field of measuring instruments, these are divided not only according to their kinds, but also according to their accuracy and measurement ranges.

6. CONTENTS AND PRACTICAL REALISATION OF HIERARCHY SCHEMES

6.1 Content of a national hierarchy scheme

The national hierarchy scheme for a certain kind of measuring instruments contains:

- name of the scheme, nominal values or ranges of values of quantity,
- recommended kinds of measuring instruments capable to fulfil the role of a standard at different accuracy levels and measurement ranges, typical measuring instruments (kinds of verified or calibrated measuring instruments)
- recommended methods and means of unit value transfer between standards themselves and measuring instruments (methods of comparison, comparison devices),
- recommended graduation of accuracy level (uncertainties) of reference and working standards and measuring instruments,
- links between elements of the scheme.

6.2 Content of a local hierarchy scheme

6.2.1 The local hierarchy scheme for the certain kind of measuring instruments contains:

- the name of laboratory, the reference and working standards of which are traced to national standards,
- all elements of laboratory traceability (reference and working standards, measuring instruments, means of comparison),
- range of measurement (nominal values or ranges of values of quantities, ranges of the most important conditions of measurements which define the procedure for transferring the unit) of all the standards and measuring instruments indicated in the hierarchy scheme,
- estimates of characteristics of the accuracy (uncertainty) of all standards, methods and means of comparisons used,
- all used links between elements of laboratory traceability (used verification or calibration procedures),
- specification of procedures of uncertainties calculation,
- intervals between calibrations of standards,
- links between elements of the scheme.

6.2.2 The local hierarchy scheme for a given kind(s) of measuring instruments has to unambiguously prove that all requirements for traceability in accordance with relevant regulations and guidelines are fulfilled in the given laboratory.

6.3 Graphic part of a hierarchy scheme

6.3.1 Name of hierarchy scheme is given in the header. Fields of national standard, reference and working standards and measuring instruments are separated in graphic part of hierarchy scheme by full lines. Description of individual fields of scheme is on the left side of the scheme. Horizontal dashed lines separate individual levels of standards in the field of working standards.

6.3.2 Standards and measuring instruments are presented as rectangles. The designation of the primary standard is enclosed in a rectangle formed by a double line.

6.3.3 Methods and means of calibration and verification are presented either in the field of the standard, which comparison is made to or at the bottom borderline of this field as ovals.

6.3.4 Graphical representation of the procedure for transferring the value of the unit is performed in accordance with the following principles (see Appendix 2):

- if calibration or verification of the standard or measuring instrument is carried out by means of two or more than two standards, solid lines representing the transfer of the value of the unit (units) to an object of calibration are connected together into a point,
- if calibration or verification of a standard or measuring instrument can be performed by means of any of the two or more than two methods or by standards indicated on the scheme, then the solid lines representing the transfer of the value of the unit are not connected into a point,
- intersection lines (if it is possible to avoid it) are to be shown by a symbol, as it is shown in Fig. 1 Appendix 2 (ψ).

6.3.5 The form of expressing of metrological characteristic (absolute or relative) of standards and of measuring instruments in a single hierarchy scheme should be as similar as possible.

6.3.6 Description given in graphic part of local hierarchy scheme should contain the following data especially:

- for standards: kind and name of standard, identification number of standard, measurement range, metrological characteristics specifying level of the standards, the lower limits of the admitted values of characteristics of their uncertainty, the range of special condition of measurements,
- for methods and means of comparison: name of method, name and identification number of mean of comparison, characteristics of the uncertainty of the method,
- for measuring instruments: kinds of verified or calibrated measuring instruments, their measurement ranges and basic metrological characteristics (accuracy class, the maximum permissible error, etc.).

Note: The simplified example of national hierarchy scheme which contains three levels of measurement standards and field of measuring instruments is in Appendix 1. An example of graphic part of local hierarchy scheme is in Appendix 3.

6.4 Commentary to the hierarchy scheme

6.4.1 Commentary to the hierarchy scheme should contain all the data concerning measuring instruments traceability, including information, requirements and notes, which are not included in the graphic part of scheme for any other reason and cannot be ignored from the traceability view.

6.4.2 Specification of (reference and working) standards should at least contain data as follows:

- name of standard, manufacturer, serial or identification number,
- nominal value(s) or measurement range(s) of quantity(ies) value(s) reproduced by the standard and the measurement conditions,

- information on metrological or technical characteristics of standard (accuracy class, errors, uncertainty of values of quantities reproduced by standard, time stability of standard etc. – important metrological characteristics of standard according to document OIML D 15 [6],
- name of legal metrology laboratory or accredited laboratory, which the reference or working standard is compared to,
- recalibration interval,
- location of the standard and name of specialist responsible for the standard.

6.4.3. Specification of methods, means and conditions of comparison should contain at least data as follows:

- means of comparison – name of device, manufacturer, serial or identification number, and basic metrological characteristics according to document OIML D 15 [6].
- method of verification or calibration – identification number of normative – technical document, its name, year of publication or version number,
- verification or calibration procedure – identification number of document, its name, year of publication or version number,
- uncertainty of verification or calibration (best measurement capability),
- specification of reference conditions of verification or calibration (if necessary).

Note: Calibration devices which contain several function parts in one compact unit (e.g. multiquantity calibration devices with built in standards for several quantities, multiquantity calibrators etc.) are usually calibrated as a whole. Such devices are usually a part of different working hierarchy schemes. The position of such a device in individual scheme depends on its measurement ranges and declared metrological characteristics.

6.4.4 Specification of measuring instrument should contain at least the following data (according to document OIML D 15 [6]):

- kinds of verified or calibrated measuring instruments and their measurement ranges,
- metrological characteristics of measuring instrument (accuracy class or the maximum permissible errors, nominal range, instrument constant, discrimination, resolution, stability, etc.).

Bibliography

[1] ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories. ISO, Geneva, 1999

[2] International Vocabulary of Basic and General Terms in Metrology (VIM), Second Edition. ISO, Geneva, 1993

[3] International Vocabulary of Terms in Legal Metrology (VIML), OIML, Edition 2000

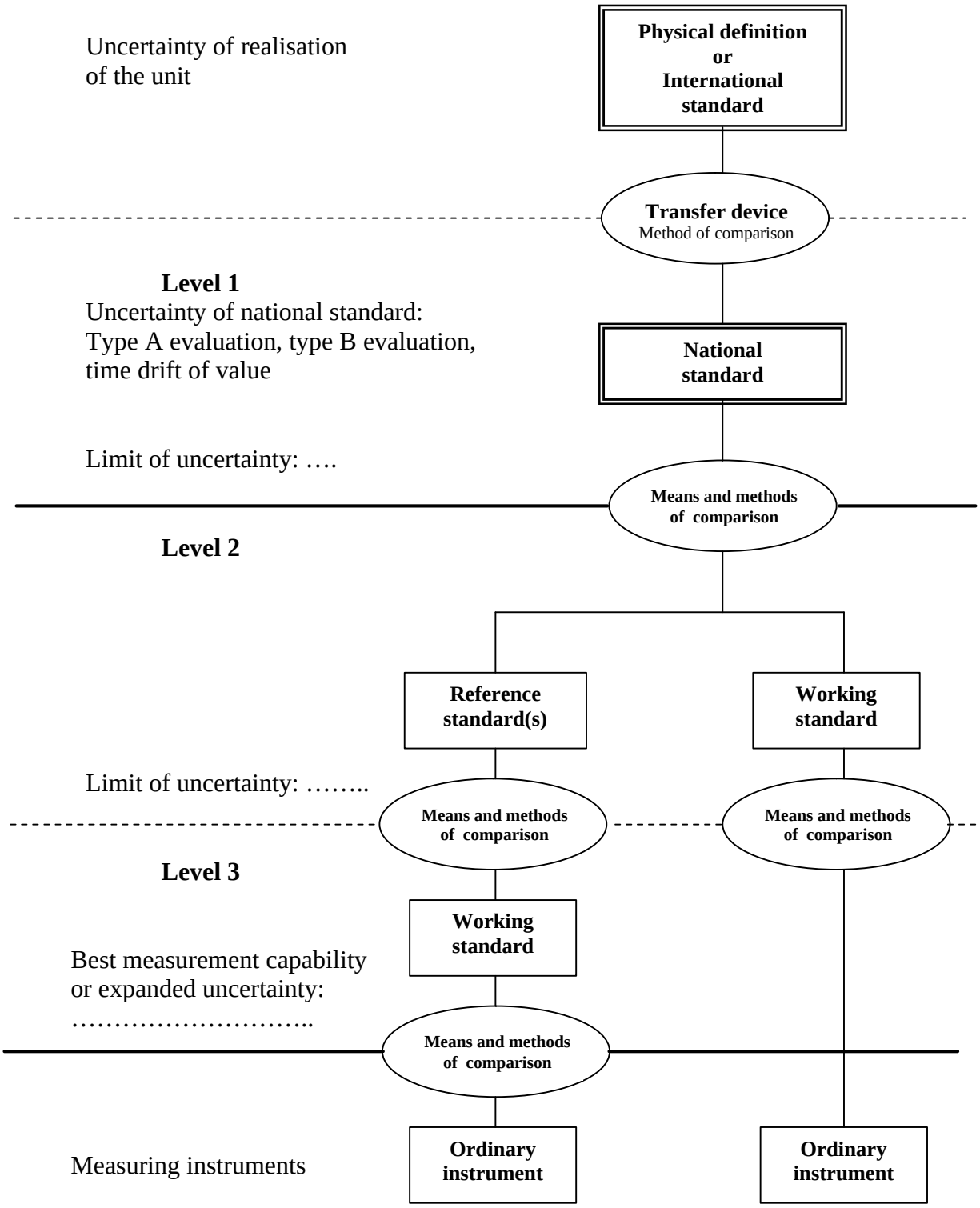
[4] Guide to the Expression of Uncertainty in Measurement. ISO, IEC, OIML, BIPM, Edition 1993, corrected in 1995

[5] OIML D 8 Measurement standards. Choice, recognition, use, conservation and documentation, OIML, Edition 2004

[6] OIML D 15 Principles of selection of characteristics for the examination of measuring instruments, Edition 1986

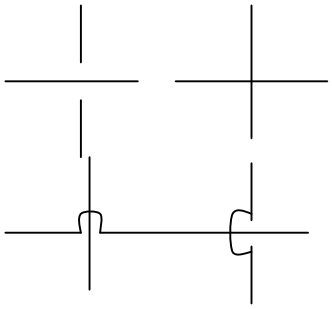
Appendix 1

NATIONAL HIERARCHY SCHEME
(Example)

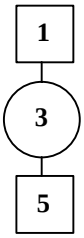


Appendix 2

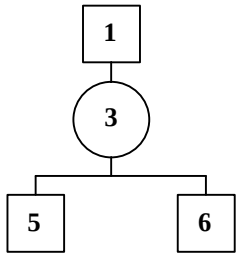
The ways of expression different links (the ways of transferring the value of unit) between structural elements in graphic part of hierarchy scheme



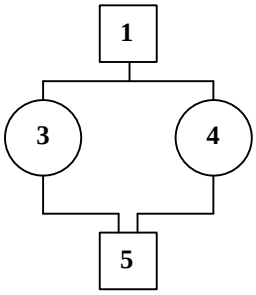
1. Crossing lines



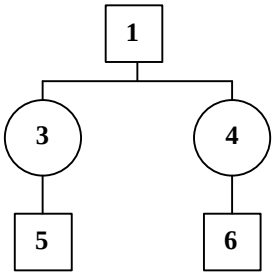
2. From the standard 1 to meas. instr. 5 by the method 3



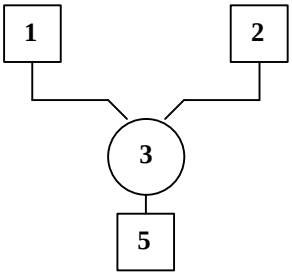
3. From the standard 1 to meas. instr. 5 and 6 by the method 3



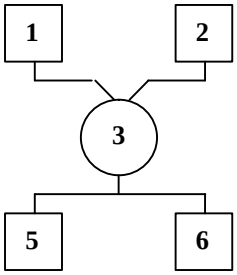
4. From the standard 1 to meas. instr. 5 by the method 3 or the method 4



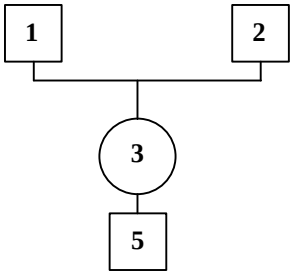
5. From the standard 1 to meas. instr. 5 by the method 3 and to meas. instr. 6 by the method 4



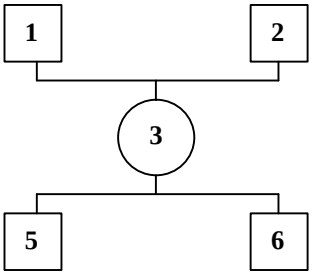
6. From the standard 1 or from the standard 2to meas. instr. 5 by the method 3



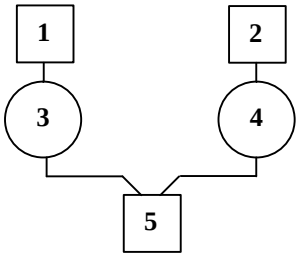
7. From the standard 1 or from the standard 2 to meas. instr. 5 and 6 by the method 3



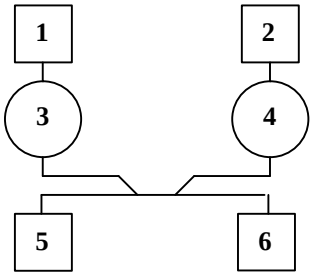
8. From standards 1 and 2 to meas. instr. 5 by the method 3



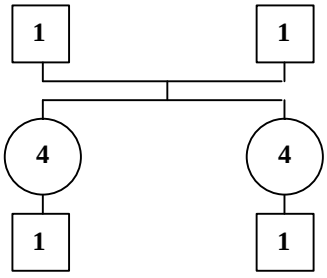
9. From standards 1 and 2 to meas. instr. 5 and 6 by the method 3



10. From the standard 1 to meas. instr. 5 by the method 3 or from standard. 2 by the method 4



11. From the standard 1 to meas. instr. 5 and 6 by the method 3 or from the standard 2 by the method 4



12. From standards 1 and 2 to meas. instr. 5 by the method 3 and to meas. instr. 6 by the method 4

Appendix 3

LOCAL HIERARCHY SCHEME
for measuring instruments of ……
(Example)