EURAMET and the Operation of NMIs

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Further information

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Content

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This document has been prepared by EURAMET as a guide to the operation of National Metrology Institutes (NMIs). It aims to provide information for the top level management of an NMI and those persons who are responsible in the respective ministry for the national metrological infrastructure.

Depending on the size of a country and the specific metrological needs of industry, society and the scientific community, the scope of an NMI will vary, but key elements for the structure and the operation can be identified. The information contained in this guide reflects the experience of larger and smaller European NMIs obtained over recent years and reflects the growing need for European and international cooperation.

1. Introduction

The national measurement system is the technical infrastructure which makes it possible to obtain accurate and reliable measurements which are fit for purpose in the country and are accepted worldwide. A comprehensive national measurement system includes several areas of responsibility:

- maintaining measurement standards for the units of measurement;
- calibration and testing;
- continuous development of measurement standards to meet future needs;
- laboratory accreditation;
- training in metrology;
- legal metrology;
- relevant documentary standards.

An essential and indispensable component of any national measurement system is the national metrology institute (NMI). An NMI is the institute which is by national decision responsible for developing and maintaining national measurement standards, providing internationally recognised traceability to the SI, ensuring the suitability of these standard for national needs and providing metrological expertise and knowledge to national users through high level calibration services, advice, training and other assistance.

At a regional level, the NMIs collaborate through Regional Metrology Organisations (RMOs). In Europe the RMO is EURAMET e.V., with 32 European NMIs as members at the beginning of October 2007 and the IRMM of the European Union as an associate. The RMOs carry out a variety of tasks which include:

- facilitating traceability to the primary realisations of the SI;
- coordinating intercomparisons of national measurements standards;
- cooperation in metrological research and development;
- sharing technical capabilities (in particular special facilities);
- developing technical competencies and quality systems.

Worldwide comparability of national measurement standards and recognition of calibration and measurement capabilities (CMCs) is achieved by participation of the NMIs in the “Mutual Recognition Arrangement” of the International Committee of Weights and Measures (the CIPM MRA) of October 1999, which requires the signatory NMIs to participate in key and supplementary comparisons as well as in the peer review of the CMCs and the respective quality management system covering these CMCs. These reviews are performed within the framework of the RMOs, which play an essential role in the international recognition of the national measurement capabilities so that membership of an NMI in its RMO is essential if it wishes to benefit from participation in the MRA.

2. Options for NMIs

A country has several options for creating and operating a NMI:

- a single NMI for all metrological activities (e.g. scientific, industrial, legal metrology);
- one NMI maintaining primary and/or secondary standards with a separate institute for legal metrology;
- a lead NMI, supported by one or more other designated institutes, which are responsible for certain national standards and associated services in areas that are not covered by the activities of the lead NMI;
- two or more equal status NMIs.

As the importance of metrology grows in chemistry, medicine and food, as well as in traditional fields, concepts of traceability to the SI in these areas are less clear than in physics and engineering and it is rare to find all the necessary competencies in a single NMI. This means that even large countries with large NMIs may have to distribute the responsibility for national measurement standards among different but complementary institutes with the competencies needed to address the full range of metrological requirements of the country concerned. In some countries appropriate laboratories may be readily identifiable with related responsibilities, but in others a process for designating an institute may have to be established. In this case the principal steps would be:

- definition of designation criteria;
- completion of the selection process;
- preparation of a legally binding contract;
- follow-up of implementation.

3. Stages in creating an NMI

The size, structure and tasks of a NMI should be directed to the national needs of society, industry and science. Its creation, function and institutional status may be defined in a National Metrology Act. Where an established NMI does not already exist, the creation of a new entity or the modification of one or more existing laboratories is likely to involve the following stages:

Legislation:

If required by the national legal system, appropriate legislative provisions should define the national metrology infrastructure, including elements of a national metrology policy and the role of the NMI. It may also define legal units of measurement.

Organisation:

A properly constituted NMI, suitable for the national needs, has to be established according to the options of section 2.

Financing:

The successful operation of a NMI is inherently dependent on material and human resources. The sustainable financing of these resources is a crucial issue.

Personnel:

The NMI has to ensure that it has sufficient qualified personnel, with particular attention to the availability of experienced staff. Metrological work requires not only a high level of training but also experience in metrology, which is equally important. This sustained level of experience can be seriously undermined if staff turnover is too high.

Equipment:

The NMI must be equipped with the appropriate measurement facilities for the tasks to be performed.

Premises:

The measuring equipment has to be operated in laboratories that provide suitable environmental conditions, with particular attention to temperature stability and the elimination of vibrational and electromagnetic disturbances.

Traceability:

For those national measurement standards which are not primary realisations of the SI, traceability must be established to such realisations through either another NMI or the BIPM.

Quality system:

A quality system according to EN ISO/IEC 17025 should be implemented. Apart from being best practice for any calibration laboratory, this is a requirement for international recognition through the peer review system of the CIPM MRA. In specific areas of metrology, e.g. metrology in chemistry involving reference materials, the requirements of other documentary standards such as ISO Guide 34 also need to be met.

Intercomparisons:

Participation in international comparison measurements is required to confirm a NMI's technical competence.

International recognition:

The final goal should be international recognition of the declared calibration and measurement capabilities within the framework of the CIPM MRA.

4. National measurement standards

A country should set up national measurement standards according to its needs. When relevant, these national measurement standards will be primary realisations of the SI units, and in other cases the national measurement standards may be secondary standards traceable to national standards of another country or to the BIPM. For quantities whose traceability can be easily obtained by calibration laboratories with respect to the national standards of another country, a national measurement standard may not be necessary. For quantities where establishing and maintaining a measurement standard may be considered an unacceptable financial load for one country an agreement may be discussed within a group of neighbouring countries to share the costs of setting up and maintaining a shared facility.

5. Tasks and activities of an NMI

The main **focus** of a NMI is to maintain progress and reliability in metrology to benefit society, science and the economy. This is normally achieved by providing **scientific and technical services**, including:

- scientific metrology;
- metrology for industry;
- international cooperation;
- consultancy;
- knowledge transfer;
- technology transfer.

To deliver all these services at the highest level involves a NMI in a wide range of activities:

- maintaining and developing national measurement standards according to national needs;
- promoting the concept of traceability to the SI;
- disseminating the SI units to accredited laboratories, to other industrial and commercial laboratories and to other users in their country, as well as to customers from outside the country;
- establishing traceability arrangements with other NMIs or the BIPM for those units for which there are no national primary standards;
- ensuring traceability of the measurement standards used for verification by legal metrology authorities;
- maintaining a general overview of the complete national calibration/traceability hierarchy (the National Measurement System);
- carrying out comparisons of their national realisations of SI units with other NMIs and participating in CIPM or RMO comparisons within the CIPM MRA framework;
- maintaining a quality system consistent with the requirements of the CIPM MRA (In EURAMET: EN ISO/IEC 17025).

In addition, many NMIs also:

- appoint other designated institutes;
- coordinate the activities of the designated institutes with respect to the CIPM MRA;
- cooperate with other NMIs, regional and international metrology organisations and represent the country in those organisations;

- cooperate with the national accreditation body;
- organise comparison measurements for calibration laboratories, if appropriate together with the national accreditation body;
- increase the efficiency, accuracy and reliability of measurement;
- establish reference materials with properties traceable to SI units;
- determine material properties;
- offer technical support to industry in matters related to measurement, reference materials, calibrations and data to establish the traceability of their measurements;
- cooperate in standardisation;
- provide training and consultation services for clients;
- promote collaboration and share technical capabilities.

Furthermore, some NMIs also:

- contribute to the increase of scientific knowledge and technological innovation through research and development programmes;
- develop precise and reliable measuring methods;
- determine fundamental and physical constants;
- review the technical competencies and quality systems of other NMIs;
- actively support the worldwide standardisation of metrology and the removal of technical barriers to trade.

6. EURAMET membership criteria

As individual NMIs are tailored to meet national needs, not all the activities in the extensive list of section 5 are performed by each NMI, especially in smaller and/or less developed countries. EURAMET in its byelaws has defined three criteria, which have to be fulfilled by applicant NMIs before they can become full members and which can be regarded as the basic requirements for a National Metrology Institute:

1. The traceability routes to the SI shall be identified and have been in operation for the last three years;
2. The National Metrology Institute shall show evidence of appropriate participation in international comparisons;
3. The National Metrology Institute shall show evidence of active participation in EURAMET projects.

Criterion 1 means that the national measurement standards have to be clearly identified and, if necessary, appropriate traceability arrangements with other NMIs or the BIPM must have been

established. Criterion 2 requires the proof of technical competence through international comparison measurements. If traceability arrangements and comparisons are performed in the frame of EURAMET projects these are of course the first steps towards fulfilling criterion 3.

In order to establish, keep, maintain, and continuously improve the national measurement standards it is desirable that a NMI should participate in at least a minimum of research and development activities. Preferably this should be done in cooperation with other NMIs, e.g. in the form of EURAMET Consultation and Cooperation projects and participation in EU projects on metrology. Beside these technical requirements, a NMI has to provide metrological information in its national language to support all the national stakeholders. Suitable structures for disseminating knowledge and competencies in metrology may have to be established (e.g. training, education, publications etc). Consultation services for government, industry, commerce and society are of major importance.

One of the purposes of EURAMET is the promotion of science and research, in particular by the development and implementation of a European Metrology Research Programme (EMRP). The participation in the EMRP is optional. An NMI will decide whether to participate in this regional research programme according to its national metrology policy, the needs in its country and the availability of appropriate resources. In order to participate, a NMI has to be:

a) a member of EURAMET;

b) conducting a national research programme in the field of metrology;

c) prepared to commit national contribution to the EMRP.

7. NMIs and legal metrology

Due to the extension into new fields and the application of new technologies, high levels of competence are also more and more important in legal metrology. Thus it is highly recommended that synergies should be developed between scientific and legal metrology activities. This can be achieved either by combining scientific and legal metrology in the same institute, or by establishing close cooperation between the institutes in charge of these two fields of metrology. Including both activities in the same institute may help to achieve the critical minimum size of the institute, permitting better management of resources and facilitating a coherent policy in metrology. In any case the NMI will normally provide traceability for legal metrology laboratories.

8. Cooperation with accreditation

The NMI of a country should be the national reference for the national accreditation system of calibration laboratories, regarding technical competence and measurement standards. This requires a close cooperation between the national accreditation body (NAB) and the NMI. It is good practice for NABs to use experts from the NMI as technical assessors in the accreditation procedure.

NMIs will also often collaborate with NABs to organise inter-laboratory comparisons for calibration laboratories. These accredited calibration laboratories provide the bridge between the national measurement standards at the NMI and the many users of calibration services in industry and elsewhere. In cases where similar calibration services are offered both by the NMI and by calibration laboratories, national policy may require this to be done in such a way that it does not constitute unfair competition. Some NMIs have developed a policy of declining to

provide calibration services to customers when the same level of service can be provided by an accredited calibration laboratory. The provision to end users of calibration services beyond the capabilities of calibration laboratories (high end calibrations), as well as the transfer of related expertise, will always remain the task of the NMI.

9. International cooperation and the world measurement system

Global economies need global metrology. That is why, as early as 1875, the leading industrial countries of the age signed the “Convention of the Metre” as a diplomatic treaty with the aim of establishing a global metric system of units. In order to ensure this task they created the “International Bureau of Weights and Measures” (BIPM) and the “International Committee of Weights and Measures” (CIPM). The CIPM is supported by 10 “Consultative Committees” (CCs) which coordinate the international scientific research in metrology and the universal availability of traceable measurements. Every four years the member states meet in Paris to discuss and agree on new developments in international metrology and endorse the programme of work of the BIPM.

In the field of legal metrology, the “International Organisation for Legal Metrology” (OIML) was established in Paris in 1955, while the “International Laboratory Accreditation Cooperation” (ILAC) first started as a conference in 1977 with the aim of developing international cooperation for facilitating trade by promotion of the acceptance of accredited test and calibration results. Like the NMIs the national legal metrology authorities as well as the NABs also work together in regional organisations. For Europe these are the “European Cooperation in Legal Metrology” (WELMEC) and the “European co-operation for Accreditation” (EA), respectively. All three international organisations work closely together in order to promote a world-wide metrology system for industry, commerce, science and trade. This world measurement system (WMS) is, according to these three organisations, a combination of:

- comparable national measurement standards, traceable to the SI and operated by the NMIs validated through the peer review of the CIPM MRA for the national dissemination of the SI;
- effective national traceability and measurement systems in which measurements are traceable to these national measurement standards, at whatever level of accuracy is appropriate to the user. This is generally through a network of technically competent calibration and testing laboratories accredited to ISO/IEC 17025 and other appropriate documents such as ISO Guide 34 for reference material production, by a nationally recognised Accreditation Body (NAB) which is a signatory to the ILAC Arrangement;
- similar arrangements through organisations responsible for legal metrology at a national level, which normally require national legal metrology laboratories to be accredited as testing laboratories to the appropriate ISO standards; and
- internationally recognised specifications, written standards and regulatory requirements.

Hence in order to achieve international confidence in a way which will avoid technical barriers to trade, national measurement systems must be integrated into these three international strands. In the case of a NMI this means participating in the CIPM MRA. To do this, it must maintain a quality system, participate in comparisons defined by the international measurement community and declare its calibration and measurement capabilities (CMCs), which are subject to peer

review and are published in the BIPM Key Comparison database. The implementation and realisation of the CIPM MRA is to a large extent achieved through the activities of RMOs like EURAMET, so that EURAMET membership is an indispensable asset for each NMI in Europe.

10. Supporting documents

- Evolving Needs for Metrology in Trade, Industry and Society and the Role of the BIPM, BIPM 2007
- Common statement and declaration by BIPM, OIML and ILAC on the relevance of various international agreements on metrology to trade, legislation and standardisation, January 2006
- NMIs and other designated institutes, CIPM 2005-07
- Elements for a law on metrology, OIML document D1, 2004
- Metrology - in short, EUROMET, 2nd edition, December 2003
- Kose V., Competition and cooperation among national metrology institutes for achieving an efficient and sustainable global metrology, Metrologia 2000, **37**, 75-80
- Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes, BIPM, October 1999
- Kochsieck M., Odin A., An efficient metrological infrastructure – benefit for industry and society, OIML bulletin Volume XXXIX, Number 2, April 1998, 26-32.

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