

5-4 Frequency Calibration

5-4-1 Global Mutual Recognition Arrangement (Global MRA) and Traceability

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The field of calibration is changing greatly due to the internationalization of industry. We previously only considered Japanese law, but now we need to internationalize our Calibration Reports.

In this paper, we explain the current trends in Global Mutual Recognition Arrangement (Global MRA) and the traceability of international standards and ISO/IEC 17025. We then report on how our work is affected by these trends.

Keywords

Calibration, Global MRA, Key Comparison, Traceability, ISO/IEC 17025

1 Introduction

The Communications Research Laboratory was commissioned to calibrate the frequency standards with the revision of Notification of December 14, 1984^{[1][2]}. According to the *Kojien*, published by Iwanami Shoten, calibration (較正) is defined as "the action of correcting aberration and imprecision of a measuring instrument using a standard prior to experiment," which is a general definition that could equally be applied to define "calibration (校正)". Thus, in this report, we adopt to calibration (較正) the stricter definition specified in Article 102-18 of the Radio Law: "the action of calibrating the measuring instruments and other instruments to be used for examination of radio equipment."

Before the amendment of Article 102-18 of the Radio Law in October of 1997, calibration was performed in accordance with Article 5-22-12 of the Act of Incorporation of the Ministry of Posts and Telecommunications (presently Article 10-5 of the Independent Administrative Institution Communications Research Laboratory Law); such calibration

(較正) will hereinafter be referred to as "commissioned calibration." However, following this amendment, the CRL became responsible for the calibration (較正) of the frequency standards used by certified inspection businesses (hereinafter referred to as "calibration for certified inspection businesses").

All of these calibration (較正) duties are performed in accordance with the domestic laws of Japan, and the calibration certificates issued in connection with these duties are valid within Japan. However, with the recent internationalization of trade, demand has grown for international recognition of Japanese certification; until now such recognition was subject to the separate approval of individual countries.

In 1999, the Global Mutual Recognition Arrangement (hereinafter referred to as the Global MRA) was signed by the representatives of the national metrology institutions (NMIs) of participating countries at the 21st Conference Generale des Poids et Mesures (CGPM).

Since the CRL is responsible for the national frequency standard in Japan, it began

participation in the Global MRA along with the National Metrology Institute of Japan (NMIJ), AIST (incorporating the former National Research Laboratory of Metrology, the Electrotechnical Laboratory and the National Institute of Material and Chemical Research). Since then, the Chemicals Evaluation and Research Institute has joined the group, and as a result three major institutions in Japan now take part in the Global MRA.

Participation in the Global MRA will respond to industry's call for international recognition of the calibration certifications issued by the CRL. A frequency calibration system which satisfied ISO/IEC 17025 requirement has been under development since 2000, with methods of only "commissioned calibration" made to conform to the ISO/IEC 17025 standard. Certification of conformity in the ISO/IEC 17025 standard was acquired in 2002.

Furthermore, in 2002, preparations were made to begin calibration (校正) for the Japan Calibration Service System, created based on the Measurement Law, in addition to the calibration for certified inspection businesses based on the Radio Law and the commissioned calibration in accordance with the ISO/IEC 17025 standard.

Here we will give an outline of the Global MRA and the process of constructing a traceability system for frequency standards, as required for mutual international recognition. We will also report on the ISO/IEC 17025, which regulates quality assurance systems and the technical capabilities of the calibration organizations.

2 Measurement Standards and the Global MRA

2.1 Measurement Standards

The units of measurement such as time and frequency are essential; such quantities form the foundation of our daily lives. Thus the global trade of goods between countries using different units of measurement will require agreement on various unit-based

items, such as conversion rates, for example.

The Convention of the Metre, concluded in 1875, represented an effort to establish a universal standard by unifying the measurement systems of different countries. The SI units presently used around the globe were established in 1960 based on the metric system of measurement that grew out of the Convention of the Metre. The measurement standards are set based on the seven base units and various additional derived units from these base units. The base units measure basic properties such as length, mass, and time, while the derived units are those that can be represented as a combination of the base units, and include frequency, speed, and area.

The state or governing agencies of an individual country designate a national metrology institute (NMI) as a representative organization responsible for measurement standards; in Japan responsibility for those related to time and frequency has been delegated to the CRL.

2.2 Global MRA

Within a single country, individual measurement standards can be evaluated by the results of measurements taken using national measurement standards (this is referred to as the establishment of traceability). Similarly, it is necessary to confirm international traceability and the equivalence of the respective national measurement standards of various countries. The Global MRA was concluded in 1999 for this purpose.

The objectives of the Global MRA are:

- (1) to establish the degree of equivalence of national measurement standards maintained by NMIs;
- (2) to provide for the mutual recognition of calibration and measurement certificates issued by NMIs;
- (3) thereby to provide governments and other parties with a secure technical foundation for wider agreements related to international trade, commerce, and regulatory affairs.

[see http://www.bipm.org/enus/8_Key_Comparisons/mra.html]

The first two objectives listed above will have

a particularly significant impact on CRL's generation, maintenance, and publication of national frequency standards, as well as on frequency calibration services. If the CRL does not participate in the Global MRA, there is a danger that Japan's national frequency standard and the calibration certificates issued by the CRL will not be considered valid on a global level.

To participate in the Global MRA and to establish the international equivalence of its measurement standards, an NMI must provide the technical basis for mutual recognition by comparing each of its measurement standards with international standards (referred to as key comparisons) and recording the results in the database described in the next section. The fundamental concept of the Global MRA is to use the values in this database to establish mutual recognition of calibration and measurement certificates issued by the NMIs of the participating countries.

2.3 The Global MRA and the Database

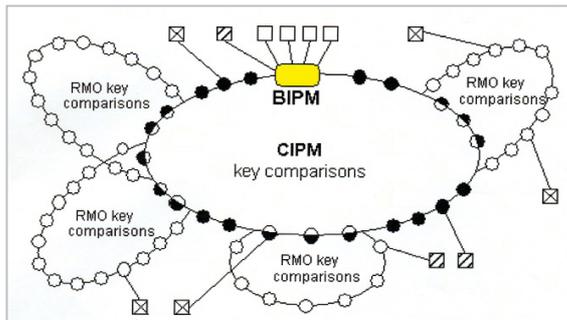


Fig. 1 Scheme of key comparisons for a normal standard
(For time and frequency standards, the network presented in Fig.3 will function as the CIPM key comparisons; the RMO key comparisons will not.)

As shown in Fig.1, there are two types of key comparisons, consisting of the "CIPM" key comparisons [under the auspices of the International Committee of Weights and Measures (CIPM) and the Bureau International des Poids et Mesures (BIPM)] and the regional metrology organization (RMO) key comparisons for each region. The Asia-Pacific

Metrology Programme (APMP) forms the RMO for the Asian and Pacific region. Most countries perform only RMO key comparison, as a CIPM comparison of all units would be prohibitively time-consuming. A few NMIs are selected from each RMO to take part in the CIPM key comparisons; these representatives must be technically capable of the more exhaustive comparison, must have the requisite experience, and must be a member of the RMO's Consultative Committee (CC). The NMI participating in CIPM key comparisons assumes a heavy burden; thus not all NMIs are equipped to perform these comparisons.

In contrast, the RMO key comparisons are conducted by all NMIs participating in the RMO. An NMI from a given RMO wishing to participate in the activities of a different RMO may do so insofar as the NMI conforms to the regulations of the new RMO.

The database containing the results of key comparisons are maintained and publicized by the BIPM as Appendixes A, B, C, and D. The contents are as follows:

Appendix A: MRA signatories

List of national metrology institutes that are signatories to the arrangement.

Appendix B: Key and supplementary comparisons

Information on CIPM (Comit International des Poids et Mesures) and PMO (Regional Metrology Organization) key and supplementary comparisons, together with results when they become available.

Appendix C: Calibration and Measurement Capabilities (CMCs)

Quantities for which calibration and measurements certificates are recognized by institutes participating in part two of the arrangement.

Appendix D: List of key comparisons

Appendix E: Items commissioned to RMO and JCRB (Joint Committee of the RMO and the BIPM)

The database is publicized on the Internet on the BIPM website. Fig.2 shows the process of registering as a user of the database.

The left-hand side of Fig.2 shows the procedure by which the results of key compar-

isons to establish equivalence between NMIs for each measurement standard are compiled (mainly by the respective consultative committees). The procedures for time and frequency standards will be explained in the next section.

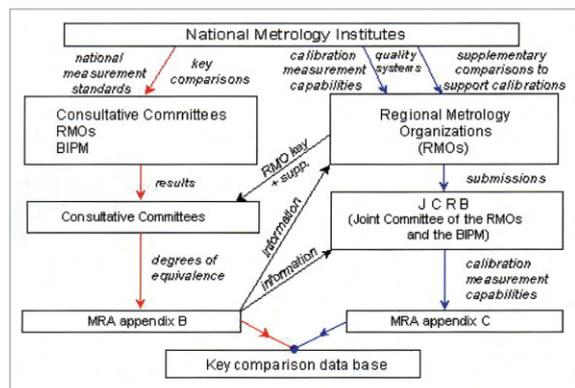


Fig.2 Flow of registration in Global MRA database

The right-hand side of Fig.2 shows the procedure for registering the CMC, as required to permit mutual recognition of calibration and measurement certificates among the NMIs. To qualify for CMC registration, the NMI's calibration method must be as set forth in the ISO/IEC 17025 standard or be otherwise equivalent. The registered content is examined by each RMO and submitted to the biannual JCRB (Joint Committee of the RMO and the BIPM). After the content has passed inter-regional examination between RMOs, it is re-examined by the JCRB, and then registered in Appendix C.

2.4 Key Comparisons of Time and Frequency Standards

In normal measurement, primary standards are transported to the site where the key comparisons shown in Fig.1 are to be performed. However, it is extremely difficult to transport time and frequency standards physically. Furthermore, international organizations (such as those shown in Fig.3) already exist to coordinate time and frequency standards. Today international time comparisons are conducted regularly by these organizations, in order to assist the BIPM in the computation of Interna-

tional Atomic Time (TAI) and Coordinated Universal Time (UTC). Therefore, it may be said that key comparisons of time standards are already performed on a daily basis, unlike with other standards[3]. For details on the frequency of such time comparisons and on the methods of calculation of TAI and UTC, see reference 2 and the BIPM website.

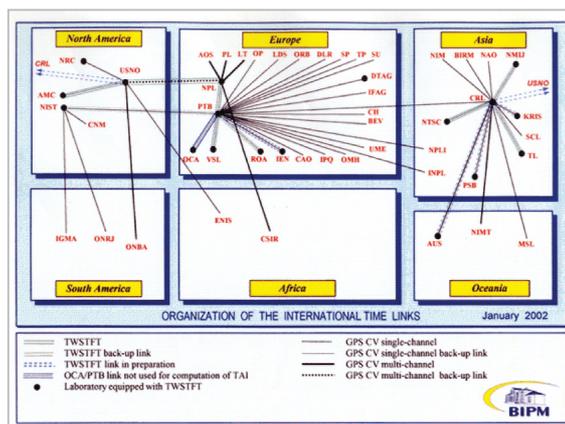


Fig.3 Network of the Organization of International Time Links

Thus, for the comparison of time and frequency standards, a basic agreement has been reached through the Consultative Committee for Time and Frequency (CCTF) to register the contents of the "Circular T," a publication of regular measurements by the international network of time-related organizations, as key comparisons. The Circular T is currently scheduled to be registered to Appendix B.

3 Traceability and ISO/IEC 17025

3.1 Traceability System

According to the International Vocabulary of Basic and General Terms in Metrology (VIM: 1993), traceability is the "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."

This means that the reliability of measurement results are indicated by an uncertainty value provided directly on the calibration certificate. The uncertainty may be traced from

national measurement standards (each having an established degree of international equivalence) through international comparisons by Global MRA, to measurements taken in various fields of industry. In other words, the establishment of traceability for a measurement means that the results of the measurement will be related to a national or international standard by a given degree of uncertainty. In order to establish such a link, a system must be constructed to form a string of comparisons through calibration, and the accuracy and uncertainty of the results of measurement at each step of calibration must be clarified.

As stated previously, an international network linking time-related organizations has already been constructed, and a function to provide key comparisons is already in place. Quality assurance is provided for this function via the ASNITE-NMI accreditation system, a calibration program by the NMI designed to ensure that calibration systems conform to the "General Requirements for the Competence of Testing and Calibration Laboratories (ISO/IEC 17025)" and to verify that calibration certificates issued by the NMI merit international recognition.

A measurement accreditation system is also being formulated in Japan to allow for the development of a traceability system for domestic measurement standards. This accreditation system referred to as the Japan Calibration Service System (JCSS), will be based on the Measurement Law. The chain of traceability will extend from the specified standard instruments maintained by the NMI all the way to the user, via specified secondary standard instruments established through the issuance of JCSS calibration certificates by JCSS-accredited calibration businesses. At the top of the JCSS hierarchy is the government's specified standard instruments; calibration by the JCSS in accordance with these specified standard instruments is referred to as "jcss calibration."

At the CRL, the frequency standard calibration program, referred to as commissioned calibration, has been extensively modified and

has since received ASNITE-NMI accreditation. Furthermore, in December 2002, the "Measurement Standards Section of the Weights and Measures Administration Council," the advisory panel for the Minister of Economy, Trade, and Industry, submitted a report to the minister in favor of the use of the CRL frequency standard as the government's specified standard within the jcss system. As a result, the CRL frequency standard was officially designated as the specified standard by the Minister of Economy, Trade and Industry on April 1, 2003; the CRL has now begun to issue jcss calibration certificates based on the specified standards.

The difference between ASNITE-NMI-accredited calibration certificates and the jcss calibration certificates lies in the region of application. The ASNITE-NMI-accredited calibration certificates are registered in Appendix C, and thus these certificates are universally recognized. In contrast, the jcss calibration certificates are only valid for calibration businesses within Japan. However, JCSS accreditation forms the foundation of the frequency traceability system in Japan, and the JCSS-accredited calibration certificates issued by JCSS-accredited calibration businesses (businesses that have been issued jcss calibration certificates) are recognized internationally. Also, multiple secondary standards that have been awarded jcss calibration certificates can be combined to construct standards for derivative measurements such as frequency, speed, and area.

Thus, the CRL now provides two types of calibration services: ASNITE-NMI-accredited calibration, which can be directly linked to the Global MRA, and jcss calibration which is at the top of the domestic traceability system established under the Measurement Law.

3.2 ISO/IEC 17025

As stated previously, the ISO/IEC 17025 standard is officially referred to as "General Requirements for the Competence of Testing and Calibration Laboratories"; this ISO standard sets the general requirements that testing

laboratories and calibration institutes must satisfy in order to be accredited as qualified to conduct specific types of testing or calibration.

A major difference between the ISO/IEC 17025 and the ISO/IEC 9000 or the ISO/IEC 14000 series lies in the fact that the ISO/IEC 9000 series is a certification system for "the examination of whether a quality management system conforms to the regulatory requirements and for the registration of such a system," while the ISO/IEC 17025 is an accreditation system allowing "an authoritative organization to examine the technical requirements regarding the competence in testing and calibration activities" for a given quality management system. Therefore, even when an institution has received ISO 9000 certification, its technical abilities have not been subject to examination; therefore, it cannot be regarded as equivalent to an ISO/IEC 17025-accredited institution. In contrast, if an institution receives ISO/IEC 17025 accreditation, then it can simultaneously acquire ISO/IEC 9002:1994 certification.

In 2000, when CRL began development of a calibration system designed to conform to the ISO/IEC 17025 standard, no accreditation institution existed in Japan that could assess compliance with the standard in terms of time and frequency. Therefore, two peer reviewers were invited from abroad to conduct the technical examination, and the National Institute of Technology and Evaluation of the Ministry of Economy, Trade and Industry (NITE; presently an Incorporated Administrative Agency) was asked to assess the quality assurance system. In March 2001, in a somewhat anomalous process, the system was issued a certificate of ISO/IEC 17025 compliance. As a point of note, the peer reviewers had been invited from abroad because, at that time, the requirements for registering with the CMC included peer review by reviewers from two different RMOs.

Since then, with the transformation of NITE into an Incorporated Administrative Agency, a new system (ASNITE-NMI) for accreditation of NMI compliance with the ISO/IEC 17025 standard was prepared and officially approved on Jan. 31, 2003.

With this development, calibration certificates issued by CRL in accordance with calibration methods approved by ASNITE-NMI have come to be internationally recognized as ISO/IEC 17025-compliant. With this accreditation, the CRL plans to register its CMC in Appendix C of the key comparisons database.

4 Conclusion

This paper, entitled Global Mutual Recognition Arrangement and Traceability, reported on the history of Global MRA from the perspective of calibration activities in recent years, discussed the traceability of measurement standards and the ISO/IEC 17025 standard certifying such traceability, and described some of the CRL's efforts to comply with these standards.

Responding to these trends, the CRL has prepared two types of calibration services: ASNITE-NMI-accredited calibration, which can be directly linked to the Global MRA, and jcss calibration, which is at the top of the domestic traceability system established under the Measurement Law. For these services, a calibration system conforming to the ISO/IEC 17025 standard was constructed to ensure the reliability of measurement results based on known uncertainties indicated on calibration certificates.

In the future, CRL plans to respond to evolving needs in the field by registering CRL's calibration and measurement capabilities (CMC) in Appendix C of the key comparisons database and by issuing jcss calibration certificates.

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