

I. Measurement standards/reference material

[Index for examples of utilization]

Category of use and application Classification of standards	Safety/security	Innovation Advanced measurement technique	Industrial competitiveness Core technology of manufacturing international expansion	Environment/energy	Regulatory compliance
Time/frequency		1	2		
Length/dimensions/angle		1, 4	3, 4, 5, 6		
Mass/force/pressure/leak	<u>7</u> , 10, 11	8	9	<u>9</u> , 11	<u>7</u>
Temperature/humidity	<u>12-15</u>		<u>12-15</u>		
Electricity/magnetism		<u>24</u>	16-19, <u>20-24</u>	<u>20-22</u>	<u>23</u>
Vibration/ultrasonic waves/hardness	25, 26		27		
Antenna/EMC/high frequency wave					28-31
Light/radiation/radioactivity	35-38	34	32, 33		
Density/flow rate	42		39	40, 41	
Reference material	43, <u>44</u> , <u>46</u> , 50, 53, <u>54</u> , 55	59	45, <u>54</u> , 56-58	52	<u>44</u> , <u>46</u> , 49, 51
Database			47, 48		

Note: A number assigned to the example falling under multiple categories of use and application is underlined.

What are measurement standards/reference material?

時間は、セシウム原子の固有の周期



1 s

原子束方式セシウム周波数標準器

我が国の質量標準「日本国キログラム原器」



1 kg

日本国キログラム原器

1メートルとは、光が一定時間に真空中を進む長さ



1 m

国際メートル原器

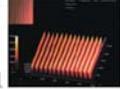
電圧標準は、ジョセフソン効果により発生する電圧



10 V

10ボルトの電圧標準器

ナノメートル計測用の標準スケール



1 nm

1ナノメートル標準器のATM装置

pH (水素イオン活量指数)



pH

pH測定用Harnedセル

光度 (明るさ)



1 cd

標準光度源

Triple point of water



0.01 °C

0.01度セル

水流量校正設備の最大流量



12000 m³/h

水流量校正設備

安全・安心を支える標準物質



Reference: Recruitment Information "Measure the Future" of National Institute of Advanced Industrial Science and Technology

Measurement Standards

1. What are measurement standards?

Measurement standards for length, weight, etc. are the "rulers" which will be the standards for measuring. Measurement standards are widely used in people's lives and the socio-economic activities, and contributes to maintaining and reinforcing international competitiveness of our country, to promoting innovation, to improving reliability of corporate activities, to securing the core technology of manufacturing in small and medium-sized enterprises, and to assuring safety and security of people's lives, etc.

For example, in people's lives, reliability of measured numeric values and data from everyday time management, measurement of water, gas and electricity consumption, weighing control of food in supermarket etc. is secured by properly calibrated measuring instruments, and the measurement standards support and protect the everyday lives of every person.

Furthermore, in a series of business activities such as research, development, designing, manufacturing, inspection, sales, disposal and recycle in enterprises, they have been supporting optimization of business activities, quality control of products, smoothing of transactions and certification inside and outside Japan, etc. as "rulers" for measurement and analysis, and have been contributing to improving reliability of enterprise activities, securing international competitiveness, etc.

2. Measurement system in Japan

The measurement system used in Japan is one of metric institution based on the Measurement Act.

The Ministry of Economy, Trade and Industry drastically revised the Measurement Act in 1992, and organized the environment to match the international framework such as unification to the International System of Units (SI) and development of a system to supply measurement standards.

Currently, the Ministry of Economy, Trade and Industry is the center of measurement administration, the National Institute of Advanced Industrial Science and Technology (AIST) prepares and supplies national measurement standards, and the National Institute of Technology and Evaluation (NITE) examines registered calibration services based on the Measurement Act. In this manner, a system to supply standards in Japan in an integral manner is realized.

From 2001, development of national measurement standards is positioned as important infrastructure development of Japan, and as a result of conducting development based on the intellectual infrastructure development plan of the Ministry of Industry and Information Technology, about 300 each of measurement standards and reference materials were prepared, and the basic measurement standards required for international mutual approval were raised to the level of Europe and America.

Target of development for national measurement standard and reference materials

Type of measurement standards	Length, geometric values, time, mass, force, torque, gravitational acceleration, pressure, vacuum, flow rate, volume, density, viscosity, sound, ultrasonic wave, vibrational acceleration, impact acceleration, sound velocity, temperature, humidity, solid state properties, hardness, impact values, particle/powder properties, luminous quantity/radiant quantity, radiation, radioactivity, neutron, electricity (DC/low frequency), electricity (high frequency), etc.
Type of reference materials	Standard gases, inorganic standard solutions, organic standard solutions, pH standard solutions, organic compounds, inorganic compounds, reference materials related to environment/food/clinical inspection, etc.

3. Request for measurement standards for a new era

Until now, preparation of measurement standards has been lead by its developer, however, along with diversification of people's lives, complication of socio-economic activities and rapid development of information-oriented society, the demand is arising for preparation of measurement standards which is more focused on the user's point of view.

In the field of semiconductors, the required dimensions have been further refined along with the progress in highly integrated devices, and there arises the need to accurately measure and control the dimensions of these micro structures. To fulfill the needs of industries, micro rulers with fine scales by 25 nanometers (measurement standards) are currently researched and developed, contributing to maintaining and strengthening international competitiveness of the semiconductor industry. From now on, by strategically preparing measurement standards which will be the core of manufacturing technology in Japan such as those in the nanotechnology fields, contribution for creating new technology and new industry as well as strengthening international competitiveness will be made.

Furthermore, due to rapid increase in substances subject to regulation such as toxic substances in industrial products and residual pesticides in food, and spread of analytical instruments which allow simultaneous multicomponent analysis and microanalysis, higher demand is arising for more convenient reference material mixture and low concentration reference materials. Until now, reference materials etc. compliant to the RoHS directive originated in Europe have been developed, and a system to supply reference materials which can quickly respond to the expanding and diversifying needs of users and regulations and official methods inside and outside Japan will be established.

Moreover, people's interest toward reliability of measuring instruments, measurement values, etc. related to radiation and radioactivity has been kept high after the Great East Japan Earthquake. From now on, the focus will be on preparation of measurement standards necessary to secure reliability of radiation and radioactivity measurement, and to assure safety and security of people's lives, as well as informing and utilizing the calibration system based on the Measurement Act.

I. Measurement standards/reference material

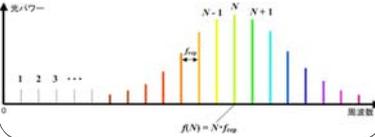
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| <p>1. "Optical frequency comb"
- National standards of length in Japan
"Optical frequency comb" -</p> <p>2. "Frequency remote calibration technology"
- Frequency remote calibration that supports global corporate expansion -</p> <p>3. "Length standards (gauge block)"
- Reference of dimension measurement used at various manufacturing sites -</p> <p>4. "Nanoscale standards"
- Assists high quality manufacturing with fine scales -</p> <p>5. "Dimensional standards"
- Assists manufacturing industry by promoting productive 3-dimensional measurement -</p> <p>6. "Angle standards"
- Assists manufacturing industry with angle calibration technology from Japan -</p> <p>7. "Mass standards"
- Accurate mass measurement that is critical for analyzing the environment and developing medicine -</p> <p>8. "Improving mass standards using the Avogadro constant measurement"
- Contributes to achieving a mass standard based on a fundamental physical constant -</p> <p>9. "Torque standards"
- Contribution to improvement of reliability for fastening parts and energy saving with accurate torque measurement -</p> <p>10. "Pressure standards"
- Disseminates highly precise pressure standards over a wide pressure range and contributes to highly reliable pressure measurements -</p> | <p>11. "Leakage rate standards"
- Wide utilization from safety and security maintenance to measures against global warming -</p> <p>12. "High temperature standards"
- Contributes to improving reliability for high temperature measurement for quality and safety control in the manufacturing process (materials industry, etc.) -</p> <p>13. "Radiation temperature standards for medium and room temperatures"
- Contributes to improving reliability of thermometers for controlling quality and safety -</p> <p>14. "Low temperature standards"
- Contributes to improving reliability of low temperature measurement for quality and safety control in the manufacturing process for food, pharmaceuticals, aircraft parts, etc. -</p> <p>15. "Humidity standards"
- Contribution to improving reliability for humidity measurement -</p> <p>16. "DC voltage/resistance and capacitance standards"
- Contributes to quality improvements in the production workplace -</p> <p>17. "Inductance standards"
- Contributes to quality improvements in the production workplace -</p> <p>18. "DC high voltage standards"
- Contributes to cutting edge technology and maintaining safety by expanding the measurement range for DC voltage -</p> <p>19. "AC voltage standards (AC/DC difference standards)"
- Contributes to the supply of AC voltage standards to the industrial sector -</p> <p>20. "Current standards (shunt standards)"
- Contributes to energy saving using highly precise measuring technology for current -</p> | <p>21. "Transformer standards"
- Measures high current and voltage with high precision and contributes to fair power transaction -</p> <p>22. "Power and energy standards"
- Contributes to higher quality products and electric power transaction -</p> <p>23. "Batch calibration technology for multiple electrical quantities"
- Assists in the export of electrical products and electronic parts -</p> <p>24. "Precision measurement for magnetic fields"
- Contributes to measuring magnetic field in the surrounding environment and evaluating the performance of magnetic material -</p> <p>25. "Vibration and shock acceleration standards"
- Contributes to international development for the industry and maintains safety and security for society -</p> <p>26. "Ultrasonic standards"
- Contributes to evaluate "safety" and "performance" of ultrasonic medical equipment -</p> <p>27. "Hardness standards"
- Contributes to the industry and maintaining reliability for material strength -</p> <p>28. "Antenna standards for EMC measurements (6 GHz or less)"
- Precise electromagnetic waves measurement using antenna standards and contribution to EMI regulation -</p> <p>29. "High frequency antenna standards"
- Assists businesses and public research institutes by developing and supplying antenna standards that comply with EMC regulations for the microwave and millimeter wave band -</p> <p>30. "Conducted EMC testing"
- Contributes to popularizing effective conducted EMC testing -</p> |
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| <p>31. "RF (radio frequency) standards"
- Contributes to safe use of telecommunications equipment using highly precise measurement standards for electromagnetic waves -</p> <p>32. "Illuminance standards"
- Contributes to improving illuminance reliability for environment control in living, working and education places -</p> <p>33. "Photometric standards for LED"
- Contributes to promoting the utilization of LEDs through highly reliable photometry -</p> <p>34. "Spectral diffuse reflectance standards"
- Contributes to advanced material evaluation by precise measurement of reflection -</p> <p>35. "Dosimetry standards"
- Contributes to safe and reliable measurement of radiation -</p> <p>36. "Medical radiation standards"
- Improves the reliability of radiation therapy by evaluating the dose at high precision -</p> <p>37. "Radioactivity standards"
- Protects society using technology to precisely measure radioactivity -</p> <p>38. "Neutron standards"
- Contributes to maintaining safety, security and reliability for society -</p> <p>39. "Density, refractive index and viscosity standards"
- High precision and reliability references that support various fields using fluids -</p> <p>40. "Oil flow standards"
- Contributes to fair trading and low energy by accurately measuring oil -</p> | <p>41. "Hydrogen gas flow rate standards"
- Aiming to popularize hydrogen as the next-generation fuel -</p> <p>42. "High-Reynolds-number fluid flow standards"
- Contributes to improving safety and energy reduction for power generating plants, etc. -</p> <p>43. "Standard gases"
- Standard gases used to keep atmosphere clean -</p> <p>44. "Particle standards"
- Maintains safety and security based on accurate nanoparticle control and particle measurement technology -</p> <p>45. "High purity inorganic materials and inorganic standard solutions"
- Purity analysis traceable to SI units such as mass, current and time -</p> <p>46. "Organic standard solutions"
- Contributions to provide safe and secure water -</p> <p>47. "Thermophysical property standards on solids"
- Effectively supports the decision of definite solutions to thermal issues -</p> <p>48. "High precision standard spectral data (SDBS)"
- The spectral database that supports global users -</p> <p>49. "RoHS directive compliant certified reference materials"
- Contributes to reliable chemical analysis related to the RoHS directive -</p> <p>50. "Environmental and food certification reference materials"
- Contributes to ensuring safety and security for the environment and food -</p> | <p>51. "Reference materials for perfluoroalkyl substance analysis"
- Contributions to management of environmental risks and compliance with regulations for industrial products -</p> <p>52. "Reference materials for biofuel analysis"
- Contributions to biofuel popularization -</p> <p>53. "Reference materials for clinical examination"
- Contributions to maintaining competitiveness and reliability for clinical examinations -</p> <p>54. "Quantitative NMR technology"
- Contributes to food safety by enhancing calibration technology for reference materials -</p> <p>55. "Reference materials for PCB analysis"
- Contributions to rapid and accurate analysis of PCB -</p> <p>56. "Reference materials for semiconductor device development"
- For strengthening competitiveness in global semiconductor industry through the highly-reliable technique for the ultra-shallow depth evaluation -</p> <p>57. "Reference materials for electron probe microanalysis"
- Contributes to product assurance by maintaining highly accurate material measurement -</p> <p>58. "Thin film standards for compositional depth profile analysis"
- International standards linking to CRMs for high precision film-thickness measurements -</p> <p>59. "Reference materials for nanopore evaluation"
- For R&D of innovative materials with engineered nanopores -</p> |
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1. Examples of utilizing optical frequency comb

What is "optical frequency comb"?

Optical frequency comb is an ultrashort optical pulse train generated from a mode-locked laser. The optical pulse train is called as "optical frequency comb" because it has a broad and comb-like spectrum. When the frequency interval of the comb (f_{rep}) is synchronized with an atomic clock linking a frequency reference such as UTC, the comb is able to count absolute frequencies of lasers.



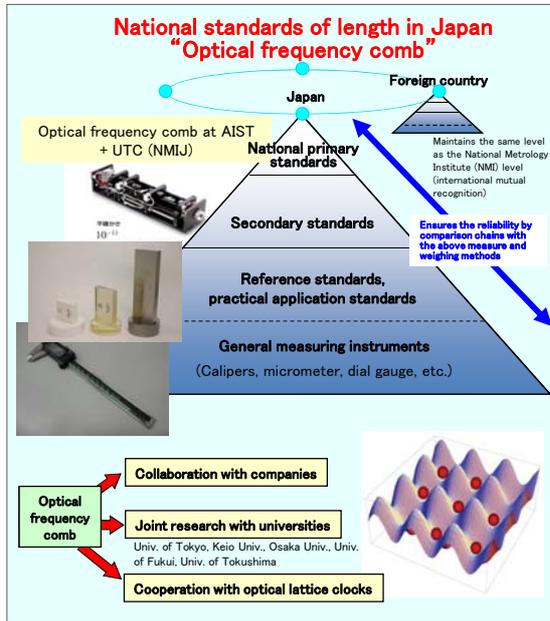
Fiber-based frequency comb developed in AIST



- Home-made, compact, and high cost-effectiveness
- Long-term operation over 1 week is possible
- Achieve high performance such as narrow spectral linewidth
- "Optical frequency comb" kept by AIST is a national standard of length in Japan

Industrial needs

- Industry needs still more compact and low-cost optical frequency comb
- Many applications need broad wavelength range from vacuum ultraviolet up to terahertz



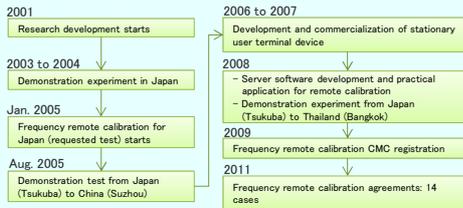
2. Examples of utilizing frequency remote calibration technology

What is frequency remote calibration technology?

Frequency remote calibration technology is a technology that uses GPS satellites and the internet to calibrate calibration instruments such as oscillators and measuring instruments over a long distance based on the AIST national standard without needing to transport the instruments.



Developing, maintaining and supplying frequency remote calibration



Industrial needs

- Users are increasing in a wide variety of fields including positioning, science and communication, therefore, they need to be supported.

Frequency remote calibration that supports global corporate expansion

With existing methods (bring-in calibration):

- (1) Management costs increase during the period of non-use (1 month)
- (2) Risks of accidents during transport, etc.
- (3) Worsening of uncertainty (precision) of equal calibration values

With remote calibration technology:

It is now possible to fully use the latest information and communication technology and supply standards fast, cheaply and accurately.



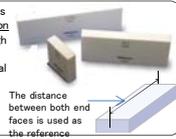
Current usage conditions

- 12 companies including domestic calibration operators and measuring instrument manufacturers are using it and their number is increasing each year.
- 2 locations overseas (China) are currently receiving the remote calibration service.

3. Examples of utilizing length standards (gauge block)

What is a gauge block?

A gauge block is an item used as a reference for various dimension measuring instruments, from high precision shape measuring instruments called 3-dimensional measuring instruments to general-purpose dimension measuring equipment such as calipers and micrometers.



The distance between both end faces is used as the reference.

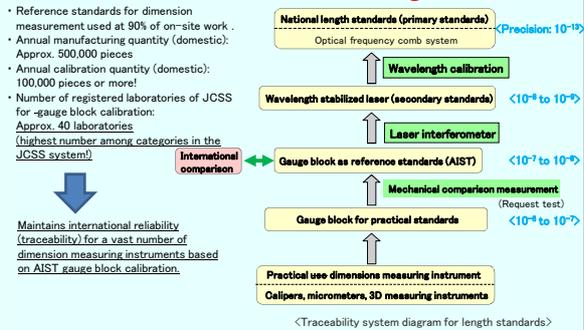
Developing, maintaining and supplying gauge block calibration systems

- High precision calibration technology for gauge blocks is an important foundation technology that is indispensable for manufacturing.
 - AIST develops 2 block gauge calibration systems, for short gauge blocks (0.5 mm to 250 mm) and long gauge blocks (150 mm to 1,000 mm), and provides a calibration service.
 - Uses originally developed laser light sources and a signal analysis program. Only a metrology institute in Germany owns a similar system.
 - Also calibrates national standard gauge blocks of Asian countries (for example, Thailand).
 - Conduct international comparisons as the pilot laboratory.
- Industrial needs**
- Gauge blocks made of new materials (low thermal expansion materials) have been developed, but characteristic evaluation on the materials (thermal expansion coefficient and stability) is insufficient.



Long block gauge calibration device (laser interferometer)

Reference of dimension measurement used at various manufacturing sites



Examples of dimension measuring instruments that use gauge blocks as reference



Calipers, micrometer



3D measuring instrument

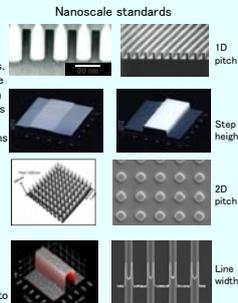
4. Examples of utilizing nanoscale standards

What are nanoscale standards?

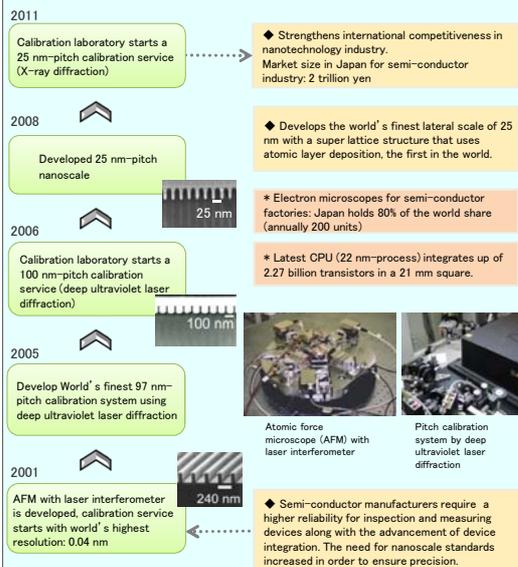
- References for measurements during the manufacturing process and inspection of ultra-high density semiconductor circuits.
- Enable measurement of the dimensions of small high density electronic devices, and steady manufacturing of high quality products.

Developing, maintaining and supplying nanoscale standards

- Drive innovation for manufacturing on nanotechnology with the achievement of nanoscale standards traceable to SI units. Contributes to a market on the scale of at least several trillion yen in Japan and ten times this amount overseas including semi-conductors, and maintains international competitiveness.
 - Establishes a calibration system that meets needs through close dialogue with inspection/measuring device manufacturers and calibration service organizations.
 - Guarantees dimensions for extremely fine construction of next generation semi-conductor circuits and allows to control them.
 - Japanese measurement technology leads and supports the global semiconductor industry.
- Industrial needs**
- The minimum process size of the most advanced integrated circuits is anticipated to be 18 nanometers in 2013 and 10 nanometers in 2020. In order to accommodate the rapidly changing demands from industry, research and development aimed at further miniaturization is necessary.



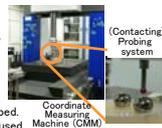
Assists high quality manufacturing with fine scales



5. Examples of utilizing dimensional standards

What are coordinate measuring machines?

An instrument for measuring 3-dimensional size and features of parts and products in industry as a combination of coordinates consisting of X, Y, and Z coordinate values by detecting interference between surface of them and probing systems equipped. The instrument has widely been used in manufacturing industry mostly due to its consistency with digitized product information despite complexity in uncertainty estimation.



Developing, maintaining and supplying dimensional standards

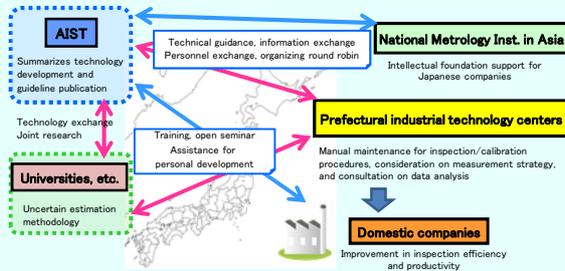
- Maintains traceability for coordinate measurement
 - Uncertainty estimation methodology
 - Provides calibration services (7 items)
 - To participate in International comparison, furthermore to plan, and to take pilot responsibility
- Develops and promotes various types of reference artifact (gauge)
 - Performs calibration and inspection of CMM *in situ*
 - Calibrates reference artifact of customer
- Leads development of industrial standard concerning evaluation method of CMM
 - Establishes and standardizes calibration and test procedures for CMM



It is demanded to establish a method to evaluate uncertainty in dimensional measurement in relation with surface geometry intended and that of actually measured data as point cloud.

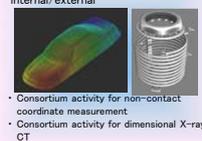
Assists manufacturing industry by promoting productive 3-dimensional measurement

- Supplies measurement standards, technology, and builds the progressive system



- Promotes establishment of 3-dimensional measurement to manufacturing industry for 3-dimensional measurement technology via public research organizations with AIST.
- Advances standardization for calibration and inspection procedures through international comparison and domestic round robin.

Progresses measurement from point-to-point to point-cloud and both internal/external



- Consortium activity for non-contact coordinate measurement
- Consortium activity for dimensional X-ray CT

Education, dissemination and personnel training for reliability evaluation technology



6. Examples of utilizing angle standards

What are angle measuring instruments?

Rotary encoder: An instrument that measures angle over a wide range of 360° and is built into rotary table on machine tool or into robot arm joints.

Autocollimator: An optical instrument having similar structure to a telescope that measures tilt, deflection, fine angle differences, and etc., for plane mirrors and other items.

Polygon mirror: An equi-angled polyhedron mirror. When there are 12 surfaces, it is used as an angle standard of 30° for the angle between surfaces.

Leveling instrument: An instrument that measures tilt angle with respect to the gravity.

Total station: A measuring instrument built into the rotary encoder that measures the angle, etc.

Protractor: A protractor instrument.



Supplying angle standards

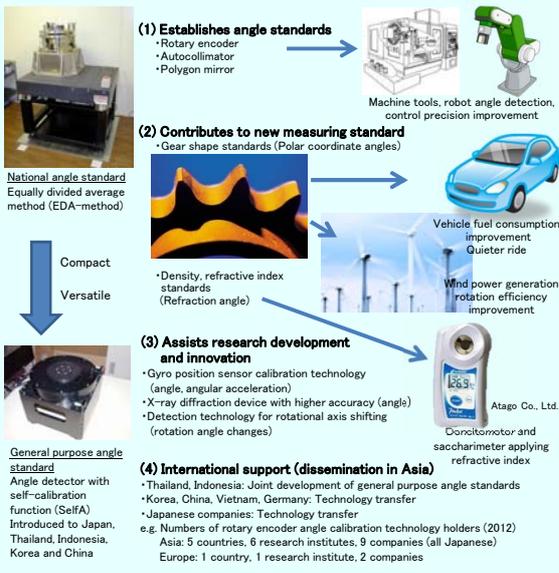
- Developed the world's most precise angle calibration device using two angle calibration principles established in Japan.
- Equally divided average method (EDA-method)
 - Angle detector with self-calibration function (SelfA)

JCSS: Rotary encoder
Calibration service: Autocollimator, polygon mirror

Industrial needs

- Each angle measuring instrument typically requires different calibration devices. This causes a capital investment burden on small and medium-sized enterprises and developing countries, and delays the spread of angle standards. It is essential to establish a traceability system for the autocollimator, polygon mirror and leveling instrument.
- International comparison has been made only for polygon mirrors which are critical for mutual agreement. It is essential to expand types of international comparison to other angle instruments.

Assists manufacturing industry with angle calibration technology from Japan



7. Examples of utilizing mass standards

What is mass?

Mass expresses the two properties of an object, which are (1) the difficulty in moving or stopping an object (inertial mass) and (2) the strength of attraction due to gravitational forces to other objects such as the earth (gravitational mass).
The unit for mass "Kilogram (kg)" is one of the base units in the International System of Units (SI).

Developing, maintaining and supplying mass standards



Japan prototype kilogram



1 mg to 5,000 kg standard weights

From the origin of 1 kg (prototype kilogram), AIST calibrated 1 mg to 5,000 kg standard weights, and then set and maintained these as the standards for mass. These standard weights were then used as a reference to calibrate weights for regulations and reference weights used by accredited laboratories to supply standards.

Industrial needs

- Improvement in reliability is being sought for measuring mass at an even smaller mass range than 1 milligram which is the weight supported by the current standards.
- General users of mass measurement demand provision of standards with greater accuracy even within the range of 1 mg to 5,000 kg, which is the range for existing standards.

Accurate mass measurement that is critical for analyzing the environment and developing medicine

- During the development and manufacture of medicine, to prepare samples, it is vital that mass at milligram size or smaller is measured with a high precision.
- Also, when analyzing the environment, to prepare standards samples such as standard gases for inspection and calibration of analysis equipment, it is vital that mass is measured with high precision and traceability.
- In other situations, it is also required to inspect reference weights used for regulations, and to set and maintain standards for values that are required in industries such as pressure, density, force, torque and liquid flow rate.



Mass measurement for samples in medicine development and their manufacturing process



Mass adjustment and calibration for deadweights on a force standard machine (national measurement standard for force)



Standard gas preparation for environmental analysis equipment (Photo: AIST NMI Organic Analysis Department, Gas Standards Laboratory)

8. Improving mass standards using the Avogadro constant measurement

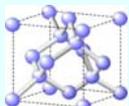
What is the Avogadro constant?

The Avogadro constant is a fundamental physical constant which links the amounts of "substances" in the macroscopic world and "particles" in the microscopic world that shows the number of elementary entities (molecules and atoms, etc.) in 1 mole of a substance. It is one of the most important fundamental physical constants along with such as the speed of light and the Planck constant. An international project is coordinated to measure the constant with high precision and in the future, define the kilogram, a unit for mass, using the fundamental physical constant.

Determining the Avogadro constant using high precision density standard technology



Silicon single crystal sphere



Crystal structure of silicon

The national standards for density are silicon single crystal spheres and realized by measuring their masses and volumes. A laser interferometer is used to measure the volume with high precision. The lattice constant and the mole mass of the silicon crystal are combined with the density, and the Avogadro constant is determined from the number of atoms within the silicon sphere. AIST has cooperated in international research with seven national metrology research institutes to determine the Avogadro constant with the world's highest precision at 3×10^{-8} .

Industrial needs

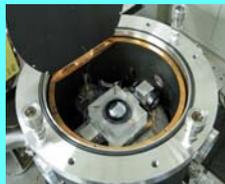
- Responding to the issues for long-term stability of the mass of the international prototype of the kilogram by improving the accuracy of the Avogadro constant.

Contributes to achieving a mass standard based on a fundamental physical constant

Improving precision of the Avogadro constant using a ^{28}Si -enriched crystal



^{28}Si -enriched crystal



Laser interferometer for measuring the diameters of the silicon sphere



International prototype of the kilogram (Current standard)



International research cooperation for improving precision of the Avogadro constant (2012~)
(International Avogadro Coordination Project)

The first mass standard based on a fundamental physical constant

- Uses high precision density standard technology to contribute to determining the Avogadro constant with greater accuracy (2×10^{-8}).
- Contributes to redefining a mass standard based on a fundamental physical constant that is currently defined based on the international prototype of the kilogram.

9. Examples of utilizing torque standards

What is torque?

Torque is the "degree of twisting force" and torque standards are assembled by using standards of mass, length and acceleration of gravity.



Prototype kilogram Absolute gravimeter

Development and dissemination of torque standards

A torque standard machine (TSM) is a machine that generates a primary torque by assembling weights with precisely adjusted mass, beams (moment-arm) with precisely measured length and measurement values for acceleration of gravity at the setup location.



Developed 1 kN-m torque standard machine

TSMs with the world's top class performance for medium capacity (5 N-m to 1 kN-m) and high capacity (1 kN-m to 20 kN-m) have been developed and the standards have been already supplied to meet the high demands from the industry sector. A TSM even for low capacity (0.01 N-m to 5 N-m) range is also under development.

Industrial needs

- There is a need for further range expansion for torque standards.
- Improvement of reliability in measurement of dynamic torque that changes with time.

Contribution to improvement of reliability for fastening parts and energy saving with accurate torque measurement

- ◆ The measurement values with torque wrenches used in airplane maintenance have become traceable to NMJ torque standards, therefore, they are recognized as equivalent to being traceable to US NIST standards by the US Federal Aviation Administration (FAA). The fact reduced the burden on airplane maintenance industry in Japan.
- ◆ Fastening torque control of screw and bolt is necessary for maintenance of plants, manufacture and maintenance of general machines such as airplanes and vehicles. Torque standards are used in calibration of torque wrenches and torque screwdrivers used for such cases.
- ◆ It is necessary to measure the torque accurately to evaluate and certify the performance of outputs of various types of motors in OA devices and trains, and vehicle engines. Torque standards are required in such corresponding fields.



Airplane maintenance



Torque wrenches used for airplane maintenance

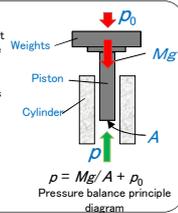


Power train measurement system for vehicles (Manufactured by HORIBA Europe GmbH) Source: S.Kuhn, Proc. XIX IMEKO World Congress, pp.351-355, Lisbon, Portugal, 2009.

10. Examples of utilizing pressure standards

What are pressure standards?

Pressure is the measurement quantity defined as the force applied perpendicular to a surface per unit area. AIST maintains and develops "pressure balance" and "liquid column manometer" at high precision, which realize the definition. These instruments are used to disseminate the standards.



Developing, maintaining and disseminating pressure standards

Types: gauge pressure, absolute pressure, differential pressure
Media: Gas, liquid
Pressure standards range: 1 Pa to 1 GPa (10^9 Pa)

Precise pressure standards over a wide pressure range



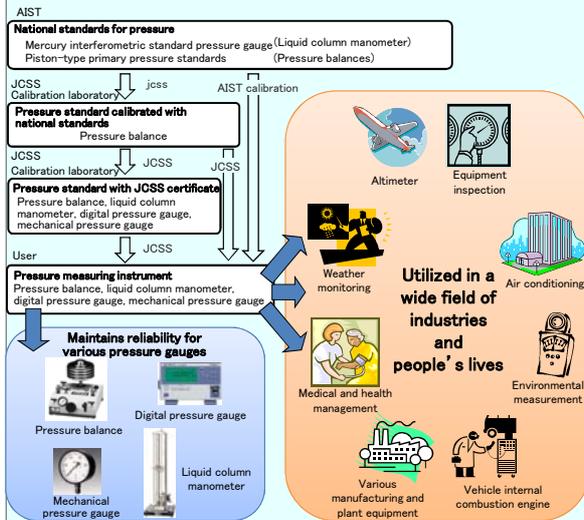
Large pressure balance to achieve high pressure standards

Industrial needs

- Methods for disseminating standards and effective calibration
- Ensuring reliability for pressure measurement in an industrial environment

Disseminates highly precise pressure standards over a wide pressure range and contributes to highly reliable pressure measurements

National measurement standards provision system for pressure



11. Examples of utilizing leakage rate standards

What are leak standards?

A helium leak test is a non-destructive test for detecting leaks using helium gas. Leaks can be detected with a high sensitivity because helium gas passing through a leak is detected as helium partial pressure. To quantify the amount of leakage, it is necessary to link the helium leak amount (flow rate) with the helium partial pressure gauge.

A helium standard leak that generates a constant helium flow rate is used in many workplaces as a leak reference regardless of whether it is for industry or research. References for calibrating helium standard leaks are fundamental leakage rate standard.



Developing, maintaining and supplying leakage rate standards

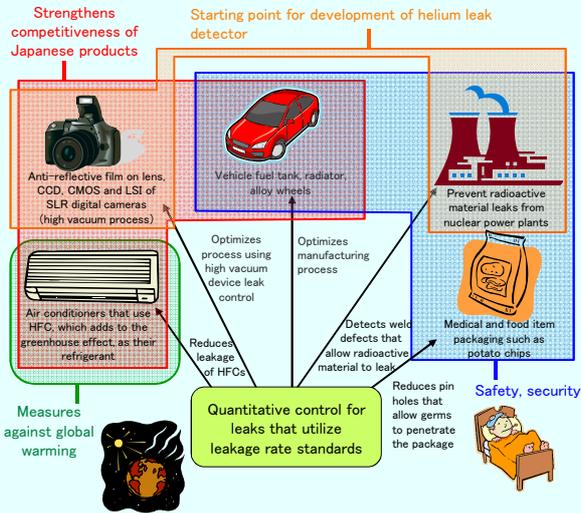
Subject for calibration: Helium standard leak
 Calibration method: Comparison with reference helium flow
 Calibration range: 10^{-8} Pa m³/s to 10^{-6} Pa m³/s
 International comparison: Excellent international equivalent with COMP-K12
 ISO/IEC 17025 supported



Industrial needs

- Development of standards for leakage rate into the atmospheric pressure (actual operating environment)
- Support for HFC, HFO, carbon dioxide, etc. as refrigerant

Wide utilization from safety and security maintenance to measures against global warming



12. Examples of utilizing high temperature standards

What are high temperature standards?

Non-contact high temperature measurement using a radiation thermometer

Thermal Radiation
 $L(\lambda, S) = \epsilon_{\lambda} L_{\text{BB}}(\lambda, T)$
 Planck's law
 Industrial thermocouple

There is a demand for high temperature control in manufacturing process at high temperatures of 1000°C or above from the material industry, etc., with the purpose of reducing carbon dioxide and improving competitiveness through higher quality and reducing the energy consumption rate. The precision of thermometers used to control the temperature is maintained with high temperature standards traceability.

Developing, maintaining and disseminating high temperature standards

High temperature standards have been established since the 80's to respond to the needs of Japan's domestic production sector, notably the steel industry. Subsequently, calibration services for high temperature thermocouples, which are non-contact thermometers often used in the industrial sector, began. In addition, standards of up to 2800°C to cover almost all the needs of the industrial sector were developed and maintained also for non-contact radiation thermometers.



Industrial needs

- Establish thermodynamic temperature measurement technique for high temperature regions
- Establishment of traceability for radiation thermometers in medium and room temperature regions

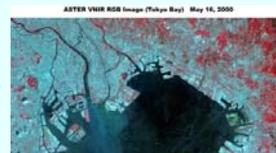
Contributes to improving reliability for high temperature measurement for quality and safety control in the manufacturing process (materials industry, etc.)

- Enabling stable operation and high quality product manufacturing through improvements in precision for welding and molten steel temperature control in the steel industry.
- Contributes to internationally competitive product quality management through temperature control at temperatures around 2800°C in the carbon material manufacturing process, one of the highest temperature processes in the materials industry.
- In addition, thermal radiation from high temperature blackbodies is also a standard for spectral radiance. This is applied to calibration of earth observation satellite sensors and contributes to resource mapping and monitoring of natural disasters.



From JISF homepage

Earth observation satellite sensor calibration



Copyright: METI/NASA Image created by: J-spacesystems

13. Examples of utilizing radiation temperature standards for medium and room temperatures

What are radiation thermometry standards for medium and room temperatures?

Temperature standards are largely classified into those for contact thermometers and radiation thermometers. Both of these have been established and operated based on the International Temperature Scale of 1990 (ITS-90). Among them, medium and room temperature ranges generally indicate the temperature range from roughly 0.01°C, the triple point of water, to 1000°C.

Contact thermometers are the most common for thermometers used in this temperature range. However, currently the development of radiation thermometers in the infrared range is progressing and now widely used even in the industrial sector.



Examples of radiation thermometers for medium and room temperatures

Developing, maintaining and disseminating radiation thermometry standards for medium and room temperature

Dissemination of standards for radiation thermometers in the temperature range from 400°C to 2000°C has already been established and a system to accredit bodies under the measurement laws (JCSS system) has started.

For 400°C or below, the spread of radiation thermometers in the industrial sector is remarkable so that there is an urgent need to establish dissemination of standards and start the JCSS system.

In addition, since radiation thermometers on the market can be used to measure temperature below 0°C, the dissemination of standards for the temperature range below 0.01°C (specifically down to -30°C) is also currently supported.



Room temperature radiation thermometer calibration system

Industrial needs

- Since many radiation thermometers are unable to set the instrument emissivity setting to 1 and, therefore, it is difficult to disseminate standards using the current blackbody furnaces, there is a need to establish calibration systems and methods for them.

Contributes to improving reliability of thermometers for controlling quality and safety

- Radiation thermometers such as ear thermometers are used at medical facilities or during pharmaceutical research, for the development of biotechnology, etc.



- Since radiation thermometers measure temperatures hygienically without contact, they are used for product quality control in such purposes as heating temperature control in fast food shops, temperature control for manufacturing processes of processed food, and storage temperature control for frozen and perishable food.



- Since temperatures can be measured safely at a sufficiently remote distance, radiation thermometers are used in dangerous environment in which high temperature liquid or low temperature gas is flowing, or in electricity facilities such as high voltage switchboards and transformers. They are utilized to prevent accidents and also for daily maintenance and inspection, etc.



- Utilized to improve product quality and productivity by ensuring a stable and uniform temperature during the molding process for plastic, resin, rubber, etc., and when baking after applying coatings.

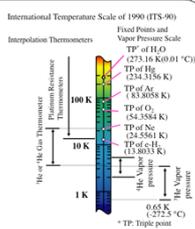
14. Examples of utilizing low temperature standards

What are low temperature standards?

Current temperature standards are based on the International Temperature Scale of 1990 (ITS-90) and low temperature standards mostly support temperature ranges at or below the triple point of water temperature (273.16 K) from ITS-90.

ITS-90 achieves scales for defined fixed points and vapor pressure, and is achieved by interpolating between fixed points using interpolation thermometers such as helium gas thermometers and platinum resistance thermometers.

Traceability is maintained for the temperature scale achieved with ITS-90 which guarantees quality and safety control for products when their temperature is measured in the industrial sector.



Developing, maintaining and supplying low temperature standards



Defined fixed-point system

A defined fixed-point system which is at a top level in the world (uncertainty 0.1 mK or less) was developed, and based on this system, a standards dissemination system with a lower limit temperature of 14 K for platinum resistance thermometers was perfected. Standards for very low temperatures of down to 0.65 K were achieved, and the dissemination system was perfected.

In addition, to respond to the needs of the industry, the standard dissemination based on the JCSS system was expanded to the triple point temperature for argon (approx. 190 °C).

Devices and technology for easy calibration in the low temperature range in an industrial environment were developed and evaluated, and their information was sent out.

Industrial needs

- Establish an easy optional temperature calibration method and technology for -100 °C or below.
- Establish standards dissemination for temperatures distributed widely in the industrial sector for the triple point temperature of neon (24 K, approximately -250 °C) or less.

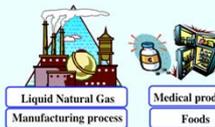
Contributes to improving reliability of low temperature measurement for quality and safety control in the manufacturing process for food, pharmaceuticals, aircraft parts, etc.

(1) Disseminating temperature standards and quality/safety control for the industry



Aircraft parts

Aircraft fuel



Liquid Natural Gas

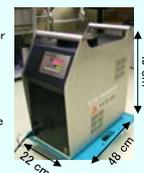
Medical products

Foods

(2) Low temperature calibration device

- There is a great need for low temperature thermometer calibration up to -100 °C in particular for quality and safety control for the product in the industrial environment.

- Using AIST low temperature standards technology, the performance of portable low-temperature thermometer calibration device developed to respond to these needs was evaluated and improvements were made through joint research with companies, and the device was successfully commercialized.



40 cm
40 cm
22 cm

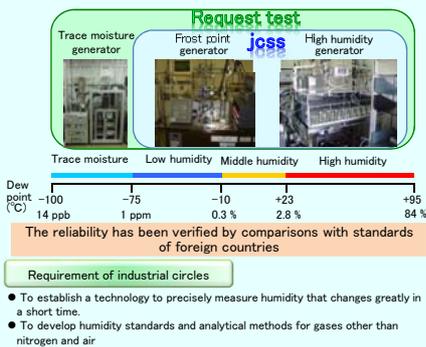
15. Examples of utilizing humidity standards

What is humidity?

Humidity is the term used for water vapor existing in the atmosphere or in other gases and expresses the amount and percentage of water vapor. In normal atmosphere, water is the third most abundant component after nitrogen and oxygen and also has the largest volume in polar molecules existing in the atmosphere. Since water exists in any environment, for example, in rooms, the product manufacturing line, ultra-high purity gases, ultra-high vacuum equipment and the upper atmosphere, there is some influence by humidity (even if the effect is large or small). To correctly understand the influence, the ability to measure humidity with a high reliability is essential and humidity standards are fundamental to keep humidity measurement reliable.



Developing, maintaining and supplying humidity standards



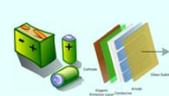
Contribution to improving reliability for humidity measurement



Control the humidity environment inside building (enforcement ordinance for building control laws)



Electrical and electronic products environmental testing (JIS C 60068-2-30, etc.)



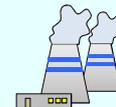
Dew point control for dry rooms used for manufacturing rechargeable batteries and OLED, etc.



Residual trace moisture control in ultra-high purity semiconductor material gases (ITRS2011)



Aerological observation and climate monitoring



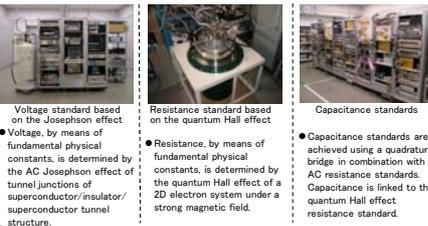
Leakage rate test from nuclear reactor containers (JEAC-4203-2008)

NMIJ contributes to improvements in reliability for routine humidity measurements in Japan by domestically supplying high quality humidity standards that are at the top level in the world.

16. Examples of utilizing DC voltage/resistance and capacitance standards

What are DC voltage/resistance and capacitance standards?

Electrical standards are based on voltage standards from the Josephson effect and resistance standards from the quantum Hall effect (the foundation of JCSS calibration based on measurement laws).



Developing, maintaining and supplying DC voltage/resistance and capacitance standards

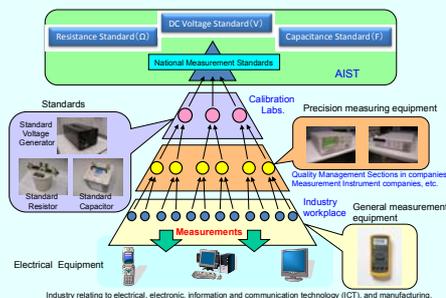
- Voltage:** 1 V, 1.018 V, 10 V supplied with uncertainty in the order of 10^{-8} . Development of AC quantum voltage standards is underway.
- Resistance:** 1 m Ω to 1 T Ω supplied with uncertainties in the order of 10^{-8} to 10^{-5} . For AC resistance, 10 k Ω (1 kHz) is supplied with uncertainty in the order of 10^{-8} . Research for robust and easy-to-use quantum standards, e.g. graphene and quantum Hall array) is underway.
- Capacitance:** From 10 pF to 1000 pF supplied with uncertainty of 8 digits. Research of the AC quantum Hall effect is underway.

Industrial needs

- Improvements in performance of standards built into electrical measuring instruments and compact secondary standards that are more accurate, easily maintained, and easy to use in workplaces are demanded.

Contributes to quality improvements in the production workplaces

- The DC voltage, resistance, capacitance and AC resistance standards establish the traceability of measurements of various types of electrical measuring equipment including voltmeters, ammeters, ohmmeters, multimeters, calibrators and LCR meters in the industrial sector, research and manufacturing workplaces.
- 8,000 JCSS calibration certificates for low frequency electrical quantities are issued annually and are being an important foundation for international business and international parts supply based on one-stop testing.
- Highly precise standards that can be traceable to national measurement standards are used to conduct high-quality equipment development, e.g. high stability compact standard resistors, high stability compact standard voltage generators, etc.



17. Examples of utilizing inductance standards

What is an inductor?

An inductor is a device that resists the passage of AC electric current and is widely used as an energy storage device for electronic equipment power source.

Due to the miniaturization of electronic equipment and such, inductors with iron cores are used on the production floor. However, air core type inductors with superior properties are used as standard inductors.



Example of an inductor (standard)

Developing, maintaining and supplying inductance standards



Inductance measuring equipment

- Inductance standards are formulated using inductance measuring equipment and based on capacitance standards and AC resistance standards. They are supplied within range between 100 μ H and 10H with uncertainty from approximately 0.01% to 0.1%. Furthermore, standards supply using JCSS calibration is also supported.

* 1 H (henry): Inductance caused by 1 volt of electricity when current flows at a rate of 1 ampere in 1 second

Industrial needs

- There is a demand for inductance standards greater than 10 H, the level for currently supplied standards.
- There is a demand for inductance standards for a high frequency along with the change to higher frequencies for electronic equipment.

Contributes to quality improvements in the production workplaces

- Inductors are one of the most important parts for electronic equipment and it is critical that inductance is measured with high precision for stable power source operation for such as electronic equipment.

- Low frequency current passes easily and high frequency current passes with difficulty through inductors, therefore, this plays a particularly important role along with capacitors in terms of parts for when designing filters.

- In combination with an iron core, they are used as transformers (for voltage and current) and are widely used from various electric appliances to large-scale power plants.

- Inductors operate based on the principles of electromagnetic induction, and they generate a magnetic field when an electric current is applied. They are used for audio equipment that includes speakers, earphones, and microphones since they exert mutual forces when combined with a permanent magnet.

- In addition, inductors are also used in engine areas for such as vehicles and non-destructive inspection, which makes inductance standards necessary.

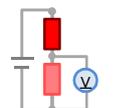
Various electrical products (Manufacturing industry)



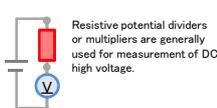
18. Examples of utilizing DC high voltage standards

What are DC high voltage standards?

DC voltage of 750 V or more is particularly known as DC high voltage. Equipment for measurement of this voltage range generally have a voltage divider and voltage measuring device designed for high voltages. Furthermore, since circuits are charged by high voltage it is important to safeguard against accidents involving electric shocks.



Resistive potential divider connections



Multiplier connections

Resistive potential dividers or multipliers are generally used for measurement of DC high voltage.

Developing, maintaining and providing DC high voltage standards



- DC high voltage standards are formulated from a DC high voltage measurement system that employs a resistive potential divider which performs DC voltage measurement up to 200 kV as the standard.
- This system is used to provide DC high voltage standards to the industrial sector via voltmeters for high voltages and resistive potential dividers, etc.

DC high voltage standards range up to ± 200 kV

Contributes to cutting edge technology and maintaining safety by expanding the measurement range for DC voltage

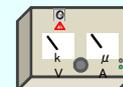
- High-voltage DC transmission is utilized for electric power transmission between Honshu and Shikoku and between Honshu and Hokkaido because high voltage DC transmission often provides less loss compared with AC power transmission.



- DC high voltage standards are used to calibrate withstand voltage testers that check the safety of electric equipment, parts and cables, etc. The standards are also used to calibrate high voltage voltmeters that are utilized for the calibration of such testers.



- In addition, DC High voltage measurement is also used in quantum accelerators, and it supports cutting edge research and development.



19. Examples of utilizing AC voltage standards (AC/DC difference standards)

What is AC/DC difference?

AC/DC difference is used to deduce AC voltage standards from DC voltage standards. An AC/DC converter is used as the standard. An AC/DC converter is a device that compares the effective value of the AC voltage and DC voltage. The AC/DC difference is the conversion error when converting from DC to AC. AC/DC difference is calibrated on a 10^{-6} level.



AC/DC converter

Developing, maintaining and providing AC/DC difference standards

- An AC/DC difference measurement system has been developed as a device to measure the AC/DC difference of AC/DC converters, and this is used to provide AC/DC difference to the industrial sector.



AC/DC difference measurement system

- Range for AC/DC difference standards
0.3 V to 1000 V
10 Hz to 1 MHz

Industrial needs

- There is a demand for improvement in the uncertainty of calibration for AC/DC standards.

Contributes to the supply of AC voltage standards to the industrial sector

- AC/DC difference standards, as well as being provided as AC/DC difference standards, are used to provide AC voltage standards in combination with DC voltage standards.
- AC voltage standards are widely provided to the industrial sector as standards for calibration of AC measuring equipment. Such equipment is used for maintenance and inspection of electrical equipment.



From power plants



To various household electrical appliances



20. Examples of utilizing current standards (shunt standards)

What is a shunt?

A shunt is a resistor that has a special construction to allow current to flow. Shunts that enable high precision current measurement also play an important role in energy saving for electrical and electronic equipment and also power measurement.



Examples of shunt resistors

Developing, maintaining and supplying shunt standards

AC shunt standards traceable for quantized Hall resistance standards have been developed and started to be supplied to the industrial sector. They are expected to be widely used for power measurement, new current sensor standards (for comparing) as well as calibrating the standard. Current supply range: 0.1 A, 5 A @45 Hz-65 Hz, 400 Hz. Expansion of the frequency and current range is scheduled.



Current sensor evaluation system

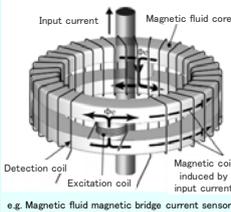
Industrial needs

- Support for harmonic current and power measurement technology, and frequency expansion in current standards.
- Development assistance and popularization of safe, secure and smart electrical and electronic equipment, and implementation of energy saving.

Contributes to energy saving using highly precise measuring technology for current

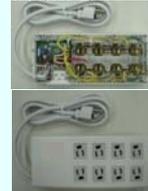
(1) Precision evaluation of current sensor

Support the needs for precision measurement and control of current that aims to provide energy saving for vehicles and electrical/electronic equipment. Precision evaluation and development assistance of current sensors.

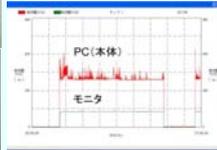


e.g. Magnetic fluid magnetic bridge current sensor

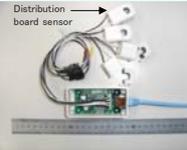
Power consumption visualization for each piece of equipment using a smart power tap



Power consumption visualization (display example) (for each piece of equipment)

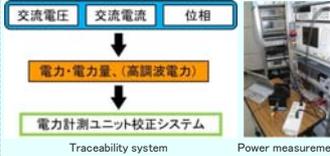


Visualization of power consumption for distribution board level using a distribution board sensor



(2) Power, Energy, harmonic power

Power measurement unit calibration system. Evaluation traceable to the national standards is possible for a power consumption visualized system. Contributes to the development and spread of HEMS and smart grid technology by precisely evaluating the measurement values of these types of equipment.



Traceability system

Power measurement unit calibration system

Calibration of power visualization system

(Power measurement unit calibration system)

→ Visualization of power consumption traceable to national standards

21. Examples of utilizing transformer standards

What is a transformer?

A transformer is a general name used for current transformers, instrument transformers, etc. A transformer is a power device that is directly connected to the power system line and is a device for expanding the measurement range of voltage, current and power. Transformers are largely divided into that for testing purpose, for protective relays, and for metering service that are used in combination with electricity meters.

Recently "electronic type" transformers that are important components for smart grids have been developed in addition to existing "wire type" transformers.



Developing, maintaining and providing transformer standards

Instrument transformer

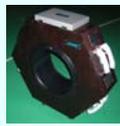
A calibration method that expands from 10 V for inductive voltage dividers to 110% of a rated voltage of 550/√3 kV:110/√3 V, the maximum voltage value, has been established, and seven standard instrument transformers that have different rated voltages are prepared and provided the standard to industrial sector.

Current transformer

A calibration method that expands from 50 A for a specific standard to 120% of a rated current of 40 kA:5 A, the maximum current value, has been established, and current comparators and standard current transformers are prepared and provided the standard to industrial sector.



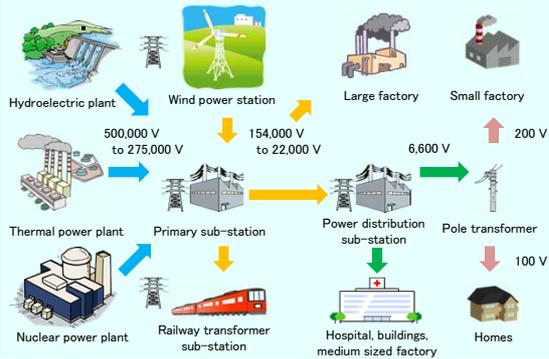
Standard instrument transformer (550/√3 kV)



Standard current transformer (40 kA)

Measures high current and voltage with high precision and contributes to fair power transaction

- Transformers for metering service are inspected accurately using transformer standards for fair power transaction.
- Transformers for protective relays are used to detect short circuits or ground faults that occur in power plants, transformer sub-stations, transmitting/distributing power lines and load systems that make up an electric power system. They are critical to power system control that involves transmitting and distributing power. Establishing and supplying transformer standards makes it possible to accurately monitor high current and high voltage, which contributes to a safely controlled system.



22. Examples of utilizing power and energy standards

What is power and energy ?

Power is the amount of work consumed by electrical equipment, and the cumulative sum total of power consumed per unit time is called the energy (or electrical energy).

Power and energy measurement is used over a wide range of areas, from meters for general household power transaction to the industrial sector for such as measuring power for industrial products and plants.



Developing, maintaining and providing power and energy standards

- Participated in key comparison of Asia-Pacific Metrology Programme (APMP)
- Provided standards based on jciss calibration service
- Provided standards based on the Japan Calibration Service System (JCSS system)
- Provided standards to verification standards

Start point for JCSS calibration and verification standards (specific measuring instruments) based on measurement laws

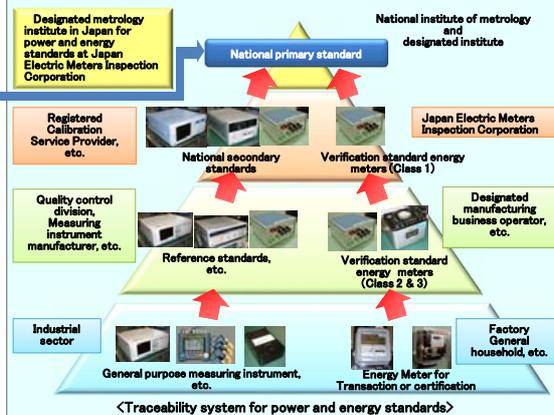
The power and energy calibration system supplies stable AC power to watt meters (power), watt-hour meters (energy), or reference instrument to be calibrated and measures the applied power or energy accurately.



Power and energy calibration system

Contributes to higher quality products and electric power transaction

- Equipment for measuring power and energy used in the industrial sector, research field, the manufacturing field, etc. is traceable to the power and energy calibration system (specific standard: national primary standard) based on Japan Calibration Service System (JCSS system).
- MPRA (international mutual recognition agreement) calibration service to industrial sector based on JCSS system is offered through supplying power and energy standards.
- Electric energy meters for transaction or certification in Japan (specific measuring instruments) should be verified using verification standards in compliance with the Measurement Law. The verification standards should be calibrated using the power and energy calibration system.



23. Examples of utilizing batch calibration technology for multiple electrical quantities

What is realtime calibration?

All electrical products in the US require UL standards to be met to ensure that the product is safe. UL standards require traceability to national standards for electronic measuring instruments used for inspecting the product. For operators, a technology that can achieve batch calibration for multiple electrical quantities at any time and place (realtime calibration) is critical.



Realtime calibration system

Supplying realtime calibration

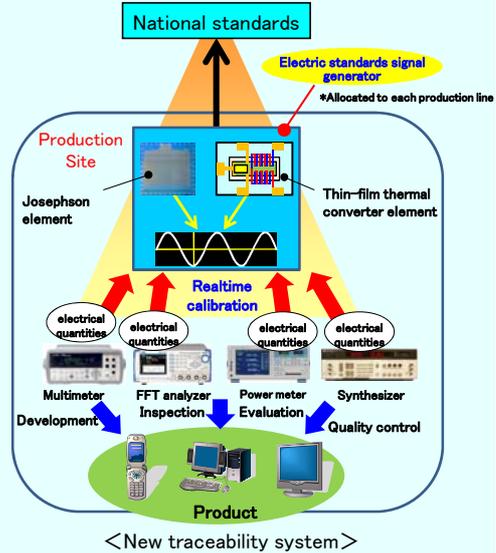
Features:

- Calibrates multiple electrical quantities for measuring equipment at a single pass
- Calibration of measuring equipment can be done any time on the production floor-site
- Tracing to national standards is available
- Calibration for the device itself will not be necessary over a long period (5-10 years)
- System that achieve realtime calibration can calibrate electronic measuring instruments in industrial environments and also allow instruments to be easily traceable to the national standards.
- Josephson voltage standard devices, which are not particularly dependent on the environment, and stable thin-film thermal converters for AC/DC transfer standards enable users to always utilize calibrated values.

Industrial needs

- Automatic calibration program of a realtime calibration system allows users to reduce the burden of calibration workload.

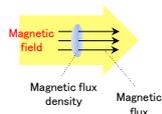
Assists in the export of electrical products and electronic parts



24. Examples of utilizing precision measurement for magnetic fields

What are magnetic fields?

Magnetic fields are produced at areas where electric lines with running current surround the area and is generally expressed as a physical quantity using magnetic flux density (T, Tesla).



For basic magnetic charge, a calibration system has been established for magnetic flux (units: Wb or weber), the number of magnetic force lines penetrating a plane in space, and magnetic flux density (units: T or tesla), the number of magnetic flux per unit area.

Developing, maintaining and supplying magnetic standards



Nuclear magnetic resonance magnetometer

Measuring the magnetic field generated by an electromagnet using a nuclear magnetic resonance magnetometer establishes the magnetic flux density standard.



Standard Helmholtz coil

- DC magnetic flux density (calibration range: 2.5 T to 1 μ T)
- AC magnetic flux density (calibration range: 3 mT to 0.1 mT, 50 Hz, 60 Hz)
- Magnetic flux (calibration range: 10 Wb to 1 mWb)

Contributes to measuring magnetic field in the surrounding environment and evaluating the performance of magnetic material

- ◆ Magnetic mattresses, necklaces and performance tests for such as AC magnetic induction therapy apparatus and magnetic pulse induction therapy apparatus which are becoming popular as magnetic therapy apparatus and medical examinations using magnetocardiography and magnetoencephalography.
- ◆ Measuring instruments to predict volcanic eruptions or earthquakes based on geomagnetic observation, space development, and attitude control for rockets and artificial satellites, etc.
- ◆ Measuring magnetized items in air cargo and for metal detectors, etc.



Among protection guidelines involving low frequency region electromagnetic fields, for example, in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines, the limit value (reference level) is stipulated as "the spatial average value for the entire body of an exposed person". For the method to actually measure the spatial average value, ICNIRP indicates the mission and its recognition to the International Electrotechnical Commission (IEC/TC106) and similar. However, international standards do not currently exist so this is a priority issue which needs to be worked out by the IEC.

25. Examples of utilizing vibration and shock acceleration standards

What is vibration and shock acceleration measurement?

This refers to measuring the motion state (vibration or shock) of an object. It is particularly necessary for fields involving "safety and security" such as crash tests for vehicles, vibration pollution and earthquake prediction. Accelerometers and vibration level meters are mostly used to measure it.



Developing, maintaining and supplying standards

Acceleration (vibration or shock waveform) is applied to the item to be measured with a vibration measurement instrument and then the electrical signal output from the instrument along with the acceleration at this time is measured using measuring equipment (a primary calibration device) with secured traceability for each amount of length, time and electricity. The standards are supplied by calculating the sensitivity.



JCSS calibration service (as of end of March, 2011)

- Ultra-low frequency vibration acceleration (0.1 Hz - 2 Hz)
- Low frequency vibration acceleration (1 Hz - 200 Hz)
- Medium frequency vibration acceleration (20 Hz - 5 kHz)
- High frequency vibration acceleration (5 kHz - 10 kHz)

Request test service (as of end of March, 2011)

- Shock acceleration (200 m/s² - 5000 m/s²)

Industrial needs

- Verify integrity of centrifugal acceleration calibration and shock acceleration calibration.
- Maintain reliability relating to gyroscope.

Contributes to international development for the industry and maintains safety and security for society



Cited from the Hokuriku Plant Services Co., Ltd homepage.
http://www.hokuhatsu.co.jp/skill/pr/ev_mainte.html



(1) Plant equipment inspection and diagnosis:
 Used to maintain reliability for portable vibration calibration devices and vibrometer installed on large-scale plants such as nuclear power plants and thermal power plants. (Supports low and medium frequency acceleration)

(2) Safety and quality assurance for vehicles, etc.:
 Used to maintain reliability for accelerometers used in the development of engines and safety for crash test. (Supports medium and high frequency acceleration)



(3) Vibration pollution (construction sites, highways and rail lines):
 Used to maintain reliability for vibration reference instruments and vibration level meters determined by the Measurement Law. (Supports low frequency acceleration)



(4) Earthquake prevention and geological survey research:
 Used to maintain reliability for seismometers such as seismic meter test for meteorological instruments. (Supports ultra-low and low frequency acceleration)

26. Examples of utilizing ultrasonic standards

What are ultrasonic standards?

They generally refer to measurement standards required to determine ultrasonic power, sound pressure, etc. of ultrasound transmitting through water. Currently, they are mostly used to calibrate the output from ultrasonic medical equipment. There is an increasing need for industrial-use such as ultrasonic cleaning equipment as well.

Development, maintenance and supply of ultrasonic standards

● Sound pressure standard for ultrasound (hydrophone sensitivity calibration)

Hydrophones are devices to measure sound pressure in water and NMIJ calibrates their sensitivities. The frequency range of the calibration is 0.5 MHz to 20 MHz. Calibration is carried out using a laser interferometer and in compliance with IEC 62127-2.



● Ultrasonic power standard (ultrasonic transducer output calibration)

Calibrates ultrasonic power radiated from ultrasonic transducers. The frequency and power range of the calibration is 0.5 MHz to 20 MHz, and 1 mW to 15 W. Calibration is carried out using a radiation force balance method in compliance with IEC 61161.



● Ultrasonic field parameters

Calibrates sound intensity and negative peak sound pressure as human safety indices for ultrasonic medical equipment. Complies with IEC 62127-1, etc. Frequency range is 0.5 MHz to 20 MHz.

Industrial needs

- Establish measurement standards for ultrasonic medical equipment at high sound pressure and high output level.
- Provide verification for ultrasonic medical equipment at high frequency range.

Contribute to evaluate "safety" and "performance" of ultrasonic medical equipment

In order to ensure safety for ultrasonic medical treatment, manufacturers of ultrasonic medical equipment are required to verify the equipment. They require reliable national measurement standards to determine the upper limit for ultrasonic power and sound pressure based on IEC standards or similar. Thus NMIJ supplies measurement standards indispensable to determine the main physical quantities of ultrasound in water.

◆ Sound pressure standard for ultrasound (hydrophone sensitivity calibration)

Cavitation by the high ultrasound pressure can be applied to therapy. Accurate sound pressure measurement is essential because the cavitation may destroy living tissue. NMIJ is supplying services for hydrophone sensitivity calibration.

◆ Ultrasonic power standard (ultrasonic transducer output calibration)

Ultrasonic power raises the temperature of living tissue. Medical treatment by using the resultant heat has already been put into practical use. However, unintentional temperature rise may destroy living tissue and there is a demand for measuring ultrasonic power accurately. NMIJ is supplying services for ultrasonic power calibration.

◆ Ultrasonic field parameters

Ultrasonic field parameters are essential to evaluate the degree of damage to living tissue caused by the ultrasonic exposure. NMIJ is supplying services for the calibration of ultrasonic field parameters.



27. Examples of utilizing hardness standards

What is hardness?

Pushing an indenter with a fixed shape into a test sample and measuring the size (for example, area of indentation) of the permanent deformation is a method of measuring the material's resistance to deformation. Hardness has correlation with tensile strength, and it is used in various industries as an indicator for the strength of the material. There are various test methods to measure hardness depending on the size and shape of a material to be measured, so if different testing methods are used, the values will not be compatible.



Developing, maintaining and supplying hardness standards

Hardness is an industrial quantity which can only be defined with the test method specified, and even Rockwell hardness scale has 15 types (ISO standards) of hardness. Since there is no compatibility between the values measured different methods, measurement standards are developed and supplied sequentially considering the user's needs.



Rockwell hardness standard block

- ◇ Rockwell C scale hardness (test machine and standards block)
 - The numerical value can be read directly so is widely used by industry associations including for vehicles.
- ◇ Vickers hardness (test machine and standards block)
 - Low dependence on testing force so the support range is broad for such as materials and thickness.
- ◇ Brinell hardness (standards block)
 - Evaluates the average hardness of a comparatively large area.
- ◇ Micro hardness (standards block)
 - Mainly for regions lower than microns in depth such as measuring thin-film and material strength distribution. Utilizing for hard coating and the semi-conductor, and is also used to measure elastic properties.

Industrial needs

- Develop technology and establish a supply system to supply measurement standards over a wide range.
- International standardization activities in ISO to develop and maintain the test methods.

Contributes to the industry and maintaining reliability for material strength

Establish traceability system and improve reliability of hardness values

- Rockwell, Vickers and Brinell hardness standards -
 - Participation for international key-comparisons and supplementary comparisons as member or host institute
 - Cooperation with proficiency testing among calibration laboratories for new measurement standards
 - More than ten private laboratories starting calibration service
 - Dispatch technical experts to ISO standards revisions



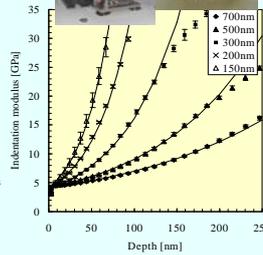
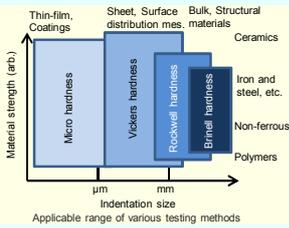
Improve reliability of hardness measurement values

Develop mechanical properties evaluation technology for materials in micro range and improve its reliability

- Micro hardness standards used for semiconductor, thin-films and micro regions -
 - Develop interferometer for calibration on testing machines
 - Develop detection method for surface contact points
 - International standardization activities based on ISO 14577
 - Feedback to industrial section via joint research



Develop technology and establish supply system to maintain reliability



Mechanical property evaluation at 100 nm region thickness films. Development and joint research on calibration techniques and analysis method

28. Examples of utilizing antenna standards for EMC measurements (6 GHz or less)

What is EMC measurement?

The measurement of the unwanted electromagnetic fields emitted from a device using a standard antenna to comply with the international electromagnetic compatibility (EMC) regulations. Every manufacturer should claim that their products comply with EMC regulations.

Maintaining antenna standards for EMC measurements

The antenna standards required for EMC measurements have been provided:

- Dipole antennas
- Bi-conical antennas
- Log-periodic antennas
- Dual-ridged waveguide horn antennas



Dipole antennas in the standard measurement



Log-periodic antennas in the standard measurement

Industrial needs

- The contribution in making the small and medium enterprises' products comply with the regulations by distributing these antenna standards to the prefectural research institutes is indispensable.

Precise electromagnetic waves measurement using antenna standards and contribution to EMI regulation



Comparison measurement at Industrial Technology Center of Tochigi Prefecture

- Distributes reference data of national standards level to antennas owned by public research institutes.
- Provides training and evaluation for public research institute equipment and assists establishing traceability.

- Develops the protocol for comparison measurement (proficiency test) which required to acquire accreditation for EMC measurement.
- Performs comparison measurement in the anechoic chamber of many public research institutes and establishes the anechoic chamber performance equivalent to accredited laboratories.



Evaluation measurement in anechoic chamber at the Yamaguchi Prefectural Industrial Technology Institute

29. Examples of utilizing high frequency antenna standards

Applications of antenna standards for communication/radar fields

Anti-collision radar for commercial vehicles:

For safety examination of commercial vehicles, RCS (Radar cross section) standards and antenna standards are required for international conformity.



Image of millimeter wave radar for vehicles that improve safety and security

Activities in U.S. NIST:

Development of scatterer standards for the microwave and millimeter frequency band is currently being conducted for the main purpose of human body detection.

Radio astronomy observation conducted by JAXA and NASA:

Radio astronomy observes various frequencies of electromagnetic waves in the microwave and millimeter wave frequency band and requires antenna standards for international conformity.



Photo of radar antenna

Developing, maintaining and supplying microwave and millimeter wave antenna standards

Development of microwave and millimeter wave antenna standards for the purpose of use in various communications and radar systems

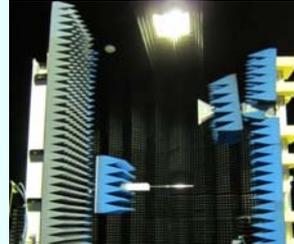
- Development of antenna standards for ultra-wideband frequency range over 1 GHz to 110 GHz.
- Development of new measurements for mobile communication application.
- Development of measuring devices that are inexpensive and compact which use optical devices and can be introduced into the business at low cost.

Industrial needs

- It is necessary to support all antenna types since antenna shapes are different depending on their communication use.
- It is necessary to develop antenna standards in the frequency bandwidth of 110 GHz to THz which is expected to be popular in the future.

Assists businesses and public research institutes by developing and supplying antenna standards that comply with EMC regulations for the microwave and millimeter wave band

- ◆ Start supplying antenna standards which complies with the regulations before the enforcement of the regulation. Promote their spread to the industrial sector via public research institutes.



Antenna calibration for EMC regulation measurement using optical devices



Millimeter wave antenna properties measurement using optical devices

30. Examples of utilizing conducted EMC testing

What is conducted EMC testing?

Conducted EMC testing is a test that evaluates the conformity with international standards by measuring how much electromagnetic noise generated by electronic equipment or similar affects power lines it passes through. When measuring electromagnetic noise signals using a high frequency receiver or similar apparatus, a Line Impedance Stabilization Network (LISN) is used as a coaxial impedance converter for the noise signal source and electromagnetic wave measuring instrument. In recent years, its use in EMC testing for LED lighting and built-in parts on vehicles that have seen advances in electrification is critical.

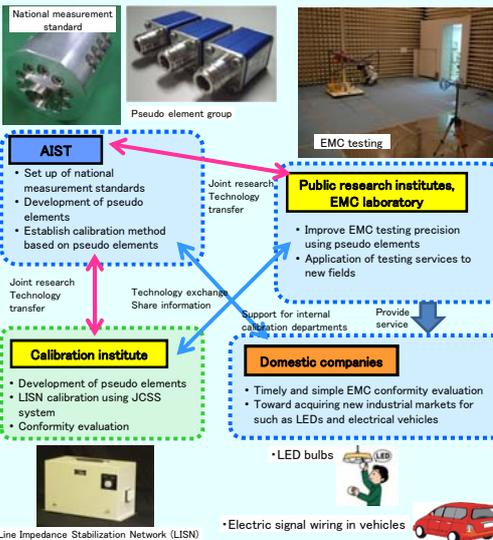
Initiatives towards calibration for EMC testing equipment such as a Line Impedance Stabilization Network

1. Maintain traceability for high frequency properties
 - Maintain standards in RF bandwidth (no cases overseas above 9 kHz)
 - Establish individual standards based on new method
 - Establish calibration technology (S parameter evaluation technology)
 - Supply standards based on JCSS
2. Develop pseudo elements that conform to CISPR 16-1-2
 - Achieve pseudo elements that imitate properties specified in the standards
 - Determine uncertainty and calibration values for pseudo elements
3. Develop methods to determine compatibility and simple calibration for Line Impedance Stabilization Network
 - Establish methods to evaluate compatibility and calibration methods that do not require evaluation with a vector network analyzer (VNA)
4. Develop verification methods for EMC testing using Line Impedance Stabilization Network (LISN)
 - Verify the difference in LISN installation requirements for multiple test sites that use pseudo elements
 - Maintain technical guidelines for testing, calibration and technical documents containing verification methods and conformity evaluation methods

Industrial needs

- Technical and extremely high difficulty evaluations are required such as VNA evaluation when calibrating a Line Impedance Stabilization Network.

Contributes to popularizing effective conducted EMC testing



Promoting the establishment and spread of calibration and conformity methods to the industrial sector with cooperation from AIST, public research institutes, calibration and testing operators.

31. Examples of utilizing RF (radio frequency) standards

What are RF standards?

RF standards are basic measurement standards for physical quantities required to measure the properties of electromagnetic waves. It is necessary to measure this correctly in order to use electromagnetic waves safely.

高周波電気物理量の基本量

赤字: 電磁波の基本物理量

Developing, maintaining and supplying RF standards

- The frequency used for electromagnetic waves has expanded into the gigahertz (GHz) band and in order to communicate at even higher speeds at a higher capacity, we are progressing development in research towards using 100 GHz and higher.
- We are supplying society with a calibration service up to 100 GHz for basic high frequency standard quantities.

高周波標準の校正サービス

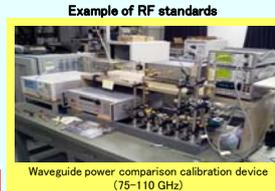
RF電力計	減衰量	測音	インピーダンス
RF電力計	減衰量	測音 (Doble)	インピーダンス
Frequency Power 10 MHz - 110 GHz	100 kHz - 40 GHz 50 GHz - 75 GHz	10 MHz - 26.5 GHz 9 MHz - 33 GHz	コネクタ
Coaxial & Waveguide	Coax. and WG	Coax. and WG	Coax. PCT,N,PC1.5
校正機関 → 高周波計測機器ユーザー			

Industrial needs

- It is necessary to establish RF standards that respond to the use of expanding frequencies and the advances in changes to higher frequency use of electromagnetic waves.
- There is an increase in demand for high frequency physical properties evaluation of dielectric and functional materials.

Contributes to safe use of telecommunications equipment using highly precise measurement standards for electromagnetic waves

Guarantees measuring precision using measuring traceability to improve reliability for measurement results from RF measuring equipment.



Usage scenarios in society



Regulations based on measuring standards for power output from electromagnetic waves transmitted from broadcasting stations, etc.



Certifies that the performance of electronic equipment affected by EMC regulations meets the standards.

32. Examples of utilizing illuminance standards

What is illuminance?

Photometric quantities, unlike physical quantities such as length, weight and voltage, etc., is the intensity referenced by the human eye sensitivity. Among photometric quantities, illuminance is a psychological physical quantity that expresses the brightness of a light shining on a planar object. The international unit used for illuminance is the lux (lx) which is equal to one lumen per square meter (lm/m²).

Developing, maintaining and supplying illuminance standards

National standards
Specified standard instruments

Specified secondary standard
commonly used reference standard

Specified substandard instrument

Illuminance reference instrument

Specified substandard instrument calibrated against specified standard is used to calibrate specified secondary standard and commonly used reference standard of the Japan Electric Meters Inspection Corporation, and is maintained and controlled as a standard for illuminance meters.

Specified measuring instrument (Illuminance meter)

Separate from this, specified substandard instrument is used to inspect the illuminance reference instrument at the Japan Electric Meters Inspection Corporation, and official verification test is performed for specified measuring instruments (illuminance meters) for laws and regulations.

Industrial needs

- There is a need to expand the calibration range to support measurable illuminance range more widely for digital illuminance meters currently sold by the manufacturers.

Contributes to improving illuminance reliability for environment control in living, working and education places

☆ It is necessary to measure illuminance accurately and to confirm whether illuminance conforms to standards to safeguard health, maintain safety and improve work efficiency in places such as hospitals, libraries, schools and various work environments including offices.

☆ Illuminance meters used for transactions and certifications must conform to official verification based on the Measurement Law and related laws and ordinances.

- Schools (indoors)
Classrooms, experimental labs, practical training rooms, reading rooms, infirmary ⇒ 200 to 700 lx
- Schools (outdoors)
Basketball court, volleyball court, swimming pool ⇒ 50 to 150 lx
Athletic field, football (soccer) pitch ⇒ 30 to 75 lx
- Hospitals
Surgery ⇒ 750 to 1500 lx
Examination room, treatment room ⇒ 300 to 750 lx
- Factories
Control room (instrument panel, control panel) ⇒ 1500 to 3000 lx
Control room (general manufacturing process) ⇒ 300 to 750 lx



33. Examples of utilizing photometric standards for LED

What are LED photometric standards?

An LED (light emitting diode) consists of a semi-conductor element that emits light when voltage is applied to it. White LEDs have attracted attention as next generation energy-efficient light sources. Since the lights emitted by LED and traditional light sources differ on the spatial and spectral distribution, traditional photometric methods and standards cannot be applied.



Developing, maintaining and supplying photometric standards for LED

Establishing LED photometric standards
 Calibration instruments suitable for LED photometric quantity calibration were independently developed. LED photometric quantity calibration method based on rigorous uncertainty evaluation was established, and the calibration service was started. In addition, the international equivalence of LED calibration was ensured by participating the first LED international comparisons (APMP PR S3-a, S3-b, S3-c).

Developing reference standards for LEDs
 Reference standards based on LEDs were jointly developed with a LED manufacturer. The reference standards achieve high reliability by introducing LEDs designed and developed specifically, and a proprietary temperature control.

- Industrial needs**
- Calibration requirement are increasing due to highly increased LED total luminous flux and the rapid spread of LED lightings.
 - UV (ultraviolet) - LED is being developed and becoming popular as a mercury lamp alternative (such as light sources for ultraviolet curing resin or black light, etc.) Therefore, UV-LED radiant flux calibration requirement is increasing.

Contributes to promoting the utilization of LEDs through highly reliable photometry

◆ **Calibration service using standard LEDs**
 Calibration range of luminous intensity is from 0.1 cd to 10 cd and that of luminous flux is from 0.1 lm to 10 lm. Assigns reference value to the standard LEDs during on-site inspection or proficiency tests for JCSS (Japan Calibration Service System) or JNLA (Japan National Laboratory Accreditation System). Contributes to checking calibration or testing capability, and expanding JNLA accredited testing laboratories and JCSS accredited calibration laboratories by providing the calibration service.



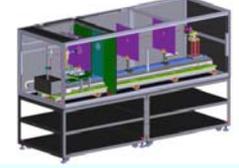
Luminous intensity standard LED (front) and Luminous flux standard LED (back)

◆ **Specification of the standard LEDs are referred by JIS standards**
 Since the standard LEDs are easy to use and the performances are extremely high, a document standard JIS C 8152:2007 "Photometry of white light emitting diode for general lighting" cited the standard LED as the best reference for LED calibration and referred the performance specifications. Due to the above, the standard LEDs have been introduced by domestic LED manufacturing companies, used as a standard to maintain LED quality and contributed to improving those calibration capabilities.

◆ **Manufacturers and public testing laboratories have introduced LED calibration instrument developed by AIST**

LED calibration instrument independently developed by AIST have been re-designed and optimized for ensuring to answer the measurement application and demand of public testing laboratories, LED manufacturers or etc. The laboratories that have introduced the instruments are planning JCSS calibration by using the instruments.

Calibration instruments, which are based on AIST instrument, introduced by public testing laboratories.



LED photometric calibration device developed by AIST

34. Examples of utilizing spectral diffuse reflectance standards

What is spectral diffuse reflectance?

The ratio of light (radiant flux) reflected in half-space from a sample for light (radiant flux) entering a sample
 → A basic optical property and is used for analyze, identify and evaluate materials in various fields.

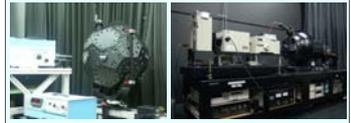
The "spectral diffuse reflectance standard" is the reference for spectral diffuse reflectance measurement.

Developing, maintaining and supplying spectral diffuse reflectance standards

- Original absolute reflectance measurement method based on integrating sphere measurement.
- Development of an integrating sphere system that reduces reflectance non-uniformity (the greatest cause of uncertainty) by approximately 1/10 compared to previous types.
- Correction method study for incompleteness of integrating sphere.
- Establishing spectral diffuse reflectance standard which is of the best level in the world.

Establishing international equivalence
 ● Checks equivalence from international key comparison (CCPR-K5)
 ● Registers calibration and measurement capabilities (CMC)

Calibration service
 ● Provides the calibration service authorized by NMIJ



New type integrating sphere that allows high precision measurement which is of the best level in the world. High precision comparative calibration instrument used for calibration service.

- Industrial needs**
- Expand the wavelength range and geometry conditions.
 - Standardize the measuring method, prepare technical documents and transfer technology, etc.

Contributes to advanced material evaluation by precise measurement of reflection

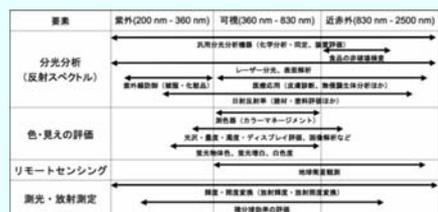
◆ **Calibration service authorized by NMIJ: Total of 42 cases (from April 2003 to March 2012)**
 Wavelength range: 360 nm to 1600 nm (visible, near infrared range)
 Geometry requirements: 2 types (0°:ob, ob:0°)

◆ **Establish traceability for standard diffuser panel which is a reference for measuring colored objects**
 Maintain traceability for white reference (and grayscale reference) and disseminate domestically
 → Major breakthrough in improving a problem (ensuring domestic traceability is difficult) that have been concerned the color related industries with over many years
 Disseminate traceability for measuring colored objects
 → Traceability requirements for JIS Z8722 (Methods of colour measurement - Reflecting and transmitting objects)
 → Contributes to improved reliability for measurement results



Example of standard diffuser plate traceable to national standard

◆ **Improve reliability of spectroscopic analysis technology that supports industrial applications**
 Calibration reference for various types of spectroscopic analysis equipment such as spectrophotometers
 → Provides fundamental factors that support reliability of spectroscopic analysis technology and its application technology
 e.g. Determination of reflectance of solar radiation by paint film (JIS K5602)

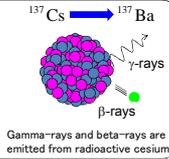


Main application areas in which the reliability for measurements ensures by the spectral diffuse reflectance standards (ultraviolet, visible, near infrared range)

35. Examples of utilizing dosimetry standards

What is ionizing radiation?

Ionizing radiation is electromagnetic waves and particles that can ionize substances such as X-rays, gamma-rays and beta-rays. Absorbed dose and air kerma (Gy, gray) standards are disseminated. However, when actually measuring radiation dose, a unit of dose equivalent (Sv: Sievert) that takes into account the effects of radiation on the human body is used.



Developing, maintaining and disseminating radiation dose standards

Gamma-ray standards

Air kerma standards are developed using an ionization chamber made with graphite (graphite wall cavity ionization chamber). Several types of Co-60 and Cs-137 gamma-ray sources are used for disseminating dosimetry standards from an environmental level to an industrial level.



X-ray standards

X-ray air kerma standards and mammography X-ray standards are developed using a parallel-plate free air ionization chamber. X-rays are generated from X-ray tubes with W, Mo and Rh anode materials. The X-ray tube voltage is in the range of 10 to 300 kV.



Industrial needs

- Disseminate dose equivalent x-ray and gamma-ray standards (Sv) to firmly secure uniformity in domestic survey meters and personal dosimeters.
- Expand the lower limit of dosimetry standards to correspond to the environmental level such as 0.23 $\mu\text{Sv/h}$, which is the decontamination level.

Contributes to safe and reliable measurement of radiation

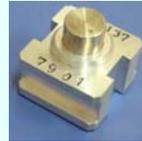
Survey meter and personal dosimeter calibration

AIST dosimetry standards (air kerma) are disseminated to calibration laboratories. Calibration laboratories calibrate survey meters and personal dosimeters.



Calibration of irradiation equipment and standard sources

A dose value is calibrated for sealed radiation sources and irradiation equipment, and then they are distributed as the standard radiation sources. These calibrated irradiation equipment and standard radiation sources are used for calibrating instruments such as survey meters.



Cs-137 gamma-ray source

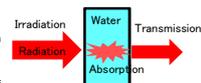


Calibrating irradiation equipment

36. Examples of utilizing medical dosimetry standards

What is absorbed dose to water?

Absorbed dose to water is the term used for the amount of energy that 1 kg of water, the main component of the human body, absorbs from radiation. When using radiation therapy, the irradiated radiation dose is determined by the unit of the absorbed dose to water.



Developing, maintaining and disseminating Co-60 gamma-ray absorbed dose to water standards



Co-60 gamma-ray absorbed dose to water was developed using a graphite calorimeter.

Industrial needs

- Improve uncertainty for LINAC dose evaluation used for medical treatment.
- Develop standards that support the progress in medical treatment technology (standards for Ir-192, Ru-106, etc.).

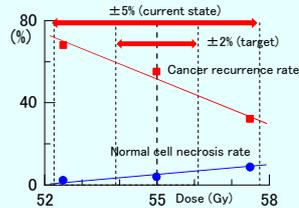
Improves the reliability of radiation therapy by evaluating the dose at high precision

Required dose evaluation at high precision

When the dose is low by 5%, the effects of radiation therapy are impaired by 10% or more. By contrast, when the dose is high, serious side-effects are increased. Therefore, there is a demand to evaluate the dose accurately.

Improvement in uncertainty for dose evaluation by absorbed dose to water standards

The uncertainty in evaluating the absorbed dose to water for radiation at medical sites is expected to improve from the current 5% approximately to about 3% by FY 2012 due to the development of the graphite calorimeter.



Effects of radiation on normal cells and tumors

Cited from: Stewart & Jackson, Laryngoscope, 85, 1107 (1975)



High precision absorbed dose to water measurement using graphite calorimeter

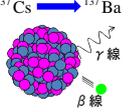


LINAC for medical treatment, which is used for high precision dose evaluation

37. Examples of utilizing radioactivity standards

What is radioactivity?

Radioactivity is the ability to send out radiation following atomic nucleus decay. The unit for radioactivity is Bq (Bequerel) and it shows the number of atomic nuclei that decay in one second.



Decay of radioactive cesium

Developing, maintaining and supplying radioactivity concentration standards



Radioactivity standards were developed using a $4\pi\beta-\gamma$ coincidence counting device. With this device, a standard radioactivity liquid solution with a determined radioactivity concentration value was prepared to calibrate the user's equipment. Furthermore, through activities such as continuous participation in international comparisons for radioactivity measurements hosted by the International Bureau of Weights and Measures, efforts are made for international conformity of radioactivity standards.

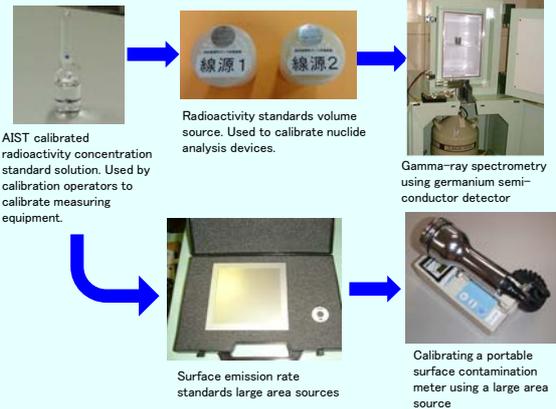
Industrial needs

- Construct a distribution system for standard samples to use in ability tests at gamma-ray spectrometry laboratories.
- Expand the lower limit for the concentration of radioactivity standards to 20 Bq/kg in order to support an environmental level activity.

Protects society using technology to precisely measure radioactivity

Calibration of portable surface contamination meters and gamma-ray spectrometer

AIST radioactivity standards are supplied to calibration operators. The calibration operators distribute radioactivity standards, a large area sources with calibrated emission rate of beta-rays and standards volume sources for radioactivity concentration. Germanium semiconductor detectors used for gamma-ray spectrometry, NaI (TI) scintillation spectrometers and also portable surface contamination meters are calibrated using these standards, and inspections where traceability is taken are performed.



38. Examples of utilizing neutron standards

What are neutron standards?

Neutrons, which are a kind of radiation, are used in many fields such as production sites and research development for the nuclear power industry and steelworks, and neutron precision measuring technology is required. Therefore, neutron fluence and neutron dose equivalent standards for wide energy range are necessary to protect workers from exposure to neutrons.

Developing, maintaining and supplying neutron standards

- Neutron fluence standards (neutron detector response calibration):** The absolute neutron fluence is determined, and the response of a neutron detector is calibrated for mono-energetic neutrons within a wide energy region from thermal (0.025 eV) up to 14.8 MeV.
- Neutron dose equivalent standards (neutron dosimeter calibration):** The sensitivities of neutron personal dosimeters and neutron survey meters are calibrated using neutrons emitted from a neutron source Am-Be or Cf-252.
- Neutron emission rate standards:** The number of neutron emission per second (s^{-1}) from the radioisotope neutron source such as Am-Be or Cf-252 neutron source is calibrated.



Industrial needs

- Support for exposure dose evaluation for crews on airplanes and the semiconductor soft error occurred by high energy neutrons produced from cosmic rays.
- Support for neutron dose evaluation in work places that simulate the neutron energy distribution in actual neutron facilities.

Contributes to maintaining safety, security and reliability for society



- Safety and security at neutron generating facilities**
Used in neutron facilities such as nuclear power plants and nuclear fuel facilities to maintain safety, security and reliability for radiation by controlling the surrounding environment and the workers. For this purpose, it is necessary to use the survey meters and neutron dosimeters that are traceable to neutron standards. (Neutron fluence and neutron dose equivalent standards)
- Industrial use of neutron radiation sources**
Used to maintain reliability for neutron emission rates from neutron radiation sources used in hydroelectric power plants, road construction, steelworks, etc. (Neutron emission rate standards)
- Popularization of traceability**
Standards are being provided through JCSS (Japan Calibration Service System) to support numerous needs and the calibration range offered by calibration operators is also expanding. (Neutron fluence standards, neutron dose equivalent standards and neutron emission rate standards)
- Research and development for high precision neutron measurement technology**
New neutron measurement techniques are developed cooperating with academic institutions, companies and other research institutes to satisfy new various needs of society.

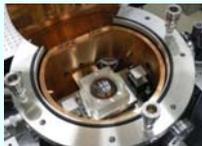
39. Examples of utilizing density, refractive index and viscosity standards

What are density, refractive index and viscosity standards?

Density, refractive index and viscosity are used in the manufacturing process, quality control and material development and evaluation for various industrial fields such as petroleum, chemical, food, alcohol, brewing and printing. The standards are references to calibrate scales on instruments for each of these physical properties.

Developing, maintaining and supplying standards

Density standards:
A traceability system with density of silicon single-crystal sphere at the top was established by developing technologies for precision density comparison measurement and density absolute measurement while also developing for high precision measurement technologies for the Avogadro constant, detecting solid density difference and PVT properties.



Setting density standards based on silicon sphere

Viscosity standards:
A traceability system was established by maintaining calibration system for viscosity standard liquids that cover a wide viscosity range employing precision viscosity comparison technology based on water viscosity (internationally accepted value stated in ISO).



Hydrostatic weighing apparatus for supplying solid density standards

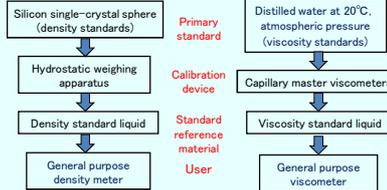
Refractive index standards:
Traceability system is established by developing high precision measurement technology for liquid refractive index.

To accommodate increasing demands for evaluation of newly developed materials such as the alternative fuels including bio fuels and the working fluids with low global warming potential in the field of developing energy conservation technologies, standards and standard reference data contributing to physical properties evaluations for such materials are required.

Industrial needs

High precision and reliability references that support various fields using fluids

Density and viscosity traceability system



Various density standard liquids (Kyoto Electronics Manufacturing Co., Ltd.)



13 types of JIS viscosity standard liquids (Nippon Grease Co., Ltd.)

- Supply of solid density standards: Approx. 10 cases/year
- Calibration of viscosity standard liquids: Approximately 20 cases per year
- Supply of standard liquids to users
 - Density standard liquids: Approx. 3500/year (Number of JCSS calibration certification issued)
 - Viscosity standard liquids: Approx. 7000 bottles/year
 - Refractive index standard liquids: Approx. 700/year (Number of JCSS calibration certification issued)
- JCSS calibration for vibration type density meters and refractometers

Contributes to manufacturing process control, quality control and material evaluation

Testing and evaluation for petroleum products such as fuel and lubricants, ink material quality control, alcohol concentration control, food control such as sugar and salt content, cosmetics development, food development, heavy oil fuel control, working fluid physical properties evaluation, etc.

40. Examples of utilizing oil flow standards

What are oil flow meters?

These meters are used for transaction and taxation quantities of petroleum products and also used in various fields such as production control in petrochemical plants. Calibration with actual flow is required in order to use oil flow meters with high accuracy.



Developing, maintaining and supplying oil flow standards

Oil flow calibration facility, the national standard for oil flow meters, is ultra-accurate large-scale facility that achieve the best uncertainty of 0.030% in the world.



Large oil flow calibration facility



Medium oil flow calibration facility

It is possible to calibrate kerosene and diesel (including some spindle oils) at the flow rate range of 0.01 to 300 m³/h. In the future the flow rate lower limit is expected to be lowered to 0.0005 m³/h.

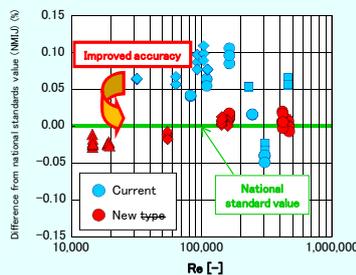
Industrial needs

- The current flow rate range and calibration fluid types are limited, and flow standards for heavy oil, which are high viscosity fluids, are insufficient.
- There are cases where the calibration uncertainty performed by current calibration laboratories is insufficient depending on the fluid type.

Contributes to fair trading and low energy by accurately measuring oil

Improves capability to calibrate flow meters

Considerably improves the calibration capability to domestic calibration laboratory by using national standards.



The role as a flow meter development platform

The role as flow meter development platforms for the meter industry is important. High accurate flow meters are continuously developed in collaboration with flow meter manufacturers with the aim of improving work efficiency and lower uncertainty due to viscosity effect on flow meters, and contributions are made to strengthen the power of the domestic industry.



New type rotor of a flow meter

Popularizes measuring traceability

Fluid types (to gasoline and heavy oils) and the flow rate range (to up to 810 m³/h) that can be calibrated by calibration laboratories via the JCSS using national standards are expanded to support the industrial needs that uses flow meters over a wide flow rate range and a wide variety of petroleum types.



Calibration labs' calibration facility



New type flow meter

41. Examples of utilizing hydrogen gas flow rate standards

What are hydrogen gas flow rate standards?

It is necessary to maintain hydrogen gas flow rate standards to ensure appropriate measurement for trading of hydrogen gas as a fuel for fuel cells which are expected to grow rapidly to resolve our energy issues, counteract the global warming, etc.

Developing, maintaining and supplying hydrogen gas flow rate standards

Working standard are critical nozzles, which are standardized by ISO 9300 and are calibrated against the primary standard at NMIJ.



As a result of hydrogen gas flow research, the working standard multi-nozzle system has been developed. The system consists of several critical nozzles to expand the flow rate.



Calibration service for flow rate range from 5 mg/min to 100 g/min is expected to start during FY 2014.

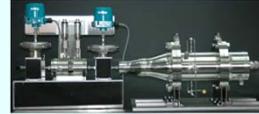
Industrial needs

- It is necessary to expand the standard flow rate range with line pressure up to 100 MPa.
- It is difficult for a private company to independently maintain high pressure hydrogen large flow rate supply equipment.

Aiming to popularize hydrogen as the next-generation fuel

Establishing calibration technology for high pressure flow meters at hydrogen refueling stations

During joint research with Iwatani Industrial Gases Corporation, a goal was set to establish flow meter calibration technology and maintaining high pressure hydrogen large flow rate supply equipment that is traceable to the national measurement standards to encourage the hydrogen and fuel cell vehicle infrastructure development. Until now, performance evaluation has been conducted on Coriolis type flow meters used at demonstration hydrogen station dispensers that have been promoted in Japan, and real gas property evaluation has been conducted for the discharge coefficient and critical back pressure ratio of critical nozzle type flow meters for high pressure hydrogen.



Technical verification of a hydrogen measuring system for household fuel cells

During joint research with Iwatani Industrial Gases Corporation, a goal was set to create a measuring system that assumes future hydrogen commercial trading and achieve a safe and stable hydrogen supply using flow meters for household fuel cell. Also, long-term stability evaluations and measuring system performance evaluations have been conducted, and measurement methods have been established. Verification tests are being conducted using internal demonstration houses (Higashida ward, Kitakyushu) in Kitakyushu Hydrogen Town, which is a HySUT (The Research Association of Hydrogen Supply/Utilization Technology) project.



In addition to hydrogen gas, maintenance and supply of city gas flow rate standards are planned for the middle of FY 2014.

42. Examples of utilizing high-Reynolds-number fluid flow standards

What is high-Reynolds-number fluid flow?

At electric power plants, fluid flow measurement is performed using an extremely high Reynolds number (a dimensionless number that establishes the fluid mechanics similarity rule). From the perspective of improving safety and energy efficiency, it is necessary to calibrate the flow meter being used with the same Reynolds number as actual.



Contributes to improving safety and energy reduction for power generating plants, etc.

Feed water flowmeters at nuclear power plants

Ultrasonic flow meters used for feed water flowrate measurement (previously flow nozzles according to ASME-PTC 6) to manage thermal output of nuclear power plants, are tested.

The test is also performed downstream of 3D piping to ensure that upstream pipe conditions and Reynolds number effect are as close to the actual plant conditions as possible.

In the U.S., actual plant calibration values are obtained from calibration results for a low Reynolds number and extrapolation techniques. However, it has been indicated by this research that calibration at high Reynolds number is necessary to accurately measure the flowrate.



Developing, maintaining and supplying fluid flow standards

- High Reynolds number actual flow facility (Hi-Reff) was built as a part of the national standards of water flowrate. This facility is the world's largest water flow calibration one.



- Achieved the maximum Reynolds number of 2.0×10^7 and the maximum flowrate of 12,000 m³/h. This Reynolds number is the largest in the world and equivalent value with an actual plant. The calibration uncertainty is from 0.08% to 0.10%.



Industrial needs

- Testing must be done at the actual temperature and there are some insufficiencies regarding testing equipment at high temperature and pressure.

Steam turbine evaluation at electric power plants, etc.

Flow nozzles are widely used for evaluating the performance of steam turbines at electric power plants. Testing is performed under a high Reynolds number which is the same as the actual plant, and problematic points for extrapolation methods using ASME standards are now about to be revealed. In addition, it is also about to be clear that actual flow (actual Reynolds number) calibration is highly necessary even for these nozzles. Furthermore, flow nozzles supplied to the actual plants are also being calibrated.



- Along with the active construction of electric power plants overseas, the supply of standards for high Reynolds number water flowrate for overseas countries is expected to start in the future due to the uniqueness of the high-Reynolds-number calibration equipment.
- The supply of standards for flow meter calibration used to evaluate pumps is expected in the future in addition to the above.

43. Examples of utilizing standard gases

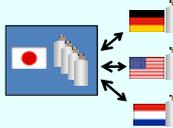
What are standard gases?

Standard gases are used as a scale of gas analyzer in measuring the concentration and quantity of a target component. Concentrations of target species of the standard gases are accurately determined, and they are used to make calibration curves and adjust the scale on an analyzer.



Developing, maintaining and supplying standard gases

- JCSS standard gases, based on the Measurement Law in Japan, are:**
 - for determination of air pollution species such as nitrogen oxide, sulfur oxide and carbon monoxide.
 - for purity analysis of medical oxygen and oxygen determination for human safety (lack of oxygen, oxygen in blood) by the oxygen standard gases including highly pure one.
 - traceable to high-purity standard gases which has been developed and supplied by the National Metrology Institute of Japan.
- Certified reference materials of greenhouse gases**
 - are of CF_4 , SF_6 and so on used mainly in semiconductor industry.
- Participations in the international comparisons**
 - Results of the comparisons are scientific evidence that standard gases developed by the National Metrology Institute of Japan are internationally appreciated under CIPM-MRA.
 - CERI participates in the comparisons corresponding to the JCSS standard gases.
 - NMIJ participates in other comparisons.



Requirement of industrial circles

- To develop standard gases whose precision exceeds the achievable one by current technique in global environment analysis.
- To develop a preparing and generating methods of unstable gas is required.

Standard gases used to keep atmosphere clean

- To measure pollutant species in vehicle exhaust gases is a necessary item of the automobile inspection in Japan to keep the atmosphere clean. JCSS standard gases are used to calibrate analyzers for the pollutant species.
- To measure the purity of medical oxygen is essential to avoid medical accidents. JCSS standard gases of high-purity oxygen are necessary for calibrating an oxygen analyzer for determination of the purity. (It may be adopted in the pharmacopoeia in future)
- JCSS standard gases are used for periodic calibration and type testing of exhaust gas analyzers for factories.



- We have come to recognize the increase and distributions of concentrations of carbon dioxide and carbon monoxide by monitoring the global warming species in the atmosphere over a long period of time.
- Standard gases to monitor the atmosphere are required to have an extremely high precision at an uncertainty of 0.01%, and BIPM and WMO intend to cooperate and develop the standard gases. AIST, NIES and JMA in Japan are attempting to create a system to cooperate on the supply of the high precision gases.

Greenhouse gases	Global warming potential	Emissions in Japan, one million tons of CO ₂ equivalent	Previous year comparison
Carbon dioxide (CO ₂)	1	1191.9	4.5%
Methane (CH ₄)	21	20.4	-2.1%
Nitrous oxide (N ₂ O)	310	22.1	-2.1%
HFC such as HFC-134a	1,300	18.3	10.3%
PFC such as PFC-14	6,500	3.4	4.2%
Sulfur hexafluoride (SF ₆)	23,900	1.9	0.6%

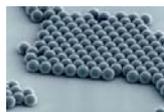
These data are referred from April 2012 greenhouse gas inventory, edited by the Center for Global Environmental Research, National Institute for Environmental Studies

44. Examples of utilizing particle standards

What is particle measurement?

Measuring particle size, size distribution, and concentration for cases such as:

- Airborne particles (particles in clean rooms, diesel nanoparticles, atmospheric aerosol particles, etc.)
- Liquid-borne particles (impurity particles in pure water and liquid pharmaceuticals, blood cells, etc.)
- Particles on solid surfaces (impurity particles on semi-conductor wafers, etc.)



Polystyrene particles for particle size standards

Recently, there has been a lot of international interests in measuring nanoparticles (industrial nanoparticles and diesel nanoparticles).

Developing, maintaining and supplying particle standards

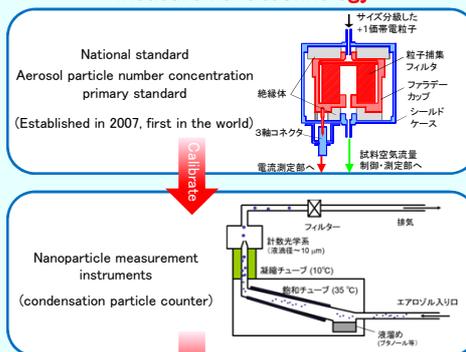
Standards to calibrate and test particle measurement instruments:

- Particle size and mass standards
- Particle size distribution width standards (for resolution tests)
- Airborne particle number concentration standard (primary standards, measuring instrument type)
- Airborne particle number concentration standard (secondary standards, generator type)
- Liquid-borne particle number concentration standard
- Nanomaterial reference materials (for industrial nanoparticle safety testing)

Industrial needs

- Extension of the ranges of number concentration and particle size that the particle standards cover.

Maintains safety and security based on accurate nanoparticle control and particle measurement technology



Achieves traceability in living environments and production sites

Regulations on vehicle nanoparticle emission

- International regulations for exhaust nanoparticles from vehicles (EUROS regulations for EU)

Contamination control in clean rooms

- International regulations for exhaust nanoparticles from vehicles (EUROS regulations for EU)

Nanoparticle regulations for residential and industrial environments

- Regulation on nanoparticle emission from office equipment (Blue Angel eco-label certification in Germany)
- Certification of products that include industrial nanoparticles (being investigated internationally)

45. Examples of utilizing high purity inorganic materials and inorganic standard solutions

What are high purity inorganic materials and inorganic standard solutions?

The reference material and standard solution which are certified chemical purity, concentration, or physicochemical property is essential for calibration of analytical instrument or chemical analysis.

Developing, maintaining and supplying reference materials

Metal standard solution/non-metal ion standard solution

Inorganic standard solution is used for calibration of analytical instrument, for example, atomic absorption spectrometer, ICP optical emission spectrometer, ICP mass spectrometer, and ion chromatography.

Al, Bi, Cd, Pb, Mn, As, Sb, Hg, Zn, etc.
NO₂⁻, Cl⁻, Br⁻, NH₄⁺, etc.

High purity inorganic materials

Inorganic high purity material is used for reference for neutralization titration, redox titration, precipitation titration.

Potassium hydrogen phthalate, sodium dichromate, diarsenic trioxide, amidosulfuric acid, sodium carbonate, potassium iodate, sodium oxalate [NMIJ CRM 3000 series]

pH standard solution

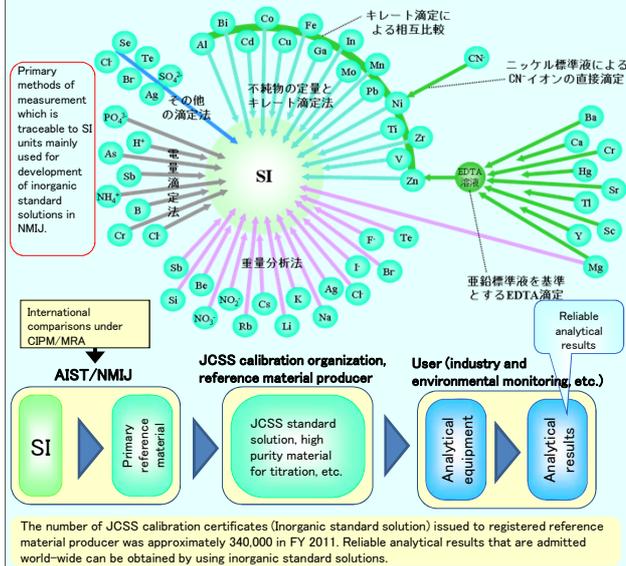
Establishes the Harned cell method, which is a primary method of pH measurement, and supplies six types of pH standard buffer solutions. These pH standard buffer solutions used to calibration of pH meter.

Oxalate, phthalate, neutral phosphate, phosphate, borate, carbonate

Industrial needs

- High purity inorganic materials are required to precisely determine the concentration based on titration.

Purity analysis traceable to SI units such as mass, current and time



International comparisons under CIPM/MRA

AIST/NMIJ

SI

Primary reference material

JCSS calibration organization, reference material producer

JCSS standard solution, high purity material for titration, etc.

User (industry and environmental monitoring, etc.)

Analytical equipment

Analytical results

Reliable analytical results

The number of JCSS calibration certificates (Inorganic standard solution) issued to registered reference material producer was approximately 340,000 in FY 2011. Reliable analytical results that are admitted world-wide can be obtained by using inorganic standard solutions.

46. Examples of utilizing organic standard solutions

What are organic standard solutions?

Organic standard solutions are a measure for quantitative analysis of organic compounds in air, water and other matrices.

They are solutions with accurately characterized component concentration and are used to draw the calibration curve and align the scale on analytical instruments.



Developing, maintaining and supplying organic standard solutions

JCSS organic standard solutions (organic standard solutions based on the Measurement Law)

- Substances that directly affect human health such as volatile organic compounds (VOCs) in the air.
- Trihalomethanes and other compounds that are regulated by the Water Supply Act for analysis of service water.
- Benzo[a]pyrene, phthalate esters and similar chemicals that have activities as endocrine disruptors are sometimes included in plastics as additives.
- Formaldehyde and other volatile compounds which are considered as the cause of sick house syndrome, etc.
- NMIJ supplies approximately 40 types of organic high purity substances (such as benzene and toluene) as primary standards to keep metrological traceability of the above standard solutions.

Other organic standard solutions (NMIJ Certified Reference Materials (CRMs))

- Standard solutions of sulfur for analysis of fuel
- High purity organic compound to calibrate thermometer for thermal analysis, etc.

Industrial needs

- Supply traceable sources for analysis of 25 compounds based on the Water Supply Act.
- Highly accurate standard gases that far exceeds the current availability are required for global environment analysis.

Contributions to provide safe and secure water

- The Water Supply Act requires monitoring of various harmful components and ensures that no harmful components are contaminated in the water supply. There are currently 25 volatile organic compounds that are subject to the regulations among those items. At this point in time, standard solutions for 23 of these compounds are supplied under the JCSS system.
- Development of primary standards of the two remaining organic compounds has been finished to be able to support all 25 compounds in the near future.
- Furthermore, regulated concentrations for trichloroethylene and similar contaminants detected from time to time at defunct factories have been provided based on the Soil Contamination Countermeasures Act, and organic standard solutions for their analysis are supplied under the JCSS system.

Regulated 25 VOCs based on the Water Supply Act (The red boxes show compounds currently supported by the JCSS system)

<規制>			
Benzene	1,2-Dichloro ethane	<i>cis</i> -1,3-Di chloropropene	1,1,1-Trichloro ethane
Bromodichloro methane	1,1-Dichloro ethylene	<i>trans</i> -1,3-Di chloropropene	1,1,2-Trichloro ethane
<i>tert</i> -Butyl methyl ether	<i>cis</i> -1,2-Di chloroethylene	1,4-Dioxane	Trichloro ethylene
Carbon tetrachloride	<i>trans</i> -1,2-Di chloroethylene	Tetrachloro ethylene	<i>o</i> -Xylene
Chloroform	Dichloromethane	Toluene	<i>m</i> -Xylene
Dibromo chloromethane	1,2-Dichloro propane	Tribromomethane (Bromoform)	<i>p</i> -Xylene
1,4-Dichloro benzene			

47. Examples of utilizing thermophysical property standards on solids

What is thermophysical property on solids?

Thermophysical property on solids is a basic physical value, such as thermal conductivity, thermal diffusivity, specific heat capacity and the coefficient of thermal expansion. These properties are much important in various industrial fields and are required to the design of devices, the control of heat transfer on electronic devices, energy saving of buildings, etc.

Developing, maintaining and supplying standards

● Reference material of thermophysical property
Reference materials of thermophysical properties on solids are used to confirm the validation of thermal analysis and to calibrate equipment. Currently, we have developed and supplied 3 certified reference materials (CRM) and 4 reference materials (RM).



CRM of thermal diffusivity RM of heat diffusion time across the thickness of thin film

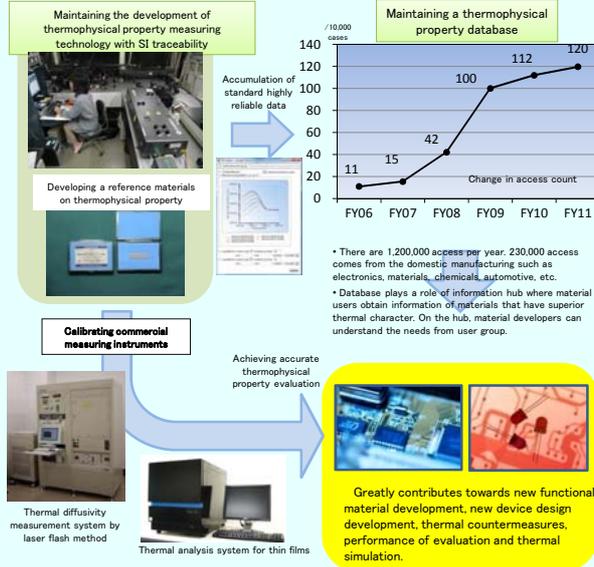
● Thermophysical property database
Network database system for thermophysical property data provides more than 10,000 reliable thermophysical properties data via Internet. The data consists of thermophysical property data of thin film, high temperature melts and others. A part of data are measured by instrument traceable to national standard and its uncertainties are evaluated.

● Calibration service on thermophysical property
8 items of calibration service on thermophysical properties (including thermal diffusivity, specific heat capacity and the coefficient of thermal expansion) are available in wide temperature range. These calibration services are conducted with SI traceability.

Industrial needs

- Selecting the effective standard supply method to support various needs and constructing a rapid supply system.
- Improving more amount of thermophysical property data with guaranteed reliability.

Effectively supports the decision of definite solutions to thermal issues



48. Examples of utilizing high precision standard spectral data (SDBS)

What is spectral data?

AIST operates a free access spectral database for organic compounds (SDBS) that compiles quality evaluated electron spin resonance (ESR), Raman (Raman), mass (MS), infrared (IR), carbon (^{13}C) and proton (^1H) nuclear magnetic resonance (NMR) spectra of some 30,000 organic compounds, via the web.

Spectral database SDBS

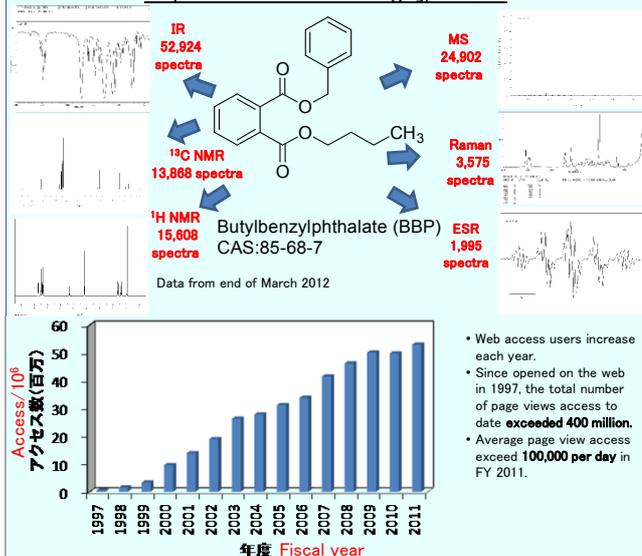
- Started collection of spectra from the 1980's and the activity is currently continuing.
- High quality spectra evaluated by researchers at AIST.
- Up to 8 kinds of spectra are compiled for a single compound.
- NMR spectral assignment to the structure is provided.
- Available on the web freely since 1997.
- In recent years, data collection prioritizes on pesticides and hazardous substances.
- Used for a standard reference spectra for flavor and fragrance materials.
- Responses to questions from the users.
- The service was stopped for approximately one month due to the damage caused by the Great East Japan Earthquake. When it recovered, users sent many positive comments concerning the service.

Industrial needs

- Sustainable high quality spectral collection and evaluation.
- Select between quality and quantity of data collection.

The spectral database that supports global users

<http://riodb01.ibase.aist.go.jp/sdbs/>



49. Examples of utilizing RoHS directive compliant certified reference materials

What is the RoHS directive?

The **RoHS** (Restrictions of the use of certain **Hazardous Substances** in electrical and electronics equipment) **directive** is one of the EU directives that prohibits the use of specific hazardous substances (Cd, Cr (VI), Hg, Pb and several brominated flame retardants) in electrical and electronic equipment. This directive was effective as of July 2006. Any electrical or electronic equipment that does not pass the RoHS directive cannot be exported to EU so it has become a big problem in Japan.

Developing, maintaining and supplying reference materials

The reference material for RoHS directive is used for precision control at analysis and testing, and manufacturing (green procurement items designed with the environment in mind) which complies with regulations and directives (such as REACH regulations and WEEE directives) involving the recycle of products and disposal of electrical and electronic equipment.

- ABS resin pellets and disks for heavy metal analysis (Pb, Cd, Cr); NMIJ CRM 8102-a, 8103-a, 8105-a, 8106-a
- ABS resin pellets and disks for heavy metal analysis (Pb, Cd, Cr, Hg); NMIJ CRM 8112-a, 8113-a, 8115-a, 8116-a
- PP resin pellets for heavy metal analysis (Pb, Cd, Cr, Hg); disks NMIJ CRM 8133-a, 8136-a
- PVC resin pellets for heavy metal analysis (Pb, Cd, Cr, Hg); NMIJ CRM 8123-a
- Lead-free solder chips
NMIJ CRM 8202-a, 8203-a

Industrial needs

- Reference materials that are similar in concentration as components targeted for analysis with a similar composition as materials that need to be analyzed are needed for calibration and validity check.

Contributes to reliable chemical analysis related to the RoHS directive

It is possible to know the content of hazardous substances in electrical and electronic products targeted by the regulations and allows exports from Japan to EU countries without any hindrances



[Total up to 2010: 826 units distributed]

IEC62321 "Procedure manual to measure the content of regulated substances in electrical and electronic equipment and products" - 2008 - for which Japan (AIST) leads the contribution to standards

- Evaluation of testing results and validity of testing method on plastic materials
- Reduces the economic burden on operators (approx. 500) that perform analysis in Japan
- Promotes recycling and reduces the burden on the environment by obeying the regulations
- Avoids trade barriers for exporting to the EU

50. Examples of utilizing environmental and food certification reference materials

What are environmental and food certified reference materials?

These materials are prepared from natural environment samples and food samples. Toxic elements or substances (analytes) containing these materials are naturally occurring, in a similar form in analytical samples.

They are mainly used for internal quality control and for validation of analytical methods and results.

Developing, maintaining and supplying reference materials

- NMIJ CRM 7202-b River water → Proficiency testing
- NMIJ CRM 7302-a Marine sediment
- NMIJ CRM 7303-a Lake sediment
- NMIJ CRM 7402-a Cod fish tissue powder
- NMIJ CRM 7403-a Swordfish tissue powder
- NMIJ CRM 7405-a Seaweed powder
- NMIJ CRM 7501-a, 7502-a, 7503-a White rice flour
- NMIJ CRM 7505-a Tea leaf powder → Proficiency testing
- NMIJ CRM 7511-a Soybean powder
- NMIJ CRM 7531-a Brown rice flour → Proficiency testing
- NMIJ CRM 7901-a Arsenobetaine solution
- NMIJ CRM 7912-a Arsenic acid [As (V)] solution
- NMIJ CRM 7913-a Dimethylarsinic acid solution

In addition to internal quality control, candidate materials during the development of certified reference material (CRM) are used as testing materials for external quality assurance (proficiency testing). The proficiency tests for trace elements in river water, tea leaf powder and brown rice flour were actually provided. [At FY 2010: 287 units distributed]

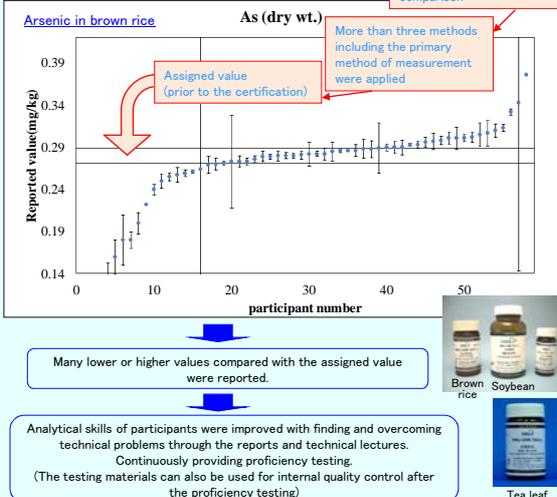
Industrial needs

- Reference materials both similar in analyte concentrations and matrix compositions as food and environmental samples are needed for calibration and validation in chemical analysis.

Contributes to ensuring safety and security for the environment and food

Examples of external quality assurance (proficiency testing):

The measurement capability was proven in the CIPM-MRA international comparison



51. Examples of utilizing reference materials for perfluoroalkyl substance analysis

What are perfluoroalkyl substances?

Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA), which are perfluoroalkyl substances, have been widely used in the industries due to excellent properties such as heat resistance, chemical resistance and optical characteristics. However, because they have been known to be persistent and/or toxic, a proper management of them is desired. Therefore, accurate analysis of them is essential, and correctly characterized reference materials are playing an increasingly important roles.

Developing, maintaining and supplying certified reference materials

The certified reference materials for reliable analysis of PFOA added to survey items for quality standards for drinking water, and PFOS designated by the Act on the Evaluation of Chemical Substances and Regulation of Their Manufacture (class 1 specified) have been developed. These can be used to calibrate instruments, or confirm the validity of analytical methods or instruments.

- Potassium perfluorooctanesulfonate in methanol (standard solution)
NMIJ CRM 4220-a
- PFOA (high purity material)
NMIJ CRM 4056-a

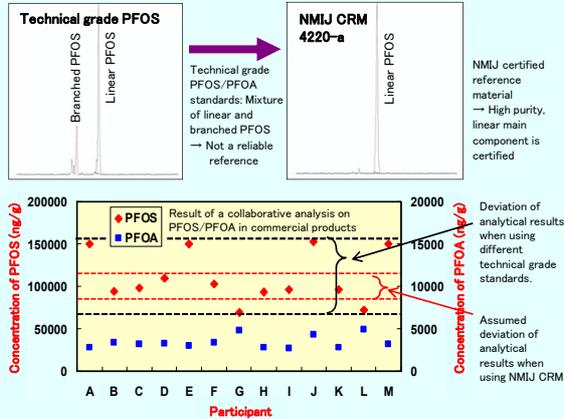
These certified reference materials can also be applied to confirm the validity of official methods provided in the Japan Industrial Standards, and are useful to ensure traceability of analytical results to the International System of Units.

- Testing methods for PFOS and PFOA in industrial water and wastewater
JIS K 0450-70-10:2011

Industrial needs

- Quality control of analyses is required based on reference materials similar in concentration and composition to the actual industrial materials because regulatory values on PFOS and PFOA have been specified in commercial products in Europe.

Contributes to management of environmental risks and compliance with regulations for industrial products



(Revised based on the abstract for 19th Symposium on Environmental Chemistry, 2010, Ooi et al.)



- Utilizing certified reference materials
- Advances the reliability of analysis
 - Ensures the traceability of analytical results
 - Assists in improvement of analytical skill of analysts
- Maintains international competitiveness among the export industry
Properly manages and controls environmental risk

52. Examples of utilizing reference materials for biofuel analysis

What are biofuels?

The popularity of biofuels such as biodiesel fuel synthesized from oil including canola oil, palm oil and waste cooking oil; and bioethanol produced from sugarcane and wood is increasing as a measure against global warming. However, these may cause engine troubles due to moisture absorption, oxidation and raw material derivative contamination. In addition, biofuels are given preferential tax treatment but there are possibilities of camouflage by items produced from raw materials that are not derived from biomass, and there is a demand for appropriate quality control to accompany the popularization of biofuels.

Developing, maintaining and supplying reference materials

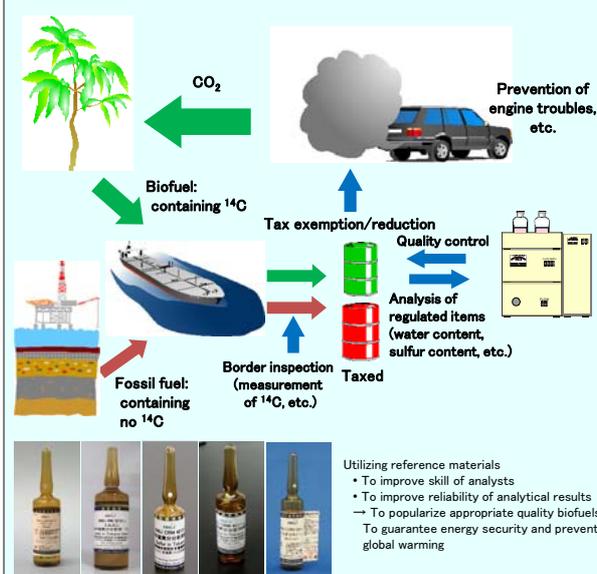
Regarding measurements that conform to such as the Japan Industrial Standards (JIS K 2190 and JIS K 2390) for quality control of biofuels and official analytical method (ASTM D 6866) for biomass ratio determination, the reference materials are used to evaluate the skill of analysts and check the validity of instruments and analytical methods in addition to calibrate analytical instruments.

- High purity ethanol (Certified value: purity, indicative value: carbon 14 concentration)
NMIJ CRM 4001-b
- Standard solution for analyzing sulfur content in fuel (Certified value and indicative value: sulfur content)
NMIJ CRM 4215-a, CRM 4217-a, RM 4216-a, CRM 4221-a
- Bioethanol (Certified value: water, methanol, sulfur, copper concentration)
NMIJ CRM 8301-a
- High purity triolein (value: purity)
NMIJ CRM 6009-a

Industrial needs

- Quality control of more various types of fuels with reference materials such as dimethyl ether (DME), biodiesel fuels, etc.

Contributing to biofuel popularization



- Utilizing reference materials
- To improve skill of analysts
 - To improve reliability of analytical results
- To popularize appropriate quality biofuels
To guarantee energy security and prevent global warming

53. Examples of utilizing reference materials for clinical examination

What is NMIJ certified reference material?

At the National Metrology Institute of Japan (NMIJ), certified reference materials with "metrologically" correct values of such as concentration and purity are developed. These are essential to maintaining reliability for chemical analysis, evaluating analysis methods and calibrating analysis equipment.

Developing, maintaining and supplying reference materials for clinical examination

In order to be able to mutually compare and evaluate clinical examination data obtained using any type of measurement methods and equipment, at anytime and anywhere, developing a reference material based on "universal values" and using it as a common reference is effective. To achieve this, NMIJ is developing certified reference materials for clinical examination as shown below.

- Pure substance reference materials that have certified values for substance purity existing in living organisms as metabolites and hormones, etc.
- Serum reference materials that have certified values for steroid hormone concentration
- Standard solutions for proteins and peptides measured as hormones and markers, etc.

These reference materials

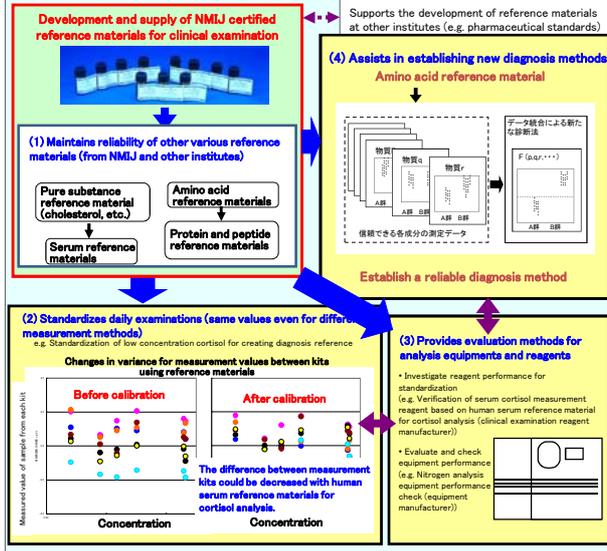
realize standardization of daily examinations by being used in evaluation and assigning values for calibrating products provided by manufacturers of clinical examination reagents (by establishing measurement traceability).



Industrial needs

- Various reference materials are required because there are many items covered in clinical examinations.

Contributes to maintaining compatibility and reliability for clinical examinations



54. Examples of utilizing quantitative NMR technology

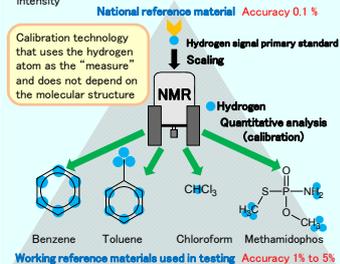
What is quantitative NMR technology?

This is calibration technology that uses nuclear magnetic resonance (NMR) equipment. By measuring the amount of hydrogen nuclei in a chemical substance, the amount of substance (mole) even for chemical substances which do not have national standards can be accurately determined. With this technology, a rapid development in measurement standards is expected.



Developing, maintaining and supplying reference materials (Quantitative NMR technology development)

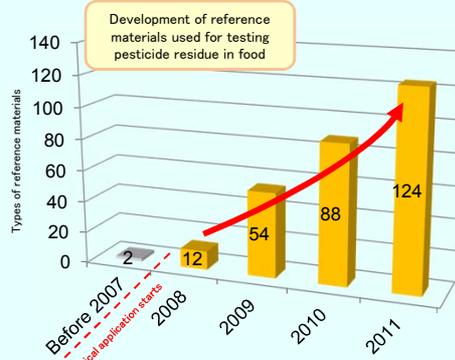
- Improve measurement accuracy for a level that can calibrate reference materials
- Develop reference material for referencing hydrogen signal intensity



Contributes to food safety by enhancing calibration technology for reference materials

- Improves the food safety by maintaining reliability of testing for pesticide residue in food for quarantine, etc.

Pesticides constantly monitored at quarantine stations: 200 types



55. Examples of utilizing reference materials for PCB analysis

What is PCB (polychlorinated biphenyl)?

PCB has excellent properties and was widely used as an insulating oil and for other products. However, its toxicity and persistence in the environment have become clear so that its complete treatment is being promoted based on an Act on Special Measures.



Developing, maintaining and supplying certified reference materials (CRMs)



NMIJ CRM 7902-a to 7905-a: Mineral oil CRMs for PCB analysis



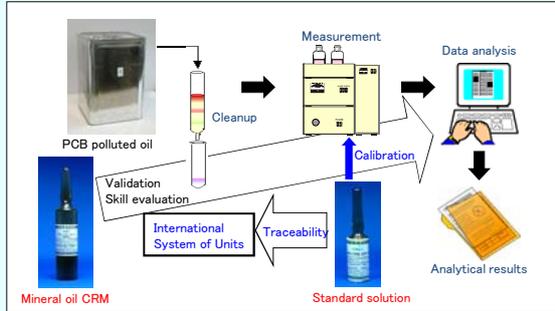
NMIJ CRM 7906-a: PCB mixture in nonane (standard solution)

FY 2005: PCB standard solutions (6 types) were certified
 FY 2007: Mineral oil CRMs for PCB analysis (4 types: insulating oil and fuel oil; high and low PCB concentrations) were certified
 FY 2011: PCB mixture in nonane was certified

Industrial needs

- Quality control for various samples (insulating oil types)
- Analytical methods independent of PCB congeners or expansion of certification items.

Contributions to rapid and accurate analysis of PCB



Correct evaluation of health and environmental risk, determination of PCB before and after decomposing treatment, validation of new analytical method, and facilitation for PCB treatment



Absorbent for PCB separation for accurate analysis: Commercialized in 2009 by SUPELCO based on an AIST patent

JIS K 0464: 2009 (Guidances for PCB immunoassay): NMIJ mineral oil CRMs for PCB analysis were cited as reference materials for quality control of analysis.

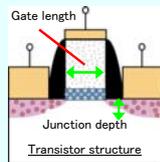
"Official Methods for Simple Determination of PCB in Insulating Oil (2nd edition)" Ministry of the Environment (2010): NMIJ PCB CRMs (standard solutions and mineral oils) were cited and two analytical methods using the absorbent were adopted.

56. Examples of utilizing reference materials for semiconductor device development

What are reference materials for semiconductor device development?

Chemical analysis and highly-reliable evaluation of physico-chemical properties are required for the effective semiconductor miniaturization. These reference materials are apposite for the use in precision control of analysis.

Ion implant certified reference material (CRM)



A standard is required for chemical analysis of ions implanted to a depth suitable for the device size.

Dopants (arsenic, etc.) to attain electrical conductivity



Certified reference materials for calibrating dopant concentrations at an ultra shallow depth (to 15 nm) were developed.

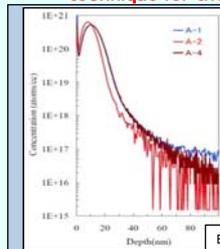


CRM	Certified value (ng/cm ²)	Expanded uncertainty (ng/cm ²)
5603	381.7	9.0
5604	78.6	2.1

Industrial needs

- Due to a further need in electric properties for insulating thin films, suitable CRMs are required and are being developed.

For strengthening competitiveness in global semiconductor industry through the highly-reliable technique for the ultra-shallow depth evaluation



Example of SIMS results for CRM 5604a.

The CRM was used as a reference standard for controlling the precision of the analyzed data at an interlaboratory comparison for shallow-doped arsenic analysis using secondary ion mass spectrometry (SIMS) in the international standard support businesses project for nano-level analysis technology.

Cited from: International standard support businesses report for nano-level analysis technology with regards to the mechanical industry in FY 2011, Japan Research Industries and Industrial Technology Association

Calibration using this CRM allows quantitative comparison for the data recorded by various users.

Calibration using identical matrix

Cited from: Feasibility study report regarding enhancements to analysis technology for advanced technological research and development fields in the mechanical industry, The Mechanical Social Systems Foundation



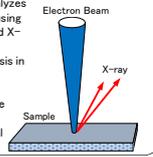
Contributes to establishing a standard system for the quantitative analysis of ion implants in materials for semi-conductor devices.

57. Examples of utilizing reference materials for electron probe microanalysis

What is electron probe microanalysis (EPMA)?

EPMA is a surface analysis technique that analyzes the constituent elements of the materials by using a fine electron beam and detecting the emitted X-rays. Features are as follows:

- Widely used for material composition analysis in medicine, semi-conductors, minerals and iron/steel.
- Comparatively high precision in quantitative analysis.
- Can analyze microscopic regions of several microns.



Developing, maintaining and supplying reference materials for EPMA

Iron based alloy standards with practically useful compositions are supplied to improve EPMA quantitative analysis.

- | | |
|----------------------------------|-----------------|
| • Fe-Cr alloy Reference Material | CRM1001 to 1005 |
| • Fe-Ni alloy Reference Material | CRM1006 to 1010 |
| • Carbon Steel for EPMA | CRM1011 to 1015 |
| • Stainless Steel for EPMA | CRM1017 |
| • Ni(36%)-Fe Alloy for EPMA | CRM1018 |
| • Ni(42%)-Fe Alloy for EPMA | CRM1019 |
| • High Nickel Alloy for EPMA | CRM1020 |

Concentrations were certified using chemical analysis based on titration methods.



Industrial needs

- These standards benefits EPMA analysis that is suitable for in-plane composition analysis in micro scale.

Contributes to product assurance by maintaining highly accurate material measurement

Certified reference materials (CRMs) for EPMA

Ensures analysis precision

EPMA analysis is extensively used for:

- (Iron/steel) Evaluating carburized layer and decarburized layer, grain boundary evaluation of stainless steel, precipitates analysis, etc.
- (Electrical) Evaluating alloy composition at soldered sections, element distribution of the electrode cross section, composition of the display thin film, etc.
- (Magnetic) Grain boundary analysis, etc.

★ The supply of the reference materials is essential for the daily measurement calibration and makes sure to control the production quality through the measurement.

Links to international standards

Guidelines established by ISO/TC202

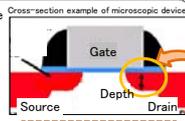
- ISO 14595: Guidelines for the specification of CRMs
- ISO 14594: Guidelines for the determination of experimental parameters for wavelength dispersive spectroscopy
- ISO 17470: Guidelines for qualitative point analysis by wavelength dispersive X-ray spectrometry
- ISO 22489: Quantitative point analysis for bulk specimens using wavelength-dispersive X-ray spectrometry
- ISO 16592: Guidelines for determining the carbon content of steels using a calibration curve method

★ Extensive use of EPMA has driven the establishment of the international standards. Both the guidelines and the reference materials help the accurate material measurements.

58. Examples of utilizing thin film standards for compositional depth profile analysis

What is compositional depth profile analysis?

For the analysis of advanced materials using multiple thin-film layers, the element distribution in depth direction needs to be measured within several nm resolutions. A typical technique used is the secondary ion mass spectrometry (SIMS) in which the surface species are measured by an ion beam irradiation sputtering the sample surface.



Depth profile is calibrated by using a depth scale.

Element depth-distribution analysis within several 10 nm

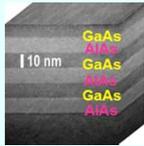
Developing, maintaining and supplying thin-film standards

The certified reference materials (CRMs) consist of thin-film layers of which thickness are defined and are:

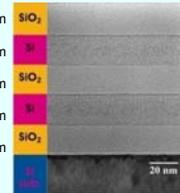
- made of SiO₂/Si.
- made of GaAs/AIAs.
- single-layer or multi-layer thin film.

Development of certified reference material for semi-conductor device analysis is prioritized, because of the large demands on the accurate depth-profile evaluation.

NMIJ CRM 5201a



NMIJ CRM 5202a



Each layer thickness acts as a calibration scale.

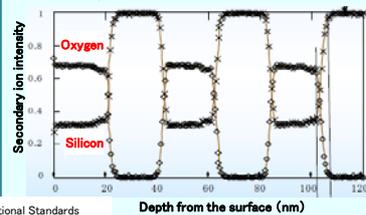
Industrial needs

- There is a need to develop thin-film standards with improved quality in response to analysis technology improvements

International standards linking to CRMs for high precision film-thickness measurements

Application of the secondary ion mass spectrometry (SIMS)

Extensive usage for depth profile analysis



International Standards established by ISO/TC201

Shows element distribution in depth direction

International standards working together with CRMs

- ISO14606** Optimization using layered systems as reference materials
- ISO20341** Method for estimating depth resolution parameters with multiple delta-layer reference materials
- ISO23812** Method for depth calibration for silicon using multiple delta-layer reference materials

59. Examples of utilizing reference materials for nanopore evaluation

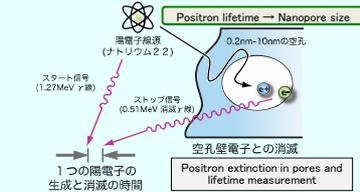
What are nanopores?

Since the intermolecular spaces in substances, i.e. nanopores, affects various physical properties including the refractive index and thermal conductivity, "how to form, evaluate and utilize nanopores" is a key factor for the development of functional materials in the environmental science field and nanotechnology field.

Therefore **Nanopore measurement with high reliability is important!**

Developing, maintaining and supplying reference materials for nanopore evaluation

Much emphasis is being placed on positron lifetime measurements that can detect nanopores to a high sensitivity level and standards are being developed to ensure reliability and equivalence of results from different labs.



- Developing high precision positron lifetime measurement technology
- Establishing the quality system for producing certified reference materials for positron lifetime measurement
- Establishing lifetime measurement protocols and verifying based on an interlaboratory comparison

Industrial needs

- Development of reference materials that is applicable to the evaluation of semi-conductors and metals.
- Expand and improve the support range using other methods such as highly-sensitive adsorption methods.

For R&D of innovative materials with engineered nanopores

Development of the world's first nanopore reference material



NMIJ CRM 5601a:
Synthetic fused silica for positron hole-size measurements
(Certified value: 1.63 ns, converted radius: 0.26 nm)

NMIJ CRM 5602a:
Polycarbonate for positron hole-size measurements
(Certified value: 2.10 ns, converted radius: 0.29 nm)

Establishment of measurement standards for positron lifetimes



That can offer improved reliability in positron lifetime measurements for polymer materials along with the above certified reference materials.

Expected to be used by analysis service companies, domestic/international universities and research institutes

