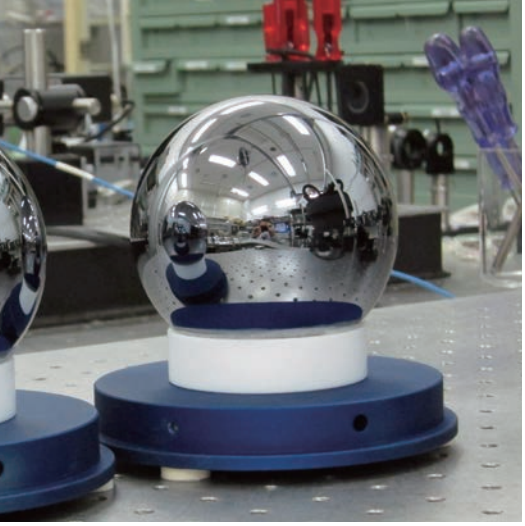
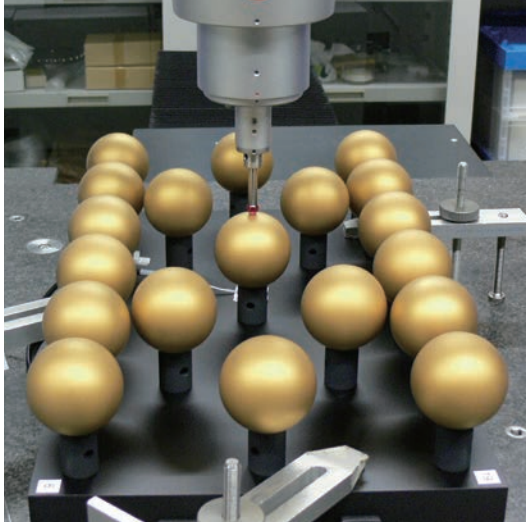
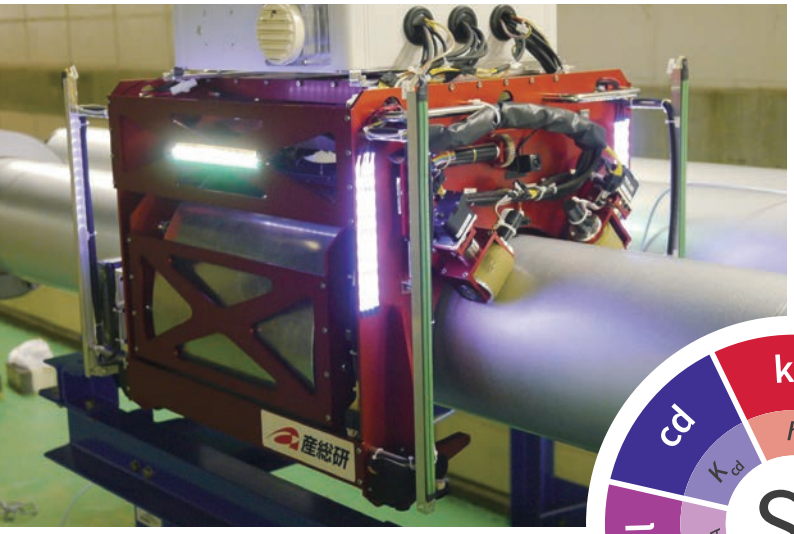
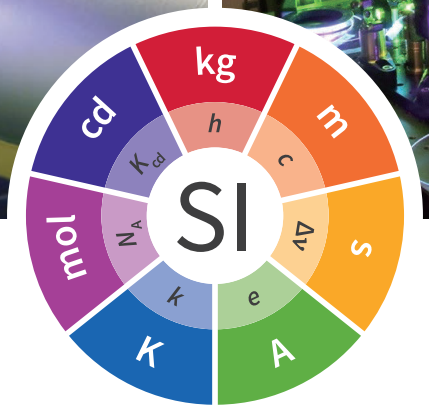








NATIONAL INSTITUTE OF
ADVANCED INDUSTRIAL SCIENCE
AND TECHNOLOGY (AIST)

National Metrology Institute of Japan

AIST

Greetings from the Director General

USUDA Takashi
Director General of NMIJ
Executive Officer of AIST

Measurement standards play a vital role in society by guaranteeing the reliability of acts of measurement, and the results of such acts, which make up the infrastructure of daily life, industry, research, and much more. The National Metrology Institute of Japan (NMIJ), which is the national metrology institute (NMI) in Japan, was established in 2001 as a part of the National Institute of Advanced Industrial Science and Technology (AIST) to integrate all former national research institutes and related offices. Since then, NMIJ has actively engaged in the establishment and dissemination of internationally equivalent measurement standards to society.

With the support and understanding of the stakeholders and industries, calibration services that are traceable to the NMIJ have become widespread under the Japan Calibration Service System (JCSS). Additionally, we were heavily involved in the determination of the Planck constant for the kilogram, which was one of the base units of the International System of Units (SI) redefined in May 2019. The NMIJ has contributed to the development of the international measurement standards and has also carried out other fundamental, essential research efforts that will be vital to the next generation of metrology and measurement standards.

However, as the state of the industrial world has grown more challenging, the demand for ever more precise measurements has grown beyond all initial expectations. As a result, the need for ever more precise measurement standards, as well as fast and simple calibration services, has blossomed as well. We even see this in our daily domestic lives, where there are ongoing requirements to improve the reliability of commercial transactions involving new types of consumption, such as subscription services and the digital economy.

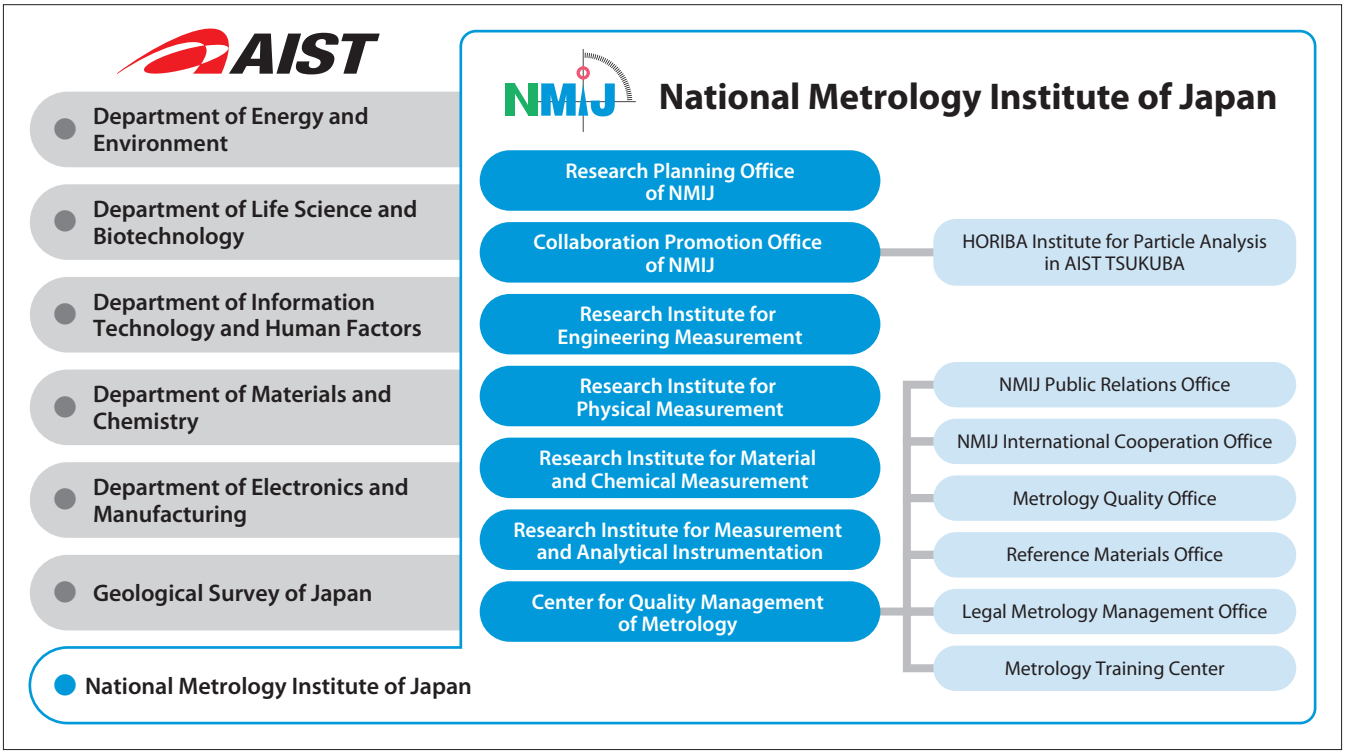
With these points in mind, the NMIJ will continue to work earnestly on the development and dissemination of the measurement standards that meet both the demands of industry and the trends in our modern consumer society. At the same time, we will continue our work on the development of measurements and analysis technologies required by modern industry and endeavor to ensure the reliability of measurements used in commercial transactions in legal metrology.

AIST entered its 5-year-midterm period on April 1, 2020. AIST has been pioneering solutions to social issues and developing innovations that contribute to strengthening economic growth and industrial competitiveness. Looking ahead, AIST is focusing on the following three themes:

- Enhancing research and development that lead to innovations aimed at solving societal issues
- Strengthening innovation ecosystems through the expansion of "bridging" functions
- Developing the infrastructure underpinning innovation ecosystems

The NMIJ will continue to work on research and development in collaboration with other AIST research departments and external organizations to contribute to solving these societal issues.

Accordingly, we would like to ask for your continued understanding, support, and cooperation as we look ahead to the future.



Activities Related to Measurement Standards and Legal Metrology

The NMIJ, in collaboration with other NMIs, is working on the smooth supply, dissemination, and enlightenment of measurement standards, the quality control of supply services, the training of certified measurers, and the execution of legal metrology services. To facilitate those efforts, we actively support numerous activities, including those listed below.

Technical Seminars, Publications, and Personnel Training for Metrology

●Technical Seminar and Publications

The NMIJ organizes a variety of activities such as seminars, lectures, symposium, NMIJ measurement club and presents displays at exhibitions, to promote the utilization of the measurement standards and to enlighten on the need for metrological traceability. In addition, NMIJ disseminates the outcome of the activities related to metrology and measurement technologies via website and brochures.

Exhibition display

●Personnel Training for Metrology

While the primary mission of our Metrology Training Center is to train applicants for the national qualification of certified measurer, it also provides various training activities to support metrology-related personnel employed by prefectural and city governments, as well as engineers in private companies. These opportunities include general measurement training, special measurement training, environmental measurement special training, and short-term measurement training.

General measurement training

International Activities

In the current era of economic globalization, measuring instruments, calibration certificates, and the results of type approval tests in legal metrology have become mutually recognized by many countries as part of efforts to remove barriers to international trade. These mutual recognitions are based on the premise that international equivalences in national measurement standards and testing capabilities must be mutually confirmed and approved among the participating countries. To make this system function more effectively, the NMIJ is actively engaged in building cooperative relationships with international organizations and other NMIs, and conducting international comparisons. We are also actively holding international conferences and workshops, hosting overseas researchers, and supporting developing countries by providing trainings.

The Emerging Scientist Workshop 2017, which was joined by young researchers from NMIJ, KRISS (Korea), and NIM (China)

Dissemination of the Measurement Standards

●Calibration and Testing Services

The results of our research and development efforts for measurement standards are disseminated to society through calibration and testing services. We also conduct calibration of reference standards and testing services for customers at our calibration laboratories. These services are conducted under a management system based on ISO/IEC 17025, thus ensuring their reliability and international equivalence.

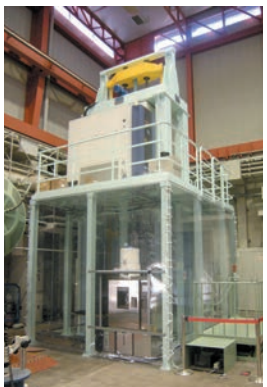
●Distribution of the Certified Reference Materials

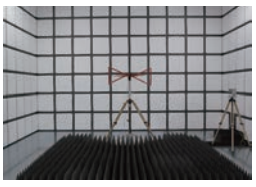
The NMIJ produces and distributes Certified Reference Materials (NMIJ CRMs), which are produced by the NMIJ's management system to comply with ISO 17034 and ISO/IEC 17025. The CRMs are intended to facilitate the calibration of analytical instruments and for use in the evaluation of analytical methods.

※ISO/IEC 17025 General requirements for the competence of testing and calibration laboratories
※ISO 17034 General requirements for the competence of reference material producers

NMIJ Certified Reference Materials

Legal Metrology





▲ Radiated, radio-frequency, electromagnetic field immunity tests

◀ Test equipment for high-capacity load cells

In Japan, non-automatic weighing instruments (NAWI), automatic weighing instruments (AWI), water meters, taximeters, and other measuring instruments that contribute significantly to the reliability of transactions and certifications are stipulated in the Measurement Act as specified measuring instruments, and type approval for such instruments is required. The NMIJ is responsible for issuing type approval for most of the specified measuring instruments and the inspection of verification standards. As a member of the International Organization of Legal Metrology (OIML) Certification System (CS), the NMIJ is also responsible for maintaining a testing laboratory as well as serving as an issuing authority in the instrument categories on R 60 (load cells) and R 76 (non-automatic weighing instrument) in Scheme A. OIML certificates issued in other countries may be accepted based on the mutual recognition arrangements made under OIML-CS.

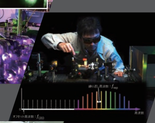
Developing, Maintaining, Disseminating, and Promoting Utilization of Measurement Standards

The NMIJ develops next-generation measurement standards based on the redefinition of the SI units, develops and maintains measurement standards that meet industrial and social needs, and reliably disseminates established measurement standards. Furthermore, the NMIJ pursues a sophisticated measurement traceability system to promote the utilization of measurement standards in the areas mentioned below.

Time

The SI unit of time, the second, is defined by taking the fixed numerical value of the caesium frequency $\Delta\nu_{Cs}$ to be 9 192 631 770 when expressed in the unit Hz, which is equal to s^{-1}. We are now in the process of developing 'optical lattice clocks', which will be based on optical transitions in an ensemble of neutral atoms trapped in the optical lattices, as part of efforts to achieve much lower uncertainty than the present definition.

Optical lattice clock



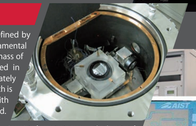
Optical frequency comb system

Length

The SI unit of length, the metre, is defined by the speed of light in vacuum. The length standards are developed and disseminated based on the laser frequencies calibrated by an optical frequency comb with an accuracy of 10^{-15}. The optical frequency comb links the optical frequencies to the microwave frequency standard.

Mass

The SI unit of mass, the kilogram, is defined by the Planck constant, which is a fundamental physical constant associated with the mass of one atom. We have already succeeded in developing the technology to accurately count the atoms in a silicon sphere, which is necessary to create a mass standard with the highest level of accuracy in the world.



Laser interferometer to measure the diameter of a silicon sphere with sub-nanometer uncertainty

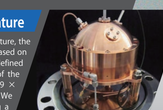
Josephson array device integrated with 500 000 junctions and the programmable Josephson voltage standard

Electric current

The SI unit of electric current, the ampere, is defined by taking a fixed numerical value of the elementary charge, which is the magnitude of the electric charge for one electron. We are now developing quantum current standards based on this definition using single-electron pump devices and improving both the Josephson Voltage Standard and the Quantized Hall Resistance Standard.

Thermodynamic temperature

The SI unit of thermodynamic temperature, the kelvin, which was previously defined based on the triple point of water, has been redefined by taking the fixed numerical value of the Boltzmann constant k to be 1.380 649 × 10^{-23} when expressed in the unit J K^{-1}. We are now in the process of developing a system that will make thermodynamic temperature measurements applicable over an extended temperature range.



Acoustic gas thermometer for thermodynamic temperature measurement

Nuclear magnetic resonance (NMR) apparatus

Amount of substance

The SI unit of amount of substance, the mole, is defined by the Avogadro constant. We are now developing advanced technologies, such as nuclear magnetic resonance (NMR) spectroscopy, that can measure amount of substance quickly and accurately.

Luminous intensity

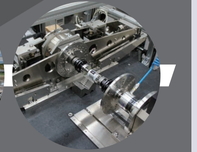
The SI unit of luminous intensity, the candela, is defined by taking the fixed numerical value of the luminous efficacy of monochromatic radiation of frequency 540 × 10^{12} Hz, K_{cd}, to be 683 when expressed in the unit lm W^{-1}. The luminous efficacy represents the response to light by human vision. Luminous intensity is a quantity that describes light intensity emitted to a specific direction, and its scale is traceable to the electrical-substitution cryogenic radiometer.

Instruments to be used to realize luminous intensity scale (electrical-substitution cryogenic radiometer, SI trap detector, and luminous intensity standard lamp)

Derived quantities

The NMIJ is maintaining and disseminating the measurement standards for derived quantities, such as flow rate (m^3/h), torque (N·m), density (kg/m^3), pressure (Pa), electric field strength (V/m), absorbed dose (Gy), and so on, which are essential for daily life and use in industries.

Water flow calibration facility



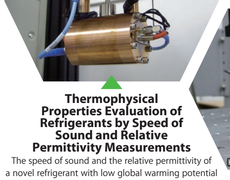
10 N·m deadweight type torque standard machine

Support for Manufacturing and Services

The NMIJ is developing measurement technologies that are indispensable for ensuring the reliability of IoT, next-generation communication infrastructures that support high-quality product manufacturing, and emerging trends in various manufacturing industries such as automobiles.

Millimeter and Terahertz Waves Measurement Technology

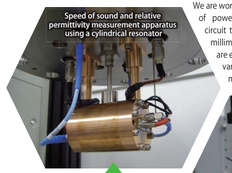
We are working on technological developments in the fields of power measurement, attenuation measurement, circuit testing, and material characterizations in the millimeter and terahertz wavebands – all of which are expected to have important applications in various fields such as next-generation mobile communications.



High-sensitivity terahertz power sensor

Thermophysical Properties Evaluation of Refrigerants by Speed of Sound and Relative Permittivity Measurements

The speed of sound and the relative permittivity of a novel refrigerant with low global warming potential are simultaneously measured to evaluate its performance in the thermodynamic cycle.



Speed of sound and relative permittivity measurement apparatus using a cylindrical resonator

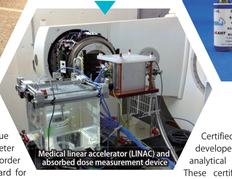
Inspection device for metering accuracy of hydrogen refuelling dispensers

Hydrogen Refuelling Dispenser Metering Accuracy

We are developing an inspection technique for metering accuracy using the master meter traceable to gas flow rate national standard in order to implement a suitable measurement standard for transactions at hydrogen refuelling stations.

Dosimetry Standards for Supporting Radiation Therapy

Radiation is widely used in the medical and industrial sectors. We are actively developing radiation measurement techniques and radiation therapy standards for safety and assurance.



Medical linear accelerator (LINAC) and absorbed dose measurement device

Certified Reference Materials for Use in Doping Analysis

Certified reference materials have been developed as required for calibration of the analytical instruments used in doping analyses. These certified reference materials contribute to accurate testing in sporting events such as the Olympic and Paralympic Games.

Certified reference materials for use in doping analysis (2 types)

Smart Calibration Techniques for Organic Analytes

We are developing innovative calibration techniques for organic analytes such as quantitative nuclear magnetic resonance (qNMR) that will enable the calibration of various analytes from single primary standards.

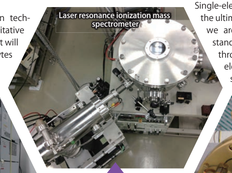
Combination of separation and qNMR techniques

Support for Biological, Medical, and Agricultural Industries

The NMIJ is developing medical radiation evaluation technology that supports improvements to medical equipment, quantitative evaluation and functional analysis technology that enables the expansion of the use of biological components, and food-related measurement technology that will become indispensable for our future safe living environments.

Mass Spectrometric Technique with High Sensitivity and Selectivity

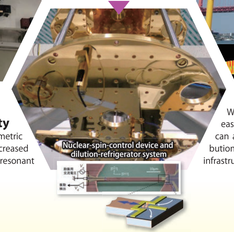
We are developing mass spectrometric techniques for higher sensitivity and increased accuracy via laser ionization at the resonant wavelengths of atoms and molecules.



Laser resonance ionization mass spectrometer

Single-electron Control Technology

Single-electron control is a technology that achieves the ultimate in measurement accuracy. At the NMIJ, we are working to realize quantum current standards and small current measurements through the development of single-electron pumps and sensors, nuclear-spin control, etc.



Nuclear-spin-control device and dilution-refrigerator system

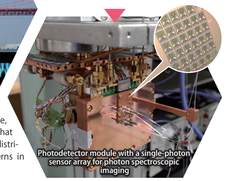
Moiré Methodology

We are developing an inexpensive, easy-to-use moiré imaging technique that can accurately measure displacement distributions by recording the periodic patterns in infrastructures.

Deflection measurement of bridges

Single-photon-based Spectroscopic Imaging Technology

We are developing a single-photon-based imaging sensor comprised of superconducting transition-edge sensors as an ultra-sensitive photon detector that makes the maximum use of the quantum nature of light.



Photodetector module with a single-photon sensor array for photon spectroscopic imaging

Development of Advanced Measurement and Evaluation Technology

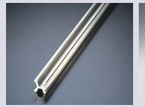
The NMIJ is aiming at the realization of advanced measurement and evaluation technologies that will lead to the creation of new value for objects that are difficult to measure by extending existing technologies. These include quantum measurements, ultra-trace measurements, and extreme state measurements.

Contribution to Solving Social Issues, Strengthening Industrial Competitiveness, and Innovation Creation

Transition of Units and Standards

1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

- Sanction of the international prototypes of the metre and the kilogram (1889)
- Japan becomes a member state of the 'Metre Convention (Convention du Mètre)' (1885)
- Development of Weston voltage standard cell (1892)
- Promulgation of the Weights and Measures Act (1891)
- Promulgation of the Electrical Measurement Act (1910)
- Revision of the International Temperature Scale (1948)
- Definition of thermodynamic temperature by the triple point of water (1954)
- Enforcement of the Measurement Act (1952)
- International comparison of luminous intensity using M-shaped luminous intensity standard lamp (1957)
- Definition of length by the wavelength of ^{86}Kr (1960)
- Adoption of "The International System of Units" (1960)
- Definition of time by using caesium atomic clock (1967)
- Japan becomes a member state of the OIML (1961)
- Development of standard platinum resistance thermometer (1971)
- Revision of the International Temperature Scale (ITS-90) (1990)
- Adoption of the Josephson effect voltage standard (1977)
- Definition of luminous intensity by monochromatic radiation (1979)
- Definition of length by the speed of light (1983)
- Shift to the quantum Hall effect resistance standard (1990)
- Revision of the conventional value of the Josephson constant (1990)
- Development of high temperature fixed points of the metal-carbon eutectics (1998)
- Specification of the optical frequency comb as Japanese national standard of length (2009)
- Determination of high accuracy measurement of the Avogadro constant (2004)
- **Enforcement of the redefinition of the SI base units (2019)** (kilogram, ampere, kelvin, and mole)



The national prototype of the metre of Japan

The national prototype of the kilogram of Japan

Weston voltage standard cell

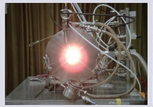
Water triple-point cell

M-shaped luminous intensity standard lamp

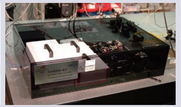
Krypton lamp

Josephson voltage standard device

Iodine stabilized He-Ne laser



High-temperature fixed points of the metal-carbon eutectics



Optical frequency comb

1 kg silicon single-crystal sphere to determine the Avogadro constant

History

1880 1890 1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010 2020

- Electrotechnical Laboratory
- Central Inspection Institute of Weights and Measures
- Weights and Measures Training Institute
- National Research Laboratory of Metrology
- Electrotechnical Laboratory
- Central Inspection Institute of Measuring Instrument
- National Metrology Institute of Japan
- Government Industrial Research Institute
- The Government Chemical Industrial Research Institute, Tokyo
- Silk Laboratory
- Textile Research Institute
- Industrial Art Institute
- Industrial Arts Institute
- National Chemical Laboratory for Industry
- Research Institute for Polymers and Textiles
- Industrial Products Research Institute
- National Institute of Materials and Chemical Research
- Independent Administrative Agency National Institute of Advanced Industrial Science and Technology
- National Metrology Institute of Japan
- National Research and Development Agency National Institute of Advanced Industrial Science and Technology
- National Metrology Institute of Japan

Overall view of AIST Tsukuba Central

AIST Tsukuba Central 3-1 Building

AIST Tsukuba Central 3-9 Building

Organization

National Metrology Institute of Japan

【Director General】
USUDA Takashi

【Deputy Director General】
KOBATA Tokihiko

Research Planning Office of NMIJ

The Research Planning Office (RPO) decides on research policies and strategies, and then creates research projects and their budgets. The RPO also serves as a liaison with other AIST research departments, the Ministry of Economy, Tade and Industry (METI), other national research and development agencies, universities, and other related organizations.

【Director, Research Planning Office】
AKOSHIMA Megumi

Collaboration Promotion Office of NMIJ

The Collaboration Promotion Office (CPO) plans and promotes collaboration with external organizations such as companies, regarding research activities of the NMIJ. The CPO also promotes and supports technology transfers to companies, as well as conducts research and development activities on a Cooperative Research Laboratory.

【Director, Collaboration Promotion Office】
SHITOMI Hiroshi

Research Institute for Engineering Measurement

Development of measurement technologies and national standards contributing to manufacturing industries

URL : https://unit.aist.go.jp/riem/en/intro/

Among our missions is the development of measurement technologies and measurement standards such as dimension, mass, mechanics, flow, and their related quantities, which are indispensable for creating high-quality products in the manufacturing industries. These efforts include work aimed at solving social issues such as technological developments and standardization to facilitate the advancement and expansion of hydrogen infrastructure, along with promoting technological developments for extending infrastructure lifespans. In the realization of mass based on new SI unit definitions, we will cooperate with countries around the world to promote the spread of the new kilogram. In addition, we will actively promote the development of next-generation measurement standards, such as microforce technology, and also continue contributing to industrial standardization, conformity assessment, and accreditation efforts. Another mission in our institute is to conduct type approval and inspection of verification standards in legal metrology, which help to protect consumers in commercial transactions.

Length Standards Group
Dimensional Standards Group
Mass Standards Group
Force and Torque Standards Group
Pressure and Vacuum Standards Group
Material Strength Standards Group
Liquid Flow Standards Group
Gas Flow Standards Group
Research Group on Data Science for Metrology
Type Approval Group
Testing and Inspection Group
Legal Weighing Metrology Group
Legal Flow Metrology Group

【Director】
OTA Akihiro

Research Institute for Physical Measurement

Measurement standards and measurement technologies in the fields of electricity, time and frequency, temperature, and optical radiation – all of which support industrial infrastructure

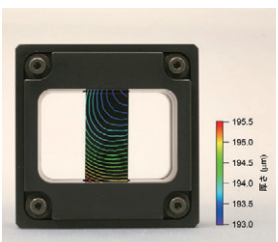
URL : https://unit.aist.go.jp/ripm/en/

The Research Institute for Physical Measurement (RIPM) is responsible for the development and dissemination of national measurement standards in the fields of electricity, time and frequency, temperature, and optical radiation – all of which underpin the industrial competitiveness, product reliability, and safety in our daily lives. To that end, the RIPM is engaged in cutting-edge research and development (R&D) for measurement standards such as optical lattice clocks towards the redefinition of the second, and quantum current standards using single-electron pump devices for quantum metrology triangle experiments. The RIPM also develops measurement technologies for promoting industrial innovations, such as the generation and application of optical frequency combs, single-photon detection/imaging, material characterization and sensing technologies using electromagnetic waves, and precise electric measurements for thermoelectric devices.

Time Standards Group
Optical Frequency Measurement Group
Quantum Electrical Standards Group
Applied Electrical Standards Group
Electromagnetic Measurement Group
Radio-Frequency Standards Group
Electromagnetic Fields Standards Group
Thermometry Research Group
Optical Thermometry Group
Applied Optical Measurement Group
Photometry and Radiometry Research Group
Advanced Quantum Measurement Group

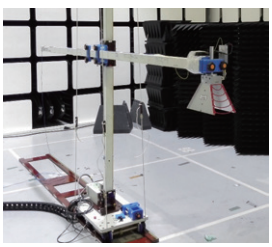
【Director】
HOSAKA Kazumoto

Pressure calibration system for high-pressure gas

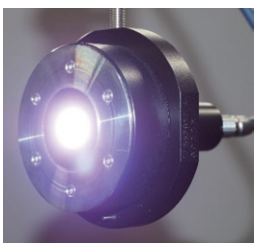


Thickness distribution measurement of a silicon wafer

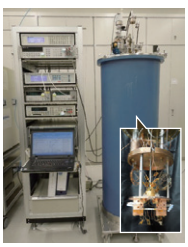
Balances (inspection of verification standards)



Broadband antenna gain measurement system



LED-based standard source



Thermoelectric property measurement system

2023, Oct.

Center for Quality Management of Metrology

Dissemination of measurement standards that ensure the quality of metrological traceability

URL : https://unit.aist.go.jp/nmij/english/info/center/

The Center for Quality Management of Metrology (CQMM), which is responsible for administrative support tasks in NMIJ, has an important role of promoting the results of activities related to metrology and measurement to our society while ensuring the proper dissemination of measurement standards. The CQMM performs public relations and consulting related to measurement standards and legal metrology in collaboration with international organizations such as NMIs and other international legal metrology organizations. The CQMM also provides administrative support for issues pertaining to calibration, testing, and verification services, distributes certified reference materials, and cooperates with central and local governments both to ensure the integrity of the national legal metrology system and provide training related to metrology and measurement.

【Director】
TAKETOSHI Naoyuki

NMIJ Public Relations Office
NMIJ International Cooperation Office
Metrology Quality Office
Reference Materials Office
Legal Metrology Management Office
Metrology Training Center

Research Institute for Material and Chemical Measurement

Establishment of dependable measurement infrastructure via material and chemical metrology

URL : https://unit.aist.go.jp/mcml/en/intro/

The Research Institute for Material and Chemical Measurement develops and disseminates certified reference materials that support the basics of chemical analysis, and conducts research and development on measurement, analysis and evaluation technologies for chemical industries. Typical certified reference materials include pH standard solutions and elemental standard solutions, which support the basis of chemical analysis; biological or composition-based reference materials, which are indispensable to ensure safety of our life and foods; and reference materials for advanced materials used in the development and production of high-quality industrial products. In addition, comprehensive databases with stated reliability, which are useful in the field of materials, metrology and evaluation technologies, are provided and further improvement of the databases is being pursued.

Reference Material Evaluation Group

Inorganic Standards Group
Reference Material Evaluation Group
Gas and Humidity Standards Group
Organic Analytical Standards Group
Organic Primary Standards Group
Bio-medical Standards Group
Particle Measurement Research Group
Thermophysical Property Standards Group
Nanomaterial Structure Analysis Research Group
Nanodimensional Standards Group
Material Structure and Property Analysis Research Group

【Director】
GONDA Satoshi

Research Institute for Measurement and Analytical Instrumentation

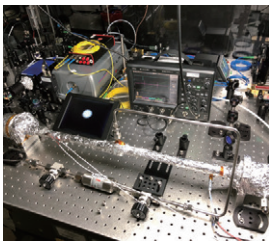
Measurement standards and advanced measurement technologies supporting industrial analysis and inspection

URL : https://unit.aist.go.jp/rima/en/

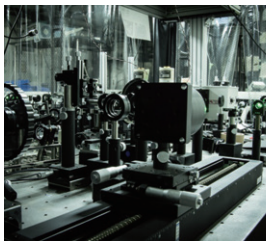
Our mission is to develop and disseminate national measurement standards for ionizing radiation, acoustics, and vibration, which are supplied to users in healthcare and a wide range of industries. National measurement standards for ionizing radiation and radioactivity have been disseminated for radiation therapy facilities and radiation protection, while advanced standardized neutron technologies are under development for novel boron-neutron capture therapy (BNCT). In addition, the improvement of acoustic and vibration standards has been carried out for environmental evaluations and infrastructural diagnoses. We are also engaged in research and development aimed at advanced measurement methods and instruments, such as a positron annihilation lifetime technique for advanced material science. Furthermore, non-destructive diagnostic techniques involving X-ray imaging as well as optical phase analysis methods are currently being intensively investigated to address industry needs. These research results are disseminated to analytical and testing industries, thus ensuring that our institute contributes to making society safer and more prosperous.

Sound and Vibration Standards Group
Ionizing Radiation Standards Group
Radioactivity and Neutron Standards Group
Advanced Beam Measurement Group
Applied Nanoscopic Measurement Group
Radiation Imaging Measurement Group
Non-destructive Measurement Group

【Director】
ISHII Juntaro

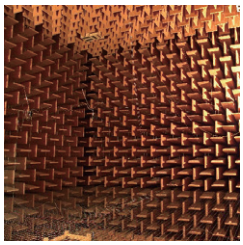


Ultra-high sensitive trace-moisture measurement in gas

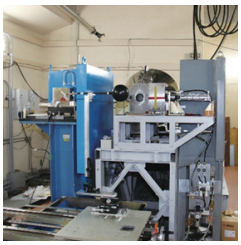


Laser transient absorption spectroscopy

Standard gases



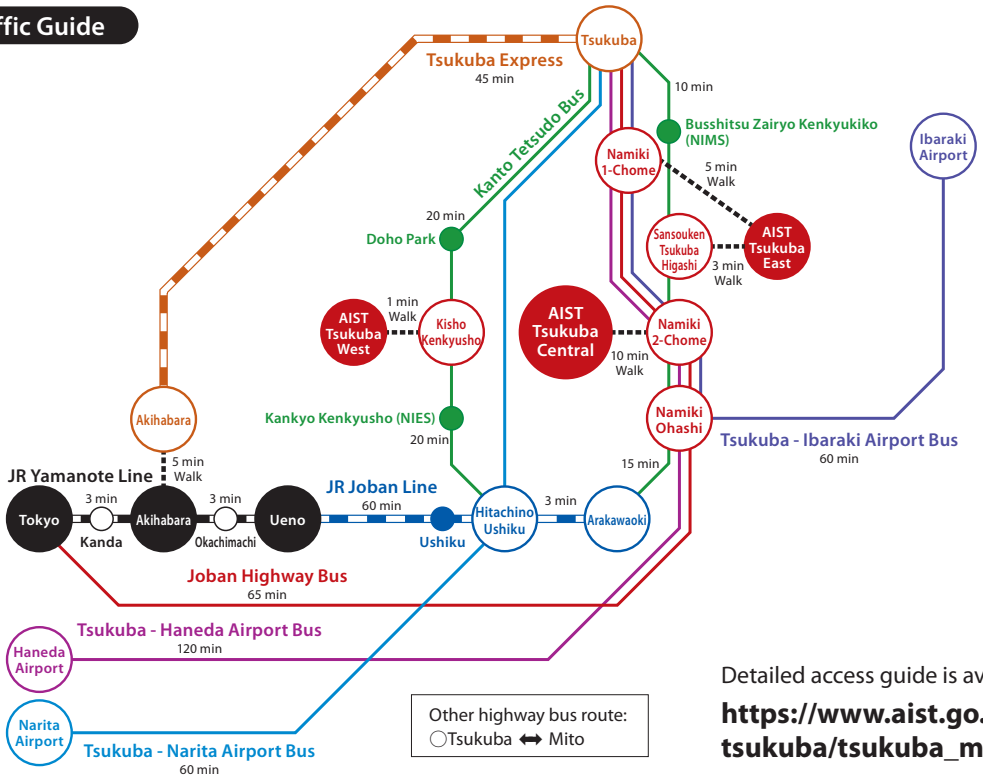
Acoustic anechoic room



High dose rate gamma-ray irradiation system

Portable X-ray computer tomography apparatus

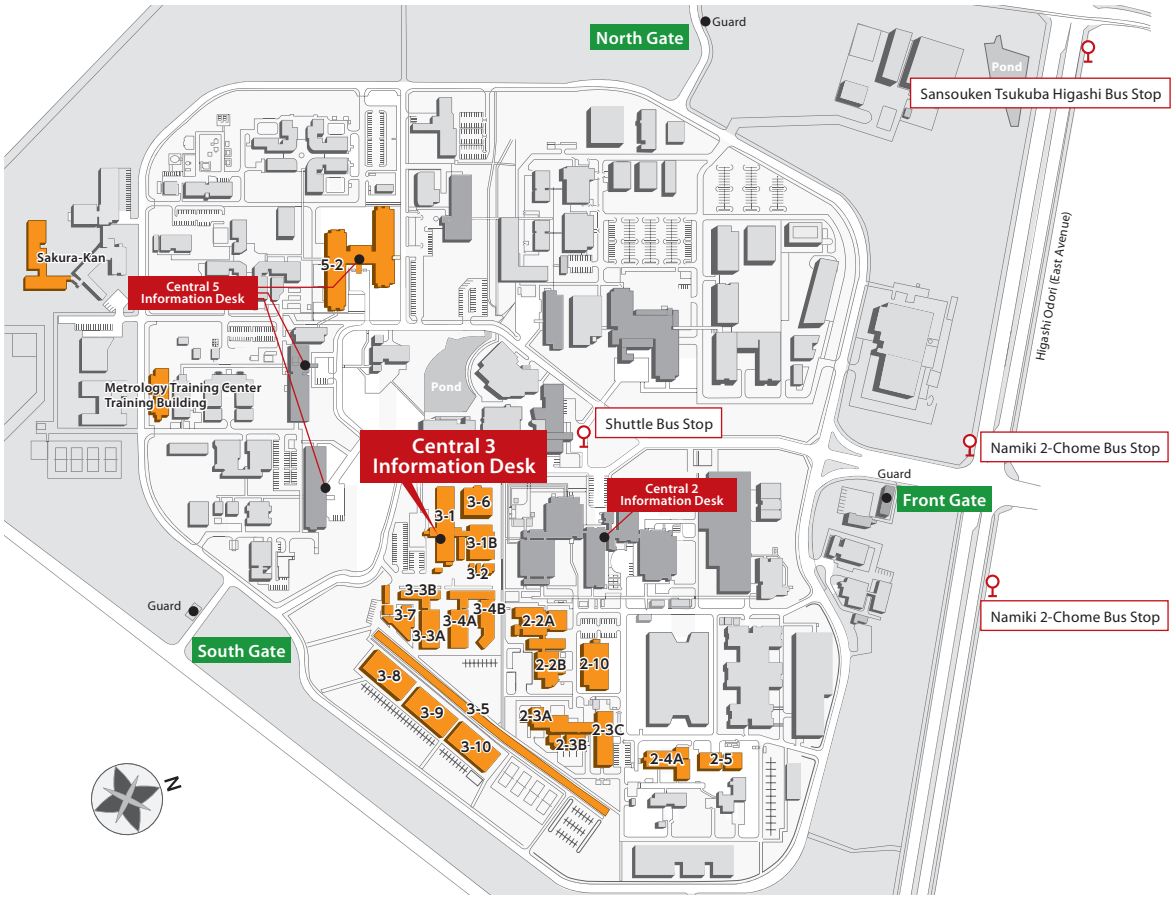
Traffic Guide



Detailed access guide is available at,

https://www.aist.go.jp/aist_e/guidemap/tsukuba/tsukuba_map.html

Map of AIST Tsukuba Central



Inquires to: **NMIJ Public Relations Office, Center for Quality Management of Metrology, National Metrology Institute of Japan (NMIJ), National Institute of Advanced Industrial Science and Technology (AIST)**

AIST Tsukuba Central 3, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8563, Japan

TEL +81-29-861-4346 FAX +81-29-861-4099

URL: https://unit.aist.go.jp/nmij/english/info/inquiry/

National Metrology Institute of Japan

〈2023, May.〉