Precision Measurement and Quality Control

2018 – 2019

CSIR- National Physical Laboratory
Dr. K. S. Krishnan Marg
New Delhi-110012

CSIR-NPL to Strengthen India

Shri Narendra Damodardas Modi
Honourable Prime Minister of India
President, CSIR

Dr. Harsh Vardhan
Vice President, CSIR
Honourable Cabinet Minister for Ministry of Science & Technology, Ministry of Environment, Forest and Climate Change and Ministry of Earth Sciences

Dr. Shekhar Mande
Director General, CSIR & Secretary DSIR

Dr. Dinesh Kumar Aswal
Director, CSIR-NPL

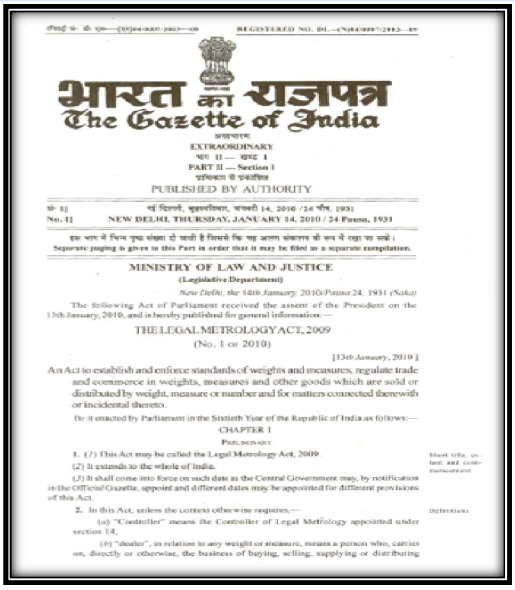
Vision and Mission

"Accurate and precise measurements are essential to drive the growth engines of Indian Science & Industry as it removes chaos and prompts innovations, which in turn, would save precious lives, resources and time...

- ✓ Developing India's measurement standards that are internationally accepted and disseminating the measurement capabilities to industry, government, strategic and academia that underpin the India's prosperity and quality of life.
- ✓ Conducting multidisciplinary R&D with a mission to establish the futuristic quantum standards and upcoming technologies so that India remains on par with international measurement laboratories.
- ✓ Developing sophisticated analytical equipments (i.e. import substitutes) under "Make in India" programme to cater the ever increasing demands of emerging India.
- ✓ Training of young scientists and industry personnel in the areas of measurements under "Skill India" programme.

Mandate

CSIR-National Physical Laboratory (NPL-India) is mandated to be India's "National Measurement Institute" (NMI) by "Act of Parliament – Associated Rules" is the custodian of "National Standards" with a responsibility of the dissemination of measurements to the needs of country.



भारत का राजपत्र
The Gazette of India

EXTRAORDINARY
PART II — Section 1
PUBLISHED BY AUTHORITY

NEW DELHI, THURSDAY, JANUARY 14, 2010 / 24 Pausa, 1931

MINISTRY OF LAW AND JUSTICE
(Legislative Department)

THE LEGAL METROLOGY ACT, 2009
(No. 1 OF 2010)

An Act to establish and enforce standards of weights and measures, regulate trade and commerce in weights, measures and other goods which are sold or distributed by weight, measure or number and for matters connected therewith or incidental thereto.

Be it enacted by Parliament in the Sixtieth Year of the Republic of India as follows:—

CHAPTER I

PRELIMINARY

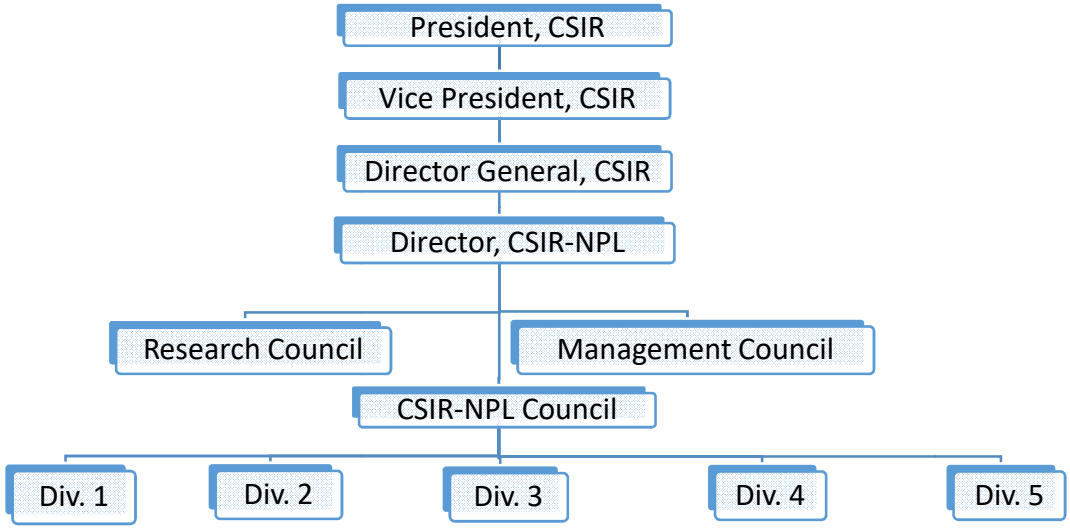
Certification Course in Precision Measurements and Quality Control (PMQC 2018-2019)

1. About CSIR-NPL

CSIR-National Physical Laboratory (NPL, India) is mandated to be India's 'National Measurement Institute (NMI)' and is the custodian of "National Standards" with a responsibility of the dissemination of measurements to the needs of country.

The CSIR-National Physical Laboratory was conceptualized in 1943 by the Governing Body of Council of Scientific and Industrial Research (CSIR), with a view to pave the way utilizing science and technology as a means for industrial growth and development, as well as to give fillip to the fledgling Indian industries. Over the years, the Laboratory has not only fulfilled its primary mandate as the custodian of National Measurement Standards for the nation but has also expanded its research activities substantially to emerge as a leading national institution for research in a wide gamut of areas.

CSIR-NPL Today: Paradigm Shift



Current R&D Focus and Priorities

The broad areas of focus are:

- Physico-mechanical Metrology
- Time & Frequency and Electrical & Electronics Metrology
- Advanced Materials and Devices
- Environmental and Biomedical Metrology
- Bhartiya Nirdeshak Dravya (BND): Indian Reference Materials

NPL, India's services in areas of calibration, testing and consultancy are used by various sectors be it manufacturing, calibration and certification services sector, or strategic sector in India and neighbouring countries. NPL, India is a national hub in the area of precision measurements.

CSIR-NPL as "Growth Engine" of the Country

(Selected list of organizations to whom support, advices and apex calibration services are being provided)

Government / Semi-Government Organizations

Air Force; Air India; Bharat Electronics; BHEL; Bhilai Steel Plant; Bureau of Indian Standards; Central Pollution Control Board; Central Power Research Institute; Central Public Works Department; Railway Information System; Central Institute of Mining and Fuel Research; Defense Electronics Applications Laboratory; Delhi Jal Board; Directorate of Border Security Force; Hindustan Aeronautic Limited; Indian Oil; ISRO Inertial Systems Unit; Maharashtra State Electricity; Micro, Small and Medium Enterprise Testing Center; NTPC; Nuclear Fuel Complex (DAE); Ordnance Factory; Rail Coach Factory; etc.

Industries

ABB India; ACC; AIMIL Ltd.; Alstom India; Ambuja Cement; Binani Cement; Birla Tyres; Blue Star; Bureau Veritas; Casio India; Crompton Greaves Limited; Diesel Locomotive Works; Essar Oil Ltd.; Godrej & Boyce Mfg. Co. Ltd; Havells India; Honda Cars; International Zinc Association; J.K. White Cement; JK Lakshmi Cement; Kirloskar Brothers; Larsen & Toubro; Maruti Suzuki; Mysore Paints & Varnish; Philips India; Piramal Healthcare; Ranbaxy; Rapid Metro Rail Gurgaon; Samsung India; Department of Telecommunication, UIDAI, Controller of Certifying Authority, Indian Air Force, Indian Railways, State Bank of India etc.

SAARC Nations

Nepal Bureau of Standards & Metrology (NBSM), Nepal; Bangladesh Standards and Testing Institution (BSTI), Bangladesh; Measurement Units, Standards and Services Department (MUSSD), Sri Lanka; National Physical and Standards Laboratory (NPSL), Pakistan; Bhutan Standards Bureau (BSB), Bhutan; Afghanistan National Standards Authority (ANSA), Afghanistan; Maldives Standards and Metrology Unit (MSMU), Maldives.

2. Precision Measurements and Quality Control

The recent policies of Government of India have created vast opportunities in India in various programme, one of them is the "Skill Development" programme for various industries and other stakeholders. In view of increasing global competition many industries are going for ISO certification, using precision measurements and implementing quality control techniques is the key to success. The industries in India need support in terms of providing specific trained manpower. Lack of the trained manpower is not only a major constraint for industries and manufacturing/production sector but also for calibration and testing laboratories. NPL, India, being the NMI of India, is uniquely positioned to cater the needs of training in these areas of industrial importance.

Today due to increasing pressure of demand of high quality products as well as their global acceptability at the same time, Industries and production units are standardizing their products with ISO/IEC conformity assessments following several International Standards of quality control, namely; ISO/IEC 17025: 2005 (General Requirements for the Competence of Testing and Calibration Laboratories), ISO/IEC 17043: 2010 (Conformity assessment - General requirements for Proficiency testing), ISO 15189: 2012 (Medical laboratories - Requirements for quality and competence), ISO Guide 34: 2009 (General requirements for the competence of reference material producers) etc. to overcome technical trade barriers, compete globally and also to cater international needs making their brand recognized internationally.

During interactions with Industry, it is emerged that knowledge of precision measurements and quality control is generally, available with senior management and Technical persons. However, the people at shop floor level who are involved in day to day production and measurement do not have adequate knowledge of the subject. In today's competitive world, in order to maintain the quality of products and reduce the rejection ratio, it is essentially required that the staff actually working at shop floor level must have training exposure.

NPL, India, being NMI of the country, therefore, decides to create trained manpower in areas of precision measurements and quality control to accelerate the growth of industry. This course would also contribute to

'National Accreditation Board for Testing and Calibration Laboratories (NABL)' accredited testing and calibration labs, legal metrology labs and improvement in efficiency of manpower and industries.

2.1 Why CSIR-NPL?

CSIR-National Physical Laboratory, India, being National Metrology Institute (NMI) of India, has got excellent infrastructure for standards and measurements, is at par with international level in precision measurements. It has earned its reputation internationally by signing Mutual Recognition Arrangement (MRA) of CIPM, (www.bipm.org). It implements a quality system as per ISO/IEC 17025 Standard and undergoes international peer review for technical expertise and Calibration and Measurement Capabilities (CMCs), regularly. NPL, India is uniquely positioned to cater the emerging needs of training in these areas because of the availability of relevant expertise.

Young certificate holders trained in CSIR-NPL in the field of metrology have ample opportunities to become professional in precision measurements and quality controls to serve Industries, accredited testing and calibration laboratories, MSMEs, strategic sectors at their various key positions.

3. Course Offered and Objective of the Course

One Year Certification Course in Precision Measurement and Quality Control (PMQC 2018-2019)

Participants will be introduced to basic concepts and role of precision measurements and quality control in manufacturing, inspection, and accreditation process. The course basically focuses on precision measurements and quality control aspects and their applications which would help participants to acquire knowledge, develop skills in precision measurements and quality control.

Employment Opportunities

The young minds trained in this discipline would have opportunities to become professional in precision measurements and quality controls to serve Industries, accredited testing and calibration laboratories, MSMEs, strategic sectors and other related areas. They will have unique advantage of getting exposure and hands on training on best measuring equipment through this course. The manpower trained by NPL, India will be a brand attractive to these sectors.

They will not only be the most suited candidates for Government or private industries, manufacturing sectors but would also be a brand attractive to Government run legal entities, e.g. National Accreditation Board for Testing and Calibration Laboratories (NABL), Quality control sections, Testing and Calibration Laboratories from Private/ public/ Government sector, Legal Metrology Department, Standardisation, Testing and Quality Certification (STQC), Quality Council of India (QCI), etc. The demand of skilled manpower in precision measurements in manufacturing sector and quality sectors identified above will be increasing day by day. This way the trained manpower in precession measurements through is Certification course would have ample job opportunity.

Course Structure and Detail

The Certification course in precision measurements and quality control is designed to create competent professionals in this field of Physico-Mechanical, electro-technical measurements, quality control and management.

This Certification course will be of one year full time duration. The lectures will be delivered by eminent scientists and metrologists of NPL, India who have decades of experience and expertise in precision

measurements. It consists of four quarters with modules of theory classes and practical, projects and industrial training. The course modules are,

S. No.	Course
1	Basic Metrology
2	Quality Control and Management
3	Mass, Force and Related Parameters
4	Pressure, Vacuum and Fluid Flow
5	Optical Radiation
6	Length and Dimension
7	Temperature, Humidity, Acoustics and Ultrasonics
8	AC and DC Standards
9	Time and Frequency, AC Power, Energy, High voltage and High Current,
10	Environment Metrology
11	Industrial Training

Eligibility for Admission

- B.Sc.(Physics & Maths) or
- 3 years Diploma / B.Sc. Engg./ B.E / B.Tech in Mechanical/ Electrical/ Electronics / Electronics & Communication/ Instrumentation.

Age Limit

25 yrs. for fresh candidates as on 31-08-2018
40 yrs. as on 31-08-2018 for industry sponsored candidates.

Number of Seats

The total numbers of seats are 45 (forty five).

Admission Procedure

The application format will be available at CSIR-NPL website (www.nplindia.org). The application form duly filled and printed, should be **submitted to, HRD, CSIR-National Physical Laboratory, Dr K S Krishnan Marg, New Delhi-110 012.** There is no application fee.

Selection Procedure

Candidates will be selected on the basis of aptitude test (objective type) / Interview. The final decision will be taken by the Competent Authority.

Course Fee

The fee is Rs 50,000/-(Rs. Fifty thousand only) for fresh candidates and Rs 1,00,000/- (Rs. one lakh only) for Industry sponsored candidates.

Reservation Policy

We shall follow the reservation policy applicable for CSIR as per GOI.

For any further queries, please email to Project Co-ordinator or HRD

Nodal Officer: Dr. Anurga Gupta
Co-ordinator: Dr. Rina Sharma
Co-Coordinator: Mr. Satish

Syllabus

One Year Certification Course in Precision Measurements and Quality Control (PMQC-2018): Syllabus

First Quarter (22 October, 2018- 31 January 2019)

- **Basic Metrology**

Faculty: **Rina Sharma (**Senior Principal Scientist***)*** *and* ***Parag Sharma (****Senior Scientist****)***

Introduction to international and national measurement system including standards, accreditation, legal metrology, Introduction to metrology : Definition, types, need of inspection, terminologies, methods of measurement, selection of instruments, measurement errors, units, measurements standards, calibration, statistical concepts in metrology, Basics of evaluation of uncertainty in measurements, Six sigma methods, measurement system analysis

- **AC/ DC and Microwave Metrology**

Faculty: **Thomas John** (Chief Scientist), **Saood Ahmed** (Principal Scientist) and **Satish** (Scientist)

Introduction to Josephson Voltage Standard and Quantum Hall Resistance, AC & DC, voltage, resistance, current and related measurement techniques, techniques to measure capacitance and inductance, their traceability, reference standards, AC & DC Transfer difference, multi-junction/ single-junction thermal converters, AC/ DC calibrator, measurement methods and calibration techniques to assign AC-DC voltage/current transfer difference to reference standards, digital multimeter and Zener reference voltage calibration, precise voltage ratio measurements, electrical properties of materials (resistivity, conductivity, dielectric constant and loss tangent), Measurement Automation and Control, Microwave measurement techniques and traceability.

- **Time and Frequency, AC Power, Energy, High voltage and High Current,**

Faculty: **J. C. Biswas** (Senior Principal Scientist) and **M. A. Ansari** (Principal Scientist) **Ashish Aggarwal (**Principal Scientist**)**

Introduction to AC power and energy measurements, measurement standards and techniques, testing and calibration methods of AC power and energy measuring instruments, traceability. Introduction to AC high voltage and high current standards, Power generation, transmission and distribution, instrument transformer, bulk energy metering, capacitance and tandelta measurement, Reference Standards, Various calibration methods, Precautions & safety.

Introduction to Time and Frequency standards, Quartz, Atomic Clocks, Cesium Standard, Rubidium Standard, International Time Scale, Time Dissemination, Time Transfer, Navigation systems, Calibration of Clocks, Time Interval Counters, Hour meters, GPS receivers and Stop watches, traceability, reference standards.

Second Quarter (February – April 2019)

- **Quality Control and Management**

Faculty: **Anil Kumar** (Chief Scientist) and **M. A. Ansari** (Principal Scientist)

Introduction to quality management, Introduction to proficiency testing and key comparison exercises, Introduction to relevant ISO standards e.g. ISO 9000, ISO 14000, ISO/IEC 17025 and auditing techniques, Techniques for quality control: proficiency testing, inter-laboratory comparisons, retesting, replicate testing, control charts.

- **Optical Radiation**

Faculty: **Ranjana Mehrotra** (Chief Scientist), **V. K. Jaiswal** (Senior Scientist) and **Parag Sharma** (Senior Scientist)

Basics of Radiometry and Photometry including definitions of various parameters, Primary Standards traceability of Optical Radiation: Cryogenic radiometer and Blackbody source, Realization of Spectral irradiance scale, Realization of SI base unit of luminous intensity, 'candela', Measurement techniques for Illuminance, Illuminance responsivity, Luminous intensity, Luminous flux and Luminance, Correlated Color Temperature (CCT) and Color coordinates, UV Radiometry, IR Radiometry, Photometry of advanced solid state optical devices: Light Emitting Diode (LED), basic principles of Photometry, Radiometry and Colorimetry, traceability, reference standards.

- **Length and Dimension**

Faculty: **Rina Sharma** (Senior Principal Scientist), **Girija Moona** (Senior Scientist) and **Mukesh Jewaria** (Scientist)

Primary standards for length and dimension, Traceability to SI metre, basics of dimension measurements including linear, angle, form and surface finish, limits and tolerances, Sources of uncertainty in dimensional measurements, Introduction to interferometry and optical techniques, Gauges and instruments used in dimension measurements: Gauge block comparator, LMM, profile projector, 3D profiler, roughness and roundness measuring instruments, gauge blocks, ring gauges, plug gauge, Dial Gauge, calliper checkers, Autocollimator and levels etc., Coordinate metrology and CMM, Calibration procedures and evaluation of uncertainty.

Third Quarter (May to July 2019)

- **Temperature, Humidity, Acoustics and Ultrasonics Metrology**

Faculty: **D. D. Shivagan** (Senior Scientist), **Mahavir Singh** (Senior Principal Scientist), **Naveen Garg** (Senior Scientist) and **P. K. Dubey** (Senior Scientist)

Basic concepts in temperature metrology, Importance of International Temperature Scales, ITS- 90,Traceability of temperature measurements, Concept and Realization of Temperature Fixed Points, Traceability of temperature measurements, Calibration and practices in temperature metrology related to SPRT, LIGT, TCs and Pyrometry, Instrumentation, Measurement techniques and procedure for uncertainty evaluation in the Temperature related metrology and Hygrometry. Practical Demonstration & Training on Calibration procedures, calculations, reports etc. for LIG Thermometers, SPRTs, RTDs Thermocouples, Hygrometers and Pyrometers. Estimation & reporting of Uncertainty in the temperature and humidity related metrology. Introduction to acoustic, ultrasonic and vibration, measurement standards and techniques and traceability, testing and calibration methods of acoustic, ultrasonic and vibration measuring instruments, traceability, reference standards.

- **Mass, Force and Related Parameters**

Faculty: **Anil Kumar** (Chief Scientist), **Goutam Mandal** (Principal Scientist), **Nidhi Singh** (Senior Scientist), **S. K. Titus** *(Principal Scientist)* and ***Rajesh Kumar*** *(Principal Scientist)*

Introduction to Mass, Volume and Density measurements, Realization and dissemination of SI base unit of mass, Traceability of mass, Volume and Density, Various reference standards of mass, Volume and Density, Concepts of true mass and conventional mass, Archimedes principle, Air buoyancy correction, Calibration techniques of weights, weighing balances, volumetric instruments, hydrometers, Density determination of solids and liquids, Computation of uncertainty in measurements of weights, weighing balances, volumetric instruments, hydrometers. Introduction to force, torque and hardness, measurement standards and techniques, Traceability of force and hardness measurements, testing and calibration methods of force, torque and hardness measuring instruments, traceability, reference standards.

- **Pressure, Vacuum and Fluid Flow**

Faculty: **Sanjay Yadav** (Senior Principal Scientist), **Nita Sharma** (Senior Principal Scientist), **Ashok Kumar** (Senior Scientist) and **S. K. Jaiswal** (Principal Scientist*)*

Basics, applications, concepts and technology of pressure and vacuum science and devices, different types of pressure and vacuum measurement devices, measurement procedures, precautions, safety, difference between absolute and differential pressure gauges, calibration, traceability, units of measurements and its inter-conversion, principles of pressure and vacuum measurements, basic of pneumatic and hydraulic pressures, dynamic and static pressure and vacuum principles, hand-on training on primary and secondary standards with hierarchy of standards. Introduction to fluid flow measurements,

measurement standards and techniques, traceability of fluid flow measurements, testing and calibration methods of fluid flow measuring instruments and reference standards. traceability of fluid flow measurements, testing and calibration methods of fluid flow measuring instruments and reference standards.

- **Environmental Metrology**

Faculty: **Chhemendra Sharma** (Sr. Pr Scientist), T K. Mandal, Sachchidanand Singh, Monika J. Kulshrestha, Shankar G. Aggarwal

Basics of Earth's atmosphere (components and processes); Radiation Budget; Climate change; Environmental impacts; Air Quality; Regulated measurements and instruments (legal metrology); Confidence of testing and measurement protocols for certification/standardization/calibration (industrial metrology) including wind tunnel testing, CAAQMS & OCEMS; traceability to the international systems of units (scientific metrology); Introduction to Indian and International environmental laws and policies.

Fourth Quarter (August –October 2019)

- **Industrial Training**

Faculty: Industries preferably in Delhi NCR

Students will undergo industrial training at industries in India or accredited calibration, testing laboratories who are pioneers in area of measurement and quality control. A work report will be submitted in partial requirement of the course

Time Table

First Quarter

Time (hrs.) / Days	Theory / Tutorials		
	10:00-10:50	**11.00-11:50**	**12:00-12:50**
Monday	**PHY-NPL-2-4618**	**PHY-NPL-2-4611**	**PHY-NPL-2-4619**
Tuesday	**PHY-NPL-2-4618**	**PHY-NPL-2-4611**	**PHY-NPL-2-4619**
Wednesday	**PHY-NPL-2-4618**	**PHY-NPL-2-4611**	**PHY-NPL-2-4619**
Thursday	**PHY-NPL-2-4618**	**PHY-NPL-2-4611**	**PHY-NPL-2-4619**
Friday	Extra Class/ Practical$		

$: These class slots are for extra/ revision classes (to be notified to the students & HRD in advance by each teaching faculty)

Course # PHY-NPL-2-4611 : Basic Metrology

Course # PHY-NPL-2-4618 : AC /DC and Microwave Metrology
Course # PHY-NPL-2-4619 : Time & Frequency, AC Power Energy, High Voltage & Current

Practical : Monday to Thursday from 2:00 PM to 5:00 PM

2 # PHY-NPL-2-4618 : AC /DC and Microwave Metrology
3 # PHY-NPL-2-4619 : Time and Frequency, AC Power, Energy, High voltage and High Current,

Second Quarter

Time (hrs.) / Days	Theory / Tutorials		
	10:00-10:50	**11.00-11:50**	**12:00-12:50**
Monday	PHY-NPL-2-4615	PHY-NPL-2-4616	PHY-NPL-2-4614
Tuesday	PHY-NPL-2-4615	PHY-NPL-2-4616	PHY-NPL-2-4614
Wednesday	PHY-NPL-2-4615	PHY-NPL-2-4616	PHY-NPL-2-4614
Thursday	PHY-NPL-2-4615	PHY-NPL-2-4616	PHY-NPL-2-4614
Friday	Extra Class/ Practical$		

$: These class slots are for extra/revision classes (to be notified to the students & HRD in advance by each teaching faculty)

Course # PHY-NPL-2-4614 : Quality Control and Management
Course # PHY-NPL-2-4615 : Optical Radiation
Course # PHY-NPL-2-4616 : Length and Dimension

Practical : Monday to Thursday from 2:00 PM to 5:00PM

1 # PHY-NPL-2-4615 : Optical Radiation
2 # PHY-NPL-2-4616 : Length and Dimension

Third Quarter

Time (hrs.) / Days	Theory / Tutorials		
	10:00-10:50	**11.00-11:50**	**12:00-12:50**
Monday	PHY-NPL-2-4612	PHY-NPL-2-4613	PHY-NPL-2-4617
Tuesday	PHY-NPL-2-4612	PHY-NPL-2-4613	PHY-NPL-2-4617
Wednesday	PHY-NPL-2-4612	PHY-NPL-2-4620	PHY-NPL-2-4617
Thursday	PHY-NPL-2-4620	PHY-NPL-2-4613	PHY-NPL-2-4617
Friday	PHY-NPL-2-4620	PHY-NPL-2-4613	PHY-NPL-2-4612

Course # PHY-NPL-2-4617 : Temperature, Humidity, Acoustic and Ultrasonic
Course # PHY-NPL-2-4612 : Mass, Force and related parameters
Course # PHY-NPL-2-4613 : Pressure, Vacuum and Fluid Flow

Practicals : Monday to Friday from 2:00 PM to 5:00 PM

1 # PHY-NPL-2-4617 : Temperature and Humidity

2.# PHY-NPL-2-4612 : Mass, Force and related parameters

3.# PHY-NPL-2-4613 : Pressure, Vacuum and Fluid Flow

4. # PHY-NPL-2-4620 : Environment Metrology

Fourth Quarter

Industrial Training

1# PHY-NPL-2-4621: Industrial Training

4. Metrology Activities and Facilities of CSIR-NPL to be used in this Course

4.1 Physico-Mechanical Metrology

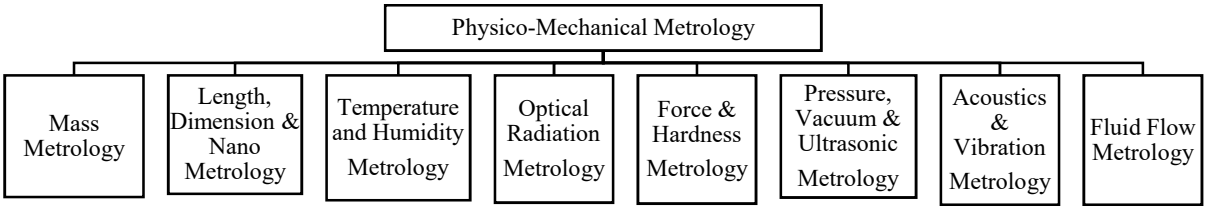
Head: Dr Ranjana Mehrotra, Chief Scientist

CSIR-National Physical Laboratory (NPL-India) is mandated to be India's "National Measurement Institute" (NMI) by an act of Parliament and its associated rules for legal metrology. CSIR-NPL is the custodian of "National Standards" with a responsibility of realization, establishment, up gradation, maintenance and dissemination of standards at par to international level through R and D and latest technology. CSIR-NPL's National Metrology has not only championed in its primary mandate as the custodian of Measurement Standards for the nation but also served the Indian industry, academia and strategic sectors to excel in their endeavours.

CSIR-NPL maintains international equivalence of its standards by way of Inter-comparison. It represents India in CIPM - Mutual Recognition Arrangement of NMIs. It maintains a quality system in accordance with ISO/IEC 17025: 2005 and its calibration measurements capabilities (CMC) are peer reviewed by international experts for mutual recognition. These CMCs are displayed in Appendix C of MRA athttp://kcdb.bipm.org/AppendixC/default.asp

This division has a mandate to realize, establish, upgrade, maintain and disseminate standards for various Physico-Mechanical parameters. These include, Mass; Length, Dimension and Nano-metrology; Optical Radiation; Force and Hardness, Pressure, Vacuum and Ultrasonic; Acoustics and Vibration; Fluid Flow. The measurements capabilities of NPL are efficiently disseminated among various stake-holders in the country for the benefit of the nation.

This division is engaged in dissemination of apex calibration facilities not only to Indian industries, strategic-sector, and academia and government agencies but also to the SAARC and other Nations. CSIR–NP's National Metrology, owing to its untiring efforts on precision measurement and its dissemination, has occupied a pivotal position for the all-round development of the country.



4.2 Time & Frequency and Electrical & Electronics Metrology

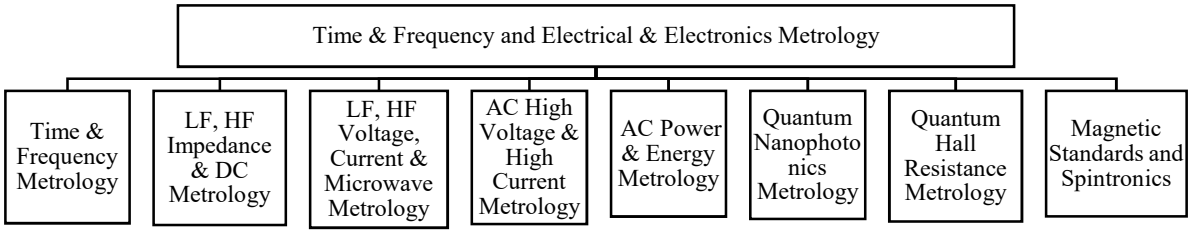
Head: Mr. Thomas John, Chief Scientist

The main objective of this division is to strengthen and encourage the overall development in the field of science and technology for the country. The main responsibility is the realization, establishment, custody, maintenance, dissemination and up-gradation of the national standards for Time & Frequency and Electrical & Electronics parameters.

CSIR-NPL is responsible for the highest level of time and frequency measurements in India and keeping them traceable to the International Bureau of Weights and Measures (BIPM) using ultra precision satellite links. CSIR-NPL is the Timekeeper of the India and generates the Indian Standard Time (IST) using "Primary Reference Clock", which is traceable to the Coordinated Universal Time (UTC) provided by BIPM. IST (i.e. UTC-NPLI Plus 5.30 hours) generated by "Primary Reference Clock" (i.e. a bank of caesium clocks and hydrogen maser) has current uncertainty of ± 20 nano-seconds. CSIR-NPL has been disseminating the IST to various users (particularly to strategic sectors like ISRO and Indian Air Force and also to airports, banking sectors, parliament etc.) for past several decades through teleclock, two-way satellite link and internet time service. In addition, CSIR-NPL carries out research and development on primary atomic clocks. The first Cs fountain frequency standard, with an accuracy of a few parts in 10-15, became operational in 2011.

The Division also maintains the primary standards like Josephson Voltage Standards and Quantum Hall Resistance Standards. A dedicated group is working for establishing the Device Fabrication and Characterization for Quantum Metrology.

The division is also providing various apex level calibration services in Time & Frequency, Electrical and Electronic parameters to the industry & user organizations of the country and provides educational training on industrial metrology to support the economic growth. The various Electrical & Electronic parameters are LF, HF Impedance and DC Metrology, LF, HF Voltage, Current & Microwave Metrology, AC High Voltage & Current Metrology and AC Power & Energy Metrology.



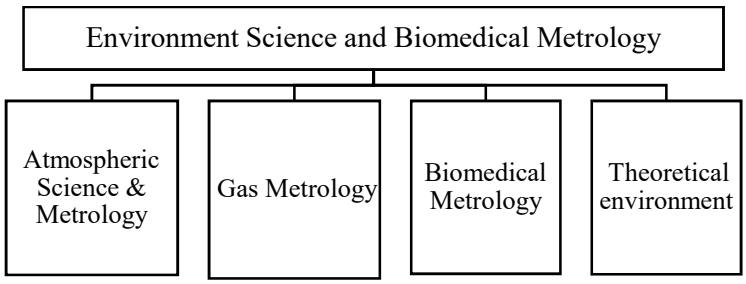
4.3 Environment Science and Biomedical Metrology

Head: Dr. Chhemendra Sharma, Sr. Pr. Scientist

In view of the nationwide increased awareness and concerns about the state of environment, CSIR-NPL has now embarked upon developing quality measurement system for atmospheric species besides developing standards for ensuring quality measurements. CSIR-NPL has been working on the development of gas primary reference standards and the current focus is on providing the greenhouse gas (e.g. CH_4 and CO_2) and pollution gas (e.g. SO_2, NO, CO) standards to various stake holders which include air quality monitoring stations being run by different pollution boards. NPL is providing primary calibration facility to calibrate ozone analyzers.

The major focus of the Environmental Sciences and Biomedical Metrology Division is to provide apex level traceability to the measurements in the areas of atmospheric and biomedical measurements. A variety of instruments based on different techniques are being used to measure atmospheric and biomedical parameters in the country but the test and calibration facilities for many of these equipment are not available in the country. The division is putting efforts to fill this void. It has focused to develop national test and calibration facilities for `Online Continuous Emission Monitoring System (OCEMS)', `Continuous Ambient Air Quality Monitoring System (CAAQMS)' and `PM2.5 and PM10 Aerosols Samplers' out of which the later is already established. These test and calibration facilities will also contribute in the certification of equipment which would enable Indian manufacturers to participate in international trade. A detailed CSIR NPL-Indian Certification Scheme (NPL-ICS) has also been prepared to facilitate certification process. The division is also preparing standard reference gases for use in calibration of equipment used for measurements of air pollution and greenhouse gases

Apart from environment, the human health is also a very important concern for the society. This division is also actively engaged in fabricating indigenous point-of-care devices using novel biocompatible sensing materials for the diagnosis of chronic diseases. The initiatives have been taken to establish standardization of medical equipments which are used to evaluate various human health parameters. New facilities are being set up for the calibration and testing of biomedical equipments in NPL. The division has already established the calibration facility for defibrillators and now in the process of establishing calibration facilities for other biomedical equipment like syringe pump, incubators etc.



5. Contact details

Dr. Anurag Gupta, Nodal Officer, 011-4560 9366

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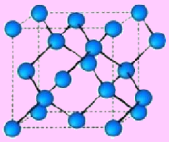
Theoretical environment	Dr. (Ms.) Meena Jain (Sr. Principal Scientist)	mjain

SI Units of Measurement

Quantity, Unit, Symbol and Definition	Realization of Units and National Standards at NPL, India
Length [meter (m)] The meter is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second. The SI unit 'meter' is realized as per recommendations of International Bureau of Weights and Measures (BIPM) for practical realization of the unit 'meter'.	An Iodine (127_{I_2}) frequency stabilized He-Ne laser is maintained as per recommendations of BIPM. This is the primary optical frequency standard. The frequency of this radiation (stabilized w.r.t. f component) is 473612353604.1 kHz and the corresponding vacuum wavelength is 632.99121258 nm with overall uncertainty in measurement $< \pm 2 \times 10^{-11}$ ($k = 1$)*. 
Mass [kilogram (kg)] The kilogram is the unit of mass; it is equal to the mass of the international prototype of the kilogram. This international prototype kilogram (IPK) is made of platinum iridium and is kept at the BIPM, Serves, Paris, France.	India has copy no. 57 (national prototype kilogram - NPK) of the IPK, which serves as primary standard. Multiple and sub-multiple of 1 kg, ranging from 1 mg to 2000 kg are calibrated against the NPK using precision balance with measurement uncertainty ranging from ± 2 µg to ± 10 g ($k = 2$)*. 
Time [second (s)] The second is the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.	The second is realized by an ensemble of five cesium beam frequency standards and an Active Hydrogen Maser with an uncertainty of 2.8 ns ($k = 2$). The time scale of NPL, designated as UTC (NPLI), is linked to the internationally maintained time scale UTC through GPS AND GNSS network. 
Electric current [ampere (A)] The 'ampere' is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 metre apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per metre of length.	The ampere is based on the volt and the ohm with an overall relative uncertainty $\pm 2 \times 10^{-6}$ ($k = 2$)*. The 'volt' is maintained in the form of standard cell/Zener based voltage reference standard traceable to Josephson series array voltage standard at 1 V and 10 V levels established at NPLI. The 'ohm' is maintained is form of a bank of standard resistor at 1 Ω. These are traceable to Quantum Hall Resistance standard (QHR) establish at NPLI. 
Thermodynamic temperature [kelvin (K)] The 'kelvin', unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water.	The triple point of water is realized with an uncertainty of ± 0.17 mK ($k = 2$)* in cells similar to the one illustrated here. Practical temperature in the range 84 K to 2500 K can be measured with appropriate uncertainties throughout this range of temperature. Calibration can be done of all temperature-measuring instruments in this range. 
Luminous intensity [candela (cd)] The 'candela' is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has radiant intensity in that direction of $^1/_{683}$ watt per steradian.	The standards of luminous intensity are maintained through a set of incandescent lamps traceable to international standards. The range covered is 1 cd to 1000 cd at 2856 K. Uncertainty in the measurement is in the range of ± 1.6 % to ± 1.4 % (k = 2)*. Radiometric measurement has shown that 1 cd is equivalent to $^1/_{683}$ watt per steradian. 
Amount of substance [mole (mol)] A 'mole' is the amount of substance of a system, which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12. When the 'mole' is used, the elementary entities must be specified and may be atoms, molecules, ions, elements, other particles, or specified groups of such particles.	The mole is not realized directly from its definition. It can be realized in various indirect ways. The related Avogadro constant, the number of elementary entities for silicon per mole is now known to have an uncertainty in silicon molar mass of about a part in a million.  Space Lattice Silicon Avogadro constant: $6.022\ 045 \times 10^{23}\ mol^{-1}$ * k is coverage factor which corresponds to a coverage probability of approximately 95 % confidence level.

CSIR-National Physical Laboratory

(National Measurement Institute (NMI) of India by the Act of Parliament)