भौतिक-यांत्रिक मानक

PHYSICO-MECHANICAL STANDARDS
भौतिक-यांत्रिक मानक

भौतिक-यांत्रिक मानक प्रभाग, राष्ट्रीय भौतिकी प्रयोगशाला, भारत के सात अर्थ एक डी प्रभागों में से एक है। प्रभाग निम्न पैरामीटरों सहित यांत्रिक मानक गतिविधियों से संबंधित हैं:—

1. द्वारकान, आयतन, घनत्व और श्यानता मानक
2. लामाई एवं विनिमय मापकी
3. लामाई और आईटी मानक
4. प्रकाशीय विकिरण मानक (द्वारकान अवरक्त और परमाणु क्षेत्र)
5. बल, टार्क और कठोरता मानक
6. दाब एवं निवांत मानक
7. ध्वनिक मानक
8. तरल बहाव मानक (केवल पती माध्यम)
9. परस्पर मानक
10. प्रगाह एवं संपेन्द्र

इस प्रभाग का उपयोग गतिविधियों से संबंधित मानक के राष्ट्रीय मानकों की स्थापना, उनका अनुसरण और लगातार अप्रेश करने और मानकों का प्रशासन करने व उसके राजा उद्धोगों और संस्थाओं की उच्च स्तर की अंशक तर्क सुरक्षित करने का उत्तरदायित्व है और इस प्रकार इससे निर्दिष्ट तर्क की अनुमानीयता को सुनिश्चित करना है।

मानक और अंशकन में सातम वजन की मापन और अंशकन क्षेत्रों का Peer पुनर्निर्माण विश्व की अग्रणी तकनीकी विशेषज्ञों द्वारा किया गया। इस प्रकार राष्ट्रीय भौतिक प्रयोगशाला BIPM के परस्पर मान्यता देते संबंधी परमाणु की अपेक्षाओं को पूरा करती है, जिसकी राष्ट्रीय भौतिक प्रयोगशाला एक हल्दक्षेतरक्ता (Signatory) है। परिषद् स्वरूप उपरोक्त गतिविधियों के CMCs BIPM वेबसाइट (www.bipm.org) पर प्रस्तुत है और राष्ट्रीय भौतिक प्रयोगशाला की इन गतिविधियों द्वारा जारी किए गए अंशकन प्रमाण—पत्र पूर्व विश्व में स्वीकायें हैं।

इन गतिविधियों ने BIPM और अन्य APMP (पश्चिम पैंसिक मैट्रिलॉजी प्रोग्राम) /RMO (श्रीवल्ल रेल्लिओली, आर्गेनाइजियन और पश्चिम रीजन) द्वारा आयोजित समन्वित अंतर्राष्ट्रीय अंतर्गत भाषा संगठनों में नियमित रूप से भाग लिया।

वर्ष 2006-2007 में प्रभाग की विभिन्न गतिविधियों ने अंतर्गत भाषा संगठनों में सक्षमतापूर्वक भाग लिया, उद्धोगों, संस्थाओं और प्रशासित प्रयोगशालाओं को 2267 अंशकन रिपोर्ट जारी की। मापकी संबंधी समस्याओं को हल करने के लिए नॉ प्राइडेट/परस्पर उद्धोगों को पारमाणविक संबंधी सेवाएं प्रदान की, देश में मापकी के क्षेत्र में तद्व नामांकन शक्ति (man power) के विकास में योगदान देने के लिए विभिन्न पैरामीटरों में सात प्रशिक्षण कार्यक्रम आयोजित किए।
प्रभाग ने जर्नलस में 27 लेख प्रकाशित किए और राष्ट्रीय व अंतरराष्ट्रीय सम्मेलनों में 52 पेपर्स प्रस्तुत किए 41 आमंत्रित वार्ताएं प्रदान की और माध्यमिकी के क्षेत्र में उनके द्वारा अर्जित ज्ञान का प्रचार करने, गुणवत्ता प्रणाली और अंशाकन प्रयोगशालाओं को स्थापित करने में सहायता प्रदान की।

ध्वानिकी मानकों की अंशाकन मापन क्षमताओं का पीआर पुनरीक्षण NMIA ऑस्ट्रेलिया के तकनीकी विशेषज्ञों द्वारा किया गया। वेबसाइट के परिशिष्ट ‘सी’ पर को बाल्टजा जाने से पूर्व के दिशा निर्देशों के अनुसार संचालन और इनके तकनीकी सम्पत्ति के अध्यक्ष द्वारा का सूचना परीक्षण किया गया।

इस प्रभाग के वैज्ञानिक परीक्षण और अंशाकन प्रयोगशालाओं के लिए राष्ट्रीय प्रत्यावेशन बोर्ड (NABL), भारत में अंशाकन और परीक्षण प्रयोगशालाओं के प्रत्यावेशन के लिए एक सरकारी निकाय, के मार्गदर्शक और तकनीकी निर्धारित हैं जो राष्ट्रीय मापन प्रणाली के नेटवर्क को विकसित कर रहे हैं।

युप के द्रौपदान, लंबाई, दांत और ताप गतिविधियों ने NABL द्वारा अनुमोदित अंशाकन प्रयोगशालाओं की तकनीकी क्षमताओं का आकलन करने के लिए एक दक्षता परीक्षण पादत्मक का आयोजन किया। इस प्रकार एन पी एल देश की राष्ट्रीय मापन प्रणाली को सशक्त बनाने में NABL को वैज्ञानिक एवं तकनीकी सहायता प्रदान कर रही है।

इस प्रभाग के दो वैज्ञानिकों को APMP तकनीकी समितियों के अध्यक्ष के रूप में चुना गया है। इस प्रभाग के वैज्ञानिकों को BIS, नई दिल्ली की भिंतिन विभागीय समितियों का अध्यक्ष/सदस्य नामांकित किया गया है और वे माध्यमिकी व अन्य क्षेत्रों से संबंधित विभिन्न भारतीय मानकों को सूचनारूप करने की आवश्यकता को सुनिश्चित करने के लिए BIS का तकनीकी और वैज्ञानिक जानकारी उपलब्ध करार रहे हैं।
The Physico-Mechanical Standards Division is one of seven R&D Division of National Physical Laboratory, India. The division constitutes of mechanical measurement activities involving the parameters of

1. Mass, Volume, Density and Viscosity Standards
2. Length and Dimension Standards
3. Temperature and Humidity Standards
4. Optical Radiation Standard (visible infrared and ultraviolet regions)
5. Force, Torque and Hardness Standards
6. Pressure and Vacuum Standards
7. Acoustic Standards
8. Fluid Flow Standards (Water medium only)
9. Ultrasonic Standards
10. Shock and Vibration Sensors

The division is responsible to establish, maintain and continually upgrade the National Standards of Measurements related to above said activities and disseminate the standards by providing the apex level calibration services to the industry and institutions of the country and thus ensures the traceability to measurements made by these.

The calibration and measurement capabilities (CMCs) of all the activities engaged in measurement and calibration have been peer-reviewed by Technical experts of leading NMIs in the world. NPL has thus met the requirements of Mutual Recognition Arrangement (MRA) of BIPM of which NPL, India is the signatory. As a result, the CMCs of the above said activities are available on BIPM website (www.bipm.org) and the calibration certificates issued by these activities of NPL are acceptable world over.

The activities regularly participate in international inter-comparison organized/coordinated by BIPM and or APMP (Asia Pacific Metrology Program) / RMOs (Regional Metrology Organization of Asian region) regularly.

In 2006-07 various activities of the division successfully participated in four intercomparison, issued 2267 calibration reports to industries, institutions, organisations and accredited laboratories, provided consultancy to nine private/public entrepreneur in solving the metrology related problems, seven training programs in various parameters were organized contributing to the development of skilled man power in the field of metrology in the country.

The division published 27 articles in Journals and presented 52 papers in National and International conferences, delivered 4 invited talks and helped in disseminating the knowledge acquired by them in the field of metrology, quality system and setting up of calibration laboratories.
Calibration Measurement Capabilities (CMCs) of Acoustic Standards were peer-reviewed by technical experts from NMIA, Australia. The CMCs are being scrutinized by APMP Secretariat and respective Technical Committee Chairmen as per guidelines laid down by CIPM-MRA before CMCs are placed on Appendix 'C' of BIPM website.

The scientists of this division are the Lead and Technical Assessors for National Accreditation Board for Testing and Calibration Laboratories (NABL), a Govt. body for accreditation of the Calibration and Testing Laboratories in India which is developing the network of National Measurement System. The scientists have helped NABL in assessing technical capabilities of several laboratories.

Mass, Length, Pressure and Temperature activities of the group have organized proficiency testing program in assessing the technical competence of NABL accredited calibration laboratories. NPL have thus been providing scientific and technical support to NABL in strengthening the National Measurements System in the country.

Two scientists of this division have been elected as Chairperson of APMP Technical Committees. The scientists of this division are nominated Members/Chairmen of various Sectional Committees of BIS (Bureau of Indian Standards), New Delhi and have been providing technical and scientific inputs to BIS for deciding the requirements for formulating the various Indian Standards related to Metrology and other areas.
Mass Standards

APMP-M.M.K2 Intercomparison

The work related to the coordination and monitoring of the APMP-M.M.K2 intercomparison in mass was continued during the year, the NPL being the pilot laboratory. A set of Mass Standards from NPL (10 kg, 500 g, 20 g, 2 g, 100 mg) are in circulation among the participating laboratories.

APMP-TCM

APMP-TCM accepted the NPL proposal for international intercomparison in Mass measurement among SAARC Countries and included it in Appendix B of BIPM Database with the Identification as APMP-M.M.M1.

NPL-NABL Proficiency Testing Program

The preparatory work as coordinator and reference laboratory for NPL-NABL Proficiency Testing Program (Phase-III) in Mass Measurements in which 20 calibration laboratories are participating, was carried out. The artifact to be used for this intercomparison was procured and a revised protocol has been prepared. The comparison will be started soon.

Length and Dimension Standards

Length and Dimension standard realizes definition of SI Unit 'metre' and maintains apex level standards and disseminates traceability by way of calibration. Development work on enhancement of resolution for Autocollimator has been carried out and filing of patent in this regard is in process. It has wide applications in terms of calibration of polygon & autocollimators with improved uncertainty.

A new approach of Surface Roughness measurement using optical method and image processing has been developed. It has an advantage over traditional tracing type of stylus method as no contact is required with the surface. Experimental results demonstrated good correlation between the received signal parameters and the root mean square value of surface roughness. A range of roughness up to 10\(\mu\text{m}\) was detected with a resolution of 0.01\(\mu\text{m}\).

The system for image acquisition is developed around National Instruments Image Acquisition Card, PCI 1408, installed on the computer. A monochrome image with a maximum transfer rate of 132 Mbytes/sec on 32 bit wide bus is grabbed. Image grabbing window is configured to acquire the image size 640 x 480 pixels and pixel depth of 8 bits. The image is transferred from the camera to the computer at a rate of 30 frames per second. Roughness standard under study was illuminated from two different angles. The image was recorded by Pulnix TMC-76 CCD camera and image acquisition system. The image was stored in the two dimensional arrays shown in Fig. 1.1 (a) and Fig.1.1 (b).

Discrete wavelet transform is used to analyze the acquired image. The two-dimensional wavelet transform decomposes the image in horizontal, vertical, and diagonal components at different level of intensities containing roughness information. The

![Image](https://example.com/image1.png)

Fig. 1.1 (a) : Original image of roughness standard sample
Fig. 1.1 (b) : Analyzed image of roughness standard sample

processing is done through Labview 5.1 software and Matlab 5.2. Standard roughness sample is analysed by using machine vision system and Symlet wavelet transform. Object coordinates were generated by applying the space intersection theory, where conjugate points are resulted by matching, and exterior orientation elements are obtained by the calibration process of systematic error.

In order to evaluate measurement-processing capability of the proposed system resultant values of a CCD camera were compared with the resultant values of surface roughness obtained by using standard contact type surface roughness measuring instrument perthometer model S6P.

To keep equivalence of standards to other National Metrology Institutes, the section participates in international intercomparisons. This year the section participated in several comparisons:

APMP LK1: Gauge Block Measurement: 10 Gauge Blocks (0.5, 1.01, 1.1, 6, 7, 8, 15, 80, 90, 100 mm) were calibrated interferometrically. The results have been submitted to the Pilot lab which is NMIJ, Japan. The final report is awaited.

APMP LK 5: Step Gauge 620 mm Measurement: One step gauge of length 620 mm was measured by substitution method. Nine NMIs are participating in this comparison and KRISS Korea was the Pilot lab. Results of the measurements have been submitted to the Pilot lab. The final report is awaited.

APMP LK 3: Four Angle Gauge Blocks and one polygon Measurement: 4 Angle Gauge Blocks of size 5°, 5', 30', 5° and one 12 face polygon were calibrated using autocollimator and index table. Thirteen laboratories are participating. It is expected that all the laboratories will be able to complete the measurements by December 2007. National Metrology Laboratory CSIR South Africa is the pilot lab.

The Coordinate Measuring Machine was upgraded under network project. Now this machine is equipped with the windows based software, which offers ease of CNC programming and curve measurement. The performance evaluation of machine is completed. The calibration & measurements services were provided to clients from industries and other organizations and 532 calibration reports were issued.

Proficiency Testing Program (MoU with NABL)

National Physical Laboratory has MoU with NABL for assessing the technical competence of NABL accredited laboratories.

1. Conducted proficiency testing for the measurement of surface roughness parameters viz.\( Ra = 0.6 \) m, \( Rz = 3.29 \) m, \( Rmax = 4.01 \) m, and \( Pt = 10.1 \) m and \( D \) (Depth of groove) = 9.1 m. Ten NABL accredited laboratories participated. The final report has been prepared. 87% results are in agreement.
2. Initiated proficiency testing for the calibration of Length of Length Bars of size 150 mm, 300 mm, 500 mm. Ten NABL accredited laboratories are participating. The program is in progress and is likely to be completed by March 2008.

3. Initiated proficiency testing for the calibration of Ring Gauges of diameter 5 mm, 12 mm, 50 mm and 100 mm. Ten NABL accredited laboratories are participating.

**Temperature & Humidity Standards**

The temperature standards group participated in the APMP Regional Comparison (APMP-T-S1-04) of Type-R thermocouples in the range from 0 to 1100 °C. The measurements were carried out at 17 different temperature points. The comparison, which started in March 2005 was coordinated by NMIA Australia. 12 NMIs namely, NMIA Australia, NIM China, SCL Hong-Kong, NPL India, KIMLIPI Indonesia, NMJ Japan, KRISS Korea, SIRIM Malaysia, SPRING Singapore, CSIR South Africa, CMS Taiwan and NIMT Thailand participated in the comparison program, which was completed in June 2006. Our results are quite satisfactory in the range 0 to 1100 °C as per first draft copy APMP-T-S1-04 issued by NMIA Australia.

The temperature standards group realized the copper point (1084.62 °C) by using copper sealed cell with an uncertainty of ± 0.36 °C with Type-S and ± 0.33 °C with Type-R standard thermocouples and using high temperature three-zone heating furnace. This fixed point is to be used for calibration of noble metal standard thermocouples to extend the calibration range of thermocouples from 1000 °C to 1600 °C.

A high temperature furnace of 1700 °C was procured and installed for calibration of noble metal thermocouples in the range 1000-1600 °C against a high precision Type-S/R standard thermocouple calibrated on fixed points.

A new Fluidized Bed Bath was procured and installed for calibration of precision thermometers and thermocouples. The stability performance of the bath was studied in the range 50 °C to 700 °C. The overall stability of the bath was measured to be ± 0.05 °C.

A low temperature calibration set-up with aluminum comparison block was designed and developed to work at boiling point of nitrogen (-196 °C) for calibration of special dial gauges having gas-filled temperature probes in different temperature ranges from -200 °C to -50 °C.

The performance and stability of one Type-S thermocouple and two Liquid-in-Glass thermometers were carried out which are to be used as artifacts for the intercomparison under SAARC-PTB Intercomparison in temperature metrology.

Apex level calibration was provided to various accredited laboratories and user industries in the temperature range from -200 °C to 2200 °C. This included 235 reports in calibration of high precision thermometers, gas-filled low temperature dial gauges, noble metal thermocouples and digital thermocouple indicators, temperature liquid baths, digital temperature hygrometers (RHT), optical and infrared radiation thermometers, tungsten strip lamps, high temperature blackbody sources, etc. and 71 reports in calibration of SPRTs, TPW cell, RTD / Digital Temperature Indicators.

The humidity standards group maintained the reference humidity standard (an aspirated psychrometer using two precise quartz thermometers) for calibrating RH instruments/hygrometers, in the RH range 15 % to 95 % RH with an uncertainty of ±1 % RH.

The Humidity Standards group developed a prototype simple and compact Dew Point/RH...
Physico-Mechanical Standards

Generator based on two pressure technique for humidity calibration to meet the industry requirement in the range of 15 to 95 % RH, with ± 1% RH stability. The device was tested in the whole range for its satisfactory performance. A laboratory model was given to M/s. ICL Calibration & Testing Services Pvt. Limited, Panchkula (HR) to have customer feedback at a nominal charge of Rs. 49,500/-. 

The humidity standards group procured and installed 2500 Bench-top Two Pressure Humidity Generator, capable of generating Relative Humidity in the range 10 % to 95 %, with accuracy ± 0.5 % RH and resolution 0.02 %. This will be used as Reference Humidity standard for the calibration of Industrial hygrometers (Digital / Dial Type) with lower uncertainties.

In total 54 Hygrometers/RH measuring instruments (Dial and Digital type) from different industries were calibrated.

Optical Radiation Standards

Research and developmental work on studying the photometric characteristics of light emitting diodes including their color characteristics, wavelength and intensity variations on the environmental conditions were carried out. The calibration facility for the photometric parameters of the LEDs has been established. Calibration facilities for the photometric parameters were extended to various lamp and lighting industries, R and D institutions etc. Calibration & Measurement facilities in air UV spectral region were maintained and extended to user industries and institutions.

Measurement of Ozone generated from Mercury Discharge Lamps

In a temperature and humidity controlled laboratory, the ozone production due to different low pressure and high pressure mercury lamps has been studied. The ozone produced has been measured using Teledyne, USA make Ozone Analyzer (Model 400E). This analyser has the overall uncertainty of measurement ± 2%. With low pressure Hg lamp the production of ozone is less efficient due to the low intensity of ozone absorption line. With high pressure mercury lamp, the production of ozone has found efficient and rapid and generation of Ozone as high as 110 ppb was observed. It may be due to the emission of continuum superimposed by Hg lines. It implies that most of the ozone production is from discrete emission lines in UV region. As the background surface concentration of ozone has already increased even in unconfined space, the ozone buildup could be substantial and harmful by using these Hg lamps.

Sponsored projects

“Studies on Spatial-coherence spectral filters and their applications”

The Project is completed however the research work is continued. The applications of the correlation-induced spectral changes have been extended to construction of spatial-coherence spectral filters and the phenomenon of spectral switching which in turn have led to new findings for information encoding and hiding. This study has resulted in few original papers which have been published.

Birla Management Corporation Limited, Bombay Sponsored project entitled "NIR spectroscopy technique for cellulosic materials"

Near infra-red and mid infra-red spectral studies of different varieties of pulp, alkcell and viscose samples obtained from the Grasim Chemical Laboratory, Nagda were analyzed using attenuated total reflectance and diffused reflectance accessories. Since the project was
completed in March 2007, a complete report on the study conducted has been submitted to Nagda.

**CSIR sponsored project entitled "Optical and spectral properties of organic compounds used as building blocks for nanostructures"**

Optical studies for investigating the morphology of polyaniline nanotubules of different dimensions, fabricated on a ground glass surface by a novel method, were conducted. This research was presented in the international conference on nanomaterials and the poster entitled “Optical Properties of anthracene nanotubes fabricated on a ground glass surface”, presented in the Nanoscience and Technology conference was adjudged as one of the best out of four posters chosen by the Hon'ble President of India. Photograph of the nanotubes developed is shown in Fig. 1.2.

![Fig. 1.2: SEM image of synthesized polyaniline nanostructures](image)

**DST sponsored project on "Studies on the effect of dynamic multiple scattering on the frequency shift of spectral lines and applications"**

To provide explanation for discordant redshift in quasars Doppler-like wavelength shift studies by dynamic multiple scattering of radiation by a medium whose dielectric susceptibility is a function of both time and space called an anisotropic plasma medium (the source and the medium are at rest with respect to the observer) were conducted. The redshift and broadening the lines emanated from discharge sources were studied. Results obtained have been published and presented in various forums.

**Space Application Sponsored project on “Development of Calibration-Validation (CAL-VAL) site at Kavaratti Island”**

In this particular project for developing in-situ calibration facility for spectral radiance and spectral irradiance, methods were developed for calibration of hyperspectral radiometers procured by SAC, Ahmedabad for ocean color studies. Fundamental research for determination of the immersion factor at various levels of water and various type of water was also carried. A paper on the calibration procedures developed at NPL was presented in the XXXII OSI Conference held at Vadodara in March 2007.

**Force and Hardness Standards**

The Force standards group became among the first ones to design, develop and fabricate a fully automated force machine (Fig.1.3) to realize force in the range 5-50 Newton by primary method with an uncertainty of ± 0.004% (k=2). The development would not only help to establish a facility to calibrate low capacity force instruments with low uncertainty, but would also act as a stepping stone to realize forces in low range for comparison purposes.

As an extension to the load cell calibrator development project for Regional Reference Standard Laboratories (Ministry of Consumer Affairs, Food & Public Distribution), design, fabrication and characterization of force transfer standards up to 5 kN was successfully
completed under the consultancy project to provide national traceability of the force calibrator maintained at the respective regional reference standard laboratories.

![Dead weight force machine (5-50 N)](image)

Fig. 1.3: Dead weight force machine (5-50 N)

Metrological characterization of the individual load cells (700 kN) which are to be used in 2MN buildup system and its direct calibration against NPL 1MN reference standard machine was carried out (Fig. 1.4). This has expedited the process to estimate the best measurement capability of 3MN hydraulic force machine.

**Torque:** The new torque primary standard machine to realize torque up to 2000 Nm with an uncertainty of better than ± 0.01% (k=2) was inducted in the quality management system. The group is now undertaking the calibration of higher accuracy torque transducers. A new type of the coupling was designed and developed to facilitate calibration of the conventionally used flange type torque transducers of higher accuracy using the torque standard machine as against the existing provision for the calibration of round type torque transducers only. It is now possible to provide national traceability in torque measurement with lower uncertainty and also to calibrate torque calibration machine on site.

![Rotation effect on build-up system output](image)

Fig. 1.4: Rotation effect on build-up system output

**CCM.TKI Torque Key Comparison:** The group also participated in CCM sponsored key comparison up to 1000 Nm, where PTB, Germany is the pilot Laboratory and 7 other NMIs around the world including NPL (UK), NMII (Japan), KRISS (Korea), CEM (Spain), CENAM (Mexico), INMETRO (Brazil), METAS (Switzerland) etc. are participating in this exercise. Two artifacts of 1000 Nm torque transducers, received from PTB, Germany, were calibrated directly against the torque primary standard machine established at NPL. The draft of the intercomparison reports is awaited.

**Establishment of Vickers hardness primary standard machine:** It is a unique facility at NPL to be used as national standard of Vickers hardness (Fig. 1.5). The group has now the capability to provide national traceability in calibration of Vickers hardness reference/standard blocks used by quality control, NABL accredited laboratories and different industries operating both in public and private sectors.
The group is providing national traceability in force, torque and Rockwell hardness through the calibration of force and torque measuring devices and hardness blocks to various users from industries, defence and other government organizations and also from other countries including Kuwait, Oman and Nepal. The facilities are being used extensively, which is well reflected in the ECF of Rs 47 lakhs (approx.) and the number of calibration reports issued as 500, which is 10% more than last year due to addition of new users.

Fig. 1.5: Vickers cum Rockwell superficial Hardness standardizing Machine recently established

A training course was organized during September 15-16, 2006 at Jadavpur University as a part of a proposed project to be sponsored by the University to NPL for setting up a Calibration centre for force, dimension, pressure and DC voltage at the University. The aim of the training course was to give lectures and practical training to technical personnel at the University in some of the metrological parameters such as force, a.c. voltage and current, dimensional measurements, etc. About 40 participants from the university and the industries from the nearby region attended the course. It is expected that more such courses in remaining parameters would be organized at Jadavpur University in future.

An Indo-Italian training course was organised during 5-8 Dec. 2006 in collaboration with ICE-INRIM (Italy). The aim of the training program was to train middle level managers and quality assurance personnel from accredited calibration laboratories and industries operating both in public and private sectors within India and in neighbouring countries by providing them first hand knowledge, exposure and hands on experience in the modern practices of force and torque measurement. In all 42 participants from India and one each from Nepal, Malaysia and two each from Thailand, Saudi Arabia were selected for the training course. The faculty comprised of experts from NMIs of Italy, Germany and India. Ten invited talks including those from eminent speakers such as Dr. Konrad Herrmann, Head, Hardness Standard Laboratory and Dr. Jens Illemann, Force Standard Laboratory, both from PTB Germany, Dr. Carlo Ferrero, Head Force & Torque Laboratory INRIM, Italy, Mr. G. J. Gyani, Secretary General, Quality Council of India, etc. were delivered during these four days deliberations. The practical training was provided on calibration of force transducers against dead weight & hydraulic multiplication force machine, calibration of torque transducers against the dead weight lever type torque standard machine.

Pressure and Vacuum Standards

Heydemann and Welch (HW) model:

HW model is based on a thermodynamic fluid flow equation known as Navier-Stokes (NS) Equation in the laminar flow approximation. There are several limitations of this model equation. We have attempted to overcome these limitations through introducing a rigorous statistical analysis. Based on this method, a complete characterization of a Controlled...
Clearance Piston Gauge (CCPG) was carried out at the NIST (USA) in a span of two years. The HW parameters determined from the characterization have also been repeated to within the Type A uncertainty from the two characterizations. The relative combined standard uncertainty of the effective area using the HW model ranges from $23.6 \times 10^{-6}$ at 20 MPa to $36.8 \times 10^{-6}$ at 200 MPa. Operating at a jacket pressure up to 40% of the system pressure, reduces the uncertainty slightly. The effective area from the HW model agrees to within the combined standard uncertainty of a direct comparison to the NIST pressure scale at all conditions from 20 MPa to 200 MPa.

**Experimental study on the effect of phase sensitive detector (PSD) outputs in the uncertainty measurement of UIM**

During experimental evaluation of measurement uncertainty of Ultrasonic Interferometer Manometer (UIM), it was observed that there is significant difference between this value and the theoretical value, particularly at low pressure below 1000 Pa. After analyzing the detailed behavior of variation of uncertainty in real operating conditions it was found that the variation depends significantly on the PSD output parameters, such as imperfection in 90 degree phase difference between two singles, unequal gain in two channels and eccentricity of the circle thus formed by the two signals. After this finding, further experimental work was carried out and as a result of which the PSD parameters were properly adjusted to the extent that maximum reduction in uncertainty was obtained. After these adjustments the output signals of PSD in the form of sine and cosine values were measured at different multiple frequencies. The results obtained are reproduced in Fig. 1.6, which shows a significant improvement in the signals such as perfect 90 degree phase difference and same amplitude of sine and cosine values. This work has improved the measurement uncertainty of UIM in low pressure region.

**Final report: APMP.SIM.M.P-K1c: Bilateral comparison between NIST (USA) and NPL (India) in the pneumatic pressure region 0.4 MPa to 4.0 MPa**

A bilateral comparison of pressure measurement between NIST and NPLI using a piston gauge transfer standard (TS), designated as NPLI-4, over the range of nominal applied pressure 0.4 MPa to 4.0 MPa was carried out.

![Phase sensitive detector (PSD) outputs in the uncertainty measurement of UIM](image1)

**Fig. 1.6:** Phase sensitive detector (PSD) outputs in the uncertainty measurement of UIM

![Effective areas as a function of pressure as measured by the laboratory standards at NIST (USA) and NPL (India). Standard uncertainty shown as error bars.](image2)

**Fig. 1.7:** Effective areas as a function of pressure as measured by the laboratory standards at NIST (USA) and NPL (India). Standard uncertainty shown as error bars.
Fig. 1.7 shows the effective area as a function of pressure as measured by the laboratory standards at NIST (USA) and NPL (India). The comparison data were analyzed in terms of the effective area \([A_e \text{ (mm}^2)\)] as a function pressure \([p \text{ (MPa)}]\) of the TS at the above-mentioned pressures. The zero pressure effective area \([A_0 \text{ (mm}^2)\)] and the pressure distortion coefficient \([\lambda \text{ (MPa}^{-1})]\) of the transfer standard were also estimated. The degree of equivalence between NPLI and NIST is 11.4x10\(^{-6}\) or better.

**Final report APMP.SIM.MP-K7: Bilateral comparison between NIST (USA) and NPL (India) in the hydraulic pressure region 40 MPa to 200 MPa**

Another bilateral comparison of pressure measurement between NIST (USA) and the NPLI over the range of nominal applied pressure 40 MPa to 200 MPa was carried out. The comparison data were analyzed in terms of the effective area \([A_e \text{ (mm}^2)\)] as a function of pressure \([p \text{ (MPa)}]\) of the two transfer standards in the respective pressure ranges of (40 to 80) MPa and (80 to 200) MPa. The degree of equivalence between NPLI and NIST evaluated as the relative difference in the institutes' results for effective areas of the transfer standards is within 7.7x10\(^{-6}\) in the whole pressure range (40 to 200) MPa.

**Coordination of NABL Sponsored Proficiency Testing in the Hydraulic Pressure Measurements up to 70 MPa**

In view of the success of the previous three NABL-NPL sponsored proficiency testing exercises in the hydraulic pressure measurements, NABL-NPL has entrusted our group to coordinate three more proficiency testing programs, namely PT004, PT005 and PT006 in the pressure range 0 - 70 MPa using dead weight tester, digital pressure calibrator and pressure dial gauge respectively as the artifacts. A total number of 65 NABL accredited pressure laboratories from all over India are participating in these programmes.

**Raman work under high pressures**

High pressure Raman experiments were carried out at BARC, Mumbai wherein the pressure induced behaviour of polycrystalline rare earth sesquioxides, Gd\(_2\)O\(_3\), Sm\(_2\)O\(_3\), and Y\(_2\)O\(_3\), were studied. Interestingly, high pressure studies on Gd\(_2\)O\(_3\) (shown in Fig. 1.8) and Sm\(_2\)O\(_3\) have not been reported anywhere and in addition, being nano-sized samples, the results obtained have been found to be very interesting. These samples showed a partial amorphization as the pressure was increased. However, Y\(_2\)O\(_3\),
(shown in Fig. 1.9) showed transformation to a new phase while releasing the pressure. These results are presently being analyzed and preliminary findings were reported at the MRSI meeting.

**Acoustic Standards**

The International Peer Review of Acoustics Standards was carried out during 3-5 October, 2006 under the supervision of Dr. Prem Narang of NMI, Australia and Mr. Basavaiah, Quality Expert, Bangalore and 9 CMCs were approved.

**APMP AU.V.A-K3 Key Comparisons:**
The Acoustics Section participated in APMP AU.V.A-K3 Regional Key Comparison involving two LS2P microphones with KRISS, Korea as the pilot laboratory. The comparison results showed that the NPL sensitivity values were within ±0.03dB of the average value. Also the repeatability of NPL results was within ±0.01 dB.

**CCAUV.V-K1.1 Key Comparison:**
Acoustics Section also participated in a tetrilateral key comparison CCAUV.V-K1.1 involving two standard accelerometers (B&K Type 8305) with NIM, China, PTB, Germany and INMETRO, Brazil as participating laboratories. The results are in compiling stage.

The Acoustics Section organized the National Symposium on Acoustics (NSA-2006) in collaboration with Acoustical Society of India as a part of NPL Diamond Jubilee (1947-2007) celebration during November 16-17, 2006. Also, a one day workshop on 'Noise Control Measures for D.G. Sets' was arranged on November, 15, 2006 as a curtain raiser to NSA 2006.

A continuous sodar monitoring system was deployed at CPCB, Agra. The mixing height studies at Paradeep, Orissa for EIA in respect of the upcoming mega steel project in Orissa were successfully completed. The group participated in multi-technique/ multi-institutional on ship measurements of Atmospheric boundary layer (ABL) parameters under Integrated Campaign for aerosols, gases and radiation budget (ICARB).

**Ultrasonic Standards**

The ultrasonic Standards continued to provide services to the industries for the calibration of ultrasonic non-destructive testing equipment and ultrasonic medical equipment. Calibration procedure was developed for ultrasonic response and dimensional accuracy of test rails for the on-line ultrasonic inspection of rails manufactured in India for high speed trains and high volume of traffic. Since uncertainty is seldom mentioned in the test reports of nondestructive testing, NPL has taken the initiative to develop procedures for estimating uncertainty in ultrasonic NDT. The first of its attempts has been made in the angle beam testing of ultrasonic NDT where uncertainty has been estimated for location of defect in a parallel plate.

In an attempt to degas water to DO (Dissolved Oxygen) level of 2mg/L, a methodology has been developed and standardized. The method to retain this level for 8 hours of experimentation has also been developed and found satisfactory.

In yet another experiment, a new procedure has been developed which increases the frequency resolution in digital signal processing from $1/T$ to $1/2T$.

**Fluid Flow Standards**

The primary Standard Facility for Fluid Flow (water) has been upgraded and
modernized to make it operator friendly, with indigenous software. Now the upgraded system is under evaluation for its performance. Testing of the water meters was carried out for the water meter industry.

**Shock and Vibration Sensors**

The indigenous accelerometers, developed at NPL, with proven overall excellent performance characteristics of International quality, is now being used confidently by the high profile users from both core and strategic sectors. The Technological Process Know-How for the commercial production of the device has already been transferred to the two industries. Many other industries are also likely to acquire this technology, in the near future. Currently, the group is engaged in the development of a tri-axial accelerometer.

As part of its regular on going activities the group has continued to provide its specialized scientific services to the users from almost all sectors, and provided them low cost, high value solutions for their requirements. A special accelerometer was also developed for the Defence Lab., SSPL, Delhi. Test and Calibration services were also provided to a large number of industries and other organizations.