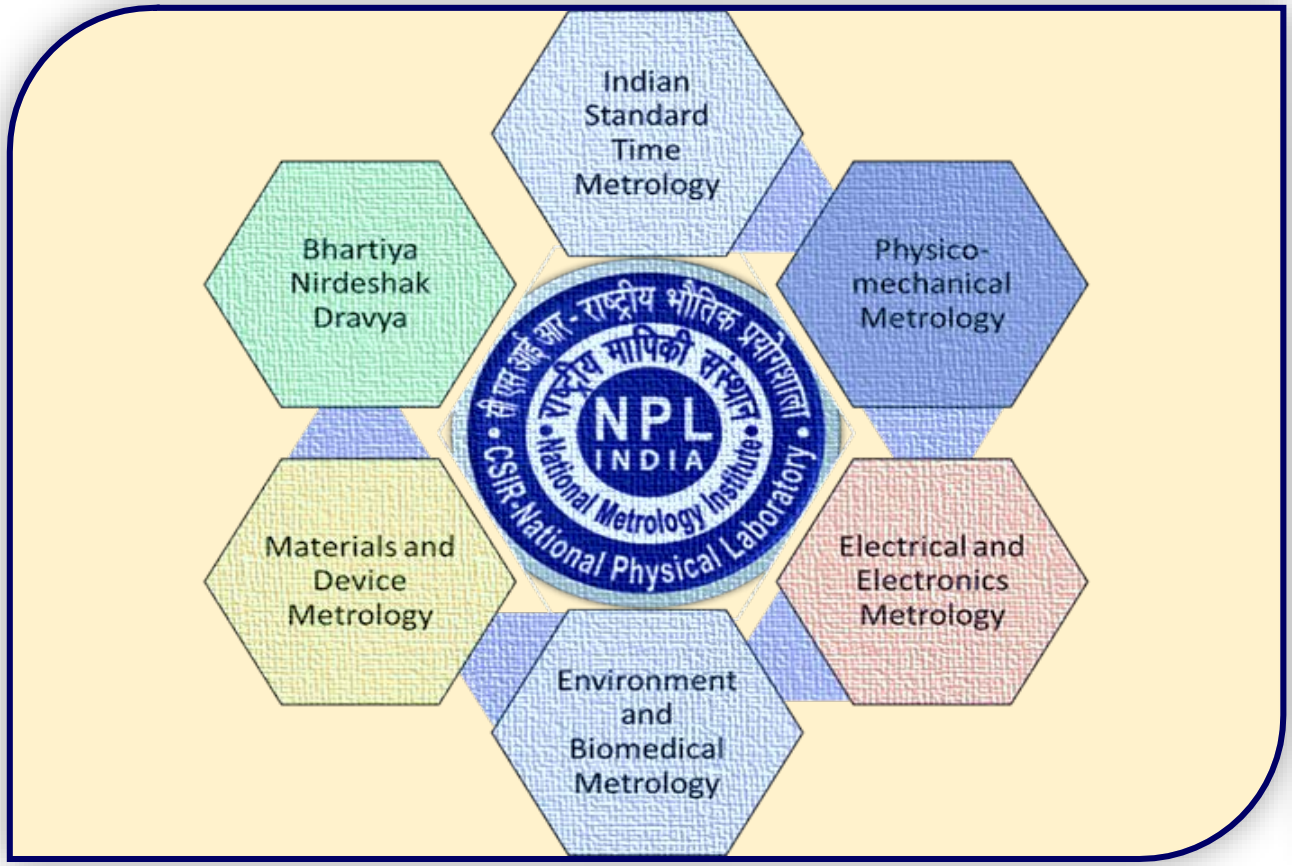
Recent Progress in Mass Related Activities at NPLI

Dr. S.S.K.Titus TCM Chair APMP

NPLI, New Delhi, India

Various Activities of NPLI and its Quality Policy



सी एस आई आर–राष्ट्रीय भौतिक प्रयोगशाला
(भारत का राष्ट्रीय मापिकी संस्थान)
CSIR–NATIONAL PHYSICAL LABORATORY
(National Metrology Institute of India)
डॉ. के. एस. कृष्णन मार्ग, नई दिल्ली - 110012, भारत / Dr. K. S. Krishnan Marg, New Delhi - 110012, India
www.nplindia.in

गुणवत्ता नीति : Quality Policy

अंतरराष्ट्रीय मानकों के अनुरूप सतत् अनुसंधान और विकास के माध्यम से राष्ट्रीय मापन मानकों का प्रापण, स्थापना, रखरखाव व उन्नयन करना और भारतीय निर्देशक द्रव्य (बी एन डी®) का विकास/उत्पादन करना।

आई एस/आई एस ओ/आई ई सी 17025 : 2017 की आवश्यकताओं के अनुरूप ग्राहकों को मापन की अनुमार्गणीयता बनाए रखने के लिए शीर्षस्तरीय अंशांकन/परीक्षण सेवाओं तथा मानकों का प्रसार निष्पक्ष और प्रभावी ढंग से प्रदान करना।

आई एस/आई एस ओ 17034 : 2016 की आवश्यकताओं के अनुरूप प्रयोक्ताओं हेतु अनुमार्गणीयता के प्रसार के लिए बी एन डी का विकास/उत्पादन करना और निर्देशक द्रव्य उत्पादकों (आर एम पी) को बी एन डी के विकास/उत्पादन में तकनीकी सहायता प्रदान करना।

To realize, establish, maintain and upgrade the national standards of measurement compatible to international standards and to develop/produce Bharatiya Nirdeshak Dravya (BND®), through continuous research and development.

To provide apex level calibration/testing services and dissemination of standards for maintaining the traceability of measurements to the customers fulfilling the requirements of IS/ISO/IEC 17025 : 2017, impartially and effectively.

To develop/produce BNDs for disseminating traceability to the users and to provide technical support to the Reference Material Producers (RMPs) in the development/production of BNDs, conforming to the requirements of IS/ISO 17034 : 2016.

उद्देश्य : Objectives

ग्राहकों/प्रयोक्ताओं की संतुष्टि के लिए निर्दिष्ट समय-सीमा में निष्पक्षता व सक्षमता से अंशांकन/परीक्षण सेवाएं और बी एन डी प्रदान करना।

अंशांकन, परीक्षण व बी एन डी विकास/उत्पादन से संबंधित सभी कर्मियों को गुणवत्ता प्रणाली प्रलेखन तथा नीतियों और प्रक्रियाओं के कार्यान्वयन से परिचित कराना।

To provide calibration/testing services and BND within the specified time, impartially, competently and to the satisfaction of the customers/users.

To familiarize all personnel concerned with calibration, testing and BND development/production with the quality system documentation and implementation of policies and procedures.

प्रो. वेणु गोपाल आचन्ता
निदेशक

Prof. Venu Gopal Achanta
Director

Physico-Mechanical Metrology (PMM) Division

PMM at the sevice of nation: R&D, Industry and Outreach

PMM Subdivisions:

1.01 Mass
1.02 Length, Dimension
1.03 Temperature and Humidity
1.04 Optical Radiation
1.05 Force and Hardness
1.06 Pressure, Vacuum and Ultrasonic
1.07 Acoustics and Vibration
1.08 Fluid Flow

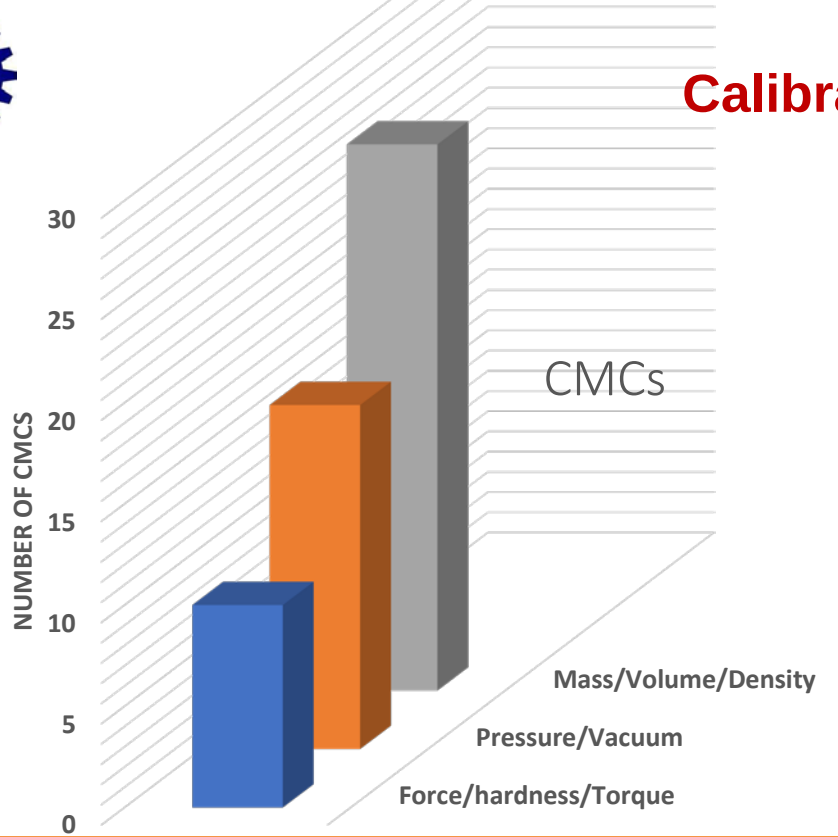
PMM Parameters with four SI base units:

Mass, Volume, Density,
Viscosity
Length, Angle and Geometrical
Forms
Temperature and Humidity
Luminous Intensity Flux,
Illuminance, Spectral Irradiance,
Force, Torque and Hardness
Pressure, Vacuum, Ultrasonic
Velocity, Power
Sound Pressure, Vibration
Amplitude
Totalized Mass & Volume, Mass
& Volume Flow Rates

Major Stakeholders:

- Aerospace, Electronics and instrumentation & Strategic sectors
- Civil infrastructure and Engineering
- Mining, Minerals, Metals and Materials
- Chemical and Petrochemicals
- Ecology, Environment, Earth Sciences & Water
- Medical and Health care

Calibration and Measurement Capabilities



Activity	Existing CMCs	Proposed CMCs
Mass, Volume, Density, Viscosity	27 (16,3,2,6)	5*
Pressure, Vacuum	17	4
Force, Torque and Hardness	10	Nil
Total	54	9

*New CMCs on volume will be added for the range of 1 µl to 5 ml.

Key comparisons Completed / Participated/Planned

1. SAARC-PTB Intercomparison on Volume ; In progress; Volume Micropipettes, 3 Nos. (5 µl, 100 µl, 1000 µl) CSIR-National Physical Laboratory. Final observations completed in September 2022, currently first draft under progress. This intercomparison is to compare the performance of laboratories in the SAARC region in volume measurement using three variable volume piston pipettes of 1-10, 10-100 and 100-1000 respectively to be measured at 5µl, 100µl, 1000µl. This comparison will provide evidence to support their calibration and measurement capabilities (CMCs).

2. Participated in APMP key comparison (APMP.M.FF-K4.2.2021) on Volume comparison during July, 2021 as per protocol. Five nos. of 100 µl micro-pipettes were used in the comparison. National Institute of Metrology (NIM), China is Pilot laboratory.

3. The pneumatic pressure section intends to participate in the international key comparison in any pressure range between 0.04 to 40 MPa.

4. CCM comparison, Planned, Mass, 1kg weight, 1 kg mass standard intercomparison undertaken by CCM for the dissemination of mass parameter.

First Robotic Mass Comparator installed in India.

Specifications –

- e5 Robotic Mass Comparator
- Mettler Toledo
- Maximum Capacity: 6.1 g
- Readability: 0.1 µg
- Weight Handler: 3-axis robot
- 60 position magazine
- Repeatability: ABA at Nominal Load 0.4 µg
- Guaranteed Repeatability 0.15 µg
- Automated Draft shield

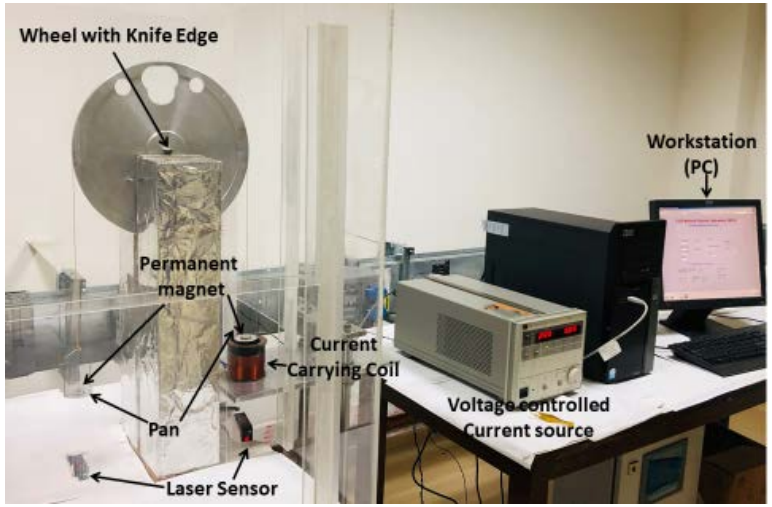
Using RMC, CMC of mass for the range of 1 mg to 1 g will be improved from existing 2 µg to ≤ 0.5 µg; $k = 2$.

A robotic mass comparator is a high-performance comparator balance coupled with a robotic arm that enables a large number of weights to be calibrated in an automatic process. The robotic arm transfers reference and test weights from the magazine and places them in turn on the weighing pan of the mass comparator. Even entire weight sets with different nominal values can be calibrated without human interaction.

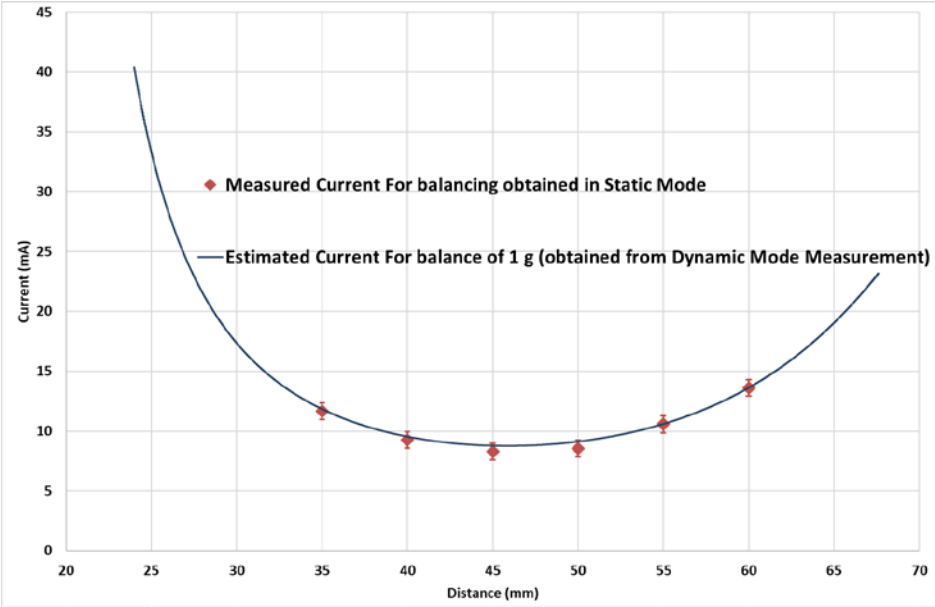
Major Advantages :

- Significant reduction of air drafts and vibrations from a robotic system in the course of comparison,
- Majorly minimized risk of human error, fewer errors due to weights mix up and imprecise placement
- Stable environmental conditions inside the weighing chamber owing to the compact device dimensions
- Protection of valuable reference weights.
- Minimized uncertainty and Highest Accuracy

Demonstrational model of 10 g Kibble balance



The NPL's demonstration model of 10 g Kibble balance



Presence of oscillations in Dynamic Mode due to Horizontal and Angular Displacements of the mechanical setup which include magnet, pan and thread detected by Signal Processing of the Acquired Data

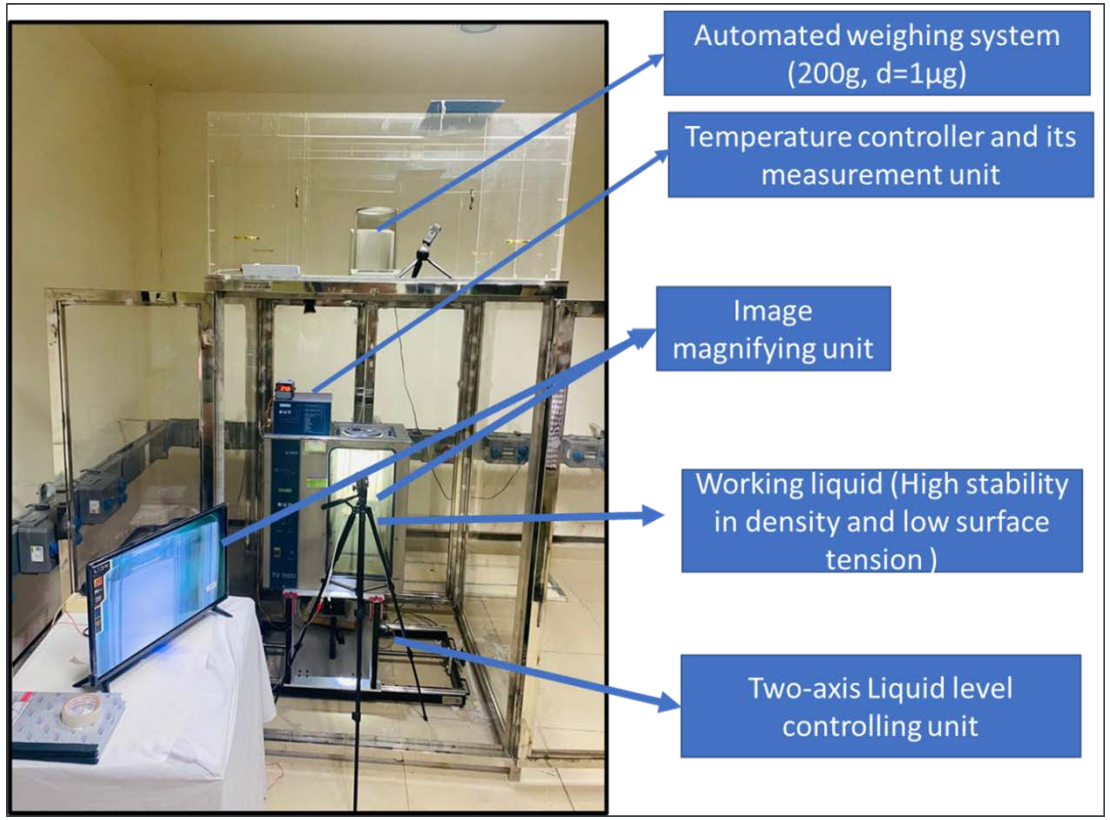
Coil Velocity	Noise source	Frequency (Hz)
0.5 mm/s	Horizontal displacement	1.7
1 mm/s	Horizontal displacement	1.7
2 mm/s	Horizontal displacement	1.7
4.71 mm/s	Horizontal displacement	1.7
9 mm/s	Horizontal displacement	1.7

The estimated current obtained from dynamic mode measurement was found to be in agreement with the measured current for balancing in static mode. Successfully minimized the electrical noise in the induced EMF signal.

Coil Velocity	Noise source	Frequency (Hz)
0.5 mm/s	Axle rotation	0.12
1 mm/s	Axle rotation	0.24
2 mm/s	Axle rotation	0.45
4.71 mm/s	Axle rotation	1.05
9 mm/s	Axle rotation	2.2

Up-gradation of the Primary density Standard

An semi-automated hydrometer calibration system has been established and realized that employs the hydrostatic weighing technique using Cuckow's method. (Phase-I)



Specifications

Solid Density Primary Standard
Weighing System:
Maximum Capacity: 200 g
Readability: 1 µg
Twin-axis platform for bath level control
Measurement range: 0.600 to 2.000 g/cm^3
Semi-automatic data collection
Draft shield

Pressure and Vacuum

1. **Design, development, fabrication and establishment of customized indigenous working standards for verification of blood pressure measuring instruments**

2. **Strengthening Metrological Activity for Research and Technology in Physico-Mechanical Parameters(SMART-PM)**
    1. **Extension of pneumatic pressure capability to 100 MPa**
    2. **Development of primary vacuum and pressure standard in the range of <150 kPa**
    3. **Dynamic Pressure Calibration system (500 MPa)**
    4. **Up-gradation of Primary Solid Density Standard**
    5. **Modernization of Viscosity Measurement System**

3. **Technical services to enhance the performance of testing and calibration facilities in Testing Centres (TCs) and Testing Stations (TSs) under the Ministry of MSME**

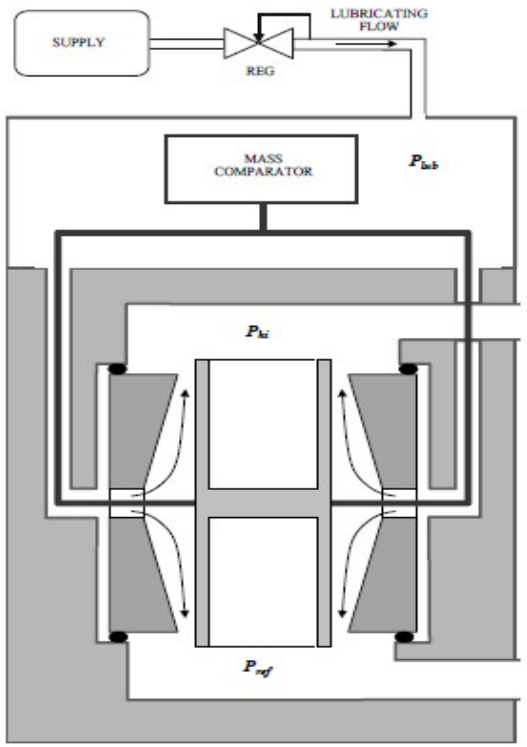
4. ***Design Development and Establishment of Optical Interferometer Manometer: A Primary Quantum Pressure Standard at CSIR-NPL***

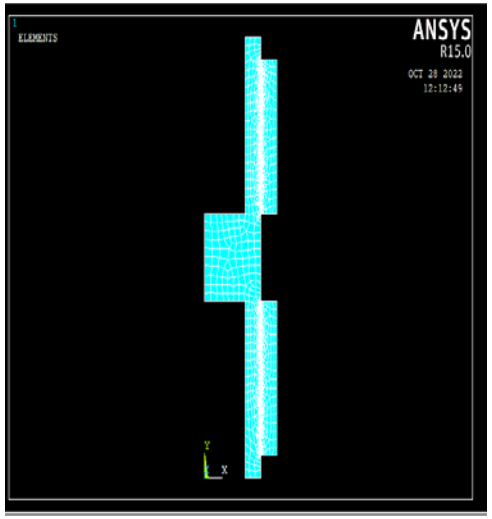
Pressure and Vacuum

5. Software development and up-gradation from manual to semi-automatic testing facility for NIBP measurement devices for the Ministry of Consumer Affairs, New Delhi under Legal Metrology Project entitled “Design, Development, Fabrication And Establishment Of Customized Indigenous Working Standards For Verification Of Blood Pressure Measuring Instruments (2 Systems)”

- Establishment of Air Piston Gauge as Primary Pressure standard in the range of 6.5 kPa to 360 kPa was completed
- Set up for calibration and testing of dynamic NIBP (Non-invasive Blood Pressure) monitoring devices was fabricated and demonstrated successfully
- Establishment of type approval testing facility for NIBP measurement devices has been completed

Establishment of Force Balanced Piston Gauge (FPG8601) as primary pressure standards





Pressure (kPa)	A_{eff} (mm^2)
0	980.5468443426
2	980.5468446785
4	980.5468450143
6	980.5468453502
8	980.5468456860
10	980.5468460218
12	980.5468463577
14	980.5468466935

	Diameter @ (20 ±1)℃	uncertainty at k = 2
piston (mm)	17.66599	70 nm
cylinder (mm)	17.6687	700 nm
Dimension uncertainty		19.9093665 ppm

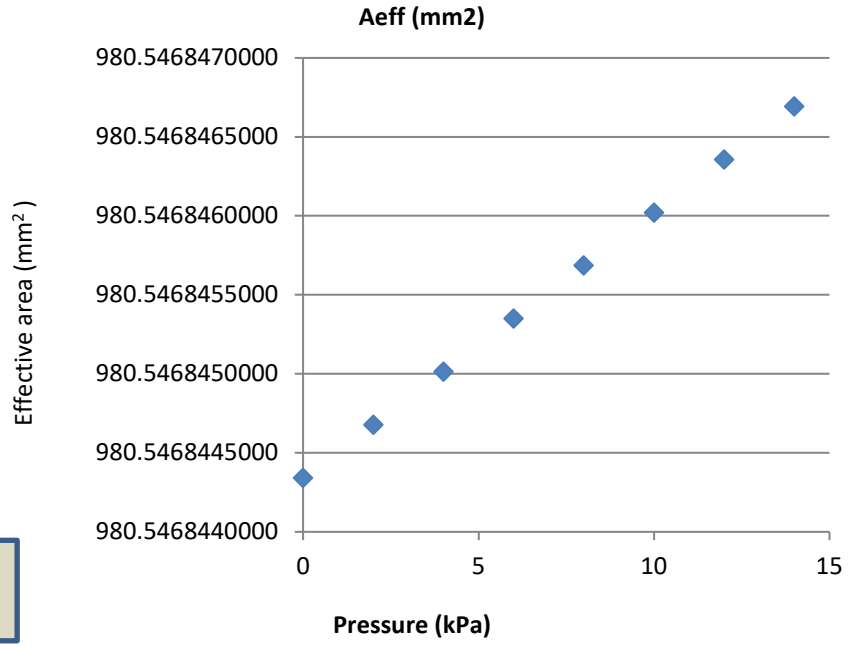
U(x), u(x), R0,ro

$$r_i = r_0 + u_i$$
$$R_i = R_0 + U_i$$
$$h_i = R_i - r_i$$

$$G_{P_i} = \frac{-1}{2\sqrt{\pi}} ln \frac{h_i}{r_i} + \frac{\pi}{2}$$

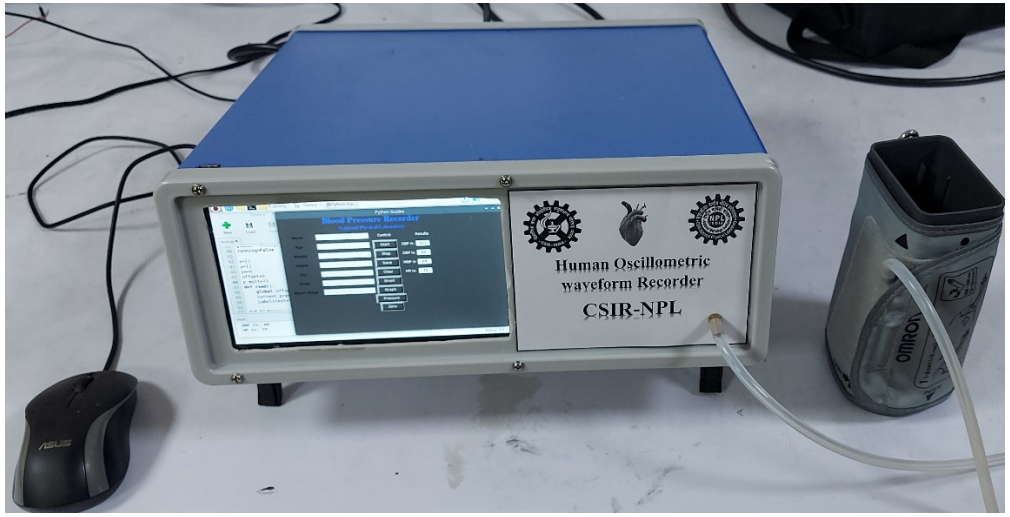
$$P_i = \left[p_{lub}^2 - (p_{lub}^2 - p_{meas}^2) \frac{\int_0^z \frac{1}{h_i^2 G_{P_i}} dz}{\int_0^{L_T} \frac{1}{h_i^2 G_{P_i}} dz} \right]^{1/2}$$

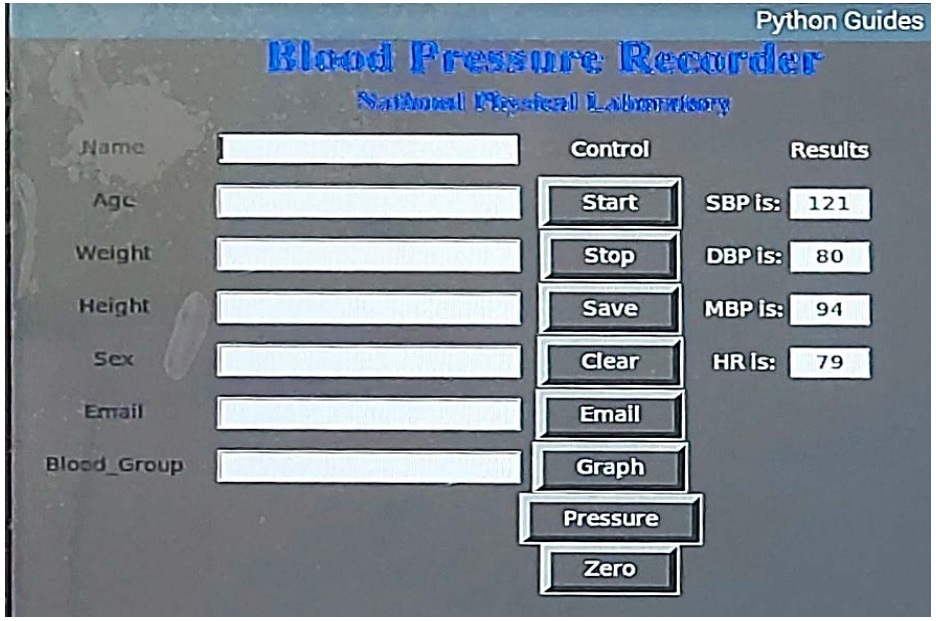
$$A_T = \pi r_0^2 \left(1 + \frac{h_0}{r_0} - \frac{1}{(p_{lub} - p_{meas})} \int_0^{L_T} (U_i + u_i) \frac{dp_i}{dz_i} dz_i \right)$$



Human Oscillometric waveform Recorder

CSIR-NPL





Records and displays the oscillometric waveform graphically

CSIR-NPL has Developed a Human Oscillometric Waveform recorder for Testing and Calibration of Non-Invasive Blood Pressure measuring Devices

New Facility creation for Non-Invasive Blood Pressure Measuring instruments

calibration/testing system for non-invasive BP monitoring system

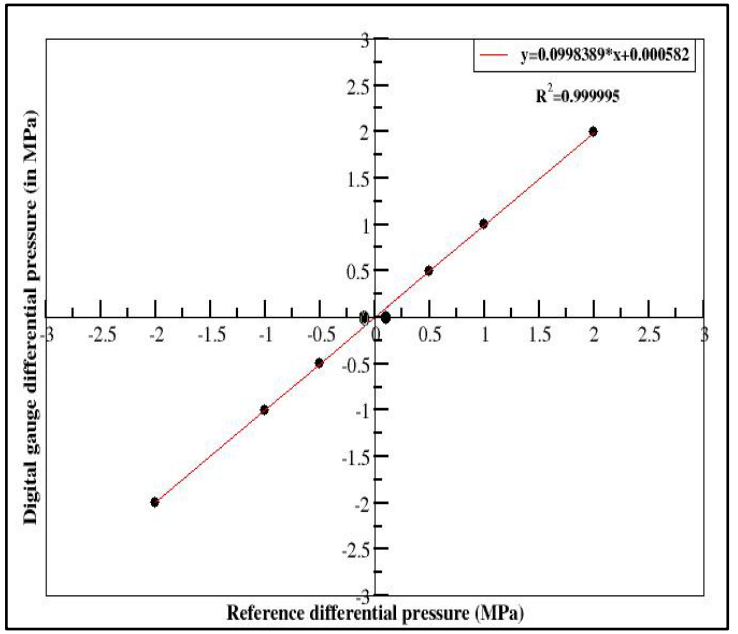
CSIR-NPL developed the calibration/testing system for non-invasive BP monitoring system. This system can operate in semi-automatic as well as manual mode both. It is capable of simultaneous calibration/testing of 20 BP monitoring devices altogether.

CSIR-NPL Developed Working Standard of Blood Pressure Measuring instruments

This Technical Services of Design, development, fabrication and establishment of customized indigenous working standards for verification of blood pressure measuring instruments was developed for our client Legal Metrology Department, Department of Consumer Affairs and was installed at two different locations (Varanasi and Faridabad India).

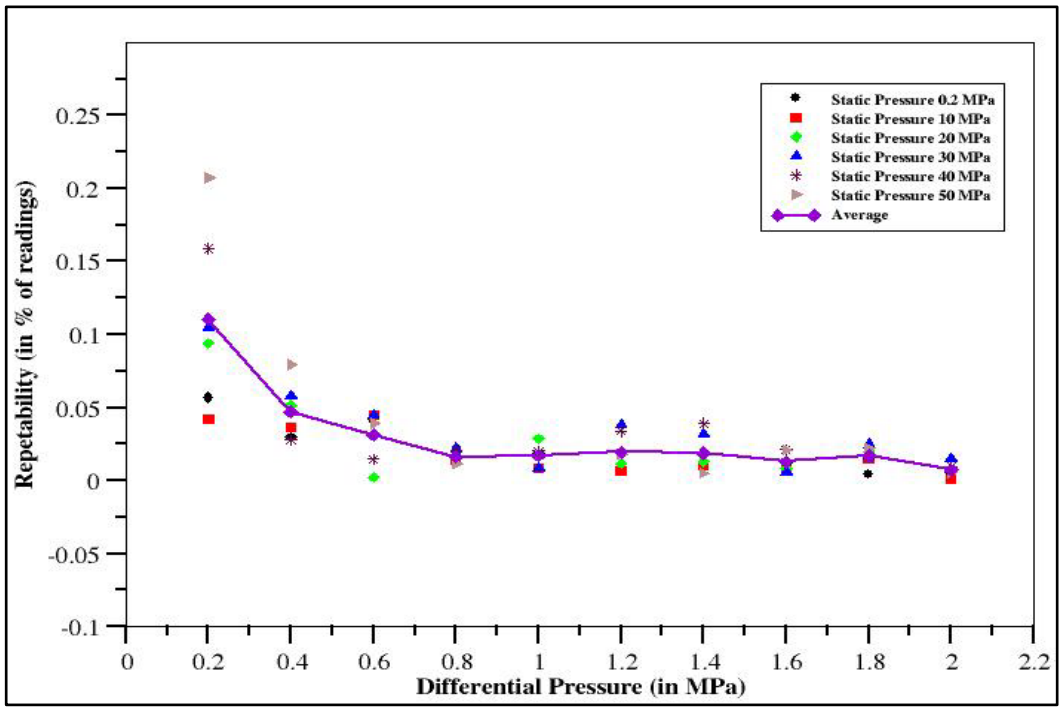
Hydraulic Differential Pressure Calibration System Established

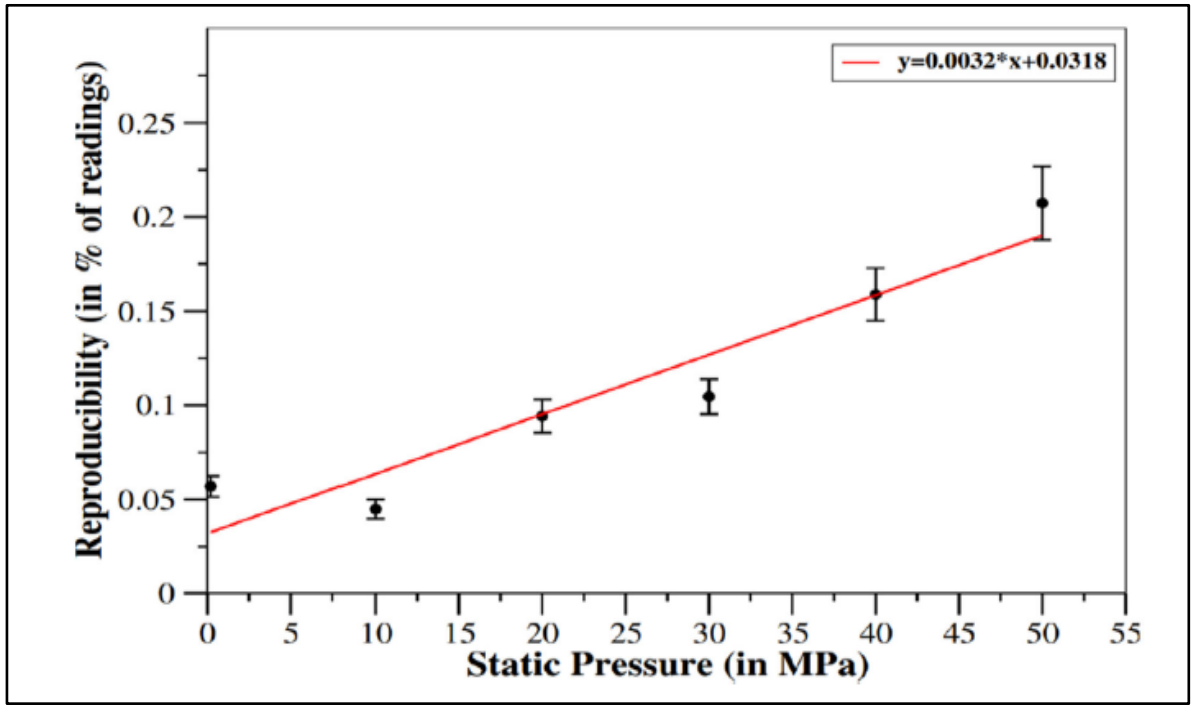
Standard used: twin-pressure balance (Model 55614, Desgranges & Huot)
DUC : Make ABB
Line Pressure: 50 MPa
Differential Pressure: 2 MPa



This Hydraulic Differential Pressure System has been Established recently and we are planning to obtain a new CMC in hydraulic differential pressure

Planning a CMC Hydraulic Differential Pressure





The uncertainty in pressure measurement using twin pressure balance has been estimated, which shows a maximum uncertainty of 3.681E-3 MPa (coverage factor *k* = 2). The device under calibration shows a maximum error of 0.42% of reading, average uncertainty due to repeatability of 0.12% of reading and maximum uncertainty due to reproducibility of 0.21% of reading.

Establishment of high pneumatic pressure standard up to 100 MPa

Fluke PG 7202

- Piston gauge, FLUKE PG 7202
- Range : 0.2 to 100 MPa
- Nominal Area 9.8 mm^2
- Liquid Lub Gas Piston Cylinder Module, 1MPa/kg (PC-7202-1)
- Sensitivity 20 pa + 1 ppm Reproducibility ± 3 ppm
  Typical measurement uncertainty ± [15Pa + (20 ppm +0.15 ppm/MPa)]
  Typical drop rate 0.25 mm/min @50 mpa
- High-pressure modular controller chassis, 2 bay
- High-pressure measurement module, 100 mpa , gauge
- Gas booster kit, 152:1, 110 mpa (16000 psi)
- Maximum mass load : 100 kg
- Expected to be installed during Jan. 2023.

FORCE, TORQUE & HARDNESS

Objectives:

To establish, up-grade and maintain the primary standard of force, torque & hardness and to provide the traceability to the user organization.

Strategic sectors:

Automobile, Mechanical and cement industries, Defense, Railways, ISRO,

Recently established 5 kN Force Primary Standard
BMC ± 0.008 (at k=2)

Rockwell Hardness machine to be established soon
BMC ± 0.3/± 0.5 HR ± 0.4/± 0.6 HRN/T (at *k* = 2)

Future Developmental Work planned

- Establishment of a Comparator type force calibration machines of 5 MN and 200 kN capacities
- Torque calibration for higher (> 2000 Nm) and lower ranges (< 100 Nm)
- Up-gradation of Vickers/ Brinell hardness machine
- Charpy Impact Testing facility

Summary

- Robotic Mass Comparator installed
- Density measurements updated
- New Facilities in Force Standards
- Differential pressure measurement in hydraulic ranges
- FPG as primary standard
- Pneumatic Pressure being updated to 100 MPa
- Blood pressure calibration initiated
- Blood pressure calibration systems delivered to Regional Reference Labs
- Diploma course in precision measurements, training programs
- International conference on Advances in Metrology ADMET 2022


thank you!