

Section 1: Main Research Activities

During the last year, the following CCM related activities were carried out at NPLI:

- We have installed and commissioned a 5kN automatic Dead weight force machine having a measurement capability of $\pm 0.008\%$, this is would also enable us to provide the traceability in the force measurement to our customers in this range of (0.05 – 5)kN with a better uncertainty.
- Establishment of type approval testing facility for Non-Invasive Blood Pressure (NIBP) measurement devices has been completed
- Robotic mass comparator of 5 g (0.1 μg) has been procured to improve CMCs in milligram range. In an effort to improve the CMCs of mass parameter, this robotic mass comparator has been procured. The comparator was delivered at CSIR-NPL in the month of February, 2020. As soon as installation is complete, measurements and other necessary processes to improve the CMC will be initiated.
- *Upgraded the Primary Water Flow Calibration Facility* for calibration of different types of flowmeters of sizes DN2 to DN200 in the *flow range 0.03 m³/h to 650 m³/h* using weighing method as per ISO 4185 Standard. The new system was completely designed by CSIR-NPL where five pipe lines (DN25, DN50, DN100, DN150 and DN200) have been installed and connected to 3 high accuracy weighing systems (300 kg, 3000 kg and 6000 kg capacities) through fishtail, nozzle and diverter systems. A separate line of DN15 size has been also derived for calibration of DN2 to DN4 size mass flowmeters using 12 kg weighing scale employing standing start and standing finish method. The uncertainty in flowmeter calibration for *totalized mass* and *totalized volume* parameters is in the range of *0.01-0.02% (at k=2)* whereas for *mass flow rate* and *volume flow rate* parameters it is in the range of *0.03-0.05% (at k=2)* which are at par with the international level. Thus NMI status in water flow area is maintained now by CSIR-NPL.
- We have provided calibration and testing services to about 1000 customers in the areas of Pressure, vacuum, mass, density, volume, viscosity, force, torque, hardness scales and fluid flow.
- Organized a two days Preparatory Workshop to discuss technical protocol of ILC on volume among participants of SAARC NMIs during (19th - 20th) November, 2019 at CSIR-NPL. BSTI, Bangladesh, BSB, Bhutan, NBSM, Nepal and MUSSD, Sri Lanka had participated in this program. Director, SAARC and Deputy Director, SARSO also attended this program to strengthen the collaboration between SAARC countries.
- A significant contribution made in compiling a book entitled “**Metrology for Inclusive Growth of India**” which has been published by Springer in late 2020. This book highlights the role of metrology for inclusive growth of India and describes various metrological applications in the areas of physico-mechanical, electrical and electronics, Indian standard time measurements, environment, biomedical, materials and Bhartiya Nirdeshak Dravyas (BND®) / Certified Reference Materials (CRMs) etc.
- At present there are total 54 CMCs of NPLI registered in KCDB of BIPM. Efforts have been initiated to add another 20 CMCs in near future. Prepared revised documents (Document Manuals) for implementing the transition of quality system based on ISO/IEC 17025: 2017. The new quality system has been implemented in all the

parameters related to CCM following an internal audit exercise. Undergone on-site Peer Review of the Quality System based on ISO/IEC 17025 : 2017 through APMP in all the parameters related to CCM during Nov. 17-19, 2020. No NC was raised in any of the parameter. Report is under review at APMP,

- A project on design, development, fabrication and establishment of customised indigenous working standards for verification of blood pressure measuring instruments (2 systems) is in final stages for the Legal Metrology department, Ministry of consumer affairs, Government of India.
- A project has been completed on “Fabrication and establishment of pressure calibration system in the range upto 140 MPa” for National Council for cement and building materials, (NCCCBM) Ballabgarh, India.
- A project has been initiated for the realization of the Quantum Pascal.
- Efforts have been made to minimize the electrical noise in the induced EMF signal of 1 g Kibble Balance.
- Foreign deputation of Mr. Afaqul Zafer (Scientist) in Malaysia for training course on “Calibration and Testing of Non-Invasive Sphygmomanometers”, jointly organized by APMP, APLMF & PTB, Germany within the framework of the MEDEA 2 Project (Metrology Enabling Developing Economies in the Asia Pacific).
- Phase transitions under ultra-high pressures are also being researched on using high pressure x-ray and Raman measurements on strategic materials.
- Design and development of 2 technologies; a) Environmental Conditions Monitoring and Recording Module (NPL-EMRM) and b) Cross Volume Valve (NPL-CVV) for calibration of pressure balances.
- Provided technical support to Indian Accreditation Body (AB) i.e. National Accreditation Board for Calibration and Testing Laboratories (NABL) through online training (Feb. 28, 2020) on “Pressure Metrology: Measurement Techniques, Calibration and Computation of Associated Measurement Uncertainties” and “Specific Requirement for Mass & Volume and Uncertainty in Measurement” to about 30 Legal Metrology Officers organized NABL. Online Webinar organised on “Concept of SI Units, Their Redefinition and Impact” by DYP College of Engineering, Pune, July 14, 2020. Provided technical support to NABL by Online Training organised on Pressure Metrology: Concept, Theory and Calibration on July 17, 2020 and on Mass and Volume Metrology on July 20, 2020.
- Provided support to NABL in terms of Subject Experts as assessors, members and chairman of the various technical committees and also to conduct the Proficiency Testing Programmes.
- Our Experts also provided their technical support to Bureau of Indian Standards (BIS), which is a national body to provide the written standards.
- Provided Technical Support, Traceability and Training to Legal Metrology Laboratories in India. We have trained hundreds of Legal Metrology Officers.
- Successfully conducting a one-year post-graduate diploma in Precision Metrology and Quality Control (PMQC) for the development of skilled manpower.
- The **“2020 APMP Award for Developing Economies”** was awarded to Dr. Sanjay Yadav by APMP General Assembly held in Nov. 2020 online. This prestigious APMP award is conferred on him for his contribution and as an appreciation of the work done in past in the area of metrology.
- The current year has been very exciting as well as more challenging due to humongous outbreak of CoVID-19 pandemic. During this pandemic period, special arrangements were made to keep our traceability services functional for the

industries which were specially involved in medical devices and parametric certifications. In some of areas extra efforts were put in such as late hours after office timings so that emergent services were not affected and works related to fighting corona virus continued unperturbed. These services of CSIR-NPL were well appreciated by different stakeholders.

- Organized several national and international events such as World Metrology Day, National Metrology Conclave (NMC-2021), and 7th National AdMet Conference. These events have provided national and global visibility of India, provided platform for scientists and researchers for exchanging ideas and have collaborative framework with experts in the field and presenting and discussing the new results and technologies.

Section 2: Participation in International Key Comparisons

- Participating in APMP key comparison APMP.M.FF-K4.2.2021, Volume comparison at 100 μ L – Calibration of micropipettes. NPLI will be performing measurements during July, 2021. The transfer standards used are 5 single channel fixed micropipettes of 100 mL volume. NIM, China is the pilot laboratory.
- Participated in APMP M.P.K15 key comparison absolute pressure in the range 1×10^{-4} Pa to 1 Pa. Draft A received in September 2020.
- Participated in APMP M.P.K14 key comparison absolute pressure in the range 1 Pa to 10 kPa. Measurement results submitted during May 2019 and Draft A report is awaited.
- Participated in APMP key comparison APMP.MFF-K6.2018 low pressure gas flow in the range (10-100) m³/h, Measurements Completed during January-March 2020 and results submitted in April 2020. Draft A report is awaited.
- APMP Supplementary comparison on water flow (APMP.M-S3.2020), Pilot Laboratory: NIMT, Thailand, Artifact used Mass Flowmeter of size $\frac{3}{4}$ inch (DN20), Measurement performed in March-April 2021.

Relevant Publications

- 1) Evaluation of effective area of air piston gauge with limitations in piston-cylinder dimension measurements, Vikas Narayan Thakur, Felix Sharipov, Yuanchao Yang, Sandeep Kumar, Jokhan Ram, Harish Kumar, Rina Sharma, **Sanjay Yadav**, Ashok Kumar, *Metrologia*, vol, 58(3), 2021 <https://iopscience.iop.org/article/10.1088/1681-7575/abe222/pdf>.
- 2) Flexible microhyperboloids facets giant sensitive ultra-low pressure sensor, Shubham Kumar, Bijender, **Sanjay Yadav** and Ashok Kumar, *Sensors and Actuators A: Physical*, Vol 328(1) Sept. 2021, 112767, <https://doi.org/10.1016/j.sna.2021.112767>.
- 3) A Monte Carlo simulation investigation on the effect of the probability distribution of input quantities on the effective area of a pressure balance and its uncertainty, Jasveer Singh, L.A Kumaraswamidhas, Neha Bura and Nita Dilawar, *Measurement* (2020) 172(1):108853
- 4) Characterization of a standard pneumatic piston gauge using finite element simulation technique vs cross-float, theoretical and Monte Carlo approaches, Jasveer Singh, L. A. Kumaraswamidhas, Neha Bura, Shanay Rab, Nita Dilawar Sharma, *Advances in Engineering Software*, 150 (2020) 102920.

- 5) Past, Present and Future of Blood Pressure Measuring Instruments and Their Calibration, Rahul Kumar, PK Dubey, Afaqul Zafer, Ashok Kumar and **Sanjay Yadav**, *Measurement*, 108845, 2021, doi.org/10.1016/j.measurement.2020.108845 3.
- 6) On long-term stability of an air piston gauge maintained at National Physical Laboratory, India, Vikas N Thakur, Rakesh Sharma, Harish Kumar, DA Vijayakumar, **Sanjay Yadav**, Ashok Kumar, *Vacuum*, 176(2020) 109357, doi.org/10.1016/j.vacuum.2020.109357.
- 7) Giant pressure sensitivity in piezo/ferro-electricceramics, Vikas N. Thakur, Bhanu P. Singh, **Sanjay Yadav** and Ashok Kumar, *RSC Adv.*, 10, 9140-9145, 2020, DOI: 10.1039/d0ra00484g.
- 8) 75th Foundation Day of CSIR-National Physical Laboratory: Celebration of Achievements in Metrology for National Growth, S. Yadav, G. Mandal , V. K. Jaiswal, D. D. Shivagan and D. K. Aswal, *MAPAN-Journal of Metrology Society of India*, May 2021, https://doi.org/10.1007/s12647-021-00442-4
- 9) Challenges in Sensors Technology for Industry 4.0 for Futuristic Metrological Applications, A. Varshney, N. Garg, K. S. Nagla, T. S. Nair, S. K. Jaiswal, S. Yadav and D. K. Aswal, *MAPAN-Journal of Metrology Society of India*, May 2021, DOI: 10.1007/s12647-021-00453-1
- 10) Quality Infrastructure of National Metrology Institutes: A Comparative Study, ShanayRab, **Sanjay Yadav**, S.K Jaiswal, Abid Haleem and D. K. Aswal, *Indian Journal of Pure and Applied Physics*, Vol. 59 (4), March 2021, pp. 285-303. http://op.niscair.res.in/index.php/IJPAP/article/view/46202.
- 11) Design and Development of a Temperature-Compensated Body Mass Index Measuring System, R. Kumar, P. K. Dubey, Afaqul Zafer, Ashok Kumar and Sanjay Yadav, *MAPAN-Journal of Metrology Society of India*, May 2021, DOI: 10.1007/s12647-021-00448-y
- 12) Establishment of air piston gauge as primary pressure standard at CSIR-National Physical Laboratory, India, V. N. Thakur, **S. Yadav**, A. Kumar, *Acta IMEKO*, Vol. 9, No. 5, 329, 2020. DOI: 10.21014/acta_imeko.v9i5.994
- 13) Design and Development of an Indigenous Cross-Floating Pressure Calibration System up to 140 MPa, Raman Kumar Sharma, ShanayRab, Lalit Kumar, Afaqul Zafer and Sanjay Yadav, *MAPAN-Journal of Metrology Society of India*, April 2021, DOI: 10.1007/s12647-021-00450-4.
- 14) Simulation based design analysis of pressure chamber for metrological applications up to 200 MPa, ShanayRab, **Sanjay Yadav**, Abid Haleem, Afaqul Zafer, Raman Sharma and Lalit Kumar, *Indian Journal of Pure and Applied Physics*, Vol. 59 (3), March 2021, pp. 202-205. http://nopr.niscair.res.in/bitstream/123456789/56513/1/IJPAP%2059%283%29%20202-205.pdf.
- 15) Process and Insight of Pascal Traceability, V.N. Thakur, S. Yadav, A. Kumar, *MAPAN-Journal of Metrology Society of India*, April 2021, DOI: 10.1007/s12647-021-00447-z.
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- 17) A Simplified Software for Uncertainty Estimation Using Monte Carlo Method, Jasveer Singh, L.A Kumaraswamidhas, Neha Bura, Kapil Kaushik and Nita Dilawar, *Advanced Science Engineering and Medicine*, (2020) 12(8):1050-1053
- 18) Evolution of Measurement System and SI Units in India, S Rab, S Yadav, N Garg, S Rajput, DK Aswal, *MAPAN Journal of Metrology Society of India*, 35(4) (2020), doi.org/10.1007/s12647-020-00400.
- 19) Realization of Quantum Pascal Using Natural Fundamental Physical Constants, VN Thakur, S Yadav, A Kumar, *MAPAN Journal of Metrology Society of India*, 35(4), 2020, doi.org/10.1007/s12647-020-00411-3.
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- 22) Journey of Kilogram from Physical Constant to Universal Physical Constant (h) via Artefact: A Brief Review, B Ehtesham, T John, S Yadav, HK Singh, G Mandal, *MAPAN Journal of Metrology Society of India*, 35(4), (2020), doi.org/10.1007/s12647-020-00392-3
- 23) Continuous Wave Ultrasonic Interferometers with Relatively Higher Excitation are Inappropriate for Liquid Characterization, Sahil Sharma, **Sanjay Yadav** and P. K. Dubey, *MAPAN Journal of Metrology Society of India*, (2020), doi:10.1007/s12647-019-00389-y.
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- 25) A review of diameter measurement and a proposal for the improvement thereof, M ArifSanjid, **Sanjay Yadav**, Mrinal Sen, Sanjoy K Ghoshal, *MAPAN Journal of Metrology Society of India*, 35(2), (2020) 275-286, doi:10.1007/s12647-019-00360-6.
- 26) Redefined SI Units and Their Implications, **S. Yadav** and D. K. Aswal, *MAPAN Journal of Metrology Society of India*, 35(1), 2020, 1-10, doi:10.1007/s12647-020-00369-2.
- 27) Development of Remote Wireless Environmental Conditions Measurement, Monitoring and Recording Device for Metrological and Other Scientific Applications, R. Kumar, P. K. Dubey, A. Zafer, A. Kumar and **S. Yadav**, *MAPAN Journal of Metrology Society of India*, 35(1), 2020, 1-10, doi:10.1007/s12647-020-00368-3.
- 28) Design and simulation studies on the development of a high pressure cell upto 1.0 GPa for industrial and scientific metrological application Rab S., Yadav S., Haleem A., Zafer A., Sharma R., Kumar L., (2020), *Materials Today: Proceedings*, Volume 21, part 3, pp 1632-1636, <https://doi.org/10.1016/j.matpr.2019.11.272>

Books Edited /Book Chapters

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- **“Proceedings of International Conference in Mechanical and Energy Technology”** edited by **Sanjay Yadav**, D. B. Singh, P. K. Arora and Harish Kumar, ISSN 2190-3018 ISSN 2190-3026 (electronic) Smart Innovation, Systems and Technologies ISBN 978-981-15-2646-6 ISBN 978-981-15-2647-3 (eBook) <https://doi.org/10.1007/978-981-15-2647-3>.
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