Chapter 6
Physico-Mechanical Metrology

Part I: Impetus for Inclusive Industrial Growth

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Abstract  Measurement standards and metrological activities provide a proper scientific and economically sustainable infrastructure to the country [1]. It plays a pivotal role as an engine for industrial revolution, growth and support for the overall development of any nation. Metrology is essential to protect the planet, ensuring a dignified quality life for all people to achieve inclusive economic growth and prosperity. It is the main pillar for trade, scientific comparison, innovation of emerging technologies, technical cooperation and even for simple exchange of information. With the advent of better-quality products through metrological advancement, our industries can compete internationally by overcoming all the trade barriers/constraints to achieve the final exports targets. It ultimately translates into growth of industries through rapid industrialization, economic growth and societal upliftment. For industrial and scientific development of any country, the role of NMIs is significant and irreplaceable in the advancement of metrological fields and their related

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technologies. Dissemination of measurement standards through apex level traceable calibration certificates, training and consultancy services to the industry, government, strategists and academia in different parameters are extremely important. The dissemination of measurement standards in SI units, now related with fundamental constants of nature (FCN), is the prime responsibility of NMI of the country. As India wishes and approaching to become ‘Atma Nirbhar or Self Reliant’, the NMI of India i.e. CSIR-NPL has to play a significant role, not only for providing traceability of measurement standards but also to work in close association with industries, especially with Medium, Small and Micro Enterprises (MSMEs) which contributes almost 38% of the Gross Domestic Product (GDP). It would directly correlate with India’s economic growth and better quality of life for its citizens. The mandate of Physico-Mechanical Metrology (PMM) of CSIR-NPL is to establish, maintain, upgrade and disseminate the standards of mass, volume, density, viscosity; length, dimensions, angle, surface roughness and nanometrology; temperature and humidity; optical radiation (non-ionizing radiation-ultraviolet, visible and infrared region, LED lighting); force, torque and hardness; pressure, vacuum and ultrasonic; acoustic and vibration; and fluid flow. The PMM is the backbone and mainstay for Indian industries and other user organizations. As is evident, these measurements are ubiquitous and cross most strategic sectors and technologies. These parameters play a significant role in the industrial development and their traceable measurements to SI units provide basis for barrier free trade across the continent and the world. The services of these measurements underpin just about every area of human endeavour. The PMM of CSIR-NPL contributes enormously to the economic development of the country by providing traceability to almost all the strategic sectors, MSMEs, Public and Private Sector Undertakings, Government organizations, regulatory bodies, academic institutions as well SAARC nations and other countries through calibrations, testing, need based technical and consultancy services, organization of proficiency testing programmes, industrial trainings and development of academic expertise. The present Chapter of this book is mainly focused on highlighting the significance and importance of PMM, its role and impact in industrial and sectorial growths, applications and relevance with their global compatibility, and finally concludes with some futuristic perspectives.

An experiment is a question which science poses to Nature, and a measurement is the recording of Nature’s answer.

– Max Planck (1858-1947)
6.1 Introduction

Physico-Mechanical Parameters (PMPs), play a crucial and pivotal role for the sustainable development as an important component of metrology which is essential to protect the environment, ensure a quality life for all citizens to achieve inclusive economic growth and prosperity. Though the PMPs are important in almost all walks of day–to-day life however, precision measurements of the same play a vital role in strategic sectors and industries. In order to attain self-sustenance, as per the Government plan, we need to provide the necessary metrological support to manufacturing industries for developing globally competitive products and services. Metrology would contribute significantly in such endeavours. Further, as India is aiming to become a 5.0 trillion economy, the in-house production of quality products must grow exponentially which is supported by the in-house manufacturing capability. The strong metrological and quality infrastructure is the one phrase answer for such sustainable growth. Over the years, though the PMM at CSIR-NPL is playing its part and offering reasonably good services, yet much more needs to be achieved.

The PMM, being backbone of the industrial growth has a very wide scope and its embodiment in a single chapter is a very difficult task. Though, one can easily write a separate chapter even on a single parameter, authors have tried to accommodate all the parameters, [mass, volume, density, viscosity; length, dimensions, angle, surface roughness and nanometrology; temperature and humidity; optical radiation (non-ionizing radiation-ultraviolet, visible and infrared region, LED lighting), force, torque and hardness; pressure, vacuum and ultrasonic; acoustic and vibration; and water and gas flow] into 4 Chapters as 4 Parts of the PMM.

There exists a close interaction between various PMPs, measurement techniques, and industrial and technological applications. Such interactions are extremely important when in present time worldwide international competition in industry and production engineering is huge. Any manufacturing process requires multiple measurements of multiple PMPs. For example, the manufacturers of force measuring instruments have started using more advanced and sophisticated electronics in their design for easy, effective, fast data acquisitions and collection. This not only requires the expertise and new capabilities of load cells to measure more than just force, clients demand load cells that can also measure barometric pressure, temperature, humidity, air density and location etc. Such devices of multiple functionalities help the users with additional benefits of simplified design and multiple data quality. Therefore, inclusion of the parameters and their understanding will hugely benefit the readers.

While Part 1 (present Chap. 6) is of generic nature which describes the insinuations, impact and role of PMM in inclusive industrial growth, the next 3 Chaps. 7, 8 and 9, are focused on Mass and Length Metrology (Part II); Thermal, Optical and Acoustic Metrology (Part III) and Force, Pressure and Flow Metrology (Part IV), respectively. Figure 6.1 depicts the overview of all the chapters.
6.2 Significance and Importance

With modern business becoming diversified, bigger and better, competition is higher than ever before. Therefore, it is incredibly important to ensure that a company/service provider, is offering top range of the products/services to consumers to keep up pace and competition with its rivals. The one particular way by which companies/service providers can ensure the excellence in deliverables, is by performing rigorous quality checks beforehand. This can only be achieved through a strong national quality infrastructure (NQI) as described in detail in Chap. 1, harmonization of international measurement system in Chap. 2 and harmonization of international and national dissemination mechanisms in Chap. 3 of this book.

The metrology has huge economic and social impact. It has strong role in NQI of the nation as one of the major pillars. The inaccurate measurement leads to cost of poor quality (COPQ) which may not be tangible but have enormous economic losses. The challenges of today’s industries are driven by the demands of good quality products/services from the customers. The customers demand cost-effective wares of good quality that suffice their specific needs. For long term sustainability of any industry, the supply of its products must be stable, quality-competitive and cost-effective.
As discussed in previous Chapters, metrology is absolutely essential for make in India, trade, innovation and new technology developments which in the national context are the pillars on which the “Atam Nirbhar Bharat” would grow. The 5 pillars of the development as put forward by our honourable Prime Minister, viz. economy, infrastructure, system, demography and demand can be achieved only with precise measurements and their certification for product approval. Thus, the honourable Prime Minister’s call for ‘Vocal for Local’ leading to “Atam Nirbhar Bharat” is conceivable and for this purpose, metrological traceability and reliability in measurements would play a big role culminating in indigenous products with global acceptance and quality and it would finally result into quantum jump in economic growth.

The MSMEs are the major force for India to achieve the goals of 5.0 trillion economy and “Atam Nirbhar Bharat”. These MSMEs heavily depend on locally available NQI services to support their participation in the regional and international markets. The stronger NQI would help them to have access to better services for consumer’s benefit as well having improved product quality, health and consumer protection.

Customers want good quality products and services on very competitive rates that fulfil their specific needs. Therefore, the industrial outputs and products must be stable, competitive, innovative as well as indigenous. India is entering into the 4th industrial revolution which demands the digitization of the production industry. The bottlenecks to be overcome to adapt these new technologies for Indian industries, that have a clear archetype need for conformance in accordance to the standards, is to work towards consistent innovation. As the products/services are available a click away, the needs and satisfaction levels of the customers are also changing with the time. Therefore, all the stakeholders should be aware of the changing scenario and be always ready for adoption, innovation and competition to stay in business.

6.3 Role of PMM in Nation Building

The PMM systems, enabled with modern sensors, transducers, robust electronics and software, are the backbone of the Indian industries, especially in majority of the industrial sectors. As is evident, these precise measurements are ubiquitous and essential across most of the strategic and R&D sectors. Physico-mechanical parameters play a significant role in the industrial developments and its traceable measurement to SI units provide barrier free trade across the continents.

The precision measurement services of PMM at CSIR-NPL contribute hugely to the economic development of the Nation by way of providing traceability to the industrial sector, strategic sectors, MSMEs, Public Sector undertakings as well as government and regulatory bodies through apex level calibrations, technical and consultancy projects; and industrial training. On an average CSIR-NPL generates more than 2000 calibration/test reports and serves for more than 1500 customers annually only in PMPs.
The average direct cash flow from these services, range between 60–70 million Indian Rupees annually. However, the economic impact of these services, far outweigh the expected returns on investment but include benefit to cost ratios and indirect contributions to the GDP of the Indian economy. In a recent client/service targeted survey, it was estimated that for the services to the industry, the social return ratio was as high as 180% for the direct beneficiaries and as high as 980% to the second level clients/beneficiaries [1].

Apart from providing these direct services, the CSIR-NPL has focused its objectives on the 5 pillars of the development as put forward by our honourable Prime Minister, as discussed above. With a vision to realize these goals, significant strides are being made. These new challenges in measurements are being met with the continuous up-gradation of measurement capabilities at CSIR-NPL which lead to competence at par with the other NMIIs of the world and further contribute significantly to economic development. Figure 6.2 explicitly depicts the PMPs and the role

Fig. 6.2 The major physico-mechanical parameters and their role in different strategic and industrial sectors presented as a single window information
of its metrology in almost all major sectors of a Nation, which play significant role in its inclusive industrial growth.

As the SI units have been redefined in terms of fundamental constants, the leading NMIs are making efforts to realize the base units through quantum metrology. To keep pace with these NMIs, PMM is also endeavouring in the frontier areas of quantum metrology for realization of 4 base units through fundamental constants, such as realization of mass (kg) through Watt-balance, length (m) by frequency comb, thermodynamic temperature (K) by Boltzmann constant ($k$) and few photon metrology of light sources.

The country has a huge clientele base having more than 5000 calibration and testing laboratories in organized sector apart from more than 4 lakh laboratories in unorganized sectors. Sooner or later all these laboratories would require traceability from CSIR-NPL and major responsibility to serve these clients is of PMM and PMM is ready to accept the challenges and add new clientele base in coming days. The various socio-economic benefits of PMM are listed in Fig. 6.3 which clearly reflect the mirror image of the contribution of PMM in national growth.

The *Economic Infrastructure* of a country depends upon the industrial sectors which support the economy with livelihood, transport, water supply, health and sanitation and communication. These sectors are further reinforced by *Social Infrastructure* like academics, hospitals, legal system and enforcement. Being public goods, the economic and social infrastructures are regulated and governed by state agencies and

![Impact of Metrology](image)

**Fig. 6.3** Socio-economic benefits of physico-mechanical metrology
regulators. Apart from these socio-economic infrastructures, the Technical/Scientific Infrastructure also ropes the economy. Such infrastructure includes measuring instruments, standards, measurement techniques and methods, artefacts, standard reference materials which are used for efficient, authentic and valid scientific and engineering data, process for interfaces between manufacturing technologies such as factory controls, monitoring, recoding, automation and communication.

In this context, the role of PMM is substantial and paramount to support the consistency of measurements related to PMPs that are used as the basis for decision making both in industry, science and technology as described in next 3 Chapters. Also, such national metrological infrastructure includes the International System of units (SI) of physical quantities (Chap. 2), and harmonization of their dissemination mechanisms (Chap. 3) and technical and scientific details about the calibration and measurement facilities, maintenance of traceability chain, support services to different organizations, training imparted to measurement engineers and technicians (Chaps. 7, 8 and 9). The overall socio-economic benefits are already listed in Fig. 6.3.

6.4 Impact of PMM on Sectorial Growth

The main contribution of PMM is already highlighted in previous section. However, the major sectors and the stakeholders who are regularly taking traceability of PMPs are shown in Fig. 6.4.

One of such important sectors is pharmaceutical industries which are making drugs and medicines. According to some studies, during this pandemic situation, Hydroxychloroquine (HCQ) has shown strong antiviral effects on the corona virus infection and sudden demand for increased production of HCQ came up. Zydus Group and IPCA Labs have backward integrated HCQ making capability and the PMM at CSIR-NPL has provided traceability to their E2 class weights which are used in manufacturing of these medicines. Similarly, paracetamol is always in huge demand. Traceability has also been provided to Ajanta Pharma. As per the reports, Indian pharmaceutical companies would raise the production of HCQ to their peak capacity of 35 crore (350 million) tablets of 200 mg [2]. The government has already placed an order with leading domestic manufacturers Zydus Cadila and IPCA Labs for which traceability is provided by CSIR-NPL. The HCQ is also being exported and has made great impact internationally as India’s visibility, strength and capabilities.

Dimensional measurements are extremely important in automobile and automotive sector apart from other fields. Automobile sector uses measurement intensively for product innovation, design models, materials and manufacturing processes at each and every stage of manufacturing to support trade with suppliers and end users. Calibration of automobile parts for measurements of surface roughness, straightness, roundness, angle measurements, coaxiality, centricity, flatness etc. are very important. In a liberal estimate, the automobile industry contributes almost 8% percent of India’s GDP and a whopping 49 percent of manufacturing GDP with a large
economic multiplier impact. CSIR-NPL provides traceability to major automobile giants like Maruti Suzuki, Tata Motors, Hero MotoCorp etc. [3].

Another important sector is lighting industry. LED based energy efficient illumination technology is paving way as a future lighting source phasing out the old inefficient lighting devices. CSIR-NPL has taken it up as a priority and endeavouring to establish testing and calibration facility for LED and LED based lighting as per national/international standards. Upon establishment of such services CSIR-NPL additionally, would be able to cater to the countries present need of evaluation of the photo-biological safety of lamps and lamp systems to safeguard users from potential hazards of radiation exposure to eyes and skin given by the increasing deployment of sources of invisible radiation in purification and sanitization industries. The LED market is accounting for about 60% of India’s total lighting industry (approximately ₹ 376 billion) in 2020 [4].

Construction and civil infrastructure is the fundamental necessity which enable and serve a city or a country, to accommodate and provide all the operational functionalities to the people of the country. Cement, steel, aluminium, plastics and wood are the basic elements required by every construction sector for building and developing the desired Administrative, Business, Commercial, Domestic, Educational, Financial, Government offices, Healthcare and Industrial, infrastructure in the country. Therefore, the infrastructure sector provides direct and indirect employment to a large number of people promoting self-reliance, contributing a major part to Gross Domestic Product (GDP). The Indian Cement Industry is one of the booming sectors
of the Indian economy and therefore, cement industry is the most important basic primary industry for the economic development and next comes the iron and steel industry [5, 8]. CSIR-NPL provides the traceability, either directly or indirectly, to the testing machines used in the cement and iron industries across the country.

Accurate pressure, vacuum, temperature, humidity and flow measurements are not only important to improve the quality of products and increase the productivity but also crucial for the safety of plants, manpower and machinery. Such measurements are essentially performed during manufacturing/processes and contribute significantly to the advancement of technology. Being the most used process parameters, their measurements become a key to industry, research and society because of their extremely wide range of applications such as optimization, process monitoring and controlling parameters in nuclear and thermal power plants, food sterilization, vessel manufacturing and production, machine components/parts designing and fabrication, autofrettage, chemical, petrochemical, drugs and pharmaceutical industries, water jet cleaning and cutting, hydro-static forming and isostatic pressing in automobile, diesel engineering, micro-and nanotechnologies and metal casting and forming. In order to define efficiency and ensure safety of the processes, the pressure and vacuum are measured/monitored as process parameters. CSIR-NPL contributes significantly in these parameters to fulfil the customer’s requirements of traceability of various equipment used in such applications and their training needs.

Oil and gas equipment-manufacturing sector is another noticeable field wherein record keeping, quality control and traceability are critical. As part of their company-wide quality protocol, various large oil and gas companies invest continually in a preventive maintenance programme that employs machine tool probes and calibration products to check and verify the accuracy of the CNC machine tools and measuring instruments.

The biomedical metrology has got boost after implementation of new Medical Device Rules 2017 by Ministry of Health and Family Welfare, Government of India. As per the rules, now medical devices require testing and calibration for their optimum performance and for having confidence on measurement results of diagnostics. CSIR-NPL has established bio-medical laboratory for testing and calibration of various types of medical devices (Chap. 15). At present, PMM provides traceability to various biomedical laboratories in India by calibration of infusion pumps, infusion device analyzers, gas flow analyzers, ventilator testers and defibrillators and contributes effectively in the health mission of Govt. of India. Recently CSIR-NPL has also initiated for establishment of Testing Facilities for gloves, gowns, masks, ventilators and thermal scanners as per National/International standards. The project has been approved by CSIR and work is going on this direction. This would lead to self-reliance in biomedical field and saving of foreign currency spent on testing and calibration.

The applications of ultrasonic metrology in health, for both therapeutic and diagnostic, physiotherapy, cleaning, underwater navigation and communication, NDT, material quality and adulteration assessment, concrete testing, detection of liquid or gas leakages and material characterization etc., are well proved. Ultrasonic phased array, cleaning, acoustic emission, are the key technologies which are finding new
applications in testing of materials for flaw and crack detection, cleaning purposes and for detection of leakage in the pipeline including liquid and gas.

*Noise pollution* is a growing issue in the country and therefore, *noise mapping* is significant in the present scenario, which is being adequately addressed by CSIR-NPL which has established several SODAR centres at different parts of the country. It is focused on developing noise mapping of various cities of India in collaboration with State Pollution Control Boards. Apart from focusing on such societal issues, CSIR-NPL has also planned to develop facilities for future metrological support in the country. Efforts are being made to develop the new facilities for calibration of sound intensity probes, primary free-field microphones, primary and secondary shock, audiometer and related testing.

The parameter specific contributions are described in the next 3 Chaps 7, 8 and 9 of the book in detail.

### 6.5 Conclusion and Future Perspectives

From the metrological studies carried out over the years, it has been well understood that the precision and traceable measurements of physico-mechanical parameters such as mass, length, temperature, luminous intensity, force, hardness, pressure, vacuum, ultrasonic, acoustics, vibration, fluid flow, etc. are vitally important for sustainable infrastructure development and revolutionary industrial growth of the country leading to a better quality of life to its citizens in every sphere of human activity. It is therefore very much essential to realize all these physical parameters with a highest level of accuracy by way of establishing the national primary standards and systems. The measurement capabilities of such established primary standards are reaffirmed by periodically participating in the international inter-comparisons which enable us to obtain the global competence and recognition.

Every country needs such a robust metrology system in place to provide the necessary traceability in measurements to each and every sector of the economy. This process is inevitable for maintaining the uniformity in all the measurements for achieving sustainable growth in several fronts like science, engineering, technology, industry, commerce, business trade, etc. which ultimately enables us to attain self-reliance. Hence, it is also mandatory for the NMIs to continuously upgrade and maintain such systems at par with the other NMIs of world in accordance with the new technological advancements and challenges arising in the global scenario. The primary standards thus established and maintained provide traceable measurements of global equivalence which enables our county to overcome trade barriers, save a huge foreign exchange and the process time.

Over the years, CSIR-NPL has developed and achieved proven measurements capabilities in PMPs in its specific domain. The metrological activities have been established and maintained as per CIPM-MRA requirements, demonstrating international measurement equivalence and the calibration capabilities. It has also successfully participated in 81 international inter-comparisons and reaffirmed its CMCs
which are registered in BIPM-KCDB database. So far it has registered 150 CMCs in BIPM-KCDB database which stands at 27th place in the world and 7th in APMP region. For maintaining these CMCs CSIR-NPL has been constantly maintaining and upgrading the standards at par with the other leading NMIs and is also in the process of expanding the scope of measurement activities by adding new parameters or measurement ranges depending upon the rising needs of the industries. These precision measurement activities of CSIR-NPL have also been extended for providing the required traceability to a chain of testing and calibration laboratories and industries across the county on a continuous basis and on the other hand, generating a substantial amount of funds for the organization.

The major beneficiaries of the calibration, testing, technical consultancy and training services in PMPs are several stakeholders in a variety of sectors such as manufacturing, lighting, pharmaceutical & healthcare, automobiles, aviation, etc. This persistent apex level traceability support of CSIR-NPL for various PMPs has been the foundation for these Indian industries, and PMM is playing its significant role in providing traceability, technical and consultancy services, technical experts for several national and international committees related to metrology, accreditation, standardization which in turn results into over-all growth of the country.

The apex level measurement and calibration capabilities thus developed at CSIR-NPL for 4 SI base units i.e. mass, length, temperature and luminous intensity; and further for their derived units namely, density, volume, viscosity, area, humidity, heat capacity, conductivity, illuminance, illuminance responsivity, luminous flux, luminance, colour temperature, colour coordinates, spectral irradiances, force, torque, hardness, pressure, vacuum, ultrasonic velocity, ultrasonic attenuation, ultrasonic power, sound pressure, vibration amplitude, sound transmission and absorption coefficients, totalized mass and volume, mass and volume flow rates in water and gas flow etc., have been playing their profound role in the growth of Indian economy through various industries as its stake holders, together with the flag-ship programmes of Govt. of India, namely the Make in India, and other initiatives.

The pharmaceutical industry in India is one of the largest in the world and ranks within five in the world, which caters to almost 70% of the domestic demand for bulk drug and around 40% of the total is exported to more than 200 countries in the world (including a large component for the US and UK). As per ‘Pharma Vision 2020’, Department of Pharmaceuticals, Govt. of India, it is aimed to make India a major hub for end-to-end drug discovery and production which would help to further enhance the market share of India’s domestic pharmaceutical industries, which was Rs. 1.4 lakh crore (US$ 20.03 billion) in 2019 in terms of turnover. As an example, affordable medicines under the Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP) itself achieved a record sales turnover of Rs. 52 crores (US$ 7.38 million) in the month of April 2020. The CSIR-NPL’s mass and its allied derived parameters are constantly contributing, providing traceability to pharmaceuticals, drugs, chemicals and fertilizers industries on a regular basis [2].

Lighting industry, with an estimated market share of about Rs. 20,000 crores, is also witnessing tremendous growth especially in LED segment alone with a growth of about 80%. Long lamp life, energy saving and environment friendly LED technology
can surprisingly reduce the country’s electricity demand by as much as 40 percent. The LED lighting market in India is projected to register a compound annual growth rate (CAGR) of 26.6% during 2017–23 and is expected to reach $3758.74 million by 2022 with growing government initiatives encouraging the use of LED lights through, Pradhan Mantri Sahaj Bijli Har Ghar Yojana—Saubhagya, Ujala scheme etc. and development of smart cities under the Smart City Mission. It would also help in generating employment opportunities and would need to be supplemented with adequate number of professionals or skilled manpower in this vital field of lighting or LED or solar energy. The contribution of CSIR-NPL is extremely vital as traceability and other services are regularly being extended to lighting industries [4, 6].

State of the art test and calibration facilities to cater to the present and future calibration need of lighting industries as per the National/International standards for the next generation energy efficient LED based lighting products is also underway at CSIR-NPL. The project needs to be continued for achieving its objectives. It would help support the energy saving and green initiative of Govt. of India by not only eliminating sub-standard LED products from the market but would also help the nation in saving over Rs. 40,000 crores a year and reduction of approximately 2.7 crore tonnes of CO₂ every year.

Further, the automobile sector of India, which is one of the largest in the world and accounts for over 7.1% of India’s GDP, also contributes to nearly 22% of the country’s manufacturing GDP. The government of India aims to maintain the upward growth trend of the automobile industry and has launched the Automotive Mission Plan 2016–26 (AMP 2016–2026) endeavouring to make India among the top 3 automotive industries in the world and increase exports exponentially to reach 35–40% of overall output. It also intends to increase its contribution to the GDP to over 12%, by 2026. The traceability provided by CSIR-NPL in length, dimension, force, pressure and temperature is a noticeable contribution in the growth of automobile sector [3, 7].

Infrastructure and its development is the fundamental requirement that enables a country, to accommodate all the desired administrative, business, commercial, domestic, educational, financial, healthcare and industrial, infrastructure in the country. Therefore, the infrastructure sector provides direct and indirect employment to a large number of people promoting self-reliance, contributing a major part to GDP. As per an estimate, the Indian Cement Industry is one of the booming sectors of the Indian economy. The next comes the iron and steel industry. The market size of cement production is reached to 337.32 million tonnes in 2018–19 and stood at 278.79 million tonnes from April 2019-January 2020 [5]. Cement is the most commonly used building material due to its high compressive strength, which is tested using compression testing machines (CTM). These CTMs are duly calibrated either directly by CSIR-NPL or through NABL accredited laboratories whose traceability is mostly established from CSIR-NPL, providing the quality assurance related to the cement produced across the country.

Similarly, the manufacturing sector has seen its GDP contribution improved to 17.1% in the last 2 years, primarily due to the ‘Make in India’ drive and the inherent measurement traceability provided by CSIR-NPL towards the quality products [8].
In a nutshell, the traceability is disseminated through apex level calibration services to R&D laboratories, calibration & testing laboratories, strategic sectors, process and automobile industries, illumination and lighting, display, opto-electronics, defence, space, power, health and safety, pollution monitoring, manufacturing industries, government sectors, research organizations and some of the SAARC NMIs.

Every year more than 2000 calibration and testing reports are generated by CSIR-NPL in PMPs, for direct beneficiaries. These 2000 calibration reports are used by the stakeholders to further extend the services to huge number of their clients, ultimately resulting in percolation of NPL’s traceable measurement scale to every consumer. For example, ERTL (North) gets its photometric measurement systems and dead weight testers calibrated from CSIR-NPL and automobile industry like Maruti Suzuki India Limited etc. gets its instruments calibrated from ERTL (North). These types of users are huge and contribute significantly to the economy of the country. Also, the product and services vendors called sub-contractors, supply different components and parts to these large companies (like Maruti Suzuki India Limited) and these big companies maintain the quality and compatibility of these parts through testing and calibration. Thus, the users of the calibration and testing facility for traceability, multiply enormously down the chain.

As per an estimate made in one of the studies carried out at CSIR-NPL [1] for one of parameters (pressure and vacuum), based on an industrial survey, an overall social rate of return SRR, an indicator of system efficiency, is found to be 180% which is quite high as compared to the present rate of return, PRR (8%). In economic terms, the system is considered efficient if SRR is more than the PRR. This indicates that the activity is quite efficient, and future investment in the activity is safe and would provide excellent returns. Further, SRR increased from 180 to 980% in case of increase in number of beneficiaries at different levels as described in the above paragraph. This is an indicator of huge social impact of pressure and vacuum facilities of CSIR-NPL and services provided to industries. Admittedly, the study was carried out for only one parameter of the PMM, but in the same way it can be extended to other parameters and as a whole for the institution. The studies are very useful for broader understanding of the economic benefits and to improve understanding of the decision and policy makers about the relevance of metrology, and continuation of services and further investment in the activity.

The industries requiring all such traceability services from CSIR-NPL, are from all over India, and sometime far away from Delhi. They have to send their instruments to Delhi through air or road transportation, which at times, leads to delay and high cost, and occasional mishandling of the instruments during transportation. Sometimes these costs become higher and customer at his part avoids to send instruments for calibration and try to get calibration done locally by even compromising on the accuracy. In future, CSIR-NPL may adopt a policy to collaborate with some of the regional centres of NABL accredited laboratories or legal metrology laboratories, as reference laboratories for maintaining the sanctity of the unbroken chain of traceability and quality of services. Also, on-site calibration services may be augmented and encouraged to address the traceability needs for industries which are unable to bring their equipment to CSIR-NPL.
Keeping in view the significance, relevance and importance of metrology, the metrology programme of NPL requires sustained administrative and financial support on regular basis so that the existing CMCs can be maintained and further CMCs may be added at par with other advanced NMIs. Presently, some of our standards and measurement capabilities are now getting obsolete due to rapid technological advancements. Now, it is of utmost priority to upgrade, replace and establish new measurement standards including the upcoming quantum standards to maintain and enhance our CMCs to cater to modern days industrial demands. For enhancing and achieving measurement scopes, some of the PMM facilities need to be established or expanded to meet the new demands arising in the present industrial scenario. All such requirements are described in detail in respective Chaps. 7, 8 and 9.

The CSIR-NPL being a signatory of Metre Convention and key member of the APMP, it is essential that Scientists must attend the meetings of BIPM and APMP on regular basis, where the important metrology related polices are formulated and voted upon and international inter-comparisons are planned apart from discussions on other matters. Normally, most of the NMIs from APMP countries send large delegations (15–40 members) to attend these meetings. In the existing system, the CSIR-NPL finds it very difficult to send a single delegate to the respective TC (Technical Committee) meetings. The metrological activities of CSIR-NPL would be greatly benefitted by participation in such meetings. The acquired knowledge, sharing of ideas and collaborations with experts of different NMIs would help in future in enhancing and expanding the existing apex calibration capabilities, creating new calibration capabilities. *No country can be self-reliant if its metrology programme is not strong.*

This non-participation hampers the planned key and supplementary comparisons, decision/policy development and other related issues in various fields of metrology. Therefore, participation of CSIR-NPL in these techno-business meetings is highly important and essential. During the last several years, non-participation by CSIR-NPL in adequate numbers, in these meetings has not only resulted in a great loss in metrology per se but also loss in consistent credibility for India, being a giant nation among APMP region which possesses a great global standing in almost all disciplines of science & technology and requires to strengthen its emerging prospects of leadership among leading NMI members, like NIM, China, NMI, Japan, NMI, Australia, KRISS, South Korea and A*STAR, Singapore.

Apart from all the pro-active efforts towards establishment of new facilities and up-gradation of existing calibration facilities to the requirement of testing labs and industries, it is also important to have regular healthy interactions with the industries and the laboratories. This will enable us to work in harmony to address various metrological challenges faced by them, resulting in a better coordination between the NMI and its stakeholders working towards sustainable growth and self-reliance of the country.

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