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Study of Best International Practices in Legal Metrology

Ankit Kumar Tripathi[1] ✉, Ashutosh Agarwal[2], Saurabh Kr Rajput[3]

[1]DCM Shriram Industries Limited, New Delhi
[2]Regional Reference Standard Laboratory , Legal Metrology, Govt. of India
[3]Madhav Institute of Technology and Science Gwalior, MP, India

✉ ankittripathi2000@gmail.com

Abstract: Metrology means a field of science related to measurements. When people buy anything from the market or pay its utility bills then whatever he paid for the quantity he received & to ensure value for money & the accuracy of weighment & measurement, Legal Metrology plays an important role in it. Thereby, legal metrology means a legal way of measurements. It deals with the consumer safety and provides harmonious environment for traders. The need of research in Legal metrology field is the need for the transaction & protection of the consumers today. Everywhere all around the world, we are concern of accurate measurements for taking decision. This study brings out a general review on legal metrology at international level. A systematic literature review approach has been used to extract the contribution towards legal metrology. In this paper, a study has been performed on Japan, Brazil, Thailand, Australia and India where the main focus is on its legal metrology control, laws, structural controlling authorities, Type Approvals & Offences & Penalties.

Keywords: Metrological Activities, Legal Metrology, Testing, Calibration.

1 Introduction

In year 1891, a legal metrological system was formed with adoption of the Law of Weights and Measures. The legal units for measurement were merged into metric system based on International System of units commonly known as SI system in 1921. The law was then updated and was published as Measurement act in 1951. To meet the requirement of new social needs such as deregulations, internationalization and technological innovation, the rules, laws & related regulations were again updated according to the modernization demands in 1992. The act of measurement requires a basic policy of scientific metrology, domestic traceability system (JCSS- Japan Calibration Service System), measurement unit based on SI & legal metrological control system. Mainly, the use of SI system was enforced in the measurement act in 1992. Some of non SI units are also permitted such as calorie, carat, Are, Hectare, mmHg & mmH_2O, Knot [1-4].

2 Literature Review

2.1 Structure of metrological control authorities

2.1.1 National Organization for Legal Metrology: Metrological Police Office in Japan which comes under Ministry of Economic, Trade and Industry (METI) is in charge to manage the execution of legal aspects and scientific aspects related to the Measurement act & to manage

metrological basic policies along with its strategies in Metrological department. This ministry is also responsible for creating an awareness & more understanding in public related to the field of metrology [1-2].

2.1.2 **National Metrology Institute of Japan (NMIJ), AIST:** NMIJ is a part of National Institute of Advance Industrial Science & Technology (AIST). Generally, this institute is responsible for following factors [3-4]:

- Provision of Verification Standards for legal metrology.
- Provision of certified reference materials (CRMs).
- Provision of calibration services for JCSS.
- Type approval in legal metrology.
- Trainings at the metrology centers.
- Maintenance of the national primary standards.
- Cooperation with the international organizations.

2.1.3 Chemicals Evaluation & Research Institute (CERI):- This institute provides facilities for testing and evaluating chemical substances/materials. Further in reference materials for states of liquid and gas, their concentration of chemical substance is being certified by CERI in corporation with National Metrology Institute of Japan (NMIJ) [5].

2.1.4 Japan Electric Meters Inspection Corporation (JEMIC):- JEMIC is one of the civil corporation which works under the supervision of METI (Ministry of Economic, Trade & Industry) and is thus responsible for performing various types of tasks which are as follows [6-7]:

- For providing Verification services and Type Approval of Electricity meters within the field of Legal metrology.
- In case of low frequency, JEMIC works to manage the national primary standards of electrical power.
- At last, with the help of calibration services, it provides standards for physical quantities along with Temperature and photometry.

2.1.5 National Institute of Information and Communications Technology (NICT): In Information & Communication Technology, NICT is responsible to promote the R&D(Research & Development) field under the directions of Ministry of Internal Affairs & Communication. Furthermore, it is also responsible for maintaining the primary standards of frequency& telecast radio wave for continuously informing the Japan Standard Time (JST).

2.1.6 Regional and Local Verification Organizations:- The main responsibilities of these type of organizations are [8]:

- Periodical inspection of weighing instruments.
- for measuring instruments, it is responsible for registrations of manufacturers, repairers & retailers.
- Verification of the specified measuring instruments.
- Survey of prepackaged commodities & products.

2.1.7 Japan Calibration Service System (JCSS): JCSS was established in 1992 along with revised Measurement Act. This system consist of accreditation system for calibration of laboratories and national traceability system to national measurement standards. Here in this accreditation system, based on the necessity of the measurement act, calibration laboratories takes action and for this accreditation system, IA Japan (International Accreditation system) is the authorized system to take action upon this.

2.2 **Type approval** [9-10]

2.2.1 **REQUIREMENTS –** When a measuring instruments are manufactured in a huge quantity of production of uniform in nature then type approval is essential in such situations and based on the instrument type if got approved then a national certificate along with the type approval number is issued for each particular equipment.

2.2.2 **ISSUING AUTHORITY**- Various authorities are responsible for issuing the type approval certificate such as NMIJ in AIST issues certificate for most of the specified measuring instruments and load cells. For electricity meters, JEMIC also provides the national certificates. But there certificates are only valid for 10 years. After the expiration of certificates, these certificates can be renewed without testing as well with having a considerable fees.

2.2.3 **TESTING AUTHORITY** - NMIJ and JEMIC carries out the type approval test on the instrument categories for which the institutes issues the OIML and National certificates and Electric measuring instruments respectively.

ACCEPTANCE: In other countries, OIML (International Organization of Legal Metrology) certificates are accepted by having a mutual agreements which comes under the OIML-CS (OIML Certificate system) as long as Japan is participating as an Issuing authority.

Few Testing equipment used for type approval are as follows:

- Testing Apparatus for Thermometer.
- Testing Apparatus for pressure gauge.
- Testing Apparatus for fuel dispensers and many more. [1]

2.2.5 Sanctions [11-12]

Table 1 Penalties in Japan

S. N.	Reason	Penality
1	If an aneroid blood pressure or a clinical thermometer is delivered without a verification mark.	● fine of up to 1,000,000 JPY. ● Imprisonment up to 1 year
2	Misuse of type Approval Misuse of measuring instrument for trade without a valid verification mark.	● Up to 6 months of imprisonment. ● fine up to 500,000 JPY.
3	if illegal measurement of units are used for trade or certification. Any violation of packaging requirement. If any failure of periodical inspection of a specified measuring instruments.	● fine of up to 500,000 JPY
4	if manufactures, retailers & repairers of specified instruments provides service without registering to the local government.	● fine of up to 300,000 JPY.

3 Results & discussions

3.1 International practices

During 2016, According to World Bank, Brazil is the fifth largest country considering its total area and 9th economy in world. In the same year, according to the report of IGBE Southeast and South region, these two among 5 regions (South, Southeast, Central North, and North-East) of Brazil has the majority of the population which is about 56 % of total population, comprises of 5570 municipalities & 26 states. Therefore, Metrological system in Brazil has to be designed to cover this huge structure. By providing uniformity & equity to national market. In 1862, Metric system was adopted by Brazil and since 1983, Brazil has been both BIPM and OIML Member. The National Institute of Metrology, Quality & Technology (INMETRO) is the government Institute responsible for Legal Metrology in Brazil. In Brazil, Legal Metrology mainly focusses on four basic directions such as

- The quality of measuring instruments.
- For performing measurements and to control the guarantee security, fairness & effectiveness to the action of state.
- Aiming for the improvement of quality of products belonging to the national industry measuring instruments & pre packed goods and also to increase its competitiveness.

- In the productive activities to give the companies adequate & compatible measuring instruments [2].

The metrological control understands three conditions which are

- Metrological Skill – These are the set of operations whose purpose is to examine & certify the conditions of measuring instruments, to determine their performance characteristics in comparison to their existing standards or requirement.
- Metrological Supervision – It is one type of control which is used for measuring instruments used during their process of importation, installations, manufacturing process, its use, maintenance and repairing process. Its aim is to verify if the measuring instruments is being used in a correct way or not, according the laws and metrological regulations.
- The legal control of measuring instruments: These are the controlling authorities who assigns the legal operations such as appreciation techniques of models, subsequent verification, initial verification of newly instruments, declaration of installation etc. to submit for the approval.

Basically the testing & calibration of measuring instruments in Brazil is done by INMETRO or by the Brazilian Net of calibration also named as RBC (Rede Brasileira de Calibração) or either by the RBLE (Rede Brasileira de Laboratórios de Ensaios) which provides the highly sureness or trustworthy calibration to the user. In general we can also say that these laboratories are having a mutual collaboration with the research institutes, industries and institution or with many instruments and measuring centers. These laboratories also have the tie up with the International systems of units. All these calibration and accreditation institute/centers meets the requirement of INMETRO through its (CGCRE – Comissão Geral de Acreditação) which is also the General Coordination of Accreditation whose totally responsibility is to recognize the agreement internationally with ILAC (International Laboratory Accreditation Cooperation). There are separate maintenance workshops for repairs of the regulated instruments of measurement according to the standards of legal metrology. There are few organizations as well responsible for autoverifications of the instruments under the supervision of INMETRO and its assigned agencies, and these authorizations are granted through INMETRO only under the supervision of Legal Metrology. [3]

The act which is responsible for legal metrology in Australia is National Measurement Act (1960) and its supporting regulations such as the National Measurement Regulations (1999) and National Trade Measurement Regulations (2009) which further specifies Australia's Legal units of measurement of physical quantities and also ensures that measurement made for any legal purpose of physical quantities are according to the Australia's standards. This act also helps in verification of trade and legal measurement instruments and in type approval as well. Further, the Act legal requirement for traceability requires measurement of physical quantities should be done on the basis of comparison

with standards of measurement including certified reference materials. As far as case of legal units of measurement in Australia is concerned, then they follows the International Systems of Units i.e. SI unit system.

- National Organization for Legal Metrology, Australia :- On 1st July 2004, the Australian Government Analytical Laboratories, National Standard Commission & the National Measurement Laboratory-CSIRO, they combined formed a common system National Measurement Institute, Australia (NMIA) which was responsible for enforcement functions of states and territory Governments and for trade measurement inspection. It is also responsible for presentation on OIML committees & publishes Australian standards and guideline of type approval for manufactures & importers of measuring instruments.
- National Measurement Institute, Australia is responsible for maintaining primary standards of measurements.
- Regional and local verification organizations: Many number of Australian Laboratories from outside source are appointed by NMIA for calibration and verification of measuring instruments.
- Custodian of national primary standards was managed by NMIA.
- Instrument Calibration & Evaluation System:- Testing laboratory of Australia i.e. NMIA is responsible for pattern approval used for trade & legal purpose. NATA stands for National Association of Testing & Authority which is responsible for calibration & testing procedure and then to provide its certificate. Furthermore, it also approve laboratories in different sectors. NATA also represents ILAC (International Laboratory Accreditation Cooperation) from Australia.

Testing Facilities: Testing facilities are operated by NMIA which are as follows-

- Flow metering facilities for petroleum products such as LPG etc.
- Electrostatic discharge & line borne electrical interference testing system.
- Environment chambers for testing temperature and humidity levels.
- Load cell testing facilities up to 50 tonnes.
- Electromagnetic susceptibility chamber.

NMIA appoints other bodies to support its responsibilities as Australia Legal Metrology Authority such as-

- Certified Authorities for certifying measuring instruments.
- Utility Meter Verifiers to inspect water and electricity meters.
- Approving Authorities to conduct pattern approval testing.
- Verifying Authorities to verify reference standard of measurement.

NMIA provides training in physical, chemical, biological & legal metrology. The measurement of prepackaged articles is controlled by trade measurement legislation by means of its Quantities. NMIA is responsible for administering packaging legislation.

According to APLMF, the first act on weights and measures formed in 1923. In 1999 this act is changed by Weights & Measures Act 1999 and amendment 2014. Before submitting for approval, Council State of Thailand is responsible for reviewing rules & regulations of ministries formed under this law. Notifications formed according to this law are advice by the committee for weights and Measures, CWM. Here, different Sections of the Weights & Measures Act 1999 like 12,13,14,15 provides the Traceability of measurement in relation to Legal Metrology. [5]

- CPWM (Central Bureau of Weights & Measures), is responsible to ensure the traceability of reference standards used in the field of legal metrology to national standards. In Thailand, there are 28 local offices and 4 regional weights and measures centres that are spread throughout the country. 154 weights and measure official works in CPWM and other local weights and measure offices.
- National Organization for Legal Metrology.
- Custodian of National Standard– Its is the responsibility of the National Institute of Metrology, Thailand (NIMT). NIMT was works under the supervision of the Ministry of Science and Technology. It is founded on 1 June 1998 as a public autonomous agency.
- National Organizations accountable for maintaining primary standards.
- They have different Local and Regional verification organization.
- Calibration of instruments and Evaluation system.

All kinds of weighing instruments and volumetric devices comes under the Weights and Measures Act 1999 and Amendment 2014.Except some kinds of weighing instruments and volumetric devices that are exempted by the minister on the advised of CWM. Other measuring instruments under this Act shall be the kinds of which are included by the Minister, on the advice of CWM. Currently, there is no specified pattern for type approval in Thailand legal metrology system. For measuring instrument there are two types of verification are used. The first one is done for measuring instrument which has never been verified, and is known as initial verification and other one is reverification after repairing or expiration of the term of validity for verification is called a reverification. The number of weighing and measuring instruments certificates that were verified between October 2019- September 2020 are shown in graph below

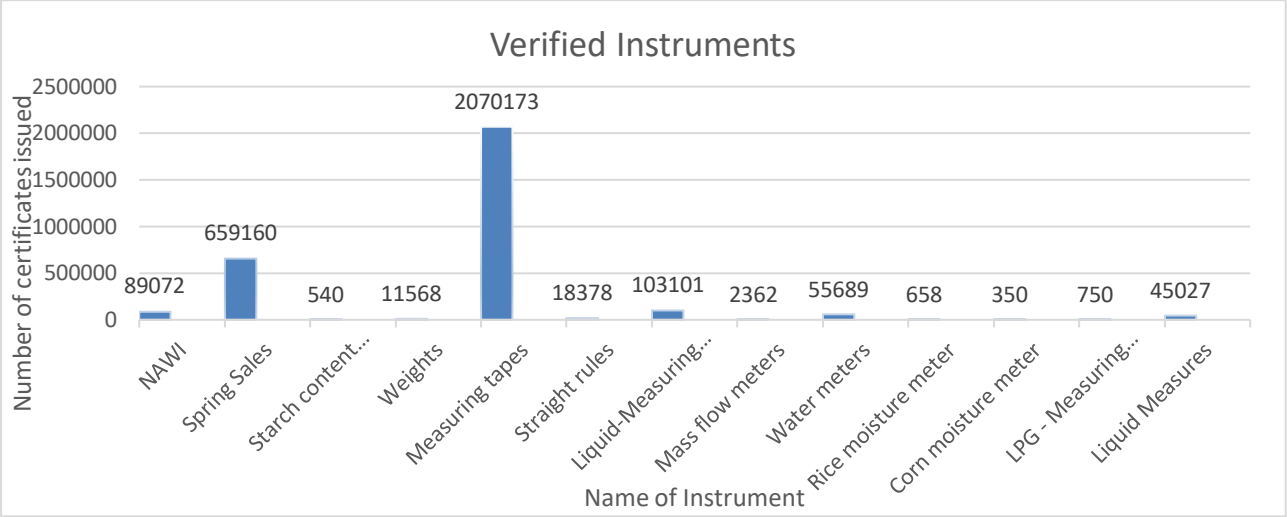

Figure 1 Number of certificates as per Instrument

3.2 Certification system

3.2.1 Accreditation systems for legal metrology, calibration and testing laboratories:

The Weights and Measures Act 1999 made to carry out verification of measuring instruments for private organizations, manufacturers and repairers which are or repaired, respectively. The verification test can be performed by these accredited laboratories, and can issue verified certificates for the measuring instruments that were found correct in the testing. The time period for verification of instruments verified by manufacturers is 2 years and for instruments verified by repairers it is 60 days.

3.2.2 Legal and Applied Metrological Activities in Products Certification:

The only recognized government organization that provides product certification in Thailand is Thailand Industrial Standard Institute (TISI).

TISI must approve the license for any product to use the standard mark.

Legal and Applied Metrological Activities in ISO 9000 Quality Management System:

Thailand has adopted the ISO 9000 series as Thai Industrial Standards in 1991 as the TIS 9000 series.

Legal Metrology Practitioners:

- Legal metrology functions with 154 officials; Central Bureau of Weights and Measures have 60 official and 94 officials' works in the regional verification branch.
- Weights and measures officials can have qualification in the fields of engineering, physics and vocational certificate.
- The following program are organized and coordinated by CBWM.

- Inspector Training Course.
- Verification of Measuring Instruments.
- Calibration of Measuring Instruments.
- Checking the Net Content of Prepacked Good

3.2.3 Sanctions:

It was updated in October 2020 that, if rules & regulations of Weights & Measurement of Act are being disobeyed by someone then that personnel will be paying penalty of fines up to $85,000 under the administrative offence and if it has been found as a criminal offence then it is liable to imprisonment of not more than 7 years. From a consumer protection point of view, it is important to have a legal control on measurements which involves human safety and public health along with the environmental protection. As in comparison with other countries, Legal Metrology in India can be better understood by Legal Metrology Act 2009. This Act is implemented to establish Standards of weights & measures or numbers & other good which are sold and distributed by weight & measure, and for associated matters. It extends to the whole of India. Only 57 sections are provided under this Act [6].

Like other countries, India also follows the metric convention of SI units (International Standards of Units) which can be better understood by the following chart given by BIPM (International Bureau of Indian Standards).

Table 2 Quantities and SI unit

S. No.	Name of Fundamental Quantities	SI Units
1	Mass	Kilogram (Kg)
2	Time	Seconds (s)
3	Length	Meter (m)
4	Thermodynamic Temperature	Kelvin (K)
5	Electric Current	Ampere (A)
6	Amount of Substance	Mole (mol)
7	Luminous Intensity	Candela (cd)

Preferring to the table 2 base units along with 22 derived units with special name and symbol was accepted by BIPM.

In case of numeration of unit, the numeration should be made in accordance with decimal system. Seven rules were formed under the LM Act which are as follows:

- LM (Legal Metrology) general rules,2011 – In this rule, the main focus was on prescribing the main specifications of the weighing & measuring instruments and there are such 40 types of weighing and measuring instruments which includes water

meter, clinical thermometer, petrol pumps etc. These instruments are continuously verified by state govt. officers using their standards and procedure as per the rules.

- The LM (Packaged Commodities) Rule,2011 :- According to this rule, certain declaration must be there on each product/package such as Country name from where the package is imported, Manufactured/Validity date till when it is valid, Net quantity, Consumer care details etc.
- LM (Approval of Models) Rules, 2011: Any manufacture/importer who is manufacturing or importing any product then he should have his type approval from Government of India before manufacturing or importing the product. However, there are some equipment such as brass, cast iron, bullion or carat weights, length measures as they are continuously being used in retail trade are not required to get any type approval.
- The LM (National Standard) Rule, 2011: According to this rule,

a) Various standards or national prototypes are allowed to be stored in NPL (National Physical Laboratory),

b) There are five RRSL's (Regional Reference Standard Laboratories) established at Ahmedabad, Faridabad, Bangalore, Guwahati and Bhubaneshwar to maintain Reference standards of weights & measures and these standards are further responsible for the verification of Secondary standards of weights which are also a part of state government laboratories.

- The LM (Numeration) Rules, 2011: According to this rule, there is a separate provision for numbering and in which sequence the numbers are being written.
- The IILM (Indian Institute of Legal Metrology) Rules, 2011: This is a type of institute approved by Government of India to provide training to the state/ UT LM (Legal Metrology) officers in the field of Legal Metrology .
- The Legal Metrology GATC (Government Approved Test Centres), 2013 : Any Laboratory that is doing the verification of weight and balance and setup by any private organization needs to take approval as per Government Approved Test Centre (GATC) Rules. According to GATC the weights and measure are prescribed such as water meters, clinical thermometer, tape measures etc.

3.3 Verification & Stampings of Weights & Measures:

a) Each person having any weights & measures for purpose of any transaction or for protection used by him should be verified at such place.

b) The central government and state government should notify GATCs (Government Approved Test Centres) on such terms & conditions or on a payment of such fee may be prescribed.

c) The central government may prescribed the kinds of weights & measures for verification done through GATCs.
d) The GATCs might appoint some persons having relevant qualification & experience for verification of weights & measures.

A legal metrology usually provides the following:

a) Metrological, Technical control of measuring instruments coving all the requirements.
b) Legal measurement & physical representation of units.
c) Maintenance & custody of measurement standards.
d) Metrological control of manufacture, repair, import and control of pre-packaged commodities.

Table 3 Offences wise Penalties

S.N.	Offences	Penalties
1	For use of nonstandard weight or measure	a) Fine of up to Rs 25000 b) for second and subsequent offence, imprisonment of about six months with fine.
2	For manufacture/sale of nonstandard weight or measure	a) fine of up to Rs 25000 for first offence. b) for second and subsequent offence, imprisonment of about three years with fine.
3	For alteration of weights & Measures	a)Fine of up to Rs 50000 for first offence. b) for second and subsequent offence, imprisonment of six months to 1 year.
4	For tampering with license	Fine of up to Rs 25000 along with imprisonment of one year, if needed.
5	For manufacturing Weights & Measures without license	a) Fine of up to Rs 20000 for first offence b) for second and subsequent offence, imprisonment of about one year with fine.
6	For giving false information or false return	a) Fine of up to Rs 5000 for first offence b) for second and subsequent offence, imprisonment of about six months with fine.

4 Conclusion

The study shows that the requirement of legal metrology in Japan, Brazil, Thailand, Australia and in India are more or less similar. There are different strategies to deal with the measurement and inspections We studied about the legal metrology rules being followed by these countries. Just like we observed that in Brazil, the system of legal metrology faces several issues in accordance to bring accurate results. Although to tackle these problems, INMETRO has done a lot in field of Information & Communication Technology tools and with the help of this, up to a few extent they succeeded as well. Further in Japan, we observerd that how structured legal metrology system they have. Like this, we further studied about Thailand legal metrological system and then at last the Legal Metrological system of India. It may be recommended that National Metrological Institutes of other countries should come forward and share the information and data with other countries as well. These comparisons of various countries might help peoples to study and develop their best ideas related to Legal metrology and further contributing towards the harmonization at the international level. These type of studies allows us to gain knowledge through the use of consolidated methodology.

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