ACTA IMEKO
ISSN: 2221-870X
September 2025, Volume 14, Number 3, 1 - 4

Legal control of moisture meters for cereals, grains, and oilseeds in Brazil

Bruno A. Rodrigues Filho[1], Rafael F. Farias[1], Fábio Nakashima[2], Luiz Yassuhiro Kanzaki[2]

[1] *National Institute of Metrology, Quality and Technology, Nossa Sra das Graças 50, Duque de Caxias, Brazil*
[2] *Weights and Measures Institute, Santa Cruz 1922, São Paulo, Brazil*

ABSTRACT
Soybeans, corn, rice, beans, and coffee are commodities that represent an important role in the Brazilian economy, performing USD 60 billion only in exports in 2022. Consequently, moisture measurement for cereals, grains, and oilseeds has a key role in the commodities market of the national economy, as moisture content influences the monetary value of grains. Moisture meter regulation was first enforced in Brazil in 2013, and a quality infrastructure for legal control is being settled. The current scenario shows an increasing number of both initial and subsequent verifications, as well as of repairers, in 2022 totalling 1,472 initial verifications, 506 subsequent verifications, 10 verification laboratories, 20 repairers, and 2 manufacturers, followed by a stable number of instruments being put on the market annually. The main challenge now remains in finding an alternative to the reference method for verifications, as it currently represents a bottleneck for production processes, and there are also logistics issues for moisture meters in agricultural areas far from verification laboratories. Moreover, a moisture meter as a working standard is under study as a method for verifications.

Section: RESEARCH PAPER

Keywords: legal metrology; legal control; moisture meter; measurements

Citation: B. A. Rodrigues Filho, R. F. Farias, F. Nakashima, L. Y. Kanzaki , Legal control of moisture meters for cereals, grains, and oilseeds in Brazil, Acta IMEKO, vol. 14 (2025) no. 3, pp. 1-4. DOI: 10.21014/actaimeko.v14i3.1955

Section Editor: Rodrigo Costa-Felix, INMETRO, Brazil

Received October 22, 2024; **In final form** August 22, 2025; **Published** September 2025

Corresponding author: Bruno A. Rodrigues Filho, e-mail: bafilho@inmetro.gov.br

1. INTRODUCTION

Legal metrology is an important process in national quality infrastructure, in charge of ensuring fairness in trade. Market asymmetry between buyers and sellers may lead to a misunderstanding of what is being traded, and consequently to an unfair competition between parties, affecting not only the buyer but also the competitors, and consequently decreasing the quality of products and compromising the market [1]. Moreover, an economic distortion regarding monetary losses due to measurement deviations in trade may affect the market, influencing the economy of a country [2]–[5]

Legal control of measuring instruments, such as type approval, initial, subsequent and after-repair verification, is used in legal metrology to ensure quality in the measurement of devices used not only for trade, but also for environmental measurements, as well as health regulating instruments, such as non-automatic weighing devices (scales), fuel dispensers, sphygmomanometers, gas analysers, and others.

Inmetro is the Brazilian National Metrology Institute (NMI) in charge of legal metrology regulation, as well as of verifications. To support Inmetro and to expand its actions across the country, 24 delegated bodies, known as Weights and Measures Institutes, also conduct verifications and surveillance activities covering the entire country.

In Brazil, agriculture plays an important role in the economy, where only between 2021 and 2022, crop production was around 113.1 Mt for corn, 125.5 Mt for soybeans, 10.7 Mt for rice, and 2.9 Mt for beans. This production represented exports of around USD 60.6 billion in 2022, and USD 28.1 billion in 2023, as ofl the current available data [6].

Temperature, moisture, and time of storage are the main external factors that influence the quality of grains. A study showed that, over a 180-day storage period, grains with 15–18 % moisture at 35 °C experienced a reduction in quality when compared to grains with 12 % moisture at 15 °C [7]. Moreover, moisture measurement has an important part in grain valuation, since it limits the development of bacteria, fungi, actinomycetes, yeast, and bugs, which are the main reasons for the deterioration of storage grains [8].

Because of the importance of the agriculture sector to the national economy, and to ensure fair trade in the sector, Brazil, as a member state of the International Organization of Legal Metrology (OIML), started a program to regulate moisture meters for cereals, grains, and oilseeds, based on the OIML recommendation R 59 - Moisture meters for cereal grains and oilseeds [9], hereinafter called Moisture Meter (MM) for simplification. It is important to note that the legal control established in the OIML recommendation applies exclusively to grains intended for consumption, and not to seeds intended for planting. Metrological control applies to moisture meters covered by the OIML recommendation that are, in fact, used in the grain production chain due to their speed and ease of use. In 2013, Inmetro released a regulation for MMs, with a four-year deadline for MM manufacturers to produce the meters according to the regulation, and, accordingly, all MMs produced without type approval shall be removed from the market by 2028 [10].

The present study shows the progress of the legal control of MMs since 2017, based on data from Inmetro's Management System (SGI) used for verifications, presenting the current situation and the national infrastructure.

2. TYPE APPROVAL, INITIAL AND SUBSEQUENT VERIFICATION

Type approval, initial and subsequent verification consist of distinct tests comprising stamping, marking, sealing, software, and measurement tests according to the regulation. Inmetro is responsible for type approval, conducted in Inmetro laboratories in Rio de Janeiro. Inmetro and the delegated bodies conduct initial and subsequent verifications. Even though regulation comprises several tests, the measurement test is the main bottleneck of the process.

The air-oven method is set as the reference for moisture measurements. In general, grain crops or oilseeds are dried in an air oven for 16 to 72 hours, at a temperature of around 100 °C, depending on the grain. The moisture content *M* of the sample is given by

$$M = \frac{m_0 - m_\mathrm{f}}{m_0} \times 100\,\%\,, \tag{1}$$

where m_0 is the initial and m_f is the final mass of the sample.

The reference method assumes that only water is lost in the air oven [11]. The samples consist of rice, coffee, soybeans, corn, or beans. The specifications, given on the basis of the OIML recommendation [9]–[12], are the following:

- Calibrated oven, with temperature variation control of ± 1 °C;
- Calibrated analytical balance, with a minimum resolution of 0.001 g;
- Calibrated reference thermometer, with a minimum resolution of 0.1 °C;
- Moisture content of the sample determined in triplicate, with a maximum allowable difference between replicates of 0.2 %.

Maximum Permissible Errors (MPE) for subsequent (annual periodic and after-repair) and initial verifications are given by equations (2) and (3), respectively, where *U* represents the grain moisture [9]–[12]:

$$MPE = \begin{cases} 0.8 & \text{if } 0.05 \times \%\,U < 0.8 \\ 0.05 \times \%\,U & \text{if } 0.05 \times \%\,U \geq 0.8 \end{cases} \tag{2}$$

and

$$MPE = \begin{cases} 0.4 & \text{if } 0.025 \times \%\,U < 0.4 \\ 0.025 \times \%\,U & \text{if } 0.025 \times \%\,U \geq 0.4\,. \end{cases} \tag{3}$$

For subsequent verifications, logistics may be an issue for the air-oven reference method, since most MMs are located in agricultural areas in remote zones, usually far from metrological laboratories. Additionally, the method is also a bottleneck for initial verification at manufacturers. In order to mitigate these difficulties, an alternative method has also been developed, in which an MM is used as a working standard. Nevertheless, the MM has to fulfil the metrological requirements according to the National Technical Standards [12]. The working standard is selected from the MMs by the manufacturer during the initial verification processes. However, as MMs are produced in a production line following standard procedures, it is most of the time not possible to select a working standard, as the MM does not meet the necessary requirements, and the reference method is the only option available.

It is worth noting that research on the development of a reference material for verification is currently being conducted by Inmetro; however, no such reference materials are available to date.

3. NATIONAL INFRASTRUCTURE AND VERIFICATION RESULTS

Even though the National Regulation, published in 2013, is still in a provisional period until 2028, a quality infrastructure comprising metrology bodies, verification laboratories, and private repairers is being implemented. Figure 1 shows the current national quality infrastructure for the legal control of MMs in Brazil. In particular, Figure 1 shows 29 repairers, 2 manufacturers, and 8 verification laboratories of delegated bodies, as well as 2 Inmetro verification laboratories (Goiania and Porto Alegre). There are currently 2 types of MM approved according to Inmetro's regulation, from two different manufacturers.

The analysis of the current scenario is based on information from Inmetro's Integrated Management System (SGI), which contains information about initial, subsequent, and after-repair tests regarding measurement instruments, conducted by Inmetro

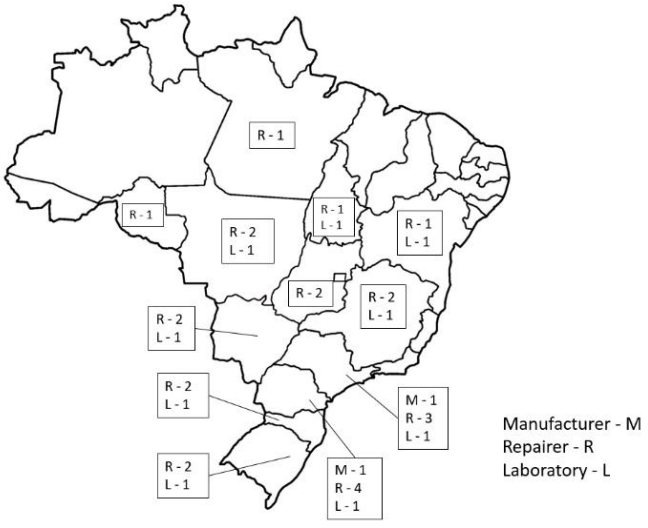

Figure 1. Stamp issued to help people getting familiar with SI units.

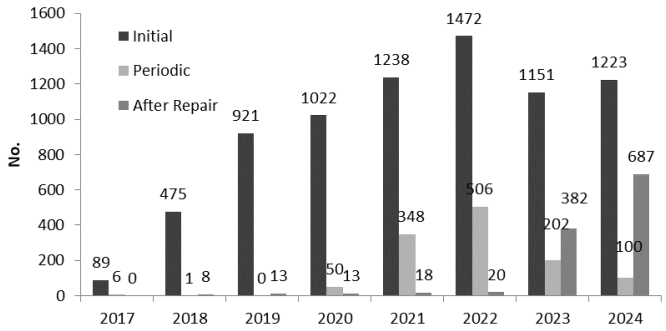

Figure 2. Evolution of initial and subsequent verifications and repairers from 2017 to October 2024.

and the delegated bodies responsible for legal metrology activities [13]. The quality infrastructure, as shown in Figure 1, is resulting in an increasing number of both initial and subsequent verifications, as displayed in Figure 2.

Figure 3 shows the infrastructure of a verification laboratory, comprising samples from different grains, precision scales, MMs, and air oven devices.

The increasing number of initial verifications from 2017 (89) until 2022 (1472) show the engagement of manufacturers in producing MMs according to Inmetro's regulation, even though the provisional period lasts until 2028. On the other hand, as costs are involved in MM replacements for the users, a slower growth of subsequent verifications is observed due to the great number of non-approved MMs still in use.

From 2022 to 2023, a decrease in the number of initial verifications (1,151) can be observed, while an increase is observed in 2024 (1,223), suggesting a consolidation of the number of instruments produced annually.

A great increase in the number of after-repair verifications (687) can also be observed in 2024, compared to the other years. As instruments are constantly being put on the market each year, an increase of after-repair verifications is still expected.

Even though a decrease in the number of periodic verifications is noted, from 506 in 2022 to 100 in 2024 , the number of subsequent verifications, consisting of periodic and after-repair verifications, has slowly increased throughout 2022 (526), 2023 (584), and 2024 (787). It may suggest that repaired instruments are in use on the market, still demanding for periodic verification.

4. CONCLUSIONS

The national quality infrastructure for moisture measurement of cereals, grains, and oilseeds was initiated in Brazil after 2013, due to the national regulation. Even though the regulation is under a provisional period, the infrastructure, comprising verification laboratories of delegated bodies, private repairers, and manufacturers, is continuously expanding, as it can be seen from the results of initial and subsequent verifications. It is also important to highlight that even though the regulation was initially released in 2013, there is a gap until 2017, due to deadlines set for starting the processes and settling a minimal infrastructure.

However, some methodologies are still under improvement to minimize the impact of legal control in manufacturers' production lines (initial verification) and to decrease logistics costs (subsequent verification).

Figure 3. Laboratorial infrastructure for MM verifications. (Source: the authors).

AUTHORS' CONTRIBUTION

Bruno A. Rodrigues Filho conducted the study and was responsible for conceptualization, methodology, data curation, writing the original draft, and review and editing.

Rafael F. Farias was responsible for formal analysis, validation, and review and editing.

Fábio Nakashima and Luiz Yassuhiro Kanzaki participated in the validation and formal analysis.

ACKNOWLEDGEMENT

The authors acknowledge the National Institute of Metrology, Quality and Technology – Inmetro, and the Weights and Measures Institute of São Paulo – Ipem-SP for supporting this research.

REFERENCES

[1] G. Akerlof, The market for "lemons": quality uncertainty and the market mechanism, Quarterly Journal of Economics 84(3) (1970), pp. 488–500.
DOI: 10.2307/1879431

[2] W. Stiefel, Management assistance for weights and measures progress, Measuring Inaccuracy's Economic Distortion, 1973.

[3] B. A. Rodrigues Filho, R. F. Gonçalves, Legal metrology, the economy and society: A systematic literature review, Measurement 69 (2015), pp. 155–163.
DOI: 10.1016/j.measurement.2015.03.028

[4] R. F. Dias, L. A. C. Caldas, R. R. F. A. Costa, Distorção econômica evitada pelas ações do Inmetro: o caso do Rio Grande do Sul. Rio de Janeiro, 2010. Online [Accessed 21 August 2025] [In Portuguese]
http://repositorios.inmetro.gov.br/handle/10926/599

[5] B. A. Rodrigues, A. N. Soratto, L. L. Nunes, C. O. Afonso, Economic distortion as an indicator to measure the impact of legal metrology activities, J. Phys.: Conf. Ser. 2606 012003.
DOI: 10.1088/1742-6596/2606/1/012003

[6] Companhia Nacional de Abastecimento. Online [Accessed 21 August 2025] [In Portuguese]
https://portaldeinformacoes.conab.gov.br/produtos-360.html

[7] L. B. A. Jaques, A. Ely, L. Hareberlin, E. P. Medeiros, R. T. Paraginski, Efeitos da temperatura e da umidade dos grãos de milho nos parâmetros de qualidade tecnológica, Revista Eletrônica Científica Da UERGS 4(3) (2018), pp. 409–420. [In Portuguese]
DOI: 10.21674/2448-0479.43.409-420

[8] R. H. Sinha, W. E. Muir, Grain storage: Part of a system. Connecticut, 1973, ISBN-10. 087055123X.

[9] International Organization of Legal Metrology Recommendation OIML R 59 - Moisture meters for cereal grains and oilseeds, 2016. Online [Accessed 21 August 2025]
https://www.oiml.org/en/publications/recommendations/en/files/pdf_r/r059-p-e16.pdf

[10] Inmetro Portaria nº 47, de 7 de fevereiro de 2022 - a regulamentação técnica metrológica consolidada para Medidores de Umidade de Grãos. Online [Accessed 21 August 2025]. [In Portuguese]
http://sistema-sil.inmetro.gov.br/rtac/RTAC002911.pdf

[11] Inmetro Norma Inmetro Específica – NIE Dimel 125 Verificação inicial de medidores de umidade de grãos, 2023. Online [Accessed 21 August 2025]. [In Portuguese]
http://www.inmetro.gov.br/metlegal/docDisponiveis.asp

[12] Inmetro Norma Inmetro Específica – NIT Sefiq 004 Verificação inicial de medidores de umidade de grãos, 2023. Online [Accessed 21 August 2025]. [In Portuguese]
http://www.inmetro.gov.br/Sidoq/pesquisa_link.asp?seq_tipo_documento=4&cod_uo_numeracao=00878&num_documento=004

[13] B. A. Rodrigues Filho, A. N. Soratto, An overview of legal metrology activities in Brazil, OIML Bull. 58(1)(2017), pp. 11–15. Online [Accessed 23 August 2025]
https://www.oiml.org/en/publications/bulletin/pdf/oiml_bulletin_jan_2017.pdf