



# Legal control of moisture meter for cereal, grains and oilseeds in Brazil

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**Abstract.** Soybean, corn, rice, bean 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 cereal, grains and oilseed has a key role in the commodities market for the national economy once its moisture influences the monetary value of the grains. Moisture meter regulation was first released in Brazil in 2013 and a quality infrastructure for the legal control is being settled. The current scenario shows an increasing number of both initial and subsequent verification, as well as the number of repairers, totalizing, in 2022, 1472 initial verifications, 506 subsequent verifications, 10 verification laboratories, 20 repairers and 2 manufacturers. The main challenge now remains in an alternative to the reference method for verifications, as it is a bottleneck for production processes and there are 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.

## 1. Introduction

Legal metrology is an important process in a National Quality Infrastructure responsible for ensuring fair 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 parts affecting not only the buyer but also the competitors, consequently decreasing the quality of products and compromising the market (AKERLOF, 1970). Moreover, an economic distortion regarding monetary losses due to measurement deviations in trade may affect the market influencing the economy of a country (STIEFEL, 1973; DIAS *et al*, 2021; RODRIGUES FILHO *et al*, 2021).

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

Inmetro is the Brazilian National Metrology Institute (NMI) responsible for legal metrology regulation as well as verifications. To support Inmetro and to expand its actions across the country, 24 delegated bodies, known as Weigh and Measure Institutes, also conduct verification and surveillance activities covering all the territory.

In Brazil, agriculture plays an important part in the economy, where only between 2021 and 2022 crop production was around: 113.1 Mt for corn; 125.5 Mt for soybean; 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 until the current date of available data (CONAB, 2023).

Temperature, moisture and time of storage are the main external factors that influence the quality of grains. A study shows that moisture between 15%-18% at 35°C quality reduction of grains is observed when compared to moisture of 12% at 15°C in 180-day storage period (JAQUES *et al*, 2018). 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 reason of deterioration of storage grains (SINHA; MUIR, 1973).

Due to 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), initiated a program to regulate moisture meters for cereal, grains and oilseeds based on the OIML recommendation R 59 - Moisture meters for cereal grains and oilseeds (OIML, 2016), hereinafter called moisture meter (MM) for simplification. In 2013, Inmetro released a regulation for MM with a four year deadline for MM manufacturers to produce according to the regulation and all MM produced without type approval shall be removed from the market until 2028 (INMETRO, 2022).

The present study shows the progress of MM legal control since the 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 in distinct tests comprising stamping, marking, sealing, software and measurement tests according to regulation. Inmetro is responsible for type approval, conducted at Inmetro laboratories in Rio de Janeiro. Inmetro and the delegated bodies conduct initial and subsequent verifications. Even though regulation comprises several tests, measurement test is the main bottleneck of the process.

The air oven method is set as the reference for moisture measurements. In general, grains crops or oilseeds are dried in the air oven from 16 to 72 hours and in a temperature of around 100°C depending on the grain. The moisture content  $M$  of the sample is given by (1), where  $m_0$  is the initial and  $m_f$  the final mass of the sample. The reference method also assumes that only water is lost in the air oven (OIML, 2016; INMETRO, 2023). The samples consist of rice, coffee, soybean, corn or bean.

$$M = \frac{m_0 - m_f}{m_0} \times 100\% \quad (1)$$

Maximum permissible errors ( $MPE$ ) for subsequent (annual periodic and after repair), and initial verifications are given by (2-3) and (4-5) respectively, where  $U$  represents the grain moisture.

$$MPE = \begin{cases} 0.8; & \text{if } 0.05 \times \%U < 0.8; \\ 0.05 \times \%U; & \text{if } 0.05 \times \%U \geq 0.8 \end{cases} \quad (2)$$

$$MPE = \begin{cases} 0.4; & \text{if } 0.025 \times \%U < 0.4; \\ 0.025 \times \%U; & \text{if } 0.025 \times \%U \geq 0.4 \end{cases} \quad (4)$$

For subsequent verifications, logistics is may be an issue for the air oven reference method since most of MM 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 a MM is used as a working standard. However, the MM has to fulfill metrological requirements according to the National Technical Standards (INMETRO, 2023). The working standard is selected amongst the MM in the manufacturer during the initial verification processes. However, as MM are produced in a production line following standard procedures, most of the time it is 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.

### 3. National infrastructure and verification results

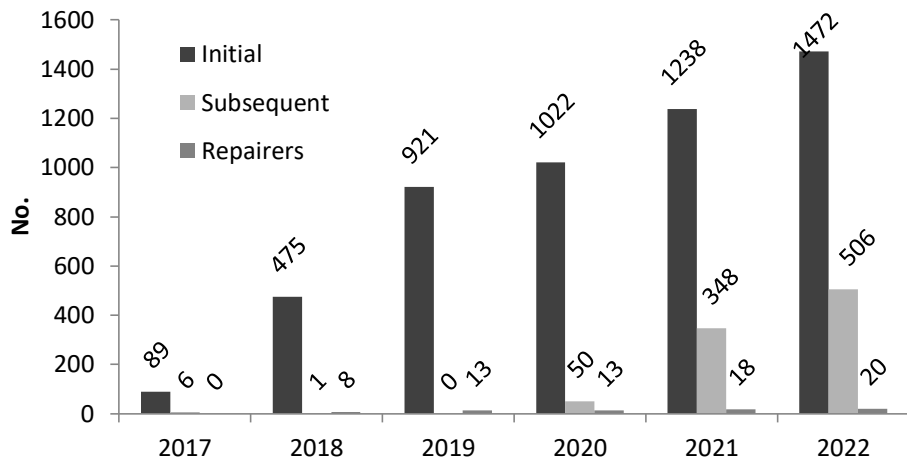
Even though the National Regulation, published in 2013, is still under a provisional period until 2028, a quality infrastructure comprising metrology bodies verification laboratories and private repairers is being implemented. Figure 1 shows, using a Google Map overview, the current quality infrastructure to the legal control of MM in Brazil.



**Figure 1.** Map representation of MM infrastructure. (Adapted from Google Maps).

Figure 2 shows 29 repairers, 2 manufacturers and 8 verification laboratories in delegated bodies and 2 Inmetro verification laboratories (Goiania and Porto Alegre). There are currently 2 MM type approved according to Inmetro's regulation from two different manufacturers.

The analysis of the current scenario is based on information from Inmetro Integrated Management System (SGI), which contains information about initial, subsequent and after repair tests regarding measurement instruments conducted by Inmetro and the delegated bodies responsible for legal metrology activities (RODRIGUES FILHO; SORATTO, 2017). The quality infrastructure, 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, MM and air oven devices.



**Figure 2.** Evolution of initial and subsequent verifications, and repairers, from 2017 to 2022.

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



**Figure 3.** Laboratorial infrastructure for MM verifications.



#### 4. Conclusion

The national quality infrastructure from moisture measurement for cereal, 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 from delegated bodies, private repairers and manufacturers, is continuously expanding as seen in the results of initial and subsequent verifications. It is also important to highlight even though the regulation was initially released in 2013, there is a gap to 2017 due to deadlines to start the processes and settle 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).

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