Information systems as a tool to improve legal metrology activities

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Abstract. This study explores the importance of information systems applied to legal metrology as a tool to improve the control of measuring instruments used in trade. The information system implanted in Brazil has also helped to understand and appraise the control of the measurements due to the behavior of the errors and deviations of instruments used in trade, allowing the allocation of resources wisely, leading to a more effective planning and control on the legal metrology field. A study case analyzing the fuel sector is carried out in order to show the conformity of fuel dispersers according to maximum permissible errors. The statistics of measurement errors of 167,310 fuel dispensers of gasoline, ethanol and diesel used in the field were analyzed demonstrating the accordance of the fuel market in Brazil to the legal requirements.

1. Introduction

Legal metrology is responsible for apply regulations to measuring instruments that impact both economy and society, establishing requirement, as maximum permissible error, in order to provide the accuracy of measurements, maintaining measurement deviations to acceptable levels, arising the confidence to the market [1].

Also, the impacts of measuring instruments can be significant to a country, affecting a significant part of its Gross National Product (GNP) [2], since a 0.1% error in measurements would represent 0.05% of the Gross Domestic Product (GDP) [1]. Moreover, deviations in the commerce can be related to fair competition and consumers´ protections issues.

The asymmetry between buyers and sellers in the market due to a measurement error, causing a monetary impact, is described as an economic distortion, or asymmetry of information, and it is higher as the instrument is less accurate. This asymmetry can also be used as an indicator to measure the economic impact of legal metrology [3].

The legal metrological control is the tool used to maintain under control this asymmetry, using type approval, verifications and surveillance activities to keep these errors according to established in the regulations regarding measuring instruments used in trade.

Information systems (IS) were introduced in organizations mainly to support managers [4]. The concept of an information system involves not only technical aspects of a system as the software or hardware, but also all the information flow, i.e. data and human resources [5].

The aspects of developing an information system, a technology information tool, are wider than developing software or a platform as it also incorporates human, administrative and organization

aspects [6]. In addition, the IS when properly lined up to the strategic requirements of the organization contributes to innovation [7].

Recently, information systems have been introduced in legal metrology successfully in order to organize and improve the control, as the system proposed to assist the implementation of the Measuring Instrument Directive in Europe, simulating the behaviour of measuring instruments in the market [8]. Also in Europe a system was developed to organize and manage the information among notified bodies in legal metrology [9].

In prepackaged, a system was also proposed to control of the mark on the products in order to comply the regulation in the European Union [10].

The present study aims to explore how information systems applied to the legal metrology activities have helped Inmetro, the National Metrology Institute in Brazil, to improve the level of control over the market arising confidence in measurements. The fuel market is used as a study case to relate the enhancements achieved in the sector.

2. Legal Metrology

The legal metrological control comprises the activities that aim to provide confidence to measurements used in trade and economy. These activities are divided in three distinct levels of control [11]: type approval and initial verification; subsequent verification; surveillance.

Type approval represents the compliance of the devices to constructive characteristics before their production, in order to guarantee that the instruments manufactured or imported are according to the national regulation and initial verification checks the instruments accordance to the approved features. Afterwards, the subsequent verification represents the level of control of the instruments after they are put in the market, testing periodically or after a repair if the device fulfils the requirements. Finally, the surveillance is the level of control focused mainly in identifying metrological frauds and misuses of the instruments in the market. These activities may be conducted by public or private bodies according to each country necessity.

In Brazil, the activities of legal metrological control are aligned to International Organization of Legal Metrology recommendations. The National Metrology Institute (NMI), Inmetro is responsible for legal metrology in Brazil, aggregating the activities of regulation, accreditation, conformity assessment and traceability of standards to the International System (IS).

Specifically in the legal metrology field, while type approval is conducted by the Inmetro, both initial and subsequent verifications (periodic and after repair) as well as surveillance are conducted by the 26 delegated public bodies over the country [12].

Despite after repair verification being conducted by the delegate bodies, the repairs are executed by 3,281 notified bodies that are responsible for maintenance and putting the instrument in use in the market [13]. The delegate bodies conduct the after repair verification based on the repair reported informed by the repairer.

3. Information System

3.1. Acquiring data of subsequent verification

The Brazilian NMI has implanted in 2011 an Integrated Management System (IMS) in order to aggregate the information provided from legal control of measuring instruments carried out by the delegated bodies, unifying the results of metrological tests in the market, integrating the results, allowing Inmetro to plan and act more efficiently.

The metrologists in the field transmit the information regarding the metrological tests of subsequent verifications and inspections, according to OIML recommendations, using a data collector.

Afterwards, the information inserted during the tests are synchronized periodically to a database server, integrating all the results allowing to the system to produce reports for a more effective control of the legal metrology activities.

Figure 1 displays the data collector screen for a fuel dispenser verification test for high volume flow test (45 ℓ/min), where the instrument displays a volume of 19.8 ℓ and the standard 20.0 ℓ.

Figure 1. Data collector connected to IMS database used to perform metrological tests.

3.2. Harmonization and standardization

One of the main aspects of an integrated information system regards about harmonization of procedures, once metrological tests according to OIML recommendations are already programed in the data collector. The harmonization of procedures also contributes to the standardization of instruments used in trade as they are subjected to harmonized procedures of verification.

The consistence of data due to harmonized and standard information allows obtaining macroeconomic indicators regarding the economic impact of measuring errors in the market.

3.3. Output data reports and data mining

Once measuring errors of the instruments in the market are collected and storage in a single data base, it is possible to obtain reports informing metrological characteristics and geographical location of measuring instruments in the market; repairs executed by notified bodies; workforce necessary to meet the demand; measuring errors; and others.

The errors of the instruments used in the market are an important output of the system as they allow computing the economic distortion indicator, representing the impact of the legal metrology activities on the economy.

4. Methodology

The results represent the tests carried out by the delegated bodies in both periodic and after repair verification in fuel dispensers used in the market from June to December 2014, covering 20 of 26 states in Brazil. The subsequent verifications covered 78,804 dispersers of gasoline, 37,719 of ethanol and 50,787 of diesel during the mentioned period.

The metrological tests used for the present study are conducted considering the volume accuracy at maximum flow rate, according to Brazilian Regulation [14] that is aligned to OIML Recommendation [15]. The measure procedure for the volume tests consists in a measurement standard of nominal standard value of 20 ℓ and tests conducted at the maximum and minimum flow rate current regulation. The maximum permissible error for the tests is $\pm$ 0.5% what represents a volume of $\pm$ 100 ml for 20 ℓ dispensed.

Furthermore, the measurement error bias is also an important aspect to be considered in the analyses of the results. A measurement error is described as a measured quantity value minus a reference quantity value. Thus, in the commerce involving buyers and sellers, positive values would represent consumers´ losses and negative values sellers´ losses.

5. Results and discussion

The distribution of the measurement errors of fuel dispensers trading gasoline used in the market is showed in figure 2. Similar distributions are obtained to both ethanol and diesel dispensers.

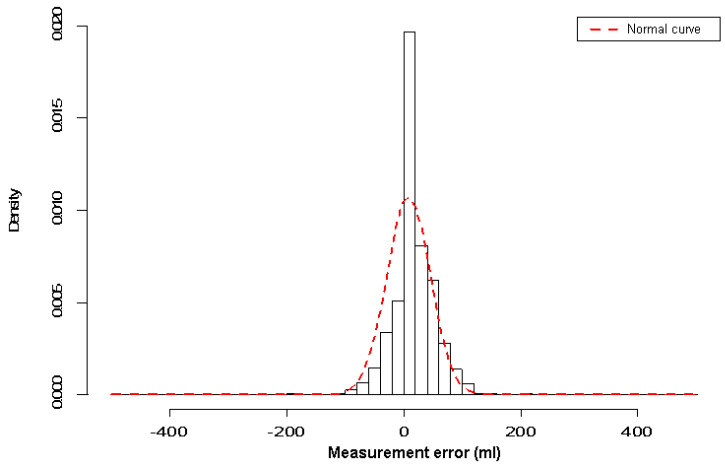

Figure 2. Measurement error distribution for gasoline fuel dispenser.

Table 1 displays the average value x of the measuring errors as well as the standard deviation σ for the dispensers according to the fuel traded, and figure 3 shows the average and standard deviation for gasoline, ethanol and diesel dispensers.

Table 1. Average and standard deviation of fuel dispensers used in trade.

Fuel dispenser	x	σ
Gasoline	7.99	45.99
Ethanol	4.22	40.83
Diesel	6.68	49.52

Average values of x =7.99 ml to gasoline, 4.22 ml to ethanol and 6.68 to diesel dispensers represent a bias toward consumer´s losses, however these values are inferior to the MPE, demonstrating the accordance of to the current regulation.

Despite average values closer to zero, the standard deviations, according to table 1 shows a big dispersion around the average. However, since the measurement errors of volume of the fuel dispensers varies from negative to positive values, and this measure is regulated, a standard deviation bigger than the average is expected.

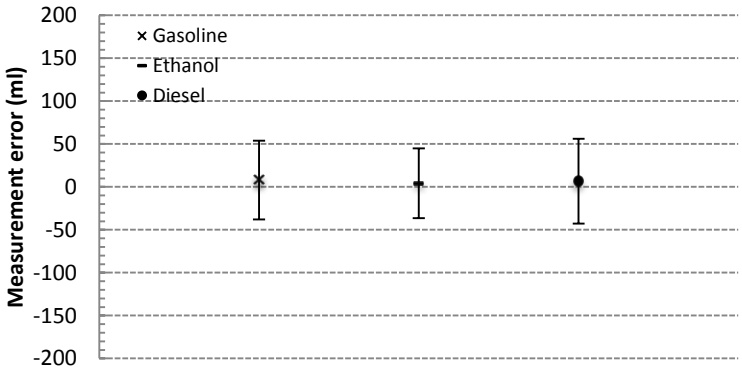

Figure 3. Average and standard deviation of fuel dispensers according to fuel delivered.

It is also possible to conclude that even when the standard deviation values (σ) 45.99, 40.83 and 49.52 are considered, the devices used in the fuel market are according to the MPE established in the national regulation.

Then, due to the x and σ analysis, as shown in figure 3, it can be seen how the legal metrology provides the confidence to measuring instruments used in trade, specifically in the fuel market in this study. High values of standard deviation are due to statistics fluctuations of the accuracy test, once fuel dispensers are greatly influenced by environmental temperature.

The harmonized procedures provided by a unified information system give the reliability for the distribution of measuring errors for fuel dispenser in the market.

6. Conclusion

The concept of an information system is wider than only technology and hardware, involving also human resources and data flow. In the legal metrology context it involves the NMI (Inmetro) and the 26 delegate public bodies responsible for the subsequent verification in Brazil.

The Integrated Management System used to connect the stakeholder has showed an adequate tool to harmonize procedures regarding verifications and metrological tests leading the whole system to an adequate level of standardization.

The metrological tests conducted in verifications show that the control of fuel dispensers is according to regulation, detailing both average and standard deviation for the instruments errors.

Both information (x and σ) allows the NMI to make decisions regarding technology used in the sector, regulations and procedures review, in order to decrease the impact of measures in trade due to either accuracy or precision control.

Both average and deviation results measuring errors are relevant information in order to obtain macroeconomic indicators and the economic distortions in order to measure the impact of legal metrology to the economy.

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