Metrologia Fortaleza - CE 2017

A risk analysis approach applied for field surveillance in utility meters in legal metrology

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Abstract: Field surveillance represents the level of control in metrological supervision responsible for checking the conformity of measuring instruments in-service. Utility meters represent the majority of measuring instruments produced by notified bodies due to self-verification in Brazil. They play a major role in the economy once electricity, gas and water are the main inputs to industries in their production processes. Then, to optimize the resources allocated to control these devices, the present study applied a risk analysis in order to identify among the 11 manufacturers notified to self-verification, the instruments that demand field surveillance.

Keywords: metrological supervision; risk management; regulation.

1. INTRODUCTION

Legal control of measuring instruments and metrological supervision are both the activities responsible for metrological assurance, guarantying the conformity and confidence of measuring instruments under the legal metrology umbrella. Especially the accordance of the measurement errors to the maximum permissible values avoid the economic distortion, which represents the amount of money at risk due to inaccurate measurements [1]. These measurement errors might represent a significant amount of the GDP [2].

Utility meters represent measuring instruments to control public services on utility mains, such as water, electricity and gas. They are also an important part of the economies since they work as main inputs to most of the supply chains in the industry, aggregating their distortion due to measurement inaccuracies, impacting the price of the products impacting the entire economy at all its levels.

While the legal control of measuring instruments comprises type approval and verifications, metrological supervision represents an additional level of control within legal metrology and is responsible for checking the accordance of metrology regulations [3]. Especially in the activities wherein the notified bodies work as substitutes to the metrological authorities, as self-verifications, metrological supervision plays a major role.

The activity is structured in three different and complementary levels [4]:

- Quality surveillance – Aiming at establishing that the quality systems of bodies working in legal metrology complies with regulation;
- Market surveillance – Aiming at a measuring instrument and prepackage before their placement in the market;
- Field surveillance – Aiming at establishing that a measuring instrument

in use in the field complies with the statutory requirements.

According to these levels, considering the self-verification as an example, it represents that the notified body needs a structured quality system, demonstrating the capacity to produce measuring instruments in accordance with regulation; then market surveillance checks the accordance of the produced devices; and finally the field surveillance tests the behavior of the instruments in-service. These three stages guarantee the conformity/reliability life cycle of measuring instruments.

However, the utility meters represents the majority of measuring instruments in-service, and the surveillance of each one of them, as well as they replacement would represent great costs to the society. Consequently, the rational usage of the available resources demands for optimization of the budget allocated in legal metrology services.

As the risk analysis is a consolidate tool in quality management and it has been successfully applied to decision-making processes and to predict events wherein risk is involved [5-8] , the present study uses a risk analysis approach to identify the utility meters subjective to field surveillance.

2. METHODOLOGY

2.1. Risk analysis

The risk analysis considers two parameters in order to determine the risk [6]:

- Impact – representing the impact of an unwanted legal interest;
- Probability – Degree to which the unwanted occurrence has happened;

The Likert scale is applied to measure both impact and probability, ranging from 1 – 5, whereas impact, 1 represents minimal and 5 significant impacts. Probability ranges from very unlikely (1) to very likely (5). Then, the risk is defined as (1):

$$Risk = Impact \times Probability \qquad (1)$$

We considered as legal interests in order to compute the impact: economic; environmental; and consumer´s protection. Since utility services share similarities, the impact evaluation is a constant for all the manufacturers.

The parameter choose to determine the probability is the non-conformities of measuring instruments during market surveillance.

Finally, matrix displays the risk, showing the higher risk instruments, guiding the field surveillance process more efficiently. Figure 2 shows an example of a risk matrix.

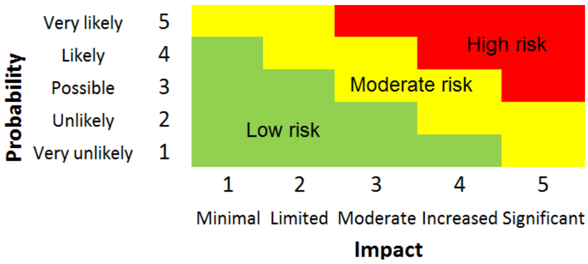

Figure 1. Risk matrix. Adapted from [6].

Once the water meters were selected to be tested according to the risk analysis, the field surveillance, the inspection lot sampling was based on the ISO2859-2:2001 [9].

Table 1. Inspection lot sampling.

Lot	Sample size	Non-conformities	
		Accept	Reject
50 - 1.200	50	1	2
1.201 - 3.200	80	3	4
3.201 - 10.000	125	5	6
10.001 - 35.000	200	10	11

2.2. Case test

We carried out the method for water meters for cold potable water, hereinafter called water meters, considering the 11 manufacturers in the country and the city of São Paulo (estimated population of 12,038,175 in 2016 , representing the biggest metropolitan area in Brazil [10], consequently representing the biggest density of water meters.

To conduct the risk analysis, similar devices must be considered due to sampling procedures. We considered the residential type, class C, nominal flow rate Q_n = 1.5 m³/h, produced from 2013 to 2014.

For confidential purposes, the manufacturers are represented from A to K. The parameters applied for the risk analysis are shown in table 2.

Table 2. Risk analysis parameters.

Manufacturer	Probability	Impact	Risk
A	1	2	2
B	1	2	2
C	1	2	2
D	1	2	2
E	1	2	2
F	1	2	2
G	4	2	8
H	5	2	10
I	1	2	2
J	2	2	4
K	1	2	2

3. RESULTS

The risk matrix, based on the parameters displayed in table 2 is shown in figure 2. All the manufacturers are in the limited impact column once this parameter is a constant. Thus, probability, in this analysis, is the parameter that distinguishes the manufacturers more likely to be surveyed.

According to the risk analysis, nine manufacturers are classified as low risk and two as moderate risk. H followed by G presented more non-conformities elevating their probability, resulting in a higher risk when compared to the others. In addition, no manufacturers were classified in the high-risk region.

After the identification of the manufacturer, we applied a sampling procedure in order to identify the instruments to be collected for metrological tests. Based on the total of water meters installed in the city of São Paulo, the selected sample is represented by 80 instruments. The Google Maps tool was used to display the samples. Figure 3 shows the geographic location of the selected water meters.

4. CONCLUSION

The utility services represent a major importance to both the economy as an input to supply chains in basically every industry, and the society since water, energy and gas are vital goods to people´s everyday consumption.

This study presented a risk analysis based method in order to optimize the field surveillance, using water meters as a case test, optimizing the resources in legal metrology in areas that present a higher risk to both economy and society.

The methodology allowed identifying the higher risk instruments (manufacturer) for a specific class of meters, as well as to locate them geographically.

Finally, this study was limited to the identification of the instruments. Further studies may conduct the tests in order to verify the conformity of the selected devices and nonconformity rate.

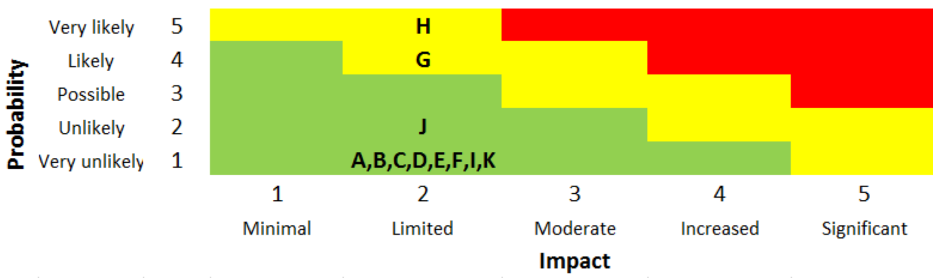

Figure 2. Risk matrix for the case test.

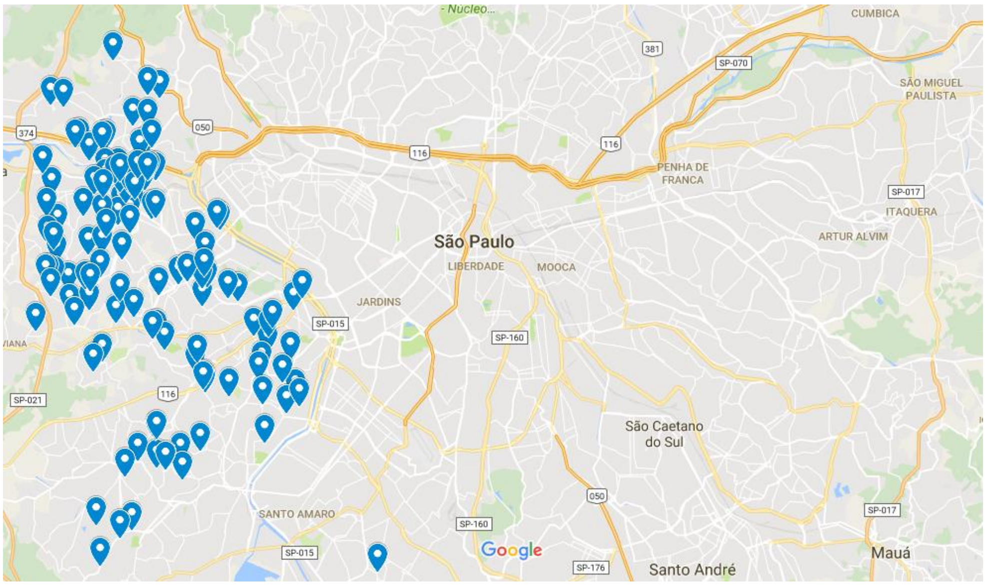

Figure 3. The geographic location of the higher risk water meter, representing the manufacture H.

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