

Performance study in fuel dispensers in the field of volume measurements

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Abstract

Like any type of measuring instruments used for commercial transactions, fuel dispensers, commonly known as petrol pumps, are submitted to metrological control in order to assure consumer protection and provide society in general and citizens in particular the guarantee of accurate measurements, the verification being directly linked with the volume measurement of the delivered fuel.

In Portugal, the fuel dispenser approved under the MID is subject to metrological control in service taking into account its annual verification by the verification bodies, following the procedures defined by IPQ, according to specific national regulations.

Presently there are 45 000 hoses of the fuel dispensers in Portugal, verified by several verification bodies equally distributed in the national territory.

In order to evaluate the influence factors in volume error determination of fuel dispensers, a study using standard test measures of different type, materials and volume was designed and implemented. The uncertainty of the volume determination according to the GUM methodology was evaluated, considering different atmospheric conditions, volume variation over time, different fuel types and determination of error the in different types of standard test measures.

There was some difference in performance and error determination when using different standard test measures, but in all implemented tests, the maximum permissible error was not exceeded.

The results allowed simplifying the internal procedure while maintaining the accuracy of results.

1. Introduction

Metrological verification of some measuring instruments, such as petrol pumps (SMDCs), water meters, meters for liquids other than water, gas meters and fluid storage tanks is directly related to volume measurement.

In particular, with respect to SMDCs, it is necessary to use appropriate methods and standards for the determination of the volume of these measuring instruments subject to metrological control [2], [3], to guarantee the accuracy of the measurements.

The graduated standards capacity (RVG) measures between 2 L and 50 L, with removable scale, are the standards used in determining the volume of SMDCs. These measures have suffered over time a technical evolution evidenced both by a better resolution and by the type of material with which they are constructed.

The calibration of the RVG may be carried out by the gravimetric method, according to ISO 4787 [4], or by the volumetric method, using the procedure described in the EURAMET cg - 21 [5] guide, depending on the accuracy of the required measurement and uncertainty.

The SMDCs are subject to annual legal metrological control, carried out by entities recognized and qualified by the Portuguese Institute for Quality (IPQ), using calibrated volume standard measures and the IPQ Technical Procedure PT1039107501. The metrological control of these measuring instruments is defined in the Ordinance n.º 19/2007 [6], with a maximum permissible error (MPE) of 0,5 % for these instruments .

2. Experimental conditions and equipment

In this experimental study, a SMDC from ABA CODEISA was chosen with resolution of 0,01 L.

The tests were conducted in the south of Portugal, mainly in Almodôvar.

Three types of standard test measures were used to determine the error of the SMDC. Two types of RVG were made of carbon fiber - CFX (Fig.1a) and PWLite (Fig.1b) and one made of Stainless Steel (Fig.1c). The tests were performed at 20 L and 5 L.



Figure 1: a) on the left a CFX standard test measure, b) on the centre a PWLite measure and c) on the right a Stainless Steel measure.

The environment conditions of the tests are described in table 1.

Table 1: Environmental conditions of the tests

	May 2017	November 2017	January 2018
Air temperature (°C)	30	16	16
Humidity (%)	35	27	65
Gasoline temperature (°C)	25	20	16
Diesel temperature (°C)	25	22	17

5. Volume and uncertainty calculation

The equation used to determine volume of the SMDC at 20 °C is as follows:

$$V_{20} = V_t [1 + \gamma(20 - t)] \quad (1)$$

Where, γ is the coefficient of the cubic thermal expansion of the RVG and t is the temperature of the liquid test.

The uncertainty components associated with the volume determination of the fuel dispensers are:

- uncertainty of RVG;
- RVG resolution;
- SMDC resolution;
- uncertainty in reading the meniscus;
- liquid temperature;
- expansion of material of the RVG.

The uncertainty component with the greatest influence on the determination of the volume of SMDCs is the resolution of the measuring instrument (SMDC). In the case of PWLite and Stainless Steel equipment, the resolution of the RVG and the value of its calibration are also relevant.

6. Results

In order to verify the influence of factors such as environmental conditions (air temperature and humidity), fuel temperature, evaporation and fuel type in the measurement of volume of SMDC, were performed the following tests:

- determination of the SMDC error at different atmospheric conditions, in different months of the year (reproducibility);
- determination of the repeatability of the assay, with different types of RVG;
- determination of volume variation over time (evaporation study).

In the evaluation of results, a significant variation is considered if when comparing the obtained errors they are outside of the uncertainty of each test.

The error indicated in the following figures is obtained by the difference between the read value in the RVG scale and its nominal value.

For the repeatability values, each point corresponds to only one test.

6.1 Reproducibility tests results

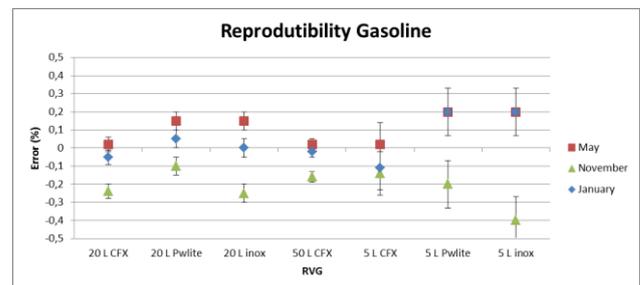


Figure 2: Reproducibility values for gasoline.

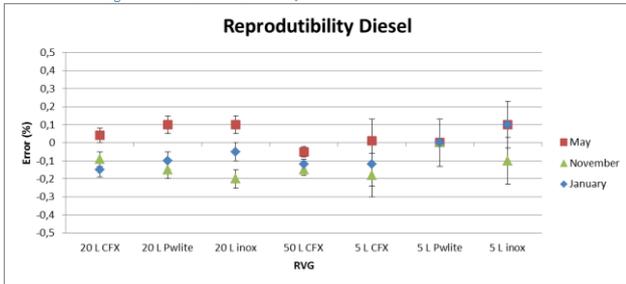


Figure 3: Reproducibility values for diesel

When analyzing the results it can be observed that the values obtained in November for gasoline are visibly lower than in other months since it was very windy, which caused a higher rate of evaporation and therefore a lower volume. With diesel, this effect is not so pronounced.

6.2 Repeatability tests

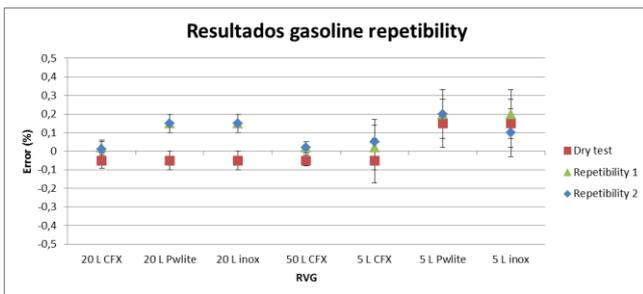


Figure 4: Repeatability values for gasoline

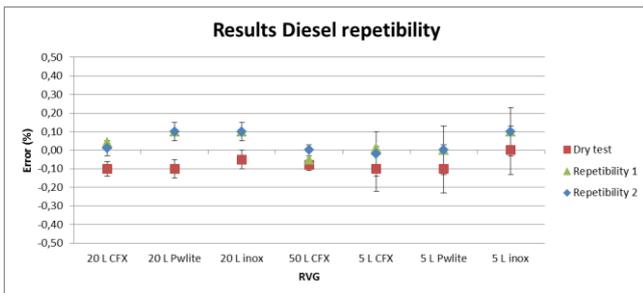


Figure 5: Repeatability values for diesel

From the previous figures, it can be verify that there is only some variation between the dry and the wet results obtained in the tests of the 20 L stainless steel and PwLite RVG. The consecutive repeatability tests with wet RVG do not show any variability in the results, for both diesel and gasoline.

6.3 Volume variation with time and temperature test (evaporation study)

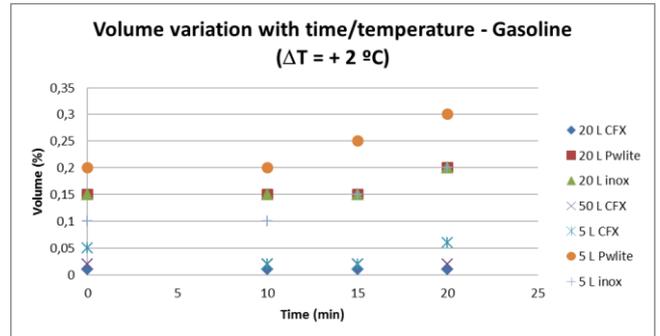


Figure 6: Volume variation with time and temperature for gasoline

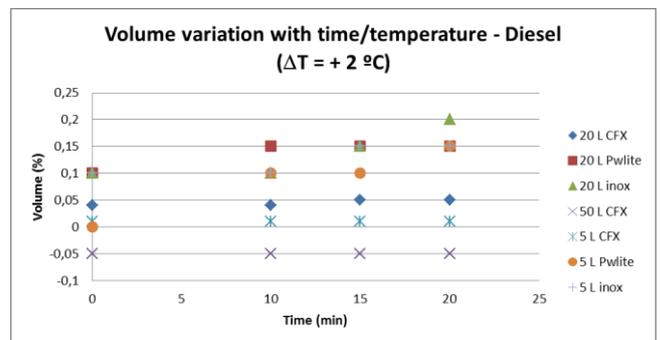


Figure 7: Volume variation with time and temperature for diesel

During the evaporation study for the two fuels, the liquid temperature increased by 2 °C in 20 minutes. There is also an increase in the volume of gasoline and diesel, especially in stainless steel and PwLite RVG, which is due to their open neck characteristics, which means that they are more subject to variations in atmospheric conditions. The fact is that an increase in volume with temperature results from the expansion of the liquid ($0.0009 \text{ } ^\circ\text{C}^{-1}$) which is much higher than the expansion of the material ($0.000001 \text{ } ^\circ\text{C}^{-1}$ for carbon fiber and $0.000048 \text{ } ^\circ\text{C}^{-1}$ for stainless steel).

7. Conclusion

Several performance tests were affected on the same petrol pump, in different months, using standard test measures with different characteristics. The objective of this study was to verify the influence factors in the determination of volume that should be considered relevant in the metrological verification of SMDC.

By the analysis of the obtained results, it was verified that the RVG CFX is not affected by any change in the type of liquid used, temperature or test, dry or wet.

No significant differences were identified between consecutive repeatability tests in wet RVG, even with liquid temperature variations above 0,5 °C.

It was concluded that, for air temperature values between 16 °C and 30 °C and for humidity values between 27 % and 65 %, in no case the maximum permissible error of the SMDCs (0,5 %) was achieved and therefore no rejection of result was obtained.

In the evaporation test some variation in volume was observed, especially for gasoline in the stainless steel and PWLite RVG, which is due to their open neck characteristics. However, evaporation or condensation of liquid, where relevant, only occurs after 5 minutes (operator cannot be expected to wait 5 minutes to read the meniscus).

The study of volume variation over time revealed that in very windy situations the results obtained are much smaller. There are also some situations of increase or decrease of volume with temperature due to the expansion of the liquid, and in the case of diesel, the volume variation with the atmospheric conditions is not so significant.

It was also established that no case exceeded the maximum permissible error of the SMDC, 0,5 %, than meaning that the verified SMDC would be approved at any time of the year, regardless of the atmospheric conditions or RVG used.

References

- [1] PT IPQ 1039107501-03, Metrological control- Petrol pumps.
- [2] Decree-Law n.º 291/90, of 20 of September.
- [3] Ordinance n.º 962/90, of 9 of October.
- [4] ISO 4787 (2011) - Laboratory glassware -- Volumetric instruments -- Methods for testing of capacity and for use.
- [5] Calibration Guide EURAMET cg - 21 - Guidelines on the Calibration of Standard Capacity Measures Using the Volumetric Method, version 1.0, 2013;
- [6] Ordinance n.º 19/2007, of 5 de January.