

# Abstracts

In Uruguay there are different technical regulations that establish the metrological requirements of the measuring instruments involved in the commercialization of fuels and solvents. Legal Metrology has the competence to carry out verifications and monitoring of use of instruments, for example; fuel cargo tanks (usually named as cistern tanks). An important part of verification procedure is to determine the nominal and total capacity of the compartment(s) that make up these types of tanks. For this purpose, it has a verification plant which had a limited capacity due to the use of 500 liter master tanks. These 500 liter standard tanks are calibrated by the national metrological laboratory, which is responsible for providing traceability to the country's Legal Metrology. In Uruguay, the demand for volume verifications related to fuel distribution has increased and there have been technological advances in fuel transportation (tank trucks). For this reason, is necessary to increase the productivity of tank trucks verification plant, and modify the facilities to meet technical requirements such as tanks with more height, etc. In addition, it is necessary to expand the the calibration capabilities of tanks ,500 liters or higher by the volumetric transfer method with uncertainties in accordance with the country's requirements for calibration of volumetric fuel meters. The expansion involved building infrastructure, as well as the patterns used. Standards with capacities of 1000 liters and 5000 liters were acquired, which allows verification of tank trucks faster and cistern tanks with larger dimensions. To provide the traceability of these standard tanks, was mandatory to the National Volume Metrological Laboratory to improve its measurement capabilities in terms of uncertainties of gravimetric method as well as the development of volumetric transfer method. Having achieved better volume measurement capabilities of the National Metrological Laboratory, it was possible to perform the tank trucks verifications more efficiently and improve the calibration uncertainty of 2000 and 3000 liters tanks. In order for these tanks to be used as standards to control volumetric meters for wholesale fuel dispatch, it is necessary to improve the calibration uncertainty of standard tanks by the gravimetric method. With this objective, the National Metrological Laboratory needs to expand the large mass laboratory in order to use a comparator with lower uncertainties than balance currently used and performing calibrations under controlled environmental laboratory conditions water and ambient temperatures controlled during calibrations. This task is presented as the next challenge to face. This poster demonstrates the work of the national metrological laboratory addressing national needs, its interrelation with legal metrology, and its contribution to the fuel sales and distribution chain to guarantee fair marketing of the transported product foreveryone involved.

# Results

In Uruguay, the sale of fuel involves the use of different measuring instruments depending on which part of the commercialisation chain is being referred to. For example, the volume of the tanker trucks that transport fuel to the fuel stations serving the final consumer is checked. This ensures that the fuel's quality and quantity are not altered. To carry out these checks, the volumetric transfer method is used, with tanks serving as the reference standards. The responsibility for carrying out these verifications lies with Legal Metrology, which had a facility equipped with two 500-litre reference tanks. In recent years, there has been an increase in the demand for tanker truck verifications (both initial and periodic), and the technical characteristics of the tanker trucks have also changed, with larger volumes and taller tanks. As a result, it became necessary to increase the productivity of the verification plant and modify the facilities to accommodate the current tanker truck verifications. The modification of the facilities included a significant increase in the height of the platforms where the reference tanks are placed, to optimise gravity-based unloading and minimise the use of hoses for discharge. Additionally, a 5000-litre reference tank and two 1000-litre tanks were acquired. The use of these tanks has considerably reduced the time required to verify the tanker trucks, thus increasing the productivity of the plant and making it possible to meet the annual demand for tanker truck verifications.

Figures 1 and 2 show the current facilities for checking fuel transport tankers:



The entity responsible for providing traceability for the reference tanks used by legal metrology is the Volume Laboratory of the National Metrology Laboratory (located at LATU). To meet uncertainty requirements, it was necessary to develop a calibration method for volumetric transfer tanks based on a 100-litre reference tank, and to improve the calibration uncertainties of the gravimetric calibration method used for the 100-litre reference tank. The volumetric transfer method involves the use of a calibrated reference tank (or several), which is filled and emptied repeatedly until the volume of the tank being calibrated is complete. The liquid used is tap water, with no need for distilled water in these calibrations. It is important that the temperature of the reference tank and the tank being calibrated do not differ by more than 2 °C throughout the entire calibration process.

The transfer equation for calculating the volume of the tank being calibrated at the reference temperature of 20 °C is shown below:

$$V_{IBC \text{ a } 20^{\circ}C} = \frac{\sum_{i=1}^n [\rho_{wpi} (V_{p20^{\circ}C} + L_{pi} \cdot kp) (1 + \alpha_p (T_{pi} - 20))]}{\rho_{WIBC}} \cdot (1 + \alpha_{IBC} (20 - T_{IBC})) - L_{IBC} \cdot k_{IBC}$$

Where:

$\rho_{wpi}$  = density of water in the standard tank at discharge i (Tanaka equation is assumed)

$\rho_{WIBC}$  = density of water in the tank under calibration (Tanaka equation is assumed)

$V_{p20^{\circ}C}$  = Volume of the standard tank (in nominal volume) at the reference temperature of 20 °C

$L_{pi}$  = Reading of the standard tank at discharge i

$kp$  = scale constant of the standard tank.

$\alpha_p$  = coefficient of volumetric expansion of the standard tank

$\alpha_{IBC}$  = coefficient of volumetric expansion of the tank in calibration

$T_{Pi}$  = Water temperature in the standard tank at discharge i

$T_{IBC}$  =Water temperature in the tank under calibration

$L_{IBC}$  = Reading on the tank in calibration (with respect to the nominal volume)

$k_{IBC}$  = Tank scale constant in calibration (determined during calibration)

$V_{IBC \text{ a } 20^{\circ}C}$  = Volume (delivered or contained) of the tank in calibration corresponding to the nominal volume

The uncertainty in the volume of the tank being calibrated is estimated using the guidelines of the GUM JCGM 100: 2008 for determining measurement uncertainties. The tolerance in volume for fuel tanker trucks is 0.25% for initial verification and 0.5% for periodic verification. In general, the uncertainty of the reference standards must be less than a third of the tolerance. The uncertainty achieved for the volume determination by the transfer method is around 0.035%, with the largest contributing factor being the calibration of the reference standard. To achieve this level of uncertainty, it was necessary to reduce the calibration uncertainty of the gravimetric method.

The uncertainty of the reference standards calibrated by the National Metrology Laboratory using the gravimetric method is suitable for use in the verification of tanker trucks but is too large for use as a reference standard in the calibration of tanks for fuel volumetric meter calibration. An analysis of the sources of uncertainty in the gravimetric calibration method shows that the largest contributions come from the uncertainty of the balance and from temperature variations in the water and the laboratory. Currently, gravimetric calibrations of tanks are carried out in a laboratory that does not have controlled ambient temperature and with a balance that has an uncertainty of approximately 0.013% of the calibration volume.

# Conclusions and Future Challenges

Because the uncertainty of the reference standards calibrated by the gravimetric method at the National Metrology Laboratory is suitable for use in the verification of tanker trucks but too large for use as a reference standard in the calibration of tanks for fuel volumetric meter calibration, the National Metrology Laboratory of Volume must work on improving the gravimetric calibration method in order to reduce calibration uncertainty. One of these improvements is the construction of a large-volume laboratory with controlled ambient temperature, and another is the use of a balance with a lower uncertainty (almost 10 times smaller than the one currently used). This modification of the laboratory involves a building reform that will be undertaken in the coming years. The uncertainty is expected to decrease significantly, allowing for the calibration of tanks up to 500 litres using the gravimetric method, with uncertainties of approximately 0.01% of the volume (depending on the type of reference tank).

In order to improve the measurement capabilities of legal metrology in a country, it is necessary for scientific metrology to support it, either by improving the uncertainty of existing calibration methods or by developing new calibration methods. The main function of the National Metrology Laboratory is to act in accordance with national needs.

The interaction between both fields of metrology is crucial to ensure that the fuel distribution and sales chain is safe for the consumer.

# References

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