Proposed model for legal control applied to stand-alone meters and measuring systems for crude oil

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Abstract. The joint resolution ANP/Inmetro 001/2013 approves the Technical Regulation for Oil and Natural Gas Measurements, establishing the technical, constructive and metrological conditions and requirements that oil and natural gas meters and measuring systems must comply, to ensure the credibility of the measurement results. This is a singular regulation in the field of legal metrology in Brazil, and this study presents technical details that may justify the possibility of implementing differences between the legal control of meters and measuring systems used on the crude oil production. Emphasis is given to the singleness of the measuring systems employed on oil platforms, designed for unique installation conditions, on specific platforms, which limit the possibility of presenting a “prototype”, a common practice in the control of serial manufactured instruments. The possibility of a project type approval model, presented by the metering station developer is suggested.

1. Introduction
Measurements and instruments included in the scope of legal metrological control of the crude oil area in Brazil involve different challenges. In particular, it is worth highlighting the need of using different measurement principles and different types of meters, and even measuring systems composed of several different instruments, calculators and devices. These measuring systems, employed in crude oil production, are based on volumetric and dynamic flow measurements, with volume compensation due to variables like temperature and pressure. On the other hand, during storage, for later refining, the crude oil is often stored in large stationary tanks, and the measurement is performed by static methods, using the stored product level and a table height x volume of the tank. At the end of the chain, refined fuels are sold through liquid fuel metering dispensers, which in Brazil do not use temperature compensation [1,4].

Several measurements and instruments applied to oil industry are subject to legal control by Inmetro. As an example, the technical, metrological and safety requirements for software and hardware applicable to liquid fuel metering dispensers, used in volume measurements, are detailed in Inmetro Ordinance number 559/2016 [1]. This means that the instruments applied in this activity must necessarily be subject to the requisites described in this document.
Regarding the measurement of crude oil and natural gas produced in Brazil, the instruments employed are also subject to legal control. However, in this case, the regulation of these instruments presents a difference: the participation of ANP, the Brazilian National Oil Agency. This is because oil and natural gas production measurements define the calculation of government stakes, royalties and so on. In this
way, the document that lays the groundwork for this regulation is the joint resolution ANP / Inmetro 001/2013 [4].

2. The joint resolution ANP/Inmetro 001/2013

The use of a joint resolution in the oil exploration and production market defines the requirements for the measurements, based on good metrological and management practices. As the ordinance itself defines, "it defines the minimum technical, construction and metrological conditions and requirements that oil and natural gas measurement systems must comply with in order to ensure the measurement results credibility".

However, as it is a joint resolution, an important question arises, related to a clear definition about the respective attributions of each institution: ANP and Inmetro. The challenge here was to avoid excessive regulation requisites or overlapping activities. This has been clarified with a table presented on Annex A of the joint resolution, called “assignment matrix”, reproduced here as table 1.

| Table 1. Assignment matrix |
|-----------------------------|
| **Activity** | **ANP** | **Inmetro** |
| Regulation of measuring instruments used in oil and gas measurements |  | X |
| Regulation of using measurement results from oil and gas measurements | X |  |
| Measuring point approval | X |  |
| Metering station legal control |  | X |
| Metering station application authorization | X |  |
| Metering station documentation approval | X |  |
| Measuring systems routine inspections | X |  |
| Calibration of fixed storage tanks |  | X |
| Metering approval for fluids out of specification | X |  |
| Increase/decrease calibration intervals | X |  |
| Measurement reports type approval | X |  |
| Flare gas and produced water estimation approval | X |  |
| Shared fiscal metering approval | X |  |

Source: [4]

As the table presents, metrological focused activities, including the fixed storage tanks calibration, typical works of legal metrology, are Inmetro responsibility. All the other activities related to the regulation of the oil and gas market are activities of ANP.

Considering that the measurement results are necessary information for decision making and management of the oil and gas market, it can be said that Inmetro acts as a collaborator of ANP, in order to contribute to the measurement results reliability. This collaboration is accomplished through the application of the legal control of measuring systems, attribution of Inmetro in table 1, which contributes to provide the right measurement results to the market manager, ANP.

3. Legal control

Legal control of measuring instruments is defined in VIML - the international vocabulary of legal metrology – [2, 6] and is the term used to designate globally the legal operations to which measuring instruments may be subjected, like type approval, verifications, and so on.

However, in the scenario presented here, of different challenges and measurements principles, is it possible to apply all the possible steps of legal control in the same way? Should type approval process
of a flow meter be performed in the same way as evaluation of a complete measurement system? A possible answer to this question may begin with an analysis of OIML Recommendation R-117 [5], the scope of which involves “Dynamic measuring systems for liquids other than water”.

The first section of this recommendation, in scope, says “This Recommendation specifies the metrological and technical requirements applicable to dynamic measuring systems for quantities (volume or mass) of liquids other than water subject to legal metrology controls. It also provides requirements for the approval of parts of the measuring systems (meter, etc.) ”, which suggests the separation between the approval of the measuring system and its parts, that is, the possibility of differentiated control between a complete measuring system and a stand-alone meter, for example.

4. Inmetro Regulation
As shown in Table 1, the legal control of measurement systems is a responsibility of Inmetro. To fulfill this assignment, different technical regulations have been developed. Based on OIML recommendation R-117, the Inmetro Ordinance 64/2003 was published, the scope of which includes “technical and metrological requirements applicable to metering systems equipped with fluid meters, used in the measurement of petroleum, its liquid derivatives, anhydrous alcohol and hydrated fuel alcohol ”.

Thus, this ordinance defines the requirements for both flow meters and flow measurement systems.

4.1. Stand alone flow meters
The legal metrological control of the flow meters, established by Ordinance Inmetro 64/2003 [3], defines the performance tests for the meter, including the error curve and repeatability calculation. The maximum permissible error according to the accuracy class is shown in row “B” of table 2.

| Accuracy Class => | 0.3 | 0.5 | 1.0 | 1.5 |
|------------------|-----|-----|-----|-----|
| A* (%)           | 0.3 | 0.5 | 1.0 | 1.5 |
| B* (%)           | 0.2 | 0.3 | 0.6 | 1.0 |

Source: [3]

For any quantity equal to or greater than five times the minimum measurable quantity, the meter repeatability error shall not exceed 40% of the value specified in row A from Table 2.

Because these meters are large scale production instruments, the application of traditional legal control is easy to realize. The presentation of a prototype, submitted to the tests, generating the type approval, which will later be the reference for the initial and subsequent verification procedures, typically procedures that will be similar to the type approval process, but in a simplified way, aiming to guarantee initial verification of compliance with the approved model, and subsequent verification, correct system performance and maintenance of integrity to the original model.

4.2. Full measuring systems
When realizing flow/volume measurements, volume totalization is not performed only by a flowmeter. This is due to the characteristic of volume measurement, which is influenced by other variables, such as temperature. Thus, the totalization is performed by measuring the flow, under operating conditions, and the influence variables, such as temperature and pressure, which will enable conversion to base conditions, which in Brazil are set at 20° C and 1 atm. These measurements and conversions are illustrated in figure 1.
Due to the nature of the production fields and sedimentary basins, the volumes produced on each platform changes from one to the other, as the measurement conditions and available physical space influence the constructive issues of each measuring system project. Thus, it can be said that the measurement systems are special projects, mounted one single time, and it is not common that one same project can attend two different production points. Unlike meters, which are large scale produced, measuring systems are specific designs, typically tailor-made for each situation. Therefore, metrological control of the systems included in the scope of joint resolution ANP / Inmetro 001/2013 needs to be performed in a different way.

Measuring system evaluation should not be based on a prototype, as this concept for a single part (system) does not apply. Thus, one possibility is to evaluate the project documentation, which should be presented by the integrator. At first, the aspects related to the flow computer and meter used should be evaluated.

With respect to the flow computer, it is evaluated against its model approval ordinance. The software configuration of the flow computer, as well as the selected calculation algorithm, are also part of the documentation presented by the manufacturer. It is important to highlight that the capacities considered in the evaluation are only those that are described in the ordinance.

Flow meters are also evaluated considering their respective type approval ordinances. The parameters and characteristics of the field of application of the system shall be compatible with meter approval. The system must be designed to perform measurements within the range of the meter or meters employed in the measurement system. Installation conditions, including the required upstream and downstream straight paths, are assessed.
The construction of the system against the standards cited in the joint resolution ANP-Inmetro is also evaluated. Positioning of secondary meters (temperature and pressure) and other requirements within reference standards are considered.

Thus, the model evaluation is performed through a documentary evaluation of the project. After this approval, the system can then be constructed, and the tests are performed at initial verification, according to procedures detailed in NIT-Seflu-014. In this case, unlike the control performed on the flow meters, the initial verification is the most detailed part of the process. Type approval here is simplified.

5. Conclusions

Technical and practical issues were presented that justify differentiated legal control strategies for flow meters and metering systems.

Flowmeters are large scale produced instruments, so it is feasible to apply the conventional legal control model. Type approval, initial verification and subsequent verification through traditional modes of operation are applicable and there is no indication of practical limitations in this case. The complete measuring systems applicable in oil production, and contemplated by joint resolution ANP-Inmetro 001/2013, on the other hand, are unique designs and tailor-made to meet specific metering points. The concept of prototype is not applicable, so differentiated metrological control with simplified type approval process and more complex initial verification is recommended to meet this demand.

References

[1] Lazari R F, Aguiar Júnior E A de, Almeida R O de, Hartmann V N. Flow computers regulation in Brazil: state of the art and next steps. In: CONGRESSO BRASILEIRO DE METROLOGIA, 2011, Natal; A reference

[2] Brasil. Portaria INMETRO, nº 163 de 06/09/2005. Adota, no Brasil, o Vocabulário Internacional de Termos de Metrologia Legal, em anexo, baseado no documento elaborado pela Organização Internacional de Metrologia Legal, com a devida adaptação ao nosso idioma, às reais condições existentes no País e às já consagradas pelo uso.

[3] Brasil. Portaria INMETRO, nº 64, de 11/04/2003. Aprovar o Regulamento Técnico Metrológico, que com esta baixa, estabelece os requisitos técnicos e metrológicos aplicáveis aos sistemas de medição equipados com medidores de fluido, utilizados na medição de petróleo, seus derivados líquidos, álcool anidro e álcool hidratado carburante;

[4] Brasil. Resolução Conjunta ANP/INMETRO, nº 1, de 10/06/2013. Estabelece as condições e os requisitos técnicos, construtivos e metrológicos mínimos que os sistemas de medição de petróleo e gás natural deverão observar, com vistas a garantir a credibilidade dos resultados de medição;

[5] Organização Internacional de Metrologia Legal. R117-en: Measuring systems for liquids other than water. Available at <https://www.oiml.org/en/files/pdf_r/r117-e95.pdf>. Accessed on Aug 1st, 2019.

[6] OIML, International Vocabulary on Legal Metrology on-line, <http://viml.oiml.info/en/index.html>. Accessed on Aug 1st, 2019.