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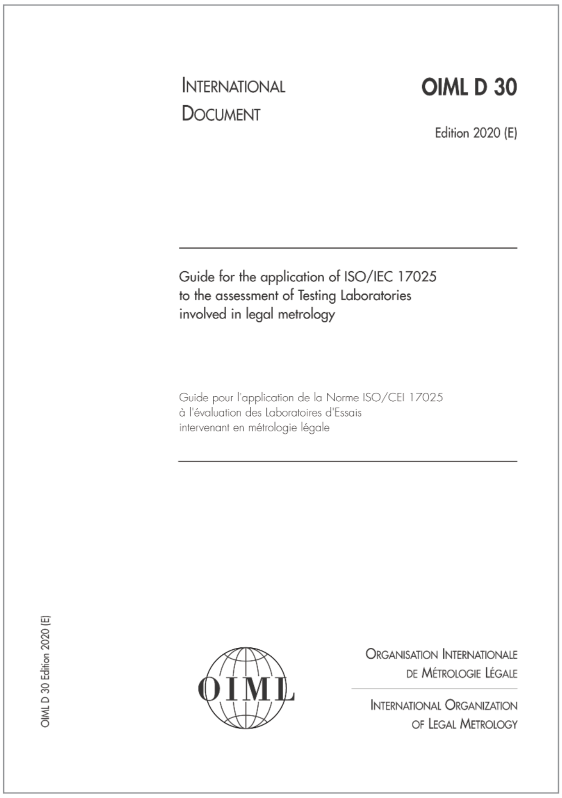

International Document

OIML D 30

Edition 2020 (E)

Guide for the application of ISO/IEC 17025
to the assessment of Testing Laboratories
involved in legal metrology

Guide pour l'application de la Norme ISO/CEI 17025
à l'évaluation des Laboratoires d'Essais
intervenant en métrologie légale

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# ■ Editorial

## Métrologie légale : La confiance en période d'incertitude

En tant que métrologues légales, on nous rappelle fréquemment la pertinence des publications de l'OIML et leur importance pour de nombreux aspects de notre vie quotidienne et de nos modes de vie.

Nous sommes nombreux à nous préparer pour les vacances d'été et beaucoup d'entre nous, peut-être plus que d'habitude cette année, voyagerons dans notre véhicule personnel. Lorsque nous faisons le plein de nos réservoirs de carburant, on nous rappelle, par exemple, la nécessité de disposer de normes fiables, assurées et cohérentes au niveau international pour garantir la précision des distributeurs de carburant (comme la R 117 *Ensembles de mesurage dynamique de liquides autres que l'eau*). Ce sujet est abordé en détail dans un article très intéressant qui commence à la page cinq de cette édition du Bulletin.

Il nous est également rappelé comment les publications de l'OIML se rapportent non seulement à nos vies et modes de vie quotidiens avec les instruments et techniques de mesure traditionnels, mais aussi comment elles s'appliquent aux nouvelles technologies et instruments. L'importance de l'innovation et de la recherche et du développement, de la promotion d'une culture d'adaptabilité, de la réaction rapide au changement, et comment tout cela peut être réalisé de manière efficace et efficiente est abordée dans un article sur les nouvelles technologies énergétiques. Ces technologies comprennent l'hydrogène comme source d'énergie pour les véhicules, et l'article décrit le processus de développement de la Recommandation R 139 de l'OIML *Ensembles de mesurage de gaz compressé pour véhicules*, de manière à répondre avec précision et réactivité aux besoins de l'industrie, de la société et des gouvernements. Il explique également l'impact de cette technologie sur notre vie quotidienne, tant aujourd'hui que dans le futur.

L'un des piliers essentiels de l'OIML qui facilite l'utilisation mondiale des publications de l'OIML telles que la R 117 et la R 139 est le Système de Certification de l'OIML (OIML-CS). L'OIML-CS établit un cadre international de métrologie légale à travers un système coordonné dans le but de faciliter le commerce. Ce faisant, il apporte la confiance et l'assurance dont nous avons tous besoin dans nos vies et nos activités de mode de vie qui impliquent des mesures légales.

En rapport avec l'OIML-CS, ce numéro du Bulletin comprend également un article sur la publication du Document OIML D 30 *Guide pour l'application de la Norme ISO/CEI 17025 à l'évaluation des Laboratoires d'Essais intervenant en métrologie légale*. Cette publication a été récemment approuvée par le biais de la procédure d'approbation directe du CIML en ligne de l'OIML. Il s'agit d'une publication précieuse qui soutient le fonctionnement de l'OIML-CS en fournissant des conseils sur l'application d'une norme internationale clé, ISO/CEI 17025.

Le rôle de la métrologie légale n'a jamais été aussi important. Je suis heureux de dire que cette édition du Bulletin contribue à illustrer la façon dont l'OIML s'adapte constamment aux nouvelles technologies et aux nouveaux développements. C'est extrêmement important car les individus, les familles et les entreprises doivent avoir confiance dans les mesures lorsque leur santé, leurs finances et leur sécurité sont en jeu.

En cette période de détresse et de perturbations mondiales dues à la pandémie COVID-19, si les avantages que l'OIML – avec son solide cadre international de métrologie légale – peuvent contribuer à assurer la confiance et à éliminer un certain degré d'inquiétude, alors c'est une bonne chose.

Je me réjouis de votre participation à la 55ème Réunion du CIML en ligne du 20 au 22 octobre 2020 et j'espère que vous apprécierez ce numéro du Bulletin. ■

ANTHONY DONNELLAN
BIML DIRECTOR

## Legal metrology: Confidence in a time of uncertainty

As legal metrologists, we are frequently reminded of the relevance of OIML publications and their importance to many aspects of our everyday lives and lifestyles.

Many of us are preparing for the summer holiday season and a lot of us, perhaps more than usual this year, will be travelling in our personal vehicles. When we fill up our fuel tanks we are reminded, for example, of the need for trusted, assured and internationally consistent standards to ensure fuel dispenser accuracy (such as R 117 *Dynamic measuring systems for liquids other than water*). This is discussed in detail in a very interesting article beginning on page five of this edition of the Bulletin.

We are also reminded of how OIML publications relate not only to our everyday lives and lifestyles with traditional measuring instruments and techniques, but also of how they apply to new technologies and instruments. The importance of innovation and of research and development, fostering a culture of adaptability, rapidly responding to change, and how all this can be achieved efficiently and effectively is discussed in an article on new energy technologies. These technologies include hydrogen as a source of energy for vehicles, and the article describes the process of how OIML Recommendation R 139 *Compressed gaseous fuel measuring systems for vehicles* was developed in a responsive and accurate way to accommodate industry, societal and governmental needs. It also explains how this technology impacts on our everyday lives both now and going into the future.

One of the OIML's crucial pillars which facilitates the worldwide use of OIML publications such as R 117 and R 139 is the OIML Certification System (OIML-CS). The OIML-CS establishes an international legal metrology framework through a coordinated system with the goal of facilitating trade. In doing so, it brings the confidence and assurance that we all need in our lives and lifestyle activities which involve legal measurements.

Related to the OIML-CS, this edition of the Bulletin also includes an article on OIML Document D 30 *Guide for the application of ISO/IEC 17025 to the assessment of Testing Laboratories involved in legal metrology*. This publication was recently approved through the OIML's direct CIML online approval procedure. It is a valuable publication which supports the operation of the OIML-CS by providing guidance on the application of a key international standard, ISO/IEC 17025.

The role of legal metrology has never been so important. I am pleased to say that this edition of the Bulletin helps exemplify how the OIML is constantly adapting to new technologies and developments. This is extremely important because individuals, families and businesses need to have confidence in measurements when their health, finances and safety are involved.

In this time of worldwide distress and disruption due to the COVID-19 pandemic, if the benefits that the OIML – together with its solid international legal metrology framework – can contribute to deliver confidence and eliminate a degree of worry, then this is a good thing.

I look forward to your participation in the online 55th CIML Meeting from 20–22 October 2020 and hope you enjoy this edition of the Bulletin. ■

FUEL DISPENSERS

# Evaluation of measurement uncertainty in accuracy tests for fuel dispensers

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## Abstract

The OIML Certification System (OIML-CS) is an international system for the mutual acceptance and utilization of test results among countries. It follows globally uniform rules for standardizing measuring instruments, which are subject to legal metrological control used in commercial transactions. To participate in the OIML-CS, the National Metrology Institute of Japan evaluated the uncertainty in the accuracy test for fuel dispensers. The uncertainty sources were systematically analyzed and the major sources were quantified experimentally during severe conditions in summer and winter. The results show that the major sources of uncertainty are the temperature difference between the liquid at the outlet of the dispenser nozzle and the liquid inside the standard tanks, the error of the standard tanks, and repeatability. It is confirmed that the expanded uncertainty in the accuracy test (Calibration and Measurement Capability) is less than 0.1 %, which meets the requirement of the relevant International Recommendation.

## 1 Introduction

Approximately 115 000 fuel dispensers (petrol pumps) are installed in Japan. From the viewpoint of consumer protection, fuel dispensers are legally controlled under Japanese Measurement Law and are subject to type approval and verification. These regulations ensure the conformity of fuel dispensers to relevant technical standards, and thus highly reliable fuel dispensers are supplied to the public market. In particular, the guaranteed accuracy of their measurement results enables fair trade.

In Japan, the verification of individual fuel dispensers is performed every 7 years by local offices of each prefecture. The type approval test for each model is performed by the National Metrology Institute of Japan (NMIJ) because it includes tests such as endurance tests and electromagnetic tests for electronic devices and thus requires a long time. Both the verification and the type approval test are based on JIS B 8572-1:2008 *Fuel oil flow meters*, which is consistent with OIML R 117 *Dynamic measuring systems for liquids other than water* [1, 2].

Japanese manufacturers export fuel dispensers. To reduce technical barriers in international trade, OIML R 117 was formulated as an international technical standard in the field of legal metrology. NMIJ conducts conformity assessments based on R 117 and provides OIML certificates of conformity and test reports.

Regarding OIML certificates of conformity based on R 117, the OIML-CS was created. OIML certificates of conformity can be used in countries where a declaration has been signed by the national Issuing Authority or national responsible body from an OIML Member State or Corresponding Member. Test laboratories wishing to participate in this global mutual recognition system are required to provide evidence of their capability to test the relevant measuring instruments in compliance with ISO/IEC 17025 [3]. Participation is approved based on the evaluation results via third-party accreditation or peer assessment based on ISO/IEC 17025 [4].

At present, NMIJ participates in the OIML-CS as an OIML Issuing Authority and a Testing Laboratory for OIML R 60 *Load cells* and for R 76 *Non-automatic weighing instruments*. Furthermore, NMIJ is aiming to participate in the category of fuel dispensers in OIML R 117. One of the major requirements for laboratory performance in ISO/IEC 17025 is that a laboratory must identify and evaluate error sources that contribute to the measurement uncertainty in the testing of the measuring instrument.

In most of the tests for type approval stated in OIML R 117, the conformity to the requirements are judged based on whether the results of the accuracy tests under the specified condition satisfy the maximum permissible error (MPE). Thus, evaluating the uncertainty of an accuracy test is critical.

Some reports on the evaluation of measurement uncertainty in the accuracy test for fuel dispensers have been published by the Instituto Portugues da Qualidade (IPQ) in Portugal [5, 6]. However, the details of the uncertainty analysis were not provided and it is unclear whether their methods can be applied to the accuracy test at NMIJ.

In the present study, theoretical and experimental analyses are performed using devices that are used in the actual accuracy test. Summer and winter experiments are conducted to consider the effects of the seasonal temperature difference in Japan and the uncertainty of the accuracy test at NMIJ is evaluated.

This report describes the sources of measurement uncertainty in the accuracy test, the calculation methods, and the final evaluation results. A major part of this report is also being published in the AIST Bulletin of Metrology in the Japanese language [7].

## 2 Method of accuracy test at NMIJ

The evaluation of the conformity of fuel dispensers is performed in accordance with the test requirements specified in OIML R 117. The relative error of indication, which is the common evaluation parameter, is expressed as the ratio of the deviation of the indicated value from the true value to the true value of the fuel dispenser under standard conditions. The calculation of the relative error is referred to as the accuracy test. At NMIJ, this test is performed using a comparison method with a standard tank. The fuel oil discharged from a nozzle of the fuel dispenser under test is poured into a standard tank and the indicated value of the fuel dispenser is compared with the value of the standard tank. The liquid temperature in the standard tank is measured and the thermal expansion of the standard tank is corrected for.

For the accuracy test in R 117, it is specified that the relative errors of the fuel dispenser must be determined at a minimum of six flowrates distributed over the measurement range at regular intervals between the maximum and minimum flowrates. At each flowrate, the relative errors must be independently determined at least three times.

## 3 Measurement uncertainty

### 3.1 Symbols and units

In this report, the following symbols and units are used in the uncertainty analysis:

$E_{V_i}$: Error of indicated volume at one measurement (relative value) (-)

$V_i$: Indicated value of the Equipment Under Test (EUT) (L)

$V_{i,si}$: Scale interval (resolution) of the EUT (L)

$V_{ref}$: Reference value of volume (L)

$R_\rho$: Density ratio of test liquid between the EUT and the standard tank

$V_n$: Reading value of the standard tank (L)

$V_{n,si}$: Scale interval of the standard tank (L)

$C_{V_n}$: Error of the standard tank determined by calibration (L)

$T_{tank}$: Indicated value of the thermometer of the standard tank (°C)

$T_{tank,si}$: Scale interval of the thermometer of the standard tank (K)

$T_{base}$: Base temperature; in this report, $T_{base}$ = 15 °C

$T_{dis}$: Difference between the average temperature of the test liquid in the standard tank and the temperature at the position where the thermometer is placed in the standard tank (K)

$\Delta T$: Difference between the average temperature of the test liquid in the standard tank and the temperature of the test liquid at the outlet of the EUT nozzle (i.e., at the transfer point) (K)

$C_T$: Error of the thermometer of the standard tank determined by calibration (K)

$\alpha_L$: Thermal expansion coefficient of test liquid; for gasoline, $\alpha_L = 0.001\ 1$ ($K^{-1}$)

$\beta$: Thermal expansion coefficient (coefficient of volume expansion) of the material constituting the standard tank; for stainless steel, $\beta = 0.000\ 048$ ($K^{-1}$)

$\rho_{tank}$, $\rho_{meter}$: Average density of the test liquid in the standard tank and density of the test liquid at the outlet of the EUT nozzle (i.e., at the transfer point), respectively (kg/m$^3$)

$u_{rep}$: Standard uncertainty due to repeatability (L)

### 3.2 Mathematical model for calculating the relative error

The measurement uncertainty is estimated according to the *Guide to the Expression of Uncertainty in Measurement* [8]. As described in Section 2, the test for the relative error is performed using a comparison method in which the fuel oil discharged from the fuel dispenser is poured into the standard tank. The indicated value for the fuel dispenser is then compared with the reading of the standard tank. The final result is obtained using equations (1), (2), (3), and (4) as the average value of three repeated measurements.

$$\bar{E} = \frac{1}{3}\sum_{j=1}^{3} E_{V_{\mathrm{i}},j} \tag{1}$$

$$E_{V_{\mathrm{i}}} = \frac{V_{\mathrm{i}}}{V_{\mathrm{ref}}} - 1 \tag{2}$$

$$V_{\mathrm{ref}} = R_{\rho}[1 + \beta(T_{\mathrm{tank}} - C_{\mathrm{T}} - T_{\mathrm{dis}} - T_{\mathrm{base}})](V_{\mathrm{n}} - C_{V_{\mathrm{n}}}) \tag{3}$$

$$R_{\rho} = \frac{\rho_{\mathrm{tank}}}{\rho_{\mathrm{meter}}} = (1 - \alpha_{\mathrm{L}}\Delta T) \tag{4}$$

Because the outlet of the EUT nozzle and the standard tank are open to the atmosphere, the compressibility of the test liquid is not considered. In addition, because the temperature at the outlet of the EUT nozzle is not measured during the test, it is assumed that $\Delta T = 0$ resulting in $R_{\rho} = 1$ and $\Delta T$ is considered to be a source of uncertainty. Furthermore, $T_{\mathrm{dis}}$ cannot be measured during the test. It is assumed that $T_{\mathrm{dis}} = 0$ and $T_{\mathrm{dis}}$ is considered to be a source of uncertainty.

### 3.3 Uncertainty analysis

The uncertainty of the reported value $\bar{E}$ (instrument error) consists of the systematic effects of a single measurement $V_{\mathrm{i}}$ and the standard uncertainty $u_{\mathrm{rep}}$ caused by the repeated measurement of $V_{\mathrm{i}}$. Therefore, the standard uncertainty of the reported value $u(\bar{E})$ can be expressed by equation (5).

$$u^2(\bar{E}) = u^2(E_{V_{\mathrm{i}}}) + \left(\frac{\partial \bar{E}}{\partial V_{\mathrm{i}}}\right)^2 u_{\mathrm{rep}}^2 = u^2(E_{V_{\mathrm{i}}}) + \left(\frac{1}{V_{\mathrm{ref}}}\right)^2 u_{\mathrm{rep}}^2 \tag{5}$$

Based on the mathematical model in Section 3.2, the combined standard uncertainty of relative error based on the sources excluding the uncertainty due to the repeatability of relative error is obtained as follows.

Equations (6), (7), and (8) are obtained from equation (2).

$$u^2(E_{V_{\mathrm{i}}}) = \left(\frac{\partial E_{V_{\mathrm{i}}}}{\partial V_{\mathrm{i}}}\right)^2 u^2(V_{\mathrm{i}}) + \left(\frac{\partial E_{V_{\mathrm{i}}}}{\partial V_{\mathrm{ref}}}\right)^2 u^2(V_{\mathrm{ref}}) \tag{6}$$

$$\frac{\partial E_{V_{\mathrm{i}}}}{\partial V_{\mathrm{i}}} = \frac{1}{V_{\mathrm{ref}}} \tag{7}$$

$$\frac{\partial E_{V_{\mathrm{i}}}}{\partial V_{\mathrm{ref}}} = -\frac{V_{\mathrm{i}}}{{V_{\mathrm{ref}}}^2} \cong -\frac{1}{V_{\mathrm{ref}}} \qquad \left(\because \frac{V_{\mathrm{i}}}{V_{\mathrm{ref}}} \cong 1\right) \tag{8}$$

Equation (9) is obtained from equation (3).

$$\begin{aligned} u^2(V_{\mathrm{ref}}) = {} & \left(\frac{\partial V_{\mathrm{ref}}}{\partial R_{\rho}}\right)^2 u^2(R_{\rho}) + \left(\frac{\partial V_{\mathrm{ref}}}{\partial \beta}\right)^2 u^2(\beta) + \left(\frac{\partial V_{\mathrm{ref}}}{\partial T_{\mathrm{tank}}}\right)^2 u^2(T_{\mathrm{tank}}) + \left(\frac{\partial V_{\mathrm{ref}}}{\partial C_{\mathrm{T}}}\right)^2 u^2(C_{\mathrm{T}}) \\ & + \left(\frac{\partial V_{\mathrm{ref}}}{\partial T_{\mathrm{dis}}}\right)^2 u^2(T_{\mathrm{dis}}) + \left(\frac{\partial V_{\mathrm{ref}}}{\partial T_{\mathrm{base}}}\right)^2 u^2(T_{\mathrm{base}}) + \left(\frac{\partial V_{\mathrm{ref}}}{\partial V_{\mathrm{n}}}\right)^2 u^2(V_{\mathrm{n}}) + \left(\frac{\partial V_{\mathrm{ref}}}{\partial C_{V_{\mathrm{n}}}}\right)^2 u^2(C_{V_{\mathrm{n}}}) \end{aligned} \tag{9}$$

Here, because the base temperature is defined as a fixed value, the uncertainty is zero, as shown in equation (10).

$$u(T_{\mathrm{base}}) = 0 \tag{10}$$

Equations (11), (12), (13), (14), (15), and (16) are also obtained from equation (3).

$$\frac{\partial V_{\mathrm{ref}}}{\partial R_{\rho}} = \frac{V_{\mathrm{ref}}}{R_{\rho}} \cong V_{\mathrm{ref}} \qquad (\because \; R_{\rho} = 1) \tag{11}$$

$$\frac{\partial V_{\mathrm{ref}}}{\partial \beta} = R_{\rho}(T_{\mathrm{tank}} - C_{\mathrm{T}} - T_{\mathrm{dis}} - T_{\mathrm{base}})\left(V_{\mathrm{n}} - C_{V_{\mathrm{n}}}\right) \cong (T_{\mathrm{tank}} - T_{\mathrm{base}})V_{\mathrm{ref}}$$
$$\left(\because \frac{T_{\mathrm{tank}} - C_{\mathrm{T}}}{T_{\mathrm{tank}}} \cong 1, \frac{V_{\mathrm{n}} - C_{V_{\mathrm{n}}}}{V_{\mathrm{n}}} \cong 1\right) \tag{12}$$

$$\frac{\partial V_{\mathrm{ref}}}{\partial T_{\mathrm{tank}}} = R_{\rho}\beta\left(V_{\mathrm{n}} - C_{V_{\mathrm{n}}}\right) \cong \beta \cdot V_{\mathrm{ref}} \tag{13}$$

$$\frac{\partial V_{\mathrm{ref}}}{\partial C_{\mathrm{T}}} = \frac{\partial V_{\mathrm{ref}}}{\partial T_{\mathrm{dis}}} = -R_{\rho}\beta\left(V_{\mathrm{n}} - C_{V_{\mathrm{n}}}\right) \cong -\beta \cdot V_{\mathrm{ref}} \tag{14}$$

$$\frac{\partial V_{\mathrm{ref}}}{\partial V_{\mathrm{n}}} \cong \frac{V_{\mathrm{ref}}}{V_{\mathrm{n}}} \cong 1 \tag{15}$$

$$\frac{\partial V_{\mathrm{ref}}}{\partial C_{V_{\mathrm{n}}}} \cong -\frac{V_{\mathrm{ref}}}{V_{\mathrm{n}}} \cong -1 \tag{16}$$

Equation (17) is obtained from equation (4).

$$u^2\left(R_{\rho}\right) = \left(\frac{\partial R_{\rho}}{\partial \alpha_{\mathrm{L}}}\right)^2 u^2(\alpha_{\mathrm{L}}) + \left(\frac{\partial R_{\rho}}{\partial \Delta T}\right)^2 u^2(\Delta T) \tag{17}$$

Here, the partial derivatives can be expressed as:

$$\frac{\partial R_{\rho}}{\partial \alpha_{\mathrm{L}}} = \Delta T = 0 \tag{18}$$

$$\frac{\partial R_{\rho}}{\partial \Delta T} = -\alpha_{\mathrm{L}} \tag{19}$$

Equation (20) is obtained by substituting equation (18) and equation (19) into equation (17).

$$u^2\left(R_{\rho}\right) = {\alpha_{\mathrm{L}}}^2 \cdot u^2(\Delta T) \tag{20}$$

Substituting equations (11) to (16) and equation (20) into equation (9) yields:

$$u^2(V_{\mathrm{ref}}) \cong [V_{\mathrm{ref}} \cdot \alpha_{\mathrm{L}}]^2 \cdot u^2(\Delta T) + [(T_{\mathrm{tank}} - T_{\mathrm{base}})V_{\mathrm{ref}}]^2 \cdot u^2(\beta)$$
$$+ [\beta \cdot V_{\mathrm{ref}}]^2[u^2(T_{\mathrm{tank}}) + u^2(C_{\mathrm{T}}) + u^2(T_{\mathrm{dis}})] + u^2(V_{\mathrm{n}}) + u^2\left(C_{V_{\mathrm{n}}}\right) \tag{21}$$

Finally, equation (22) is derived as the uncertainty of the relative error $u(E_{V_{\mathrm{i}}})$ by substituting equations (7), (8), and (21) into equation (6). This equation is based on sources excluding the uncertainty due to the repeatability of the relative error ($E_{V_{\mathrm{i}}}$).

$$u^2\left(E_{V_{\mathrm{i}}}\right) = \left(\frac{1}{V_{\mathrm{ref}}}\right)^2 u^2(V_{\mathrm{i}}) + {\alpha_{\mathrm{L}}}^2 \cdot u^2(\Delta T) + (T_{\mathrm{tank}} - T_{\mathrm{base}})^2 \cdot u^2(\beta)$$
$$+ \beta^2\left[u^2(T_{\mathrm{tank}}) + u^2(C_{\mathrm{T}}) + u^2(T_{\mathrm{dis}}) + \left[\left(\frac{1}{V_{\mathrm{ref}}}\right)^2 u^2(V_{\mathrm{n}})\right] + \left[\left(\frac{1}{V_{\mathrm{ref}}}\right)^2 u^2\left(C_{V_{\mathrm{n}}}\right)\right]\right] \tag{22}$$

The uncertainty of the relative error is caused by the systematic effect and does not decrease with additional measurements. The standard uncertainty $u_{rep}$ due to the repeatability of $V_i$ included in equation (5) is experimentally evaluated in Section 3.4.9.

The effect of the observer on the readings of the standard tank liquid level is not included in the uncertainty sources because the analysis of variance of the summer experiment (see Section 3.4.9) indicated that this effect was insignificant compared with the repeatability of the measurements.

## 3.4 Calculation of uncertainty

In this section, the standard uncertainties and the sensitivity coefficients in each term of equation (22) are evaluated.

### 3.4.1 Uncertainty caused by the resolution (scale interval) of indicated value of EUT[1]

There are two resolution values for the EUT, namely 0.01 L and 0.001 L. Here, $V_{i,si}$ = 0.001 L is adopted as the best existing device (BED). Because the error distribution is considered to be a rectangular distribution with a range of ± 1/2 of the resolution, the standard uncertainty is obtained using equation (23).

$$u(V_{\mathrm{i}}) = \frac{V_{\mathrm{i,si}}}{2\sqrt{3}} = 0.000\ 29\ \mathrm{L} \tag{23}$$

In addition, because the standard value $V_{ref}$ of the volume corresponds to the nominal capacity of the standard tank, the sensitivity coefficient is the inverse of the nominal capacity of the standard tank.

### 3.4.2 Uncertainty caused by a temperature difference between the outlet of the EUT nozzle and the test liquid in the standard tank

In the actual test, only the liquid temperature inside the standard tank is measured to obtain the test result. However, it is considered that there is a temperature difference between the outlet of the EUT nozzle, which is the transfer point, and the liquid inside the standard tank. This temperature difference can be a significant error source and is affected by the external environmental conditions in the test of fuel dispensers. Therefore, experiments were conducted to evaluate the temperature difference for two days each in summer and winter, which are the most severe environmental conditions in Japan.

As shown in Figure 1 (see page 10), the liquid temperature at the outlet of the EUT nozzle and in the standard tank was measured in both summer and winter and its contribution to the uncertainty was estimated. The experiment was performed using a 200 L standard tank at a maximum flowrate of 45 L/min, which is generally used in fuel dispensers. The measurement results are shown in Figure 2 (see page 10). The equipment used for the experiments in this section and Sections 3.4.6 and 3.4.9 is specified in Section 3.5.

Here, $\Delta T_{max}$ is the maximum value of $\Delta T$. From the results of the experiment, the maximum difference in the liquid temperature in winter, namely 0.7 K, is adopted as $\Delta T_{max}$. The distribution of $\Delta T$ is assumed to be a rectangular distribution with a range of ± 0.7 K. The standard uncertainty is obtained using equation (24).

$$u(\Delta T) = \frac{\Delta T_{\mathrm{max}}}{2\sqrt{3}} = \frac{0.7}{2\sqrt{3}} = 0.202\ \mathrm{K} \tag{24}$$

The thermal expansion coefficient of the test liquid, which is the sensitivity coefficient, is taken as $\alpha_L$ = 0.001 1 $K^{-1}$, i.e., the value for gasoline.

[1] In principle, the uncertainty from the resolution of the indicated value of the EUT need not be taken into account because it should be included in the repeatability of the measurement. However, in this paper, the resolution is considered to be an uncertainty source in accordance with the requirement of OIML R 117.

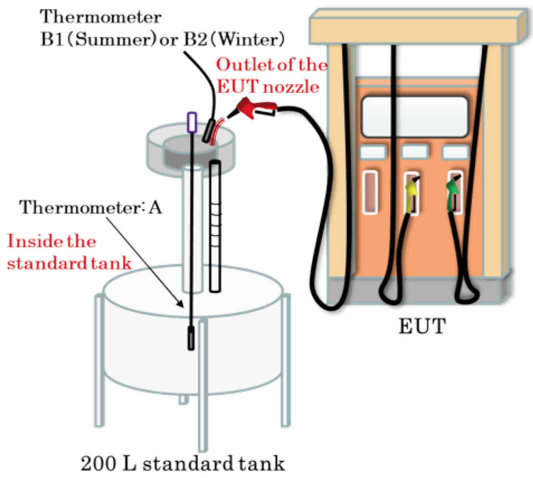


Figure 1 Schematic of the experiment used to evaluate the temperature difference of the test liquid between the outlet of the EUT nozzle and inside the standard tank

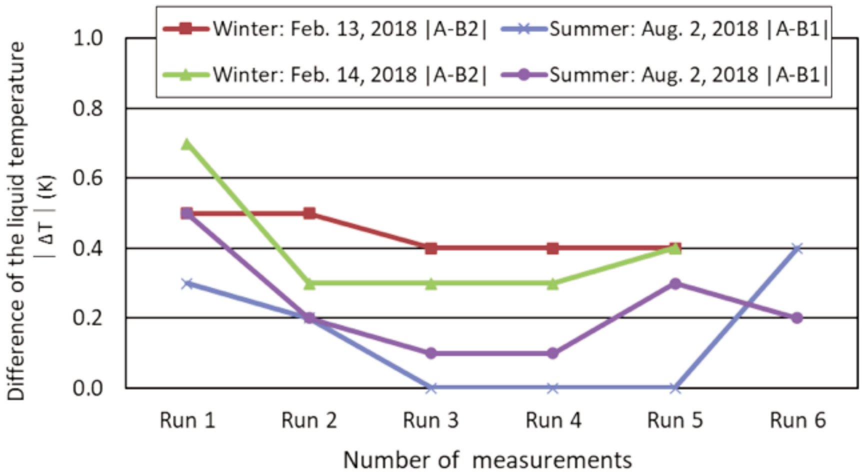


Figure 2 Temperature difference of the test liquid between the outlet of the EUT nozzle and inside the standard tank

### 3.4.3 Uncertainty of the thermal expansion coefficient of the standard tank material

The standard uncertainty of the coefficient of thermal expansion of the stainless steel in the standard tank is unclear. A relative uncertainty of 10 % is a conservative value. The coefficient for stainless steel is $\beta = 0.000\ 048\ K^{-1}$. Therefore, the standard uncertainty is obtained using equation (25).

$$u(\beta) = 4.8 \times 10^{-5} \times 0.1 = 0.000\ \ 004\ \ 8\ \ \mathrm{K}^{-1} \tag{25}$$

The sensitivity coefficient, which is the difference between the base temperature (15 °C) and the value indicated by the standard tank thermometer, was estimated to be 17 K from the highest temperature (32 °C) in the summer experiment, which produced a larger temperature difference than the lowest temperature in the winter experiment. 17 K is expected to be the maximum value from this experiment.

### 3.4.4 Uncertainty of reading of the standard tank thermometer

Because the thermometer used to measure the temperature of the test liquid in the standard tank is used after correcting for relative errors, the uncertainty of the reading is determined by the resolution of the thermometer.

Because the resolution was 0.1 K, the error distribution is considered to be rectangular with a range of ± 1/2 of the resolution. The standard uncertainty is calculated using equation (26).

$$u(T_{\text{tank}}) = \frac{T_{\text{tank,si}}}{2\sqrt{3}} = \frac{0.1}{2\sqrt{3}} = 0.029 \text{ K} \tag{26}$$

The sensitivity coefficient is $\beta$ = 0.000 048 $K^{-1}$. This value is used in Sections 3.4.5 to 3.4.7.

### 3.4.5 Uncertainty of error of thermometer for standard tank

The thermometer for the standard tank was calibrated at NMIJ. The standard uncertainty of the error is obtained by combining the standard uncertainty of this calibration result and the long-term stability of the thermometer. The long-term stability is considered to be 0.13 K per year based on the manufacturer's specifications. Because the calibration cycle of the thermometer is 5 years, the error distribution is assumed to be rectangular with a range of 0.13 × 5 = ± 0.65 K. This half width is divided by √3 to obtain 0.375 K. The standard uncertainty is estimated as shown in Table 1.

Table 1 Uncertainty of the thermometer

| Uncertainty source | Standard uncertainty |
|---|---|
| Calibration of thermometer | 0.024 K |
| Long-term stability of thermometer | 0.375 K |
| Error of thermometer | 0.38 K |

The standard uncertainty of the error of the thermometer is therefore 0.38 K.

$$u(C_T) = 0.38 \text{ K} \tag{27}$$

### 3.4.6 Uncertainty due to the temperature distribution of the test liquid in the standard tank

The temperature of the test liquid collected in the standard tank during the test is measured only at the middle part of the standard tank. This temperature is used for relative error calculation. It is assumed that there is a temperature distribution in the standard tank. The distribution of the liquid temperature was examined through experiments using a 200 L standard tank, which is the largest tank and is supposed to have the largest temperature distribution, as shown in Figures 3 to 5.

In the experiment, the liquid temperatures at the upper part (A), middle part (B), and lower part (C) of the standard tank were measured as shown in Figure 3 under the extreme environmental conditions of winter and summer described in Section 3.4.2.

The observed temperature distribution is shown in Figure 4 for winter and Figure 5 for summer, where the ordinates indicate the temperature deviation at each point from the upper part (A).

Based on the results of the experiment, the maximum temperature deviation was 0.2 K. The distribution of $T_{\text{dis}}$ is assumed to be a rectangular distribution with a range of ± 0.2 K. The standard uncertainty is obtained using equation (28).

$$u(T_{\text{dis}}) = \frac{0.2}{2\sqrt{3}} = 0.058 \text{ K} \tag{28}$$

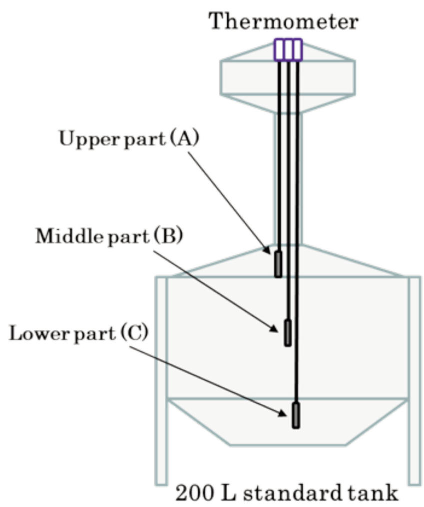


Figure 3 Measurement method of the temperature distribution of the test liquid in the standard tank

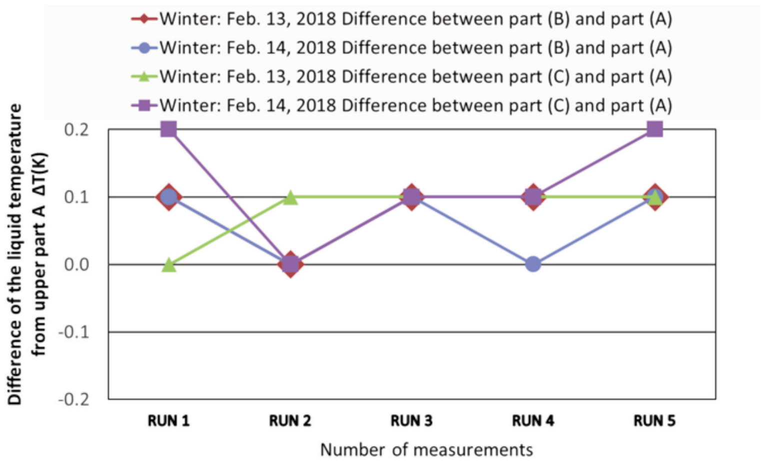


Figure 4 Measurement results of the temperature distribution of the test liquid in the standard tank for winter

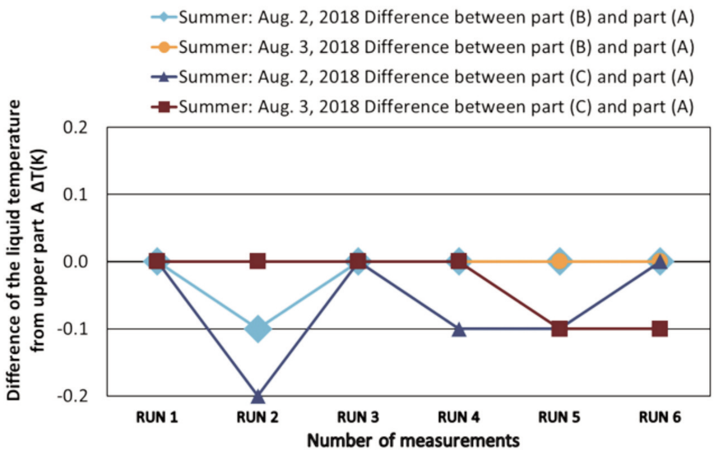


Figure 5 Measurement results of the temperature distribution of the test liquid in the standard tank for summer

### 3.4.7 Uncertainty of reading of standard tanks

The scale interval of the gauge glass in the standard tanks is 0.01 L. In the reading of the gauge glass, 1/10 of the scale interval is read; consequently, 0.001 L is assumed to be the resolution. The error distribution is considered to be a rectangular distribution within ± 1/2 of the resolution. The standard uncertainty is obtained using equation (29).

$$u(V_{\mathrm{n}}) = \frac{V_{\mathrm{n,si}}}{2\sqrt{3}} = \frac{0.001}{2\sqrt{3}} = 2.9 \times 10^{-4} \ \mathrm{L} \tag{29}$$

The sensitivity coefficient is the inverse of the nominal capacity of the standard tank, as shown in 3.4.1.

### 3.4.8 Uncertainty of the error of standard tanks

The standard tanks are calibrated using the weighing method at NMIJ. Table 2 shows the calibration and measurement capability for the standard tanks.

Table 2 Calibration and measurement capability of the standard tank

| Nominal capacity of standard tank | Relative combined standard uncertainty |
|---|---|
| 10 L | 129 ppm |
| 50 - 100 L | 57 ppm |
| 100 - 200 L | 51 ppm |

The uncertainty of the error of the standard tanks is obtained by combining the above-mentioned calibration and measurement capability of the standard tank, repeatability during calibration, and long-term stability within the calibration cycle. However, the latter two are negligibly small compared to the calibration and measurement capability. Here, the maximum value of 129 ppm in Table 2 is used as the representative value. Because the 5 L tank uses the same calibration equipment as the 10 L tank, the value for the latter is adopted for the former. Equation (30), which includes the sensitivity coefficient, is obtained.

$$\frac{u(C_{V_\mathrm{n}})}{V_\mathrm{ref}} = 1.29 \times 10^{-4} \tag{30}$$

### 3.4.9 Uncertainty due to repeatability of error of indication

In an actual accuracy test, the average value of repeated measurements is used as the final result of the test. Therefore, it is necessary to take the uncertainty due to repeatability into account. Generally, the uncertainty of the average value of the relative error should be determined from the standard deviation of repeated measurements. However, the number of repetitions in the regular accuracy test is three, which is insufficient for accurate estimation of the standard deviation. Thus, the uncertainty due to repeatability was evaluated based on the data from a larger number of repeated measurements performed in advance. To evaluate the effects of extreme changes in environmental conditions, as in Sections 3.4.2 and 3.4.6, the experiment for repeatability was performed in winter and summer. The experimental standard deviation $s$ is expressed by equation (31).

$$s = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}\left(E_{V_\mathrm{i},j} - \bar{E}\right)^2} \tag{31}$$

Here, $n$ is the number of repetitions ($n$ = 10 in winter and $n$ = 12 in summer), $E_{V_\mathrm{i},j}$ is the $j$-th measured value (instrument error), and $\bar{E}$ is the arithmetic mean. The accuracy test (relative error measurement) was performed at the maximum flowrate (45 L/min, 200 L standard tank), middle flowrate (18 L/min, 50 L standard tank), and minimum flowrate (3 L/min, 5 L standard tank) for two days each in winter and summer. Figures 6 and 7 show the results for winter and summer, respectively, in terms of % of relative error measurements. Tables 3 and 4 show the results of detailed relative error measurements in terms of % and L in winter and summer, respectively. Table 5 shows the results of the experimental standard deviation of the relative error obtained from the repeated measurements.

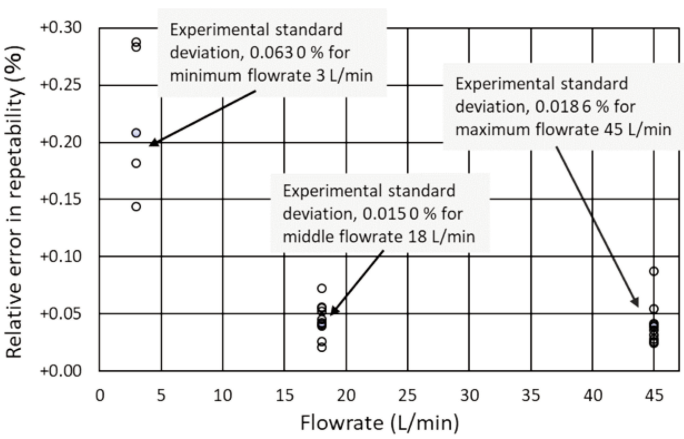


Figure 6 Relative error and experimental standard deviation of repeated measurements for winter.
Note: The data in Table 3 are outliers and were excluded

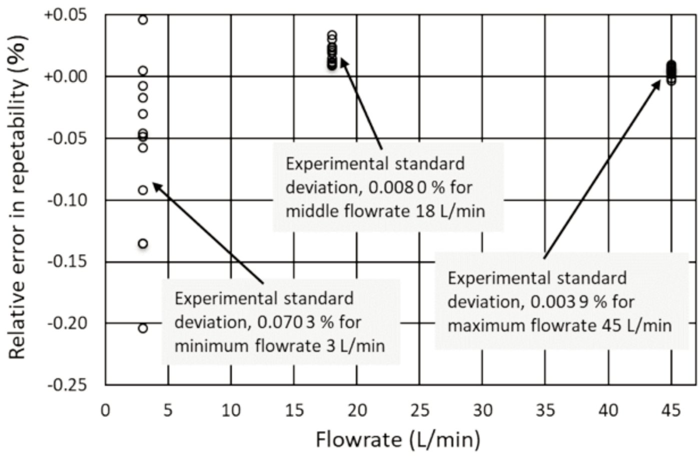


Figure 7 Relative error and experimental standard deviation of repeated measurements for summer

Table 3 Results of relative error measurement in winter

| Flowrate (L/min) | Relative error of indication (%) | | Error of indication (L) | |
|---|---|---|---|---|
| | Feb. 13, 2018 | Feb. 14, 2018 | Feb. 13, 2018 | Feb. 14, 2018 |
| Maximum flowrate 45 | +0.04 | +0.05 | +0.081 | +0.109 |
| | +0.02 | +0.09 | +0.049 | +0.175 |
| | +0.04 | +0.03 | +0.084 | +0.052 |
| | +0.03 | +0.03 | +0.057 | +0.064 |
| | +0.04 | +0.04 | +0.078 | +0.072 |
| Experimental standard deviation | 0.018 6 | | 0.037 2 | |
| Middle flowrate 18 | +0.04 | +0.03 | +0.021 | +0.013 |
| | +0.07 | +0.04 | +0.036 | +0.020 |
| | +0.06 | +0.05 | +0.028 | +0.023 |
| | +0.05 | +0.02 | +0.026 | +0.011 |
| | +0.06 | +0.04 | +0.028 | +0.021 |
| Experimental standard deviation | 0.015 0 | | 0.007 5 | |
| Minimum flowrate 3 | +0.21 | +0.13 | +0.010 | +0.006 |
| | +0.29 | +0.41 | +0.014 | +0.020 |
| | +0.14 | +0.02 | +0.007 | +0.001 |
| | +0.28 | +0.42 | +0.014 | +0.021 |
| | +0.18 | +0.14 | +0.009 | +0.007 |
| Experimental standard deviation | 0.063 0 | 0.179 7 | 0.003 1 | 0.009 0 |

Note to Table 3: From a statistical point of view, the standard deviation on the first and second days of winter for a flowrate of 3 L/min is inconsistent with the range of variation. Therefore, the measurement results on the second day in the highlighted columns were regarded as outliers and were not adopted.

Table 4 Results of relative error measurement in summer

| Flowrate (L/min) | Relative error of indication (%) | | Error of indication (L) | |
|---|---|---|---|---|
| | Aug. 2, 2018 | Aug. 3, 2018 | Aug. 2, 2018 | Aug. 3, 2018 |
| Maximum flowrate 45 | 0.00 | 0.00 | +0.010 | −0.003 |
| | +0.01 | 0.00 | +0.016 | −0.006 |
| | +0.01 | 0.00 | +0.013 | +0.008 |
| | +0.01 | 0.00 | +0.015 | +0.009 |
| | 0.00 | +0.01 | +0.009 | +0.020 |
| | 0.00 | +0.01 | +0.004 | +0.017 |
| Experimental standard deviation | 0.003 9 | | 0.007 9 | |
| Middle flowrate 18 | +0.01 | +0.01 | +0.007 | +0.005 |
| | +0.01 | +0.03 | +0.006 | +0.015 |
| | +0.02 | +0.02 | +0.010 | +0.012 |
| | +0.01 | +0.03 | +0.005 | +0.017 |
| | +0.01 | +0.02 | +0.006 | +0.011 |
| | +0.02 | +0.02 | +0.011 | +0.012 |
| Experimental standard deviation | 0.008 0 | | 0.004 0 | |
| Minimum flowrate 3 | −0.05 | −0.20 | −0.002 | −0.010 |
| | −0.05 | −0.01 | −0.002 | 0.000 |
| | +0.05 | −0.03 | +0.002 | −0.002 |
| | −0.14 | −0.09 | −0.007 | −0.005 |
| | −0.02 | 0.00 | −0.001 | 0.000 |
| | −0.06 | −0.14 | −0.003 | −0.007 |
| Experimental standard deviation | 0.070 3 | | 0.003 5 | |

Table 5 Summary of experimental standard deviation (underlined values were used for uncertainty evaluation)

| Flowrate (L/min) | | Winter | Summer |
|---|---|---|---|
| Maximum flowrate | 45 | <u>0.037 2 L</u> | 0.007 9 L |
| Middle flowrate | 18 | <u>0.007 5 L</u> | 0.004 0 L |
| Minimum flowrate | 3 | 0.003 1 L | <u>0.003 5 L</u> |

As shown in Tables 3 and 4, the experimental standard deviation was larger in winter for all flowrates. A possible cause is the change in temperature of the liquid during measurement being larger in winter than in summer. In particular, for the minimum flowrate, the variation in repeatability on the second day of winter (February 14, 2018) was extremely large compared to that on the first day of winter. The experimental standard deviation on the second day was three times larger than that on the first day. The relative error on the second day was excluded from the evaluation because the measurement environment was possibly not sufficiently stable due to a sudden change in liquid temperature in the test of the minimum flowrate at that time.

The standard uncertainty due to repeatability was evaluated using the larger value (underlined in Table 5) of the experimental standard deviation at each flowrate in winter and summer obtained from the evaluation results. The standard uncertainty is obtained using equations (32), (33), and (34) for the maximum, middle, and minimum flowrates, respectively, because the regular test is performed using three repeated measurements. Moreover, the sensitivity coefficient is the inverse of the nominal capacity of the standard tank, as shown in Section 3.4.1.

Maximum flowrate: $$u_{\mathrm{rep}} = \frac{s}{\sqrt{3}} = \frac{0.037\ 2}{\sqrt{3}} = 0.021\ 5\ \mathrm{L} \tag{32}$$

Middle flowrate: $$u_{\mathrm{rep}} = \frac{s}{\sqrt{3}} = \frac{0.007\ 5}{\sqrt{3}} = 0.004\ 3\ \mathrm{L} \tag{33}$$

Minimum flowrate: $$u_{\mathrm{rep}} = \frac{s}{\sqrt{3}} = \frac{0.003\ 5}{\sqrt{3}} = 0.002\ 0\ \mathrm{L} \tag{34}$$

The standard uncertainty of the relative error due to repeatability was estimated to be constant values, as shown in Table 6, which depend on the nominal capacity of the standard tank used.

Table 6 Standard uncertainty of error of indication due to repeatability

| Nominal capacity of standard tank | Standard uncertainty |
|---|---|
| 200 L | 0.021 5 L |
| 100, 50 L | 0.004 3 L |
| 20, 10, 5 L | 0.002 0 L |

## 3.5 Equipment used for experiment

Table 7 shows the specifications of the standard tanks used in the experiment. Table 8 shows an overview of the fuel

Table 7 Specifications of the standard tanks used in the experiment

| Nominal capacity | 200 L (maximum flowrate) | 50 L (middle flowrate) | 5 L (minimum flowrate) |
|---|---|---|---|
| Scale range | 199.5 - 200.5 L | 49.5 - 50.5 L | 4.7 - 5.3 L |
| Scale interval | 0.01 L | 0.01 L | 0.01 L |
| Material | Stainless steel | Stainless steel | Stainless steel |

Table 8 Overview of the fuel dispensers used in the experiment

| Test dates | Feb. 13 to 14, 2018 (Winter) | | Aug. 2 to 3, 2018 (Summer) | |
|---|---|---|---|---|
| Test site | Company X | | Company Y | |
| Test liquid | Gasoline | | Kerosene | |
| Resolution | 0.01 L | | 0.001 L | |
| Test flowrate | Maximum flowrate | 45 L/min | Maximum flowrate | 45 L/min |
| | Middle flowrate | 18 L/min | Middle flowrate | 18 L/min |
| | Minimum flowrate | 3 L/min | Minimum flowrate | 3 L/min |

Figure 8 Standard tanks used in the experiment
(from left to right: 200 L, 50 L and 5 L)

Figure 9 The experiment being conducted. The test liquid delivered from the fuel dispenser under test is being poured into the standard tank.

Table 9 Uncertainty budget (maximum flowrate, 200 L standard tank)

| Uncertainty source | Type | Standard uncertainty $u$ | Sensitivity coefficient $c$ | | $u \times c$ |
|---|---|---|---|---|---|
| Resolution of EUT | B | 0.000 29 L | $1 / V_{\mathrm{ref}}$ | 0.005 $\mathrm{L}^{-1}$ | 0.000 1 % |
| Temperature difference between EUT nozzle outlet and test liquid in standard tank | B | 0.202 K | $\alpha$ | 0.001 1 $\mathrm{K}^{-1}$ | 0.022 2 % |
| Thermal expansion coefficient of standard tank material | B | 0.000 004 8 $\mathrm{K}^{-1}$ | $T_{\mathrm{tank}} - T_{\mathrm{base}}$ | 17 K | 0.008 2 % |
| Reading of standard tank thermometer | B | 0.029 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.000 1 % |
| Error of thermometer for standard tank | B | 0.38 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.001 8 % |
| Temperature distribution of test liquid in standard tank | B | 0.058 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.000 3 % |
| Reading of standard tank | B | 0.000 29 L | $1 / V_{\mathrm{ref}}$ | 0.005 $\mathrm{L}^{-1}$ | 0.000 1 % |
| Error of standard tank | B | | | | 0.012 9 % |
| Repeatability of error of indication | A | 0.021 5 L | $1 / V_{\mathrm{ref}}$ | 0.005 $\mathrm{L}^{-1}$ | 0.010 7 % |
| Combined standard uncertainty | | 0.029 1 % | | | |
| Coverage factor $k$ (95 %) | | 2 | | | |
| Expanded uncertainty | | 0.058 % | | | |

Table 10 Uncertainty budget (middle flowrate, 50 L standard tank)

| Uncertainty source | Type | Standard uncertainty $u$ | Sensitivity coefficient $c$ | | $u \times c$ |
|---|---|---|---|---|---|
| Resolution of EUT | B | 0.000 29 L | $1\ /\ V_{\mathrm{ref}}$ | 0.02 $\mathrm{L}^{-1}$ | 0.000 6 % |
| Temperature difference between EUT nozzle outlet and test liquid in standard tank | B | 0.202 K | $\alpha$ | 0.001 1 $\mathrm{K}^{-1}$ | 0.022 2 % |
| Thermal expansion coefficient of standard tank material | B | 0.000 004 8 $\mathrm{K}^{-1}$ | $T_{\mathrm{tank}} - T_{\mathrm{base}}$ | 17 K | 0.008 2 % |
| Reading of standard tank thermometer | B | 0.029 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.000 1 % |
| Error of thermometer for standard tank | B | 0.38 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.001 8 % |
| Temperature distribution of test liquid in standard tank | B | 0.058 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.000 3 % |
| Reading of standard tank | B | 0.000 29 L | $1\ /\ V_{\mathrm{ref}}$ | 0.02 $\mathrm{L}^{-1}$ | 0.000 6 % |
| Error of standard tank | B | | | | 0.012 9 % |
| Repeatability of error of indication | A | 0.004 3 L | $1\ /\ V_{\mathrm{ref}}$ | 0.02 $\mathrm{L}^{-1}$ | 0.008 6 % |
| Combined standard uncertainty | | 0.028 4 % | | | |
| Coverage factor $k$ (95 %) | | 2 | | | |
| Expanded uncertainty | | 0.057 % | | | |

Table 11 Uncertainty budget (minimum flowrate, 5 L standard tank)

| Uncertainty source | Type | Standard uncertainty $u$ | Sensitivity coefficient $c$ | | $u \times c$ |
|---|---|---|---|---|---|
| Resolution of EUT | B | 0.000 29 L | $1\ /\ V_{\mathrm{ref}}$ | 0.2 $\mathrm{L}^{-1}$ | 0.005 8 % |
| Temperature difference between EUT nozzle outlet and test liquid in standard tank | B | 0.202 K | $\alpha$ | 0.001 1 $\mathrm{K}^{-1}$ | 0.022 2 % |
| Thermal expansion coefficient of standard tank material | B | 0.000 004 8 $\mathrm{K}^{-1}$ | $T_{\mathrm{tank}} - T_{\mathrm{base}}$ | 17 K | 0.008 2 % |
| Reading of standard tank thermometer | B | 0.029 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.000 1 % |
| Error of thermometer for standard tank | B | 0.38 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.001 8 % |
| Temperature distribution of test liquid in standard tank | B | 0.058 K | β | 0.000 048 $\mathrm{K}^{-1}$ | 0.000 3 % |
| Reading of standard tank | B | 0.000 29 L | $1\ /\ V_{\mathrm{ref}}$ | 0.2 $\mathrm{L}^{-1}$ | 0.005 8 % |
| Error of standard tank | B | | | | 0.012 9 % |
| Repeatability of error of indication | A | 0.002 0 L | $1\ /\ V_{\mathrm{ref}}$ | 0.2 $\mathrm{L}^{-1}$ | 0.040 8 % |
| Combined standard uncertainty | | 0.049 6 % | | | |
| Coverage factor $k$ (95 %) | | 2 | | | |
| Expanded uncertainty | | 0.099 % | | | |

dispensers used in the experiment. Figures 8 and 9 show photographs of the standard tanks and the experiment being conducted, respectively.

## 4 Summary of uncertainty estimation and discussion

Tables 9 to 11 show the uncertainty budgets, which contain the standard uncertainties and sensitivity coefficients of each uncertainty source obtained in the previous sections.

Based on the results of the experiments at the maximum, middle, and minimum flowrates, which are commonly used in fuel dispensers, the relative expanded uncertainty is 0.057 % to 0.099 %. This confirms that the accuracy test of fuel dispensers at NMIJ can be performed with an expanded uncertainty of less than 0.10 % (coverage factor $k = 2$) over the entire flowrate range.

The main sources of uncertainty were the uncertainty due to the temperature difference between the test liquid at the outlet of the EUT nozzle and the test liquid in the standard tank, the error of the standard tanks, and repeatability. When the 5 L standard tank was used for the small flowrate, repeatability was the major error source, giving the minimum limit of uncertainty in the volume measurement with a standard tank, as shown in Table 11.

The above result indicates that it is effective to increase the number of repeated measurements in a test using a small standard tank to reduce the uncertainty of the accuracy test. Furthermore, the temperature of the test liquid at the EUT outlet nozzle, which is the transfer point, is not measured in the regular accuracy test procedure. Therefore, the temperature difference between the liquid at the outlet of the EUT nozzle and the liquid in the standard tank is an uncertainty source. To solve this problem, the accuracy test procedure can be modified to include a measurement of the temperature of the test liquid at the outlet of the EUT nozzle.

Fuel dispensers are installed outdoors, and thus the results of accuracy tests are supposed to be significantly affected by the external environmental conditions. In the present study, the experiments were conducted in summer and winter, which give the most severe conditions in terms of temperature stability. Thus, the collected experimental data contain sufficient information to make a precise evaluation. This supports the validity of the estimated uncertainty.

## 5 Conclusions

OIML R 117 specifies that the MPE for fuel dispensers is 0.5 %. In the accuracy test evaluated here, the expanded uncertainty was less than 1/5 of the MPE (0.1 %). It was confirmed that the accuracy test at NMIJ using standard tanks (5 L to 200 L) in the range of generally used maximum to minimum flowrates can achieve an expanded uncertainty of less than 0.1 %, as required in OIML R 117. The calibration and measurement capabilities of NMIJ were verified to satisfy the expanded uncertainty required by the OIML Recommendation.

## Acknowledgements

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OIML R 139

# Enabling legal control of fuel dispensers for hydrogen –

# Fast and efficient revision of OIML R 139:2014

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## 1 Introduction

Environmental protection and optimization of energy resources are urgent issues for humankind, hence individuals should make every contribution they can to resolve them. Metrologists can improve the reliability of those metrological elements that are relevant to the environment and the use of energy. Additionally, legal metrologists should implement these outcomes in the legal metrology framework and execute them as effective measures.

One potential technological innovation to ensure environmental protection and energy conservation is the use of hydrogen as an energy source. Once the use of hydrogen becomes more widespread, it will be bought and sold in a similar way to conventional fossil fuels such as gasoline and natural gas, and then the need for legal metrology in the field of hydrogen will arise.

However, the measurement of hydrogen is considerably more difficult than that of conventional fossil fuels. The lack of a viable legal metrology framework for commercial transactions is another issue to be overcome. Although the 2014 edition of OIML Recommendation R 139 *Compressed gaseous fuel measuring systems for vehicles* could be applied to the measurement of hydrogen fuel, its practical application was not so easy for several reasons.

The OIML Technical Committee 8/Subcommittee 7 proposed the revision of R 139 to the CIML at its 51st meeting in 2016. It subsequently took two years to produce the Final Draft Document, which was approved by the CIML at its 53rd meeting in 2018. A lead-time of only two years to revise a Recommendation is extremely short compared to the time normally required, and in recognition of this achievement I was awarded a Letter of Appreciation by the CIML President at the 2018 CIML meeting.

In the following chapters, I will explain the tasks involved in moving towards hydrogen as a fuel and the necessity to revise OIML R 139:2014. Then I will present my personal view concerning the reasons and "secrets" of why I was able to complete the revision in such a short period of time. Each "secret" is summarized by a "Component", of which there are eight in total. I hope that this article will be helpful to those who propose a new or revised Recommendations in the future.

## 2 Real-world challenges in moving towards a hydrogen-based society

The Toyota Motor Company launched its first hydrogen fuel cell vehicle, the MIRAI, in Japan in 2014 (see Figure 1), and in the same year a commercial hydrogen station entered into service. Although six years have passed since then, hydrogen fuel cell vehicles have yet to establish a dominant position. There are many projects and roadmaps for the realization of the future hydrogen-based society, however I am not going to explain them here because that is not the main topic of this article.

Although some people claim that electric vehicles won the battle against hydrogen fuel cell vehicles based on the number of vehicles actually in use, I do not agree. Both vehicles make use of electric engines as a power source, and each has its pros and cons. I also believe they will coexist and compensate for the other shortcomings. Another concern for hydrogen is its ignitability and explosiveness, however hydrogen is not particularly dangerous compared to gasoline so long as it is properly handled.

The metrology of hydrogen as a fuel has not matured as much as that of existing fossil fuels either technically or institutionally. In the next chapter, these technical problems will be explained briefly.

## 3 Need to revise OIML R 139:2014

The most accurate method to test the measurement capability of hydrogen dispensers is to measure the difference in the test reservoir weight before and after filling. As hydrogen is the lightest gas, the weight of the hydrogen filled is much less than that of the tank itself and auxiliary items, hence the measurement of hydrogen is an extremely difficult task.

The second reason is a depressurization loss. In order to extend the driving distance of hydrogen vehicles, hydrogen should be filled at as high a pressure as possible. Compared to the pressure of the filling for conventional natural gas of 20 MPa (200 times higher than atmospheric pressure), hydrogen is filled at more than 70 MPa. If the filling nozzle is suddenly detached from the hydrogen vehicle after the filling, the highly pressurized hydrogen will gush out. To avoid such an incident, a cutoff valve is installed between the meter and the filling port (receptacle) of the vehicle, and the gas between them will be vented into the atmosphere after the filling (shown by the red lines in Figure 2). Despite the fact that this gas has already gone through the meter, it will not be filled in the fuel tank. The amount of this gas is called depressurization loss. The manufacturers of hydrogen dispensers are trying hard to minimize the loss, but it cannot be zero.

Due to the numerous technical difficulties, the achievable measurement accuracy for hydrogen dispensers is limited to a few percent which is much larger than for other fuel measuring instruments. For example, the maximum permissible error (MPE) of fuel dispensers defined in OIML R 117 is 0.5 %. This MPE value is considerably large and is unacceptable for the customer, and therefore this was the most controversial issue when the accuracy class was defined.

There are many other technical issues. When hydrogen is filled at an extremely high pressure, adiabatic compression occurs and the temperature of the hydrogen increases; it is cooled when the hydrogen is vented. Even if the testing procedure including the repeated cycle of filling and venting is defined, an extremely long waiting time is necessary until the heating and cooling processes stop, and therefore the execution of the test becomes unrealistic.

Each issue was examined from both technological and economic points of views, and the Project Group (PG) tried to produce a Recommendation which both sellers and buyers in commercial transactions would be satisfied with.


Figure 1 Dr. Morioka (right) and Dr. Takatsuji (left) with the Toyota MIRAI hydrogen fuel cell vehicle

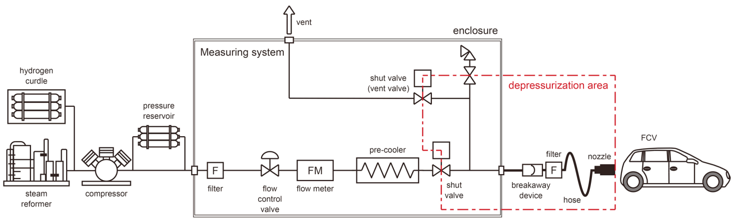



Figure 2 Explanation of depressurization loss – the hydrogen between the valve and the filling port is vented after filling

## 4 Revision of the OIML Recommendation

### 4.1 Commonality in making document standards

OIML R 139:2018 was published in a very short period of time following the proposal to revise it. The key factor leading to this success was the cooperation of the many people involved – and also good fortune! In addition to that, I kept some “secrets” in mind throughout the revision process and I also learned some lessons. Let me explain them.

To be honest, this was my first experience of playing the PG convener role and producing an OIML publication. Indeed, I had not been involved in this role before; instead, I had played the role of project leader in developing a number of ISO standards. Although the procedures and culture of publication production in both Organizations are not the same, the experience and hindsight I obtained through the ISO roles helped me to some extent in revising R 139. In terms of drafting document standards, or rather in terms of working cooperatively in making international agreements, there are similarities.

### 4.2 Before starting the revision of R 139:2014

The revision of OIML R 139 was an urgent matter since hydrogen, as a next generation fuel, was anticipated by many people. Because many OIML Member States were aware of the necessity of this revision, it was possible to shorten the lead-time needed from the project proposal to the final publication. In addition, in order to raise the awareness of OIML Members, at the 2016 CIML meeting when the revision process started, we gave a presentation showing the necessity to revise this Recommendation and the critical technical points that needed to be dealt with.

Despite the rapid spread of hydrogen fuel, not many Member States were actually using it. Before the proposal, we visited a few countries in which hydrogen fuel was in use, and had a technical exchange concerning the revision. The technical suggestions we received largely orientated the revision process.

▶ *Component 1: Advance preparation*

## 4.3 Before the Project Group meeting

Needless to say, the meeting preparation stage is very important. As shown in *Component 1* above, the opinions of stakeholders should be collected to make the discussion points clearer. Generally speaking, by the first meeting project leaders like to make a draft containing these points, and the meeting participants also expect such a draft. Nevertheless, I do not recommend this practice.

This is a lesson I learned through my long experience in ISO standardization. Once the participants take a look at the draft text, the discussion is likely to deviate from the essential points and center around trivial and editorial issues. Instead, a summary document which contains only unresolved issues should be prepared. Any unresolved points need to be itemized and agreement sought one by one. Once agreement is reached for all the points, it just remains to document them.

▶ *Component 2: Summarizing the discussion points and building consensus*

## 4.4 Calling the meeting

Each Member State decides who will participate in the meeting; however, it is desirable to have participants from as many diverse sectors as possible. As the role of legal metrology is to draft and implement legal regulations, participants from regulatory authorities are also required. Additionally, legal metrology deals with measuring instruments, so technical discussions are also indispensable.

Thanks to the participation of major hydrogen dispenser manufacturers, technical issues which emerged in the meeting were resolved immediately. Any requirements which are technically difficult or impossible must not be included. It was rare to revert to issues and discuss them again at the following meeting.

▶ *Component 3: Participation of essential stakeholders*

## 4.5 During the meeting

While not all issues can be resolved from a technical point of view in drafting legal metrology documents, they should be rendered as technical as possible based on technical evidence. The Project Group convener should always bear this point in mind, and stop when a discussion begins just for the sake of argument.

As described in 4.4, many manufactures took part in this revision, and many technical issues were resolved during the meeting.

▶ *Component 4: Discussion based on technical evidence*

## 4.6 After the meeting

It is common practice that all discussions are recorded, and detailed minutes are produced later. For technical meetings, I think that the value of such detailed minutes is less than the effort it takes to compile them. Instead, we should focus on creating a detailed and strict resolution at the end of (and not after) the meeting. As soon as any discussion starts on issues which have been adopted in previous meetings, the convener must put a stop to it. The resolution may be changed at a later date, but it must be based on technical evidence.

▶ *Component 5: Making and observing resolutions*

## 4.7 For the following meeting

Some issues may be carried over to the following meeting. Between meetings, technical evidence is collected by experiments, and opinions are summarized in each Member State. I understand that these tasks are time-consuming, but in general the intervals between meetings are too long. Of course, OIML B 6 *Directives for OIML technical work* must be observed – including the time needed for the announcement of the meeting – and we should also give consideration to the situation in each Member State. However, a date set for the following meeting a long time into the future will make it harder for participants to recall the previous meeting, and as a result the same discussions as the previous time are likely to be repeated. In addition, participants may change due to relocation within their national institute and they may therefore not be aware of the past history; consequently, the same discussions as in the past may begin.

The R 139 revision was accomplished in a very short period of time, but this did not happen by luck. It was achieved because we consciously aimed for a short period of time.

▶ *Component 6: Intensive discussions in a short time*

### 4.8 Understanding the rules

There are many complex procedures in accordance with OIML B 6 until a draft is actually published, and the timeline to carry out these procedures must also be adhered to. If the publication development schedule is not planned with the CIML meeting in mind, a slight delay can cause a year's delay in obtaining CIML approval at a CIML meeting (Note: online CIML approval is possible, though it has often proved to be difficult to obtain the required number of votes using the online vote). In the revision of R 139, Mr. George Teunisse (NL) and I played the PG co-convener roles collaboratively. With his long experience and knowledge of OIML work, he led the discussions and devoted himself to this project. Although Mr. Teunisse has now retired, I would like to take this opportunity to thank him for his work on the revision of R 139.

▶ *Component 7: Deep understanding of the rules and meticulous scheduling*

## 5 Acknowledgements

The seven components mentioned above undoubtedly had some effect in ensuring that R 139 was revised in a timely manner. However, the largest factor of this success was the cooperation by all the international and national participants. I would like to extend my gratitude to all of them, especially to Dr. Yoshiya Terao of NMIJ who carried out the secretarial work, and Dr. Toshihiro Morioka who provided technical assistance (see Figure 1). I would also like to express my thanks to the BIML, which played a significant role in ensuring that R 139 was developed and published as quickly as possible.

Sufficient time should be allowed for the necessary discussion, and we should not waste precious time on unproductive argument or repetitions of previous discussions. To achieve this objective, the mood of the meeting is particularly important. Throughout the revision of R 139, the discussion was efficient and the mood was friendly (see Figure 3).

▶ *Component 8: Cooperation amongst colleagues and appreciation of their work*

## 6 Future issues

What we can do as metrologists in order to work towards the realization of a hydrogen-based society is to ensure the improvement of measurement accuracy of hydrogen, and also the establishment of an adequate legal metrology framework.

We determined that a revision of OIML R 139:2014 was required to achieve this objective. The revision proceeded smoothly and was completed within two years, and the revised Recommendation was published in 2018. Some factors of this success were specific to this particular publication, however there are doubtless common tips and "secrets" which can be globally applied in making document standards. Presenting these tips and "secrets" has been the purpose of this article, and I hope it is useful to those who will be creating and revising standards in the future.

There are many remaining issues concerning hydrogen measurement. For example, research and development to improve the measurement uncertainty is urgent. Although only the weighing method is defined in the current R 139, a master meter method which enables verification to be carried out more efficiently should be developed.

We would appreciate receiving as much cooperation and assistance as possible from the international community for this long-term task. ■

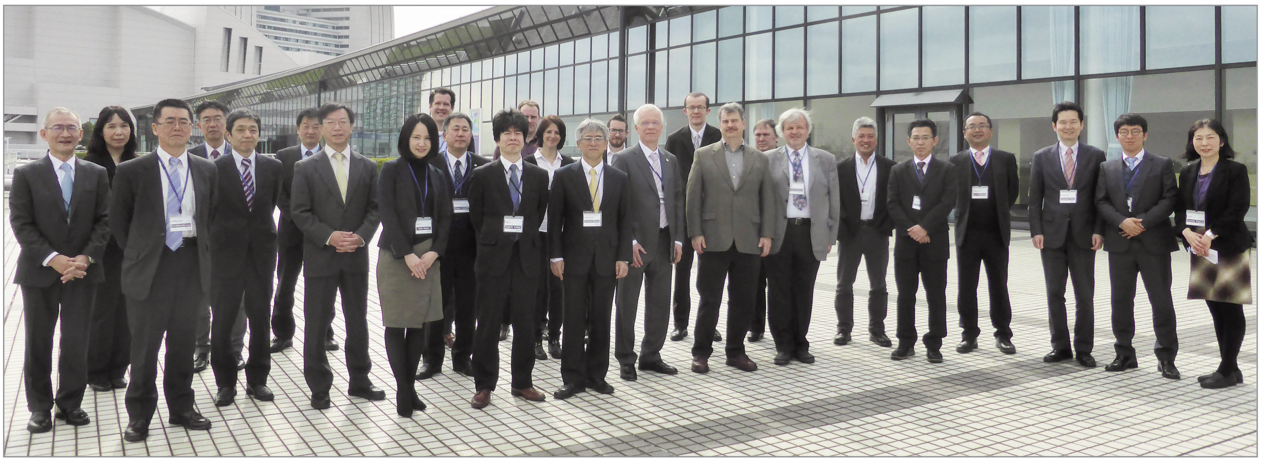


Figure 3 Group photo of the OIML R 139 revision kick-off meeting in 2017 in Yokohama, Japan

# D 30 – ISO/IEC 17025

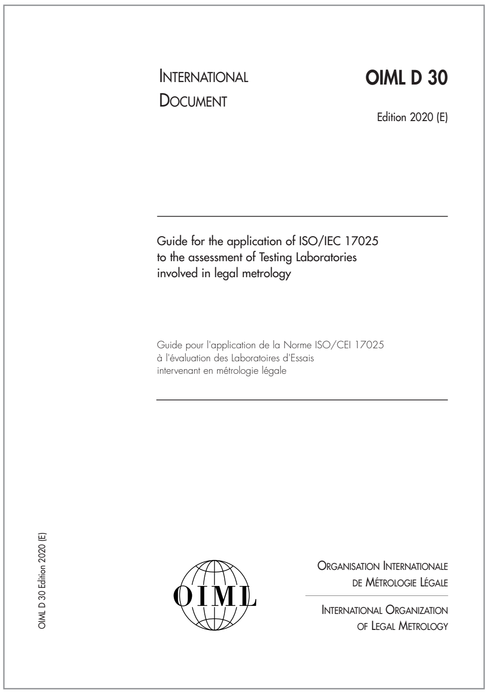
# Revision and CIML approval of OIML D 30

Paul Dixon, BIML

## Background

OIML D 30 *Guide for the application of ISO/IEC 17025 to the assessment of Testing Laboratories involved in legal metrology* was first published in 2008. It was developed by OIML Technical Subcommittee TC 3/SC 5 *Conformity assessment* with the aim of supporting accreditation assessments of testing laboratories, most notably those that were intending to participate in, or were already participating in the OIML Mutual Acceptance Arrangement (MAA).

A project (TC 3/SC 5/p 12) had been established to revise D 30, with the aim of modifying the guidance in parallel with the revision of the requirements of OIML B 3 *OIML Basic Certificate System for OIML Type Evaluation of Measuring Instruments* and OIML B 10 *Framework for a Mutual Acceptance Arrangement on OIML Type Evaluations*. However, the project was suspended as the International Organization for Standardization (ISO) started a project to revise ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories* and work had commenced on developing the OIML Certification System (OIML-CS) to replace the MAA and Basic Certificate System.


International Document

OIML D 30

Edition 2020 (E)

Guide for the application of ISO/IEC 17025 to the assessment of Testing Laboratories involved in legal metrology

Guide pour l'application de la Norme ISO/CEI 17025 à l'évaluation des Laboratoires d'Essais intervenant en métrologie légale

OIML D 30 Édition 2020 (E)

Organisation Internationale de Métrologie Légale

International Organization of Legal Metrology

OIML D 30 *Guide for the application of ISO/IEC 17025 to the assessment of Testing Laboratories involved in legal metrology* was approved for publication by the CIML in July 2020

## Convenership of the project

With the new edition of ISO/IEC 17025 published in November 2017 and the OIML-CS launched on 1 January 2018, the revision project was restarted with the aim of revising D 30 to align with the new edition of ISO/IEC 17025 and the requirements of the OIML-CS.

At the first OIML-CS Management Committee (MC) meeting in March 2018, the MC considered a proposal to transfer the convenership of the project from OIML TC 3/SC 5 to the OIML-CS MC. The proposal had been developed as it was felt that responsibility for the revision should fall under the MC rather than TC 3/SC 5 as D 30 is of direct relevance and importance to the operation of the OIML-CS. This proposal had already been discussed and supported by the Presidential Council, and it also had the support of the Secretariat of OIML TC 3/SC 5, Dr Charles Ehrlich and the then OIML-CS MC Chairperson, Mr Cock Oosterman. Following a consultation, there was support for the proposal from members of TC 3/SC 5/p 12.

The MC made a recommendation to the 53rd CIML Meeting in October 2018 to approve the proposal to transfer the convenership of the project from OIML TC 3/SC 5 to the OIML-CS MC. The CIML approved the proposal under Resolution No 2018/20.

## Project roadmap and progress

Project OIML TC 3/SC 5/p 12 was closed and a new project (Working Group) was established under the MC. Members of OIML TC 3/SC 5 who were not represented on the MC were given the opportunity to participate in the new project.

A project roadmap was developed which outlined the various stages and the intended timeline for the development of the revision of D 30. The project roadmap was developed to comply with the stages and timelines specified in OIML B 6-1 *Directives for OIML technical work*, with the intention of submitting a Final Draft revision of D 30 for approval at the 55th CIML meeting in October 2020.

The Working Group successfully progressed through the first Working Draft (1WD) and Committee Draft (1CD and 2CD) stages in accordance with the project roadmap. Following approval of the 2CD by the Working Group, a Draft revision of D 30 was submitted to the CIML for Preliminary Online Ballot (POB) in December 2019. The Draft revision of D 30 passed the POB at the end of March 2020, and a Final Draft revision of D 30 was produced to address the minor comments received.

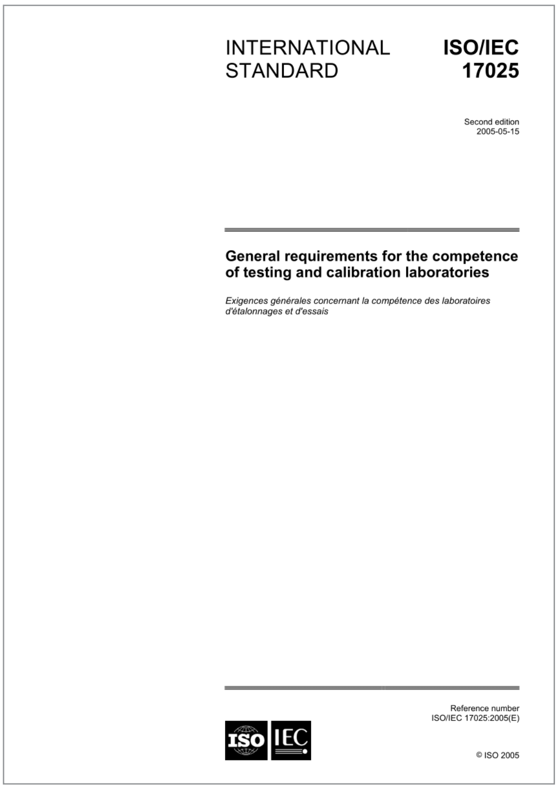
## Direct CIML online approval

Due to the COVID-19 pandemic, at the time that the Final Draft revision of D 30 was developed there was uncertainty as to whether the 55th CIML Meeting would go ahead. A decision was therefore taken to proceed with CIML approval of the Final Draft revision of D 30 by "direct CIML online approval" rather than approval at the 55th CIML Meeting.

The direct CIML online approval was successfully concluded on 30 June 2020, with 43 "Yes" votes and one "Abstention", and OIML D 30:2020 was published immediately following the vote in early July 2020.

Using the direct CIML online approval has enabled the project to be completed four months ahead of schedule, and has demonstrated that the OIML's existing procedures provide flexibility and enable technical work to be progressed effectively and efficiently.

The 2020 edition of D 30 provides guidance and interpretation on the requirements in ISO/IEC 17025:2017 when applied to testing laboratories involved in legal metrology. It will support the accreditation assessments of testing laboratories that participate, or wish to participate in the OIML-CS. ■


INTERNATIONAL STANDARD

ISO/IEC 17025

Second edition
2005-05-15

General requirements for the competence of testing and calibration laboratories

*Exigences générales concernant la compétence des laboratoires d'étalonnages et d'essais*

Reference number
ISO/IEC 17025:2005(E)

© ISO 2005

The new edition of ISO/IEC 17025 *General requirements for the competence of testing and calibration laboratories* was published in November 2017. The aim of the project to revise OIML D 30 was to align it with the new edition of ISO/IEC 17025 and with the requirements of the OIML-CS.

OIML-CS

# OIML-CS Management Committee meetings

PAUL DIXON, BIML

## Introduction

The third OIML-CS Management Committee (MC) meeting and associated events were scheduled to take place in New Delhi, India during week commencing 16 March 2020. In early March, the situation regarding COVID-19 was evolving rapidly, and so a decision was taken to cancel the meeting and associated events. This was a difficult decision to take at the time as the representatives from the Legal Metrology Department of the Indian Government Department of Consumer Affairs had already made considerable efforts and commitments to organise the meeting and associated events. However, the health, safety and welfare of the meeting participants was paramount and this, combined with the increasing number of travel restrictions that were being imposed, meant that the correct decision was taken.

## Online meetings

To ensure continuity of work, and to progress activities essential to the smooth running of the OIML-CS, a decision was taken to hold an online MC meeting on 19 May 2020. The meeting was intended as a "trial run", with the aim of testing the feasibility of holding an online MC meeting and to test the use of the video-conferencing technology. The first meeting was successful, so a second online MC meeting was held on 2 June 2020. As it was not possible to cover all of the agenda items at the second meeting, a further meeting was held on 2 July 2020. This enabled all of the key issues to be given sufficient time for discussion and consideration by the MC.

At each of the online MC meetings, a significant majority of the countries and liaison organisations were represented. A quorum of MC Members from OIML Member States was achieved at each meeting, so the MC was able to take decisions in accordance with the voting rules in the OIML-CS documentation.

Over the course of the three meetings, the following key items were discussed:

- Marking of measuring instruments with the OIML certificate number;
- Availability of Legal Metrology Experts;
- COVID-19 contingencies;
- "Top-10" publications and periodic reviews; and
- Updates/reports from the Review Committee, Maintenance Group and Working Groups.

During the meeting on 2 June 2020, the selection of the nominees for the positions of MC Chairperson and Deputy Chairperson took place. The MC selected Mr Mannie Panesar to be appointed as the MC Chairperson and Mr Bill Loizides to be re-appointed as Deputy Chairperson. The appointment of these positions will be considered by the CIML at the online 55th CIML Meeting in October 2020.

## Looking forward

The meetings have demonstrated that online meetings can be a useful tool in supporting the work of the OIML. They have also proven to be a very useful test for the online 55th CIML Meeting that will be held in October 2020. Experience has been gained within the organisation on video-conferencing technology and how best to organise and manage online meetings.

It is hoped that an in-person MC meeting can be held in March or April 2021, but this will require a significant improvement in the global situation regarding COVID-19. The situation will be closely monitored and, if an in-person meeting is not feasible, online meetings will be used to ensure continuity in the work of the MC and the running of the OIML-CS.

More use of online meetings will also be considered by the various committees and working groups established under the OIML-CS to reduce the need for face-to-face meetings and the associated travel, and to convene ad-hoc meetings to address issues that cannot wait until the formal annual meeting. ■

# OIML Certification System (OIML-CS)

## Introduction

The OIML-CS is a system for issuing, registering and using OIML Certificates and their associated OIML type evaluation reports for types of measuring instruments (including families of measuring instruments, modules, or families of modules), based on the requirements of OIML Recommendations.

The OIML-CS comprises two Schemes: Scheme A and Scheme B. Competence of the OIML Issuing Authorities and their Test Laboratories is demonstrated through self-declaration under Scheme B and accreditation or peer assessment under Scheme A.

The aim of the OIML-CS is to facilitate, accelerate and harmonize the work of national and regional bodies that are responsible for type evaluation and approval of measuring instruments subject to legal metrological control. In the same way, instrument manufacturers, who are required to obtain type approval in some countries in which they wish to sell their products, should benefit from the OIML-CS as it will provide evidence that their instrument type complies with the requirements of the relevant OIML Recommendation(s).

It is a voluntary system and OIML Member States and Corresponding Members are free to participate. Participating in the OIML-CS commits, in principle, the signatories to abide by the rules of the OIML-CS that are established in OIML B 18:2018 *Framework for the OIML Certification System (OIML-CS)*. Signatories voluntarily accept and utilize OIML type evaluation and test reports, when associated with an OIML Certificate issued by an OIML Issuing Authority, for type approval or recognition in their national or regional metrological controls.

The OIML-CS was launched on 1 January 2018 and has replaced the former OIML Basic Certificate System and the OIML Mutual Acceptance Arrangement (MAA).

Further information can be found at:

https://www.oiml.org/en/oiml-cs

For enquiries regarding the OIML-CS, please contact the OIML-CS Executive Secretary Paul Dixon (executive.secretary@oiml.org).

## OIML certificates

OIML certificates issued under Scheme A and Scheme B can be downloaded from the database on the OIML website at https://www.oiml.org/en/oiml-cs/certificat_view.

The database also includes certificates issued under the former OIML Basic Certificate System and the MAA. Although these two systems are no longer in operation, the certificates remain valid.

## OIML Issuing Authorities, Utilizers and Associates

A summary of the approved OIML Issuing Authorities is given on the page opposite, and on the following pages a summary is published of those Utilizers and Associates that have declared that they will accept OIML certificates and/or OIML type evaluation reports as the basis for a national or regional approval.

## Transition update

OIML Recommendations R 61 *Automatic gravimetric filling instruments*, R 85 *Level gauges for stationary storage tanks* and R 129 *Multi-dimensional measuring instruments* transitioned from Scheme B to Scheme A on 1 July 2020.

A range of OIML Recommendations will transition from Scheme B to Scheme A on 1 January 2021 (see https://www.oiml.org/en/oiml-cs/categories), and this will result in all of the OIML Recommendations in the scope of the OIML-CS being in Scheme A.

OIML Recommendation R 117:2019 *Dynamic measuring systems for liquids other than water* has been included in the scope of the OIML-CS following its publication.

## Recent OIML-CS events

Following the cancellation of the third OIML-CS Management Committee (MC) meeting and associated events that were due to be held in New Delhi, India in March 2020, online MC meetings were held on 19 May, 2 June and 2 July 2020. A report on these online meetings is provided on page 26.

# OIML Certification System (OIML-CS)

# List of OIML Issuing Authorities and their scopes

*The list of OIML Issuing Authorities is published in each issue of the OIML Bulletin and can be downloaded at www.oiml.org/oiml-cs/oiml-issuing-authorities*

## Updated: 2020-07-20

| | | R 21:2007 | R 46:2012 | R 49:2006 | R 49:2013 | R 50:2014 | R 51:2006 | R 60:2000 | R 60:2017 | R 61:2004 | R 61:2017 | R 75:2002 | R 76:1992 | R 76:2006 | R 85:2008 | R 99:2008 | R 106:2011 | R 107:2007 | R 117:1995 | R 117:2007 | R 117:2019 | R 126:1998 | R 129:2000 | R 134:2006 | R 137:2012 | R 139:2014 | R 139:2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AU1** | National Measurement Institute Australia (NMIA) | | | | | ■ | | | | | | | ■ | ■ | | | | | | | | | | | | | |
| **CH1** | Federal Institute of Metrology (METAS) | | | | | ■ | | ■ | | | | | | ■ | | | ■ | ■ | | | | ■ | | ■ | | | |
| **CN2** | National Institute of Metrology, China (NIM) | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | | | | ■ | | | | | | ■ | | | |
| **CZ1** | Czech Metrology Institute (CMI) | | | | ■ | | ■ | | | | ■ | ■ | | ■ | | | | | | ■ | | | | | ■ | ■ | |
| **DE1** | Physikalisch-Technische Bundesanstalt (PTB) | | | | ■ | | ■ | ■ | | ■ | | ■ | | ■ | | | | | | | | | | | | | |
| **DK2** | FORCE Certification A/S | | | | | ■ | ■ | ■ | ■ | | | | | ■ | | | ■ | ■ | | | | | | ■ | | | ■ |
| **FR2** | Laboratoire National de Métrologie et d'Essais (LNE) | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | | | | | | | | ■ | | | | | |
| **GB1** | NMO | ■ | | | | ■ | | ■ | | | | | ■ | ■ | | | ■ | ■ | | | | | | ■ | | | |
| **JP1** | NMIJ/AIST | | | | | | | ■ | | | | | ■ | ■ | | | | | | | | | | | | | |
| **NL1** | NMi Certin B.V. | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | ■ | ■ | ■ | ■ |
| **SE1** | Research Institutes of Sweden (RISE) | | | | | | ■ | ■ | ■ | ■ | ■ | | | ■ | ■ | | | | ■ | ■ | | | | | | | |
| **SK1** | Slovak Legal Metrology (SLM) | | | ■ | ■ | | | | | | | | | ■ | | | | | | | | | | | | | |

# OIML Certification System (OIML-CS)

# List of Utilizers, Associates and their scopes

*The list of Utilizer and Associate scopes is published in each issue of the OIML Bulletin and can be downloaded at www.oiml.org/oiml-cs/utilizers-and-associates*

## Updated: 2020-07-23

**1 = Scheme A only**
**2 = Scheme A and MAA**
**3 = Scheme A and B**
**4 = Scheme A, B and MAA**
**5 = Scheme B only**

| | | R 16:2002 | R 21:2007 | R 35:2007 | R 46:2012 | R 49:2006 | R 49:2013 | R 50:2014 | R 51:2006 | R 58:1998 | R 59:2016 | R 60:2000 | R 60:2017 | R 61:2004 | R 61:2017 | R 75:2002 | R 76:1992 | R 76:2006 | R 81:1998 | R 85:2008 | R 88:1998 | R 93:1999 | R 99:2008 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | National Measurement Institute, Australia (NMIA) | | | | | | 2 | | | | | 2 | | | | | 2 | 2 | | | | | |
| BE | Federal Public Service Economy | | 3 | | 3 | | 3 | 3 | 3 | | | 1 | | 3 | | 3 | | 1 | | 3 | | 3 | |
| CA | Measurement Canada | | | | | | | | | | | 2 | 1 | | | 1 | | 2 | | | | | |
| CH | Federal Institute of Metrology (METAS) | | | | 1 | 2 | 2 | 1 | 1 | | | 2 | | 1 | | 1 | | 2 | | | | | |
| CN | State Administration for Market Regulation (SAMR) | | | | | | | | 1 | | | 2 | 1 | 1 | 1 | | 2 | 2 | | | | | |
| CO | Superintendencia de Industria y Comercio (SIC) | | 3 | | 3 | 4 | 4 | 3 | 3 | | | 2 | | 3 | | 3 | 2 | 2 | | 3 | | 3 | |
| CU | Oficina Nacional de Normalizacion (NC) | 3 | 3 | 3 | 1 | | 1 | 3 | 1 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | | 1 | 3 | 3 | 3 | 3 | |
| CZ | Czech Metrology Institute (CMI) | | | | | | 1 | | 1 | | | | | | 1 | | | 1 | | | | | |
| DE | Physikalisch-Technische Bundesanstalt (PTB) | | 5 | | 3 | 3 | 4 | 3 | 3 | | | 2 | | 3 | | 3 | | 2 | | | | | 5 |
| DK | FORCE Certification A/S | | | | | 2 | 2 | 1 | 1 | | | 2 | | 1 | | | 2 | 2 | | | | | |
| FR | Laboratoire National de Métrologie et d'Essais (LNE) | | 1 | | 1 | 1 | 1 | 1 | 1 | | | 1 | | 1 | | 1 | 1 | 1 | | 1 | | 1 | |
| GB | NMO Certification | | 3 | | | 4 | 4 | 3 | 3 | | | 2 | | 3 | | | 2 | 2 | | 3 | | | |
| IN | Legal Metrology Division, Department of Consumer Affairs | | 3 | | 3 | | 4 | 3 | 3 | | | 2 | | 3 | | 3 | | 2 | | 3 | | | |
| JP | NMIJ/AIST | | | | | | | | | | | 2 | | | | | 2 | 2 | | | | | |
| KE | Weights and Measures Department | | | 3 | 3 | 4 | 4 | | 3 | | | 4 | 4 | 3 | 3 | | 4 | 4 | | 3 | | | |
| KH | National Metrology Centre (NMC) | | 3 | | 3 | 3 | 3 | 3 | 3 | | | 1 | | 3 | | 3 | 1 | 1 | | 3 | | 3 | |
| KI | Ministry of Commerce, Industry and Cooperatives | 5 | 5 | 5 | 5 | 1 | 1 | 5 | 1 | | 5 | 1 | 1 | 5 | 5 | 5 | 1 | 1 | 5 | 5 | | | |
| KR | Korea Testing Certification (KTC) | | | | | | | | | | | | | | | | 2 | 2 | | | | | |
| LV | LNMC Ltd. Metrology Bureau | | | | | | | | | | | | | | | | | | | | | | |
| NA | Namibian Standards Institution | | | | 3 | 4 | 4 | 3 | 3 | | | 2 | | 3 | | | 4 | 4 | | 3 | | | |
| NL | NMi Certin B.V. | | 3 | | 3 | 3 | 4 | 3 | 3 | | | 2 | 1 | 3 | 3 | 3 | 1 | 2 | | 3 | | 3 | |
| NZ | Trading Standards (Ministry of Business, Innovation and Employment) (MBIE) | | | | | 4 | 4 | 3 | 3 | | | 2 | | | | | 2 | 2 | | 3 | | | |
| RU | VNIIMS | | | | | | | | | | | | | | | | | | | | | | |
| RW | Rwanda Standards Board | 3 | 3 | 3 | 3 | 3 | 3 | | 3 | 3 | 3 | 1 | 1 | 3 | 3 | | 1 | 1 | | | | 3 | |
| SA | SASO (Saudi Standards, Metrology and Quality Organization) | | | | 3 | | 1 | | | | | | 1 | | | | | 1 | | | | | |
| SE | RISE Research Institutes of Sweden AB | | | | | | | | 3 | | | 2 | 1 | 3 | | | | 2 | | 3 | | | |
| SK | Slovak Legal Metrology (SLM) | | | | | | | | | | | | | | | | | 2 | | | | | |
| TN | National Agency of Metrology (ANM) | | 3 | | 3 | 2 | 2 | 3 | 3 | | | 2 | | 3 | | | 2 | 2 | | 3 | | 3 | |
| UG | Uganda National Bureau of Standards (UNBS) | | | | 3 | 1 | 3 | | | | | 1 | 1 | | | | 1 | 1 | | | | | |
| US | National Conference on Weights and Measures (NCWM) | | | | | | | | | | | 2 | | | | | | | | | | | |
| ZA | NRCS: Legal Metrology | | | | | 3 | 3 | | 3 | | | 1 | | | | | 1 | 1 | | 3 | | | |
| ZM | Zambia Metrology Agency | | 3 | | 3 | 3 | 3 | 3 | 3 | | | 1 | | 3 | | 3 | 1 | 1 | | 3 | | | |

# OIML Certification System (OIML-CS)

# List of Utilizers, Associates and their scopes (Cont'd)

*The list of Utilizer and Associate scopes is published in each issue of the OIML Bulletin and can be downloaded at www.oiml.org/oiml-cs/utilizers-and-associates*

## Updated: 2020-07-23

**1 = Scheme A only**
**2 = Scheme A and MAA**
**3 = Scheme A and B**
**4 = Scheme A, B and MAA**
**5 = Scheme B only**

| | | R 102:1992 | R 104:1993 | R 106:2011 | R 107:2007 | R 110:1994 | R 117:1995 | R 117:2007 | R 117:2019 | R 122:1996 | R 126:1998 | R 128:2000 | R 129:2000 | R 133:2002 | R 134:2006 | R 136:2004 | R 137:2012 | R 139:2014 | R 139:2018 | R 143:2009 | R 144:2013 | R 145:2015 | R 146:2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AU | National Measurement Institute, Australia (NMIA) | | | | | | | | | | | | | | | | | | | | | | |
| BE | Federal Public Service Economy | | | 3 | 3 | | | 3 | | | | | 3 | | | | 3 | 3 | | | | | |
| CA | Measurement Canada | | | | | | | | | | | | | | | | | | | | | | |
| CH | Federal Institute of Metrology (METAS) | | | 1 | 1 | | | | | | 1 | | 1 | | 1 | | 1 | | | | | | |
| CN | State Administration for Market Regulation (SAMR) | | | | | | | | | | | | | | | | | | | | | | |
| CO | Superintendencia de Industria y Comercio (SIC) | | | 3 | 3 | | 3 | 3 | | | 3 | | 3 | | 3 | | 3 | 3 | | | | | |
| CU | Oficina Nacional de Normalizacion (NC) | 3 | 3 | 3 | 3 | 3 | | 3 | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| CZ | Czech Metrology Institute (CMI) | | | | | | | 1 | | | | | | | | | 1 | | | | | | |
| DE | Physikalisch-Technische Bundesanstalt (PTB) | | | 1 | 3 | | | 3 | | | | | 3 | | 1 | 5 | 3 | | | | | | |
| DK | FORCE Certification A/S | | | 1 | 1 | | | | | | | | 1 | | 3 | | | | | | | | |
| FR | Laboratoire National de Métrologie et d'Essais (LNE) | | | 1 | 1 | | | 1 | | | 1 | | 1 | | 1 | | 1 | 1 | | | | | |
| GB | NMO Certification | | | 3 | 3 | | 3 | 3 | | | | | 3 | | 3 | | | | | | | | |
| IN | Legal Metrology Division, Department of Consumer Affairs | | | 1 | 3 | | | 3 | | | | | 3 | | 1 | | 3 | 3 | | | | | |
| JP | NMIJ/AIST | | | | | | | | | | | | | | | | | | | | | | |
| KE | Weights and Measures Department | | | 3 | | | 3 | 3 | | | 3 | | | | 3 | 3 | 3 | 3 | 3 | | | | |
| KH | National Metrology Centre (NMC) | | | 3 | 3 | | 3 | 3 | | | 3 | | 3 | | 3 | | 3 | 3 | | | | | |
| KI | Ministry of Commerce, Industry and Cooperatives | | | 5 | | 5 | 1 | 1 | | | | | | 5 | 5 | | 5 | 5 | 5 | | | | |
| KR | Korea Testing Certification (KTC) | | | | | | | | | | | | | | | | | | | | | | |
| LV | LNMC Ltd. Metrology Bureau | | | | | | | | | | 3 | | | | 3 | | | | | | | | |
| NA | Namibian Standards Institution | | | 3 | 3 | | 3 | 3 | | | 3 | | 3 | | 3 | | | | | | | | |
| NL | NMi Certin B.V. | | | 3 | 3 | | 3 | 3 | 1 | | 3 | | 3 | | 3 | | 3 | 3 | 3 | | | | |
| NZ | Trading Standards (Ministry of Business, Innovation and Employment) (MBIE) | | | 3 | 3 | | 3 | 3 | | | | | 3 | | 3 | | | | | | | | |
| RU | VNIIMS | | | | | | 3 | 3 | | | | | | | | | | | | | | | |
| RW | Rwanda Standards Board | 3 | 3 | 3 | | 3 | 3 | 3 | | 3 | 3 | | 3 | 3 | 3 | | 3 | | | 3 | 3 | | 3 |
| SA | SASO (Saudi Standards, Metrology and Quality Organization) | | | | | | | 3 | | | | | | | | | | | | | | | |
| SE | RISE Research Institutes of Sweden AB | | | | | | 3 | 3 | | | | | | | | | | | | | | | |
| SK | Slovak Legal Metrology (SLM) | | | | | | | | | | | | | | | | | | | | | | |
| TN | National Agency of Metrology (ANM) | | | 3 | 3 | | 3 | 3 | | | 3 | | 3 | | 3 | | 3 | 3 | | | | | |
| UG | Uganda National Bureau of Sandards | | | | | | 1 | 1 | 3 | | | | | | 3 | | 3 | | | | | | |
| US | National Conference on Weights and Measures (NCWM) | | | | | | | | | | | | | | | | | | | | | | |
| ZA | NRCS: Legal Metrology | | | | 3 | 3 | | 3 | 3 | | 3 | | 3 | | 3 | | 3 | 3 | | | | | |
| ZM | Zambia Metrology Agency | 3 | | | 3 | 3 | | 3 | 3 | | 3 | | 3 | | 3 | | 3 | 3 | | | | | |

# Countries and Economies with Emerging Metrology Systems (CEEMS)

# 2020 OIML CEEMS AWARD

## Background

Many countries and economies with emerging metrology systems suffer from a lack of resources for the operation of a sound legal metrology system. Although these resources cannot be provided by the OIML, the Organization supports initiatives for the development of legal metrology. To highlight the importance of metrology activities in CEEMS, and to provide an incentive for their improvement, in 2009 the OIML established an Award for "*Excellent achievements in legal metrology in Developing Countries*".

Following the establishment of the Advisory Group on matters of Countries and Economies with Emerging Metrology Systems (CEEMS), and an increased focus on OIML activities in this area, it was decided to rename the Award the "OIML CEEMS Award" from 2018.

The OIML CEEMS Award is intended to raise the awareness of, and create a more favorable environment for legal metrology and to promote the work of the OIML.

The Award intends: "*to acknowledge and honor new and outstanding activities achieved by individuals, national services or regional legal metrology organizations contributing significantly to legal metrology objectives on national or regional levels.*"

## How can candidates be proposed?

Nominations may be made by any individuals or organizations concerned with legal metrology, including the individual or organization seeking the Award.

Nominations should be sent to Ian Dunmill at the BIML and must contain facts, documents and arguments explaining why the candidate deserves the Award. The closing date is 31 August 2020.

## Selection procedure

The BIML will prepare a list of candidates highlighting the importance of the achievements. The Award winner will be selected by the CIML President and announced at the 55th CIML Meeting in October 2020.

## Selection criteria

The criteria which will be used to assess the candidates' contribution or achievement will include:

- its significance and importance;
- its novelty;
- its attractiveness and adaptability for other legal metrology services.

## The Award

The Award will consist of:

- a Certificate of Appreciation signed by the CIML President;
- a token of appreciation, such as an invitation to make a presentation of the Award-winning achievement at the next CIML Meeting or OIML Conference at the OIML's expense;
- an engraved Award trophy.

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## Further information

For more details, please contact:

**Ian Dunmill**
BIML Assistant Director
ian.dunmill@oiml.org

## Past Awards (none in 2019)

2018 - Prof. Carlos Augusto de Azevedo of the Ministerio Da Industria, Comercio Exterior e Serviços, Instituto Nacional De Metrologia, Qualidade E Tecnologia – INMETRO, Brazil

2017 - Superintendencia de Industria y Comercio, Colombia
- Dr. Osman Bin Zakaria, Senior Director, National Metrology Institute of Malaysia (NMIM)
- Dato' Roslan Bin Mahayudin, Director of Enforcement Division, Ministry of Domestic Trade, Co-operatives and Consumerism
- Haji Ibrahim Bin Hamzah, Chairman Executive, Metrology Corp. Malaysia Sdn. Bhd. (MCM)

2016 - Institute of Trade Standards Administration, Kenya

2015 - Mr. Nam Hyuk Lim, Director of Korea Testing Certification
- The Metrology Department, Saint Lucia Bureau of Standards

2014 - Serbian National Metrology Institute (DMGM)

2013 - Weights and Measures Agency, Tanzania

2012 - Loukoumanou Osséni, Benin

2011 - José Antonio Dajes, Peru and Juan Carlos Castillo, Bolivia

2010 - Thai Legal Metrology Service

2009 - Mr. Osama Melhem, Jordan

# info

The OIML is pleased to welcome the following new

## CIML Members

**Brazil:**
Mr. Periceles José Vieira Vianna

**Greece:**
Mrs. Ourania Panou-Diamanti

**Iran:**
Mr. Ahad Mohammadi Livari

**Romania:**
Mr. Razvan Cristian Zaharia

## Committee Draft

Received by the BIML, 2020.05 – 2020.07

| | | | | |
|---|---|---|---|---|
| Revision of OIML R 54: pH scale for aqueous solutions | 2 CD | TC 17/SC 3/p 1 | RU | 2020-07-27 |

## OIML meeting

**October 2020**

**Online 55th CIML Meeting**
20–22 October 2020

**www.worldmetrologyday.org**
World Metrology Day Website

**Bulletin online**

Download the OIML Bulletin
free of charge

www.oiml.org/en/publications/bulletin


# Call for papers

**OIML Members**
**RLMOs**
**Liaison Institutions**
**Manufacturers' Associations**
**Consumers' & Users' Groups, etc.**


- Technical articles on legal metrology related subjects
- Features on metrology in your country
- Accounts of Seminars, Meetings, Conferences
- Announcements of forthcoming events, etc.



The **OIML Bulletin** is a forum for the publication of technical papers and diverse articles addressing metrological advances in trade, health, the environment and safety - fields in which the credibility of measurement remains a challenging priority. The Editors of the Bulletin encourage the submission of articles covering topics such as national, regional and international activities in legal metrology and related fields, evaluation procedures, accreditation and certification, and measuring techniques and instrumentation. Authors are requested to submit:

- a titled, typed manuscript in Word or WordPerfect either on disk or (preferably) by e-mail;
- the paper originals of any relevant photos, illustrations, diagrams, etc.;
- a photograph of the author(s) suitable for publication together with full contact details: name, position, institution, address, telephone, fax and e-mail.

*Note: Electronic images should be minimum 150 dpi, preferably 300 dpi.*

Technical articles selected for publication will be remunerated at the rate of 23 € per printed page, provided that they have not already been published in other journals. The Editors reserve the right to edit contributions for style, space and linguistic reasons and author approval is always obtained prior to publication. The Editors decline responsibility for any claims made in articles, which are the sole responsibility of the authors concerned. Please send submissions to:

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(chris.pulham@oiml.org)