

Final Report on APMP.M.M-K2.1 - Bilateral Comparison of Four Stainless Steel Mass Standards (500 g, 20 g, 2 g and 100 mg) between KRISS and NPLI

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Abstract:

This report describes a bilateral comparison of 500 g, 20 g, 2 g and 100 mg stainless steel mass standards between Korea Research Institute of Standards and Science (KRISS), and National Physical Laboratory, India (NPLI), which is registered in the KCDB as APMP.M.M-K2.1. These nominal values were chosen as they followed the nominal values of CCM.M-K2. This bilateral comparison was piloted by KRISS. The Measurement Standard Laboratory (MSL), New Zealand has provided a linkage analysis of this bilateral comparison to CCM.M-K2. The set of four weights was circulated between KRISS and NPLI laboratories in June 2010 and received back from the last participant in July 2010. NPLI has tried to improve their calibration and measurement capabilities (CMCs) for mass below 1 kg. KRISS participated in both this comparison and CCM.M-K2, providing the link between the NPLI results and the KCRV of CCM.M-K2. The final report of this comparison is being given in this document.

1. Introduction

This report describes a bilateral comparison of 500 g, 20 g, 2 g and 100 mg stainless steel mass standards between KRISS (Korea) and NPLI (India). The objectives of the comparison were to facilitate the demonstration of metrological equivalence between the two participating national laboratories, and to check the capabilities of NPLI to improve quoted calibration and measurement capabilities (CMC) at the scales. Both laboratories have participated in the key comparison APMP.M.M-K2.1, which has been linked to the key comparison CCM.M-K2. The link was provided by KRISS in APMP.M.M-K2.1.

2. Transfer standards

The transfer standards for this comparison comprise three stainless steel cylindrical weights (500 g, 20 g, and 2 g) with a knob and one wire weight (100 mg) of OIML R111 design [1]. The weights were housed in a wooden container. They were produced by SP Technical Research Institute of Sweden and purchased by KRISS in 2003 then leased to NPLI for APMP.M.M-K2. The physical properties such as volumes and density of the standards and associated uncertainties are given as a part of the measurement report from NPLI.

3. Participants and Contributors

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4. Circulation scheme and time schedule

The transfer standards were hand-carried by NPLI personnel between NPLI and KRISS. No special custom procedures were required between Korea and India. Agreed and realized time schedule was as follows:

- Measurements at NPLI, New Delhi: June 2010 (marked as NPLI_1 in Result section)
Transport to KRISS, Daejeon
- Measurements at KRISS, Daejeon: July 2010 (KRISS)
Transport to NPLI, New Delhi
- Measurements at NPLI, New Delhi: July 2010 (NPLI_2)

5. Technical protocol

The agreed technical protocol for APMP.M.M-K2.1 is the same as that of APMP.M.M-K2.

6. Intercomparison Results

As shown in the technical protocol, completed measurement reports containing the measurement results, data of the ambient conditions, lists of instruments used and a description of the traceability of the participant's reference standards were submitted to KRISS, which was acting as a collector of all results in the comparison. After all measurements were completed, the measurement reports were sent to KRISS, which provided the link to CCM.M-K2 through APMP.M.M-K2.1.

6.1 Measurement Results

Table 1 shows the results of the reported mass values and their combined standard uncertainties as given by NPLI and KRISS. The value m_A ($= m_{A\text{reported}} - m_0$) represents

residual value from the nominal mass value and u_c is combined standard uncertainty ($k=1$) claimed by each laboratory. The number of significant digits has been restricted to a maximum of three for m_A and two for u_c .

Table 1. Measurement results for transfer standards reported from NPLI and KRISS.

Labs.	500 g		20 g		2 g		100 mg	
	m_A /mg	u_c /mg	m_A /mg	u_c /mg	m_A /mg	u_c /mg	m_A /mg	u_c /mg
NPLI_1	-0.0600	0.0078	0.0050	0.0023	-0.0008	0.00074	-0.0007	0.00068
KRISS	-0.0493	0.0075	0.0062	0.0021	0.0009	0.00066	-0.0027	0.00060
NPLI_2	-0.0700	0.0078	0.0040	0.0023	-0.0005	0.00074	-0.0004	0.00068

6.2. Linked Results

The measurement data were analyzed using the method in Reference 3. This method links APMP.M.M-K2.1 to CCM.M-K2 and gives the degrees of equivalence required by the MRA [2] without the need for an APMP.M.M-K2.1 reference value. The result of analysis was checked doubly for each mass standard.

Table 2 gives the uncertainties in mg that are due to correlation between the measurement results. For each nominal mass, the NPLI correlation is between their two measured values in APMP.M.M-K2.1 while for KRISS the correlation is between their measured values in CCM.M-K2 and APMP.M.M-K2.1. For NPLI, each uncertainty due to correlation is nearly as large as the uncertainty in the measurement result because the uncertainty is dominated by the uncertainty in the NPLI reference standard. For 500 g and 20 g, the difference is obscured by rounding.

Table 2. Uncertainties due to intra-laboratory correlation. Values are given in mg.

Lab.	500 g	20 g	2 g	100 mg
NPLI	0.0078	0.0023	0.00072	0.00065
KRISS	0.0073	0.00077	0.00032	0.00010

The results of these analyses are presented in Table 3 which, for each transfer standard, shows the difference between the result for each participating laboratory and the CCM.M-K2 key comparison reference value (KCRV) along with the expanded uncertainty in this

difference [4]. These results are also shown in Fig. 1 with zero mass value corresponding to the KCRV of CCM.M-K2.

Table 3. Deviation from the KCRV and associated expanded uncertainty U ($k=2$) for each of the four transfer standards.

Labs.	500 g		20 g		2 g		100 mg	
	$m\text{-KCRV/mg}$	U/mg	$m\text{-KCRV/mg}$	U/mg	$m\text{-KCRV/mg}$	U/mg	$m\text{-KCRV/mg}$	U/mg
NPLI	-0.0147	0.0184	-0.00298	0.00795	-0.00086	0.00251	0.00169	0.00194
KRISS	0.0010	0.0170	-0.00130	0.00540	0.00070	0.00180	-0.00050	0.00080

7. Conclusion

The results of KRISS and NPLI are consistent with each other for all four nominal mass values of 500 g, 20 g, 2 g, and 100 mg. The NPLI results are consistent with the KCRV of CCM.M-K2 within their uncertainties ($k = 2$). This can be seen in Fig. 1 where the expanded uncertainty bars for all the results cross each other and the line of zero mass.

8. References

- [1] Weights of classes E_1 , E_2 , F_1 , F_2 , M_1 , M_2 , M_3 , International recommendation OIML R 111, OIML, Paris 2004.
- [2] Mutual recognition of national measurement standards and of calibration and measurement certificates issued by national metrology institutes, BIPM, Paris, 14 October 1999.
- [3] C.M. Sutton, Analysis and linking of international measurement comparisons, *Metrologia* **41**, 272-277 (2004).
- [4] M Gläser et al.: Final report on CIPM key comparison of multiples and submultiples of the kilogram (CCM.M-K2), *Metrologia* **40**, 07004 (2003).

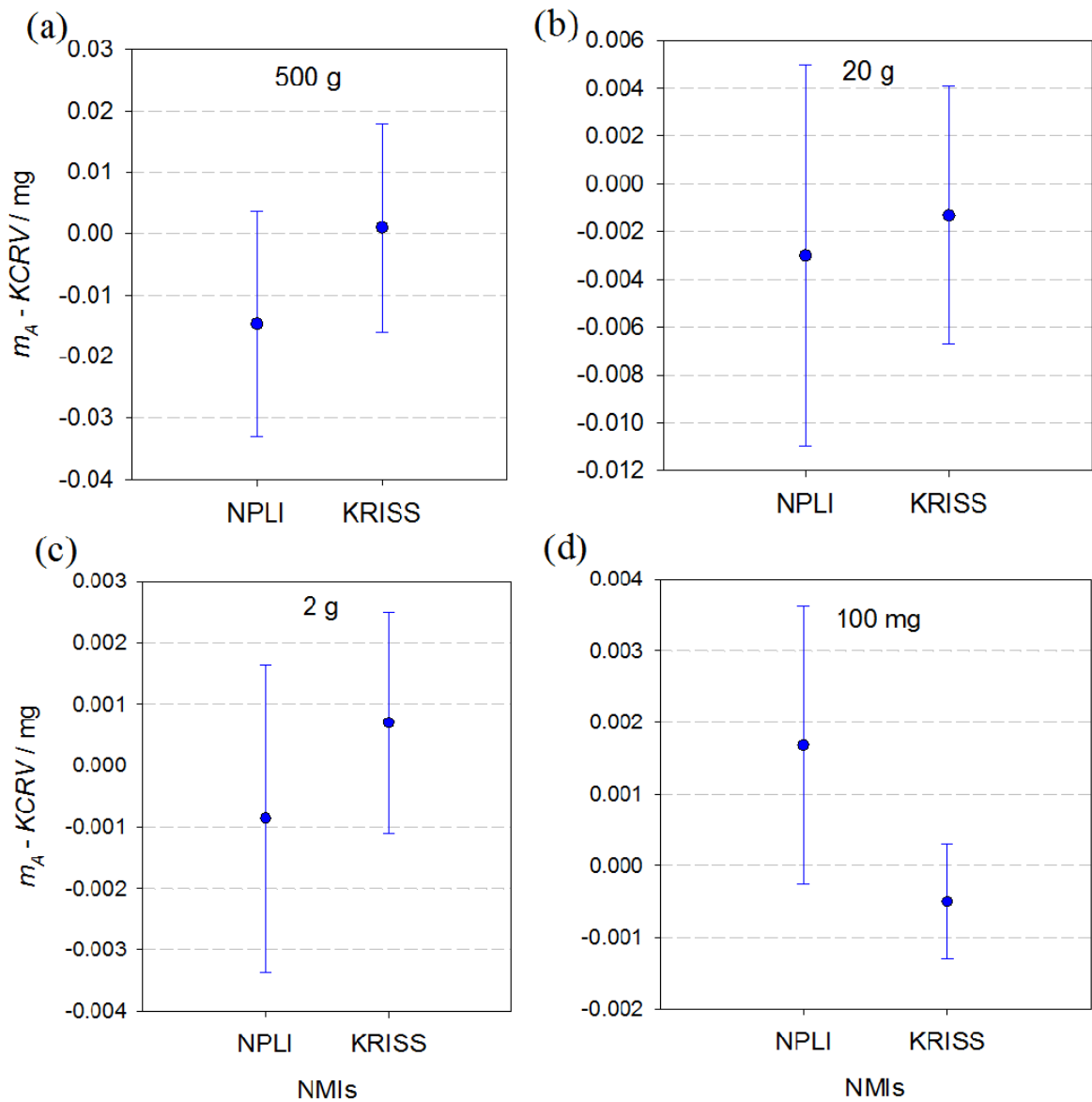


Figure 1. (a)-(d) Results for 500 g, 20 g, 2 g and 100 mg. The difference between each participant's mass value (m_A) and the key comparison reference value (KCRV) of CCM.M-K2 with bars representing expanded uncertainties U ($k=2$). KRISS is the link laboratory to CCM.M-K2.