



# **APLAC M017**

## **MASS INTERLABORATORY COMPARISON (SOUTH LOOP)**

### **Final Report - January 2007**

#### **ACKNOWLEDGMENTS**

The APLAC Secretariat wishes to acknowledge gratefully the support provided by Komite Akreditasi Nasional (KAN) for coordination of this program and also to the APLAC members for their participation and cooperation. Our thanks also to Research Centre for Calibration, Instrumentation and Metrology – Indonesian Institute of Sciences (Puslit KIM LIPI) who acted as the reference laboratory for this program

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## 1. Introduction

This report summarizes the results of an interlaboratory comparison on measurement of conventional masses of a set of mass standards by laboratories accredited by bodies that are members of the Asia Pacific Laboratory Accreditation Cooperation (APLAC).

This program was the seventeenth APLAC calibration interlaboratory comparison. This program was divided into two groups. The first group - identified as north loop - was coordinated by Hongkong Accreditation Services (HKAS), while the second group – identified as *south loop* - was coordinated by Komite Akreditasi Nasional (KAN), Indonesia.

## 2. Aim of the Program

One of APLAC's main aims is to build up and maintain mutual confidence in the technical competence of APLAC members. Interlaboratory comparisons provide objective evidence that laboratories are competent and they can achieve the level of accuracy for which they are accredited. They also provide means for improving the quality and performances of laboratories throughout the region.

APLAC M017 Mass program was designed to test the participants' ability to perform measurement of conventional mass values of a sets of mass standards comprises 1 g, 10 g and 100 g nominal mass and to obtain values within their accredited uncertainties of measurement. A secondary aim was to assess the participants' ability to estimate their uncertainty of measurement.

## 3. Design of the Program

This group of APM 017 interlaboratory comparison program coordinated by KAN was involved the double loops circulation of two set of artifacts around two groups of participating laboratories. The first set of artifacts was marked with "576" and circulated over 16 participating laboratories, while the second was marked with "28494" circulated over 17 participating laboratories.

Research Centre for Calibration, Instrumentation and Metrology – Indonesian Institute of Sciences (KIM LIPI) acted as the Reference Laboratory, deriving the reference values from the measurement of conventional mass values of the artifacts at the beginning, half-way and the end of the program.

Laboratories were asked to do measurement of conventional mass in accordance with their accredited procedure and reporting appropriate uncertainty of

measurement in accordance with their accredited least uncertainty in their scope of accreditation.

#### **4. Participants**

Thirty three laboratories from ten accreditation bodies, and two laboratories accredited by bodies outside Asia Pacific Region nominated by APLAC members participated in this program. These laboratories are accredited for various levels of accuracy as defined in their scope of accreditation which lists their least uncertainty of measurement.

To keep the schedule all participants were asked to carry out the measurement within one week of receipt of the artifacts. A circulation schedule listing the accreditation bodies that participated appears in Appendix B.

To maintain confidentiality, participating laboratories were assigned a random laboratory code number and these numbers are used in the report

#### **5. Reporting by Participants**

Laboratories were asked to report their measurement results on a Result Sheet form (refer to Appendix A) and also to provide formal calibration reports for consideration of their accredited status. The participating laboratories were asked to report uncertainties at the 95% confidence levels.

The instruction requested participating laboratories to report the Conventional Mass Values of the Artifacts as the results of weighing in air without Buoyancy Correction.

#### **6. Stability of the Artifacts**

A set of initial measurement of the artifacts involving subsequent measurements to predict long-term stability of the artifacts during the circulation in this program were done by KIM LIPI before the send of artifacts around all participating laboratories.

In the half-way of this program, these artifacts were sent back to KIM LIPI for stability check. The final stability check was done by KIM LIPI at the end of the circulation.

The report of stability monitoring of the artifacts is recorded in control charts as appear in the Appendix C and the calibration certificate from KIM LIPI appear in Appendix D

## 7. Reference Values

The reference values of the artifacts are derived from the mean of a set of calibrations carried out by KIM LIPI before, half-way and the end of circulation of the artifacts. 12 (twelve) independent calibrations were done by KIM LIPI for each set of artifacts comprises 6 (six) measurements before circulating artifacts, 4 (for) measurements in the half way of circulation, and 2 (two) measurements at the end of circulation. A calibration certificate for each set of artifacts were issued by KIM LIPI at the end of circulation containing reference values of this program and the uncertainty of the reference values.

As the single calibration certificate for each set of artifacts issued by reference laboratories based on a set of 12 (twelve) independent measurements, the uncertainties of each reference values has taken into account uncertainty contribution due to the variation observed in the measurement at KIM LIPI.

## 8. Summary of Results

A summary of the result returned by the participating laboratories, compared to the reference values, appears in section 9 of this report in the tables and graphs along with the technical comments. The graph plots the difference between each laboratory's result and the reference values (LAB – REF).

In accordance with international practice, measurement performance has been assessed on the basis of En ratio for each measurement. The En ratios are calculated using standard statistical technique for comparing values and derived from the following expression:

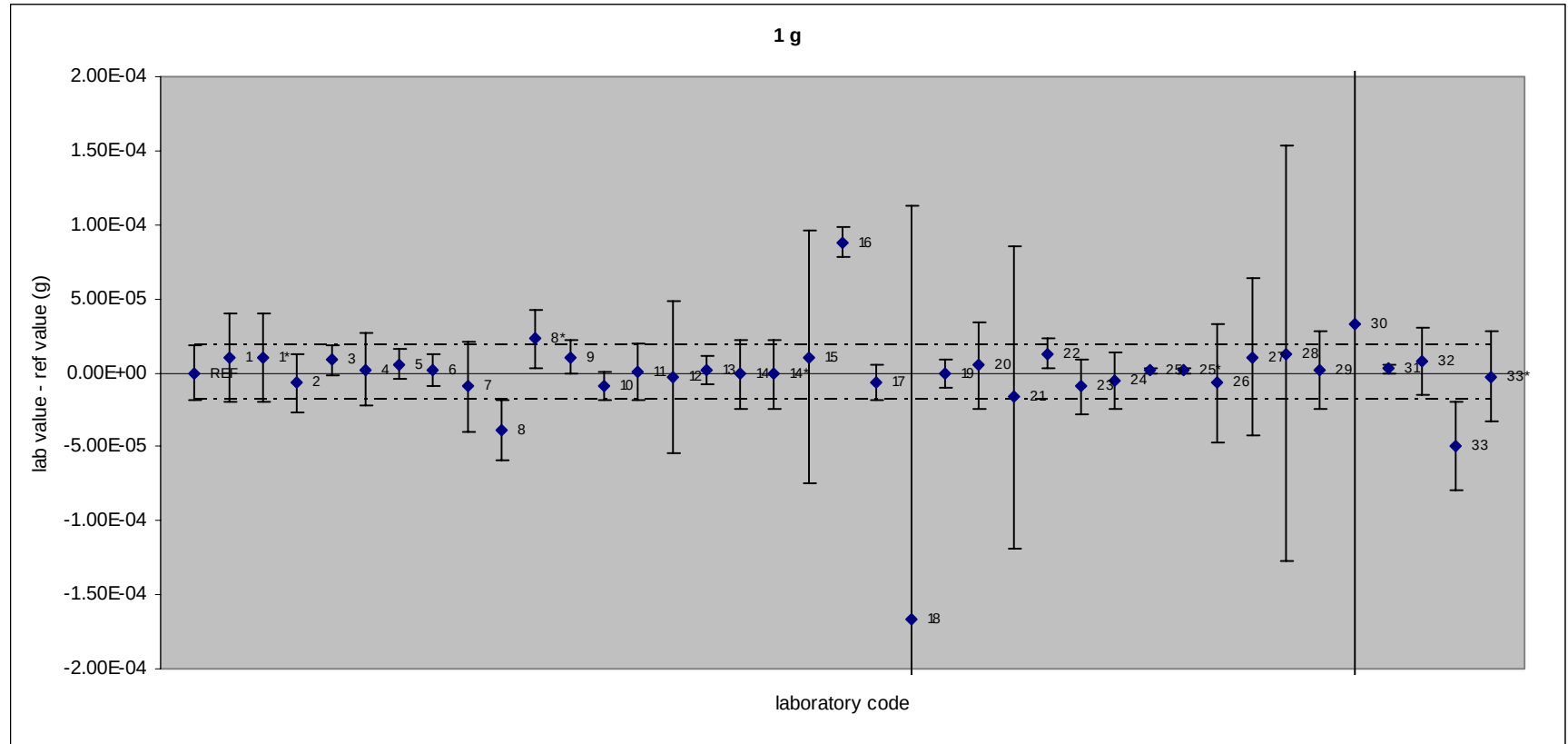
$$En = \frac{\text{Laboratory Result} - \text{Reference Value}}{\sqrt{U_{\text{lab}}^2 + U_{\text{ref}}^2}};$$

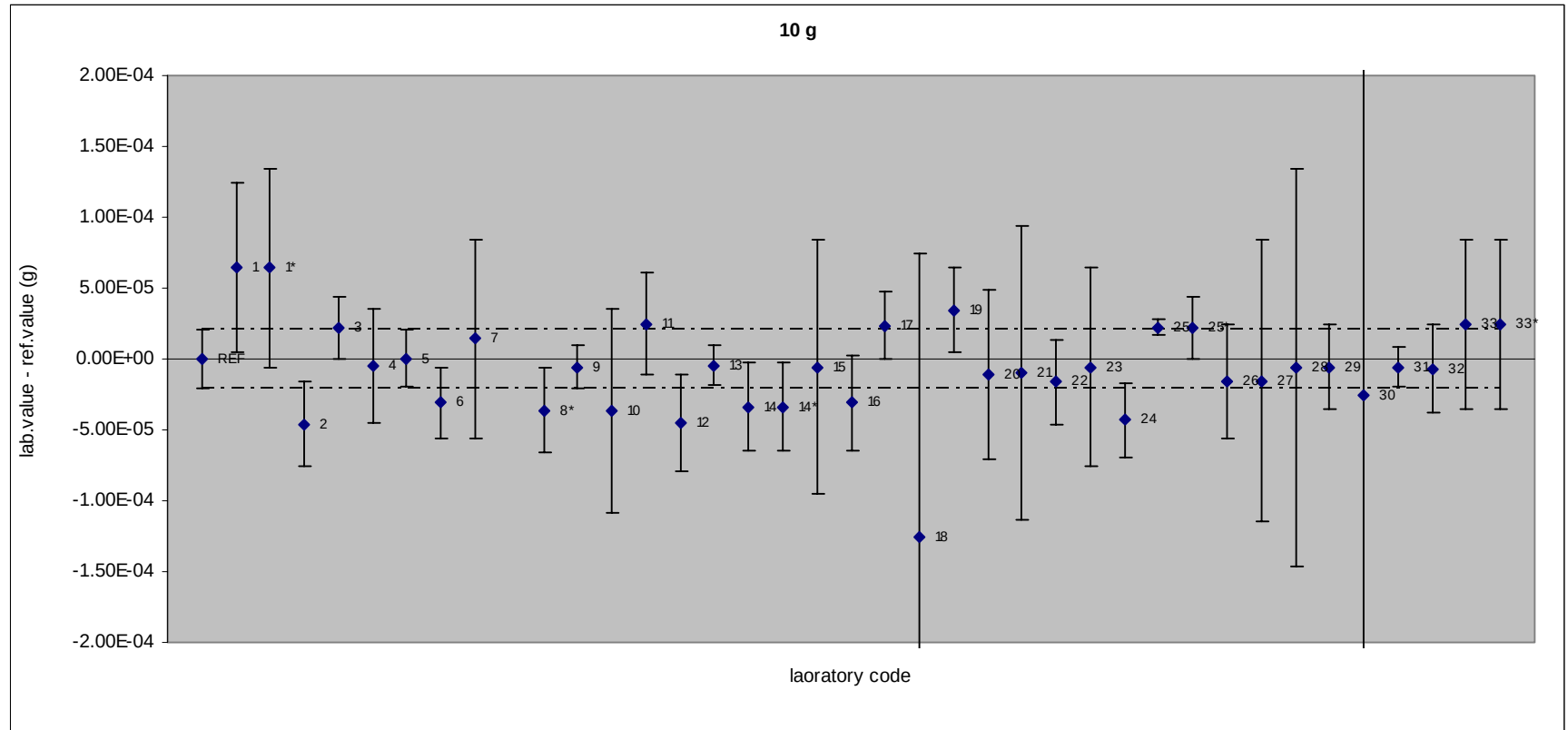
where,  $U_{\text{lab}}$  is the laboratory's reported uncertainty of measurement at a 95% confidence level, and  $U_{\text{ref}}$  is the reference uncertainty at a 95% confidence level. For the result to be acceptable, absolute values of En less than unity are required.

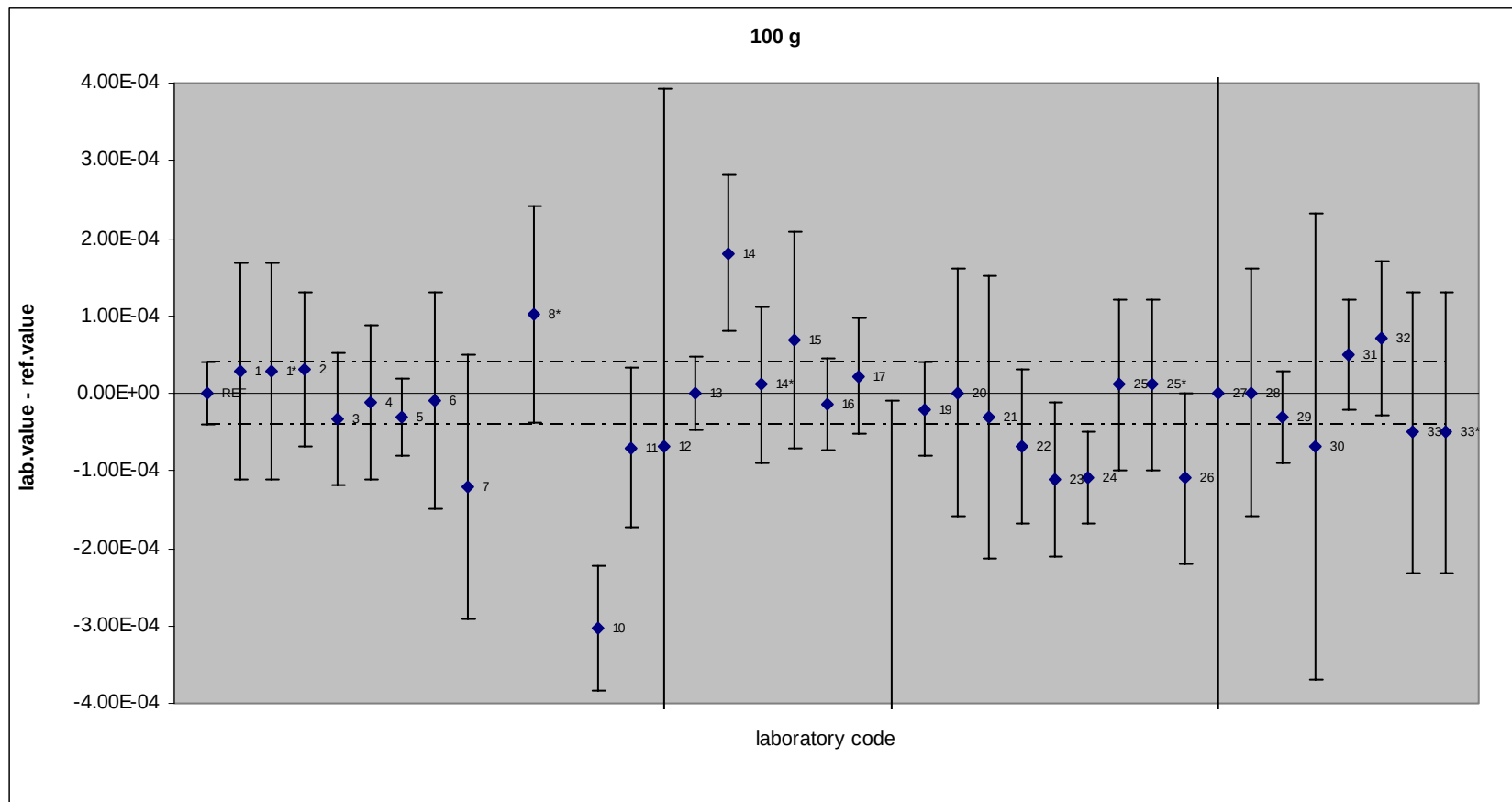
Values of  $|En| > 1$  require investigation and corrective action by both the laboratory concerned and its accreditation body, and it is detailed in Section 11.

## SUMMARY OF APM 017 (south loop) RESULTS

| LAB.<br>CODE | 1 g              |                 |              | 10 g             |                 |              | 100 g            |                 |              |
|--------------|------------------|-----------------|--------------|------------------|-----------------|--------------|------------------|-----------------|--------------|
|              | LAB-REF          | U(LAB)          | En           | LAB-REF          | U(LAB)          | En           | LAB-REF          | U(LAB)          | En           |
|              | (g)              | (g)             |              | (g)              | (g)             |              | (g)              | (g)             |              |
| REF          | 0.00E+00         | 1.90E-05        | 0.00         | 0.00E+00         | 2.10E-05        | 0.00         | 0.00E+00         | 4.10E-05        | 0.00         |
| 1            | 1.05E-05         | 3.00E-05        | 0.30         | 6.44E-05         | 6.00E-05        | <b>1.01</b>  | 2.91E-05         | 1.40E-04        | 0.20         |
| 1*           | 1.05E-05         | 3.00E-05        | 0.30         | 6.44E-05         | 7.00E-05        | 0.88         | 2.91E-05         | 1.40E-04        | 0.20         |
| 2            | -7.04E-06        | 2.00E-05        | -0.26        | -4.60E-05        | 3.00E-05        | <b>-1.26</b> | 3.11E-05         | 1.00E-04        | 0.29         |
| 3            | 8.54E-06         | 1.00E-05        | 0.40         | 2.14E-05         | 2.20E-05        | 0.70         | -3.29E-05        | 8.60E-05        | -0.34        |
| 4            | 2.36E-06         | 2.50E-05        | 0.08         | -4.70E-06        | 4.00E-05        | -0.10        | -1.19E-05        | 1.00E-04        | -0.11        |
| 5            | 5.54E-06         | 1.00E-05        | 0.26         | 4.17E-07         | 2.00E-05        | 0.01         | -3.09E-05        | 5.00E-05        | -0.48        |
| 6            | 1.96E-06         | 1.10E-05        | 0.09         | -3.10E-05        | 2.50E-05        | -0.95        | -8.94E-06        | 1.40E-04        | -0.06        |
| 7            | -9.46E-06        | 3.00E-05        | -0.27        | 1.44E-05         | 7.00E-05        | 0.20         | -1.21E-04        | 1.70E-04        | -0.69        |
| 8            | <i>-3.90E-05</i> | <i>2.00E-05</i> | <b>-1.42</b> | <i>-2.50E-04</i> | <i>3.00E-05</i> | <b>-6.82</b> | <i>-7.69E-04</i> | <i>1.40E-04</i> | <b>-5.27</b> |
| 8*           | 2.30E-05         | 2.00E-05        | 0.83         | -3.60E-05        | 3.00E-05        | -0.98        | 1.01E-04         | 1.40E-04        | 0.69         |
| 9            | 1.05E-05         | 1.11E-05        | 0.48         | -5.58E-06        | 1.50E-05        | -0.22        | -5.51E-04        | 1.02E-04        | <b>-5.01</b> |
| 10           | -9.04E-06        | 1.00E-05        | -0.42        | -3.70E-05        | 7.20E-05        | -0.49        | -3.03E-04        | 8.10E-05        | <b>-3.34</b> |
| 11           | 5.44E-07         | 1.90E-05        | 0.02         | 2.44E-05         | 3.60E-05        | 0.59         | -7.09E-05        | 1.03E-04        | -0.64        |
| 12           | -3.04E-06        | 5.10E-05        | -0.06        | -4.50E-05        | 3.40E-05        | <b>-1.13</b> | -6.89E-05        | 4.63E-04        | -0.15        |
| 13           | 1.54E-06         | 9.50E-06        | 0.07         | -4.58E-06        | 1.38E-05        | -0.18        | -8.61E-07        | 4.75E-05        | -0.01        |
| 14           | -1.04E-06        | 2.30E-05        | -0.03        | -3.40E-05        | 3.10E-05        | -0.91        | 1.81E-04         | 1.00E-04        | <b>1.68</b>  |
| 14*          | -1.04E-06        | 2.30E-05        | -0.03        | -3.40E-05        | 3.10E-05        | -0.91        | 1.11E-05         | 1.00E-04        | 0.10         |
| 15           | 1.05E-05         | 8.50E-05        | 0.12         | -5.58E-06        | 9.00E-05        | -0.06        | 6.91E-05         | 1.39E-04        | 0.48         |
| 16           | 8.80E-05         | 1.00E-05        | <b>4.10</b>  | -3.10E-05        | 3.33E-05        | -0.79        | -1.39E-05        | 5.96E-05        | -0.19        |
| 17           | -6.46E-06        | 1.20E-05        | -0.29        | 2.34E-05         | 2.40E-05        | 0.73         | 2.20E-05         | 7.40E-05        | 0.26         |
| 18           | -1.67E-04        | 2.80E-04        | -0.60        | -1.26E-04        | 2.00E-04        | -0.63        | -4.69E-04        | 4.60E-04        | <b>-1.02</b> |
| 19           | -4.56E-07        | 1.00E-05        | -0.02        | 3.44E-05         | 3.00E-05        | 0.94         | -2.09E-05        | 6.00E-05        | -0.29        |
| 20           | 4.96E-06         | 2.90E-05        | 0.14         | -1.10E-05        | 6.00E-05        | -0.17        | 1.06E-06         | 1.60E-04        | 0.01         |
| 21           | -1.65E-05        | 1.02E-04        | -0.16        | -9.58E-06        | 1.04E-04        | -0.09        | -3.09E-05        | 1.83E-04        | -0.16        |
| 22           | 1.30E-05         | 1.00E-05        | 0.60         | -1.60E-05        | 3.00E-05        | -0.44        | -6.89E-05        | 1.00E-04        | -0.64        |
| 23           | -9.46E-06        | 1.90E-05        | -0.35        | -5.58E-06        | 7.00E-05        | -0.08        | -1.11E-04        | 1.00E-04        | <b>-1.03</b> |
| 24           | -5.04E-06        | 1.90E-05        | -0.19        | -4.30E-05        | 2.60E-05        | <b>-1.29</b> | -1.09E-04        | 6.00E-05        | <b>-1.50</b> |
| 25           | 1.54E-06         | 1.60E-06        | 0.08         | 2.24E-05         | 5.40E-06        | <b>1.03</b>  | 1.11E-05         | 1.10E-04        | 0.09         |
| 25*          | 1.54E-06         | 1.60E-06        | 0.08         | 2.24E-05         | 2.20E-05        | 0.74         | 1.11E-05         | 1.10E-04        | 0.09         |
| 26           | -7.04E-06        | 4.00E-05        | -0.16        | -1.60E-05        | 4.00E-05        | -0.35        | -1.09E-04        | 1.10E-04        | -0.93        |
| 27           | 1.05E-05         | 5.35E-05        | 0.19         | -1.56E-05        | 9.94E-05        | -0.15        | -8.61E-07        | 4.00E-03        | 0.00         |
| 28           | 1.30E-05         | 1.40E-04        | 0.09         | -6.00E-06        | 1.40E-04        | -0.04        | 1.06E-06         | 1.60E-04        | 0.01         |
| 29           | 1.54E-06         | 2.60E-05        | 0.05         | -5.58E-06        | 3.00E-05        | -0.15        | -3.09E-05        | 6.00E-05        | -0.42        |
| 30           | 3.30E-05         | 3.00E-03        | 0.01         | -2.60E-05        | 3.00E-04        | -0.09        | -6.89E-05        | 3.00E-04        | -0.23        |
| 31           | 2.54E-06         | 3.00E-06        | 0.13         | -5.58E-06        | 1.40E-05        | -0.22        | 4.91E-05         | 7.10E-05        | 0.60         |
| 32           | 7.96E-06         | 2.30E-05        | 0.27         | -7.00E-06        | 3.10E-05        | -0.19        | 7.11E-05         | 1.00E-04        | 0.66         |
| 33           | <i>-4.95E-05</i> | <i>3.00E-05</i> | <b>-1.39</b> | 2.44E-05         | 6.00E-05        | 0.38         | -5.09E-05        | 1.80E-04        | -0.28        |
| 33*          | -2.46E-06        | 3.00E-05        | -0.07        | 2.44E-05         | 6.00E-05        | 0.38         | -5.09E-05        | 1.80E-04        | -0.28        |







## 9. Performance of Participants

The table of En ratios shows an overall good performance by the majority of participating laboratories. In this inter-laboratory comparisons program 34 laboratories were received the artifacts, and 1 of them was discarded by the nominating AB.

A total of **99 measurement results** were reported by **33 participants**. At the issuance of interim reports **16 reported results among them** show  $|En|$  greater than unity:

laboratory number 008 has  $|En| > 1$  for all nominal values,

laboratory number 024 has  $|En| > 1$  for 10 g and 100 g,

laboratories number 016 and 033 have  $|En| > 1$  for 1 g only,

laboratories number 001, 002, 012, 025 have  $|En| > 1$  for 10 g only, and

laboratories number 009, 010, 014, 018, 023 have  $|En| > 1$  for 100 g only.

Following the issuance of interim reports, comments and corrective actions from laboratories number 001, 008, 014, 025 and 033 were received. Re-evaluation results based on the laboratory's corrective action were marked with asterix (\*).

Generally, comments and corrective actions from those laboratories satisfactorily resolve the causes of outlier results. At the issuance of this draft of final report, among **99 reported results**, the numbers of results having  $|En|$  greater than unity were decreased to be **9 (nine)**. Details of comments and corrective actions were summarized in chapter 11.

## 10. Uncertainties of Measurement

Uncertainty calculations were generally adequate and covered the major sources of uncertainty. The introduction of ISO Guide to the Expression of Uncertainty in Measurement ensures a consistent approach to the determination of uncertainties particularly with respect to Type A evaluation of uncertainties, which can be evaluated statistically. A sample of uncertainty calculation to the ISO Guide is provided in Appendix E.

The maximum permissible uncertainty for the verification of OIML F1 mass standards for 1 g, 10 g and 100 g in accordance with International Recommendation OIML R 111: 2004 were listed below:

| Nominal Mass<br>(g) | Maximum Permissible<br>Errors OIML R 111<br>(OIML F1 Class)<br>(g) | Maximum Tolerable<br>Uncertainty at<br>verification<br>(g) |
|---------------------|--------------------------------------------------------------------|------------------------------------------------------------|
| 1                   | 1.00e-04                                                           | <b>3.3e-05</b>                                             |
| 10                  | 2.00e-04                                                           | <b>6.3e-05</b>                                             |
| 100                 | 5.00e-04                                                           | <b>1.7e-04</b>                                             |

The listed Maximum Tolerable Uncertainty shows the capability of laboratories to verify the metrological characteristic of the OIML F1 weights. However, for the purpose of this program, participants were asked to report uncertainty in accordance with their Best Measurement Capabilities instead of their capabilities to verify the artifacts.

## 11. Corrective Action

The interim reports of this program were sent to all participating laboratories through their ABs on October 09, 2006 and corrective actions for the outlying results were asked to be sent to coordinator no later than 15 November 2006.

Responses were received from participant with code number 001, 008, 014, 025 and 033. Comments and corrective actions received from those laboratories are summarized as follows:

Laboratory number 001: this laboratory report uncertainty lower than their accredited Best Measurement Capabilities due to the procurement of their new mass comparator that will be used to propose smaller Best Measurement Capabilities to the AB. At the time of comparison, verification by the AB was scheduled. Based on the interim report of this comparison this laboratory revised their proposed BMC to be (1/3) MPE of OIML F1 mass standard. Based on the new proposed uncertainty, *the result of this laboratory for 10 g shows satisfactory result.*

Laboratory number 008: this laboratory fill the result sheet with the conventional mass and uncertainty of standards used to calibrate the artifacts, while measurement results on the artifacts were reported in the calibration certificate. Based on the instruction provided to all participants, En number reported in the interim reports were based on the measurement data contained in the result sheets. Re-calculation of En number for laboratory code 008 using measurement results reported in the calibration certificate attached to the result sheet show *satisfactory results for all nominal value.*

Laboratory number 014: this laboratory revised the reported result for 100 g artifact, the calculation of  $En$  number based on the revised reported result show *satisfactory result for 100 g artifact. The cause of revision is a typo error in the data transcription from the computerized data acquisition system.*

Laboratory number 025: this laboratory reported smaller uncertainty than their accredited Best Measurement Capability cited in the nomination form for this ILC program. After receiving the interim report, this laboratory revised their result sheet reporting uncertainty consistent with the accredited BMC and the re-calculation of *En number for 10 g artifact shows satisfactory result.*

Laboratory number 033: this laboratory revised their reported result for 1 g artifact based on the new calibration certificate for the mass standard used in this ILC program. At the time of comparison, the recalibration schedule standard used by this laboratory will be due in next 2 (two) weeks. After receiving the new calibration certificate, this laboratory re-calculates the measurement result based on the new certificate. Re-calculation of *En number based on the revised result sheet shows satisfactory result.*

## **12. References**

- (1) APLAC PT 001: Calibration Interlaboratory Comparisons, 2006
- (2) ISO Guide to the Expression of Uncertainty in Measurement, 1995
- (3) OIML R 111-1: Weights of Classes  $E_1$ ,  $E_2$ ,  $F_1$ ,  $F_2$ ,  $M_1$ ,  $M_{1-2}$ ,  $M_2$ ,  $M_{2-3}$  and  $M_3$ , 2004
- (4) ISO Guide 43-1,2: Proficiency Testing by Interlaboratory Comparisons, 1997
- (5) ISO 13528: Statistical Methods for Use in Proficiency Testing by Interlaboratory Comparisons, 1995

## **APPENDIX A**

### **Instruction to Laboratories and Result Sheet**

## **APPENDIX A**

### **Instruction to Laboratories and Result Sheet**

#### **APLAC INTERLABORATORY COMPARISON APM 017 - MASS INSTRUCTIONS TO LABORATORIES**

##### **EQUIPMENT**

A metal case containing:

1. a stainless steel mass standard marked 100 g
2. a stainless steel mass standard marked 10 g
3. a stainless steel mass standard marked 1 g
4. a pair of plastic tweezers
5. an airbrush
6. a pair of gloves

##### **DO NOT HANDLE THE MASSES WITH BARE HANDS !!!**

On receipt, unpack the masses (using the gloves and tweezers provided) and inspect them for any defects such as scratches, stains or finger marks.

Leave the masses in their box when not in use. When ready to start, place them on a suitable work surface. Lightly brush each mass with the airbrush provided.

##### **DO NOT CLEAN THE MASSES WITH SOLVENT OR CLOTHES !!!**

If they appear dirty or damaged, please contact your accreditation body.

##### **MEASUREMENTS TO BE CARRIED OUT**

Participants are asked to carry out calibration of these artifacts (determination of conventional mass of mass standards) by comparison method or by their documented procedures. Please also provide descriptions of the procedures used for the calibration..

Measurement of density of these artifacts is not required. All artifacts are assumed to fulfil the density range of OIML R111 F<sub>1</sub> class.

##### **UNCERTAINTY OF MEASUREMENT**

Uncertainty should be calculated using the method described in the ISO Guide to the Expression of Uncertainty in Measurement. The expanded uncertainty,  $U_{lab}$ , for each mass standard is to be reported at a 95% level of confidence.

Uncertainty sources should be estimated by each participant in evaluating uncertainty based on OIML R111, and should be reported for this comparison.

## **DOCUMENTS TO BE SUBMITTED**

Within one week of the completion of the measurements, the participating laboratory is required to send the attached Results Form **and** the calibration report/certificate for the artifacts to its accreditation body. Description of the calibration procedure used shall also be provided if it is not included in the calibration report/certificate.

No other documents are required. Laboratories should make a copy of the Results Form for their own records.

Participants should report their accredited Best Measurement Capability, and shall give explanatory remarks if their reported uncertainty in this programme differs from their BMC.

A final report will be issued at the end of the programme with each laboratory only identified by a **confidential** code number.

## **GENERAL INFORMATION**

For general queries, please contact your accreditation body. Additional information may be obtained from:

Donny Purnomo (Mr)  
Komite Akreditasi Nasional (KAN), Indonesia  
Mangala Wanabakti Building Block IV, 4<sup>th</sup> floor,  
Jl. Jendral Gatot Subroto – Senayan, Jakarta  
Tel : +62 21 5747043      Fax: +62 21 57902948  
Email: laboratorium@bsn.or.id

## APLAC INTERLABORATORY COMPARISON APM 017 - MASS RESULTS SHEET

Lab.code ( filled by coordinator) : \_\_\_\_\_  
 Laboratory : \_\_\_\_\_  
 Accreditation Number (accredited by) : \_\_\_\_\_  
 Calibration officer : \_\_\_\_\_  
 Date of calibration : \_\_\_\_\_  
 Standard test specification/method : \_\_\_\_\_  
 Environmental temperature : \_\_\_\_\_ °C  
 Environmental relative humidity : \_\_\_\_\_ %  
 Atmospheric pressure : \_\_\_\_\_ mmHg  
 Ambient air density : \_\_\_\_\_ kg/m<sup>3</sup>

| Nominal Mass<br>( g ) | Conventional<br>Mass<br>( g ) | Expanded<br>Uncertainty at<br>95% c.l<br>( ± g ) | Accredited Best<br>Measurement<br>Capability<br>( ± g ) |
|-----------------------|-------------------------------|--------------------------------------------------|---------------------------------------------------------|
| 1                     |                               |                                                  |                                                         |
| 10                    |                               |                                                  |                                                         |
| 100                   |                               |                                                  |                                                         |

**Explanatory remarks, if reported uncertainty differs from BMC** :

**Reference standard used**

Class / Manufacturer : \_\_\_\_\_  
 Sequence of reading : \_\_\_\_\_  
 Number of times this sequence was done to determine measured value for the mass : \_\_\_\_\_

**Mass comparator used**

1. Capacity / Range : \_\_\_\_\_  
 Resolution : \_\_\_\_\_  
 2. Capacity / Range : \_\_\_\_\_  
 Resolution : \_\_\_\_\_  
 3. Capacity / Range : \_\_\_\_\_  
 Resolution : \_\_\_\_\_

**APPENDIX B**  
**Circulation Schedule**

## APPENDIX B

### Circulation Schedule

#### APLAC INTERLABORATORY COMPARISON

#### APM017 – MASS

#### CIRCULATION SCHEDULE

##### Loop 1 (KAN F<sub>1</sub> 576)

| Circulation Group | Time schedule<br>(including international transportation) | Participating Accreditation Body | Economy    | Number of Lab. | Artifacts                                             |
|-------------------|-----------------------------------------------------------|----------------------------------|------------|----------------|-------------------------------------------------------|
| I - 1             | From: 1 January 2006<br>To : 15 January 2006              | Ministry of Development          | Bunei      | 1              | Mass standards<br>(F1 class OIML)<br>1 g, 10 g, 100 g |
|                   | From: 15 January 2006<br>To : 15 February 2006            | SAC                              | Singapore  | 4              |                                                       |
|                   | From: 15 February 2006<br>To : 10 March 2006              | DSM                              | Malaysia   | 3              |                                                       |
|                   | Return to KAN<br>for stability check in<br>ref.lab        | KAN                              | Indonesia  |                |                                                       |
|                   | From: 1 May 2006<br>To : 28 May 2006                      | TLAS                             | Thailand   | 4              |                                                       |
|                   | From: 1 June 2006<br>To : 15 June 2006                    | BPS                              | Philippine | 2              |                                                       |
|                   | From: 20 June 2006<br>To : 10 July 2006                   | VILAS                            | Vietnam    | 3              |                                                       |
|                   | Return to KAN<br>for stability check in<br>ref.lab        | KAN                              | Indonesia  |                |                                                       |

# **APLAC INTERLABORATORY COMPARISON**

## **APM017 – MASS**

### **CIRCULATION SCHEDULE**

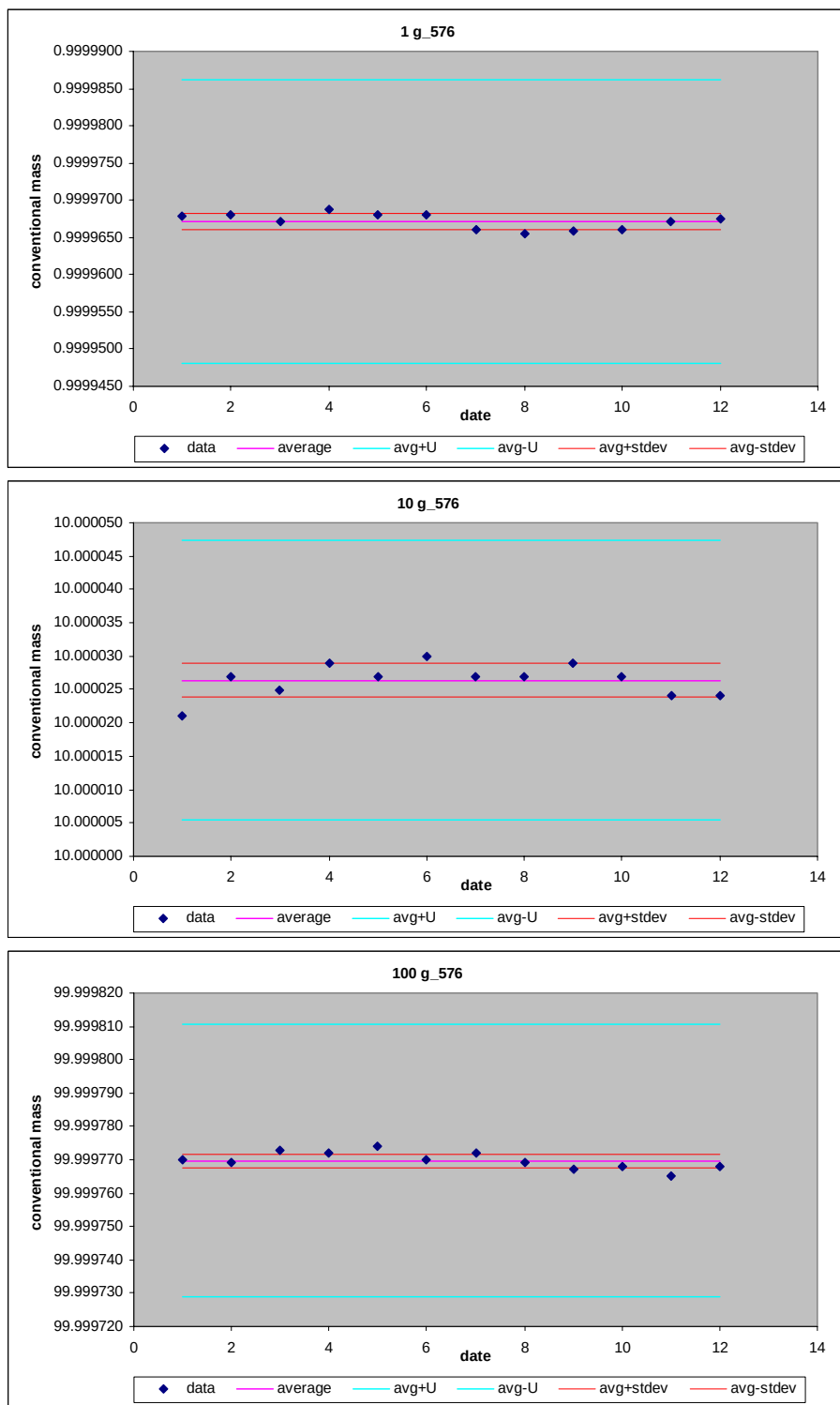
#### **Loop 2 (F<sub>1</sub> KAN 28494)**

| Circulation Group | Time schedule<br>(including international transportation) | Participating Accreditation Body | Economy          | Number of Lab. | Artifacts                                             |
|-------------------|-----------------------------------------------------------|----------------------------------|------------------|----------------|-------------------------------------------------------|
| I - 2             | From: 1 January 2006<br>To : 15 January 2006              | NISIT                            | Papua New Guinea | 1              | Mass standards<br>(F1 class OIML)<br>1 g, 10 g, 100 g |
|                   | From: 15 January 2006<br>To : 15 February 2006            | NABL                             | India            | 4              |                                                       |
|                   | From: 15 February 2006<br>To : 15 March 2006              | IANZ                             | New Zealand      | 4              |                                                       |
|                   | Return to KAN<br>for stability check in ref.lab           | KAN                              | Indonesia        |                |                                                       |
|                   | From: 1 May 2006<br>To : 28 May 2006                      | NATA                             | Australia        | 4              |                                                       |
|                   | From: 1 June 2006<br>To : 28 June 2006                    | EMA                              | Mexico           | 4              |                                                       |
|                   | From: 1 July 2006<br>To : 15 July 2006                    | KAN                              | Indonesia        | 4              |                                                       |
|                   | Return to KAN<br>for stability check in ref.lab           | KAN                              | Indonesia        |                |                                                       |

**APPENDIX C.**  
**Artifacts Stability**

## APPENDIX C. Artifacts Stability

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**APPENDIX D.**  
**KIM LIPI Calibration Reports**

**APPENDIX D. KIM LIPI Calibration Reports****Form: M-4.4-010**

Nomor Sertifikat : APLAC APM 017\_001 ref

Nomor Order : **APLAC\_01\_2006**

Subbidang Metrologi Massa

**Lembar ke 2 dari 3****Spesifikasi Anak Timbangan**

Massa nominal 100 g, 10 g &amp; 1 g

Bahan Stainless Steel

Kelas / No seri F1 / 576

Merk / Pabrik Mettler Toledo

Kalibrasi dilakukan di laboratorium massa Puslit KIM LIPI yang dikendalikan dalam kondisi berikut, dengan satu set sistem pengukuran densitas udara :

Densitas udara :  $(1.2 \text{ kg/m}^3 \pm 6 \%)$ Temperatur :  $(20 \pm 1) ^\circ\text{C}$ Kelembaban relatif :  $(55 \pm 10)\%$ 

Kalibrasi dilakukan dengan perbandingan langsung terhadap standar massa berdasarkan prosedur Prk.MM.2.01

Nilai massa yang dilaporkan adalah nilai massa konvensional, yaitu hasil penimbangan di udara tanpa koreksi buoyancy

Ketidakpastian pengukuran yang dilaporkan adalah ketidakpastian bentangan pada tingkat kepercayaan sekitar 95 % dengan faktor cakupan  $k = 2$ , yang dievaluasi berdasarkan ISO '*Guide to the Expression of Uncertainty in Measurement*',

Stabilitas jangka panjang dari anak timbangan yang dikalibrasi tidak diperhitungkan dalam ketidakpastian pengukuran yang dilaporkan dalam sertifikat ini.

Kovariansi antara anak timbangan yang dikalibrasi tidak dilaporkan, tetapi dari analisis terhadap hasil kalibrasi, kovariansi mempunyai nilai yang signifikan, sehingga ketidakpastian dari gabungan beberapa anak timbangan yang digunakan secara bersama harus diperhitungkan dengan  $u_c = \sum u_i$

Standar massa yang digunakan adalah anak timbangan standar kelas E2 nomor seri 274, dengan nomor sertifikat S021054

Hasil pengukuran yang dilaporkan tertelusur ke SI melalui NMI - Australia



Form: M-4.4-010

*Lanjutan .....*

Nomor Sertifikat : APLAC APM 017\_001 ref

Nomor Order : **APLAC\_01\_2006**

Subbidang Metrologi Massa

*Lembar ke 3 dari 3***HASIL PENGUKURAN**

| Nominal | Massa<br>Konvensional | Ketidakpastian |
|---------|-----------------------|----------------|
| g       | g                     | g              |
| 100     | 99.999769             | 0.000041       |
| 10      | 10.000026             | 0.000021       |
| 1       | 0.999967              | 0.000019       |

Tanggal

Kalibrasi:

-

====akhir sertifikat====



Form: M-4.4-010

Nomor Sertifikat : APLAC APM 017\_002 ref

Nomor Order : **APLAC\_02\_2006**

Subbidang Metrologi Massa

**Lembar ke 2 dari 3****Spesifikasi Anak Timbangan**

Massa nominal 100 g, 10 g &amp; 1 g

Bahan Stainless Steel

Kelas / No seri F1 / 28494

Merk / Pabrik Mettler Toledo

Kalibrasi dilakukan di laboratorium massa Puslit KIM LIPI yang dikendalikan dalam kondisi berikut, dengan satu set sistem pengukuran densitas udara :

Densitas udara :  $(1.2 \text{ kg/m}^3 \pm 6 \%)$ Temperatur :  $(20 \pm 1) ^\circ\text{C}$ Kelembaban relatif :  $(55 \pm 10)\%$ 

Kalibrasi dilakukan dengan perbandingan langsung terhadap standar massa berdasarkan prosedur Prk.MM.2.01

Nilai massa yang dilaporkan adalah nilai massa konvensional, yaitu hasil penimbangan di udara tanpa koreksi buoyancy

Ketidakpastian pengukuran yang dilaporkan adalah ketidakpastian bentangan pada tingkat kepercayaan sekitar 95 % dengan faktor cakupan  $k = 2$ , yang dievaluasi berdasarkan ISO '*Guide to the Expression of Uncertainty in Measurement*',

Stabilitas jangka panjang dari anak timbangan yang dikalibrasi tidak diperhitungkan dalam ketidakpastian pengukuran yang dilaporkan dalam sertifikat ini.

Kovariansi antara anak timbangan yang dikalibrasi tidak dilaporkan, tetapi dari analisis terhadap hasil kalibrasi, kovariansi mempunyai nilai yang signifikan, sehingga ketidakpastian dari gabungan beberapa anak timbangan yang digunakan secara bersama harus diperhitungkan dengan  $u_c = \sum u_i$

Standar massa yang digunakan adalah anak timbangan standar kelas E2 nomor seri 274, dengan nomor sertifikat S021054

Hasil pengukuran yang dilaporkan tertelusur ke SI melalui NMI - Australia



Form: M-4.4-010

*Lanjutan .....*

Nomor Sertifikat : APLAC APM 017\_002 ref

Nomor Order : **APLAC\_02\_2006**

Subbidang Metrologi Massa

*Lembar ke 3 dari 3***HASIL PENGUKURAN**

| Nominal | Massa<br>Konvensional | Ketidakpastian |
|---------|-----------------------|----------------|
| g       | g                     | g              |
| 100     | 100.000051            | 0.000041       |
| 10      | 9.999996              | 0.000021       |
| 1       | 0.999989              | 0.000019       |

Tanggal

Kalibrasi:

-

====akhir sertifikat====

## **APPENDIX E**

### **Example Uncertainty of Measurement Analysis**

## APPENDIX E

### Example Uncertainty of Measurement Analysis

#### Description of Measurement

The measurement involves the determination of CONVENTIONAL MASS VALUES of a set of an unknown mass standard of 100 g nominal masses. The mass standards were characterized as fulfill the metrological characteristic of OIML F<sub>1</sub> weights. In this example calibration of the unknown mass standards was performed using 100 g mass standard fulfilling metrological characteristic of OIML E<sub>2</sub> class accompanying with calibration certificate from a recognized NMI, 1 kg balance of 0.01 g resolution as a comparator and a controlled environment condition fulfilling  $(1.2 \pm 0.12) \text{ kg/m}^3$  air density

#### Mathematical Model of the Measurement

$$M_T = M_S + \Delta m + \delta b$$

dimana :

$M_T$  is the conventional mass of UUT

$M_S$  is the conventional mass of mass standard used for the calibration

$\Delta m$  is difference between mass of UUT and mass of standard as observed in the measurement process

$\Delta m$  is the buoyancy correction

#### Input Quantities

##### Calibration Certificate of Standard used (dari sertifikat kalibrasi):

|                                                  |            |
|--------------------------------------------------|------------|
| Conventional Mass ( $M_S$ )                      | 99.99997 g |
| Expanded Uncertainty at 95% c.l.<br>( $U_{95}$ ) | 0.043 mg   |
| Coverage factor (k)                              | 2          |

##### Balance:

|            |          |
|------------|----------|
| Capacity   | 100 g    |
| Resolution | 0.001 mg |

### Observed Measurement Data

Direct comparison weighing of STTS scheme is performed in three series. The observation data is summarized as follows:

| Load              | Balance Reading | Difference |
|-------------------|-----------------|------------|
| S                 | 0.213           | -0.200     |
| T                 | 0.013           |            |
| T                 | 0.022           | -0.219     |
| S                 | 0.241           |            |
| S                 | 0.244           | -0.204     |
| T                 | 0.040           |            |
| T                 | 0.045           | -0.222     |
| S                 | 0.267           |            |
| S                 | 0.233           | -0.200     |
| T                 | 0.033           |            |
| T                 | 0.034           | -0.217     |
| S                 | 0.251           |            |
| Mean difference = |                 | -0.210     |

### Calculation of Conventional Mass Value

As the laboratory environment is controlled to meet conventional condition for mass measurement, the buoyancy correction is neglected, thus conventional mass value of UUT may be calculated as:

$$\begin{aligned}
 M_T &= M_s + \Delta m \\
 &= 99.999970 \text{ g} + (-0.210 \text{ mg}) = 99.999760 \text{ g}
 \end{aligned}$$

### Evaluation of Uncertainty Components

Dalam kalibrasi anak timbangan terdapat lima komponen ketidakpastian yang berarti, yaitu:

1. uncertainty of calibration of mass standard
2. uncertainty due to instability of mass standard
3. uncertainty due to repeatability of balance reading
4. uncertainty due to balance resolution
5. uncertainty due to uncorrected buoyancy error

### Uncertainty due to calibration of mass standard ( $u_1$ )

The calibration certificate of mass standard gives expanded uncertainty as 0.043 mg at a 95% confidence level, an effective degree of 30 and coverage factor of  $k = 2$ . Therefore dividing the expanded uncertainty by the coverage factor converts the reported standard uncertainty to a standard uncertainty:

$$\begin{aligned}u_1 &= U_{95} / k \\&= 0.043 \text{ mg} / 2 \\&= 0.0215 \text{ mg}\end{aligned}$$

**Uncertainty due to instability of mass standard ( $u_2$ )**

As the mass standard is calibrated periodically in accordance with the laboratory procedure, it is also necessary to take into account the maximum likely change in mass of the reference mass standard since its last calibration. The simple approximation of the instability limit is taken from results of successive calibration of reference mass standard. Assuming the calibration interval of reference mass standard is 1 (one) year, and the difference between results of successive calibration is not more than one third of the uncertainty of the calibration of mass standard, therefore uncertainty contribution due to instability of reference may be estimated as:

$$\begin{aligned}u_1 &= (1/3) \times 0.043 \text{ mg} / \sqrt{3} \\&= 0.00248 \text{ mg}\end{aligned}$$

**Uncertainty due to repeatability of reading ( $u_3$ )**

Three series of STTS scheme were observed in this measurement, six differences were obtained from the measurement data. Thus the standard deviation of difference is calculated as:

$$\sigma(T - S) = \frac{\sum_{i=1}^n [(T_i - S_i) - (\bar{T} - \bar{S})]}{n - 1}$$

$$\sigma(T-S) = 0.0092 \text{ mg}$$

Standard uncertainty of difference is calculated as estimated standard deviation of the difference as follows:

$$u_2 = \sigma(T-S) / (6^{0.5}) = 0.0038 \text{ mg}$$

**Uncertainty due to resolution of balance reading ( $u_4$ )**

The resolution of balance used in this calibration is 0.01 mg, this means all values between 0.01 mg  $\pm$  0.005 mg, will be rounded to the nearest resolution of balance. Taking half of resolution as the semi-range of rectangular distribution, the uncertainty contribution due to the resolution of balance reading is estimated as:

$$u_3 = 0.005 \text{ mg} / \sqrt{3} = 0.00289 \text{ mg}$$

### Uncertainty due to uncorrected air buoyancy error ( $u_5$ )

While the laboratory environment fulfilling conventional weighing condition, no correction is made for air buoyancy error. An air density limit  $\pm 10\%$  of  $1.2 \text{ kg/m}^3$  is used as semi range for uncertainty contribution from the variation of air density in the laboratory (assuming the altitude of laboratory is lower than 750 m), the density value of UUT is taken from density limit for OIML F<sub>1</sub> class of 7390  $\text{kg/m}^3$  and the density of mass standard of 8000  $\text{kg/m}^3$ . Thus, contribution of uncertainty due to uncorrected buoyancy error is calculated as:

$$u_5 = \frac{\sigma_{\rho_a}}{(\rho_T - \rho_R)} (\rho_T - \rho_R) M_T,$$

for 100 g weight that is equal with 0.0715 mg.

### Combined Standard Uncertainty

Ketidakpastian baku gabungan dari anak timbangan yang dikalibrasi adalah:

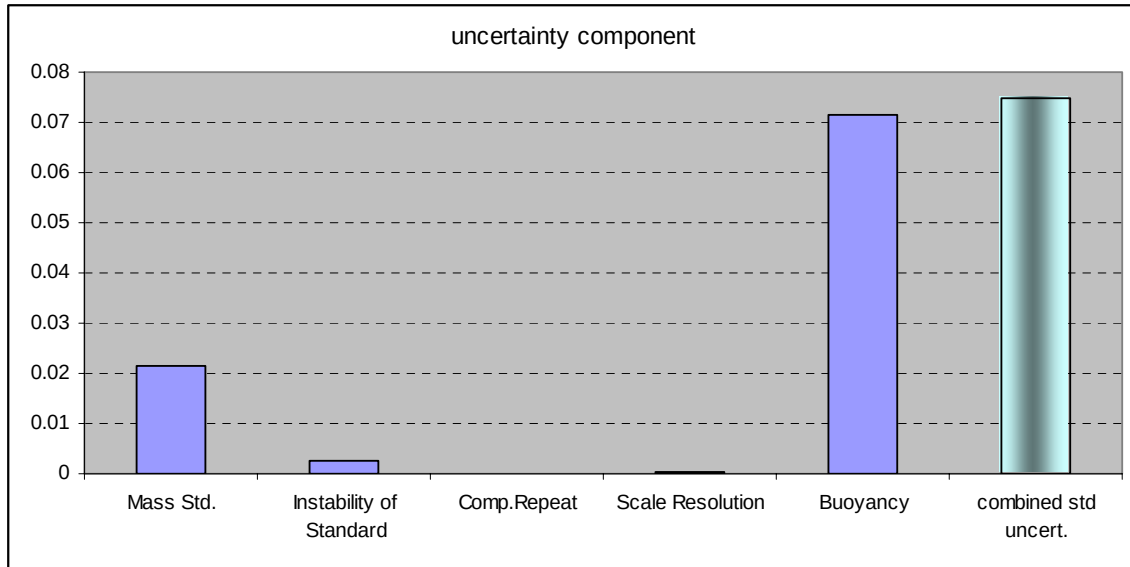
$$u_c = \sqrt{(u_1^2 + u_2^2 + u_3^2 + u_4^2)} = 0.723372 \text{ mg}$$

### Expanded Uncertainty

As, the type B component due to calibration of mass standard and uncorrected buoyancy error dominantly contribute to the combined standard uncertainty of measurement, coverage factor  $k = 2$  will be a reliable to cover expanded uncertainty at 95% level of confidence, thus:

$$U_{95} = 2 \times 0.0747 \text{ mg} = 0.15 \text{ mg}$$

| Component                                    | Units | Dist.  | U        | Divisor     | $u_i$       | $C_i$      | $u_i C_i$   | $(u_i C_i)^2$ |
|----------------------------------------------|-------|--------|----------|-------------|-------------|------------|-------------|---------------|
| Mass Std.                                    | mg    | Normal | 0.043    | 2.00        | 0.0215      | 1          | 0.0215      | 0.00046225    |
| Instability of Mass Standard                 | mg    | Rect.  | 4.30E-03 | 1.732050808 | 2.48E-03    | 1          | 0.002482606 | 6.16333E-06   |
| Comp.Repeat                                  | mg    | Normal | 0.0002   | 2.45        | 6.80414E-05 | 1          | 6.80414E-05 | 4.62963E-09   |
| Scale Resolution                             | mg    | Rect.  | 0.0005   | 1.732050808 | 0.000288675 | 1          | 0.000288675 | 8.33333E-08   |
| Uncorrected buoyancy error                   | mg    | Rect.  | 1.20E-01 | 1.732050808 | 0.069282032 | 1.0318E-06 | 0.071485182 | 0.005110131   |
| Sums                                         |       |        |          |             |             |            |             | 0.005578633   |
| Combined Standard uncertainty, $u_c$ , mg    |       |        |          |             |             |            |             | 0.074690244   |
| Coverage factor, $k$ for $V_{eff}$ & CL 95 % |       |        |          |             |             |            |             | 2             |
| Expanded uncertainty, $U = k u_c$ , mg       |       |        |          |             |             |            |             | 0.15          |



### Reporting the Results

The measurement result is reported in the following table:

|                      |                           |                       |
|----------------------|---------------------------|-----------------------|
| Massa Nominal<br>(g) | Massa Konvensional<br>(g) | Ketidakpastian<br>(g) |
| 100                  | 999.999760                | 0.00015               |

Reported Uncertainty is Expanded Uncertainty at approximately 95% level of confidence of coverage factor = 2.