

Draft Report

of

SADCMET.M.M.S1 Comparison of 1 kg Mass Standards

Draft A

23 January 2008

Co-ordinated by:

National Metrology Institute of South Africa (NMISA)

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Assisted by:

Scientific and Industrial Research and Development Centre (SIRDC) Zimbabwe

Kenya Bureau of Standards (KEBS) Kenya

Tanzania Bureau of Standards (TBS) Tanzania

Draft A: SADCMET.M.M.S1 Comparison of 1 kg Mass Standards**ABSTRACT**

This report summarizes the results of a comparison of 1 kg mass standards conducted between seventeen participating NMIs including the pilot laboratory. The participating members are mainly of the Southern African Development Community, (SADC) but some other African NMIs were also allowed to participate. Four 1 kg mass standards were used as travelling artefacts. This value was chosen as it follows the nominal value of CCM.M-K1. The programme was piloted by the National Metrology Institute of South Africa (NMISA) with the assistance of the Scientific and Industrial Research and Development Centre (SIRDC) Zimbabwe, Kenya Bureau of Standards (KEBS) Kenya and Tanzania Bureau of Standards (TBS) Tanzania. The four standards were circulated among the participating laboratories from February 2005 until July 2007.

1. INTRODUCTION

The working group for mass (WG-M) Technical Committee TC-1 of the Southern African Development Community (Metrology), SADCMET, held in November 2004 in Walvis Bay (Namibia), decided to conduct a supplementary comparison. This regional supplementary comparison complements the APMP-IC-3-96 which complements the key comparison CCM.M-K1 in a similar denomination of 1 kg and extends the demonstration of metrological equivalence to economies in the SADC region and Africa at large. This comparison is aimed at OIML class F1 to F2 level. The NMIs that have taken part in APMP-IC-3-96, NMISA and the National Institute of Standards (NIS), Egypt, will through APMP-IC-3-96 act as links to the CCM comparison enabling degrees of equivalence to be calculated.

2. OBJECTIVES

The main objectives of this comparison are:-

To facilitate the demonstration of metrology equivalence between the participating NMI's in the SADC region and to verify and/or establish calibration measurement capabilities (CMC's).

To extend the demonstration of metrological equivalence to other African countries including those who have not yet participated in, or do not usually take part in comparisons. It is intended to complement the metrological equivalence of the Comité Consultatif la Masse et les Grandeurs Apparentées (CCM) with two of the participating NMIs having previously taken part in the corresponding key comparison APMP-IC-3-96.

To ensure the harmonisation of primary mass measurements throughout SADC, Africa and the rest of the world in the proposed mass range of 1 kg.

To enable the degrees of equivalence of the participating NMIs to be determined using the links to the APMP comparison and the Key Comparison Reference Value found in that comparison, and that in turn is linked to the CCM key comparison.

To enable a high level technology transfer from the more to the less developed National Metrology Institutes.

3. ORGANISATION

According to the decision of WG-M of SADCMET, four NMIs formed a technical management group for the comparison and agreed to help organise and run the comparison to cut down the burden on any one NMI and to speed up the comparison process. The management group is headed by Mr BF van der Merwe of the NMISA who agreed to take overall responsibility for the comparison. These four NMIs are:-

National Metrology Institute, South Africa (NMISA)

Contact person: Mrs Ireen Field

Kenya Bureau of Standards, Kenya (KEBS)

Contact person: Mr David Tonui

National Metrology Institute of SIRDC, Zimbabwe

Contact person: Mr Brian Masara

Tanzania Bureau of Standards, Tanzania (TBS)

Contact person: Mr Edna Ndumbaro

NMIs of the following countries expressed their interest in participating in the SADCMET M.M.S1 supplementary comparison:-

South Africa, Botswana, Namibia, Lesotho, Swaziland, Zimbabwe, Zambia, Democratic Republic of Congo (DRC), Kenya, Ethiopia, Uganda, Egypt, Tanzania, Malawi, Mozambique, Angola and Mauritius

The comparison consisted of five (5) Petals, first the inner Petal (Petal 1) where an artefact was sent to the four laboratories that were the pilot laboratories for Petals 2 to 5 (see Figure 1). Only when results from this Petal proved equivalence between the laboratories were Petals 2 to 5 initiated. All the artefacts were calibrated by the NMISA before the start of each Petal and on the completion thereof.

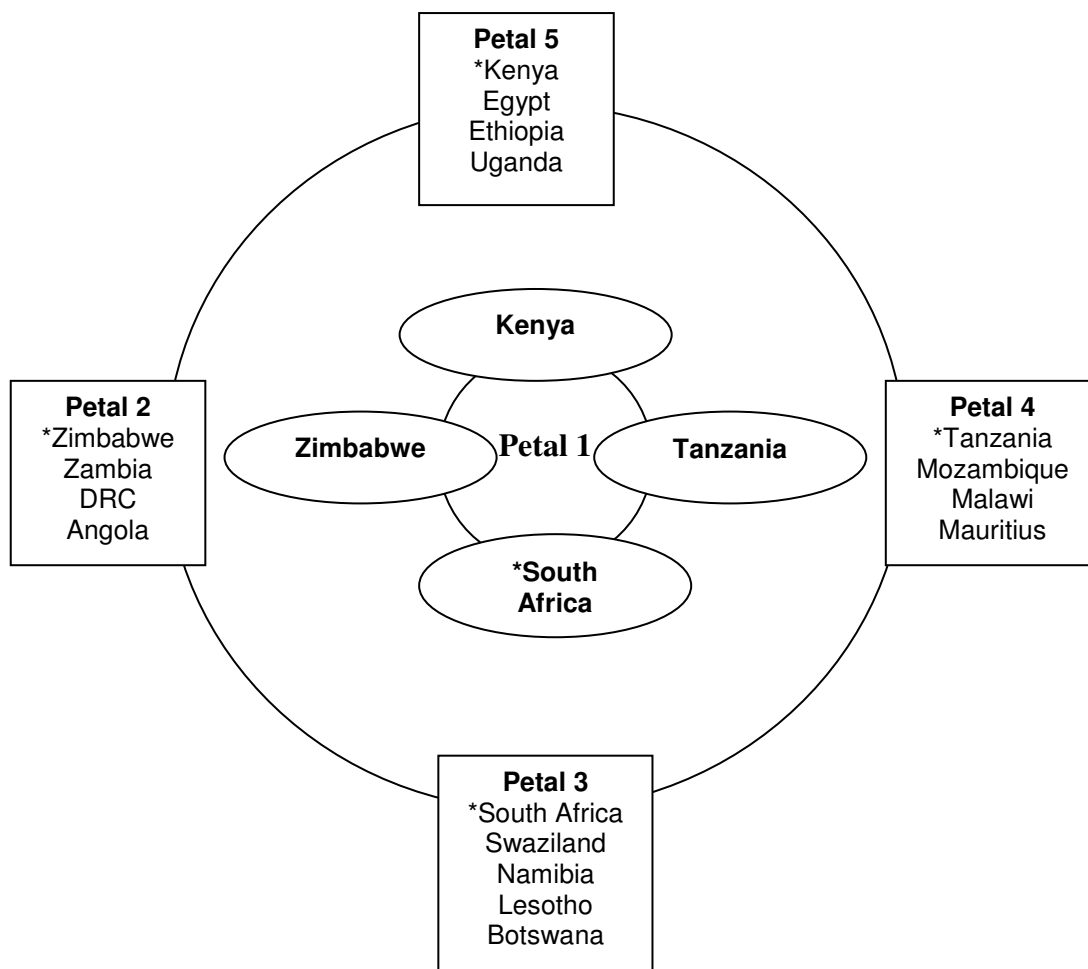


Figure 1: Organisation of the SADCMET.M.M.S1 comparison. The NMI marked with an asterisk was the pilot laboratory for that Petal.

Later Angola, with the approval of the SADCMET working group for mass (WG-M) chairman Mr David Toniou, was withdrawn from participation as it did not submit results.

The pilot laboratory was NMISA, South Africa with its address as follows:

Mr BF van der Merwe

National Metrology Institute of South Africa (NMISA)

Private Bag X34

Lynnwood Ridge

0040

South Africa

4. PARTICIPANTS

The participating laboratories are listed in table 1 below:

Table 1: List of participants

NMI	Country
National Metrology Institute of South Africa (NMISA)	South Africa
Mauritius Standards Bureau (MSB),	Mauritius
Malawi Bureau of Standards (MBS)	Malawi
Scientific & Industrial Research & Development Centre (SIRDC)	Zimbabwe
Quality & Standards Authority of Ethiopia (QSAE),	Ethiopia
Instituto Nacional De Normalização E Qualidade (INNOQ),	Mozambique
Zambia Bureau of Standards (ZBS)	Zambia
Office Congolais de Contrôle (OCdC),	Democratic Republic of Congo (DRC)
Botswana Bureau of Standards (BOBS)	Botswana
Kenya Bureau of Standards (KEBS),	Kenya
Department of Standards	Lesotho
Uganda National Bureau of Standards (UNBS),	Uganda
Ministry of Enterprise and Employment	Swaziland
National Institute of Standards (NIS),	Egypt
Tanzania Bureau of Standards (TBS),	Tanzania
Weights and Measures Namibia	Namibia

5. DESCRIPTION OF ARTEFACTS

Four 1 kg mass standards that belong to the NMISA were made available for the comparison. The standards are made of nickel chrome and have been calibrated by NMISA over numerous years, proving their stability. They were assigned a density of 8422 kg/m³.

6. TRANSPORTATION AND TIME SCHEDULE

The weights were transported in a wooden case. It was the responsibility of the participating laboratory, when it had the weight, to organize and make all necessary arrangements to transport the wooden case containing the weight, to the next participating laboratory through shipment or by hand-carrying, and ensuring that all necessary customs and importation documents (Carnet, where needed) were in order.

Table 2: Time schedule for Petal 1

NMI	Country	Week of arrival
NMISA	South Africa	7 February 2005
KEBS	Kenya	14 March 2005
TBS	Tanzania	18 April 2005
National Metrology Institute	Zimbabwe	30 May 2005
NMISA	South Africa	11 July 2005

Petals 2 to 5

The time-schedule of each of the Petals was discussed and agreed between the laboratories in each Petal. The pilot laboratory completed the time-schedule and ensured that it was kept. The deadline for the return of the artefacts to NMISA was the end of February 2006, results to be submitted by end of March 2006.

7. SUMMARY OF THE RESULTS REPORTED BY THE PARTICIPANTS**7.1 VALUES OF MASS AND EXPANDED UNCERTAINTY OF MEASUREMENT**

Sixteen of the seventeen laboratories submitted results and all attempts to solicit results from the remaining laboratory failed so the report was compiled without those results. The results as reported by the participating laboratories were converted to conventional mass where needed, thus all results in this report refer to conventional mass.

Table 3: Results for Petal 1

Lab.Code	Result (g)	Expanded uncertainty as claimed by NMI (g)
L-01	1 000,006 8	$\pm 0,000 5$
L-15	1 000,007 3	$\pm 0,000 7$
L-13	1 000,006 9	$\pm 0,001 0$
L-09	1 000,006 0	$\pm 0,000 8$
L-01	1 000,006 8	$\pm 0,000 5$

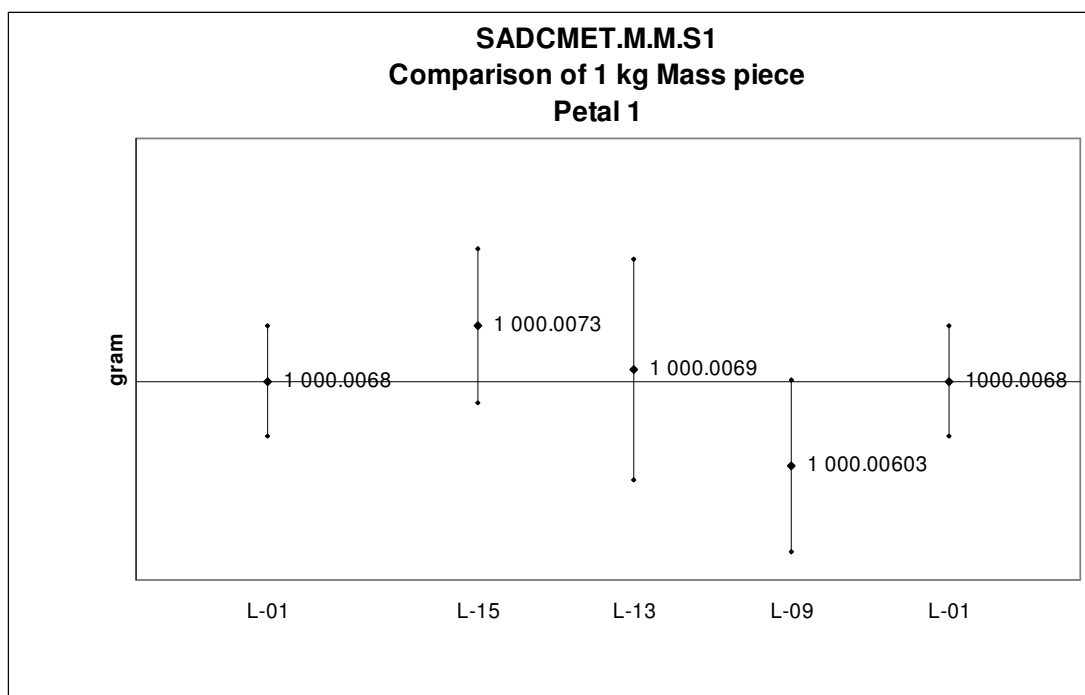
Graph 1: Results for Petal 1

Table 4: Results for Petal 2

Lab.Code	Result (g)	Expanded uncertainty as claimed by NMI (g)
L-01	1 000,006 7	$\pm 0,000 5$
L-02	1 000,008 3	$\pm 0,005$
L-14	1 000,000 7	$\pm 0,004 4$
L-04	1 000,006 8	$\pm 0,000 1$
L-05	1 000,005 2	$\pm 0,002$
L-01	1 000,006 5	$\pm 0,000 5$

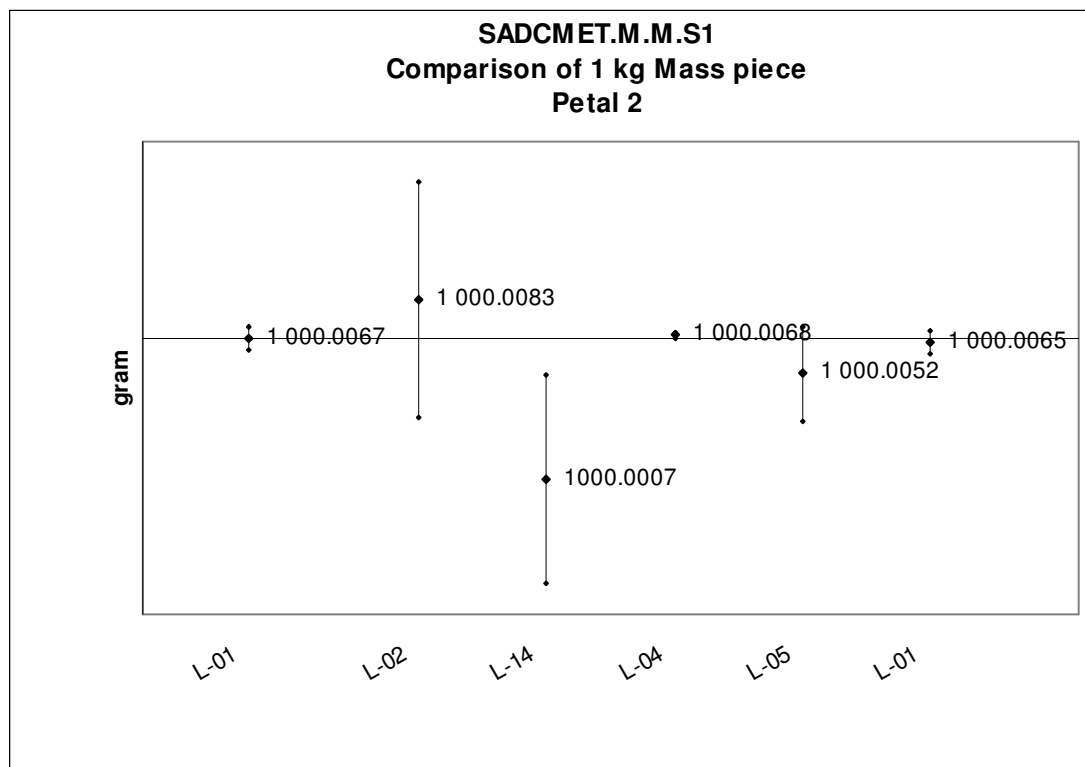
Graph 2: Results for Petal 2

Table 5: Results for Petal 3

Lab. Code	Result (g)	Expanded uncertainty as claimed by NMI (g)
L-01	1 000,006 8	$\pm 0,000 5$
L-15	1 000,006 9	$\pm 0,001 0$
L-07	1 000,006 1	$\pm 0,001 1$
L-08	1 000,005 1	$\pm 0,007 2$
L-15	1 000,007 4	$\pm 0,000 6$
L-01	1 000,006 8	$\pm 0,000 5$

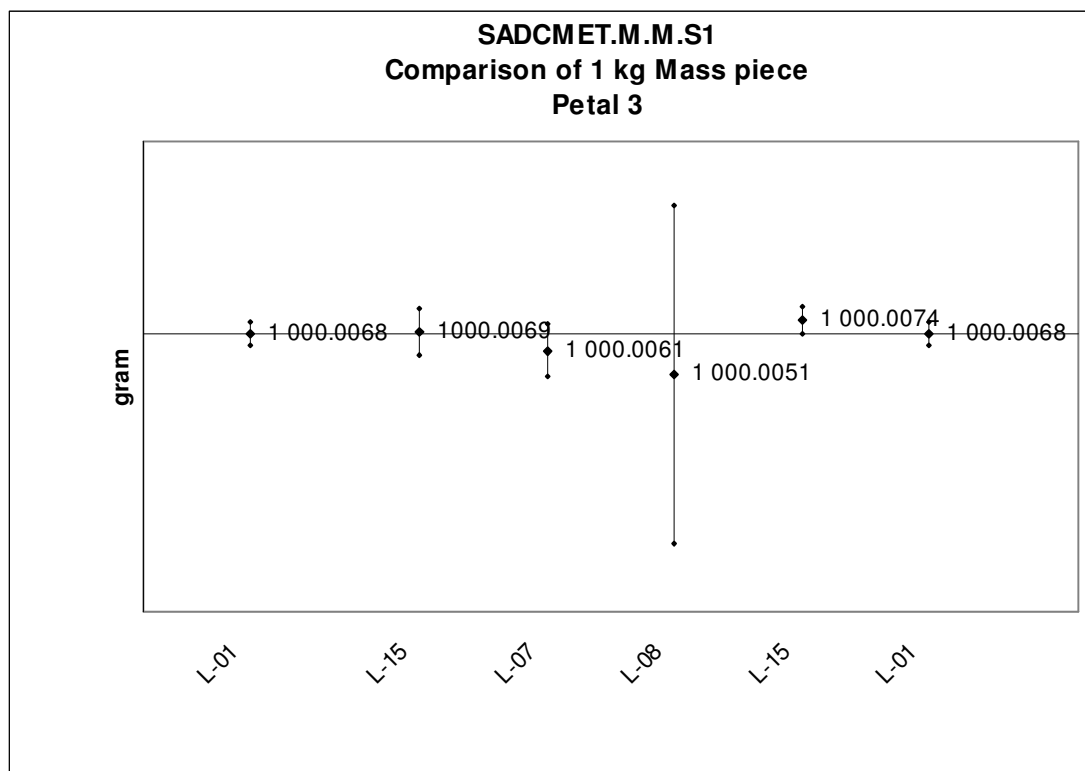
Graph 3: Results for Petal 3

Table 6: Results for Petal 4

Lab. Code	Result (g)	Expanded uncertainty as claimed by NMI (g)
L-01	1 000,006 9	$\pm 0,000 5$
L-09	1 000,007 0	$\pm 0,000 2$
L-12	1 000,006 8	$\pm 0,000 1$
L-16	1 000,006 9	$\pm 0,001 6$
L-11	1 000,006 8	$\pm 0,000 3$
L-09	1 000,007 0	$\pm 0,000 2$
L-01	1 000,006 9	$\pm 0,000 5$

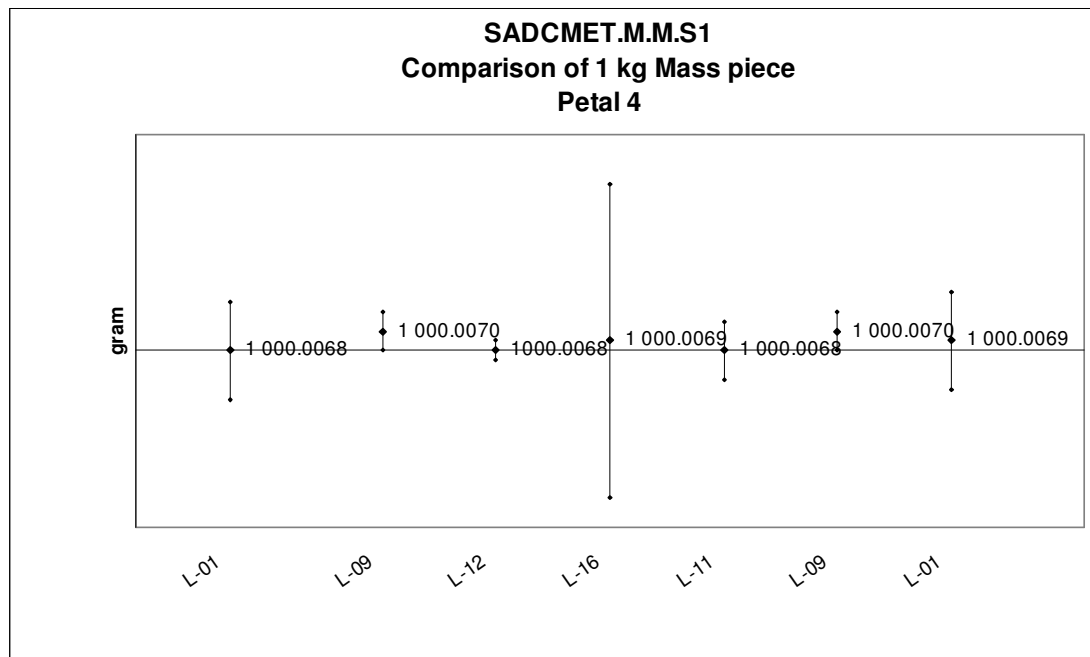
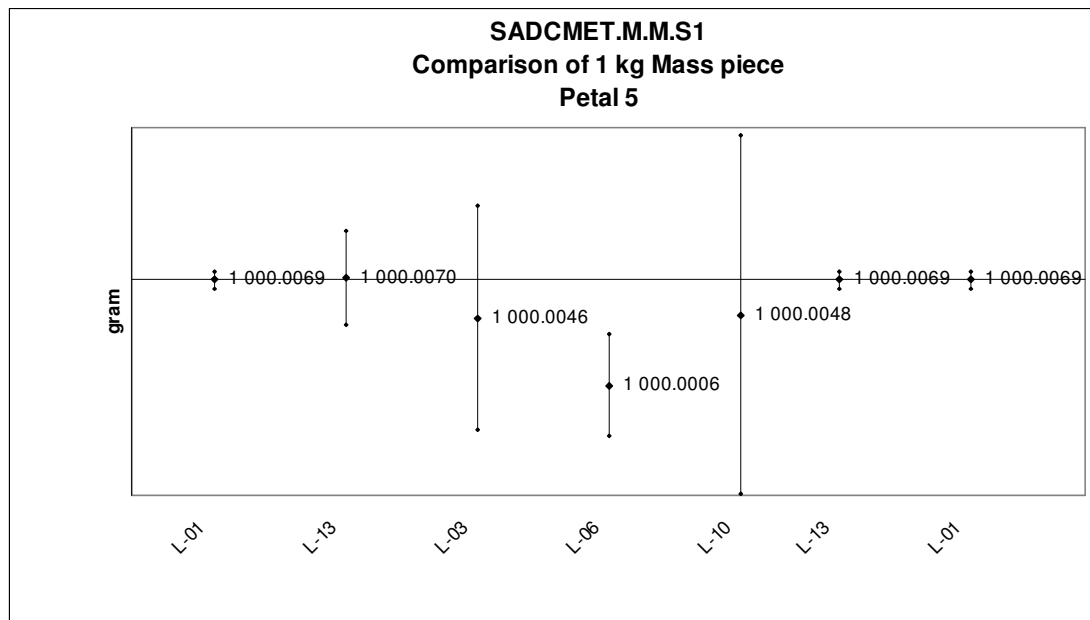
Graph 4: Results for Petal4

Table 7: Results for Petal 5

Lab. Code	Result (g)	Expanded uncertainty as claimed by NMI (g)
L-01	1 000,006 9	$\pm 0,000 5$
L-13	1 000,007 0	$\pm 0,002 8$
L-03	1 000,004 6	$\pm 0,006 7$
L-06	1 000,000 6	$\pm 0,003$
L-10	1 000,004 8	$\pm 0,011$
L-13	1 000,006 9	$\pm 0,000 5$
L-01	1 000,006 9	$\pm 0,000 5$

Graph 5: Comparison of results for Petal 5

7.2. STABILITY OF THE TRAVELLING STANDARDS

The standards were calibrated by the NMISA before the start of Petal 1 and at the end of the comparison. The results are reported as Conventional Mass.

Table 8: Stability of the artefacts

	NMISA Feb 2005	SIRDC	TBS	KEBS	NMISA Sept 2007
1 kg #1	1 000,006 7				1 000,006 5
σ (g)	$\pm 0,000 02$				$\pm 0,000 07$
1 kg #2	1 000,006 8				1 000,006 8
σ (g)	$\pm 0,000 02$				$\pm 0,000 07$
1 kg #3	1 000,006 9				1 000,006 9
σ (g)	$\pm 0,000 02$				$\pm 0,000 07$
1 kg #4	1 000,006 9	1 000,007 3	1 000,006 9	1 000,006 0	1 000,006 9
σ (g)	$\pm 0,000 02$				$\pm 0,000 07$

The worst case standard deviation was used for each σ value. The results show that the weights were stable over the period of calibration. The OIML uncertainty requirement for class F1 1 kg weights is $\pm 0,002$ g.

7.3. ANALYSIS OF COMPARISON DATA, CALCULATING THE REFERENCE VALUE AND LINKING TO APMP-IC-3-96

The comparison results were analysed by comparing the results of the participants with the comparison reference values as measured by the NMISA. The comparison reference value is link to the KCRV of APMP-IC-3-96 via the result of the pilot laboratory (NMISA) and the result of National Institute of Standards (NIS) Egypt that both participated in APMP-IC-3-96. The difference between the result of the pilot laboratory and the result of National Institute of Standards (NIS) Egypt, in Patel 4 is 0,000 1g, well within the uncertainty of the comparison reference value of 0,000 5g ($k=2$).

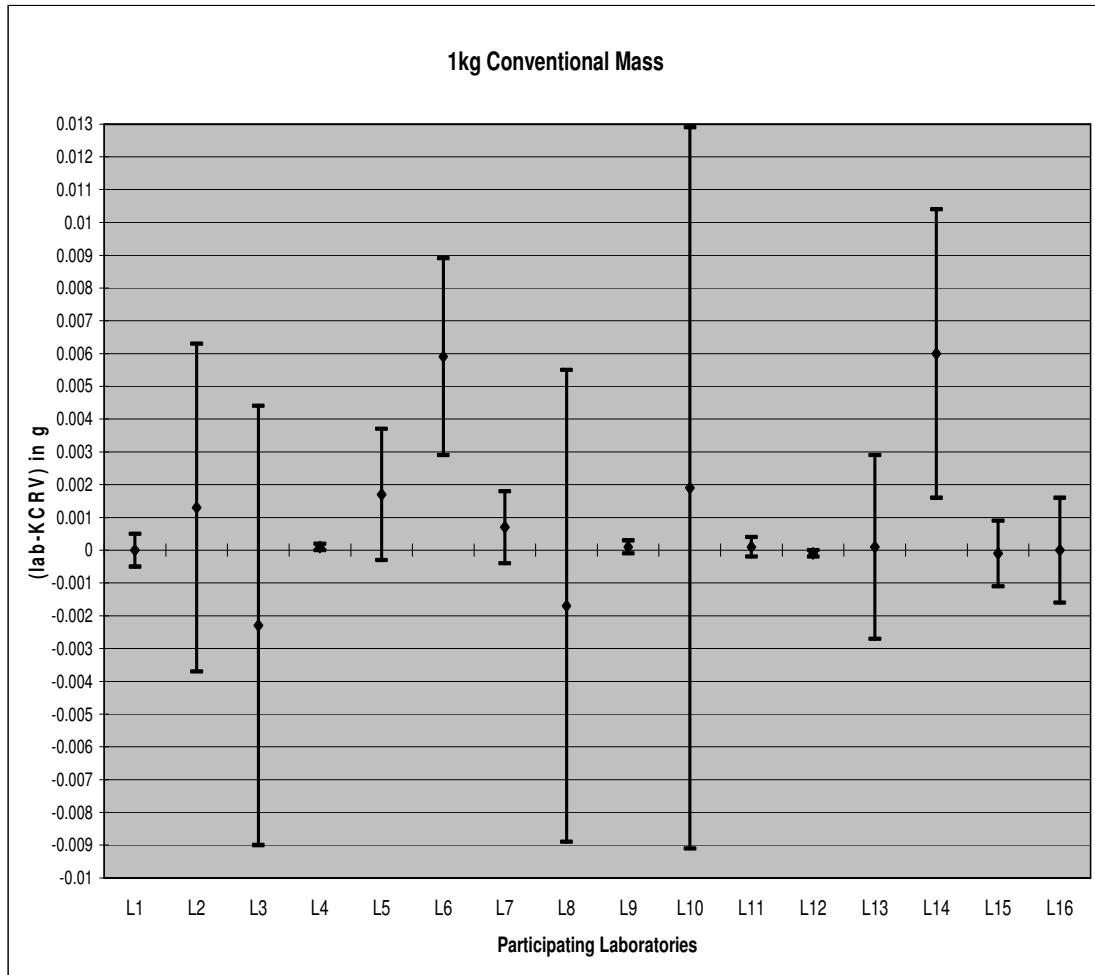
The difference between the mass values determined by the participants and the KCRV of APMP-IC-3-96 was calculated and is noted as $m\Delta$ in table 9 the uncertainties given are those as given by the participating laboratories.

The results of Petal 1 is not reflected in table 9, these results were of a pilot study and were used to determine the degree of equivalence between the pilot laboratories before the comparison was started. The first results of the pilot laboratories in Petals 2 to 5 were used as reported results of the respective laboratories, the set of second results were merely to establish if the artefacts were damaged during transportation between laboratories in the respective Petals.

Table 9: Differences between the participant's result and the KCRV ($m\Delta$) and assigned expanded uncertainties U with a level of confidence of 95%

Lab. Code	$m\Delta$ (g)	U (g)
L-01	0	0,000 5
L-02	0,001 3	0,005
L-03	0,002 3	0,006 7
L-04	0,000 1	0,000 1
L-05	0,001 7	0,002
L-06	0,005 9	0,003
L-07	0,000 7	0,001 1
L-08	0,001 7	0,007 2
L-09	0,000 1	0,000 2
L-10	0,001 9	0,011
L-11	0,000 1	0,000 3
L-12	0,000 1	0,000 1
L-13	0,000 1	0,002 8
L-14	0,006 0	0,004 4
L-15	0,000 1	0,001 0
L-16	0	0,001 6

Graph 6: Mass values assigned by the participating NMIs with bars representing expanded uncertainties. Zero value corresponds to the KCRV of APMP-IC-3-96. The uncertainty of the comparison reference value is 0,005g (k=2).



7.4. EQUIVALENCE BETWEEN ANY COMBINATION OF TWO PARTICIPATING LABORATORIES

The difference between the reported values of the participant A and participant B is calculated using the pilot's laboratory measurements as a link, because the pilot's reference values is considered constant and an average of the initial and final measurements of the travelling standards in each Petal as the best estimate.

Table 10: Difference in assigned mass value between laboratory A and laboratory B for 1 kg (conventional mass) in grams

	L01	L02	L03	L04	L05	L06	L07	L08	L09	L10	L11	LL12	L13	L14	L15	L16
L01	0.0000	-0.0016	0.0023	-0.0001	0.0015	0.0063	0.0001	-0.0001	-0.0001	0.0021	0.0000	0.0001	-0.0001	0.0060	-0.0001	-0.0001
L02	-0.0016	0.0000	0.0039	0.0015	0.0031	0.0079	0.0017	0.0015	0.0015	0.0037	0.0016	0.0017	0.0015	0.0076	0.0015	0.0015
L03	0.0023	-0.0039	0.0000	-0.0024	-0.0008	0.0040	-0.0022	-0.0024	-0.0024	-0.0002	-0.0023	-0.0022	-0.0024	0.0037	-0.0024	-0.0024
L04	-0.0001	-0.0015	0.0024	0.0000	0.0016	0.0064	0.0002	0.0000	0.0000	0.0022	0.0001	0.0002	0.0000	0.0061	0.0000	0.0000
L05	0.0015	-0.0031	0.0008	-0.0016	0.0000	0.0048	-0.0014	-0.0016	-0.0016	0.0006	-0.0015	-0.0014	-0.0016	0.0045	-0.0016	-0.0016
L06	0.0063	-0.0079	-0.0040	-0.0064	-0.0048	0.0000	-0.0062	-0.0064	-0.0064	-0.0042	-0.0063	-0.0062	-0.0064	-0.0003	-0.0064	-0.0064
L07	0.0001	-0.0017	0.0022	-0.0002	0.0014	0.0062	0.0000	-0.0002	-0.0002	0.0020	-0.0001	0.0000	-0.0002	0.0059	-0.0002	-0.0002
L08	-0.0001	-0.0015	0.0024	0.0000	0.0016	0.0064	0.0002	0.0000	0.0000	0.0022	0.0001	0.0002	0.0000	0.0061	0.0000	0.0000
L09	-0.0001	-0.0015	0.0024	0.0000	0.0016	0.0064	0.0002	0.0000	0.0000	0.0022	0.0001	0.0002	0.0000	0.0061	0.0000	0.0000
L10	0.0021	-0.0037	0.0002	-0.0022	-0.0006	0.0042	-0.0020	-0.0022	-0.0022	0.0000	-0.0021	-0.0020	-0.0022	0.0039	-0.0022	-0.0022
L11	0.0000	-0.0016	0.0023	-0.0001	0.0015	0.0063	0.0001	-0.0001	-0.0001	0.0021	0.0000	0.0001	-0.0001	0.0060	-0.0001	-0.0001
L12	0.0001	-0.0017	0.0022	-0.0002	0.0014	0.0062	0.0000	-0.0002	-0.0002	0.0020	-0.0001	0.0000	-0.0002	0.0059	-0.0002	-0.0002
L13	-0.0001	-0.0015	0.0024	0.0000	0.0016	0.0064	0.0002	0.0000	0.0000	0.0022	0.0001	0.0002	0.0000	0.0061	0.0000	0.0000
L14	0.0060	-0.0076	-0.0037	-0.0061	-0.0045	0.0003	-0.0059	-0.0061	-0.0061	-0.0039	-0.0060	-0.0059	-0.0061	0.0000	-0.0061	-0.0061
L15	-0.0001	-0.0015	0.0024	0.0000	0.0016	0.0064	0.0002	0.0000	0.0000	0.0022	0.0001	0.0002	0.0000	0.0061	0.0000	0.0000
L16	-0.0001	-0.0015	0.0024	0.0000	0.0016	0.0064	0.0002	0.0000	0.0000	0.0022	0.0001	0.0002	0.0000	0.0061	0.0000	0.0000

10. CONCLUSIONS

1. The majority of the participating laboratories achieved results equivalent to OIML Class F1.
2. The laboratories were not specifically asked to report the results in conventional mass. The variety of reporting, Absolute, Conventional and Effective Mass without specifically saying what was being reported would cause customers confusion and should be more specific in the certificates.
3. Some of the uncertainties were both incorrectly calculated (not according to the GUM) and had serious deficiencies.
4. The time schedule was seriously compromised and some blame should be placed at the customs departments of the various countries.
5. One wooden box was reported damaged, it had to be repaired by the laboratory who reported it. The weight did not seem to suffer any significant change.
6. The program co-ordinator sent out two notifications to laboratories for re-checking and re-confirming their results while preparing the Draft A report. Of the two only one responded.
7. One laboratory has still not submitted any results.

11. Acknowledgement

The program co-ordinator would like to thank all the laboratory staff and their management for their co-operation during the inter-comparison. The results are a great improvement on the last attempt at reaching some equivalence in the SADC MET Region.