



المركز الوطني للقياس والمعايرة
National Measurement & Calibration Center



المواصفات السعودية
Saudi Standards

الهيئة السعودية للمواصفات والمقاييس والجودة
Saudi Standards, Metrology and Quality Org.

Technical Protocol for the Bilateral Comparison of Mass Standards (5 kg, 100 g, 10 g, 5 g, 500 mg, 100 mg)

GULFMET.M.M-K7.2026

Name: National Measurement and Calibration Center (NMCC)
Address: Riyadh - Al Muhammadiyah - in front of King Saud University
P.O.Box: 3437 Riyadh 11471- KINGDOM of SAUDI ARABIA
Tel/Fax: Tele: 0096 112529715, Phone: +966 500602523
Technical Contact: Mr. Saud AlQarni (sm.qarni@saso.gov.sa)





المركز الوطني للقياس والمعايرة
National Measurement & Calibration Center



التجمع الخليجي للمترولوجيا

المواصفات السعودية
Saudi Standards



الهيئة السعودية للمواصفات والمقاييس والجودة
Saudi Standards, Metrology and Quality Org.

Contents

1General Information	3
2Timetable for the Comparison	3
3Participating Institutes	3
4Plan of Comparison	4
5Description of the Travelling Standards	4
6Transport and Handling of the Travelling Standards	5
6.1General instructions	5
6.2Sending the travelling standards	5
6.3Receiving the travelling standards	6
7Measurement and calibration procedures	6
7.1Cautions	6
7.2Measurements required	6
7.3Reporting	6
8Statistical evaluation	7
8.1Reference values and their associated uncertainties	7
8.2Evaluation of degree of equivalent	7
8.3Evaluation of the <i>En – numer</i>	7
9References	8
Annexes	9
ANNEX B. Transportation Form (Arrival)	9
ANNEX C. Transportation Form (Departure)	10
ANNEX D. Travelling Standard Visual Inspection Form	11
ANNEX F. Uncertainty Budget	15
ANNEX G. Characteristics of Instruments and Measuring Room and Description of Air Buoyancy Determination	16
ANNEX H. Traceability	18



1 General Information

The present regional bilateral comparison in calibration of mass standards aims to evaluate the degree of equivalence and provide evidence supporting the quoted Calibration Measurement Capabilities (CMCs) of the participating NMI/DIs,

DGSM, will provide the travelling artifacts, and SASO-NMCC agreed to act as Pilot Laboratory and be the Support Laboratory. Conduct the associated initial and final measurements, perform the statistical analysis, and issue the initial and final reports.

2 Timetable for the Comparison

Table 1. Timetable for the comparison

- Start date: 01/2026

Participant	measurement start	Send Artifact	Send The results to NMCC
SASO-NMCC	04/2026	21/05/2026	-
DGSM	24/05/2026	14/06/2026	05/07/2026
SASO-NMCC	16/06/2026	-	-

- NMCC-SASO will issue Report No.1 on 07/2026

3 Participating Institutes

Table 2. Shows participating Institutes and Technical Contacts

Participating Institutes	Acronym	Technical Contact
SASO - National Measurement and Calibration Center Riyadh - Al Muhammadiyah - in front of King Saud University PO. B 3437 Riyadh 11471 KINGDOM of SAUDI ARABIA http://www.saso.gov.sa/	SASO-NMCC (Pilot Lab)	Saud AlQarni email: sm.qarni@saso.gov.sa tel: +966 50 060 2523
Directorate General for Standards & Metrology, National Metrology Center P.O 550 - Postal Code 100 Muscat Oman	DGSM	Abdullah Alkadori a.alkadori@tejarah.gov.om +96897606023



4 Plan of Comparison

The participating institute will receive stainless steel travelling standards in the order as listed in Table 1. The participating will have **three weeks** for the comparison and **one week** for transportation of the travelling standards to next participant. The results by participant are expected to be reported to the PL within **three weeks** following the completion of their measurements.

In case the involved laboratory confronts with unexpected delays, the pilot lab should be informed as soon as possible about the cause and the expected duration of the delay.

5 Description of the Travelling Standards

The travelling standards are (5 kg, 100 g, 10 g, 5 g, 500 mg, 100 mg) stainless steel knob weights. The weights are CLASS E2 in Figure 1.

5.1 The stability of the artifacts

The PL will track the stability of the travelling standards via the measurements in the beginning and at the end of the entire comparison. The stability criterion demonstrates that;

$$\delta^s \leq U(Y_{ref}) \quad 1$$

where δ^s is the difference between the two measurements, and $U(Y_{ref})$ is the uncertainty of the reference value expanded using a coverage factor of $k = 2$.

The transfer standard set consists of weights of nominal values 5 kilograms, 100 grams, 10 grams, 5 grams, 500 milligrams and 100 milligrams. The densities of the mass standard have been determined by SASO-NMCC and are listed in Table 3.

Table 3. The data of the travelling standards.

	5 kg	100 g	10 g	5 g	500 mg	100 mg
Density ρ (kg/m ³)						
Density Uncertainty U_ρ (kg/m ³)						





Figure 1. The transfer standards.

6 Transport and handling of the travelling standards

6.1 General instructions

- The cost for transportation of the travelling standards, any custom charges and any damage that may occur within the corresponding country or while in transit will be covered by the concerned institute.
- In case, there is damage on the travelling standards during transport, the receiving institute should report details by email and return them to the PL as soon as possible. PL will be responsible for making a judgment on the suitability of the standards for the rest of the comparison.
- In case of delay in sending the travelling standards, the institute sending them must report to PL and sending and receiving institutes must strive to resolve the transportation failure in order to minimize its impact on the running of the comparison.

6.2 Sending the travelling standards

- The travelling standards should be inspected visually before sending them to the next laboratory. Any possible scratches, surface contamination or other damage shall be noted in the travelling standard visual inspection form given in Annex D. The form should be sent to the PL via email within 24 hours of inspection.
- Annex C shall be completed and sent to the receiving laboratory and PL via email.
- Appropriate packaging for a safe transportation of travelling standards should be assured by the sending institute.
- **In principle, "the transportation and delivery of the travelling standards should be performed hand-to-hand between participants."**
- Photographs of the open containers as given in Figure 1 should be provided for the customs and airport security. In addition, the participating laboratory should prepare a document describing the standards and their metrological importance.
- In case the containers must be opened for inspection the person, transporting the standards should carry out all handling operations using appropriate gloves provided by PL.
- It should be ensured by the sending institute that the travelling standards will be delivered to the next participating institute on time according to the planned schedule given in Table 1.



6.3 Receiving the travelling standards

- The mass standards should be moved to the mass laboratory where the measurements will be carried out.
- Photographs of the open containers should be taken.
- The travelling standards should be inspected visually as soon as they arrive at the receiving institute after transport. Any possible scratches, surface contamination or other damage shall be noted in the travelling standard visual inspection form given in Annex D.
- Annex B shall be completed.

7 Measurement and calibration procedures

7.1 Cautions

- Each participant shall calibrate the travelling standards against their own **stainless steel** mass standards.
- The standards should **never be touched by bare hands** but with appropriate tools like pinchers and gloves.
- When not in the weighing instrument for calibration, the mass standards should be stored in their storage boxes or on a plate covered with a clean bell jar where they are protected from dust, aerosols and vapor.
- Before calibration, the mass standards should be kept in the laboratory within an appropriate acclimatization time for temperature stabilization.
- Before calibration, dust or any foreign particle should be removed from the surface of the standard by using a soft brush. Care must be taken not to scratch the surface properties of the weight. **Never use alcohol, distilled water or other solvents while cleaning weights.**
- The magnetic properties of the travelling standards should **never** be checked.

7.2 Measurements required

The NMI is required to determine the following items:

- the mass value of the travelling standards in air to the best of its ability and their standard uncertainty ($k=2$),
- The mass difference between the travelling standards,
- The air density for the buoyancy corrections should be determined by using the CIPM-2007 formula [4]. For institutes with buoyancy artifacts, it is recommended that the air density is determined by means of both methods (CIPM-2007 formula and air buoyancy artifacts).

7.3 Reporting

The templates for reporting the results of measurements, uncertainties, data of the ambient conditions, instruments used and traceability of the reference standards of participating laboratories should be filled out and sent to the PL **within three weeks** after the measurements are completed (See Table 1 for the date of sending the results).



- Participating NMI shall determine the **conventional values** of the travelling standards and their associated uncertainties by comparing against their own **stainless steel** working standards together with the environmental data during calibration. All uncertainties should be reported in accordance with the Guide to the expression of uncertainty in measurements (GUM) document using a coverage factor of unity ($k = 2$) [5]. The results are expected to be reported by filling Annex E.
- A complete table of uncertainty budget (including estimated degrees of freedom) is requested. Annex F will be used for providing the required information.
- The participant will be responsible for giving the pilot laboratory general information on its calibration abilities. The required information shall be provided by filling Annex G.
- Annex H should be filled for the traceabilities of the standards (including additional weights) used for the calibration back to the international prototype of the kilogram.

8 Statistical evaluation

8.1 Reference values and their associated uncertainties

The reference values and their associated expanded uncertainties will be provided by SASO-NMCC pilot NMI.

8.2 Evaluation of degree of equivalent

The degree of equivalent, and its associated uncertainty of the participating NMI will be calculated as;

$$d_i = y_i - Y_{ref} \quad 2$$

$$U(d_i) = k u(d_i), \quad u(d_i) = \sqrt{u^2(y_i) + u^2(Y_{ref})} \quad 3$$

8.3 Trueness assessment

The aim of this statistical test is to investigate whether there is a significant bias in the results reported by the participant. The error in the measurements' results reported by participant will be assessed regardless of his reported uncertainty. A suitable statistical criterion demonstrates that the results reported by the participant fulfills the following criterion;

$$\Delta_i \leq X_{ref} \pm 2\sigma, \quad p - value^{t-test} \geq 0.05 \quad 4$$

The $t - test$ can be subjected to provide a numerical assessment for the deviation between the results reported by the participant and the reference value.

8.4 Evaluation of the $E_n - number$

The performance of the participating NMI will be assessed via the normalized $E_n - number$ which is expressed as;

$$E_n - number = \frac{(y_i - Y_{ref})}{\sqrt{U^2(y_i) + U^2(Y_{ref})}} \quad 5$$

where y_i and $U(y_i)$ are the corrections and its associated expanded uncertainty reported by the participating NMI, while the Y_{red} and $U(Y_{ref})$ are the correction and its expanded uncertainty of the





reference value. The reported uncertainties were expanded using a coverage factor $k = 2$. The consistency of the results reported by the participating NMI demonstrates that $|E_n - numer| \leq 1.0$. Otherwise, the uncertainty estimate need to a review or the measurement require a correction.

9 References

1. OIML R-111 Weights of classes E1, E2, F1, F2, M1, M1-2, M2, M2-3 and M3
2. Part 1: Metrological and technical requirements, 2004.
3. Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement (GUM), JCGM 100, First edition, September 2008(available on the BIPMwebsite:http://www.bipm.org/utis/common/documents/jcgm/JCGM_100_2008_E.pdf).
4. OIML R-111 Weights of classes E1, E2, F1, F2, M1, M1-2, M2, M2-3 and M3
- 5.Part 1: Metrological and technical requirements, 2004.



Annexes

ANNEX B. Transportation Form (Arrival)

Please fill in the transportation form on the arrival of travelling standards and send it to the PL via email within 24 hours from package receipt.

Arrival of the travelling standards		
Filled by		
Arrival date		
Sending institute		
Receiving institute		
Delivery by (If by courier, write down the name of the courier company)	<input type="checkbox"/> Hand-carriage	<input type="checkbox"/> Courier
Conditions of the travelling standards on arrival		
Transportation box		
Was the transportation box in good condition?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Was the transportation box locked with the padlocks?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Travelling Standards		
Any scratches, surface contamination or other damage on the travelling standards? (Use travelling standard visual inspection form for indicating the scratches)	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Other Remarks		
List of package content as arrival		
5 kg mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
100 g mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
10 g mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
5 g mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
500 mg mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
100 mg mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Gloves	<input type="checkbox"/> YES	<input type="checkbox"/> NO
1 wood box	<input type="checkbox"/> YES	<input type="checkbox"/> NO
1 tweezers	<input type="checkbox"/> YES	<input type="checkbox"/> NO

ANNEX C. Transportation Form (Departure)

Please fill in the transportation form on the departure of travelling standards and send it to the PL and receiving institute via email.

Departure of the travelling standards		
Filled by		
Departure date		
Sending institute		
Receiving institute		
Delivery by (If by courier, write down the name of the courier company)	<input type="checkbox"/> Hand-carriage	<input type="checkbox"/> Courier
Conditions of the travelling standards on arrival		
Transportation box		
Was the transportation box in good condition?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Was the transportation box locked with the padlocks?	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Travelling Standards		
Any scratches, surface contamination or other damage on the travelling standards? (Use travelling standard visual inspection form for indicating the scratches)	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Other Remarks		
List of package content as departure		
5 kg mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
100 g mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
10 g mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
5 g mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
500 mg mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
100 mg mass standard	<input type="checkbox"/> YES	<input type="checkbox"/> NO
Gloves	<input type="checkbox"/> YES	<input type="checkbox"/> NO
1 wood box	<input type="checkbox"/> YES	<input type="checkbox"/> NO
1 tweezers	<input type="checkbox"/> YES	<input type="checkbox"/> NO



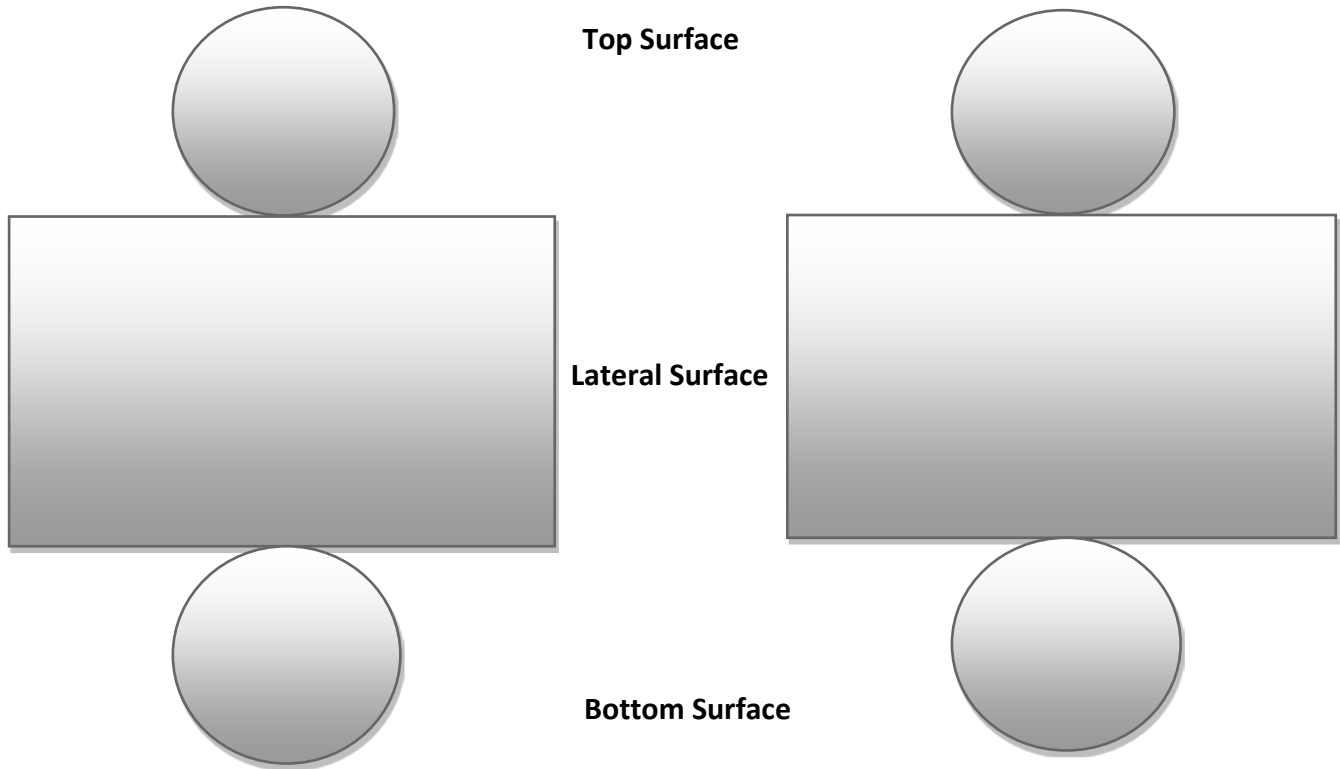
ANNEX D. Travelling Standard Visual Inspection Form

Filled by	
Date	
Institute	

Record any marks (scratches, contamination or other damage) on the travelling standards and send it to the PL via email within 24 hours from package receipt. Use the same format both for arrival and departure of the travelling standards. Additional remarks may be noted in the space provided in the transportation forms as "other remarks".

5 kg Mass Standard

100 g Mass Standard

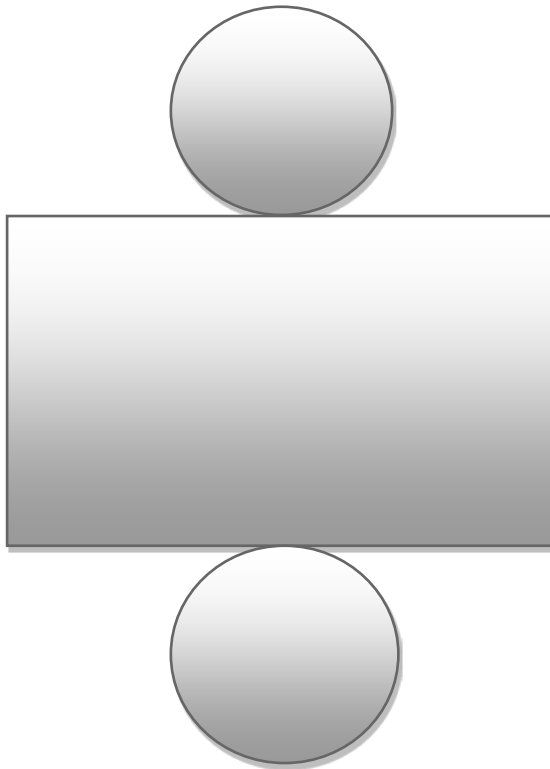


Filled by	
Date	
Institute	

Record any marks (scratches, contamination or other damage) on the travelling standards and send it to the PL via email within 24 hours from package receipt. Use the same format both for arrival and departure of the travelling standards. Additional remarks may be noted in the space provided in the transportation forms as "other remarks".

10 g Mass Standard

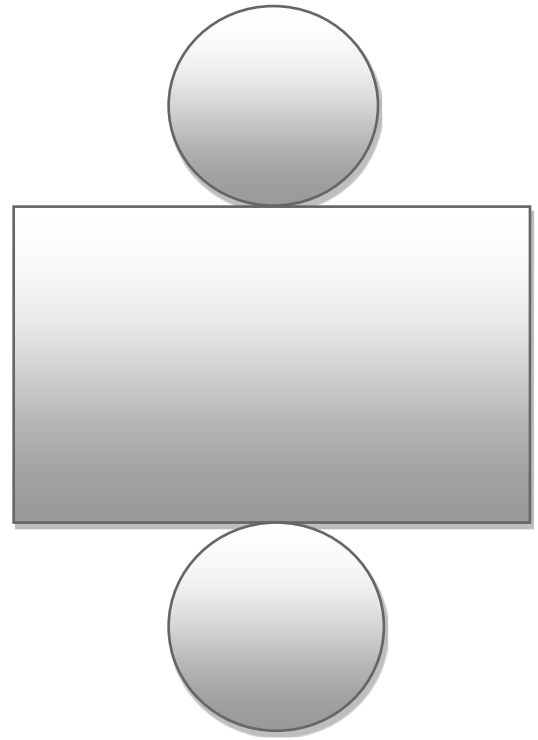
5 g Mass Standard



Top Surface

Lateral Surface

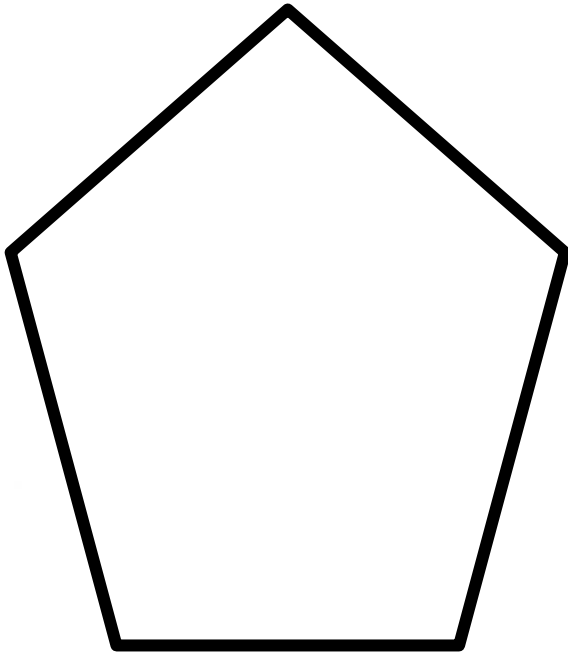
Bottom Surface



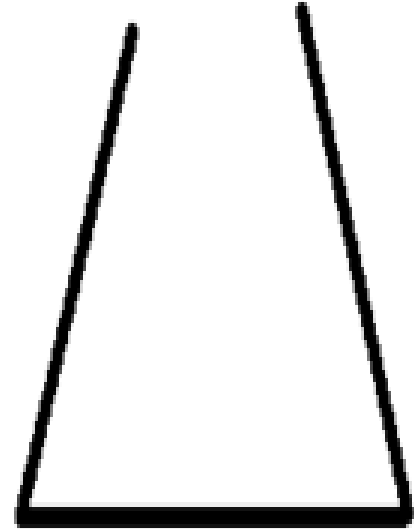
Filled by	
Date	
Institute	

Record any marks (scratches, contamination or other damage) on the travelling standards and send it to the PL via email within 24 hours from package receipt. Use the same format both for arrival and departure of the travelling standards. Additional remarks may be noted in the space provided in the transportation forms as “other remarks”.

500 mg Mass Standard



100 mg Mass Standard



Top Surface

Lateral Surface

Bottom Surface



ANNEX E. Calibration Results and Environmental Conditions

Filled by	
Date	
Institute	

Mass Values: All uncertainties should be reported in accordance with ISO guidelines using a coverage factor of unity ($k=2$).

Mass ID	conventional mass $m - m_0$ (mg)	conventional mass Uncertainty U_m (mg)	Number of cycles N
5 kg			
100 g			
10 g			
5 g			
500 mg			
100 mg			

Environmental data during calibration:

Insert the minimum and maximum values of the measured quantities and their uncertainties using a coverage factor of unity ($k=2$), for example: temperature t (°C): $20.4 - 20.6 \pm 0.1$.

Mass ID	Temperature t (°C)	Pressure p (mbar)	Relative Humidity h (%)
5 kg			
100 g			
10 g			



5 g			
500 mg			
100 mg			

ANNEX F. Uncertainty Budget

Filled by	
Date	
Institute	

Uncertainty Parameter	500 g	100 g	10 g	500 mg
Mass of the reference standard				
Instability of the reference standard				
Drift of the reference standard				
Volume of the reference standard				
Volume of the transfer standard				
Air density				
Balance linearity				
Balance sensitivity				
Balance reading				
Weighing difference				
Any other (Please specify)				

Uncertainty Budget: All uncertainties should be reported in accordance with ISO guidelines using a coverage factor of unity ($k=2$).

Use the additional spaces if necessary.



ANNEX G. Characteristics of Instruments and Measuring Room and Description of Air Buoyancy Determination

Filled by	
Date	
Institute	

Characteristics of the Instruments used for Air Density Determination:

Mass ID	Physical Quantity	Manufacturer	Range	Resolution	Standard Uncertainty
5 kg	Temperature t (°C)				
	Pressure p (mbar)				
	Relative Humidity h (%)				
100 g	Temperature t (°C)				
	Pressure p (mbar)				
	Relative Humidity h (%)				
10 g	Temperature t (°C)				
	Pressure p (mbar)				
	Relative Humidity h (%)				
5 g	Temperature t (°C)				
	Pressure p (mbar)				
	Relative Humidity h (%)				
500 mg	Temperature t (°C)				
	Pressure p (mbar)				
	Relative Humidity h (%)				
100 mg	Temperature t (°C)				
	Pressure p (mbar)				
	Relative Humidity h (%)				



Description of air buoyancy determination:

Characteristics of the Balance:

Mass ID	Manufacturer	Type	Range	Resolution	Standard Deviation	Manual/ Automatic
5 kg						
100 g						
10 g						
5 g						
500 mg						
100 mg						

Characteristics of the Measuring Room:

Mean Temperature	
Minimum Temperature	
Maximum Temperature	
Mean Humidity	
Minimum Humidity	
Maximum Humidity	
Mean Pressure	
Minimum Pressure	
Maximum Pressure	

