# CCM.M-K3.1 comparison / 50 kg Mass

The 7th of April 2010

G. MANN - T. MADEC - P.A. MEURY
Laboratoire Commun de Métrologie LNE-CNAM

**Abstract**

This comparison is a subsequent to the CCM.M-K3 comparison performed in 2001-2002 and published in 2005 [1]. This comparison is between the CEM (Spain) as participating laboratory and the LNE (France) as pilot laboratory.

The aim of this comparison was to compare the results obtained by each laboratory when calibrating the same two 50 kg stainless steel mass standards, one provided by CEM and one by LNE.

## 1. Introduction

The purpose of this document is to define the organisation of the subsequent comparison and to provide instructions on the transport of the transfer standards and the reporting of the measurement results.

It is defined by applying the “guidelines for CIPM key comparisons” (appendix F to the “MRA”).

## 2. Organisation

Two travelling 50 kg standards circulated between the pilot and the participant of the comparison, one belongs to LCM and the other one belongs to CEM.
The LCM standard was used to perform the loop 1. It was calibrated by LCM before and after the CEM calibration.
The CEM standard was used to perform the loop 2. It was calibrated by the CEM before and after the LCM calibration.

### *2.1 Participating laboratories*

#### 2.1.1 Pilot

| **Laboratory** | | **Country** |
|---|---|---|
| Laboratoire Commun de Métrologie LNE-CNAM | LCM | France |

#### 2.1.2 Participant

| **Laboratory** | | **Country** |
|---|---|---|
| Centro Español de Metrología | CEM | Spain |

### *2.2 Comparison scheme*

Two travelling 50 kg standards circulated among the participants.

The travel of the standards was set up in a circular form with two loops:

- Loop 1, using the first travelling standard (January 2009 to July 2009) from France to Spain, then return to France,
- Loop 2, using the second travelling standard (January 2009 to November 2009) from Spain to France, then return to Spain.

***Comparison schedule:***

| Dates | Activity |
|---|---|
| January 09 | By each laboratory, calibration of one's own travelling standard |
| January 09 | transfer CEM travelling standard from Spain to France then transfer LCM travelling standard from France to Spain |
| February – May 09 | By each laboratory, calibration of travelling standard of the other laboratory |
| June 09 | transfer LCM travelling standard from Spain to France then transfer CEM travelling standard from France to Spain |
| July 09 | New calibration of one's own travelling standard by LCM |
| November 09 | New calibration of one's own travelling standard by CEM |

Table 1 - Comparison schedule

### *2.3 Characteristics of the Mass standards*

*Loop 1: travelling standard **6'***

The LCM travelling standard, used in loop 1, is in stainless steel X 18 M 25 W and was manufactured by the ZWIEBEL company. It is cylinder with a circular fork groove. This standard is called "six comma (6')" and identified by a serial number engraved on the top plane face. A handling fork was supplied with this standard.

| **Parameter** | **Value** | **expanded uncertainty** *(95% coverage)* |
|---|---|---|
| Density at 20°C | 7 987.2 $kg.m^{-3}$ | 1.4 $kg.m^{-3}$ |
| Magnetic susceptibility | 3.30 $x10^{-3}$ | 0.60 $x10^{-3}$ |
| Height | 224.8 mm | 0.20 mm |
| Diameter | 190.0 mm | 0.20 mm |
| Height of centre of gravity above base | 110.9 mm | 0.40 mm |

Table 2: Characteristics of the LCM standard

Picture 1 - the LCM travelling standard (n°6')

*Loop 2 : travelling standard* ***MP9***

The CEM travelling standard, used in loop 2, is identified by a serial number engraved on the top plane face: number MP9. It has the following features:

| **Parameter** | **Value** | **expanded uncertainty** *(95% coverage)* |
|---|---|---|
| Density at 20°C | 8053.1 $kg.m^{-3}$ | 1,5 $kg.m^{-3}$ |
| Height | 306.9 mm | 0.2 mm |
| Diameter | 185.0 mm | 0.2 mm |
| Height of centre of gravity above base | 117.8 mm | 2.0 mm |

Table 3 : Characteristics of the CEM standard

Picture 2 - the CEM travelling standard (n°MP9)

2.4 Travelling conditions

Staff from CEM was in charged of standards transportation between institutes.

The travelling standards were examined on receipt and any scratches or other marks, if any, were recorded on the “Travelling standard visual inspection form”. This form was sent by fax or e-mail to LCM within 24 hours after the inspection.

### *2.5 Measurement*

#### *2.5.1 Cleaning*

No cleaning is applied to the standards. If necessary a light brushing was made with a soft-haired sable brush.

#### *2.5.2 Ambient conditions*

The measurements were made under ambient conditions of air. The parameters contributing to air density were recorded for each weighing and the air density was calculated using the CIPM 2007 formula.

#### *2.5.3 Weighing procedure*

The laboratory applied its own weighing procedure.

## 3. Results of the comparison

### *3.1 Stability of the travelling mass standards*

Each laboratory compared its one’s own travelling standards before and after calibration made by the other laboratory.

The results of these comparisons are given in tables 4a and 4b below.

| travelling standard 6’ LCM | | travelling standard MP9 CEM | |
|---|---|---|---|
| Date | value | Date | value |
| Jan 2009 | + 18.50 mg | Jan 2009 | - 80.50 mg |
| July 2009 | + 16.80 mg | Nov 2009 | - 82.06 mg |

Table 4a: Deviations *d* of the travelling standards from the nominal value

| travelling standard **6'** | | travelling standard **MP9** | |
|---|---|---|---|
| $\Delta d$ | $u(\Delta d)$ | $\Delta d$ | $u(\Delta d)$ |
| - 1.70 mg | 0.92 mg | - 1.56 mg | 0.84 mg |

Table 4b: drift $\Delta d$ of the travelling standards during the comparison and standard uncertainty $u(\Delta d)$ of this drift

These results show that the mass of the two travelling standards did not change significantly during the comparison.

### *3.2 Results reported by the CEM*

Table 5 shows the results and combined uncertainties as given by the CEM. Reported results of the participant ($m$: mass of the travelling standard - $m_0$; nominal value of the standard) are as follows:

$u\ (m\text{-}m_0)$ standard uncertainty reported.

| Loop 1 | Date | Laboratory | $m\text{-}m_0$ | $u(\text{m-m}_0)$ |
|---|---|---|---|---|
| **Travelling Standard 6'** | May 09 | CEM | + 17.64 mg | 3.96 mg |

| Loop 2 | Date | Laboratory | $m\text{-}m_0$ | $u_c$ |
|---|---|---|---|---|
| **Travelling Standard MP9** | January 09 | CEM | - 80.50 mg | 3.96 mg |
| | November 09 | CEM | - 82.06 mg | 3.96 mg |

Table 5 - Results reported by the CEM

### *3.3 Reference value coming from CCM.M-K3 comparison*

The two travelling standards (n°6' and n°MP9) were calibrated each by two mass standards (n°9 and n°7) used in the previous CCM.M-K3 comparison [1]. According to this comparison, the reference value $mc_{ref}$ and its expanded uncertainty are as follows:

| *Reference* | reference standard | Value | Expanded uncertainty *(95% coverage)* |
|---|---|---|---|
| *CCM.M-K3* | n°9 | + 42.65 mg | 2.10 mg |
| | n°7 | + 51.25 mg | 2.10 mg |

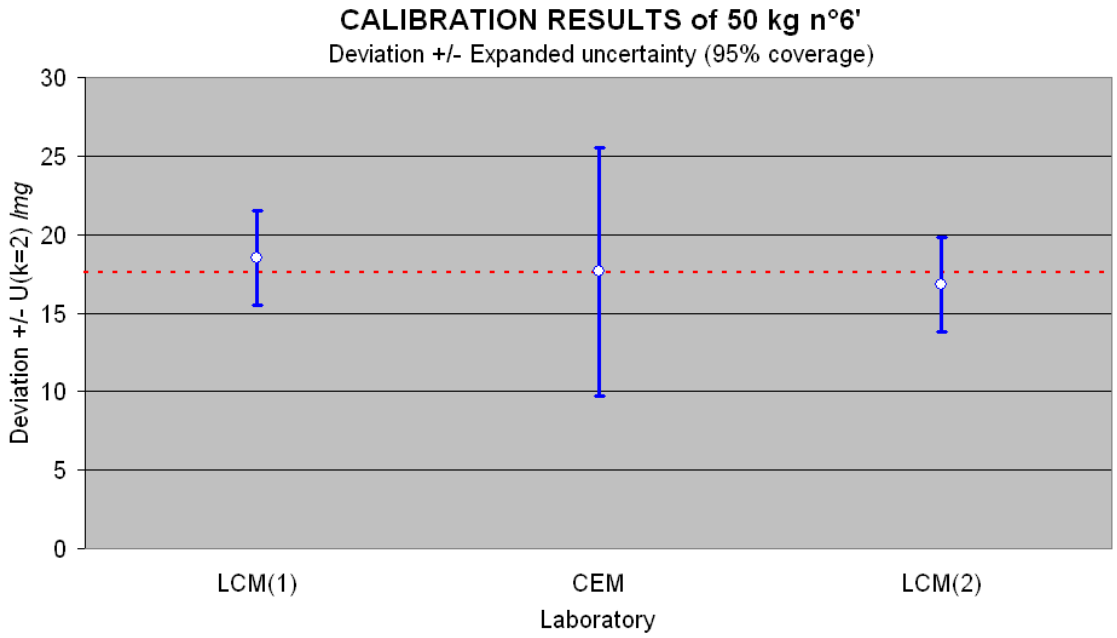
Table 6 - Reference values coming from CCM.M-K3 comparison

### *3.4 Reference value of the travelling standards*

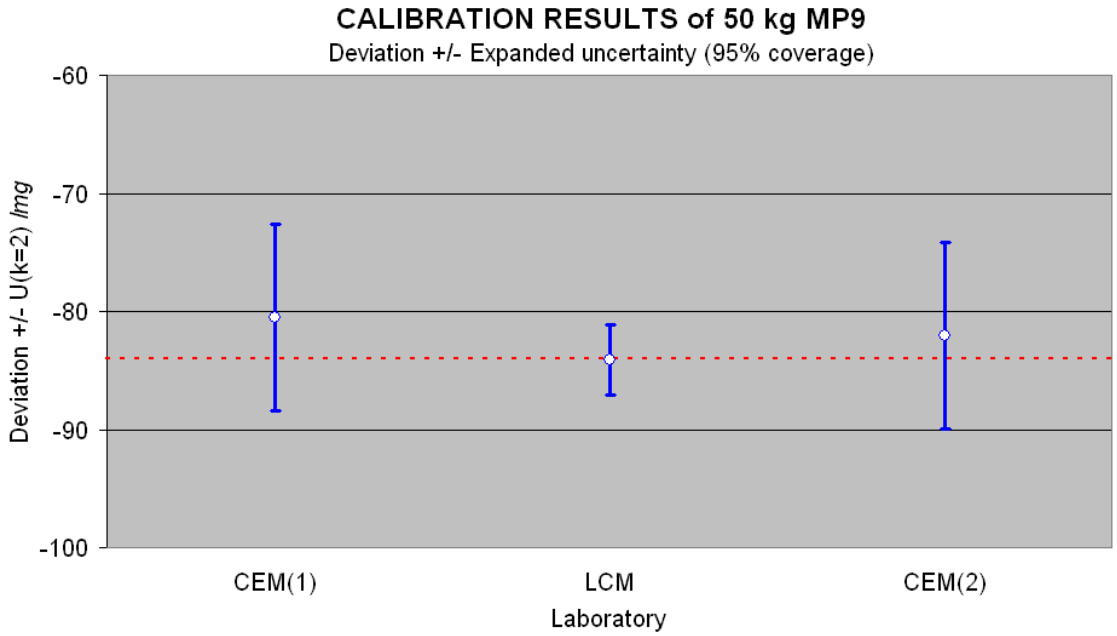
Results of the LCM, coming from the calibration, are given in table 7. The reference value of n°6' travelling standard is the mean value of calibration before and after CEM (see table 4a).

| *Reference* | Travelling standard | Value | Expanded uncertainty *(95% coverage)* |
|---|---|---|---|
| *Calibrated vs n°9 and n°7* | n°6' | + 17.6 mg | 3.0 mg |
| | n°MP9 | - 84.1 mg | 3.0 mg |

Table 7 - Reference value of the travelling standards




Graph 1 – Calibration results of 50 kg n°6'




Graph 2 – Calibration results of 50 kg MP9

### *3.5 Degree of equivalence of the CEM*

The degree of equivalence $deq_A$ of the CEM laboratory (noted A) is equal to the difference $mc_A - mc_{ref}$ between the participant's corrected value and the reference value.

For the 6' travelling standard, $mc_{ref}$ is the mean value of the calibration before and after CEM.

For the MP9 travelling standard, $mc_A$ is the mean value of the calibration before and after LCM.

The uncertainty of the degree of equivalence $u(deq_A)$ takes into account the uncertainty components coming from the result given by the laboratory $u(m_A)$, the

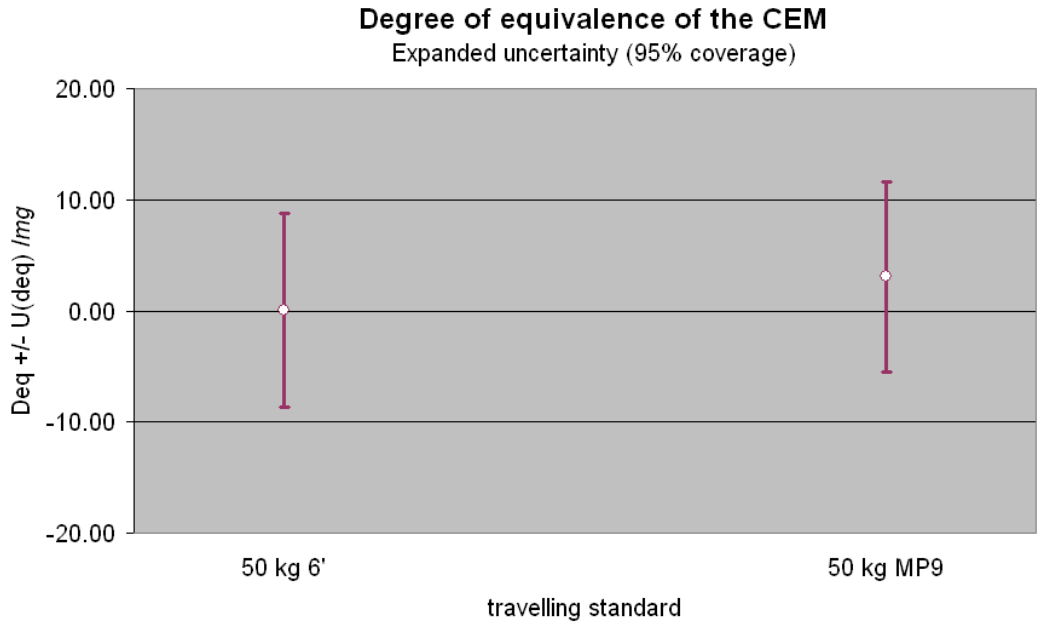
correction applied to this result $u(\overline{d})$, the drift of the travelling standard $\Delta d$ (with the assumption of a rectangular distribution) and the uncertainty $u(mc_{ref})$ of the reference value :

$$u(deq_A) = \sqrt{u^2(m_A) + u^2(\overline{d}) + \frac{(\Delta d)^2}{12} + u^2(mc_{ref})} \qquad (1)$$

Table below gives the degree of equivalence $deq_A$ of each laboratory with the assigned expanded uncertainty $U(deq)$ *(95% coverage)*.

| (mg) | reference value calibration by n°7 and n°9 from CCM.M-K3 comparison | |
|---|---|---|
| | $deq_A$ | $U(deq_A)$ |
| MET6 | - 0.08 mg | 8.70 mg |
| MP9 | - 2.83 mg | 8.40 mg |

Table 8 - Degree of equivalence of the CEM




Graph 3 – degree of equivalence of the CEM

## 4. Mass Comparator used by participant

| Laboratory | Manufacturer | Type | Resolution | Standard deviation (1) | Degree of freedom |
|---|---|---|---|---|---|
| CEM | Mettler Toledo | AX64004 | 0,1 mg | 0.4 mg | ∞ |

(1) Standard deviation of repeatability or reproducibility of the result of one comparison process

Table 9 - Mass Comparator used by CEM

## 5. References

[1] CCM.M-K3: *Metrologia*, 2005, **42**, *Tech. Suppl*., 07003