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EMRP SIB-05 Work Package 4
Deliverable 4.1.1

Report detailing requirements of NMIs for storage and transfer equipment compatible with existing apparatus

Pauline Barat (BIPM), James Berry (NPL), Michael Borys (PTB), Stuart Davidson (NPL), Thomas Fehling (Sartorius Weighing Technology GmbH), Peter Fuchs (EJPD), Andrea Malengo (INRIM), Paul-André Meury (LNE) and Zaccari Silvestri (CNAM)

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National
Measurement
System

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Engineering Measurement Team

ABSTRACT

A survey of transfer equipment and storage vessels available at JRP-partners with such facilities has been undertaken. Two different approaches to transferring mass artefacts in vacuum or inert gas were identified. The first approach uses storage vessels based on standard vacuum components in combination with glove box type transfer apparatus and the second approach uses a commercial Sartorius storage vessel and transfer apparatus compatible with the Sartorius CCL1007 mass comparator.

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Approved on behalf of NPLML by Stuart Davidson, (Science Area Leader - Mass).

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1 INTRODUCTION

The aim of this task is to report on existing designs of apparatus for storage, transport and transfer of mass artefacts under vacuum or inert gas conditions used by JRP-partners (SIB-05 NewKILO).

As part of the redefinition and the subsequent maintenance and dissemination of the mass scale, apparatus will be required to:

- **Transfer** weights (typically of nominal mass 1 kilogram) between experiments such as vacuum mass comparators and Watt balance apparatus. Typical masses will be kilogram weights of cylindrical (or spherical) construction.

- **Transport** weights between NMIs to allow comparisons and validation of vacuum mass comparators performance and watt balance results and to achieve traceability to the IPK for redefinition experiments.

- Maintain weights in the short to medium term (up to 10 years) under optimised **storage** conditions to provide on-going traceability for the mass scale between primary realisations of the kilogram.

Such apparatus could, at its most basic, consist of a vessel suitable for the storage, transfer and transport of mass standards under a controlled environment of inert gas or vacuum and a means for transferring the mass standards between the vessel and the apparatus without exposure to ambient air, such as a glove box type facility linked to the apparatus.

Table 1 lists the participating laboratories. NPL is the lead participating laboratory

Table 1: List of Participating Laboratories

Laboratory		**Country**
National Physical Laboratory	NPL	United Kingdom
Laboratoire national de métrologie et d'essais	LNE	France
Physikalisch-Technische Bundesanstalt	PTB	Germany
Eidgenöessisches Justiz- und Polizeidepartement	EJPD	Switzerland
Conservatoire national des arts et métiers	CNAM	France
Bureau International des Poids et Mesures	BIPM	
Istituto Nazionale di Ricerca Metrologica	INRIM	Italy

NPL, LNE, EJPD, CNAM, PTB, BIPM and INRIM provided input to a survey of the requirements of the individual NMIs for storage and transfer of primary mass standards, including;

- Compatibility of mass transfer apparatus with existing NMI equipment (to include handling of mass standards)
- Storage and transfer for existing and planned mass standards
- Transfer of mass standards between mass comparator and watt balance apparatus

2 DESCRIPTION OF PARTICIPANTS' TRANSFER APPARATUS

Details of each participant's transfer apparatus is given in Appendix A. All of the participants' transfer apparatus use a modified glove box arrangement to transfer mass artefacts from the vacuum chamber/load-lock to a storage vessel. This limits the transfer to inert gas only but permits flexibility in accommodating a range of designs and sizes of storage vessel. The PTB and the BIPM also have type YVTS01C transfer apparatus produced by Sartorius weighing technology GmbH that permits transfer in both inert gas and vacuum conditions, though this is limited to compatibility with Sartorius model YVC01C storage vessels.

3 DESCRIPTION OF PARTICIPANTS' STORAGE VESSELS

Details of each participant's storage vessels are given in appendix B. All of the participants' storage vessels, with the exception of PTB and the BIPM, use modified standard vacuum fittings with plastic inserts for supporting the mass artefacts made from either PTFE or PEEK. PTB use Sartorius model YVC01C storage vessels which use PEEK for the plastic inserts. EJPD also has two other types of storage vessel:

1. 24 place UHV storage vessel used with their combined instrument
2. Glass/Perspex inert gas vessel for storing up to 3 artefacts

The BIPM has both its own design of inert gas/vacuum storage vessel as well as the Sartorius model YVC01C storage vessels.

4 DISCUSSION ON THE MERITS OF EXISTING TRANSFER APPARATUS AND STORAGE VESSELS

4.1 COMPARISON OF APPARATUS

Two different types of apparatus for the transfer and storage of mass artefacts in vacuum or inert gas have been identified from the survey of JRP-participants' existing apparatus:

1. The first approach uses storage vessels constructed in-house which are based around conventional vacuum components with custom plastic inserts for supporting the mass

artefacts. A glove box attached to either a vacuum mass comparator or Watt balance is used to transfer the mass artefacts in an inert gas environment to/from the storage vessels.

2. The second approach uses a commercial design of storage vessel and transfer apparatus supplied by Sartorius that permits the transfer and storage of mass artefacts in either inert gas or vacuum. However, the design of the transfer apparatus is limited to compatibility with the Sartorius CCL1007 mass comparator. However, both PTB and the BIPM also have glove box systems that permit compatibility with other types of storage vessel.

4.2 COMPATIBILITY WITH REQUIREMENTS

The first requirement for the transfer apparatus and storage vessels is to permit transfer between experiments such as vacuum mass comparators and Watt balance apparatus without exposure to ambient air. All of the designs submitted by the participants potentially meet this requirement.

The second requirement is to transport weights between NMIs to allow comparisons and validation of vacuum comparator and watt balance results. The glove box transfer method and storage vessel approach meets this requirement as the storage vessels are small and light enough to transport between NMIs. Some designs of storage vessel incorporate glass vacuum windows that allow visual inspection of the mass artefacts by custom officials. The commercial Sartorius model YVC01C storage vessels are not as well suited to transport between NMIs due to a larger height of vessel (243 mm compared to a typical height of 150 mm with the other vessels) and the lack of a large window for visual inspection.

The third requirement is to maintain weights in the short to medium term (up to 10 years) under optimised storage conditions. All of the designs submitted by the participants potentially meet this requirement as the storage vessels can all be connected to either a vacuum system for vacuum storage or an inert gas supply for storage in inert gas.

4.3 POTENTIAL LIMITATIONS

The two main transfer and storage methods identified both have potential limitations in their use. The glove box transfer method and storage vessel approach does not allow direct vacuum to vacuum transfer, for example from a mass comparator in vacuum to a Watt balance in vacuum, as the transfer in the glove box operation is only performed in inert gas. The types of storage vessel used in this approach also have a number of vacuum clamps to unfasten before the lid of the vessels can be removed. These have screw threads which can introduce particles into the glove box environment through the frictional wear of the threads.

The commercial Sartorius model YVC01C storage vessels allow both inert gas to inert gas transfer and vacuum to vacuum transfer. However, the additional height of the vessels compared with the other type of vessel (about 90 mm extra) in addition to the lack of a visual inspection window for customs officials is a disadvantage when transporting artefacts between NMIs. However, as both PTB and the BIPM have glove box type transfer apparatus other types of storage vessels can be used for transport between NMIs.

4.4 SUGGESTED IMPROVEMENTS/MODIFICATIONS

The type of storage vessel used with a glove box transfer mechanism can be improved by replacing the bolted clamps used to attach the lid of the vessel with a bespoke clamp that requires only one bolt to hold the lid in place. This would reduce the time taken to remove the lid of the vessel when inside a glove box and with only one threaded fastening the quantity of particulates introduced into the chamber through frictional wear would be reduced.

The Sartorius model storage vessel could be improved by introducing a viewing window to the container that would allow visual inspection by customs officials. A reduction in height of the storage vessel for smaller artefacts would also make the vessel easier to transport between NMIs.

5 APPROACHES OF OTHER NMIS

The National Institute of Standards and Technology (NIST) are working on an alternative method of providing mass traceability between vacuum measurements and air measurements without the use of conventional sorption artefacts. In this approach the mass standards used to provide traceability to a Watt balance in vacuum are kept in vacuum and are linked with standards in air through the use of a magnetic levitation balance [1]. As there is no need to transfer mass artefacts between air and vacuum, there is no need to apply a correction for the mass of water and other volatile components that are removed from the surface of a mass when it is exposed to vacuum.

NIST have demonstrated the principle through a publication in Metrologia [1], though the uncertainty in the measurement is limited by the 1 mg sensitivity of the balance used in the test apparatus. The attracting force is also very sensitive to distance change and sub-nanometre positioning control is required, although this can be achieved using laser interferometers. NIST are currently working on an improved magnetic levitation device that incorporates a high-precision balance with the aim of achieving an uncertainty of 1 part in 10^8 for air to vacuum comparisons.

6 CONCLUSIONS

The majority of participants have storage vessels constructed from adapted conventional vacuum equipment and glove box type transfer apparatus. The cross compatibility of these types of equipment permits a straightforward exchange of artefacts between both Watt balance and Avogadro experiments and vacuum mass comparators, and between NMIs. Both PTB and the BIPM have Sartorius type storage vessels and transfer apparatus. The Sartorius type transfer apparatus and storage vessels have the advantage of permitting complete transfer in vacuum which the glove box transfer method cannot achieve. They also both have glove box type transfer apparatus and their inclusion in a comparison would permit NMIs with either type of apparatus to participate.

NIST have been working on an alternative method of providing traceability from mass measurements in vacuum to mass measurements in air that does not require the transfer of mass artefacts between air and vacuum. This could eliminate the need for storage vessels and transfer apparatus, though the method would require validation with conventional sorption mass artefacts.

7 RECOMMENDATIONS

7.1 WITH REGARD TO JRP PROJECT COMPARISON

This report gives the following recommendations for storage vessels and transfer apparatus to meet the requirements mentioned above:

1. It is not necessary to design and manufacture additional storage vessels as there are enough existing storage vessels at participant NMIs. However, it may be necessary to design new inserts for supporting mass artefacts within the vessels depending on the research output from deliverable 4.1.2.
2. Five participants (and the BIPM) have glove box transfer devices. This is a sufficient number of participants for the comparison in task 4.3. Therefore there is no need to design and manufacture an additional transfer apparatus.
3. Just 6 months has been allocated for the comparison in task 4.3. Therefore the comparison should be split into two petals with half the participants measuring one set of artefacts and the other half measuring a separate set of artefacts.

7.2 WITH REGARD TO LONGER TERM TRANSPORT AND STORAGE REQUIREMENTS

Although this report primarily addresses the requirements for work package four, there will be a need for longer term storage and transfer of mass artefacts to support current efforts to redefine the kilogram and facilitate traceability to a new definition once the kilogram has been redefined. The storage vessel designs submitted by the participants are suitable for long term storage as they all have

valves connected to either the side or the lid which permits the vessel to be connected to either an inert gas supply or a vacuum pumping system. Regarding the optimum storage medium for storing the mass artefacts, work has been scheduled in this Joint Research Project to evaluate this. Both types of storage vessel and transfer apparatus are capable of complete transfer of mass artefacts in inert gas. However, only the Sartorius type transfer apparatus and storage vessels permit complete transfer and storage in vacuum.

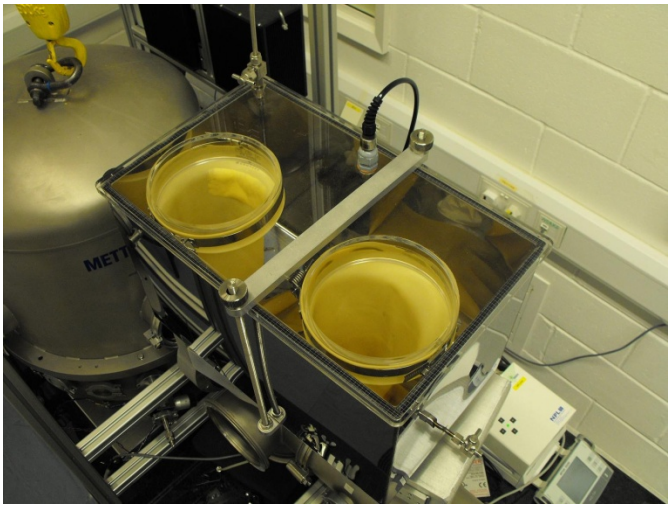
8 REFERENCES

[1] Jabbour Z J, Abbott, P, Williams E, Liu R and Lee V 2009 Linking air and vacuum mass measurement by magnetic levitation *Metrologia* 46 339-344

APPENDIX A: TRANSFER APPARATUS INFORMATION SUPPLIED BY PARTICIPANTS

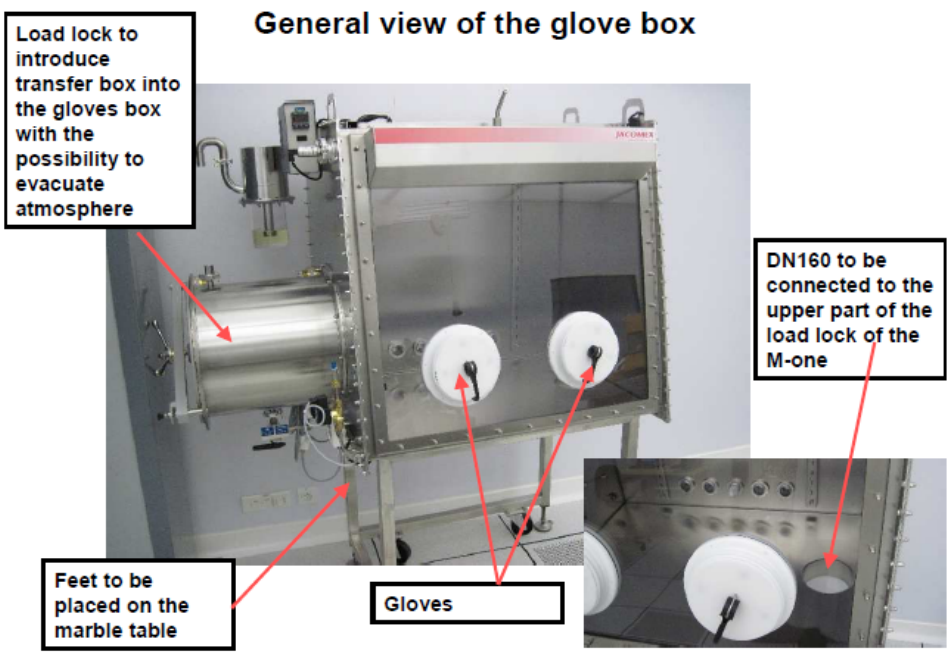
A1. NATIONAL PHYSICAL LABORATORY

Table 1: NPL transfer apparatus

Type (Inert gas storage to vacuum or vacuum storage to vacuum)	Inert gas storage to vacuum only
Dimensions	Height = 300 mm, Width = 460 mm, Depth = 280 mm
Type of Vacuum Comparator	Mettler-Toledo Mone. Connects to Mone load-lock
Date in Operation	Operational
Description	 Glove box type inert gas transfer chamber. Constructed from welded stainless steel with a Perspex glove box lid. Glove box has two stainless steel valves, one is fitted to the side wall of the chamber and an Argon gas supply is connected to this valve. The other valve is connected to the Perspex lid of the glove box and exhausts through a filter. During operation a constant flow of Argon gas is flowed through the chamber and the chamber itself is kept slightly above atmospheric pressure. Latex glove box gloves are used in the apparatus. These gloves are used to manipulate a mass artefact storage vessel and the tools used to tighten or undo clamps holding the lid of the storage vessel to the base. Duraclean Lycra gloves are kept within the transfer apparatus and these are used solely for handling the mass artefacts. Connects to the Mone load-lock through a standard ISO 160 size vacuum fitting. A gate valve is used to isolate the Mone load-lock from the inert gas transfer chamber.
Maximum Size of Storage Vessel that can be accommodated	Storage vessels made from vacuum fittings up to size ISO 160 can be accommodated

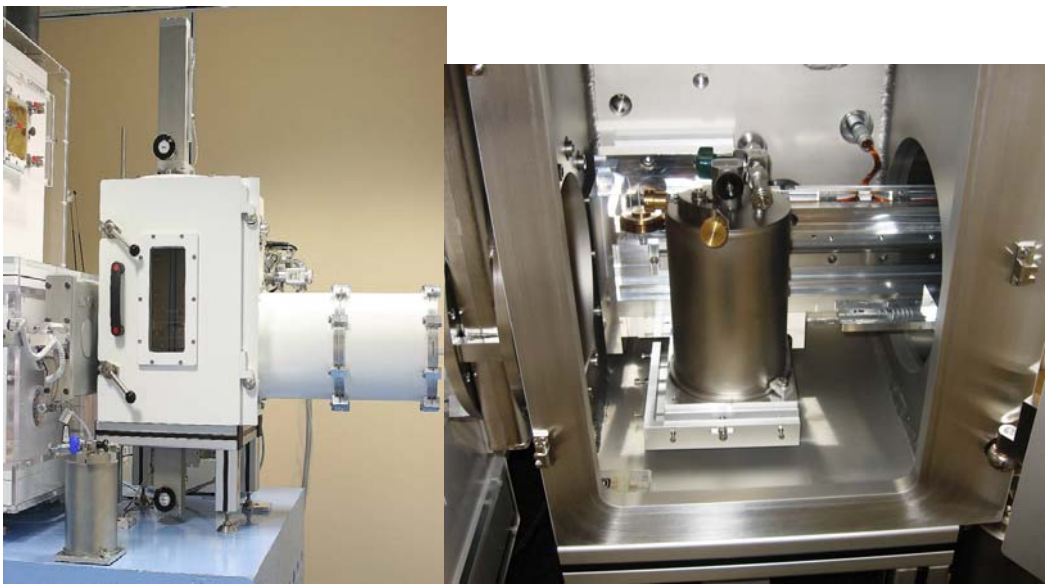
A2. LABORATOIRE NATIONAL DE METROLOGIE ET D'ESSAIS

Table 2: LNE transfer apparatus

Type (Inert gas storage to vacuum or vacuum storage to vacuum)	Glove box under inert gas to transfer artefacts to the load lock of the M-one under inert gas and/or vacuum
Dimensions	1000 x 725 x 900 mm
Type of Vacuum Comparator	M-one 6V with load lock
Date in Operation	September 2012
Description	
Maximum Size of Storage Vessel that can be accommodated	Up to 300 mm

A3. PHYSIKALISCH-TECHNISCHE BUNDESANSTALT

Table 3: PTB transfer apparatus1

Type (Inert gas storage to vacuum or vacuum storage to vacuum)	Sartorius YVTS01C (Inert gas storage to vacuum and vacuum storage to vacuum)
Dimensions	1081 mm x 1044 mm x 1261 mm (width x depth x height)
Type of Vacuum Comparator	Sartorius CCL1007
Date in Operation	Operational
Description	- Transfer system made of aluminium - Vacuum fitting between vacuum mass comparator and transfer system: DN200ISO-F - Door with glass window 100 mm x 200 mm - Separate pumping system (scoll pump and turbomolecular pump) - Pressure range: 10^{-6} mbar to 10^{3} mbar  (Vacuum transfer system photos supplied by Sartorius Weighing Technology GmbH)
Maximum Size of Storage Vessel that can be accommodated	Dimensions base plate: 138 mm x 138 mm, height: 243 mm (vessel type: YVC01C)

1 PTB also have a glove box facility that provides compatibility with other types of storage vessel

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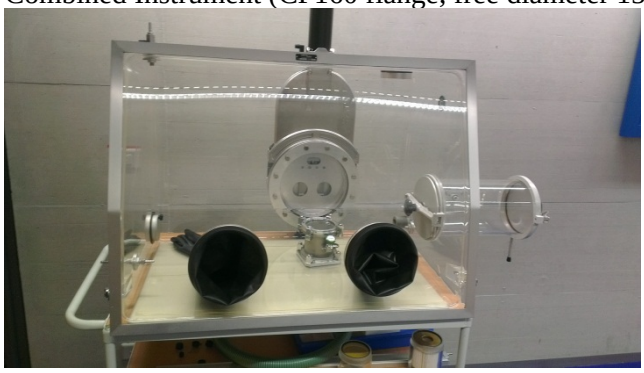
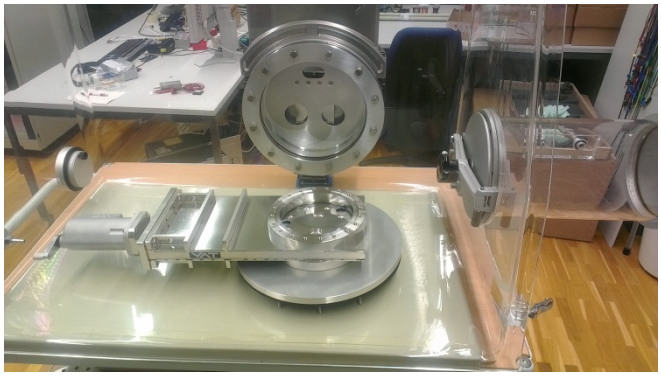
Table 4: EJPD transfer apparatus

Type (Inert gas storage to vacuum or vacuum storage to vacuum)	Glove-box for sample handling in inert gas
Dimensions	
Type of Vacuum Comparator	M_One (Mettler) and Combined Instrument (UHV comparator and XPS)
Date in Operation	Operational, not yet in use
Description	Mobile glove-box unit, dimensions (inside) 900 x 500 x 700 mm, fits to the M_One comparator with gate valve (DN 250 ISO-K, free diameter 260mm) and to Combined Instrument (CF160 flange, free diameter 150mm)  For the combined instrument a reducing flange must be used to fit the small gate valve 
Maximum Size of Storage Vessel that can be accommodated	200x200mm

A5. CONSERVATOIRE NATIONAL DES ARTS ET METIERS

Table 5: CNAM transfer apparatus

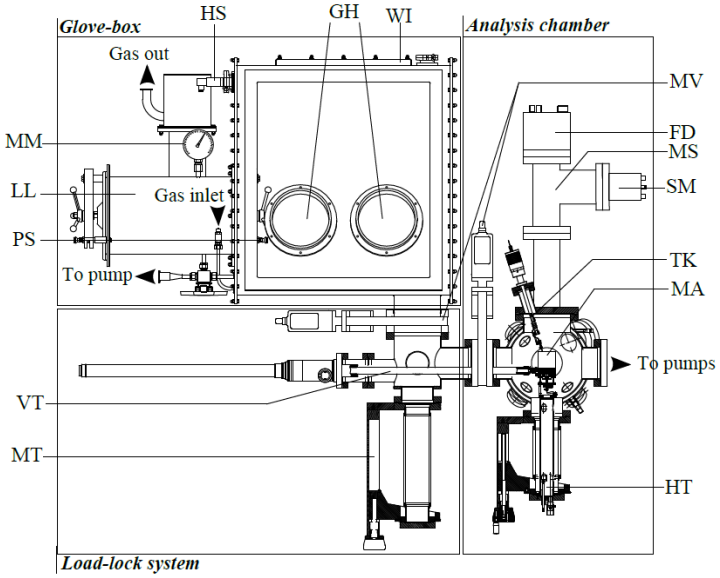
Type (Inert gas storage to vacuum or vacuum storage to vacuum)	Glove box on the TDS device for contamination analysis [inert gas storage to vacuum]
Dimensions	load-lock (diameter 250 mm, length 400 mm) Glove box (700 × 750 × 650 mm)
Type of Vacuum ~~Comparator~~	10^{-6} Pa in the TDS chamber analysis
Date in Operation	
Description	 FIGURE 2: Schematic of the experimental TDS device. Three main parts : an analysis chamber, a load-lock system and a glove-box. Key : MM : manometer, LL : glove-box load-lock, PS : glove-box pressure sensor, VT : vertical translator, MT : motorized translator, HS : humidity sensor, GH : gloves holders, WI : glove-box window, MV : manual gate valves, FD : Faraday detector, MS : mass spectrometer, SM : SEM detector, TK : K thermocouple, MA : mass standard, HT : horizontal translator. The glove-box, custom designed and built by Jacomex, allows the transfer of artefacts in inert gas [Ar or N_2]. It is directly connected to load-lock system and consists of : - a load-lock (diameter 250 mm, length 400 mm) with the possibility of making vacuum and equipped with a manometer, a sliding plate and two aluminum doors hinged on jacks ; - a stainless steel enclosure (700 × 750 × 650 mm) with a transparent front panel and two gloves ; - a smart control of moisture and pressure able to cut the sweep gas through the use of a solenoid valve,below a predened threshold of the moisture sensor (relative rate about 30 x 10^{-6}). Finally, a motorized translator with its artifact support, allows the passage thereof between the glove-box and the load-lock system. 2 types of gloves : Piercan 13750 and Piercan 13800
Maximum Size of Storage Vessel that can be accommodated	Dimension of the glove box load-lock

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Table 6: INRIM transfer apparatus

Type (Inert gas storage to vacuum or vacuum storage to vacuum)	Load-lock Mettler Toledo for M_one Comparator
Dimensions	Mettler specifications
Type of Vacuum Comparator	M_one Mettler Toledo, six positions
Date in Operation	January 2011
Description	The load-lock allows mass artefacts to be inserted into the weighing chamber without breaking the vacuum or changing the pressure of the inert gas in the weighing chamber. At present INRIM does not have a transfer apparatus, such as a glove box, allowing to transfer a mass standard from its travelling /storage vesselto within the load lock. We are planning to design and realize our own storage vessel. At the same time we are prepared to co-operate in the definition of an agreed vessel to be used in comparisons and in general for circulating mass standards.
Maximum Size of Storage Vessel that can be accommodated	As per Mettler specifications.

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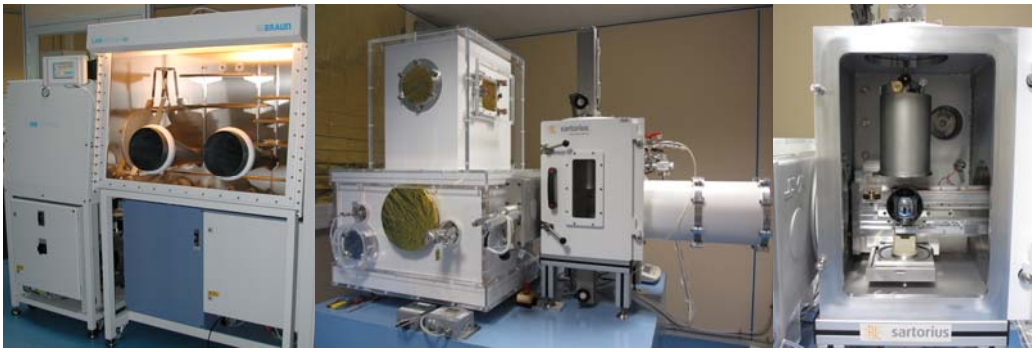
Table 7: BIPM transfer apparatus

Type (Inert gas storage to vacuum or vacuum storage to vacuum)	The transfer apparatus allows transferring: - Inert gas storage to vacuum - Vacuum storage to vacuum
Dimensions	MBraun Gloves box: width = 1000 mm (1700 mm with gloves) and length = 2360 mm (2650 mm with drawer of the oven open) Sartorius CCL1007 mass comparator + Sartorius YVTS01C Vacuum Transfer System (VTS): Width = 1200 mm and length = 2100 mm + rack for Sartorius electronics: width = 880 mm and length = 900 mm
Type of Vacuum Comparator	Sartorius CCL1007 mass comparator
Date in Operation	Sartorius CCL1007 mass comparator and VTS are operational MBraun Gloves box is operational
Description	The transfer apparatus consists of three parts: 1. A MBraun LABmaster sp gloves box equipped with an oven. The oven is used as load lock. 2. A Sartorius YVTS01C Vacuum Transfer System (VTS) using Sartorius YVC01C containers. 3. A Sartorius CCL1007 mass comparator (the VTS is directly attached to the mass comparator). 
Maximum Size of Storage Vessel that can be accommodated	Inert gas storage to vacuum: size limited by the load lock/oven of the glove box (height < 250 mm and width < 220 mm)

APPENDIX B: STORAGE VESSEL INFORMATION SUPPLIED BY THE PARTICIPANTS

B1. NATIONAL PHYSICAL LABORATORY

Table 8: NPL storage vessels

Number of Storage Vessels	Two
Type (Inert gas storage/ vacuum storage)	Both vessels are suitable for inert gas storage and vacuum storage
Dimensions	Maximum diameter = 210 mm Height = 150 mm
Date in Operation	Operational
Material used to support mass artefacts	PTFE
Maximum dimensions of mass artefact that can be accommodated	Diameter = 85 mm Height = 85 mm
Description	 Both storage vessels are manufactured from standard ISO 100 size vacuum fittings, with the exception of the base which is machined from a bespoke piece of Aluminium to reduce weight. The sides of the chamber are made from a stainless steel vacuum tube with ISO 100 flanges at both ends. Two Swagelok 1/4 inch right angle valves welded onto the side walls permit either connection to an inert gas supply or connection to a vacuum pumping system. The lid is an ISO 100 observation window allowing visual inspection into the storage vessel. Mass artefacts are held in place using bespoke PTFE inserts. NPL has inserts suitable for clamping Pt/Ir prototypes, stainless steel cylindrical kilograms and silicon cylindrical kilograms.

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Table 9: LNE Storage vessels

Number of Storage Vessels	2
Type (Inert gas storage/ vacuum storage)	Inert gas storage
Dimensions	~ 200 x 170 x 150 mm
Date in Operation	In operation
Material used to support mass artefacts	Teflon
Maximum dimensions of mass artefact that can be accommodated	One is designed for a 1 kg PtIr prototype. The other one is designed for a stack of 5 x 200 g discs
Description	 

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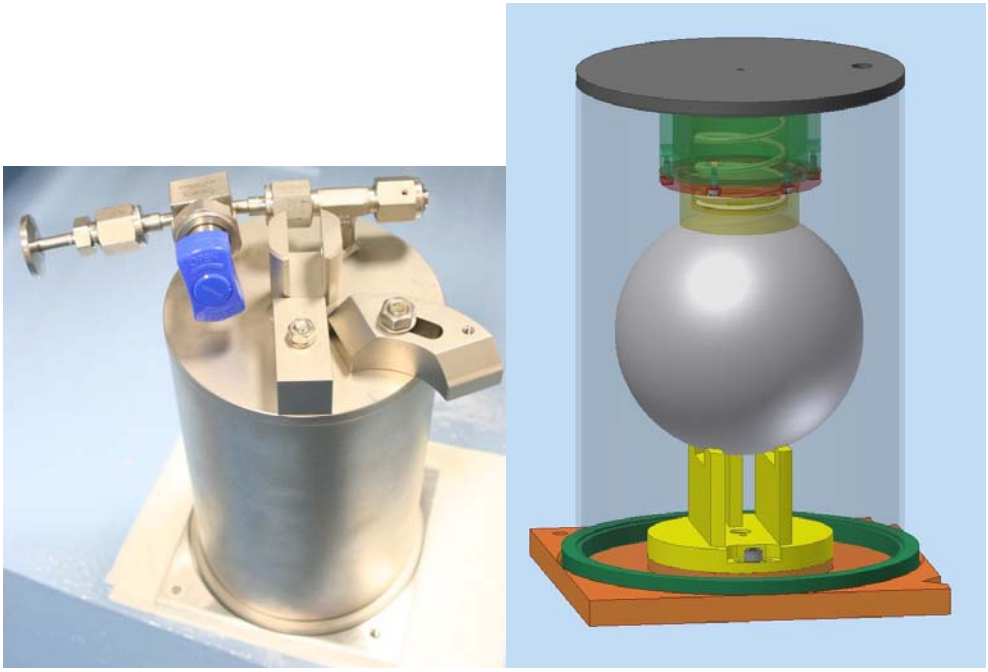
Table 10: PTB Storage vessels

Number of Storage Vessels	4
Type (Inert gas storage/ vacuum storage)	YVC01C (inert gas storage and vacuum storage)
Dimensions	Dimensions base plate: 138 mm x 138 mm, height: 243 mm
Date in Operation	Operational
Material used to support mass artefacts	PEEK
Maximum dimensions of mass artefact that can be accommodated	- 34 mm to 95 mm (diameter) x 110 mm (height) - Diameter range Si spheres: 45 mm to 100 mm
Description	- Material: stainless steel and aluminium (base plate) - Pressure range 10^{-6} mbar to 10^{3} mbar - 3 optional adapters for 1-kg-mass standards made of SS, PtIr and Si - Adapter material: PEEK  (Vacuum storage vessel images supplied by Sartorius Weighing Technology GmbH)

B4. EIDGENOESSISCHES JUSTIZ- UND POLIZEIDEPARTEMENT

Table 11: EJPD Type 1 Storage vessels

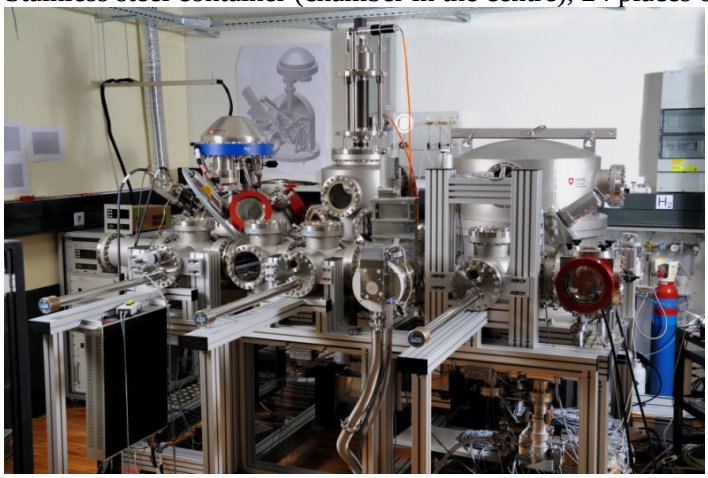
Type (Inert gas storage to vacuum or vacuum storage to vacuum)	3 pc transport containers for transportation under vacuum / inert gas (copy of the NPL design)
Dimensions	KF100 x 100mm
Type of Vacuum Comparator	M_One (Mettler) and Combined Instrument (UHV comparator and XPS)
Date in Operation	not yet in use
Description	Inside diameter 100 mm x 100 (+ 4mm gasket). Outside 140 x 140 x 145. 10 mm square Aluminum base plate, view port at the top, Weight: 2.5 kg Inserts for different samples in production 
Maximum Size of Vessel that can be accommodated	

Table 12: EJPD Type 2 Storage vessels

Number of Storage Vessels	1
Type (Inert gas storage/ vacuum storage)	UHV, p<5 x 10 E-9
Dimensions	Dia 400, x h = 1000
Date in Operation	2006
Material used to support mass artefacts	Ni plated Al forks
Maximum dimensions of mass artefact that can be accommodated	100 mm

Description

Stainless steel container (chamber in the centre), 24 places on 3 platforms.



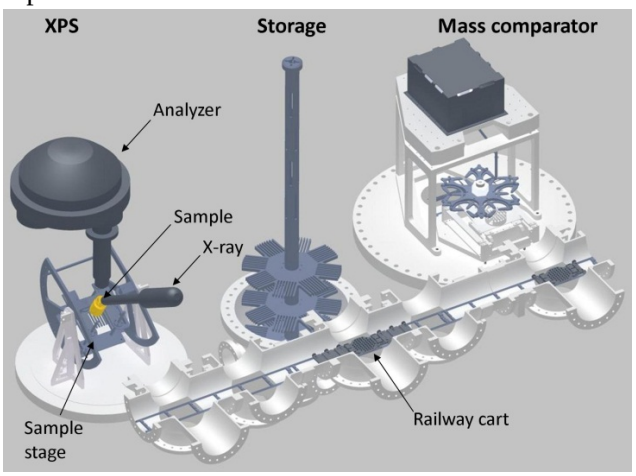
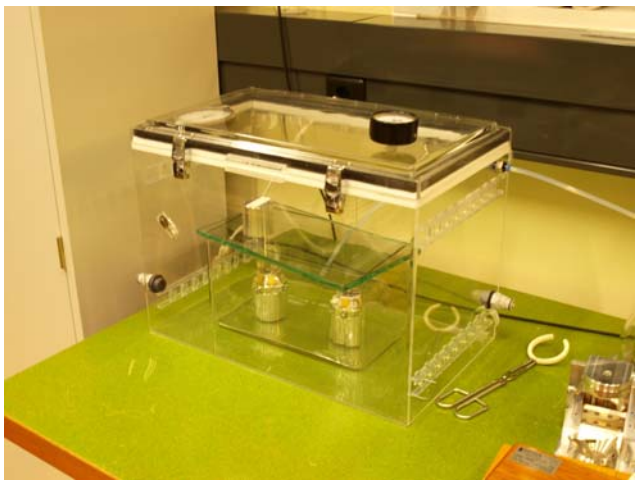


Table 13: EJPD Type 3 Storage vessels

Number of Storage Vessels	1
Type (Inert gas storage/ vacuum storage)	Inert gas Ar
Dimensions	Inner glas container 300 x 150 x 150 (larger container can be used) Outer Plexiglas container 480 x 280 x 360
Date in Operation	2006
Material used to support mass artefacts	glass
Maximum dimensions of mass artefact that can be accommodated	100 x 100 (3 pc)
Description	Inner and outer storage container. The inner container is continuously supplied with Ar (slight overpressure). Humidity is controlled (0 %rH = clean)  

B5. CONSERVATOIRE NATIONAL DES ARTS ET METIERS

Table 14: CNAM Storage vessels

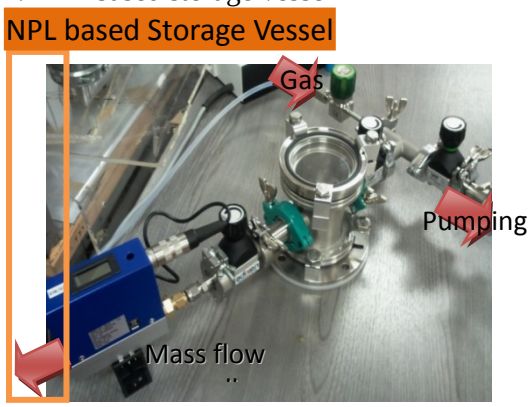
Number of Storage Vessels	3
Type (Inert gas storage/ vacuum storage)	Inert gas storage and vacuum storage for 1 kg mass standards and samples
Dimensions	1. 130 mm diameter, 130 mm high 2. 200 mm diameter, 130 mm high
Date in Operation	
Material used to support mass artefacts	Teflon
Maximum dimensions of mass artefact that can be accommodated	55 mm diameter, 55 mm high max
Description	1. Cnam storage vessel x 2  2. NPL based storage vessel x 1  With a mass flow controller.

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Table 15: Type I BIPM Storage Vessels

Number of Storage Vessels	12
Type (Inert gas storage/ vacuum storage)	The 12 vessels can be used to store standards both in vacuum or under inert gas. At present we use 8/12 for gas storage and 4/12 for vacuum storage.
Dimensions	Height: 210 mm Base diameter: 200 mm
Date in Operation	Since the beginning of 2012
Material used to support mass artefacts	PEEK
Maximum dimensions of mass artefact that can be accommodated	We have different mass holders for different dimensions of the standards. All different mass holders can be adapted inside the vessels. We have holders for 1 kg PtIr cylinder, holders for 1 kg stainless steel cylinders and holders for 1 kg silicon spheres. We have four of each.
Description	1. BIPM Gas/vacuum vessel  2. BIPM Gas/vacuum mass holder 

Table 16: Type II BIPM Storage Vessels

Number of Storage Vessels	4
Type (Inert gas storage/ vacuum storage)	Vacuum storage
Dimensions	Height: 243 mm Base plate: 138 mm × 138 mm
Date in Operation	Four in construction (according to the Sartorius YVC01C model), will be ready in early 2013
Material used to support mass artefacts	PEEK
Maximum dimensions of mass artefact that can be accommodated	We plan to have different mass holders for different dimensions of the standards. All different mass holders can be adapted inside the vessels. We plan to have holders for the 1 kg PtIr cylinder, holders for 1 kg stainless steel cylinders and holders for 1 kg silicon spheres.
Description	Type II BIPM storage vessels will be produced according to Sartorius vacuum container