

ASIA-PACIFIC METROLOGY PROGRAMME

Technical Protocol

for

Volume Intercomparison at 20L and 100mL

Comparison Identifier: APMP.M.FF-K4

(Version 3.0)

Pilot Laboratory:

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1. Introduction

During the APMP meeting, hold in Daejeon Korea in September 2014, it was proposed to perform the round of APMP.M.FF-K4 for Volume of Liquids at 20L and 100mL. At its meeting in Beijing 2015, the APMP TCFF confirmed the Key Comparison. NIM offered to act as the pilot laboratory. The objective of this comparison is to compare the performance of volume measurements of a 20 L test measure and two 100mL pycnometers and to demonstrate the degree of equivalence (DoE) of the volume measurement standards held at National Measurement Institutes (NMIs) and to provide supporting evidence for the calibration and measurement capabilities (CMCs) claimed by the participating laboratories in the Asia-Pacific regions, and to link the comparison results to the corresponding CCM key comparison, CCM.FF-K4.

A 20L test measure made in China and two 100mL pycnometers commercially will be selected as the Transfer Standards. It's better repeatability and reproducibility were expected for the KC.

2. Participating Institute

A list of participants along with contact information and shipping addresses is given in Table 1:

Table 1 The information of participating laboratories in the KC.

| No. | Economy | NMI | Contact information |
|-----|------------------|---|--|
| 1 | China | National Institute of Metrology (NIM) Address: 18, BeiSanHuanDongLu, Beijing 100029, China | Ligong GUO guolg@nim.ac.cn Lin TONG tonglin@nim.ac.cn Fax: +86-10-64218628 Tel: +86-10-64524650 |
| 2 | Thailand | National Institute of Metrology (Thailand) (NIMT) Address: 3/4 -5 Moo 3. Klong 5, Klong Luang, Pathumthani 12120 Thailand | Theerarak Chinarak theerarak@nimt.or.th Nongluck Tangpaisarnkul nongluck@nimt.or.th Tel: +66 2 577 5100 ext 2103 |
| 3 | Vietnam | Vietnam Metrology Institute (VMI) Address: No 08 Hoang Quoc Viet Road, Cau Giay District, Ha Noi, Vietnam | Thai Nguyen-Xuan thainx@vmi.gov.vn xuanthai.vmi@gmail.com Tel: (+84).984 788 769 |
| 4 | Hong Kong, China | Standards and Calibration Laboratory, Hong Kong, China (SCL) Address: 36/F., Immigration Tower, 7 Gloucester Road, Wanchai, Hong Kong | Mr. Raymond Leung wmleung@itc.gov.hk Fax: (852) 2755 5341 Tel: (852) 2798 7347 |
| 5 | Philippines | National Metrology Laboratory of the Philippines (NMLPhil-ITDI) Address: Metrology Building, DOST Compound, General Santos Avenue, Bicutan, Taguig City 1631, Philippines | Jose Marco Latosa jmdlatoa@itdi.dost.gov.ph / marcolatosa@yahoo.com Manuel Ruiz mmruiz@itdi.dost.gov.ph Fax: +632 8837 2071 loc. 2272 Tel: +632 8683 7750 loc. 2255 |
| 6 | Australia | National Measurement Institute Address: Bradfield Road, Lindfield, NSW 2070 Australia | Simon Dignan Simon.Dignan@measurement.gov.au Tel: +61 2 8467 3556 |

| No. | Economy | NMI | Contact information |
|-----|-------------------------------|---|---|
| 7 | Indonesia | National Measurement Standards, National Standardization Agency of Indonesia (SNSU-BSN) Address: Komplek Puspipstek Gedung 420 Kota Tangerang Selatan, BANTEN 15314 | Renanta Hayu Email: renanta@bsn.go.id renanta.hk@gmail.com |
| 8 | Malaysia | National Metrology Institute of Malaysia (NMIM) Address: SIRIM Berhad, PT 4803, Bandar Baru Salak Tinggi, 43900 Sepang, Selangor, Malaysia | Kamarudin Mohamad Nor / Hafidzi Hamdan Email: kddin@sirim.my / hafidzi@sirim.my Tel: +603-8778 1600 Fax: +603-8778 1661 |
| 9 | Sri Lanka | Measurements Units, Standards and Services Department (MUSSD) Address: Mahenawatta, Pitipana, Homagama, Sri Lanka | H L I S Sampath Email: indika_sampathh@yahoo.com Fax: +94 718584 947 Tel: +94 112 182269 |
| 10 | Kingdom of Saudi Arabia | Saudi Standards, Metrology and Quality Organization (SASO) – National Measurement & Calibration Center (NMCC). Address: Riyadh Almuhammadiyah in front of King Saud University. PO. B 3437 Riyadh 11471, Kingdom of Saudi Arabia. | Abdulkarim A. Al-shahrani Email: a.shahrany@saso.gov.sa Tel: +9662529761 |
| 11 | Russia | The D.I. Mendeleev All-Russian Institute for Metrology (VNIIM) Address: Russia, 198412, St. Petersburg, Lomonosov Feduninsky str, 2 | Konstantin Popov k.v.popov@vniim.ru Fax: +7 (812) 422-12-73 Tel: +7 (921) 744-41-76 |
| 12 | Egypt | National Institute for Standards of Egypt (NIS-Egypt) Address: M. A. El-Sadat (Tersa) St., El Haram El Giza, P.O. 136 Giza – Code 12211 | Dr. Ali A.Zahran ali.zahran@nis.sci.eg Tel: 20233889783 Fax: +20233889783 |
| 13 | Uzbekistan | State Enterprise "Uzbek National Institute of Metrology" (UzNIM) Address: 333 "A" Farabi str., Tashkent, 100049 Republic of Uzbekistan | Karimov Rustam Email: karimov@nim.uz interdep@nim.uz Tel: +998981262122/+998998712122 Fax: +99878 1502603 |
| 14 | India | CSIR - National Physical Laboratory (NPLI) Address: New Delhi - 110 012, India | Nidhi Singh singhnidhi@nplindia.org Shiv Kumar Jaiswal skjaiswal@nplindia.org Tel: +91-11-45609426 Fax: +91-11-45609310 |

The National Institute of Metrology (NIM) took part in the CCM.FF-K4.1.2011 as APMP pilot, acting as the pilot laboratory will perform the initial and final measurements of the transfer standards.

This arrangement follows the APMP guidelines on conducting comparisons (APMP-G2) to ensure that APMP.FF-K4 is properly linked to the CCM.FF-K4.

3. Schedule

The comparison work is proposed to be scheduled in October 2022 to December 2024 (See table 2). This timetable may be changed by the pilot laboratory (hereinafter referred to as NIM) in consultation with the Participating institutes / laboratory (hereinafter referred to as participant), according to the progress of the circulation of the travelling artifacts.

Table 2 Tentative timetable

| No. | NMI | | Period of measurement | ATA Carnet |
|-----|---|----------------------------|-----------------------|------------|
| 1 | NIM | China | 11 – 20 November 2022 | Y |
| 2 | NIMT | Thailand | 11 – 20 December 2023 | Y |
| 3 | VMI | Vietnam | 11 – 20 January 2022 | N |
| 4 | SCL | Hong Kong, China | 11 – 20 February 2023 | Y |
| 5 | NMLPhil-ITDI | Philippines | 13 – 22 March 2023 | N |
| 6 | NMIA | Australia | 12 – 21 April 2023 | Y |
| / | Note: 1. The transfer artifacts and ATA carnet had be transported separately . 2. The transfer artifacts and ATA carnet had be sent back to NIM by NMIA . | | | |
| 7 | SNSU-BSN | Indonesia | 20 –29 May 2024 | Y |
| 8 | NMIM | Malaysia | 19 – 28 June 2024 | Y |
| 9 | MUSSD | Sri Lanka | 19 – 28 July 2024 | Y |
| 10 | NPLI | India | 18 – 27 August 2024 | Y |
| / | Note: 1. The transfer artifacts and ATA carnet should be transported separately . 2. The transfer artifacts should be sent to SASO by NPLI . If the ATA Carnet will expire after 2 months, NPLI should sent transfer artifacts back to NIM. 3. The ATA carnet should be transported to NIM by NPLI . | | | |
| 11 | SASO | Kingdom of Saudi Arabia | 17 –26 September 2024 | N |
| 12 | NIS-Egypt | Egypt | 17 – 26 October 2024 | N |
| 13 | UzNIM | Republic of Uzbekistan | 16 – 25 November 2024 | N |
| / | Note: 1. The transfer artifacts and the ATA carnet should be transported separately . 2. The transfer artifacts and ATA carnet should be sent back to NIM by UzNIM . 3. If the ATA Carnet will expire after 1 month, The NMI should sent transfer artifacts back to NIM as soon as possible after Transfer standard measurement is complete. | | | |
| 14 | VNIM | Russia | 16 – 25 December 2024 | Y |
| / | Note: 1. The transfer artifacts and ATA carnet should be transported separately . 2. The transfer artifacts and ATA carnet should be sent back to NIM by VNIM . | | | |
| 15 | NIM | China | 15 – 24 January 2025 | Y |

Participant should strictly adhere to the time schedule for conducting all the measurements. Each participant should have a work plan in place and make every effort to ensure all the measurements are completed within the allocated time. After the period of measurement, each participant should send the transfer packages to the next Participants as soon as possible. It is worth mentioning that **the transfer artifacts and the ATA Carnet should be transported separately**.

A period of at least 20 days has been allocated for the transportation of the transfer packages and ATA carnet.

In the case of unforeseen difficulty that may **delay the progress** of this key comparison, the Participant must inform NIM at once such that suitable arrangements may be sought to minimize the scheduling problem.

Participant must **notify NIM** if they **do not receive** the artifact and ATA carnet on schedule.

4. Description of the transfer standard

4.1 20L

NIM chooses one of two 20 L pipettes which made in China as the transfer standard (TS) for the 20 L volume measurement. (See figure 1)

The artifact is made of stainless steel with a built-in 4-wire Pt-100 temperature sensor. The sensor coupled with a handheld digital thermometer is used to measure the temperature of the water inside the 20 L pipette. **Do not make any attempt to remove the Pt-100 temperature sensor.**

4.2 100mL

The transfer standards for volume measurement at 100 mL (see figure 8) are two commercially available glass pycnometers of Gay Lussac type supplied by NIM. They were made from borosilicate glass and manufactured according to ISO 3507. The pycnometers should never be touched with bare hands. One should use a suitable tong, or the cotton gloves provided to handle the pycnometer.

5. Transfer package

The transfer standard (TS) will be shipped in a special case (see figure 9). The box has size (width x height x depth) (mm) is 860 x 580 x 660. The weight of the package is approximately 30 kg including the TS. A torque wrench is supplied with the transfer package to provide reproducible torque values for assembling the transfer standards. The wrench has been set to 10.0 N.m for assembling purposes. The contents in the package are shown in Table 3.

Table 3 Content of the transfer package

| TS | No. | Item | Quantity | Manufacture | Serial number | Notes |
|--------|-----|---|-------------------------------|-----------------------------|---------------------|---|
| 20L | 1 | 20 L pipette | 1 | KeiFeng Instrument Co. Ltd. | YC180040 | One half is fitted with a thermometer and a cable (very delicate). |
| | 2 | Metal leg for pipette | 3 | | | Attach to the bottom half of the pipette. The heights of the legs are adjustable for levelling the pipette. |
| | 3 | 3-way valve | 1 | Swagelok | | Fixed to the outlet of the pipette |
| | 4 | Acrylic cover | 1 | | | To be fitted to the top of the pipette with 1 washer |
| | 5 | Pt-100 sensor | 1 | / | 07215 | Fixed to the pipette. With 1 power cable. |
| | 6 | cable | 1 | | | Connect Pt-100 and Fluke 1523 |
| | 7 | Digital Thermometer | 1 | Fluke 1523 | 3500761 | connected to Pt 100 sensor. |
| | 8 | Torque wrench | 1 | XITE XT2-014 | 023698 | To be used at 10 N.m (in a black container) |
| | 9 | 8mm drive fitting for the torque wrench | 1 | XITE | | In a plastic bag |
| | 10 | Locating Pin | 2 | | | In a plastic bag. |
| | 11 | Baffle for Locating | 3 | | | In a plastic bag. Accessories used for assembling the pipette |
| | 12 | Screw | 9 (M10×40 long flange screws) | | | |
| | 13 | Dash pot | 3 | | | |
| | 14 | Stud | 3 (M10×20×50) | | | Accessories used for assembling metal leg |
| | 15 | Anchor | 3 | | | |
| | 16 | Steel plate | 3 (Near triangle) | | | |
| 100 mL | 1 | Glass pycnometer | 2 | Brand GMBH | 21.0103 21.01242 | Handle gently |

6. Transportation

The transfer standard package is transported unaccompanied by air cargo. Each participant is responsible for customs clearance in its own country/Economy and organizing the door-to-door transportation to the next participating institute according to the circulation scheme.

Upon receipt of TS, the **former** participant must **inform the latter**. The latter shall inform the **former and NIM** of the relevant information of transportation company and contact person (As shown in the following Table 4).

Table 4 The information of transportation company for participant

| Economy | NMI | Transportation company & contact person |
|---------|-----|--|
| | | Company name: Contact person: Fax: Tel: |

Each participant is responsible for its own costs for the measurements, transportation to the next participant and any customs charges as well as any damages that may occur within its country / Economy. The transfer artifacts shall be insured for US\$16,000 during their transportation to the next participant.

Each participant bears all loss or damage of the transfer artifacts that may occur during their stay at the participant. The participant should insure the transfer artifacts while they are under its responsibility. NIM should be informed without delay of all incidents that may cause damage to the transfer standard. NIM should also be informed of delay or a requirement for a change of schedule.

An **ATA carnet**, valid for one year, will be used for the temporary importation of the transfer artifacts to the participating country/economy.

Upon each movement of the package the person organizing the transit must ensure that *the paperwork of the ATA carnet is filled out properly and presented to customs on leaving the country, and upon its arrival in the country of destination*. The carnet must be included with other forwarding documents so that the handling agent can obtain customs clearance.

If the customs of a country/economy do not accept ATA carnet, the participant shall bear the tariff and other associated fees, if any, for the temporary importation of the artifacts.

Note:

ATA Carnet is an international customs and temporary export-import document. It is used to clear customs without paying duties and import taxes on merchandise that will be re-exported within 12 months.

6.1 Arrival

The transfer standards must be handled with care, i.e., only by qualified metrology personnel. When the transfer packages arrive at the participant, the packages must be unpacked and checked for any damages at once. For occupation health and safety reasons, the 20 L transfer standard should be removed from the container by two people. The status of the carrying case should also be checked to see if there are any damages.

The contents and conditions of the transfer standards should be reported on the proper arrival form attached in Appendix A1. This form should be sent by e-mail to the NIM without delay.

6.2 Departure

Participants must notify NIM as soon as possible by email if they are unable to dispatch the transfer standards on schedule.

The participant is responsible to ensure that all the items of the transfer packages are packed in their original carrier cases appropriately. The contents and appearance of the transfer standards should be inspected and reported on the proper departure form attached in Appendix A2.

These forms should be sent by email to NIM as soon as possible. The participant should arrange the best feasible way for transporting the packages to the next participant. Before dispatching the packages, each participant must inform the next Participant in the circulation schedule and NIM, giving transportation details.

The proper page(s) of the ATA carnet shall be filled out properly and handed over to the handling agent.

It should be noted that: ***Do not pack the ATA Carnet with the artifacts in the transfer package.***

7. Measurements

Measurements should be conducted after a proper acclimatization time (at least one day after receipt), and the results reported on the forms provided in A4.

Each participant shall use a source of pure (distilled or deionized) water for the evaluation of density of water using the recommended tables or formulas as given in the literature [1-6]. The ambient conditions and their associated uncertainties should be reported in the uncertainty budget provided in A5. According to the schedule, every participant laboratory has 10 days to complete the measurements. It is expected that after the period of measurement, each participant laboratory will send the transfer packages to the next participant as soon as possible.

7.1 20 L transfer standard

The cubic coefficient of expansion of the transfer standard material is stated as $(47.7 \pm 2.0) \times 10^{-6} \text{ }^{\circ}\text{C}^{-1}$. This value was recommended for the CCM.FF-K4 comparison. The uncertainty is expressed as standard uncertainty.

7.1.1 Cleaning and Assembling

The transfer standard should be cleaned and assembled according to the instructions.

1. Place the lower part of the transfer standard over a soft material as illustrated in Figure 2. The soft material should prevent any scratch on the flange.
2. Attach all three metal legs and baffle for Locating to the lower part by leg's screws.
3. By hand screw the three M10 screws of Metal leges all the way down (Figure 4).

Then screw three studs into threaded holes, insert studs into the steel plate holes, tighten nuts, and attach the anchors (Figure 2).

4. Set the lower part in the upright position.
5. Generously rinse the inner surface of both lower and upper parts of the transfer standard with an ethyl alcohol-pure water mixture (50–50 %). Video 1 supplied by NIM illustrates the cleaning process.
6. The surface is properly cleaned if there are no water layers or drops staying on the surface after draining. When this condition is reached, the transfer standard is ready to be assembled for measurement. Otherwise repeat the cleaning process using acetone as the cleaning fluid, if necessary, until the surface is properly cleaned.
7. Gently dry the inner surface using soft rags or cotton fuzz free cloth.
8. Gently place the upper part over the lower part of the transfer standard (see Figure 3). Prevent any protrusion of strange material either into the transfer standard or over the flanges. Align the flanges with according to the locating hole as shown in Figure 4 and 6.
9. Gently place the two locating pins.
10. **By hand** again screw the remaining nine (M10 x 40) long screws. The screw threads should be able to go all the way into the thread hole. If this is not the case, check the alignment of the upper and lower flanges and replace any damaged screws.

Great care should be exercised to prevent any crossed thread; it may be extremely difficult to unscrew them.

11. Use the supplied torque wrench with a pre-set value of 10 N·m to tighten all screws according to the sequence shown in Fig. 5. If the value of the torque wrench has been changed, adjust the torque wrench to 10.0 N·m.
12. Place the transfer standard at a sufficient height so that it can deliver the total amount of water.
13. Attach the acrylic cover to the top of the transfer standard.
14. Check the level of the transfer standard by placing a spirit level on the outer rim of the upper flange (Fig. 6). Use the adjustable studs to level the transfer standard.
15. Connect the source of water to the inlet port of the 3-way valve.

Note: Do not make any attempt to remove the Pt-100 temperature sensor on upper part.

7.1.2 Getting the transfer standard ready

To improve the temperature uniformity in the 20 L transfer standard, it is highly advisable to place the transfer standard and the pure water container in the measurement laboratory at least 24 hours before starting the measurement.

Fill the transfer standard with water for checking of leaks. Ensure there are no leaks between the two flanges. To evaluate for eventual leaking, fill the water until it overflows both tubes inside the acrylic cover at the top of the transfer standard. Let the water drain out of the acrylic cover through the excess draining port (see Video 2). A meniscus will be formed. The meniscus should stay visible for at least 10 minutes (see figure 7).

Before starting the first measurement run, the transfer standard needs to be filled and the water kept for a period of at least 12 hours. As a guide, the transfer standard can be filled in the afternoon and then drained in the following morning. This allows the water to fill out all tiny recesses between the flanges and allows the transfer standard to reach thermal stability.

7.1.3 Temperature Measurements

The transfer package includes a FLUKE handheld digital readout, model 1523, and a precision Pt-100 temperature sensor (No. 07215) for measuring the water temperature in the transfer standard. The temperature sensor has been calibrated in NIM's Temperature Laboratory.

7.1.4 Observation of the Meniscus

To get a repeatable observation of the meniscus, it is recommended to:

1. Fill the transfer standard until water overflows both tubes inside the acrylic cover at the upper part of the transfer standard.
2. Let the water drain out through the excess draining port inside the acrylic cover. At this stage, the meniscus will show a flat profile as produced by the surface tension.
3. Gently tap the transfer standard with fingers all the way around its periphery so that any air bubbles inside are buoyed to the liquid/air surface.
4. Slightly open the inlet valve, so that the water again overflows both tubes.
5. Once more, let the water to be drained out through the excess draining port. At this stage, the meniscus will show a flat profile and the transfer standard is considered ready to deliver the water.

To minimize the effect of eventual leaking, it is recommended to set the meniscus just before taking the mass measurement of the delivered water

7.1.5 Delivery of water

1. Deliver the water via the three-way valve to a clean container.
2. When the main flow of water has ceased (water just started to drip), allow a "drip-off" time of 60 seconds for draining out any remaining water.
3. Close the three-way valve. Weigh the water collected.
4. Report measurement results in the form provided in A4.

7.2 100 mL transfer standard

The participating laboratory shall determine **the volume of pure water that each of the two 100 mL glass pycnometers is able to contain, at a reference temperature of 20 °C.**

The pycnometers should be cleaned and rinsed with ethyl alcohol before each measurement. The pycnometers should never be touched with bare hands. They should be placed under a bell jar to avoid contamination when not being weighed in the balance.

Each participating laboratory shall make use of its own instruments and procedures to measure the water temperature contained in each of the pycnometers.

The pycnometers are not protected against evaporation by a supplementary cap. If the loss of water due to evaporation is found to be significant during weighing of the filled pycnometer, each participating laboratory may need to devise a procedure to measure the loss of water evaporation and take this into account in determining the volume.

According to the manufacturer of the pycnometers, the cubic expansion coefficient is $(9.9 \pm 1) \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ (uncertainty is expressed as standard). This value is recommended to be used to determine the volume at the reference temperature.

8. Reporting of results

Each participating laboratory will conduct **10 measurements** for each transfer standard. It is recommended to conduct **five measurements in a day.**

Each participating institute must report the following information, using the proper format given in the Appendix, to NIM as soon as possible and at the latest six weeks after the measurements are completed.

- (i) Details of the participating institute's instruments and water source (Appendix A3)
- (ii) Measurement results (Appendix A4)
- (iii) Uncertainty budget (Appendix A5)

Uncertainty calculations should be performed in accordance with the Guide to the Expression of Uncertainty in Measurement (GUM) [10].

The participant may add other information which they think is useful. All data and information should be sent as an attachment to an email.

9. References

1. Tanaka, M., et. al; Recommended table for the density of water between 0 °C and 40 °C based on recent experimental reports, *Metrologia*, 2001, 38, 301-309.
2. Bettin, H., and Spieweck, F., Die Dichte des Wassers als Funktion der Temperatur nach Einfuehrung der Internationalen Temperaturskala von 1990, *PTB-Mitteilungen*, 100, 1990, 195-196.
3. Wagenbreth, H. and Blanke, W., Die Dichte des Wassers im Internationalen Einheitensystem und in der Internationalen Praktischen Temperaturskala von 1968, *PTB –Mitteilungen*, 81, 1971, 412-415.
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5. Patterson, J. B. and Morris, E. C., Measurement of Absolute Water Density, 1 °C to 40 °C, *Metrologia*, 31, 1994, 277-288.
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9. Jones, F. E., The Air Density Equation and the Transfer of the Mass Unit, *J. Res. Nat. Bur. Stand. (U.S.)*, 83, 1978, 419-428.
10. JCGM 100:2008, Guide to the expression of uncertainty in Measurement.
11. BIPM, International temperature scale of 1990, Part 2. Techniques and thermometers traceable to the international temperature scale of 1990; Section 16. Industrial platinum resistance thermometers.
12. Miller R, *Flow Measurement Handbook*, McGraw Hill 1996, 3rd edition.
13. John Man, *Technical Protocol for Volume Intercomparison at 20 L and 100 mL*, 2nd Edition. (Comparison Identifier: APMP.M.FF-K4)

10. Figures

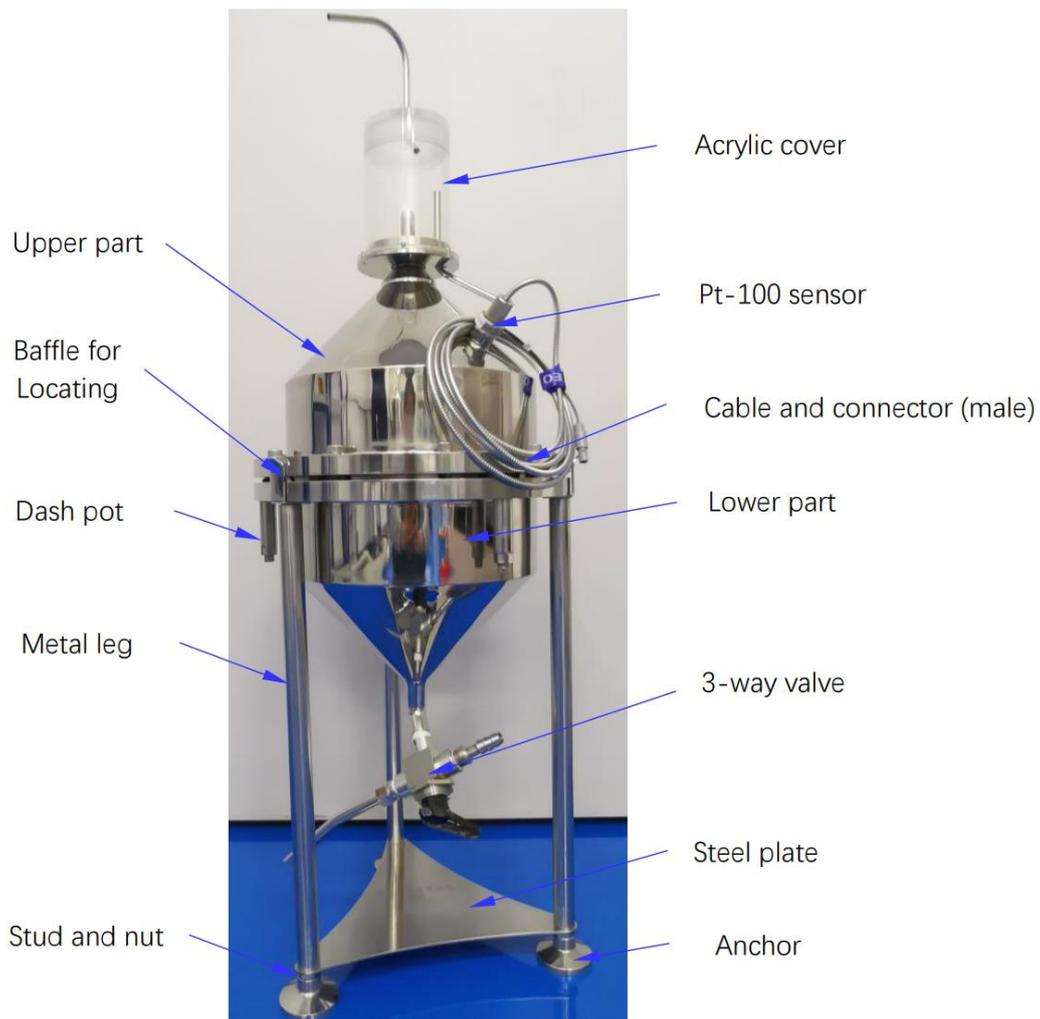


Figure 1 A photograph of the assembled 20 L transfer standard



Figure 2 A photograph of assembling the three metal legs to the lower part of the 20 L transfer standard

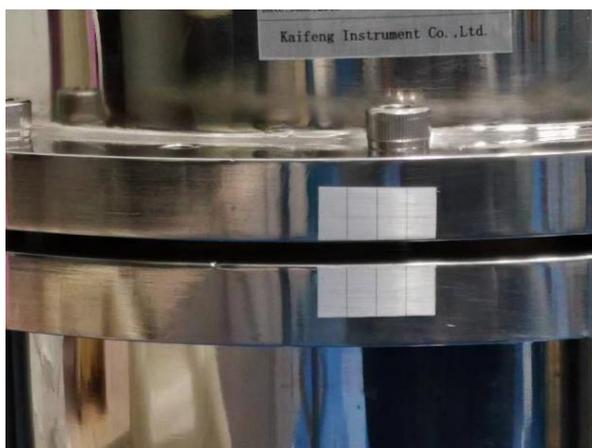


Figure 3 Alignment of the upper and lower flanges

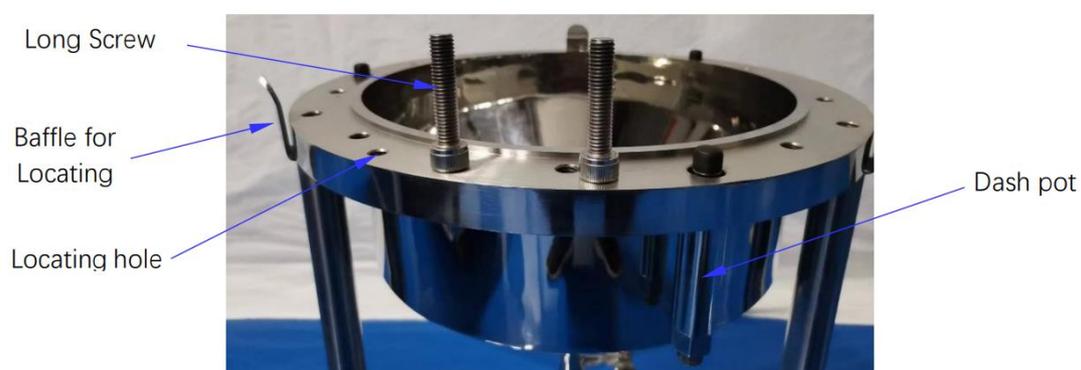


Figure 4 The screws must be put into the threaded holes on the upper and lower flanges

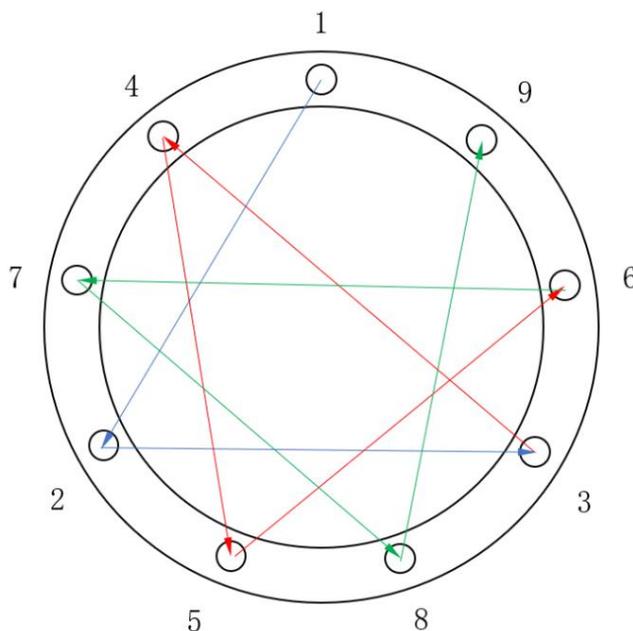


Figure 5 Sequence for tightening the screws for joining the upper and lower parts of the 20 L transfer standard



Figure 6 Top view of the 20 L transfer standard



Figure 7 Meniscus, formed at the top of the transfer standard, should stay visible for at least 10 minutes for checking of leaks



Figure 8 A photograph of the 100 mL glass pycnometers



Figure 9 A photograph of the Transfer Package

11. Figures of accessories

| No. | Item | Number | Figure |
|-----|---|--------|---|
| 1 | Metal leg for pipette | 3 |  |
| 2 | 3-way valve | 1 |  |
| 3 | Acrylic cover | 1 |  |
| 4 | Digital Thermometer & Power adapter | 1 |  |
| 5 | Torque wrench | 1 |  |
| 6 | 8mm drive fitting for the torque wrench | 1 |  |
| 7 | Locating Pin | 2 |  |
| 8 | Anchor | 3 |  |
| 9 | Nut | 3 |  |
| 10 | Stud | 3 |  |
| 11 | Baffle for Locating | 3 |  |
| 12 | Long screw | 9 |  |
| 13 | Dash pot | 3 |  |

Appendix A1: Arrival form: 20L

| | |
|--------------|--|
| NMI: | |
| Report date: | |

Arrival of standard:

| | |
|-------|--|
| Date: | |
| Time: | |
| From: | |

Contents(refer to protocol):

| | |
|-----------------|--|
| Check contents: | |
| Other remarks: | |

Conditions of the TC on arrival:

| | |
|--------------------|--|
| Transport Box: | |
| Transfer standard: | |
| Other remark: | |

Contact person:

| | |
|------------------|--|
| Name: | |
| Mailing Address: | |
| Telephone: | |
| Fax: | |
| E-mail: | |

Appendix A1: Arrival form: 100mL

| | |
|--------------|--|
| NMI: | |
| Report date: | |

Arrival of standard:

| | |
|-------|--|
| Date: | |
| Time: | |
| From: | |

Contents(refer to protocol):

| | |
|-----------------|--|
| Check contents: | |
| Other remarks: | |

Conditions of the TC on arrival:

| | |
|--------------------|--|
| Transport Box: | |
| Transfer standard: | |
| Other remark: | |

Contact person:

| | |
|------------------|--|
| Name: | |
| Mailing Address: | |
| Telephone: | |
| Fax: | |
| E-mail: | |

Appendix A2: Departure form: 20L

| | |
|--------------|--|
| NMI: | |
| Report date: | |

Departure of standard:

| | |
|-------|--|
| Date: | |
| Time: | |
| To: | |

Contents(refer to protocol):

| | |
|-----------------|--|
| Check contents: | |
| Other remarks: | |

Conditions of the TC on departure:

| | |
|--------------------|--|
| Transport Box: | |
| Transfer standard: | |
| Other remark: | |

Contact person:

| | |
|------------------|--|
| Name: | |
| Mailing Address: | |
| Telephone: | |
| Fax: | |
| E-mail: | |

Appendix A2. Departure form: 100mL

| | |
|--------------|--|
| NMI: | |
| Report date: | |

Departure of standard:

| | |
|-------|--|
| Date: | |
| Time: | |
| To: | |

Contents(refer to protocol):

| | |
|-----------------|--|
| Check contents: | |
| Other remarks: | |

Conditions of the TC on departure:

| | |
|--------------------|--|
| Transport Box: | |
| Transfer standard: | |
| Other remark: | |

Contact person:

| | |
|------------------|--|
| Name: | |
| Mailing Address: | |
| Telephone: | |
| Fax: | |
| E-mail: | |

Appendix A3. Technical specification and traceability: 20L

| NMI: | | | | | | |
|---------------------|-------------------|--------------------|------------|-------------------------|---------------------|--------------|
| Report date: | | | | | | |
| Instrument | Manufacturer | Model/ capacity | Resolution | Standard uncertainty | Calibration Date | Traceability |
| Balance | | | | | | |
| Weights | | | | | | |
| Ambient temperature | | | | | | |
| Ambient pressure | | | | | | |
| Relative Humidity | | | | | | |
| | Production Method | | | | | |
| Water | | | | | | |

Appendix A3. Technical specification and traceability: 100L

| NMI: | | | | | | |
|---------------------|-------------------|--------------------|------------|-------------------------|---------------------|--------------|
| Report date: | | | | | | |
| Instrument | Manufacturer | Model/ capacity | Resolution | Standard uncertainty | Calibration Date | Traceability |
| Balance | | | | | | |
| Weights | | | | | | |
| Ambient temperature | | | | | | |
| Ambient pressure | | | | | | |
| Relative Humidity | | | | | | |
| | Production Method | | | | | |
| Water | | | | | | |

Appendix A4. Measurement Results: **20L**

| | | | | | | | | |
|---------------------------------|------------------|-------|-------------------|-------|------------|------|-------------------|------------------|
| Institute: _____ | | | | | | | | |
| Serial number _____ | | | | | Date _____ | | | |
| | m_{water}^{**} | t_w | ρ_w | t_a | p | RH | ρ_a | $V_{20^\circ C}$ |
| | g | °C | g/cm ³ | °C | Pa | % | g/cm ³ | cm ³ |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| Best estimate of the measurand | | | | | | | | |
| ** Weighing Method _____ | | | | | | | | |

Appendix A4. Measurement Results: 100mL

| | | | | | | | | |
|---------------------------------|------------------|-------|-------------------|-------|------------|------|-------------------|------------------|
| Institute: _____ | | | | | | | | |
| Serial number _____ | | | | | Date _____ | | | |
| | m_{water}^{**} | t_w | ρ_w | t_a | p | RH | ρ_a | $V_{20^\circ C}$ |
| | g | °C | g/cm ³ | °C | Pa | % | g/cm ³ | cm ³ |
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| Best estimate of the measurand | | | | | | | | |
| ** Weighing Method _____ | | | | | | | | |

