Draft Protocol for APMP.M.FF.K1.1.2022 key comparison
Water flow 5 kg/min to 60 kg/min (1st version)

Pilot laboratory: **CMS** Center for Measurement Standard
Flow &Green Energy Metrology Laboratory
Industrial Technology Research Institute
No.30, Ta Hsueh Rd., Hsinchu, 30080
Taiwan, R.O.C.

KC coordinator:	Chun-Lin Chiang	
	Phone:	+886 3 5741211
	Fax:	+886 3 5710335
	Email:	C.L.Chiang@itri.org.tw
Coordination assistant:	Che-Wei Yeh	
	Phone:	+886 3 5741213
	Fax:	+886 3 5710335
	Email:	jerwei2003@itri.org.tw

Participating Laboratory: CMS(Chinese Taipei, pilot and linking Lab), KRISS(linking Lab.), ……

Table of contents

1. Introduction

The key comparison, APMP.M.FF.K1.1.2022 for water flow measurement has been undertaken by APMP/TCFF, which is Technical Committee for Fluid Flow(TCFF) and was piloted by Center for Measurement Standard (CMS/ITRI) of Chinses Taipei. The purpose of this key comparison is to demonstrate the degree of equivalence of the water flow standard at the participating laboratories to the CCM.FF-K2.1 2011 key comparison reference value (KCRV) and to provide supporting evidence for the calibration and measurement capabilities (CMCs) claimed by the participating laboratories in the Asia-Pacific regions. CMS and KRISS serve as the linking lab in this comparison.

Both Standing Start Finish (SSF) and Flying Start Finish (FSF) are allowed in this key comparison. It should be noted that when using the SSF method, each measurement should be at least one minute. At 5 kg/min this should be two minutes.

This document serves as the technical protocol for the comparison and includes e.g. specific instructions for calibrating the transfer standard and timetables for a successful and timely completion of the comparison.

1.1 Test liquid

Following the CCM.FF-K2.1.2011 key comparison project, the water is the test liquid

2. Administrative Information

The information of the schedule will be demonstrated after the collection of the questionnaire. We plan that the comparison starts after one year of preparation. Each participant should share the expense from the comparison.

2.1 Participants

Table 1. Information of participants

NMI/DI	Country	Contact	Test	Shipping	Remark
CMS/ITRI	Chinese Taipei	Chun-lin Chiang	2022/07/01-2022/07/22	2022/07/22-2022/08/01	First-round test (TEMPORARY ADMISSION Carnet)
KRISS	Republic of Korea	Sejong Chun	2022/08/01-2022/08/19	2022/08/19-2022/08/31	(ATA Carnet)
NMIM	Malaysia	Ts. Mohd Noor bin Mohd Ghafar	2022/09/01-2022/09/21	2022/09/21-2022/10/03	(ATA Carnet)
NIMT	Thailand	Theerarak	2022/10/03-	2022/10/21-	(ATA Carnet)

		Chinarak	2022/10/21	2022/11/04	
NMC	Singapore	Zeng Yan	2022/11/04-2023/11/25	2023/11/25-2023/12/05	(ATA Carnet)
KRISS	Republic of Korea	Sejong Chun	-	2022/12/05-2022/12/16	(ATA Carnet) (Shipping)
CMS	Chinese Taipei	Chun-lin Chiang	2023/12/16-2023/01/09	2023/01/09-2023/02/10	Second-round test (Christmas Day, New year, Chinese New Year)
NPLI	India	Shiv Kumar Jaiswal	2023/02/10-2023/03/03	2023/03/03-2023/03/17	(TAITRA/FICCI Carnet)
CMS	Chinese Taipei	Chun-lin Chiang		2023/03/17-2023/04/07	(Shipping)
AIST/NMIJ	Japan	Sanehiro Wada	2022/04/07-2022/04/28	2022/04/28-2022/05/12	(SCC Carnet)
CMS	Chinese Taipei	Chun-lin Chiang	2023/05/12-2023/05/31	-	Final test

3. Description of the transfer standard

The transfer meter package made by aluminum extrusion is connected with one Coriolis flow meter(as picture 1), stainless pipes, two on-off valves and hoses with quick coupling. The specification of the flange is ANSI #150 RF 1 inch. The flange connection will be connected with the NMI's test facility in the upstream and downstream. One absorbing pad can be placed under the transfer meter package to reduce the impact of the external vibration.

3.1 Description summary of the transfer standard

Skid

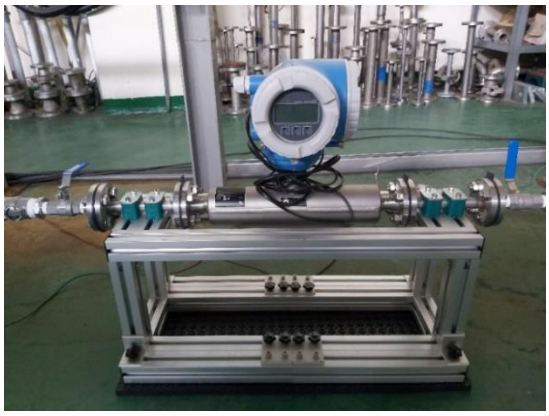
Maximum pressure	: 5×10^5 Pa gauge
Temperature range	: (20 to 30) °C
Mass flow rate	: (5 to 60) kg/min
Connection	: ANSI #150 RF flange
Hose/quick coupling size	: DN25
Ball valve size	: DN15
Special adoptions	: One absorbing pad

	: two 2.5 m hoses
Coriolis flow meter(sensor)	
Manufacturer	: ENDRESS + HAUSER
Type	: Promass F
Serial number	: S5128C02000
Size	: DN15
Output signal	: Frequency
Pulse value	: 1000 pulses/kg
Coriolis flow meter(display)	
Manufacturer	: ENDRESS + HAUSER
Type	: Promass 300
Serial number	: S5128C02000
Laptop computer	
Manufacturer	: ASUS
Type	: ASUS X415
Serial number	: MCN0CV02P708483
Accessories	: a bag, a mouse, a laptop computer transformer with power cord suitable for 110 V_{AC}, a universal plug mentioned below
OS/Software	: Windows 11 / Microsoft office 2021
Power supply	
Manufacturer	: OMRON
Type	: S8FS
Input	: (100 to 240) V_{AC}
Output	: 24 V_{DC}
Universal plug	
Manufacturer	: SAMPO
Type	: EP-UF1C(B)
Input	: (100 to 240) V_{AC}
Area (~110 V, Type 1)	Taiwan, Japan
Area (~220 V, Type 1)	Philippines, China, Thailand, Vietnam
Area (~220 V, Type 2)	China, Australia, New Zealand
Area (~220 V, Type 3)	Hong Kong, U.A.E, Singapore, Malaysia
Area (~220 V, Type 4)	China, Russia, U.A.E., India
Area (~220 V, Type 5)	U.A.E., Korea, Indonesia, Russia, Vietnam

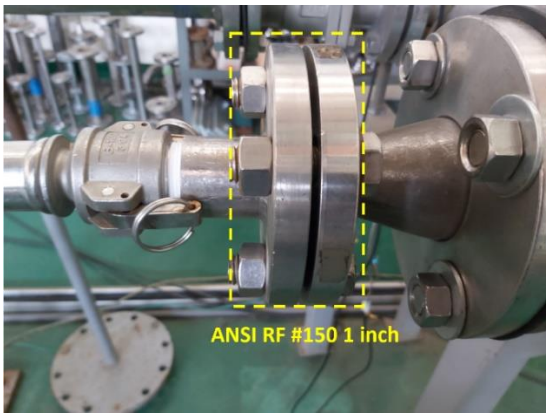
We provide two ANSI RF #150 1 inch flange connections in the upstream and downstream as shown in picture 2. The participant also needs to take care of appropriate space for the placement of transfer standard package including the hoses in the upstream and downstream as picture 3 showing. One 24 V_{DC} power supply for the mass flow meter is located on the aluminum extrusion. The “L”, “N”, and “E” correspond to positive electrode, negative electrode, and ground as shown in picture 4. We will provide one line used for 110 V_{AC} that installed on the power supply. For the participants using other voltages, please replace the electrical line and connect to three electrodes correctly. It should be noted that the voltage selector switch on the side of the power supply should be changed when using other voltage range as shown in picture 5.

The input voltage for laptop computer ranges from (100 to 240) V_{AC}. There is an universal plug that connected to the electrical line for the laptop computer in the laptop computer bag as showin in picture 6. For the participants using different voltages, the universal plug can be changed and connected to the power of participants. Participants can change the plug type in five types as shown in picture 7. Besides, the pin number of the laptop computer is “dannydanny25”.

3.2 Picture

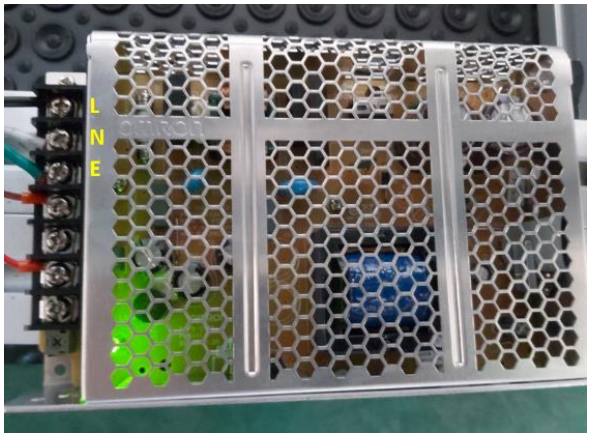


Picture 1 Coriolis mass flow meter package

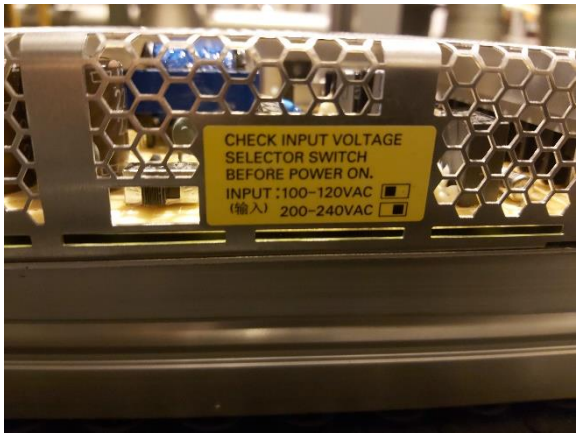


Picture 2 ANSI RF #150 1 flange

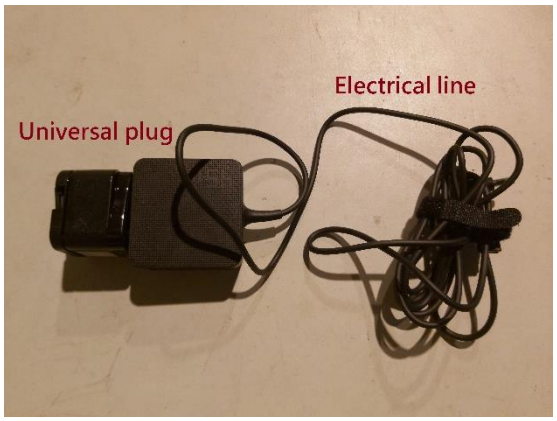
Picture 3 The hose in the upstream and downstream



Picture 4 24 V_{DC} power supply



Picture 5 Voltage selector switch



Picture 6 Universal plug and electrical line of laptop computer

Picture 7 Types of universal plug

4 Checks before the measurement for the KC

In this chapters the checks before the measurement are presented including filling the transfer standard, instrument health status check and zero adjustment procedures. These procedures are needed to be checked before the measurement for the KC.

The transfer standard package is shipped in one transportation boxes, which are sufficiently robust to ensure safe transportation. The boxes should be opened by laboratory trained professional personnel upon receiving at the laboratory. Check the package casing for damage and then check the contents against the Receiving Checklist Excel spreadsheet. “SHOCKWATCH” labels were given on box for damage check. If any of the “SHOCKWATCH” labels are activated, note it on the Receiving Checklist and notify the pilot laboratory immediately. Note any damage or missing items on the Receiving Checklist and report to the pilot laboratory and the previous laboratory.

4.1 Filling the transfer standard procedure

00 Make sure that all ball valves of the transfer package are closed.

01 Water fill the test facility upstream the transfer package according to the participants' own procedure.

02 Make sure that no leakage and no air inside the upstream pipe happens in the transfer standard and the participant's own facility.

03 Open the upstream ball valve and then downstream ball valve of the transfer package in order the let the flow passes through the mass flow meter.

04 Flow at least five minutes at 50 kg/min to bleed of air or vapors and make sure that the temperature is stable.

05 Slowly close the ball valve in the downstream.

06 Carry out the instrument health status check procedure and the zero adjustment procedure below before the measurement for the KC.

4.2 Instrument health status check procedure

The E+H Coriolis flow meter can be set as an wi-fi hotspot to let the laptop computer connect to the mass flow meter through the browser. This method can be used to carry out the health status check procedure.

00 Connect the power supply to the Coriolis flow meter. Find the wi-fi hotspot "EH_Promass 300 500_8C02000" in the wi-fi menu of the laptop and connect to it.

01 Open the chrome browser and enter the ip address: "192.168.1.212" to connect to the Coriolis meter login page. Make sure that the menu can be connected successfully. Enter the access code "0000" and click the "Login" button to go to the main menu.

02 The display language can be chosen according to your needs in the main menu. The default set is English. The information of the Coriolis flow meter including device name, device tag, flow rate and density are shown in the main menu. The "status signal " should presented "Device ok".

03 Click the "Instrument health status", "Diagnostics", "Heartbeat", and "Performing verification" button in order.

04 In the "Performing verification" menu, enter the Day, Hour and Minute term of the measuring time.

05 Change the "Cancel" status to the "Start" status in the "Start verificat." term. It takes about few seconds to wait for the process till the progress bar reaches to the end.

4.3 Zero adjustment of mass flow meters

The zero adjustment is an important step before any measurement can take place for this KC. This procedure needs to be performed every time when the transfer standard is connected to another test facility. At the start of each day a zero check as described in will be sufficient. The zero adjustment procedures are presented below.

01 Click the "Setup", "Advanced setup", "Sensor adjustment", and "Zero point adjustment" button in order. It should be noted that the installation direction should not be changed in the "Sensor

adjustment" menu and then click the "Zero point adjustment" button.

02 Click the "Zero point adjustment control" menu and change the "Cancel" status to the "Start" status. And then the zero adjustment procedure will start.

03 It takes about few minutes to wait for the zero adjustment procedure til the "Busy" status change to the "Cancel" status and the progress bar reaches to the end. Make sure that the valves in the upstream and downstream should be closed and the pipe is full and static before starting the zero adjustment procedure.

04 Back to the main menu, Check the zero point value in the menu.

4.4 Measurements procedures

The measurement process follows the contents in the CCM.FF-K2.1.2011 key comparison as shown in Table 1. The steps in Table 2 should be performed before the KC measurement.

Table 2. KC measurement procedure

Flow-rate (kg/min)	Number of Repeats (n)	Remarks
5	3	Not in KCRV calculation
20	5	--
40	10	5 extra tests for repeatability
60	5	--
50	5	--
30	5	--
10	5	--
5	3	Not in KCRV calculation

5 Data to be provided by the participating NMI's

5.1 Description of test facility and a simplified P&ID

Each participant needs to provide a description and a simplified P&ID drawing to show how the transfer standard is connected to the participant's test facilities.

5.2 Time for measurement

It is recommended to spend 3 weeks for measurements and the following 2 weeks for transport to the next laboratory

5.3 Report the measurement data

It is recommended to send calibration results to the pilot laboratory within 1 month after completion of the measurement. For reporting the results a dedicated Excel workbook is provided to the participants.

5.4 Measurement failure of the transfer standard

If a participant suspects failure of the transfer standard it shall be reported immediately to the pilot laboratory. The pilot laboratory shall decide if repair is required and make arrangements for any repairs. The total costs for repairing (including shipping) will be shared equally among all participants

6 Data analysis by the pilot NMI (KCRV calculation)

The data analysis follows the calculation method that determining the reference value at each flow will correspond to procedure presented by M. G. Cox [1] and the report for CCM.FF-K2.1.2011 key comparison Water flow 5 – 60 kg/min. Each flow includes (10, 20, 30, 40, 50, 60) L/min as shown in Table 2. The reference value will be determined in each flow separately, which provide linkage to CCM.FF-K2.1.2011. CMS/ITRI and KRISS will serve as a linking laboratories.

Draft A and Draft B will be distributed to the participants in accordance with the Guidelines.

6.1 Determination of the KC Reference Value (KCRV) and its uncertainty

The APMP.M.FF.K1.1.2022 can be linked to the CCM.FF-K2.1.2011 results by correcting the results of link laboratories with the following procedures.

$$D = \sum w_{\mathrm{i}} D_{\mathrm{i}}$$

Where D_i is the correcting term calculated by the same link laboratory in CCM KC and APMP KC results. w_i is the weighing coefficient calculated by the equations below. And then the correcting term can be obtained in each flow rate condition.

$$D_i = x_{\mathrm{i,CCM}} - x_{\mathrm{i,APMP}}$$

$$w_i = \frac{\frac{1}{u_{\mathrm{xi}}^2}}{\sum \frac{1}{u_{\mathrm{xi}}^2}}$$

The KC Reference value (KCRV) and the expanded uncertainty of the KCRV of the APMP KC can be obtained by the same procedures in CCM.FF-K2.1.2011 KC.

When the KCRV will be determined, the differences between the KCRV and the participating laboratories will be calculated according to

$$\mathrm{di} = x_{\mathrm{i}} - x_{\mathrm{KCRV}} + D$$

Based on these differences, the Degree of Equivalence (DoE) will be calculated according to:

$$\mathrm{Ei} = \left| \frac{\mathrm{di}}{U(\mathrm{di})} \right|$$

The DoE is a measure for the equivalence of the results of any laboratory with the KCRV or with any other

laboratory, respectively. The results of a laboratory will be equivalent (passed) if Ei ≤ 1. The laboratory will be determined as not equivalent (failed) if Ei >1.2.- For values of DoE in the range 1 < Ei ≤ 1.2 the “warning level”is defined. In this case some actions to check are recommended to the laboratory. The standard uncertainty and the expanded uncertainty can be calculated as follows

$$u(\mathrm{di}) = \sqrt{u_{\mathrm{xi}}^2 + u_{\mathrm{xref}}^2 + u_D^2}$$

$$U(\mathrm{di}) = 2u(\mathrm{di})$$

7 References

1. Draft Protocol for CCM.FF-K2.1.2011 key comparison Water and Hydrocarbon flow 5 – 60 kg/min, 2011.
2. Template for WGFF-KCs Technical Protocol for CIPM Key Comparison, Version 1, 2009.8.
3. Cox M.G., Evaluation of key comparison data. Metrologia, 2002, 39, 589-595.
4. Cox M.G., The evaluation of key comparison data: determining the largest consistent subset. Metrologia, 2007, 44, 187-200.
5. Rousseeuw P.J., Leroy A.M., Robust Regression and outlier detection, John Wiley & Sons, New York, 1987.