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Comparison reports

APMP.M.FF-S2.2016

Water flow

SUPPLEMENTARY COMPARISON

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Final Report on the APMP supplementary comparison in the field of liquid (water) flow (0.5 m^3/h to 30 m^3/h) APMP.M.FF-S2.2016

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1. Introduction

The supplementary comparison, APMP.M.FF-S2.2016 in the field of water flow was organized and conducted between two National Metrology Institutes (NMIs), National Metrology Institute of Japan (NMIJ/AIST) and Research Center for Metrology (RCM) in Indonesian Institute of Sciences (Lembaga Ilmu Pengetahuan Indonesia or LIPI) in Indonesia. This bilateral comparison was undertaken by the Technical Committee for Fluid Flow (TCFF) of Asia Pacific Metrology Program (APMP), and was piloted by RCM-LIPI.

The travelling standards are two turbine meters provided by RCM-LIPI covering the range of 0.5 m^3/h to 30 m^3/h (about 8 L/min to 500 L/min). Each of turbine meters was tested by each participating NMIs in the measurement ranges of 0.5 m^3/h to 4.5 m^3/h and 3.5 m^3/h to 30 m^3/h.

The degree of equivalence between RCM-LIPI and NMIJ/AIST was obtained at every measurement point. The final report was prepared in accordance with some guidelines.

2. Participants and organization of the comparison

2.1. List of participants

The participants are listed in Tables 1.

Table 1. List of Participants

Pilot Laboratory	RCM-LIPI
Delivery Address	Pusat Penelitian Metrologi Lembaga Ilmu Pengetahuan Indonesia (Puslit Metrologi-LIPI) Kompleks PUSPIPTEK Gedung 420 Tangerang Selatan Banten Indonesia 15314
Contact	Mrs. Nur Tjahyo Eka Darmayanti/ Mr. Bernadus Herdi Sirenden Tel : +6221 7560533 ext 3115 E-Mail : nur.tjahyo.eka@gmail.com, bernadushs@gmail.com
Participating Laboratory	NMIJ/AIST
Delivery Address	National Metrology Institute of Japan National Institute of Advanced Industrial Science and Technology AIST North site 15, 1497-1Teragu, Tsukuba, Ibaraki, 300-4201,Japan Tel : +81298691905
Contact	Dr. Takashi SHIMADA/ Dr. Noriyuki FURUICHI/ Dr. Sanehiro WADA Tel : +81298614377 E-Mail : t-shimada@aist.go.jp, furuichi.noriyuki@aist.go.jp, wada.s@aist.go.jp

2.2. Comparison schedule

Table 2 shows the whole comparison schedule. RCM-LIPI started the measurement and then sent the traveling standards (TSs) to NMIJ/AIST. After NMIJ/AIST finished the measurement, TSs were sent back to RCM-LIPI to evaluate the reproducibility of the TSs.

Table 2. Comparison schedule

Measurement at RCM-LIPI	July ~ Oct 2017
Transportation to NMIJ	Nov 2017
Measurement at NMIJ	March ~ May 2018
Transportation to RCM-LIPI	June 2018
Measurement at RCM-LIPI	July ~ Sept 2018

3. Travelling Standards and measurement instruments

3.1. Description of Standards

Two turbine meters were used as travelling standards (TSs). The specifications of the standards are shown in Table 3. The pictures of the TSs, the pipes and the amplified pickoff with cable in the box for transportation are shown in Figure 1 to Figure 3.

Table 3. Description of Travelling Standards

ID	Meter 1	Meter 2
Manufacturer	FTI	FTI
Model	FT-12AEU3-LEA-0	FT-24AEU3-LEA-0
SN	12013288	2407168
Nominal range	0.45 m^3/h to 4.54 m^3/h (7.57 L/min to 75.71 L/min)	3.4 m^3/h to 34.1 m^3/h (56.78 L/min to 567.81 L/min)
Output	TTL Pulses	TTL Pulses
Pickoff	Described in Technical Protocol	Described in Technical Protocol
Upstream/Downstream Pipe	Described in Technical Protocol	Described in Technical Protocol
Travelling Box	Described in Technical Protocol	Described in Technical Protocol

Figure 1. Travelling Standard, Flanges, Amplied Pickoff with Cable, Gasket and Manual Book inside Travelling Box

Figure 2. FT-12 (Meter 1) with Adapter and Reducer Pipe

Figure 3. FT-24 (Meter 2) with Adapter and Reducer Pipe

3.2. Quantities to be measured and conditions of measurement

The participants calculated actual K factors at calibration condition. The K factors obtained at the participants were used to calculate a corrected K factor based on 20 ºC expressed as:

$$K_{f20} = K_f\{1 + 3\alpha(Tw - 20)\} \quad (1)$$

K_{f20} : Corrected K factor (pulse/L)
K_f: Actual K-factor (pulse/L)
α: Coefficient of linear expansion of material. (Stainless Steel 316 for flow meter housing, =1.6 x 10^{-5} (K^{-1})).
T_w: Water temperature during measurement near TS (ºC).

Relative K factor against the nominal K factor of the travelling standard (K) expressed as:

$$K = \frac{K_{f20} - K_{fnom}}{K_{fnom}} \quad (2)$$

K_{fnom}: Nominal K factor (= 1585.03 pulse/L for Meter 1 and 158.503 pulse/L for Meter 2).

The test points were as follows:

- Meter 1
  0.5 m^3/h, 1 m^3/h, 2 m^3/h, 3.5 m^3/h and 4.5 m^3/h
  (8.3 L/min, 16.7 L/min, 33.3 L/min, 58.3 L/min, 75 L/min)
- Meter 2
  3.5 m^3/h, 4.5 m^3/h, 10 m^3/h, 20 m^3/h and 30 m^3/h
  (58.3 L/min, 75 L/min, 166.7 L/min, 333.3 L/min, 500 L/ min)

The measurements were performed under the following conditions:

- Pressure: less than 3 bar abs
- Water temperature: 10 °C to 30 °C
- Ambient temperature: 10 °C to 30 °C

4. Methods of measurement

A summary of the calibration methods used by the participants are shown in Table 4.

Table 4. Calibration method

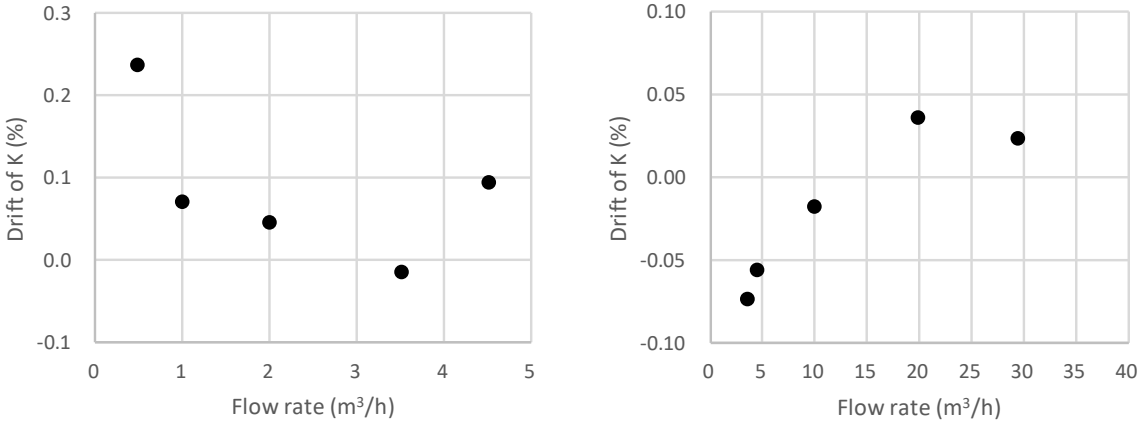
NMI	Range	Calibration method	Reference standard	Expanded uncertainty
NMIJ/AIST	0.3 m^3/h to 30 m^3/h	Static and gravimetric standard with flying start and stop	Weighing scale	0.044%
RCM-LIPI	(4 ~ 500) L/min	Volumetric standard with flying and stop	Piston prover	0.40%

5. Repeated measurements at the pilot institute, behavior of the travelling standards

The traveling standards were recalibrated in RCM-LIPI after measurement in NMIJ/AIST in order to evaluate the long term reproducibility of the travelling standards. The drift of relative K factors during APMP.FF-S2.2016 is shown in Figure 4. The maximum drift of the relative K factors in the calibrated flow rate range are 0.237% at Meter 1 and 0.074% at Meter 2. The standard uncertainty due to reproducibility of the

Meter 1 and Meter 2 including transport effect are estimated to be 0.068% and 0.021%, respectively.

The other uncertainties due to the travelling standard, namely, the effects due to differences of flow rates, Re number, temperature, pressure and the upstream condition between RCM-LIPI and NMIJ/AIST are assumed to be included in the uncertainty of reproducibility.



(a) Meter 1 **(b) Meter 2**

Figure 4. Drift of relative K factors during the comparison.

6. Measurement Result

6.1. Results of the participating institutes

6.2. Degrees of equivalence

The degree of equivalence (d) between NMIJ/AIST and RCM-LIPI and its standard uncertainty u (d) are expressed by

$$d = K_{NMIJ} - K_{LIPI} \tag{3}$$

$$u^2(d) = u_{NMIJ}^2 + u_{LIPI}^2 + u_{TS}^2 \tag{4}$$

With,
K_{NMIJ} : Relative K-factor at NMIJ
K_{LIPI} : Relative K-factor at RCM-LIPI
u_{NMIJ} : Standard uncertainty of relative K-factor at NMIJ
u_{LIPI} : Standard uncertainty of relative K-factor at RCM-LIPI
u_{TS} : Standard uncertainty due to the travelling standard

The expanded uncertainty of the degree of equivalence *U(d)* is obtained by

$$U(d) = ku(d) = 2u(d) \tag{5}$$

The En values are obtained by

$$En = \frac{|d|}{U(d)} \tag{6}$$

The degree of equivalence between RCM-LIPI and NMIJ/AIST is shown in Table 6 and Figure 6.

Table 6. Degree of equivalence between RCM-LIPI and NMIJ/AIST

Meter 1					
Flow rate (m^3/h)	**K_{LIPI} (%)**	**K_{NMIJ} (%)**	***d* (%)**	***U*(d) (%)**	**E_n**
0.5	-5.82	-5.348	0.47	0.43	1.10
1.0	-5.71	-5.508	0.20	0.43	0.47
2.0	-5.43	-5.335	0.09	0.43	0.22
3.5	-5.36	-5.308	0.06	0.43	0.13
4.5	-5.50	-5.361	0.14	0.43	0.32
Meter 2					
Flow rate (m^3/h)	**K_{LIPI} (%)**	**K_{NMIJ} (%)**	***d* (%)**	***U*(d) (%)**	**E_n**
3.5	-7.51	-7.410	0.10	0.40	0.25
4.5	-7.63	-7.500	0.13	0.41	0.33
10	-8.06	-7.907	0.15	0.40	0.37
20	-8.28	-8.136	0.15	0.41	0.36
30	-8.20	-8.117	0.08	0.41	0.19

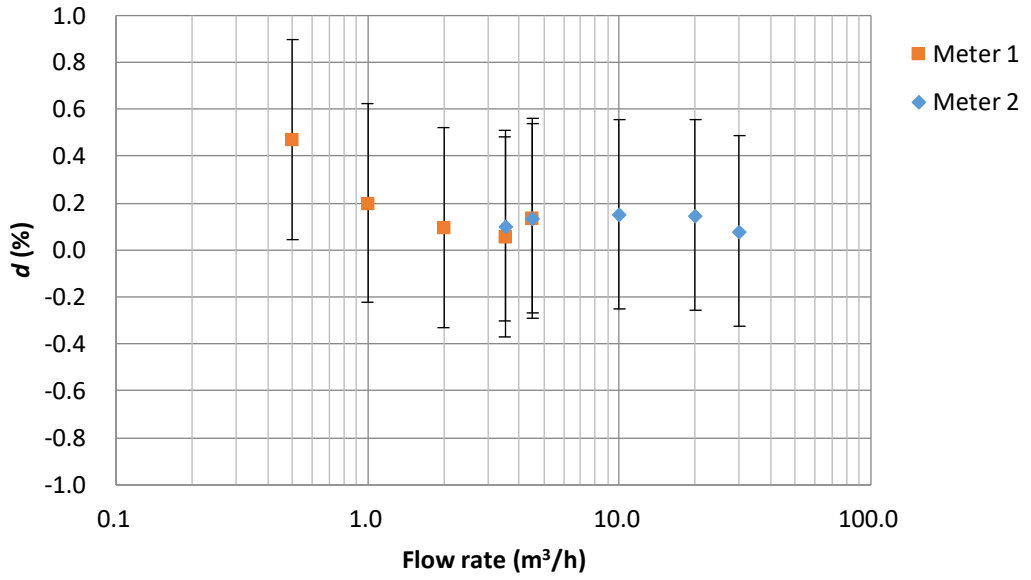


Figure 6. Degree of equivalence and its expanded uncertainty

6. Summary

The supplementary comparison APMP.M.FF-S2.2016 for water flow measurement has been conducted between RCM-LIPI (Indonesia) and NMIJ/AIST (Japan). Two turbine meters were selected as travelling standards.

The stability of the travelling standards was evaluated from the measurements of the pilot institute, RCM-LIPI. The travelling standards showed good stability for check of the capability in RCM-LIPI since the uncertainty due to the transfer standard was less than quoted uncertainty in RCM-LIPI.

The En values were less than 1 in the flow rate range between 1 m^3/h and 30 m^3/h, resulting the RCM-LIPI results match those of NMIJ within the claimed uncertainties. However, En value at the 0.5 m^3/h was from 1 to 1.2, indicating "warning".

8. References

- Comité International des Poids et Mesures (CIPM), Mutual Recognition of National Measurement Standards and of Calibration and Measurement Certificates Issued by National Metrology Institutes, Paris, France, October, 1999.
- APMP-G2, The Guidelines on conducting comparisons
- CCM-WGS, CCM Guidelines for approval and publication of the final reports of key and supplementary comparisons, 29 August 2013.
- CCEM, CCEM Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons.
- Cox, M. G., The Evaluation of Key Comparison Data, Metrologia, 39, 589-595, 2002.
- WGFF Guidelines for CMC Uncertainty and Calibration Report Uncertainty, October 21, 2013

APPENDIX A

Table of final results

A.1 NMIJ/AIST

Table A.1.a NMIJ/AIST, Meter 1

Meter 1

	maximum	minimum	mean value
Room temperature (°C)	21.3	19.9	20.7
Atmospheric pressure (hPa)	1007	1006	1007

No	Date	Flow rate	Flow rate	Water temperature	Uncertainty of water temperature	Pressure	Kf	Kf20	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition	K
	(dd/mm/yy)	(L/min)	(m3/h)	(°C)	(°C)	(hPa)	(pulse/L)	(pulse/L)	(%)	(%)	(%)	(-)	(%)
1	24/05/2018	76.3	4.58	21.2	0.046	1316	1499.98	1500.07	0.022	0.002	0.044	5	-5.361
2	24/05/2018	57.9	3.47	21.3	0.046	1757	1500.81	1500.90	0.022	0.007	0.044	5	-5.308
3	24/05/2018	32.6	1.96	21.5	0.046	2179	1500.37	1500.48	0.022	0.007	0.044	5	-5.335
4	24/05/2018	15.8	0.95	21.7	0.046	2338	1497.61	1497.73	0.022	0.003	0.044	5	-5.508
5	24/05/2018	7.9	0.47	22.1	0.046	2378	1500.12	1500.27	0.022	0.019	0.047	5	-5.348

Table A.1.a NMIJ/AIST, Meter 2

Meter 2

	maximum	minimum	mean value
Room temperature (°C)	21.5	20.7	21.1
Atmospheric pressure (hPa)	1018	1015	1016

No	Date	Flow rate	Flow rate	Water temperature	Uncertainty of water temperature	Pressure	Kf	Kf20	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition	K
	(dd/mm/yy)	(L/min)	(m3/h)	(°C)	(°C)	(hPa)	(pulse/L)	(pulse/L)	(%)	(%)	(%)	(-)	(%)
1	26/03/2018	501.4	30.08	14.8	0.046	1037	145.674	145.637	0.022	0.005	0.044	5	-8.117
2	26/03/2018	332.3	19.94	14.9	0.046	1789	145.642	145.607	0.022	0.001	0.044	5	-8.136
3	26/03/2018	166.1	9.97	15.0	0.046	2249	146.006	145.971	0.022	0.001	0.044	5	-7.907
4	26/03/2018	75.0	4.50	15.2	0.046	2378	146.649	146.615	0.022	0.004	0.044	5	-7.500
5	26/03/2018	59.5	3.57	15.4	0.046	2391	146.791	146.759	0.022	0.003	0.044	5	-7.410

A.2 RCM-LIPI

Table A.2.a RCM-LIPI, Meter 1

Meter 1

	maximum	minimum	mean value
Room temperature (°C)	23.0	18.8	21.1
Atmospheric pressure (hPa)	1009	1003	1006

No	Date	Flow rate	Flow rate	Water temperature	Uncertainty of water temperature	Pressure	Kf	Kf20	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition	K
	(dd/mm/yy)	(L/min)	(m3/h)	(°C)	(°C)	(hPa)	(pulse/L)	(pulse/L)	(%)	(%)	(%)	(-)	(%)
1	12/07/2017	8.0	0.48	21.3	0.54	5516	1492.7	1492.8	0.20	0.007	0.40	6	-5.82
2	17/07/2017	16.7	1.00	20.8	0.54	5516	1494.5	1494.6	0.20	0.004	0.40	6	-5.71
3	18/07/2017	33.2	1.99	21.3	0.54	5516	1498.9	1499.0	0.20	0.004	0.40	6	-5.43
4	21/07/2017	58.5	3.51	21.0	0.54	5516	1499.9	1500.0	0.20	0.018	0.40	6	-5.36
5	02/08/2017	75.1	4.51	21.6	0.54	5516	1497.8	1497.9	0.20	0.003	0.40	6	-5.50

Meter 1

	maximum	minimum	mean value
Room temperature (°C)	25.6	22.3	23.9
Atmospheric pressure (hPa)	1010	1003	1006

No	Date	Flow rate	Flow rate	Water temperature	Uncertainty of water temperature	Pressure	Kf	Kf20	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition	K
	(dd/mm/yy)	(L/min)	(m3/h)	(°C)	(°C)	(hPa)	(pulse/L)	(pulse/L)	(%)	(%)	(%)	(-)	(%)
1	26/07/2018	8.6	0.51	22.9	0.54	5516	1496.4	1496.6	0.20	0.005	0.40	6	-5.58
2	30/07/2018	16.0	0.96	23.5	0.54	5516	1495.4	1495.7	0.20	0.004	0.40	6	-5.64
3	02/08/2018	33.2	1.99	23.5	0.54	5516	1499.4	1499.7	0.20	0.002	0.40	6	-5.38
4	07/08/2018	58.2	3.49	24.3	0.54	5516	1499.5	1499.8	0.20	0.026	0.40	6	-5.38
5	14/08/2018	75.9	4.55	25.3	0.54	5516	1499.0	1499.4	0.20	0.025	0.40	6	-5.40

Table A.2.b RCM-LIPI, Meter 2

Meter 2

	maximum	minimum	mean value
Room temperature (°C)	26.5	21.1	23.8
Atmospheric pressure (hPa)	1009	1001	1005

No	Date	Flow rate	Flow rate	Water temperature	Uncertainty of water temperature	Pressure	Kf	Kf20	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition	K
	(dd/mm/yy)	(L/min)	(m3/h)	(°C)	(°C)	(hPa)	(pulse/L)	(pulse/L)	(%)	(%)	(%)	(-)	(%)
1	09/09/2017	58.3	3.50	23.2	0.54	5516	146.57	146.60	0.20	0.006	0.40	6	-7.51
2	13/09/2017	75.0	4.50	23.4	0.54	5516	146.38	146.40	0.20	0.010	0.40	6	-7.63
3	18/09/2017	166.2	9.97	24.8	0.54	5516	145.70	145.73	0.20	0.005	0.40	6	-8.06
4	20/09/2017	331.2	19.87	25.9	0.54	5516	145.33	145.37	0.20	0.023	0.40	6	-8.28
5	06/10/2017	490.0	29.40	25.5	0.54	5516	145.47	145.51	0.20	0.009	0.40	6	-8.20

Meter 2

	maximum	minimum	mean value
Room temperature (°C)	25.2	22.9	24.2
Atmospheric pressure (hPa)	1008	1001	1005

No	Date	Flow rate	Flow rate	Water temperature	Uncertainty of water temperature	Pressure	Kf	Kf20	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition	K
	(dd/mm/yy)	(L/min)	(m3/h)	(°C)	(°C)	(hPa)	(pulse/L)	(pulse/L)	(%)	(%)	(%)	(-)	(%)
1	15/08/2018	59.0	3.54	25.0	0.54	5516	146.44	146.48	0.20	0.022	0.40	6	-7.59
2	20/08/2018	75.2	4.51	26.3	0.54	5516	146.27	146.31	0.20	0.004	0.40	6	-7.69
3	27/08/2018	167.9	10.07	26.4	0.54	5516	145.66	145.70	0.20	0.010	0.40	6	-8.08
4	30/08/2018	332.6	19.96	26.3	0.54	5516	145.38	145.43	0.20	0.083	0.43	6	-8.25
5	04/09/2018	494.8	29.69	26.2	0.54	5516	145.50	145.55	0.20	0.006	0.40	6	-8.17

APPENDIX B

Technical Protocol

Bilateral APMP comparison in the field of liquid (water) flow (0.5 to 30 m^3/h)

APMP.M.FF-S2.2016

1. Introduction

Two National Metrology Institutes take part in this comparison: Research Centre for Metrology (RCM)-LIPI (Indonesia) and National Metrology Institute of Japan (NMIJ-Japan). This bilateral comparison, APMP.M.FF-S2.2016, was undertaken by the Technical Committee for Fluid Flow (TCFF) of Asia Pacific Metrology Program (APMP).RCM-LIPI is acting as the pilot laboratory and in this function is responsible for the evaluation of the measurement results and the final report.

The comparison will be accomplished in accordance with the Measurement Comparisons in the CIPM MRA and the APMP Guidelines on Conducting Comparisons.

The travelling standards are two turbines provided by RCM-LIPI covering the range of 0.5 m^3/h to 30 m^3/h (about 8 dm^3/min to 500 dm^3/min). Each of turbines will be tested by each participating laboratory in the measurement ranges of 0.5 m^3/h to4.5 $m^3/h$and 3.5 m^3/h to 30m^3/h.

After the measurement is completed, the En values between RCM-LIPI and NMIJ will be obtained at every measurement point.

2. Travelling Standards

2.1 General Requirement

The participating laboratory should have the following requirement to be able to participate in the activity:

a. Flow generator which able to produce flowrate in the range 7 dm^3/min- 500 dm^3/min.
b. Mechanical test bench, equip with flange and valve.
c. Pulse counter which able to read TTL pulse output
d. Power supply 24 volt DC to power the amplified pickoff.

2.2 Description of Standards

As mentioned before, two turbines will be used as travelling standards (TS). The specifications of the standards are shown in the following table.

Table 1. Description of Travelling Standards

Manufacturer	FTI	FTI
Model	FT-12AEU3-LEA-0	FT-24AEU3-LEA-0
SN	12013288	2407168
Nominal range	7.57 – 75.71 dm^3/min	56.78 – 567.81 dm^3/min
Output	TTL Pulses	TTL Pulses

Pickoff	Described in Annex 1	Described in Annex 1
Upstream/Downstream Pipe	Described in Annex 2	Described in Annex 2
Travelling Box	Described in Annex 3	Described in Annex 3

2.3 Quantities to be Measured

The following quantities should be measured for each measuring point:

a. Water flow rate (Q) in dm^3/min.
b. Actual K-factor of TS (K_f) in pulse/dm^3.
c. Water temperature during measurement near TS (T_w) in ºC.
d. Water pressure (P_w) during measurement near TS in hPa.

Quantities to be calculated by the pilot lab are:

a. Corrected K factor based on 20 ºC (K_{f20}) in pulse/dm^3 expressed as :

$$K_{f20} = K_f\{1 + 3\alpha(Tw - 20)\} \quad (1)$$

With α: Coefficient of linear expansion of material. (Stainless Steel 316 for flow meter housing,=1.6 x 10^{-5} (K^{-1})).

b. Relative K factor against the nominal K factor of the transfer standard expressed as:

$$K = \frac{K_{f20} - K_{fnom}}{K_{fnom}} \quad (2)$$

With K_{fnom}: Nominal K factor of the transfer standard (pulse/dm^3).

2.4 Method of Computation of the degree of equivalence and the En value

The degree of equivalence (d) between NMIJ and RCM-LIPI and its expanded uncertainty $U(d)$ are expressed by

$$d = K_{NMIJ} - K_{LIPI} \quad (3)$$

$$U^2(d) = U_{NMIJ}^2 + U_{LIPI}^2 + U_{TS}^2 \quad (4)$$

With,

K_{NMIJ} : Relative K-factor at NMIJ
K_{LIPI} : Relative K-factor at RCM-LIPI
U_{NMIJ} : Expanded uncertainty of relative K-factor at NMIJ
U_{LIPI} : Expanded uncertainty of relative K-factor at RCM-LIPI
U_{TS} : Expanded uncertainty due to the travelling standard

The En values are obtained by

$$En = \frac{|d|}{U(d)} \qquad (35)$$

3. Organization

3.1 Participants

Table 1. List of Participants

Pilot Laboratory	RCM-LIPI
Delivery Address	Pusat Penelitian Metrologi Lembaga Ilmu Pengetahuan Indonesia (Puslit Metrologi-LIPI) Kompleks PUSPIPTEK Gedung 420 Tangerang Selatan Banten Indonesia 15314
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ParticipatingLaboratory	NMIJ
DeliveryAddress	National Metrology Institute of Japan (NMIJ) National Institute of Advanced Industrial Science and Technology (AIST) AIST North site 15, 1497-1Teragu, Tsukuba, Ibaraki, 300-4201,Japan

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Tel : +81298614377

E-Mail :t-shimada@aist.go.jp, furuichi.noriyuki@aist.go.jp, wada.s@aist.go.jp

3.2 Time Schedule

RCM-LIPI will starts the measurement and then send the travelling standards (TS) to NMIJ. After NMIJ finish the measurement, TS will be send it back to RCM-LIPI for re-measurement. The time duration of activity are shown in table 2, the time count will begin after the comparison start date is approved.

Table 2. Time Duration of Activity.

No	Activity	Duration
1.	Measurement at RCM-LIPI	25 work days
2.	TS Delivered to NMIJ	2 months
3.	Measurement at NMIJ	20 work days
4.	TS Delivered to RCM-LIPI	2 months
5.	Measurement at RCM-LIPI	25 work days
6.	Comparison Report Generation	20 work days

3.3 Transportation

The transportation between RCM-LIPI and NMIJ will be handled by RCM-LIPI. All the transportation cost will be covered by RCM-LIPI.

3.4 Unpacking, Handling, Packing

3.4.A Unpacking

1) When the transfer standard arrives at a participating lab, Form 1 "Receiving Checklist" (see, annex4) must be filled out and emailed to the pilot lab (bernadushs@gmail.com)
2) Make a visual check of the external of the transportation boxes.

3) Take out all the items from the boxes and inspect them visually one by one. Take some pictures of the inlet and outlet of the flow meter and then the pictures should be emailed to the pilot lab (bernadushs@gmail.com). Report any damage or missing parts to the pilot lab.
4) After the check is completed, the Form 1 "Receiving check list" should be e-mailed to the pilot lab (bernadushs@gmail.com). If problems are found, the participant should describe them in detail on a separate sheet (preferably in a MS-Word file), and send it along with the Form 1

3.4.B Handling

1) Install both flanges with flange seals in up-stream and down-stream position
2) Attach the flow-meter, straightener and reducer circuit to the flanges. Do not de-assemble flow-meter, straightener and reducer, treat them as one system.
3) Perform leak test as mention in 4.1.A
4) Install amplified pickoff to flow-meter
5) Perform pickoff test as mention in 4.1.B
6) Perform measurement as mention in 4.3
7) When measurement are finish, un-install the pickoff.
8) Then un-install the flow-meter, straightener and reducer circuit from the flanges. Do not de-assemble flow-meter, straightener and reducer, treat them as one system.
9) Put alcohol to flow-meter, straightener and reducer to remove water from the turbine.
10) Place the unused flow-meter to the box safely.
11) When measurement of both flow-meters are done, un-install the flanges and place it in the box

3.4.C Packing

1) Put all the package items in the box according to figure 20 in annex 3, take some picture before putting the buffers
2) Put the buffers to guard all the items from mechanical vibration or shock
3) Close the box and send the box to appointed delivery service.
4) Report to the pilot lab when the delivery service received the box.

3.5 Failure of Travelling Standards

The transfer standard is robust and it is contained in a strong shipping container, however if the TS is damaged or a participating NMI finds it to be malfunctioning, they should consult the pilot lab for advice.

3.6 Financial Aspects, Insurance

The transportation and insurance cost will be covered by RCM-LIPI.

4. Measurement Instructions

4.1 Test Before Measurements

4.1.A Leak Test

1) Set the TS and mechanical valve in series according to following diagram

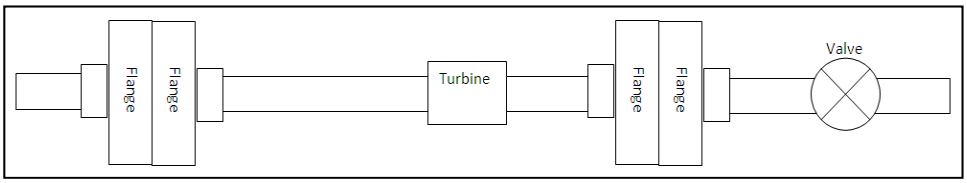

Fig 1. Test Leak Mechanical Circuit

2) Fill the installation with water.
3) Remove air from installation.
4) Close the valve
5) Apply pressurized water to installation
6) Observe water leak in the installation
7) If there is a leak, fix the leak when no water pressure in the installation
8) If there is no leak, continue to next step

4.1.B Pickoff Test

1) Install the pickoff according to the following diagram.

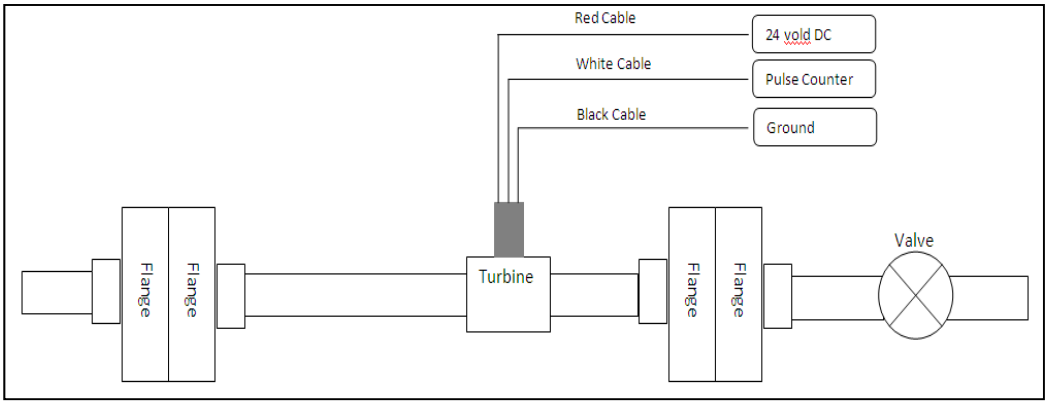

Fig 2. Amplified Pickoff Installation

2) Connect the pickoff to pulse counter. Make sure all the electrical connection are properly connected
3) Power the pickoff with 24 volt DC

4) Gently apply minimum water flow to the TS (approximately 10% of maximum measuring range).
5) Observe pulse counter for changes of pulse
6) If there is no pulse changes, contact pilot lab for advice
7) If there is a pulse change, proceed with the measurement.

4.2 Measurement Performance

The measurements should be performed under the following conditions:

- Pressure: less than 3 bar abs
- Water temperature: 10°C to 30°C
- Ambient temperature: 10°C to 30°C

The following flow rate should be reached:

- Turbine FTI Model FT-12AEU3-LEA-0 (SN 12013288)
  0.5, 1, 2, 3.5 and 4.5 m^3/h(8.3, 16.7, 33.3, 58.3, 75 dm^3/min)
- Turbine FTI Model FT-24AEU3-LEA-0 (SN 2407168)
  3.5, 4.5, 10, 20 and 30 m^3/h(58.3, 75, 166.7, 333.3, 500 dm^3/min)

Where the laboratory can not reach the maximum flow rate, the maximum achievable flow rate may be reported on the summary sheet in place of the next highest specified point.

4.3 Method of Measurements

1) The required test liquid is clean water, if it necessary use water filter to ensure the test water is clean.
2) Set the TS and laboratory standard in series according to normal procedure of each participating laboratory.
3) Apply water flow through the TS and laboratory standard, record the parameters mentioned in (2.3) section.
4) Repeat the measurement according to the normal procedure of each participating laboratory.

5. Uncertainty of Measurement

The standard uncertainty of K factor is combined with the base uncertainty of the reference standard based on the ISO “Guide to the expression of uncertainty in measurement” (GUM) and the standard uncertainty due to the repeatability of calibration results in according to WGFF Guidelines. The expanded uncertainties of K factors should be quoted in percentage term at 95 % confidence level. Each quoted value should be rounded up to two decimal places.

6. Measurement Report

A report should be sent to the pilot laboratory within 6 weeks after the measurements are completed. The report should include:

- Brief description of the measurement method.
- The reference standard.
- The traceability to the SI.
- The following results of the quantities to be measured and calculated (See 9.5 Annex 5).

  Date, flow rate (dm^3/min), water temperature during measurement near TS (°C), standard uncertainty of water temperature during measurement (°C), water pressure during measurement near TS (hPa), actual K factor (pulse/dm^3), base standard uncertainty due to the facility, standard uncertainty due to repeatability (%), expanded uncertainty of K factor (%) and number of repetition.
- The air parameter (temperature and pressure) of the environment during measurement (See 9.5 Annex 5)
- A summary of the main uncertainty components for the measurement

7. Report of the Comparison

The degree of equivalence and the En values will be shown in the comparison report, as well as graph of measurement results from participating laboratories. Draft A and B of the comparison report will follow CCM guidelines for final report.

8. References

- CCM-WGS, CCM Guidelines for approval and publication of the final reports of key and supplementary comparisons, 23 May 2017
- CCEM, CCEM Guidelines for Planning, Organizing, Conducting and Reporting Key, Supplementary and Pilot Comparisons
- WGFF Guidelines for CMC Uncertainty and Calibration Report Uncertainty, October 21, 2013
- EURAMET-1361_FLOW_Protocol.
- ILC_1361_DraftA

9. Annexes

9.1 Annex 1 : Amplified Pickoff

The specification of amplified pickoff used in this comparison can be found in the page 7 of manual book. The pickoff can receive input power from 8 to 32 VDC, but for this comparison, the input power must be 24 VDC. The output of the amplified pickoff is digital signal 0-5 VDC or TTL signal, output impedance is 2.2 KΩ. Other participant beside RCM LIPI must use pickoff cable in figure5.

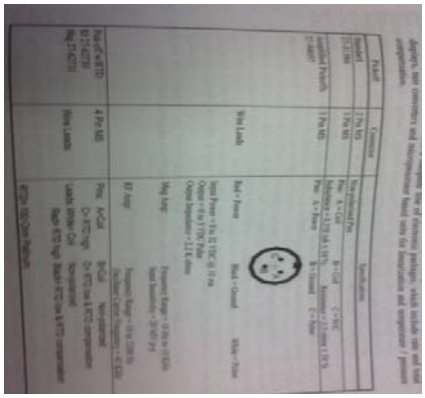

Fig 3. Amplified Pickoff Technical Data in Manual Book

Fig 4. Amplified pick-off with connector

Fig 5. Pickoff Cable, Red (24 volt), Black (ground), White (pulse signal)

Fig 6. Connector that use only by RCM LIPI Facility, other participant please do not use this connector.

Fig 7. Amplified Pickoff installed on Turbine Meter

Fig 8. Connector installed on Amplified Pickoff

9.2 Annex 2 : Flange, Upstream and Downstream Pipe

There are two flanges use in this comparison, one is up-stream other is down-stream. The flanges is use to connect travelling standard-pipe with the participant test bench.

Fig 9. Flanges installed in RCM LIPI Test Bench

When carried in the travelling box, to protect mechanical seal attach to the flange, reducer adapter are used. When the flange already installed in the test bench, please remove the adapter before connecting travelling standard-pipe to the flange.

Fig 10. Reducer Pipe as Protector of Mechanical Seal in the Flange

Fig 11. Flange without Reducer Pipe as Protector

Fig 12. Mechanical Seal in the Flange

Fig 13. Installation of FT-24 Pipe to the Flange with Mechanical Seal Attach to The Flange

Fig 14. Installation of FT-12 Pipe to the Flange with Mechanical Seal Attach to The Flange

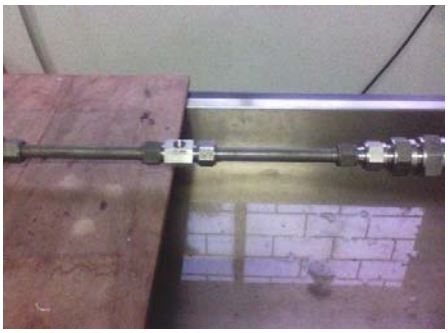

Fig 15. FT-12 Fully installed

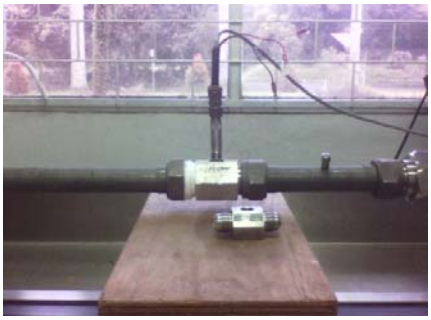

Fig 16. FT 24 Fully installed

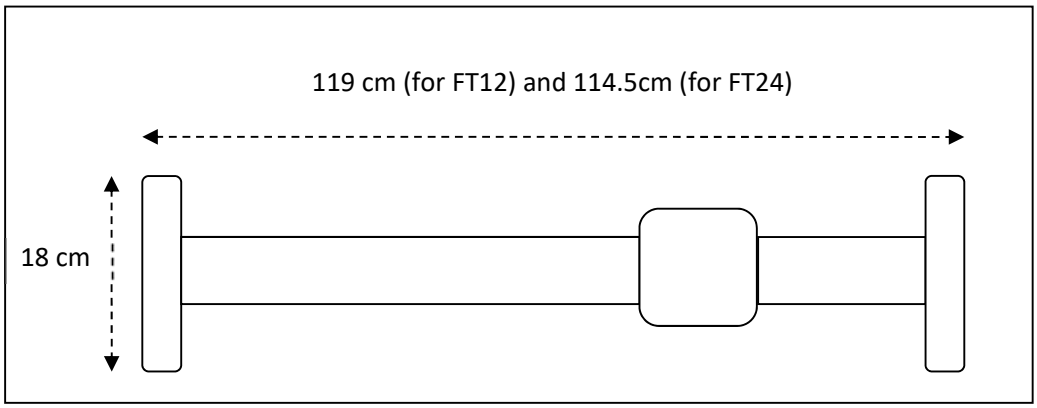

Fig 17. Dimension when the Flange and Pipe are Assembled

9.3 Annex 3 : Traveling Box

Fig 18. Traveling Box

Fig 19. Travelling Box Lock

Fig 20. Buffer inside Travelling Box as Protector

Fig 21. Travelling Standard, Flanges, Amplied Pickoff with Cable, Gasket and Manual Book inside Travelling Box

Fig 22.Turbine Flow-meter Manual Book

Fig 23. Flanges

Fig 24. Gasket

Fig 24.Amplified Pickoff with Cable

Fig 25. FT-12 with Adapter and Reducer Pipe

FT-24 with Adapter and Reducer Pipe

9.4 Annex 4 : Form 1"Receiving Checklist"

Laboratory	**:**	
Receiving Date	**:**	
Receiving Personnel Name and Signature	**:**	**(……)**

No.	Item	Quantity	Check
1	FT-12+Pipe circuit	1	☐ Complete ☐ In-complete
2	FT-24+Pipe circuit	1	☐ Complete ☐ In-complete
3	Up-Stream Flange	1	☐ Complete ☐ In-complete

4	Down-Stream Flange	1	☐ Complete ☐ In-complete
5	Flange Gasket	2	☐ Complete ☐ In-complete
6	Amplified Pickoff+cable	1	☐ Complete ☐ In-complete

9.5 Annex 5 : Form 2 “Report Form”

	maximum	minimum	mean value
Room temperature (^{o}C)			
Atmospheric pressure (hPa)			

No	Date	Flow rate	Water temperature	uncertainty of water temperature	Pressure	K_f	Base uncertainty	Uncertainty due to repeatability	Expanded uncertainty of K factor	Number of repetition
	(dd/mm/yy)	(dm^3/min)	(^{o}C)	(^{o}C)	(hPa)	(pulse/dm^3)	(%)	(%)	(%)	(-)