CIPM key comparison CCM.FF-K2.2011

Water and Hydrocarbon flow (5 - 60) kg/min

VSL - National Metrology Institute of The Netherlands

Final report

Pilot

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Index

Introduction and purpose

The purpose of the Key Comparison (KC) for "Water" and "Hydrocarbon" flow measurement is to support the Calibration and Measurement Capabilities (CMC) of the participating National Metrology Institutes and Designated Institutes as part of the CIPM MRA.

The comparison should lead to 'the key comparison reference value (KCRV) and the Degree of Equivalence (d_i, $U(d_i)$) found between participants and the KCRV'.

The flow range of (5 – 60) kg/min is of big interest for legal metrology since fuel dispensers operate in this range and a good reference value is essential for society and governments.

In first instance when VSL proposed this project in 2009 only Hydrocarbon flow was introduced. After a good review and talks with other NMIs/DIs Water flow has been introduced to link the key comparison to CCM.FF-K1 as well as CCM.FF-K2. The transfer standard (IKS-SKID) has been designed in such a way that it can be used both for Water and Hydrocarbon flows and a cleaning procedure is put in place.

The advantage of the IKS-SKID is that influences due to building in the meters and/or operators are eliminated as much as possible. This leads to a comparison of the realization of the references of the participating labs. On a BIPM level this is the kind of comparison that should be performed.

1   Participants

Table 1 shows the participants of the CIPM key comparison. After two years of preparation the comparison measurements started on 19 of August 2013 and finished on 24 of February 2015.

table 1 test dates

NMI/DI	Country	Contact	Test Date
VSL[1]	The Netherlands	Erik Smits	19-08-2013
TUV NEL	United Kingdom	Linda Rowan	06-09-2013
BEV	Austria	Petra Milota	10-12-2013
VSL[2]	The Netherlands	Erik Smits	13-01-2014
NIST	United States of America	Jodie Pope	06-03-2014
NMIJ/AIST	Japan	Takashi Shimada	04-06-2014
CMS	Chinese Taipei	Chun-Min Su	14-08-2014
KRISS	South Korea	Sejong Chun	19-11-2014
PTB	Germany	Enrico Frahm	28-01-2015
VSL[3]	The Netherlands	Erik Smits	24-02-2015

[1]   First measurements at VSL that will be the results presented for the KCRV values

[2]   Check measurements at VSL before IKS-SKID is send outside Europe; water measurements only

[3]   Final measurements at VSL

2   Description of the transfer standard (IKS-SKID)

The transfer standard is a skid with two Coriolis mass flow meters and auxiliary equipment. The piping and ball valves in the skid are placed in a so-called X-configuration. This makes it possible to place the mass flow meters upstream or downstream of each other just by opening and closing valves. Furthermore, it is possible to test each mass flow meter individually and in parallel if needed. This was a very nice option during the commissioning tests at the pilot laboratory to prove that the mass flow meters do not interact with each other.

The transfer standard has been given the name "IKS-SKID" based on mirroring partly 'SKI'D and the Dutch phonetic representation of 'X'. In the industries many skids are built and the pilot wanted to make sure that the skid for this KC has a unique name.

A detailed description of the transfer standard can be found in the technical protocol of CCM.FF-K2.1.2011.

figure 1 Picture of the IKS-SKID connected to a calibration facility (VSL Water Flow)

A shockwatch was connected to the IKS-SKID which monitored the movements of the IKS-SKID during transportation. The position of the shockwatch is shown in.figure 2.

figure 2 position of the shockwatch on the IKS-SKID

Three events are reported in the logfile. Details of the events can be seen in the reports of the shockwatch from which an example can be seen in figure 3 and figure 4. A registration of the temperatures during the two years of the comparison can be seen in figure 5. If necessary, it is possible to zoom in on specific time frames. There was no need to do so.

The most severe shock was event #2. It registered an acceleration in the z-direction of 24 g which could have been caused e.g. by a lift truck bumping into the IKS-SKID. The force is exerted only for a very short period of approximately 10 ms.

No visual damage was reported by any of the participating laboratories. So we assume that no damage was inflicted on the IKS-SKID.
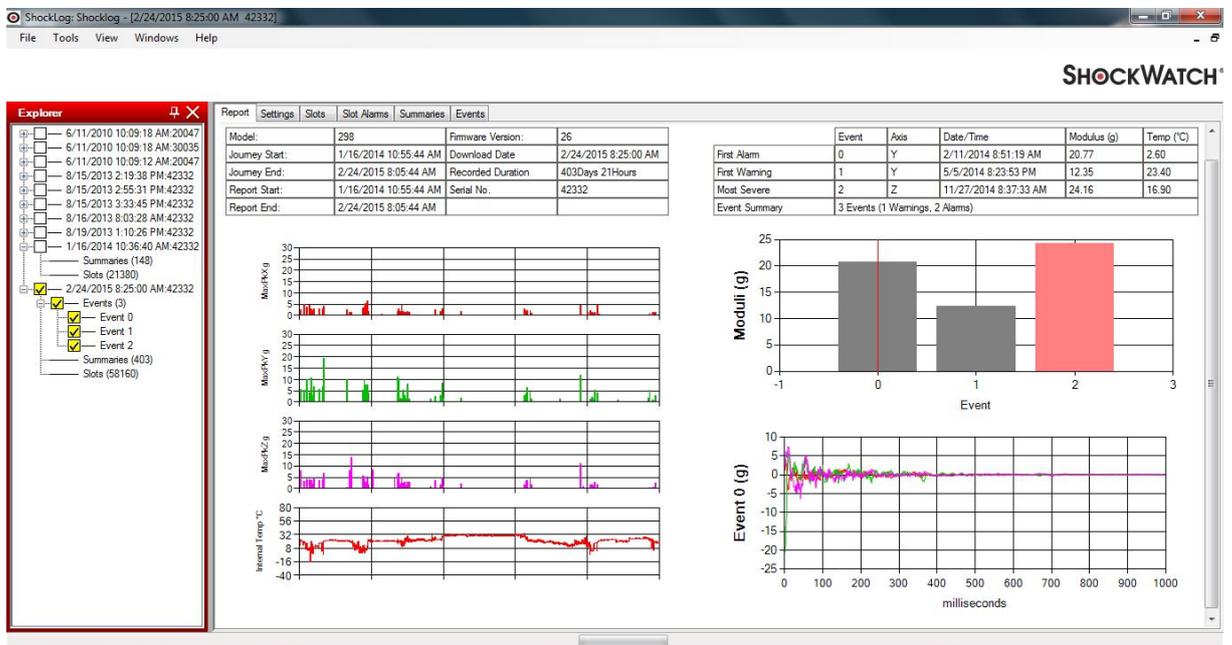
figure 3 report of the shockwatch
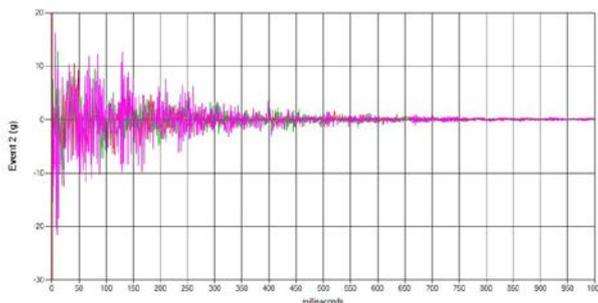
figure 4 detail of event #2
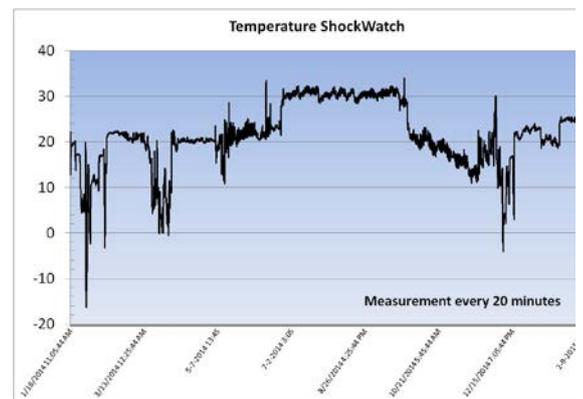
figure 5 temperature registered by the shockwatch during the time of the comparison

3   Measurement procedure

3.1   The reference value and flows

In the CCM.FF-K2.2011 key comparison project one reference value is used:

"The mass quantity of a flowing liquid passing through the transfer standard at given flow rates."

The measured flows ranged from 5 to 60 kg/min. The test point of 5 kg/min has the function to determine the stability of the meters during the tests. This test point has been measured at the start and at the end of the series. If there is a too large difference between the first test at 5 kg/min and the last test at 5 kg/min something might have happened. The test points that will be considered as key points in this comparison are 30, 40 and 50 kg/min. The results of all test points (except 5 kg/min) are presented but only the key points will be analyzed.

The results of the key comparison are the measurement errors of the reference flows at the MUT as determined by each NMI/DI. The measurement errors are calculated for each mass flow meter making use of the pulse output of the meter or the display reading. During the commissioning tests of the IKS-SKID no difference was found between display reading and pulse counting. Therefore, each NMI/DI could choose what indication they wanted to use to calculate the measurement error. The mass flow meters are set up with a base k-factor (set to 1000 pulses per kilogram so 1 pulse is equal to 1 gram).

Each laboratory performed the tests according to their own procedures. For this comparison both Standing Start Finish (SSF) and Flying Start Finish (FSF) methods could be used by the participating NMI/DI. The different methods should not lead to differences in the errors as both mass flow meters are setup with a low flow cutoff to avoid that pulses are missed at the start and end of one single test when using SSF method. (or mass reading on the display is too low) 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.

3.2   Test liquids

Water
Five out of eight NMIs/DIs used water as test liquid in the KC.

Hydrocarbon
All NMIs/DIs tested with hydrocarbon in a viscosity range from 0.8 up to 23 mm^2/s. Most NMIs/DIs have a liquid between 1 and 2 mm^2/s. It was strongly suggested to at least include a hydrocarbon in this low viscosity range preferably close to 2 mm^2/s. Other hydrocarbons were allowed as according to the measurement principle of Coriolis mass flow meters it should make no difference in measurement results for the viscosity range as mentioned in the protocol. However, fluid property effects on the meters were observed in this comparison. No corrections were made nor was any uncertainty included for these effects in this work.

Only one laboratory performed tests with two different hydrocarbon liquids. One test series of this laboratory has been used for the analysis of the data.

3.3 Methods used for calibration

Each laboratory provided the pilot laboratory with a description and a simplified P&ID drawing to show how the IKS-SKID is connected to the participant's test facilities. The facilities are described in Annex 6. The method of FSF and/or SSF is described in Annex 6 as well. All laboratories have an independent traceability in the realization of their standards.

An overview of the methods of the participating laboratories is presented in table 2.

NMI/DI	Country	Method	CMC Water CIPM MRA Database	CMC Hydro Carbon CIPM MRA Database
VSL	The Netherlands	Gravimetric – SSF	0.02%	0.04%
TUV NEL	United Kingdom	Gravimetric - SSF	0.1%	0.05%
BEV	Austria	Water: Gravimetric - FSF Hydrocarbon: Volumetric - FSF	0.05%	0.07%
NIST	United States of America	Volumetric - FSF	--	0.04% - 0.07%
NMIJ/AIST	Japan	Gravimetric - FSF	--	0.02%
CMS	Chinese Taipei	Gravimetric – FSF (water) SSF (hydrocarbon)	0.06%	0.05%
KRISS	Korea	Gravimetric - FSF	0.08%	--
PTB	Germany	Gravimetric - FSF	--	0.05%

table 2 Methods used for the tests

3.4 Test points

The following flow rates were used for the KCRV for each liquid. All participants were able to generate the requested flow rates. The tests are performed in the given order. The repeatability based on the test at 40 kg/min is used to calculate the uncertainty as presented by each laboratory.

Flow-rate (kg/min)	Number of Repeats	Remarks
20	5	--
40	10	5 extra tests for repeatability
60	5	--
50	5	--
30	5	--
10	5	--

table 3 flow rates and number of repeats for the key comparison tests

4   Data analysis by the pilot NMI (KCRV calculation)

The key comparison reference value (KCRV) will be determined for each flow rate separately. The data have been processed using procedure B of the recommended approaches for processing key comparison data [4], because the submitted data did not meet the consistency criterion for calculating a KCRV when using procedure A (an uncertainty-weighted mean). The Monte Carlo method as described by Cox [4] was implemented in R [6]. The median was used as key comparison reference value (KCRV). From a sample with size $M = 200000$, the difference and associated standard uncertainty were computed as well as degrees-of-equivalence. The standard uncertainty was expanded using $k = 2$. The number of samples has been determined according to chapter 7.2.2 of Supplement 1 to the GUM (3).

To support the interpretation of the results of the data processing, the correlation coefficient between the laboratory result and the KCRV have been calculated from the simulated data. The equation to calculate the correlation coeficient (DoE.r) can be found in GUM C.3.6 (2).

No distinction has been made between the results of the meters in the upstream or downstream position since there was no significant difference between the results in the upstream and downstream position. The results of the two positions are considered as one set of results. This implies that there are 4 sets of results to be presented. The results of two fluids through each of the two meters.

The difference d_i between the result of a laboratory and the KCRV and the corresponding uncertainty $U(d_i)$ are calculated to form the Degree of Equivalence (DoE) which is the combination (d_i , $U(d_i)$) . (see chapter 4.2) The standardized Degree of Equivalence E_n has been used to indicate whether a laboratory's result is consistent with the KCRV. Consistency is demonstrated when $E_n < 1$. If $1 < E_n < 1.2$ a warning level is defined. With $E_n > 1.2$ the results are considered to be inconsistent with the KCRV.

4.1   Determination of the KC Reference Value (KCRV) and it's uncertainty

The KCRV was determined using the Monte Carlo method with the median as estimator for the KCRV.

The standard uncertainties of the measurement error xi in different laboratories $u_{x1}, u_{x2},.....u_{xn}$ include the long term stability of the transfer standards. For transfer standard Meter 2 also the influence of temperature on the measurements are included in $u_{x1}, u_{x2},.....u_{xn}$. Uncertainty due to the influence of fluid properties is not included in this work. The uncertainties $u_{x1}, u_{x2},.....u_{xn}$ are calculated by

$$u_{xi} = \sqrt{\left(\frac{U_{xi\_lab}}{2}\right)^2 + \left(\frac{U_{ts}}{2}\right)^2} \qquad (1)$$

With

$U_{xi\text{-}lab}$ *the expanded uncertainty (k=2) determined by laboratory i and presented in the results of laboratory i*

U_{ts} *estimated expanded uncertainty caused by the stability (reproducibility) of the transfer standard. The mass flow meter has been tested three times in the pilot laboratory (based on the time schedule) and from these results U_{ts} has been determined. The U_{ts} value of Meter 2 includes dependency of the meter on temperature.*

4.2   The determination of the difference "Lab to KCRV" (DoE)

After the KCRV (= x_{ref}) was determined by Monte Carlo simulation with the median as estimator for the KCRV, the differences between the results of the participating laboratories and the KCRV were calculated according to

$$d_i = x_i - x_{ref} \tag{2}$$

The standard uncertainty and expanded uncertainty of the KCRV and of the difference d_i were computed from the output of the Monte Carlo method as described in [4]. The expanded uncertainty was computed as the half-width of the 95% coverage interval. The coverage factor was computed as the ratio of the expanded and standard uncertainty.

Based on these differences and the corresponding uncertainties the standardized Degree of Equivalence (or normalized deviation) can be calculated according to:

$$E_n = \left| \frac{d_i}{U(d_i)} \right| \tag{3}$$

The standardized *DoE* E_n is a measure for the consistency of the results of any laboratory with the KCRV. The limit for demonstrating equivalence is that the difference between the measurement error of the laboratory and the KCRV is equal to the expanded uncertainty of the difference d_i:

-                    The results of a laboratory will be considered consistent (passed) if $E_n \leq 1$.
-                    The laboratory will be considered as not consistent (failed) if $E_n > 1.2$.
-                    For values of *DoE* in the range $1 < E_n \leq 1.2$ the "warning level" is defined. In this case actions to check are recommended to the laboratory.

The calculation of the *DoE* needs the information about the uncertainty of the difference d_i (equation (2) and (3)). To make statements about the uncertainty of the difference d_i, it is necessary to consider first the general problem of the difference of two values x_1 and x_2. If we look to the pure propagation of (standard) uncertainty we find:

$$u_{x_1-x_2}^2 = \begin{pmatrix} \frac{\partial(x_1-x_2)}{\partial x_1} & \frac{\partial(x_1-x_2)}{\partial x_2} \end{pmatrix} \begin{pmatrix} u_1^2 & cov \\ cov & u_2^2 \end{pmatrix} \begin{pmatrix} \frac{\partial(x_1-x_2)}{\partial x_1} \\ \frac{\partial(x_1-x_2)}{\partial x_2} \end{pmatrix} = u_1^2 + u_2^2 - 2 \times cov \tag{4}$$

The (standard) uncertainty of the difference is the quadratic sum of the uncertainties of the inputs (u_1 and u_2) subtracting twice the covariance (cov) between the two input values.

Equation (4) uses the standard uncertainties. The expanded uncertainty $U(d_i)$ is determined by

$$U(d_i) = 2.u(d_i) \tag{5}$$

Note: According to the 14th CCM meeting (February, 2013) pair-wise degrees of equivalence ($d_{i,j}$) should no longer be published in the KCDB. Information on pair-wise degrees of equivalence published in KC reports should be limited to the equations needed to calculate them, with the addition of any information on correlations that may be necessary to estimate them more accurately.

5   Measurement results

On examination of the data received from all the participants, the pilot laboratory observed that the results from NIST and BEV appeared to be anomalous. In accordance with the CIPM guidance rules these laboratories were asked to check their results for computational errors. Neither institute was informed about the magnitude or sign of the anomaly.

BEV made some corrections to the presented data since they found some copy paste mistakes, some sign mistakes and a temperature calculation mistake. Further they increased the uncertainty for the hydrocarbon measurements by adding uncertainty due to the conversion of volume to mass.

NIST reviewed their results and made changes in the data. NIST increased their uncertainty claim due to the fact that they neglected some components originally. Further NIST found some minor mistakes made when copying data from the data reduction spreadsheets to Form M.

NIST submitted a formal request to withdraw the results with Meter #2 from the comparison. The changes and the reason why NIST wishes to exclude Meter #2 are explained in Annex 3.
According to CIPM MRA-D-05 this is only possible with the consent of all participants. All participants agreed with the withdrawal of the measurement results of NIST of Meter #2.

NEL changed the uncertainty calculation for the results with hydrocarbon. On second thought they used the CMC as base uncertainty for the calculation. This influenced slightly the KCRV and the results for the E_n.

After the measurements had been finished it was suggested by NMIJ that fluid properties such as density and viscosity had an influence on the results of the transfer standards. It seemed that each meter responded differently to the density and the viscosity of the fluid.
The influence of the temperature on the performance of the Meter 1 is so small that it has no influence on the outcome of the Monte Carlo simulation and it was decided to ignore the contribution to the uncertainty of Meter 1 due to temperature effects.
The influence of the temperature on the performance of the Meter 2 has been incorporated in the uncertainty of Meter 2. The temperature effect on the transfer meters among the hydrocarbon laboratories was estimated to be 0.034 % for Meter 2 as shown in Annex 2. Therefore, the temperature effect of 0.034 % is adopted as the expanded uncertainty due to temperature for Meter 2 in Equation (1).
It was decided that the influence of fluid properties such as density and viscosity were not considered for the comparison CCM.FF-K2.2011. The main reason is that this effect was not known at the start of the comparison. The protocol did not prepare for this kind of influences. The effect of fluid property on the performance of a meter will be investigated in a separate project/comparison that will be proposed after the closure of the actual project. The comments about the fluid properties made by NMIJ are attached to this report. (Annex 1)

5.1   Stability of the transfer standards

The stability of the meters has been determined based on three tests with water as the calibration liquid performed by the pilot laboratory. Water was used since the uncertainty of the facility of the pilot laboratory is lowest for this liquid. The first test was performed before the start of the comparison. The second test was performed before the IKS-SKID was send to NMIs/DIs outside Europe. The third test was performed at the end of the comparison after the last test was performed by PTB. The stability of the meters has been calculated using the maximum difference between the 3 measurement errors determined by the pilot laboratory on three different occasions for each flow rate assuming a rectangular distribution.

$$u_{drift} = \left(\frac{\varepsilon_{max} - \varepsilon_{min}}{2\sqrt{3}} \right) \qquad (6)$$

The maximum average of the results has been used as the contribution to the uncertainty for drift of the transfer standard. The contribution u_{drift} to the uncertainty of the laboratory results is determined to be 0.003 % for Meter 1 and 0.006 % for Meter 2.
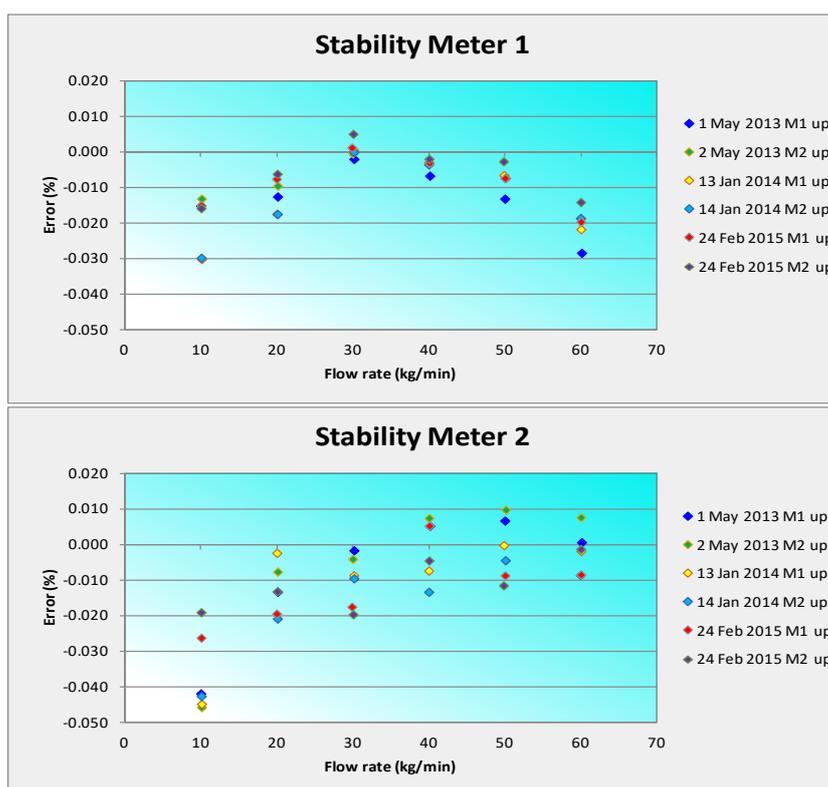
figure 6: test results to determine the stability of the transfer standards

Based on the calculations performed by NMIJ an additional contribution to the uncertainty of the transfer Meter 2 is incorporated in the calculations of the KCRV for the hydrocarbon measurements. Based on the average value of the coefficients and the temperature difference among the hydrocarbon laboratories, the temperature effect on Meter 2 is estimated to be 0.034 %. (see Annex 2) The temperature effect of 0.034 % is adopted as the expanded uncertainty due to temperature for Meter 2 in Equation (1)

6 Test results

The IKS-SKID gave the possibility to use two different configurations for the test by changing the order of the two travel standards. Either Meter 1 is upstream or Meter 2 is upstream. Each configuration results in two sets of data. The measurement errors of the meters in the IKS-SKID were reported. For each fluid (water and hydrocarbon) four sets of measurement errors are reported each related to the configuration of the meter setup:

- Measurement error of Meter 1 in the upstream position
- Measurement error of Meter 1 in the downstream position
- Measurement error of Meter 2 in the upstream position
- Measurement error of Meter 2 in the downstream position

It appeared that there was no significant difference between the results with a meter in the upstream position or in the downstream position. For the comparison the results of a meter in upstream and downstream position are considered as one set of results.

6.1 Results of the tests with water

6.1.1 Measurement error of Meter 1. Test liquid is water.

The standardized DoE for each result is within the limits. The d_i is smaller than the corresponding uncertainty $U(d_i)$ which leads to a standardized DoE that is smaller than 1. Figure 7 states the DoE.

The graph of the Degree of Equivalence shows the difference d_i (dots) and its related expanded uncertainty $U(d_i)$.
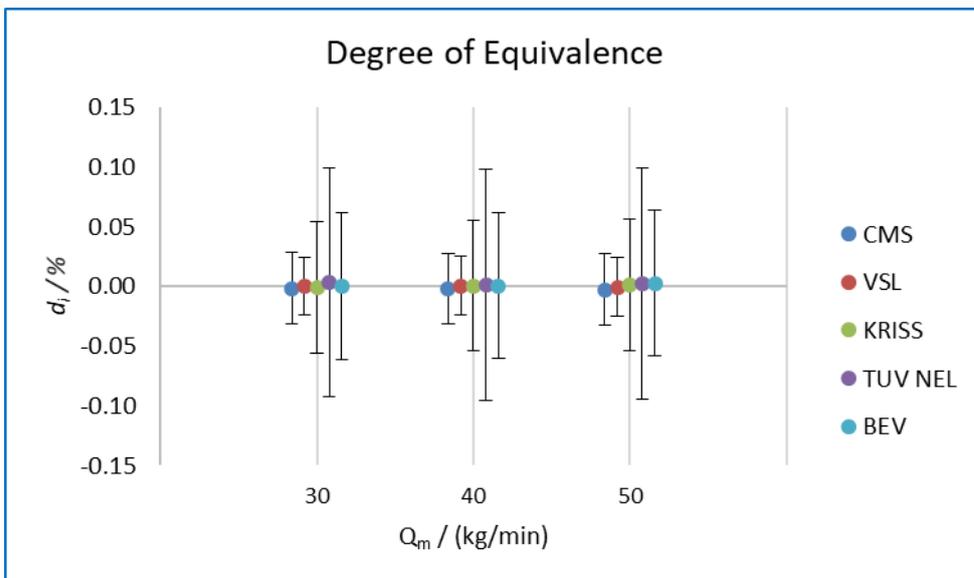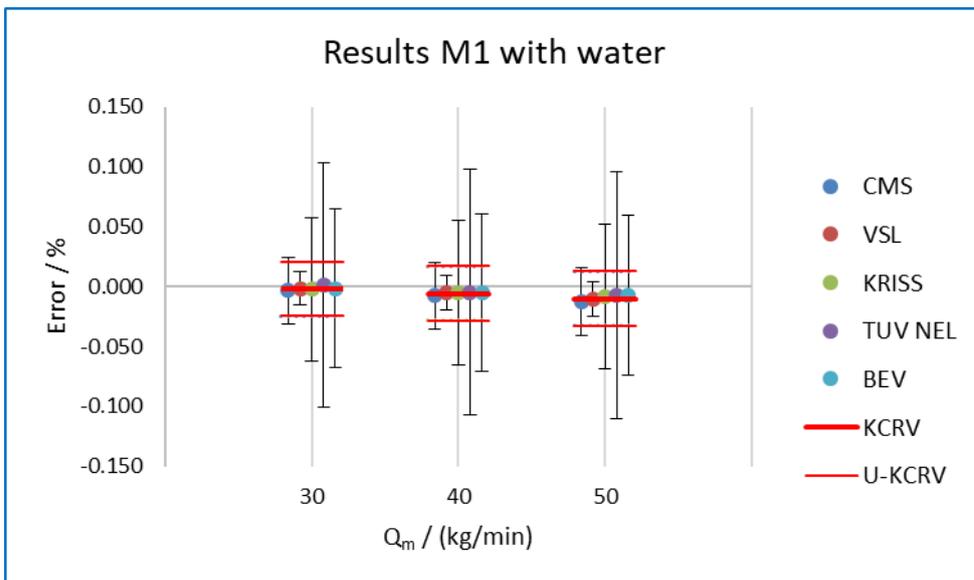
figure 7 Measurement error with its uncertainty of Meter 1 and DoE of Meter 1 at 30, 40 and 50 kg/min with water

6.1.2 Measurement error of Meter 2. Test liquid is water.

The standardized DoE for each result is within the limits. The d_i is smaller than the corresponding uncertainty $U(d_i)$ which leads to a standardized DoE that is smaller than 1. In figure 8 the DoE is shown.

The graph of the Degree of Equivalence shows the difference d_i (dots) and its related expanded uncertainty $U(d_i)$.
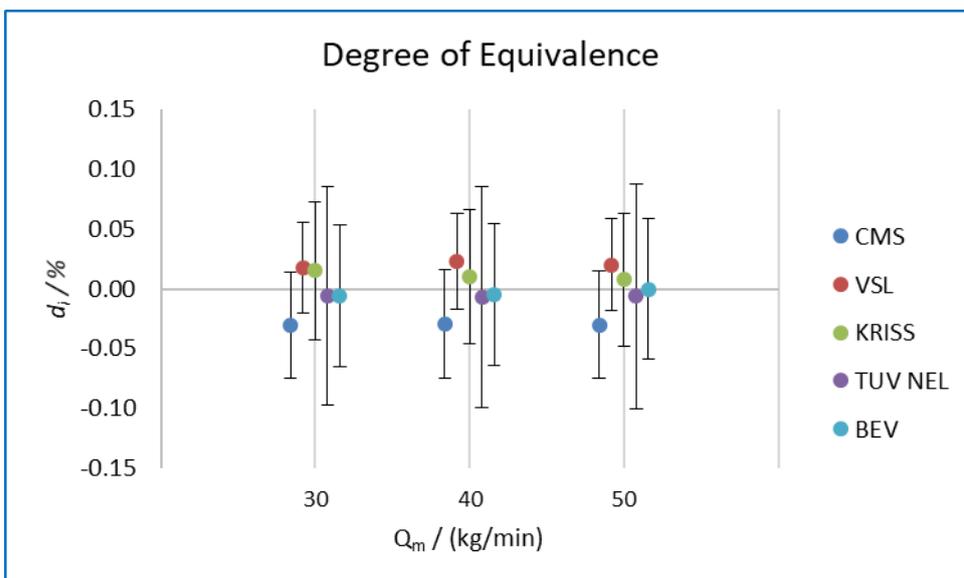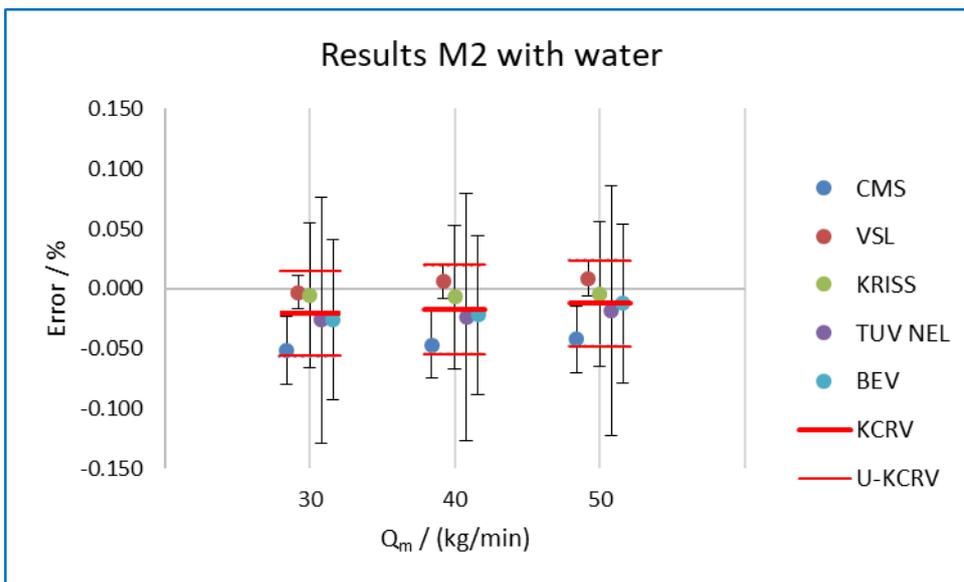
figure 8 Measurement error with its uncertainty of Meter 2 and DoE of Meter 2 at 30, 40 and 50 kg/min with water

6.2 Results of the test with HydroCarbon

6.2.1 Measurement error of Meter 1. Test liquid is hydrocarbon.

One laboratory has a standardized DoE larger than 1 for the three cardinal flow rates.

The graph of the Degree of Equivalence shows the difference d_i (dots) and its related expanded uncertainty $U(d_i)$.
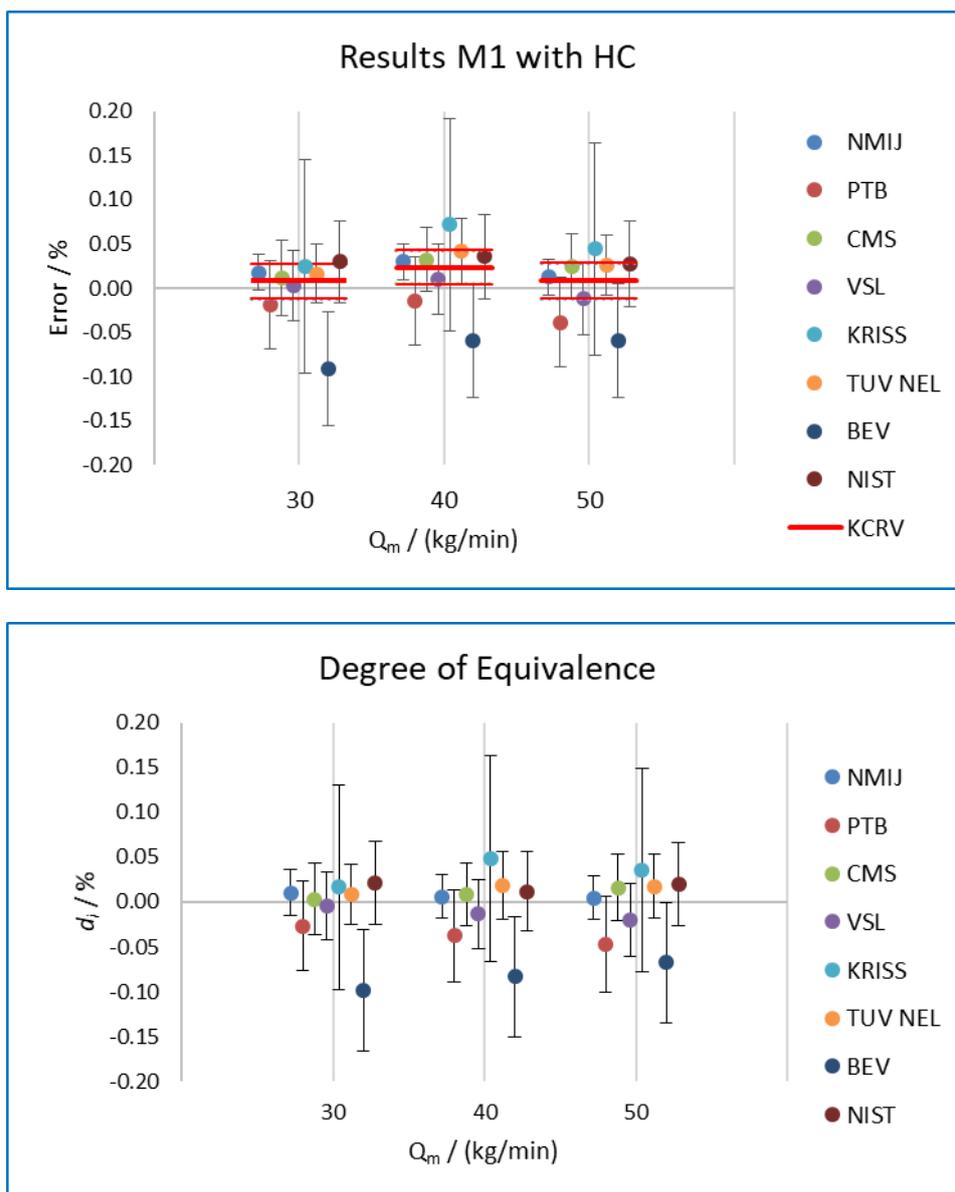
figure 9 Measurement error with its uncertainty of Meter 1 and DoE of Meter 1 at 30, 40 and 50 kg/min with Hydro Carbon

6.2.2 Measurement error of Meter 2. Test liquid is hydrocarbon.

One laboratory has a standardized DoE larger than 1 for two out of three cardinal flow rates and one laboratory has one standardized DoE larger than 1.

The graph of the Degree of Equivalence shows the difference d_i (dots) and its related expanded uncertainty $U(d_i)$.
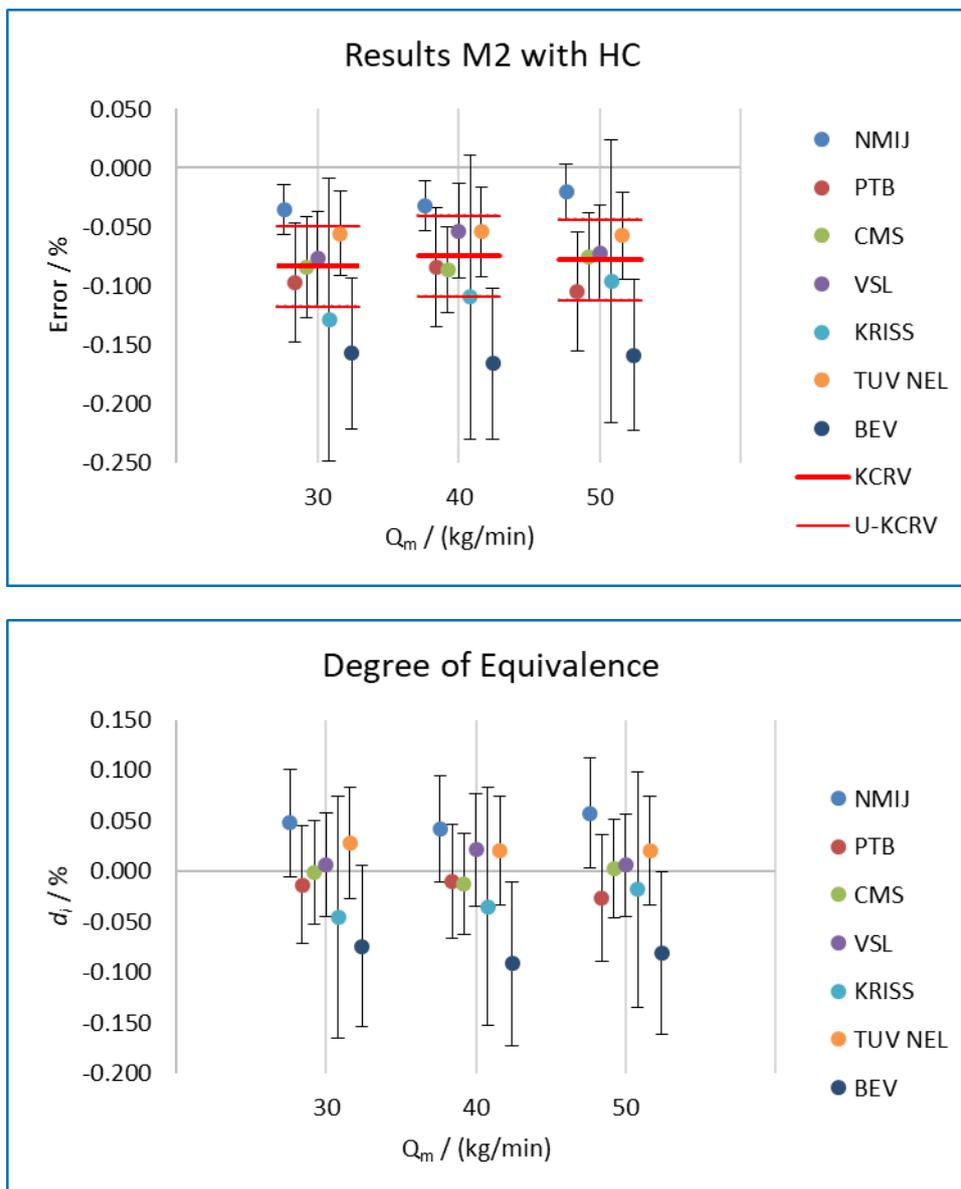
figure 10 Measurement error with its uncertainty of Meter 2 and DoE of Meter 2 at 30, 40 and 50 kg/min with Hydro Carbon

7 Tables with KCRV and DoE

In tables 4 and 5 the results of the different labs are presented together with the KCRV and U(KCRV) calculated by the MC-method. The columns show respectively the laboratory, the error as determined by the laboratory (Error), the expanded uncertainty of the error (U), the uncertainty of the transfer standard, the difference with the KCRV (di), the expanded uncertainty of the difference (U(di)), the E_n-value (En) and the correlation coefficient between the results of a lab and the KCRV (DoE.r).

Water Meter 1

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
CMS	-0.003	0.028	0.003	-0.002	0.030	0.052	-0.428
VSL	-0.001	0.014	0.003	0.000	0.024	0.018	-0.790
KRISS	-0.002	0.060	0.003	0.000	0.055	0.009	0.038
TUV NEL	0.001	0.102	0.003	0.003	0.096	0.033	0.177
BEV	-0.001	0.066	0.003	0.000	0.061	0.007	0.066

30 kg/min	KCRV	$U_{(KCRV)}$
	-0.002	0.023

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
CMS	-0.008	0.028	0.003	-0.002	0.030	0.065	-0.435
VSL	-0.005	0.014	0.003	0.001	0.024	0.028	-0.795
KRISS	-0.005	0.060	0.003	0.001	0.055	0.013	0.035
TUV NEL	-0.005	0.103	0.003	0.001	0.096	0.013	0.182
BEV	-0.005	0.066	0.003	0.001	0.061	0.008	0.070

40 kg/min	KCRV	$U_{(KCRV)}$
	-0.006	0.023

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
CMS	-0.012	0.028	0.003	-0.002	0.030	0.082	-0.435
VSL	-0.010	0.014	0.003	0.000	0.024	0.020	-0.791
KRISS	-0.008	0.060	0.003	0.002	0.055	0.029	0.033
TUV NEL	-0.007	0.104	0.003	0.003	0.097	0.029	0.179
BEV	-0.007	0.066	0.003	0.003	0.061	0.042	0.066

50 kg/min	KCRV	$U_{(KCRV)}$
	-0.010	0.023

Water Meter 2

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
CMS	-0.051	0.028	0.006	-0.031	0.044	0.693	-0.725
VSL	-0.003	0.014	0.006	0.018	0.038	0.471	-0.872
KRISS	-0.005	0.060	0.006	0.015	0.057	0.266	-0.188
TUV NEL	-0.026	0.102	0.006	-0.006	0.091	0.063	0.159
BEV	-0.026	0.067	0.006	-0.005	0.059	0.092	-0.043

30 kg/min	KCRV	$U_{(KCRV)}$
	-0.021	0.035

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
CMS	-0.047	0.028	0.006	-0.030	0.045	0.653	-0.744
VSL	0.006	0.014	0.006	0.023	0.040	0.586	-0.888
KRISS	-0.007	0.060	0.006	0.010	0.056	0.181	-0.186
TUV NEL	-0.024	0.103	0.006	-0.007	0.092	0.072	0.139
BEV	-0.022	0.066	0.006	-0.005	0.060	0.083	-0.082

40 kg/min	KCRV	$U_{(KCRV)}$
	-0.017	0.037

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
CMS	-0.042	0.028	0.006	-0.030	0.045	0.674	-0.732
VSL	0.008	0.014	0.006	0.020	0.039	0.524	-0.879
KRISS	-0.005	0.060	0.006	0.008	0.056	0.137	-0.154
TUV NEL	-0.018	0.104	0.006	-0.006	0.094	0.066	0.140
BEV	-0.012	0.066	0.006	0.000	0.059	0.002	-0.060

50 kg/min	KCRV	$U_{(KCRV)}$
	-0.012	0.036

Table 4 Water KCRV and DoE

HC Meter 1

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
NMIJ	0.018	0.020	0.003	0.010	0.026	0.389	-0.602
PTB	-0.019	0.050	0.003	-0.027	0.050	0.532	-0.180
CMS	0.011	0.043	0.003	0.003	0.040	0.079	-0.084
VSL	0.003	0.040	0.003	-0.005	0.038	0.134	-0.119
KRISS	0.025	0.120	0.003	0.017	0.114	0.146	0.238
TUV NEL	0.017	0.034	0.003	0.009	0.034	0.256	-0.265
BEV	-0.091	0.064	0.003	-0.099	0.068	1.465	-0.289
NIST	0.030	0.047	0.003	0.022	0.046	0.472	-0.192

30 kg/min	KCRV	$U_{(KCRV)}$
	0.008	0.020

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
NMIJ	0.030	0.020	0.003	0.006	0.024	0.246	-0.552
PTB	-0.014	0.050	0.003	-0.038	0.052	0.732	-0.242
CMS	0.033	0.036	0.003	0.009	0.035	0.249	-0.169
VSL	0.010	0.040	0.003	-0.014	0.039	0.351	-0.158
KRISS	0.072	0.120	0.003	0.048	0.115	0.419	0.171
TUV NEL	0.042	0.037	0.003	0.018	0.038	0.482	-0.270
BEV	-0.059	0.064	0.003	-0.083	0.067	1.239	-0.274
NIST	0.036	0.048	0.003	0.012	0.045	0.267	-0.019

40 kg/min	KCRV	$U_{(KCRV)}$
	0.024	0.019

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
NMIJ	0.013	0.020	0.003	0.004	0.024	0.183	-0.548
PTB	-0.039	0.051	0.003	-0.047	0.053	0.889	-0.299
CMS	0.024	0.037	0.003	0.016	0.037	0.431	-0.248
VSL	-0.012	0.040	0.003	-0.020	0.040	0.507	-0.234
KRISS	0.044	0.120	0.003	0.036	0.114	0.316	0.269
TUV NEL	0.026	0.034	0.003	0.017	0.035	0.496	-0.329
BEV	-0.059	0.065	0.003	-0.068	0.067	1.011	-0.251
NIST	0.028	0.048	0.003	0.019	0.046	0.421	-0.099

50 kg/min	KCRV	$U_{(KCRV)}$
	0.008	0.020

HC Meter 2

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
NMIJ	-0.036	0.021	0.018	0.048	0.053	0.899	-0.615
PTB	-0.097	0.050	0.018	-0.013	0.058	0.231	-0.190
CMS	-0.084	0.043	0.018	-0.001	0.051	0.015	-0.194
VSL	-0.077	0.040	0.018	0.007	0.051	0.134	-0.249
KRISS	-0.129	0.120	0.018	-0.046	0.120	0.380	0.036
TUV NEL	-0.056	0.036	0.018	0.028	0.055	0.504	-0.437
BEV	-0.158	0.064	0.018	-0.074	0.080	0.929	-0.382

30 kg/min	KCRV	$U_{(KCRV)}$
	-0.084	0.034

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
NMIJ	-0.032	0.021	0.018	0.042	0.052	0.803	-0.607
PTB	-0.084	0.050	0.018	-0.010	0.057	0.172	-0.147
CMS	-0.087	0.036	0.018	-0.012	0.050	0.243	-0.302
VSL	-0.053	0.040	0.018	0.021	0.055	0.384	-0.349
KRISS	-0.110	0.120	0.018	-0.035	0.118	0.298	0.092
TUV NEL	-0.054	0.038	0.018	0.021	0.054	0.382	-0.372
BEV	-0.166	0.064	0.018	-0.092	0.081	1.135	-0.407

40 kg/min	KCRV	$U_{(KCRV)}$
	-0.075	0.034

Laboratory	Error (%)	$U_{(xi\_lab)}$ (%)	u_{ts} (%)	di (%)	U(di) (%)	En (-)	DoE.r
NMIJ	-0.02	0.024	0.018	0.058	0.055	1.051	-0.614
PTB	-0.10	0.051	0.018	-0.027	0.063	0.427	-0.295
CMS	-0.08	0.037	0.018	0.003	0.049	0.055	-0.270
VSL	-0.07	0.040	0.018	0.006	0.051	0.115	-0.241
KRISS	-0.10	0.120	0.018	-0.018	0.117	0.152	0.130
TUV NEL	-0.06	0.037	0.018	0.021	0.054	0.387	-0.386
BEV	-0.16	0.064	0.018	-0.081	0.080	1.003	-0.397

50 kg/min	KCRV	$U_{(KCRV)}$
	-0.078	0.034

Table 5 Hydro Carbon KCRV and DoE

8   Repeatability of the meters at 5 kg/min

Each laboratory performed measurements at 5 kg/min at the beginning and the end of the tests. These measurements were intended to demonstrate the repeatability of the meters.

Table 6 shows the differences between the results of the first and the last measurement at 5 kg/min of each series of measurements.

It is to be discussed whether this number can be a diagnostic tool. CMS did not perform calibrations at 5 kg/min with hydrocarbon.

lab		Water	HydroCarbon
NMIJ	M1_Upstream		0.001
	M2_Downstream		-0.002
	M1_Downstream		0.001
	M2_Upstream		-0.010
PTB	M1_Upstream		-0.039
	M2_Downstream		-0.028
	M1_Downstream		-0.030
	M2_Upstream		-0.036
CMS	M1_Upstream	0.000	
	M2_Downstream	-0.022	
	M1_Downstream	-0.040	
	M2_Upstream	-0.018	
VSL	M1_Upstream	-0.006	0.012
	M2_Downstream	0.001	0.062
	M1_Downstream	-0.006	0.019
	M2_Upstream	0.032	0.043
KRISS	M1_Upstream	-0.001	0.022
	M2_Downstream	0.012	0.026
	M1_Downstream	0.007	0.010
	M2_Upstream	-0.081	0.006
NEL	M1_Upstream	-0.016	0.009
	M2_Downstream	0.001	0.012
	M1_Downstream	0.051	0.005
	M2_Upstream	0.044	0.004
BEV	M1_Upstream	0.032	0.024
	M2_Downstream	0.030	0.030
	M1_Downstream	0.035	0.024
	M2_Upstream	0.037	0.016
NIST	M1_Upstream		0.004
	M2_Downstream		
	M1_Downstream		0.009
	M2_Upstream		

table 6 differences (%) between the results of the first and the last measurement at 5 kg/min

9 Uncertainty

9.1 The measurement uncertainty

Data of the measurement uncertainty calculation was reported. At 40 and 20 kg/min a full uncertainty calculation was sent to the pilot laboratory. At all other flows the participant reported type A, type B, the combined uncertainty and the expanded uncertainty without all individual sources. The expanded uncertainty is reported with a coverage factor k=2.

9.2 Calibration and Measurement Capabilities CMC

Based on the uncertainty of measurement the participant could decide whether the tests are reported according to their CMC claim in the BIPM CMC database or with the actual calculated uncertainty.

KC with Water Meter 1 upstream Meter 2 downstream

NMI	VSL		NEL		BEV		CMS		KRISS	
Ref. flow rate	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2
[kg/min]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
10	0.014	0.015	0.101	0.103	0.067	0.067	0.028	0.030	0.060	0.061
20	0.014	0.014	0.101	0.103	0.066	0.067	0.028	0.028	0.060	0.060
30	0.014	0.014	0.102	0.102	0.066	0.067	0.028	0.028	0.060	0.060
40	0.014	0.014	0.103	0.103	0.066	0.066	0.028	0.028	0.060	0.060
50	0.014	0.014	0.104	0.104	0.066	0.067	0.028	0.028	0.060	0.060
60	0.014	0.014	0.104	0.104	0.066	0.066	0.028	0.028	0.060	0.061

KC with Water Meter 2 upstream Meter 1 downstream

Ref. flow rate	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2
[kg/min]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
10	0.014	0.015	0.101	0.101	0.066	0.067	0.028	0.029	0.060	0.060
20	0.014	0.015	0.102	0.105	0.066	0.067	0.028	0.030	0.060	0.060
30	0.014	0.014	0.101	0.101	0.067	0.068	0.028	0.028	0.060	0.061
40	0.014	0.014	0.102	0.103	0.066	0.066	0.028	0.028	0.060	0.060
50	0.014	0.014	0.104	0.104	0.067	0.066	0.028	0.028	0.060	0.060
60	0.014	0.014	0.104	0.104	0.066	0.066	0.028	0.028	0.060	0.061

table 7 expanded uncertainties for the results with water as reported by the laboratories

KC with Hydrocarbon Meter 1 upstream Meter 2 downstream

NMI	VSL		NEL		BEV		NIST		NMIJ		CMS		KRISS		PTB	
Ref. flow rate	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2
[kg/min]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
10	0.040	0.040	0.032	0.033	0.064	0.064	0.050		0.020	0.021	0.053	0.053	0.121	0.120	0.057	0.059
20	0.040	0.040	0.032	0.037	0.065	0.064	0.050		0.020	0.021	0.053	0.053	0.120	0.120	0.050	0.050
30	0.040	0.040	0.034	0.036	0.065	0.065	0.047		0.020	0.022	0.043	0.043	0.120	0.120	0.050	0.050
40	0.040	0.040	0.037	0.038	0.064	0.065	0.048		0.020	0.022	0.037	0.037	0.120	0.120	0.050	0.050
50	0.040	0.040	0.034	0.037	0.066	0.065	0.048		0.021	0.031	0.039	0.038	0.121	0.121	0.051	0.052
60	0.040	0.041	0.040	0.043	0.065	0.066	0.052		0.023	0.025	0.036	0.037	0.121	0.120	0.051	0.051

KC with Hydrocarbon Meter 2 upstream Meter 1 downstream

Ref. flow rate	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2	U mtr 1	U mtr 2
[kg/min]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
10	0.040	0.040	0.032	0.034	0.064	0.064	0.050		0.020	0.021	0.053	0.054	0.120	0.120	0.057	0.058
20	0.040	0.040	0.033	0.039	0.065	0.065	0.050		0.020	0.021	0.052	0.053	0.121	0.121	0.050	0.050
30	0.040	0.040	0.034	0.035	0.065	0.064	0.047		0.020	0.021	0.043	0.043	0.122	0.121	0.051	0.051
40	0.040	0.040	0.036	0.038	0.064	0.064	0.048		0.020	0.022	0.036	0.037	0.120	0.120	0.050	0.050
50	0.040	0.041	0.041	0.042	0.065	0.065	0.048		0.021	0.024	0.036	0.037	0.121	0.121	0.051	0.051
60	0.041	0.040	0.040	0.042	0.065	0.065	0.052		0.023	0.037	0.038	0.038	0.121	0.120	0.050	0.050

table 8 expanded uncertainties for the results with hydrocarbon as reported by the laboratories

10 Conclusion

For the evaluation of the results procedure B (Monte Carlo simulation) as suggested by Cox (4) has been used. After the measurements had been finished it was suggested by NMIJ that fluid properties such as density and viscosity had an influence on the results of the transfer standards. It seemed that each meter responded differently to the density and the viscosity of the fluid. The influence of the temperature on the performance of Meter 1 is so small that it has no influence on the outcome of the Monte Carlo simulation and it was decided to ignore the contribution to the uncertainty of Meter 1 due to temperature effects.

Due to the influence of the temperature on the performance of the transfer standards with hydrocarbon as the calibration fluid the uncertainty related to the KCRV of Meter 2 is almost twice as high as the uncertainty related to the KCRV of Meter 1. This explains partly the results with Meter 2. Whether the results with Meter 2 are good enough to underpin the CMC-claims of the participating laboratories can be a point of discussion.

It was decided that the influence of fluid properties such as density and viscosity were not considered for the comparison CCM.FF-K2.2011. The main reason is that this effect was not known at the start of the comparison. The protocol did not prepare for this kind of influences. The effect of fluid property on the performance of a meter will be investigated in a separate project/comparison that will be proposed after the closure of the actual project. Therefore, no corrections were made for fluid properties nor was any uncertainty assigned for the effects in this work. The comments about the fluid properties made by NMIJ are attached to this report. (Annex 1)

10.1 Water flow comparison

The lab results with Meter 1 and Meter 2 with water as the calibration liquid show good agreement with the KCRV.
The results of the laboratories with Meter 1 and Meter 2 are within the limits regarding the standardized DoE.
These results underpin the CMC claims of the participating laboratories for water flow.
Temperature effects are not included in the uncertainties of to the transfer standards.

10.2 Hydrocarbon flow comparison

The lab results with Meter 1 with hydrocarbon as the calibration liquid show good agreement with the KCRV. One laboratory has an E_n-value larger than 1.
The influence of the temperature on the performance of the Meter 2 has been incorporated in the uncertainty of Meter 2. The value of the uncertainty due to temperature has been estimated by NMIJ as shown in Annex 2. After that the results of Meter 2 with hydrocarbon as the calibration liquid show good agreement with the KCRV. One laboratory has E_n-values between 1 and 1.2 for two flow rates and one laboratory has an E_n-value between 1 and 1.2 for one flow rate.

11 References

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2. JCGM 100:2008, Evaluation of measurement data – Guide to the expression of uncertainty in measurement, 2008 (GUM 1995 with minor corrections)

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4. Cox M.G., *Evaluation of key comparison data.* Metrologia, 2002, 39, 589-595

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6. R Core Team (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

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9. Transfer standard uncertainty can cause inconclusive inter-laboratory comparisons, John Wright et al., Metrologia 53 (2016) 1243-1258

10. Measurement comparisons in the CIPM MRA, CIPM MRA-D-05, Version 1.5

11. Guidelines for CIPM key comparisons (Appendix F to the "Mutual recognition of national measurements standards and of measurement certificates issued by national metrology institutes" (MRA)), 1 March 1999

12 Terms and abbreviations

BIPM	= Bureau International des Poids et Mesures (International Bureau of Weights and Measures)
CCM	= Consultative Committee for Mass and Related Quantities
CIPM	= Comité International des Poids et Mesures (International Committee for Weights and Measures)
CMC	= Calibration and Measurement Capabilities
DI	= Designated Institute
DoE	= Degree of Equivalence
FF	= Fluid Flow
FSF	= Flying Start Finish method
GUM	= Guide to the Expression of Uncertainty in Measurement
KC	= Key Comparison
KCRV	= Key Comparison Reference Value
MRA	= Mutual Recognition Arrangement
NMI	= National Metrology Institute
RTD	= Resistive Temperature Device
SSF	= Standing Start Finish method
TS	= Transfer Standard
VIM	= Vocabulaire International de Metrologie
VSL	= The National Metrology Institute of the Netherlands
WGFF	= Working Group for Fluid Flow

Annex 1. 1st and 2nd comment from NMIJ

1st comment from NMIJ on viscosity effects

NMIJ performed some analytical works based on the data reported in Draft A and also made some investigations on the liquid viscosity effect that appears to influence the results of this comparison using a Coriolis meter of our own similar to Meter 1. From the investigation results, we see a similar trend with Meter 1 in terms of viscosity effect. Anyway, we think it is more appropriate to keep the discussion here within the data scope of this comparison.

Figure A1.1 shows the meter errors for Meter 1 and Meter 2 against liquid viscosity of working liquids (hydrocarbon and water) used by the participating labs. This graph is plotted using the averaged values of 10 calibration results at 40 kg/min available in P.31~33 in Draft A_v3. Though there is some scatter, apparently the two meters show different trends, indicating a correlation between the affected meter outputs and the kinematic viscosity.
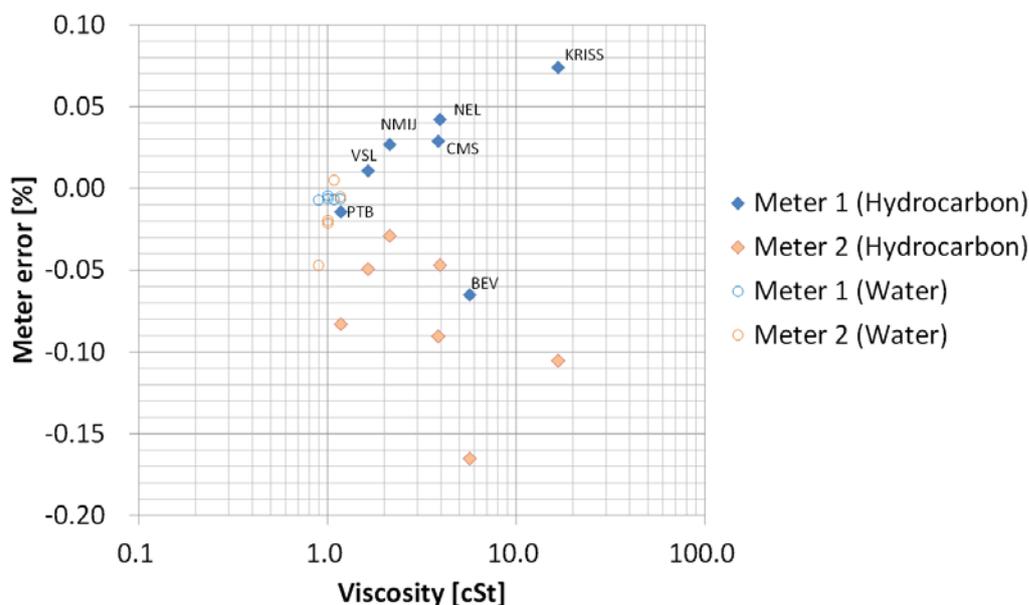
Fig. A1.1 Meter error at 40 kg/min against viscosity (Viscosity of water was estimated by temperature)

If there is any systematic shift due to the participants' labs included in the respective meter error, we assume that the magnitude of the systematic shift should be the same in both meters since they were calibrated simultaneously at a single reference flow value provided by the lab. To cancel the systematic shift due to the facility, we obtained the difference of meter errors plotted against the liquid viscosity in Fig. A1.2. The increasing difference of meter errors with higher viscosity indicates an increasing gap in the opposing behavior trend of the respective meter against increasing viscosity.

Therefore it can be concluded that the meters show a certain dependence on liquid viscosity and this should be taken into account in the uncertainty of the transfer standards.
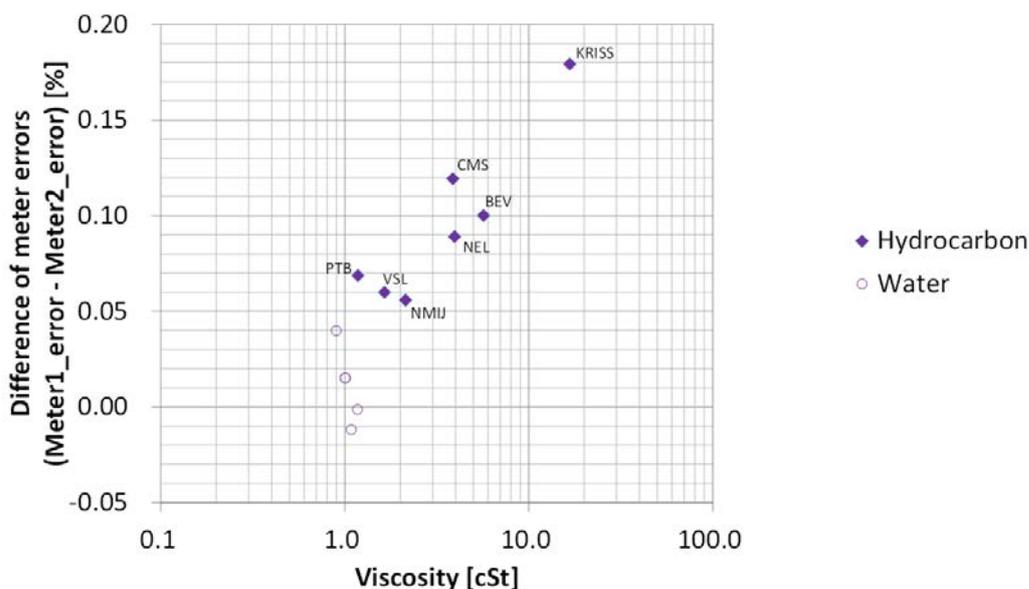
Fig. A1.2 Difference of meter errors at 40 kg/min against viscosity (Viscosity of water was estimated by temperature)

2nd comments from NMIJ on correction by temperature and density effects

As we mentioned, the differences of the KCRVs evaluated in hydrocarbon from those in water at the same flow rate seem to be from +0.009 % to +0.028 % in Meter1 and from -0.060 % to -0.068 % in Meter2, respectively, indicating that these differences due to liquid type, which depend on the flow rate, are not negligible in comparison with the uncertainties of the KCRVs. This indicates that the uncertainty due to the transfer standard may be underestimated in the comparison.

We suggested that the uncertainty due to the effect of the difference of the liquid property between each pair of the participants on the transfer standard should be included in the hydrocarbon comparison, since the different type of oils was used at each participant.

In different way, we would like to suggest that the KCRVs based on liquid temperature of 20 ºC and density of 998.2 kg/m³ at each flow rate are obtained using all calibration results with water and hydrocarbon corrected by temperature and density effects. The temperature effect may be caused by measuring temperature on the vibrating tube to compensate the spring constant in the Coriolis meters, and the density effect may be caused by the deviation of the center of gravity of a tube in the Coriolis meters due to the liquid density. As results, the KCRVs obtained by some correction are common to water and hydrocarbon at each flow rate.

A2.1 Results of the participating institutes

The actual errors obtained at the participants were used to calculate a corrected error based on liquid temperature of 20 ºC and density of 998.2 kg/m³.

$$E_{\mathrm{C}} = E_{\mathrm{C,T}} - E_{\mathrm{COR,rho}}$$
$$= E - E_{\mathrm{COR,T}} - E_{\mathrm{COR,rho}} \qquad \text{(A2.1)}$$

E : Actual error at calibration condition

$E_{\mathrm{C,T}}$: Corrected error based on liquid temperature of 20 ºC

$E_{COR,T}$: Temperature correction obtained by the weighted least squares linear fitting curve of actual error with water against liquid temperature T .

E_C : Corrected error based on liquid temperature of 20 ºC and density of 998.2 kg/m³

$E_{COR,rho}$: Density correction obtained by the weighted least squares linear fitting curve of the corrected error based on liquid temperature of 20 ºC against density ρ .

The temperature correction and the density correction are obtained by Equations (A2.2) and (A2.3).

$$E_{COR,T} = a_{COR,T}(T-20) \qquad \text{(A2.2)}$$
$$E_{COR,rho} = a_{COR,rho}(\rho - 998.2) \qquad \text{(A2.3)}$$

Where the correction coefficient of temperature $a_{COR,T}$ is obtained by a linear correction curve for the actual errors with water by the method of weighted least squares and the correction coefficient of density $a_{COR,rho}$ is obtained by a linear correction curve for the corrected error based on liquid temperature of 20 ºC with water and hydrocarbon by the method of weighted least squares.

The temperature and density effects of Meter 1 and Meter 2 at 40 kg/min are shown in Fig. A2.1 and Fig. A2.2, respectively.
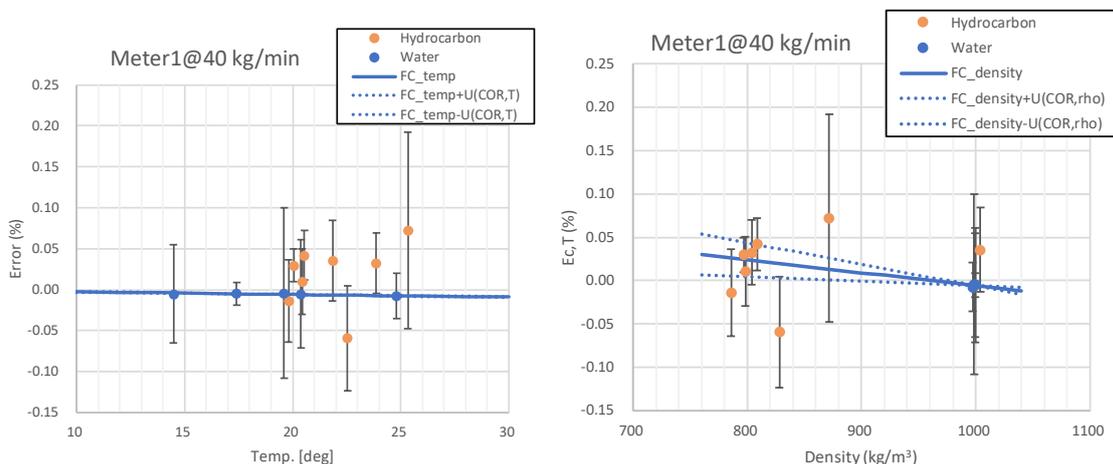
Fig. A2.1 Temperature and density effects of Meter 1 at 40 kg/min.
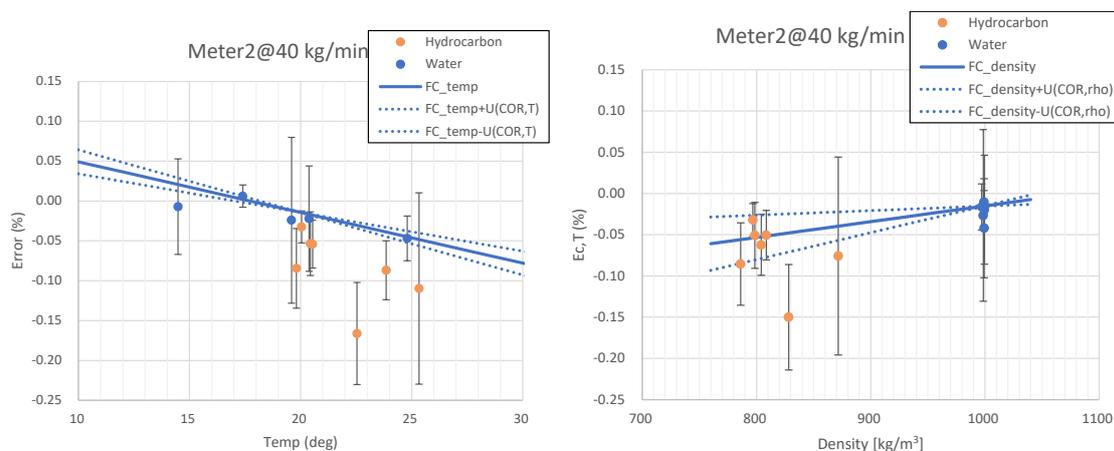
Fig. A2.2 Temperature and density effects of Meter 2 at 40 kg/min.

A2.2 Calculation of the reference value and its uncertainty

The analysis of the results was carried out according to the methods specified by Cox.

At the flow rates of 30 kg/min, 40 kg/min and 50 kg/min, the key comparison reference values (KCRV) of CCM.FF-K2.2011 E_{KCRV} based on liquid temperature of 20 ºC and density of 998.2 kg/m³ are obtained as the weighted mean by Equation (A2.4) using the corrected error $E_{\mathrm{C,i}}$ and the standard uncertainty of the corrected error $u(E_{C,i})$ at the participating laboratory i. The uncertainty of the KCRV of CCM.FF-K2.2011 $u(E_{\mathrm{KCRV}})$ is expressed by Equation (A2.5).

$$E_{\mathrm{KCRV}} = \frac{\sum_{i}^{n}\left(E_{\mathrm{C},i}\big/u^{2}\left(E_{\mathrm{C},i}\right)\right)}{\sum_{i}^{n}\left(1\big/u^{2}\left(E_{\mathrm{C},i}\right)\right)} \qquad (A2.4)$$

$$\frac{1}{u^{2}\left(E_{\mathrm{KCRV}}\right)} = \sum_{i}^{n}\left(\frac{1}{u^{2}\left(E_{\mathrm{C},i}\right)}\right) \qquad (A2.5)$$

The expanded uncertainty of the KCRV of CCM.FF-K2.2011 $U(E_{\mathrm{KCRV}})$ is obtained by Equation (A2.6).

$$U\left(E_{\mathrm{KCRV}}\right) = k \cdot u\left(E_{\mathrm{KCRV}}\right) = 2u\left(E_{\mathrm{KCRV}}\right) \qquad (A2.6)$$

The standard uncertainty of the calibration results, that is the corrected error at each participating laboratory, is expressed by Equation (A2.7).

$$u^{2}\left(E_{\mathrm{C},i}\right) = u_{f,i}{}^{2} + u_{\mathrm{DUT},i}{}^{2} + u_{\mathrm{TS}}{}^{2} + u_{\mathrm{COR,T}}{}^{2} + u_{\mathrm{COR,rho}}{}^{2} \qquad (A2.7)$$

$u_{f,i}$: Standard uncertainty due to calibration facility in the laboratory i, Base uncertainty

$u_{\mathrm{DUT},i}$: Standard uncertainty due to repeatability of transfer standard at calibration, DUT uncertainty

u_{TS} : Standard uncertainty due to the transfer standard

$u_{\mathrm{COR,T}}$: Standard uncertainty due to correction of temperature difference from 20 ºC.

$u_{\mathrm{COR,rho}}$: Standard uncertainty due to correction of density difference from 998.2 kg/m³.

The standard uncertainty due to corrections $u_{\mathrm{COR,T}}$, $u_{\mathrm{COR,rho}}$ are obtained as follows;

$$u_{\mathrm{COR,T}}{}^{2} = u^{2}\left(a_{\mathrm{COR,T}}\right)\left(T - 20\right)^{2} \qquad (A2.8)$$

$$u_{\mathrm{COR,T}}{}^{2} = u^{2}\left(a_{\mathrm{COR,rho}}\right)\left(\rho - 998.2\right)^{2} \qquad (A2.9)$$

The standard uncertainties of the correction coefficients of temperature and density $u(a_{\mathrm{COR,T}})$, $u(a_{\mathrm{COR,rho}})$ are obtained by the weighted least squares linear fitting.

The expanded uncertainty of the corrected error at each of the participating laboratories is obtained by Equation (A2.10).

$$U\left(E_{\mathrm{C},i}\right) = k \cdot u\left(E_{\mathrm{C},i}\right) = 2u\left(E_{\mathrm{C},i}\right) \quad \text{(A2.10)}$$

The calculation results are shown in Table A2.1 and the chi-squared test was carried out for those data. The chi-squared value is calculated by Equation (A2.11).

$$\chi_{obs}{}^{2} = \sum_{i=1}^{n} \frac{\left(E_{\mathrm{C},i} - E_{\mathrm{KCRV}}\right)^{2}}{u^{2}\left(E_{\mathrm{C},i}\right)} \quad \text{(A2.11)}$$

The observed chi-squared values at the calibrated flow rates are shown in Table A2.1. The observed chi-squared values $\chi_{obs}{}^{2}$ at Meter 1 and Meter 2 are less than the chi-squared values χ^{2} of 21.03 and 19.67 for the 95 % confidence and the degrees of freedom ($n - 1 = 12$ and $n - 1 = 11$, respectively), indicating that the consistency check does not fail at the 95 % confidence level.

Table A2.1 KCRV of CCM.FF-K2.2011, its uncertainty and chi-squared value

Flow rate (kg/min)	Name of NMI	Liquid	Meter 1					Meter 2				
			$E_{C,i}$ (%)	$U(E_{C,i})$ (%)	E_{KCRV} (%)	$U(E_{KCRV})$ (%)	χ_{obs}	$E_{C,i}$ (%)	$U(E_{C,i})$ (%)	E_{KCRV} (%)	$U(E_{KCRV})$ (%)	χ_{obs}
30	NMIJ	Hydrocarbon	0.0073	0.029	-0.0017	0.010	12.40	0.0013	0.036	-0.0233	0.012	11.44
	PTB	Hydrocarbon	-0.0300	0.055				-0.0568	0.059			
	CMS	Hydrocarbon	0.0016	0.043				-0.0285	0.047			
	VSL	Hydrocarbon	-0.0073	0.045				-0.0254	0.049			
	KIRSS	Hydrocarbon	0.0190	0.121				-0.0730	0.122			
	NEL	Hydrocarbon	0.0066	0.036				-0.0180	0.041			
	BEV	Hydrocarbon	-0.0998	0.067				-0.1136	0.069			
	NIST	Glycol solution	0.0310	0.047				-	-			
	CMS	Water	-0.0023	0.029				-0.0215	0.031			
	VSL	Water	-0.0019	0.015				-0.0178	0.019			
	KRISS	Water	-0.0034	0.060				-0.0388	0.062			
	NEL	Water	0.0011	0.104				-0.0281	0.105			
	BEV	Water	-0.0012	0.067				-0.0245	0.068			

Flow rate (kg/min)	Name of NMI	Liquid	Meter 1					Meter 2				
			$E_{C,i}$ (%)	$U(E_{C,i})$ (%)	E_{KCRV} (%)	$U(E_{KCRV})$ (%)	χ_{obs}	$E_{C,i}$ (%)	$U(E_{C,i})$ (%)	E_{KCRV} (%)	$U(E_{KCRV})$ (%)	χ_{obs}
40	NMIJ	Hydrocarbon	-0.0005	0.029	-0.0047	0.010	13.56	0.0062	0.037	-0.0175	0.012	12.61
	PTB	Hydrocarbon	-0.0458	0.055				-0.0452	0.059			
	CMS	Hydrocarbon	0.0047	0.042				-0.0254	0.048			
	VSL	Hydrocarbon	-0.0195	0.045				-0.0126	0.050			
	KIRSS	Hydrocarbon	0.0548	0.121				-0.0518	0.122			
	NEL	Hydrocarbon	0.0137	0.036				-0.0145	0.041			
	BEV	Hydrocarbon	-0.0840	0.067				-0.1177	0.069			
	NIST	Glycol solution	0.0371	0.049				-	-			
	CMS	Water	-0.0062	0.029				-0.0161	0.031			
	VSL	Water	-0.0057	0.015				-0.0105	0.019			
	KRISS	Water	-0.0067	0.060				-0.0424	0.062			
	NEL	Water	-0.0047	0.104				-0.0267	0.105			
	BEV	Water	-0.0048	0.066				-0.0199	0.067			

Flow rate (kg/min)	Name of NMI	Liquid	Meter 1					Meter 2				
			$E_{C,i}$ (%)	$U(E_{C,i})$ (%)	E_{KCRV} (%)	$U(E_{KCRV})$ (%)	χ_{obs}	$E_{C,i}$ (%)	$U(E_{C,i})$ (%)	E_{KCRV} (%)	$U(E_{KCRV})$ (%)	χ_{obs}
50	NMIJ	Hydrocarbon	-0.0056	0.029				0.0201	0.039			
	PTB	Hydrocarbon	-0.0584	0.055				-0.0592	0.060			
	CMS	Hydrocarbon	0.0075	0.043				-0.0142	0.049			
	VSL	Hydrocarbon	-0.0298	0.045				-0.0196	0.051			
	KIRSS	Hydrocarbon	0.0343	0.121				-0.0366	0.123			
	NEL	Hydrocarbon	0.0087	0.036				-0.0151	0.042			
	BEV	Hydrocarbon	-0.0739	0.067	-0.0096	0.010	12.49	-0.0964	0.070	-0.0139	0.012	12.08
	NIST	Glycol solution	0.0290	0.048				-	-			
	CMS	Water	-0.0112	0.029				-0.0137	0.031			
	VSL	Water	-0.0110	0.015				-0.0076	0.019			
	KRISS	Water	-0.0098	0.060				-0.0389	0.062			
	NEL	Water	-0.0072	0.104				-0.0203	0.105			
	BEV	Water	-0.0070	0.067				-0.0107	0.067			

A2.3 Degrees of equivalence

The degree of equivalence (d_i) and its standard uncertainty $u(d_i)$ are expressed by Equations (A2.12) and (A2.13) according to the procedure A specified by Cox.

$$d_i = E_{C,i} - E_{KCRV} \qquad \text{(A2.12)}$$

$$u^2(d_i) = u^2(E_{C,i}) - u^2(E_{KCRV}) \qquad \text{(A2.13)}$$

The expanded uncertainty of the degree of equivalence $U(d_i)$ is obtained by Equation (A2.14).

$$U(d_i) = k \cdot u(d_i) = 2u(d_i) \qquad \text{(A2.14)}$$

The En value (En_i), that is the standardized degree of equivalence, is obtained by Equation (A2.15).

$$En_i = \left| \frac{d_i}{U(d_i)} \right| \qquad \text{(A2.15)}$$

The degree of equivalence of each participating laboratory is shown in Table A2.2 and Fig. A2.3 .

Table A2.2 Degree of equivalence of each participating laboratory

(a) 30 kg/min

Flow rate (kg/min)	Name of NMI	Liquid	Meter 1			Meter 2		
			d_i (%)	$U(d_i)$ (%)	En_i	d_i (%)	$U(d_i)$ (%)	En_i
30	NMIJ	Hydrocarbon	0.009 1	0.027	0.34	0.024 6	0.034	0.73
	PTB	Hydrocarbon	-0.028 2	0.054	0.52	-0.033 5	0.057	0.58
	CMS	Hydrocarbon	0.003 4	0.041	0.08	-0.005 2	0.046	0.11
	VSL	Hydrocarbon	-0.005 5	0.044	0.13	-0.002 1	0.048	0.04
	KRISS	Hydrocarbon	0.020 7	0.121	0.17	-0.049 8	0.122	0.41
	NEL	Hydrocarbon	0.008 4	0.034	0.24	0.005 3	0.039	0.14
	BEV	Hydrocarbon	-0.098 0	0.066	1.48	-0.090 3	0.068	1.33
	NIST	Glycol solution	0.032 7	0.046	0.71	-	-	-
	CMS	Water	-0.000 5	0.027	0.02	0.001 7	0.029	0.06
	VSL	Water	-0.000 1	0.012	0.01	0.005 4	0.015	0.37
	KRISS	Water	-0.001 6	0.060	0.03	-0.015 5	0.061	0.26
	NEL	Water	0.002 8	0.104	0.03	-0.004 9	0.104	0.05
	BEV	Water	0.000 5	0.066	0.01	-0.001 2	0.067	0.02

(b) 40 kg/min

Flow rate (kg/min)	Name of NMI	Liquid	Meter 1			Meter 2		
			d_i (%)	$U(d_i)$ (%)	En_i	d_i (%)	$U(d_i)$ (%)	En_i
40	NMIJ	Hydrocarbon	0.004 2	0.027	0.16	0.023 7	0.035	0.69
	PTB	Hydrocarbon	-0.041 1	0.054	0.76	-0.027 7	0.058	0.48
	CMS	Hydrocarbon	0.009 4	0.041	0.23	-0.007 9	0.046	0.17
	VSL	Hydrocarbon	-0.014 9	0.044	0.34	0.004 8	0.048	0.10
	KRISS	Hydrocarbon	0.059 5	0.121	0.49	-0.034 3	0.122	0.28
	NEL	Hydrocarbon	0.018 4	0.034	0.53	0.003 0	0.040	0.08
	BEV	Hydrocarbon	-0.079 3	0.066	1.20	-0.100 2	0.068	1.47
	NIST	Glycol solution	0.041 8	0.048	0.86	-	-	-
	CMS	Water	-0.001 5	0.027	0.06	0.001 2	0.029	0.04
	VSL	Water	-0.001 0	0.011	0.09	0.006 8	0.015	0.47
	KRISS	Water	-0.002 0	0.059	0.03	-0.025 0	0.061	0.41
	NEL	Water	0.000 0	0.104	0.00	-0.009 3	0.104	0.09
	BEV	Water	-0.000 1	0.066	0.00	-0.002 6	0.066	0.04

(c) 50 kg/min

Flow rate (kg/min)	Name of NMI	Liquid	Meter 1			Meter 2		
			d_i (%)	$U(d_i)$ (%)	En_i	d_i (%)	$U(d_i)$ (%)	En_i
50	NMIJ	Hydrocarbon	0.004 0	0.027	0.15	0.034 0	0.037	0.91
	PTB	Hydrocarbon	-0.048 8	0.054	0.90	-0.045 3	0.059	0.77
	CMS	Hydrocarbon	0.017 1	0.042	0.41	-0.000 3	0.047	0.01
	VSL	Hydrocarbon	-0.020 2	0.044	0.46	-0.005 6	0.049	0.11
	KRISS	Hydrocarbon	0.043 8	0.121	0.36	-0.022 7	0.122	0.19
	NEL	Hydrocarbon	0.018 3	0.035	0.53	-0.001 1	0.041	0.03
	BEV	Hydrocarbon	-0.064 3	0.066	0.97	-0.082 5	0.069	1.20
	NIST	Glycol solution	0.038 6	0.047	0.81	-	-	-
	CMS	Water	-0.001 6	0.027	0.06	0.000 2	0.029	0.01
	VSL	Water	-0.001 5	0.012	0.12	0.006 2	0.015	0.43
	KRISS	Water	-0.000 2	0.060	0.00	-0.025 1	0.061	0.42
	NEL	Water	0.002 4	0.104	0.02	-0.006 5	0.104	0.06
	BEV	Water	0.002 5	0.066	0.04	0.003 2	0.066	0.05
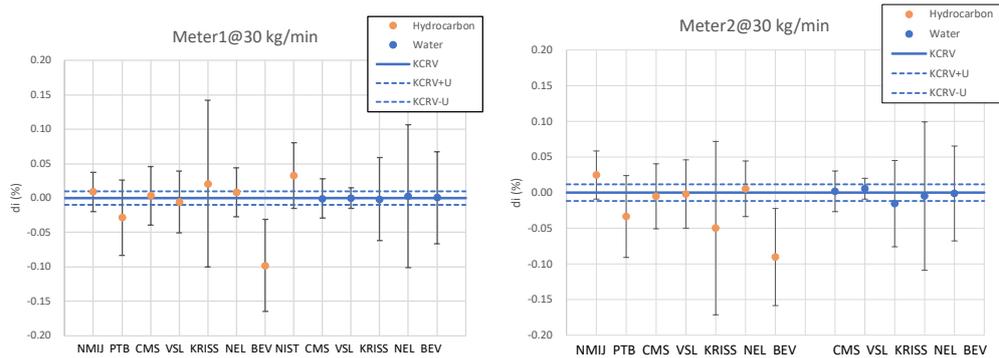
(a) 30 kg/min
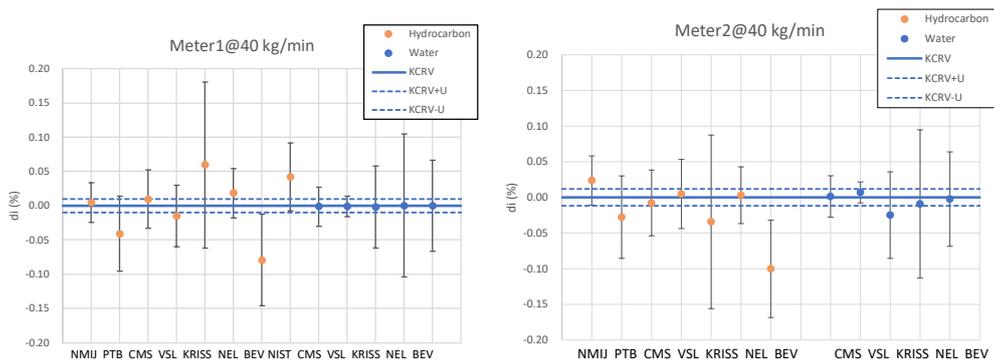
(b) 40 kg/min
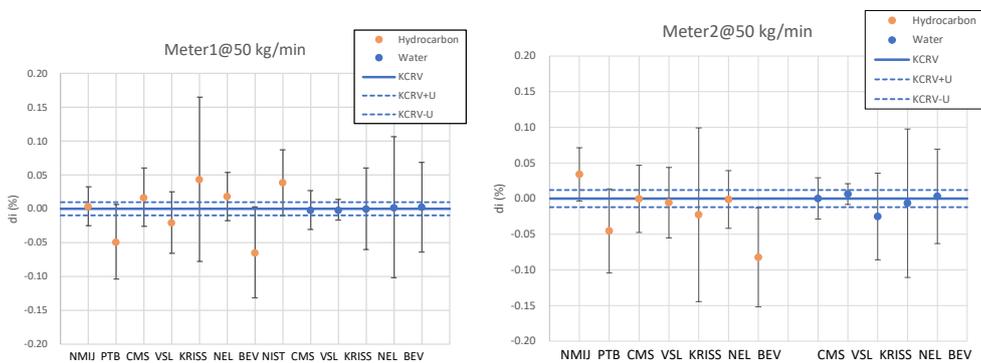
(c) 50 kg/min

Fig. A2.3 Degree of Equivalence and its expanded uncertainty

Annex 2.　　3rd comments from NMIJ on temperature effect

It's a pity that K2 couldn't reach an agreement on our proposed calculation method to include the corrections.

In the technical protocol, it is being stated that "The Uts value will include dependence of meter on temperature range, too". We made a fitting curve to the meter errors obtained by all participants for water against the temperature conditions of each participating laboratory (see the left figures in Fig. A2.1 and Fig. A2.2). We think that the coefficient of the fitting curve can represent the temperature effect of the meter to a satisfactory degree by considering the claimed uncertainty of each participating laboratory. As being pointed out by Dr. Mickan, we expect that this temperature and density effects to be consistent at all flow rate conditions. To confirm this, we compared the temperature and density effects at three flow rate conditions (30, 40, 50 kg/min) based on the coefficients of temperature and density effects obtained at each flow rate condition (see the table below). (Note: the previous NMIJ analysis has been revised by adding NIST results.) From the table below, one can notice that the temperature and density effects are very consistent at all flow rate conditions and can be considered as general effects at all flow rate conditions. The temperature and density effects obtained from the comparison results will be meaningful if the consistency of the effects at all flow rate conditions can be confirmed.

Based on the average value of the coefficients and the temperature difference among the hydrocarbon laboratories, the temperature effect on the transfer meters is estimated to be 0.0015 % for Meter 1 and 0.034 % for Meter 2, respectively. Regarding Meter 2, even if only the temperature effect is considered, this value is already larger than the claimed CMC of NMIJ (0.020%). Therefore, we think that at least this temperature effect of Meter 2 should be considered before concluding the consistency of Meter 2 results of NMIJ against the KCRV. Otherwise, Meter 2 results of NMIJ should be treated as inconclusive. On the other hand, regarding Meter 1, the temperature effect is considered small enough compared to NMIJ's CMC. Thus the original analysis is acceptable for us as far as Meter 1 is concerned.

		Meter 1		Meter 2	
Flow rate	Coeff. temp	Coeff. density	Coeff. temp	Coeff. density
[kg/min]	[%/K]	[%/(kg/m^3)]	[%/K]	[%/(kg/m^3)]
30	-0.000221	-0.000041	-0.00619	0.000182
40	-0.000318	-0.000135	-0.00635	0.000191
50	-0.000291	-0.000078	-0.00636	0.000199
Average	-0.000277	-0.000085	-0.00630	0.000190
STD	0.000050	0.000047	0.00010	0.000008

			Meter 1		Meter 2	
Flow rate	Diff. temp @hydro.	Diff. Density @hydro.	Temp effect @hydro.	Density effect @hydro.	Temp effect @hydro.	Density effect @hydro.
[kg/min]	[K]	[kg/m^3]	[%]	[%]	[%]	[%]
30	5.23	218.26	0.0014	0.0185	0.0330	0.0416
40	5.52	218.00	0.0015	0.0185	0.0348	0.0415
50	5.30	218.64	0.0015	0.0186	0.0334	0.0416

By the way, this K2 is going to adopt two KCRVs, one each for Meter 1 and Meter 2. NMIJ is worried that if the effects of the transfer standard are not being considered, this will result in large underestimation of the uncertainty of the KCRVs in K2, making it difficult to be linked to RMO comparisons in the future. Therefore, NMIJ would like to suggest that the KCRVs of Meter 1 in K2 should be linked to RMO comparisons, since the effects of Meter 1 are much smaller than those of Meter 2.

Annex 3.   Response of NIST

Response to request to re-analyze NIST results for CCM.FF-K2.1.2011 key comparison

NIST re-analyzed their results from both Coriolis meters included in the transfer skid. Upon further inspection of results, we request that only Meter #1, the Micro Motion meter, be included as a basis for comparing our facilities to the other NMIs. This is because we used a piston prover that is not capable of collecting data for a long enough period to obtain a steady state reading from a meter that has a significant time constant (flow damping factor) enabled in the meter electronics. Meter #1 has software that allowed us to turn the time constant off, *i.e.*, set to 0 s. Meter #2 has a time constant that could not be turned completely off: the minimum value allowed is 0.2 s.

In order to try to abide by the comparison protocol with respect to collecting data for a minimum of 1 minute, we summed data from multiple piston strokes so our total collection time was greater than 0.5 minute. The piston prover can collect data for a maximum of 3 s at the flow of 60 kg/min and for a maximum of 45 s at the flow of 5 kg/min. For our original data submission, we neglected how the summing of multiple strokes affected our uncertainty budget. We have considered possible approaches for correcting the data for the time constant effects (or determining the extra uncertainty introduced) and decided that we cannot correct Meter #2's results for the delay in time response to the piston prover and our data are not a good representation of the meter's or piston prover's performance. Figure 1 shows an example of how the time constant affects the meter response. The piston prover is a bidirectional one, however, it comes to a complete stop when it changes direction and hence the meter response time will influence its pulse count during a piston stroke.

In addition, NIST is resubmitting results for Meter #1. This data was re-analyzed and small errors were found in entered values in five of the data tables. The tables affected from the sheet titled "Results KC Set Water 1" are those for flows of 20 kg/min, 60 kg/min, and the second table for 5 kg/min. The tables affected from the sheet titled "Results KC Set Water 2" are those for flows of 50 kg/min and 60 kg/min. We have increased our measurement uncertainty to account for the small number of pulse counts we are measuring from the MUT in a single piston stroke, which is significantly less than from a typical turbine meter calibration that this prover is primarily used for, and to include the standard deviation of the mean of measurements from the summed piston strokes. Based on this new analysis, the uncertainty of the measurements made for the comparison are updated in Form M and we have entered the data from Meter #1 that we wish to be used as the basis for comparison.
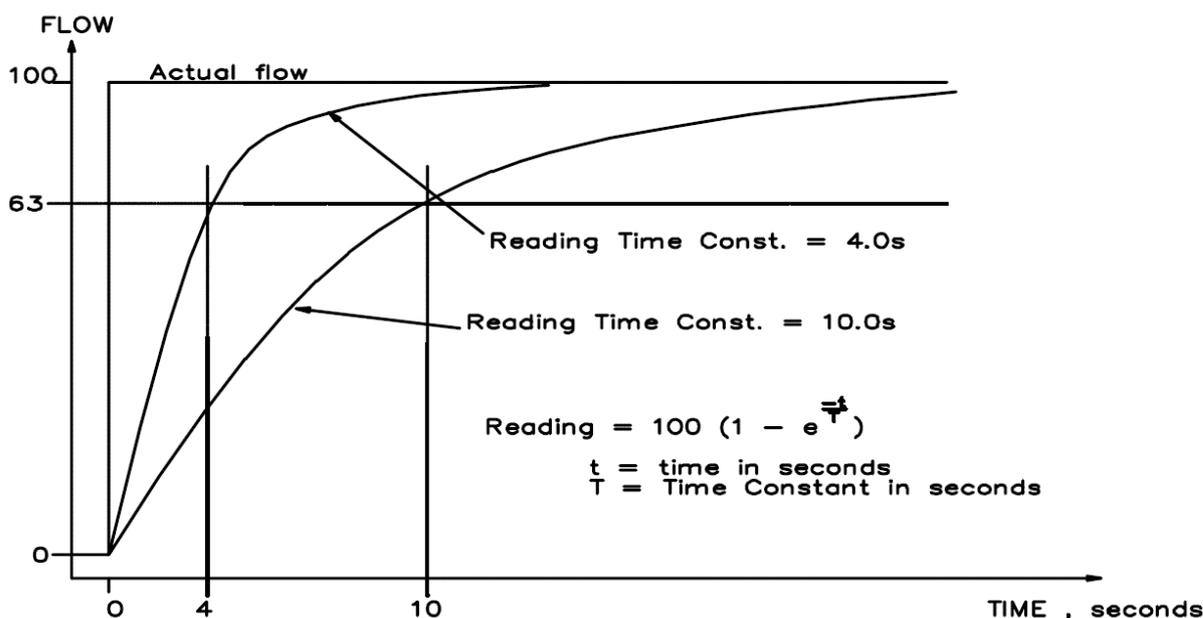
Fig. 1. Typical response of Meter #2 for varying time constants and a rapid change in flow. Image copied from Krohne's Installation and Operating Handbook for the OPTIMASS series of mass flowmeters and 050/051 converters.

Annex 4. Data of the stability tests

KC Set Water 1 Meter 1 upstream Meter 2 downstream

1 May 2013		13 January 2014		24 February 2015			
Ref. flow rate [kg/min]	Error mtr 1 mass [%]	Ref. flow rate [kg/min]	Error mtr 1 mass [%]	Ref. flow rate [kg/min]	Error mtr 1 mass [%]	Max Δ Error mtr 1 [%]	u drift WGFF [%]
20.06	-0.013	19.96	-0.017	19.93	-0.008	0.010	0.003
40.09	-0.007	39.95	-0.003	40.04	-0.003	0.004	0.001
60.08	-0.028	59.99	-0.022	59.98	-0.020	0.009	0.003
49.97	-0.013	49.85	-0.007	50.00	-0.007	0.007	0.002
30.12	-0.002	30.09	0.000	29.84	0.001	0.003	0.001
9.95	-0.015	10.06	-0.030	10.00	-0.015	0.015	0.004
						Average u	0.003

KC Set Water Meter 2 upstream Meter 1 downstream

2 May 2013		14 January 2014		24 February 2015			
Ref. flow rate [kg/min]	Error mtr 1 mass [%]	Ref. flow rate [kg/min]	Error mtr 1 mass [%]	Ref. flow rate [kg/min]	Error mtr 1 mass [%]	Max Δ Error mtr 1 [%]	u drift WGFF [%]
20.07	-0.010	20.04	-0.018	20.02	-0.006	0.011	0.003
40.00	-0.003	39.96	-0.004	40.00	-0.002	0.002	0.000
59.98	-0.019	59.93	-0.019	59.97	-0.014	0.005	0.001
50.10	-0.007	50.04	-0.007	49.80	-0.003	0.005	0.001
29.95	-0.001	30.12	0.000	30.01	0.005	0.006	0.002
10.05	-0.013	10.02	-0.030	9.99	-0.016	0.017	0.005
						Average u	0.003

KC Set Water Meter 1 upstream Meter 2 downstream

1 May 2013		13 January 2014		24 February 2015			
Ref. flow rate [kg/min]	Error mtr 2 mass [%]	Ref. flow rate [kg/min]	Error mtr 2 mass [%]	Ref. flow rate [kg/min]	Error mtr 2 mass [%]	Max Δ Error mtr 2 [%]	u drift WGFF [%]
20.06	-0.013	19.96	-0.002	19.93	-0.019	0.017	0.005
40.09	0.005	39.95	-0.007	40.04	0.005	0.013	0.004
60.08	0.001	59.99	-0.002	59.98	-0.008	0.009	0.003
49.97	0.007	49.85	0.000	50.00	-0.009	0.015	0.004
30.12	-0.002	30.09	-0.009	29.84	-0.018	0.016	0.005
9.95	-0.042	10.06	-0.045	10.00	-0.026	0.019	0.005
						Average u	0.005

KC Set Water Meter 2 upstream Meter 1 downstream

2 May 2013		14 January 2014		24 February 2015			
Ref. flow rate [kg/min]	Error mtr 2 mass [%]	Ref. flow rate [kg/min]	Error mtr 2 mass [%]	Ref. flow rate [kg/min]	Error mtr 2 mass [%]	Max Δ Error mtr 2 [%]	u drift WGFF [%]
20.07	-0.008	20.04	-0.021	20.02	-0.013	0.013	0.004
40.00	0.007	39.96	-0.013	40.00	-0.005	0.021	0.006
59.98	0.008	59.93	-0.009	59.97	-0.001	0.016	0.005
50.10	0.010	50.04	-0.004	49.80	-0.012	0.021	0.006
29.95	-0.004	30.12	-0.010	30.01	-0.020	0.016	0.004
10.05	-0.046	10.02	-0.043	9.99	-0.019	0.027	0.008
						Average u	0.006

Annex 5. Schedule

NMI/DI	Country	Latest arrival [dd-mm-yyyy]	Dispatch before [dd-mm-yyyy]	Number of weeks at NMI	ATA Carnet
VSL[(1)]	The Netherlands	--	19-08-2013	--	No
TUV NEL	United Kingdom	02-09-2013	30-09-2014	4	No
BEV	Austria	14-10-2013	11-11-2013	4	No
PTB	Germany	25-11-2013	23-12-2013	4	No
VSL[(2)]	The Netherlands	06-01-2014	20-01-2014	2	No
NIST	United States of America	17-02-2014	17-03-2014	4	Yes
NMIJ	Japan	26-05-2014	16-06-2014	3	Yes
KRISS	Korea	30-06-2014	21-07-2014	3	Yes
CMS	Chinese Taipei	04-08-2014	25-08-2014	4	Yes
VSL[(3)]	The Netherlands	29-09-2014	--	--	No

[4)] First measurements at VSL that will be the results presented for the KCRV values

[5)] Check measurements at VSL before IKS-SKID is send outside Europe water measurements only

[6)] Final measurements at VSL

Annex 6.   Test facilities

Austria (Euramet)	BEV BEV - Bundesamt für Eich- und Vermessungswesen Arltgasse 35 1160 Vienna Austria
Chinese Taipei (APMP)	CMS Center for Thermometry and Fluid Flow Metrology, Division of Physical Metrology 30 Ta Hsueh Road, Hsinchu 30080 Chinese Taipei
Germany (Euramet)	**PTB** Physikalisch-Technische Bundesanstalt (PTB) Bundesallee 100 38116 Braunschweig Germany
Japan (APMP)	NMIJ/AIST National Metrology Institute of Japan National Institute of Advanced Industrial Science and Technology AIST Liquid Flow Standards Section, Fluid Flow Divsion North site 14, 1497-1 Teragu, Tsukuba, Ibaraki, 300- 4201 Japan
Korea (APMP)	Korea Research Institute of Standards and Science (KRISS) Center for Thermometry and Fluid Flow Metrology, Division of Physical Metrology Korea Research Institute of Standards and Science 205-dong, Gajeong-ro 267, Yuseong-gu, Daejeon (ZIP 34113) South Korea
The Netherlands [pilot] (Euramet)	VSL B.V. VSL B.V. Water Flow Hugo de Grootplein 1 3314 EG Dordrecht The Netherlands
UK (Euramet)	TUV NEL TUV SUD NEL Ltd Receiving Stores James Young Building East Kilbride Glasgow G75 0QF United Kingdom
USA NIST	NIST National Institute of Standards and Technology 100 Bureau Drive, Mail Stop 8361 Gaithersburg, MD 20899 USA
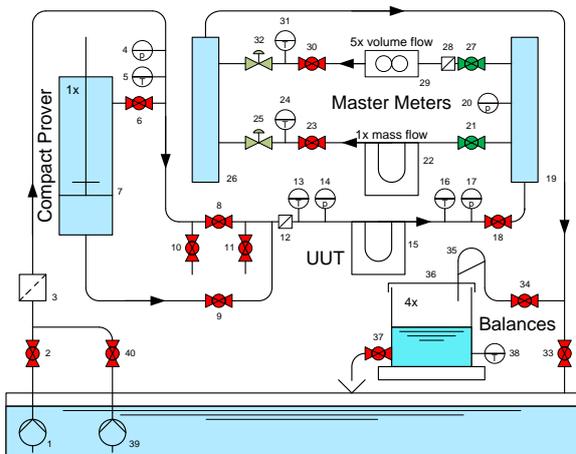
VSL the Netherlands	VSL installation has several possibilities to determine the reference flow. Reference can be a weigh scale, a small volume prover or a master meter. For the Key Comparison the procedure with the lowest uncertainty has been chosen: the weigh scale. Results with the weigh scale are always compared with results from master meters. The Standing Start Finish method is used.
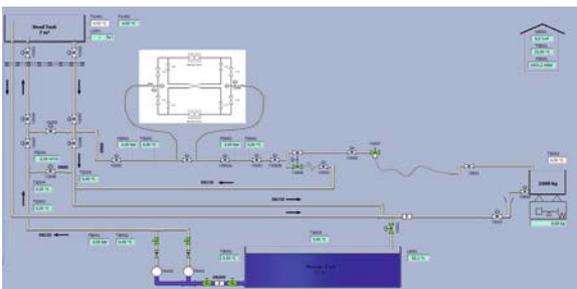
PTB Germany	The scientific work on the development of fluid-independent transfer standards requires experimental investigations and verifications with liquids other than water. In particular for this purpose, the PTB's petroleum test rig has been developed. This test rig works volumetrically as well as gravimetrically. Four volume standards with capacities of 5000 l, 1000 l, 200 l and 100 l are used as primary standards for the volumetric measurements whereat the filling level of the tanks is effected by means of an automatic height measurement system on magnetostrictive basis. The gravimetric part of the test rig consists of an electronic balance with a capacity of 1000 kg and a resolution of 0.05 kg. The reproducible flowrate range lies between 0.6 m³/h and 120 m³/h. The petroleum test rig can be operated both in flying and in standing start-stop operating modes. The flow generating may be effected by an elevated tank or in direct operation mode via a pump. At the moment, the test liquid is white spirit with a dynamic viscosity of 0.8 mPa·s and a density of 0.78 g/cm³. The confirmed (by international comparisons) extended uncertainty of measurement is 0.05%.
	The pictures show the tank on the weighing instrument and a simplified P&ID of the test set up at the PTB facility.
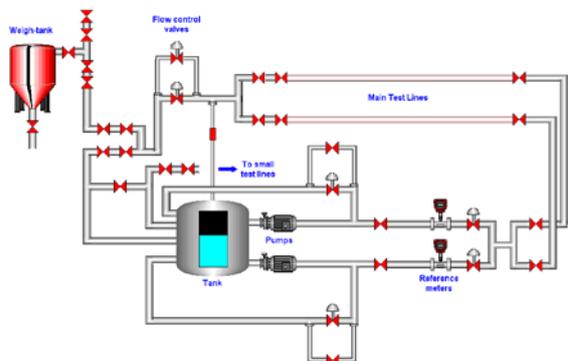
TUV-NEL United Kingdom	The UK National Standards Oil Flow Facility, located at NEL in East Kilbride, Scotland, consists of two separate flow circuits (A and B), each with a high capacity and a low capacity flow line. These can accommodate nominal pipe sizes from 0.5 to 8 inches, and can operate at line pressures up to 10 bar. Test fluids can be delivered at flowrates up to 720 m3/hr.
	The figure at the left provides a schematic diagram of one of the flow circuits. The oil for each circuit is drawn from a 30 m^3 supply tank into the suction stream of the main pumps, from where it is discharged to the test lines. A conditioning circuit, linked to each tank, maintains the oil temperature to within ±1 ºC of a pre-selected value (itself set in the range 5 – 60 ºC). Each test line can accommodate up to 30 m of horizontal straight lengths or alternative configurations as required. At the outlet of each test section, a manifold directs the fluid back to the storage tank or to one of the calibrated weigh tanks. Line temperature and pressure are monitored both upstream and downstream of the test section.
	The flow lines share a common primary standard weighbridge system consisting of four separate weightanks of 150, 600, 1500 and 6000 kg capacity. The facility is fully traceable to National Standards and is accredited by the United Kingdom Accreditation Service (UKAS).
	For 'primary' calibrations, a gravimetric 'standing-start-and-finish' method is used to determine the quantity of fluid (volume or mass) which has passed through the flowmeter under test and into the selected weightank.
	The gravimetric weightanks constitute the primary reference standard of the NEL oil flow facility. Using the above technique, the overall uncertainty in the reference flowrate, expressed at the 95% confidence level is approximately ±0.03 % (k = 2).
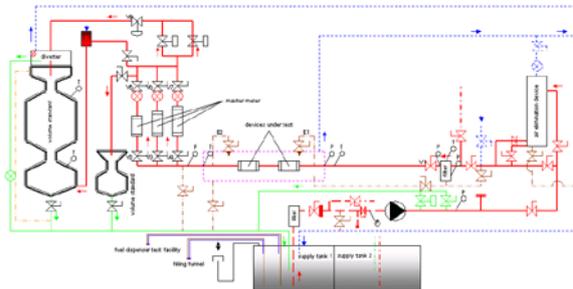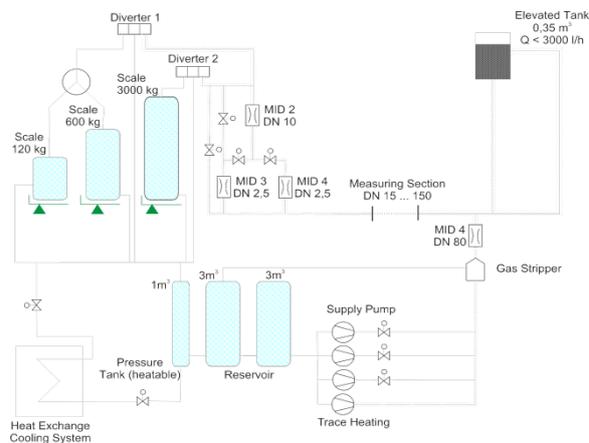
BEV Austria	The water test rig at the BEV is the primary standard in Austria for water flow – since it is the realization with the highest precision. The main responsibilities are to carry out type approval tests and calibrations of water meters and heat meters and conduct general scientific analysis in flow sensors.

The test rig is suitable for flow-, volume-, and energy measurements in a range form 6 l/h up to 180 000 l/h under temperature conditions between 2,5°C and 90°C in the open mode. Three different scales with a metering capacity up to 3 000 kg are the reference standards supplemented by four magnetic inductive master meters.

The BEV has 2 identical test benches for hydrocarbons. One for low viscosity fluids similar to gasoline (Exxsol D60, 2 mm^2/s) and the other for higher viscosity fluids similar to diesel oil (Exxsol D120, 6,6 mm^2/s). The flow rate Q is settable from 0,1 l/min (operation with standard capacity tank) respectively up to 1500 l/min (operation with master meter). The pressure range is 0,5 – 6 bar (settable) and the temperature range which is not settable is 14 – 20 °C. The test benches are automatically controlled (preset quantity, flow rate, pressure) by a storage programmed control (SPC).

Path of the liquid flow: The liquid is sucked in from the underground supply tank by a frequency controlled pump. Then it is pumped over a gas separator to the devices under test. Furthermore the liquid is pumped over the selected master meter then either to the fixed / mobile standard, or over the diverter either into the fixed standards tanks or back to the supply tank. Test benches are used for type approval of meters / measuring systems (e.g. fuel dispensers), calibration of meters, 1st stage of a 2-stage verification of a measuring system and test of air elimination devices by metered addition of air.

NIST USA	The facility is a temperature controlled enclosure that uses piston provers for volume and mass flow calibrations

The piston prover used in the comparison is the 2.5 L/s Liquid Flow Standard

5% propylene glycol and water mixture is the working fluid.

The prover is like a syringe pump that is automated. It is bi-directional, meaning it has a piston inside a shaft that pushes fluid in one direction through the MUT, then comes to a stop and changes directions and pushes fluid through the MUT again while moving in the opposite direction. The valving is positioned such that the fluid is moving in the same direction through the MUT regardless of the direction the piston is moving. Each time it switches directions, the piston ramps up in speed to reach the flow set point. Once a steady flow (via steady velocity of the piston) is achieved, it starts counting marks on piece of glass along the shaft (pulses) as it travels until it reaches the end of the stroke and it stops counting. The prover has been calibrated to know the number of pulses per volume of fluid by the piston. The pulses/time from the prover are compared to the pulses/time from the MUT. The data acquisition software collects data from the MUT and the prover when steady flow is achieved and it initiates counting glass tick marks over a time period along with pulses over the same time period from the MUT.

IKS-SKID

IKS-SKID Valve Assembly

Reservoir tank

Motor driven piston

Encoder

Etched glass rule

NMIJ Japan	The medium hydrocarbon flow calibration facility employs calibration principles of the static and gravimetric method with flying start and finish based on ISO4185:1980(OLI 03). Specifically working liquid (kerosene / light oil / spindle oil) passing through flowmeter (MUT) is corrected to weighing tank installed on weighing scale via diverter for a predetermined time, and mass of working liquid measured with the weighing scale is divided with the collection time to be converted to standard mass flow rate. Then the standard mass flow rate is divided with measured density to be converted to standard volumetric flow rate. The MUT is to be calibrated by comparing its readings with the standard mass flow rate or with the standard volumetric flow rate. By using another pump, the working liquid is fed to a test line. After passing a flow meter under test, working liquid flows into a diverter via one of three flow control lines (40 A lines, 15 A lines, 6 mm line) according to a flow rate. A weighing tank system is one set and is shared to all the flow control lines. The amount of the maximum collection weight is 32 kg.

CMS Chinese Taipei	Water
	The calibration method for water flowmeters is static weighing coupled with the flying-start-and-finish mode. The system uses a diverter to manipulate flow along its bypass loop or towards the weighing tank. Then the quantity of water accumulated in the tank is compared with that measured by the meter under test. Both quantity-type and rate-type flowmeters could be calibrated by the system. The output of flowmeters could be volume, mass, volume flowrate, mass flowrate, or velocity. The parameter used to express the calibration result could be relative error, error, meter factor, K-factor, converting factor for electrical current to flow. The measurement range is defined as follows: Temperature: 10 °C to 45 °C; Pressure: 0 kPa to 500 kPa (gauge); Accumulated volume: 0.02 m3 to 0.6 m3 ; Accumulated mass: 20 kg to 550 kg ; Volume flow rate: 0.3 m3/h to 33 m3/h ; Mass flow rate: 300 kg/h to 33000 kg/h ; Velocity: 0.1 m/s to 10 m/s.
	Hydrocarbon 1 The transfer standard (TS) is calibrated by the low viscosity oil flow calibration system. A solvent oil of Exxon D110 is used as the working fluid. Meanwhile, the standing-start-and-finish mode with static weighing method is used to calibrate flowmeters. The low viscosity oil flow facility is a circulating system. The working fluid is pumped from a reservoir and flows through the meter under test, a flowrate control valve, an on-off valve, and a constant level device. Then the liquid falls freely into the weightank. After being weighed, the liquid in the weightank flows back to the main reservoir by opening a valve on the outlet pipe of the weightank.

KRISS Korea	Water Flow
 Schematic diagram of water flow standard system Water flow standard system at KRISS Heavy oil flow standard system at KRISS	A water flow standard system (WFSS) is a gravimetric flow measurement system. Four weighing tanks, of which capacities are 100 kg, 1 t, 5 t, and 25 t, are located to measure water flows ranging from 0.5 m^3/h to 2000 m^3/h. Flow diverters are located beside the weighing tanks to determine elapsed time to start and finish flow measurement. The WFSS is operating with the flying-start-and-finish method. Constant level head tank is located upstream of pipelines to generate constant water flows with pressure up to 200 kPa (gauge). Operating conditions of the WFSS are as follows: - temperature: 10 °C ~ 40 °C - pressure: up to 200 kPa (with head tank), up to 300 kPa (with direct pumping) - flow range: 0.5 m^3/h ~ 2000 m^3/h Hydrocarbon Flow A heavy oil flow standard system (HOFSS) is another gravimetric flow measurement system. A weighing tank, of which capacity is up to 500 kg, is located to measure heavy oil flows ranging from 1 m^3/h to 25 m^3/h. A flow diverter is located beside the weighing tank to determine elapsed time to start and finish flow measurement. The HOFSS is operating with the flying-start-and-finish method. Direct pumping can generate pressure in the pipeline up to 300 kPa (gauge). Operating conditions of the HOFSS are as follows: - temperature: 10 °C ~ 40 °C - pressure: up to 300 kPa (with direct pumping) - flow range: 1 m^3/h ~ 25 m^3/h

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

Annex 7.　　Calibration data from the different labs

Tests with water

VSL

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
6.01	13:33	30.1	45.521	45.524	17.31	17.35	3.83	3.13					30.11	45.5227	999.22	-0.004	0.002
6.02	13:39	30.1	46.218	46.219	17.35	17.42	3.83	3.13					30.12	46.2190	999.22	-0.001	0.000
6.03	13:45	30.1	45.662	45.661	17.37	17.44	3.83	3.13					30.08	45.6625	999.21	-0.001	-0.004
6.04	13:51	30.1	45.879	45.878	17.40	17.45	3.83	3.13					30.13	45.8799	999.21	-0.003	-0.005
6.05	13:57	30.2	46.360	46.360	17.41	17.46	3.83	3.13					30.15	46.3603	999.21	-0.001	-0.001
reversed order of the transfer standards																	
6.01	12:56	29.9	45.994	45.992	17.76	17.79	3.67	2.99					29.92	45.9948	999.14	-0.002	-0.007
6.02	13:03	30.0	45.948	45.949	17.79	17.82	3.67	2.99					30.03	45.9481	999.13	-0.001	0.002
6.03	13:09	29.9	46.120	46.118	17.80	17.85	3.67	2.99					29.92	46.1197	999.13	0.000	-0.003
6.04	13:20	29.9	46.484	46.482	17.78	17.90	3.67	2.99					29.87	46.4848	999.13	-0.001	-0.006
6.05	13:26	30.0	46.061	46.058	17.80	17.87	3.67	2.99					30.02	46.0610	999.13	0.001	-0.007

KRISS

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
6.01	19:36	30.2	30.251	30.250	14.55	14.60	2.96	2.25	14.44	14.40	2.97	2.91	30.18	30.2516	999.30	-0.002	-0.005
6.02	19:39	30.2	45.348	45.344	14.57	14.62	2.95	2.27	14.45	14.40	2.96	2.90	30.20	45.3488	999.30	-0.002	-0.011
6.03	19:42	30.2	45.356	45.354	14.57	14.61	2.96	2.26	14.46	14.39	2.96	2.90	30.20	45.3558	999.30	0.000	-0.004
6.04	19:45	30.2	45.341	45.344	14.57	14.62	2.95	2.26	14.45	14.40	2.97	2.91	30.20	45.3428	999.30	-0.004	0.003
6.05	19:48	30.2	45.400	45.394	14.56	14.61	2.94	2.25	14.44	14.40	2.97	2.90	30.18	45.3999	999.30	0.000	-0.013
reversed order of the transfer standards																	
6.01	12:54	30.0	45.377	45.381	14.61	14.67	2.96	2.27	14.34	14.45	2.98	2.92	30.00	45.3813	999.30	-0.009	-0.001
6.02	12:58	30.0	45.258	45.254	14.60	14.70	2.97	2.27	14.37	14.45	2.98	2.92	30.01	45.2591	999.30	-0.002	-0.011
6.03	13:00	30.0	45.382	45.374	14.64	14.69	2.97	2.28	14.37	14.46	2.98	2.91	30.01	45.3833	999.30	-0.003	-0.020
6.04	13:04	30.0	45.443	45.442	14.65	14.69	2.96	2.28	14.39	14.47	2.98	2.92	30.01	45.4433	999.30	-0.001	-0.003
6.05	13:07	30.0	45.215	45.220	14.66	14.70	2.97	2.28	14.40	14.47	2.99	2.95	30.01	45.2151	999.30	0.000	0.011

CMS

30 kg/min

Test no.	Start time	Meter 1 - MM upstream Flow rate	Meter 1 - MM upstream Mass total	Meter 2 - Kr. Mass total	IKS-SKID T Upstream	IKS-SKID T Downstream	IKS-SKID P Upstream	IKS-SKID P Downstream	Facility T Upstream	Facility T Downstream	Facility P Upstream	Facility P Downstream	Calc. Ref. flow rate	Calc. Reference mass	Calc. Density Upstream	Meter 1 MM Error mass	Meter 2 Kr Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa5(g)]	[bar(g)][Pa5(g)]	[°C]	[°C]	[bar(g)][Pa5(g)]	[bar(g)][Pa5(g)]	[kg/min]	[kg]	[kg/m3]	[%]	[%]
6.01	11:15	30.2	551.398	551.114	25.24	25.33	1.53	0.85	25.11	25.52	1.73	0.26	30.22	551.4000	997.02	-0.001	-0.052
6.02	11:38	30.2	551.230	550.956	25.11	25.20	1.53	0.86	24.87	25.23	1.71	0.25	30.20	551.2400	997.09	-0.002	-0.052
6.03	12:00	30.2	551.085	550.817	24.93	25.04	1.53	0.86	24.71	25.06	1.71	0.26	30.19	551.0900	997.13	-0.001	-0.050
6.04	12:22	30.2	551.170	550.935	24.80	24.90	1.53	0.86	24.58	24.92	1.70	0.26	30.19	551.1900	997.17	-0.004	-0.047
6.05	12:44	30.2	551.107	550.861	24.73	24.81	1.53	0.86	24.50	24.84	1.71	0.26	30.18	551.1400	997.19	-0.006	-0.051
reversed order of the transfer standards																	
6.01	14:12	30.0	551.144	550.880	24.38	24.48	1.53	0.86	24.14	24.51	1.70	0.27	29.93	551.1700	997.27	-0.005	-0.053
6.02	14:33	29.9	551.028	550.778	24.26	24.35	1.53	0.86	24.09	24.35	1.70	0.27	29.90	551.0500	997.30	-0.004	-0.050
6.03	14:53	29.9	551.048	550.785	24.39	24.48	1.53	0.86	24.22	24.46	1.70	0.27	29.90	551.0700	997.27	-0.004	-0.052
6.04	15:13	29.9	551.185	550.913	24.49	24.57	1.53	0.86	24.32	24.61	1.70	0.27	29.90	551.2000	997.24	-0.003	-0.053
6.05	15:34	29.9	551.139	550.861	24.54	24.63	1.53	0.86	24.41	24.69	1.70	0.27	29.90	551.1500	997.21	-0.003	-0.053

BEV

30 kg/min

Test no.	Start time	Meter 1 - MM upstream Flow rate	Meter 1 - MM upstream Mass total	Meter 2 - Kr. Mass total	IKS-SKID T Upstream	IKS-SKID T Downstream	IKS-SKID P Upstream	IKS-SKID P Downstream	Facility T Upstream	Facility T Downstream	Facility P Upstream	Facility P Downstream	Calc. Ref. flow rate	Calc. Reference mass	Calc. Density Upstream	Meter 1 MM Error mass	Meter 2 Kr Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa5(g)]	[bar(g)][Pa5(g)]	[°C]	[°C]	[bar(g)][Pa5(g)]	[bar(g)][Pa5(g)]	[kg/min]	[kg]	[kg/m3]	[%]	[%]
6.01	20:40	30.7	100.001	99.981	19.59	20.28	1.95	1.21	19.59	20.28	1.95	1.21	30.72	100.0000	999.53	0.001	-0.019
6.02	20:50	30.7	99.994	99.964	19.61	20.26	1.94	1.21	19.61	20.26	1.94	1.21	30.71	100.0000	999.53	-0.006	-0.036
6.03	21:02	30.7	100.003	99.973	19.71	20.37	1.96	1.22	19.71	20.37	1.96	1.22	30.73	100.0000	999.53	0.003	-0.027
6.04	21:13	30.7	100.007	99.977	19.68	20.37	1.97	1.24	19.68	20.37	1.97	1.24	30.74	100.0000	999.53	0.007	-0.023
6.05	21:24	30.8	99.989	99.959	19.67	20.37	1.97	1.23	19.67	20.37	1.97	1.23	30.77	100.0000	999.53	-0.011	-0.041
reversed order of the transfer standards																	
6.01	23:52	29.9	100.014	99.952	19.52	20.21	2.01	1.30	19.52	20.21	2.01	1.30	29.92	100.0000	999.54	0.014	-0.048
6.02	00:06	30.0	99.986	99.990	19.65	20.29	2.01	1.30	19.65	20.29	2.01	1.30	29.95	100.0000	999.53	-0.014	-0.010
6.03	00:20	29.9	100.009	99.966	19.68	20.33	2.02	1.32	19.68	20.33	2.02	1.32	29.92	100.0000	999.54	0.009	-0.034
6.04	00:33	29.9	99.995	99.988	19.66	20.34	1.99	1.28	19.66	20.34	1.99	1.28	29.93	100.0000	999.53	-0.005	-0.012
6.05	00:47	29.9	99.988	99.989	19.69	20.34	2.01	1.30	19.69	20.34	2.01	1.30	29.91	100.0000	999.53	-0.012	-0.011

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

NEL

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
30	13:34	30.3	n/a	n/a	19.67	19.71	2.67	1.99	19.67	19.59	2.62	1.86	30.28	230.5642	998.46	-0.006	-0.031
31	13:46	30.3	n/a	n/a	19.72	19.77	2.67	1.99	19.73	19.60	2.62	1.86	30.28	230.5882	998.45	-0.002	-0.027
32	13:58	30.3	n/a	n/a	19.73	19.77	2.67	1.99	19.74	19.61	2.62	1.86	30.29	230.5342	998.45	-0.002	-0.025
33	14:12	30.3	n/a	n/a	19.70	19.75	2.67	1.99	19.71	19.61	2.62	1.86	30.31	230.5323	998.45	0.009	-0.018
34	14:25	30.3	n/a	n/a	19.65	19.71	2.67	1.98	19.65	19.57	2.62	1.86	30.32	230.5561	998.46	-0.001	-0.028
reversed order of the transfer standards																	
32	13:27	30.2	n/a	n/a	19.63	19.69	2.59	1.90	19.62	19.63	2.53	1.78	30.22	230.4892	998.46	0.004	-0.026
33	13:39	30.2	n/a	n/a	19.61	19.68	2.59	1.91	19.48	19.62	2.53	1.78	30.19	230.4952	998.47	0.005	-0.024
34	13:50	30.2	n/a	n/a	19.57	19.62	2.59	1.90	19.54	19.59	2.53	1.78	30.16	230.5171	998.47	0.002	-0.030
35	14:03	30.1	n/a	n/a	19.61	19.68	2.59	1.91	19.59	19.67	2.53	1.78	30.13	230.7552	998.45	0.002	-0.028
36	14:28	30.1	n/a	n/a	19.62	19.67	2.59	1.91	19.60	19.67	2.53	1.78	30.09	230.3928	998.45	0.002	-0.026

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

VSL

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
3.01	10:23	40.0	61.312	61.318	17.17	17.25	3.76	2.60					40.04	61.3158	999.25	-0.006	0.004
3.02	10:26	40.1	62.329	62.338	17.26	17.32	3.76	2.60					40.08	62.3326	999.23	-0.006	0.009
3.03	10:32	40.2	61.619	61.627	17.27	17.35	3.76	2.60					40.24	61.6241	999.23	-0.008	0.005
3.04	10:39	40.0	61.698	61.706	17.30	17.35	3.76	2.60					40.02	61.7007	999.22	-0.004	0.008
3.05	10:46	40.1	59.403	59.413	17.32	17.37	3.76	2.60					40.10	59.4069	999.22	-0.007	0.010
3.06	10:52	40.1	60.776	60.785	17.36	17.41	3.76	2.60					40.06	60.7813	999.21	-0.009	0.005
3.07	10:59	40.0	60.742	60.748	17.36	17.43	3.76	2.60					40.04	60.7472	999.21	-0.008	0.001
3.08	11:06	40.1	62.324	62.329	17.36	17.44	3.76	2.60					40.13	62.3283	999.21	-0.007	0.001
3.09	11:13	40.1	61.064	61.070	17.41	17.48	3.76	2.60					40.06	61.0685	999.20	-0.007	0.002
3.10	11:20	40.1	60.960	60.967	17.44	17.50	3.76	2.60					40.13	60.9645	999.20	-0.007	0.005
reversed order of the transfer standards																	
3.01	09:33	39.7	61.382	61.390	17.18	17.25	3.59	2.45					39.73	61.3843	999.24	-0.003	0.009
3.02	09:43	40.5	61.467	61.474	17.25	17.31	3.59	2.45					40.53	61.4687	999.22	-0.003	0.008
3.03	09:47	39.9	60.847	60.855	17.29	17.35	3.59	2.45					39.91	60.8498	999.22	-0.005	0.009
3.04	09:54	39.9	61.223	61.231	17.27	17.36	3.59	2.45					39.90	61.2249	999.22	-0.003	0.009
3.05	10:01	40.1	61.342	61.347	17.35	17.40	3.59	2.45					40.07	61.3430	999.21	-0.002	0.007
3.06	10:07	39.9	61.051	61.057	17.33	17.39	3.59	2.45					39.90	61.0530	999.21	-0.004	0.006
3.07	10:14	40.0	60.630	60.638	17.38	17.43	3.59	2.45					40.02	60.6320	999.20	-0.003	0.009
3.08	10:21	40.1	61.890	61.894	17.41	17.49	3.59	2.45					40.14	61.8912	999.19	-0.002	0.005
3.09	10:28	39.9	61.142	61.149	17.44	17.51	3.59	2.45					39.93	61.1445	999.19	-0.004	0.007
3.10	10:34	39.9	73.211	73.216	17.48	17.56	3.59	2.45					39.87	73.2135	999.18	-0.003	0.004

KRISS

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa⁵(g)]	[bar(g)][Pa⁵(g)]	[°C]	[°C]	[bar(g)][Pa⁵(g)]	[bar(g)][Pa⁵(g)]	[kg/min]	[kg]	[kg/m³]	[%]	[%]
3.01	18:13	40.0	60.641	60.644	14.42	14.47	2.88	1.71	14.34	14.23	2.96	2.84	40.02	60.6462	999.32	-0.009	-0.004
3.02	18:17	40.0	60.287	60.282	14.40	14.49	2.88	1.71	14.36	14.25	2.96	2.83	40.02	60.2878	999.31	-0.001	-0.010
3.03	18:20	40.0	60.731	60.733	14.41	14.48	2.88	1.71	14.37	14.26	2.94	2.83	40.03	60.7333	999.31	-0.004	0.000
3.04	18:24	40.1	60.156	60.159	14.44	14.48	2.88	1.70	14.37	14.24	2.95	2.83	40.13	60.1587	999.31	-0.004	0.000
3.05	18:27	40.1	60.591	60.596	14.43	14.46	2.88	1.70	14.38	14.26	2.95	2.83	40.07	60.5952	999.31	-0.007	0.001
3.06	18:32	40.1	60.452	60.452	14.41	14.49	2.88	1.70	14.41	14.26	2.95	2.83	40.10	60.4560	999.31	-0.007	-0.007
3.07	18:35	40.1	60.300	60.309	14.44	14.51	2.88	1.70	14.42	14.26	2.94	2.83	40.10	60.3059	999.31	-0.010	0.005
3.08	18:40	40.1	60.511	60.510	14.44	14.52	2.87	1.70	14.40	14.25	2.95	2.84	40.06	60.5171	999.31	-0.010	-0.012
3.09	18:43	40.1	60.534	60.530	14.43	14.49	2.88	1.70	14.41	14.27	2.95	2.83	40.08	60.5381	999.31	-0.007	-0.013
3.10	18:47	40.1	60.741	60.738	14.44	14.51	2.88	1.70	14.42	14.28	2.94	2.83	40.10	60.7443	999.31	-0.005	-0.010
reversed order of the transfer standards																	
3.01	11:37	39.9	60.211	60.210	14.40	14.45	2.87	1.71	14.28	14.21	2.94	2.82	39.88	60.2146	999.32	-0.006	-0.008
3.02	11:42	39.9	60.593	60.596	14.40	14.46	2.88	1.72	14.29	14.22	2.95	2.82	39.90	60.5969	999.32	-0.006	-0.001
3.03	11:47	39.9	60.344	60.345	14.38	14.46	2.87	1.71	14.30	14.21	2.94	2.83	39.88	60.3486	999.32	-0.008	-0.006
3.04	11:50	39.9	60.357	60.356	14.38	14.46	2.87	1.71	14.32	14.22	2.95	2.83	39.87	60.3586	999.32	-0.003	-0.004
3.05	11:53	39.9	60.173	60.177	14.41	14.45	2.88	1.72	14.33	14.23	2.95	2.83	39.92	60.1744	999.32	-0.002	0.004
3.06	11:57	39.9	60.260	60.249	14.40	14.48	2.88	1.72	14.35	14.24	2.94	2.83	39.92	60.2615	999.32	-0.002	-0.021
3.07	12:00	39.9	60.520	60.508	14.41	14.48	2.88	1.72	14.34	14.25	2.94	2.83	39.88	60.5227	999.32	-0.004	-0.024
3.08	12:03	39.9	60.278	60.272	14.44	14.50	2.88	1.72	14.30	14.27	2.94	2.83	39.89	60.2785	999.32	-0.001	-0.011
3.09	12:07	39.9	60.321	60.313	14.44	14.52	2.88	1.71	14.34	14.27	2.95	2.83	39.90	60.3235	999.31	-0.004	-0.017
3.10	12:09	39.9	60.779	60.777	14.44	14.49	2.88	1.72	14.34	14.29	2.95	2.84	39.90	60.7800	999.31	-0.002	-0.005

CMS

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
3.01	15:55	40.0	551.125	550.920	24.51	24.59	1.52	0.39	24.20	24.51	1.70	0.27	40.04	551.1700	997.26	-0.008	-0.045
3.02	16:13	40.0	551.631	551.432	24.56	24.66	1.52	0.39	24.48	24.68	1.70	0.27	40.05	551.6900	997.21	-0.011	-0.047
3.03	16:31	40.0	551.538	551.359	24.71	24.80	1.52	0.39	24.67	24.88	1.70	0.27	40.06	551.5900	997.16	-0.010	-0.042
3.04	16:47	40.0	551.509	551.311	24.61	24.69	1.52	0.39	24.39	24.66	1.69	0.27	40.05	551.5600	997.22	-0.009	-0.045
3.05	17:07	40.0	551.150	550.959	24.44	24.52	1.52	0.39	24.25	24.49	1.69	0.27	40.04	551.2100	997.26	-0.011	-0.046
3.06	17:22	40.0	551.241	551.034	24.57	24.63	1.52	0.39	24.47	24.67	1.70	0.27	40.05	551.2900	997.21	-0.009	-0.047
3.07	20:15	39.8	551.871	551.630	24.92	25.00	1.52	0.39	24.56	24.99	1.69	0.28	39.83	551.9000	997.16	-0.006	-0.049
3.08	20:34	39.8	551.233	550.995	24.67	24.72	1.52	0.39	24.37	24.71	1.69	0.28	39.82	551.2600	997.22	-0.005	-0.048
3.09	20:51	39.8	551.417	551.147	24.88	24.95	1.52	0.39	24.76	25.07	1.70	0.28	39.84	551.4200	997.12	-0.001	-0.050
3.10	21:10	39.8	551.714	551.434	24.97	25.06	1.52	0.39	24.83	25.14	1.70	0.28	39.84	551.7200	997.11	-0.002	-0.052
reversed order of the transfer standards																	
3.01	12:00	40.1	551.302	551.074	25.07	25.15	1.52	0.40	24.78	25.06	1.70	0.29	40.10	551.3500	997.12	-0.009	-0.050
3.02	12:17	40.1	551.208	551.008	24.81	24.87	1.53	0.40	24.61	24.91	1.70	0.29	40.10	551.2400	997.16	-0.006	-0.042
3.03	12:39	40.1	551.946	551.732	24.60	24.69	1.52	0.39	24.41	24.75	1.70	0.29	40.10	551.9900	997.21	-0.008	-0.047
3.04	12:52	40.1	551.094	550.882	24.54	24.64	1.52	0.39	24.35	24.65	1.70	0.29	40.10	551.1400	997.23	-0.009	-0.047
3.05	13:10	40.1	551.262	551.063	24.71	24.79	1.53	0.39	24.54	24.82	1.70	0.29	40.11	551.3100	997.18	-0.009	-0.045
3.06	13:27	40.1	551.544	551.333	24.86	24.93	1.53	0.39	24.67	24.95	1.70	0.29	40.12	551.5900	997.15	-0.008	-0.047
3.07	13:45	40.1	551.035	550.780	24.97	25.04	1.53	0.39	24.83	25.11	1.70	0.29	40.13	551.0800	997.11	-0.008	-0.054
3.08	14:02	40.1	551.297	551.106	24.83	24.92	1.52	0.39	24.61	25.00	1.70	0.29	40.12	551.3400	997.15	-0.008	-0.042
3.09	14:20	40.1	551.718	551.510	24.60	24.71	1.52	0.39	24.38	24.77	1.69	0.29	40.11	551.7700	997.21	-0.009	-0.047
3.10	14:36	40.1	551.229	551.012	24.62	24.72	1.52	0.39	24.43	24.77	1.71	0.29	40.11	551.2600	997.20	-0.006	-0.045

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

BEV

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
3.01	13:54	40.1	99.996	99.976	19.95	20.68	2.09	0.90	19.95	20.68	2.09	0.90	40.07	100.0000	999.53	-0.004	-0.024
3.02	14:04	40.1	99.971	99.961	19.82	20.64	2.06	0.87	19.82	20.64	2.06	0.87	40.09	100.0000	999.53	-0.029	-0.039
3.03	14:14	40.1	100.000	99.990	19.66	20.41	2.07	0.87	19.66	20.41	2.07	0.87	40.08	100.0000	999.53	0.000	-0.010
3.04	14:24	40.1	99.986	99.966	19.65	20.35	2.06	0.87	19.65	20.35	2.06	0.87	40.10	100.0000	999.53	-0.014	-0.034
3.05	14:34	40.1	99.990	99.980	19.68	20.34	2.06	0.87	19.68	20.34	2.06	0.87	40.05	100.0000	999.53	-0.010	-0.020
3.06	14:44	40.1	99.997	99.977	19.65	20.33	2.06	0.87	19.65	20.33	2.06	0.87	40.09	100.0000	999.53	-0.003	-0.023
3.07	14:54	40.1	100.001	99.991	19.67	20.34	2.06	0.87	19.67	20.34	2.06	0.87	40.07	100.0000	999.53	0.001	-0.009
3.08	15:04	40.1	99.987	99.977	19.63	20.33	2.06	0.87	19.63	20.33	2.06	0.87	40.09	100.0000	999.53	-0.013	-0.023
3.09	15:15	40.1	100.008	99.998	19.62	20.33	2.06	0.87	19.62	20.33	2.06	0.87	40.07	100.0000	999.53	0.008	-0.002
3.10	15:24	40.1	100.000	99.970	19.63	20.32	2.06	0.87	19.63	20.32	2.06	0.87	40.08	100.0000	999.52	0.000	-0.030
reversed order of the transfer standards																	
3.01	17:04	40.1	100.006	99.976	19.90	20.60	2.11	0.91	19.90	20.60	2.11	0.91	40.09	100.0000	999.53	0.006	-0.024
3.02	17:14	40.0	99.999	99.969	19.76	20.57	2.05	0.87	19.76	20.57	2.05	0.87	40.04	100.0000	999.53	-0.001	-0.031
3.03	17:25	40.1	99.990	99.980	19.64	20.36	2.06	0.86	19.64	20.36	2.06	0.86	40.05	100.0000	999.53	-0.010	-0.020
3.04	17:34	40.0	100.008	99.998	19.63	20.32	2.05	0.86	19.63	20.32	2.05	0.86	40.05	100.0000	999.53	0.008	-0.002
3.05	17:45	40.1	99.985	99.955	19.65	20.30	2.05	0.86	19.65	20.30	2.05	0.86	40.08	100.0000	999.53	-0.015	-0.045
3.06	17:55	40.1	99.996	99.966	19.60	20.30	2.05	0.86	19.60	20.30	2.05	0.86	40.09	100.0000	999.53	-0.004	-0.034
3.07	18:05	40.1	100.006	99.986	19.60	20.29	2.04	0.87	19.60	20.29	2.04	0.87	40.06	100.0000	999.54	0.006	-0.014
3.08	18:15	40.1	100.004	99.984	19.59	20.29	2.05	0.87	19.59	20.29	2.05	0.87	40.08	100.0000	999.54	0.004	-0.016
3.09	18:25	40.1	99.985	99.985	19.59	20.28	2.06	0.86	19.59	20.28	2.06	0.86	40.11	100.0000	999.54	-0.015	-0.015
3.10	18:36	40.1	99.983	99.973	19.58	20.27	2.05	0.86	19.58	20.27	2.05	0.86	40.10	100.0000	999.54	-0.017	-0.027

NEL

40 kg/min

General		Meter 1 - MM upstream	Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
10	09:44	39.3	n/a	n/a	19.46	19.51	3.10	1.99	19.44	19.25	3.05	1.86	39.34	230.4455	998.53	-0.010	-0.027
11	09:54	39.3	n/a	n/a	19.60	19.68	3.10	1.99	19.63	19.40	3.05	1.86	39.35	230.8723	998.49	-0.008	-0.025
12	10:04	39.3	n/a	n/a	19.45	19.54	3.11	1.99	19.51	19.42	3.05	1.86	39.34	230.8283	998.50	0.003	-0.014
13	10:13	39.3	n/a	n/a	19.53	19.58	3.10	1.99	19.51	19.35	3.05	1.86	39.34	230.7642	998.51	-0.006	-0.023
14	10:24	39.3	n/a	n/a	19.61	19.68	3.10	1.99	19.65	19.44	3.05	1.86	39.33	230.6640	998.49	0.006	-0.012
15	10:34	39.3	n/a	n/a	19.53	19.60	3.10	1.99	19.58	19.50	3.05	1.86	39.33	230.9204	998.49	-0.005	-0.023
16	10:44	39.3	n/a	n/a	19.52	19.58	3.10	1.99	19.52	19.41	3.05	1.86	39.33	230.8502	998.50	-0.006	-0.016
17	10:54	39.3	n/a	n/a	19.62	19.69	3.10	1.99	19.62	19.45	3.05	1.86	39.33	230.8983	998.49	-0.008	-0.020
18	11:04	39.3	n/a	n/a	19.57	19.63	3.10	1.99	19.61	19.51	3.05	1.86	39.33	230.7440	998.48	-0.005	-0.014
19	11:14	39.3	n/a	n/a	19.55	19.63	3.10	1.99	19.56	19.45	3.05	1.86	39.33	230.6197	998.49	-0.006	-0.023
reversed order of the transfer standards																	
11	08:52	39.6	n/a	n/a	18.74	18.77	3.01	1.88	18.58	18.10	2.96	1.75	39.57	230.8508	998.72	-0.003	-0.024
12	09:04	39.6	n/a	n/a	19.54	19.55	3.01	1.89	19.43	18.88	2.96	1.76	39.59	230.6504	998.56	-0.009	-0.037
13	09:15	39.6	n/a	n/a	19.86	19.90	3.00	1.88	19.88	19.48	2.95	1.76	39.60	231.0173	998.45	-0.010	-0.032
14	09:26	39.6	n/a	n/a	19.92	19.98	3.01	1.88	19.94	19.66	2.96	1.76	39.59	231.2213	998.43	-0.007	-0.034
15	09:37	39.6	n/a	n/a	19.89	19.95	3.01	1.88	19.91	19.72	2.95	1.76	39.58	230.6362	998.43	-0.004	-0.032
16	09:48	39.6	n/a	n/a	19.66	19.75	3.01	1.88	19.74	19.66	2.95	1.76	39.58	231.4791	998.45	-0.003	-0.026
17	09:59	39.6	n/a	n/a	19.43	19.55	3.00	1.88	19.50	19.48	2.95	1.76	39.56	230.7121	998.49	-0.002	-0.023
18	10:10	39.5	n/a	n/a	19.23	19.31	3.00	1.88	19.27	19.29	2.95	1.76	39.54	230.7201	998.53	-0.003	-0.025
19	10:21	39.5	n/a	n/a	19.29	19.35	3.01	1.88	19.26	19.14	2.95	1.75	39.53	230.6117	998.55	0.003	-0.019
20	10:33	39.5	n/a	n/a	19.53	19.58	3.00	1.88	19.51	19.31	2.95	1.76	39.55	230.7256	998.51	-0.007	-0.031

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

VSL

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
5.01	12:52	50.0	66.751	66.764	17.24	17.33	3.68	1.94					50.00	66.7594	999.23	-0.013	0.007
5.02	13:00	50.0	71.332	71.346	17.26	17.36	3.68	1.94					49.95	71.3420	999.23	-0.013	0.006
5.03	13:08	50.0	71.619	71.635	17.24	17.36	3.68	1.94					49.99	71.6281	999.23	-0.013	0.009
5.04	13:14	50.0	71.921	71.936	17.25	17.34	3.68	1.94					49.95	71.9309	999.23	-0.014	0.007
5.05	13:20	50.0	71.559	71.572	17.27	17.36	3.68	1.94					49.97	71.5688	999.22	-0.014	0.004
reversed order of the transfer standards																	
5.01	11:41	50.1	67.978	67.988	17.68	17.73	3.51	1.78					50.10	67.9800	999.14	-0.003	0.012
5.02	11:48	50.1	70.069	70.080	17.71	17.79	3.51	1.78					50.12	70.0740	999.14	-0.008	0.009
5.03	11:55	50.1	69.260	69.274	17.70	17.80	3.51	1.78					50.12	69.2678	999.14	-0.010	0.009
5.04	12:01	50.0	69.706	69.718	17.70	17.78	3.51	1.78					50.03	69.7131	999.14	-0.010	0.007
5.05	12:12	50.1	71.904	71.916	17.69	17.77	3.51	1.78					50.12	71.9087	999.14	-0.006	0.011

KRISS

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
5.01	19:15	50.2	91.174	91.185	14.53	14.59	2.80	1.02	14.42	14.36	2.91	2.75	50.18	91.1851	999.30	-0.012	0.000
5.02	19:19	50.2	70.321	70.330	14.52	14.61	2.78	1.02	14.45	14.37	2.91	2.75	50.24	70.3287	999.30	-0.011	0.002
5.03	19:23	50.2	70.564	70.578	14.55	14.63	2.78	1.01	14.45	14.38	2.92	2.75	50.24	70.5710	999.30	-0.010	0.010
5.04	19:26	50.2	70.704	70.711	14.55	14.62	2.79	1.02	14.45	14.39	2.91	2.74	50.24	70.7111	999.30	-0.010	0.000
5.05	19:29	50.2	70.775	70.771	14.53	14.61	2.78	1.02	14.45	14.38	2.92	2.75	50.23	70.7802	999.30	-0.007	-0.013
reversed order of the transfer standards																	
5.01	12:35	50.4	70.927	70.925	14.55	14.63	2.80	1.02	14.38	14.37	2.93	2.76	50.40	70.9316	999.30	-0.006	-0.009
5.02	12:38	50.4	70.488	70.489	14.55	14.62	2.80	1.02	14.36	14.35	2.93	2.76	50.39	70.4971	999.31	-0.013	-0.011
5.03	12:42	50.4	70.546	70.542	14.57	14.65	2.80	1.02	14.34	14.39	2.93	2.75	50.40	70.5482	999.31	-0.003	-0.009
5.04	12:45	50.4	70.430	70.428	14.57	14.66	2.79	1.02	14.37	14.41	2.93	2.75	50.37	70.4330	999.30	-0.004	-0.007
5.05	12:48	50.3	70.472	70.471	14.58	14.66	2.79	1.02	14.36	14.41	2.93	2.75	50.35	70.4760	999.30	-0.006	-0.007

CMS

50 kg/min

Test no. [--]	Start time [u:mm]	Flow rate [kg/min]	Mass total [kg]	Mass total [kg]	T Upstream [°C]	T Downstream [°C]	P Upstream [bar(g)][Pa^5(g)]	P Downstream [bar(g)][Pa^5(g)]	T Upstream [°C]	T Downstream [°C]	P Upstream [bar(g)][Pa^5(g)]	P Downstream [bar(g)][Pa^5(g)]	Ref. flow rate [kg/min]	Reference mass [kg]	Density Upstream [kg/m^3]	Error mass [%]	Error mass [%]
5.01	09:10	50.1	551.440	551.291	24.58	24.67	2.48	0.79	24.57	24.94	2.65	0.28	50.21	551.4800	997.16	-0.008	-0.035
5.02	09:24	50.2	551.992	551.818	24.40	24.51	2.48	0.80	24.21	24.57	2.67	0.28	50.27	552.0600	997.25	-0.013	-0.045
5.03	09:38	50.2	551.845	551.697	24.31	24.40	2.49	0.80	24.20	24.51	2.69	0.28	50.23	551.9100	997.26	-0.012	-0.039
5.04	09:52	50.3	551.875	551.700	24.34	24.43	2.49	0.81	24.22	24.54	2.69	0.28	50.25	551.9400	997.26	-0.012	-0.044
5.05	10:07	50.3	551.717	551.555	24.35	24.44	2.49	0.80	24.21	24.52	2.70	0.28	50.23	551.7800	997.26	-0.012	-0.041
reversed order of the transfer standards																	
5.01	16:18	50.3	551.719	551.542	24.23	24.28	2.48	0.78	24.04	24.38	2.67	0.30	50.39	551.7900	997.30	-0.013	-0.045
5.02	16:33	50.4	552.133	551.960	24.45	24.53	2.48	0.78	24.39	24.65	2.66	0.30	50.38	52.2000	997.22	-0.012	-0.044
5.03	16:47	50.5	551.544	551.397	24.51	24.60	2.49	0.78	24.37	24.68	2.66	0.30	50.37	551.6200	997.22	-0.014	-0.041
5.04	17:02	50.3	552.076	551.908	24.30	24.41	2.49	0.78	24.21	24.53	2.65	0.29	50.40	552.1400	997.26	-0.012	-0.042
5.05	17:16	50.3	551.743	551.570	24.30	24.41	2.50	0.77	24.17	24.45	2.67	0.30	50.36	551.8300	997.27	-0.016	-0.047

BEV

50 kg/min

Test no. [--]	Start time [u:mm]	Flow rate [kg/min]	Mass total [kg]	Mass total [kg]	T Upstream [°C]	T Downstream [°C]	P Upstream [bar(g)][Pa^5(g)]	P Downstream [bar(g)][Pa^5(g)]	T Upstream [°C]	T Downstream [°C]	P Upstream [bar(g)][Pa^5(g)]	P Downstream [bar(g)][Pa^5(g)]	Ref. flow rate [kg/min]	Reference mass [kg]	Density Upstream [kg/m^3]	Error mass [%]	Error mass [%]
5.01	19:36	50.1	100.000	99.990	19.59	20.25	2.21	0.43	19.59	20.25	2.21	0.43	50.11	100.0000	999.50	0.000	-0.010
5.02	19:49	50.1	99.996	99.986	19.68	20.35	2.21	0.43	19.68	20.35	2.21	0.43	50.09	100.0000	999.51	-0.004	-0.014
5.03	20:01	50.1	99.982	99.992	19.62	20.31	2.21	0.43	19.62	20.31	2.21	0.43	50.13	100.0000	999.52	-0.018	-0.008
5.04	20:13	50.1	99.991	99.991	19.62	20.28	2.22	0.43	19.62	20.28	2.22	0.43	50.11	100.0000	999.53	-0.009	-0.009
5.05	20:27	50.1	99.980	99.970	19.61	20.26	2.22	0.43	19.61	20.26	2.22	0.43	50.13	100.0000	999.53	-0.020	-0.030
reversed order of the transfer standards																	
5.01	22:47	50.1	100.001	99.991	19.57	20.22	2.21	0.43	19.57	20.22	2.21	0.43	50.10	100.0000	999.50	0.001	-0.009
5.02	23:00	50.1	99.997	99.997	19.68	20.34	2.21	0.42	19.68	20.34	2.21	0.42	50.07	100.0000	999.51	-0.003	-0.003
5.03	23:13	50.1	99.977	99.977	19.63	20.29	2.22	0.43	19.63	20.29	2.22	0.43	50.09	100.0000	999.52	-0.023	-0.023
5.04	23:26	50.1	100.009	99.989	19.61	20.27	2.21	0.42	19.61	20.27	2.21	0.42	50.10	100.0000	999.53	0.009	-0.011
5.05	23:39	50.1	99.995	99.995	19.61	20.23	2.21	0.43	19.61	20.23	2.21	0.43	50.12	100.0000	999.53	-0.005	-0.005

NEL

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values			Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[kg/m^3]	[%]	[%]
25	12:46	50.4	n/a	n/a	19.50	19.58	3.65	1.90	19.52	19.54	3.60	1.76	50.44	230.9205	998.50	0.004	0.000
26	12:55	50.4	n/a	n/a	19.41	19.51	3.65	1.90	19.40	19.40	3.60	1.76	50.39	231.0145	998.52	-0.003	-0.008
27	13:03	50.4	n/a	n/a	19.46	19.53	3.65	1.90	19.47	19.40	3.60	1.77	50.38	230.8623	998.52	-0.007	-0.017
28	13:11	50.4	n/a	n/a	19.51	19.59	3.65	1.90	19.52	19.45	3.60	1.77	50.37	231.0685	998.51	-0.010	-0.013
29	13:20	50.4	n/a	n/a	19.58	19.65	3.65	1.90	19.60	19.51	3.60	1.77	50.38	231.6811	998.49	-0.010	-0.021
reversed order of the transfer standards																	
26	11:43	50.1	n/a	n/a	19.73	19.79	3.75	2.02	19.71	19.62	3.70	1.89	50.13	230.9790	998.48	-0.008	-0.022
27	11:53	50.1	n/a	n/a	19.80	19.86	3.75	2.02	19.81	19.72	3.70	1.89	50.13	231.0151	998.46	-0.009	-0.024
28	12:02	50.1	n/a	n/a	19.75	19.85	3.75	2.02	19.77	19.72	3.70	1.89	50.13	230.9650	998.46	-0.011	-0.029
29	12:12	50.1	n/a	n/a	19.76	19.84	3.75	2.02	19.76	19.72	3.70	1.89	50.12	230.9908	998.46	-0.008	-0.021
30	12:22	50.1	n/a	n/a	19.83	19.88	3.75	2.02	19.79	19.75	3.70	1.89	50.13	230.9645	998.46	-0.009	-0.030

Test with hydrocarbon

VSL

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01	14:58	30.3	79.724	79.664	22.10	22.20	4.25	3.35					30.30	79.7209	1.581	797.27	0.004	-0.071
6.02	15:06	30.5	79.425	79.359	22.00	22.10	4.25	3.35					30.50	79.4233	1.583	797.35	0.003	-0.081
6.03	15:16	29.8	79.695	79.633	21.90	22.00	4.25	3.35					29.80	79.6914	1.586	797.42	0.004	-0.073
6.04	15:23	30.3	79.657	79.593	21.90	22.00	4.25	3.35					30.30	79.6544	1.586	797.42	0.003	-0.077
6.05	15:32	30.1	79.666	79.604	21.90	22.00	4.25	3.35					30.10	79.6650	1.586	797.42	0.002	-0.076
reversed order of the transfer standards																		
6.01	13:33	30.0	79.329	79.267	22.80	22.90	4.24	3.36					30.03	79.3266	1.562	796.75	0.003	-0.075
6.02	13:41	30.4	79.642	79.580	22.70	22.80	4.24	3.36					30.40	79.6389	1.565	796.83	0.004	-0.073
6.03	13:49	30.4	80.024	79.957	22.70	22.70	4.24	3.36					30.40	80.0226	1.565	796.83	0.002	-0.083
6.04	13:57	30.4	79.988	79.919	22.60	22.60	4.24	3.36					30.40	79.9848	1.567	796.90	0.004	-0.082
6.05	14:05	30.2	79.744	79.682	22.50	22.60	4.24	3.36					30.20	79.7426	1.570	796.98	0.001	-0.076

PTB

30 kg/min @25°C

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01	11:58	30.0	204.671	204.523	19.39	19.38	3.20	2.30	19.21	20.35	3.10	1.05	29.64	204.7085		786.29	-0.018	-0.091
6.02	12:15	30.0	205.089	204.938	19.48	19.89	3.20	2.29	19.43	20.80	3.11	1.04	29.64	205.1068		786.03	-0.009	-0.082
6.03	12:31	30.0	204.213	204.055	19.48	19.87	3.20	2.30	19.47	20.85	3.11	1.05	29.65	204.2608		786.00	-0.023	-0.101
6.04	12:47	30.0	204.014	203.860	19.79	19.73	3.19	2.30	19.47	20.85	3.10	1.05	29.65	204.0617		786.00	-0.023	-0.099
6.05	13:03	30.0	204.613	204.461	19.65	19.74	3.19	2.30	19.55	20.90	3.11	1.05	29.65	204.6590		785.95	-0.022	-0.097
reversed order of the transfer standards																		
6.01	13:36	30.0	204.093	203.934	20.81	20.88	3.16	2.25	20.53	21.95	3.07	1.09	29.66	204.1489		785.17	-0.027	-0.105
6.02	13:52	30.0	205.211	205.035	20.82	20.78	3.16	2.25	20.57	21.83	3.07	1.10	29.66	205.2437		785.20	-0.016	-0.102
6.03	14:08	30.0	204.058	203.897	20.80	20.78	3.16	2.25	20.53	21.85	3.07	1.10	29.67	204.0988		785.21	-0.020	-0.099
6.04	14:24	30.0	204.793	204.622	20.76	20.68	3.16	2.25	20.50	21.74	3.08	1.11	29.67	204.8453		785.26	-0.026	-0.109
6.05	14:40	30.0	204.244	204.072	20.72	20.71	3.16	2.25	20.50	21.74	3.07	1.11	29.66	204.2479		785.26	-0.002	-0.086

KRISS

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01	19:20	30.2	101.113	100.959	25.22	25.32	2.39	0.99	25.46	25.46	2.41	0.96	30.17	101.0913	16.690	871.58	0.021	-0.131
6.02	19:22	30.2	101.120	100.964	25.22	25.31	2.40	1.01	25.46	25.46	2.40	0.97	30.16	101.0913	16.690	871.58	0.028	-0.126
6.03	19:26	30.1	101.167	101.016	25.21	25.33	2.39	1.01	25.46	25.46	2.40	0.95	30.13	101.1414	16.690	871.58	0.025	-0.124
6.04	19:31	30.1	101.077	100.928	25.22	25.32	2.38	1.01	25.47	25.47	2.40	0.95	30.13	101.0413	16.680	871.58	0.035	-0.112
6.05	19:35	30.1	101.099	100.936	25.21	25.30	2.39	1.01	25.46	25.46	2.40	0.98	30.13	101.0812	16.690	871.58	0.018	-0.144
reversed order of the transfer standards																		
6.01	22:47	30.0	101.234	101.077	25.18	25.32	2.38	1.02	25.46	25.46	2.41	0.98	29.95	101.1818	16.690	871.58	0.052	-0.104
6.02	22:52	29.9	101.083	100.922	25.20	25.30	2.39	1.02	25.46	25.46	2.41	0.98	29.93	101.0416	16.690	871.58	0.041	-0.118
6.03	22:56	29.9	101.009	100.855	25.19	25.31	2.39	1.02	25.46	25.46	2.40	0.98	29.94	100.9916	16.690	871.58	0.017	-0.135
6.04	23:01	29.9	101.042	100.884	25.21	25.32	2.38	1.02	25.46	25.46	2.41	0.97	29.93	101.0419	16.690	871.58	0.000	-0.156
6.05	23:06	29.9	101.160	101.011	25.20	25.31	2.39	1.02	25.46	25.46	2.40	0.98	29.92	101.1523	16.690	871.58	0.008	-0.140

CMS

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01	15:30	30.0	622.392	621.841	21.82	22.03	1.30	0.30		22.09	1.21	0.25	30.03	622.4100	4.041	805.20	-0.003	-0.091
6.02	16:00	30.1	610.065	609.493	22.73	22.94	1.31	0.30		22.83	1.21	0.25	30.09	610.0500	3.967	804.69	0.002	-0.091
6.03	16:30	30.0	626.522	625.908	23.32	23.56	1.31	0.30		23.23	1.21	0.25	30.02	626.4200	3.929	804.42	0.016	-0.082
6.04	17:00	30.1	614.669	614.043	23.79	23.92	1.30	0.30		23.95	1.21	0.25	30.09	614.6900	3.860	803.92	-0.003	-0.105
6.05	17:30	30.1	639.290	638.650	24.32	24.48	1.30	0.30		24.01	1.22	0.25	30.08	639.1900	3.854	803.88	0.016	-0.084
reversed order of the transfer standards																		
6.01	12:30	30.0	617.752	617.150	23.36	23.57	1.29	0.30		23.27	1.21	0.25	29.99	617.6900	3.925	804.39	0.010	-0.087
6.02	13:00	30.0	624.632	624.065	23.08	23.28	1.29	0.30		22.73	1.21	0.25	29.99	624.4400	3.977	804.76	0.031	-0.060
6.03	13:30	30.0	610.842	610.278	22.61	22.83	1.29	0.30		22.72	1.21	0.25	29.99	610.7500	3.978	804.77	0.015	-0.077
6.04	14:00	30.0	630.782	630.160	23.23	23.39	1.29	0.30		23.43	1.21	0.25	29.99	630.7200	3.909	804.28	0.010	-0.089
6.05	14:30	30.0	616.562	615.967	23.13	23.32	1.29	0.30		23.07	1.21	0.25	29.98	616.4500	3.944	804.53	0.018	-0.078

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

NMIJ

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01	15:24	29.7	30.459	30.447	20.00	20.10	3.95	3.06	19.91	20.03	3.89	2.99	29.64	30.4538	2.137	796.68	0.017	-0.024
6.02	15:36	29.7	30.433	30.413	20.01	20.09	3.97	3.07	19.90	20.03	3.90	3.00	29.68	30.4277	2.137	796.68	0.016	-0.047
6.03	15:48	29.7	30.448	30.427	20.01	20.12	3.97	3.06	19.91	20.04	3.90	3.00	29.68	30.4426	2.137	796.68	0.016	-0.050
6.04	15:59	29.7	30.532	30.511	20.00	20.08	3.97	3.07	19.90	20.03	3.90	3.00	29.68	30.5260	2.137	796.69	0.019	-0.049
6.05	16:30	29.7	30.683	30.666	19.99	20.11	3.97	3.07	19.90	20.03	3.90	3.00	29.67	30.6776	2.137	796.69	0.019	-0.037
reversed order of the transfer standards																		
6.01	15:31	29.7	30.471	30.457	19.97	20.06	3.97	3.07	19.90	19.99	3.90	3.00	29.67	30.4642	2.139	796.72	0.021	-0.022
6.02	15:43	29.7	30.472	30.453	19.98	20.06	3.96	3.07	19.90	19.99	3.90	2.99	29.67	30.4662	2.139	796.72	0.020	-0.044
6.03	15:55	29.7	30.529	30.515	19.99	20.07	3.96	3.07	19.90	19.99	3.90	3.00	29.69	30.5238	2.139	796.71	0.016	-0.030
6.04	16:07	29.7	30.480	30.466	20.00	20.07	3.97	3.07	19.90	19.99	3.90	3.00	29.68	30.4743	2.139	796.70	0.019	-0.026
6.05	16:18	29.7	30.488	30.474	19.98	20.06	3.97	3.07	19.89	20.00	3.90	2.99	29.68	30.4829	2.139	796.72	0.017	-0.030

BEV

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01	15:06	29.8	41.717	41.690	23.72	23.80	2.22	1.21	23.72	23.73	2.34	1.77	29.79	41.7614	5.683	827.39	-0.106	-0.170
6.02	15:29	29.8	41.558	41.528	23.36	23.36	2.22	1.21	23.34	23.42	2.34	1.79	29.79	41.5968	5.683	827.61	-0.093	-0.164
6.03	15:43	29.8	41.663	41.637	23.36	23.36	2.22	1.21	23.17	23.36	2.34	1.70	29.80	41.7067	5.683	827.65	-0.106	-0.168
6.04	16:07	29.8	41.355	41.331	23.30	23.30	2.22	1.21	23.08	23.24	2.34	1.78	29.80	41.3871	5.683	827.73	-0.076	-0.136
6.05	16:21	29.8	41.166	41.142	0.00	0.00	0.00	0.00	22.97	23.12	2.33	1.50	29.80	41.2069	5.683	827.81	-0.100	-0.157
reversed order of the transfer standards																		
6.01	13:37	29.7	41.550	41.517	25.56	25.51	2.21	1.21	26.77	25.28	2.33	1.51	29.75	41.5798	5.683	826.34	-0.072	-0.152
6.02	13:47	29.7	41.627	41.599	25.69	25.70	2.22	1.21	26.79	25.56	2.34	1.75	29.74	41.6621	5.683	826.15	-0.083	-0.151
6.03	14:06	29.7	41.442	41.415	25.29	25.39	2.21	1.20	26.06	25.27	2.33	1.72	29.75	41.4796	5.683	826.34	-0.090	-0.157
6.04	14:22	29.8	41.404	41.376	25.17	25.19	2.21	1.20	25.98	24.96	2.34	1.81	29.76	41.4457	5.683	826.55	-0.101	-0.168
6.05	14:33	29.8	41.464	41.435	25.13	25.05	2.22	1.21	25.98	24.77	2.35	1.81	29.76	41.4988	5.683	826.68	-0.084	-0.153

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

NEL

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
33	17:57	30.3	144.158	144.055	20.48	20.52	2.57	1.54	20.59	20.56	2.56	1.52	30.28	144.1327	3.9378361	808.47	0.018	-0.054
34	18:06	30.3	144.247	144.140	20.53	20.60	2.57	1.54	20.65	20.54	2.56	1.52	30.30	144.2249	3.9358971	808.45	0.015	-0.059
35	18:15	30.3	144.497	144.391	20.51	20.57	2.57	1.54	20.65	20.53	2.56	1.52	30.31	144.4752	3.9362258	808.45	0.014	-0.060
36	18:23	30.3	144.041	143.936	20.49	20.54	2.57	1.54	20.59	20.53	2.56	1.52	30.32	144.0147	3.9388898	808.47	0.017	-0.055
37	18:32	30.3	144.447	144.336	20.54	20.58	2.57	1.54	20.67	20.51	2.56	1.52	30.32	144.4273	3.9361565	808.45	0.013	-0.064
reversed order of the transfer standards																		
30	12:12	30.1	124.195	124.114	20.38	20.42	2.58	1.55	20.52	20.40	2.56	1.53	30.06	124.1725	3.9477924	808.55	0.018	-0.048
31	12:22	30.1	124.462	124.372	20.33	20.40	2.57	1.56	20.49	20.36	2.56	1.53	30.06	124.4388	3.9509918	808.57	0.018	-0.054
32	12:32	30.1	124.278	124.186	20.34	20.40	2.58	1.56	20.50	20.34	2.56	1.53	30.05	124.2546	3.9509238	808.57	0.019	-0.056
33	12:42	30.0	124.046	123.958	20.38	20.42	2.58	1.56	20.51	20.35	2.56	1.54	30.01	124.0222	3.9501804	808.57	0.018	-0.051
34	12:52	30.0	124.566	124.474	20.30	20.41	2.57	1.56	20.47	20.35	2.56	1.54	30.01	124.5428	3.9521073	808.58	0.017	-0.055

NIST

30 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6.01		30.1	32.119		23.15	23.24	1.36	0.68	22.63	22.74	2.34	1.55	30.04	32.1083		1003.93	0.033	
6.02		30.1	32.118						22.64	22.75	2.34	1.55	30.04	32.1085		1003.93	0.030	
6.03		30.1	32.116						23.09	23.15	2.34	1.55	30.04	32.1061		1003.81	0.031	
6.04		30.1	32.117						23.07	23.15	2.34	1.55	30.04	32.1065		1003.81	0.033	
6.05		30.1	32.110						23.05	23.13	2.34	1.55	30.04	32.1010		1003.82	0.028	
reversed order of the transfer standards																		
6.01		30.1	32.120		22.63	22.69	1.35	0.66	22.57	22.68	2.32	1.53	30.04	32.1122		1003.95	0.024	
6.02		30.1	32.117						22.58	22.69	2.32	1.53	30.04	32.1078		1003.94	0.029	
6.03		30.1	32.122						22.59	22.70	2.32	1.53	30.04	32.1123		1003.94	0.030	
6.04		30.0	32.096						22.75	22.85	2.32	1.53	30.02	32.0853		1003.90	0.033	
6.05		30.1	32.121						22.76	22.86	2.32	1.53	30.04	32.1116		1003.90	0.029	

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

VSL

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01	11:33	39.8	79.906	79.858	19.70	19.80	4.24	2.77					39.82	79.8957	1.645	799.06	0.013	-0.047
3.02	11:40	39.8	80.091	80.043	19.70	19.80	4.24	2.77					39.80	80.0817	1.645	799.06	0.012	-0.048
3.03	11:48	39.7	79.631	79.583	19.70	19.80	4.24	2.77					39.70	79.6213	1.645	799.06	0.012	-0.048
3.04	11:56	39.5	79.797	79.749	19.70	19.80	4.24	2.77					39.50	79.7880	1.645	799.06	0.011	-0.049
3.05	12:04	40.0	79.714	79.670	19.80	19.90	4.24	2.77					40.00	79.7059	1.642	798.99	0.010	-0.044
3.06	12:11	40.5	79.610	79.561	19.80	19.90	4.24	2.77					40.50	79.6022	1.642	798.99	0.009	-0.052
3.07	12:19	40.4	80.238	80.189	19.80	19.90	4.24	2.77					40.40	80.2301	1.642	798.99	0.010	-0.051
3.08	12:28	39.6	79.556	79.506	19.80	19.90	4.24	2.77					39.60	79.5488	1.642	798.99	0.009	-0.053
3.09	12:35	39.5	80.050	80.000	19.80	19.90	4.24	2.77					39.50	80.0412	1.642	798.99	0.011	-0.051
3.10	12:43	39.4	80.089	80.041	19.80	19.90	4.24	2.77					39.40	80.0812	1.642	798.99	0.009	-0.050
reversed order of the transfer standards																		
3.01	10:13	40.1	79.708	79.649	21.00	21.10	4.24	2.75					40.10	79.6988	1.610	798.09	0.012	-0.063
3.02	10:21	40.4	79.767	79.712	21.00	21.10	4.24	2.75					40.40	79.7598	1.610	798.09	0.009	-0.060
3.03	10:28	40.5	79.310	79.258	21.00	21.00	4.24	2.75					40.50	79.3024	1.610	798.09	0.009	-0.056
3.04	10:35	40.4	80.008	79.953	21.00	21.00	4.24	2.75					40.40	79.9976	1.610	798.09	0.013	-0.055
3.05	10:42	40.2	79.322	79.265	21.00	21.00	4.24	2.75					40.20	79.3136	1.610	798.09	0.011	-0.062
3.06	10:50	40.5	79.854	79.799	21.00	21.00	4.24	2.75					40.50	79.8463	1.610	798.09	0.010	-0.060
3.07	10:57	40.6	79.916	79.858	20.90	21.00	4.24	2.75					40.60	79.9079	1.613	798.17	0.010	-0.062
3.08	11:05	40.7	79.879	79.825	20.90	21.00	4.24	2.75					40.70	79.8687	1.613	798.17	0.012	-0.055
3.09	11:12	40.7	80.054	80.009	20.90	21.00	4.24	2.75					40.70	80.0501	1.613	798.17	0.005	-0.052
3.10	11:19	40.7	80.070	80.025	20.90	21.00	4.24	2.75					40.70	80.0656	1.613	798.17	0.006	-0.051

PTB

40 kg/min																	@25°C
General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01	13:00	40.0	207.410	207.291	18.98	19.07	3.02	1.47	18.81	20.20	3.05	1.07	39.63	207.4420	1.180	786.81	-0.015	-0.073
3.02	13:16	40.0	206.267	206.124	19.17	19.43	3.01	1.47	19.09	20.41	3.06	1.07	39.61	206.2973	1.180	786.50	-0.015	-0.084
3.03	13:32	40.0	207.072	206.931	19.59	19.56	3.02	1.47	19.28	20.58	3.05	1.08	39.62	207.0937	1.180	786.31	-0.010	-0.079
3.04	13:47	40.0	206.101	205.943	19.63	19.76	3.02	1.47	19.44	20.68	3.05	1.08	39.65	206.1481	1.180	786.17	-0.023	-0.100
3.05	14:03	40.0	206.506	206.363	19.54	19.90	3.02	1.47	19.55	20.79	3.05	1.08	39.63	206.5463	1.180	786.07	-0.020	-0.089
3.06	14:19	40.0	207.454	207.310	19.91	19.98	3.02	1.47	19.60	20.85	3.05	1.07	39.63	207.4921	1.180	785.99	-0.018	-0.088
3.07	14:34	40.0	206.610	206.478	19.70	19.93	3.02	1.47	19.60	20.85	3.06	1.08	39.62	206.6461	1.180	785.95	-0.017	-0.081
3.08	14:50	40.0	206.976	206.832	19.63	19.75	3.01	1.47	19.66	20.92	3.05	1.08	39.61	206.9945	1.180	785.95	-0.009	-0.078
3.09	15:06	40.0	207.227	207.087	19.90	19.89	3.02	1.47	19.68	20.92	3.05	1.07	39.59	207.2434	1.180	785.90	-0.008	-0.075
3.10	15:21	40.0	205.930	205.777	19.81	20.09	3.02	1.47	19.74	20.97	3.05	1.07	39.60	205.9494	1.180	785.89	-0.009	-0.084
reversed order of the transfer standards																		
3.01	07:12	40.0	205.803	205.651	19.55	19.43	3.01	1.50	19.24	20.42	3.06	1.09	39.62	205.8415	1.180	786.34	-0.019	-0.093
3.02	07:28	40.0	206.210	206.066	19.60	19.40	3.01	1.50	19.29	20.48	3.06	1.09	39.63	206.2397	1.180	786.25	-0.014	-0.084
3.03	07:43	40.0	206.702	206.558	19.74	19.60	3.01	1.50	19.44	20.65	3.06	1.09	39.64	206.7373	1.180	786.21	-0.017	-0.087
3.04	07:59	40.0	206.104	205.956	19.85	19.67	3.01	1.50	19.54	20.70	3.05	1.09	39.66	206.1401	1.180	786.09	-0.018	-0.089
3.05	08:15	40.0	207.791	207.632	19.87	19.74	3.01	1.50	19.60	20.75	3.06	1.09	39.61	207.8323	1.180	786.03	-0.020	-0.096
3.06	08:31	40.0	207.828	207.677	19.91	19.88	3.01	1.50	19.62	20.90	3.06	1.09	39.60	207.8323	1.180	785.99	-0.002	-0.075
3.07	08:46	40.0	206.333	206.190	19.90	19.89	3.01	1.50	19.65	20.90	3.05	1.09	39.59	206.3392	1.180	785.92	-0.003	-0.072
3.08	09:02	40.0	207.563	207.412	19.96	19.83	3.01	1.50	19.66	20.90	3.06	1.09	39.61	207.5834	1.180	785.91	-0.010	-0.083
3.09	09:18	40.0	206.581	206.437	19.88	19.83	3.01	1.50	19.59	20.90	3.06	1.09	39.61	206.5880	1.180	785.91	-0.003	-0.073
3.10	09:33	40.0	207.027	206.867	21.92	21.64	3.01	1.50	21.70	22.75	3.05	1.09	39.63	207.0857	1.180	785.93	-0.028	-0.106

KRISS

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01	18:37	39.4	101.640	101.463	25.16	25.28	2.35	0.25	25.40	25.40	2.38	0.20	39.37	101.5519	16.72	871.62	0.087	-0.088
3.02	18:41	39.4	101.532	101.352	25.16	25.31	2.35	0.25	25.41	25.41	2.38	0.20	39.39	101.4820	16.72	871.62	0.049	-0.128
3.03	18:45	39.4	101.605	101.422	25.17	25.32	2.35	0.25	25.41	25.41	2.38	0.20	39.39	101.5423	16.72	871.62	0.062	-0.118
3.04	18:49	39.4	101.616	101.428	25.17	25.32	2.35	0.25	25.42	25.42	2.38	0.20	39.38	101.5423	16.71	871.61	0.073	-0.113
3.05	18:53	39.4	101.596	101.419	25.20	25.33	2.35	0.25	25.42	25.42	2.39	0.20	39.38	101.5121	16.71	871.61	0.083	-0.092
3.06	18:56	39.4	101.526	101.349	25.19	25.33	2.35	0.25	25.43	25.43	2.38	0.20	39.39	101.4520	16.70	871.60	0.073	-0.102
3.07	19:00	39.4	101.634	101.450	25.19	25.35	2.35	0.25	25.44	25.44	2.39	0.20	39.38	101.5420	16.70	871.60	0.091	-0.091
3.08	19:04	39.4	101.565	101.377	25.21	25.36	2.35	0.25	25.44	25.44	2.38	0.20	39.38	101.4719	16.70	871.60	0.092	-0.094
3.09	19:07	39.4	101.548	101.361	25.20	25.36	2.34	0.25	25.45	25.45	2.37	0.20	39.37	101.4618	16.69	871.59	0.085	-0.099
3.10	19:11	39.4	101.545	101.371	25.25	25.36	2.35	0.25	25.45	25.45	2.39	0.20	39.39	101.5018	16.69	871.59	0.043	-0.129
reversed order of the transfer standards																		
3.01	21:53	39.4	101.613	101.438	25.19	25.26	2.36	0.25	25.43	25.43	2.39	0.20	39.35	101.5422	16.70	871.60	0.070	-0.103
3.02	21:57	39.4	101.562	101.378	25.20	25.32	2.35	0.25	25.43	25.43	2.38	0.20	39.36	101.4922	16.70	871.60	0.069	-0.113
3.03	22:00	39.4	101.536	101.341	25.22	25.35	2.35	0.25	25.43	25.43	2.38	0.20	39.34	101.4621	16.70	871.60	0.073	-0.119
3.04	22:04	39.4	101.621	101.434	25.20	25.32	2.35	0.25	25.44	25.44	2.38	0.20	39.37	101.5522	16.70	871.60	0.068	-0.116
3.05	22:08	39.4	101.646	101.459	25.22	25.37	2.35	0.25	25.44	25.44	2.38	0.20	39.37	101.5724	16.70	871.60	0.072	-0.112
3.06	22:11	39.4	101.574	101.392	25.22	25.37	2.35	0.25	25.44	25.44	2.39	0.20	39.39	101.4925	16.70	871.60	0.080	-0.099
3.07	22:15	39.4	101.518	101.321	25.20	25.34	2.35	0.25	25.44	25.44	2.38	0.20	39.39	101.4426	16.70	871.60	0.074	-0.120
3.08	22:19	39.4	101.603	101.415	25.21	25.35	2.35	0.25	25.44	25.44	2.38	0.20	39.37	101.5527	16.70	871.60	0.050	-0.136
3.09	22:23	39.4	101.682	101.492	25.21	25.35	2.35	0.25	25.45	25.45	2.39	0.20	39.36	101.5825	16.69	871.59	0.098	-0.089
3.10	22:28	39.4	101.575	101.383	25.22	25.36	2.35	0.25	25.45	25.45	2.39	0.20	39.40	101.5224	16.69	871.59	0.052	-0.137

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

CMS

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01	14:10	40.0	885.655	884.599	23.89	24.09	1.99	0.31		23.81	1.90	0.25	39.98	885.2800	3.87	804.02	0.042	-0.077
3.02	14:40	40.0	810.605	809.605	24.18	24.33	2.00	0.31		24.63	1.90	0.25	39.98	810.4400	3.80	803.45	0.020	-0.103
3.03	15:10	40.0	818.422	817.454	23.11	23.38	1.99	0.31		23.09	1.90	0.25	39.95	818.0700	3.94	804.51	0.043	-0.075
3.04	15:40	40.0	813.539	812.585	23.50	25.78	1.99	0.31		23.93	1.90	0.25	39.97	813.3700	3.86	803.93	0.021	-0.097
3.05	16:10	40.0	810.715	809.751	23.95	24.20	1.99	0.31		23.96	1.89	0.25	39.96	810.4400	3.86	803.91	0.034	-0.085
3.06	16:40	40.0	811.449	810.453	24.30	24.48	1.99	0.31		24.26	1.90	0.25	39.96	811.2500	3.83	803.70	0.025	-0.098
3.07	17:10	40.0	835.870	834.890	23.27	23.53	1.99	0.31		23.29	1.90	0.25	39.97	835.5500	3.92	804.38	0.038	-0.079
3.08	17:40	40.0	827.437	826.437	23.69	23.85	1.99	0.31		24.11	1.90	0.25	39.97	827.2900	3.85	803.81	0.018	-0.103
3.09	18:10	40.0	855.810	854.826	22.89	23.14	1.99	0.31		22.99	1.90	0.25	39.95	855.4900	3.95	804.58	0.037	-0.078
3.10	18:40	40.0	828.979	827.986	23.34	23.54	1.99	0.31		24.04	1.90	0.25	39.98	828.9000	3.85	803.86	0.010	-0.110
reversed order of the transfer standards																		
3.01	12:40	40.0	827.736	826.773	23.26	23.46	1.99	0.31		23.17	1.89	0.25	39.96	827.3700	3.93	804.46	0.044	-0.072
3.02	13:10	40.0	826.445	825.428	24.58	24.69	1.99	0.31		24.49	1.90	0.25	40.00	826.2300	3.81	803.55	0.026	-0.097
3.03	13:40	40.0	859.944	858.928	23.56	23.77	1.99	0.31		23.35	1.89	0.25	39.98	859.5500	3.92	804.33	0.046	-0.072
3.04	14:10	40.0	810.074	809.109	24.02	24.16	2.00	0.31		23.82	1.90	0.25	39.96	809.7900	3.87	804.01	0.035	-0.084
3.05	14:40	40.0	810.230	809.264	23.27	23.52	2.00	0.31		23.24	1.89	0.25	39.96	809.8500	3.93	804.41	0.047	-0.072
3.06	15:10	40.0	809.731	808.757	23.56	23.75	1.99	0.31		24.04	1.90	0.25	39.96	809.5500	3.85	803.86	0.022	-0.098
3.07	15:40	40.0	817.221	816.264	21.32	21.55	1.99	0.31		21.48	1.90	0.25	39.98	816.9600	4.10	805.63	0.032	-0.085
3.08	16:10	40.0	811.370	810.416	23.14	23.33	1.99	0.31		23.17	1.90	0.25	39.96	811.0600	3.93	804.46	0.038	-0.079
3.09	16:40	40.0	815.555	814.588	23.91	24.08	1.99	0.31		23.78	1.90	0.25	39.97	815.2000	3.88	804.04	0.044	-0.075
3.10	17:10	40.0	811.464	810.436	24.33	24.47	1.99	0.31		24.40	1.90	0.25	39.98	811.2300	3.82	803.61	0.029	-0.098

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

NMIJ

40 kg/min

General		Meter 1 - MM upstream	Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01	11:40	39.5	30.298	30.275	19.91	20.04	4.60	3.08	19.85	19.97	4.54	2.99	39.57	30.2897	2.14	796.81	0.028	-0.049
3.02	11:52	39.6	30.286	30.262	19.92	20.06	4.60	3.08	19.85	19.98	4.54	3.00	39.57	30.2777	2.14	796.80	0.027	-0.051
3.03	12:03	39.6	30.305	30.278	19.94	20.05	4.60	3.07	19.85	19.98	4.54	3.00	39.59	30.2952	2.14	796.78	0.031	-0.056
3.04	12:15	39.5	30.343	30.327	19.93	20.05	4.60	3.07	19.86	19.98	4.54	3.00	39.54	30.3351	2.14	796.79	0.027	-0.028
3.05	12:26	39.6	30.292	30.271	19.93	20.03	4.60	3.08	19.85	19.98	4.54	3.00	39.55	30.2827	2.14	796.79	0.032	-0.040
3.06	12:38	39.6	30.313	30.302	19.93	20.05	4.60	3.08	19.85	19.98	4.54	3.00	39.54	30.3047	2.14	796.79	0.026	-0.010
3.07	12:49	39.6	30.281	30.260	19.95	20.07	4.60	3.08	19.86	19.99	4.54	2.99	39.55	30.2715	2.14	796.78	0.032	-0.039
3.08	13:01	39.5	30.147	30.125	19.94	20.06	4.60	3.08	19.85	19.98	4.54	2.99	39.53	30.1391	2.14	796.78	0.025	-0.047
3.09	13:12	39.6	30.267	30.249	19.94	20.05	4.60	3.08	19.85	19.98	4.54	2.99	39.55	30.2605	2.14	796.78	0.021	-0.037
3.10	13:24	39.5	30.299	30.281	19.92	20.06	4.60	3.08	19.85	19.98	4.54	2.99	39.55	30.2902	2.14	796.80	0.029	-0.030
reversed order of the transfer standards																	
3.01	11:31	39.6	30.327	30.313	19.90	20.04	4.61	3.08	19.85	19.96	4.55	3.00	39.60	30.3175	2.14	796.82	0.031	-0.014
3.02	11:43	39.6	30.307	30.285	19.92	20.04	4.60	3.08	19.85	19.96	4.54	3.00	39.58	30.2974	2.14	796.80	0.031	-0.042
3.03	11:54	39.6	30.324	30.313	19.93	20.02	4.61	3.08	19.86	19.97	4.55	3.00	39.60	30.3144	2.14	796.80	0.033	-0.005
3.04	12:06	39.6	30.334	30.317	19.90	20.02	4.61	3.08	19.85	19.96	4.54	3.00	39.59	30.3243	2.14	796.82	0.032	-0.025
3.05	12:17	39.6	30.312	30.292	19.92	20.04	4.61	3.08	19.84	19.96	4.55	3.00	39.60	30.3025	2.14	796.80	0.031	-0.035
3.06	12:29	39.6	30.301	30.284	19.94	20.05	4.60	3.08	19.85	19.97	4.54	2.99	39.56	30.2920	2.14	796.79	0.030	-0.025
3.07	12:41	39.6	30.283	30.263	19.92	20.06	4.60	3.08	19.85	19.96	4.54	2.99	39.57	30.2733	2.14	796.80	0.033	-0.034
3.08	12:52	39.6	30.245	30.229	19.92	20.06	4.60	3.08	19.85	19.96	4.55	3.00	39.59	30.2370	2.14	796.80	0.026	-0.027
3.09	13:04	39.4	30.359	30.334	19.92	20.02	4.60	3.08	19.85	19.97	4.54	2.99	39.56	30.3490	2.14	796.80	0.032	-0.048
3.10	13:15	39.6	30.286	30.273	19.92	20.03	4.61	3.08	19.85	19.96	4.55	3.00	39.60	30.2753	2.14	796.80	0.035	-0.009

BEV

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01	15:49	39.8	166.137	165.968	21.86	21.86	1.99	0.30	21.15	21.78	2.11	0.47	39.78	166.2527	5.68	828.73	-0.070	-0.171
3.02	16:09	39.8	166.780	166.630	21.84	21.85	2.00	0.33	21.28	21.93	2.11	0.54	39.77	166.8522	5.68	828.63	-0.043	-0.133
3.03	16:42	39.8	166.776	166.627	21.97	22.04	2.00	0.33	21.35	22.02	2.16	0.51	39.77	166.8587	5.68	828.57	-0.049	-0.139
3.04	17:12	39.8	166.673	166.512	22.01	22.05	2.00	0.33	21.54	22.08	2.10	0.44	39.77	166.7742	5.68	828.52	-0.061	-0.157
3.05	17:32	39.8	166.658	166.476	22.10	22.14	0.20	0.33	21.64	22.11	2.11	0.52	39.77	166.7743	5.68	828.50	-0.070	-0.179
3.06	17:49	39.8	166.535	166.355	22.30	22.30	1.99	0.30	21.84	22.25	2.11	0.48	39.76	166.6755	5.68	828.41	-0.084	-0.193
3.07	08:40	39.8	166.809	166.644	20.93	20.92	2.01	0.33	20.10	20.94	2.12	0.47	39.81	166.9352	5.68	829.30	-0.076	-0.175
3.08	09:02	39.8	166.828	166.656	21.08	21.03	2.01	0.33	20.48	21.08	2.12	0.48	39.80	166.9421	5.68	829.21	-0.069	-0.171
3.09	09:17	39.8	166.815	166.643	21.13	21.08	2.01	0.33	20.62	21.24	2.11	0.48	39.80	166.9179	5.68	829.10	-0.062	-0.165
3.10	09:33	39.8	166.796	166.626	21.13	21.09	2.00	0.33	20.71	21.30	2.11	0.43	39.79	166.9079	5.68	829.06	-0.067	-0.169
reversed order of the transfer standards																		
3.01	07:48	39.7	166.433	166.237	22.72	22.69	2.00	0.33	22.69	22.88	2.11	0.47	39.74	166.5269	5.68	827.97	-0.056	-0.174
3.02	08:07	39.7	166.268	166.082	23.00	23.00	1.99	0.33	22.94	23.12	2.11	0.47	39.73	166.3558	5.68	827.81	-0.053	-0.165
3.03	08:26	39.7	166.478	166.299	23.70	23.11	2.00	0.33	23.04	23.21	2.11	0.61	39.73	166.5696	5.68	827.75	-0.055	-0.162
3.04	08:43	39.7	166.349	166.170	23.12	23.18	2.00	0.33	23.15	23.24	2.13	1.02	39.73	166.4517	5.68	827.73	-0.062	-0.169
3.05	08:59	39.7	166.306	166.109	23.48	23.58	1.99	0.33	23.33	23.36	2.12	1.00	39.73	166.3899	5.68	827.65	-0.051	-0.169
3.06	09:25	39.7	166.246	166.050	23.65	23.76	2.00	0.33	23.57	23.59	2.12	1.01	39.72	166.3350	5.68	827.49	-0.053	-0.171
3.07	09:41	39.7	166.291	166.100	23.70	23.80	2.00	0.33	23.66	23.60	2.13	1.00	39.72	166.3850	5.68	827.48	-0.056	-0.171
3.08	09:56	39.7	166.382	166.189	23.72	23.76	2.00	0.33	23.73	23.66	2.12	1.00	39.72	166.4681	5.68	827.44	-0.052	-0.167
3.09	10:14	39.7	166.403	166.218	23.79	23.89	2.00	0.33	23.78	23.68	2.12	1.02	39.72	166.4856	5.68	827.43	-0.050	-0.161
3.10	10:32	39.7	166.388	166.199	23.68	23.69	2.00	0.33	23.85	23.73	2.12	1.00	39.71	166.4684	5.68	827.39	-0.049	-0.162

NEL

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
6	11:48	39.2	145.053	144.915	20.24	20.34	3.23	1.57	20.39	20.32	3.22	1.55	39.19	144.9876	3.96	808.64	0.044	-0.050
7	12:04	39.2	145.220	145.085	20.25	20.32	3.23	1.57	20.41	20.32	3.22	1.55	39.20	145.1598	3.96	808.64	0.041	-0.051
8	12:16	39.2	145.434	145.301	20.26	20.35	3.23	1.57	20.38	20.33	3.22	1.55	39.20	145.3699	3.96	808.64	0.044	-0.047
9	12:28	39.2	145.466	145.338	20.27	20.37	3.23	1.57	20.38	20.34	3.22	1.55	39.22	145.4079	3.96	808.64	0.039	-0.047
10	12:40	39.2	145.041	144.910	20.24	20.33	3.23	1.57	20.36	20.33	3.22	1.55	39.22	144.9773	3.96	808.65	0.043	-0.044
11	12:53	39.2	145.398	145.265	20.29	20.35	3.23	1.57	20.36	20.34	3.22	1.55	39.22	145.3337	3.96	808.65	0.045	-0.047
12	13:04	39.2	145.009	144.873	20.31	20.39	3.23	1.57	20.40	20.35	3.22	1.55	39.22	144.9451	3.95	808.63	0.043	-0.049
13	13:16	39.2	145.092	144.967	20.29	20.41	3.23	1.57	20.40	20.39	3.22	1.55	39.23	145.0311	3.95	808.62	0.041	-0.042
14	13:29	39.2	144.953	144.827	20.31	20.43	3.23	1.57	20.42	20.41	3.22	1.55	39.22	144.8949	3.95	808.60	0.039	-0.047
15	13:40	39.2	145.623	145.492	20.33	20.42	3.23	1.57	20.42	20.43	3.22	1.55	39.22	145.5617	3.95	808.59	0.041	-0.046
reversed order of the transfer standards																		
9	16:20	39.4	143.895	143.755	20.57	20.68	3.15	1.48	20.68	20.65	3.14	1.47	39.34	143.8385	3.93	808.42	0.039	-0.059
10	16:27	39.3	144.619	144.312	20.62	20.72	3.15	1.48	20.73	20.69	3.14	1.47	39.33	144.4051	3.93	808.39	0.039	-0.063
11	16:36	39.3	144.299	144.148	20.62	20.74	3.15	1.48	20.75	20.71	3.14	1.47	39.33	144.2349	3.92	808.37	0.044	-0.060
12	16:46	39.4	144.194	144.041	20.63	20.71	3.15	1.48	20.75	20.68	3.14	1.47	39.33	144.1311	3.93	808.39	0.042	-0.062
13	16:59	39.3	144.025	143.875	20.61	20.68	3.15	1.48	20.74	20.65	3.14	1.47	39.32	143.9607	3.93	808.40	0.044	-0.060
14	17:06	39.4	144.385	144.235	20.57	20.63	3.15	1.48	20.73	20.68	3.14	1.47	39.34	144.3232	3.93	808.39	0.042	-0.060
15	17:16	39.3	144.149	144.000	20.59	20.66	3.15	1.48	20.75	20.66	3.14	1.47	39.30	144.0869	3.93	808.39	0.042	-0.061
16	17:24	39.3	144.349	144.199	20.66	20.75	3.15	1.48	20.83	20.70	3.14	1.47	39.30	144.2872	3.92	808.35	0.042	-0.060
17	17:31	39.3	144.292	144.142	20.67	20.76	3.15	1.48	20.81	20.74	3.14	1.47	39.31	144.2312	3.92	808.34	0.041	-0.062
18	17:38	39.3	144.166	144.014	20.69	20.78	3.15	1.48	20.83	20.73	3.14	1.47	39.30	144.1050	3.92	808.34	0.042	-0.063

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

NIST

40 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
3.01		40.1	36.834		21.18	21.23	1.93	0.74	21.17	21.40	2.91	1.55	40.05	36.8222		1004.32	0.03	
3.02		40.1	36.824						21.22	21.41	2.91	1.55	40.06	36.8095		1004.31	0.04	
3.03		40.1	36.816						21.26	21.45	2.91	1.55	40.05	36.8037		1004.29	0.03	
3.04		40.1	36.842						21.29	21.48	2.91	1.55	40.05	36.8299		1004.29	0.03	
3.05		40.1	36.825						21.33	21.52	2.91	1.55	40.05	36.8133		1004.27	0.03	
3.06		40.1	36.837						21.44	21.62	2.91	1.55	40.05	36.8231		1004.25	0.04	
3.07		40.1	36.824						21.48	21.65	2.91	1.55	40.05	36.8087		1004.24	0.04	
3.08		40.1	36.844						21.52	21.69	2.91	1.55	40.05	36.8294		1004.23	0.04	
3.09		40.1	36.838						21.55	21.72	2.91	1.55	40.05	36.8215		1004.22	0.04	
3.10		40.1	36.835						21.58	21.75	2.91	1.55	40.05	36.8202		1004.21	0.04	
reversed order of the transfer standards																		
3.01		40.1	36.822		22.38	22.46	1.89	0.72	22.41	22.51	2.88	1.53	40.04	36.8087		1003.99	-8.05	
3.02		40.1	36.826						22.45	22.57	2.88	1.53	40.04	36.8147		1003.98	-8.04	
3.03		40.1	36.833						22.47	22.59	2.88	1.53	40.05	36.8169		1003.97	-8.02	
3.04		40.1	36.817						22.50	22.61	2.88	1.53	40.04	36.8054		1003.97	-8.06	
3.05		40.1	36.818						22.54	22.66	2.88	1.53	40.04	36.8066		1003.95	-8.05	
3.06		40.1	36.817						22.62	22.73	2.88	1.53	40.04	36.8012		1003.93	-8.06	
3.07		40.1	36.811						22.64	22.75	2.88	1.53	40.04	36.7997		1003.93	-8.07	
3.08		40.1	36.830						22.67	22.77	2.88	1.53	40.05	36.8188		1003.92	-8.03	
3.09		40.1	36.824						22.71	22.81	2.88	1.53	40.04	36.8119		1003.91	-8.04	
3.10		40.1	36.817						22.73	22.83	2.88	1.53	40.04	36.8063		1003.90	-8.06	

VSL

50 kg/min

Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01	14:05	50.4	80.282	80.243	21.60	21.80	4.22	1.95					50.40	80.2984	1.594	797.64	-0.020	-0.069
5.02	14:13	50.4	79.673	79.631	21.50	21.70	4.22	1.95					50.40	79.6827	1.597	797.72	-0.012	-0.065
5.03	14:22	50.5	80.503	80.458	21.50	21.60	4.22	1.95					50.50	80.5125	1.597	797.72	-0.012	-0.068
5.04	14:30	50.5	80.040	79.986	21.50	21.60	4.22	1.95					50.50	80.0475	1.597	797.72	-0.009	-0.077
5.05	14:37	50.3	79.769	79.723	21.40	21.50	4.22	1.95					50.30	79.7803	1.599	797.79	-0.014	-0.072
reversed order of the transfer standards																		
5.01	12:46	50.2	79.990	79.938	22.40	22.50	4.22	1.98					50.20	79.9899	1.573	797.05	0.000	-0.065
5.02	12:53	50.1	80.088	80.030	22.30	22.40	4.22	1.98					50.10	80.0992	1.575	797.12	-0.014	-0.087
5.03	13:00	50.2	79.529	79.476	22.20	22.30	4.22	1.98					50.20	79.5375	1.578	797.20	-0.011	-0.077
5.04	13:06	50.3	79.873	79.829	22.20	22.30	4.22	1.98					50.30	79.8859	1.578	797.20	-0.016	-0.071
5.05	13:13	50.5	79.515	79.468	22.20	22.30	4.22	1.98					50.50	79.5246	1.578	797.20	-0.012	-0.071

PTB

50 kg/min   @25°C

Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01	09:41	50.0	208.239	208.111	20.03	20.10	3.42	1.26	19.93	21.22	3.41	1.03	49.45	208.3417		785.68	-0.049	-0.111
5.02	09:55	50.0	209.509	209.377	20.11	20.17	3.42	1.26	19.95	21.28	3.41	1.03	49.44	209.6359		785.65	-0.061	-0.124
5.03	10:08	50.0	208.184	208.067	20.27	20.26	3.42	1.26	20.04	21.33	3.41	1.04	49.42	208.2422		785.60	-0.028	-0.084
5.04	10:21	50.0	209.500	209.353	20.40	20.43	3.42	1.26	20.09	21.39	3.41	1.03	49.43	209.5862		785.55	-0.041	-0.111
5.05	10:35	50.0	208.025	207.890	20.02	20.35	3.42	1.26	19.86	21.21	3.41	1.03	49.42	208.0928		785.71	-0.033	-0.097
reversed order of the transfer standards																		
5.01	12:12	50.0	208.266	208.128	20.82	20.61	3.42	1.28	20.58	21.66	3.42	1.04	49.59	208.3797		785.26	-0.055	-0.121
5.02	12:26	50.0	209.320	209.175	20.91	20.82	3.42	1.28	20.62	21.89	3.42	1.04	49.55	209.3751		785.16	-0.026	-0.096
5.03	12:40	50.0	209.811	209.665	20.92	20.80	3.42	1.28	20.65	21.89	3.42	1.04	49.54	209.8728		785.15	-0.029	-0.099
5.04	12:53	50.0	207.898	207.759	21.13	20.83	3.42	1.28	20.84	21.94	3.42	1.05	49.56	207.9814		785.06	-0.040	-0.107
5.05	13:07	50.0	209.615	209.465	21.16	20.98	3.42	1.28	20.90	22.05	3.42	1.04	49.58	209.6735		784.99	-0.028	-0.099

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

KRISS

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01	00:36	50.0	102.089		25.20	25.34	2.30	0.69	25.41	25.41	2.36	0.62	49.97	102.0226	16.720	871.62	0.065	-0.075
5.02	00:40	50.0	102.030		25.21	25.34	2.30	0.69	25.41	25.41	2.36	0.62	50.00	101.9926	16.720	871.62	0.037	-0.097
5.03	00:43	50.0	102.058		25.22	25.33	2.31	0.69	25.42	25.42	2.35	0.63	50.02	102.0327	16.710	871.61	0.025	-0.115
5.04	00:46	50.0	101.979		25.21	25.33	2.31	0.60	25.43	25.43	2.36	0.62	50.01	101.9328	16.700	871.60	0.045	-0.092
5.05	00:50	50.0	102.094		25.20	25.34	2.31	0.70	25.44	25.44	2.36	0.63	50.02	102.0432	16.700	871.60	0.050	-0.100
reversed order of the transfer standards																		
5.01	01:41	49.7		101.906	25.31	25.43	2.30	0.88	25.51	25.51	2.37	0.80	49.76	101.9829	11.660	871.55	0.065	-0.075
5.02	01:44	49.7		101.954	25.29	25.43	2.31	0.87	25.51	25.51	2.36	0.81	49.76	102.0532	11.660	871.55	0.037	-0.097
5.03	01:47	49.7		101.996	25.31	25.41	2.30	0.87	25.50	25.50	2.35	0.81	49.78	102.1133	11.660	871.55	0.025	-0.115
5.04	01:50	49.7		101.829	25.29	25.41	2.31	0.88	25.50	25.50	2.36	0.80	49.75	101.9230	11.660	871.55	0.045	-0.092
5.05	01:53	49.7		101.901	25.30	25.41	2.30	0.87	25.50	25.50	2.36	0.81	49.73	102.0030	11.660	871.55	0.050	-0.100

CMS

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01	12:30	50.0	1031.164	1030.200	21.80	22.04	2.89	0.33		22.61	2.78	0.26	50.03	1031.2000	3.989	804.84	-0.003	-0.097
5.02	13:00	50.0	1018.964	1017.946	24.15	24.37	2.88	0.33		23.77	2.78	0.26	49.98	1018.6100	3.877	804.04	0.035	-0.065
5.03	13:30	50.0	1082.957	1081.854	24.32	24.48	2.87	0.33		24.71	2.78	0.26	49.99	1082.8700	3.789	803.39	0.008	-0.094
5.04	14:00	50.0	1041.288	1040.275	23.29	23.56	2.88	0.33		23.19	2.78	0.26	49.99	1040.9900	3.932	804.44	0.029	-0.069
5.05	14:30	50.0	1021.355	1020.386	22.67	22.89	2.88	0.33		22.78	2.78	0.26	50.02	1021.1300	3.972	804.73	0.022	-0.073
reversed order of the transfer standards																		
5.01	09:30	50.0	1015.838	1014.831	23.26	23.57	2.88	0.33		23.27	2.78	0.26	49.97	1015.5600	3.925	804.39	0.027	-0.072
5.02	10:00	50.0	1025.173	1024.087	23.82	24.04	2.88	0.33		24.04	2.78	0.26	49.98	1024.9400	3.851	803.86	0.023	-0.083
5.03	10:30	50.0	1016.498	1015.544	22.25	22.52	2.88	0.33		22.24	2.77	0.26	49.98	1016.1900	4.026	805.10	0.030	-0.064
5.04	11:00	50.0	1025.316	1024.265	23.51	23.70	2.88	0.33		23.29	2.77	0.26	49.95	1024.9800	3.923	804.38	0.033	-0.070
5.05	11:30	50.0	1026.056	1024.972	24.17	24.40	2.88	0.33		23.91	2.77	0.26	49.94	1025.6600	3.864	803.95	0.039	-0.067

NMIJ

50 kg/min

		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01	14:33	49.5	30.532	30.519	19.94	20.08	5.38	3.09	19.86	20.02	5.34	3.00	49.47	30.5303	2.138	796.84	0.005	-0.038
5.02	14:45	49.5	30.359	30.351	19.93	20.10	5.39	3.09	19.86	20.02	5.34	3.00	49.47	30.3567	2.138	796.85	0.009	-0.019
5.03	14:56	49.5	30.437	30.438	19.93	20.08	5.38	3.08	19.85	20.01	5.34	3.00	49.47	30.4352	2.138	796.85	0.005	0.009
5.04	15:07	49.4	30.258	30.237	19.93	20.09	5.39	3.08	19.86	20.02	5.32	2.99	49.40	30.2544	2.138	796.85	0.012	-0.058
5.05	15:19	49.5	30.518	30.511	19.94	20.08	5.39	3.09	19.85	20.02	5.34	3.00	49.48	30.5121	2.138	796.84	0.020	-0.002
reversed order of the transfer standards																		
5.01	14:28	49.5	30.466	30.457	19.91	20.08	5.39	3.08	19.85	19.99	5.33	3.00	49.42	30.4600	2.139	796.87	0.019	-0.009
5.02	14:39	49.5	30.423	30.407	19.93	20.06	5.38	3.08	19.85	19.99	5.34	3.00	49.44	30.4172	2.139	796.85	0.017	-0.033
5.03	14:51	49.5	30.375	30.373	19.90	20.07	5.38	3.08	19.85	19.99	5.34	3.00	49.47	30.3738	2.139	796.87	0.005	-0.001
5.04	15:02	49.5	30.339	30.322	19.91	20.06	5.39	3.09	19.85	19.99	5.34	3.00	49.48	30.3331	2.139	796.87	0.018	-0.037
5.05	15:14	49.5	30.424	30.413	19.91	20.07	5.38	3.08	19.85	19.99	5.34	3.00	49.47	30.4181	2.139	796.87	0.018	-0.016

BEV

50 kg/min

		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01	11:45	49.7	165.323	165.164	23.10	23.20	2.88	0.35	22.86	23.08	3.02	0.54	49.67	165.3893	5.683	827.84	-0.040	-0.136
5.02	13:51	49.7	164.880	164.741	22.85	23.02	2.88	0.35	22.62	22.95	3.02	0.54	49.68	165.0117	5.683	827.93	-0.080	-0.164
5.03	14:06	49.7	165.328	165.182	23.14	23.24	2.88	0.35	22.81	23.21	3.01	0.54	49.67	165.4395	5.683	827.75	-0.068	-0.156
5.04	14:22	49.7	165.567	165.418	23.40	23.50	2.88	0.35	23.19	23.36	3.01	0.43	49.66	165.7094	5.683	827.65	-0.086	-0.176
5.05	14:39	49.6	165.406	165.259	23.35	23.45	2.88	0.35	23.52	23.60	3.02	0.65	49.65	165.5036	5.683	827.49	-0.059	-0.148
reversed order of the transfer standards																		
5.01	12:11	49.6	164.377	164.191	25.60	25.75	2.87	0.35	26.69	25.61	3.03	1.48	49.57	164.4395	5.683	826.11	-0.038	-0.151
5.02	12:31	49.6	165.231	165.058	25.25	25.41	2.86	0.35	26.07	25.41	3.03	1.47	49.57	165.3186	5.683	826.24	-0.053	-0.158
5.03	12:49	49.6	165.644	165.460	25.40	25.50	2.86	0.35	26.20	25.27	3.03	1.46	49.58	165.7229	5.683	826.34	-0.047	-0.158
5.04	13:07	49.6	165.704	165.533	25.55	25.68	2.86	0.35	26.45	25.46	3.03	1.49	49.57	165.8065	5.683	826.21	-0.062	-0.165
5.05	13:22	49.6	165.457	165.266	25.81	25.87	2.87	0.35	26.60	25.32	3.03	1.55	49.58	165.5577	5.683	826.31	-0.061	-0.176

CIPM key comparison CCM.FF-K2.2011
Water and Hydrocarbon flow 5 – 60 kg/min

NEL

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
28	17:12	49.6	144.050	143.936	20.67	20.86	4.06	1.48	20.84	20.86	4.06	1.49	49.54	144.0147	3.9136698	808.32	0.025	-0.055
29	17:20	49.6	144.490	144.364	20.72	20.84	4.07	1.49	20.87	20.80	4.06	1.49	49.56	144.4532	3.9151472	808.33	0.025	-0.062
30	17:27	49.5	144.319	144.197	20.70	20.88	4.06	1.49	20.84	20.79	4.06	1.49	49.53	144.2790	3.9164094	808.35	0.027	-0.058
31	17:34	49.5	144.162	144.053	20.70	20.89	4.06	1.49	20.88	20.80	4.06	1.49	49.52	144.1308	3.9145120	808.33	0.021	-0.055
32	17:41	49.5	143.902	143.785	20.70	20.84	4.07	1.49	20.81	20.81	4.06	1.49	49.52	143.8605	3.9172180	808.35	0.028	-0.053
reversed order of the transfer standards																		
25	11:13	49.2	142.202	142.074	20.51	20.62	4.07	1.53	20.63	20.56	4.08	1.52	49.19	142.1562	3.9357941	808.50	0.032	-0.058
26	11:23	49.2	142.031	141.911	20.46	20.54	4.08	1.53	20.64	20.49	4.07	1.52	49.17	141.9940	3.9383908	808.52	0.025	-0.058
27	11:34	49.2	142.316	142.193	20.44	20.55	4.08	1.53	20.60	20.49	4.08	1.52	49.17	142.2723	3.9404246	808.54	0.030	-0.056
28	11:46	49.2	142.456	142.328	20.42	20.55	4.08	1.53	20.58	20.47	4.08	1.53	49.17	142.4165	3.9417899	808.55	0.027	-0.061
29	11:57	49.2	142.462	142.352	20.46	20.56	4.08	1.53	20.64	20.47	4.08	1.53	49.16	142.4344	3.9389333	808.53	0.019	-0.058

NIST

50 kg/min

General		Meter 1 - MM upstream		Meter 2 - Kr.	IKS-SKID temperatures and pressures				Facility temperatures and pressures				Calculated values				Meter 1 MM	Meter 2 Kr
Test no.	Start time	Flow rate	Mass total	Mass total	T Upstream	T Downstream	P Upstream	P Downstream	T Upstream	T Downstream	P Upstream	P Downstream	Ref. flow rate	Reference mass	Viscosity Upstream	Density Upstream	Error mass	Error mass
[--]	[u:mm]	[kg/min]	[kg]	[kg]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[°C]	[°C]	[bar(g)][Pa^5(g)]	[bar(g)][Pa^5(g)]	[kg/min]	[kg]	[mm^2/s]	[kg/m^3]	[%]	[%]
5.01		50.1	33.501		21.95	22.01	2.59	0.82	22.02	22.18	3.59	1.55	50.05	33.4911		1004.09	0.030	
5.02		50.1	33.508						22.06	22.21	3.59	1.55	50.05	33.4985		1004.08	0.028	
5.03		50.1	33.498						22.10	22.24	3.59	1.55	50.05	33.4904		1004.07	0.023	
5.04		50.1	33.499						22.48	22.60	3.59	1.55	50.05	33.4872		1003.97	0.035	
5.05		50.1	33.505						22.51	22.63	3.59	1.55	50.05	33.4970		1003.96	0.024	
reversed order of the transfer standards																		
5.01		50.1	33.493		22.33	22.36	2.56	0.79	22.26	22.38	3.57	1.53	50.05	33.4860		1004.03	0.021	
5.02		50.1	33.507						22.28	22.41	3.57	1.53	50.05	33.4957		1004.02	0.034	
5.03		50.1	33.504						22.31	22.44	3.57	1.53	50.05	33.4951		1004.02	0.027	
5.04		50.1	33.512						22.41	22.53	3.57	1.53	50.04	33.5029		1003.99	0.027	
5.05		50.1	33.509						22.44	22.55	3.57	1.53	50.05	33.4987		1003.98	0.031	