EURAMET EM-K5

Key comparison of 50/60 Hz power

TECHNICAL PROTOCOL

Organizing laboratories: VSL – PTB – NPL – LNE

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1. INTRODUCTION

Committed to underpin the Mutual Recognition Arrangement as proposed by the Committee International of Weights and Measures, CIPM, a key comparison of 50/60 Hz of power standards is currently being organized under the auspices of the Consultative Committee of Electromagnetism, CCEM.

In order to link the National Metrology Institutes organised in EURAMET to the key comparison CCEM-K5, the EURAMET-EM-K5 is proposed.

This protocol has been prepared based on the protocol of the CCEM-K5 and following the EURAMET guide on Comparison N0. 4 Version 1.0 (05/2016).

VSL, PTB, NPL and LNE jointly coordinate the EURAMET comparison

- VSL and NPL are the pilot laboratories and in charge of the analysis and reporting task
- PTB and VSL will each supply one travelling standard
- PTB is in charge of the reference measurements
- LNE is in charge of the production and the monitoring of the schedule

2. TRAVELLING REFERENCE STANDARDS

2.1 Description of the reference standards

Two traveling reference standards, of the type RADIAN RD-22-332S, will be used in this key comparison. These standards have been adapted to measure active power at 120 V and 240 V and 5 A with outstanding stability in time.

VSL and PTB will provide the reference standards for this EURAMET key comparison.

- ✓ PTB provides the reference standard S/N 207172 that will be use for the loop 1
- ✓ VSL provides the reference standard S/N 208014 that will be use for the loop 2

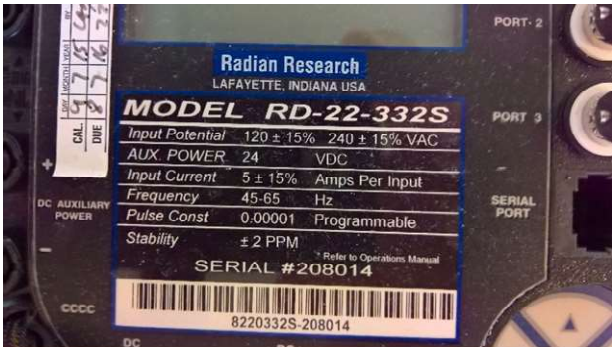

Figure 1: reference standard: RD-22-332S, serial number: 208 014

Figure 2: reference standard: RD-22-332S, serial number: 207 172

SPECIAL CONNECTIONS ON THE REFERENCE STANDARDS

24 V DC Power Supply:

The travelling standards should be powered using a 24 V DC power supply delivered with the standards. See Figure 4 for the location of the connections.

MAKE SURE that the voltage input selector of the 24 V DC power supply is set to the correct value – 120 V or 240 V – before connecting the power supply to the AC mains.

AC current measurements:

As shown in Figure 3, the reference standards have been fitted to provide high accuracy measurements of 5 A current. As shown in the picture below, a couple of posts out of the reference standard allow for the measurement of 5 A current. This allows for the connection of cables with either banana plugs or spades.

To ensure that the standard reference correctly measures the phase angle between the applied voltage and current, take post in red as the HIGH side of the 5 A current measurement circuit.

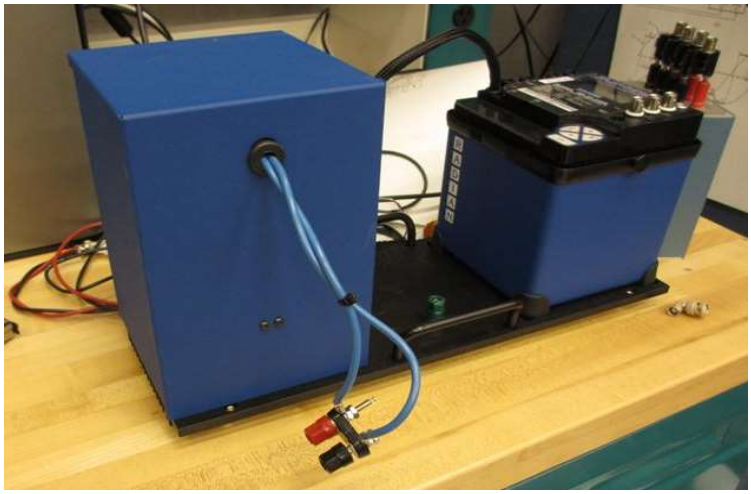

Figure 3. Special connection for current measurements on the reference standard

AC voltage measurements:

As shown in Figure 4, the V_{CA} input voltage of the reference standards are on the left-hand side of the panel of the references. Be aware of the connection of the auxiliary power input of 24 V DC, which is located below the V_{CA} posts.

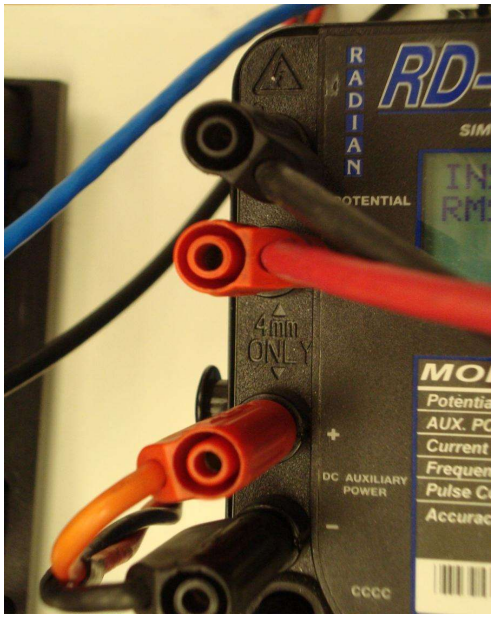

Figure 4: The V_{CA} input posts on the reference standards. The 24 V DC auxiliary power input is below the V_{CA} input posts

2.2 Measurement Quantity

The quantity to be reported is the calibration error of the travelling standard when measuring active power; the calibration error will be expressed in µW/VA.

The participating laboratory should report a single measurement result and its uncertainty for each of the testing points as given in Table 2.

Parameter	Value
RMS voltages	**120 V** **240 V**
RMS current	**5 A**
power factor	**1.0** **0.5 lead** **0.5 lag** **0 lead** **0 lag**
testing frequency	**53 Hz**
Total amount of testing points	**10**

Table 2. Testing points for the measurement of Active Power.

Notes:

1. The "lead" is defined as the current phase leading the voltage phase, and "lag" as the current phase lagging the voltage phase.
2. The measurement result to be reported is the calibration error of the travelling standard, defined as the difference between the measured quantity indicated by the travelling standard and the quantity applied to it, and divided by the nominal apparent power VA.
3. The error and uncertainty of the calibration should be expressed in terms of µW/VA.
4. The travelling standard should be de-energized between each set of measurements for 1 minute, followed by at least 15-minute warm-up period.
5. The total estimated expanded uncertainty quoted in the report shall encompass the Type A uncertainty and the Type B uncertainty of the corresponding NMI calibration system. The expanded uncertainty should be estimated for a level of confidence of 95.45 %.

2.3 Relevant parameters

The values of RMS voltage, RMS current, PF (power factor/phase angle) and frequency are relevant parameters to the 50/60 Hz key comparison power. As indicated in Annex A4 *Layout of the Measurement Report*, participants must record the mean value of voltage, current, PF (power factor/phase angle) and frequency for each of the testing points in Table 1. As shown in Annex A3 *Typical scheme of an uncertainty budget*, the participant laboratory must report all uncertainty sources pertinent to the measurement of power.

2.4 Software for data logging the power readings from the reference standards

EURAMET is grateful to Radian Research Inc. for supporting the CCEM-K5 key comparison of power for the provision of a software package that the participating laboratories may download.

Laboratories may download the following two ftp sites where versions of PC Suite software can be found.

Note that the first file 02.00.13 is for Microsoft XP, whereas version 04.00.04.zip is for Microsoft WIN 7 platform.

PC suit software	**platform**
www.radianresearch.com/upgrade/PC_Suite_4_00_20.zip	Microsoft WIN 7 or higher
www.radianresearch.com/upgrade/PCSuite_02_00_13.zip	Microsoft XP

2.5 The key comparison reference value and the degrees of equivalence

This protocol has been prepared based on the protocol of the CCEM-K5/2017 following the EURAMET guide on Comparison N0. 4 Version 1.0 (05/2016). The principles of the method of computation of the reference values are as follows.

The comparison will follow the data analysis method used during the last Key Comparison CCEM-K5 and EURAMET.EM-K5.1 and described in the document “Link Between CCEM-K5 and EURAMET.EM-K5” from March 2011.

2.6 Preparation of Drafts A and B of this key comparison.

As stated in the EURAMET guide on Comparison No. 4 Version 1.0 (05/2016), for this key comparison, the following information shall be considered in preparing Drafts A and B with the results of the comparison:

- individual values for each institute together with their declared uncertainties;
- the key comparison reference value with its associated uncertainty;
- for each institute, the deviation from the key comparison reference value and the uncertainty in that deviation (at a 95.45 % level of confidence), i.e. its degree of equivalence.

3. ORGANIZATION

3.1 Coordinator and members of the support group

The organization of the comparison is shared between four institutes: VSL, NPL, PTB, and LNE.
VSL with NPL are the pilot laboratories and in charge with the final report. PTB is performing multiple measurements during the comparison in order to determine the stability of the standards, and LNE is in charge with the schedule of the comparison, including the proposition of the technical protocol for EURAMET loop.

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3.2 Participants

(see also Annex A1 Detailed list of participants)

Participating NMI	Contact person	e-mail address
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3.3 Time Schedule

The comparison will be organized in two loops. Each loop has one travelling reference standard.
See Annex 2 for details of schedule of the measurements

3.4 EURAMET Toolbox

The EURAMET Toolbox will be used to follow and manage this comparison.
The adress is http://tssl.de/euramet
Information are available at https://tssl.de/euramet/keynote
Each participant will be registered by the Support group which is composed of VSL, PBT, NPL, LNE

3.5 "Door-to-door delivery scheme"

In order to reduce delay times at customs, the travelling standards shall be sent directly to the address of the following laboratory according to the schedule program given. Make sure that the address of the following laboratory is as given in Annex 1.

The standards will be provided with an individual rugged plastic container, suitable for shipping the standards on airplane. The standards and accompanying accessories, like connectors and 24 V DC power supply are to be transported inside the rugged plastic container.

The standards are packaged along with a temperature/humidity miniature logger. During measurements at the participant's laboratory, make sure that the logger remains on the top surface of the travelling standard, mainly close to the backlit LCD of the travelling standard, in order to log measurements of ambient temperature and humidity. There is no need for the participating laboratory trying to gain access to the logger; its contents will be downloaded at PTB in order to keep track of the changes of temperature or humidity which may have occurred during transportation or while staying at the participating laboratory.

IMPORTANT: In order to have the final time schedule of the comparison, all the participants should inform LNE whether they agree to send the travelling standard by a customs agency or may want to be responsible of a different way to transport the travelling standard.

The contact person of the participant laboratory must inform LNE of all the pertinent information when sending the travelling standards to the destine customs agency.

Costs involved with sending the travelling standard either to PTB or to the next participant, should be paid by the participant laboratory.

3.6 Unpacking, handling and packing

Unpacking:

1. Upon arrival, the participant laboratory must carefully inspect the travelling standard before it is removed from the plastic rugged container. In case of damage to the travelling standard, please take a photograph and send it to the pilot laboratory.
2. For removing the travelling standards from their containers, please refer below to the handling instructions.
3. Fill the *Confirmation note of receipt* (Annex A5) and send it to the pilot laboratory.

Handling:
Extreme care should be taken to remove the travelling standards out the rugged plastic container.

For removing the RD-22 from the container, the metal handlers located at both sides of its platform must be used.

Packing:

1. For packing the travelling standards, make sure that the travelling standard is comfortably put inside the container. For maneuvering the travelling standards, please refer to the above handling instructions.
2. **All accompanying accessories should be put inside the container**. Make sure that the **miniature data logger** is put along the standards in the container.
3. Inform the pilot laboratory of pertinent details regarding the clearance of customs, shipping and flights. If the travelling standards should be sent to another participant, make sure that both the recipient and the pilot laboratories are informed about travelling details.
4. Fill the *Confirmation note of shipment* (Annex A6) and send it to the pilot laboratory.

3.7 Failure of the travelling standard

In case of failure:

1. Unplug the travelling standard.
2. Write immediately to the pilot laboratory describing the behavior of the travelling standard. Send along any message displayed on the backlit LCD. Take photographs of the measuring system and of the connecting cables to the travelling standard.
3. Wait for instructions from the pilot laboratory on the way to proceed.

3.8 Financial aspects, insurance, customs

In every case, the participant laboratory should ensure that its organization covers insurance for any defect to the travelling standards while they are in its premises.

All the participants will be responsible for expenses related with sending the travelling standards either to the next participant or to the pilot laboratory.

4. MEASUREMENT INSTRUCTIONS

4.1 General instructions

There are no performance tests on the reference standard to be performed before measurements at the participant's laboratory.

4.2 Particular requirements for energizing and connecting the travelling standards

4.2.1 Energizing the reference standards at 24 V DC.

The reference standards are provided with a 24 V DC power supply, which shall be connected to the mains at either 120 V or 240 V, 45 Hz or 65 Hz.

Before connecting the 24 V DC power supply to the mains:

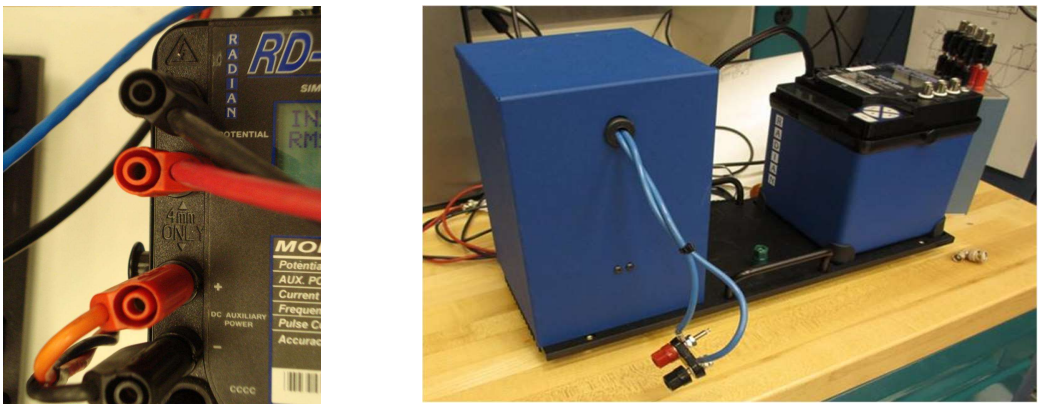
1. **MAKE SURE that the voltage input selector of the 24 V DC power supply is set to the correct value – 120 V or 240 V.**
2. Make sure that this supply is properly connected to the Auxiliary Power input port of the reference standard as shown in Figure 5.
3. Then, plug the 24 V DC power supply to the mains power.

The auxiliary power to the travelling standard should be applied at least 4 hours before starting the tests.

IMPORTANT: In order to achieve the best measurement capability of the travelling standard, allow it to warm up at least 4 hours at room temperature. Then, switch the reference standard off and on again. This action will set the internal DC voltage reference of the standard being corrected at its current internal temperature.

4.2.2 Connecting the reference standards

Make sure that the testing voltage and current sources are properly connected to the input terminals of the reference standard. Refer to Figure 5 for details.



V_{CA} input for 120 and 240 V
DC auxiliary power = 24 V DC

I_{CA} input for 5 A

Figure 5. Connecting the reference standard for V_{CA} = 120 V and 240 V, I_{CA} = 5 A, and auxiliary power of 24 V DC.

4.3 Method of measurement of active power

The measurement method is that used by the participating laboratory for the provision of a calibration. Make sure that testing voltage and current are within at least 0.2 % of the values shown in Table 1.

1. Upon arrival, allow the reference standard to warm up at least 4 hours after powering it with the 24 V DC power supply. Then switch the unit off and on in order for its internal DC voltage reference to correct according to its internal temperature.
2. For the voltage and current sources, make sure that their frequency is set at 53 Hz, according to the testing points shown in Table 1.
3. At every power factor/phase angle shown in Table 1, make as many independent measurements as stated on the calibration procedures of your laboratory.
4. Record the readings of active power, voltage, current, power factor/phase angle and frequency displayed on the backlit LCD of the travelling standard.
5. Calculate the calibration error of the travelling standard at the testing points shown in Table 1. The calibration error is defined as the difference between the measured quantity indicated by the reference standard and the quantity applied to it, and divided by the applied VA. The calibration error should be expressed in μW/VA for active power. The error is positive if the reference standard's indication is more positive than the applied quantity.
6. The average of at least five sets of measurements should be reported. The reference standard should be de-energized between each set of measurements for 1 minute, followed by at least 15 minute warm-up period.
7. The total estimated expanded uncertainty quoted in the laboratory's report should encompass the Type A and Type B uncertainties of the corresponding NMI calibration service. The expanded uncertainty should be estimated for a level of confidence of 95.45 %.
8. Report the mean value and spread of the ambient temperature and relative humidity of the laboratory.
9. The measurement report of the participant may be completed according to Annex A4 *Layout of the measurement report*.

5. UNCERTAINTY OF MEASUREMENT

(See Annex A3 *Typical scheme of uncertainty budget*)
The uncertainty of measurement must be determined following the Guide for the Expression of Uncertainty in Measurement [4].

Participant laboratories are requested to report the main uncertainty components of their measurement systems, identifying all the pertinent uncertainty sources and quantifying their contribution to the expanded uncertainty.

In order to have a comparable uncertainty evaluation, each laboratory is asked to report the following information in the form of an uncertainty budget:

i. The result of the type A method of uncertainty estimation which yields the standard deviation of the mean values of data sets recorded by the participant in order to calculate its final report value.
ii. The result of the type B method of uncertainty estimation.
iii. The expanded uncertainty estimated at a 95.45 % level of confidence.
iv. The degrees of freedom for the estimation of the expanded uncertainty at a 95.45 % level of confidence.

6. MEASUREMENT REPORT

(See Annex A4 *Layout of the measurement report* and the template Excel reporting file)
The participant laboratory should report the following information within 2 (two) months from the end of measurements:

1. The mean of the calibration error of the travelling standard. The calibration error should be expressed in terms of µW/VA.
2. The expanded uncertainty of the calibration error of the travelling standard should be estimated at a 95.45 % level of confidence. The expanded uncertainty should be expressed in terms of µW/VA.
3. The uncertainty components coming out from the Type A and B methods of uncertainty estimation of the calibration error of the travelling standard.
4. The mean value and standard uncertainty of the relevant parameters of the active power value, such as: RMS voltage, RMS current, power factor / phase angle, frequency. The standard uncertainty of the relevant parameters should be determined for a 95.45 % level of confidence (k = 2 for a normal distribution).
5. The final results for all 10 test points must also be reported using the Excel template file associated with the comparison.
6. Measurement uncertainty estimation shall comply with the Guide to the Expression of Uncertainty in Measurement [4].
7. A complete uncertainty budget and any additional information must be reported as shown in Annex A3.

All participants must report the results of the comparison to VSL as soon as possible, in every case, not later than 2 (two) months after the measurements are completed.

7. REFERENCES

1. N. Oldham, T. Nelson. R. Bergeest. G. Ramm, R. Carranza. A. C. Corney, M. Gibbes, G. Kyriazis, H. Laiz, L. Liu, Z. Lu, U. Pogliano, K. Rydler, E. Shapiro, E. So, M. Temba, and P. Wright, “An International Comparison of 50/60 Hz Power (1996-1999), IEEE Trans. Instr. and Meas., Vol. 50, Num. 2, pp. 356-360, Apr. 2001.
2. N. Oldham, T. Nelson, T. N. F. Zhang and H. K. Liu, “CCEM-K5 Comparison of 50/60 Hz Power. Final Report”, Metrologia 40, Technical Supplement 01003.
3. EURAMET guide on Comparison N0. 4 Version 1.0 (05/2016)
4. Link Between CCEM-K5 and EURAMET.EM-K5 - March 2011
5. Guide to the Expression of Uncertainty in Measurement, 1999. International Organization of Standards, Geneva, Switzerland. ISO ENV 13005:1999.

A1. DETAILED LIST OF PARTICIPANTS

The indicated NMI addresses are the shipping addresses.

NMI	Country	Contact person	Email Contact person	Adresse
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A2. SCHEDULE OF THE MEASUREMENTS

Table A.2.1. Circulation schedule of the reference standard

Loop 1 - Standard S/N 207172 - Provided by PTB

	NMI	Country	Planning			Accomplish		
			Start date Initial schedule	End date Initial schedule	Duration (calendar days)	Start date Updated	End date Updated	Duration (calendar days) Updated
Loop No. 1 Standard S/N 207172 Provided by PTB	PTB	Germany		*04/02/2019*				
	Transport from PTB to GUM		*04/02/2019*	*11/02/2019*	*7*	04/02/2019	04/02/2019	0
	GUM	Poland	*11/02/2019*	*11/03/2019*	*28*	04/02/2019	28/02/2019	24
	Transport from GUM to PTB		*11/03/2019*	*18/03/2019*	*7*	28/02/2019	04/03/2019	4
	PTB	Germany	*18/03/2019*	*18/03/2019*	*0*	04/03/2019	08/03/2019	4
	Transport from PTB to CMI		*18/03/2019*	*18/03/2019*	*0*	08/03/2019	15/03/2019	7
	CMI	Czech Republic	*18/03/2019*	*15/04/2019*	*28*	15/03/2019	16/04/2019	32
	Transport from CMI to SMU		*15/04/2019*	*22/04/2019*	*7*	16/04/2019	16/04/2019	0
	SMU	Slovakia	*22/04/2019*	*20/05/2019*	*28*	16/04/2019	22/05/2019	36
	Transport from SMU to BEV		*20/05/2019*	*27/05/2019*	*7*	22/05/2019	22/05/2019	0
	BEV	Austria	*27/05/2019*	*24/06/2019*	*28*	22/05/2019	24/06/2019	33
	Transport from BEV to INM		*24/06/2019*	*01/07/2019*	*7*	24/06/2019	26/06/2019	2
	INM	Romania	*01/07/2019*	*26/08/2019*	*56*	26/06/2019	26/08/2019	61
	Transport from INM to PTB		*26/08/2019*	*02/09/2019*	*7*	26/08/2019	29/08/2019	3
	PTB	Germany	*02/09/2019*	*30/09/2019*	*28*	29/08/2019	30/09/2019	32
	Transport from PTB to UME		*30/09/2019*	*14/10/2019*	*14*	30/09/2019	04/11/2019	35
	UME	Turkey	*14/10/2019*	*13/11/2019*	*28*	04/11/2019	15/11/2019	11
	Transport from UME to PTB		*14/11/2019*	*28/11/2019*	*14*	15/11/2019	02/12/2019	17
	PTB	*Germany*	*28/11/2019*	*28/11/2019*	*0*	02/12/2019	03/12/2019	1
	Transport from PTB to MIRS/SIQ		28/11/2019	05/12/2019	7	03/12/2019	06/12/2019	3
	MIRS/SIQ	Slovenia	05/12/2019	17/01/2020	43	06/12/2019	16/01/2020	41
	Transport from MIRS/SIQ to INRIM		17/01/2020	21/01/2020	4	16/01/2020	17/01/2020	1
	INRIM	Italy	21/01/2020	18/02/2020	28	17/01/2020	24/02/2020	38
	Transport from INRIM to BIM		18/02/2020	25/02/2020	7	24/02/2020	27/02/2020	3
	BIM	Bulgaria	25/02/2020	10/06/2020	106	27/02/2020	11/06/2020	105
	Transport from BIM to EIM		10/06/2020	17/06/2020	7	11/06/2020	12/06/2020	1
	EIM	Greece	17/06/2020	15/07/2020	28	12/06/2020	13/07/2020	31
	Transport from EIM to PTB		15/07/2020	22/07/2020	7	06/08/2020	07/08/2020	1
	PTB	Germany	22/07/2020	19/08/2020	28	10/08/2020	14/08/2020	4
	Transport from PTB to UMTS		19/08/2020	13/10/2020	55	14/08/2020		
	UMTS	Ukraine	13/10/2020	10/11/2020	28			
	Transport from UMTS to PTB		10/11/2020	24/11/2020	14			
	PTB	Germany	24/11/2020	22/12/2020	28			

Loop 2 - Standard S/N 208014 - Provided by VSL

	NMI	Country	Planning			Accomplish		
			Start date Initial schedule	End date Initial schedule	Duration (calendar days)	Start date Updated	End date Updated	Duration (calendar days) Updated
Loop No. 2 Standard S/N 208014 Provided by VSL	PTB	Germany		*04/02/2019*				
	Transport from PTB to TRESCAL		*04/02/2019*	*11/02/2019*	*7*	04/02/2019	05/02/2019	1
	TRESCAL	Denmark	*11/02/2019*	*11/03/2019*	*28*	05/02/2019	05/03/2019	28
	Transport from TRESCAL to PTB		*11/03/2019*	*18/03/2019*	*7*	05/03/2019	11/03/2019	6
	PTB	Germany	*18/03/2019*	*18/03/2019*	*0*	11/03/2019	14/03/2019	3
	Transport from PTB to RISE		*18/03/2019*	*18/03/2019*	*0*	14/03/2019	18/03/2019	4
	RISE	Sweden	*18/03/2019*	*15/04/2019*	*28*	18/03/2019	23/04/2019	36
	Transport from RISE to MIKES VTT		*15/04/2019*	*22/04/2019*	*7*	23/04/2019	24/04/2019	1
	MIKES VTT	Finland	*22/04/2019*	*20/05/2019*	*28*	24/04/2019	24/05/2019	30
	Transport from MIKES VTT to METROSERT		*20/05/2019*	*27/05/2019*	*7*	24/05/2019	27/05/2019	3
	METROSERT	Estonia	*27/05/2019*	*24/06/2019*	*28*	27/05/2019	21/06/2019	25
	Transport from METROSERT to VSL		*24/06/2019*	*01/07/2019*	*7*	21/06/2019	26/06/2019	5
	VSL	Netherlands	*01/07/2019*	*26/08/2019*	*56*	26/06/2019	26/08/2019	61
	Transport from VSL to PTB		*26/08/2019*	*02/09/2019*	*7*	26/08/2019	27/08/2019	1
	PTB	Germany	*02/09/2019*	*30/09/2019*	*28*	27/08/2019	30/09/2019	34
	Transport from PTB to VSL		*30/09/2019*	*14/10/2019*	*14*	30/09/2019	14/10/2019	14
	Transport from VSL to JV					16/10/2019	01/11/2019	16
	JV	Norway	*01/11/2019*	*29/11/2019*	*28*	01/11/2019	02/12/2019	31
	Transport from JV to VSL		29/11/2019	13/12/2019	14	04/12/2019	16/12/2019	12
	Transport from VSL to METAS		06/01/2020	13/01/2020	7	13/01/2020	13/01/2020	0
	METAS	Switzerland	13/01/2020	13/03/2020	28	13/01/2020	17/03/2020	64
	Transport from METAS to VSL		13/03/2020	27/03/2020	14	17/03/2020	18/03/2020	1
	VSL	*Netherlands*	*27/03/2020*	*27/03/2020*	*0*	18/03/2020	18/03/2020	0
	Transport from VSL to CEM		13/05/2020	*18/05/2020*	5	13/05/2020	18/05/2020	5
	CEM	Spain	18/05/2020	15/06/2020	28	18/05/2020	18/06/2020	31
	Transport from CEM to LNE		15/06/2020	22/06/2020	7	23/06/2020	26/06/2020	3
	LNE	France	22/06/2020	20/07/2020	28	26/06/2020	04/08/2020	39
	Transport from LNE to PTB		20/07/2020	03/08/2020	14	10/08/2020	17/08/2020	7
	PTB	Germany	03/08/2020	31/08/2020	28	18/08/2020	21/08/2020	3
	Transport from PTB to VSL		31/08/2020	07/09/2020	7	31/08/2020	03/09/2020	3
	Transport from VSL to NPL		07/09/2020	21/09/2020	14	03/09/2020	08/09/2020	5
	NPL	United Kingdom	21/09/2020	19/10/2020	28	08/09/2020		
	Transport from NPL to VSL		19/10/2020	02/11/2020	14			
	Transport from VSL to PTB		02/11/2020	09/11/2020	7			
	PTB	Germany	09/11/2020	07/12/2020	28			

A3. TYPICAL SCHEME OF AN UNCERTAINTY BUDGET

The uncertainty of measurement must be determined following the Guide for the Expression of Uncertainty in Measurement [4]. Information of the uncertainty of measurements must be provided in this form.

Participant laboratories are requested to report the main uncertainty components of their measurement systems, identifying all the pertinent uncertainty sources and quantifying their contribution to the expanded uncertainty.

In order to have a comparable uncertainty evaluation, each laboratory is asked to report the following information in the form of an uncertainty budget:

i. The result of the type A method of uncertainty estimation which yields the standard deviation of the mean values of data sets recorded by the participant in order to calculate its final report value.
ii. The result of the type B method of uncertainty estimation.
iii. The expanded uncertainty estimated at a 95.45 % level of confidence.
iv. The degrees of freedom for the estimation of the expanded uncertainty at a 95.45 % level of confidence.

Main uncertainty components y_i	Standard uncertainty $u(y_i)$	Type method A or B of evaluation/probability distribution function	Sensitivity coefficient c_i	Uncertainty contribution $u(R_i)$	Degrees of freedom n_i
1) Standard deviation of the calibration error of the travelling standard		Type A pdf: Normal			
2) uncertainty components of the reference standard of the participant					
3) Ambient conditions					
3.1) temperature 3.2) humidity					
Root square sum of Type A standard uncertainties and effective degrees of freedom					
Root square sum of Type B standard uncertainties and effective degrees of freedom					
Combined standard uncertainty and effective degrees of freedom					
Expanded uncertainty (95.45 % coverage factor)					

A4. LAYOUT OF THE MEASUREMENT REPORT

1. Identification of the travelling standard: RD-22
2. Identification of the participant laboratory and its representative
3. Measurement set-up and traceability scheme
4. Measurement procedure
5. Results:
   a. Mean value of the calibration error of reference standard at the active power values shown in Table 1, expressed in µW/VA.
   b. Expanded uncertainty estimated at a 95.45 % confidence level and the degrees of freedom of the calibration error of the travelling standard at active power.
   c. Mean value of the relevant parameters measured by the reference standard: voltage, current, power factor, frequency.
   d. Mean date of measurement.
   e. Ambient conditions: mean value and spread of temperature and humidity measurements.

   These measurement results must (also) be reported using the template xls file that comes with this protocol
6. Detailed uncertainty budget as in *Annex 3*.
7. Report the date and time when the reference standard is de-energized and energized.
8. Signature and title of the laboratory representative.

A5. CONFIRMATION NOTE OF RECEIPT

To:
Daniela Istrate and Pierre-Jean Janin, daniela.istrate@lne.fr ; pierre-jean.janin@lne.fr
LNE, France

CC: ……
(previous participating laboratory)

From: …….
(participating laboratory)

Re: EURAMET-K5 Receipt of travelling standard (identification of the travelling standard: RD-22

We confirm having received the travelling standard of the EURAMET-K5 key comparison 50/60 Hz power on (date)….

After visual inspection:

No damage of the transport package and the travelling standard has been noticed.

Or

The following damage(s) are reported. In such a case, please add pictures of damages.

Date: ……..

A6. CONFIRMATION NOTE OF SHIPMENT

To:
Daniela Istrate and Pierre-Jean Janin, daniela.istrate@lne.fr ; pierre-jean.janin@lne.fr
LNE, France

CC: ……
(next participating laboratory)

From: ……..
(participating laboratory)

Re: EURAMET -K5 Dispatch of travelling standard (identification of the travelling standard: RD-22)

We confirm having shipped the travelling standard of the EURAMET -K5 key comparison 50/60 Hz power on (date)…. to the following address**:**

a) if the travelling standard will be sent to the pilot laboratory:
PTB Braunschweig
Kristian Dauke
Working Group 2.33
Bundesallee 100
38116 Braunschweig
Germany

b) if the travelling standard will be sent to another participant laboratory**:**
Shipping address of the next participant (see Annex 1)

We confirm that we have included in both shipping containers, the accessories:
- ☐ 24 DC power supply
- ☐ Cable for PC read out of the RD22
- ☐ Datalogger for temperature / humidity

In any case, add the following information:

- flight number,
- airline,
- estimated time of arrival,
- air bill number and
- any other pertinent information about the shipment

Date: ……..