MINUTES OF THE 14TH MEETING OF THE CCEM WORKING GROUP ON LOW FREQUENCY QUANTITIES (WGLF)

Wednesday, 22 March 2017, 9:00 -13:00

BIPM Sèvres, France

The Working Group on Low Frequency Quantities (WGLF) of the Consultative Committee for Electricity and Magnetism (CCEM) held its fourteenth meeting on 22 March 2017 at the Bureau International des Poids et Mesures, Pavillon de Breteuil, Sèvres, France.

The list of attendees is given below:
Dr Marc-Olivier André (METAS)
Dr David Aviles-Castro (CENAM)
Mr Jon Bartholomew (EMI)
Dr Vittorio Basso (INRIM)
Dr Ilya Budovsky (NMIA, Chairman of the WGRMO)
Dr Luca Callegaro (INRIM)
Dr Mustafa Cetintas (UME)
Dr Sze Wey Chua (NMC-A*STAR)
Dr Lucas Di Lillo (INTI)
Dr Murray Early (MSL)
Dr Mohammed Abd El-Raouf (NIS)
Mr Nick Fletcher (BIPM)
Dr Eugène Golovins (NMISA)
Dr Pierre Gournay (BIPM)
Dr Ghislain Granger (NRC)
Dr Gleb Gubler (VNIIM)
Dr Daniela Istrate (LNE)
Dr Nobuhisa Kaneko (NMIJ/AIST)
Dr No-Weon Kang (KRISS)
Dr Alexander Katkov (VNIIM)
Dr Gregory Kyriazis (INMETRO)
Dr Hyung-Kew Lee (KRISS)
Dr Helge Malmbekk (JV)
Dr Antti Manninen (VTT MIKES)
Mr Alexander Matlejoane (NMISA)
Dr Jürgen Melcher (PTB)
Dr Thomas Nelson (NIST)
Dr Vijay Narain Ohja (NPLI)
Dr François Piquemal (LNE)
Dr He Qing (NIM)
Dr Gerrit Rietveld (VSL, President of the CCEM)
Dr Carlos Sanchez (NRC)
Dr Bernd Schumacher (PTB)
Dr Haiming Shao (NIM)
Dr Uwe Siegner (PTB)
Dr Michael Stock (BIPM, Executive Secretary of the CCEM)
Mr Jiri Streit (CMI)
Dr Valter Tarasso [RISE]
Dr Anton Widarta (NMIJ/AIST)
Prof Jonathan Williams (NPL, Chairman of the WGLF)
Dr Aaron (Yui Kuen) Yan (SCL).

1. MINUTES AND ACTIONS OF THE LAST MEETING, APPROVAL OF THE AGENDA

The 14th meeting of the CCEM Working Group on Low Frequency Quantities (WGLF) was held on 22 March 2017 at 9:00, with Prof Williams as the chair.

The Chairman welcomed the participants to the meeting. All participants briefly introduced themselves. Mr Bartholomew was appointed rapporteur.

The agenda was published as working document CCEM-WGLF/17-01. The draft agenda was adopted without changes.

The previous (13th) meeting of the WGLF was held at the BIPM in 2015. There were no comments on the minutes. The minutes prepared by Dr Luca Callegaro for the 13th meeting (see working document CCEM-WGLF/17-02) were adopted.

2. REVIEW OF CURRENT AND RECENTLY COMPLETED CCEM COMPARISONS

Four ongoing CCEM comparisons were discussed at the meeting.

a. CCEM-K2: DC resistance, 10 MΩ and 1 GΩ, pilot NRC

Dr Sanchez (NRC, pilot laboratory) reported on the present status of the CCEM-K2 comparison (see working document CCEM-WGLF/17-10). There had been some delays but the measurements are complete. The reports were still awaited from some laboratories. There were some issues with the behaviour of the travelling standards, particularly at 10 MΩ, so it is not yet clear how best to evaluate the data. The draft A report is expected in June 2017.

b. CCEM-K5: primary power, pilot CENAM, PTB, VSL

Dr Rietveld (VSL, pilot laboratory) reported on the comparison (see working document WGLF/17-09). The comparison pilot activity is shared between three NMIs (CENAM, organization; PTB, characterizing the travelling standard and multiple measurements during circulation; VSL, data processing and reporting).

There has been a problem with one travelling standard instrument (Radian Research RD22) which has delayed the start of the intercomparison. The travelling standard used in the SIM.EM-K5 intercomparison may be used as a replacement. The pilot laboratories will be contacting the participants in the SIM loop to confirm rescheduled dates with a delay of around six months.

Dr Budovsky commented that VNIIM are part of COOMET not APMP as shown in the presentation.

c. CCEM-K13: harmonics of voltage and current, pilot NIM, NRC, NIST, NPL, RISE

Dr Tarasso (RISE, pilot laboratory) reported on the comparison. (See working document WGLF/17-06). The support group includes NIST, NRC, RISE, NPL, and NIM. NRC has prepared a draft technical protocol and the final protocol will be made together with SP. NIM provides and characterizes the travelling standard and also monitors its stability during the circulation. RISE coordinates and will organize the circulation of the traveling standard. NIST has investigated the loading effect and found it to be negligible. NPL will analyze reported results and write the comparison report.

The circulation of the travelling standard will be made in three rounds, first to SIM, then to EURAMET and finally to COOMET with measurements at NIM in between. Fluke are modifying the travelling standards with a 10 MHz output and the circulation is expected to start after summer.

The comparison will call for the measurement of three sets of waveforms at a frequency of 53 Hz.

1. Sinusoidal waveform conditions of voltage and current of 120 V, 5 A, PF=1.
2. IEC signals (see IEC62053-21) of fundamental voltage plus 5th harmonic 10%, and fundamental current plus 5th harmonic 40%.
3. A field recorded waveform.

Dr Budovsky commented that APMP were underrepresented and that NMIA would like to participate as they are developing a new method for these measurements. The Chairman agreed that NMIA should join the intercomparison.

ACTION 1: RISE to add NMIA to the intercomparison CCEM-K13.

There was some discussion of the title of the comparison, the intercomparison is sometimes referred to as harmonic power or power harmonics, and there was some debate of what this means. Dr Rietveld confirmed that the correct title as given on the agenda is harmonics of voltage and current.

Dr Budovsky informed the meeting that the phase of current harmonics is of interest to industry. IEC Subcommittee SC77A is presently considering a revision of the standard *IEC 61000-3-2: Electromagnetic compatibility (EMC) - Part 3-2: Limits - Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)* to include limits on harmonic phases of emission currents produced by lighting equipment. The measurements of harmonic phases to test compliance with the above standard will require traceability that will be ultimately supported by the CCEM-K13 comparison.

d. CCEM-K4 capacitance, 10 pF (optional 100 pF), Pilot BIPM

Dr Gournay (BIPM, pilot laboratory) reported on the comparison (see working document WGLF/17-11).

A first version of the comparison protocol was written and the invitations to participate were dispatched in early 2016. By mid-2016, the list of the participating institutes was complete and the protocol finalized, with a starting date set in March 2017 in order to allow the completion of the comparison EURAMET.EM-S31. Measurements started at the beginning of March 2017. Eight institutes have requested to be participants in the comparison. NIST, and BIPM, which compose the task force for the organization of the comparison and METAS, NIM, NMIA, NPL, PTB, VNIIM.

The mandatory measurand is a 10 pF capacitance value measured at a frequency of 1592 Hz and a voltage of 100 V. At 10 pF an optional frequency value of 1233 Hz has been added for institutes running their quadrature bridge only at this frequency. An optional capacitance value of 100 pF has been added to offer to the participating institutes the possibility to compare their 10 to 1 scaling ratio; this measurand is defined as for the 10 pF capacitance value and measured at the same frequency, but at 10 V.

The comparison has been organized as a large-scale star of simultaneous bilaterals. This should be faster and more robust against transport problems.

The capacitance measurements will be reported in SI units, so for institutes whose traceability is based on a QHR, the last CODATA value of R_K must be used instead of $R_{K\text{-}90}$. The Key Comparison Reference Value will be evaluated from the results of all the participants.

The Chairman gave special thanks to BIPM for taking on this comparison scheme which has a lot of measurements for them to do. This is the first time this comparison scheme has been tried in EM and it will be interesting to see how well the method works. Dr Stock said that BIPM uses this scheme successfully in other areas, but the success of the approach depends on the discipline of the participants to keep to the schedule.

Dr Callegaro asked if the subsequent RMO comparisons would follow the same scheme. The Chairman said that although there was an understanding that the RMOs will run linked comparisons there was no commitment for the RMO to run the intercomparison using the same scheme.

3. NEW CCEM COMPARISONS

a. Update on plans for CCEM-K6.a and -K9: AC-DC transfer

Dr Tarasso (RISE, pilot laboratory) reported on the comparison (see working document WGLF/17-07).

This comparison will cover AC/DC voltage transfer at 1 V – 4 V, 10 Hz – 1 MHz and 500 V, 10 Hz – 100 kHz. The comparison is expected to start at the end of 2017.

NIST has offered to provide the travelling standards. RISE will prepare the technical protocol and organize the circulation of the traveling standard, PTB will characterize the travelling standards and monitor its stability during the circulation and INTI will analyze the reported results and write the comparison report.

Participants that have expressed an interest so far: RISE, INTI, PTB, NMIA, NRC, JV, NMIJ, NIM, LNE, NMISA.

Dr Tarasso asked if he need to send out a formal invitation to NMIs to participate. The Chairman said this is not necessary in this case as we already have sufficient expressions of interest.

Dr Kyriazis said that INMETRO would like to take part. The Chairman said that in principle WGLF asked for two participants from each RMO, but that additional laboratories could be included as long as this did not cause the intercomparison to become too large.

ACTION 2: RISE to add INMETRO to the intercomparison CCEM-K6.a/K9.

Dr Budovsky said CCEM-K9 had been limited to a nominal value of 500 V because of the difficulty in finding supplies for 1 kV measurements. However he said that the step from 500 V to 1 kV is difficult because the voltage coefficient can be significant. Although measuring at 1 kV over the frequency range may be difficult, many laboratories should be able to measure over a restricted frequency range.

ACTION 3: The participants of CCEM-K6.a/K9 to discuss including an optional 1 kV measurement and define the frequencies to be measured.

The Chairman said that it would be good to include a link to the recent COOMET comparison of K6. Dr Katkov said that VNIIM had been on a previous list of participants.

ACTION 4: RISE to contact VNIIM and ask them to participate, for K6 and if possible K9

c. Outlook on future comparisons in the context of the CCEM strategy

The Chairman presented a time chart of the finished, ongoing and planned CCEM comparisons. Any proposal for future comparisons has to be submitted to the CCEM for approval. CCEM comparisons will cover the key quantities, with the RMO supplementary comparisons providing coverage for the derived quantities.

As was agreed last time with respect to the key quantity DC voltage, the regional equivalence is well maintained by the BIPM ongoing comparisons (BIPM.EM-K10 and K11). There is no need for a new CCEM key comparison for this quantity.

With regard to DC resistance the 100 Ω key comparison was no longer required as it was adequately covered by the BIPM on-site QHR comparison (BIPM.EM-K12). The 1 Ω to 10 kΩ range was covered by the BIPM ongoing comparisons (BIPM.EM-K12 and K13). The 10 MΩ and 1 GΩ comparison had been run twice since 1998 and therefore the Chairman suggested that this area was adequately covered.

The Chairman said capacitance is addressed thorough the BIPM ongoing intercomparison in capacitance (BIPM.EM-K14) and CCEM-K4. The Chairman pointed out that the last WGLF meeting discussed a possible intercomparison in inductance, and asked the meeting if there was any interest in this quantity. Dr Siegner said that PTB have developed suitable standards for a new K3 intercomparison and could make available two 10 mH standards with temperature control. Delegates from the PTB, NIST, NPL, VSL, NRC, INMETRO, NMISA, CENAM, KRISS, and NMIA expressed an interest in participating in the comparison. Measurements would be made at 1 kHz. The Chairman pointed out that COOMET has just finished a K3 comparison so there would need to be a link to that; VNIIM also therefore agreed to take part. PTB are willing to be the pilot laboratory if they are supported by two further NMIs to coordinate, analyze the results, and write up the comparison report. PTB will characterize the travelling standards and monitor their stability during the circulation. (Post meeting note: the proposal for a new K3 comparison, as discussed at the 2015 WGLF meeting, was already approved to go ahead by the CCEM in 2015. Target start date for the comparison is 2018-19.)

ACTION 5: The Chairman will follow up with an email to find out who would like to be included in the inductance comparison. The NMIs' reply should state the wish to participate, the relevant uncertainty and if they would be able to support further RMO comparisons.

Dr Budovsky commented on the DC voltage ratio comparison that was subsequently discussed. He said that little has changed since the last comparison and questioned whether there was really a need to repeat the intercomparison. The Chairman replied saying that the question of why we should repeat a comparison is important, for instance is there increased demand for the measurement, or have the techniques and/or people changed. Dr Callegaro said that the previous intercomparison was limited by the transfer device. He suggested a purpose-built device with fixed ratios might be more stable. Dr Rietveld said that the voltage/power effect was important. In the last comparison many laboratories had measured the resistance ratio at low voltage and this may not really evaluate their capability for voltage ratio at 1 kV. Dr Budovsky suggested that maybe this could be dealt with by RMO comparisons using a specially constructed transfer instrument with one or two ratios.

Dr Callegaro said that the results of the last AC voltage ratio comparison had been good and the transformers were very stable. The comparison results were far better than typical declared CMCs in this area so it was agreed that this quantity is secure for the time being.

The Chairman highlighted that there are many AC/DC quantities, but no comparison of AC current has occurred for more than 10 years. Dr Budovsky said that the RMO intercomparisons were still in progress and this therefore was not yet necessary. He suggested it may be necessary to repeat in five years' time. Dr Golovins said there were five comparisons in the strategy: K6a and K9 was planned, and K12 had been discussed but that left low voltages. He suggested running a low voltage K11 intercomparison with the K12 comparison. Dr Budovsky agreed that the low voltage K11 comparison would probably be needed again as there has been a radical change from using micropotentiometers to AC voltages synthesized from Josephson voltages. The Chairman asked the timescale for this intercomparison. After some discussion the Chairman proposed that this should be revisited at the next WGLF in two years' time when there should be more information on the maturity of the new techniques. The K12 intercomparison should also be revisited at the next meeting.

Dr Rietveld asked if a repeat of the comparison K6c at high frequency was required. A number of laboratories have stopped this measurement and there seems to be less demand in industry. There are still

some laboratories providing this service so there may be support for a comparison. Dr Rietveld suggested that maybe this could be an RMO comparison with worldwide participation rather than a CCEM comparison.

ACTION 6: The Chairman will follow up with an email to find out the need for an intercomparison of AC/DC voltage transfer at high frequencies, which laboratories have this capability, and which laboratories could support this intercomparison.

The Chairman asked if comparisons are required in magnetism. Dr Basso said that EURAMET had proposed an intercomparison of flux density using a travelling NMR magnetometer, however no NMI could provide a magnetometer so the comparison had been cancelled. The Chairman asked if other RMOs had any activity in this area. Dr Early said there were some labs in APMP with measurement capabilities in magnetism. The Chairman concluded he was not getting a strong indication of the need for an intercomparison in this area at the moment.

4. REVIEW OF ONGOING BIPM COMPARISONS (M. STOCK)

Dr Stock presented working document WGLF/17-12 detailing the ongoing comparisons involving the BIPM; summarized as follows:

BIPM.EM-K10.b	10 V Josephson comparison; about two per year. DMDM and NIMT completed in 2015. No satisfactory result at JV in 2016. No comparisons planned for 2017, to allow BIPM to concentrate on AC measurements.
BIPM.EM-K10.a	1.018 V Josephson comparison. No further comparisons performed.
BIPM.EM-K11	1.018, 10 V bilateral comparison with Zeners as transfer standards; 2-3 per year. Considered also as a preparation for a Josephson comparison. Comparisons with JV, NSAI and DEFNAT since the last meeting. NMISA planned for 2017.
BIPM.EM-K12	quantum Hall resistance comparison. No publishable result from comparison at VSL, comparison at METAS postponed. Measurements at CMI planned for April 2017.
BIPM.EM-K13.a/b	(1 Ω, 10 kΩ): about two per year. Comparisons with NIMT, CMI, SMD since the last meeting.
BIPM-K14.a/b	10 pF and 100 pF bilateral. Comparisons with NIS, NMISA and NSAI since the last meeting.

BIPM are also the pilot laboratory for CCEM-K4 and are participating in EURAMET.EM-S31 and GULFMET.EM.BIPM-K11

Dr Stock reported on the first trial of an AC Josephson voltage comparison, at CENAM. This will be followed in 2017 by comparisons with NPL and PTB. A secondment from KRISS is planned starting in September 2017 to develop this further. Dr Stock asked if there would be interest in a future calibration service for AC/DC transfer standards using AC Josephson voltage standards (ACJVS).

Dr Budovsky said this was a complex question as AC/DC transfer standards are currently the start of the traceability chain as they provide better stability and uncertainty than AC meters, but there is a large technical difference between a system to compare ACJVS and a system to calibrate AC/DC transfer

standards. The Chairman asked what was the quantity to be measured, AC voltage for quantum systems or AC/DC difference? He proposed waiting for two years to see how the field develops.

Dr Stock continued the presentation by showing slides on the number of calibrations performed by the BIPM: about 2-3 per year for solid-state Zener dc voltage standards, about 25-30 per year for dc resistance standards and capacitance standards.

Dr Stock said that some dependence between 1 Ω values and the cycle time of the bridge had been reported and given this it might be better to replace 1 Ω comparisons and calibrations by a higher value and, if so, which value would be suitable (1 MΩ)?

Dr Sanchez said they still made several calibrations a year at 1 Ω, so there was a need for a comparison. He suggested thin film resistors might have better performance for comparisons but this would not change the situation for calibrations. Dr Stock suggested the report on the 10 MΩ and 1 GΩ CCEM-K2 comparison might also inform this decision.

Dr Stock summarized the future BIPM research plans which includes development of more versatile and more efficient quantum standards: ACJVS for comparison of AC voltages; table-top QHR system using graphene samples and new LFCCs at room temperature; ACQHR as impedance standard.

Dr Rietveld said that the new BIPM work program will start in 2019 and asked the members to give further thought to what the future BIPM activities should be.

5. REVIEW OF CURRENT AND RECENTLY COMPLETED RMO COMPARISONS – SUMMARY OF IMPORTANT ASPECTS AND CONCLUSIONS (RMO TCEM CHAIRS)

AFRIMETS

Mr Matlejoane presented document WGLF/17-04, which showed the comparisons ongoing and planned within AFRIMETS. The only ongoing comparison in the low-frequency field is AFRIMETS.EM-S1, DC resistance at 1 Ω, 10 Ω, 100 Ω , 1 kΩ and 10 kΩ.

Mr Matlejoane informed the meeting of the other activities within AFRIMETS.

APMP

Dr Early presented working document WGLF/17-08, which gave details of the comparisons performed within APMP. A short summary is given here:

- Comparisons with completed circulation of the standards: APMP.EM.BIPM-K11.3, DC voltage, Zener diode; APMP.EM-S8, Comparison on digital multimeter; APMP.EM-K2, Comparison of resistance standards; APMP.EM-K5.1, AC power at 50 Hz/60 Hz; APMP.EM-K12, Comparison of AC/DC current transfer standards; APMP.EM.BIPM-K11.5, DC voltage, Zener diode; APMP.EM-S12, DMM meter.
- Approved comparisons: Bilateral comparison of capacitance between NPLI and NIM.
- Comparisons being planned: DC resistance 1 Ω and 10 kΩ; Bilateral comparison of high-voltage transformers with PTB and NMIA; Supplementary comparison, DC current 3000 A; Pilot study on 100 Ω resistance standards.

The Chairman commented that APMP.EM-K5.1 will complete before CCEM-K5. He said it would be good to consider adding an Annex to link to the new CCEM-K5 KCRV once this is published.

COOMET

Dr Katkov presented working document WGLF/17-13, which highlighted the comparisons performed within COOMET. A short summary is given here:

- Completed comparisons: COOMET.EM-S14, inductance; COOMET.EM-K6.a, AC/DC voltage transfer; COOMET.EM-K4 and COOMET.EM-S4, capacitance; COOMET.EM-S6, AC high voltage; COOMET.EM-S7, DC high voltage; COOMET.EM-S8, inductance up to 10 MHz; COOMET.EM-S10, AC high voltage; COOMET.EM.BIPM-K10.b, DC Voltage; COOMET.EM-S13, capacitance; COOMET.EM-S2, power and power factor.
- Ongoing comparisons: COOMET.EM-K5, power at 50/60 Hz; COOMET.EM-S20, bilateral comparison of 1.018 V and 10 V Zener DC; COOMET.EM-S18, capacitance and loss factor on AC high voltage.
- Agreed comparisons: 681/RU-a/16, current transformers; COOMET.EM-S19, comparison of electrical resistance standards at 100 Ω.
- Proposed comparisons: 710/RU/16, impulse voltage; 709/RU/16, harmonic distortion; 707/RU/16, switching impulse from 1 to 100 kV; 683/RU/16, pulse current from 1 up to 100 kA; 682/RU/16, pulse electric and magnetic fields from 20 ps up to 10 ns.
- Excluded comparisons: COOMET.EM-S16, pulse electric and magnetic fields in ultrawide band short pulse range; 409/UA-a/07, impulse electric and magnetic fields.

EURAMET

Dr Callegaro gave a presentation on the comparisons performed within EURAMET. See working document WGLF/17-14; a short summary is given here:

- Completed comparisons: EURAMET.EM-S38, ultra-low current sources; EURAMET.EM-S39, AC-DC current transfer.
- Comparisons approaching completion: EURAMET.EM-K12, AC/DC transfer; EURAMET.EM.M-S2, polarization and specific total power loss in soft magnetic materials; EURAMET.EM-S33, AC high voltage; EURAMET.EM-S31, capacitance and capacitance ratio; EURAMET.EM-S34, capacitance and loss factor up to 200 kV; EURAMET.EM-S40, resistance; EURAMET EM-37, current transformers.
- Ongoing comparisons: EURAMET.EM-S35, high DC current; EURAMET.EM-S36, partial discharge, apparent charge etc; Project 1341, multimeter; EURAMET.EM-S42, lighting impulse voltage.
- New comparisons: EURAMET.EM-K5.2015, expected to start early 2017.

Dr Callegaro introduced the EURAMET Guide on CMCs (EURAMET Guide 3) and EURAMET Guide on Comparisons (EURAMET Guide 4). He also provided some information on the Comparison Toolbox that EURAMET is developing, a web-based tool for managing comparisons.

GULFMET

Mr Bartholomew presented an introduction to GULFMET the new provisional RMO covering the GCC countries and Yemen. See working document WGLF/17-15; a short summary is given here:

- Ongoing comparisons: GULFMET.EM-S1, DC Resistance 100 Ω; GULFMET.EM-S2, AC Power at 50/60 Hz; GULFMET.EM-S3, AC/DC voltage transfer standards.
- Planned comparisons: GULFMET.EM.BIPM-K11, DC voltage, Zener diode; expected to start summer 2017.

Mr Bartholomew thanked the GULFMET Associate Members and BIPM without whose participation GULFMET comparisons would not be credible.

SIM

Dr Kyriazis presented working document WGLF/17-05, detailing the comparisons performed within SIM. A short summary is given here:

- Completed key comparisons (SIM.EM-K4, capacitance; SIM.EM-K4.1, capacitance; SIM.EM-K9.1, AC/DC voltage transfer; SIM.EM-K5, AC power at 50/60 Hz; SIM.EM-K12, AC/DC current transfer; SIM.EM-K3, inductors.
- Completed supplementary comparisons (SIM.EM-S3, capacitance; SIM.EM-S4, capacitance; SIM.EM-S4.1, capacitance; SIM.EM-S5, voltage current and resistance; SIM.EM-S9.b, DC resistance; SIM.EM-S10, high resistance; SIM.EM-S11, high resistance.
- Two ongoing supplementary comparisons (SIM.EM-S8, current Transformer; SIM.EM-S13, voltage current and resistance.
- Two new supplementary comparisons in harmonics and voltage ratio standards.

Dr Kyriazis reported on the SIM technical meetings and the training and development events that occurred in 2013 and 2014, and the CMC review process within SIM.

6. DISCUSSION OF WGRMO PROPOSALS ON REVISED CMC CATEGORIES #8 AND #9

Dr Rietveld presented the proposed changes to CMC categories 8 and 9 (see also working document WGLF/17-16), and summarized the discussions held at the WGRMO. A working group had been tasked to produce this proposal because the terminology used in categories 8 and 9 was not recognized by industry. The working group plans to finalize the descriptions, propose the changes for the NMIs which have CMCs in these categories and update all of the categories on the KCDB. The working group requested permission to add some extra categories which was agreed by WGRMO and therefore the final draft will be submitted in a month. The draft will be circulated to WGLF and WGRMO. Comments are welcome and should be sent to Dr Budovsky, the WGRMO chair. The final document and recommendations will be submitted to the WGLF for approval.

7. UPDATE of the CCEM GUIDELINES ON COMPARISONS

Dr Stock has updated the CCEM guidelines on comparisons as working document WGLF/17-03. The previous version dated from 2007. There are no fundamental changes but references have been updated and the procedure has been clarified. All changes are shown in “track changes” mode.

ACTION 7: WGLF members to send any comments on the revised CCEM comparison guidelines to Dr. Stock and the WGLF Chairman by 19 April 2017.

8. MEMBERSHIP OF WGLF

Dr Rietveld informed the meeting that MIKES has asked to join the working group. Members are appointed by the President of the CCEM, in consultation with the WGLF chairperson. The Chairman said he thought there were good reasons to have MIKES as a member, given their large range of DCLF activities in the past decades. There were no comments from the meeting, so Dr Rietveld said that he would report that MIKES were accepted as a member of WGLF at the CCEM meeting.

9. ANY OTHER BUSINESS

Dr Callegaro had earlier presented the EURAMET guidelines on comparisons. Dr Early asked if there were exemplar reports that could be used to help produce Draft A reports. The Chairman said that comparison reports he received from RMOs had no standard format. Dr Callegaro said that although the EURAMET comparison task force was focused on developing the comparison toolbox they have some draft protocols and Draft A reports which he would give as input to the discussion. Dr Early said such templates would ease the job of the pilot laboratory.

ACTION 8: The Chairman to work with EURAMET to prepare templates for comparison reports.

Dr Nelson said that NIST had received an enquiry relating to the measurement of DC power for charging of electric vehicles. Dr Nelson said that NIST did not have this capability and enquired if any other laboratories had this capability. The range to be covered was 50 V to 500 V and 0.5 A to 200 A, in principle to a measurement uncertainty of 0.04 %. Dr Qing said that NIM were developing a standard for DC power measurements related to electrical vehicles. He explained that this is not a steady state measurement and is not simple to measure. Dr Rietveld suggested that the calibration could perhaps be made in a steady state. Dr Budovsky agreed but said that it would need to be a fast DC measurement for this to work. Dr Gubler said that VNIIM had a standard but the uncertainty was around 0.2 %. The Chairman asked if there are meters for this application. Dr Nelson said the approach to NIST had been from a company looking to develop such a meter. The Chairman asked if someone would write a short paper on what is available.

ACTION 9: Dr Nelson and Dr Qing to work together to provide a short paper on this subject (DC power measurement requirements related to charging of electrical vehicles).

10. DATE OF THE NEXT MEETING

An informal meeting of the working group to review the progress on comparisons will take place as a satellite meeting of the next Conference on Precision Electromagnetic Measurements (CPEM) to be held in Paris, France, in July 2018. The next formal WGLF meeting will be at BIPM in 2019.

The Chairman closed the meeting at 13:00 on 22 March 2017.

List of actions

Action 1: RISE to add NMIA to the intercomparison CCEM-K13.

Action 2: RISE to add INMETRO to the intercomparison CCEM-K6.a/K9.

Action 3: The participants of CCEM-K6.a/K9 to discuss including an optional 1 kV measurement and define the frequencies to be measured.

Action 4: RISE to contact VNIIM and ask them to participate, for K6 and if possible K9.

Action 5: The Chairman will follow up with an email to find out who would like to be included in the inductance comparison. Please reply stating if you wish to participate, the relevant uncertainty and if you would be able to support further RMO comparisons.

Action 6: The Chairman will follow up with an email to find out the need for an intercomparison of AC/DC voltage transfer at high frequencies, which laboratories had this capability, and which laboratories could support this intercomparison.

Action 7: Please send any comments on revised CCEM comparison guidelines to Dr. Stock and the Chairman by 19 April 2017.

Action 8: The Chairman to work with EURAMET to prepare templates for comparison reports.

Action 9: Dr Nelson and Dr Qing to work together to provide a short paper on this subject (charging of electrical vehicles).