

1. General Aspects

The EURAMET Mass and Related Quantities Technical Committee, TC-M, is characterized by the mass and a number of related quantities and by a diversity of techniques employed in the realization of the corresponding units. Nevertheless, there are two dominant issues, one is the redefinition of the kilogram, which has definitely i the activities of some NMIs and is reflected in EURAMET projects, and the other one is the EMRP/EMPIR, where many institutes are collaborating very actively.

2. Projects

The actual number of proposed, agreed and completed projects listed for TC-M in the EURAMET Projects database is shown in the table below. The projects are divided by category. . Numbers in brackets were for last year.

	Comparison	Research	Traceability	Consultation	Total
Proposed	10 (15)	1 (2)	0	0	11 (17)
Agreed	18 (20)	1 (5)	2 (3)	1	22 (28)
Completed	66 (56)	45 (40)	8 (7)	17	136 (103)
Total	94 (91)	47	10	18	169 (148)

3. Comparisons

In the following tables there is information about the status of comparisons that are/were active in the area of Mass and Related Quantities since the last annual report.

For key comparison details are given in Table 1, Supplementary Comparisons in Table 2 and In table 3 other EURAMET projects.

Comparison ID	Project no.	Title/Range	Subfield	Pilot	Contact	Status
EURAMET.M.M-K2.4	-	100 mg to 10 kg	Mass	DFM	L. Nielsen	Measurements complete
EURAMET.M.M-K2.5	1222	10 kg	Mass	BEV	Z. Zelenka	Approved for equivalence
EURAMET.M.M-K4.2015	1346	1 kg mass standards	Mass	BEV	Z. Zelenka	Planned
EURAMET.M.D-K1.1	1031	Solid 6 silicon spheres (two petals)	Density	PTB	H. Bettin	Draft A in discussion
EURAMET.M.D-K2	1019	Density of liquids	Density	BEV	C.Buchner	Approved for equivalence
EURAMET.M.P-K1.c	1179	0.7 MPa to 7 MPa	Pressure	Force	A. Atlintas	In progress
EURAMET.M.P-K4.2010	1047	0.5 Pa to 15 kPa	Pressure	CMI	D. Prazac	Approved for equivalence
EURAMET.M.P-K7	881	5 MPa to 500 MPa	Pressure	MIKES	M. Rantanen	Report in progress draft B

EURAMET.M.P-K8	1041	25 kPa to 200 kPa	Pressure	METAS	C. Wuethrich	In progress
EURAMET.M.P-K13	1091	50 MPa to 500 MPa	Pressure	UME	I. Kocas	Approved for equivalence
EURAMET.M.F-K1	535	5 kN to 10 kN	Force	MIKES	A. Pusa	Report in progress draft B
EURAMET.M.F-K2	518	50 kN to 100 kN	Force	NPL	A. Knott	Approved for equivalence
EURAMET.M.F-K3	505	500 kN to 4 MN	Force	PTB	R. Kumme	In progress

Table 1: Status of EURAMET Key Comparisons.

Comparison ID	Project no.	Title/Range	Subfield	Pilot	Contact	Status
EURAMET.M.M-S1	461	500 kg	Mass	CMI	I. Kriz	Approved and Published
EURAMET.M.M-S2	1054	100g to 0.05 mg	Mass	NPL	S. Davidson	Approved and Published
EURAMET.M.M-S3	-	100 mg to 50 kg	Mass	UME	U. Y. Akcadag	Planned
EURAMET.M.M-S5	-	100 mg to 1 kg	Mass	NSAI	R. Hanrahan	Planned
EURAMET.M.M-S7	1300	500 kg	Mass	CMI MIRS	I. Kriz Matej Grum	In progress
EURAMET.M.M-S8	1279	500 kg and 1000 kg	Mass	MIKES	Petri Koponen	Approved and published
EURAMET.M.M-S9	1310	0.5 mg to 0.05 mg	Mass	NPL	J. Berry	Draft A in preparation
EURAMET.M.D-S1	1240	Liquid Density	Density	BEV	B. Buchner	Approved and published
EURAMET.M.D-S2	1356	10 g, 20 g, 200 g, 1 kg	Density	BEV	Z. Zelenka	Approved and published
EURAMET.M.P-S5	931	50 MPa to 500 MPa	Pressure	PTB	W. Sabuga	Report in progress draft B
EURAMET.M.P-S7	1040	0.1 mPa to 1 Pa	Pressure	METAS	C. Wuethrich	Final Report CCM WG-PV
EURAMET.M.P-S9	1170	-950 hPa to 0 hPa	Pressure	MIKES /LNE	S. Saxholm / I. Morgado	Loop 1 Approved and published /Loop 2 Final Report CCM WG-PV
EURAMET.M.P-S12	-	0.3 kPa to 15 kPa	Pressure	CMI	D. Prazac	Approved and published
EURAMET.M.P-S13	1252	10 MPa to 100 MPa	Pressure	UME	Y.Durgut	In progress
EURAMET.M.P-S14	1306	50 MPa to 1 GPa	Pressure	PTB	J. Koneman	In progress
EURAMET.M.P-S15	1376	100 Pa to 3,5 kPa	Pressure	GUM	A. Brzozowski	agreed/started
EURAMET.M.P-S16	1375	250 MPa	Pressure	GUM	A. Brzozowski	finished – reporting in progress

EURAMET.M.P-S17	1385	-920 to 0 hPa. Part II	Pressure	LNE	P. Otal	Proposed
EURAMET.M.T-S2	1141	100 Nm	Torque	PTB	D. Roeske	finished – reporting in progress draft A
EURAMET.M.T-S4	1304	0,1 N.m at 50 N.m	Torque	LNE	C. Duflon	Planned
EURAMET.M.F-S2	1262	5 N to 250 kN	Force	BEV	C. Buchner	In progress
EURAMET.M.F-S3	-	1 kN to 10 kN	Force	NPL	A. Knott	Final Report CCM WG-F
EURAMET.M.F-S4	1311	10 kN to 20 kN	Force	LNE	P. Averlant	Final Report CCM WG F

Table 2: Status of EURAMET Supplementary Comparisons.

EURAMET Project no.	Title/Range	Subfield	Pilot	Contact	Status
1205	Review EURAMET cg 18	Mass	CEM	N. Medina	Completed
1210	Best practice for the dissemination of the kilogram	Mass	VSL	I. Anđel	Completed
1350	sub-multiples of the kilogram	Mass	MIRS	Goran Grgić	Proposed
1214	Measurement viscous oils	Density	VSL	I. Anđel	Completed
1314	liquid density hydrometers	Density	LNE	-----	Final Report
1316	density and volume of solid using quartz sinker	Density	LNE	-----	Final Report
1115	R-134a leak comparison	Pressure	LNE	I. Morgado	finished – reporting in progress
1206	800 to 1100 hPa	Pressure	MIKES	S. Saxholm	finished – reporting in progress
1207	200 kPa to 1,75 MPa	Pressure	MIKES	S. Saxholm	finished – reporting in progress
1253	10 MPa to 100 MPa	Pressure	UME	Y.Durgut	Proposed
1330	0,7 MPa to 7 MPa	Pressure	LNE	P. Otal	Completed
838	200 kN to 1000 kN	Force	UME	S. Fank	Completed
1097	0 kN, 5 kN, 10 kN	Force	BIM	V. Dikov	agreed/started
1278	1 MN/ up to 20 kNm	Force/ Torque	MIKES	A. Pusa	finished – reporting in progress

Table 3: Status of other EURAMET Projects and Comparisons

4. CMCs

Concerning EURAMET submissions, the following is an update of new submissions since May 2015.

Submission	NMI	Field	CMCs	State
EURAMET.M.40.2015	DPM, Albania	mass	reviewed	published
EURAMET.M.41.2015	IMBiH, Bosnia-Herzegovina	mass	reviewed	published
EURAMET.M.42.2015	BEV, Austria	mass	reviewed	not approved
EURAMET.M.45.2015	BEV, Austria	mass	reviewed	published
EURAMET.M.46.2016	NPL, United Kingdom	mass	reviewed	under review

The BEV' EURAMET.M.42.2015 submission was not accepted, but a new BEV' submission EURAMET.M.45.2015 was accepted.

5. Activities of the Subcommittees

Review of CMCs for:

APMP.M.40.2015: NIMT (Thailand) – CMC submission in Hardness

COOMET.M.26.2015: Ukrmetrteststandard (Ukraine) – CMC submission in Force

SIM.M.29 2016: INMETRO (Brazil) – CMC submission in Mass Standards and Density of Solids/Volume of Mass Standards

SIM.M.30 2016: INM Colombia – CMC submission in the field of Pressure

SIM.M.31 2016: INACAL Peru – CMC submission in the field of Density

SIM.M.32 2016: INTI Paraguay – CMC submission in the field of Pressure

EURAMET cg 18 “Guidelines on the Calibration of Non-Automatic Weighing Instruments” has been revised and published (Nov 15). It already has more than 1000 downloads from the EURAMET website. German and Spanish translations are being prepared.

EURAMET cg 17 “Guidelines on the Calibration of Electromechanical Manometers” is in revision at the moment and there was a session dedicated to it at the last TC-M Pressure SC meeting. Final draft will be approved in 2016.

Activities of the SC Mass:

Project proposal:

Sevda Kacmaz GULFMET – 1 kg mass comparison

Sevda outlined the proposed comparison. There are seven potential participants Calibration & Metrology Lab (PAI), Emirates Metrology Institute (EMI), Dubai Central Laboratory (DCL), NMCC (Saudi Arabia), Directorate General for Standards and Metrology – OMAN, Qatar Air Force Calibration Laboratories, Directorate of Standards and Metrology – Bahrain. It would make sense to coordinate this comparison with EURAMET.M.M-K4. EURAMET can provide transfer standards and advice on data analysis.

For dealing with the adjustment to the BIPM “as-maintained” mass scale

Stuart Davidson (Mass SC Convenor) made a presentation outlining how NPL had revised the mass drift models for its primary (P_{tr}) standards to account for the revised values issued by the BIPM in 2015. Michael Stock noted that A paper "Calibration campaign against the international prototype of the kilogram in anticipation of the redefinition of the kilogram, part II: evolution of the BIPM as-maintained mass unit from the 3rd Periodic Verification to 2014" will be published in Metrologia.

Other presentations:

Matej Grum EMPIR 14RPT02 AWICal - Calibration of automatic weighing instruments

Matej presented details of the JRP. The aim is to develop calibration methods and measurement uncertainty evaluation models for different groups of AWIs, which operate in a dynamic mode and additionally to Increase expertise among EURAMET members in the provision of reliable traceability of automatic weighing instruments. The scope of the project covers automatic catchweighers (ACI), automatic gravimetric filling instruments (AGFI) and automatic instruments for

weighing road vehicles in motion (WIM). The project is due for completion in May 2018, details are available at the website www.awical.eu

Stuart Davidson NewKILO Brief summary of results and proposals for ongoing research collaborations

Stuart presented a summary of the NewKILO JRP which ended in May 2015. Mass standards from new materials had been developed for use with the new primary realisation experiments and for the dissemination of the mass unit following redefinition of the kilogram. Recommendations for operating pressures in vacuum balances and for the cleaning storage and transfer of mass standards were made. Full details can be found at the website www.newkilo.eu.

Florian Beaudoux Vision of the future dissemination of the mass unit in France after the redefinition of the kilogram

Florian presented details of LNE's current primary mass standards and the dissemination of the mass unit in France. New secondary standards had been manufactured from Udimet 720 (a nickel alloy) and these are intended to replace the current stainless steel standards as they have better hardness and magnetic permeability properties. Pure iridium standards have also been manufactured and these too have a range of desirable properties. The possible hierarchy of mass standards in France following the kilogram redefinition was outlined and this included a pool of 1 kg mass standards to enhance the stability of the maintained unit.

Sevda Kacmaz Storage box system for transfer system and CO2 snow jet cleaning method for cleaning mass standards

Sevda presented details of a storage system for UMEs primary mass standards. The aim is the long term storage of primary mass standards and their (automatic) transfer onto a (vacuum) mass comparator. Storage vessels will contain three mass standards each under different environments. Sevda also described experiments with carbon dioxide snow cleaning. The technique is Non-destructive, Non-abrasive and residue free and cleans the weight surface with small particles of dry ice.

Andrea Malengo Buoyancy contribution to uncertainty of mass, conventional mass and force
Andrea gave a presentation outlining how it is preferable to use conventional mass rather than true mass for normal, in-air calibrations, as its uncertainty is smaller than that of true mass, if covariance terms are properly taken into account. The theory is contained in the paper "Buoyancy contribution to uncertainty of mass, conventional mass and force" by Andrea Malengo and Walter Bich, (Metrologia, (2016) Volume 53, Number 2).

Activities of the SC Pressure

Planned Project (MIKES-VTT): "Dynamic pressure comparison"

Research projects and activities are:

- NPL: "NPL's shock tube work, existing facilities and future plans", Ideas for new EMPIR projects, particularly the next EMPIR Industry call 2017
- MIKES-VTT: "Dynamic pressure and related aspects", Ideas for next EMPIR Industry call 2017
- UME: "Dropping weight facility of UME for dynamic pressure"
- UME: "Fall rate measurement system for cross-float measurements at UME"
- HMI: "Dimensional measurements for pressure metrology", EMPIR PRT submission 2016

Calibration guidelines

- Two new planned EURAMET Calibration guidelines for TC-M Pressure SC:

"Calibration of Positive and Negative Gauge Pressure Standards" and "Calibration of Force-Balanced Piston Gauges", working groups are being formed.

Activities of the SC Force and Torque

Presentation of "A new 1 kN Dead weight Force Standard machine of TUBITAK UME", Sinan Fank (UME)

EMRP Projects in Force and Torque:

SIB63 Force in the Meganewton range, Rolf Kumme (PTB), with contributions from WP leaders PTB, INRIM, LNE in Workshop

New EMPIR Projects in Force and Torque:

Torque measurement in the MN·m range, Rolf Kumme (PTB)

Information was given about the IMEKO TC3, TC5, TC22 conference in Finland 2017.

Activities of the SC Density Viscosity:

A new EURAMET Calibration guide for TC-M Density and Viscosity SC is planned: "Hydrostatic weighing of liquids"

Development of an interferometric oil micro-manometer with in-situ measurement of the oil density for EMPIR 14IND06: "Industrial standards in the intermediate pressure-to-vacuum range".

New comparisons:

PTB – CEM: bilateral EURAMET comparison on solid density, CEM, agreed

6. Participation in EMRP/ EMPIR

Information of the participation in projects on-going or finished in 2016:

For EMRP call 2012 (area SI Broader Scope) the following JRP has been selected:

Number	Short name	Full Name
SIB63	Force	Force traceability within the meganewton range

This project started in the last quarter of 2013 and ends in 2016.

For EMRP call 2013 (area Energy & Environment) the following JRP was selected:

Number	Short name	Full Name
ENG 59	NNL	Sensor development and calibration method for inline detection of viscosity and solids content of non-Newtonian fluids

This project started in the last term of 2014 and ends in 2017.

For EMPIR call 2014:

Two projects were chosen from the industry call:

Number	Short name	Full Name
14IND06	pres2vac	Industrial standards in the intermediate pressure-to-vacuum range
14IND14	MNm Torque	Torque measurement in the MN·m range

One project was chosen from the research potential call:

Number	Short name	Full Name
14RPT02	AWICal	Traceable calibration of dynamic weighing instruments

And two projects were chosen from the SIP call:

Number	Short name	Full Name
14SIP01	Vacuum ISO	Technical Specifications for quadrupole mass spectrometers and outgassing rates for assessing the quality of vacuum environments
14SIP08	Dynamic	Standards and software to maximize end user uptake of NMI calibrations of dynamic force, torque and pressure sensors

For EMPIR call 2015:

No projects. (JRP-s11 SISI was not selected).

7. Capacity Building: Activities of the last year and future needs

EURAMET.M.M-S3 (Mass: 200 mg, 5 g, 20 g, 50 g, 200 g and 1000 g). Comparison proposed by the WELMEC and EURAMET Focus Group on Facilitating National Metrology Infrastructure Development.

Piloted by NSAI-National Metrology Laboratory, Ireland.

Participants; BEV (Austria), BMM (Montenegro), DPM (Albania). Weights characterised and protocol complete, measurements to conclude by end 2016.

UME piloted and completed sub-multiple mass comparison for GULFMET and will pilot a kilogram comparison (to be run alongside EURAMET.M.M-K4).

Requirement for training in mass have been identified: 3 technicians from Croatia.

Training and exchange of expertise on the calibration of automatic weighing instruments (AWIs) is being promoted by EMPIR 14RPT02 AWICal.

Researcher mobility grants (RMG):

Colleagues from Macedonian NMI expressed interest to go for a RMG(s) in an EMPIR project (i.e. AWICal).

Colleague from IPQ expressed interest to go for a RMG(s) in an EMRP project (i.e. ENG59 NNL).

There are several nationally or EU supported activities going beside in TC-M.

Needs for the following training topics are registered for the future:

- Oil Pressure Balance, calibration including determination of measurement uncertainty on Oil Pressure Balance;

- Controller/Calibrator instruments for oil media;

- Controller/Calibrator instruments for gas media.

Serbian colleagues volunteered to host the activity in the autumn of this year. Preliminarily, SP can act as a trainer.

8. Meetings

The 2016 Mass and related quantities TC Contact Persons meeting was held in Budva, Montenegro on the 12th May and, as usual, was preceded by technical meetings for the various subfields to review progress in projects and discussion of technical issues in mass, force and torque, pressure, density and viscosity.

We had closed sessions for:

- EMPIR RPT02 AWICal - Traceable calibration of dynamic weighing instruments
- EMPIR IND14 MNm Torque - Torque measurement in the MN·m range
- EMRP SIB63 Force - Force traceability within the meganewton range

And also open sessions for EMRP Project Force Metrology Workshop (SIB63) and NewKILO (SIB05) JRP were held.

We had a presentation of EURAMET Comparison Guide& Toolbox (Joerg Zymnossek)

During the TC Contact Persons meeting we enjoyed the following invited talks:

1. Presentation of Bureau of Metrology - MBM (Goran Vukoslavovic)
2. BIPM Information - Michael Stock
3. NPL's latest Watt Balance work and future plan– Andy Knott
4. Related to Project KNOW:
 - Avogadro and the "Si28 experiment" - Horst Bettin
 - LNE Watt Balance - Matthieu Thomas

Apart from representatives of the BIPM it has become usual to have representatives from GULFMET in our meeting.

The manufacturers from M-T and Sartorius attended the cg-18 steering committee review meeting (closed session).

TU-Ilmenau attended the Mass SC (NewKILO) open session.

In total around 90 people attended the EURAMET TC Mass meeting itself or the other sessions in Budva this year.

In the TC-M meetings this year there was no representation from Bulgaria or Greece.



The TC-M 2017 meeting will be held in Helsinki in April.

Ireland offered to host the TC-M 2018 meeting.

9. Issues

A key technical issue is the linking of EURAMET.M.M-K4 (kilogram comparison) to CCM.M-4, due to the adjustment in the BIPM as-maintained mass scale.

Problems with existing EURAMET CMCs for liquid density will have to be solved:
CCM.D-K4 (Hydrometer): LNE, MKEH and several participants in EURAMET 1019 (Density of liquid by hydrostatic weighing) with E n-value > 1.

10. Strategic Planning

TC-M now has a Strategy WG.

The TC-M Mass SC roadmap will be reviewed and updated by the end of the year.

The TC-M Pressure SC roadmap, last version of 2012, is under revision. Some targets have been reached some become obsolete, new identified and are to be added.

The TC-M Force and Torque SC Roadmap update 2012 was discussed and also the roadmap for Dynamic Force, Torque and Pressure.

The TC-M Density Viscosity SC roadmap, last version of 2012, is under revision.

11. Outlook for 2016/2017

A steering committee has been set up to address issues with EURAMET.M.M-K4 (see Section 9). Coordination of PRTs for the 2018 EMPIR SI JRPs call will be required. Extension of CMC to submissions below 1 mg for participants in the comparison EURAMET.M.M- S9 will be possible.

