



EUROMET TC-M

Mass and related quantities

Annual report 2003/2004

1. General aspects

The EUROMET cooperation in research within the field Mass and related quantities is focused on the following topics

- Measurement of the density of moist air using buoyancy effects and comparison with the formula recommended by the BIPM.
- Identification of materials most suitable for mass standards to be used in the watt-balance experiment.
- Calculation of elastic distortion and associated uncertainty in high pressure piston-cylinder assemblies.
- Calculation of effective area and associated uncertainty in piston-cylinder assemblies with non-ideal geometries.
- Investigation of force balanced piston gauges (FPG's) used to measure pressure.

These projects are driven by a core of European NMI's. The same NMI's carry out substantial research aimed at redefining the kilogram in terms of fundamental constants. These high-profile research projects, known as *the Avogadro project*, *the watt-balance experiments*, and *the ion accumulation experiment*, are not carried out in the frame of EUROMET cooperation, however.

Whereas research is only for some of the NMI's, all NMI's are forced to take part in key and supplementary comparisons. Many resources are put into these comparisons, but for the less experienced NMI's, these resources are well spent as good results in key and supplementary comparisons are crucial for those NMI's.

On request from many contact persons, a EUROMET TC-M website has been set up. The website is accessible from the EUROMET website <http://www.euromet.ie/contacts/committees/>. The website provides information on the current projects in the field of mass and related quantities (including the recently submitted progress reports) and relevant information on future and past meetings. The website is maintained by DFM.

2. Meetings

The annual EUROMET TC-M contact persons meeting was held at BEV, Austria, 26 February 2004. Prior to this, meetings covering 15 EUROMET projects were held 24-25 February at the same location. More than 60 people from 29 countries took part in the meetings.



3. Projects

There are currently 26 agreed projects in the field of Mass and related quantities. Since the last General Assembly, 7 projects have been completed. Additionally two projects are currently proposed. The 35 projects are listed in Annex 1 sorted after the subfields *Mass*, *Density*, *Pressure*, *Force*, *Viscosity*, *Hardness* and *Others*. The distribution of the 35 projects over type of collaboration and over current status is shown in table 1. The distribution of the projects over the subfields is shown in figure 1. The trend in the number of projects sorted after type of collaboration is shown in figure 2.

Note that the increase in comparison projects and corresponding decrease in cooperation projects, which started two years ago, continues. The numbers of traceability and consultation projects are stable, but relatively small.

	Completed	Agreed	Proposed	Total
Cooperation	4 projects No. 742, 650, 676, 604	11 projects: No. 113, 144, 351, 402, 463, 499, 509, 519, 534, 734, 740	0 projects:	15 projects
Comparison	2 projects No. 761, 722	10 projects: No. 439, 442, 445, 461, 505, 510, 518, 535, 627, 702	1 project No. 786	13 projects
Traceability	1 project No. 026	4 projects: No. 005, 138, 285, 286	0 projects	5 projects
Consultation	0 projects	1 project No. 697	1 project No. 675	2 projects
Total	7 projects	26 projects	2 projects	35 projects

Table 1. Status on EUROMET Mass & RQ projects as per 2004-05-12. The projects are grouped according to the project status (Completed, agreed, proposed) and type of collaboration (Cooperation in research, comparison of measurement standards, traceability, consultation on facilities). The completed projects include only those that were active in 2003/2004.

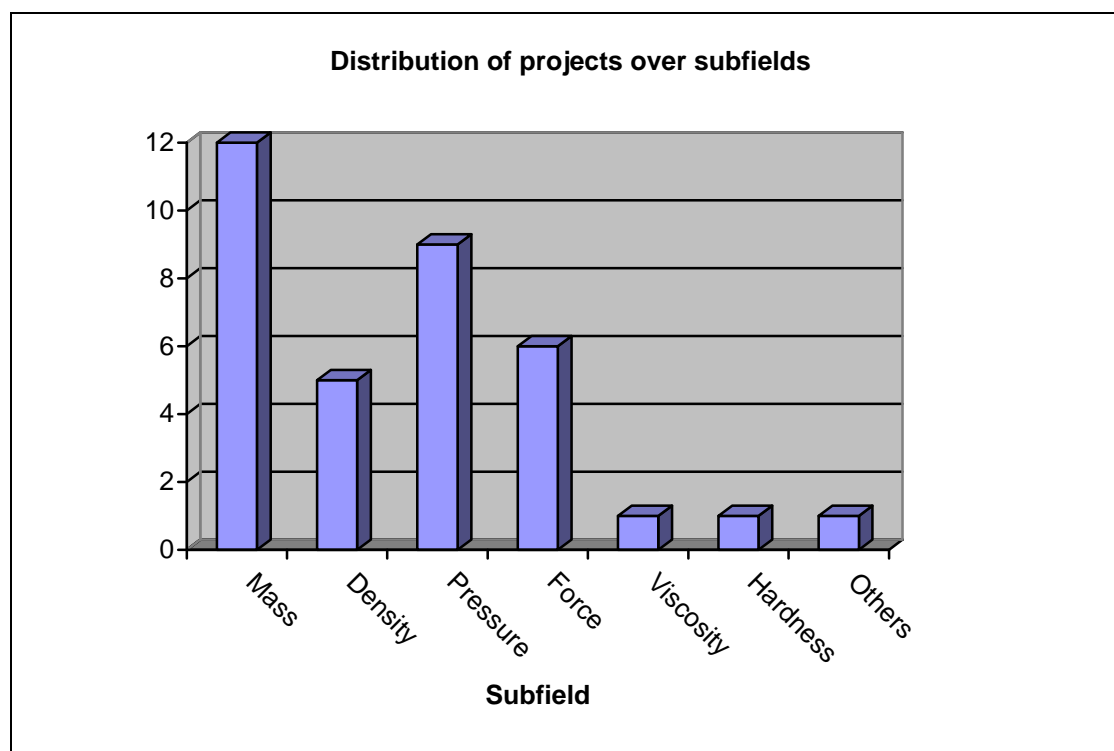


Figure 1. Distribution of EUROMET Mass & RQ projects over subfields

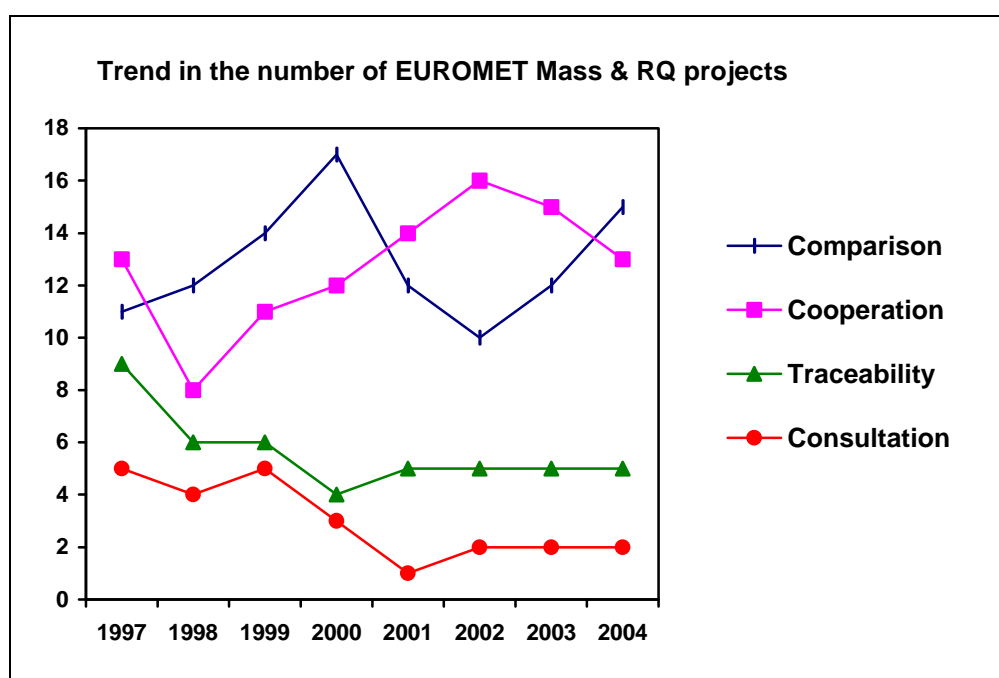


Figure 2. Trend in the number of EUROMET Mass & RQ projects sorted after type of collaboration.



4. Mutual Recognition Arrangement

4.1 Key and supplementary comparisons

The BIPM Key Comparison Database contains 57 CIPM Key Comparisons and 6 CIPM Supplementary Comparisons. The distribution of these comparisons over subfields is shown in table 2. The numbers of comparisons in which EUROMET is represented are shown in brackets. In general, the number of EUROMET participants in CIPM comparisons is sufficient to provide a strong link between EUROMET and CIPM comparisons.

In addition, EUROMET is represented in two inter-RMO bilateral key comparisons and one inter-RMO trilateral key comparison registered in the database. These three comparisons are all in the field of pressure. As for the CIPM comparisons, there are no EUROMET projects associated with the inter-RMO comparisons.

	Mass	Density	Pressure	Force	Viscosity	Hardness
No. of KC's	5 (5)	4 (4)	13 (13)	26 (22)	5 (5)	4 (4)
No. of SC's	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	6 (6)

Table 2. The number of CIPM key (KC) and supplementary (SC) comparisons in the different subfields. The numbers in brackets are the number of comparisons in which EUROMET is represented.

There is a total of 18 EUROMET Key Comparisons and 5 EUROMET Supplementary Comparisons registered in the key comparison database. These comparisons are listed in table 3 and 4. Since last year only one comparison has been initiated (EUROMET.M.M-S1).

Like last year, only 5 key comparisons have reached the final stage “Approved for equivalence” (for key comparisons that can be linked to a CIPM key comparison) or “Approved for provisional equivalence” (for old EUROMET comparisons that cannot be linked). More key comparisons have reached the status “Report in progress, Draft A/B”, but the linking problem still causes delays in the final stage.



Comparison ID	Project no.	Subfield	No. of part.	Pilot	Status	Years
EUROMET.M.M-K1	215 C	Mass	10	NPL	Draft B in progress	1992-1999
EUROMET.M.M-K2	445 A	Mass	23	SP	Draft A in progress	2001-2003
EUROMET.M.M-K4	510 A	Mass	17	NPL	Draft A in Progress	1999-2003
EUROMET.M.D-K1	339 C	Density	12	METAS	Provisional equivalence	1998-1999
EUROMET.M.D-K2.Prev	236 C	Density	5	IMGC	Provisional equivalence	1993-1994
EUROMET.M.D-K2	627 A	Density	8	PTB	Draft B in progress	2001-2002
EUROMET.M.D-K4	702 A	Density		IMGC	In progress	2003-
EUROMET.M.P-K1.a	442 A	Pressure	12	BNM-LNE	Draft B in progress	1999-2002
EUROMET.M.P-K1.b	442 A	Pressure	12	BNM-LNE	Draft A in progress	2000-2002
EUROMET.M.P-K2	305 C	Pressure	6	PTB	Approved for equivalence	1994-1995
EUROMET.M.P-K3.a	439 A	Pressure	8	LNE/NPL	Draft B in progress	1999-2001
EUROMET.M.P-K3.b	439 A	Pressure	11	NPL	Draft A in progress	1999-2001
EUROMET.M.P-K4	389 C	Pressure	14	NPL	Draft B in progress	1998-1999
EUROMET.M.P-K5	045 C	Pressure	7	BNM-LNE	Provisional equivalence	1993-1995
EUROMET.M.P-K6	110 C	Pressure	6	BNM-LNE	Provisional equivalence	1992-1994
EUROMET.M.F-K1	535 A	Force	9	MIKES	Draft A in progress	2002-2004
EUROMET.M.F-K2	518 A	Force	10	NPL	Planned	2006-2008
EUROMET.M.F-K3	505 A	Force	14	PTB	Planned	2004-2006

Table 3. *EUROMET key comparisons*



Comparison ID	Project no.	Subfield	No. of partic.	Pilot	Status	Years
EUROMET.M.V-S1	273 C	Viscosity	4	PTB	Published	1992-1993
EUROMET.M.V-S2	303 C	Viscosity	5	PTB	Published	1993-1996
EUROMET.M.V-S3	415 C	Viscosity	12	PTB	Published	2000
EUROMET.M.V-S4	415 C	Viscosity	8	PTB	Published	1997
EUROMET.M.M-S1	461 A	Mass	18	CMI	Meas. completed	2001-2003
EUROMET.M.P-S1	None	Pressure	2	METAS	In progress	2004

Table. 4 *EUROMET supplementary comparisons*

4.2 Calibration and measurement capabilities

The status of the interregional review of CMC tables is shown in table 5. Compared to last year, all the tables (with one exception) are now published in the Key Comparison Database at BIPM. The exception is SADCMET.M.3.2001, which however has been approved by the other RMO's and is only awaiting approval from JCRB.

No new CMC tables have been submitted for inter-RMO review since last year. Within the EUROMET Mass TC-C, new or revised CMC entries have been collected from 11 member countries.



CMC identifier	RMO	Description	Status	Date
APMP.M.1.2001	APMP	Mass, force, pressure, density, and hardness from 7 APMP members (including NIM, China)	Published in KCDB	2002-03-27
APMP.M.2.2002	APMP	Mass and pressure from SIRIM (Malaysia)	Published in KCDB	2002-06-10
APMP.M.3.2001	APMP	Mass, force and pressure from Japan	Published in KCDB	2002-08-12
APMP.M.4.2002	APMP	Mass, force, pressure and hardness from Japan	Published in KCDB	2004-04-26
APMP.M.5.2002	APMP	Mass, pressure and hardness from CMS/ITRI (Chinese Taipei)	Published in KCDB	2003-10-21
COOMET.M.1.2001	COOMET	Mass, force and pressure from Russia	Published in KCDB	2002-09-25
COOMET.M.2.2001	COOMET	Viscosity from Russia	Published in KCDB	2002-09-15
COOMET.M.3.2001	COOMET	Force from Russia	Published in KCDB	2002-09-25
EUROMET.M.1.2001	EUROMET	Mass, density, pressure, force, torque, viscosity, and gravimetry from 21 countries	Published in KCDB	2002-06-26
EUROMET.M.3.2003	EUROMET	Modification of viscosity from 9 countries	Published in KCDB	2003-12-11
SADCMET.M.1.2001	SADCMET	Mass and density from CSIR-NML (ZA)	Published in KCDB	2003-10-09
SADCMET.M.2.2001	SADCMET	Pressure from CSIR-NML (ZA)	Published in KCDB	2004-04-19
SADCMET.M.3.2001	SADCMET	Force, torque and hardness from CSIR-NML (ZA)	Presented for approval	2004-04-22
SIM.M.1.2001	SIM	Mass, force, torque, hardness, pressure and density	Published in KCDB	2002-06-18
SIM.M.2.2003	SIM	Mass, force (Chile)	Published in KCDB	2004-01-21

Table 5. Status on the interregional review of CMC tables for appendix C of the MRA



Appendix 1. List of EUROMET Mass & RQ projects sorted after subfields

The following list is available at the EUROMET TC-M web-site <http://volt.dfm.dtu.dk/mass> with links to progress and final reports (if available).

Projects

Subfield: Mass

Project no.	Coordinator	Title and participants	Report
351 A Type: Cooperation	Gosset (FR)	Workshop on "Secondary & reference mass standards" CZ, DE, DK, ES, FI, FR, GB, IT, NL, NO, SE, TR, BIPM	Ongoing 2004-03-08
402 A Type: Cooperation	Spurný (SK)	Mass measurement (Guide to the mass determination) CZ, DK, ES, FI, FR, GB, IT, NL, NO, SE, SK, TR	Ongoing 2000-02-11
445 A Type: Comparison	Jacobsson (SE)	Comparison of mass standards in multiples and sub-multiples of the kilogram BE, ES, IE, FI, IS, DK, DE, FR, GB, IT, SE, NO, PT, NL, CH, PL, HU, CZ, SK, LT, AT, SL, GR, TR, RO, BG, LV, EE	Ongoing 2004-03-03
461 A Type: Comparison	Kriz (CZ)	Comparison of 500 kg mass standard weight AT, BE, CH, CZ, DK, ES, FI, GB, GR, HU, IT, IE, NO, SE, SI, TR	Ongoing 2003-02-26
509 A Type: Cooperation	Davidson (GB)	Intercomparison of Pt-Ir kilogram standards AT, BIPM, BE, CH, CZ, DE, DK, ES, FI, FR, GB, HU, IT, NO, PL, SE, SI, SK, TR	Ongoing 2004-02-20
510 A Type: Comparison	Davidson (GB)	Comparison of mass standards of the kilogram (stainless steel) AT, BE, CH, CZ, DE, DK, ES, FI, FR, GB, HU, IE, IS, IT, NL, NO, PT, SI, SK, TR	Ongoing 2004-02-20
519 A Type: Cooperation	Khelifa (FR)	Correlations between air humidity & abnormal dispersion of refractive index of air BIPM, DE, DK, FR, GB, IT, SE	Ongoing 2001-12-10
697 A Type: Consultation	Bartolo (MT)	Setting up a mass lab from 1 mg to 10 kg at E1 level IT, MT	Ongoing 2004-02-14
734 A Type: Consultation	Pinot (FR)	Study of materials for the realization of mass standards BIPM, CH, FR, SE	Ongoing 2004-04-01
742 C Type: Cooperation	Nielsen (DK)	A bilateral comparison of a 1 kg platinum standard DK, RO	Final Report 2004-05-10



Project no.	Coordinator	Title and participants	Report
761 C Type: Comparison	Nielsen (DK)	A bilateral comparison of a 1 mg - 20 kg weight set calibrated by subdivision/multiplication DK, BG	Final Report 2004-05-10
786 P Type: Comparison	Jacobsson (SE)	Comparison of mass standards in multiples and sub-multiples of the kilogram II SE, UK, IT, MA, NL and others	Starting 2004-12-01

Subfield: Density

Project no.	Coordinator	Title and participants	Report
138 A Type: Traceability	Bettin (DE)	Calibration of master hydrometers DE, GB	Ongoing 2004-03-15
144 A Type: Cooperation	Gläser (DE)	Measurement of air density using specially designed masses BIPM, DE, GB, SE	Ongoing 2004-03-15
627 A Type: Comparison	Bettin (DE)	Comparison of density determinations of liquid samples DE, FI, FR, HU, IT, PL, ZA	Ongoing 2004-03-15
675 P Type: Consultation	Verbeek (NL)	Validation of facilities for density determinations of solids NL, EE	Starting 2003-07-01
702 A Type: Comparison	Lorefice (IT)	Comparison of high resolution hydrometers for liquid density determination IT, AT, DE, FI, FR, HU, PL, PT, RU, SL, TR	Starting 2003-07-01

Subfield: Pressure

Project no.	Coordinator	Title and participants	Report
439 A Type: Comparison	Severn (GB)	Pressure standard comparisons, gas media and gauge mode from 50 kPa to 7 MPa AT, BG, CZ, DE, DK, ES, FI, FR, GB, HU, IE, IT, NL, PL, PT, RU, SE, SK, TR, ZA	Ongoing 2003-03-17
442 A Type: Comparison	Legras (FR)	Comparison in the low pressure range 0,1 mPa to 1000 Pa BE, BG, CZ, DE, ES, FI, FR, GB, HU, IT, LT, NL, SE, SI, SK, TR	Ongoing 2001-12-10



Project no.	Coordinator	Title and participants	Report
463 A Type: Cooperation	Sabuga (DE)	Calculation of elastic distortion and associated uncertainty in piston-cylinders operating up to 1 GPa DE, FR, GB, IT, SK, TR	Ongoing 2004-03-03
499 A Type: Cooperation	Verbeek (NL)	Bulletin-board of concerns, problems and experiences BE, CH, DE, DK, ES, FI, FR, GB, GR, HU, IE, IT, NL, NO, PL, PT, SE, TR, ZA	Ongoing 2002-04-18
534 A Type: Cooperation	Tesar (CZ)	Low pressure digital piston manometer with nominal effective area 100 cm ² CZ, DE, GB, IE, SE	Ongoing 2002-02-17
650 C Type: Cooperation	Rantanen (FI)	Interlaboratory comparison in the pressure range 0 to 13000 Pa (differential mode), and 0,1 to 13000 Pa (absolute mode). FI, FR	Final Report 2002-01-02
676 C Type: Cooperation	Jescheck (DE)	Investigations on the force controlled piston gauge FPG8601 with non-rotating piston of nominal area 980 mm ² FI, DE	Final Report 2002-08-26
722 C Type: Comparison	Sandu (RO)	Bilateral comparison in the field of pressure measurement RO, IT	Final Report 2004-05-12
740 A Type: Cooperation	Molinar (IT)	Effective area calculation, uncertainty evaluation and studies for piston-cylinder units of non-ideal geometries used in PB's IT, DE, TR, SK, NL, FR, UK	Starting 2004-01-01

Subfield: Force

Project no.	Coordinator	Title and participants	Report
113 A Type: Cooperation	Ferrero (IT)	Force multi-component DE, FI, FR, GB, IT, PT, TR	Ongoing 2000-04-03
285 A Type: Traceability	Kumme (DE)	Calibration of precision force measuring devices and transfer standards of the capacities up to 16,5 MN DE, DK, FI, GB, IT, SE, TR, AT	Ongoing 2000-12-11
286 A Type: Traceability	Kumme (DE)	Traceability in force measurement at national laboratory level in range up to 2MN DE, FI, SE, TR, AT	Ongoing 2000-12-11



Project no.	Coordinator	Title and participants	Report
505 A Type: Comparison	Kumme (DE)	Comparison of force standards from 500 kN to 4 MN BE, CH, CZ, DE, ES, FI, GB, HU, IT, PL, SE, TR	Ongoing 2000-12-13
518 A Type: Comparison	Knott (GB)	An intercomparison of force standards at 50 kN and 100 kN AT, CH, CZ, DE, GB, GR, HU, NL, PL, PT	To start: 2003-01-01
535 A Type: Key comparison (regional)	Pusa (FI)	Intercomparison of force standards at 5 kN and 10 kN CH, CZ, DE, FI, HU, IT, PL, PT, SE	To start: 2002-01-01

Subfield: Viscosity

Project no.	Coordinator	Title and participants	Report
5 A Type: Traceability	Klingenberg (DE)	Viscosity measurement services DE, GB	Ongoing 2004-03-03

Subfield: Hardness

Project no.	Coordinator	Title and participants	Report
26 C Type: Traceability	Germak (IT)	Hardness standards GB, IT	Final report 2003-07-14

Subfield: Others

Project no.	Coordinator	Title and participants	Report
604 C Type: Cooperation	Leggat (GB)	Comparison issues AT, BE, CEC, CZ, DK, FI, FR, DE, GR, HU, IS, IE, IT, NL, NO, PL, PT, SK, SI, ES, SE, CH, TR, GB	Final Report 2004-03-05