



## EUROMET Mass & Related Quantities

### Annual report 2001/2002

#### 1 General aspects

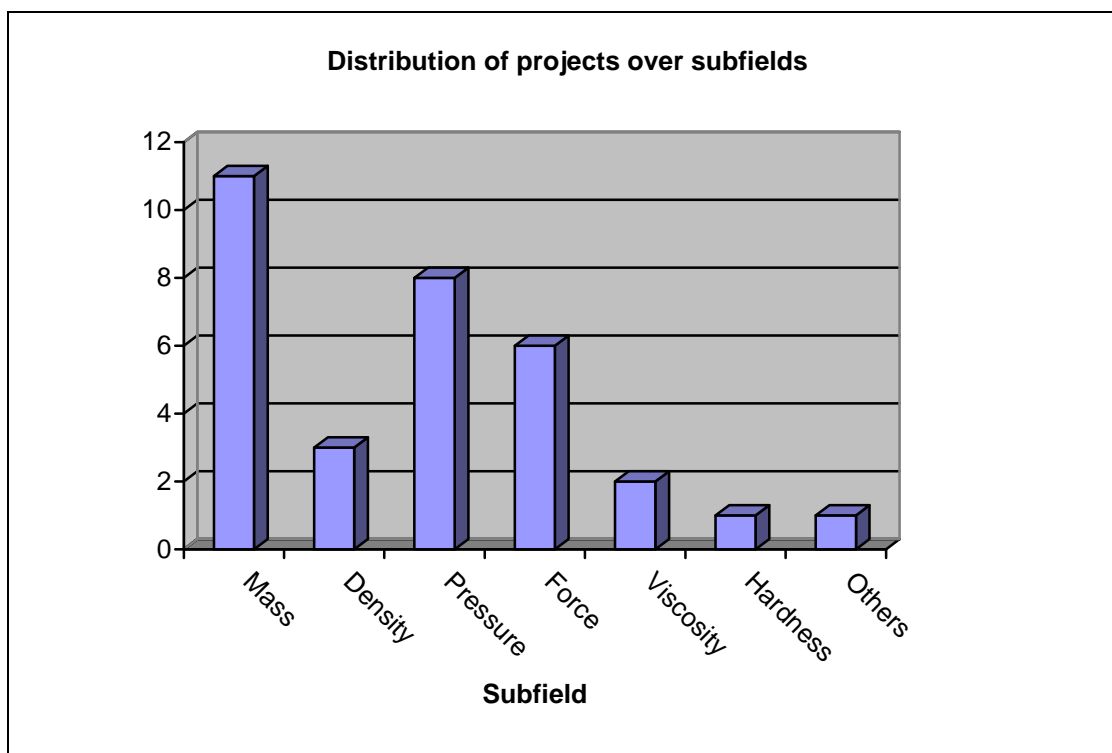
The work in the EUROMET field "Mass & Related Quantities" has been heavily influenced by organising and participating regional key comparisons and by the interregional review of CMC tables from EUROMET, APMP, SIM, SADC MET and COOMET. This work is not yet completed and may still be a dominant factor in the next year. The number of research projects is still high and increasing, but the work put into these projects seems to be less than the work put into key comparisons and CMC's. It is hoped that the focus will move from work supporting the MRA to scientific collaboration in the years to come. That could be beneficial to the many EUROMET national measurement institutes where the scientific staff is smaller than the critical mass for carrying out fundamental research on their own.

#### 2 Meetings

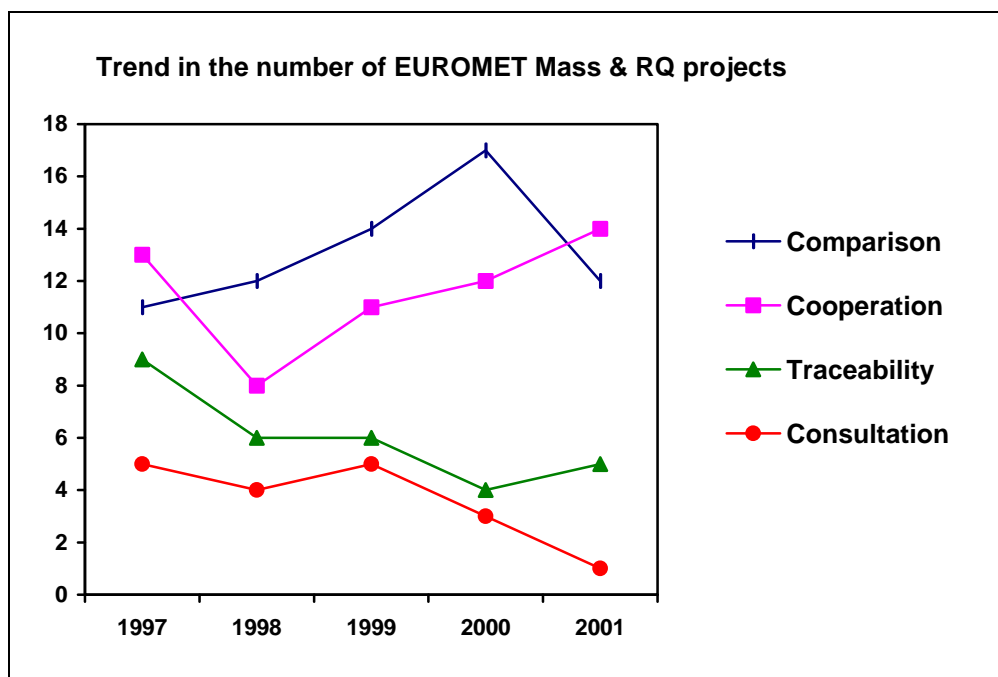
The annual EUROMET Mass & RQ TC meeting took place in Bratislava, 21-22 February 2002. A total of 45 contact persons and project coordinators representing 23 countries plus BIPM and COOMET participated in the meeting that was hosted by the Slovakian metrology institute SMU. At this meeting, status on EUROMET projects, regional key comparisons and interregional review of CMC tables was reported. Two NMI's (METAS and BNM) reported on their respective *watt experiments* for monitoring the stability of the kilogram and one NMI (MIKES) reported that they plan to start a *magnetic levitation experiment* with the same purpose. These activities are not, however, covered by any formal EUROMET projects.

|                     | Completed                   | Agreed  | Proposed    | Total       |
|---------------------|-----------------------------|---|-------------|-------------|
| <b>Cooperation</b>  | 1 project:<br>No. 395       | 13 projects:<br>No. 113, 144,<br>336, 351, 402,<br>463, 499, 509,<br>519, 534, 551.<br>598, 604 | No projects | 14 projects |
| <b>Comparison</b>   | 2 projects:<br>No. 415, 537 | 10 projects:<br>No. 439, 442,<br>445, 461, 505,<br>510, 518, 535,<br>627, 650                   | No projects | 12 projects |
| <b>Traceability</b> | No projects                 | 5 projects:<br>No. 005, 026,<br>138, 285, 286   | No projects | 5 projects  |
| <b>Consultation</b> | 1 project:<br>No. 455       | No projects   | No projects | 1 project   |
| <b>Total</b>        | 4 projects                  | 28 projects   | No projects | 32 projects |

**Table 1.** Status on EUROMET Mass & RQ projects as per 2002-05-01. 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 2001/2002.



**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.*

### 3 Projects

There are currently 28 agreed EUROMET projects within the field Mass & Related Quantities. Only four projects have been completed since the last EUROMET General Assembly and no projects are currently proposed. The 32 projects are listed in Annex 1 sorted after the subfields *Mass*, *Density*, *Pressure*, *Force*, *Viscosity*, *Hardness* and *Others*. The distribution of the 32 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 number of cooperation in research projects continues to increase and that the number of comparison of measurements projects is decreasing for the first time in 5 years.

|                    | Mass  | Density | Pressure | Force   | Viscosity | Hardness |
|--------------------|-------|---------|----------|---------|-----------|----------|
| <b>No. of KC's</b> | 5 (3) | 1 (1)   | 13 (12)  | 26 (22) | 5 (5)     | 1 (1)    |
| <b>No. of SC's</b> | 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 are represented.

| Comparison ID    | Project no. | Subfield | No. of part. | Pilot   | Status             | Years     |
|------------------|-------------|----------|--------------|---------|--------------------|-----------|
| EUROMET.M.M-K1   | 215 C       | Mass     | 10           | NPL     | Report in progress | 1992-1999 |
| EUROMET.M.M-K2   | 445 A       | Mass     | 23           | SP      | In progress        | 2000-     |
| EUROMET.M.M-K4   | 510 A       | Mass     | 17           | NPL     | In progress        | 1999-     |
| EUROMET.M.D-K1   | 339 C       | Density  | 12           | METAS   | Provisional equiv. | 1998-1999 |
| EUROMET.M.D-K2   | 236 C       | Density  | 5            | IMGC    | Provisional equiv. | 1993-1994 |
| EUROMET.M.P-K1.a | 442 A       | Pressure | 12           | BNM-LNE | In progress        | 1999-2001 |
| EUROMET.M.P-K1.b | 442 A       | Pressure | 12           | BNM-LNE | In progress        | 2000-2001 |
| EUROMET.M.P-K2   | 305 C       | Pressure | 6            | PTB     | Approved equiv.    | 1994-1995 |
| EUROMET.M.P-K3.a | 439 A       | Pressure | 8            | LNE/NPL | Report in progress | 1999-2001 |
| EUROMET.M.P-K3.b | 439 A       | Pressure | 11           | NPL     | In progress        | 1999-2001 |
| EUROMET.M.P-K4   | 389 C       | Pressure | 14           | NPL     | Meas. completed    | 1998-1999 |
| EUROMET.M.P-K5   | 045 C       | Pressure | 7            | BNM-LNE | Meas. completed    | 1993-1995 |
| EUROMET.M.P-K6   | 110 C       | Pressure | 6            | BNM-LNE | Provisional equiv. | 1992-1994 |
| EUROMET.M.F-K1   | 535 A       | Force    | 9            | MIKES   | Planned            | 2002-2004 |
| EUROMET.M.F-K2   | 518 A       | Force    | 10           | NPL     | Planned            | 2003-2005 |
| EUROMET.M.F-K3   | 505 A       | Force    | 11           | PTB     | In progress        | 2000-2003 |

**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 A       | Viscosity | 12             | PTB   | Published | 2000      |

**Table. 4** EUROMET supplementary comparisons

## 4 Mutual Recognition Arrangement

### 4.1 Key and supplementary comparisons

The BIPM Key Comparison Database contains 51 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. Those key comparisons where EUROMET is not represented are either rather old bilateral comparisons or new comparisons where only the pilot laboratory is identified. The EUROMET representation in CIPM key comparison is therefore sufficient.

The EUROMET key and supplementary comparisons are listed in table 3 and 4. The number of EUROMET comparisons is sufficient to support the MRA.

| Subfield                  | CMC Chairperson           |
|---------------------------|---------------------------|
| Mass                      | Lars Nielsen (DFM)        |
| Solid density and gravity | Philippe Richard (METAS)  |
| Liquid density            | Horst Bettin (PTB)        |
| Pressure                  | Pauline Leggat (NPL)      |
| Force                     | Rolf Kümme (PTB)          |
| Torque                    | Diedert Peschel (PTB)     |
| Viscosity                 | Günther Klingenberg (PTB) |
| Hardness                  | Alessandro Germak (IMGC)  |

**Table 5.** *The persons responsible for the review of CMC tables in different subfields.*

### 4.2 Calibration and measurement capabilities

The EUROMET CMC tables were submitted to JCRB July 2001. The interregional review of the tables was completed by APMP in August 2001 and by COOMET in April 2002. No review report from SIM has been received up to date. A response to APMP including revised CMC tables was completed by EUROMET in April 2002. The revised tables are currently being reviewed by APMP.

The APMP CMC tables were submitted to JCRB in June 2001. The interregional review was completed by EUROMET in October 2001 and by COOMET in April 2002. Revised tables were completed by APMP, approved by EUROMET and published in the BIPM KCDB in March 2002. Additional tables were submitted to JCRB in November 2001 and January 2002. The review of these tables was completed by EUROMET in May 2002.

The SADC MET CMC tables were submitted to JCRB in July 2001. The interregional review was completed by EUROMET in October 2001.

The COOMET CMC tables were submitted to JCRB in August and October 2001. The interregional review was completed by EUROMET in May 2002.

The persons responsible for the EUROMET CMC tables and the interregional review are listed in table 5.

## Subfield: Mass

| Number of Project                                 | Coordinator   | Title and participants   | Report                   |
|---|---------------|--|--------------------------|
| 336 A<br>Class: Research cooperation<br>EC funded | Becker (DE)   | Primary mass standards based on atomic mass<br>CEC, DE, IT, SE   | Ongoing<br>28.03.00      |
| 351 A<br>Class: Research cooperation              | Gosset (FR)   | Workshop on "Secondary & reference mass standards"<br>(BIPM) CZ, DE, DK, ES, FI, FR, GB, IT, NL, NO, SE, TR  | Ongoing<br>03.12.01      |
| 395 C<br>Class: Research cooperation              | Gläser (DE)   | Convection effects in mass calibration due to temperature differences or gradients<br>(BIPM) DE, DK, ES, FI, FR, GB, IT, SE, TR  | Final report<br>26.02.02 |
| 402 A<br>Class: Cooperation                       | Spurný (SK)   | Mass measurement (Guide to the mass determination)<br>CZ, DK, ES, FI, FR, GB, IT, NL, NO, SE, SK, TR   | Ongoing<br>11.02.00      |
| 445 A<br>Class: Key comparison                    | Pendrill (SE) | Comparison of mass standards in multiples and sub-multiples of the kilogram<br>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<br>26.04.02      |
| 461 A<br>Class: Comparison                        | Kriz (CZ)     | Comparison of 500 kg mass standard weight<br>AT, BE, CH, CZ, DK, ES, FI, GB, GR, HU, IT, IE, NO, SE, SI, TR  | Ongoing<br>15.03.00      |
| 509 A<br>Class: Research, comparison              | Davidson (GB) | Intercomparison of Pt-Ir kilogram standards<br>AT, (BIPM), BE, CH, CZ, DE, DK, ES, FI, FR, GB, HU, IT, NO, PL, SE, SI, SK, TR  | Ongoing<br>27.02.02      |
| 510 A<br>Class: Key comparison                    | Davidson (GB) | Comparison of mass standards of the kilogram (stainless steel)<br>AT, BE, CH, CZ, DE, DK, ES, FI, FR, GB, HU, IE, IS, IT, NL, NO, PT, SI, SK, TR   | Ongoing<br>27.02.02      |
| 519 A<br>Class: Research cooperation              | Khelifa (FR)  | Correlations between air humidity & abnormal dispersion of refractive index of air<br>(BIPM), DE, DK, FR, GB, IT, SE   | Ongoing<br>10.12.01      |
| 551 A<br>Class: Research cooperation              | Pinot (FR)    | Study of several roughness measurement techniques for the characterisation of mass standard<br>FR, SE, USA   | Ongoing<br>03.12.01      |
| 598 A<br>Class: Research cooperation              | Glaeser (DE)  | Investigation of magnetic interactions between mass standards and weighing instruments<br>CH, DE, ES, FI, FR, GB, SE   | Ongoing<br>26.02.02      |

A = Agreed  
P = Proposed  
C = Completed

| Number of Project                    | Coordinator | Title and participants   | Report              |
|--------------------------------------|-------------|--|---------------------|
| 138 A<br>Class: Traceability         | Bettin (DE) | Calibration of master hydrometers<br>DE, GB  | Ongoing<br>30.11.01 |
| 144 A<br>Class: Research cooperation | Gläser (DE) | Measurement of air density using specially designed masses (BIPM), DE, GB, SE        | Ongoing<br>12.04.00 |
| 627 A<br>Class: Comparison           | Bettin (DE) | Comparison of density determinations of liquid samples<br>DE, FI, FR, HU, IT, PL, ZA | Ongoing<br>30.11.01 |

## Subfield: Pressure

| Number of Project                          | Coordinator   | Title and participants   | Report                           |
|--|---------------|--|----------------------------------|
| 439 A<br>Class: Key comparison             | Severn (GB)   | Pressure standard comparisons, gas media and gauge mode from 50 kPa to 7 MPa<br>AT, BG, CZ, DE, DK, ES, FI, FR, GB, HU, IE, IT, NL, PL, PT, RU, SE, SK, TR, ZA | Ongoing<br>15.02.00              |
| 442 A<br>Class: Key comparison             | Legras (FR)   | Comparison in the low pressure range $1 \cdot 10^{-4}$ Pa to 1000 Pa<br>BE, BG, CZ, DE, ES, FI, FR, GB, HU, IT, LT, NL, SE, SI, SK, TR                         | Ongoing (two phases)<br>10.12.01 |
| 455 C<br>Class: Consultation on facilities | Rantanen (FI) | Intercomparison in the pressure range 50 to 350 kPa<br>CZ, ES, FI, NL, NO, SE  | Final report<br>07.11.01         |
| 463 A<br>Class: Research cooperation       | Sabuga (DE)   | Calculation of elastic distortion and associated uncertainty in piston cylinders operating up to 1 GPa<br>DE, FR, GB, IT, SK, TR                               | Ongoing<br>19.11.01              |
| 499 A<br>Class: Research cooperation       | Severn (GB)   | Bulletin-board of concerns, problems and experiences<br>BE, CH, DE, DK, ES, FI, FR, GB, GR, HU, IE, IT, NL, NO, PL, PT, SE, TR, ZA                             | Ongoing<br>18.04.02              |
| 534 A<br>Class: Research cooperation       | Tesar (CZ)    | Low pressure digital piston manometer with nominal effective area 100 cm <sup>2</sup><br>CZ, DE, GB, IE, SE  | Ongoing<br>17.02.02              |
| 537 C<br>Class: Comparison                 | Tesar (CZ)    | Bilateral linking to CCM comparison in the pressure range up to 7 MPa<br>CZ, TR  | Final report<br>17.02.02         |
| 650 A<br>Class: Comparison                 | Rantanen (FI) | Interlaboratory comparison in the pressure range 0 to 13000 Pa (differential mode), and 0,1 to 13000 Pa (absolute mode).                                       | Starting:<br>02.01.02            |

**A = Agreed**  
**P = Proposed**  
**C = Completed**

| Number of Project                            | Coordinator  | Title and participants  | Report                |
|--|--------------|---|-----------------------|
| 113 A<br>Class: Research cooperation         | Ferrero (IT) | Force multi-component<br>DE, FI, FR, GB, IT, PT, TR   | Ongoing<br>03.04.00   |
| 285 A<br>Class: Traceability                 | Sawla (DE)   | Calibration of precision force measuring devices and transfer standards of the capacities up to 16,5 MN<br>DE, DK, FI, GB, IT, SE, TR | Ongoing<br>11.12.00   |
| 286 A<br>Class: Traceability                 | Sawla (DE)   | Traceability in force measurement at national laboratory level in range up to 2MN<br>DE, FI, SE, TR                                   | Ongoing<br>11.12.00   |
| 505 A<br>Class: Key comparison<br>(regional) | Kumme (DE)   | Comparison of force standards from 500 kN to 4 MN<br>BE, CH, CZ, DE, ES, FI, GB, HU, IT, PL, SE, TR                                   | Ongoing<br>13.12.00   |
| 518 A<br>Class: Key comparison<br>(regional) | Knott (GB)   | An intercomparison of force standards at 50 kN and 100 kN<br>AT, CH, CZ, DE, GB, GR, HU, NL, PL, PT                                   | To start:<br>01.01.03 |
| 535 A<br>Class: Key comparison<br>(regional) | Pusa (FI)    | Intercomparison of force standards at 5 kN and 10 kN<br>CH, CZ, DE, FI, HU, IT, PL, PT, SE,   | To start:<br>01.01.02 |

## Subfield: Viscosity

| Number of Project                            | Coordinator      | Title and participants   | Report                   |
|--|------------------|--|--------------------------|
| 005 A<br>Class: Traceability                 | Klingenberg (DE) | Viscosity measurement services<br>DE, GB   | Ongoing<br>15.01.02      |
| 415 C<br>Class: Key comparison<br>(regional) | Klingenberg (DE) | Intercomparison in high viscosity range and test of surface tension correction factors<br>AT, DE, FR, IT, NL, PL, PT, SK<br>TR, RO, RU, JP | Final report<br>15.01.02 |

## Subfield: Hardness

| Number of Project           | Coordinator | Title and participants       | Report              |
|-----------------------------|-------------|------------------------------|---------------------|
| 26 A<br>Class: Traceability | Germak (IT) | Hardness standards<br>GB, IT | Ongoing<br>18.01.02 |

**A = Agreed**  
**P = Proposed**  
**C = Completed**

**Subfield: Others**

| <b>Number of Project</b>             | <b>Coordinator</b> | <b>Title and participants</b>  | <b>Report</b>       |
|--------------------------------------|--------------------|--|---------------------|
| 604 A<br>Class: Research cooperation | Leggat (GB)        | Comparison issues<br>AT, BE, CEC, CZ, DK, FI, FR, DE,<br>GR, HU, IS, IE, IT, NL, NO, PL, PT,<br>SK, SI, ES, SE, CH, TR, GB | Ongoing<br>20.11.00 |

**A = Agreed**  
**P = Proposed**  
**C = Completed**