

**EURAMET Supplementary Comparison
EURAMET.L-S27
Measurement of Steel Tapes of 10 m and 50 m
EURAMET project 1433**

Technical protocol

Sai Gao, Florian Pollinger (PTB)

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1 Document control

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2 Introduction

The metrological equivalence of national measurement standards and of calibration certificates issued by national metrology institutes is established by a set of key and supplementary comparisons chosen and organized by the Consultative Committees of the CIPM or by the regional metrology organizations in collaboration with the Consultative Committees.

As its meeting in Delft, 17-18 October 2016, the EURAMET Technical Committee for Length (TC-L) decided to carry out a supplementary comparison on steel tapes measurements, named EURAMET.L-S-27, with PTB (Physikalisch-Technische Bundesanstalt) as the pilot laboratory. Several APMP NMIs are interested in participation as well, others joined in the course of the project. The results of this international comparison will support the Calibration and Measurement Capabilities (CMCs) declared by the NMIs in the CIPM Mutual Recognition Arrangement (MRA). The comparison was registered in December 2017, and artefact circulation started in January 2018.

The procedures outlined in this document cover the technical procedure to be followed during the measurements. A goal of the EURAMET supplementary comparisons for topics in dimensional metrology is to demonstrate the equivalence of routine calibration services offered by NMIs to clients, as listed in Appendix C of the Mutual Recognition Agreement (MRA). To this end, participants in this comparison agree to use the same apparatus and methods as routinely applied to client artefacts.

By their declared intention to participate in this supplementary comparison, laboratories accept the general instructions and to strictly follow the technical protocol of this document. Due to the large number of participants, it is very important that participating NMIs perform their measurements during assigned dates. Participants should keep in mind that the allocated time period is not only for measurements, but transportation and customs clearance as well. Once the protocol and list of participants has been agreed, no change to the protocol or list of participants may be made without prior agreement of all participants.

3 Organization

The participating laboratories are NMIs fulfilling the following conditions:

- signatory (or applicant) of the CIPM MRA;
- having submitted CMCs for steel tape calibration (or intending to do so soon);
- calibrating steel tapes for their customers as a regular service;
- being well trained in handling steel tapes without the risk to damage the tapes;
- being capable to measure at least the shortest tape (10 m) in one setting.

3.1 Participants

Table 1. List of participant laboratories and their contacts.

Laboratory code	Contact person, Laboratory	Phone, Fax, email
PTB Coordinator	Pollinger, Florian Physikalisch-Technische Bundesanstalt Working group 5.42 Bundesallee 100 D-38116 Braunschweig Germany	Phone: +49 531 592 5420 Fax: +49 531 592 695420 florian.pollinger@ptb.de
BEV	Matus, Michael Bundesamt für Eich- und Vermessungswesen Arltgassee 35 A-1160 Wien Austria	Phone: +43 1 21 110 6540 Fax: +43 1 21 110 6000 michael.matus@bev.gv.at
VUGTK/RIGTC	Ing. Jiří Lechner, CSc. Research Institute of Geodesy, Topography and Cartography Ústecká 98 250 66 Zdíby Czech Republic	Phone: +420 226 802 330 jiri.lechner@vugtk.cz
GUM	Czulek, Dariusz Central Office of Measures ul. Elektoralna 2 00-950 Warszawa Poland	Phone: +48 22 581 95 43 d.czulek@gum.gov.pl
IPQ	Saraiva, Fernanda Instituto Português da Qualidade Rua António Gião 2 2829-513 Caparica Portugal	Phone: +351 21 294 81 60 Fax: +351 21 264 81 88 fsaraiva@ipq.pt
JV	Karlsson, Helge Justervesenet – Norwegian Metrology Service Fetveien 99 N-2007 Kjeller Norway	Phone: +47 64 84 84 84 Fax: +47 64 84 84 85 hka@justervesenet.no
Metrosert	Kruusla, Holger AS Metrosert Teaduspargi 8 12618 Tallinn Estonia	Phone: +372 681 4803 Fax: +372 681 4818 Holger.Kruusla@metrosert.ee
MIRS/UM-FS/LTM	Acko, Bojan Metrology Institute of the Republic of Slovenia /University of Maribor-Faculty of	Phone: +386 2 220 7581 Fax: +386 2 220 7586

	Mechanical Engineering /Laboratory for Production Measurement Smetanova 17 2000 Maribor Slovenia	bojan.acko@uni-mb.si
RISE	Bergstrand, Sten RISE Research Institutes of Sweden AB 50115 Borås Sweden	Phone: +46 10 516 57 73 Fax: +46 10 516 56 20 sten.bergstrand@ri.se
SMD	Pirée, Hugo FPS Economy, DG Quality and Safety, Metrology Division Boulevard du Roi Albert II 16 1000 Brussels Belgium	Phone: +32 2 277 7610 Fax: +32-2-277 5405 hugo.piree@economie.fgov.be
BIM	Denita Tamakyarska Bulgarian Institute of Metrology (BIM) 52B, G.M. Dimitrov blvd. 1040 Sofia Bulgaria	Phone : +359 2 970 27 19 Fax: +359 2 970 27 35 d.tamakjarska@bim.government.bg
UME	Özgür, Bülent Ganioglu, Okhan Aşar, Muharrem Ulusal Metroloji Enstitüsü Barış Mah. Dr. Zeki Acar Cad. No:1 41470 Gebze, Kocaeli Turkey	Phone: +90 262 679 50 00 ext. 5300 Fax: +90 262 679 50 01 bulent.ozgur@tubitak.gov.tr okhan.ganioglu@tubitak.gov.tr muharrem.asar@tubitak.gov.tr
NIM	Dr. Zi Xue National Institute of Metrology(NIM) No.18, Bei San Huan Dong Lu, Chaoyang Dist, 100013 Beijing P. R. China	Phone: +86 10 64524909 Fax: +86 10 64524902 xuez@nim.ac.cn
CMS/ITRI	Dr. Po Er, Hsu Center for Measurement Standards(CMS)/ITRI Bldg. 16, No. 321, Sec. 2, Guangfu Rd., East Dist., Hsingchu City 30011, Taiwan (R. O. C.)	Phone: +886 3 573 2176 Fax: +886 3 572 6445 samhsu@itri.org.tw
INTI	Lic. Karina Bastida UT Optica – Coordinadora Unidad Técnica Instituto Nacional De Tecnología Industrial Física y Metrología Av. General Paz Nº 5445 B1650WAB San Martín Buenos Aires, República Argentina	Phone: +54 11 4724 6200/300/400 Interno 6264 bastida@inti.gov.ar
SASO-NMCC	Faisal A. Alqahtani Length Measurements Department Saudi Standards, Metrology and Quality Org. Riyadh – Al Muhammadiyah – in front of King Saud University PO. B 3437 Riyadh 11471 Kingdom of Saudi Arabia	Phone: +966 11 2529726 Fax: +966 540455655 f.qahtany@saso.gov.sa
BFKH	Gábor Szikszai Government Office of the Capital City Budapest Metrological and Technical Supervisory Department Section of Mechanical Measurements	Phone: +36-1-4585-995 szikszai.gabor@bfkh.gov.hu

	H-1124 Budapest, Németvölgyi út 37-39 Hungary	
CEM	Mr. Aelio A. Arce Centro Español de Metrologia (CEM) C/del Alfar 2 28760 Tres Cantos (Madrid) Spain	Phone: +34 91 8074 801 aaarce@cem.es
LATMB	Larisa Svedova LNMC, LTD Metrology Bureau LATMB 157 Kr. Valdemara street Riga, LV-1013 Latvia	Phone +371 67517725 Fax +371 67362805 Larisa.Svedova@latmb.lv
MBM	Gordana Bajić Arseija Boljevica bb 81000 Podgorica Montenegro	Phone +382 20 601 360 Fax +382 20 634 651 Gordana.bajic@metrologija.gov.me
MASM	Unurbileg Darmaa Length laboratory Mongolian Agency for Standardization and Metrology Peace Avenue-46 A POB -51 Ulaanbaatar-13343	Phone +976-89086810 unurbileg@masm.gov.mn
VNIIM	Zoya Fomkina D.I. Mendeleev Institute for Metrology (VNIIM) 190005, Russia, St. Peterburg, Moskovsky pr., 19	Phone +7 812 323-9665 Z.V.Fomkina@vniim.ru

3.2 Schedule

The comparison will be carried out in the form of a circulation. The tape measures will be measured at the beginning, twice in between and at the end of the circulation by the pilot laboratory in order to monitor the stability of the tapes.

The participating laboratories were asked to specify a preferred timetable slot for their own measurements of the steel tapes – the timetable given in table 2 has been drawn up taking these preferences into account. Each laboratory has four weeks that include customs clearance, calibration and transportation to the following participant. With its confirmation to participate, each laboratory is obliged to perform the measurements in the allocated period and to allow enough time in advance for transportation so that the following participant receives them in time. If a laboratory has technical problems to perform the measurements or customs clearance takes too long, the laboratory has to contact the pilot laboratory as soon as possible and, according to whatever it decides, it might eventually be obliged to send the standards directly to the next participant before completing the measurements or even without doing any measurements.

The worldwide measures against the COVID-19 pandemic include shutdowns of laboratories as well as complications in customs affairs. These imply delays that are currently difficult to assess. The comparison schedule will probably need further adjustments to the situation.

Table 2. **Schedule of the comparison.**

No.	Laboratory	Country	Starting date of measurement
1	PTB	Germany	1 January 2018
2	BEV	Austria	1 February 2018
3	VUGTK/RIGTC	Czech Republic	1 March 2018
4	GUM	Poland	1 April 2018
5	IPQ	Portugal	1 May 2018
6	SMD	Belgium	1 June 2018
7	PTB	Germany	1 July 2018
8	Metrosert	Estonia	1 September 2018
9	MIRS/UM-FS/LTM	Slovenia	1 October 2018
10	RISE	Sweden	1 November 2018 (Millimetre graduation measurements cannot be realized. Only meter measurements)
11	PTB	Germany	1 December 2018
12	JV	Norway	1 February 2019
13	NIM	China	1 May 2019 (2 months due to delivery)
14	CMS	Taiwan China	1 July 2019 (2 months due to delivery) (10 m tape only)
15	PTB	Germany	1 September 2019
16	SASO-NMCC	Saudi Arabia	1 December 2019 (2 months due to delivery) (the measurement range is 5 m)
17	INTI	Argentina	15 March 2020 (2 months due to delivery)
18	PTB	Germany	15 July 2020
19	CEM	Spain	1 September 2020
20	LATMB	Latvia	1 October 2020
21	PTB	Germany	4 November 2020 (only 5060 PTB 03)
22	BIM	Bulgaria	21 November 2020
23	BFKH	Hungary	10 January 2021
24	SMD	Belgium	15 February 2021
25	PTB	Germany	15 March 2021
26	UME	Turkey	1 May 2021 (2 months due to delivery)
27	MBM	Montenegro	1 July 2021 (2 months due to delivery)
28	MASM	Mongolia	1 September 2021 (2 months due to delivery)
29	VNIIM	Russia	1 November 2021 (2 months due to delivery)
30	PTB	Germany	1 January 2022

3.3 Reception, transportation, insurance, costs

A plastic case containing three steel tapes, is used for the transportation of the artefacts (Figure 1). Upon reception of the package, each laboratory should check that the content is complete and that there is no apparent damage on the box or any of the standards. The reception must be confirmed immediately to the pilot with a copy to the former participant (sender), preferably using the form of Appendix A.

The organization costs will be covered by the pilot laboratory, which include the standards themselves, the cases and packaging. The pilot laboratory has no insurance for any loss or damage of the standards during the circulation.



Figure 1 – Transporting case (*the oil vial will be added*)

The steel tapes need to be protected against corrosion when not being measured by means of protective oil. The pilot laboratory will include a vial with appropriate oil in the transportation case. Please cover them with this product before packing them for transportation or when stocked for more than three days. The steel tapes shall be transported rolled up and may not be kinked during handling. Each participating laboratory shall cover the costs of shipping and transport insurance against loss or damage. The package should be shipped with a reliable parcel service of its choice.

Once the measurements have been completed, the package shall be sent to the following participant. Please inform the pilot laboratory and the following participant when the package leaves your installations indicating all pertinent information. If, at any point during circulation, the package is damaged, it shall be repaired by the laboratory before shipping it again.

Due to customs issues, all export outside and into the European Union will be handled by PTB as sender or recipient. Participants must ensure that they fulfil the respective customs requirements for the export of the standards into the recipient country.

4 Artefacts

4.1 Description of artefacts

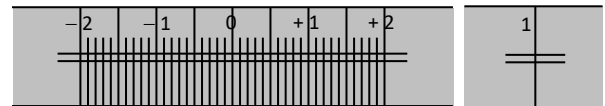
Table 3. List of artefacts.

Length	Width	Nominal load therm. expansion	Identification	Material	Line marks
10 m	13 mm	100 N (11.5 ± 1)·10 ⁻⁶ K ⁻¹	4909 PTB 01	Stainless steel	engraved
50 m	13 mm	100 N (11.5 ± 1)·10 ⁻⁶ K ⁻¹	5060 PTB 06 No. 3	Stainless steel	engraved
50 m	13 mm	50 N (11.5 ± 1)·10 ⁻⁶ K ⁻¹	5.42-0917	Stainless steel	etched

Any further details may be taken from the photographs below:



Figure 2 – 10 m tape with 5 millimeter graduation (4909 PTB 01)



Drawing of line marks at 0 m and at 1 m

Figure 3 – 50 m tape with meter graduation (5060 PTB 06 No.3)



Figure 4 – 50 m tape with millimeter graduation (5.42-0917)

5 Measuring instructions

5.1 Handling the artefact

The steel tapes should only be handled by authorized persons wearing appropriate gloves. They should be stored in such a way as to prevent damage. Before making the measurements, the steel tapes need to be checked to verify that the tapes have no kinks and their measuring surfaces are not damaged. Before measurement, the protective oil needs to be removed. The condition of the steel tapes before measurement should be registered in the form provided in appendix B. Laboratories should attempt to measure all steel tapes.

No other measurements are to be attempted by the participants and the steel tapes should not be used for any purpose other than described in this document. The steel tapes may not be given to any party other than the participants in the comparison.

The steel tapes should be examined before despatch and any change in condition during the measurement at each laboratory should be communicated to the pilot laboratory. Ensure that the content of the package is complete before shipment. Always use the original packaging.

5.2 Traceability

Length measurements should be traceable to the latest realisation of the metre as set out in the current "*Mise en Pratique*". Temperature measurements should be made using the International Temperature Scale of 1990 (ITS-90).

5.3 Measurands

The steel tapes shall be measured based on the standard procedure that the laboratory regularly uses for this calibration service for its customers.

Each tape is to be calibrated in space intervals of 1 m for the tapes of 10 m and 50 m, respectively. All the results are to be given starting from the origin (zero).

According to OIML R 35-2, five different places randomly distributed over the measure of length should be also calibrated for the tapes of 10 m with 5 millimetre graduation and 50 m with millimetre graduation (see appendix C – Results Report Form).

For the 10 m and the 50 m with millimetre graduation tapes, the lines shall be localized at nominally the bottom border of the scale (usually taking into account the first approx. 3 mm of the lines). For the 50 m with meter graduation tape, the lines are to be localized in the middle of the tape, between the two longitudinal lines.

The tapes are to be calibrated in horizontal position, loaded by the nominal force (50 N or 100 N, respectively). Any deviation of this position or force shall be appropriately corrected. The measurement results shall be corrected to the reference temperature of 20°C using the thermal expansion coefficients indicated in table 3.

5.4 Measurement uncertainty

The uncertainty of measurement shall be estimated according to the ISO Guide to the Expression of Uncertainty in Measurement. The participating laboratories are encouraged to use their usual model for the uncertainty calculation.

The laboratories are asked to report a detailed uncertainty budget. For this, the form in Appendix E may be used. There, the measurement uncertainty has to be expressed in a length-dependent form ($\sqrt{(a \cdot \mu\text{m})^2 + (b \cdot L)^2}$) using a coverage factor of $k = 2$. In the results tables in Appendix C, the measurement uncertainty of each point can be reported.

5.5 Reference condition

Measurement results should be reported for the reference temperature of 20 °C. For corrections, the linear thermal expansion coefficient provided in this document (table 3) should be used.

6 Reporting of results

6.1 Results and standard uncertainties as reported by participants

As soon as possible after measurements have been completed, the results should be communicated to the pilot laboratory **within six weeks** at the latest.

The measurement report forms in appendix C of this document will be sent by e-mail (Word document) to all participating laboratories. It would be appreciated if the report forms (in particular the results sheet) could be completed by computer and sent back electronically to the pilot. In any case, the signed report must also be sent in paper form by mail or electronically as a scanned pdf document. In case of any differences, the signed forms are considered to be the definitive version.

Following receipt of all measurement reports from the participating laboratories, the pilot laboratory will analyse the results and prepare within 3 months a first draft A.1 report on the comparison. This will be circulated to the participants for comments, additions and corrections.

7 Analysis of results

7.1 Calculation of the KCRV

The key comparison reference value (KCRV) is calculated on a tape-per-tape basis as the weighted mean of the participant results. The check for consistency of the comparison results with their associated uncertainties will be made based on the Birge ratio, the degrees of equivalence for each laboratory and each tape with respect to the KCRV will be evaluated using E_n values, along the lines of the *WG-MRA-KC-report-template*. If necessary, artefact instability, correlations between institutes, and the necessity for linking to another comparison will be taken into account.

Appendix A – Reception of Standards

To:	Florian Pollinger, Physikalisch-Technische Bundesanstalt Bundesallee 100 38116 Braunschweig, Germany Fax: +49-531 5925405 E-mail: florian.pollinger@ptb.de		
From:	NMI:	Name:	
	Signature:	Date:	

We confirm having received the steel tapes for the comparison on the date given above.

After a visual inspection:

- There are no apparent damages; their precise state will be reported in the form provided in Annex B/C once inspected in the laboratory along with the measurement results.

- We have detected severe damages putting the measurement results at risk. Please indicate the damages, specifying every detail and, if possible, include photos. If it is necessary use additional sheets to report it.

Appendix B – Conditions of Measuring artefacts

To:	Florian Pollinger, Physikalisch-Technische Bundesanstalt Bundesallee 100 38116 Braunschweig, Germany Fax: +49-531 5925405 E-mail: florian.pollinger@ptb.de		
From:	NMI:	Name:	
	Signature:	Date:	

After detailed inspection of the steel tapes these are the results. Please mark significant faults (scratches, indentations, corrosion, etc.).

Appendix C – Results Report Form

To:	Florian Pollinger, Physikalisch-Technische Bundesanstalt Bundesallee 100 38116 Braunschweig, Germany Fax: +49-531 5925405 E-mail: florian.pollinger@ptb.de		
From:	NMI:	Name:	
	Signature:	Date:	

10 m steel tape, identification: 4909 PTB 01 (with 5-mm graduation)

Interval	Length / mm	Measurement Uncertainty ($k=2$)	Measurement temperature / °C
0 .. 1 m			
0 .. 2 m			
0 .. 3 m			
0 .. 4 m			
0 .. 5 m			
0 .. 6 m			
0 .. 7 m			
0 .. 8 m			
0 .. 9 m			
0 .. 10 m			

Interval	Length / mm	Measurement Uncertainty ($k=2$)	Measurement temperature / °C
0 .. 1005.0 mm			
0 .. 1010.0 mm			
0 .. 1015.0 mm			
0 .. 2525.0 mm			
0 .. 2530.0 mm			
0 .. 2535.0 mm			
0 .. 5695.0 mm			
0 .. 5700.0 mm			
0 .. 5705.0 mm			
0 .. 7745.0 mm			
0 .. 7750.0 mm			
0 .. 7755.0 mm			
0 .. 9990.0 mm			
0 .. 9995.0 mm			
0 .. 10000.0 mm			

50 m steel tape I, identification: 5060 PTB 06 No.3 (with meter graduation)

Interval	Length / mm	Measurement Uncertainty ($k=2$)	Measurement temperature / °C
0.. 1 m			
0.. 2 m			
0.. 3 m			
0.. 4 m			
0.. 5 m			
0.. 6 m			
0.. 7 m			
0.. 8 m			
0.. 9 m			
0.. 10 m			
0.. 11 m			
0.. 12 m			
0.. 13 m			
0.. 14 m			
0.. 15 m			
0.. 16 m			
0.. 17 m			
0.. 18 m			
0.. 19 m			
0.. 20 m			
0.. 21 m			
0.. 22 m			
0.. 23 m			
0.. 24 m			
0.. 25 m			
0.. 26 m			
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0.. 29 m			
0.. 30 m			
0.. 31 m			
0.. 32 m			

0 .. 33 m		
0 .. 34 m		
0 .. 35 m		
0 .. 36 m		
0 .. 37 m		
0 .. 38 m		
0 .. 39 m		
0 .. 40 m		
0 .. 41 m		
0 .. 42 m		
0 .. 43 m		
0 .. 44 m		
0 .. 45 m		
0 .. 46 m		
0 .. 47 m		
0 .. 48 m		
0 .. 49 m		
0 .. 50 m		

50 m steel tape II, identification: 5.42-0917 (with millimetre graduation)

Interval	Length / mm	Measurement Uncertainty ($k=2$)	Measurement temperature / °C
0.. 1 m			
0.. 2 m			
0.. 3 m			
0.. 4 m			
0.. 5 m			
0.. 6 m			
0.. 7 m			
0.. 8 m			
0.. 9 m			
0.. 10 m			
0.. 11 m			
0.. 12 m			
0.. 13 m			
0.. 14 m			
0.. 15 m			
0.. 16 m			
0.. 17 m			
0.. 18 m			
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0 .. 37 m		
0 .. 38 m		
0 .. 39 m		
0 .. 40 m		
0 .. 41 m		
0 .. 42 m		
0 .. 43 m		
0 .. 44 m		
0 .. 45 m		
0 .. 46 m		
0 .. 47 m		
0 .. 48 m		
0 .. 49 m		
0 .. 50 m		

Interval	Length / mm	Measurement Uncertainty ($k=2$)	Measurement temperature / °C
0 .. 506.0 mm			
0 .. 507.0 mm			
0 .. 508.0 mm			
0 .. 2529.0 mm			
0 .. 2530.0 mm			
0 .. 2531.0 mm			
0 .. 10999.0 mm			
0 .. 11000.0 mm			
0 .. 11001.0 mm			
0 .. 29999.0 mm			
0 .. 30000.0 mm			
0 .. 30001.0 mm			
0 .. 49998.0 mm			
0 .. 49999.0 mm			
0 .. 50000.0 mm			

Appendix D – Description of the measurement instrument

To:	Florian Pollinger, Physikalisch-Technische Bundesanstalt Bundesallee 100 38116 Braunschweig, Germany Fax: +49-531 592 5405 E-mail: florian.pollinger@ptb.de		
From:	NMI:	Name:	
	Signature:	Date:	

Short description of measurement bench (ev. photo)
.....
.....
.....
.....
.....

**Length measurement instrument
(comparison with reference tape, laser interferometer...?)**
.....
.....
.....
.....

Principle of tape support
.....
.....
.....

Microscope for localisation of scale marks
.....
.....
.....

.....

Type of scale mark identification (automated yes/no)?

Temperature measurement system, number and location of sensors

.....
.....
.....
.....
.....
.....

Additional remarks

.....
.....
.....
.....
.....

(use additional pages as needed)

Combined standard uncertainty:

Expanded uncertainty ($k=2$):