Hrvatski mjeriteljski institut
Croatian metrology institute

HMI/FSB-LPMD
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European Association of National Metrology Institutes

(EURAMET)

Supplementary Comparison of

Parallel Thread Gauges

Technical protocol

HMI/FSB-LPMD
Laboratory for Precise Measurements of Length, Croatia

Contents

1 INTRODUCTION

Value of the pitch diameter depends on several parameters that have to be either measured or assumed, depending on the method that is used. Different approaches can be used which can lead to significantly different values of pitch diameter and associated uncertainties. The last comparison of screw thread calibration between European laboratories "EAL Interlaboratory Comparison M 19" took place in 1997. The comparability of screw gauge calibration within participating laboratories was poor and many questions were raised in discussion between the coordinator and the participating laboratories. Conclusion was that harmonization of procedures for determination of the pitch diameter is absolutely necessary.

In order to enhance the equivalence and mutual recognition of calibration results obtained by laboratories performing calibrations of determination of pitch diameter of parallel thread gauges by mechanical probing, EURAMET e.V., Technical Committee for Length has published Calibration Guide EURAMET cg-10, Version 2.0 (03/2011). This document gives guidance on how to determine the pitch diameter and the associated uncertainty of measurement.

During the Euramet annual TCL meeting in October 2011 HMI/FSB-LPMD, FSB-Laboratory for Precise Measurements of Length proposed to start and pilot a EURAMET comparison of parallel thread gauges.

Scope of this comparison is:

- to confirm existing measurement methods and procedures
- to verify and compare the uncertainty estimations

2 ORGANIZATION

2.1 Organization body

HMI/FSB-LPMD
FSB-Laboratory for Precise Measurements of Length
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10000 Zagreb, Croatia
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e-mail: vedran.mudronja@fsb.hr

2.2 Participants

Country (code)	Laboratory	Name of contact	Address	Contact details
1 – Croatia (HR)	HMI/FSB-LPMD	Vedran Mudronja	Laboratory for Precise Measurements of Length Ivana Lučića 5 10000 Zagreb, Croatia	Phone: +385 1 6168 327 Fax: +385 1 6168 599 Email: vedran.mudronja@fsb.hr
2 – Slovenia (SI)	MIRS/UM-FS/LTM	Bojan Acko	Metrology Institute of the Republic of Slovenia/University of Maribor-Faculty of Mechanical Engineering/Laboratory for Production Smetanova ulica 17 SI-2000 Maribor,Slovenia	Phone: +386 2 220 7581 Fax: +386 2 220 7586 Email:bojan.acko@uni-mb.si
3 – Austria (AT)	BEV	Michael Matus	Bundesamt für Eich- und Vermessungswesen Gruppe Eichwesen (Metrology Service) Arltgasse 35 AT-1160 Wien, Austria	Phone: +43 1 21110-6540 Fax +43 1 21110-6000 Email: michael.matus@bev.gv.at
4 – Hungary (HU)	MKEH	Edit Bánréti	Hungarian Trade Licensing Office Németvölgyi út 37-39 HU-1124 Budapest XII. Hungary	Phone: +36 1 458 59 97 Fax: +36 1 458 59 27 Email: banretie@mkeh.hu
5 – Estonia (EE)	Metrosert	Lauri Lillepea	AS Metrosert Riia 185B EE-51014 Tartu, Estonia	Phone: +372 6 814 810 Fax: +372 6 814 818 Email: lauri@metrosert.ee
6 – Switzerland (CH)	METAS	Rudolf Thalmann	Federal Office of Metrology METAS Lindenweg 50 CH-3003 Bern-Wabern, Switzerland	Phone: +41 31 32 33 385 Fax: +41 31 32 33 210 Email: rudolf.thalmann@metas.ch
7 – Finland (FI)	MIKES	Antti Lassila	Centre for Metrology and Accreditation Tekniikantie 1 FI-02151 Espoo, P.O. Box 9 Finland	Phone: +358 10 6054 000 Fax: +358 10 6054 499 Email: antti.lassila@mikes.fi
8- Italy (IT)	INRIM	Gian Bartolo Picotto	Istituto Nazionale di Ricerca Metrologica Strada delle Cacce 91 IT-10135 Torino, Italy	Phone: +39 011 3919 969 Fax: +39 011 3919 959 Email:g.picotto@inrim.it
9-Turkey (TR)	TUBİTAK-UME	Doc. Dr.Tanfer Yandayan Okhan Ganioglu İlker Meral	TÜBİTAK UME Gebze Yerleşkesi Barış Mah. Dr.Zeki Acar Cad. No:1 41470 Gebze KOCAELİ TÜRKİYE	Tel: +90 262 679 5000 - 5300,5353,5303 Fax: +90 262 679 5001 Email: tanfer.yandayan@ume.tubitak.gov.tr okhan.ganioglu@ume.tubitak.gov.tr ilker.meral@ume.tubitak.gov.tr

10-France (FR)	LNE	Mr Georges Vailleau	Laboratoire national de métrologie et d'essais (LNE), rue Gaston Boissier 1FR-75724 Paris cedex 15, France	Tel: +33 1 40 43 37 77 Fax: +33 1 40 43 37 37 Email: georges.vailleau@lne.fr

2.3 Time schedule

Each laboratory has five weeks for measurement, including transportation. With its confirmation to participate, each laboratory has confirmed that it is capable to perform the measurements in the limited time allocated to it. It guarantees that the standards arrive in the country of the next participant at the beginning of the next week. If for some reasons, the measurement facility is not ready or customs clearance takes too much time in a country, the laboratory has to contact the pilot immediately and - according to the arrangement made - eventually to send the standards directly to the next participant before finishing the measurements or even without doing any measurements.

Country	Laboratory	Period (starting date)
Croatia	HMI/FSB-LPMD	12 March 2012
Slovenia	MIRS/UM-FS/LTM	16 April 2012
Austria	BEV	21 May 2012
Hungary	MKEH	25 June 2012
Summer holidays		
Switzerland	METAS	03 September 2012
Finland	MIKES	08 October 2012
Estonia	Metrosert	12 November 2012
Italy	INRIM	17 December 2012
Turkey	TUBİTAK-UME	21 January 2013
France	LNE	25 February 2013
Croatia	HMI/FSB-LPMD	01 April 2013

2.4 Transportation

Transportation is on each laboratory's own responsibility and cost. The gauges are packed in a box. Inside this box, the thread gauges are packed separately in a plastic packing. Serial numbers are written on the gauges.

The box can be shipped with any appropriate carrier, preferably using a fast mail service.

You are kindly asked to inform the pilot laboratory by fax immediately after receiving the gauges using the form in the annex.

Immediately after having completed the measurements, the pack has to be sent to the next participant. It is advisable to prepare and organize this transportation beforehand. Please inform again the coordinator and the next laboratory by fax or e-mail about date of shipment, transportation company, flight details..... .

2.5 Unpacking, handling and packing

The package contains the following items:

- Three thread gauge plugs

- Three thread gauge rings

- Technical protocol

The gauges should be immediately unpacked after receipt, cleaned with the usual procedure and visually checked for damage. If any scratches, rust or other damage is observed pilot laboratory should be informed. After the measurements, the gauges must be immediately greased, carefully packed into the original container and shipped to the next participating laboratory. Ensure that the content of the package is complete before shipment. Use always the original package.

Please handle the gauges with care!

2.6 Financial aspects, Insurance

Each participating laboratory covers the costs for the measurements, transportation and eventual customs formalities as well as for any damages that may have occurred within its country. The overall costs for the organization and for the standards are covered by the organizing pilot laboratory. The pilot laboratory has no insurance for any loss or damage of the gauges during transportation.

3 DESCRIPTION OF THE GAUGES

The package contains 6 of thread gauges.

	Thread gauges	Serial Number
Thread plugs	GO M6x1 6H	FSB 01
	GO M12x1,75 6H	FSB 02
	GO M36x1,5 6H	FSB 03
Thread rings	GO M18x2,5 6g	BDU 096
	GO M42x4,5 6g	BDP 105
	GO M30x1,5 6g	BEI 234

4 MEASUREMENT INSTRUCTIONS

Participating laboratories are encouraged to follow Calibration Guide EURAMET cg-10, Version 2.0 (03/2011), however adapted to their instruments and procedures.

Each laboratory should, according to its measurement capabilities, measure:

- Simple pitch diameter
- Pitch diameter
- Thread angle
- Pitch

Detailed measurement instructions, based on which quantities can be measured, is given in the following text.

4.1 Terminology

Simple Pitch Diameter: The diameter of an imaginary cylinder, which intersects the surface of the thread profile in such a manner as to make the width of the thread groove equal to one-half of the basic (nominal) pitch.

Pitch Diameter (d_2,D_2): The diameter of an imaginary cylinder (termed the pitch cylinder), the surface of which intersects the thread profile in such a manner as to make the width of the thread ridge and the thread groove equal.

Pitch (P): The distance, measured parallel to the axis, between corresponding points on adjacent thread forms in the same axial plane and on the same side of the axis.

Flank Angles (β,γ): The angles between the individual flanks (leading and trailing flank) and the perpendicular to the axis of the thread, measured in an axial plane section.

Thread Angle (α): Sum of the two flank angles.

Indicated value (m): Value of a quantity provided by a measuring instrument.

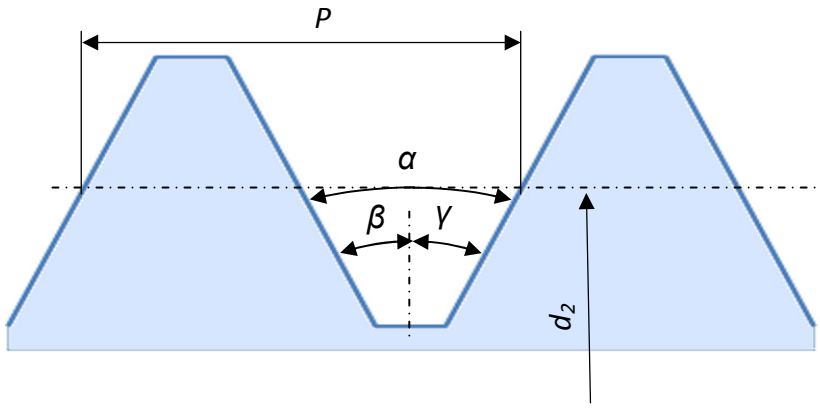

Fig. 1 Elements of the parallel screw thread (drawing and symbols apply to external thread. For internal diameters, the capital symbol D applies)

4.2 Simple Pitch Diameter (d_2,D_2)

Simple pitch diameter should be determined according to the definition:

"*The diameter of an imaginary cylinder, which intersects the surface of the thread profile in such a manner as to make the width of the thread groove equal to one-half of the basic (nominal) pitch"* [ref.1].

Table 1 shows which quantities should be measured and which assumption can be made in determination of simple pitch diameter.
(Table 1 refers mainly to mechanical probing technique).

	Parameter	Measured	Assumed
Simple pitch diameter			
1a	*m*	Measured	-
	α	-	Within tolerance
	P	-	Nominal
1b	*m*	Measured	-
	α	Measured	-
	P	-	Nominal

Table 1 Category of calibration

Measurement of diameter only (1a): The simple pitch diameter is calculated from this measured diameter, corrected for the rake and the measuring force, and from assumed nominal values for the pitch and thread angle.

Measurement of diameter and thread angle (1b): Compared to 1a, a direct measurement of the thread angle can give a more reliable measurement result of the simple pitch diameter associated with a possibly smaller uncertainty of measurement.

According to laboratory's measurement capability simple pitch diameter should be determined according to 1a and/or 1b calibration category

4.3 Pitch Diameter (d_2,D_2)

Pitch diameter should be determined according to the definition:

"*The diameter of an imaginary cylinder (termed the pitch cylinder), the surface of which intersects the thread profile in such a manner as to make the width of the thread ridge and the thread groove equal"* [ref.1].

Table 2 shows which quantities should be measured and which assumption can be made in determination of pitch diameter.
(Table 1 refers mainly to mechanical probing technique).

	Parameter	Measured	Assumed
Pitch diameter			
2a	*m*	Measured	-
	α	-	Within tolerance
	P	Measured	-
2b	*m*	Measured	-
	α	Measured	-
	P	Measured	-

Table 2 Category of calibration

Measurement of diameter and pitch (2a): The pitch diameter is calculated from this measured diameter and from the measured pitch, corrected for the rake and the measuring force, and from assumed nominal values for the thread angle.

Measurement of diameter, pitch and thread angle (2b): Compared to 2a, a direct measurement of the thread angle can give a more reliable measurement result of the pitch diameter.

According to laboratory's measurement capability pitch diameter should be determined according to 2a and/or 2b calibration category.

4.4 Pitch

If a laboratory reports values of simple pitch diameter only, pitch doesn't have to be measured; instead the nominal value for the pitch should be assumed.

4.5 Thread angle

If the flank angles are measured separately (β,γ) than the thread angle is $\alpha=\beta+\gamma$.

4.6 Measurement positions

Measurement plane:	Sectional plane defined by axis and marking direction.
Diameters measurement:	Approximately middle of the cylinder.
Pitch measurement:	Average over the three threads for pitch measurement in approximate middle of the cylinder.
Angle measurement:	Approximately middle of the cylinder.

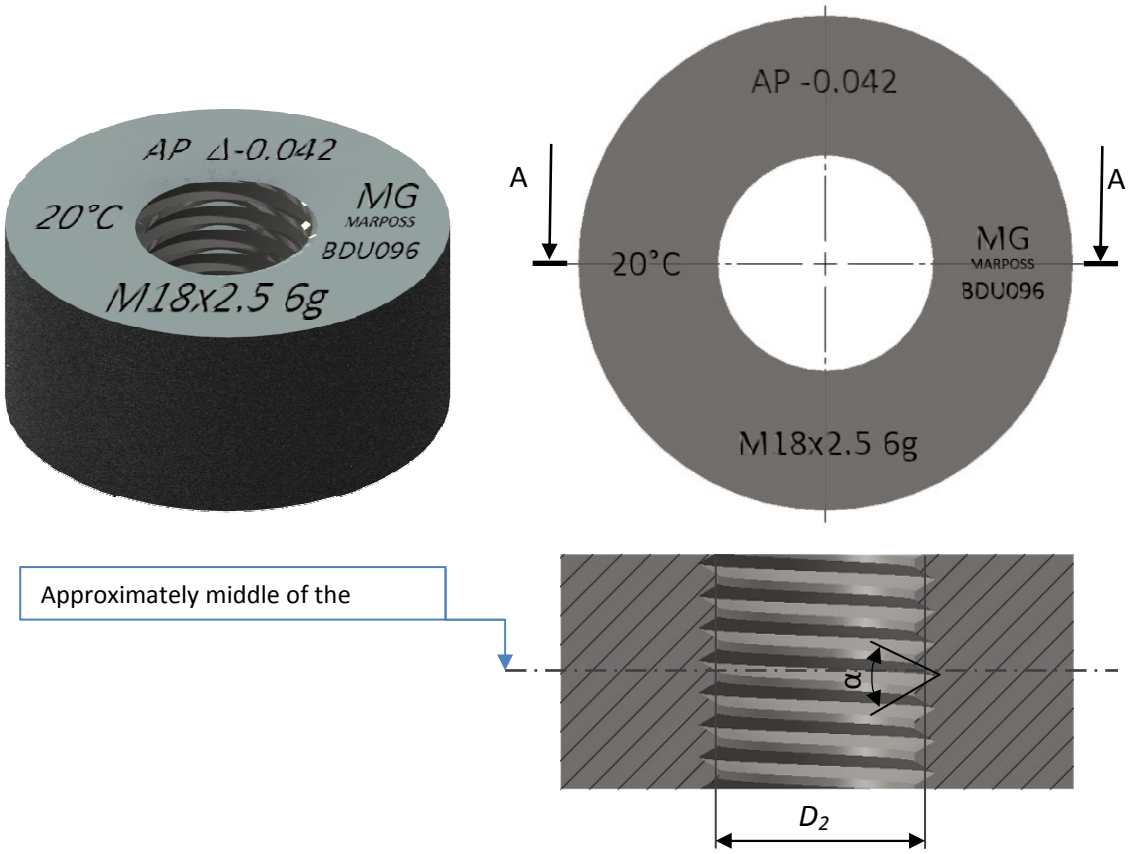

Fig. 2 Measurement positions - thread rings

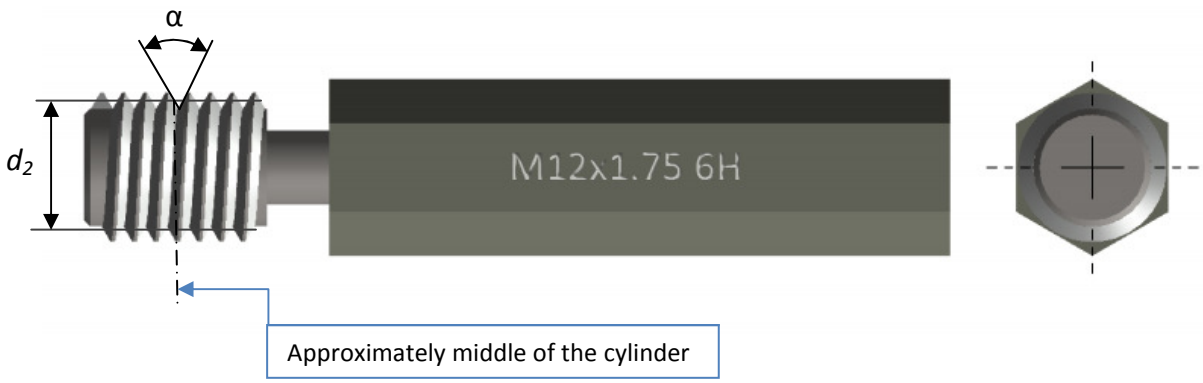

Fig. 3 Measurement positions - thread plugs

4.7 Measurement uncertainty

The uncertainty of measurement shall be estimated according to the ISO Guide for the Expression of Uncertainty in Measurement (ISO/IEC Guide 98-3:2008).

Simple Pitch Diameter

Possible uncertainty for determination of pitch diameter may include:

- Measured displacement
- Probing element (ball or wire diameter)
- Thread angle
- Measurement force
- ……

If the thread angle is not measured and instead it is assumed that it is within tolerance limits, nominal value can be assigned to the thread angle by assuming that the distribution of possible values is rectangular. If the tolerance zone is ±a (2a total), the standard uncertainty is $a/\sqrt{3}$ .The value of the pitch is defined nominal and therefore considered as constant (1a calibration category).

Pitch Diameter

Possible uncertainty for determination of pitch diameter may include:

- Measured displacement
- Probing element (ball or wire diameter)
- Thread angle
- Pitch
- Measurement force

If the thread angle is not measured and instead it is assumed that it is within tolerance limits, nominal value can be assigned to the thread angle by assuming that the distribution of possible values is rectangular. If the tolerance zone is ±a (2a total), the standard uncertainty is $a/\sqrt{3}$ (2a calibration category).

Note: **Uncertainty contributions stated above are not conclusive** and will vary for each measurement system. Participants should estimate as best as possible the contributing components of their specific system. In each calculation laboratory must also list the source of each component value.

Thread Angle and Pitch

If flank angles (or thread angle) are measured, participants should estimate the contributing components of their measurement system.

If pitch is measured participants should estimate the contributing components of their measurement system.

5 REPORTING

The measurement results and a detailed evaluation of the uncertainty of measurement have to be reported using the forms enclosed in the annex. Handwritten notes are sufficient.

The measurement report forms in the annex of this document are 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 coordinator. In any case, the signed report must also be sent in paper form by mail. In case of any differences, the paper forms are considered to be the valid version.

The reports shall be sent within six weeks after completing the measurements to the pilot laboratory. No information about differences of the reported results with respect to others will be communicated before the completion of the comparison, unless large deviations of particular laboratories with respect to the preliminary reference results obtained by the pilot laboratory have been observed. In the latter case the laboratory in question will be contacted.

Within 3 months after completion of the circulation, the pilot laboratory will prepare a first draft report and send it to the participants for comment.

6 REFERENCES

1. Calibration Guide EURAMET cg-10, Determination of Pitch Diameter of Parallel Thread Gauges by Mechanical Probing, Version 2.0 (03/2011), ISBN 978-3-942992-07-7.
2. ISO Guide for the Expression of Uncertainty in Measurement (ISO/IEC Guide 98-3:2008).

MEASUREMENT RESULTS REPORT FORM

Thread rings

Thread ring gauge:_____

Parameter	Symbol	Measured Value	Uncertainty (k=1) u_c
Thread angle is assumed to be nominal (1a or 2a calibration category)			
Pitch diameter	D_2	mm	µm
Simple pitch diameter	$D_{2\ Simple}$	mm	µm
Thread angle is measured (1b or 2b calibration category)			
Pitch diameter	D_2	mm	µm
Simple pitch diameter	$D_{2\ Simple}$	mm	µm
Flank angle	α	rad	rad
Left flank angle (optional)	β	rad	rad
Right flank angle (optional)	γ	rad	rad
Pitch	P	mm	µm

Parameters of measurement system

Parameter	Symbol	Value
Measured displacement	m	mm
Measurement force	F	N
Diameter of probing element	d_D	mm

Short description of the applied measurement method/instruments:

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

Laboratory :.....

Date : ..... Signature:.....

Thread plugs

Thread plug gauge:_____

Parameter	Symbol	Measured Value	Uncertainty (k=1) u_c
Thread angle is assumed to be nominal (1a or 2a calibration category)			
Pitch diameter	d_2	mm	µm
Simple pitch diameter	$d_{2\,Simple}$	mm	µm
Thread angle is measured (1b or 2b calibration category)			
Pitch diameter	d_2	mm	µm
Simple pitch diameter	$d_{2\,Simple}$	mm	µm
Flank angle	α	rad	rad
Left flank angle (optional)	β	rad	rad
Right flank angle (optional)	γ	rad	rad
Pitch	P	mm	µm

Parameters of measurement system

Parameter	Symbol	Value
Measured displacement	m	mm
Measurement force	F	N
Diameter of probing element	d_D	mm

Short description of the applied measurement method/instruments:

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

Laboratory :.....

Date : ..... Signature:.....

UNCERTAINTY OF MEASUREMENT REPORT FORM

x_i	$u(x_i)$	n_i	$c_i = \partial l/\partial x_i$	$u_i(l)$

Combined standard uncertainty (k = 1): $u_c(l) =$

Laboratory :……..

Date : ..... Signature:.....

Telefax Telefax Telefax Telefax Telefax

To :

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From : .....

(participating laboratory)

We confirm having received the standards of the *EUROMET supplementary comparison of parallel thread gauges* on .....(date).

After visual inspection

☐ no damage has been noticed.

☐ the following damage(s) must be reported :

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

Laboratory :.....

Date : ..... Signature:.....