



中国计量科学研究院
National Institute of Metrology, China

APMP Supplementary Comparison

Calibration of Parallel Thread Gauges

Technical protocol

National Institute of Metrology

China

Beijing, China
9 January 2019

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1. Document control

Version Draft A.1 Issued on 9 January 2019

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.

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.

There is no any comparison about determination of the pitch diameter among national metrology institute of Asian countries until now. A 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 Technical Committee for Length has published Calibration Guide EURAMET cg-10, version 2.1 (12/2012). The document gives guidance on how to determine the pitch diameter and the associated uncertainty of measurement by mechanical probing with wires or balls. Several comparisons were carried on in EURAMET.

During the APMP TCL Meeting of the 33rd APMP GA in 2017-11-27/28 – New Delhi, India, NIM, China proposed to start and pilot an APMP comparison of parallel thread gauges.

Scope of this comparison is:

- to confirm existing measurement methods and procedures;
- to verify and compare the uncertainty estimations;
- to support the CMCs of thread gauge parameters.

3. ORGANIZATION

3.1. Participants

Table 1. List of participant laboratories and their contacts

Country (code)	Laboratory Name	Contact	Address	Contact details	Note
China (CN)	NIM (pilot)	Weinong Wang	No. 18, Bei San Huan Dong Lu, 10029 Beijing, China	Tel: +86 10 64524931 Fax: +86 10 64524931 e-mail: wangwn@nim.ac.cn	APMP
Thailand	NIMT	Yodying Moukngam		yodying@nimt.or.th	APMP
Saudi Arabia	SASO-NMCC	Faisal A. AlQahtani		f.qahtany@saso.gov.sa	APMP
Germany	PTB	Marlen Krause Achim Wedmann		Marlen.Krause@ptb.de Achim.Wedmann@ptb.de	EURAMET

3.2. 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.

Table 2. Schedule of the comparison.

Country	Laboratory	Period (starting date)
China	NIM	2019-6
	PTB	2019-7
	NIMT	2019-8
	SASO-NMCC	2019-9
China	NIM	2019-10

3.3. Reception, transportation, insurance, costs

A plastic case containing 7 screw thread gauges 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 has to 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, and the shipping costs to the next laboratory. The pilot laboratory has no insurance for any loss or damage of the standards during the circulation.

Once the measurements have been completed, the package shall be sent to the following participant. The gauges need to be protected against corrosion when not being measured by means of protective oil. Please protect them before packing them for transportation or when stocked for more than three days.

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, 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.

For shipment outside the package is accompanied by an ATA carnet. The carnet shall always be shipped with the package, never inside the box, but apart. **Please be certain, that when receiving the package, you also receive the carnet!**





Figure 1 – Transporting cases

3.4. Unpacking, handling and packing

The package contains the following items:

- Four 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!

4. DESCRIPTION OF THE GAUGES

The package contains 7 of thread gauges.

	Thread gauges	Serial Number
Plugs	M6×1-6H-GO	
	M12×1.75-6H-GO	
	M36×1.5-6H-GO	
	M10×2-6H-GO	
Ring	M18×2.5-6g-GO	
	M30×1.5-6g-GO	
	M42×4.5-6g-GO	

5. MEASUREMENT INSTRUCTIONS

Participating laboratories are encouraged to follow Calibration Guide EURAMET cg-10, version 2.1 (12/2012), however adapted to their instruments and procedures.

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

- Simple pitch diameter
- Pitch diameter
- Thread angle (flank angel)
- Pitch

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

5.1. 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.

auxiliary angle (θ), for the rake corrections

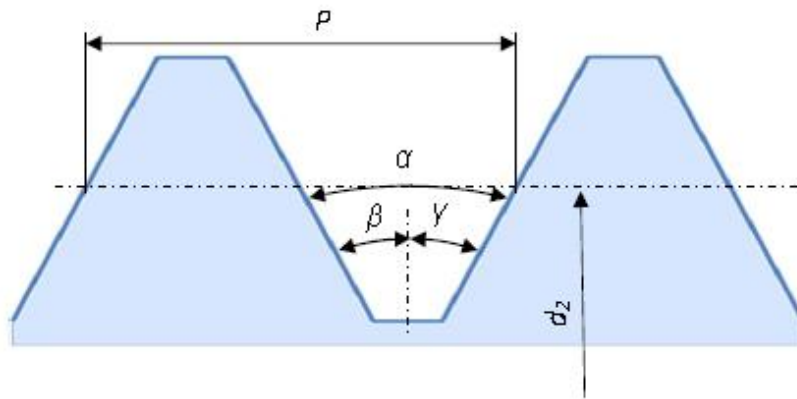


Fig. 1 Elements of the parallel screw thread (drawing and symbols apply to external thread. For internal diameters, the capital symbol D applies)

5.2. 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 auxiliary angle (θ), 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

5.3. Pitch Diameter (d₂, D₂)

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
Simple pitch diameter			
2a	m	Measured	-
	α	-	Within tolerance
	P	Measured	-
2b	m	Measured	-
	α	Measured	-
	P	Measured	-

Table2 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, helix angle , 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.

5.4. 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.

5.5. Thread angle

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

5.6. 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.

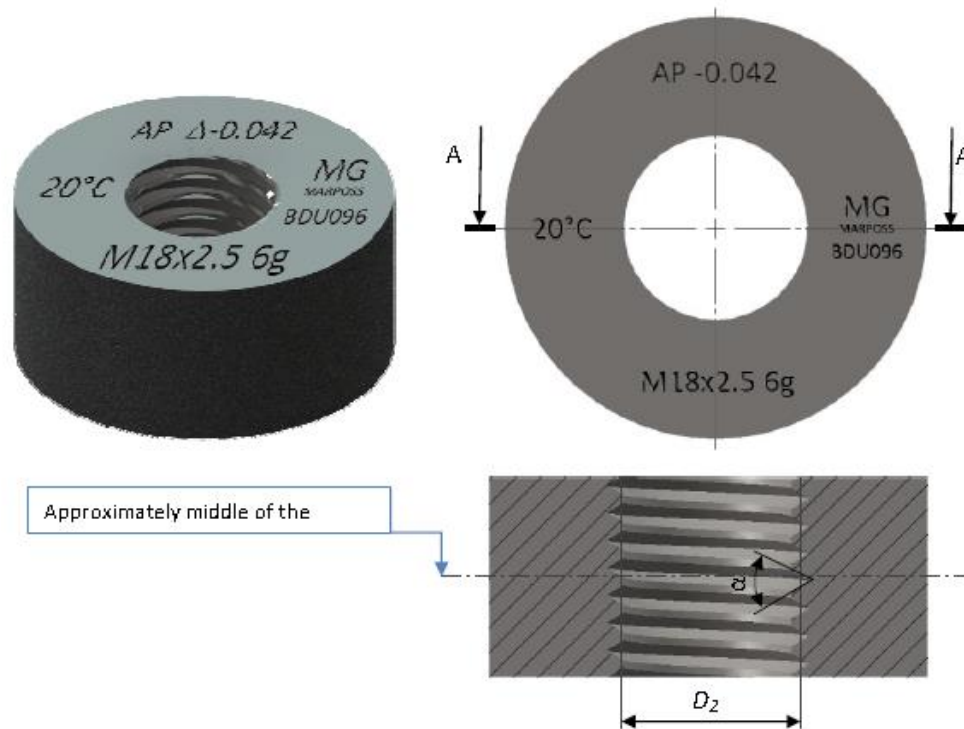


Fig. 2 Measurement positions - thread rings

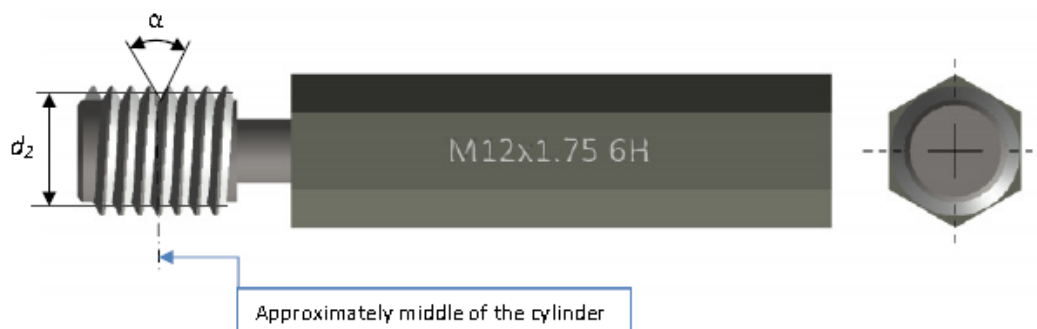


Fig. 3 Measurement positions - thread plugs

5.7. 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
- Helix angle

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 $\pm a$ (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
- Helix angle

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 $\pm a$ (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.

6. 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.

7. REFERENCES

1. Calibration Guide EURAMET cg-10, Determination of Pitch Diameter of Parallel Thread Gauges by Mechanical Probing, Version 2.1 (12/2012), ISBN 978-3- 942992 -27-5
2. ISO Guide for the Expression of Uncertainty in Measurement (ISO/IEC Guide 98-3:2008).

Appendix A - Reception of Standards

To :

National Institute of Metrology

Laboratory for Coordinate and Thread Measuring Technology, Length Division

18, Bei San Huan Dong Lu, 10029 Beijing, China

Responsible: Weinong Wang

Tel: +861064524931

e-mail : wangwn@nim.ac.cn

From :

(participating laboratory)

We confirm having received the standards of the APMP 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:.....

Appendix B - 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 <i>Simple</i>	mm	μm
Thread angle is measured (1b or 2b calibration category)			
Pitch diameter	D_2	mm	μm
Simple pitch diameter	D_2 <i>Simple</i>	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	dD	mm	
auxiliary angle	θ	°	

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	
auxiliary angle	θ	rad	

Short description of the applied measurement method/instruments:

.....

Laboratory :

Date : Signature:.....

Appendix C - 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:.....