ASIA PACIFIC METROLOGY PROGRAM

INTERCOMPARISON OF SURFACE ROUGHNESS

APMP.L-K8 2021 – 2024 or APMP.L-K8.n01

using WG-MRA guidance document GD-1
Appendix A naming convention

PROTOCOL version 7

Prepared by
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Australia

Issued 16 November 2023

This version of the protocol reflects changes to the list of participants and the order of schedule adjusted from the November 2023 mid-cycle check by the pilot.

There are no changes to the artefacts or measurement instructions from protocol version 6.

Contents

1. Introduction

The broad objective of the Asia Pacific Metrology Program (APMP) is to improve the measurement capabilities in the Asia Pacific region by sharing facilities and experience in metrology. Comparison of calibrations by different laboratories on given artefacts adds confidence in the measurement of standards and leads to international acceptance of the measurements carried out by these laboratories. This intercomparison concerns the calibration of surface roughness standards listed in section 5. Selected parameters are to be calculated according to well established international standard documents. Measurement conditions for each standard are described in the appropriate section of this document. On completion of measurements by all participants, the results of the intercomparison will be circulated for comment and a final report presented to the APMP.

2. Participation

The project will be coordinated (piloted) by Mr Andrew Baker, NMIA and supported by Dr Jariya Buajarern, NIMT. The program coordinators will be responsible for:

- Selecting, preparing and declaring the value of the artefacts,
- Planning the program and organising the schedule,
- Maintaining a list of participant's information,
- Liaising with participants,
- Making initial, mid-cycle and final measurements,
- Collating and assessing results by accepted statistical methods,
- Preparing the draft report and distributing the draft report for comment,
- Reviewing comments and completing the final report and executive report.

Participants, listed in Table 1, are expected to be ready to conduct measurements at the scheduled period, listed in Table 2. A laboratory may withdraw **any one or all** of its results from the intercomparison at any stage prior to submission of their results to the coordinator. Once the coordinator receives the submission of results, it is considered the laboratory regards them as appropriate to contribute to the calculation of mean results. The coordinator will then proceed with the analysis which will statistically determine which results are included. Any removal of results at a later date will be considered in exceptional circumstances and is at the discretion of the coordinators.

Table 1. Participants and contacts

Institute and Address	Contact
NMIA (Pilot) (APMP)	
National Measurement Institute Australia 1/153 Bertie St, Port Melbourne, 3207 Australia	**Mr Andrew Baker** andrew.baker@measurement.gov.au +61 3 9644 4902
NIMT (Co-Pilot) (APMP)	
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NIM (APMP)	
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NMIM (APMP)	
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SNSU-BSN (APMP)	
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SASO-NMCC (GULFMET)	
National Measurement and Calibration Center, Saudi Standards, Metrology and Quality Organization Building No. 4, Saudi Standards, Metrology and Quality Org. Al Imam Saud Ibn Abdul Aziz Road, Al Mohammadiyyah, Riyadh 12364, Saudi Arabia	**Mr. Faisal A. Alqahtani** f.qahtany@saso.gov.sa +96 65 4045 5655

Table 1. Participants and contacts (continued)

NPL (EURAMET)	
National Physical Laboratory (NPL) Hampton Road TW11 0LW Teddington, Middlesex United Kingdom	**Mr Dave Gunn** dave.gunn@npl.co.uk +44 20 8943 6063
VNIIMS (COOMET)	
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UzNIM (COOMET)	
UZBEK NATIONAL INSTITUTE OF METROLOGY (UZNIM) 333 “A” Farabi street, Almazar district, Tashkent UZBEKISTAN	**Ms Dildora Turdibayeva** turdibayeva@nim.uz +998 99 9242025

3. Scheduling, Packaging and Customs

The program is to commence in August 2021 with measurement at the pilot (coordinating) laboratory with the measurement schedule listed in Table 2. Each laboratory is expected to make all required measurements in a two (2) week period and allow a further two (2) week period for transferring the artefacts to the next listed laboratory. Those scheduled for December are allowed eight (8) weeks due to expected public holidays. The pilot laboratory will make repeat measurements as listed in the schedule to assess artefact condition and stability. Only the first results from the pilot laboratory will be included in the analysis.

The standards are made of glass and steel. Due to the length of this intercomparison, great care must be taken to ensure all surfaces are maintained in uncontaminated and undamaged condition. Section 5 and Appendix B list strict handling and measurement instructions including cleaning instructions. The artefacts are transported inside a solid protective case as shown in Figures 1 and 2. Each standard is also its individual case inside a single wooden box as shown in Figure 3. Each participant is responsible for carefully re-packing and shipping the artefacts to the next participant and bearing the costs associated with forwarding the artefacts. **If possible, place a new or refreshed satchel of desiccant in the wooden box with the artefacts to minimise risk of rust for the steel artefacts.**

A strong envelope is to be attached to the outside of the box (with a second copy inside the box) with of the following documents:

1. *This protocol.*
2. *Customs declaration / Proforma invoice (Appendix A of this document).*
3. *ATA Carnet covering participating countries within the scheduled period.* (Since a Carnet is valid for 12 months, multiple Carnet documents will be required.)

4. For the end of the intercomparison an additional document: *English/Russian translation letter* will be added to the list of documents for passage through Russia.

If any documents are lost or missing, please contact the coordinator immediately for replacement. When repacking the box, put a copy of the documents outside of the box as well as a copy inside to help with customs inspections.

Figure 1. Solid case.

Figure 2. Wooden box containing artefacts inside the case.

Figure 3. Individual artefact cases.

The amended schedule is listed in Table 2 with participants who have completed measurements in grey cells.

Table 2. Measurement schedule amended at mid-cycle check

Country	Lab	Region	Scheduled Month	Cumulative Months[1]	ATA Carnet	
Australia	NMIA	APMP	2021 August	1	Yes	First Closed at protocol v6 issue
Japan	NMIJ	APMP	2021 September	2	Yes	
South Korea	KRISS	APMP	2021 October	3	Yes	
Chinese Taipei	CMS/ITRI	APMP	2021 November	4	No [2]	
Hong Kong	SCL	APMP	2021 December / 2022 January	5,6	Yes	
Thailand	NIMT	APMP	2022 February	7	Yes	
Malaysia	NMIM	APMP	2022 April	8	Yes	
India	NPLI	APMP	2022 May	9	No	
Saudi Arabia	SASO-NMCC	GULFMET	2022 June	10	No	
Australia (stability check)	NMIA	APMP	2022 October	11	Yes	Second Closed at protocol v7 issue
Indonesia	SNSU-BSN	APMP	2022 November / 2022 December	12,13	Yes	
Singapore	NMC, A*STAR	APMP	2023 February	14	Yes	
Argentina	INTI	SIM	2023 May	15	No	
Mexico	CENAM	SIM	2023 June	16	Yes	
USA	NIST	SIM	2023 September	17	Yes	
China	NIM	APMP	2023 October	18	Yes	
Australia (stability check)	NMIA	APMP	2023 November	19	Yes	Third
UK	NPL	EURAMET	2023 December / 2024 January	20,21	Yes	
Uzbekistan	UzNIM	COOMET	2024 February	22	No	
Russia	VNIIMS	COOMET	2024 March	23	No [3]	
New Zealand	MSL	APMP	2024 April	24	Yes	
Australia (stability check)	NMIA	APMP	2024 May	25	Yes	

[1] Lost months due to customs and other delays not counted as of 15 November 2023.
[2] Chinese Taipei require a different type of Carnet which is not being used for this project.
[3] Russia requires an accompanying letter with direct English to Russian translation.

4. Equipment

Each laboratory has nominated the equipment listed in Table 3 for measurement of included artefacts.

Table 3. Expected measurement instruments

Lab	Instrument and software	Ranges (mm)		Traceability	
		X	Z	X	Z
NMIA	Zeiss Jena Epival Interference Microscope with He-Ne laser	-	~0.005	-	NMIA He-Ne
	Hommelwerke T8000 *Software: Turbo Wave v7.2*	200	1.6	NMIA He-Ne	NMIA Step H.
NIMT	Kosaka Surfcorder ET4000AK *Software: i-Star*	100	32	NMIT	NIMT
NIM	Metrological Interference Microscope *Software: Areal Metrology v1.2*	-	1	NIM	NIM
	Profilometer Instrument *Software: Roughness Metrology v1.0*	120	2		
CMS / ITRI	Kosaka Surfcorder ET-4100	200	0.05	CMS line scale	CMS grooves
	Taylor Hobson PGI freeform *Software: Talymap platinum 3D Astigmatism Pack*	200	14		
SCL	Taylor Hobson Talysurf i-Series M112-4581 *Software: Ultra v6.2.4.1*	120	2	NPL	METAS
NPLI	Mitutoyo Formtracer Extreme CS 5000 CNC *Software: Formtracepak v6.0 CNC*	200	12		NPLI (JCSS)
NMIJ	Taylor Hobson Talysurf S2 *Software: Homemade*	120	1	NMIJ	NMIJ
	Panasonic UA3P *Software: Homemade*	100	10		
NMIM	KLA Tencor P7 *Software: Apex analysis*	156	~0.3		NIST
	Taylor Hobson Form Talysurf 120i *Software: Ultra*	120	~2		NMIM
MSL	Mitutoyo Surftest SV-3100H4 *Software: Formtracepak*	100	0.8		MSL
NMC, A*STAR	Taylor Hobson Form Talysurf PGI2540 *Software: Ultra*	200	12.5	NPL	NPL
KRISS	Taylor Hobson Form Talysurf 2	200	10	KRISS He-Ne	KRISS Step H.
SNSU-BSN	Taylor Hobson Talysurf i120 *Software: Ultra (data acquisition only)*		1		METAS
SASO-NMCC	Mahr profilometer *Software: MarWin MarSurf XCR 20 7.00-12 SP3*	120	0.5		PTB
NPL	NanoSurf IV stylus tracing instrument	120	0.02	NPL	NPL
VNIIMS	Talysurf PGI420 *Software: Talyprofile ver. 7.4.9391 (based on Mountains)*	120	4	VNIIMS	UKAS
CENAM	Taylor Hobson Form Talysurf PGI2540 *Software: Talymap Gold v6.5.4.2*	200	12	CENAM	CENAM
INTI	Stylus roughmeter Taylor Hobson Tsi 120 *Software: Taylor Hobson µltra V 6.1.12.1*	120	1	INTI	INTI / PTB
NIST	Taylor Hobson Form Talysurf PGI 1240 stylus profilometer *Software: Ultra version 5.21.8.24*	200	12	NIST	NIST
UzNIM	Mitutoyo Formtracer Avant FTA – H4 D4000-D *Software: Formtracepak v6.002*	100	0.8	Mitutoyo	Mitutoyo

5. Artefacts and Measurement Instructions

Artefacts are to be measured to the conditions described in Table 4. ***Any or all of the listed parameters for that artefact may be submitted.*** Parameters are calculated according to ISO 5436-1 [4] or ISO 4287 [2] with measurement conditions from ISO 4288 [3] tables 1 and 3 and ISO 3274 [1] table 1 and are to be determined on the filtered roughness profile with a Gaussian filter as defined in ISO 16610 [5].

Stylus measurements should be performed without a skid, a stylus tip radius of 2 µm, a traverse speed of ≤ 0.2 mm/s and a sample spacing of ≤ 0.5 µm. For non-contact instruments, approximate the conditions as appropriate. Possible variations that should be considered and noted in any report.

- Obvious scratches or flaws should be avoided in measurement and discarded from analysis.
- A profile length may include a lead-in or lead out which may be 1 cut-off or ½ cut-off at each end. Where possible, adjust the profile location to account for this.
- Some laboratories or instruments make mathematical adjustment to parameter values due to stylus radius which may be for a 2 µm radius or for a theoretically zero tip size. Any corrections must be discussed with the pilot to ensure that submitted results are appropriate for comparison.
- R_z is to be determined from ISO 4287-1 [1997]. If the instrument reports the old ten-point-height from ISO 4287 [1984], then parameter R_y from ISO 4287 [1984] should be determined.
- For RS_m ISO 4287 recommends a height discrimination of 10% of the R_z value to be used.

IMPORTANT: Handle only with gloves. Do not touch the measurement surfaces with bare hands. Only remove items from their protective cases at the location of measurement. If an item must be transferred across a room, return it to its case and only remove it at the required instrument work table.

In measurement, the contact tip MUST be raised OFF the surface at the end of each profile. Do NOT allow automatic return of the tip across the surface! Contact with the surface must be minimised.

Table 4. Artefacts.

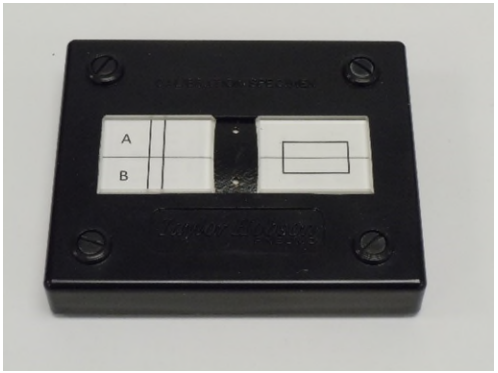
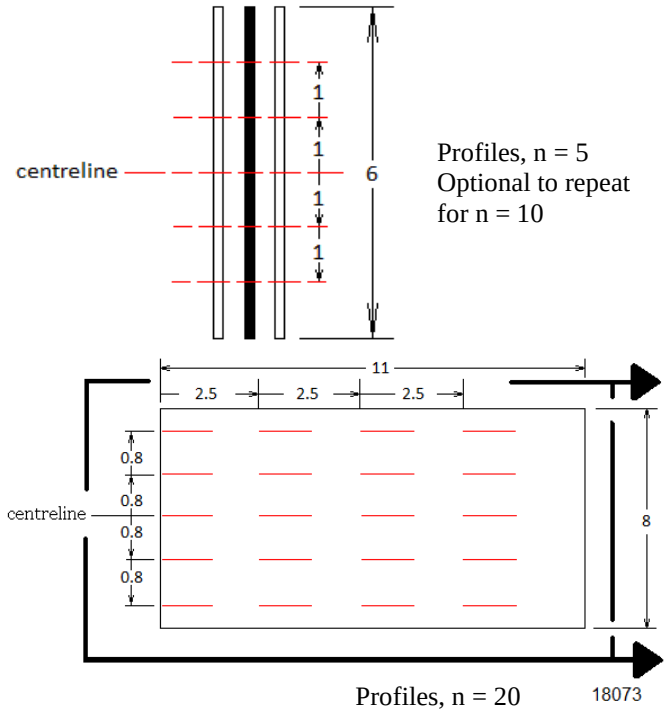
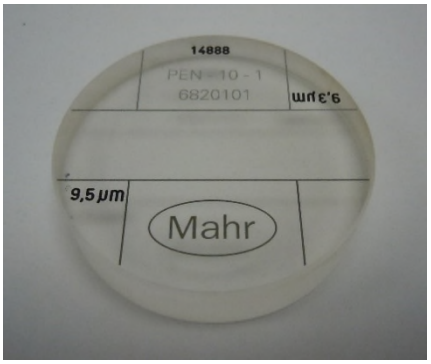
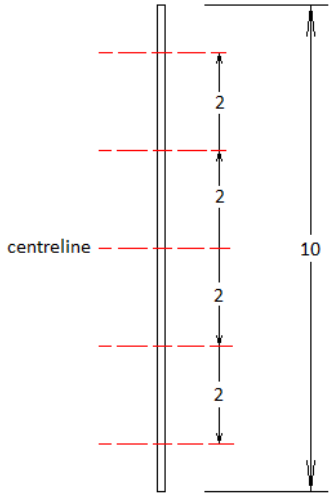
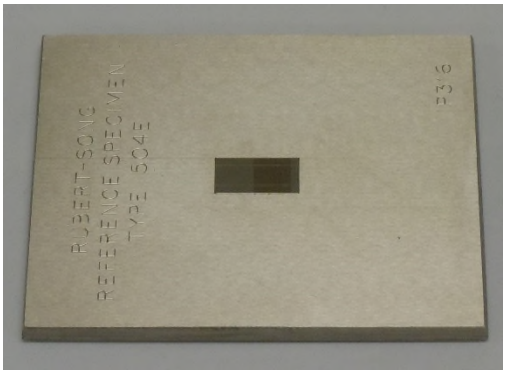
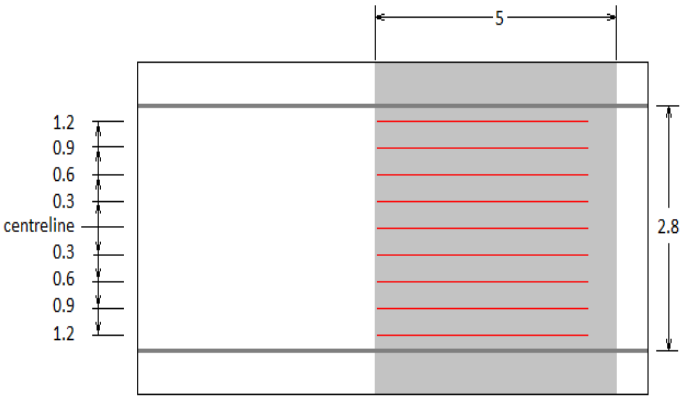
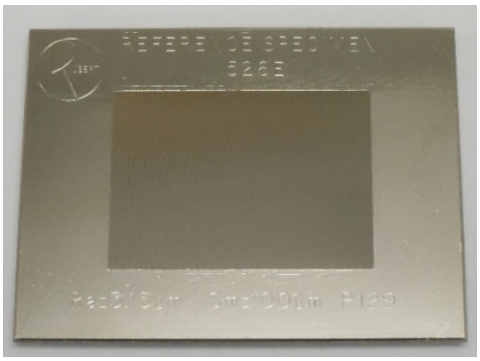
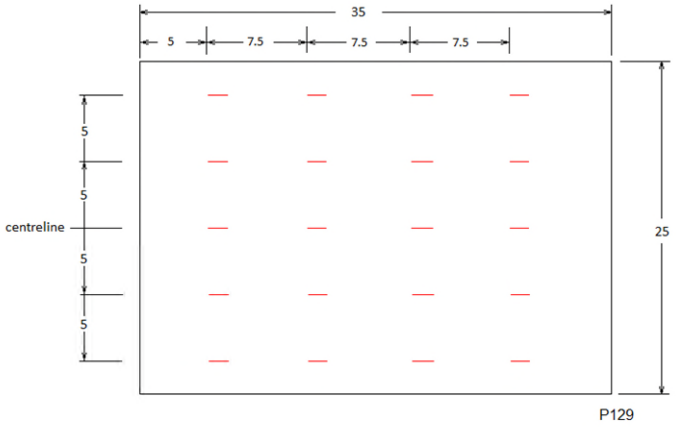
Taylor Hobson Standard s/n 18073 Type A1 Grooves and Type C1 Roughness (periodic)	
Grooves A and B centre grooves only Parameter: **d** (ISO 5436) **Roughness** Parameters: ***R_a R_z R_t RS_m*** Cut-off length, λ_c: 0.25 mm (ISO 4288 table 3) Profile length, l_n: 1.25 mm Filter ratio, λ_c/λ_s: 100:1 (ISO 3274 table 1) 	

Table 4. Artefacts (continued).

Mahr Type A1 Groove Standard s/n 6820101	
Measure only the nominal 9.5 µm groove. Do ***not*** measure the 9.3 µm groove. Parameter: **d** (ISO 5436) 	 Profiles, n = 5 Optional to repeat for n = 10
Rubert-Song Type D1 Roughness Standard s/n P316 (non-periodic)	
Parameters: R_a R_q R_z R_t Cut-off length, λ_c: 0.8 mm (ISO4288 table 1) Profile length, l_n: 4.0 mm Filter ratio, λ_c/λ_s: 300:1 (ISO 3274 table 1) 	Profiles, n = 9 Optional to repeat for n = 18 
Rubert Type C1 Roughness Standard s/n P129 (periodic)	
Parameters: R_a R_z R_t RS_m Cut-off length, λ_c: 0.25 mm (ISO4288 table 3) Profile length, l_n: 1.25 mm Filter ratio, λ_c/λ_s: 100:1 (ISO 3274 table 1) 	Profiles, n = 20 

6. Intercomparison Analysis (Coordinator)

Analysis methods are consistent with the ISO *Guide to the Estimation of Uncertainty in Measurement* (GUM). When all measurements are completed, the reference value for each measured quantity is to be the weighted mean of the values x_i from each individual laboratory, as given by

Weighted mean: $$\bar{x}_w = \left[\sum_{i=1}^{N} x_i / u^2(x_i)\right] \Big/ \left[\sum_{i=1}^{N} 1/u^2(x_i)\right] \quad (1)$$

To avoid bias, the first set of measurements only will be included from the pilot laboratory.

Assessment of each laboratory result will be made with the degree of equivalence ratio (E_n):

$$E_n = \frac{x_i - \bar{x}}{2\sqrt{u^2(x_i) - u^2(\bar{x})}} \quad (2)$$

where $u(x_i)$ is the standard uncertainty of the individual laboratory and $u(\bar{x})$ is the standard uncertainty of the weighted mean.

Any result with an $E_n > 1$ with respect to the reference value will be excluded and the reference value and E_n ratio recalculated. If more than one laboratory result is to be excluded this will be tested one result at a time.

The **Birge ratio** is a test of the consistency of a set of data and its uncertainties. If the measurements being compared come from the same population, then the propagated (internal) uncertainty $u_I(\bar{x}_w)$ should agree with that calculated from the standard deviation of the weighted mean (external uncertainty) $u_E(\bar{x}_w)$ as given in equations 3 and 4.

$$u_E^2(\bar{x}_w) = \left[\sum_{i=1}^{N} 1/u^2(x_i)\right]^{-1} \quad (3)$$

$$u_I^2(\bar{x}_w) = \left[\sum_{i=1}^{N} (x_i - \bar{x}_w)^2 / u^2(x_i)\right] \Big/ \left[(N-1)\sum_{i=1}^{N} 1/u^2(x_i)\right] \quad (4)$$

For an infinite population size, the ratio $R_B = u_E(\bar{x}_w)/u_I(\bar{x}_w)$ should approximate a value of 1. For a limited population size, the Birge criterion is given by:

$$R_B = \sqrt{1 + \sqrt{\frac{8}{N-1}}} \quad (5)$$

where N is the number of accepted measurements. The criterion is recalculated if a result is excluded.

7. Draft and Final Report (Coordinator)

It is anticipated that the draft report will be sent to all participants within two months of the final measurements. Participants are expected to correct any mistakes in the draft with respect to their own submissions and review and comment on analysis and conclusions. After all discussions are complete, the final report will then be submitted to the APMP for publication following recommended international guidelines.

8. References

[1] ISO 3274 *Surface Texture – Instruments for the assessment of surface texture – Profile method*, International Organization for Standardization, Geneva, Switzerland, 1996.

[2] ISO 4287 *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Terms, definitions and surface texture parameters*, International Organization for Standardization, Geneva, Switzerland, 1997.

[3] ISO 4288 *Geometrical Product Specifications (GPS) – Surface texture: Profile method – Rules and procedures for the assessment of surface texture*, International Organization for Standardization, Geneva, Switzerland, 1996.

[4] ISO 5436-1 *Geometrical Product Specifications (GPS) – Surface texture: Profile method; Measurement standards – Part 1: Material measures*, International Organization for Standardization, Geneva, Switzerland, 2000.

[5] ISO 16610 *Geometrical Product Specifications (GPS) – Surface texture: Profile method - Metrological characteristics of phase correct filters*, International Organization for Standardization, Geneva, Switzerland, 1996.

[6] *JCGM 100:2008 - Evaluation of measurement data - Guide to the expression of uncertainty in measurement.*

[7] M.G Cox, "The Evaluation of Key Comparison Data", Metrologia, 2002, 39, 589-595.

[8] A.Baker, et.al., APMP.L-K8 International Comparison of Surface Roughness Final report January 2013 Measurements July 2008 to June 2010, Metrologia 50, January 2013

Appendix A: CUSTOMS DECLARATION

TO WHOM IT MAY CONCERN

APMP Regional Comparison

The Asia Pacific Metrology Program (APMP) is an organisation representing the National Measurement / Standards Laboratories of a large number of countries/territories in the Asia-Pacific region. Its broad objective is to improve the measurement capabilities in the Asia-Pacific region by sharing facilities and experience in metrology. One very successful method used by the APMP is the comparison of calibrations performed by different laboratories on given artefacts. Successful completion of these intercomparisons adds confidence to the laboratories in the carrying out of measurements and leads to international acceptance of the measurements.

As part of a major intercomparison program, the APMP is conducting an intercomparison on surface roughness involving the highest level measurement laboratories in two rounds involving the following countries in order:

Round 1	**Australia, Japan, South Korea, Chinese Taipei, Hong Kong, Thailand, Malaysia, India, Saudi Arabia (then return to Australia)**
Round 2	**Australia, Indonesia, China, Singapore, Argentina, USA, Mexico, United Kingdom, New Zealand (then return to Australia)**
Round 3	**Australia, Russia (then return to Australia)**

This program is coordinated by the National Measurement Institute of Australia.

The following 4 artefacts are circulated among the participants for calibration:

Item	Item only		With Individual Case		Approx. Value
	Dimensions	Weight	Dimensions	Weight	
Taylor Hobson glass artefact s/n 18073	75 × 62 × 12	0.139 kg	110 × 92 × 28	0.265 kg	AU$3000
Mahr glass artefact s/n 6820101	46 × 11	0.038 kg	82 × 60 × 20	0.055 kg	AU$2000
Rubert steel artefact s/n P129	63 × 45 × 3	0.039 kg	82 × 60 × 20	0.054 kg	AU$450
Rubert steel artefact s/n P316	64 × 50 × 3	0.042 kg	82 × 60 × 20	0.058 kg	AU$550

The purchase/manufacturing cost of the artefacts is approximately **AUS$6,000**; however they have no commercial value (not for sale). They are meant solely for the calibration of national standards and **will be exported immediately after the calibration is complete.** Refer to the schedule on page 6 of the protocol.

The shipping case has dimensions of (440 × 380 × 200) mm and weighs approximately 4.0 kg when containing all artefacts, internal protective cases, collective box and documents.

We request that the artefacts are not handled or removed from the container/package. Please do not touch the artefacts with bare hands as this may contaminate the surfaces. If a Customs inspection is required then please contact the relevant contact for the region on pages 3 and 4 of this document so that he/she can be present and unpack the items in your presence.

<u>Comparison Coordinator</u>

Mr Andrew Baker
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1/153 Bertie St, Port Melbourne, 3207
Australia
Phone: +61 3 9644 4902
Email: andrew.baker@measurement.gov.au

Appendix B: Checklist of Instructions

Participants are expected to perform the following actions in approximate order:

Actions	Done
Prior to receiving shipment	
1. Have all resources and instrumentation ready for the scheduled month of measurement and commit to carrying out measurements according to the schedule (Table 2).	
2. Ensure funds are available for onward transport of the artefacts	
On receipt of artefacts	
3. Inspect the box on arrival for any damage. Take digital photographs of any damage.	
4. Unpack the standards from the box.	
5. Confirm the documents are in order (Carnet, customs and protocol).	
6. Treat the artefacts as if they are fragile. At all times, handle only with gloves, do not touch the surfaces with bare hands. Only remove items from their protective cases at the location of measurement. If an item must be transferred across a room, return it to its case and only remove it at the required instrument work table.	
7. Examine the standards under magnification and glancing light and note any damage including surface defects and scratches on the form in appendix C. If beneficial, take digital photographs of any damage or scratches.	
8. Remove any contamination by gentle blowing of clean air or nitrogen. If any debris remains, try a clean soft-bristle brush. Finally, only if necessary, use a soft lint-free tissue and residue free solvent such as isopar-E, ethanol or heptane.	
9. *Inform the pilot at andrew.baker@measurement.gov.au that the standards have been received and any damage to the standards or the box.*	
Measurement	
10. Check the condition of a stylus prior to measurement of EVERY standard. If any damage is apparent, do not use that stylus.	
11. Measure the standards as directed by this document. Any stylus contact must be as minimal as possible. Lift the stylus off the surface at the end of a profile measurement. Do NOT return the stylus to its initial position in contact with the surface!	
12. If applicable, measure the stylus radius, cone angle and force for each stylus to be used. Measure the system noise on the same range by measuring an optical flat or similar very smooth surface.	
13. Reassess each standard after measurements are completed for any changes to surface condition on the form Appendix C. Note any new damage or scratches. *Inform the pilot of any change in condition to any of the standards.*	
Completion of measurements	
14. If satisfied that measurements are acceptable, repack the standards with anti-rust paper over the metal standards and a new satchel of desiccant in the box, one set of documents inside the box and one set outside the box. The Carnet must be outside the box. Update the delivery address on the case to the next participant.	
15. Use a suitable transport agent for forwarding the artefacts to the next participant and organise smooth movement through customs using appropriate documents.	
16. Inform the pilot AND the next scheduled laboratory that the measurements have been completed and the artefacts are in transit.	
17. Prepare one or more typical calibration reports with appropriate uncertainty of measurement calculations for each measured parameter. Send the summary of results (Appendix D), uncertainty spreadsheets and calibration reports to the pilot **within 6 weeks of receipt of the artefacts**.	
18. Agree not to discuss any measurement results prior to distribution of the draft report (after completion of all measurements).	

Appendix C: <u>Artefact Condition: BEFORE and AFTER measurements</u> **(Page 1 of 2)**

[Print pages to fill details. Take pictures as needed. When complete, scan and email to pilot.]

Country/Laboratory: _____ Date of condition assessment: _____

Assessment before or after measurement: BEFORE / AFTER (circle)

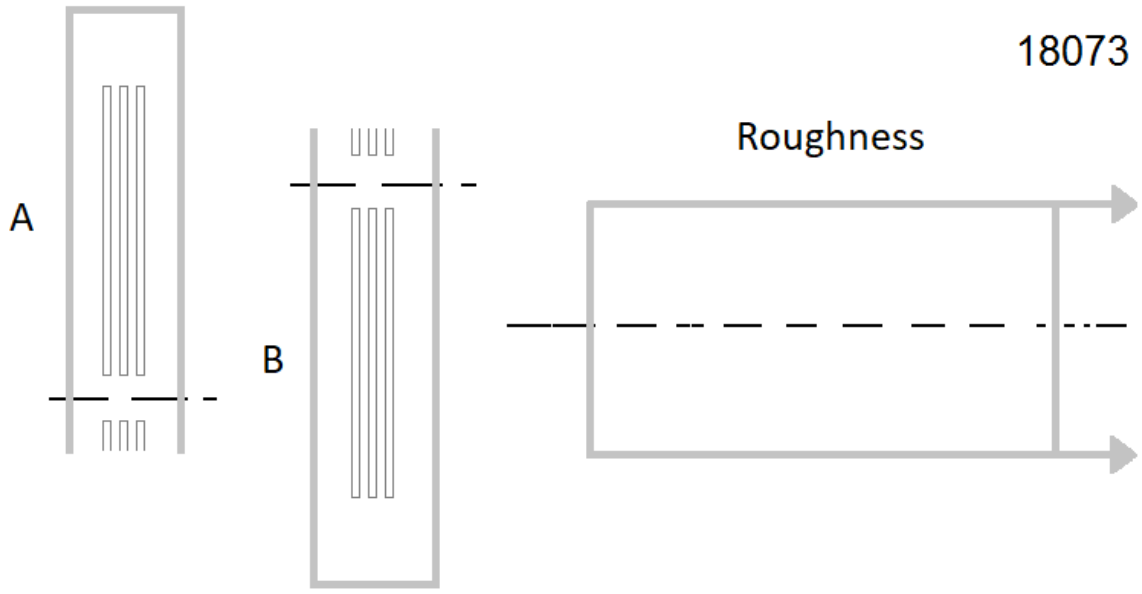
Note damage to the shipping case or artefact box: _____

_____

Serial number **18073** (separated segments)

Cleaning methods used: _____

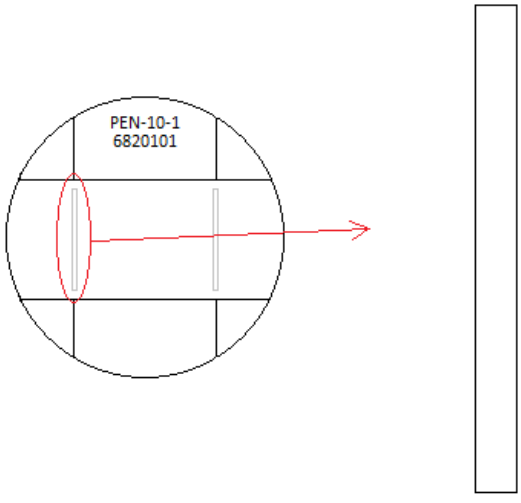
Comments: _____



Serial number **6820101, 9.5 µm groove only**

Cleaning methods used: _____

Comments: _____

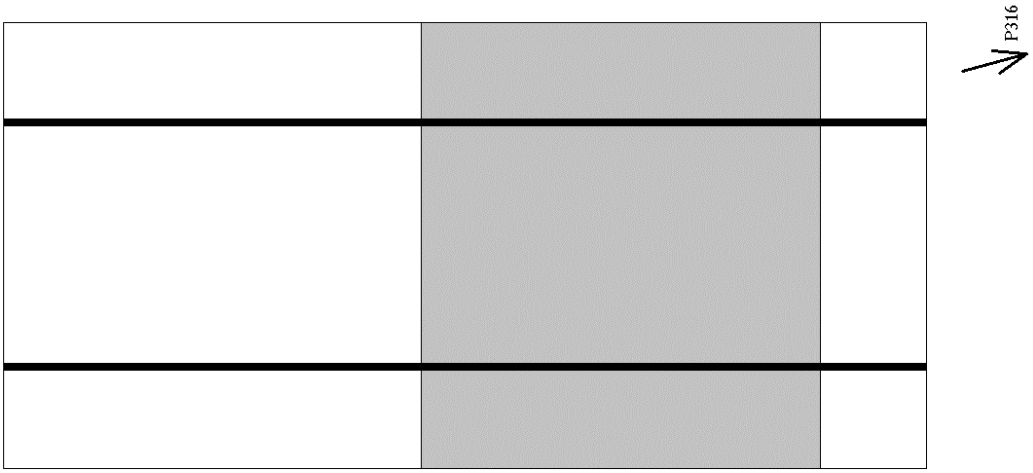


Appendix C: Artefact Condition BEFORE and AFTER measurements (Page 2 of 2)

Serial number **P316**

Cleaning methods used:_____

Comments: _____

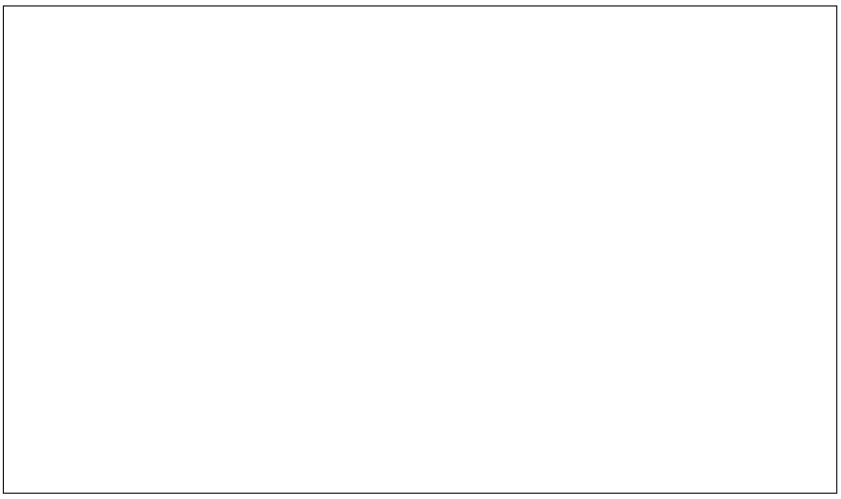


Measurement surface only

Serial number **P129**

Cleaning methods used: _____

Comments: _____



Measurement surface only

P129

Appendix D: Results for Laboratory: _____

The table is provided in an Excel spreadsheet in the shown format with additional space for listing software, traceability and additional comments.
The table assumes stylus measurement, however, if interferometric methods are used, please list details where considered influential.
Please list all results in micrometers (µm) and ensure results are clear and comments are in English.

Country:	**Australia**		**Lab:**	NMIA		**Date of submission:**			add final date	STYLUS RADIUS & CORRECTION						
Artefact s/n	Param.	Date of measurement	Result µm	σ µm	u_c ± µm	k	U ± µm	n	Instrument	tip radius µm	Was correction applied	Size of correction +/- µm	*v* mm/s	l_n mm	λ_c mm	Filter λ_c/λ_s
18073	d (A)										-	-			-	-
	d (B)										-	-			-	-
	R_a										yes/no	+/- value				
	R_z															
	R_t															
	RS_m															
6820101	d										-	-			-	-
P316	R_a															
	R_q															
	R_z															
	R_t															
P129	R_a															
	R_z															
	R_t															
	RS_m															

Symbols σ: standard deviation, u_c: standard uncertainty, k: coverage factor, U: expanded uncertainty, n: number of profiles
tip rad: tip radius, v: speed of traverse, ln: profile evaluation length, λc: cut-off length, λc/λs: filter ratio, gf: gram force.

End of Protocol.