Length, Switzerland, METAS (Swiss Federal Office of Metrology)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Class	**Instrument or Artifact: Measurand**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage Factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**NMI Internal Service Identifier**	**Comments**
Laser radiations	Stabilized laser of the mise en pratique: vacuum wavelength	Optical beat frequency	633	633	nm			0.04	fm	2	95%	No	1	
Laser radiations	Stabilized laser of the mise en pratique: absolute frequency	Optical beat frequency	474	474	THz			24	kHz	2	95%	No	1	
Laser radiations	Other stabilized laser: vacuum wavelength λ_0	Optical beat frequency	633	633	nm			1E-09 λ_0	nm	2	95%	No	2	
Length instruments	Laser interferometer: error of indicated displacement *L*	Comparison to master length interferometer	1	50	m			Q[0.01, 0.07*L*], *L* in m	µm	2	95%	No	3	
Length instruments	Laser interferometer: wavelength compensation *n*	Calibration of pressure and temperature transducers				Pressure	900 hPa to 1020 hPa	1.6E-07*n*		2	95%	No	4	
						Relative humidity	(50 ± 5) %							
						Temperature	20 °C							
End standards	Gauge block: central length *L*	Interferometry, exact fractions	0.5	100	mm			Q[19, 0.19*L*], *L* in mm	nm	2	95%	No	5	
End standards	Gauge block: central length *L*	Mechanical comparison	0.5	100	mm			Q[38, 0.50*L*], *L* in mm	nm	2	95%	No	6	
End standards	Long gauge block: central length *L*	1-D comparator and white light interferometer	125	1000	mm			Q[30, 0.17*L*], *L* in mm	nm	2	95%	No	7	
End standards	Long gauge block: central length *L*	1-D comparator and mechanical probe	125	3000	mm			Q[240, 1.4*L*], *L* in mm	nm	2	95%	No	8	
End standards	Step gauge: face spacing *L*	1-D comparator and mechanical probe	10	1000	mm			Q[170, 0.64*L*], *L* in mm	nm	2	95%	No	9	
Line standards	Precision line scale: line spacing *L*	2-D mask comparator and CCD microscope	0.01	400	mm	Illumination	episcopic	Q[20, 0.1*L*], *L* in mm	nm	2	95%	No	11	

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Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Class	**Instrument or Artifact: Measurand**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage Factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**NMI Internal Service Identifier**	**Comments**
Line standards	Grid plate: grid point coordinates *L*	2-D mask comparator and CCD microscope	(0.01x0.01)	(400x300)	mm^2	Illumination	episcopic	Q[20, 0.4*L*], *L* in mm	nm	2	95%	No	12	
Line standards	1-D grating: pitch *p*	Long range AFM	0.2	20	µm	Measurement length	50 µm to 350 µm	0.05*p*, *p* in µm	nm	2	95%	No	13	
Line standards	1-D grating: pitch *p*	Laser diffractometer	0.3	10	µm	Measurement area	1 mm^2 to 4 mm^2	Q[0.006, 0.009*p* , 0.0015p^2], *p* in µm	nm	2	95%	No	14	
Line standards	2-D grating: pitch *p*	Long range AFM	0.2	20	µm	Measurement length	50 µm to 350 µm	0.05*p*, *p* in µm	nm	2	95%	No	15	
Line standards	2-D grating: pitch *p*	Laser diffractometer	0.3	10	µm	Measurement area	1 mm^2 to 4 mm^2	Q[0.006, 0.009*p* , 0.0015p^2], *p* in µm	nm	2	95%	No	16	
Line standards	2-D grating: orthogonality	Laser diffractometer	85	95	°	Pitch	0.4 µm to 10 µm	70	µrad	2	95%	No	17	
Line standards	Tape: line spacing *L*	50 m laser bench and photoelectric microscope	0.1	50	m	Support	horizontal, flat	Q[12, 3.3*L*], *L* in m	µm	2	95%	No	18	
Line standards	Surveyor's levelling rod: line spacing	Measurement bench and projection microscope	0.1	4	m			10	µm	2	95%	No	19	
Diameter standards	External cylinder (plug): diameter *L*	1-D comparator and spherical stylus	2	300	mm			Q[63, 0.28*L*], *L* in mm	nm	2	95%	No	20	
Diameter standards	External cylinder (plug, pin, wire): diameter *L*	1-D comparator and flat probe	0.1	30	mm			Q[130, 2.7*L*], *L* in mm	nm	2	95%	No	21	
Diameter standards	Internal cylinder (ring): diameter *L*	1-D comparator and spherical stylus	1	300	mm			Q[63, 0.28*L*], *L* in mm	nm	2	95%	No	22	
Diameter standards	Sphere: diameter *L*	1-D comparator and flat probe	0.5	30	mm			Q[170, 2.9*L*], *L* in mm	nm	2	95%	No	23	

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Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Class	**Instrument or Artifact: Measurand**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage Factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**NMI Internal Service Identifier**	**Comments**
Diameter standards	Sphere: diameter *L*	1-D comparator and flat probe	10	100	mm			Q[140, 1.4*L*], *L* in mm	nm	2	95%	No	24	
Diameter standards	Sphere: diameter	Micro-CMM	0.5	2	mm	Diameter	half sphere average	20	nm	2	95%	No	57	Approved on 19 May 2007
Diameter standards	Sphere: sphericity	Micro-CMM	0	10	µm	Diameter sphericity	0.5 mm to 2 mm, half sphere mapping	30	nm	2	95%	No	58	Approved on 19 May 2007
Diameter standards	Internal cylinder: diameter	Micro-CMM	0.2	10	mm			50	nm	2	95%	No	59	Approved on 19 May 2007
Angle by circle dividers	Optical polygon: face angle	Cross calibration versus index table and rotary table and autocollimator	3	36	faces			0.1	"	2	95%	No	25	
Angle by circle dividers	Index table: index angle	Cross calibration versus polygon and rotary table	2	24	full-circle divisions			0.12	"	2	95%	No	26	
Angle by circle dividers	Rotary table: position angle	Comparison versus reference rotary table	0	360	°			0.12	"	2	95%	No	27	
Angle instruments	Autocollimator: error of indicated angle	Sine-bar and piezoelectric transducer	0	± 15	"	Orientation	horizontal	0.01	"	2	95%	No	28	
Angle instruments	Autocollimator: error of indicated angle	Comparison versus reference rotary table	0	arbitrary	"	Orientation	horizontal	0.06	"	2	95%	No	29	
Angle instruments	Electronic level: error of indicated inclination angle	Sine bar and angle interferometer	0	1	°			0.25	"	2	95%	No	30	
Angle artefacts	Angle block: included angle	Rotary table and autocollimator	0	90	°			0.15	"	2	95%	No	31	
Angle artefacts	90° granite square: squareness	Rotary table and straightness tester	90	90	°	Orientation	horizontal	0.16	"	2	95%	No	32	
						Size	up to 600 mm							
Angle artefacts	90° granite square: straightness	Straightness tester	0	100	µm	Orientation	horizontal	0.1	µm	2	95%	No	33	
						Size	up to 600 mm							

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Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Class	**Instrument or Artifact: Measurand**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage Factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**NMI Internal Service Identifier**	**Comments**
Angle artefacts	90° granite square: squareness	Granite column	90	90	°	Orientation	vertical	0.2	"	2	95%	No	34	
						Size	up to 1000 mm							
Angle artefacts	90° granite square: straightness	Granite column	0	100	µm	Orientation	vertical	0.18	µm	2	95%	No	35	
						Size	up to 1000 mm							
Angle artefacts	90° cylinder square: squareness	Granite column	90	90	°	Orientation	vertical	0.2	"	2	95%	No	36	
						Size	up to 1000 mm							
Angle artefacts	90° cylinder square: squareness	Granite column	0	100	µm	Orientation	vertical	0.18	µm	2	95%	No	37	
						Size	up to 1000 mm							
Roundness standards	External cylinder: roundness *R*	Form tester	0	100	µm	Diameter	up to 300 mm	Q[75, 16*R*], *R* in µm	nm	2	95%	No	38	
Roundness standards	Internal cylinder: roundness *R*	Form tester	0	100	µm	Diameter	up to 270 mm	Q[75, 16*R*], *R* in µm	nm	2	95%	No	39	
Roundness standards	Sphere: roundness *R*	Roundness instrument	0	1	µm	Diameter	up to 150 mm	Q[7, 17*R*], *R* in µm	nm	2	95%	No	40	
Roundness standards	Magnification standard: roundness *R*	Stylus instrument	0.1	300	µm	Diameter	up to 50 mm	Q[200, 3*R*], *R* in µm	nm	2	95%	No	41	
Straightness standards	Straight edge: straightness	Straightness tester	0	100	µm	Length *L*	up to 800 mm	(15 + 0.1*L*), *L* in mm	nm	2	95%	No	42	
Surface texture	Depth standard (ISO 5436-1 type A): depth *d*	Interference microscope	0.01	10	µm			Q[1, 16*d*], *d* in µm	nm	2	95%	No	43	
Surface texture	Depth standard (ISO 5436-1 type A): depth *d*	Stylus instrument	0.1	1000	µm			Q[10, 0.2*d*], *d* in µm	nm	2	95%	No	44	
Surface texture	Depth standard (ISO 5436-1 type A): depth *d*	AFM	0.01	2	µm	Lateral size	< 50 µm	Q[1, 5*d*], *d* in µm	nm	2	95%	No	45	

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Class	**Instrument or Artifact: Measurand**	**Instrument Type or Method**	**Minimum value**	**Maximum value**	**Units**	**Parameter**	**Specifications**	**Value**	**Units**	**Coverage Factor**	**Level of Confidence**	**Is the expanded uncertainty a relative one?**	**NMI Internal Service Identifier**	**Comments**
Surface texture	Wavelength standard (ISO 5436-1 type C): amplitude parameters	Stylus instrument	0.01	100	µm	Parameters	*Ra* , *Rq*	Q[10, 16*Ra*], *Ra* in µm	nm	2	95%	No	46	
						Parameters	*Rp* , *Rv* , *Rz* , *Rt*	Q[30, 40*Rp*], *Rp* in µm	nm	2	95%	No		
Surface texture	Roughness standard (ISO 5436-1 type D): ISO roughness parameters	Stylus instrument	0.01	20	µm	Parameters	*Ra* , *Rq*	Q[10, 30*Ra*], *Ra* in µm	nm	2	95%	No	47	
						Parameters	*Rp* , *Rv* , *Rz* , *Rt*	Q[30, 60*Rp*], *Rp* in µm	nm	2	95%	No		
Screw threads	Thread plug, plain: pitch diameter	1-D comparator and spherical stylus	2	100	mm	Pitch	0.5 mm to 6 mm	1.8	µm	2	95%	No	48	
Screw threads	Thread plug, plain: pitch	Stylus instrument	0.5	6	mm			0.4	µm	2	95%	No	49	
Screw threads	Thread plug, plain: flank angle	Stylus instrument	45	70	°	Pitch	> 0.8 mm	2	'	2	95%	No	50	
Screw threads	Thread ring, plain: pitch diameter	1-D comparator and spherical stylus	4	100	mm	Pitch	0.5 mm to 6 mm	1.8	µm	2	95%	No	51	
Screw threads	Thread ring, plain: pitch	Stylus instrument	0.5	6	mm	Minimum diameter	10 mm	0.4	µm	2	95%	No	52	
Screw threads	Thread ring, plain: flank angle	Stylus instrument	45	70	°	Minimum diameter	10 mm	2	'	2	95%	No	53	
Angle artefact	Taper gauge: taper angle	CMM	0	20	°			1.5	"	2	95%	No	54	Approved on 22 March 2005
Angle artefact	Taper gauge: diameter *D*	CMM	10	150	mm			Q[0.6, 0.7*D*], *D* in m	µm	2	95%	No	55	Approved on 22 March 2005
CMM artefacts	Ball (hole) plate: centre coordinates *L*	CMM, reversal method with 4 positions	10	600	mm			Q[0.6, 1.1*L*], *L* in m	µm	2	95%	No	56	Approved on 22 March 2005