Length, Finland, MIKES (Mittatekniikan Keskus, Centre for Metrology and Accreditation)

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	Stabilized laser of the mise en pratigue: vacuum wavelength	Optical beat frequency	532	532	nm			0.08	fm	2	95%	No	50	
Laser radiations	Stabilized laser of the mise en pratigue: absolute frequency	Optical beat frequency	563	563	THz			0.08	MHz	2	95%	No	51	
Laser radiations	Stabilized laser of the mise en pratique: vacuum wavelength	Optical beat frequency	543.5	543.5	nm			0.28	fm	2	95%	No	2	
Laser radiations	Stabilized laser of the mise en pratique: absolute frequency	Optical beat frequency	551	551	THz			0.28	MHz	2	95%	No	2	
Laser radiations	Other stabilized laser: vacuum wavelength, λ_0	Optical beat frequency	532	532	nm			1E-10 λ_0	nm	2	95%	No	52	
Laser radiations	Other stabilized laser: vacuum wavelength, λ_0	Optical beat frequency	633	633	nm			1E-10 λ_0	nm	2	95%	No	3	
Laser radiations	Other stabilized laser: vacuum wavelength, λ_0	Optical beat frequency	543.5	543.5	nm			5E-10 λ_0	nm	2	95%	No	4	
Length instruments	Laser interferometer system, error of indicated displacement *L*	Comparison to master interferometer, calibration of pressure and temperature sensors	0	40	m			Q[0.02, 0.5*L*], *L* in m	µm	2	95%	No	5	
Length instruments	EDM instruments: error of indicated distance, *L*	Comparison to master interferometer	0	30	m			Q[0.5, 0.5*L*], *L* in m	µm	2	95%	No	53	

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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**
Length instruments	1-D measuring machine: error of indicated size or displacement, *L*	Laser interferometer and test pieces, comparison	0	5	m			Q[0.2, 0.5*L*], *L* in m	µm	2	95%	No	6	
Length instruments	Height measuring instruments: error of indicated vertical size or displacement, *L*	Laser interferometer and test pieces, comparison	0	1	m			Q[0.2, 0.5*L*], *L* in m	µm	2	95%	No	7	
Length instruments	Displacement transducers (inductive, incremental e.g.), displacement	Precision digital piezo transducer	0	15	µm			4	nm	2	95%	No	54	
Length instruments	Gauge block comparators: error of indicated size	Gauge blocks, comparison	-15	15	µm	Maximum gauge block length	100 mm	0.035	µm	2	95%	No	8	
End standards	Gauge block: central length, variation in length	Mechanical comparison	0.1	100	mm			Q[50, 0.87*L*], *L* length in mm	nm	2	95%	No	10	
End standards	Gauge block: central length, variation in length	Interferometry, exact fractions	0.5	100	mm			Q[20, 0.3*L*], *L* length in mm	nm	2	95%	No	9	
End standards	Length bar (long gauge block): central length *L*	Interferometry, fringe counting and white light	100	1000	mm			Q[30, 0.11*L*], *L* in mm	nm	2	95%	No	11	
End standards	Length bar (long gauge block): central length *L*	Mechanical comparison	100	1000	mm			Q[100, 0.87*L*], *L* in mm	nm	2	95%	No	12	
End standards	Step gauges: face spacing *L*	Laser interferometer, comparison	5	1500	mm			Q[0.5, 0.00087*L*], *L* in mm	µm	2	95%	No	13	
Line standards	Precision line scale: line spacing *L*	Video microscope and interferometer	0.01	1000	mm	Line width	< 50 µm	Q[6.2, 0.082*L*] *L* in mm	nm	2	95%	No	14	Approved on 04 May 2006
Line standards	Stage micrometer: line spacing	1-d comparator, focusing microscope	0.001	50	mm			0.2	µm	2	95%	No	15	

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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**
Line standards	Grid plate: grid point coordinates	Focusing microscope and laser interferometer	0.001	50	mm			0.2	µm	2	95%	No	16	
Line standards	Engineer or surveyor tape, steel, line spacing	Travelling CCD microscope on linear rail	0.001	*L*	m	*L*	30 m, 60 m and 90 m	Q[0.035, 0.002*L*], *L* in m	mm	2	95%	No	55	
						Support	on rollers							
						Tension	50 N							
Line standards	Engineer or machinist scale, steel	Travelling CCD microscope on linear rail	0.001	5	m			10	µm	2	95%	No	56	
Line standards	1-D grating: pitch *p*	Calibrated AFM	0.1	20	µm	Masurement length	90 µm	[3.4, 0.2*p*], *p* in µm	nm	2	95%	No	57	Approved on 19 May 2007
Line standards	2-D grating: pitch *p*	Calibrated AFM	0.1	20	µm	Masurement length	90 µm	[3.4, 0.2*p*], *p* in µm	nm	2	95%	No	58	Approved on 19 May 2007
Line standards	2-D grating: orthogonality	Calibrated AFM	85	95	°			14	mrad	2	95%	No	58	Approved on 19 May 2007
Diameter standards	External cylinder: diameter *L*	1-d stylus comparator	0.0005	1	m			Q[0.2, 0.87*L*], *L* in m	µm	2	95%	No	17	
Diameter standards	Internal cylinder: diameter *L*	1-d stylus comparator	0.002	1	m			Q[0.2, 0.87*L*], *L* in m	µm	2	95%	No	18	
Diameter standards	Sphere (ball): diameter *L*	Gauge blocks, comparison	0.2	150	mm			Q[0.2, 0.001*L*], *L* in mm	µm	2	95%	No	19	
Diameter standards	Sphere (ball): diameter	1-d stylus comparator with length interferometer	0.2	200	mm			Q[0.15, 0.0007*L*], *L* in mm	µm	2	95%	No	19	Approved on 19 May 2007
Angle by circle dividers	Optical polygons: face angle	Rotary table and autocollimators, error separation	0	360	°			0.2	"	2	95%	No	20	
Angle by circle dividers	Indexing table: index angle	Optical polygons, autocollimator	0	360	°	Index angle	multiple of 15 °	0.5	"	2	95%	No	21	

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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**
Angle by circle dividers	Rotary tables, rotary encoder scale: position angle	Comparison, rotary table	0	360	°			0.2	"	2	95%	No	22	
Angle instruments	Autocollimator: error of indicated angle, axes orthogonality	Angle interferometer	0	1	°			0.02	"	2	95%	No	23	
Angle instruments	Electronic level: error of indicated inclination angle	Vertical rotary table	0	360	°			0.2	"	2	95%	No	24	
Angle instruments	Thedolite: error of indicated angle, axes orthogonality	Rotary tables (horizontal and vertical)	0	360	°	Vertical angle	limited by instrument	0.2	"	2	95%	No	25	
Angle artefacts	Angle block: included angle	Rotary table and autocollimator	0	360	°			0.2	"	2	95%	No	26	
Angle artefacts	90° steel or granite squares: squareness	Reference square, comparison	90	90	°	Maximum height	1 m	0.5	"	2	95%	No	27	
Angle artefacts	90° cylinder: squareness	Cylindricity measuring instrument, error separation	90	90	°	Maximum height	1 m	0.5	"	2	95%	No	28	
Angle prism	Optical square (pentaprism): deflection angle	Autocollimator and two mirrors	90	90	°			0.5	"	2	95%	No	29	
Flatness standards	Surface plate: flatness	Laser interferometer, straightness in three directions	0	200	µm	Maximum length, L	20 m	Q[0.5, 1.4L], L in m	µm	2	95%	No	32	
Roundness standards	External cylinders: roundness, R	Stylus-on-spindle roundness instrument	0	1000	µm	Diameter	5 mm to 300 mm	Q[0.1, 0.017R], R in µm	µm	2	95%	No	33	
						Height	100 mm							
Roundness standards	Internal cylinders: roundness, R	Stylus-on-spindle roundness instrument	0	1000	µm	Diameter	5 mm to 300 mm	Q[0.1, 0.017R], R in µm	µm	2	95%	No	34	
						Height	100 mm							

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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**
Roundness standards	Spheres (hemispheres): roundness, *R*	Stylus-on-spindle roundness instrument, error separation	0	100	µm	Diameter	20 mm to 200 mm	Q[10, 10*R*], *R* in µm	nm	2	95%	No	35	
Roundness standards	Magnification standards: roundness, *R*	Stylus-on-spindle roundness instrument, length measuring machine, form measurement machine	0	500	µm	Cylinder diameter	5 mm to 300 mm	Q[0.1, 0.001*R*], *R* in µm	µm	2	95%	No	36	
						Height	100 mm							
Straightness standards	Straight edge: straightness	Laser interferometer, angle optics	0	200	µm	Length, *L*	< 20 m	Q[0.3, 0.5*L*], *L* in m	µm	2	95%	No	37	
Straightness standards	Cylindrical straightness standard: straightness	Cylindricity measuring instrument, error separation	0	200	µm	Length, *L*	< 0.5 m	Q[0.1, 0.3*L*], *L* in m	µm	2	95%	No	38	
						Weight	50 kg							
Surface texture	Depth (step height) standard: step height, *S*	Stylus instrument	0	400	µm			Q[10, 70*S*], *S* in µm	nm	2	95%	No	41	
Surface texture	Roughness standard: ISO roughness parameters, *S*	Stylus instrument	0	400	µm			Q[10, 70*S*], *S* in µm	nm	2	95%	No	42	
Screw standards	Thread plug, plain, pitch diameter	3-wire method, length measuring machine	3	150	mm			2	µm	2	95%	No	43	
Screw standards	Thread, ring, plain: pitch diameter	Three balls, length measuring machine	3	150	mm			2	µm	2	95%	No	44a	
Screw standards	Thread ring, plain: pitch	Form measuring instrument	0.25	8	mm	Flank angle	> 55 °	0.2	µm	2	95%	No	44b	
Screw standards	Thread ring, plain: flank angle	Three balls, length measuring machine	30	70	°			2	'	2	95%	No	44c	
CMM artefacts	Ball/hole plate: ball/ hole center coordinates	CMM, swing around				Plate area	(0.55x0.55) m^2	(0.8 + 1.1*L*), *L* center distance in m	µm	2	95%	No	45	

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CMM artefacts	Large CMM artefact: dimensions	CMM, substitution method				Volume	(0.71x0.57x0.55) m^3	(0.5 + 0.8*L*), *L* distance in m	µm	2	95%	No	46	
2-D, 3-D instruments	CMM, error of indicated location	Specific lines with step gauge				Maximum length	1.020 m	(0.8 + 1.5*L*), *L* length in m	µm	2	95%	No	47	
2-D, 3-D instruments	CMM: error of indicated size, location, shape	Laser interferometer, 2-d gratings, etc., measuring 21 different error components	0	5	m			Q[0.5, 0.5*L*], *L* length in m	µm	2	95%	No	48	
Pressure artefacts	Piston /cylinder assembly: 3-D size, shape	Length measuring machine, cylindricity measuring machine	15	150	mm			Q[0.2, 0.001*L*], *L* length in mm	µm	2	95%	No	49	