Length, United States, NIST (National Institute of Standards and Technology)

Note: Approval dates are shown only for the CMCs published after 24 May 2004

Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty						
Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Laser radiations	Other stabilized laser: vacuum wavelength λ_0	Optical beat frequency	633	633	nm			4E-10 λ_0	nm	2	95%	No		1
Length instruments	Laser interferometer system: error of indicated displacement *L*	Comparison to master length interferometer	0.001	5	m			Q[0.05, 0.1*L*], *L* in m	µm	2	95%	No		2
End standards	Gauge block: central length *L*	Interferometry, exact fractions	0.1	100	mm			(18 + 0.15*L*), *L* in mm, values range from 18 nm to 33 nm	nm	2	95%	No		3
End standards	Length bar: central length *L*	Interferometry, exact fractions	100	500	mm			(18 + 0.15*L*), *L* in mm, values range from 33 nm to 93 nm	nm	2	95%	No		3b
End standards	Gauge block: central length *L*	Mechanical comparison to gauge block	0.1	101.6	mm			(25 + 0.35*L*), *L* in mm, values range from 25 nm to 61 nm	nm	2	95%	No		4
End standards	Length bar: central length *L*	Mechanical comparison to length bar	101.6	508	mm			(31 + 0.26*L)* , *L* in mm, values range from 58 nm to 163 nm	nm	2	95%	No		5
End standards	Length bar: central length *L*	Line scale interferometer with wrung graduated gage blocks	100	1000	mm			(30 + 0.09*L*), *L* in mm	nm	2	95%	No		6
End standards	Step gauge: face spacing *L*	CMM	20	1200	mm			(0.35 + 0.0001L), L in mm	µm	2	95%	No		7
Line standards	Precision line scale: line spacing, *L*	Line scale interferometer	0.002	1000	mm	Illumination	reflection only	(3 + 0.1*L*)	nm	2	95%	No	Approved on 14 June 2004	8

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty						
Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Line standards	Stage micrometer: line spacing, *L*	Line scale interferometer	0.002	100	mm	Illumination	reflection only	(3 + 0.1*L*)	nm	2	95%	No	Approved on 14 June 2004	9
Line standards	1-D grating: pitch *P*	Atomic force microscope & laser displacement interferometer scale	0.1	10	µm			Q[0.003, 0.002*P*], *P* in µm, values range from 0.003 µm to 0.02 µm	µm	2	95%	No		11
Diameter standards	External cylinder (plug, piston, pin, wire): diameter *L*	Mechanical stylus & laser displacement interferometer scale	0.01	100	mm			(35 + 1*L)* , *L* in mm, values range from 35 nm to 135 nm	nm	2	95%	No		16
Diameter standards	External cylinder (plug, piston, pin, wire): diameter	Mechanical comparison	0.1	25	mm			0.125	µm	2	95%	No		17
Diameter standards	Internal cylinder (ring): diameter *L*	Mechanical comparison	2	100	mm			(85 + 0.4*L*), *L* in mm, values range from 86 nm to 125 nm	nm	2	95%	No		18
Diameter standards	Sphere (ball): diameter *L*	Mechanical stylus & laser displacement interferometer scale	1	30	mm			Q[21, 0.5*L*], *L* in mm, values range from 21 nm to 26 nm	nm	2	95%	No		19
Diameter standards	Sphere (ball): diameter *L*	Mechanical comparison	1	100	mm			(0.1 + 0.00057*L*), *L* in mm	µm	2	95%	No		21
Angle by circle-dividers	Optical polygon: face angle	Index table and autocollimator	5	120	º	Number of faces	3 to 72 with nominally equal, integer angles between sides	0.14	"	2	95%	No		22
Angle by circle-dividers	Index table: index angle	Index table and autocollimator	360/n (n = 24)	360/n (n = 3)	º	Number of divisions	n = 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20 and 24	0.14	"	2	95%	No		23

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Calibration or Measurement Services			Measurand Level or Range			Measurement Conditions/Independent variables		Expanded Uncertainty						
Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Angle artefacts	Angle block: included angle	Indexing table and autocollimator	0.000278	45	º			0.14	"	2	95%	No		24
Angle artefacts	Angle block: included angle	Indexing table and autocollimator or two autocollimators	0.000278	45	º			0.18	"	2	95%	No		25
Angle prisms	Optical wedge: deviation angle	Autocollimator	0	60	"			0.1	"	2	95%	No		27
Roundness standards	External cylinder (plug): roundness	Spindle-based roundness measuring instrument	0	0.5	µm			12	nm	2	95%	No		29
Roundness standards	Internal cylinder (ring): roundness	Spindle-based roundness measuring instrument	0	0.5	µm			12	nm	2	95%	No		30
Roundness standards	Sphere or hemisphere: roundness	Spindle-based roundness measuring instrument	0	0.5	µm	Sphere diameter	5 mm to 100 mm	12	nm	2	95%	No		31
Surface texture	Groove or step-height standard: step height *H*	Stylus instrument	0.007	25	µm			Q[1, 7*H*], *H* in µm, values range from 1 nm to 175 nm	nm	2	95%	No		35
Surface texture	Roughness standard: ISO parameters *Ra*, *Rq*, *Rz*	Stylus instrument	0.3	10	µm			Q[0.01, 0.013*R*], *R* in µm	µm	2	95%	No		37
Screw standards	Thread plug, plain: pitch diameter	3-wire method	1	500	mm			1.25	µm	2	95%	No		38
Screw standards	Threaded plug, tapered: pitch diameter	3-wire method	1	500	mm			1.25	µm	2	95%	No		42
CMM artefacts	Ball bar: ball spacing	CMM	300	1500	mm	Kinematically supported		(0.25 + 0.0005*L*), *L* in mm	µm	2	95%	No		60

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Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Miscellaneous complex geometry	Hardness indenter: radius	Stylus instrument	180	220	µm			0.4	µm	2	95%	No		61
Reference materials	SEM magnification standard (high keV SRM 484/2070): line spacing	SEM with HeNe laser displacement interferometer	0.5	5	µm			0.034 to 0.051	µm	2	95%	No		68
Reference materials	Sinusoidal roughness standard, SRM 2071: *Ra*	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	0.3 *Ra* (period = 100)	0.3 *Ra* (period = 100)	µm			0.015	µm	2	95%	No		69
Reference materials	Sinusoidal roughness standard, SRM 2071: period	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	0.3 *Ra* (period = 100)	0.3 *Ra* (period = 100)	µm			0.31	µm	2	95%	No		70
Reference materials	Sinusoidal roughness standard, SRM 2072: *Ra*	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	1 *Ra* (period = 100)	1 *Ra* (period = 100)	µm			0.027	µm	2	95%	No		71

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Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Reference materials	Sinusoidal roughness standard, SRM 2072: period	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	1 *Ra* (period = 100)	1 *Ra* (period = 100)	µm			0.24	µm	2	95%	No		72
Reference materials	Sinusoidal roughness standard, SRM 2073: *Ra*	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	3 *Ra* (period = 100)	3 *Ra* (period = 100)	µm			0.08	µm	2	95%	No		73
Reference materials	Sinusoidal roughness standard, SRM 2073: period	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	3 *Ra* (period = 100)	3 *Ra* (period = 100)	µm			0.12	µm	2	95%	No		74
Reference materials	Sinusoidal roughness standard, SRM 2074: *Ra*	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	1 *Ra* (period = 40)	1 *Ra* (period = 40)	µm			0.02	µm	2	95%	No		75

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Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Reference materials	Sinusoidal roughness standard, SRM 2074: period	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	1 *Ra* (period = 40)	1 *Ra* (period = 40)	µm			0.06	µm	2	95%	No		76
Reference materials	Sinusoidal roughness standard, SRM 2075: *Ra*	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	1 *Ra* (period = 800)	1 *Ra* (period = 800)	µm			0.012	µm	2	95%	No		77
Reference materials	Sinusoidal roughness standard, SRM 2075: period	Stylus instrument with calibrated step heights for Z, HeNe laser displacement interferometer for X	1 *Ra* (period = 800)	1 *Ra* (period = 800)	µm			0.47	µm	2	95%	No		78
Reference materials	Linewidth, photomask - SRM 473: linewidth	Optical microscopy & laser displacement interferometer scale	0.5	30	µm			37	nm	2	95%	No		79
Reference materials	Pitch, photomask (magnification standard) - SRM 473: pitch	Optical microscopy & laser displacement interferometer scale	2	60	µm			10	nm	2	95%	No		80

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Class	**Instrument or artifact**	**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?**	**Comments**	**NMI Service Identifier**
Reference materials	Pitch, microscope (magnification standard) - SRM 2800: pitch	Optical microscopy & laser displacement interferometer scale	1	10000	µm			10	nm	2	95%	No		81
Reference materials	Pin gage for optical fiber ferrules (SRM 2522): diameter	Micrometer with laser displacement interferometer scale	125	125	µm			0.05	µm	2	95%	No		82
Reference materials	Optical fiber ferrule geometry (SRM 2523): diameter	Micrometer with laser displacement interferometer scale	2.49	2.49	mm			0.065	µm	2	95%	No		83
Reference materials	Optical fiber coating standard (SRM 2553): diameter	Micrometer with laser displacement interferometer scale	244	244	µm			0.258	µm	2	95%	No		84
Reference materials	Optical fiber coating standard (SRM 2554): diameter	Micrometer with laser displacement interferometer scale	242	242	µm			0.114	µm	2	95%	No		85
Reference materials	Optical fiber coating standard (SRM 2555): diameter	Micrometer with laser displacement interferometer scale	238	238	µm			0.058	µm	2	95%	No		86