Length, Spain, CEM (Centro Español de Metrologia)

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?**	**Comments**	**NMI Internal Service Identifier**
Laser radiations	Frequency stabilized laser: vacuum wavelength	Optical beat frequency	633	633	nm		RI 83 and CI 92 from CIPM	0.04	fm	2	95%	No		1
Laser radiations	Frequency stabilized laser: absolute frequency	Optical beat frequency	474	474	THz			24	kHz	2	95%	No		1
Laser radiations	Frequency stabilized laser: vacuum wavelength	Optical beat frequency	633	633	nm			6.2E-10		2	95%	Yes	Approved on 04 May 2006	2
Length instruments	Length interferometer: error of indicated displacement *L*	Comparison to master length interferometer	0	25	m			Q[0.01, 0.12*L*], *L* in m	µm	2	95%	No		3
Length instruments	Laser interferometer: wavelength compensation *n*	Calibration of temperature and pressure sensors				Temperature	18 °C to 22 °C	7E-08*n*		2	95%	No	Approved on 04 May 2006	4
						Pressure	800 hPa to 1000 hPa							
						Relative humidity	(50 ± 5) %							
Length instruments	EDM instrument: error of indicated distance *L*	Comparison to length interferometer	0	25	m			Q[0.1, 0.01*L*], *L* in m	mm	2	95%	No	Approved on 14 September 2018	5a
Length instruments	EDM instrument: error of indicated distance, *L*	Measurement on a reference baseline	0	50	m			1	mm	2	95%	No	Approved on 14 September 2018	5b
Length instruments	Gauge block mechanical comparator: error of indicated difference *D*	Mechanical comparison against gauge block couples	-10	10	µm	Maximum gauge block length	100 mm	Q[35, 4*D*], *D* in µm	nm	2	95%	No		6
End standards	Gauge block: central length *L*	Interferometry, exact fractions	0.5	100	mm			Q[34, 0.7*L*], *L* in mm	nm	2	95%	No	Revised on 06 November 2015	7
End standards	Gauge block: central length *L*	Mechanical comparison	0.5	100	mm			Q[50, 0.7*L*], *L* in mm	nm	2	95%	No		8
End standards	Length bar (long gauge block): central length *L*	Length interferometer and mechanical probing	125	1200	mm			Q[70, 0.4*L*], *L* in mm	nm	2	95%	No		9

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End standards	Step gauge: face spacing *L*	Length interferometer and mechanical probing	5	1200	mm			Q[90, 0.45*L*], *L* in mm	nm	2	95%	No	Approved on 04 May 2006	10
Line standards	Precision line scales: line spacing *L*	Laser interferometer and video microscope	0.01	100	mm			Q[60, 0.3*L*], *L* in mm	nm	2	95%	No	Approved on 08 October 2012	11
Line standards	Stage micrometer: line spacing *L*	Laser interferometer and video microscope	0.01	100	mm			Q[60, 0.3*L*], *L* in mm	nm	2	95%	No	Approved on 08 October 2012	11
Line standards	Engineer or survey tape, steel; geodetic tape or wire, invar: line spacing *L*	Laser bench and CCD detection	1	100	m	Support	horizontal flat	Q[40, 4*L*], *L* in m	µm	2	95%	No	Approved on 04 May 2006	12
Line standards	Surveyor leveling rod: line spacing *L*	Laser bench and CCD detection	1	3	m	Support	horizontal flat	Q[5, 0.3*L*], *L* in m	µm	2	95%	No		13
Diameter standards	External cylinder (plug): diameter	CMM as a comparator	2	100	mm			0.3	µm	2	95%	No		14
Diameter standards	Internal cylinder (ring): diameter	CMM as a comparator	3	100	mm			0.3	µm	2	95%	No		15
Diameter standards	Ball (spheres): external diameter	CMM as a comparator	10	50	mm			0.5	µm	2	95%	No		16
Diameter standards	External cylinder (plugs): diameter	1D comparator and 2 contacting probes	5	100	mm			0.15	µm	2	95%	No	Approved on 17 July 2014	14b
Diameter standards	External cylinder (plugs): diameter	1D comparator and 2 contacting probes	100	200	mm			0.25	µm	2	95%	No	Approved on 17 July 2014	14c
Diameter standards	Ball (spheres): external diameter	1D comparator and 2 contacting probes	5	60	mm			0.10	µm	2	95%	No	Approved on 17 July 2014	16b
Diameter standards	External cylinder (plug): diameter *L*	CMM in absolute mode	2	500	mm			(0.6 + 0.004*L*), *L* in mm	µm	2	95%	No		17
Diameter standards	Internal cylinder (ring): diameter *L*	CMM in absolute mode	2	500	mm			(0.6 + 0.004*L*), *L* in mm	µm	2	95%	No		18
Angle by circle-dividers	Optical polygon: face angle	Index table and autocollimator, full closure	5	90	°	Number of faces	4 to 72	0.15 to 0.25	"	2	95%	No		19
Angle instruments	Autocollimator: error of indicated angle	Comparison versus reference rotary table	0	arbitrary	"	Orientation	horizontal	0.2	"	2	95%	No	Approved on 14 September 2018	20

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Angle instruments	Theodolite: error of indicated angle	Full closure, angular interferometer	0	360	°			1	"	2	95%	No		21
Angle artefacts	Angle block: included angle	Index table and autocollimator, full closure	1	45	°, ', "	Specific angle sizes	in steps of 1, 3, 5, 15, 20, 30 and 45 ° or ' or "	0.3	"	2	95%	No		22
Angle artefacts	90º squares: squareness	CMM, reversal technique	90	90	°	Maximum size	(200 x 500) mm^2	2	"	2	95%	No		23
Flatness standards	Optical flat: flatness	Fizeau interferometer and master flat	0	1	µm	Maximum diameter	150 mm	20	nm	2	95%	No		24
						Supporting mode	vertical							24
Roundness standards	External cylinders: roundness, *R*	Spindle roundness instrument and multi step method	0	100	µm	Diameter	5 mm to 100 mm	Q[7, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	25a
Roundness standards	Spheres and hemispheres: roundness, *R*	Spindle roundness instrument and multi step method	0	100	µm	Diameter	5 mm to 100 mm	Q[7, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	25c
Roundness standards	Internal cylinders: roundness, *R*	Spindle roundness instrument and multi step method	0	100	µm	Diameter	5 mm to 70 mm	Q[7, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	25b
Roundness standards	External cylinder (plug): roundness, *R*	Stylus and index table on spindle roundness instrument	0	400	µm	Diameter	5 mm to 300 mm	Q[17, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	26
						Height	up to 500 mm							
Roundness standards	Internal cylinder (ring): roundness, *R*	Stylus and index table on spindle roundness instrument	0	400	µm	Diameter	5 mm to 270 mm	Q[17, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	27
						Height	up to 500 mm							
Roundness standards	Hemisphere: roundness, *R*	Stylus and index table on spindle roundness instrument	0	400	µm	Diameter	5 mm to 150 mm	Q[17, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	28
Roundness standards	Magnification standard (flick standard): roundness, *R*	Stylus and index table on spindle roundness instrument	0.01	30	µm	Diameter	5 mm to 150 mm	Q[17, 14*R*], *R* in µm	nm	2	95%	No	Approved on 20 February 2013	29
Straightness standards	Cylindrical straightness standard: straightness *S*	Cylinder measuring instrument	0.01	5	µm	Height *H*	up to 0.3 m	Q[0.030, 0.040*S*, 0.002*H*], *S* in µm, *H* in µm	µm	2	95%	No		30

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Surface texture	Roughness standard (ISO 5436-1 type D): ISO roughness parameters	Stylus instrument	0.01	15	µm	Parameter	*Ra*	Q[9, 30*Ra*], *Ra* in µm	nm	2	95%	No		34
			0.01	15	µm	Parameter	*Rz*	Q[14, 40*Rz*], *Rz* in µm	nm	2	95%	No		34
CMM artefacts	Ball bar: ball spacing *L*	CMM and contacting probe	10	500	mm			Q[0.4, 0.001*L*], *L* in mm	µm	2	95%	No		35
Surface texture	Groove or step-height standard: step height, *H*	Interference microscope	0.005	2	µm			Q[1.5, 6*H*], *H* in µm	nm	2	95%	No		33a
Surface texture	Groove or step-height standard: step height, *H*	Stylus instrument	0.01	15	µm			Q[2, 20*H*], *H* in µm	nm	2	95%	No		33b