Photometry and Radiometry, South Africa, CSIR-NML (Council for Scientific and Industrial Research - National Metrology Laboratory)

Calibration or Measurement Service			Measurand Level or Range			Measurement Conditions/Independent Variable		Expanded Uncertainty						
Quantity	**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 Internal Service Identifier**
Luminous intensity	Tungsten lamp	Realization according to definition of candela	1	10000	cd	Correlated colour temperature	2500 K to 3200 K	1	%	2	95%	Yes		PR/1.1.1/1
Luminous intensity	Tungsten lamp	Inverse square law	1	10000	cd	Correlated colour temperature	2500 K to 3200 K	2	%	2	95%	Yes		PR/1.1.1/2
Illuminance responsivity, tungsten source	Illuminance meter	Inverse square law			reading/lx	Illuminance	1 lx to 20 lx	1.5	%	2	95%	Yes		PR/1.2.1/1
						Correlated colour temperature	2500 K to 3200 K							
Illuminance responsivity, tungsten source	Illuminance meter	Inverse square law			reading/lx	Illuminance	20 lx to 2000 lx	1	%	2	95%	Yes		PR/1.2.1/2
						Correlated colour temperature	2500 K to 3200 K							
Illuminance responsivity, tungsten source	Illuminance meter	Inverse square law			reading/lx	Illuminance	2000 lx to 50000 lx	1.5	%	2	95%	Yes		PR/1.2.1/3
						Correlated colour temperature	2500 K to 3200 K							
Luminous flux	Tungsten lamp	Spatial integration	10	100	lm	Correlated colour temperature	2500 K to 3200 K	2	%	2	95%	Yes		PR/1.3.1/1
Luminous flux	Tungsten lamp	Spatial integration	100	20000	lm	Correlated colour temperature	2500 K to 3200 K	1.5	%	2	95%	Yes		PR/1.3.1/2
Illuminance	Tungsten lamp	Comparison	1	20	lx	Correlated colour temperature	2500 K to 3200 K	1.5	%	2	95%	Yes		PR/1.4.1/1

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Illuminance	Tungsten lamp	Comparison	20	2000	lx	Correlated colour temperature	2500 K to 3200 K	1	%	2	95%	Yes		PR/1.4.1/2
Illuminance	Tungsten lamp	Comparison	2000	50000	lx	Correlated colour temperature	2500 K to 3200 K	1.5	%	2	95%	Yes		PR/1.4.1/3
Luminance	Tungsten-based source	Filter photometer measurement	1	1500	cd/m^2	Correlated colour temperature	2500 K to 3200 K	2.5	%	2	95%	Yes		PR/1.5.1/1
Luminance responsivity	Luminance meter	Inverse square law and reflectance of diffuser			Reading/(cd/m²)	Luminance	5 cd/m^2 to 700 cd/m^2	3	%	2	95%	Yes		PR/1.6.0/1
						Type of source used	tungsten lamp with reflecting diffuser							
Responsivity, spectral, power	Broad band detector	Monochromator or bandpass filters			A/W or V/W or reading/W	Wavelength range	500 nm to 1000 nm	2.5	%	2	95%	Yes		PR/2.1.1/1
						Bandwidth	3 nm to 15 nm							
						Power level	1 µW to 100 µW							
Responsivity, spectral, power	Broad band detector	Monochromator or bandpass filters			A/W or V/W or reading/W	Wavelength range	400 nm to 2000 nm	3	%	2	95%	Yes		PR/2.1.1/2
						Bandwidth	3 nm to 15 nm							
						Power level	100 µW to 100 W							
Responsivity, spectral, irradiance	Broad band detector	Comparison			A/(W/m^2) or V/(W/m^2) or reading/(W/m^2)	Wavelength range	400 nm to 2000 nm	3	%	2	95%	Yes		PR/2.2.2/1
						Bandwidth	3 nm to 10 nm							
						Power level	1 µW/cm^2 to 100 µW/cm^2							

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Responsivity, spectral, irradiance	Broad band detector	Comparison			A/(W/m^2) or V/(W/m^2) or reading/(W/m^2)	Wavelength range	UV-A	7	%	2	95%	Yes	Spectral power distribution of source to be specified	PR/2.2.2/2
						Bandwidth	330 nm to 380 nm							
Responsivity, spectral, irradiance	Broad band detector	Comparison			A/(W/m^2) or V/(W/m^2) or reading/(W/m^2)	Wavelength range	UV-B	10	%	2	95%	Yes	Spectral power distribution of source to be specified	PR/2.2.2/3
						Bandwidth	280 nm to 310 nm							
Responsivity, spectral, irradiance	Broad band detector	Comparison			A/(W/m^2) or V/(W/m^2) or reading/(W/m^2)	Wavelength range	UV-C	13	%	2	95%	Yes	Spectral power distribution of source to be specified	PR/2.2.2/4
						Bandwidth	240 nm to 270 nm							
Responsivity, spectral, irradiance	Broad band detector	Comparison			A/(W/m^2) or V/(W/m^2) or reading/(W/m^2)	Wavelength range	0.2 µm to 16 µm	0.7	%	2	95%	Yes		PR/2.2.2/5
						Power level	1E-04 W/cm^2 to 1E-02 W/cm^2							
Responsivity, spectral, irradiance	Broad band detector	Comparison			A/(W/m^2) or V/(W/m^2) or reading/(W/m^2)	Wavelength range	0.2 µm to 16 µm	3	%	2	95%	Yes		PR/2.2.2/6
						Power level	1E-02 W/cm^2 to 1 W/cm^2							

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Responsivity, laser, power	General detector	Comparison			A/W or V/W or reading/W	Wavelength range	0.25 µm to 16 µm	0.7	%	2	95%	Yes		PR/2.4.0/1
						Power level	0.1 mW to 10 mW							
						Type of detector	photodiode or broadband							
Responsivity, laser, power	General detector	Comparison			A/W, V/W, reading/W	Wavelength range	0.25 µm to 16 µm	3	%	2	95%	Yes		PR/2.4.0/2
						Power level	10 mW to 100 W							
						Type of detector	photodiode or broadband							
Responsivity, laser, energy	General detector	Measurement of radiant power and pulse shape			A/J, V/J, Reading/J	Wavelengths	400 nm to 2000 nm	5	%	2	95%	Yes		PR/2.5.0/1
						Energy level	1E-07 J to 1 J							
						Pulse width	1 ns to 0.1 s							
						Type of detector	photodiode, pyroelectric or thermopile							
Irradiance, spectral	Tungsten lamp	Comparison	1.00E-05	10	$(W/m^2)/nm$	Wavelength range	400 nm to 750 nm	2	%	2	95%	Yes		PR/3.1.1/3
						Bandwidth	10 nm to 20 nm							
Irradiance, spectral	Tungsten lamp	Comparison	1.00E-05	10	$(W/m^2)/nm$	Wavelength range	750 nm to 1000 nm	3	%	2	95%	Yes		PR/3.1.1/4
						Bandwidth	10 nm to 20 nm							
Irradiance, spectral	Tungsten lamp	Comparison	1.00E-05	10	$(W/m^2)/nm$	Wavelength range	1000 nm to 1300 nm	4	%	2	95%	Yes		PR/3.1.1/5
						Bandwidth	10 nm to 20 nm							
Power, spectral total radiant, laser	Laser	Measurement with trap detector transfer standard	1.00E-07	3.00E-04	W	Wavelength range	500 nm to 850 nm	2.5	%	2	95%	Yes		PR/3.3.1/1
						Type of laser	He-Ne, Ar, semiconductor							
Power, spectral total radiant, laser	Laser	Measurement with photodiode transfer standard	1.00E-07	3.00E-04	W	Wavelength range	400 nm to 1700 nm	3	%	2	95%	Yes		PR/3.3.1/2

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						Type of laser	He-Ne, Ar, Nd:YAG, semiconductor							
Power, spectral total radiant, laser	Laser	Measurement with absolute radiometer	5.00E-05	5.00E-02	W	Wavelength range	0.3 µm to 9 µm	2	%	2	95%	Yes		PR/3.3.1/3
						Type of laser	He-Ne, Ar, Nd:YAG, semiconductor							
Power, spectral total radiant, laser	Laser	Measurement with thermal/black detectors	1.00E-05	1.50E+02	W	Wavelength range	0.25 µm to 16 µm	5	%	2	95%	Yes		PR/3.3.1/4
						Type of laser	He-Ne, Ar, CO2, Nd:YAG, semiconductor							
Transmittance, regular, spectral	Spectrally-neutral material	Spectrophotometer	1.00E-04	1		Wavelength range	200 nm to 2600 nm	(1.0E-04 + 4.0E-03*t*), *t* transmittance		2	95%	No		PR/4.1.1/1
						Bandwidth	0.5 nm to 4.0 nm							
						Specific measurement conditions	normal incidence							
Transmittance, diffuse, spectral	Spectrally-neutral material	Spectrophotometer	5.00E-04	1		Wavelength range	380 nm to 800 nm	(5.0E-04 + 8.0E-03*t*), *t* transmittance		2	95%	No		PR/4.2.1/1
						Bandwidth	0.5 nm to 4.0 nm							
						Specific measurement conditions	integrating sphere, 6 deg/diffuse							
Transmittance, diffuse, spectral	Spectrally-neutral material	Spectrophotometer	5.00E-04	1		Wavelength range	350 nm to 1500 nm	(5.0E-04 + 2.0E-02*t*), *t* transmittance		2	95%	No		PR/4.2.1/2
						Bandwidth	0.5 nm to 4.0 nm							
						Specific measurement conditions	integrating sphere, 0 deg/total							
Absorbance, regular, spectral	Spectrally-neutral material	Spectrophotometer	5.00E-04	1		Wavelength range	200 nm to 800 nm	0.005		2	95%	No		PR/4.3.1/1

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						Bandwidth	0.5 nm to 2.0 nm							
						Specific measurement conditions	normal incidence							
Absorbance, regular, spectral	Spectrally-neutral material	Spectrophotometer	1	2		Wavelength range	200 nm to 800 nm	0.01		2	95%	No		PR/4.3.1/2
						Bandwidth	0.5 nm to 2.0 nm							
						Specific measurement conditions	normal incidence							
Absorbance, regular, spectral	Spectrally-neutral material	Spectrophotometer	2	2.5		Wavelength range	200 nm to 800 nm	0.02		2	95%	No		PR/4.3.1/3
						Bandwidth	0.5 nm to 2.0 nm							
						Specific measurement conditions	normal incidence							
Absorbance, regular, spectral	Spectrally-neutral material	Spectrophotometer	2.5	3		Wavelength range	200 nm to 800 nm	0.04		2	95%	No		PR/4.3.1/4
						Bandwidth	0.5 nm to 2.0 nm							
						Specific measurement conditions	normal incidence							
Reflectance, diffuse, spectral	Spectrally-neutral material	Spectrophotometer	5.00E-04	1		Wavelength range	350 nm to 1500 nm	(5.0E-04 + 8.0E-03t), t reflectance		2	95%	No		PR/4.5.1/1
						Bandwidth	2 nm							
						Specific measurement conditions	6 deg/total, 6 deg/diffuse, normal/diffuse							
Reflectance, regular, spectral	Spectrally-neutral material	Spectrophotometer	5.00E-04	1		Wavelength range	200 nm to 2600 nm	(5.0E-04 + 6.0E-03r), r reflectance		2	95%	No		PR/4.6.1/1
						Bandwidth	0.5 nm to 4.0 nm							

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						Specific measurement conditions	5° incidence							
Distribution temperature	Tungsten lamp	Comparison	2000	3200	K			20	K	2	95%	No		PR/5.1.0/1
Colour, emitted, x, y	General source	Spectroradiometer	0	0.9		Bandwidth	4 nm	0.002		2	95%	No		PR/5.4.0/1
						Type of source	general source							
Colour, emitted, u, v	General source	Spectroradiometer	0	0.7		Bandwidth	4 nm	0.002		2	95%	No		PR/5.4.1/1
						Type of source	general source							
Colour, emitted, u-prime, v-prime	General source	Spectroradiometer	0	0.7		Bandwidth	4 nm	0.002		2	95%	No		PR/5.4.2/1
						Type of source	general source							
Colour, emitted, Lab, display	Display	Spectroradiometer	L*=0	L*=100		Bandwidth	4 nm	1.20 for L*		2	95%	No		PR/5.4.3/1
			(a*;b*)=(-200;-200)	(a*;b*)=(200, 200)		Type of display	CRT	0.60 for a* and b*		2	95%	No		
Colour, surface, x, y, Y	General material	Reference spectrophotometer	(x;y)=(0;0)	(x;y)=(0.9;0.9)		Specific measurement conditions	6 deg / total, 6 deg / diffuse, normal / diffuse	0.005 for x and y		2	95%	No		PR/6.1.0/1
			Y=0	Y=100		Type of material	ceramic tile	1.5 for Y		2	95%	No		
Colour, surface, x, y, Y	Diffusely reflecting material	Reference spectrophotometer	(x;y)=(0;0)	(x;y)=(0.9;0.9)		Specific measurement conditions	6 deg/total, 6 deg/diffuse, normal/diffuse	0.001 for x and y		2	95%	No		PR/6.1.2/1
			Y=0	Y=100				0.8 for Y		2	95%	No		
Colour, surface, Lab	General material	Reference spectrophotometer	L*=0	L*=100		Specific measurement conditions	6 deg / total, 6 deg / diffuse, normal / diffuse	0.80 for L*		2	95%	No		PR/6.2.0/1
			(a*;b*)=(-200;-200)	(a*;b*)=(200; 200)		Type of material	ceramic tile	0.50 for a* and b*		2	95%	No		
Colour, surface, L*a*b*	Diffusely reflecting material	Reference spectrophotometer	L*=0	L*=100		Specific measurement conditions	6 deg/total, 6 deg/diffuse, normal/diffuse	0.50 for L*		2	95%	No		PR/6.2.2/1
			(a*;b*)=(-200;-200)	(a*;b*)=(200; 200)				0.30 for a* and b*		2	95%	No		

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Colour, transmitted, x, y, Y	General material	Reference spectrophotometer	(x;y)=(0;0)	(x;y)=(0.9;0.9)		Specific measurement conditions	normal incidence	0.003 for x and y		2	95%	No		PR/6.3.0/1
			Y=0	Y=100		Type of material	filter	0.6 for Y		2	95%	No		
Colour, transmitted, Lab	General material	Reference spectrophotometer	L*=0	L*=100		Specific measurement conditions	normal incidence	0.50 for L*		2	95%	No		PR/6.4.0/1
			(a*;b*)=(-200;-200)	(a*;b*)=(200;200)		Type of material	filter	0.30 for a* and b*		2	95%	No		
Responsivity	Fibre optic power meter	Comparison with absolute radiometer, using fibre optic sources (monochromatic or quasi-monochromatic)			A/W or V/W or reading/W or dBm	Wavelength range	600 nm to 1800 nm	1.5	%	2	95%	Yes		PR/7.1.0/1
						Bandwidth	10 nm							
						Power level	1 µW to 10 mW							
Wavelength	Fibre optic source	Scanning with monochromator	600	1800	nm	Wavelength range	600 nm to 1800 nm	0.2	nm	2	95%	No	Monochromator is calibrated against line standards (e.g. Cd, Hg and Kr gas lamps) and verified against a He-Ne gas laser whose wavelength is traceable to the CSIR-NML length standard	PR/7.2.0/1

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Wavelength	Optical spectrum analyser	Scanning with monochromator	600	1800	nm	Wavelength range	600 nm to 1800 nm	0.2	nm	2	95%	No	Monochromator is calibrated against line standards (e.g. Cd, Hg and Kr gas lamps) and verified against a He-Ne gas laser whose wavelength is traceable to the CSIR-NML length standard	PR/7.2.1/1