SRI LANKA ACCREDITATION
BOARD FOR CONFORMITY
ASSESSMENTS

SPECIFIC CRITERIA *for* CALIBRATION LABORATORIES IN THERMAL & OPTICAL DISCIPLINE

AMENDMENT SHEET

Date	Doc No	Page/ Section	Description of change	Revision No	Approval

PREFACE

This document clarifies SLAB's stand on the accuracy and measurement capability levels. SLAB intends to uphold its policy of granting accreditation to laboratories as per their requirements of accuracy and measurement capability.

These criteria are applicable to laboratories, which perform repetitive calibrations in various parameters and desire accreditation from SLAB.

These criteria provide guidelines for use by laboratories and those who are associated with the program of accreditation of calibration laboratories e.g. experts, assessors, officials engaged with day-to-day activities of accreditation. These criteria cover all areas/ fields of calibration.

This document provides the laboratories with necessary information on the requirements for assessment/ surveillance and to assist them in carrying out internal audit of their system.

The information in this document has been compiled in three parts.

PART – I

General Guidelines for Accreditation of Calibration Laboratories

This part contains relevant information on general requirements of a laboratory engaged in Calibration in the field of Thermal & Optical Measurements. The laboratory seeking accreditation must comply with the requirements of ISO/ IEC 17025: 2005 and this document.

PART – II

Specific Criteria for Accreditation of Calibration Laboratories

This part provides information on special requirements of the laboratories, which are specific to the parameters covered in the respective fields

PART – III

Guidelines Regarding Accuracy of Standards & Measurement Uncertainty in Calibration

This part contains guidelines of the Specified accuracies of measurement standard and uncertainties of measurement generally achieved in laboratories using equipment and instruments of different classes of accuracies/ uncertainties for different parameters under Thermal & Optical measurements.

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PART – I

GENERAL GUIDELINES FOR ACCREDITATION OF CALIBRATION LABORATORIES

1.0 SCOPE

1.1 Calibration laboratories are accredited by SLAB after it is demonstrated that a laboratory complies with the requirements of international standard ISO/IEC 17025: 2005. In view of generic nature of the standard the requirements stated there in, need to be further redefined in specific fields of calibration. This specific criteria lays down those specific requirements in the field of mechanical calibration. This part of the document thus amplifies the generic requirements for mechanical calibration and supplement the requirements of ISO/IEC 17025:2005. Laboratories seeking SLAB accreditation in the field of mechanical calibration must also comply with the requirements stated in this part.

1.2 Best Measurement Capability (CMC) is one the parameters that is used by SLAB to define the scope of an accredited calibration laboratory, the others being parameter/quantitymeasured, standard/master used, calibration method used and measurement range. The CMC is expressed as ”the smallest uncertainty that a laboratory can achieve when calibrating a device that is effectively ideal”. It is an expanded uncertainty estimated at a confidence level of approximately 95% corresponding to a coverage factor k=2.

The laboratory’s ability to achieve their claimed CMC shall be evaluated based on its performance during the on-site assessment and by review of proficiency testing results, wherein the laboratory has participated.

1.3 The definition of CMC implies that within its accreditation a laboratory is not permitted to report a smaller uncertainty of measurement than the CMC endorsed on its scope of accreditation.

1.4 All the parameters for which accreditation is sought must be expressed in S.I. Units, wherever applicable.

2.0 CRITERIA FOR ACCREDITATION

2.1 Accreditation of a calibration laboratory will require assessment in respect of organization, staff, equipment and traceability of its calibration, laboratory accommodation and environmental conditions, safety, handling of calibrated equipment and equipment under calibration, measurement capability and recording system, etc., as per **ISO/ IEC 17025: 2005 General Requirements for the Competence of Testing and Calibration Laboratories.** Some explanatory notes of this document are given in the following clauses.

3.0 ORGANIZATION

3.1 The Calibration Laboratory shall be organized in such a way that all staff members are aware of both the extent and the limitations of their area of responsibility. This organization shall specify and document the responsibility and authority of the Technical Manager/ Quality Manager. The Quality Manager has the direct access to the top management. All personnel will perform or verify work affecting the quality of calibrations as per general guidelines and specific criteria laid down for the accredited parameters. The calibration laboratory shall be organized in such a way so as to ensure the integrity and training of its staff and operations for ensuring unbiased Calibration.

3.2 Deputies for key managerial positions should be appointed. The laboratory shall also clearly define authorized signatory for the calibration certificates/ reports issued by the laboratory.

4.0 MANAGEMENT SYSTEM

4.1 The calibration laboratory shall have a Quality Manual which shall be maintained up-to-date and available for scrutiny, in compliance with ISO/ IEC 17025: 2005 and SLAB requirements, with emphasis on following information:

a) A quality policy statement, including objectives and commitments by the top management.

b) A statement on the organization of the calibration laboratory.

c) Names, qualifications and experience of the persons responsible for managerial, and scientific/ technical activities.

d) A clearly defined charter of responsibility showing the relationship between management and support services.

e) Scope and operation together with information on measurement capability and traceability of calibration of all measuring instruments to national measurement standards.

f) The reference of document number on detailed calibration procedures adopted in the laboratory, which should be compiled in the form of a manual for the use of calibration staff.

g) The reference list of all national/ international standards being referred to or used in the performance of calibration work (copies of such standard specifications should be available in the laboratory for the use of calibration staff.)

h) All amendments made in any of the documents must be dated and listed in the Quality Manual.

4.2 The calibration facilities established in accordance with the general guidelines and specific criteria shall be audited periodically and reviewed by or on behalf of the management to ensure the continued effectiveness of the system.

4.3 The calibration laboratory shall clearly specify, document and make known to the customers, the administrative and other procedures to be followed for getting calibration done from the laboratory. The procedure for providing redress of redress of technical complaints should also be clearly specified and documented.

4.4 The laboratory shall have authorized signatories for approving and issuing calibration certificates for each calibration parameter as mentioned in the scope of accreditation. Any officer competent to evaluate calibration results critically and occupying a position involving responsibility for the adequacy of calibration results is eligible for acceptance by SLAB as an authorized signatory of endorsed calibration documents. Once the suitable persons are selected the names should be sent to the SLAB for acceptance.

5.0 PERSONNEL

5.1 The calibration laboratory shall have adequate number of qualified competent and trained personnel as follows:

Laboratory personnel performing calibration: Diploma in Engineering (relevant branch) or Physical Science graduate with 1 year of relevant experience.

Authorized Signatory: Bachelors degree from a recognized university / of Engineering/Post Graduate in Science (relevant branch) with 1 years of relevant experience or Diploma in Engineering (relevant branch) with minimum 3 years of relevant experience.

5.2 Arrangements for improvement of qualifications and periodic refresher courses and practical training should also exist for the staff so as to keep them in touch with latest developments in the relevant fields.

5.3 The Technical Manager of the calibration laboratory shall have a Post Graduate in Physical Science or Engineering or Chartered Engineering and 2 years experience in precision Mechanical and other relevant parameter measurements. In exceptional cases, a graduate in physics or diploma holder in Mechanical Engineering with long experience could be accepted.

6.0 ACCOMMODATION AND ENVIRONMENTAL CONDITIONS

6.1 Vibrations

The calibration area shall be adequately free from vibrations generated by central air-conditioning plants, vehicular traffic and other sources to ensure consistent and uniform operational conditions. The laboratory shall take all special/ protective precautions like mounting of sensitive apparatus on vibration free tables and pillars etc., isolated from the floor, if necessary.

6.2 Acoustic Noise

Acoustic noise level in the laboratory shall be maintained to facilitate proper performance of calibration work. A threshold noise level of 60 dBA is recommended unless otherwise stated.

6.3 Illumination

The calibration area shall have adequate level of illumination. Where permissible, to avoid localized heating and temperature drift. The recommended level of illumination is 450-700 lux on the working table with glare index of 19 for the laboratory.

6.4 Environmental Conditions and Monitoring

The environmental conditions for the activity of the laboratory shall be such as not to adversely affect the required accuracy of measurement. Facilities should be provided whenever necessary for recording temperature, pressure and humidity values prevailing during calibration. The atmospheric conditions maintained in the laboratory during calibration should be reported in the calibration report/ certificate whenever relevant.

6.5 **Entry to the Calibration Area**

As possible, only the staff engaged in the calibration activity shall be permitted entry inside the calibration area.

7.0 EQUIPMENT

Each calibration laboratory should have measurement standards or equipment of required accuracy in respect of each parameter covered by it in order to be able to realize and to substantiate the corresponding measurement capability claimed. Stability of the standards, accuracy of the values realized through them and repeatability, should be regularly monitored.

Any bias resulting from ageing of standards should be precisely determined. Instructions for operating each standard and equipment/ instrument should be readily available for use by the laboratory staff members.

7.2 The standards/ measuring equipment of the laboratory should be calibrated at regular intervals, with higher accuracy standards. The calibration certificates, performance history sheets in respect of the reference secondary/ working standards and measuring equipment should be held safely by the laboratory.

7.3 Proper record shall be maintained for each standard and equipment with the following information:

a) Name of the equipment
b) Manufacturers name and address
c) Type, range, identification and serial number
d) Date of procurement and commissioning
e) Details of Calibration
f) Details of maintenance and repairs
g) Performance history with dates
h) Availability of service manual

7.4 Details of periodic calibration schedule of new and old standards and measuring equipment should be worked out in consultation with higher accuracy laboratory and this schedule should be observed.

7.5 Details of re-calibration of used, serviced and repaired equipment should also be available and proper precautions shall be observed to identify equipment, which are not in service.

7.6 Any alterations in the observations/ data shall be signed by the calibration staff and duly authenticated. Instructions to this effect should be printed on data sheet used for writing observations/ data in the laboratory.

8.0 RANGE, UNCERTAINTY OF MEASUREMENT AND TRACEABILITY

8.1 The level of uncertainty of measurement of the standards to be maintained by a laboratory and the **Calibration measurement capabilities** to be generated by it in respect of various parameters shall be as demonstrated during assessment.

8.2 All the Standard Equipment of the Laboratory shall be calibrated periodically against Calibration Standards of a laboratory accredited by SLAB/ equivalent MRA partners having superior measurement capability or MUSSD/ other international NMIs.

8.3 In the event when the levels of uncertainty of measurement and measurement capability of an accredited laboratory are revised, the laboratory shall be required to intimate SLAB secretariat and undergo surveillance / reassessment as applicable.

9.0 CALIBRATION CERTIFICATE/ REPORT

9.1 The result of calibration carried out by the calibration laboratory, shall be presented in a comprehensive manner, using a standard format which shall unambiguously and objectively present the measurement results and all relevant information in order to facilitate easy comprehension and usage.

9.2 The calibration report/ certificate shall include the following additional information:

a) Date of receipt of the item and date of completion of the calibration work

b) Environmental conditions maintained during the measurements

c) Signature and title of authorized person (authorized signatory) accepting responsibility for the report and date of issue

d) A statement of the accreditation measurement capability relevant to the job under calibration

e) A symbol of SLAB or statement or both clarifying the status of accreditation of the laboratory.

f) The Uncertainty of measurement

g) An evidence that the measurements are traceable to National/ International Standards through unbroken chain of Accredited Laboratories.

9.3 The calibration report/ certificate shall not contain any recommendation on the calibration interval except where this has been agreed with the client. This requirement may be superseded by legal regulations.

10.0 PROFICIENCY TESTING PROGRAM

10.1 To give further assurance to the accuracy or Uncertainty of measurements, a laboratory will be required to participate, from time to time, in Proficiency Testing Programmes. The laboratory shall remain prepared to participate in the Proficiency Testing Programme through inter-laboratory, inter-comparison schemes wherever it is technically feasible. In case any abnormalities, in terms of En number are detected through these inter-comparisons, appropriate corrective action will be taken, the standards/ equipment shall be replaced/ repaired and re-calibrated with a higher accuracy standard. Reports on such inter-comparisons should be documented with reference. The Proficiency Testing practice should be included in the Quality Manual

PART- II

SPECIFIC CRITERIA FOR ACCREDITATION OF CALIBRATION LABORATORIES IN THE FIELD OF THERMAL & OPTICAL MEASUREMENTS

1.0 SCOPE

1.1 An accredited laboratory shall be classified as calibration laboratory for the accredited parameters in the field of Thermal & Optical Measurements in accordance with its measurement capability.

1.2 A calibration laboratory seeking accreditation to offer calibration services in the field of Thermal & Optical measurements will generally carry out calibration in the following areas:

a) Specific Heat
b) Humidity
c) Temperature
D) Optical parameters
e) Infrared
f) Radiation Measurements
g) Fibre Optics Measurements

1.3 The accredited calibration laboratory will be mainly concerned with the measurement of one or more of the parameters shown in the annexure.

2.0 RANGE AND UNCERTAINTY OF MEASUREMENT

2.1 A calibration laboratory will be accredited according to Measurement capability expressed in terms of uncertainty.

3.0 ENVIRONMENTAL CONDITIONS

3.1 The laboratory shall specify limits on the environmental conditions to be achieved in the laboratory. The condition shall appropriate to the level of accuracy required for the calibration undertaken by the laboratory.

The environmental conditions shall be monitored at appropriate intervals and calibrations stopped when environmental conditions fall outside the specified limits.

4.0 SPECIAL REQUIREMENTS OF LABORATORY

4.1 The calibration laboratory shall make arrangements for regulated and uninterrupted power supply. The recommended regulation level is ±1% or better, on the calibration bench.

4.2 Relevant IS specifications (IS: 1248, IS: 4722) regarding total harmonic content and variation in supply frequency should be followed. Voltage stabilizers of low harmonic content should be used to comply with requirement.

4.3 Adequate arrangements shall be made by the laboratory so as to ensure temperature gradient not exceeding 1.5°C per hour inside the laboratory in case of power failure.

4.4 The laboratory shall use if necessary, isolation transformers and filters etc. to ensure minimization of ground current and effects of mains hum interference.

4.5 The power supply to the calibration laboratory shall be directly obtained from the sub-station as far as possible and shall not be on the same feeder line which is supplying power to workshops and other production areas which require operation of heavy duty machines.

4.6 Effective mains earthing shall be provided in accordance with relevant specification IS: 3043. This shall be periodically checked and stary couplings minimized.

4.7 Special care shall be taken about the location of magnetic field sources like, transformers, looped wires, ferrous materials etc., in order to minimize magnetic interference in the measurements.

4.8 Adequate screening of the laboratory against electromagnetic interference shall be done if necessary. By-pass filters should also be provided to minimize conducted interference effect on the electronic equipment. Special shielding chambers shall be provided in the laboratory for measurements, particularly when signal to noise ratio is a disturbing factor for accurate measurements.

4.9 The reference standards shall be maintained at temperatures specified for their maintenance on order to ensure their conformance to the required level of operation and traceability. The laboratory should shall have specific facilities required for carrying out the calibrations of parameters chosen.

4.10 The laboratory shall be sealed against dust and external air pressure. Positive air pressure shall be maintained inside the laboratory.

4.11 Adequate protective measures, like use of transient suppressors etc. shall be taken by the laboratory toward off high current spikes and transients emanating from switching on and off, of the heavy machines, surges in power lines and other such reasons, from reaching the electronics equipment in general and computer based systems involving data storage facilities in particular.

4.12 For temperature control enclosures the laboratory shall check temperature variation in working space using different reference thermocouples (at least five points temperature probe), at the same time, for arriving at spatial variation.

5.0 REPAIR & MAINTAINENCE

5.1 A separate repair and maintenance facility, adequately equipped with repair facilities and qualified and experienced manpower, shall be available in-house or by any other means effectively accessible to the calibration laboratory. This facility shall also assist in identifying the preventive maintenance procedures which should brought to the attention of the personnel engaged in calibration work for taking necessary precautions. The repair facility should cover digital and programmable instruments also.

5.2 Every repaired equipment shall invariably be recalibrated through in-house facility or by higher accuracy laboratory before being used for further calibration work.

6.0 STORAGE & PACKAGING

6.1 The standard/measuring instruments/equipment received by the laboratory for calibration shall be safely in proper environmental conditions according to the instructions given by the supplier.

6.2 The laboratory shall have adequate arrangements for packaging of calibrated instruments and may assist the user, if necessary, about the procedure and precautions to be taken by the organization for packaging and transportation of the equipment to the calibration laboratory and back.

7.0 SAFETY PRECAUTIONS

7.1 Relevant fire extinguishing equipment for possible fire hazards, should be available in the corridors or as convenient to the laboratory. Adequate safety measures against electrical, chemical fire hazards must be available at the workplace. Laboratory rooms/areas where highly inflammable materials are used/stored should be identified. Access to the relevant fire equipment should be assured near these rooms/areas.

7.2 Specification SP.31-1986, a special publication in the form of a wall chart, giving the method of treatment in case of electric shock, should be followed. The chart should be placed near the power supply switchgear and at other prominent places as prescribed under Indian Electricity Rules 1956.

PART III

GUIDELINES REGARDING ACCURACY OF STANDARDS & MEASUREMENTS UNCERTAINTY IN CALIBRATION FOR THERMAL & OPTICAL MEASUREMENTS

GENERAL REMARKS

The following pages may be referred as guidelines and not mandatory recommendations for the laboratories. The accredited calibration laboratories are no longer required to be categorized into Echelon/ level I, II, III. Part III of this document is aimed to provide guidance to the laboratories regarding the precautions they should take with respect to Environmental conditions as appropriate to respective Best Measurement Capability of the laboratories. The laboratories, on their own, should decide/ determine to have environmental conditions in their premises, for the best measurement capability claimed corresponding to their scope of accreditation applied for. Further to note that:

1) The measurement capability is expressed as uncertainty (±) at a confidence probability level of 95%.

2) The term Uncertainty in these tables pertains to the corresponding measurement capability of the laboratory in respect of each parameter.

3) The values of Uncertainty of measurement shown in the following tables at 95% CL unless stated otherwise.

ENVIRONMENTAL CONDITIONS

Standards atmospheric conditions for calibration in a Thermal & Optical Measurements Laboratory shall be as follows:

Level	I	II	III
Temperature	$25^0C \pm 0.5^0C$	$25^0C \pm 2.5^0C$	$25^0C \pm 4.0^0C$
Relative humidity	35 - 65%	35 - 65%	not to exceed 70%

TABLE 1
SPECIFIC HEAT AND HUMIDITY MEASUREMENTS

(a) Accuracy of Reference Standards of Specific Heat and Humidity Measurements

MEASUREMENT PARAMETER	RANGE	ACCURACY%		
		LEVEL-I	LEVEL-II	LEVEL-III
SPECIFIC HEAT				
SOLID	-75 to 100°C	To be worked out later	0.3	0.5
LIQUID	-75 to 100°C	To be worked out later	0.3	0.5
GAS	--	To be worked out later	1.5	2.1
INSULATING MATERIAL	0 to 50°C	To be worked out later	1.8	2.3
HUMIDITY				
ABSOLUTE	0 to 100%	0.1	To be worked out later	
RELATIVE	0 to 100%	To be worked out later	0.5	1.6

(b) Uncertainty in Specific Heat and Humidity Measurements

MEASUREMENT PARAMETER	RANGE	UNCERTAINTY%		
		LEVEL-I	Level-II	Level-III
SPECIFIC HEAT				
SOLID	-75 to 100°C	To be worked out later	0.4	1.2
LIQUID	-75 to 100°C	To be worked out later	0.4	1.2
GAS	-75 to 100°C	To be worked out later	1.9	3.0
INSULTING MATERIAL	0 to 50°C	To be worked out later	2.1	3.0
HUMIDITY				
ABSOLUTE	0 to 100%	0.25	To be worked out later	To be worked out later
RELATIVE	0 to 100%	To be worked out later	To be worked out later	

TABLE 2
TEMPERATURE MEASUREMENTS

(a) Accuracy (In ^{0}c) of Reference Standards of Temperature Measurements

Type of Thermometer	Level-I		Level-II		Level-III	
	Range	Accuracy	Range	Accuracy	Range	Accuracy
Liquid in Glass	193K-300°C	0.02 to 0.05	193K to 0°C 0 to 300°C	0.1 0.04 to 0.1	0 to 300°C	0.06 to 0.1
Platinum Resistance Thermometer	13.81 to 630.75°C	$0.5x10^{-3}$ to $30.5x10^{-3}$	193K to 630°C	$0.9x10^{-3}$ to $32x10^{-3}$	--	--
Thermo-couple (Pt-10%, Rh Pt)	0 to 630°C, 630 to 1554°C	0.25 to 0.7	0 to 1100°C 1100 to 1500°C	0.45 to 1.1	0 to 1100°C	1.0
Pyrometry						
i) Total radiation pyrometry	50-2000°C	0.25-2.5	50-2000°C	0.4-5.0	--	--
ii) Spectral radiation pyrometry	960-2100°C, 2100-3000°C	0.25-2.5 2.5-5.0	960-2100°C, 2100-3000°C	0.4-5.0 5.0-9.0	--	--

(b) Uncertainty (In ^{0}c) in Temperature Measurements

Type of Thermometer	Level-I		Level-II		Level-III	
	Range	Uncertainty	Range	Uncertainty	Range	Uncertainty
LIQUID IN GLASS	193K-300°C	0.02-0.05	193K to 0°C 0 to 300°C	0.15 0.05	0 to 300°C	0.15 to 0.3
PLATINUM RESISTANCE THERMOMETER	13.81 K to 630.75°C	$0.7x10^{-3}$ to $31x\ 10^{-3}$	193K to 630°C	$11x10^{-3}$ to $60x10^{-3}$	--	--
THERMOCOUPLE (PT-10%, RH PT)	0 to 630°C, 630 to 1554°C	0.35 to 0.9 0.35 to 0.9	0 to 1100°C, 1100 to 1500°C	0.7 to 1.5 0.7 to 1.5	0 to 1100°C	1.5
PYROMETRY						
I) TOTAL RADIATION PYROMETRY	50-2000°C	0.25-3.0	50-2000°C	0.7-8.0		
II) SPECTRAL RADIATION PYROMETRY	960-2100°C	0.25-3.0	960-2100^{0}C	0.7-8.0		
	2100-3000°C	3.0-7.0	2100-3000^{0}C	8-12		

TABLE 3
OPTICAL MEASUREMENTS

(a) Accuracy of Reference Standards of Optical Measurements

Measurement Parameter	Range	Accuracy%		
		Level-I	Level-II	Level-III
Photometric standards*				
LUMINOUS FLUX	1 to >105lm	1.5-2.5	1.7-2.2	2.3-2.7
LUMINOUS INTENSITY	10^{-4} to > 10^{-4} cd	1.0 to 2.0	1.7 to 2.2	2.3 to 2.7
LUMINANCE	1 to > 10^{4} cd/cm^2	2	2.25	2.7
ILLUMINANCE	10^{-4} to <100 lux	2	2.25	2.7
Radiometric & Spectroradiometric Standards				
REDIANCE AND	300-400nm	4-3	4.5-3.5	
IRRADIANCE	400-1000 nm (nominal) ($5x10^{-5}$-0.5W/cm^2)	3-2.5	3.5-3	
SPECTRAL RADIANCE AND SPECTRAL IRRADIANCE	300-400 nm	4-3	4.5-3.5	
	400-2500 nm (Distribution temp. 2500 K)	3-7	3.5-8	
SPECTRAL REFLECTANCE AND SPECTRAL TRANSMITTANCE	300 to 400 nm	2.0%	2.2%	2.7%
	300 to 2000 nm	1.0%	1.5%	2.0%
WAVELENGTH	100 to 2500 nm	As per standards spectral Source		
COLORIMETRIC STANDARDS				
COLOUR (CHROMATICITY) (COORDINATES)	Standard Illuminant D64	x=0.001 y-0.001	x-0.003 y-0.003	To be worked out later To be worked out later
COLOUR TEMPERATURE	1800-3400K	10K-15K	11 to 16K	13-20
POLARIMETRIC STANDARD				
Stokes Parameters		3.0%	3.8%	4.8%
OPTICAL MATERIALS, COMPONENTS SYSTEMS				

** Temperative frequency, voltage and wave form requirements as per IEC/CIE recommendations.*

Contd.

Table 3(a) – *contd.*

REFRACTIVE INDEX*	300 to 2500nm	$1x10^{-6}$	$2x10^{-6}$	$2.2x10^{-4}$
RADIUS OF **	0.5 to 5nm	1.0µm	3.0µm	5µm
CURVATURE				
RADIUS OF CURVATURE	5 to 200mm	2 to 3µm	20µm	100µm
	200 to 5000mm	100 µm	500µm	2mm
	5 to 20 meters	5mm	10mm	15mm
FLATNESS	upto 300mm dia	λ/200	λ/50	λ/10
SURFACE FIGURE	-do-	λ/50	λ/30	λ/5
RESOLUTION		As per Standard Chart Given		At P-30, 31
FOCAL LENGTH				
(I) OPTHALMIC LENS	-25 θ to +25D	To be worked out later	-0.1D	-0.2D
			+0.1D	+0.2D
(II) SCIENTIFIC LENS	1mm-1000mm	5µm	20µm	100µm*
	1m-20m	10µm	100µm	2mm
LASER POWER AND ENERGY				
(I) CONTINUOUS	Upto 10W	3.0%	3.8%	To be worked out later
	Upto 1000W	3.0%	4.8%	To be worked out later
(II) PULSED	Upto 10J (300 to 1064nm) (Mode Locked, Q-Switched and Free Running)	10.0%	10.7%	To be worked out later
FIBRE OPTICS				
ATTENUATION***		1.5%	2.7%	4.0%

* Temperature control to ±0.1°C at STP at Level 1

** Temperature +0.5 at the working bench

*** Temperative +0.1° + Vibration isolation for Level-I

±0.25 + -do- for Level-II

Normal + -do- for Level-III

(b) Uncertainty (%) in Optical Measurements

MEASUREMENT PARAMETER		UNCERTAINTY%		
	Range	Level-I	Level-II	Level-III
Photometric Standards				
Luminous Flux	1 to >10^5lm	1.6-2.25	2-2.5	2.8-3.4
Luminous Intensity	1^{-4} to > 10^4cd	1.6-2.25	2-2.5	2.8-3.4
Luminance	1 to > 10^4cd/cm	2.25	2.7	3.5
Illuminance	10^{-4} to >100 lux	2.25	2.7	3.5
Radiometric and Spectroradiometric Standards				
+Radiance and Irradiance	300 to 400nm	4.25-3.25	5-6	-
	400 to 1000nm (nominal)	3.25-2.75	4-3	-
	($5x10^{-5}$ to 0.5W/cm)			
Spectral Radiance and Spectral Irradiance	300 to 400nm	4.25-3.25	5-4	-
	400 to 2500nm (Distribution temp. 2500K)	3.25-7.25	4.75	-
Spectral Reflectance and Spectral Transmitance	300 to 400nm	2.1%	2.5%	3.4%
	400 to 2000nm	1.2%	1.7%	2.5%
Wavelength		As per Standard Spectral Source		
Colorimetric Standards				
Colour (Chromaticity coordinates)	Standard Illuminant D-64	x-0.002	x-0.004	To be worked out later
		y-0.002	y-0.004	
Colour Temperature	1800 to 3200K	11.16	13-17.5	17 to 25K
Polarimetric Standards				
Stockes parameters		3.4%	4.3%	5.7%

Contd.

Table 3(b)—*Contd.*

Optical Materials, Components & System				
Refractive Index	300 to 2500nm	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$
	(RI 1.4-1.9)			
Radius of Curvature	0.5 to 5mm	1.5µm	5µm	8µm
	5 to 200mm	5µm	50µm	200µm
	200 to 5000mm	200µm	1mm	5mm
	5 to 20 metres	10mm	20mm	50mm
* Flatness	Upto 300 mm dia	λ/80	λ/30	λ/8
Surface Figure	-do-	λ/30	λ/10	λ/2
Resolution		As per Standard Chart Given P-33, 34		
Focal Length				
(i) Opthalmic lens	-25D to +25D	To be worked out later	-0.15D	-0.25D
			+0.15D	+0.25D
(ii) Scientific lens	1mm-1000mm	10µm	30µm	200µm
	1m-20m	20µm	200µm	5mm
Laser Power and Energy				
(i) Continuous	Upto 10W	3.4%	4.6%	To be worked out later
	Upto 1000W	4.0%	6.5%	To be worked out later
(ii) Pulsed	Upto 10J	10.4%	11.5%	To be worked out later
	(300 to 1064nm) (Mode Locked)			
	(Q-switched and Free Running)			
Fibre Optics				
Attenuation		2.2%	3.4%	5.0%

* Temperature control as given in Table 3a

TABLE 4

INFRARED RADIATION MEASUREMENT

Infrared Radiation - Radiometric and Spectroradiometric Standards

Measurement Parameters		Range	Accuracy %		
			Level-I	Level-II	Level-III
1.	Spectral Irradiance	0.8 to 14µm	5	-	-
2.	Total Irradiance	Infrared Region	2	-	-
3.	Photomatric Scale: Spectral Specular Reflectance	0 to 100% in 2.5 to 25µm Spectral Region	2	-	-
4.	Photometric Scale: Spectral Transmittance	0 to 100% in 2.5 to 25µm Spectral Region	2	-	-
5.	Wave number Scale: Spectral Transmittance/ Reflectance	2.5 to 25µm	0.2 1.0	-	-
6.	Response of Infrared Scanners	Variable Irradiance	-	-	-

Chart of Resolving Power Values for Individual Targets

Group	Target	Resolving Power (lines per mm)	Group	Target	Resolving Power (lines per mm)
0	1	1.00	4	1	16.0
	2	1.12		2	17.9
	3	1.26		3	20.2
	4	1.41		4	22.6
	5	1.59		5	25.4
	6	1.78		6	28.5
1	1	2.00	5	1	32.0
	2	2.25		2	35.9
	3	2.52		3	40.3
	4	2.83		4	45.3
	5	3.18		5	50.8
	6	3.56		6	57.0
2	1	4.00	6	1	64.0
	2	4.49		2	71.8
	3	5.04		3	80.6
	4	5.66		4	90.5
	5	6.35		5	102.0
	6	7.13		6	114.0
3	1	8.00	7	1	128.0
	2	8.98		2	144.0
	3	10.1		3	161.0
	4	11.3		4	181.0
	5	12.7		5	203.0
	6	14.3		6	228.0

TABLE 5

FIBRE OPTICS MEASUREMENTS (FOR SILICA BASED FIBERS)

Fiber Optics Calibration Parameters

S.No.	Parameter	Remarks	
1.	**Refractive index of core and clad**	Index range Spectral range	1.4-1.7 632.8nm (HeNe) 800-950 nm 1250-1350nm 1500-1750nm
		Accuracy	0.00001
2.	**Spectral Attenuation**	Spectral range Resolution Min. Increment Dynamic range of system	600-1750mm 10nm 0.2nm >50dB for SM >30dB for MM
3.	**Insertion loss** (for couplers, connectors switches, multiplexers demultiplexers etc.)	0.1dB ± 1%	
4.	**Reference sources** LED: Wavelength range Optical Power		 500-1750nm nominal ± 5% (Echelon I)
		30µW – 1mW 1mW – 5mW	nominal ± 1%
		30µW – 1mW 1mW – 5mW	nominal ± 5% (Echelon II) nominal ± 3%
	Wavelength stability		nominal ± 15 nm
	Directivity pattern		$\cos^2\theta$, $\theta \pm 1°$
	Diode Lasers (DL): Wavelength range Optical Power Wavelength Stability (single mode DL)		 500-1750 nm nominal ±1% nominal ±1nm side bands not more than two <-40dB

Contd.

Table 5 – *Contd*.

S.No.	Parameter	Remarks	
5.	**Calibrated Detectors**		
	Wavelength response Responsivity	: 500-1750 nm	
	PIN ADD	: 0.5 A/W – 0.95 A/W : 2 A/W – 50 A/W	
	Noise Equivalent Power (NEP)	: 1 x 10-10—5x10^{-15} A/Hz	
	Directivity Pattern	Cos^2 θ in horizontal plane Cos^5 θ in vertical plane ±1°	
	Bandwidth	DC – 5 GHz	
	Rise time	20 ps	
6.	**Chromatic dispersion (D)**	Spectral Range min increment measurement Range Zero dispersion wavelength Zero dispersion slope S min Fiber length	800-1750 nm 0.2 nm -50 to 50ps/nm Km ±0.1nm 0.03 ps/$(nm)^2$ Km 1 Km
7.	**Back scatter measurement** (SM and MM Fibers)	Spectral Range Max Fibre length dead zone of fiber Resolution in loss measurement Resolution in distance measurement	600-1750 nm 200km 100 m 0.01dB 1m+2x10^{-5} X distance measured
8.	**Dopants concentration** Impurities in raw materials	--	--
9.	**Birefringence**	beat length Accuracy	1 to 2mm 0.1 mm
10.	**Tensile Strength**	--	--
11.	**Bend Radius**	--	--

TABLE 6
FIBRE OPTICS COMPONENT MEASUREMENT

A. Directional Couplers: (Single Mode/Multi Mode)

S.No.	Parameter	Typical Values
1.	Split ratio	: 1.99
2.	Isolation/Directivity	: -60dB
3.	Polarization cross talk	: -35 to –65dB
4,	Uniformity of output	: 1% of nominal value

B. Wavelength multiplexers/ Demultiplexers

S.N.	Parameters	Typical Values
1.	Number of channels	: can be very large
2.	Resolution capability	: 1nm ±5%
3.	Channel spacing	: 0.1nm – 10nm ±5%
4.	Cross talk	: -35 to –65 dB

C. Connectors

S.No.	Parameters	Typical Values
1.	Mechanical measurement	
	Ferrule diameter	: nominal 0 to –1% in 0
	Concentricity of hole	:±0.1µm in axial shift
	Hole diameter	:nominal ±1µm
	Perpendicularity of end surfaces	:0.5°
	Surface finish	:5λ

D. Switches (Space division, wavelength division, time division)

S.No.	Parameters	Typical Values
1.	Channel cross talk	: -35 to –65dB
2.	Polarization cross talk	: -35 to –65 dB
3.	Switching speed	: from few msec to 1ps
4.	Wavelength switching	: 1-10nm±10%
5.	Space division range	: 100x100

TABLE 7

FIBRE OPTICS MEASUREMENTS – TEST PARAMETERS

S.No.	Parameters	Typical	
1(a)	Geometrical Measurements Core/clad diameters of multimode (MM) and single mode (SM) fibers (50/125, 62.5/125, 85/125 100/140)	Core/clad dia Resolution Repeatability (2σ points) of Clad dia Clad ovality Core dia Coreovality Concentricity Coating dia (250 µm ± 15 µm, 500µm ± 20µm)	upto 140 µm :0.2 µm : 1 µm : 1% : 1 µm : 2% : 2µm : ± 15 µm
(b)	Mode field diameter for SM fibers ($1/e^2$ points) (5% above the base line)	Wavelength range Mode field range Repeatability (2σ points) Clad dia Clad ovality Mode field dia Mode field Concentricity error Coating dia (250 µm ± 15 µm, 500 µm ± 20 µm)	: 600-1750 nm : 4-10 µm : 1 µm : 1% : 0.5 µm : nominal ± 10% : ± 15 µm
2.(a)	Numerical Aperture (NA) for MM fibers	NA Range Repeatability (2σ)	: 0.15-0.46 : 0.01
(b)	NA $(n1^2-n2^2)^{1/2}$ for SM fibers	NA Range Repeatability (2σ)	: 0.1 : 0.01
3.	Refractive index profile	Index Range Measurement at Index Resolution Spatial Resolution	: 1.4-1.7 : 632.8 nm (HeNe) : $1x10^{-4}$: <500 nm
4.	Effective cut off wavelength (2m length for matched clad fibers and 5m for depressed	Spectral Range Resolution (λc) Min. increment	: 600-1750nm : 10nm : 0.2nm
5.	Band width (Multi mode fibers)	Spectral Range Bandwidth Repeatability (2σ)	: 600-1750nm : 100 KHz-5 GHz : <5%

Annexure

SCOPE OF THERMAL AND OPTICAL MEASUREMENT

1.0 Specific Heat (solid, liquid, gas)

2.0 Humidity (absolute & relative)

3.0 Temperature

a) Liquid in Glass Thermometry
b) Platinum Resistance Thermometry
c) Thermocouple Thermometry
d) Optical Pyrometry
e) Total Radiation Pyrometry
f) Special Radiation Pyrometry

4.0 Optical Measurements

4.1 Photometric Standard

a) Luminus Flux
b) Luminous Intensity
c) Luminance
d) Illuminance

4.2 Radiometric & Spectroradiometric Measurements

a) Radiance
b) Irradiance
c) Spectral Radiance
d) Spectral Irradiance
e) Spectral Reflectance
f) Spectral Transmittance
g) Wavelength

4.3 Colorimetric Measurements

a) Colour
(choromaticity)
(coordinates)
b) Colour Temperature

4.4 Polarimetric Measurements

a) Stokes Parameters
b) Optical Materials, Components Systems
c) Refractive Index
d) Radius of Curvature

4.5 Radius of Curvature Measurements

a) Flatness Resolution
b) Surface Figure
c) Focal Length
   i) Ophthalmic
   ii) Scientific

4.6 Laser Power and Energy Measurements

a) Continuous
b) Pulsed

4.7 Fibre Optics Measurements

a) Attenuation

5.0 Infrared Radiation

5.1 Radiometric & Spectrometric Measurements

a) Spectral Irradiance
b) Total Irradiance
c) Photometric Scale
   i) Spectral
   ii) Specular
   iii) Reflectance
d) Photometric Scale
   i) Spectral
   ii) Transmittance
e) Wave Number Scale
   i) Spectral
   ii) Transmittance
   iii) Reflectance
f) Response of Infrared Scanners

6.0 Fibre Optics Measurements (for Silica-based Fibre)

6.1 Refractive Index (core and clad)

6.2 Spectral Attenuation

6.3 Insertion Loss

6.4 Chromatic Dispersion

6.5 Back Scatter Measurements (SM and MM Fibres)

6.6 Dopants Concentration

6.7 Birefringence

6.8 Tensile Strength

6.9 Bend Radius

7.0 Measurements on Fibre Optics Components

7.1 Directional Couplers (Single Mode/Multimode)

a) Split Ratio
b) Solation/Directivity
c) Polarization Cross Talk
d) Uniformity of Output

7.2 Wavelength Multiplexers/Demultiplexers

a) Number of Channels
b) Resolution Capability
c) Channel Spacing
d) Cross Talk

7.3 Connectors

a) Mechanical Measurement
b) Ferrule Diameters
c) Concentricity of Hole
d) Hole Diameter
e) Perpendicularity of End
f) Surfaces
g) Surface Finish

7.4 Switches (Space Division, Wavelength Division, Time Division)

a) Channel Cross Talk
b) Polarization Cross Talk
c) Switching Speed
d) Wavelength Switching
e) Space Division Range

8.0 Test Parameters Fibre Optics Measurements

a) Geometrical Measurements: Core/clad dismeters of multimode (MM) and single mode (SM) fibres (50/125, 62.5/125, 85/125, 100/140)
b) Mode Field Diameter for SM Fibre (I/e^2 points) (5% above the base line)
c) Numerical Aperture for MM Fibres
d) Numerical Aperture for SM Fibers
e) Refractive Index Profile
f) Effective Cut off Wavelength
g) Band Width (Multimode fibres)

8.1 Calibrated Detector

a) Wavelength Responsibility
b) Responsivity PIN, ADD
c) Noise Equivalent Power (NEP)
d) Directivity Pattern
e) Bandwidth
f) Rise Time

COMPOSITION OF THE TECHNICAL ADVISORY COMMITTEE

1	Prof. D.A.Tantrigoda Professor of Physics, Department of Physics, University of Sri Jayewardenepura, Gangodawila, Nugegoda.	Chairman
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