LG-1.0

Mini Goniophotometer

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Part 1. LG-1.0 Mini Goniometer

The LG-1.0 is a small-scale goniometer for manufacturers of LEDs, LED clusters and small luminaires; and for testing laboratories, R&D institutions and educational organisations. In its basic form, it consists of a table-top-mounted goniometer and a software interface.

Theory of Operation

The sample is mounted on the goniometer and rotated around a pivot point through two axes of rotation. This presents the different orientations of the test item towards a detector, mounted at a distance across the room. Through this way the luminous intensity distribution of the test item is measured, and from this distribution other data such as luminous flux and beam width can be determined. Easy to use Windows-based software running on a PC interfaces the equipment to coordinate the motion and the measurement, store the data and produce professional reports.

Goniometer

The goniometer is manufactured from aluminium and steel and is lightweight but robust. Once positioned and aligned it is fixed directly to the table. A counterweight is used in the horizontal rotating section.

The vertical axis can rotate through 180 degrees (e.g. rotating in elevation angles from 0 to 180 degrees) and the horizontal axis can rotate continuously through 360 degrees (e.g. rotating in C-planes from 0 to 360 degrees). Both axes have better than 0.1-degree angular accuracy. The intersection of the horizontal and vertical axes is called the “pivot point” of the goniometer.

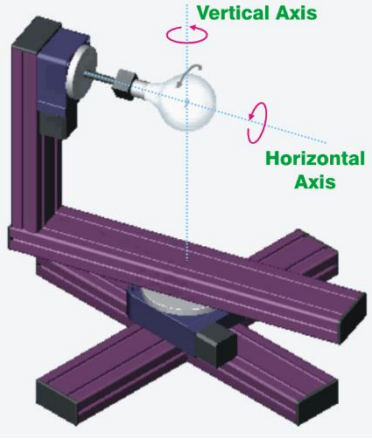


Figure 1: Schematic Diagram of the LG-1.0 Rotation Axes

Test Items

The goniometer can accept test items with mass up to 3 kg and up to 500 mm in physical diameter (250 mm clearance), although for best practice we recommend limiting the luminous dimensions to around 400 mm diameter. This caters for individual LEDs, LED lamps, LED clusters, LED modules and a variety of small luminaires.

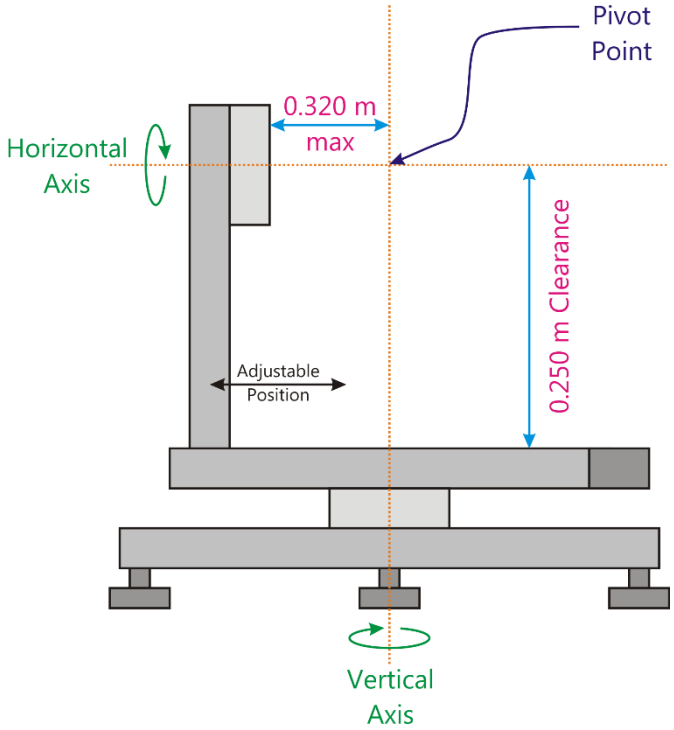


Figure 2: Schematic Diagram of LG-1.0 Dimensions

These are the standard specifications for test item limits, however these models are regularly customised for enhanced performance, including larger size and mass limitations. For more information on a customised solution, please contact PSI directly.

Test Item Mounting

When testing, the photometric reference point of the test item being measured is positioned at the pivot point of the goniometer. The vertical section on which the test item is mounted may be moved back and forth along the horizontal section to accommodate test items of different sizes.

At the top of the vertical section is a rotary stage, which has a table containing various drilled and tapped holes for attaching mounting brackets.

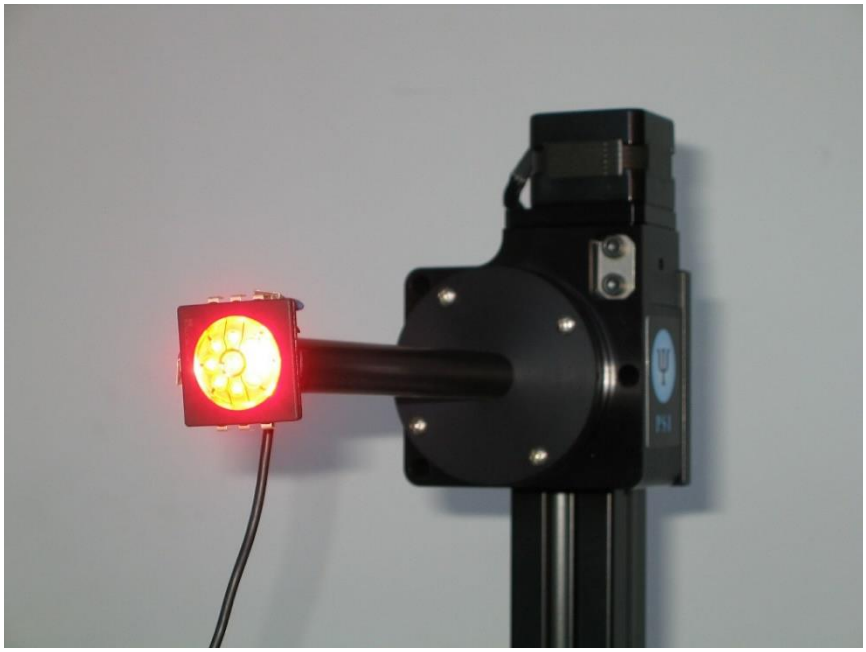


Figure 3: LED Test Item Mounted on Gonio

Photometric Measurement System

The measurement system consists of a photocell and a photocurrent preamplifier. The photocell is thermostatically controlled at 35°C and has an 8 mm receptive area and a responsivity around 14 nA/lx. The photocell has an excellent V (lambda) response with $f_1' < 1.50\%$ which is suitable for luminaires with practically all types of light sources including HPS lamps, SOX lamps and LEDs. The photocell is fed into a multi-ranging photocurrent preamplifier with built-in analogue-to-digital-converter that is controlled by the PC. Digital or software triggering from the motor controller to the data acquisition card means that fast sampling of test scans can be achieved.

The photocell is either mounted on a sturdy stand or on the rear wall of the laboratory and is appropriately masked and baffled to protect against stray light affecting the measurements. One or two c-baffles are placed in front of the photocell to prevent direct light from the luminaire striking the photocell and to minimise stray light.

Figure 4: Photocell and Amplifier

The software communicates with the amplifier using an RS-485 interface (supplied). The RS-485 communications cable is a simple, two-wire, twisted pair cable which gives great noise immunity.

Resolution of Measurement

The measurement resolution is around 10 microlux. For a 25 metre test distance, this corresponds to an excellent measurement resolution of around 10 millicandela (0.01 candela). This means that the system is sensitive enough to measure even small LED devices.

Measurement Layout

The detector is mounted on a wall or on a fixed stand at a distance across the room from the goniometer. For baffle tube and detector stand options, please see the Optional Extras section.

The minimum test distance, i.e. the distance from the goniometer's pivot point to the detector, is guided by the "five to one" rule of photometry. This rule states that the test distance should be at least five times the maximum luminous dimension of the test item. However, for narrow beams and focussed or collimated test items this is usually extended to "fifteen to one". This corresponds to a test distance of 3.0 m for test items up to 200 mm in diameter and 7.5 m for test items of up to 500 mm in diameter. These are typical test distances for the goniophotometer.

The actual test distance is not important, provided that the "five to one" or "fifteen to one" rules are observed. However, after the equipment is set up it is important that this be measured accurately for the conversion from illuminance to luminous intensity.

See the later section *Installation Requirements* for more details on the room layout and requirements.

Correction Measurements

The LG-1.0 is a rotating luminaire goniophotometer. The test item is aimed towards the detector and rotated; therefore, it is not mounted in its designed burning position and does not maintain a constant attitude during the test. This can affect the measurement of lamps whose light output changes when they are tilted to different angles, such as most types of discharge lamps.

LEDs are gravity-invariant – their light output does not change with burning position. However, for LED lamps and luminaires, the different mounting position (and therefore different air flow characteristics) may change the heat sinking ability of the device and therefore cause it to settle at a different temperature, which can affect the luminous output.

Control Software

The software that comes with the system is in two parts: control software to operate the equipment and report generation software to produce printed output. The big advantage of dividing the software into these two categories is that the report generation software can be installed onto other PCs so that reports can be produced while other measurements are being performed.

The control software that comes with the LG-1.0 is capable of performing measurements of luminous flux and luminous intensity distribution.

When the software initialises, it checks all devices attached to the system to check that they are working properly. In the event of a failure or misbehaviour of one or more of the devices, an error

message should be shown indicating which device is not functioning correctly and the most probable cause of the problem.

The control software has the flexibility to give the operator all the control that he/she needs, and is not restrictive and rigid. Features include:

- Ability to specify test angles and angular increments;
- Ability to take measurements “on the fly” without stopping;
- Bare lamp luminous flux measurement or luminous intensity distribution measurement or both;
- Facility for monitoring the stability of test items;
- Joystick control for arbitrary rotations of goniometer axes;
- Testing is normally performed in the C/γ geometry, which is standard of photometry of lamps and luminaires, however other geometries can be added, such as:
- Type B/β for floodlights;
- Type A/α for signals and automotive test items;
- Ability to set multiple calibrations, which are then selected according to lamp type (required for highest accuracy measurement);
- Stray light subtraction, by measuring a single stray light value and then subtracting this from all measured data.

Some screen captures of the control software are shown below and on the following pages.

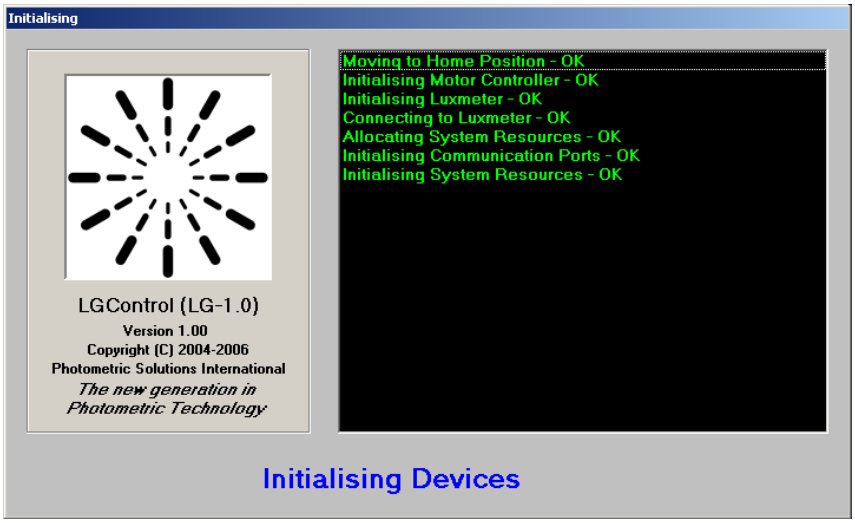


Figure 5: Initialising Devices

The software automatically checks the devices on initialisation.

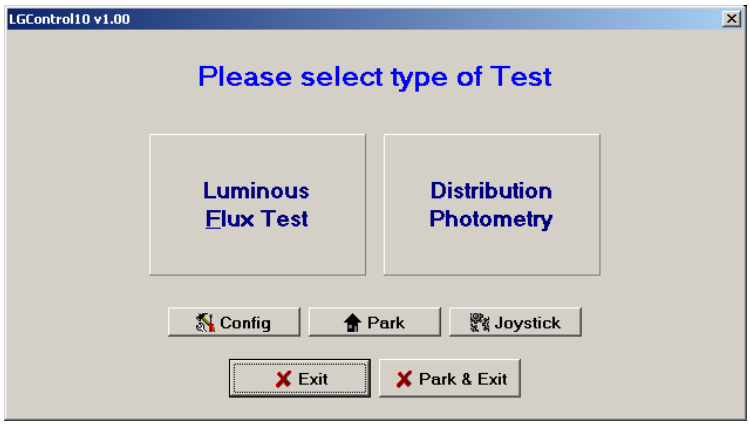


Figure 6: Main Menu

The main measurement functions clearly and easily identified.

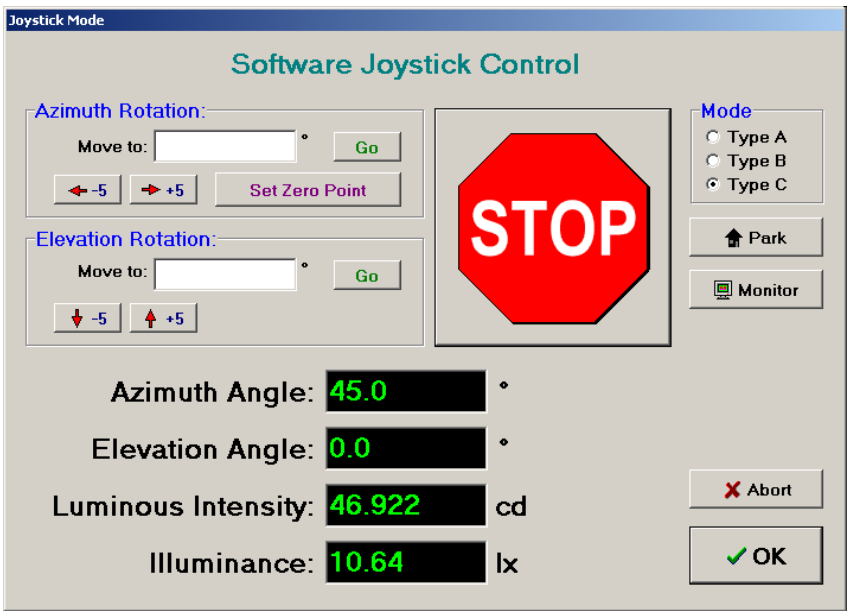


Figure 7: Joystick Control

The Joystick Control is used for arbitrary control of the Goniometer. The goniometer can be moved to different angles and the intensity distribution analysed, samples can be aligned, etc.

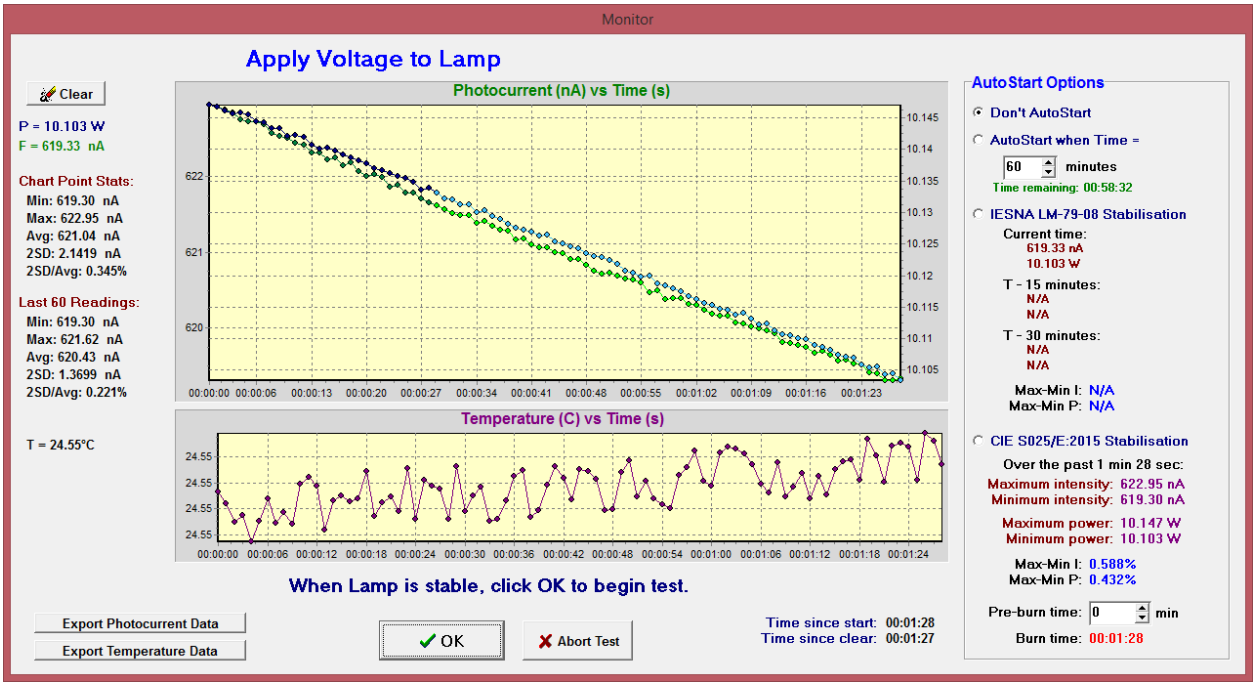


Figure 8: Detector Monitor Window

The output of the test item can be monitored to determine when the test item is fully stable. The warm-up graph can also be saved to disk in a format that can be imported into Excel for analysis.

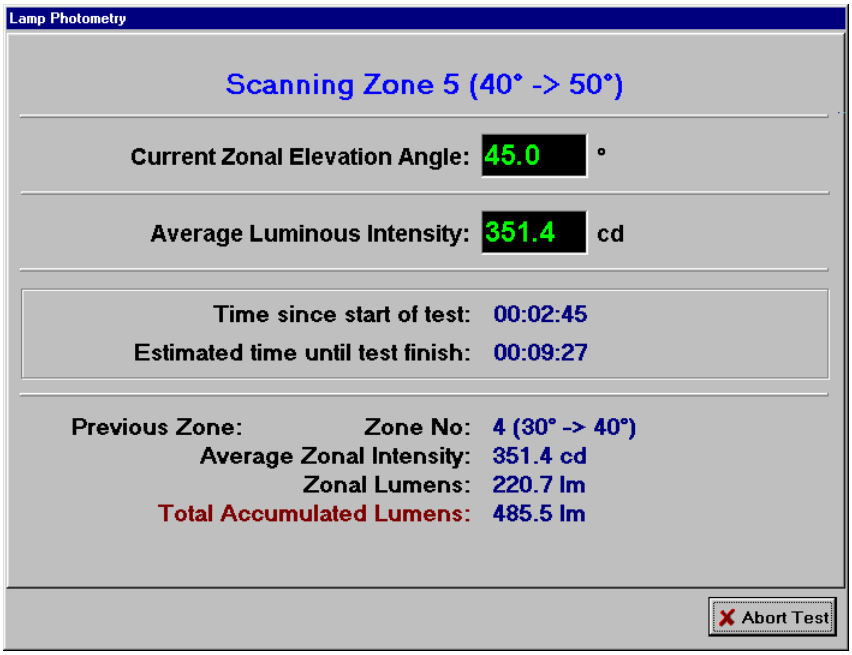


Figure 9: Bare Lamp or LED Luminous Flux Test

This window shows zonal summation of luminous flux. Alternatively, the entire luminous intensity distribution can be measured and the total luminous flux calculated along with beam width, etc.

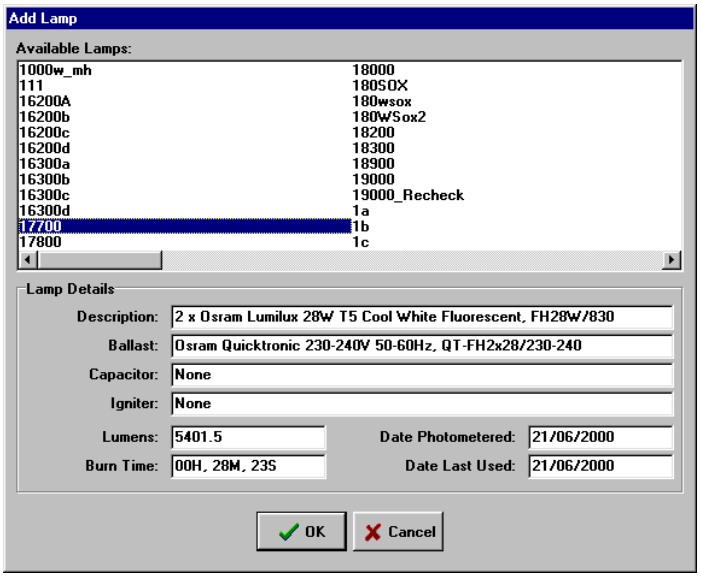


Figure 10: Standard Lamp Library

The standard lamp library is for storing the luminous flux data of reference lamps used in the photometry of luminaires using “relative” photometry (cd/klm), where the bare lamp lumens must be measured first.

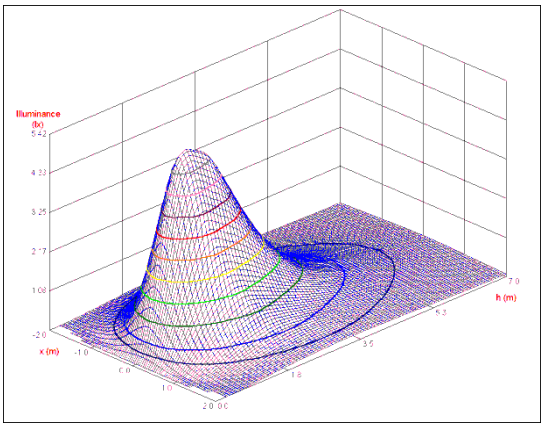
Report Software

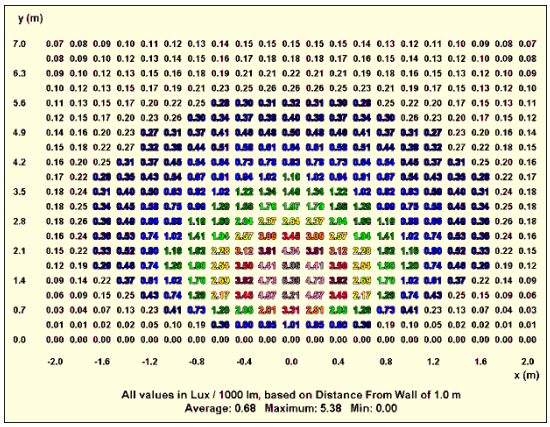
The report generation software is also flexible. The user can select which pages are to be included in a report so that the report may be customised according to each client’s needs. This gets around the limitation of fixed report generators that have a standard format for each type of test item and are too restrictive.

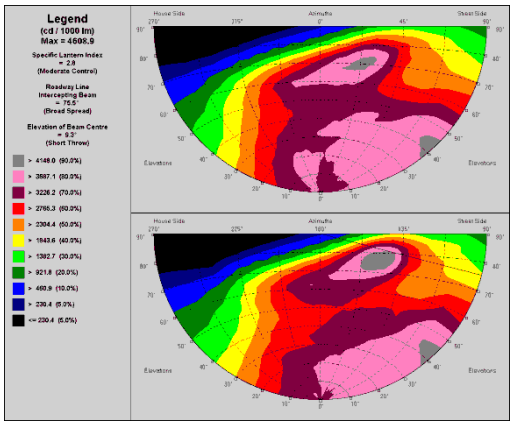
Features of our report generation software for measurements of luminous intensity distribution include:

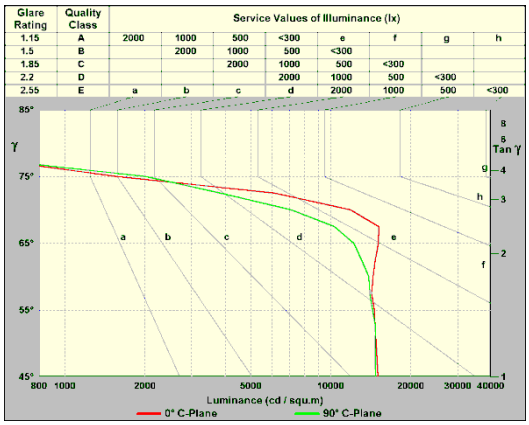
- Ability to customise the contact details and logo that appear on the printed pages;
- Test details with uncertainties of measurement;
- Polar curves and H-V plots – with ability to zoom in on lowest 10% regions to study spill-light;
- IsoCandela diagrams – Azimuthal projection format and H-V format;
- IsoLux diagrams – basic types only are needed here as there are many types of professional lighting-layout software available;
- 3D Web format for both the IsoLux and IsoCandela diagrams;
- Luminous flux summary table;
- Zonal flux diagram;
- Ability to display a digital image of the test item in the report for easy identification;

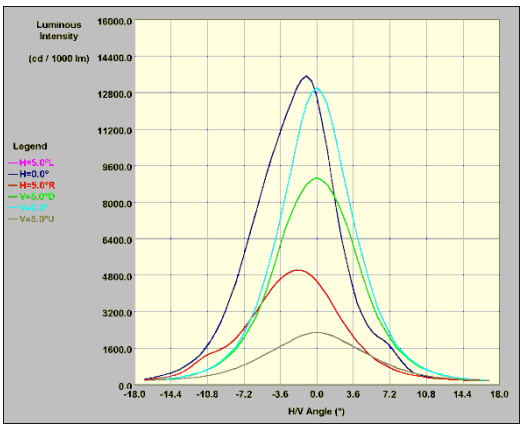
The IsoLux, IsoCandela and 3D Web format diagrams have options for line contour or shading formats, and the user can specify the values of the contours.











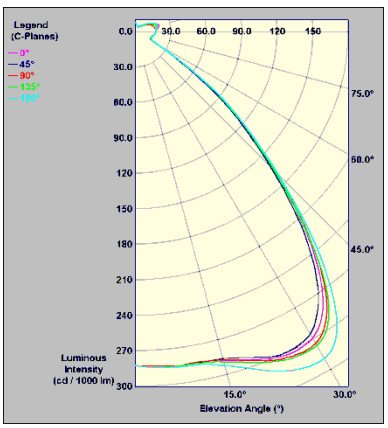


Figure 11: Sample Output from the Report Generator

Further information regarding the report software is in our other quote for our PhotometricSuite software. Please note that one licence of this software is provided free of charge with the goniophotometer system, however the other quote is given for more information or for additional licences.

The report generation software for measurements of luminous flux includes:

- Total luminous flux output, “upwards” lumens and “downwards” lumens;
- Zonal lumen analysis;
- Zonal flux diagram;
- Luminous efficacy (efficiency) calculation;

PC

The client is to provide a PC based on PSI’s recommendations. We generally find that most problems encountered are PC-related so we prefer that this is supplied locally for local servicing.

Installation Requirements

The building arrangements are the responsibility of the client. This includes:

- Laboratory construction;
- Painting of room surfaces, where appropriate, a matt black colour;
- Construction of stray light baffles and curtains, where appropriate;
- Dust-proofing and air conditioning;
- Provision of a sturdy table on which to mount the LG-1.0.

The room, or the space within the room which is dedicated to the LG-1.0 system, should be at least 2m wide and 2m longer than the test distance. Stray light baffles such as wooden panels or curtains should be placed on the walls, floor and ceiling. PSI staff can advise the client of the requirements for the baffles in advance or at the time of installation.

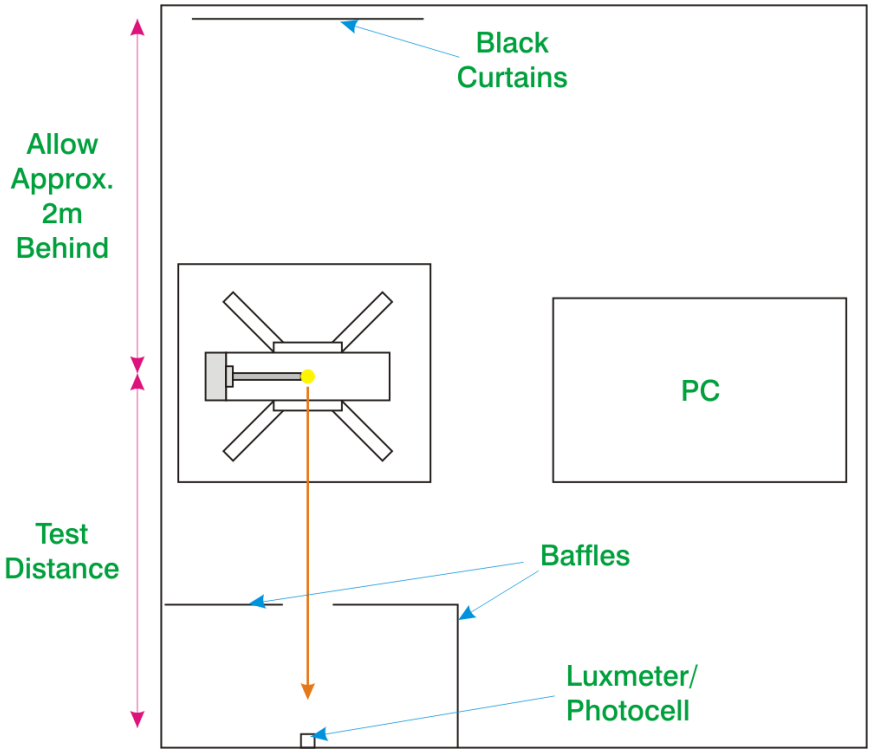


Figure 12: Typical Room Layout

The entire room or area should be light-tight and dust-proof. The room needs to be maintained at 25 degrees Celsius and preferably less than 70% humidity.

Mains supply should be properly earthed, stabilised and filtered. The mains electrical supply for the entire system should be provided through an uninterruptible power supply (UPS) system, or at the very least through a voltage stabiliser, and should include an isolation transformer and line filter. PSI can advise the client regarding the best locations of power outlets.

Documentation

The equipment and software provided comes with a User Manual (in English) which details the procedures for measuring lamp luminous flux and luminous intensity distributions with the LG-1.0 in easy to follow instructions. The manual also contains connection diagrams and troubleshooting guides to the various components of the system.

Part 2. Options

SP-4C Spectroradiometer with Software Interface

We will supply a SP-4C spectroradiometer. It includes:

- the spectrometer, with a LAN interface;
- fibre optics mounting bracket;
- PC LAN cable;
- power supply;
- instruction manual;
- ISO 17025 calibration certificate;

Figure 13: SP-4C

The software will include a module so that the operator can perform gonio-spectroradiometric measurements according to CIE S 025 and IES LM-79-08, and calculations including:

- Chromaticity coordinates (x, y) and (u', v');
- Correlated colour temperature (CCT) and D_{uv};
- Colour spatial uniformity $\Delta_{u'v'}$;
- Colour rendering index R_a.

The operator has the ability to select test angles for measurement exactly as per the luminous intensity distribution measurement, i.e. choosing the azimuth and elevation angle intervals and angle extents. However, the spectral measurement is considerably slower than the measurement of the luminous intensity distribution since the integration time needs to be optimised at each measurement point.

Key specifications include:

Spectral range:	300 nm to 1000 nm
Optical bandwidth:	approx. 4 nm
Angular acceptance:	approx. ± 1°
Wavelength resolution:	1 nm
Wavelength accuracy:	0.25 nm
Digital electronic resolution:	16 bit ADC
Integration time:	0.01 to 65,535 ms
Dynamic range:	Approx. 10^7
Power supply:	Through USB or LAN, external option

The SP-4C is factory-calibrated for:

- Wavelength response;
- Relative spectral power;
- Linearity;

It can be returned to our facility in Melbourne, Australia for annual calibrations, or alternatively the user can calibrate the instrument themselves for relative spectral power using a spectral irradiance standard.

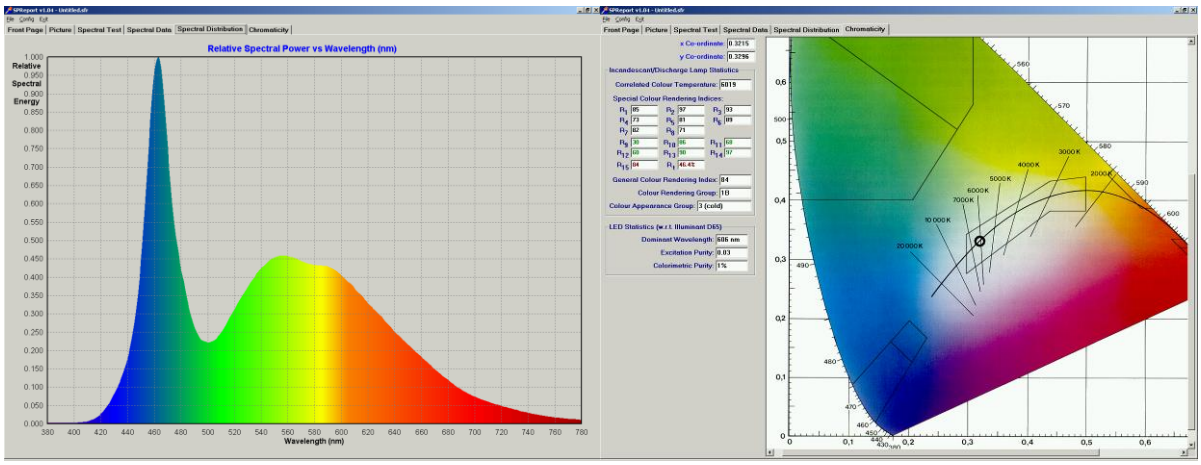


Figure 14: Spectral measurement

Power Analyser

One Yokogawa WT310E power analyser is used for monitoring the DUT operating parameters (voltage, current, power and power factor). The power analyser is interfaced with the control software in the PC so that the electrical parameters are automatically saved with the test data.

The WT310E has a basic accuracy of 0.1 % of reading + 0.05 % of the range for a frequency range of 45 Hz to 66 Hz which is good for both 50 and 60 Hz environments. It has a bandwidth of up to 100 kHz as required by CIE S 025/E:2015.

DC Linear Programmable Power Supply

A 35V 15A DC Power Supply will be supplied, along with a GPIB Interface and Software Control. The user enters the required voltage or current into the software and the software will be programmed to automatically power up and power down the test item and read the lamp's electrical parameters and save these along with the test data.

This option provides an extra level of automation and convenience for the operator, as well as reducing the possibility of operator error.

Switching-mode Programmable AC Power Source

We include a 1000 VA AC power source. This is a switching-mode power supply that outputs up to 5 A 300 V and has a frequency range of 15 Hz to 600 Hz. It has an output total voltage distortion of < 0.25 % over the frequency range 15 Hz to 200 Hz.

Linear Programmable AC Power Source

We include a 1200 VA AC power source. This is a linear power supply for lowest harmonic distortion and outputs up to 5 A 300 V or 10 A 150 V RMS and has a frequency range of 20 Hz to 5 kHz. It has an output total voltage distortion of < 0.1 % over the frequency range 45 Hz to 1 kHz.