



Photometric Solutions International[®]
THE NEW GENERATION IN PHOTOMETRIC TECHNOLOGY

ICP-1.0

Headlamp Measurement System

Control Software & Operating Manual

v2.01

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1. INTRODUCTION

The ICP-1.0 is an automatic system designed for the rapid measurement of the luminous intensity distribution of headlamp characteristic points.

The ICP-1.0 is used to determine whether samples from the production line comply with the photometric requirements of the Conformity of Production specifications. The system measures the beam distribution of the headlamp when it is completely formed, i.e. at a distance of "infinity". This may not be exactly the same beam distribution as at 25 m. However, for the purposes of complying to COP it is sufficiently good.

The headlamp type to be assessed is clamped onto the mounting plate in car position and at the height such that the (H,V) point on the headlamp is at the same level as the centre of the lens. The reflector in the headlamp is then adjusted so that it is aligned with the cut-off lines on the monitor.

It is well-known that it is very difficult to get repeatable results from measuring headlamps between laboratories and even between measurements in the same laboratory. This is because the illuminances at the various angles are very sensitive to which lamp is used and to the setting of the (H=0, V=0) point. Very small changes in these two can result in large changes in the measured illuminance values.

As an example, a headlamp was measured on a high-level goniophotometer in one laboratory and then measured on two different occasions on a goniophotometer in another laboratory. The results for the passing beam are shown in the Table below:

Point	Measurement A	Measurement B	Measurement C
75L	12.52	12.63	15.75
50L	23.68	13.88	28.76
75R	1.724	1.013	1.481
50R	8.980	6.132	8.615
50V	14.55	10.59	15.44
25L	7.924	5.234	10.58
25R	5.953	4.772	7.553

Then it cannot be expected that with the ICP-1.0 will give exact correlations with the laboratory data. However, it will accurately indicate whether the production sample meets the COP requirements.

This Operations Manual details the control software and procedures necessary to:

- (a) Set up and align a test headlamp;
- (b) Measure the intensity of characteristic points of the headlamp;
- (c) Generate reports pertaining to the headlamp test.

The control software for the ICP-1.0 system is called ICPControl. It runs under the Windows 7, 8 or 10 operating system and will coordinate all aspects of the testing.

Once this software has been installed onto a computer system, then this computer system should remain dedicated to the ICP-1.0. Operators should not install other software packages onto this computer system unless approval has been given by PSI. Should the purchaser of the ICP-1.0 system wish to transfer the ICPControl control software to another computer system for any reason, then this task can only be carried out by a technician from PSI.

ICPControl has been designed to be very easy-to-use for the operator, to make the task of testing simple and quick.

In this document, the terms "low beam" and "passing beam" are used interchangeably, as are "high beam" and "driving beam".

2. THEORY OF OPERATION

2.1 BACKGROUND

Measurement of headlamp beams for photometric compliance of various international standards (ECE (European), SAE (North American), etc.) is traditionally performed on a goniophotometer with a test distance of 25.0 metres. The testing typically comprises a series of individual test points and scanning zones.

While goniophotometric measurement is fine for prototyping and R&D, conformity of production testing on the production line requires a smaller-scale, rapid measurement device, for which an imaging digital photometer is ideal.

A Fresnel lens is used to image the beam onto a front projection screen, thus producing the far-field beam distribution as a luminance distribution spatially on the screen. A digital camera images the screen and the pixel values are used to create a luminous intensity distribution:

- The position of the pixel in the array corresponds to a particular horizontal and vertical angle; and
- The grey level of the digitized pixel value relates to the luminous intensity in that angular direction.

2.2 THE ICP-1.0 SYSTEM HARDWARE

A schematic of the physical setup of the ICP-1.0 is shown in Figure 1 below.

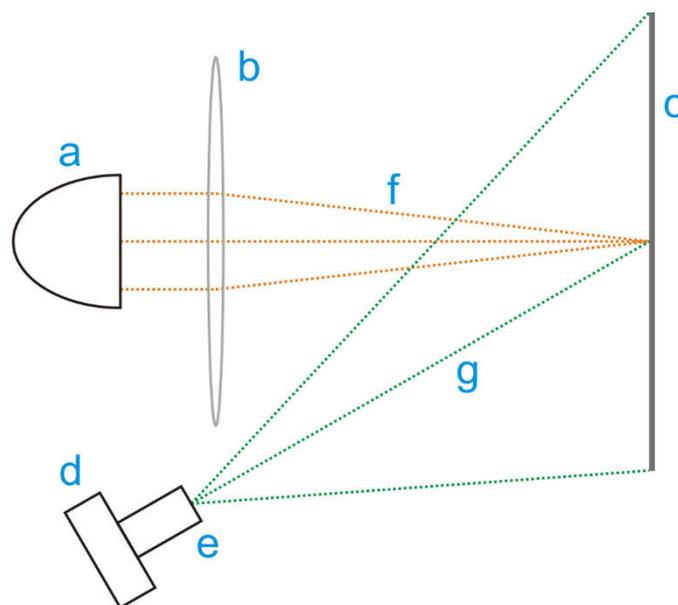


Figure 1: Schematic of the ICP-1.0 measurement setup

The parts that are shown in Figure 1 are:

- a) Device under test (DUT);
- b) Fresnel lens;
- c) Front projection screen;
- d) Digital camera;
- e) Camera lens;
- f) Imaging of headlamp beam onto screen;
- g) Field-of-view of camera.

2.3 THE ICP-1.0 SYSTEM SOFTWARE

Proprietary software developed by PSI coordinates all aspects of the measurement:

- The software interfaces the digital camera to obtain an intensity distribution of the headlamp;
- The software interfaces other devices (see Section 3) to coordinate the measurement and operation of the system
- The software operates in a user-friendly, easy-to-use, step-by-step manner to assist the operator in the operation of performing a test;

2.4 LIMITATIONS

There are several limitations of a digital camera photometer system such as the ICP-1.0 compared with a far-field goniophotometer. These include:

- The DUT is actually being measured in the far field rather than at 25.0 metres, so this may introduce an additional discrepancy in the measured data when comparing the equivalent measured data from a goniophotometer.
- The use of a Fresnel lens along with the compact housing, in order to reduce the system size and cost, introduces additional stray light.
- Digital cameras have a limited dynamic range and poorer linearity compared with high-end photometers used in goniophotometers.
- The camera has a built-in V (λ) filter to make the spectral response of the camera match the spectral response of the human eye. While the filter is high quality, there will always be some spectral mismatch when the spectrum of the source differs from the spectrum of the calibration source.

However, the intention of this equipment is usually to test conformity of production and so therefore the highest measurement accuracy is not normally required.

2.5 MODES OF MEASUREMENT

As mentioned in Section 2.4, the ICP-1.0 is designed as a production line measurement system and it and digital camera photometers has some limitations. The software therefore has two modes of measurement: relative and absolute.

2.5.1 RELATIVE MEASUREMENT

The photometric readings can be obtained by comparing a device under test (DUT) with a reference device of the same type that has been measured accurately on a goniophotometer. In the config there is a means to calibrate the system using such a reference device (see Section 9.4). The DUTs are then compared with the reference device in order to determine their performance.

Assuming that the jig used to mount the DUT is consistent with the mounting of the reference device, and the warmup time is the same, this is considered to be the most accurate method of measurement.

2.5.2 ABSOLUTE MEASUREMENT

The ICP-1.0 is calibrated absolutely, so that the pixel values can be directly related to measurements of luminous intensity. However, the measurements may be limited by stray light and other factors.

If there is no reference device to compare with then the absolute measurement mode can be used.

3. FEATURES OF THE ICP-1.0

A picture of the ICP-1.0 is shown in Figure 2 below.



Figure 2: The ICP-1.0 imaging photometer

A dimensional drawing of the model ICP-1.0L is shown in Figure 3 below.

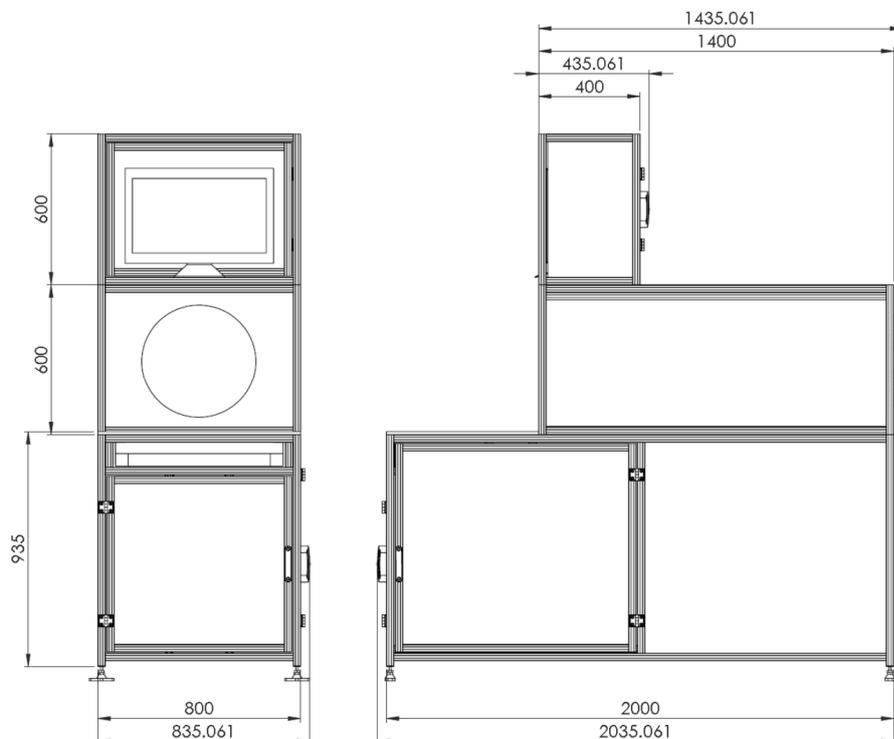


Figure 3: Dimensional diagram of the model ICP-1.0L

The ICP-1.0 is a sophisticated headlamp measurement tool, and as such, has a number of different components.

3.1 DIGITAL CAMERA SYSTEM

The Digital Camera System is contained within the ICP-1.0 case, and consists of a digital camera and a lens to focus the projected headlamp beam. The digital camera system is used to obtain a luminous intensity distribution of the headlamp. A picture of the camera system on its mounting bracket is shown in Figure 4 below.

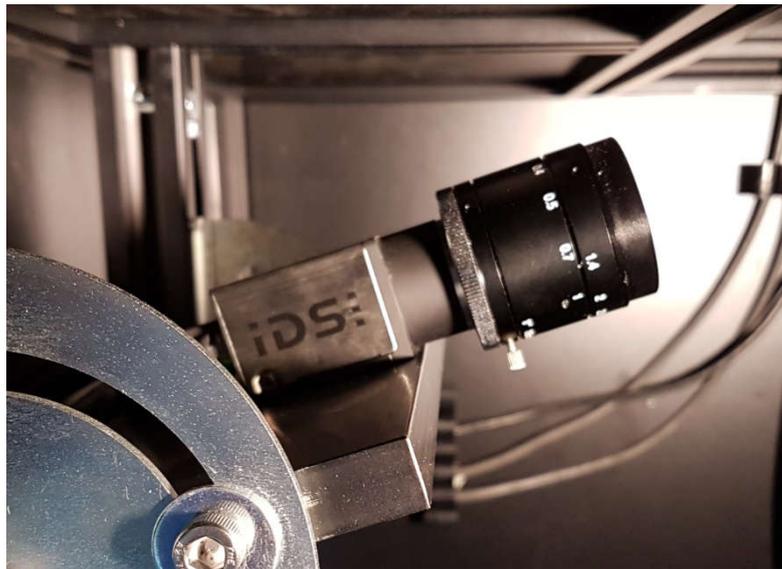


Figure 4: The digital camera

3.1.1 DIGITAL CAMERA

The digital camera has an Ethernet interface for rapid data transfer between the camera and the operating software. Some key characteristics are:

Sensor type:	CMOS mono
Shutter type:	Global shutter
Sensor characteristic:	Linear
Number of pixels:	1936 x 1216
Digitisation:	12-bit
Sensor diagonal:	13.4 mm

3.2 PC

The PC is built into a monitor and has been supplied by PSI, and has been integrated into the design of the ICP-1.0. A schematic diagram of the PC connections is shown in Figure 5 below.

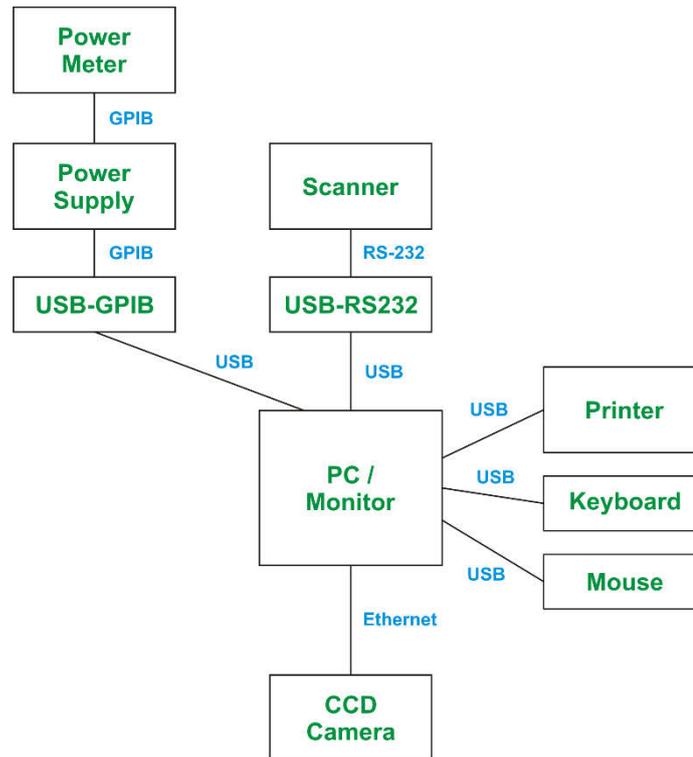


Figure 5: PC connection diagram

3.3 SOFTWARE

The software that interfaces the equipment and coordinates the measurement is called ICPControl. This is a Windows program that operates under the Windows 7 through to Windows 10 environment. Details of the operation of the software for performing tests are given in Section 6.

4. STARTUP PROCEDURE

The following procedure should be followed at the start of each testing day.

- (i) Switch on the ICP-1.0 – the PC should come on automatically.
- (ii) Switch on the other peripheral devices.
- (iii) Allow the instruments at least 15 minutes to warm up and stabilise before making any accurate measurements.

The equipment should then be left on continuously and turned off at the end of the day.

4.1 BEFORE RUNNING ICPCONTROL

There are a number of steps the operator should take before running ICPControl.

- Shut down all other software running on the computer system so that ICPControl is the only program running, other than system utilities such as virus protection software.
- It is strongly advised that the computer system running ICPControl is not connected to a network. If the computer system is connected to a network, then the network connection should be terminated before running ICPControl.

The reason for the instructions of the last two paragraphs is that ICPControl must perform a number of time-critical tasks. If ICPControl's operation is interrupted by other software or network activity, then a photometric test may need to be aborted and re-started or the PC may need to be rebooted.

5. GETTING STARTED

This section details what happens when you run the ICPControl software.

5.1 INITIALISATION

When ICPControl is started, it will quickly initialise communications with all of the devices comprising the ICP-1.0 system.

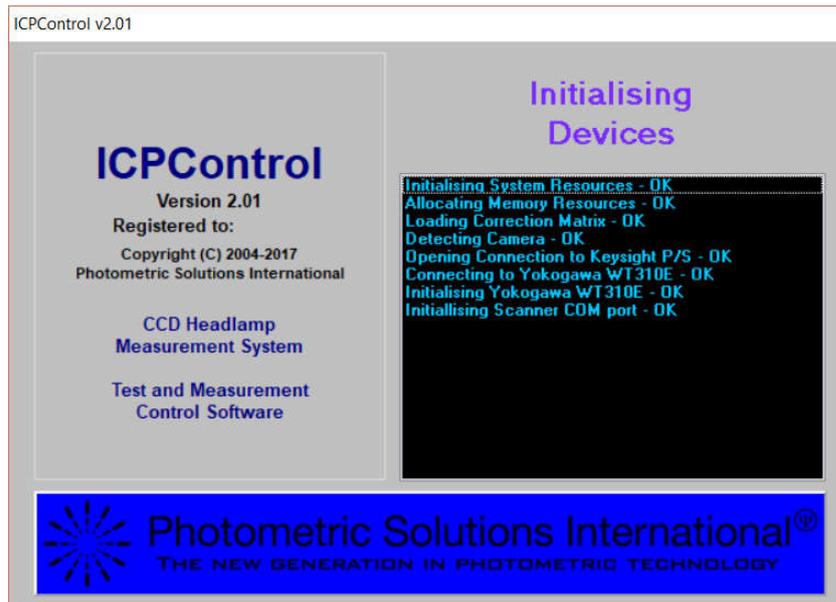


Figure 6: Initialising Devices Window

If there is a problem with any device that is attached to the system, then the problem will show up here, and the software will identify the device that is at error so that the operator can rectify the problem (usually turning the device on!).

5.2 MAIN MENU

The ICPControl Main Menu appears as shown in Figure 7.



Figure 7: ICPControl Main Menu

Perform Test. This will start the software along the procedure of performing a measurement test on a headlamp. This process is described in detail in Section 6.

Config. The ICPControl Config is used to set various settings that determine how ICPControl and the ICP-1.0 system conducts tests. The Config is described in detail in Section 9.

Exit. This option will exit ICPControl and return to the operating system.

6. HEADLAMP TESTS

This section contains a step-by-step working description of the way ICPControl performs a headlamp measurement test.

6.1 RELATIVE OR ABSOLUTE PHOTOMETRY

First you will be asked if you wish to measure using relative or absolute photometry, as shown in Figure 8 below.

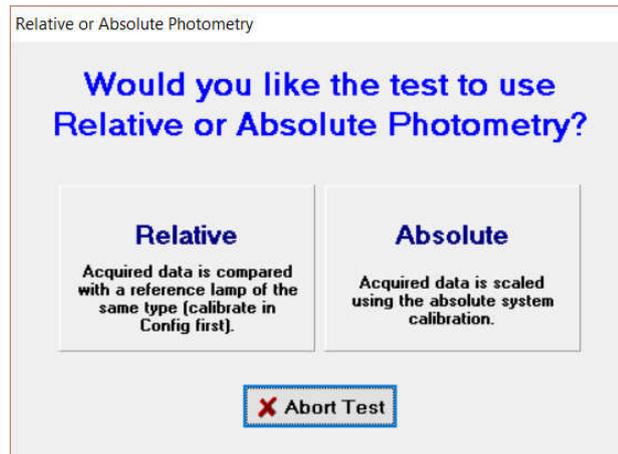


Figure 8: Relative or Absolute Photometry

The difference between relative and absolute photometry are described in Section 2.5. If you are using relative photometry, then you will need to have calibrated the system with a reference device as described in Section 9.4.

If you are performing a relative test then proceed to Section 6.2, otherwise proceed to Section 6.3.

6.2 RELATIVE TESTS

6.2.1 SELECT REFERENCE LAMP

First, select the calibration corresponding to the reference device that this test is being compared with using the Select Lamp window, as shown in Figure 9 below.

If the reference that you want is not available, then this can be measured and entered into the software using the Config as described in Section 9.4.

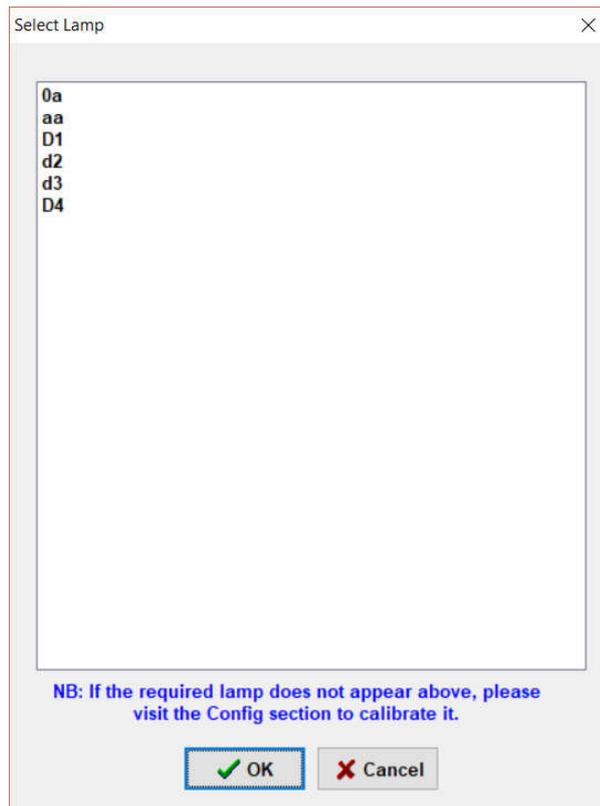


Figure 9: Select Lamp window

6.2.2 ENTER TEST DETAILS

Next, we enter in the test details for the headlamp undergoing the test. A Test Details window appears, as shown in Figure 10 below.

Test Details

Please enter test details

Test Officer: Tony

Model number: DB

Year: 17

Week number: 51

Serial number: 0044

Comments:

OK Cancel

Figure 10: Test Details window

If the product has a barcode you can scan this now, and the model number, year, week number and serial number will be scanned in.

When you have entered in the details to your satisfaction, click **OK** to continue.

6.2.3 PASSING BEAM

Normally the passing beam (low beam) will be measured before the driving beam. The passing beam is used to check and adjust the alignment and then measured, followed by the driving beam. If the reference device did not have a passing beam measurement, then this part will be skipped.

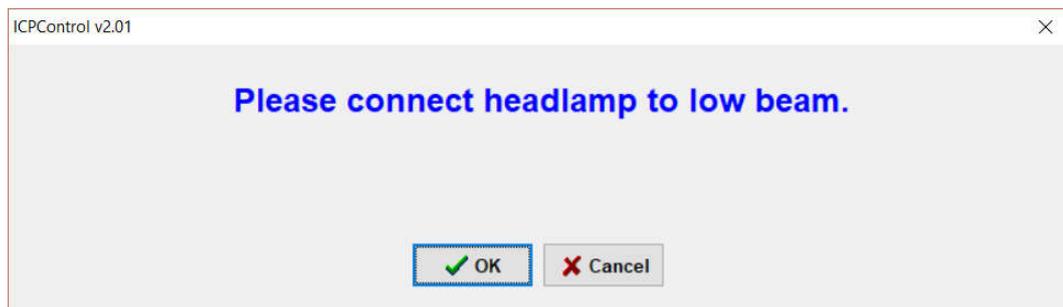


Figure 11: Connect to passing beam

6.2.4 APPLY POWER

You will now be shown the Power Supply Settings window, as described in Section 8. Choose the settings, then the software will apply power or request that you apply power if you have selected manual setting.

6.2.5 OPTIMISING

The software will now determine the optimum exposure time to measure the beam with the best signal to noise ratio.



Figure 12: Optimising

6.2.6 ALIGNMENT

The Alignment window will now appear, as shown in Figure 13 below.



Figure 13: Align low beam

The Alignment window will show a moving image of the headlamp in real time. This is so that the headlamp can be aligned with the ICP system.

The Alignment window also contains several coloured lines:

- Red lines show the H-H and V-V lines ($V = 0^\circ$ and $H = 0^\circ$);
- A green line shows the line $V = -1^\circ$;
- Blue lines show where the cut-off is being measured; and
- A yellow line connects the cut-off (the point of maximum gradient) along each of the blue lines.

Normally the cut-off would be positioned at -0.57° , i.e. 1 % down (1 % of a radian is 0.57°), in the side of the beam towards oncoming traffic. This is roughly half way between the green line and the horizontal red line.

Once the headlamp has been aligned to your satisfaction, click OK to continue.

6.2.7 PERFORMING LOW BEAM MEASUREMENT

Note: If there is no Passing test assigned, the software will skip the Low Beam measurement and move on to the High Beam measurement (See Section 6.2.9).

The software will then instruct the camera to take images of the headlamp. The data in these images will be averaged to allow for minor fluctuations. Furthermore, if you have enabled High Dynamic Range (HDR) mode (see Section 7.1) then the software will take further measurements with different exposure times to increase the dynamic range of the measurement.

6.2.8 PASSING BEAM RESULTS

The results of the test will now be shown on screen, as shown in Figure 14 below.

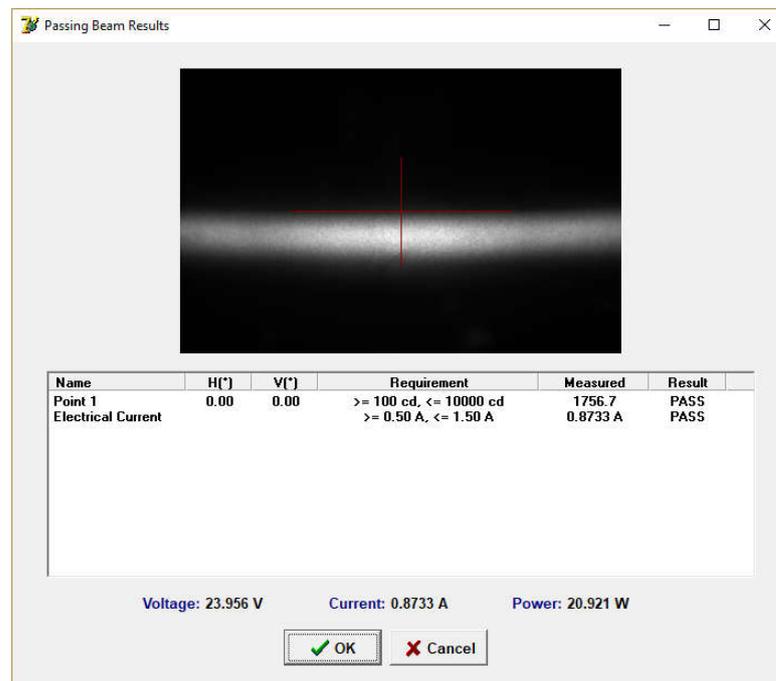


Figure 14: Passing beam results window

For each of the test points the following will be displayed:

- Test point name, if specified when the test routine was created;
- H angle and V angle, in degrees;
- The requirement, one of the following:
 - both \geq and \leq requirements;
 - \geq requirement;
 - \leq requirement; or
 - no requirement (blank).
- The measured luminous intensity, in cd; and
- The test point result PASS/FAIL.

For a headlamp to pass the test, each point must pass. It will also display an image of the measured beam along with the aiming lines.

6.2.9 PERFORMING HIGH BEAM MEASUREMENT

Note: If there is no Driving test assigned, the software will skip this part.

If there was a Low beam measurement just performed, then the software will ask to switch to the high beam and then apply power. It will then wait for the stabilisation period specified in the Config (see Section 9.1).



Figure 15: Wait for stabilisation

If no Low beam measurement was performed then the aiming window will show, as shown in Figure 16 below.

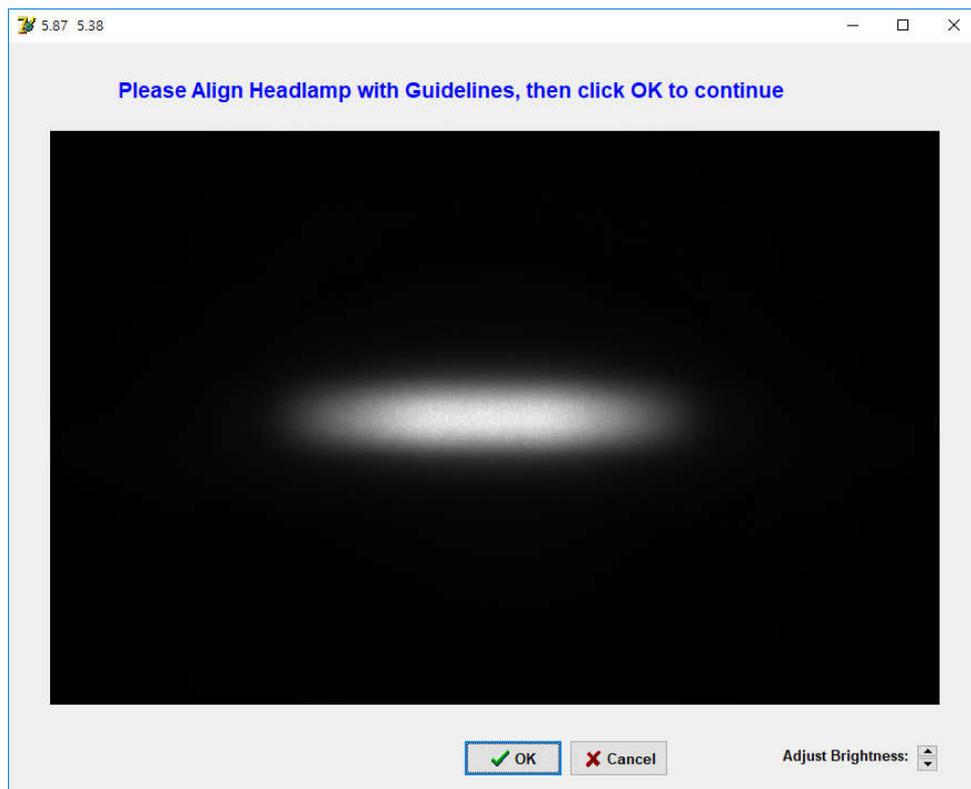


Figure 16: Align high beam

This is similar to the alignment for low beam except that the cut-off lines are not shown.

6.2.10 HIGH BEAM RESULTS

The Driving beam Results window will now be shown, as shown in Figure 17 below.

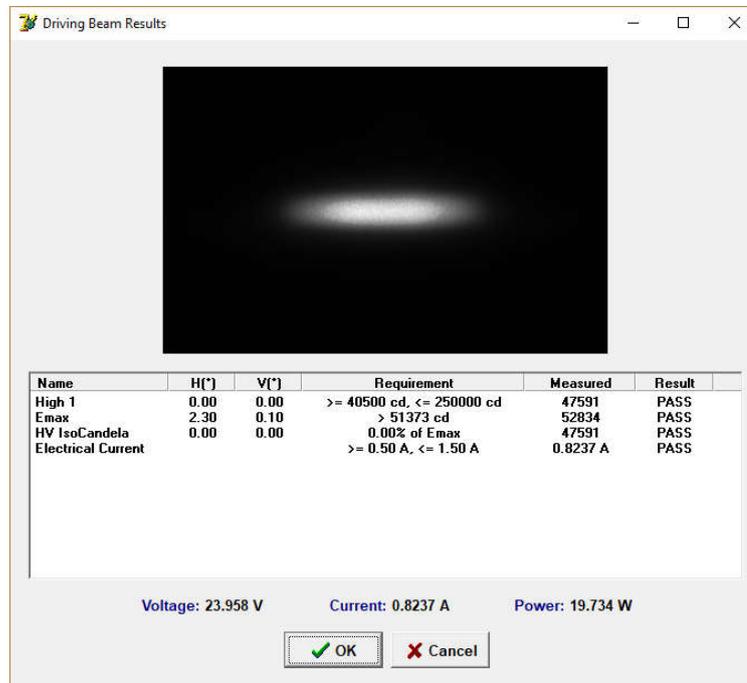


Figure 17: Driving beam results window

6.2.11 SUMMARY OF RESULTS

Once the test(s) have been completed, a Summary screen will be displayed, as shown in Figure 18 below.



Figure 18: Results summary window

The Summary window will simply re-display the results from Sections 6.2.8 and 0, but all on the one screen for ease as well as an overall PASS/FAIL. The data will also be saved at this point, and the file name with save path will also be displayed on the Summary window. The save path may be changed for preference, see Config in Section 9.5.

The Summary screen also has a checkbox labelled "Print label". If this is checked, then when the OK button is pressed the software will print a label which shows the part name and serial number and PASS or FAIL.

There is also a checkbox labelled "Measure another". If this is checked then the software will return to displaying the test details window (see Section 6.2.2) to test another product with the same test routines, reference, power supply settings, etc. when the OK button is pressed, else the software will return to the Main Menu when the OK button is pressed.

6.3 ABSOLUTE TESTS

In the case of absolute photometry, the measurement proceeds in a similar way to relative photometry except that there are some different steps at the start. Instead of selecting a lamp calibration which contains the details of the test routines, the operator is asked to specify which test routines to use. After this, the measurement procedure occurs in the same way as for relative photometry as described in Section 6.2 above.

7. MEASUREMENTS

The ICP-1.0 system uses a digital camera to perform the photometric measurements. A schematic of the digital camera is shown in Figure 19 below.

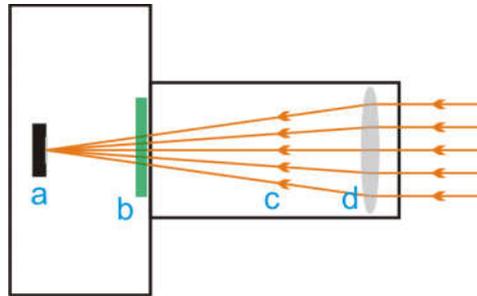


Figure 19: Schematic of digital camera

The parts of Figure 19 are as follows:

- a) Detector array;
- b) $V(\lambda)$ filter;
- c) Optical path (simplified); and
- d) Lens (simplified).

The $V(\lambda)$ filter makes the spectral response of the camera match the CIE luminous efficiency function for photopic vision (match the human eye). This is needed to perform measurements of luminous intensity.

Like all cameras, the ICP-1.0 digital camera has adjustable exposure time. When each headlight function is switched on, the software will adjust the exposure time until the optimum signal-to-noise ratio is found.



Figure 20: Optimising exposure time

If testing and this is the first measurement, then the alignment window will be shown once the optimising is finished, as described in Section 6.2.5. The software will then wait until the minimum time for stabilisation has elapsed (see Section 9.1) before taking the measurements.



Figure 21: Wait for stabilisation

If calibrating, then the alignment screen is not shown, and the stabilisation wait is not performed. Instead, the software will show a message asking if the source is stabilised. The operator needs to wait for the stabilisation time required by the calibration source before continuing.

Now the software is ready to perform the measurement. When a measurement is taken, the software will take ten measurements and average them together.

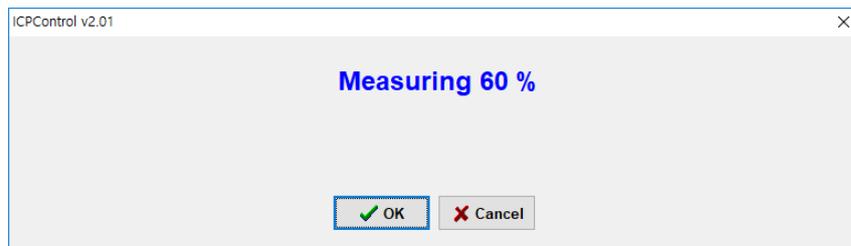


Figure 22: Measuring

7.1 HIGH DYNAMIC RANGE MEASUREMENT

If the High Dynamic Range is enabled in the config (see Section 9.1) then the software will now take a series of additional measurements. Here the exposure time is increased sequentially by a factor of 3.0 each time. For each exposure time the software will take an additional set of measurements and average them together.



Figure 23: High dynamic range measurement

The software now has measurements at the correct exposure time plus exposure times of 3.0, 9.0, 27.0, 81 and 243 times the correct exposure time.

The software then uses a proprietary method to stitch the sets measurements together to boost the signal in the lower signal areas while ignoring any saturated areas. This greatly increases the dynamic range from a single exposure time.

7.2 DARK MEASUREMENT

If performing a flat field calibration or luminous intensity calibration, then the software will ask for the source to be switched off so that it can perform a dark measurement and subtract this from the measured data. This is only needed for the calibration, it is not needed for general testing.

8. POWER SUPPLY SETTINGS

The power supply settings window is shown in Figure 24 below.

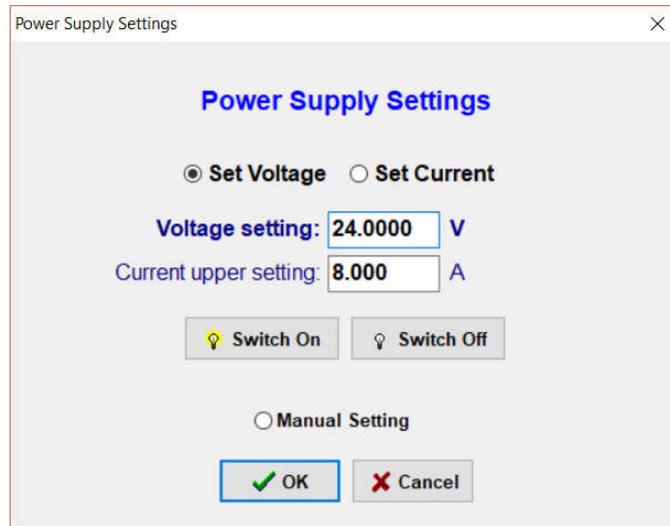


Figure 24: Power supply settings window

You can specify whether to use a set voltage or a set current. Typically, LED sources and uncalibrated lamps are measured with a set voltage. Whereas calibrated bulbs will normally have a filament current at which they have been calibrated and so the set current setting would be used.

You also need to specify the upper setting for the alternative parameter. For example, say an LED lamp is designed for use at 24 V DC and it would normally have a current of 0.6 A. Here the current upper setting could be set to 1.0 A in order not to current-limit the supply. Remember that regardless of the programming, the supply will increase the voltage until either the voltage setting or the current setting is reached.

Alternatively, if you wish to control the power supply manually or perhaps are using a different supply, then you can select to use the Manual Setting. In this case, instead of automatically applying the power the software will display a message asking for power to be applied.

9. CONFIG

The ICPControl Config is where you can specify various aspects of how ICPControl will run the ICP-1.0 system. The Config window is arrived at by clicking the “**Config**” button on the ICPControl Main Menu window.

There are several different sections of the Config, and these are detailed in the following sections.

9.1 CONFIG – GENERAL

The General section of Config is shown in Figure 25 below.

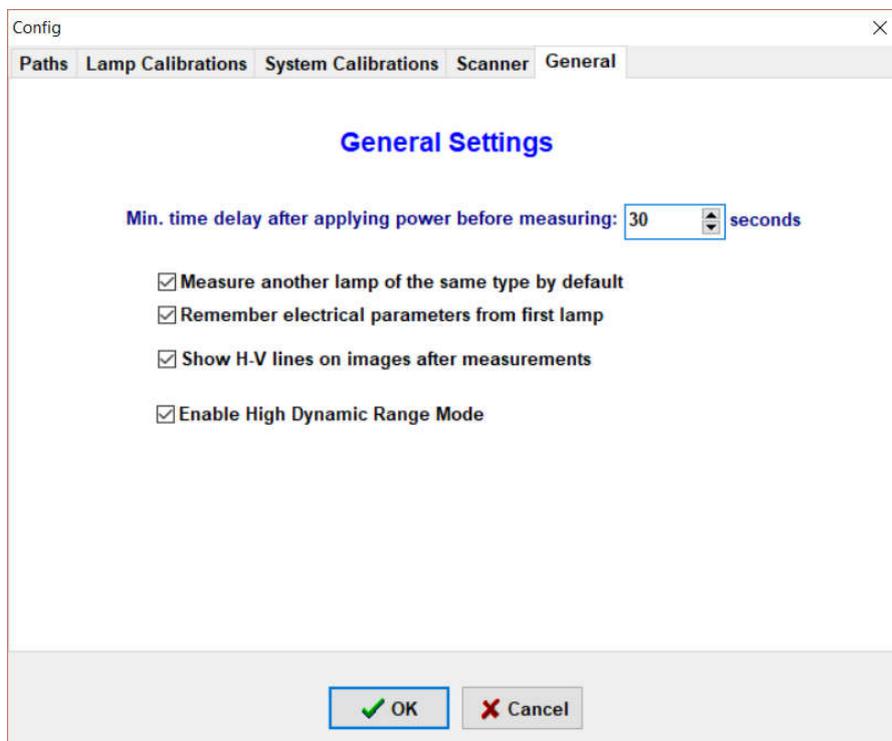


Figure 25: Config – General

There are several settings that can be programmed here:

- Specify the **minimum time delay after applying power before measuring**. Ideally the device under test should be fully stabilised before measuring, but in a production line testing this is not practical. What is needed is to determine a stabilisation time that will give consistent performance within the acceptable variations but not take too long.
- Specify whether to **Measure another lamp of the same type by default**. If this is selected, then the software will normally return to the Test Details window after measuring a device so that the next device of the same type can be measured. If this is not selected then the software will return to the Main Menu.

- Specify whether to **Remember electrical parameters from first lamp**. If this is selected then the software will not ask for the power supply settings each time a device is measured, but instead it will use the same settings from the previous device.
- Specify whether to **Show H-V lines on images after measurements**. These images are saved with the test results, so it is optional whether to have the H-V lines saved on them or not.
- Specify whether to **Enable High Dynamic Range Mode**, as described in Section 7.1.

9.2 CONFIG – SCANNER

The Scanner section of Config is shown in Figure 26 below.

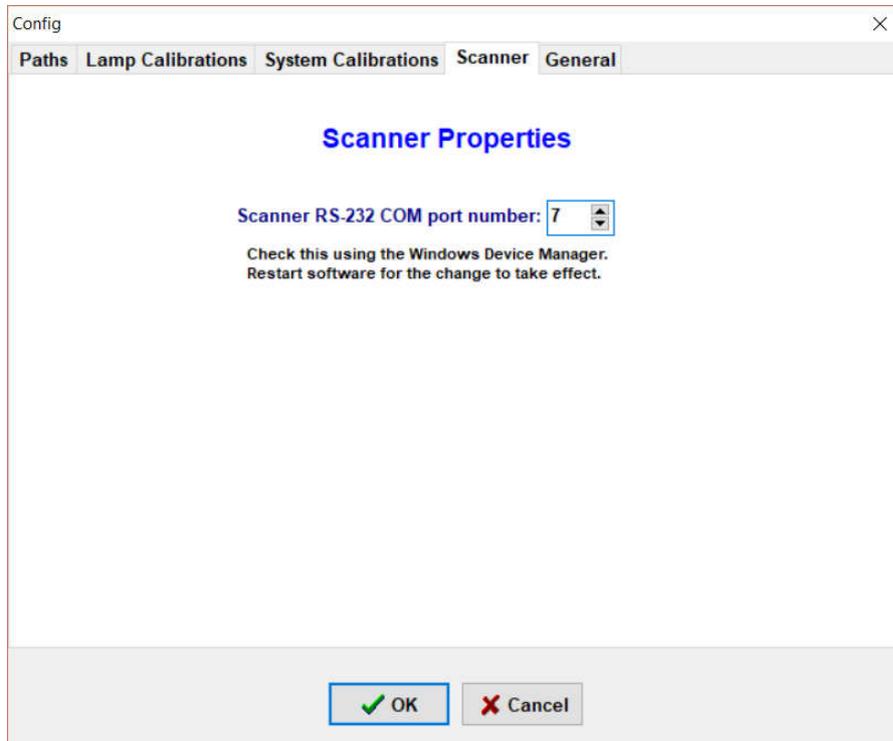


Figure 26: Config – Scanner

The bar code scanner does is a send-only device. This means that it does not respond to commands sent by the software and so the software can't automatically determine which RS-232 COM port that it is connected to. Instead this needs to be specified manually.

The software will need to be restarted in order for this to take effect.

9.3 CONFIG – SYSTEM CALIBRATIONS

The System Calibrations section of Config is shown in Figure 27 below.

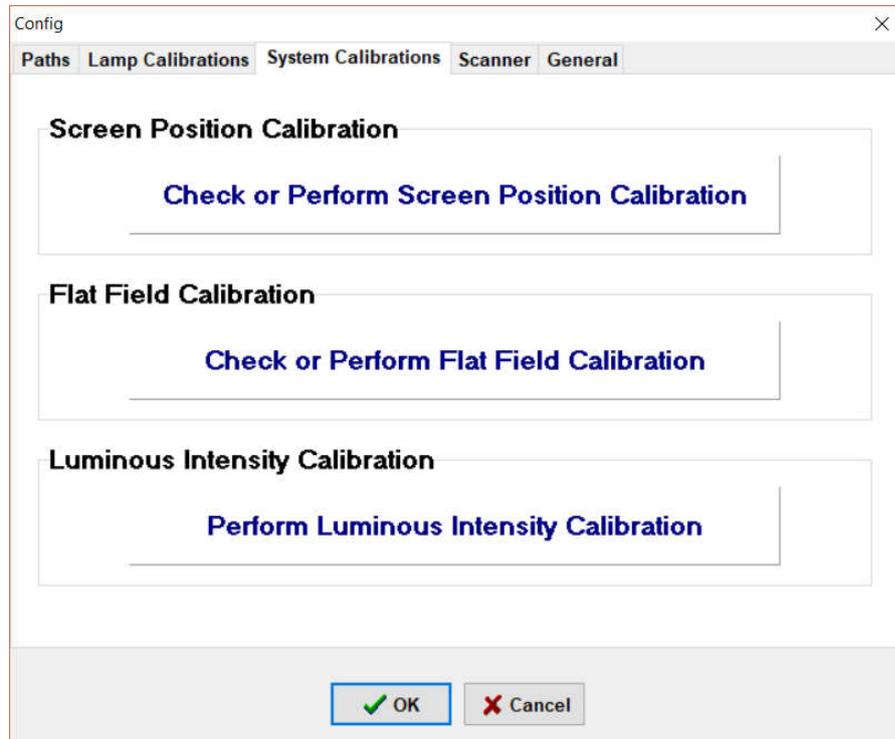


Figure 27: Config – System Calibrations

These system calibrations are described in detail in Section 10.

9.4 CONFIG – LAMP CALIBRATIONS

The Lamp Calibrations section of Config is shown in Figure 28 below.

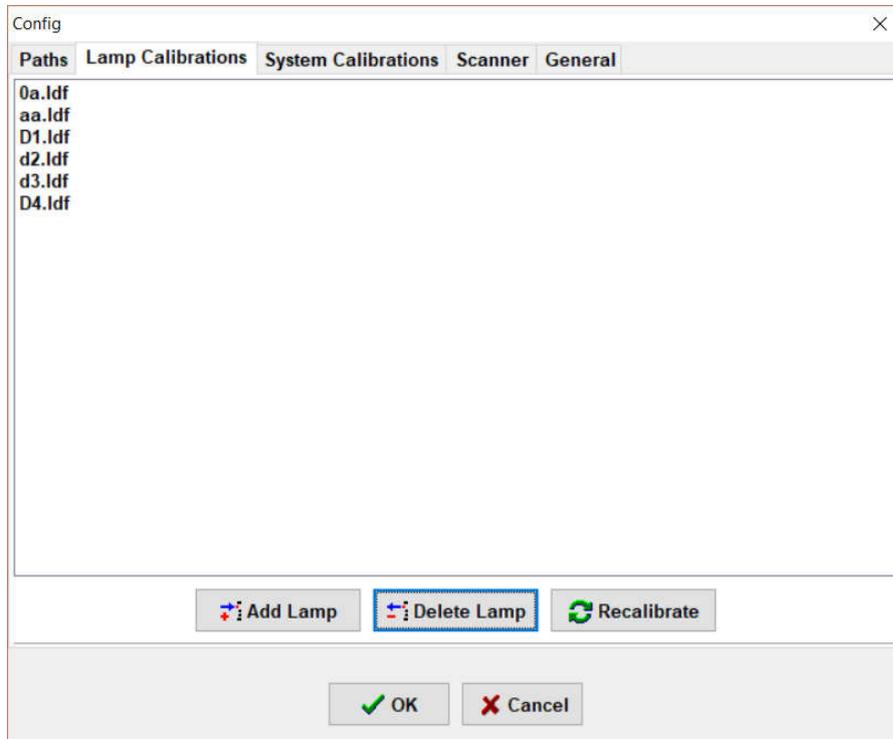


Figure 28: Config – Lamp Calibrations

The lamp calibrations are used for Relative Photometry (see Section 2.5.1). The lamps can be calibrated here.

A list of the available lamp calibrations is shown in the window in Figure 28. It is possible to **Add** a new lamp calibration, **Delete** an existing calibration, or select a lamp calibration and **Recalibrate** it.

9.4.1 ADDING A LAMP CALIBRATION

If the lamp you wish to test has not been calibrated yet, you can calibrate it from this section.

NB: To calibrate a headlamp, it must have been previously measured on a goniophotometer, and reference values of luminous intensity must be known for all test points.

Click Add Lamp under the list of lamp calibrations. You will be asked to select the passing beam test routine you wish to calibrate this lamp to, and then the Test Routines window will appear with a list of the available passing beam test routines, as shown in Figure 29 below.

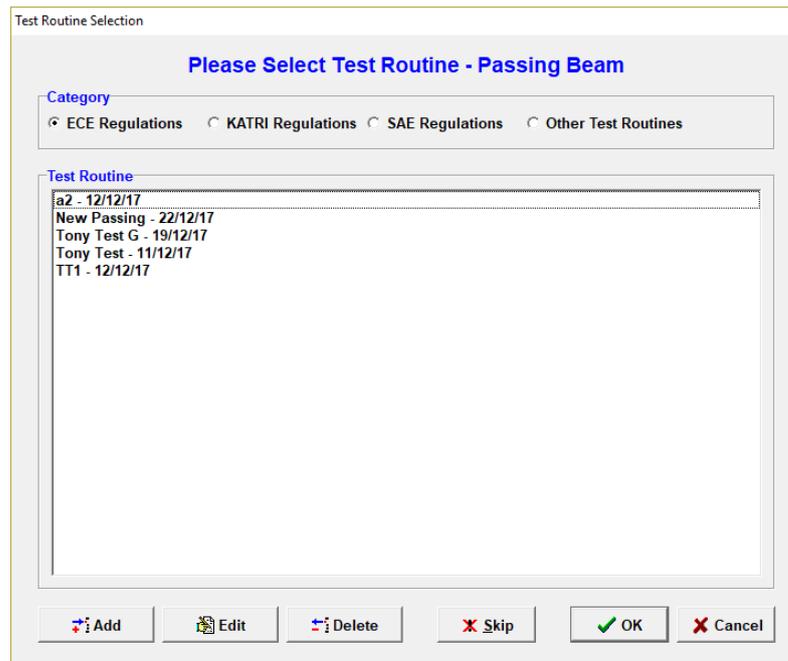


Figure 29: Select Passing Beam

You can Add, Edit and Delete the test routines here, as described in Section 11.

Select the **Passing Beam** test routine that you want to use and click **OK**. Or you can click **Skip** if you do not wish to calibrate a passing beam for this lamp. Or click **Cancel** to cancel the calibration process.

Next you will be shown the Test Routines window with the driving beams and asked to select the **Driving Beam** test routine that you wish you use, or likewise Skip if you don't wish to measure a driving beam.

If you have selected a passing beam test routine, the software will now apply power, show the alignment window and measure the beam as per in a test (see Sections 6.2.4 to 6.2.7). It will then ask you to enter in the calibrated luminous intensity for each of the test points in the test routine.

If you have selected a driving beam test routine, the software will now apply power, show the alignment window (if there was no passing beam) and measure the beam as per in a test (see Section 6.2.9). It will then ask you to enter in the calibrated luminous intensity for each of the test points in the test routine.

9.4.2 DELETING A LAMP CALIBRATION

If a lamp calibration is no longer needed, it can be selected and deleted using the **Delete Lamp** button.

9.4.3 RECALIBRATING A LAMP

If the system has undergone a System Calibration (see Section 10) or after a period of time, typically six months, then the lamp calibrations will need to be recalibrated.

Select a lamp calibration and click the **Recalibrate** button. The software will read in the passing beam and driving beam test routines and then perform the calibration as per Section 9.4.1 above.

9.5 CONFIG – PATHS

The Paths section of Config is shown in Figure 30 below.

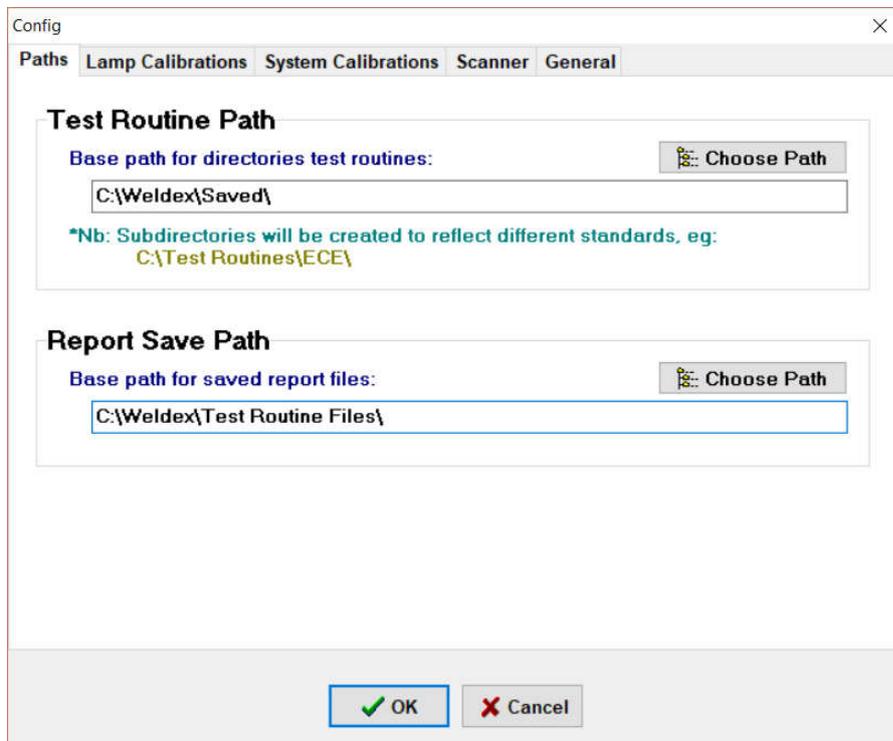


Figure 30: Config – Paths

Test Routine Path: Here you can specify the folder which contains the test routine files.

Report Save Path: Here you can specify the base folder in which to save the recorded data. It is recommended you make this something that is consistent and easy to remember so that data isn't lost!

By default, the software will create subdirectories from this base folder as follows:

- Base folder
 - Part number
 - Year
 - Week number

For example, if the base path is C:\Results and using the data from Figure 10, the results would be saved in **C:\Results\DB\17\51**.

10. SYSTEM CALIBRATIONS

There are three main system calibrations, as shown in Figure 27. These are described in the following sections and must be performed in the order given below.

10.1 SCREEN POSITION CALIBRATION

The screen position calibration is used to calibrate the aiming and field of view of the camera. Under normal circumstances, this should be performed once per year; each time the system is moved; or if the system is suspected to be out of alignment. Use the steps outlined in the following sections to perform a screen position calibration.

10.1.1 MOUNT THE SCREEN POSITION TEMPLATE

A screen position template is provided that has a set of nine aiming points marked on it. This is shown in Figure 31 below.

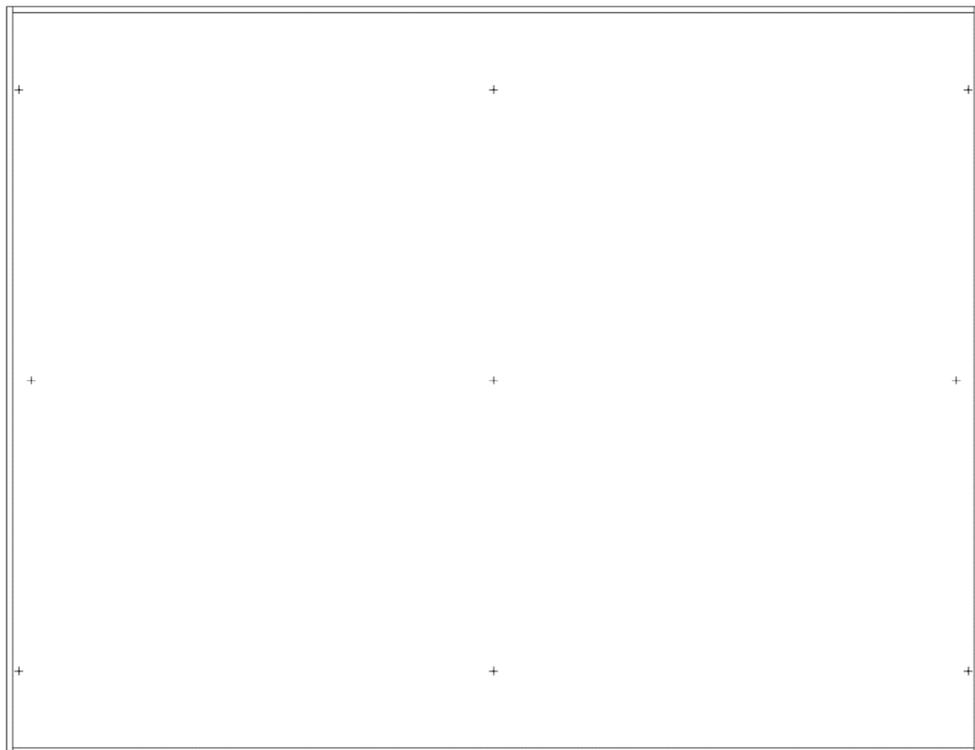


Figure 31: Screen position template diagram

The nine aiming points are at the following angular positions:

- The four corners: $(-20^\circ, +13^\circ)$, $(+20^\circ, +13^\circ)$, $(-20^\circ, -13^\circ)$, and $(+20^\circ, -13^\circ)$;

- The midpoints of the four sides: $(0^\circ, +13^\circ)$, $(0^\circ, -13^\circ)$, $(-20^\circ, 0^\circ)$, and $(+20^\circ, 0^\circ)$;
- The H-V point $(0^\circ, 0^\circ)$.

The screen position template can be fixed in place on the front projection screen inside the ICP-1.0. To do this, the side door on the middle cabinet of the ICP-1.0 needs to be opened. The screen position template can be fixed into place so that it is centred on the front projection screen using masking tape, as shown in Figure 32 below.

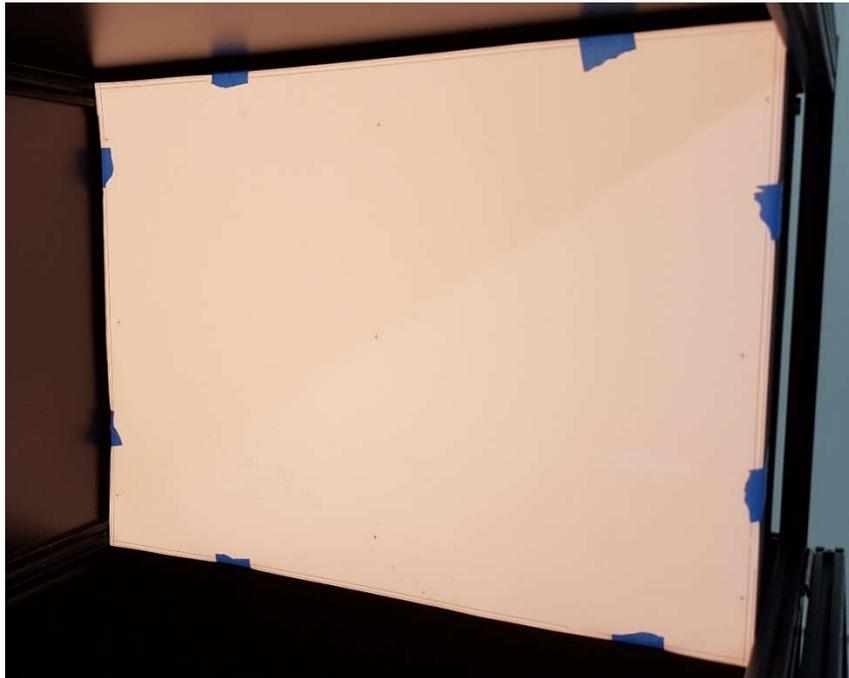


Figure 32: Screen position template in place

10.1.2 SELECT FROM CONFIG

Enter the Config section of the ICPCControl software (See Section 9 for details), and navigate to the **System Calibrations** tab. Click on the button labelled **Check or Perform Screen Position Calibration**.

10.1.3 VIEW THE SCREEN POSITION CALIBRATION POINTS

The screen will now show an image from the camera with full resolution. Only one or two of the nine aiming points will be able to be seen at any one time. A green plus is shown on the screen at the position where the each of the aiming points are registered in the software. This is shown in Figure 33 below.

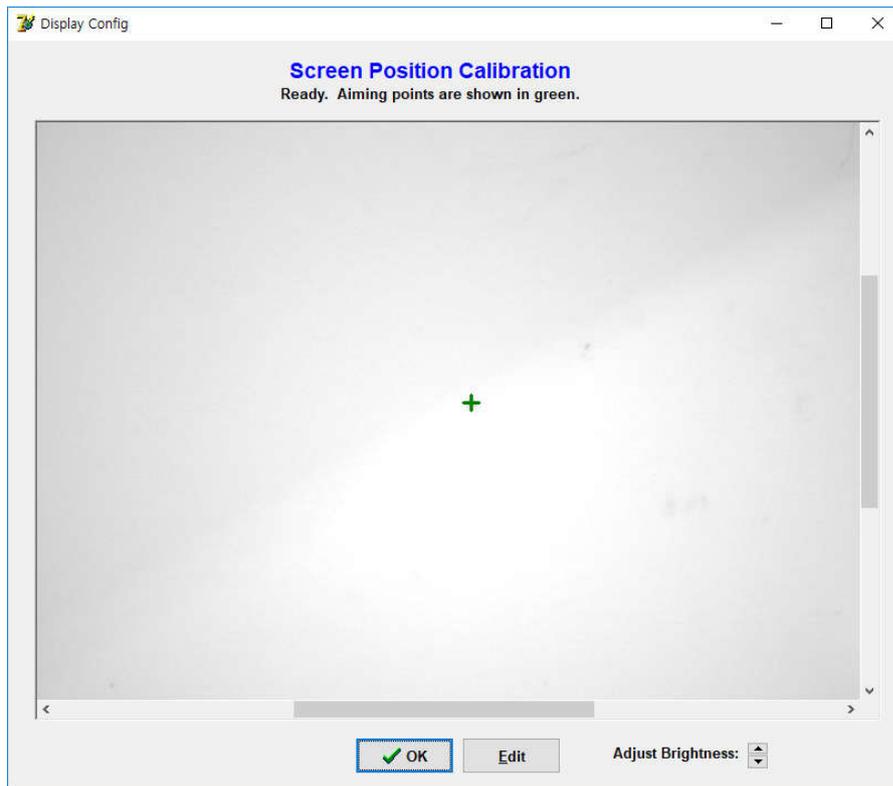


Figure 33: Screen position calibration window

If the system is aligned correctly then all of the green plus signs should overlap the aiming points. If the green plus doesn't perfectly overlap an aiming point but it is still within the width and height of the aiming point, then the aiming is still correct to within approximately 0.18° , which is normally acceptable for production measurement such as this.

A judgement about whether the screen position calibration needs to be updated or not depends on the individual preference of the person responsible for the equipment. Greater preference is normally given to the central (H-V) point. If this alignment point matches perfectly but some of the edge points are out of alignment by a small amount, then the overall calibration may be considered to be acceptable given that most measurements are done at only small angular distances from the H-V point.

Click Edit to adjust the calibration, or OK to go back to Config.

10.1.4 EDITING THE SCREEN POSITION CALIBRATION POINTS

If Edit is clicked, then the software will prompt the user that they will need to click in sequence all of the nine aiming points and to confirm if they wish to continue, as shown in Figure 34 below.

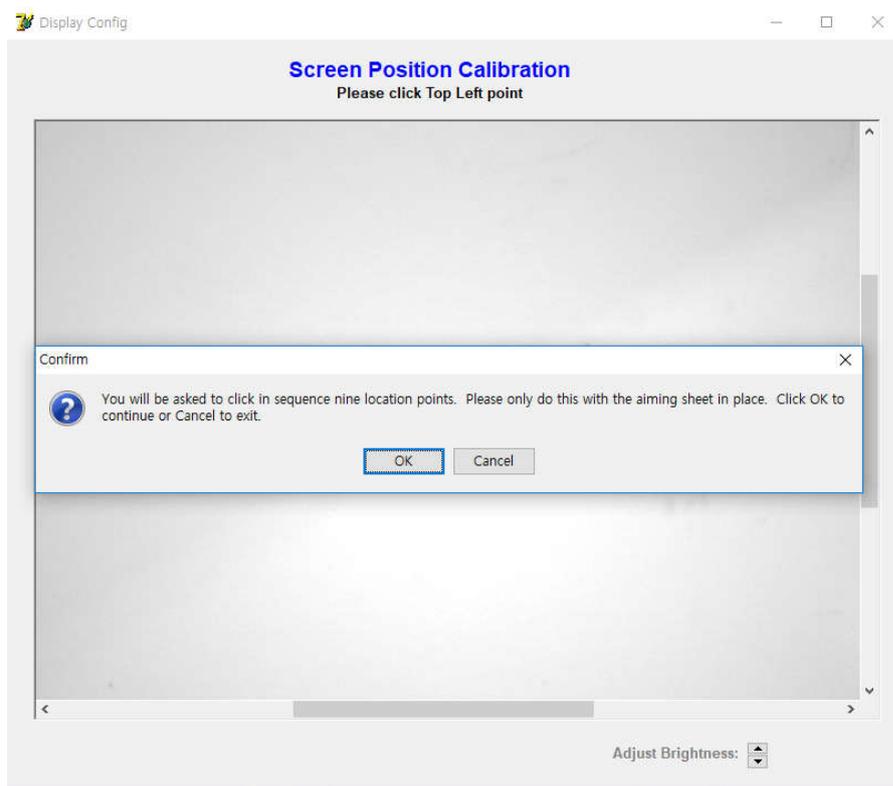


Figure 34: Prompt to confirm editing the screen position calibration

If OK is clicked, then the software will prompt the user to click on the screen all of the nine aiming points in sequence. Use the scrollbars on the sides of the image to move the image to each point in sequence, then click in the centre of each aiming point. A green plus will be placed where the software has detected the click point so that the user can see straight away if the aiming point has been correctly located.

When all nine points have been clicked, the software will ask if the user is happy with all of the calibration points. If the user selects yes, then the new calibration points will be saved. Otherwise the new calibration points will be retained and, if desired, the calibration can be performed again.

When the screen position calibration is finished, the screen position template can be removed from the front projection screen. The flat field calibration should now be performed.

10.2 FLAT FIELD CALIBRATION

The digital camera is measuring the luminance of the light reflected from the front projection screen. However, the luminance will be different in different parts of the screen for the same luminous intensity, due to aspects such as the distance to the screen, the angle of incidence of light on the screen, the throughput of the Fresnel lens in different directions, the reflectance characteristics of the screen, etc. Therefore, a calibration needs to be

performed to characterise the luminance seen from different parts of the screen in relation to the luminous intensity of the incident light. This is called a flat field calibration.

Ideally an isotropic light source would be used to perform a flat field calibration. An isotropic source is one in which the luminous intensity is the same in all directions (or at least, over the range of angles $H = \pm 20^\circ$, $V = \pm 13^\circ$). However, such a source is not readily available.

Many LED lamps will display near-cosine response characteristics. This means that the luminous intensity will vary with the cosine of the angle from normal to the source. The software therefore allows for such a source to be used. Ideally the source would be measured on a goniophotometer to verify that it has a cosine response, or model it to determine the cosine power that most closely matches its distribution.

Figure 35 shows the measured luminous intensity distribution of an example source compared with an ideal cosine distribution.

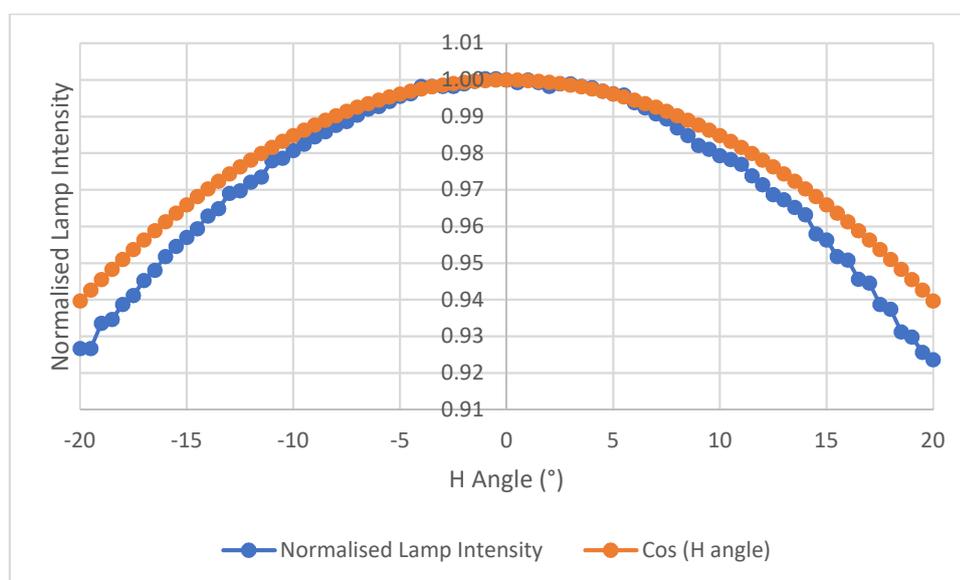


Figure 35: Luminous intensity distribution of a source compared with a cosine distribution

Clearly in this case, the luminous intensity drops off more quickly than a cosine distribution which results in an error of approximately 1.7 % at the edges. However, if one were to compare the distribution with a cosine to the power of 1.3, as shown in Figure 36, then the matching error is reduced to almost zero.

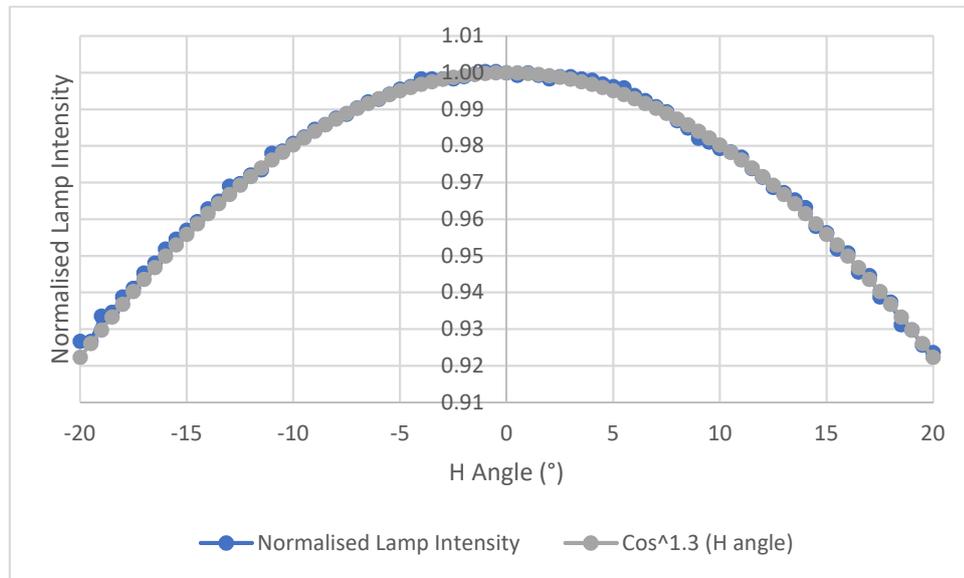


Figure 36: Luminous intensity distribution of a source compared with a $\cos^{1.3}$ distribution

The flat field calibration is described in the following sections.

10.2.1 MOUNT FLAT FIELD SOURCE ON ICP-1.0

Figure 37 shows an example of a flat field calibration source and in place on the ICP-1.0.



Figure 37: Flat field calibration source

The source is mounted on the mounting table of the ICP-1.0 and positioned in front of the centre of the Fresnel lens. It is not necessary to fully stabilise the source as the response is being normalised to the centre of the image and the entire image is acquired at the one time when the digital camera performs its measurements, however it is good if the source has been stabilised for some time so that its output is not changing significantly over the duration of the measurements.

10.2.2 SELECT FROM CONFIG

Enter the Config section of the ICPControl software (See Section 9 for details), and navigate to the **System Calibrations** tab. Click on the button labelled **Check or Perform Flat Field Calibration**.

10.2.3 SPECIFY FLAT FIELD CALIBRATION SOURCE DETAILS

You will now be shown a window asking for details about the flat field calibration source, as shown in Figure 38 below.

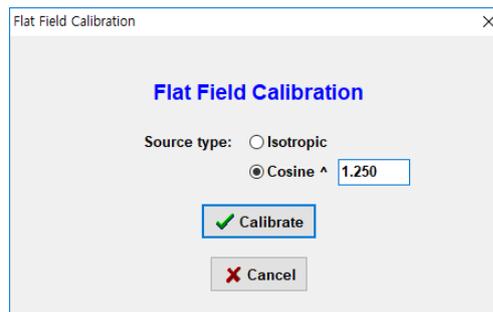


Figure 38: Flat field calibration window

Specify whether you are using an isotropic source or one which matches a cosine distribution. If using a source with a close-to ideal cosine response, then enter a power of 1.000.

Click **Calibrate** to continue with the calibration. You will be asked if the calibration source is properly aligned and stabilised and then the software will perform the measurements.

10.2.4 MEASURE THE FLAT FIELD SOURCE

The software will now determine the optimum exposure time and then measure the flat field source.



Figure 39: Measuring flat field source

Because the flat field source is reasonably uniform the software does not need to use the high dynamic range mode (see Section 7.1). Once the measurement is complete the software will ask for the source to be switched off so that a dark measurement can be performed.

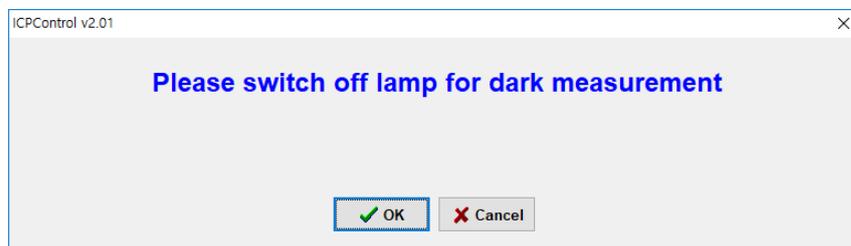


Figure 40: Switch off flat field source for dark measurement

The software will then calculate and save the flat field corrections, which will be applied immediately. The luminous intensity calibration should now be performed.

10.3 LUMINOUS INTENSITY CALIBRATION

The luminous intensity is to provide an absolute scale for testing where absolute measurements are made. To do this you will need to have a lamp which has been calibrated for luminous intensity at a rated voltage or current.

10.3.1 MOUNT LUMINOUS INTENSITY SOURCE ON ICP-1.0

The source is mounted on the mounting table of the ICP-1.0 and positioned in front of the centre of the Fresnel lens. It should be aligned as closely as possible to the aiming specified in the calibration certificate.

Apply the necessary applied voltage or current to the source and allow it to fully stabilise according to the time specified in the calibration certificate.

10.3.2 SELECT FROM CONFIG

Enter the Config section of the ICPControl software (See Section 9 for details), and navigate to the **System Calibrations** tab. Click on the button labelled **Perform Luminous Intensity Calibration**.

10.3.3 SPECIFY LUMINOUS INTENSITY CALIBRATION SOURCE DETAILS

You will now be shown a window asking for details about the flat field calibration source, as shown in Figure 41 below.

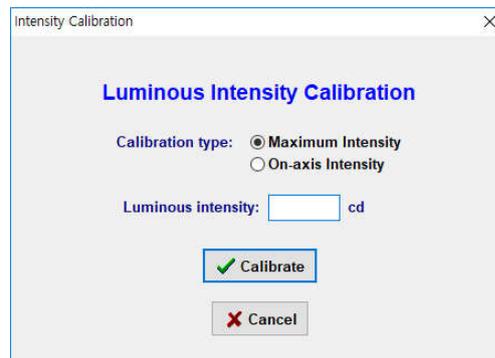


Figure 41: Luminous intensity calibration window

Specify whether the source is calibrated on-axis or for the maximum luminous intensity.

Click **Calibrate** to continue with the calibration. You will be asked if the calibration source is properly aligned and stabilised and then the software will perform the measurements.

10.3.4 MEASURE THE LUMINOUS INTENSITY SOURCE

The software will now determine the optimum exposure time and then measure the luminous intensity source.

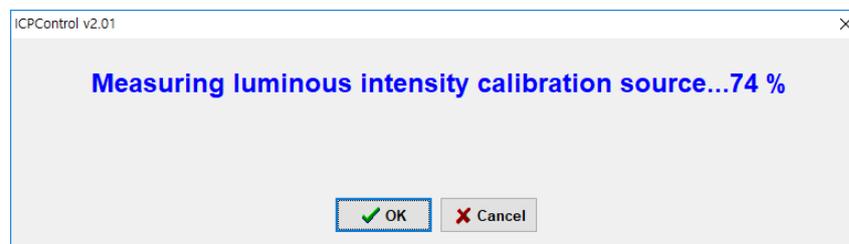


Figure 42: Measuring luminous intensity calibration source

Because the luminous intensity source is only being used in a single direction (either on-axis or in the direction of maximum intensity), the software does

not need to use the high dynamic range mode (see Section 7.1). Once the measurement is complete the software will ask for the source to be switched off so that a dark measurement can be performed.

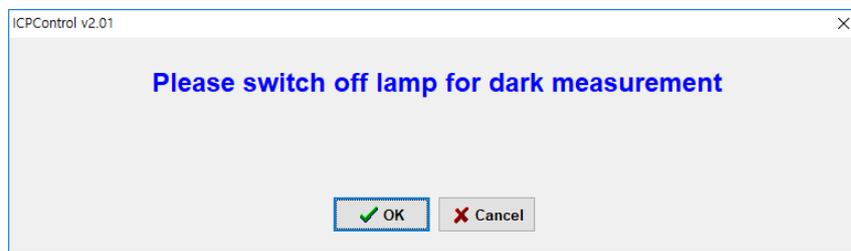


Figure 43: Switch off luminous intensity source for dark measurement

The software will then calculate and save the luminous intensity calibration factor, which will be applied immediately. The calibration is now complete!

11. TEST ROUTINES

The test routines contain the set of test points that are used when measuring the lamps. The test routines window is shown when selecting the test routines for passing beam or driving beam, either when calibrating a lamp for relative photometry or when performing a test using absolute photometry.

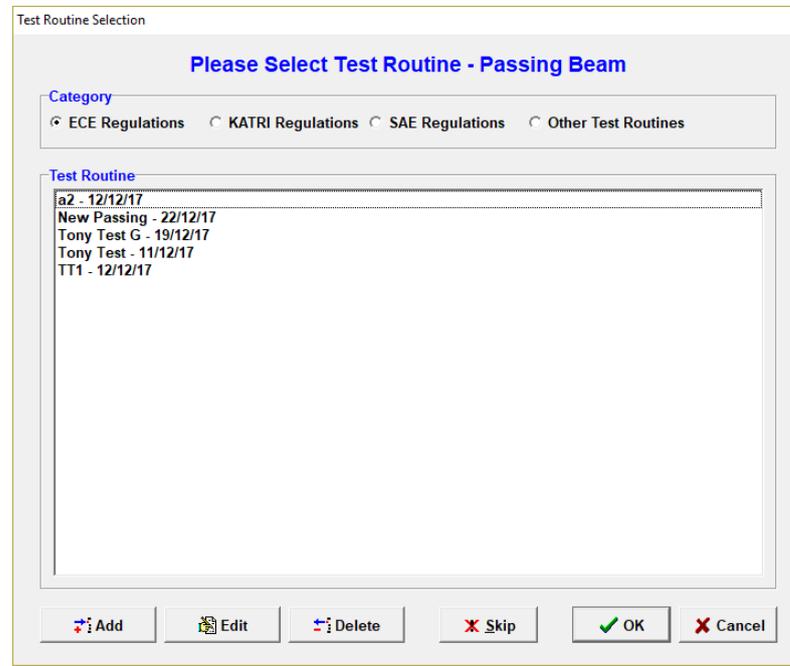


Figure 44: Test routines window

Click **Add** to create a new test routine. Select an existing test routine and click **Edit** to edit it or **Delete** to delete it.

11.1 ADDING A TEST ROUTINE

After you click **Add**, a window will appear asking whether you wish to add a passing beam or driving beam test routine, as shown in Figure 45 below.

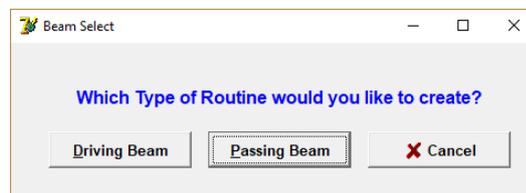


Figure 45: Specify type of test routine to create

11.1.1 ADDING A PASSING BEAM TEST ROUTINE

If you select passing beam, an edit passing beam test routine window will appear, as shown in Figure 46 below.

The screenshot shows the 'Edit Test Routine' dialog box. It features a text input field for the test routine's name or description. Below this is a table for defining test points, with columns for Name, H (*), V (*), Must be >=, and Must be <=. The table is currently empty. Below the table are buttons for 'Add', 'Delete', and 'Edit'. At the bottom of the dialog, there are input fields for 'Minimum current' and 'Maximum current', both in Amperes (A), with a note to 'Leave blank for no requirement'. Finally, there are 'Save' and 'Cancel' buttons at the bottom.

Figure 46: Add/edit a passing beam test routine

Specify a **Name or Description of Test Routine**. This will be used as the filename in which the test routine data is saved.

Add the **Test Points** in the test routine, as specified in Section 11.1.1.1 below. If a test point is no longer needed it can be selected and deleted using the **Delete** button. If the details of a test point need to be changed, it can be selected and edited using the **Edit** button and see Section 11.1.1.2 below for details.

Finally, specify the requirements for the minimum and maximum electrical current permissible for the device that this test routine is designed for, or leave these blank if there is no requirement.

When the details are OK, click **Save** to save the new test routine, which will then be added to the test routines window.

11.1.1.1 Adding a Passing Beam Test Point

If you select to add a test point, the New Point window will appear, as shown in Figure 47 below.

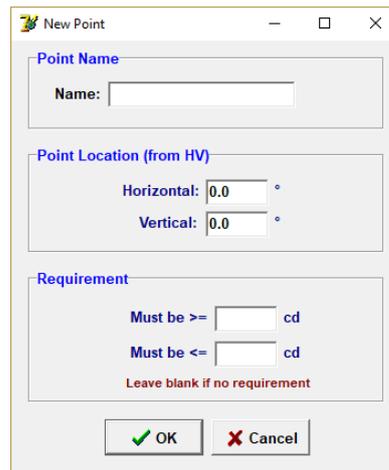


Figure 47: Add a new test point

Enter the **Name** of the test point, its **Horizontal** and **Vertical** angles, and the luminous intensity minimum (\geq) and maximum (\leq) requirements. If there is no luminous intensity minimum or maximum requirement then leave the corresponding box blank.

When the details are satisfactory, click **OK** to continue and the new test point will be added to the test points section of the edit test routine window. Or click **Cancel** to close the window without adding a new test point.

11.1.1.2 Editing a Passing Beam Test Point

If the details of a test point need to be changed, it can be selected and edited using the **Edit** button in the edit test routine window.

The same new test point window is shown as in Figure 47 above, except that the fields are filled in with the details of the selected test point. The changes that are required can now be made.

When the details are satisfactory, click **OK** to continue and the test point details will be updated in the test points section of the edit test routine window. Or click **Cancel** to close the window without changing the test point details.

11.1.2 ADDING A DRIVING BEAM TEST ROUTINE

If you select driving beam, an edit driving beam test routine window will appear, as shown in Figure 48 below.

The screenshot shows a dialog box titled "Driving Requirements". At the top is a text input field labeled "Name or Description of Test Routine". Below this is a section titled "Test Points" containing a table with the following columns: "Name", "H (*)", "V (*)", "Must be >=", and "Must be <=". Underneath the table are three buttons: "Add", "Delete", and "Edit". Below the buttons are three input fields: "H-V must be within" followed by a percentage input box and the text "% IsoCandela of Maximum", "Emax must be greater than:" followed by a cd input box, and "Electrical Current Requirements" with two input boxes for "Minimum current:" and "Maximum current:" followed by "A". A red note below these boxes says "Leave blank for no requirement". At the bottom of the dialog are "Save" and "Cancel" buttons.

Figure 48: Add/edit a driving beam test routine

Specify a **Name or Description of Test Routine**. This will be used as the filename in which the test routine data is saved.

Add the **Test Points** in the test routine, which is the same as for passing beams as specified in Section 11.1.1 above. If a test point is no longer needed it can be selected and deleted using the **Delete** button. If the details of a test point need to be changed, it can be selected and edited using the **Edit** button.

For a driving beam, there is often a requirement that the H-V point must be within the 80 % or 90 % (or other value) isocandela of the maximum intensity point. If this is the case, then enter in the percentage value here. Otherwise this can be left blank or set to 0 % so that it always passes.

Also for a driving beam, there is often the requirement that the maximum intensity must be greater than a given value. If this is the case, then enter in the minimum value for the maximum intensity here. Otherwise this can be left blank or set to 0 cd so that it always passes.

Finally, specify the requirements for the minimum and maximum electrical current permissible for the device that this test routine is designed for, or leave these blank if there is no requirement.

When the details are OK, click **Save** to save the new test routine, which will then be added to the test routines window.