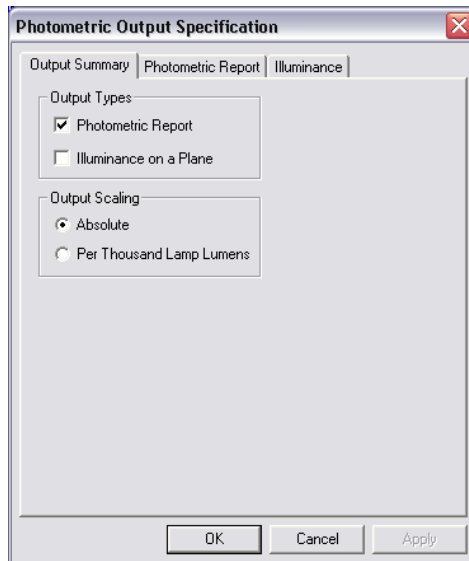


Beginner Tutorial 2 – Analyze a Luminaire

Once a 3D luminaire model is inside Photopia and its materials are assigned, it is ready to be analyzed. Photopia allows you to specify a range of settings that control the analysis process and also dictate the type and format of the photometric output produced. The following sections lead you through the details of specifying the photometric output and raytrace settings. Before starting, choose **File > Open** and find *SAMPLE1.DWG* in the C:\Program Files\LTI Optics\Photopia 3\Projects folder, if it is not already open.

Photometric Output

1. Select **Analysis > Specify Photometric Output** from the main menu. This screen allows you to select the type(s) of output Photopia will generate. Your choices include a Photometric Report and Illuminance on a Plane. Additionally, you can specify whether the photometry will be Absolute or Per Thousand Lamp Lumens.

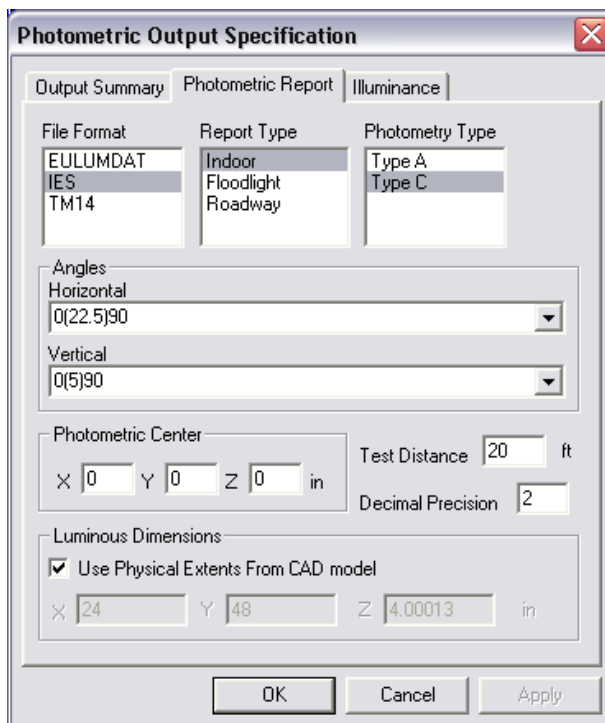


Absolute photometry is based on the lamp lumens specified in the Design Properties screen (the rated lamp lumens). Photometry reported per thousand lamp lumens is scaled so 1000 total lumens were input into the luminaire. If the SAMPLE1 luminaire were photometered using per thousand lamp lumens, it would be assumed that each of the three lamps generated only 333.33 lumens.

2. For this tutorial, choose Photometric Report and Illuminance on a Plane for the output types, and Absolute for the output scaling.

Photometric Report

3. Select the **Photometric Report** tab to specify the details of your photometric report. This screen allows you to choose a report type, photometric type, the horizontal and vertical angles in the distribution, test distance, decimal precision, and the photometric center. The following sections provide a brief description of each of these items.



File Format

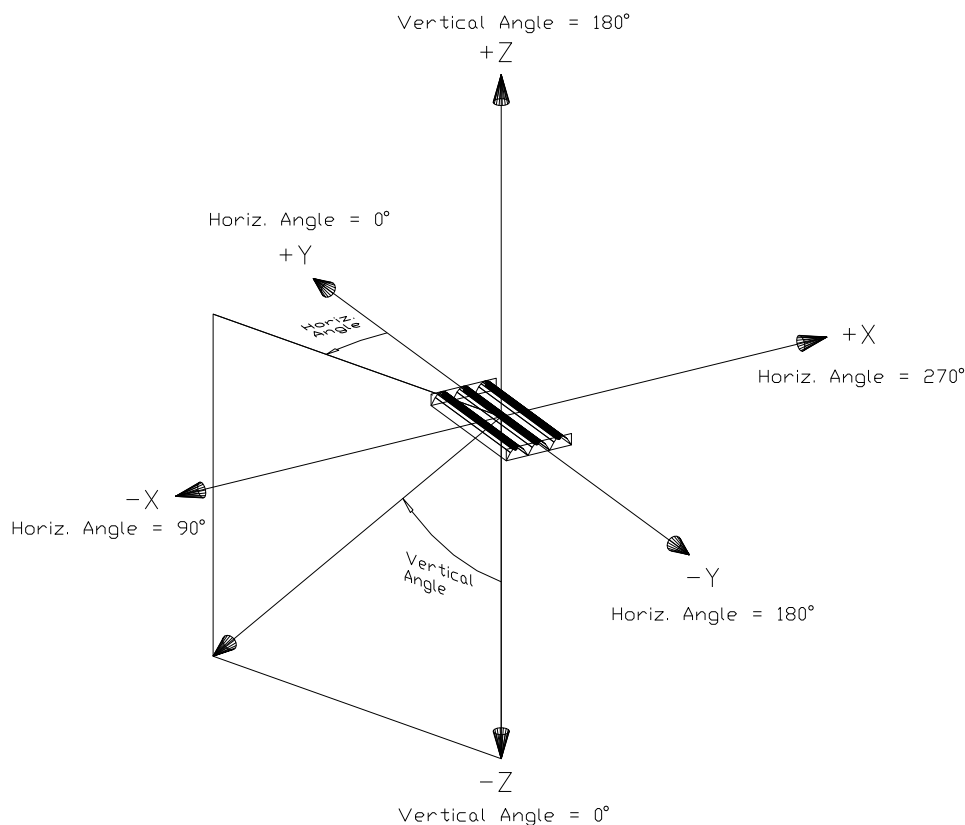
Photopia will create a standard format photometric file as part of its output. Photopia always creates an IES file that is stored with your project files in the folder you specified, using the name of your project as its filename prefix. In this example, Photopia will create a file named SAMPLE1.IES. Photopia can also create a EULUMDAT (European standard) or TM14 (British standard) format file if you select either of them in the File Format list box. The filenames will be SAMPLE1.ELX for the EULUMDAT file and SAMPLE1.T14 for the TM-14 file.

Report Type

The specific format of the photometric reports generated by Photopia can be tailored to the needs of the specific type of luminaire you have. Photopia generates reports appropriate for indoor luminaires, floodlight luminaires, and roadway luminaires. Since the SAMPLE1 luminaire is a fluorescent troffer, we will leave the default of indoor report type.

Photometry Type

The photometry type you select determines the orientation of the horizontal and vertical angles in the candela distribution as well as the constraints on these angles (as a matter of convention) set forth by the Illuminating Engineering Society of North America (IESNA). Indoor luminaires can be photometered with either Type A or Type C photometry. These photometric types define spherical coordinate systems with the poles of the coordinate system directly below (at nadir) and directly above (at zenith) the luminaire. The IES recommends that indoor luminaires be photometered as Type C. For more details about photometric types and the horizontal and vertical angles associated with them, see Chapter 6.



Type A & C Coordinate System

Specifying Horizontal and Vertical Angles

The horizontal and vertical angles determine the exact mesh or web of points to be sampled in the spherical coordinate system. Both the horizontal and vertical angles are specified as a list of angles using the following syntax: Start Angle (Angular Increment) Stop Angle. Commas are used to separate individual angles or ranges of angles, thus (0,5(10)85,90) is the same as (0,5,15,25,35,45,55,65,75,85,90). Spaces are not allowed. You can choose pre-defined angle sets from the lists provided, or define your own by typing them in using this convention.

4. Select 0(22.5)90 for the horizontal angle set and 0(5)90 for the vertical angle set.

The complete range of the horizontal angles runs from 0° to 360° . We chose 90° as a stopping point since our fluorescent luminaire is quadrilaterally symmetric. This means that a single quadrant of photometric data completely describes the photometric distribution of the luminaire. All other quadrants of data are derived from the first quadrant by assuming symmetry about the XZ and YZ vertical planes running through the luminaire's center.

The complete range of vertical angles runs from 0° to 180° . We chose 90° as a stopping point since our luminaire is a direct luminaire (it directs all of the light downward). No symmetry is assumed with vertical angles. If we had a completely indirect luminaire (one that directs the light toward the ceiling), then we would have selected vertical angles ranging from 90° to 180° . If we had a direct/indirect luminaire (one that directs light up and down), then we would have selected an angle set ranging from 0° to 180° .

Test Distance

The test distance refers to the distance from the photometric center to the photocell used to measure the amount of light in a given direction. Luminous intensity distributions (candela distributions) can vary depending on the test distance used. In general, candela distributions stabilize and approach a constant

shape if the test distance is greater than five times the maximum dimension of the luminaire. Thus, for the SAMPLE1 luminaire, which is a 2' x 4' troffer, keep the default of 20 feet.

Decimal Precision

The decimal precision refers to the number of decimal places that will be written to the photometric file. For most luminaires, two decimal places will suffice. However, if you have a low output luminaire, such as an emergency luminaire where the expected candela values are all quite low, then you may want to choose a higher number for the decimal precision to obtain the proper resolution in your calculated data. Keep the default of 2 for this tutorial.

Photometric Center

The default value for the photometric center is obtained from the luminaire CAD file, as described previously in the section on importing the luminaire CAD file. If you wish to change the default photometric center, then enter the desired location in the cells provided. For this troffer, the photometric center should be located in the aperture of the luminous opening. In this drawing, this location is at a Z height of –3 inches.

5. So enter a Z value of –3 and leave the X and Y values both at 0 for this tutorial.

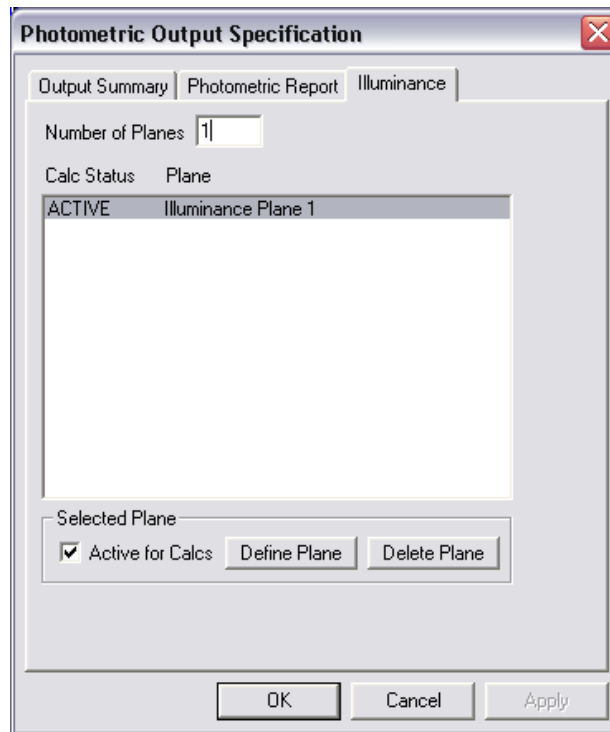
Luminous Dimensions

Photopia uses the luminous dimensions of the luminaire and the calculated candela values to estimate average luminaire brightness values for certain viewing angles. By default Photopia uses the physical extents of the luminaire for these dimensions. However, there are many cases where this assumption is not correct, and you may therefore enter the dimensions that should be used. Any recessed luminaire such as a downlight or the troffer in our tutorial are examples of luminaires for which you would want to modify the dimensions. In particular, you need to change the luminous height (Z dimension) to 0 since the sides are not luminous.

6. Uncheck the checkbox for User Physical Extents from CAD Model and enter a Z value of 0.

Illuminance on a Plane

Once you have entered all of the photometric report information, select the **Illuminance** tab.

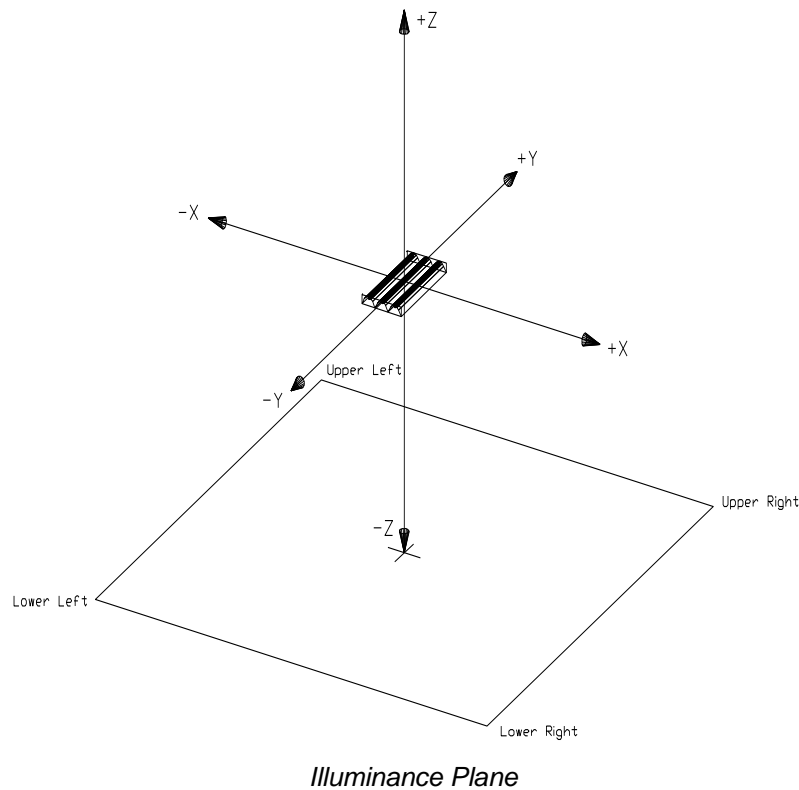


Photopia allows you to specify as many illuminance planes as you like. For each plane you must define its location and grid density. Additionally, you can deactivate planes you do not wish to participate in calculations.

7. We will specify only one plane for this tutorial, so enter a 1 into the Number of Planes cell.

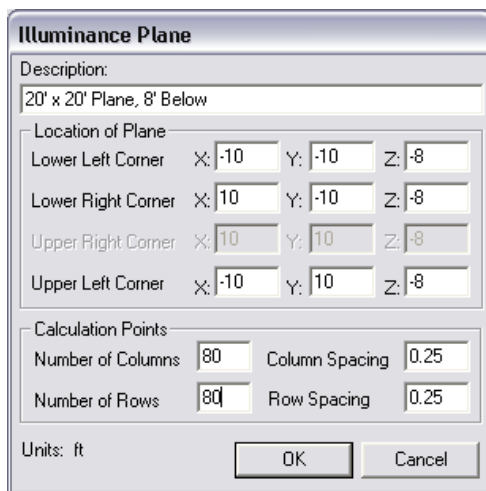
Illuminance planes are defined relative to the absolute location and orientation of the luminaire in the CAD drawing. The SAMPLE1 luminaire is centered on 0, 0, 0 and has its three lamps running along the Y-axis in the X-Y plane. The light is directed in the -Z direction. This is the orientation the luminaire should have in order for the horizontal and vertical angles, specified in the photometric report, to have meaning. For more details on the construction of a luminaire in the CAD program, see Chapter 4.

Illuminance planes are defined by four corner points, three of which you must provide, as shown in the following illustration. For more information on illuminance planes, see Chapter 6.



The illuminance plane for this tutorial will be 20' x 20' in size, centered 8 feet below the luminaire. The grid density will be 0.25' x 0.25'. With this information you can now define the illuminance plane:

8. Select the *Illuminance Plane 1* from the list.
9. Click the Define Plane button. Photopia displays an Illuminance Plane pop-up screen.
10. Edit the Description by typing in *20' x 20' Plane, 8' Below*.
11. The location of the plane is specified by 4 corner points. The descriptions of these points, for example, Lower Left Corner, refers to the location of the point you wish to view on a page. Be aware of the units for the illuminance plane coordinates. They are shown in the bottom left hand corner of this screen. Assuming the units for this tutorial are in feet, enter -10, -10, -8 for the Lower Left Corner point.
12. Enter 10, -10, -8 for the Lower Right Corner point.
13. Enter -10, 10, -8 for the Upper Left Corner point.
14. The Upper Right Corner point will be calculated automatically.
15. Enter a Column Spacing of 0.25 feet and the Number of Columns cell will automatically be filled out.
16. Enter the same value into the Row Spacing. The coordinate specifications should be as shown here.



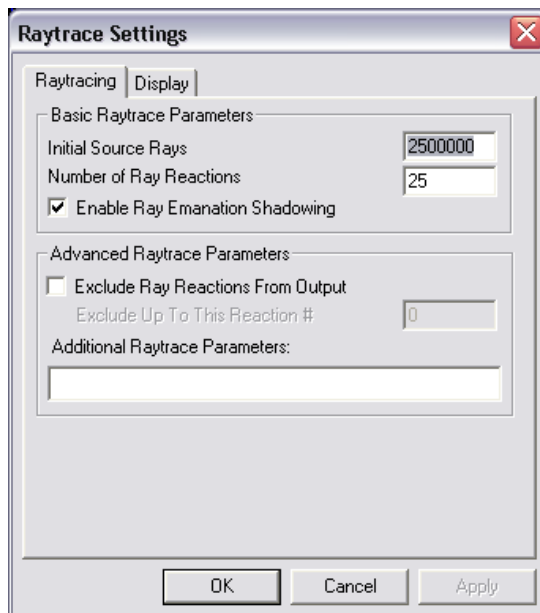
The screenshot shows the 'Illuminance Plane' dialog box. It has a 'Description' field containing '20' x 20' Plane, 8' Below'. Below this is a 'Location of Plane' section with four corner coordinate inputs: Lower Left Corner (X: -10, Y: -10, Z: -8), Lower Right Corner (X: 10, Y: -10, Z: -8), Upper Right Corner (X: 10, Y: 10, Z: -8), and Upper Left Corner (X: -10, Y: 10, Z: -8). A 'Calculation Points' section contains 'Number of Columns' (80), 'Column Spacing' (0.25), 'Number of Rows' (80), and 'Row Spacing' (0.25). At the bottom, it shows 'Units: ft' and 'OK' and 'Cancel' buttons.

17. Once you have all of your values properly entered, click the OK button on the Illuminance Plane pop-up window. Once you have finished with all of the photometric output specifications, click the OK button.

Note that you will be able to see your illuminance plane in the CAD view inside Photopia. So it should be clear if you did not enter your coordinates properly. If your plane looks like it is the wrong size and in the wrong location, then check the units of the plane coordinates and ensure you entered numbers appropriate for that unit.

Specifying Raytrace Settings

Select **Analysis > Specify Raytrace Settings** from the main menu. This screen allows you to set the parameters that control the raytrace and the display of the results. The following sections provide a brief description of each of these items.



The screenshot shows the 'Raytrace Settings' dialog box with two tabs: 'Raytracing' and 'Display'. The 'Raytracing' tab is active. It contains two sections: 'Basic Raytrace Parameters' and 'Advanced Raytrace Parameters'. Under 'Basic Raytrace Parameters', there are inputs for 'Initial Source Rays' (2500000), 'Number of Ray Reactions' (25), and a checked checkbox for 'Enable Ray Emanation Shadowing'. Under 'Advanced Raytrace Parameters', there is an unchecked checkbox for 'Exclude Ray Reactions From Output' and an input for 'Exclude Up To This Reaction #' (0). At the bottom, there is an 'Additional Raytrace Parameters' text area and 'OK', 'Cancel', and 'Apply' buttons.

Initial Source Rays

The Initial Source Rays refers to the total number of rays that will be emitted from all of the light sources. Thus, if 3,000,000 initial source rays were specified, then 1,000,000 rays would emanate from each of the three lamps in the SAMPLE1 luminaire. In general, the more rays specified, the more accurate your photometric output. However, the output becomes asymptotic at some point.

It is generally the case that the resolution of your output defines the level of the raytrace you require. A single value like luminaire efficiency can be calculated accurately (to the point at which it is not changing any further) in 50,000 rays. Accurate candela distributions can take anywhere from 2,500,000 to 5,000,000 rays, depending on the number of lamps in the luminaire and the size of the angular zones in your candela distribution. A high-resolution image of an illuminance plane using a grid density of 100 x 100 or more, could take 10,000,000 rays or more to produce a smooth looking image.

When a raytrace analysis is done with too few rays, the results are scattered and spiky when the ultimate result is smooth and contained. This behavior comes from the nature of the calculations, where the rays are randomly emanated from light sources and scattered upon reflections. The emanation and scattering directions are driven by probabilities, meaning that only after many rays do the patterns embedded in the probabilities become evident. The more rays, the more the final patterns emerge.

A luminaire such as the SAMPLE1 design will show relatively smooth output at the level we have specified using 2,500,000 rays. You can therefore keep the default number of rays.

Number of Reactions

The number of reactions traced determines how far a ray will be followed before it is disregarded. A reaction is defined to be an intersection with a surface. For surfaces that are purely reflective, one reaction reflects an incident ray into its resulting direction. For surfaces that are transmissive, one reaction intersects the surface, transmits, and reflects a ray. For light re-entering a fluorescent lamp, one reaction is necessary to get into the lamp (and reflect a ray on the outside), and another reaction is necessary to get out of the lamp. However, the ray trying to leave the inside of the lamp will go through a transmissive surface as well, thus, both transmitting a ray and reflecting another ray inside the lamp. Keep the default of 25 reactions for this tutorial.

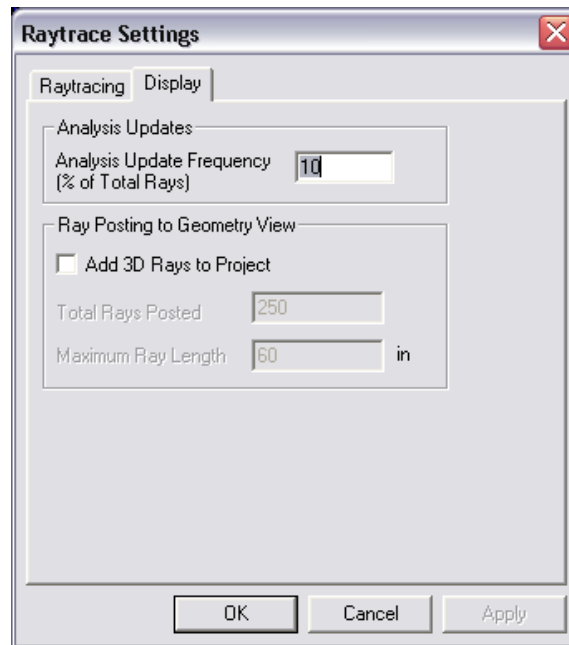
Ray Emanation Shadowing

The last item in the Basic Raytrace Parameters section controls the ray emanation shadowing feature in Photopia. Lamps having surfaces that block the view of each other from an outside viewpoint, (e.g. a compact fluorescent lamp with its multiple tubes or the filament support structure in a quartz halogen lamp) need to have special checking enabled in the calculations to ensure light does not pass through any surfaces which shade other surfaces.

18. Turn this option off for this tutorial since our lamps do not have any self shadowing.

Advanced Raytrace Parameters

These will not be used in this tutorial, so keep the default settings.



Analysis Update Frequency

Under the Display tab, the analysis update frequency specifies how often all of the output you are viewing is updated as the raytrace process proceeds. Keep the default value of 10% for the tutorial and you will get to view your calculated output as soon as 10% of the analysis is completed. You can then observe how the output changes and iterates every 10% toward a smooth solution as more rays are traced.

Ray Posting to Geometry View

Photopia will write 3D rays from the raytrace to a DXF file so that you can either view them in your CAD program or within Photopia. You can specify the number of rays and the length of the last ray segment after it exits the luminaire. Check the Add 3D Rays to Project checkbox if you want to see the rays imported into Photopia. The rays will be segregated by different CAD layers depending on the lamp from which they emanated and their reflection number. For this tutorial we will leave this option turned off.

Running an Analysis

Now that we have completed all of the necessary steps preparing our analysis, we can start the raytrace.

19. Select **Analysis > Begin Analysis** from the main menu.

On the program's bottom toolbar you can see the progress of the calculations. After the first analysis update, you will see an estimated time of completion. While the analysis is running, you can terminate the analysis at any time. To do so, select the **Analysis > Terminate Analysis** from the main menu. A terminated analysis cannot be resumed and will restart from the beginning.

Viewing the Photometric Output

While the analysis is running, we are able to view the calculated output. The first view of the output will be available after the calculations reach 10% (our specified update frequency).

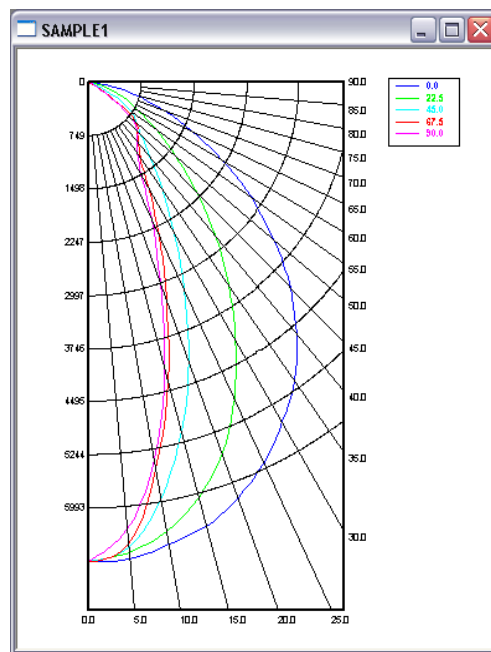
Viewing the Photometric Report

Begin with the photometric report.

20. Select **View > Photometric Report** from the main menu. Photopia displays the formatted report generated for the SAMPLE1 luminaire. You can scroll through the report by using the up and down arrow buttons located on the right hand side of the screen. Chapter 6 provides more details on the data in the report.

Viewing the Candela Distribution Polar Plots

21. To display a polar plot of the candela values, select **View > Candela Distribution > Polar Plot** from the main menu. To watch the polar plots change at each update of the results, bring up the polar plot at the start of the raytrace.



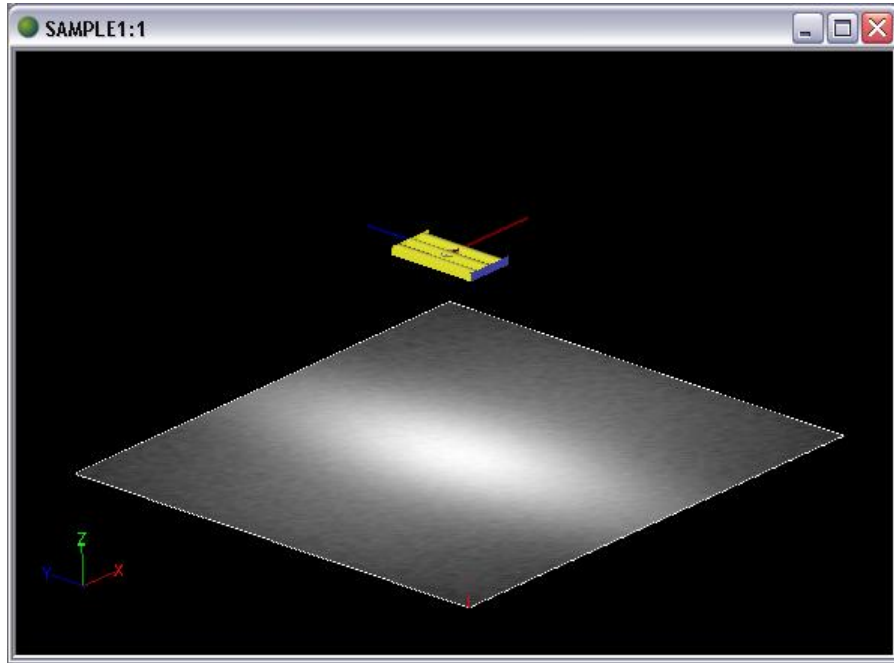
Viewing the Illuminance Plane Data

Photopia gives you the option of viewing the illuminance plane data in several different ways. You can view the data as text in tabular form, a contour plot, a gray-scale shaded plot, or a false color plot. You can also view the data directly on the illuminance plane shown in the CAD views.

22. To view the data in text form, select **View > Illuminance > Text** from the main menu.
23. To view the data as a shaded plot select **View > Illuminance > Shaded Plot**. Next, select the illuminance plane name and click the OK button.
24. To view the shaded plot in the CAD view, click on the CAD view for the project, then right click your mouse while in this view and select **Zooming > Zoom Extents** from the pop-up menu. Then pick the edge of the square defining the illuminance plane with your mouse (left-click). It will be shown in light red when it is selected. The properties of the illuminance plane will be shown in the property control at the right hand portion of the screen. Click on the property for Display Plot

under Display and change the default value of *False* to *True*. Then press Esc on your keyboard to de-select the illuminance plane. You will now see the shaded plot.

25. Change the plot settings by selecting **Settings > Plot Settings** from the main menu. Make sure the Plot Grid Lines are off for both the X and Y-axes and also set the label frequency for both axes to 8.
26. Rotate your view of the CAD model and illuminance plane by right clicking your mouse and selecting **Dynamic Views > Orbit** from the pop-up menu.



Printing the Output

You can print any of the output views by clicking in the view to make it the active view, and selecting **File > Print Active View** from the main menu or by selecting to print from the right click pop-up menu within the CAD view. You can also save the views to a BMP file or save any vector based view to a DXF or DWG file.