

How To Use Photometric Data

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The best way to decide which type of luminaire you want for a particular project is to get one and look it over. Judgements about visual proportions, quality of materials, and craftsmanship can truly be made only from a sample fixture. The problem with this method of choosing is the time it takes to visit a manufacturer, determine a fixture's availability, cost ... the list goes on. The most practical way to narrow down luminaire choices is to use catalogs, which present available products and help narrow our choices to the few we may actually want to see and examine.

The same holds true for determining fixture performance. The fixtures in the best lighting designs distribute illumination to enhance the visual composition, while supporting the functional needs of the users. A full-scale mock-up of the installation with the final furniture and finishes is the best way to judge their effectiveness. You may even want the Users to work in the space for a while and give you a post-occupancy evaluation. The logistical considerations associated with this kind of evaluation process obviously make it a poor way to begin selecting fixtures. The mock-up is usually the place to test the performance of fixtures which have already undergone some careful analysis. Of course you will want to light up some samples as part of this analysis, but first you must narrow your choices. This is why we all need photometric reports.

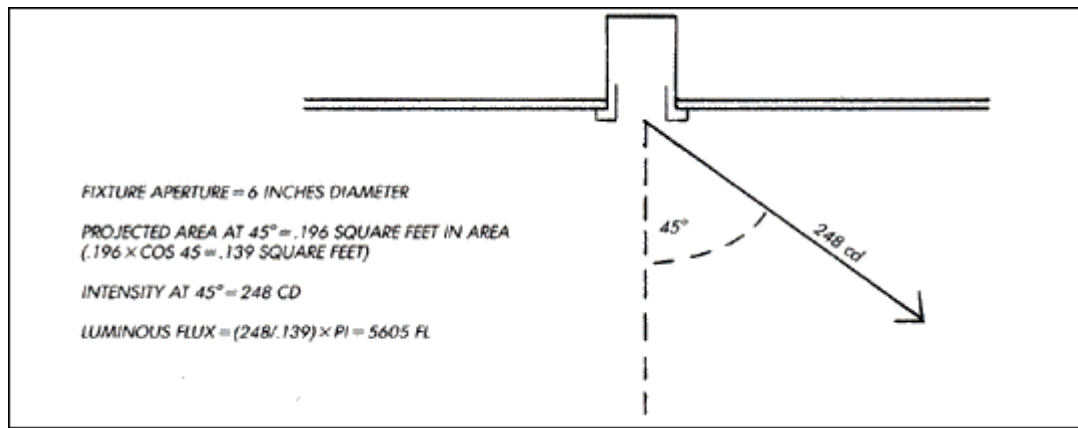
The centerpiece of a photometric report is the candela chart. This is a summary of the luminaire intensities at specific viewing angles. Essentially, measurements are made with an illuminance meter and converted to candela using the inverse square law calculation.

This method is only valid if the fixture is treated as a point source. This means that variations in performance that may occur across a large aperture fixture will not be expressed. According to Illuminating Engineering Society of North America (IESNA) standards, the distance between the fixture aperture and the meter must be at least five times that of the fixture aperture's maximum dimension. For example, a 2-foot x 4-foot troffer must be measured from at least 20 feet away.

The instrument used to take these readings has an appropriately large name -- a goniophotometer. It comes in several versions, but the one most commonly used has a system of fixed and rotating mirrors to fold the effective test distance into a manageable space.

The test luminaire is mounted in a fixed location and the mirror rotates through regular intervals of vertical angles and horizontal planes, bouncing light to the meter. What results is a type "A" chart. It usually lists the candela in 10 degree vertical zones, from 0 degrees (straight down) to 180 degrees (straight up), and in three or five horizontal planes from 0 degrees (along the lamp axis). Fixtures that distribute light from 0 to 90 vertical degrees are called direct; those distributing light only above 90 degrees are indirect; those emitting light from 0 to 180 degrees are called direct/indirect.

The greater the number of angles and planes reported in the chart, the better the resulting description of the fixture's performance. Fixtures that have a symmetric distribution can be reported in one plane (0 degrees). An asymmetric distribution requires at least three planes (0, 45, 90). Five plane data is superior to three plane, but a highly asymmetric fixture may require measurements in planes at 10 degree intervals.



TYPE “A” VERSUS TYPE “B”

Type “A” photometry is most common since it is used for general lighting fixtures. A special case is type “B” photometry. This is often used for floodlighting fixtures. This method places the light center of the fixture at the goniophotometer center (0 degrees vertical by 0 degrees horizontal) and plots the readings in the angular coordinates surrounding these axes. The information that is derived from these readings is very specific to a floodlighting application, so for this discussion we will stay with the more common “A” chart.

GRAPHIC REPRESENTATIONS

Often, the photometric data that a manufacturer shows in its catalogue does not list candela values but plots them on a curve. The result is a graphic representation of the fixture distribution. This is great if you need a visual impression of the performance -- a valuable aid to conceiving the effect upon a space. However, it is a very cumbersome and inexact way to report the actual performance. Most manufacturers will provide a candela chart if asked, but the “enlightened” ones include it on their standard catalogue sheets.

The candela values are used directly in luminance and illuminance calculations of various kinds. These include simple hand-calculations such as the point-by-point inverse square law type or computer-based flux transfer methods. They are also the sources for other data listed on the report.

CANDELA BEGETS OTHER DATA

These data can include zonal lumens, coefficients of utilization, average luminaire luminances, fixture efficiency, spacing-to-mounting height ratio, and visual comfort probability. They each describe a portion of the fixture’s performance. Some give us application criteria and numbers to use in calculations, while others quantify the lighted appearance of the fixture. As a total package of information, it provides a good profile on the fixture. Reported separately, or without the candela chart, the individual tables only tell part of the story. They can even be misleading.

FIXTURE EFFICIENCY

Fixture efficiency is just such a piece of data. This is the percentage of lamp lumens emitted by the fixture. It is often computed by summing the zonal lumens, dividing by the nominal lamp lumens, and multiplying by 100. Zonal lumens, calculated from the candela chart, are the quantity of lumens emitted by each angular zone on the chart. Simply stated, fixture efficiency tells you how much of the visible energy generated within the fixture is getting out to the space. It relates to electrical efficiency since the wattage consumed by the fixture should be effectively applied as light, not spent as heat.

Efficiency has often been used to select one fixture over another, but it is an incomplete criteria. Based on the calculation, the most efficient fixture will be a bare lamp. How many office lighting applications are best served by bare lamps? Obviously, efficiency must be evaluated along with the candela distribution and luminaire luminances as they relate to the application. Without this data for comparison, it has no meaning to the designer.

COEFFICIENT OF UTILIZATION

A coefficient of utilization (CU) is an extremely useful piece of information. This is the fraction of lamp lumens emitted by a fixture that ultimately reaches a task surface located within a room of specific proportions and surface reflectances. It is derived from the candela chart using a flux transfer calculation method. As a quantity, it relates the candela distribution of the fixture to its application. Coefficients used in zonal cavity calculations give designers a shorthand means to test their assumptions and compare the performance of alternate systems.

It is, however, a very narrow basis for comparison. The calculation assumes a symmetrical layout of fixtures in a room finished in Lambertian surfaces. It calculates one average footcandle value for the complete space. It does not address critical details such as surface luminances and brightness ratios. However, it is often good enough for an experienced designer who can intuitively add the details to their mental image of the lighted space.

Like fixture efficiency, the coefficient of utilization can be misapplied. Some specifiers use coefficients as criteria to judge the appropriateness of a fixture selection. That is, they target a coefficient as the minimum performance for fixtures in a specific application. This denies the possibility that fixtures with lower CUs, which may have lower aperture brightness, could produce higher levels of visibility -- compare the CUs of lensed and louvered troffers.

SPACING CRITERIA

The fixture spacing-to-mounting height ratio is an aid to laying out a pattern of fixtures. Multiply the ratio by the mounting and you will get the maximum fixture spacing that will still provide even illumination.

The mounting height is the distance from the fixture to the surface you are lighting. This may be the office workplane or the floor of a corridor.

The ratio is a useful piece of information to consider if you are using zonal cavity calculations. The calculation will let you do a layout that meets your average footcandle criteria but exceeds the fixtures' spacing ratio -- just change those two-lamp fixtures to four-lamp fixtures. The result is shadowy lighting. This can be a real pitfall in open-plan offices with low partitions.

But be careful of lighting offices with fixtures having spacing ratios that exceed 1.4. This ratio means the fixture will emit more of its light at high vertical angles, which may produce a glare condition. Alternately, those fixtures with spacing ratios below 1.4 will have less vertical distribution. Perimeter walls will be in shadow unless the last row of fixtures is close by. This can happen with parabolic troffers, especially the small-cell type. You must pay attention to the perimeter spacing of these fixtures or the room could take on a gloomy appearance.

VISUAL COMFORT PROBABILITY

Visual Comfort Probability (VCP) is the measurement used to evaluate discomfort glare caused by luminaires directly in the field of view. It helps the designer determine whether a room occupant will find the fixture brightness acceptable. VCP values are derived from calculations that relate the candela chart to some room parameters and test data developed on actual lighting installations. The optimum condition scores a VCP of 100. The IES tells us a VCP of 70 or greater is acceptable to avoid direct glare, although a VCP above 80 is recommended for spaces using VDT equipment.

It is important to note that VCP values are presented for very specific conditions. Room reflectances are 80 percent for ceilings, 50 percent for walls, and 20 percent for floors. Horizontal illuminance is 100 footcandles at 30 inches above the floor. The tables list VCP values calculated for a fixed program of room lengths and widths, ranging from 20 feet x 20 feet to 100 feet x 100 feet, and for ceiling heights of 8.5, 10, 13, and 16 feet. Unfortunately, these parameters do not always relate to actual project conditions which may include rooms smaller than 20 feet x 20 feet and illuminances less than 100 footcandles.

VCP is a fairly rigid metric since it cannot be directly converted to other room conditions. It is different from the other data on the photometric report because it does not directly describe the fixture or the room, but rather postulates the occupant's reaction to the lighting system. Consequently it has value only as a means to compare fixtures against a fixed set of criteria, apart from the project application.

FIXTURE LUMINANCE

With all the current interest in VDT (video display terminal) lighting, fixture luminance has become a prominent item on the photometric report -- sometimes notable by its absence. If listed, the table of luminances on the report is generally the fixture's average luminous exitance expressed in lumens per square foot (footlamberts) as viewed from the listed angles. It tells us about the perceived brightness of the fixture from a particular viewpoint. A bright fixture in the field of view makes seeing difficult. A bright fixture aperture will also create an annoying reflection in a VDT screen. It is important to evaluate the apparent brightness of a fixture within the context of its application. Usually you need the seamless appearance of "quiet" downlight apertures; sometimes you want things to "pop." You can make this determination with the photometric report.

Even if the manufacturer has not provided a table of average footlamberts, you can calculate them from the candela chart yourself. Candelas per square feet are luminous intensity. You can convert them to luminous flux through multiplication by pi. As shown in Figure A, candelas charted for a particular angle should be divided by the fixture's projected area at that angle. Multiply by pi and you have footlamberts for that viewing angle.

The biggest problem you will have is determining the actual area of the fixture aperture. Troffer manufacturers, for instance, list only the nominal door size -- 1 foot x 4 foot, 2 foot x 2 foot, etc. This is larger than the actual aperture. If you can not get the actual size, a good estimate is to assume the aperture is about 2.5 inches or 0.2 feet smaller in width and length than the nominal door size -- 0.8 foot x 3.8 foot for a 1 foot x 4 foot. Down light aperture sizes are normally listed, so your calculation can be quite accurate.

Statements about acceptable fixture luminances become quite specific when you are discussing a VDT space. Current IES recommendations are that the fixture should not present more than 250 footlamberts at 55 degrees and above. European standards are more stringent, calling out a maximum luminance of 200 candelas per square meter (approximately 60 footlamberts) at 55 degrees and above. There are no maximum luminance recommendations yet for fixtures in non-VDT areas, but follow the European standard if you want a very "quiet" look.

READ THE SUBTEXT

Manufacturers reveal a little about themselves by the way they format photometrics for their catalogues. The cut sheet that shows only a candela curve (without values) and a CU table may come from a manufacturer who does not want to tell you very much about its fixture. A candela chart with a 10-year-old test date portrays a manufacturer who either spends a long time between innovations or is not concerned with getting you the best information. Catalogue sheets that stress fixture efficiency or spacing criteria may indicate a manufacturer who misunderstands current design priorities. A manufacturer who lists VCP's but not luminances does not understand the needs of the designer.

Designers must have complete and accurate information about the lighting fixtures they include in their specifications. It should be presented in a manner that allows them to manipulate the data to study and compare aspects of the fixture as they require. Manufacturers of high-quality products have nothing to fear from this process. It will reinforce their position by allowing designers to prove the quality for themselves.