Photocells and Light Detection with the Watchdog System:

How to position photocells to achieve maximum effectiveness with the Watchdog System

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Introduction

This document describes how to properly setup and install photocells (or light sensors) to ensure proper operation with the Watchdog system.

Lighting Principles

Before detailed information about installing photocells is provided, it is important to understand some general principles of lighting. These general principles illustrate why photocells have to be setup and installed in a specific way.

Direct Light and Indirect Light

The light that can be detected by a photocell is composed of two main components: direct light and indirect (or reflected) light.

Definition: Angle of Incidence

The angle of incidence can be defined as the angle that a line (as a ray of light) falling on a surface or interface makes with a line drawn perpendicular to the point of incidence. The angle of incidence is illustrated in **Figure 1** below.

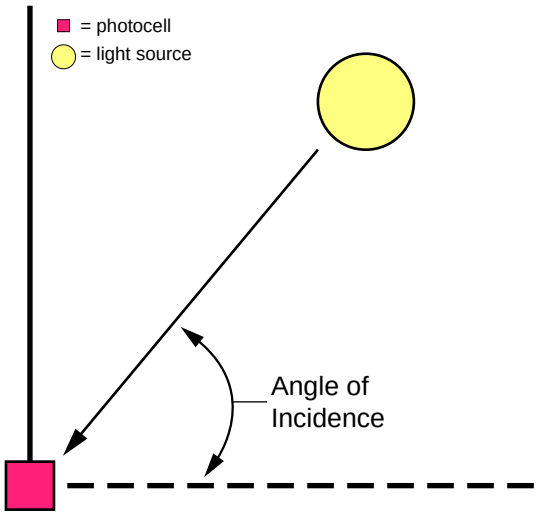


Figure 1. The Angle of Incidence. As the angle is increased, the amount of direct light detected is decreased.

The Angle of Incidence Affects the Amount of Direct Light Detected

As the angle of incidence from the light source to the photocell increases, the amount of direct light detected at the photocell decreases. The amount of direct light detected by the photocell will decrease at a rate that is equal to the cube of the cosine of the angle of incidence.

As the source of most of the light in a room comes from the ceiling, the angle of incidence is increased when a photocell is mounted close to the ground. The angle of incidence is decreased when the photocell is mounted high, away from the ground. This principle is illustrated in **Figure 2** on page 4.

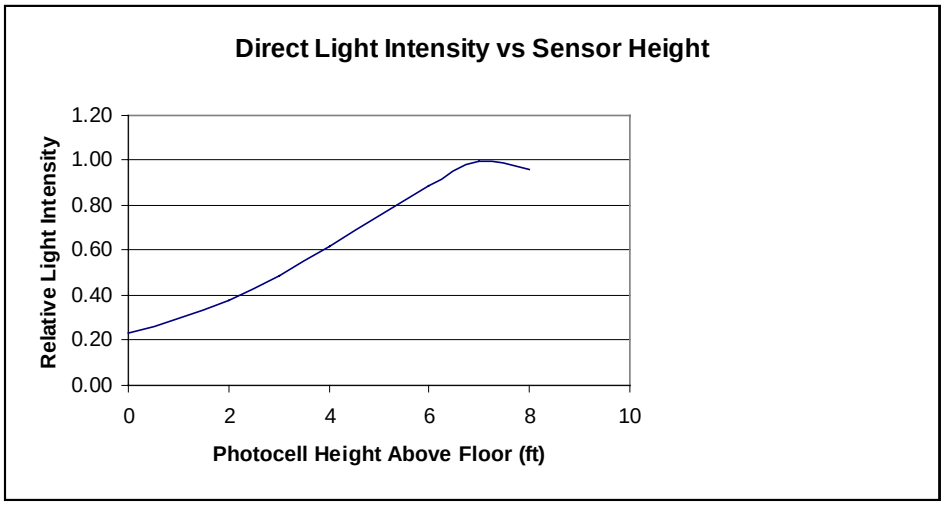


Figure 2. Where the photocell is placed affects direct light intensity. More direct light is detected when the photocell is positioned high above the floor. As the photocell is positioned lower, closer to the floor, the angle of incidence is increased and the amount of direct light detected is decreased.

The Direct Interference Zone for Direct Light

Additional objects in a room (like pieces of equipment, animal racks, and people working in the room) can cast shadows, which can decrease the amount of direct light that is detected by the photocell. The space in a room where there may be objects that can affect the amount of direct light detected is known as the Direct Interference Zone (DIZ). **As the angle of incidence increases, the size of the DIZ also increases, and it becomes increasingly likely that other objects in the room will decrease the amount of direct light detected by the photocell.**

Indirect Lighting is Primarily Affected by Room Characteristics

Because most indirect light is effectively diffused (that is, indirect light comes from all directions and not a point source), the angle of incidence to the direct source has a much smaller impact on indirect light. **With indirect lighting, the characteristics of a room have a greater effect on the amount of indirect light detected than the angle of incidence does.** Room characteristics include the room's size, the reflectivity of the room's surfaces, the characteristics and placement of room contents, and the location and number of light sources. An equation to determine exactly how the angle of incidence affects the amount of indirect light detected is beyond the scope of this document.

The Indirect Sensitivity Zone for Indirect Light

Other objects in the room can also decrease the amount of indirect light detected by the photocell. The space in a room where other objects can affect the amount of indirect light detected is known as the Indirect Sensitivity Zone (ISZ). **As a light sensor is lowered, the ISZ increases. This means the amount of indirect light received can fluctuate wildly, based on changing room conditions and occupants.**

The Effect of the Position of the Photocell on Light Detection

In a typical room, the amount of indirect light detected at the photocell can be 20-40% of the total incident light detected. As a photocell is lowered (positioned closer to the floor)

the amount of indirect light detected at the photocell can exceed 50% of the total incident light detected.

As the mounting location for the photocell is lowered, the following negative consequences occur:

1. The amount of direct light decreases more rapidly than the amount of indirect light, making the amount of indirect light a larger percentage of the total light detected.
2. The DIZ increases.
3. The ISZ increases.

The result is detected light levels will vary widely based on changing room contents and room activity. Under these conditions, accurate "on" versus "off" thresholds are difficult to set and false "off" conditions may be detected. The room will also require frequent calibration.

Figure 3 and **Figure 4** illustrate the DIZ for a typical room. **Figure 5** and **Figure 6** illustrate the ISZ for a typical room.

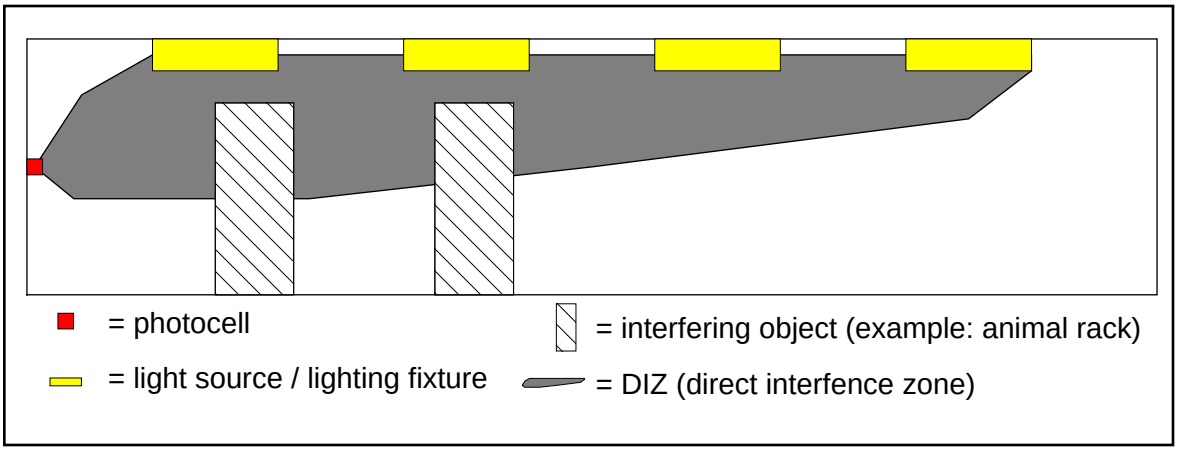


Figure 3. The DIZ for a typical room when the photocell is placed midway between the floor and the ceiling.

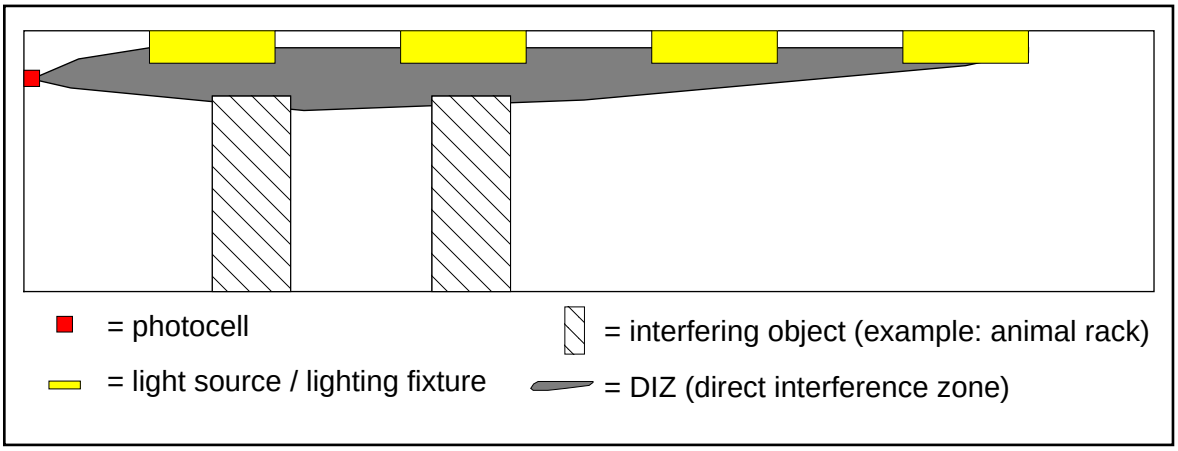


Figure 4. The DIZ for a typical room when the photocell is placed high, near the ceiling. As the position of the photocell is raised, the DIZ becomes smaller.

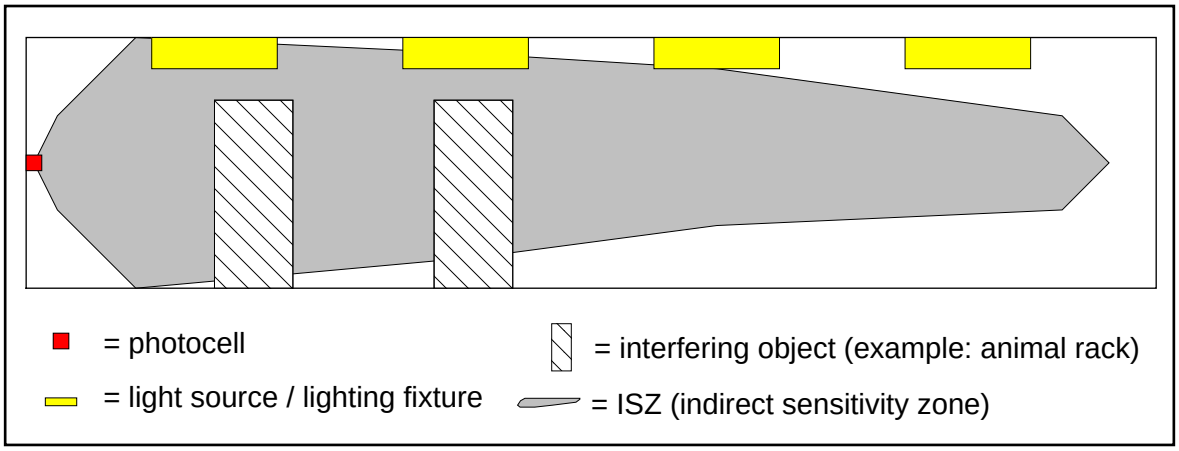


Figure 5. The ISZ for a typical room when the photocell is placed midway between the floor and the ceiling.

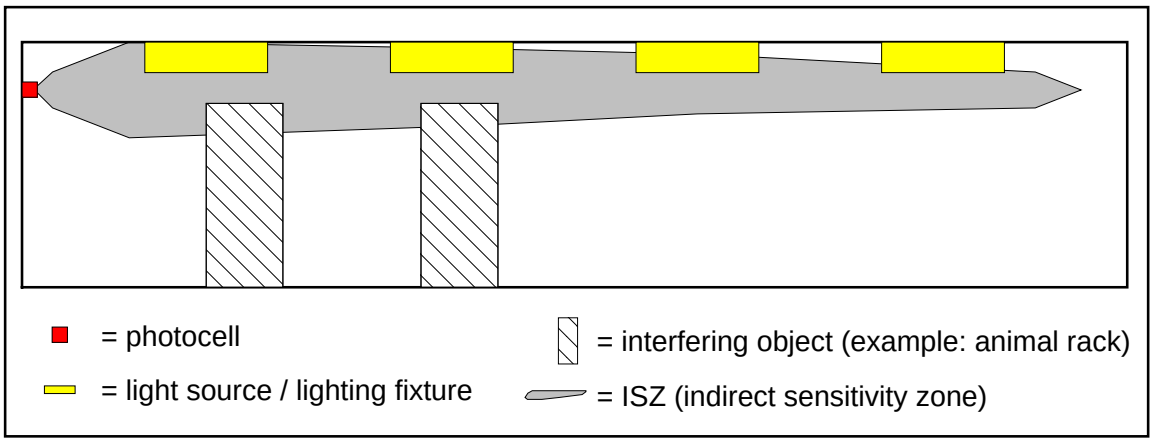


Figure 6. The ISZ for a typical room when the photocell is place high, near the ceiling. As the position of the photocell is raised, the ISZ becomes smaller.

Placement of Photocells

The principles of lighting can help illustrate how important placement of the photocell is in obtaining accurate and consistent light measurements in rooms. Using these principles, it is possible to establish some criteria for determining where photocells should be placed.

Ideal Locations for Photocells

The ideal location for placing photocells is:

- A location where direct light dominates total incident light. Generally, this means the photocell is mounted high, close to the ceiling and the light source, and away from the floor.
- A location where the DIZ and ISZ are as small as possible and where they do not overlap significantly with “filled” room space. Filled room space refers to the volume of a room that is occupied by people and equipment. Generally, this

means the photocell is mounted high, close to the ceiling and the light source, and away from the floor and interfering objects.

- A location where the distances between the photocell and all of the sources of light in a room are the same, or more exactly, a location where the light emitted from each light source contributes equally to the total amount of light detected by the photocell. This minimizes the possibility of any one fixture dominating the direct light total.
- A location that is not affected by non-Watchdog controlled lights. In other words, the use of non-Watchdog lights, or lights that are controlled by third-party systems (including night lighting or lights using Intermatic timers) are not recommend for use with the Watchdog system. If non-Watchdog-controlled lights are used, a different calibration procedure is usually required.

Poor Locations for Photocells

Some examples of poor locations for the placement of photocells include:

- Locations too close to the floor (within 6 feet of the floor).
- Locations too close to corners (within 3 to 6 feet of a corner).
- Locations where there are obstructions between the light source and the photocell. These obstructions do not always have to be permanent obstructions – for instance, if a photocell is mounted behind a door, the door is not an obstruction when the door is closed, but the door becomes an obstruction when it is opened.)
- Locations where the photocell is too close to one light source, and that one source makes up a large proportion of the total light detected by the photocell.
- Locations where non-Watchdog-controlled lights are used, particularly if these lights are not employed in a consistent manner, or the light generated from these lights will vary from room to room.

Consequences of Poor Locations

When photocells are mounted in poor locations, the placement and movement of animal racks, chairs, and people can simultaneously produce up to a 40% decrease in direct light, along with an unspecified decrease in indirect light. Though not discernable by the human eye, it is not unreasonable for there to be a 50% reduction in the light detected by the photocell in these rooms. This has a significant effect on the Watchdog system's ability to maintain calibration and accurately monitor the light levels in a room.

Calibration

When installing photocells, it is important that they are calibrated correctly. Correct calibration helps insure that various light states are successfully detected by the Watchdog system. There are two types of calibration procedures: normal and alternative.

The Normal Calibration Procedure

The normal calibration procedure can be used at most facilities. To use the normal calibration procedure, the light emitted by Watchdog-controlled, low-level lights must be

the lights that produce the lowest level of light intensity. The normal calibration procedure is fully automated.

The Alternative Calibration Procedure

Edstrom Industries does not recommend using non-Watchdog-controlled lights in conjunction with the Watchdog system. If there are non-Watchdog-controlled lights in a room, however, the alternative calibration method may need to be used instead of the normal calibration procedure. The alternate calibration procedure is used when the other lights (the non-Watchdog-controlled lights) produce light at a lower intensity than the Watchdog lights. The alternative calibration procedure always requires manual intervention. It is not automated.

Determining Which Calibration Method to Use

Before calibrating the lights, you must determine which calibration procedure to follow. This involves measuring the intensity of light emitted from different lights sources. If the intensity of light that is emitted from the Watchdog-controlled lights is the lowest, use the normal calibration procedure. If the intensity of light that is emitted from non-Watchdog controlled lights is the lowest, use the alternate lighting method. Follow the flowchart in **Figure 7** on the next page to determine which calibration method to use.

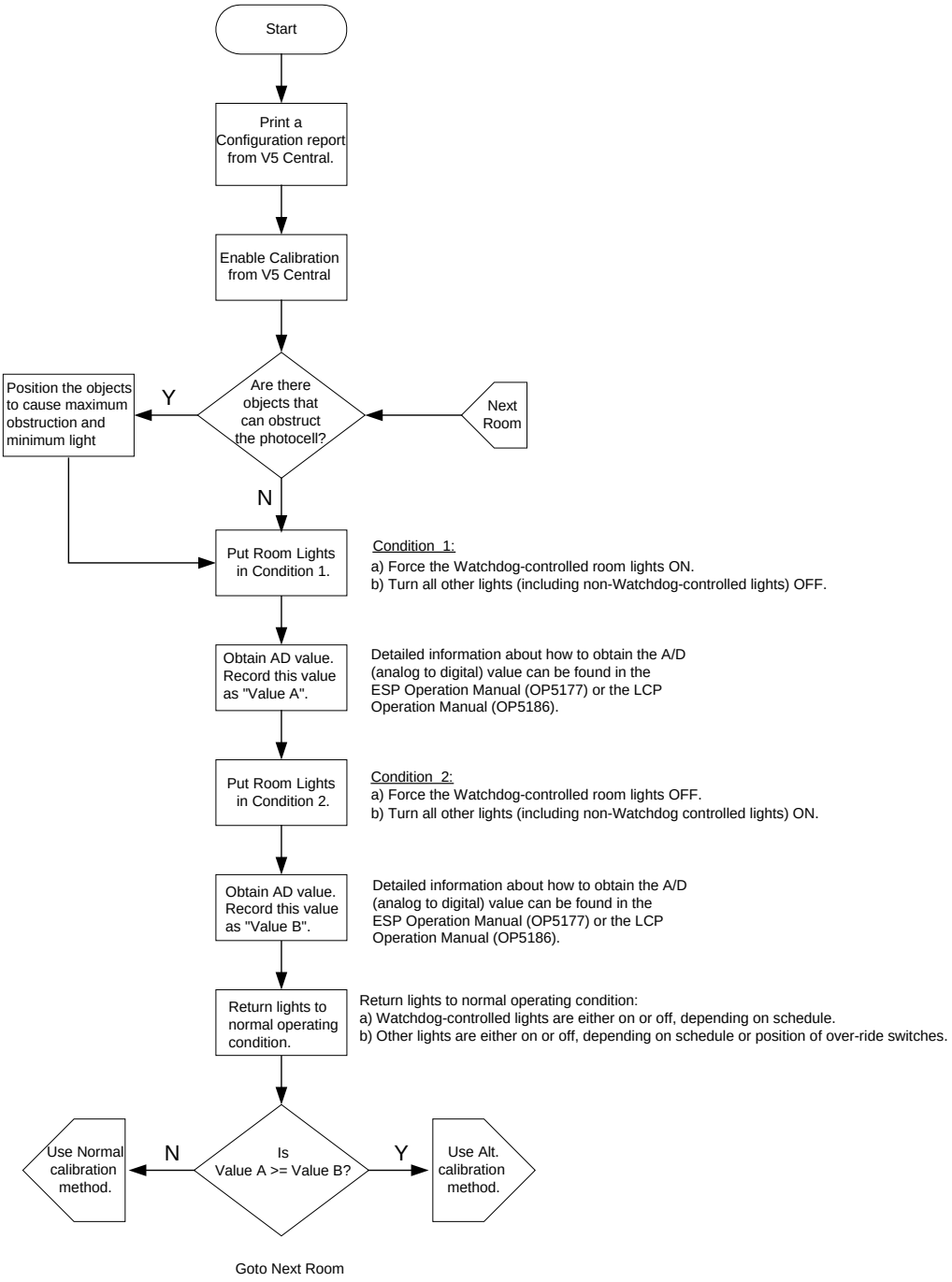
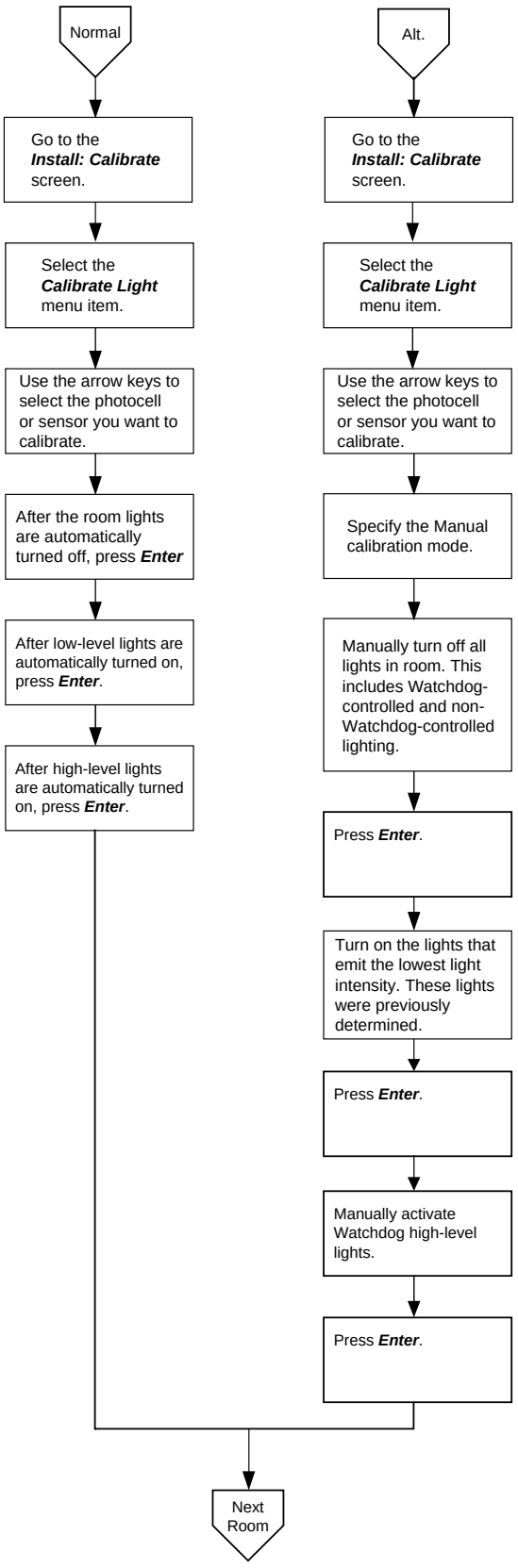


Figure 7. Determing Which Calibration Method to Use.

Performing the Calibration

A flowchart summarizing the steps necessary to perform the calibration method is provided in **Figure 8** . Note that the calibration procedure for non-Watchdog-controlled lights requires the use of the manual calibration mode.



The Alternative Calibration Method requires specifying the Manual light calibration mode on the ESP.

Note: This chart provides an overview of the steps required in calibrating photocells. The exact procedure for performing calibration will vary, depending on the type of equipment in use at a facility. Typically, an ESP or an LCP will be used to perform the calibration. Although the procedures used for both devices are basically the same, there are some minor differences. Detailed instructions can be found in the operating manuals:

OP5194 - Watchdog ESP Operating Manual
OP5186 - LCP Operating Manual

Figure 8. Steps involved in calibrating photocells.

Conclusion

A knowledge of general lighting principles is beneficial when deciding where to place photocells used with the Watchdog system. These principles can be used to develop guidelines or best practices for placing photocells in rooms requiring monitoring. When the guidelines are followed, the effects of other objects in the rooms are minimized. Proper calibration of photocells is also important. When the placement guidelines are followed, and photocells are properly calibrated, the Watchdog system can accurately and consistently measure the amount of light in monitored rooms.

Other Documents

Other documents that contain information about photocells and lighting with the Watchdog system are shown below.

Part Number / Reference Number	Description
4230-OP5193	*Watchdog V5 User Guide*
4230-OP5194	*Watchdog ESP Operation Manual*
4230-OP5196	*Watchdog LCP Operation Manual*
4230-SVB4778	*Application Engineering Technical Notes Manual*

Figure 9. Related Documentation.