# A novel method to set up and calibrate goniophotometer

**Ziyi Wu**

University of Arizona

(520) 258-8094

December 4 2016

**Abstract**

In this report, I described a new method to set up and calibrate goniophotometer. Instead of using black tunnel which is a standard equipment for goniophotometer, I implemented three baffles in the system which has advantage of low-cost and space-saving. For each baffle, I explained the design and alignment procedure. The test method and results for this system were provided in this report.

**Introduction**

Goniophotometer is a photometer which measures the light emitted by an object in different angle. With the development of LED lighting technology in automotive industry, the use of goniophotometer has rapidly increased in recent years. The goniophotometer is normally used inside a black tunnel which is a tunnel shielded by black baffles. The black tunnel is necessary for an accurate testing results which there is no stray light in the system. At Grote Industries, there are several goniophotometers inside the black tunnel operating by test and evaluation department. However, the formal testing results take up to two days to receive depends on work load at the testing department. A ready to use goniophotometer with acceptable accuracy is needed by the department of optical engineering. Due to the space and budget limit, the goniophotometer must be set up without the black tunnel and the test result must be within 8% error at 0, 10 and 20 degree compare with the results from goniophotometers inside the black tunnel.

## Background

Goniophotometer can be used to measure light intensity distribution, luminous flux and efficiency of lamps. Photometer head rotate around the center of light source to create an angle between light source and detector. Detector is placed 100 feet away from light source, and the data collected by the detector is displayed in a computer paired with the detector. The traditional setup for goniphotometer is shown in Figure 1[1]:

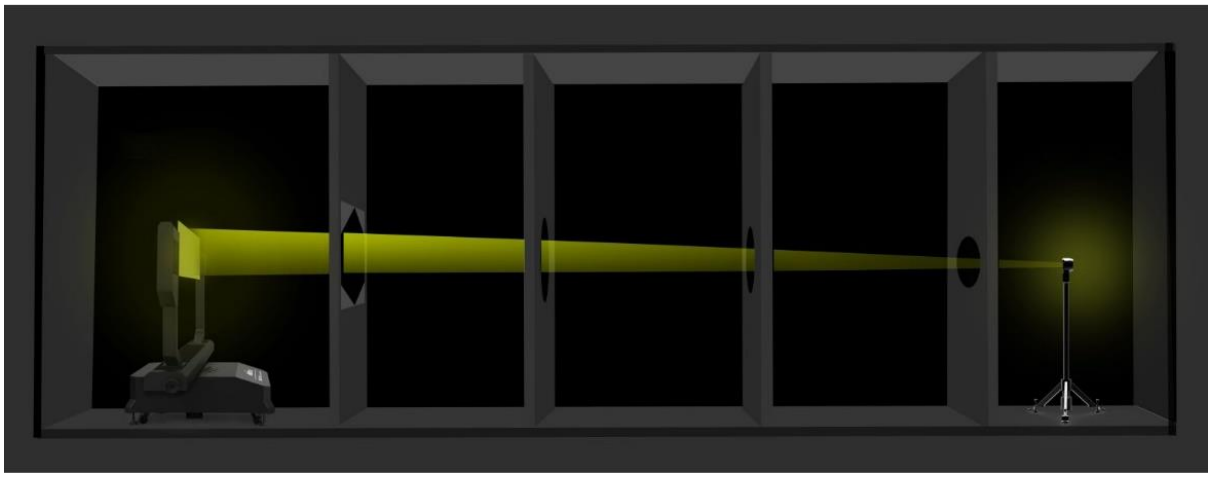

**Figure 1**. the traditional setup for goniophotometer

There are two factors to ensure an accuracy test results from goniophotometer. The first and the most important factor is blocking the stray light. Stray light is the light detected which emitted by other light source rather than the test object. In traditional setup for goniophotometer, the system must be isolated inside a black tunnel and a baffles are used in the tunnel in order to block the stray light. Another factor is the stability of the light source. The mount of the test object is very rigid which provided the tight fixture for the light source. As long as the goniophotometer is isolated from strong vibration or sudden collision, the light source will remain stable.

Building a black tunnel can be a costly project in budget, time, and space. A standard black tunnel requires an individual room made with concrete or other materials which will be painted in flat black. The estimated cost will be more than 8,000 dollars to build. If the black tunnel is built inside a manufactory facility, time of construction and material delivery will be delayed depends on the work load of the facility. At least 2000 $ft^2$ area will be needed to build a black tunnel which takes large space inside a manufactory facility.

## System setup

Without using the black tunnel, the goniophotometer will be placed in normal room light condition. I need to block the light emitted by any other source rather than the test object such as room light and sunlight through the window. My setup for the system shown in Figure 2.:

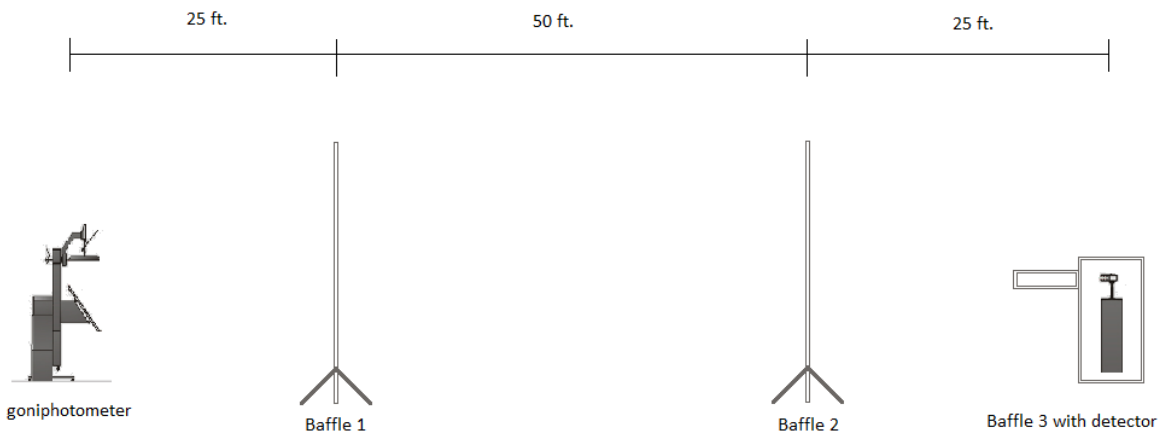


**Figure 2.** system setup without black tunnel

The system consisted of the gonophotometer, three baffles and the detector with distance shown above. Goniophotometer, baffles and detector must be aligned for accurate test results. The alignment method will be introduced Alignment and calibration section.

## Baffle design

Baffle 1 and baffle 2 have same structural and materials. I focused on weight-saving, cost-reduction and mobility when I designed those two baffles. I choose plastic board over other materials for its light weight and low-cost. The frame which holds the white board is made with T-slotted aluminum profile. Any structure made with T-slotted aluminum profile can be easily assembled and disabled without labor cost. Aluminum is also much lighter than steel. I added four rollers with brakes under the frame so that it can be move to any desired location. The weight of each baffle is less than 100 lbs. and costs less than 200 dollars.

On each board, I cut a rectangular window to allow the test light to pass the baffle. I painted the back surfaces (face to detector) of both baffle to flat black for better anti-reflectivity.

Baffle 1 and 2 with blacken surface is shown in Figure 3.

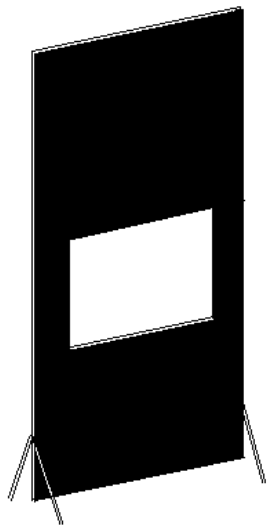

**Figure 3.** Flat black surface of the baffle 1 and 2

Baffle 3 is essentially a mini black tunnel designed for the detector only. The detector is placed inside the box with a tube extended out of the box. The tube is the only opening for this box and it will block any stray light passed through baffle 1 and baffle 2. The box is made with plastic board painted in black on both surface, and the frame is made with flat black T-slotted aluminum profile. Baffles 3 is shown in Figure 4.

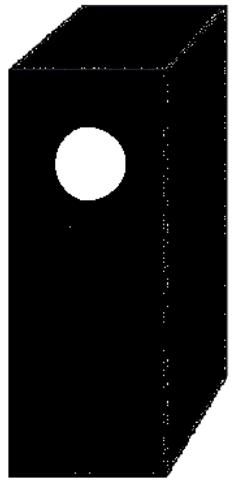

**Figure 4.** Isometric view of baffle 3

## Alignment and calibration

The alignment is the one of the key factors for the goniophotometer to have accurate results. The distance between the detector and the goniophotometer is 100 ft., I used the laser to align the goniophotometer, three baffles and the detector. The system alignment procedure is shown below

- place the laser on the goniophotometer with no rotation angle.
- placed a two white boards to cover the windows on baffle 1 and 2.
- Calibrate baffle 1 until the laser is hitting its midpoint, then fix the position of baffle 1
- Remove the cover on baffle 1 to allow laser to pass through it.
- Calibrate baffle 2 until the laser is hitting its midpoint, then fix the position of baffle 2
- Remove the cover on baffle 1 to allow laser to pass through it.
- Calibrate baffle 3 until the reading from the detector reach its maximum, then fix the position of baffle 3

Since the system is not fully isolated, moving of baffles and detector may happen. Alignment is required if any baffle or detector has been misplaced.

## Test method and results

I used 8 vehicle stop lamps in the test. I first tested them using the goniophotometer in black tunnel which is the standard setup, then I tested them using my setup. By comparing two sets of test results, I can obtain the error percentile for my system.

Two types test lamps are shown in Figure 5. and Figure 6.

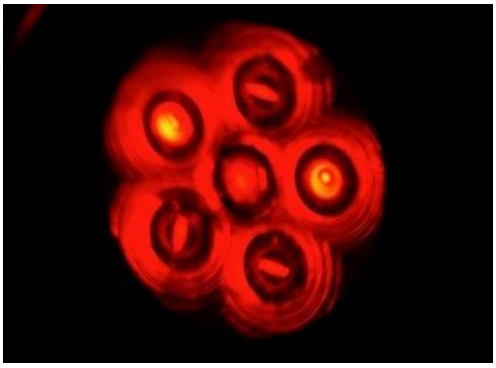

**Figure 5.** 6 LEDs red stop lamp

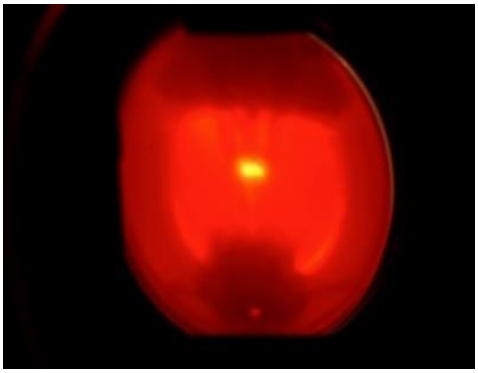

**Figure 6.** red incandescent stop lamp

The test results are shown in Table 1.

**Table 1.** Test results using 8 different stop lamps

| Light source | Pattern | Color | Error in 0° | Error in 10° | Error in 20° |
|---|---|---|---|---|---|
| LED | 6 LEDs | Amber | 1.5% | 3.0% | 4.4% |
| LED | 10 LEDs | Amber | 2.1% | 3.3% | 4.6% |
| LED | 6 LEDs | Red | 1.3% | 3.6% | 5.1% |
| LED | 32 LEDs | Red | 2.9% | 3.9% | 6.2% |
| Incandescent | | Amber | 1.8% | 2.1% | 3.7% |
| Incandescent | | Amber | 2.0% | 2.3% | 4.9% |
| Incandescent | | Red | 1.9% | 3.1% | 4.0% |
| Incandescent | | Red | 2.3% | 3.6% | 5.0% |

My system meets the requirement of with requirement of less than 8% of error at 0, 10 and 20 degrees. From the test results we can see the error is proportional to the degree of rotation and increase with number of LEDs used in the lamp. For 64 LEDs lamp, the error may exceed 8% limit, but 64 LEDs lamp is very rare in automotive light application.

**Conclusion**

My setup for goniophotometer reduces the budget, time-cost, and space-cost compare with the traditional setup. The project took one month to complete and the whole setup costs less than 700 dollars. The system has been placed in an unused area inside the facility which requires no expansion for the current facility. Within the acceptable error, the department of optical engineering can use this goniophotometer to test their prototypes and samples before send them to Test and Evaluation department.

**Reference**

1."MGO-200H Goniophotometer & Goniospectroradiometer - Goniophotometers - Product - Metrue." Metrue, Web. 10 Oct 2016. <http://www.metrue.com/product_info.php?id=195>.