# Light Intensity Meter Calibration System using Comparison Method

Saurabh Rabade, Chaitanya Adkar, Miten Dandavate, Amita Shinde

**Abstract**— Lux meter is a precision measuring instrument used in Lux value measurement under Quality Assurance and Testing. Lux meters are used in a wide range of industrial applications. Lux meter being an electronic instrument; it undergoes wear and tear during its operation which results in inaccurate readings and increased errors in measured Lux value. This can incur losses (monetary and material) and inferior quality of product. Hence, Lux meters need to be calibrated and repaired (if necessary) periodically. In this paper, a new calibration system is proposed for the calibration of Lux meters. The proposed system uses the comparison method for calibration i.e. the industrial Lux meter (Unit Under Test) is compared against the pre-calibrated Lux meter (Master) against a regulated source simultaneously. The master which is calibrated from the National Laboratory (Apex Laboratory) has 10 times better uncertainty. This makes the proposed system part of a continuous chain of traceable standard which will deliver the quality measurements and continuity to the end customer.

**Index Terms**— Calibration, Comparison method, Integrating Sphere, Lux meter, Master, Photometry, Solid Angle, Unit Under Test.

## 1 Introduction

Lux meter is a photo-electronic device which is used in the measurement of illuminance in industries like paints and polymer, automobile, pharmacy, building automation. During normal operation the characteristics of these meters deviate from the design characteristics due to wear and tear in the sensor due to exposure to the high intensity light. Hence industries need to calibrate their Lux meters periodically for reliability of the equipment and ensuring superior quality of final product.

Lux meter calibration systems are available only at the national level. These laboratories have a dedicated setup for Lux meter calibration which includes setting up of dark room, optical bench, source lamp of specific Lux range, pre-calibrated master Lux meters from international laboratories, interfacing software, and computerized process control.

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## 2 Object

The existing calibration systems are available at the National Level laboratories and calibrating a Lux meter from these laboratories is inconvenient to the manufacturing industry spread along the length and breadth of the country. The new proposed system is very useful to the commercial laboratories which can provide calibration facility to this industry.
The second problem is the size of existing systems. Since these systems are developed by apex laboratories they have dedicated setup and floor space. The third problem is the initial cost involved in acquiring/ manufacturing and setting up the equipment for existing systems is very high. The new system is compact and can be employed in the existing setup of small scale laboratories. Also the initial cost is much lesser and re-curring cost involves periodic calibration of master Lux meter from National Laboratory.

## 3 Existing Systems

### 3.1 Physikalisch-Technische Bundesanstalt (PTB), Germany

This system is developed at the National Laboratory in Germany, which has a 42 meter long horizontal chassis on which reference lamp, test lamp, movable slits and Lux meter mounting are available. The system is controlled by various sensors, transducers for its motion control which are interfaced with a computerized system using a dedicated software. The event log and readings obtained are handled using data acquisition system [3].
Initial setup cost is very high and cannot be adopted by the small scale laboratories. Moreover it is not feasible for manufacturing industries to get the calibration done from PTB, Germany or any equivalent laboratory. Initial setup involves manufacturing of reference masters based on the research done earlier in line with the same.
A specific method as per their standard is followed in the calibration procedure of Unit Under Test (UUT).

### 3.2 National Physical Laboratory (NPL), Delhi

National Physical Laboratory (NPL), Delhi is the apex organization in the field of testing and measurement technology and its advancement in India.
The calibration setup at NPL, Delhi consists of 3 meter long optical bench, tungsten filament lamp of high quality which is free from any manufacturing defects, a Lux meter which is periodically calibrated from PTB, Germany [2]. NPL being a National Level laboratory the calibration of Lux meter is costly for the industry.

### 3.3 National Institute of Standards and Technology (NIST), USA

A photometry bench is used for the luminous intensity and illuminance calibrations. The base of the bench
consists of three 1.8 m long steel optical tables. A 5 m long rail system with movable carriages is mounted. Two telescopes are rigidly mounted to focus the lamps. Measurements with standard photometers and test photometers are made automatically. The photometers are aligned against the front surface of the mounts fixed on the carousel[1].
The position of the carriage on the rails is monitored by a computer-readable, linear encoder providing absolute position with high resolution. The encoder reading is verified by comparison with a NIST calibrated vernier calliper. The optical bench is covered by a light-tight box, the inside of which is covered with black velvet[1].

## 4 PROPOSED SYSTEM

### 4.1 Working Principle

Light from any point source is propagated in the form of spherical wavelets. Luminous flux (Φv) is the time rate of flow of light $(dQ/dt)$[1] .

$$1\ lumen = 1\ candela\ .steradian$$

A sphere has a solid angle of 4π steradians, thus a source radiating 1 candela in all directions has a total luminous flux of 4π lumens.

At research grade experiments and calibrations, integrating spheres are used which reflect and focus all the available intensity of light at one point where sensors of Lux meter are placed. Thus in integrating spheres the total luminous flux emitted by the source is made incident on the sensors of Lux meter. But these integrating spheres require high grade of thermal and mechanical stability. Sources used in this system are of fix value and require frequent calibration as well as replacement. This results in higher calibration cost for customer.

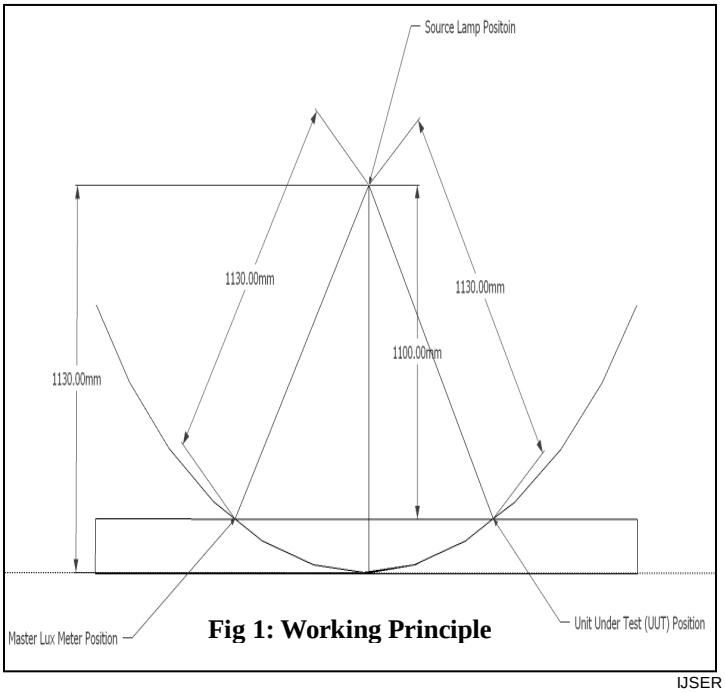


**Fig 1: Working Principle**

Instead the proposed system is designed such that it replicates a section of the integrating sphere. The source is kept at the centre of an imaginary sphere. Solid angle of imaginary sphere is limited by using non-reflecting bellows. The master and UUT are kept on radial surface points of the imaginary sphere. Hence Lux at the detector plane of master and UUT is equal.

The source is maintained at recommended current and temperature values. This assembly is mounted on a height gauge which is used to vary the distance between source and Lux meter plane for carrying out five-point calibration. Readings obtained from the U.U.T. and Master instrument are fed to the computer software used by the laboratory for its calculations and report generation.

### 4.2 System Design

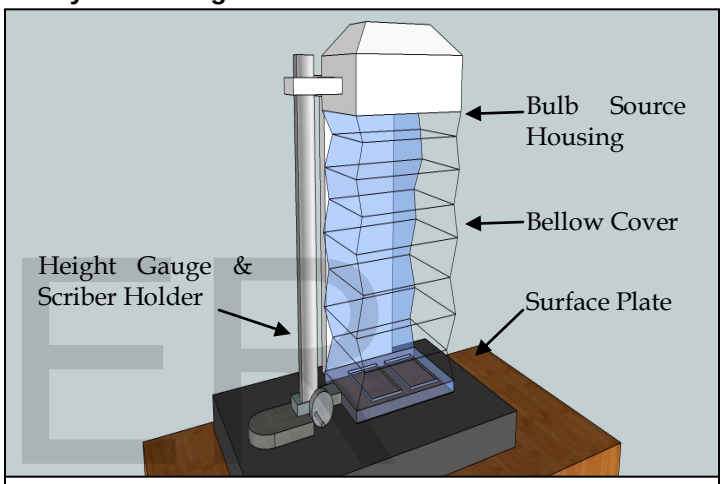


**Fig 2: Proposed System**

#### 4.2.1 Master Lux Meter

Master Lux meter or reference Lux meter is the device which acts as a standard for comparison for the UUT. The master Lux meter is calibrated from the apex laboratory.

#### 4.2.2 Regulated Light Source

Regulated light source is used to provide identical input to both the master and UUT. The light source is regulated to ensure that it is isolated from line and load fluctuations.

#### 4.2.3 Surface Plate

A granite block is used as a surface plate which is used as a base reference for Lux meter assembly. It has a flatness of 2.5μ throughout its surface area.

#### 4.2.4 Bellow Covers

Bellow covers are used for insulation from external (ambient) light as well as to prevent scattering of light from source.

#### 4.2.5 Height Gauge

Height gauge is used for precise movement of the Lux meters from base reference along the axis of light source.

#### 4.2.6 Length Bars

Length bars are used to set height gauge at specific distance from the base reference to ensure repeatability of the readings.

## 5 Conclusion and Future Scope

The deigned system efficiently reduces the cost of calibration as well as it efficiently compacts the system. The system is easy to maintain and problem associated with frequent source calibration is eliminated due to the implementation of comparison method. The system is reliable and gives repeatability in the readings of Lux value against the length standards given as input.

Future scope includes calibration of lamp (source) and other photometric units associated with it.

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