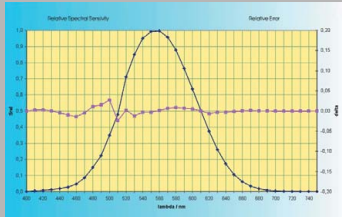


INTEGRATING SPHERES

*World Standard
in Light Measurement since 1968*





Highest accuracy-superior spectral response of X-Rite's silicon detectors

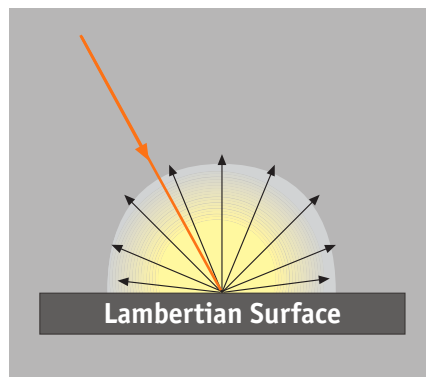
X-Rite GmbH – Optronik, a subsidiary of X-Rite Incorporated, is one of the most experienced suppliers of light measurement technology in the world. Product offerings include best-of-class light measurement systems, photopic detectors, system photometers, goniophotometers, integrating spheres, colorimeters, DC power supplies, reflectance and transmittance measuring systems and uniform light sources as well as various accessories for light measurement.

Since 1968 when it constructed one of the worldwide first digital luxmeters, Optronik has specialized in the design and manufacture of photopic detectors, photometer systems and integrated laboratory solutions for a variety of electro-optical testing,

measurement, and calibration applications: Optronik is an acknowledged leader in the design and manufacture of precision photometric equipment.

Optronik's photometers provide a photopically-corrected (eye response) measurement of the brightness (candle power), illuminance (in lux), and tristimulus color coordinates from optical radiation sources. The photometric solutions are used in the design, development, and production QA testing of lamps and in the certification of the final product according to relevant national and international standards & regulations; e.g., CIE 69, CIE 15.2 (1966), CIE 121, CIE 84, CIE 127, DIN 5032, and DIN 5033.

Diffuse Lambertian Coating



Lambert's Cosine Law (also known as Lambert's cosine emission law) is the mathematical statement that a radiance of certain idealized optical sources is directly proportional to the cosine of the angle – with respect to the direction of maximum radiance – from which the source is viewed. Lambert's cosine law also applies to certain idealized diffuse reflectors or coatings.

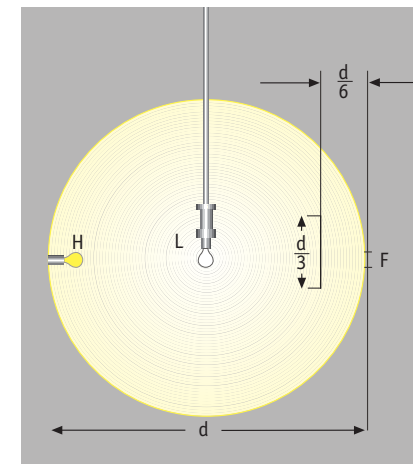
Integrating Sphere – Theory and Application

Based upon the principle of multiple diffuse reflection (resulting from the Lambertian coating), the integrating sphere is used to spatially integrate radiant flux, either from an external or an internal source of radiation. The efficiency of an integrating sphere is determined by a number of factors, including the size and number of ports, the size and location of baffles or screens, the number of inclusions in the sphere, and most importantly, the reflectance and diffuse nature of the sphere coating that has to be "Lambertian" (ideally diffuse reflecting).

Depending on port position, baffling, and to an extent, sphere size, integrating spheres can be configured for a number of applications, including:

- Light collection from internal or external source (lamp measurement photometry)
- Uniform light sources
- Laser power measurement
- LED spectral and flux measurement
- Reflectance of either specular or scattering samples
- Total or diffuse only transmittance measurement
- Cosine receptors

Lamp Measurement Systems



Sphere construction according to DIN 5032 and CIE 84 for lamp flux measurement

The oldest application for the integrating sphere is the measurement of total geometric luminous flux from electric lamps. The technique originated at the turn of the 20th century (by Richard Ulbricht in Germany, which is why it is also called an Ulbricht sphere) as a simple and fast method of comparing the lumen output of different lamp types. It is still widely used in the lamp industry for quality control during manufacture. The alternative method is a goniophotometer which would need to rotate a photodetector in a complete sphere around the lamp (or rotate the

sample in relation to a detector). Each discrete intensity point (lm/sr) is then integrated over 4π steradians.

In contrast to the absolute measuring method using a goniophotometer that scans the complete intensity distribution of the lamp and integrates the flux, the integrating sphere is the relative measuring method requiring calibration of the sphere with a calibrated flux (or spectral distribution) bulb that should be traceable to a national standard (PTB or NIST).

In a sphere photometer, the lamp to be measured is mounted at the center of the integrating sphere and baffled from a viewing port equipped with a diffuser and photopic response detector. The baffle is usually positioned at $2/3$ of the radius from the sphere center. Its size should be as small as possible yet large enough to screen the maximum dimension of the lamp.

The lumen output from the test lamp is determined by first calibrating the photodetector signal using a lamp standard of known luminous flux. The lamps are alternately substituted into the integrating sphere. An auxiliary lamp can be permanently mounted inside the sphere to compensate for the substitution error caused by different self-absorption from the test and standard lamps.



Classic application: flux measurement of bulbs



Uniform Light Source: Luminance Standard

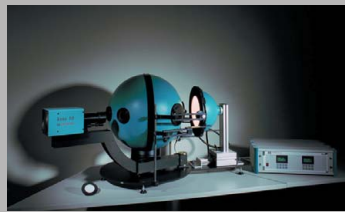


Integrating spheres provide the ideal means for creating a uniform light source. Light collected by a sphere is diffusely reflected many times, so that any spatial characteristics are integrated for light leaving the sphere exit port plane. The emitted light is nearly perfectly Lambertian. Our uniform source sphere LDN10 is internally coated with a special photometer paint, a proprietary diffuse white coating that produces excellent diffuse reflectance over the VIS-NIR wavelength region.

The functional principle is that a lamp or several lamps are placed inside the integrating sphere around the perimeter of the viewing port. The lamps are baffled from the port. The radiance of the sphere is a function of the wattage rating of the lamp.

Tungsten halogen lamps are most commonly used with integrating sphere sources. These lamps provide a continuous spectrum free of emission lines or temporal instability when operated from a regulated current power supply. The spectral radiance of the sphere source can be estimated by combining the sphere radiance equation with blackbody equations for the spectral radiant flux.

Reflectance and Transmittance Measurement



KMS10

Another application for integrating spheres is the measurement of the reflectance and transmittance of diffuse or scattering materials. The measurements are performed photopically or spectrally, as a function of wavelength. The measurement of luminous reflectance or transmittance is performed using a photopic response detector. A transmittance measurement places a material sample at the entrance port to the sphere.

In reflectance measurements, the sample can be placed at a port opening opposite the entrance port. The incident flux is reflected by the sample. The total hemispherical reflectance, both the diffuse and specular components, is collected by the integrating sphere. There are special applications such as ECER46 that also require a specific sphere design (see below).

ITS10 Integrating Sphere Photometric Lamp Measurement Systems

The OPTRONIK ITS10 integrating sphere photometer systems are designed to measure the total luminous flux, luminous color, and spectral distribution of lamps according to DIN 5032 and CIE No. 84.

The systems accommodate most lamp types, including arc, fluorescent, incandescent, HID, and LED.

Each lamp measurement system features an integrating sphere, optionally



Detector ports for flux and luminous color measurement, thermometer

calibrated lamp standard, precision power supply, photopic response detector, and display unit. The digilumen 9500 luminous flux meter used in conjunction with the sphere features the highest photometer accuracy classes L and A according to DIN 5032 and CIE No. 69 with excellent spectral matching of the high precision photopic Si-detectors to the sensitivity for brightness of the human eye.

Optional software is available for enhanced operation of the ITS10 lamp measurement system.

X-Rite – Optronik manufactures spheres with diameters of 50 cm and 100 cm.

In cooperation with our sister company, Labsphere, we can offer any kind of lamp measurement system with spheres as large as 5 meters as well as very small spheres with a diameter of a few inches.

Applications

High performance precision photometer for lamp flux measurement used in laboratory environments.

ITS10-50 / ITS10-100

General characteristics

- Equipment for luminous flux measurement of light sources by comparison with a standard lamp
- Construction according to DIN 5032 Section 1 and CIE Publication No.84 "The Measurement of Luminous Flux"
- Metal frame construction with swiveling mechanism to open the sphere
- Light-tight mechanical lock
- Flexible adjustment bar to connect X-Rite Optronik lamp holders
- 3 burning positions (2 vertical, 1 horizontal), clamping device for fixing holders in pendent, upright, and horizontal position
- Coated inside with Optronik BaSO₄ photometer paint with Lambertian white diffusing surface, reflectance 80% with variation of reflectance < 1.5% in wavelength range 400 to 700 nm
- Diameter: 0.50 meter (ITS10-50) 1 meter (ITS10-100)
- Sphere material: Aluminum
- Sphere paint (outside): RAL 5018
- Thermometer: Digital, resolution 0.1°C
- Universal flange prepared to install several photometer heads for V (λ) (Digilumen 9500) and (ITS10-100) tristimulus colorimeter head (FMS 10)
- Baffle to be shifted
- Auxiliary lamp



Internal view: three burning positions, up-side, down-side (vertical), front-side (horizontal)



ITS10-50



ITS10-50 open

Scope of supply

- Sphere ITS10-50 or ITS10-100
- Stable stand
- Auxiliary lamp
- Baffle
- Thermometer
- Adjustment bar for positioning sample
- Instruction manual

Photometer Digilumen 9500

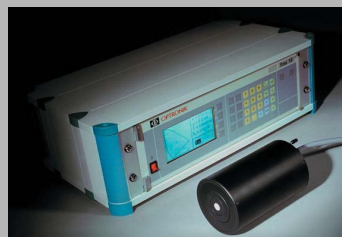


digilux/ digilumen 9500

- Precision photometer head with Si-photopic detector
- Diameter of light sensitive area: 30 mm
- Superior $V(\lambda)$ -approximation, class L (highest accuracy) or A (high accuracy) according to DIN 5032 Section 6
- Thermostatic stabilization of photometer head to approx. $35^{\circ}\text{C} \pm 0.1^{\circ}\text{C}$
- Diffuser built-in flush with inner surface of sphere
- Electronic, microprocessor-controlled display unit digilumen 9500
- $4\frac{1}{2}$ -digit LED seven segment display
- Ranging auto/manual or remote programmable
- Fixed lux calibration, freely selectable lumens calibration
- Attenuator: Adjustable factor 0.001...99.99
- Approx. 5 readings/s, automatic average creation for alternating light
- Interface: Serial RS 232
- Power supply: International wide range power supply
80...270 V, 40...400 Hz
- Power consumption: Max. 20 W
- Dimensions: (W x H x D) 291 x 88 x 199 mm
- Weight: 2 kg
- Display range: 10^{-3} lm (last digit) to 2×10^5 lm

Options

- Range extension
- X-Rite Optronik FMS10 colorimeter for luminous color measurements
- X-Rite Optronik SNT10 DC power sources and voltage / current stabilizer
- AC power supplies / multimeters
- Spectral measurement with CAS140B (Instrument Systems)
- System integration with 19-inch electronic rack
- Software LightCon sphere program package for integrating spheres
- Lamp holders (automotive bulbs, general lighting lamps)
- Flux and spectral calibration bulbs
- X-Rite Optronik photometer paint



FMS10-tristimulus colorimeter for luminous color and correlated color measurement according to DIN5033

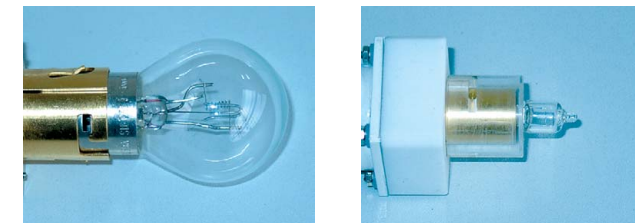
Optronik – Labsphere Product Selection Chart

Part No.	Sphere Diameter	Max. Lamp Length	Lamp Ratings		Spectral Range	Lamp Standard		Application Software
			Min.	Max.		Power	Flux	
PLMS-1000	254 mm	127 mm	0.1 lm	100 W	Photopic	35 W	450 lm	Available
ITS10-50	500 mm	250 mm	0.4 lm	400 W	Photopic	35 W	450 lm	Available
ITS10-100	1000 mm	600 mm	0.5 lm	1500 W	Photopic	75 W	1400 lm	Available
PLMS-6500	1650 mm	860 mm	3.0 lm	4000 W	Photopic	75 W	1400 lm	Available
PLMS-7600	1930 mm	1320 mm	6.0 lm	5000 W	Photopic	75 W	1400 lm	Available

Other Sphere diameters on request.
Spectral lamp measurement spheres available on request.



Small sphere for miniature bulbs



Precision lamp holders for different lamp types

Sphere Accessories

Lamp Sockets for Integrating Spheres

Precision measuring sockets are special quadri-pole lamp holders with two separate galvanic connections, each of which has a point of contact with the lamp, one for the supply of the lamp and the other for the voltage / current measurement.

Electrical Data of Measuring Sockets for Vehicle Lamps

Unom 24 V DC, I_{max} 20 A, Test voltage U_{test} 50 V DC

Electrical Data of Measuring Sockets for General Purpose Lamps

Unom 250 V AC/300 V DC, I_{max} 10 A, Test voltage U_{test} 2000 V_{eff}
Other High Voltage Sockets on Request

Standard Lamps for Integrating Spheres and Goniophotometers

Luminous flux standard lamps with calibration certificates to calibrate luminous flux test equipment with integrating spheres or for use the goniophotometers

Standard Flux Lamps for Vehicle Lights

Standard lamps for testing vehicle lights according to ECE Regulation No. 37 with certificate issued by an accredited testing laboratory. The test certificate includes the relevant geometrical, electrical, and photometrical values.

Standard Flux Lamps for General Lighting

Standard lamps for calibration of luminous flux test equipment with certificate issued by an accredited testing laboratory. The test certificate includes the relevant electrical values and the luminous flux.

Spectral Calibration Bulbs

Set of spectrally calibrated bulbs with Labsphere calibration certificate.

Photometer Paint for Integrating Spheres

X-Rite Optronik photometer paint for integrating spheres acc. to CIE Publication No. 84 (1989), characterized by Lambertian diffuse and selective reflectance and composed of highly purified BaSO₄.

Characteristics

- Lambertian white diffusing surface
- Reflectance 80% (DIN 5036 Section 3)
- Variation of reflectance < 1.5% in wavelength range 400 to 700 nm
- Particularly suitable for coating integrating spheres according to CIE Publ. No. 84 (1989) "The measurement of luminous flux"
- Recommended quantity approx. 1.25kg/m²
- Individual test report for reflectance, spectral reflectance, and sphere factor
- Option: Photometer paint (Spectrafect™) with 98% reflectance on request

Sphere diameter	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m
Quantity	1 kg	4 kg	9 kg	16 kg	25 kg	35 kg

DC Power Supplies

X-Rite Optronik manufactures a range of laboratory DC power supplies, SNT10, developed mainly to meet the needs of the automotive lighting and neighboring industries. For additional information, please ask for the DC Power Supplies SNT10 brochure.

Standard versions available:

SNT10-50 V/12 A (20 A for U < 18 V)
SNT10-32 V/20 A
SNT10-50 V/6.5 A
SNT10-50 V/3.2 A

Standard resolution:

0.001 V / 0.001 A

Optional resolution:

0.2 mA or 0.1 mA

LDN10-50 Luminance Standard (Uniform Light Source)

Features and Applications

The OPTRONIK LDN 10-50 is an integrating sphere uniform light source with color temperature regulation. Each model includes a sphere photometer and control unit. The LDN 10 luminance standard creates on its light emitting surface a luminance which is accurately defined.

Alternatively, you can control constant luminance or color temperature. The LDN 10 is therefore an excellent tool for testing and calibrating a variety of photometers, such as:

- Luminance meters
- Retroreflectometers
- Photo receivers
- Colorimeters and video cameras

The LDN 10-5 model has a diameter of 500 mm. The light emitting area has a diameter of 100 mm (LDN 10-5), which can be reduced in size to 3 mm with an optional iris diaphragm. The power supply is integrated into a separate control unit. A keyboard on the control device's front plate serves to control the following functions:

- Automatic maintenance of constant luminance
- Automatic maintenance of constant color temperature
- Continuous adjustment of luminance and/or color temperature
- Storage of frequently used values

The measured values are indicated on a separate display and control unit or on an integrated display. An RS-232 serial interface allows for control of the LDN 10 via PC; e.g., if the device is used for automated measuring applications.



LDN10-5, uniform light source

Technical Data

Luminance Standard LDN 10-5

- Integrating sphere, 500 mm
- Sphere material: Aluminum
- Special sphere coating diffuse (Lambertian) reflecting, 80% reflectance, spectral characteristics according to DIN 5032
- Halogen incandescent bulb 12 V / 100 W
- Baffle to shield the light exit port against direct light
- 3 Si-photo detectors to regulate luminance and correlated color temperature
- Light exit port with diffuse cover, 100 mm
- Luminance at standard illuminant A approx. 1100 cd/m²
- Luminance range approx. 200 ...2200 cd/m²
- Uniformity of luminance > 98% on a center circle of 90 mm
- Total dimension with stand: 500 mm x 700 mm (height)
- Weight: Approx. 15 kg

Display and Control Unit

Lamp Power Supply

- Table housing, optionally to be integrated in 19" configuration
- Lamp power supply for halogen bulb 100 W
- Microprocessor-controlled electronic regulation unit, regulation of either voltage, luminance, or correlated color temperature
- Regulation range of correlated color temperature: 2500 K ... 3000 K
- Digital display of lamp voltage, luminance, and correlated color temperature on graphic LC display with background illumination
- Integrated lamp burning time and switching cycle counter
- Serial interface (RS-232) for remote control and readout of measured values
- Mains supply: 230 V / 50 Hz, max. 130 W
- Power cable with Euro plug
- Calibration traceable to PTB standard with X-Rite Optronik calibration certificate

Options

- Additional X-Rite Optronik calibration certificate for luminous intensity
- Measured color filter with specification of chromaticity coordinates
- Filter for conversion to other illuminants
- Power supply for 115 V, 50-60 Hz

Reflectance and Transmittance Measurement KMS10

Applications



The X-Rite Optronik KMS10 is a specialized measuring instrument used for various applications to measure luminous reflectance and transmittance of different materials.

KMS10—transmittance and reflectance measurement instrument

- Its design is based upon the properties of an integrating sphere.
- Its design follows the guidelines defined by DIN5036 Section 3 and CIE Publication No. 38 (1987) (Measurement of transmittance and reflectance)
- In addition, it is suitable for measurements according to ECE-R46,

ISO 5740–1982 (Measurement of the reflectance of flat and convex rear mirrors).

- Many additional applications are possible wherever information on reflectance and transmittance is needed.
Relative measuring method: Reflectance and/or transmittance standards with defined reflectance properties required.

Equipment for Measurement of

- Reflectance ρ
- Diffuse reflectance ρ_d
- Transmittance τ
- Diffuse transmittance τ_d
- Reflectance of flat and convex surface rear-view mirrors
- Transmittance τ_{dif} dif at diffuse light incidence (optional)

Measurement According to the Following Standards:

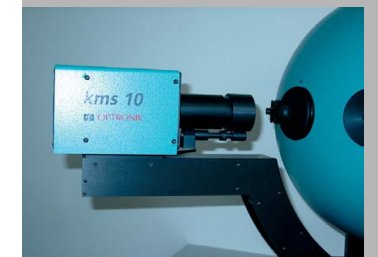
- CIE Publication No.38
- DIN 5036 Section 3
- ECE Regulation R 46
- ISO 5740 – 1982
- Integrating sphere 500 mm diameter mounted on base plate with sample holders. Sphere construction according to DIN 5036 Section 3 and ISO 5740–1982 with integrated photometer head, 30 mm diameter of light sensitive surface, superior $V(\lambda)$ -approximation
- Moveable ρ and τ -illuminant source for connection to integrating sphere, for measurements of ρ and ρ_d with a color temperature acc. to standard illuminant A, with color temperature control system via several Si-photo elements
- Power supply and control circuit for illuminant source, connection cables, power supply for 230 V, 50-60 Hz, power cable with Euro plug
- Digital display unit digilux 9500 with amplifier and $4\frac{1}{2}$ -digit display of measuring value, attenuator for adjusting the display value to the calibration standard value, RS232 serial interface; power supply: international wide range power supply 80...270 V, 40...400 Hz, Euro plug

Options

- Working standards to calibrate the measuring equipment, with calibration certificate: Regular reflecting standard (surface reflecting mirror), diffuse reflecting standard (Labsphere Spectralon™)
- τ_{dif} -illuminant source for connection to integrating sphere for measurements of τ_{dif}
- Power supply for 115 V, 50-60 Hz



Display and control of color temperature



Directional light source, color temperature regulated to standard illuminant A



X-Rite – Optronik Services

X-Rite – Optronik is more than a manufacturer of photometer and goniophotometer systems and accessories. The company also offers a range of services to support customers who purchase Optronik products, as well as customers who outsource manufacturing, test, and calibration services. Customer service reflects a legacy of expertise in photometry technology and applications. No other manufacturer offers the knowledge base or the range of products developed by X-Rite – Optronik, and no other goniophotometer series can be compared with the performance in both accuracy and speed of the OPTRONIK SMS10 series.

Get assistance with all your test and measurement needs at: info@optronik.de

Custom Development

X-Rite – Optronik welcomes inquiries for the design and manufacture of custom optical radiation measurement and test systems. Experienced research and development engineers work closely with our customers to provide the highest level of product development, applications, and technical support. Customer focus, quality, innovation and excellence drive our culture.

You are welcome to visit our R&D and production plant in Berlin.

OPTRONIK. The World Standard in Light Measurement since 1968

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