uku / uls

Technical Data Sheet – Integrating Spheres

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Contents

1 Introduction

Integrating spheres are built in order to spatially spread light as homogeneously as possible. Ideally, the inner surface of the sphere would scatter the light perfectly diffuse respectively lambertian and the sphere would be closed completely.

In reality, these preconditions are very hard to achieve. The performance of the sphere is considerably influenced by the type and the grade of reflection of the internal coating as well as by the size and the number of ports.

Integrating spheres are used for a wide range of measurement types.

Typical applications are:

- Measurement of the luminous flux
- Measurement of the reflection or transmission of materials
- Luminance measurement standard (uls)

Depending on the application, other sphere parameters become relevant and/or additional component parts are used.

The way each port interferes with the ideal performance of a sphere, the way any additional element within the sphere interferes. However, these elements are often absolutely necessary to carry out the measurement.

Such interferences can usually be eliminated by means of auxiliary light sources.

When measuring light it is important to avoid that light hits the detector(s) directly or directly after the first reflection at the sphere. Baffles are mounted within the spheres to avoid this negative effect.

The luminous flux measurement can be carried out by insertion of the luminous flux from the outside through one of the ports or within the sphere.

The measurement of the reflection or transmission makes an additional light source as well as several measurements necessary.

A homogeneous luminance surface can be generated directly at the inside of the sphere, at a target fixed in the sphere or at one of the ports with the respective cover.

The larger the sphere the smaller is the impact of the disturbance. On the other hand, however, the luminance within the sphere declines considerably with larger diameters.

For additional technical information please refer to the end of this document.

2 uku Data

2.1 uku120

Solid integrating sphere made of compact aluminum

Internal coating made of high-quality barium sulfate ($BaSO_4$)

Outside coating RAL9005 (deep black), further coatings available on request

Hemisphere screwed

Plane port surfaces for easy mounting of samples and detectors

M6 screw threads for integration into a laboratory setup

Specifications

Sphere diameter	120	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/45	20	mm
Diameter Port 2 @ 90/-45	20	mm
Diameter Port 3 @ 90/135	20	mm
Port fraction f	< 0,7	%
Sphere factor M	about 11,5	
Dimensions (Width x Depth x Height)	126 x 130 x 130	mm^3
Weight	about 2	kg

2.2 uku240

- Solid integrating sphere made of compact aluminum
- Internal coating made of high-quality barium sulfate ($BaSO_4$)
- Outside coating RAL9005 (deep black), further coatings available on request
- Hemisphere screwed
- Plane port surfaces for easy mounting of samples and detectors
- ±6° reflection order of the Ports 2, 3 and 4
- Ergonomically designed recessed grips for carriage
- M6 screw thread for integration in laboratory setups

Specifications

Sphere diameter	240	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/45	20	mm
Diameter Port 2 @ 90/-45	40	mm
Diameter Port 3 @ 90/129 (-6° to Port 2)	20	mm
Diameter Port 4 @ 90/141 (+6° to Port 2)	20	mm
Port fraction f	< 0,7	%
Sphere factor M	about 11,5	
Dimensions (Width x Depth x Height)	265 x 260 x 260	mm³
Weight	about 14	kg

2.3 uku315

- Robust integrating sphere made of aluminum
- Solid welded construction in cantilever Al-frame
- Internal coating made of high-quality barium sulfate (BaSO4)
- Outside coating RAL9005 (deep black), further coatings available on request
- Hinged hemisphere
- Ergonomically designed working height (table-top device)
- Sample holder in the center of the sphere (optional)
- Sample holder at the side port (optional)

Specifications

Sphere diameter	315	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/180	60	mm
Diameter Port 2 @ 30/0	60	mm
Diameter Port 3 @ 90/45	20	mm
Diameter Port 4 @ 90/-45	20	mm
Diameter Port 5 @ 150/0	60	mm
Port fraction f	< 2,95	%
Sphere factor M	about 7,79	
Dimensions (Width x Depth x Height)	320 x 435 x 460	mm^3
Weight	about 20	kg

2.4 uku500

- Robust integrating sphere made of aluminum
- Solid welded construction in cantilever
- Al-frame
- Internal coating made of high-quality barium sulfate (BaSO4)
- Outside coating RAL9005 (deep black), further coatings available on request
- Hinged hemisphere
- Ergonomically designed working height (table-top device)
- Sample holder in the center of the sphere (optional)
- Sample holder at the side port (optional)

Specifications

Sphere diameter	500	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/180	100	mm
Diameter Port 2 @ 20/0	60	mm
Diameter Port 3 @ 90/45	20	mm
Diameter Port 4 @ 90/-45	20	mm
Diameter Port 5 @ 160/0	60	mm
Port fraction f	< 1,81	%
Sphere factor M	about 8,54	
Dimensions (Width x Depth x Height)	525 x 700 x 800	mm^3
Weight	about 28	kg

2.5 uku800

- Robust integrating sphere made of aluminum
- Solid welded construction in cantilever Al-frame
- Internal coating made of high-quality barium sulfate (BaSO4)
- Outside coating RAL9005 (deep black), further coatings available on request
- Hinged hemisphere
- Ergonomically designed working height (table-top device)
- Sample holder in the center of the sphere (optional)
- Sample holder at the side port (optional)

Specifications

Sphere diameter	800	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	100	mm
Diameter Port 2 @ 20/0	60	mm
Diameter Port 3 @ 45/45	20	mm
Diameter Port 4 @ 45/-45	20	mm
Diameter Port 5 @ 160/0	60	mm
Port fraction f (in the standard configuration)	< 0,71	%
Sphere factor M	about 9,44	
Dimensions (Width x Depth x Height)	850 x 1000 x 1200	mm^3
Weight	about 46	kg

2.6 uku1000

- Robust integrating sphere made of aluminum
- Solid welded construction in cantilever Al-frame
- Internal coating made of high-quality barium sulfate (BaSO4)
- Outside coating RAL9005 (deep black), further coatings available on request
- Hinged hemisphere
- Ergonomically designed working height (adjustable)
- Sample holder in the center of the sphere (optional)
- Sample holder at the side port (optional)

Specifications

Sphere diameter	1000	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	125	mm
Diameter Port 2 @ 12/0	60	mm
Diameter Port 3 @ 45/45	20	mm
Diameter Port 4 @ 45/-45	20	mm
Diameter Port 5 @ 168/0	60	mm
Port fraction f (in the standard configuration)	< 0,59	%
Sphere factor M	about 9,45	
Dimensions (Width x Depth x Height)	1400 x 1200 x 1600	mm^3
Weight	about 90	kg

2.7 uku1600

- Robust integrating sphere made of aluminum
- Solid welded construction in cantilever Al-frame
- Internal coating made of high-quality barium sulfate (BaSO4)
- Outside coating RAL9005 (deep black), further coatings available on request
- Half of the sphere mounted on and moveable by linear guides
- Ergonomically designed working height
- Sample holder in the center of the sphere (optional)
- Sample holder at the side port (optional)

Specifications

Sphere diameter	1600	mm
Sphere wall thickness	about 4	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	250	mm
Diameter Port 2 @ 10/0	60	mm
Diameter Port 3 @ 45/45	20	mm
Diameter Port 4 @ 45/-45	20	mm
Diameter Port 5 @ 170/0	60	mm
Port fraction f (in the standard configuration)	< 0,69	%
Sphere factor M	about 9,45	
Dimensions (Width x Depth x Height)	2500 x 1800 x 2300	mm^3
Weight	about 320	kg

3 uls

All types of the uku series are available as "uls" version (uniform light source).

These spheres come with one or several light sources, perhaps one or several detector ports and an exit port with homogeneous luminance and lambertian radiation.

The luminous flux within the sphere and with it the luminance at the exit port is variable or fix, depending on the configuration. The luminous flux is controlled by a motor baffle without spectral power distribution inside the sphere.

The port of the homogeneous luminance lies at position 90/0. The port of the light source lies at 45/45. In case further light source or detector ports are necessary, they are available optionally at positions 45/-45, 135/45 and 135/-45.

Depending on the application, either the sphere wall itself, an additional target within the sphere or a diffuse shutter at the port of the sphere can be used as target with homogeneous luminance. The sphere shutter is realized by the use of diffuse silica glass with a very good scattering performance. However, it reduces the luminance achievable at constant luminous flux values within the sphere.

A baffle is installed in front of the light sources in case the spheres are run with open exit ports. Closed systems with window do not need this installment.

3.1 uls Data

3.1.1 uls315

Sphere diameter	315	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	100	mm
Diameter Port 2 @ 45/45	60	mm
Port fraction f	< 3,5	%
Sphere factor M	about 8,4	
Dimensions (Width x Depth x Height)	320 x 435 x 460	mm³
Weight	about 20	kg
Power of the light source(s)	150	W
Correlated color temperature T_n	ca. 2900 - 3000	K
Luminance within the sphere	about 20	kcd/m²
Luminance at diffuse silica glass shutter (optional)	about 2	kcd/m²

3.1.2 uls500

Sphere diameter	500	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	100	mm
Diameter Port 2 @ 45/45	60	mm
Port fraction f	< 1,4	%
Sphere factor M	about 10,3	
Dimensions (Width x Depth x Height)	525 x 700 x 800	mm³
Weight	about 28	kg
Power of the light source(s)	150	W
Correlated color temperature T_n	ca. 2900 – 3000	K
Luminance within the sphere	about 9	kcd/m²
Luminance at diffuse silica glass shutter (optional))	about 0,9	kcd/m²

3.1.3 uls800

Sphere diameter	800	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	100	mm
Diameter Port 2 @ 45/45	60	mm
Diameter Port 3 @ 45/-45	60	mm
Port fraction f (in the standard configuration)	< 0,95	%
Sphere factor M	about 11,2	
Dimensions (Width x Depth x Height)	850 x 1000 x 1200	mm³
Weight	about 46	kg
Power of the light source(s)	2 x 150	W
Correlated color temperature T_n	about 2900 - 3000	K
Luminance within the sphere	about 8	kcd/m²
Luminance at diffuse silica glass shutter (optional)	about 0,8	kcd/m²

3.1.4 uls1000

Sphere diameter	1000	mm
Sphere wall thickness	about 3	mm
Internal coating	$BaSO_4$	
Reflection factor of the internal coating	about 93	%
Diameter Port 1 @ 90/0	100	mm
Diameter Port 2 @ 45/45	60	mm
Diameter Port 3 @ 45/-45	60	mm
Port fraction f (in the standard configuration)	< 0,45	%
Sphere factor M	aobut 9,7	
Dimensions (Width x Depth x Height)	850 x 1000 x 1200	mm³
Weight	about 46	kg
Power of the light source(s)	2 x 150	W
Correlated color temperature T_n	about 2900 – 3000	K
Luminance within the sphere	about 5	kcd/m²
Luminance at diffuse silica glass shutter (optional)	about 0,5	kcd/m²
Power of the light source(s)	4 x 150	W
Luminance within the sphere	about 10	kcd/m²
Luminance at diffuse silica glass shutter (optional)	about 1	kcd/m²

4 Accessories

Port Adapter

OTS-Z-UKU-A0	Port lock cover plate for the integrating sphere for prevention against light and dust
OTS-Z-UKU-A1	Port lock cover plate for mounting an SMA connector light fiber to the integrating sphere
OTS-Z-UKU-A2	Port lock cover plate for mounting a fiber collimator (3/8-24 UNF) to the integrating sphere
OTS-Z-UKU-A4	Fixing claw for mounting the frc'3 photometer to the integrating sphere
OTS-Z-UKU-A5	Universal support for mounting of detectors to the integrating sphere
OTS-Z-UKU-A6	Fixing claw for mounting the spr'3 spectroradiometer to the integrating sphere with improved cable management
OTS-Z-UKU-A7	Port cover/window for ports with diameter of 100 mm with lambertian scattering material (ceramics) and threads for brackets to fix samples

Detectors

OTS-FRC-F	Photometer
OTS-SMS-SP3-x	Spectrometer
OTS-SMS-SPR3	Spectroradiometer
OTS-LMS-x	Luminance measurement system

Light Sources

OTS-Z-UKU-HLQ01	Auxiliary light source, needs 60 mm port
OTS-Z-KLQ-HAL100	Luminous flux calibration light source, Halogen, 100W

Power Supply

OTS-Z-LSV-PS512	Fixed voltage supply for the auxiliary light source
OTS-Z-LSV-I803210T	High-quality programmable laboratory power supply for defined and controlled start of calibration light sources (uls)

Mechanics

OTS-UKU-xxx-PT1	Sample platform for the positioning of sources or luminaires in the center of the sphere (needs 168/0 port)
OTS-UKU-xxx-PT2	Sample platform for the positioning of samples at the side port (needs 90/0 or 90/180 port)

Coating Service

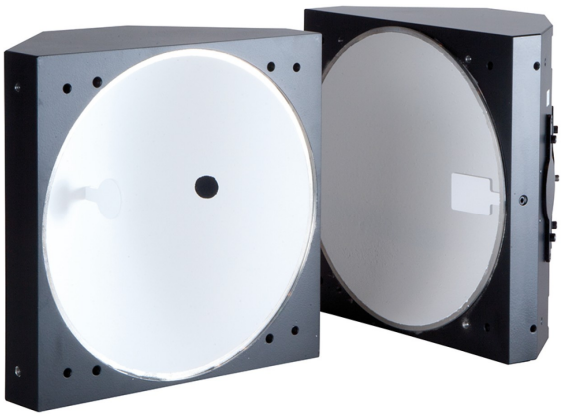
OTS-UKU-xxx-NB	New coating of an integrating sphere

Further accessories on request

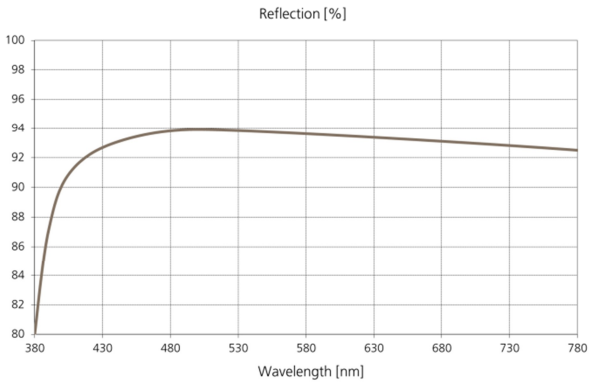
5 Technical Information

5.1 Coating

The internal coating of the der opsira integrating spheres is made of several layers of barium sulfate ($BaSO_4$) showing very good lambertian reflection and clearly more robust than the magnesium oxide used formerly.



By the barium sulfate coating an average reflection ratio of ρ = 93% over the visible spectral region. The coating is almost grey and shows a very low change over the wavelength within the visible area.



The reflection of the barium sulfate declines considerably within the UV-region.

Working within NIR is possible up to about 2500 nm. However, the reflection begins to fall off from about 2000 nm on.

5.2 Ports

Different ports are used depending on the application respectively configuration of the spheres.

The ports are defined by their position at the sphere and their diameters. The position of the ports is described by their position in a polar coordinate system. The pole of the spheres always points upright and lies in the parting plane of the two hemispheres. The position results from the zenith angle ϑ and the mathematically positive azimuth angle φ around the sphere. The azimuth angle starts at the pole of the not movable part of the sphere respectively at the main port of the sphere. Thus it is positioned at 90/0.

The standard diameters are 20 mm, 60 mm and 100 mm.
The 1000 mm Sphere has a 125 mm main port, the 1600 mm sphere a 250 mm main port.

5.3 Photometry

When a luminous flux Φ is induced into the sphere the luminance within the sphere is calculated as follows:

$$L = \frac{\Phi \cdot \rho}{\pi \cdot A} \text{ in } \left[\frac{W}{m^2 \cdot sr}\right] \text{ or } \left[\frac{cd}{m^2}\right]$$

π being the projected solid angle of the sphere surface and A being the sphere surface itself.

6 List of References

DIN EN 13032	Light and lighting - Measurement and presentation of photometric data of lamps and luminaires
DIN 5032-1	Photometry – Methods of measurement
	User manual uku – opsira GmbH
	A Guide to integrating sphere - labsphere