



Illuminating
ENGINEERING SOCIETY

ANSI/IES TM-33-18

Standard Format for the Electronic Transfer of Luminaire Optical Data

ANSI/IES TM-33-18: Standard Format for the Electronic Transfer of Luminaire Optical Data



Full document details: IES TM-33 2018
Copyright Illuminating Engineering Society of North America



Documents

Document Sharing Hub

Standard Format for the Electronic Transfer of Luminaire Optical Data

Publication of this Technical Memorandum
has been approved by IES.
Suggestions for revisions
should be directed to the IES.

Prepared by the File Format Subcommittee
of the IES Computer Committee

Copyright 2018 by the Illuminating Engineering Society.

Approved by the IES Standards Committee, September 4, 2018, as a Transaction of the Illuminating Engineering Society.

Approved as an American National Standard July 27, 2018.

All rights reserved. No part of this publication may be reproduced in any form, in any electronic retrieval system or otherwise, without prior written permission of the IES.

Published by the Illuminating Engineering Society, 120 Wall Street, New York, New York 10005.

IES Standards and Guides are developed through committee consensus and produced by the IES Office in New York. Careful attention is given to style and accuracy. If any errors are noted in this document, please forward them to the IES Director of Standards at standards@ies.org or the above address, for verification and correction. The IES welcomes and urges feedback and comments.

Printed in the United States of America.

ISBN# 978-0-87995-381-2

DISCLAIMER

IES publications are developed through the consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on lighting recommendations. While the IES administers the process and establishes policies and procedures to promote fairness in the development of consensus, it makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

The IES disclaims liability for any injury to persons or property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on this document

In issuing and making this document available, the IES is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the IES undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The IES has no power, nor does it undertake, to police or enforce compliance with the contents of this document. Nor does the IES list, certify, test or inspect products, designs, or installations for compliance with this document. Any certification or statement of compliance with the requirements of this document shall not be attributable to the IES and is solely the responsibility of the certifier or maker of the statement.

**Prepared by the File Format Subcommittee
of the IES Computer Committee**

Jianzhong Jiao, *Subcommittee Chair*

Ian E. Ashdown
Willi J. Brandenburg*
Dominique Chabaud*
Oliver Dross*

Sanjay Gangadhara*
Kevin J. Garcia
Michael A. Gauvin
Groot Gregory

Dirk Hansen
Gunther Hasna*
Kei Haraguchi*
Gregg A. Hauser

Ryan Kelley
Richard J. Koshel
Julius A. Muschaweck

IES Computer Committee

Paul Erickson, *Chair*

Ian E. Ashdown
Wilson Dau
Michael A. Gauvin
Gregg A. Hauser

Jianzhong Jiao
Ryan Kelley
Randall King
Lance Livingston

Avraham Mor
David Randolph
Todd Saemisch

* Advisory Member

AMERICAN NATIONAL STANDARD

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether that person has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation to any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

CAUTION NOTICE: This American National Standard may be revised at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise, or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Contents

1.0 INTRODUCTION AND SCOPE	1
1.1 Introduction	1
1.2 Scope	1
2.0 NORMATIVE REFERENCES	1
3.0 DEFINITIONS	3
3.1 Bandpass Correction	3
3.2 Channel Multiplier	3
3.3 Dimensions	3
3.4 Document	4
3.5 Emission Areas	4
3.6 Emitter	4
3.7 Emitter Center	4
3.8 Far-field Versus Near-field	4
3.9 Geometric Center	4
3.10 Goniometer	4
3.11 Luminous	5
3.12 Photon Flux	5
3.13 Photon Intensity	5
3.14 Photon Flux Density	5
4.0 XML SCHEMA FOR LUMINAIRE OPTICAL DATA	5
4.1 Version Element	5
4.2 Header Element	5
4.2.1 Manufacturer Element	5
4.2.2 Catalog Number Element	5
4.2.3 GTIN Number Element	5
4.2.4 Description Element	6
4.2.5 Laboratory Element	6
4.2.6 Report Number Element	6
4.2.7 Report Date Element	6
4.2.8 Document Creator Element	6
4.2.9 Document Creation Date Element	6
4.2.10 Unique Identifier Element	6
4.2.11 Comment Element	6
4.2.12 Reference Element	7
4.2.13 More Information Uri Element	7
4.3 Luminaire Element	7
4.3.1 Dimensions Element	7
4.3.2 Shape Element	7
4.3.3 Number Of Emitters Element	8
4.4 Equipment Element	8
4.4.1 Goniometer Element	8

4.4.2	Integrating Sphere Element	9
4.4.3	Spectroradiometer Element	9
4.5	Emitter Element	9
4.5.1	Quantity Element	10
4.5.2	Description Element	10
4.5.3	Catalog Number Element	10
4.5.4	Rated Emitter Lumens Element	10
4.5.5	Input Wattage Element	11
4.5.6	Power Factor Element	11
4.5.7	Ballast Factor Element	11
4.5.8	Tilt Angles Element	11
4.5.9	Correlated Color Temperature Element	11
4.5.10	Color Rendering Element	11
4.5.11	D _{uv} Element	14
4.5.12	S/P Ratio Element	14
4.5.13	Data Generation Element	14
4.5.14	Luminous Data Element	15
4.5.15	Radiant Data Element	16
4.5.16	Photon Data Element	17
4.5.17	Spectral Data Element	18
4.5.18	Illuminance Data Element	19
4.5.19	Irradiance Data Element	20
4.5.20	Photon Flux Density Data Element	21
4.5.21	Spectral Irradiance Data Element	22
4.5.22	Channels Element	23
4.5.23	Emission Areas Element	24
4.5.24	Emitter Center Element	29
4.5.25	Regulatory Element	29
4.6	Custom Data Element	31
4.6.1	Name Element	31
4.6.2	Unique Identifier Element	31
4.6.3	Any Data element	31
4.7	XML Schema	32
ANNEX A – SAMPLE LUMINOUS (PHOTOMETRIC) XML DOCUMENT		47
ANNEX B (INFORMATIVE) – PHOTON FLUX		50

1.0 INTRODUCTION AND SCOPE

1.1 Introduction

The architectural and roadway lighting communities have long relied on standardized data formats for the electronic transfer of far-field photometric data and related information. These data formats include IES LM-63-02, CIBSE TM14, and EULUMDAT. Apart from a few minor revisions, these data formats have remained essentially unchanged for the past several decades.

With the introduction of solid state lighting with color-changing capabilities, there is a need to include spectral power distributions in these data representations. There is also a need to represent radiant and photosynthetically active radiation (PAR) intensity distributions for horticultural, aquacultural, and animal husbandry lighting applications.

Unfortunately, it is difficult to impossible to incorporate such information in existing photometric data standards. It is also unreasonable to develop new standards specifically for specialized applications, such as horticultural lighting. This document therefore presents a standardized data format for use with all lighting applications.

The represented data may be obtained when testing or simulating the optical characteristics of a luminaire, which may then be used with lighting design and analysis software, architectural visualization software, or optical design software.

The data are formatted in accordance with W3C Extensible Markup Language (XML) 1.1 Recommendation and the W3C XML Schema Definition Language (XSD). This allows end users to utilize and view the data directly without the need for proprietary software.

In the event of any ambiguity or discrepancy with respect to the textual specification and the XML Schema in this document, the XML Schema shall take precedence.

In the event of any ambiguity or discrepancy with respect to the description of XML or XML Schema in this document, the W3C Recommendations shall take precedence.

1.2 Scope

This document specifies an electronic (XML-based) data format for the transfer of luminaire optical data useful for lighting design and analysis.

Details about the XML document format, XML schema, XSLT transforms and more can be found at the website of the W3C (see **Sections 2.15** and **2.16**), the authority for the XML document format. This document is intended as a description of a specific implementation of an XML document, and is not a tutorial on the XML document format itself.

2.0 NORMATIVE REFERENCES

2.1 ANSI C78.377-2017

National Electrical Manufacturers Association. American National Standard for Electric Lamps – Specifications for the Chromaticity of Solid-State Lighting Products. Rosslyn, Virginia: The Association; 2017.

2.2 ANSI/ASABE S640

American Society of Agricultural and Biological Engineers. Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms). St. Joseph, MI: The Society; 2017.

ANSI/IES TM-33-18

2.3 ANSI/IES RP-16-17

Illuminating Engineering Society. Nomenclature and Definitions for Illuminating Engineering. New York: IES; 2017. (<https://www.ies.org/standards/ansi-ies-rp-16/>).

2.4 CIE 13.3-1995

International Commission on Illumination. Method of Measuring and Specifying Colour Rendering Properties of Light Sources. Vienna: The Commission; 1995.

2.5 CIE 15:2004, 3rd ed.

International Commission on Illumination. Colorimetry. Vienna: The Commission; 2004.

2.6 CIE 63-1984

International Commission on Illumination. The Spectroradiometric Measurement of Light Sources. Vienna: The Commission; 1984.

2.7 CIE 117-1995

International Commission on Illumination. Discomfort Glare in Interior Lighting. Vienna: The Commission; 1995.

2.8 CIE 121-1996

International Commission on Illumination. The Photometry and Goniophotometry of Luminaires. Vienna: The Commission; 1996.

2.9 CIE 224-2017

International Commission on Illumination. CIE 2017 Colour Fidelity Index for Accurate Scientific Use. Vienna: The Commission; 2017.

2.10 ANSI/IES LM-63-02/R08

Illuminating Engineering Society. Standard File Format for Electronic Transfer of Photometric Data. New York: IES; 2002.

2.11 IES LM-75-01

Illuminating Engineering Society. Goniophotometer Types and Photometric Coordinates. New York: IES; 2001.

2.12 IES TM-27-14

Illuminating Engineering Society. IES Standard Format for the Electronic Transfer of Spectral Data. New York: IES; 2014.

2.13 ANSI/IES TM-30-18

Illuminating Engineering Society. IES Method for Evaluating Light Source Color Rendition. New York: IES; 2015.

2.14 RFC 4122

Leach P, Mealling M, Salz R. A Universally Unique Identifier (UUID) URN Namespace. Internet Engineering Task Force; July 2015. (RFC 4122).

2.15 W3C Extensible Markup Language (XML) 1.1, 2nd ed.

(<http://www.w3.org/TR/xml11>).

2.16 W3C XML Schema Definition Language (XSD) 1.1. Part 1: Structures

(<http://www.w3.org/TR/xmlschema11-1>).

2.17 W3C XML Schema Definition Language (XSD) 1.1. Part 2: Datatypes

(<http://www.w3.org/TR/xmlschema11-2>).

3.0 DEFINITIONS

3.1 bandpass correction

The correction of measured spectral data to account for the bandpass width of the detector element and the scanning interval. There are several methods of bandpass correction, and this correction is usually performed either in the measurement equipment itself or by the data processing software.

3.2 channel multiplier

A number between 0 and 1 that represents the contribution of a single-channel emitter to the measured or simulated spatial intensity distribution and flux of a multichannel luminaire. For example, if a three-channel theatrical luminaire with independently dimmable red, green, and blue light emitting diode light (LED) emitters generates 1,000 lumens of white light with a correlated color temperature (CCT) of 6500 K, the corresponding channel multipliers might be 0.63, 0.74, and 1.00 respectively.

3.3 dimensions

For the purposes of this document, a luminaire shall be represented as a rectangular or cylindrical object with dimensions of length, width, and (optionally) height, as shown in **Figure 1**, where the width dimension is parallel to the 0 – 180 degrees axis of the intensity distribution, and the length dimension is parallel to the 90 – 270 degrees axis of the intensity distribution. (This convention conforms with CIE 121-1996; see **Section 2.8**.)

Note: The purpose of this geometric object is to represent planar surfaces for the emission areas (see **Section 3.5**). It is not intended to represent the physical geometry of the luminaire housing.

The x-y-z coordinate system consists of the x-axis aligned with 0 degrees horizontal, the y-axis aligned with 90 degrees horizontal, and the z-axis aligned with zenith (+90 degrees vertical). The origin is coincident with

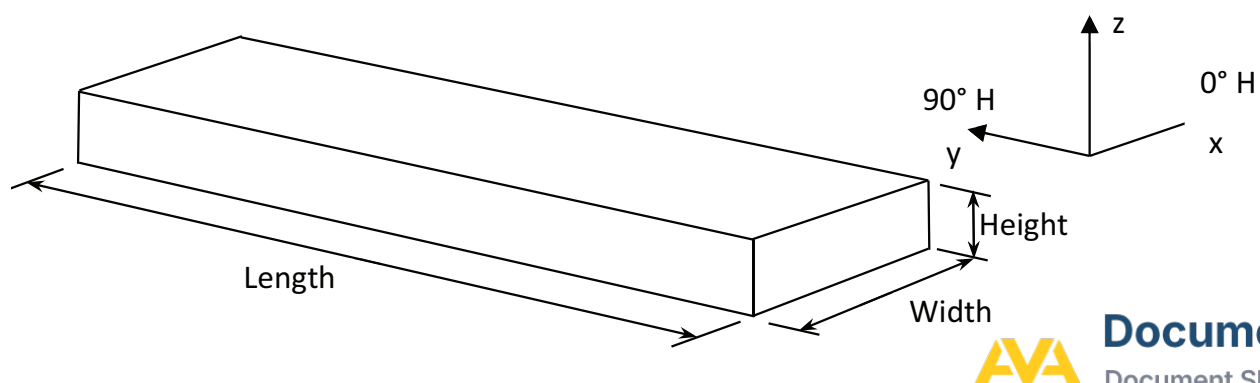


Figure 1. Luminaire dimensions.

the geometric center of the rectangular or cylindrical object (which may be different from the emitter center used for measurement purposes).

The four side faces of the enclosing box shall be identified as:

- C0 Perpendicular to 0-degree (+x) axis
- C90 Perpendicular to 90-degree (+y) axis
- C180 Perpendicular to 180-degree (-x) axis
- C270 Perpendicular to 270-degree (-y) axis

All dimensions shall be expressed in meters.

3.4 document

Instead of using *file* as the description for this data storage mechanism, the term *document* will be used. The term *document* is more appropriate when the information may not actually exist as a physical file, but may instead be generated dynamically and electronically transmitted.

3.5 emission areas

The emission areas of a specified face of the luminaire are the areas from which optical radiation is emitted. Multiple emission areas per face are allowed, including rectangular and elliptical shapes. They are intended primarily for use in CIE Unified Glare Rating (UGR) and similar glare calculations.

3.6 emitter

Any device that emits electromagnetic (“optical”) radiation within the wavelength range of 100 nm to 1,000 μm .

Note: A device that emits optical radiation within the wavelength range of 380 nm to 780 nm (that is, visible light) may also be referred to as a *light source*.

3.7 emitter center

The emitter center represents the origin for intensity distribution measurements. It may be offset from the geometric center of the rectangular or cylindrical luminaire representation. Also referred to as the *photometric center* for goniophotometric applications, it is the point in a luminaire or emitter from which the inverse square law operates most closely in the direction of maximum intensity.

3.8 far-field versus near-field

Far-field intensity measurements assume a point emitter. In practice, the distance from the emitter to the sensor should be at least five times the largest diagonal dimension of the emission area (i.e., the “five-times” rule for goniophotometry).

Near-field illuminance, irradiance, photon flux density, and spectral irradiance measurements are typically made on a regular grid on a plane. No assumptions are made about the dimensions or geometry of the emitter(s).

3.9 geometric center

The geometric center is the center of the rectangular or cylindrical object defining the luminaire dimensions.

3.10 gonioradiometer

For the purpose of this document: an instrument for measuring the directional radiant intensity, spectral radiant intensity, or spectrally weighted radiant intensity distribution of an emitter. This definition encompasses goniophotometers, gonioradiometers, and goniospectroradiometers.

3.11 luminous

For the purpose of this document, the term *luminous* is synonymous with *photometric*.

3.12 photon flux

Photon flux, also known as quantum flux, is the rate of flow of photons. It is analogous to radiant flux, except that it is measured in micromoles of photons per second ($\mu\text{mol/s}$) rather than joules of energy per second (watts). (See **Annex B – Photon Flux** for further information.)

3.13 photon intensity

The photon flux emitted by an emitter in a given direction. It is measured in micromoles of photons per second per steradian ($\mu\text{mol/s}\cdot\text{sr}$). Analogous to radiant intensity.

3.14 photon flux density

The areal density of photon flux incident upon a real or imaginary surface. It is measured in micromoles of photons per second per square meter ($\mu\text{mol/sec}\cdot\text{m}^2$). Analogous to irradiance.

4.0 XML SCHEMA FOR LUMINAIRE OPTICAL DATA

The luminaire optical data document follows the W3C XML Schema presented in **Section 4.7**.

The XML document is separated into six elements:

1. The required `Version` element, which identifies the XML schema version
2. The required `Header` element, which contains all generic information about the luminaire
3. The optional `Luminaire` element, which contains information about the luminaire dimensions, shape, and number of emitters
4. The optional `Equipment` element, which contains information about the measurement equipment used to perform the optical measurements
5. The required `Emitter` element, which contains information about the emitter(s), including generic information, intensity distribution data, and spectral power distribution data
6. The optional `CustomData` element, which contains information specific to a particular application; for example, government-mandated environmental criteria

4.1 Version Element

The required `Version` element identifies the XML schema version. For the purpose of the data storage documents described in this TM, it is always “1.1”.

4.2 Header Element

The required `Header` element is the parent of the document header section. This section contains information that is not specific to the luminaire data. Header elements are listed in **Table 1**.

4.2.1 Manufacturer Element. The optional `Manufacturer` element identifies the manufacturer of the luminaire or emitter.

4.2.2 Catalog Number Element. The optional `CatalogNumber` element identifies the manufacturer’s product catalog number.

4.2.3 GTIN Number Element. The optional `GTINNumber` element identifies the Global Trade Item Number (GTIN) of the luminaire or emitter.

Table 1. Header Element Fields

Element Description	Element Name	Data Type	Required	Document Section
Manufacturer	Manufacturer	xs:string	Optional	4.2.1
Catalog Number	CatalogNumber	xs:string	Optional	4.2.2
GTIN Number	GTINNumber	xs:integer	Optional	4.2.3
Description	Description	xs:string	Yes	4.2.4
Laboratory	Laboratory	xs:string	Yes	4.2.5
Report Number	ReportNumber	xs:string	Yes	4.2.6
Report Date	ReportDate	xs:date	Yes	4.2.7
Document Creator	DocumentCreator	xs:string	Optional	4.2.8
Document Creation Date	DocumentCreationDate	xs:date	Optional	4.2.9
Unique Identifier	UniqueIdentifier	xs:string	Optional	4.2.10
Comment	Comment	xs:string	Optional	4.2.11
Reference	Reference	xs:string	Optional	4.2.12
More Information URI	MoreInfoURI	xs:anyURI	Optional	4.2.13

4.2.4 Description Element. The required `Description` element contains a text description of the luminaire or emitter.

4.2.5 Laboratory Element. The required `Laboratory` element identifies the testing laboratory name that performed the data measurements. If the data was generated from a computer simulation and not tested at a laboratory, this field shall contain the name of the company that generated the data.

4.2.6 Report Number Element. The required `ReportNumber` element identifies the testing laboratory report number.

4.2.7 Report Date Element. The required `ReportDate` element identifies the testing laboratory report date using the XSD Date data type, YYYY-MM-DD.

4.2.8 Document Creator Element. The optional `DocumentCreator` element identifies the creator of the document, which may be a test lab, a research group, a standard body, a company, or an individual.

4.2.9 Document Creation Date Element. The optional `DocumentCreationDate` element identifies the document creation date using the XSD Date data type, YYYY-MM-DD.

4.2.10 Unique Identifier Element. The optional `UniqueIdentifier` element contains a Universally Unique Identifier (UUID), as defined by RFC 4122 (see **Section 2.14**). Most scientific programming language libraries include functions that will automatically generate UUIDs.

A UUID is a unique 128-bit value expressed as a string with 32 hexadecimal digits in the format xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx. For example:

21EC2020-3AEA-4069-A2DD-08002B30309D

The intent of the UUID is to uniquely identify the document's measurement data. The document creator shall generate a new UUID whenever the document's measurement data is modified.

4.2.11 Comment Element. The optional `Comment` element provides arbitrary additional information relating to the tested and reported data.

Multiple `Comment` elements are allowed.

4.2.12 Reference Element. The optional `Reference` element identifies one or more regulatory standards or other documents with which the luminaire or emitter complies, or the regulatory standards or other documents to which the laboratory measurements conform. This may, for example, be a document name or a web address.

Multiple `Reference` elements are allowed.

4.2.13 More Information URI Element. The optional `MoreInfoURI` element provides a Uniform Resource Identifier (URI) address for further luminaire information.

4.3 Luminaire Element

The optional `Luminaire` element is the parent of the luminaire data. Elements are detailed in **Table 2**.

Table 2. Luminaire Fields

Element Description	Element Name	Data Type	Required	Document Section
Dimensions	<code>Dimensions</code>	XML Element	Yes	4.3.1
Shape	<code>Shape</code>	xs:string	Optional	4.3.2
Number of Emitters	<code>NumEmitter</code>	xs:int	Yes	4.3.3

4.3.1 Dimensions Element. The required `Dimensions` element is the parent of the luminaire dimensions data. Elements are detailed in **Table 3**.

Table 3. Dimensions Fields

Element Description	Element Name	Data Type	Required	Document Section
Length	<code>Length</code>	xs:decimal	Yes	4.3.1.1
Width	<code>Width</code>	xs:decimal	Yes	4.3.1.2
Height	<code>Height</code>	xs:decimal	Yes	4.3.1.3

4.3.1.1 Length Element. The required `Length` element specifies the length of the luminaire housing in meters.

4.3.1.2 Width Element. The required `Width` element specifies the width of the luminaire housing in meters.

4.3.1.3 Height Element. The required `Height` element specifies the height of the luminaire housing in meters. (To support legacy photometric data file formats, the value of this element may be zero.)

4.3.2 Shape Element. The luminaire may optionally be represented as an axis-aligned cylindrical object.

The optional `Shape` element identifies the aligned axis (see **Figure 2**). Valid values are listed in **Table 4**.

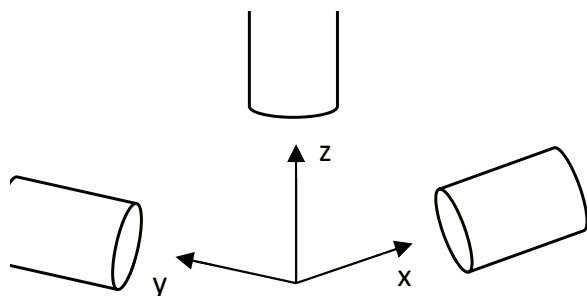


Figure 2. Axis-aligned cylindrical luminaire orientations.

Table 4: Shape Types

Type	Description
Align_X	Luminaire is circular in the y-z plane
Align_Y	Luminaire is circular in the x-z plane
Align_Z	Luminaire is circular in the x-y plane

4.3.3 Number of Emitters Element. The required `NumEmitter` element specifies the number of `Emitter` elements. (See **Section 4.5** for details.)

4.4 Equipment Element

The optional `Equipment` element is the parent of measurement equipment data. Elements are detailed in **Table 5**.

Table 5. Equipment Fields

Element Description	Element Name	Data Type	Required	Document Section
Gonioradiometer	<code>Gonioradiometer</code>	XML Element	Optional	4.4.1
Integrating Sphere	<code>IntegratingSphere</code>	XML Element	Optional	4.4.2
Spectroradiometer	<code>Spectroradiometer</code>	XML Element	Optional	4.4.3

4.4.1 Gonioradiometer Element. The optional `Gonioradiometer` element is the parent of gonioradiometric data. This element contains information that is specific to the gonioradiometer data. Elements are detailed in **Table 6**.

Table 6. Gonioradiometer Fields

Element Description	Element Name	Data Type	Required	Document Section
Type	<code>Type</code>	xs:string	Yes	4.4.1.1
Measurement Equipment	<code>MeasurementEquipment</code>	xs:string	Optional	4.4.1.2

4.4.1.1 Type Element. The required `Type` element identifies the gonioradiometer type. Valid values are listed in **Table 7**.

Table 7. Gonioradiometer Types

Type	Reference
CIE_A	CIE 121-1996
CIE_B	CIE 121-1996
CIE_C	CIE 121-1996
IES_A	IES LM-75-01
IES_B	IES LM-75-01
IES_C	IES LM-75-01
CUSTOM	Not applicable

4.4.1.2 Measurement Equipment Element. The optional `MeasurementEquipment` element contains a description of the equipment used to measure the gonioradiometric data.

Multiple `MeasurementEquipment` elements are allowed.

4.4.2 Integrating Sphere Element. The optional `IntegratingSphere` element is the parent of integrating sphere data. Elements are detailed in **Table 8**.

Table 8: Integrating Sphere Fields

Element Description	Element Name	Data Type	Required	Document Section
Measurement Equipment	<code>MeasurementEquipment</code>	xs:string	Yes	4.4.2.1

4.4.2.1 Measurement Equipment Element. The required `MeasurementEquipment` element contains a description of the equipment used to measure the integrating sphere data.

Multiple `MeasurementEquipment` elements are allowed.

4.4.3 Spectroradiometer Element. The optional `Spectroradiometer` element is the parent of spectroradiometer data. Elements are detailed in **Table 9**.

Table 9: Spectroradiometer Fields

Element Description	Element Name	Data Type	Required	Document Section
Measurement Equipment	<code>MeasurementEquipment</code>	xs:string	Optional	4.4.3.1
Bandwidth FWHM	<code>BandwidthFWHM</code>	xs:decimal	Optional	4.4.3.2
Bandwidth Corrected	<code>BandwidthCorrected</code>	xs:boolean	Optional	4.4.3.3
Bandwidth Method	<code>BandwidthMethod</code>	xs:string	Optional	4.4.3.4

4.4.3.1 Measurement Equipment Element. The optional `MeasurementEquipment` element contains a description of the equipment used to measure the spectral data.

Multiple `MeasurementEquipment` elements are allowed.

4.4.3.2 Bandwidth FWHM Element. The optional `BandwidthFWHM` attribute specifies the spectroradiometer full-width half-maximum bandwidth in nanometers.

4.4.3.3 Bandwidth Corrected Element. The optional `BandwidthCorrected` attribute specifies that bandwidth correction has been applied to the measured data.

4.4.3.4 Bandwidth Method Element. The optional `BandwidthMethod` attribute documents the bandwidth correction method.

4.5 Emitter Element

The required `Emitter` element is the parent of emitter data. Elements are detailed in **Table 10**.

Multiple `Emitter` elements are allowed as per `NumEmitter` element (**Section 4.3.3**).

Table 10. Light Source Fields

Element Description	Element Name	Data Type	Required	Document Section
Quantity	Quantity	xs:int	Yes	4.5.1
Description	Description	xs:string	Yes	4.5.2
Catalog Number	CatalogNumber	xs:string	Optional	4.5.3
Rated Lumens	RatedLumens	xs:decimal	Optional	4.5.4
Input Wattage	InputWattage	xs:decimal	Yes	4.5.5
Power Factor	PowerFactor	xs:decimal	Optional	4.5.6
Ballast Factor	BallastFactor	xs:decimal	Optional	4.5.7
Tilt Angles	TiltAngles	XML Element	Optional	4.5.8
Correlated Color Temperature (CCT)	ColorTemperature	XML Element	Optional	4.5.9
Color Rendering	ColorRendering	XML Element	Optional	4.5.10
Duv	Duv	xs:decimal	Optional	4.5.11
S/P Ratio	SPRatio	xs:decimal	Optional	4.5.12
Data Generation	DataGeneration	XML Element	Optional	4.5.13
Luminous Data	LuminousData	XML Element	Optional	4.5.14
Radiant Data	RadiantData	XML Element	Optional	4.5.15
Photon Data	PhotonData	XML Element	Optional	4.5.16
Spectral Data	SpectralData	XML Element	Optional	4.5.17
Illuminance Data	IllumData	XML Element	Optional	4.5.18
Irradiance Data	IrradData	XML Element	Optional	4.5.19
Photon Flux Density Data	PFDDData	XML Element	Optional	4.5.20
Spectral Irradiance Data	SpecIrradData	XML Element	Optional	4.5.21
Channels	Channels	XML Element	Optional	4.5.22
Emission Areas	EmissionAreas	XML Element	Optional	4.5.23
Emitter Center	EmitterCenter	XML Element	Optional	4.5.24
Regulatory	Regulatory	XML Element	Optional	4.2.25

Note: The `Emitter` element shall include at least one of the following elements: `LuminousData`, `RadiantData`, `PhotonData`, `SpectralData`, `IllumData`, `IrradData`, `PFDDData`, and `SpecIrradData`.

4.5.1 Quantity Element. The required `Quantity` element specifies the number of emitters.

4.5.2 Description Element. The required `Description` element describes the emitter type.

4.5.3 Catalog Number Element. The optional `CatalogNumber` element specifies the emitter manufacturer's catalog number.

4.5.4 Rated Emitter Lumens Element. The optional `RatedLumens` element specifies the manufacturer's rated emitter lumens. For variable-CCT emitters, this value shall be the maximum rated emitter lumens.

4.5.5 Input Wattage Element. The required `InputWattage` element specifies the input wattage.

4.5.6 Power Factor Element. The optional `PowerFactor` element specifies the power factor.

4.5.7 Ballast Factor Element. The optional `BallastFactor` element specifies the ratio of the flux emitted by the emitter when operated with a commercial ballast to the flux emitted by the same emitter when operated with a standard (reference) ballast used for rating lamp lumens. For application purposes, the ballast factor is used to adjust the emitter performance data from laboratory test conditions to actual field conditions.

4.5.8 Tilt Angles Element. The optional `TiltAngles` element is the parent of the emitter tilt angle data. Elements are detailed in **Table 11**.

Table 11. Tilt Angle Fields

Element Description	Element Name	Data Type	Required	Document Section
Number of Angles	<code>NumberAngles</code>	xs:int	Yes	4.5.8.1
Tilt	<code>Tilt</code>	XML Element	Yes	4.5.8.2

4.5.8.1 Number of Angles Element. The required `NumberAngles` element specifies the number of tilt angles.

4.5.8.2 Tilt Element. The required `Tilt` element specifies the emitter intensity multiplier for the specified tilt angle (in degrees). For example:

```
<Tilt angle="30.0">0.87</Tilt>
```

4.5.9 Correlated Color Temperature Element. The optional `ColorTemperature` element is the parent of the correlated color temperature (CCT) range data. Elements are detailed in **Table 12**.

Table 12. Correlated Color Temperature Range Fields

Element Description	Element Name	Data Type	Required	Document Section
Fixed CCT	<code>FixedCCT</code>	xs:int	Optional	4.5.9.1
Minimum CCT	<code>MinCCT</code>	xs:int	Optional	4.5.9.2
Maximum CCT	<code>MaxCCT</code>	xs:int	Optional	4.5.9.3

4.5.9.1 Fixed CCT Element. The optional `FixedCCT` element specifies the correlated color temperature of a fixed-CCT emitter.

4.5.9.2 Minimum CCT Element. The optional `MinCCT` element specifies the minimum correlated color temperature of a variable-CCT emitter.

4.5.9.3 Maximum CCT Element. The optional `MaxCCT` element specifies the maximum correlated color temperature of a variable-CCT emitter.

4.5.10 Color Rendering Element. The optional `ColorRendering` element is the parent of color rendering metrics data. Elements are detailed in **Table 13**.

Table 13. Color Rendering Metrics Fields

Element Description	Element Name	Data Type	Required	Document Section
CIE CRI	<code>CIE_CRI</code>	XML Element	Optional	4.5.10.1
IES TM-30	<code>IES_TM30</code>	XML Element	Optional	4.5.10.2

4.5.10.1 CIE CRI Element. The optional `CIE_CRI` element is the parent of CIE Colour Rendering Indices data. Elements are detailed in **Table 14**.

Table 14. CIE CRI Fields

Element Description	Element Name	Data Type	Required	Document Section
R_a	Ra	xs:int	Yes	4.5.10.1.1
R_9	R9	xs:int	Optional	4.5.10.1.2

4.5.10.1.1 R_a Element. The required `Ra` element specifies the CIE General Colour Rendering Index, R_a .

4.5.10.1.2 R_9 Element. The optional `R9` element specifies the CIE Special Colour Rendering Index R_9 .

4.5.10.2 IES_TM-30 Element. The optional `IES_TM30` element is the parent of IES TM-30 color rendering metrics data. Elements are detailed in **Table 15**.