ALL THINGS LIGHTING ASSOCIATION

Illuminating the Complicated

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ATLA S001-A

AMENDMENT TO STANDARD FORMAT FOR THE ELECTRONIC TRANSFER OF LUMINAIRE OPTICAL DATA, INCLUDING JSON SPECIFICATION

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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, aquaculture, 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, and optical design software.

The data is 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 W3C's website, 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

ANSI C78.377-2017. American National Standard for Electric Lamps – Specifications for the Chromaticity of Solid-State Lighting Products. Rosslynn, Virginia: National Electrical Manufacturers Association.

ANSI/ASABE [S640]. Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms). St. Joseph, MI: American Society of Agricultural and Biological Engineers.

ANSI/IES RP-16-17, Nomenclature and Definitions for Illuminating Engineering. New York: Illuminating Engineering Society of North America.

CIE 13.3-1995. Method of Measuring and Specifying Colour Rendering Properties of Light Sources. Commission Internationale de l'Eclairage, Vienna, Austria.

CIE 15:2004, Third Edition. Colorimetry. Commission Internationale de l'Eclairage, Vienna, Austria.

CIE 63-1984. The Spectroradiometric Measurement of Light Sources. Commission Internationale de l'Eclairage, Vienna, Austria.

CIE 117-1995. Discomfort Glare in Interior Lighting. Commission Internationale de l'Eclairage, Vienna, Austria.

CIE 121-1996. The Photometry and Goniophotometry of Luminaires. Commission Internationale de l'Eclairage, Vienna, Austria.

CIE 224-2017. CIE 2017 Colour Fidelity Index for Accurate Scientific Use. Commission Internationale de l'Eclairage, Vienna, Austria.

ECMA-404. The JSON Data Interchange Syntax, Second Edition. (http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-404.pdf)

IES LM-63-02. Standard File Format for Electronic Transfer of Photometric Data. New York: Illuminating Engineering Society of North America.

IES LM-75-01. Goniophotometer Types and Photometric Coordinates. New York: Illuminating Engineering Society of North America.

IES TM-27-14. IES Standard Format for the Electronic Transfer of Spectral Data. New York: Illuminating Engineering Society of North America.

IES TM-30-15. IES Method for Evaluating Light Source Color Rendition. New York: Illuminating Engineering Society of North America.

IES TM-33-18. IES Standard Format for the Electronic Transfer of Luminaire Optical Data. New York: Illuminating Engineering Society of North America.

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

W3C Extensible Markup Language (XML) 1.1, Second Edition (http://www.w3.org/TR/xml11).

W3C XML Schema Definition Language (XSD) 1.1 Part 1: Structures (http://www.w3.org/TR/xmlschema11-1).

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 channel multiplier is a number between zero and one 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 emitters generates 1,000 lumens of white light with a CCT of 6500K, 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 FIG. 1:

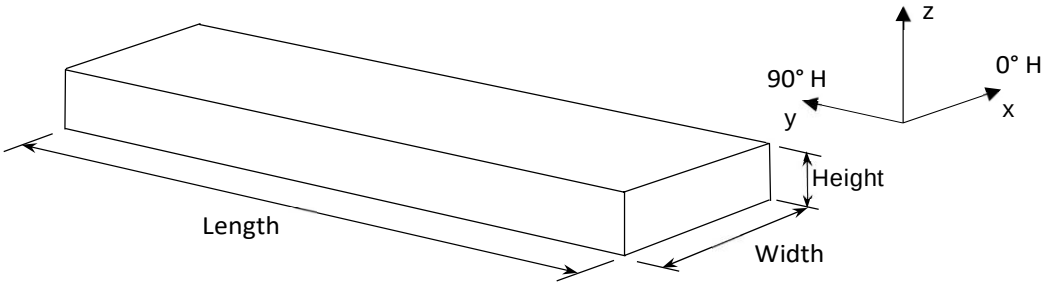

Figure 1 – Luminaire dimensions

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.)

NOTE: The purpose of this geometric object is to represent planar surfaces for the emission areas (see Clause 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 the geometric centre of the rectangular or cylindrical object (which may be different from the emitter centre 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 Emitter

Any device that emits electromagnetic (“optical”) radiation within the wavelength range of 100 nm to 1000µm.

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.”

3.6 Emitter Centre

The emitter centre represents the origin for intensity distribution measurements. It may be offset from the geometric centre of the rectangular or cylindrical luminaire representation. Also referred to as the “photometric centre” 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.

3.7 Emission Areas

The emission areas of a specified face of the luminaire are the areas from which electromagnetic 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 visual glare calculations.

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, or 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 Centre

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

3.10 Gonioradiometer

For the purposes of this document, a gonioradiometer is defined as an instrument for measuring the directional radiant intensity, spectral radiant intensity, or spectrally-weighted radiant intensity distribution of an emitter. The 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 (µmol/sec) rather than joules of energy per second (watts). See Annex B, Photon Flux, for further information.

3.13 Photon Intensity

Photon intensity is analogous to radiant intensity, except that it is the photon flux emitted by an emitter in a given direction. It is measured in micromoles of photons per second per steradian (µmol/sec-sr).

3.14 Photon Flux Density

Photon flux density is analogous to irradiance, except that it is 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 (µmol/sec/m^2).

4.0 XML Schema for Luminaire Optical Data

The luminaire optical data document is defined in terms of 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; and

6. The optional `CustomData` element, which contains information specific to a particular application, such as for example government-mandated environmental criteria.

4.1 Version Element

The required `Version` element identifies the XML schema version. It must be "1.0".

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.

Table 1: Header Element Fields

Element Description	Element Name	Data Type	Required	Document Section
Manufacturer	`Manufacturer`	xs:string	Optional	4.2.1
Catalogue Number	`CatalogNumber`	xs:string	Optional	4.2.2
GTIN Number	`GTIN`	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

4.2.1 Manufacturer Element

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

4.2.2 Catalogue Number Element

The optional `CatalogNumber` element identifies the manufacturer's product catalogue number.

4.2.3 GTIN Number Element

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

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. 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.

The document creator shall also generate a new UUID whenever an existing photometric data file is converted to this standard.

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	`Dimensions`	XML Element	Yes	4.3.1
Shape	`Shape`	xs:string	Optional	4.3.2
Number Emitters	`NumEmitter`	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	`Length`	xs:decimal	Yes	4.3.1.1
Width	`Width`	xs:decimal	Yes	4.3.1.2
Height	`Height`	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.

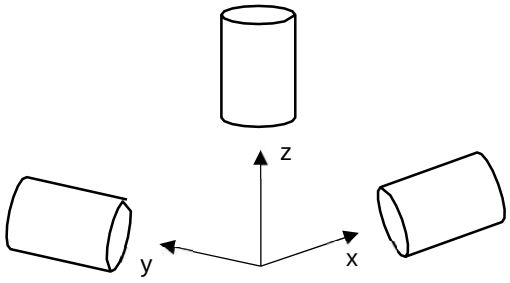

Figure 2 – Axis-aligned cylindrical luminaire orientations

The optional `Shape` element identifies the aligned axis. Valid values are listed in Table 4.

Table 4: Shape Types

Type	Description
`Align_X`	Luminaire is cylindrical in y-z plane
`Align_Y`	Luminaire is cylindrical in x-z plane
`Align_Z`	Luminaire is cylindrical in x-y plane

4.3.3 Number 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	`Gonioradiometer`	XML Element	Optional	4.4.1
Integrating Sphere	`IntegratingSphere`	XML Element	Optional	4.4.2
Spectroradiometer	`Spectroradiometer`	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	`Type`	xs:string	Yes	4.4.1.1
Measurement Equipment	`MeasurementEquipment`	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	`MeasurementEquipment`	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	`MeasurementEquipment`	xs:string	Yes	4.4.3.1
Bandwidth FWHM	`BandwidthFWHM`	xs:decimal	Optional	4.4.3.2
Bandwidth Corrected	`BandwidthCorrected`	xs:boolean	Optional	4.4.3.3
Bandwidth Method	`BandwidthMethod`	xs:string	Optional	4.4.3.4

4.4.3.1 Measurement Equipment Element

The required `MeasurementEquipment` element contains a description of the equipment used to measure the spectral data.

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: Emitter 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
Catalogue 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
Color Temperature	`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
Angular Color Data	`AngularColor`	XML Element	Optional	4.5.18
Illuminance Data	`IllumData`	XML Element	Optional	4.5.19

Irradiance Data	IrradData	XML Element	Optional	4.5.20
Photon Flux Density Data	PFDData	XML Element	Optional	4.5.21
Spectral Irradiance Data	SpecIrradData	XML Element	Optional	4.5.22
Channels	Channels	XML Element	Optional	4.5.23
Emission Areas	EmissionAreas	XML Element	Optional	4.5.24
Emitter Centre	EmitterCenter	XML Element	Optional	4.5.25
Regulatory	Regulatory	XML Element	Optional	4.5.26

NOTE: The Emitter element must include at least one of LuminousData, RadiantData, PhotonData, SpectralData, AngularColor, IllumData, IrradData, PFDData, and SpecIrradData elements.

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 Catalogue Number Element

The optional CatalogNumber element specifies the emitter manufacturer's catalogue 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 compared 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 Angles	NumberAngles	xs:int	Yes	4.5.8.1
Tilt	Tilt	XML Element	Yes	4.5.8.2

4.5.8.1 Number 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	FixedCCT	xs:int	Optional	4.5.9.1
Minimum CCT	MinCCT	xs:int	Optional	4.5.9.2
Maximum CCT	MaxCCT	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 the 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	CIE_CRI	XML Element	Optional	4.5.10.1
IES_TM30	IES_TM30	XML Element	Optional	4.5.10.2

4.5.10.1 CIE_CRI Element

The optional CIE_CRI element is the parent of the 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

Ra	Ra	xs:int	Yes	4.5.10.1.1
R9	R9	xs:int	Optional	4.5.10.1.2

4.5.10.1.1 Ra Element

The required Ra element specifies the CIE General Colour Rendering Index Ra.

4.5.10.1.2 R9 Element

The optional R9 element specifies the CIE Special Colour Rendering Index R9.

4.5.10.2 IES_TM30 Element

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

Table 15: IES_TM30 Fields

Element Description	Element Name	Data Type	Required	Document Section
Rf	Rf	xs:int	Yes	4.5.10.2.1
Rg	Rg	xs:int	Yes	4.5.10.2.2
Rfh01	Rfh01	xs:int	Optional	4.5.10.2.3
Rfh02	Rfh02	xs:int	Optional	4.5.10.2.3
Rfh03	Rfh03	xs:int	Optional	4.5.10.2.3
Rfh04	Rfh04	xs:int	Optional	4.5.10.2.3
Rfh05	Rfh05	xs:int	Optional	4.5.10.2.3
Rfh06	Rfh06	xs:int	Optional	4.5.10.2.3
Rfh07	Rfh07	xs:int	Optional	4.5.10.2.3
Rfh08	Rfh08	xs:int	Optional	4.5.10.2.3
Rfh09	Rfh09	xs:int	Optional	4.5.10.2.3
Rfh10	Rfh10	xs:int	Optional	4.5.10.2.3
Rfh11	Rfh11	xs:int	Optional	4.5.10.2.3
Rfh12	Rfh12	xs:int	Optional	4.5.10.2.3
Rfh13	Rfh13	xs:int	Optional	4.5.10.2.3
Rfh14	Rfh14	xs:int	Optional	4.5.10.2.3
Rfh15	Rfh15	xs:int	Optional	4.5.10.2.3
Rfh16	Rfh16	xs:int	Optional	4.5.10.2.3
Rcsh01	Rcsh01	xs:int	Optional	4.5.10.2.4
Rcsh02	Rcsh02	xs:int	Optional	4.5.10.2.4
Rcsh03	Rcsh03	xs:int	Optional	4.5.10.2.4
Rcsh04	Rcsh04	xs:int	Optional	4.5.10.2.4
Rcsh05	Rcsh05	xs:int	Optional	4.5.10.2.4
Rcsh06	Rcsh06	xs:int	Optional	4.5.10.2.4
Rcsh07	Rcsh07	xs:int	Optional	4.5.10.2.4
Rcsh08	Rcsh08	xs:int	Optional	4.5.10.2.4
Rcsh09	Rcsh09	xs:int	Optional	4.5.10.2.4
Rcsh10	Rcsh10	xs:int	Optional	4.5.10.2.4
Rcsh11	Rcsh11	xs:int	Optional	4.5.10.2.4
Rcsh12	Rcsh12	xs:int	Optional	4.5.10.2.4
Rcsh13	Rcsh13	xs:int	Optional	4.5.10.2.4
Rcsh14	Rcsh14	xs:int	Optional	4.5.10.2.4
Rcsh15	Rcsh15	xs:int	Optional	4.5.10.2.4
Rcsh16	Rcsh16	xs:int	Optional	4.5.10.2.4

4.5.10.2.1 Rf Element

The required `Rf` element specifies the IES TM-30 fidelity index Rf.

4.5.10.2.2 Rg Element

The required `Rg` element specifies the IES TM-30 gamut index Rg.

4.5.10.3 Rfh* Elements

The optional `Rfh*` elements specify the sixteen local fidelity values within each hue-angle range.

4.5.10.2.4 Rcsh* Elements

The optional `Rcsh*` elements specify the sixteen local chroma shift values within each hue-angle range.

4.5.11 Duv Element

The optional `Duv` element specifies the closest distance of the emitter chromaticity to the Planckian locus as defined in ANSI C78.377-2017.

4.5.12 S/P Ratio Element

The optional `SPRatio` element specifies the emitter scotopic-to-photopic lumens ratio.

4.5.13 Data Generation Element

The optional `DataGeneration` element is the parent of data generation information. Elements are detailed in Table 16.

Table 16: Data Generation Fields

Element Description	Element Name	Data Type	Required	Document Section
Simulation	`Simulation`	xs:boolean	Optional	4.5.13.1
Laboratory	`Laboratory`	XML Element	Optional	4.5.13.2
Intensity Scaling	`IntensityScaling`	xs:boolean	Optional	4.5.13.3
Angle Interpolation	`AngleInterpolation`	xs:boolean	Optional	4.5.13.4

4.5.13.1 Simulation Element

The optional `Simulation` element, if true, indicates that the intensity data was generated by means of a computer simulation rather than measured.

4.5.13.2 Laboratory Element

The optional `Laboratory` element is the parent of the Laboratory Certification data. Elements are detailed in Table 17.

Table 17: Laboratory Fields

Element Description	Element Name	Data Type	Required	Document Section
Certification	`Certification`	xs:string	Yes	4.5.13.2.1

Approval Body	ApprovalBody	xs:string	Yes	4.5.13.2.2
Approval Scope	ApprovalScope	xs:string	Yes	4.5.13.2.3
Measurement Uncertainty	MeasUncertainty	XML Element	Yes	4.5.13.2.4

4.5.13.2.1 Certification Element

The required Certification element identifies the certification type. Valid values are listed in Table 18.

Table 18: Certification Types

Type	Element Description
Accredited	Accredited test laboratory
Associated	Associated test laboratory
Customer	Customer test facilities
None	–

4.5.13.2.2 Approval Body Element

The required ApprovalBody element identifies the approval body. For example, “NVLAP”.

4.5.13.2.3 Approval Scope Element

The required ApprovalScope element identifies the scope of the approval. For example, “IESNA LM-79 [Sections 9, 10, 12]”.

4.5.13.2.4 Measurement Uncertainty Element

The required MeasUncertainty element is the parent of the Measurement Uncertainty data. Elements are detailed in Table 19.

Multiple MeasUncertainty elements are allowed.

Table 19: Measurement Uncertainty Fields

Element Description	Element Name	Data Type	Required	Document Section
Measurement Type	MeasurementType	xs:string	Yes	4.5.13.2.4.1
Uncertainty	Uncertainty	xs:decimal	Yes	4.5.13.2.4.2

4.5.13.2.4.1 Measurement Type Element

The required MeasurementType element identifies the measurement type.

4.5.13.2.4.2 Uncertainty Element

The required Uncertainty element specifies the measurement uncertainty.

4.5.13.3 Intensity Scaling Element

The optional IntensityScaling element, if true, indicates that the reported intensity data has been uniformly scaled with respect to the laboratory measurements.

4.5.13.4 Angle Interpolation Element

The optional AngleInterpolation element, if true, indicates that the reported intensity data at the reported horizontal and/or vertical angles have been interpolated with respect to the laboratory measurements.

4.5.14 Luminous Data Element

The optional `LuminousData` element is the parent of luminous data. This element contains information that is specific to the luminous data. Elements are detailed in Table 20.

Table 20: Luminous Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Luminous Intensity	`LuminousIntensity`	XML Element	Yes	4.5.14.1
Luminous Flux	`LuminousFlux`	xs:decimal	Optional	4.5.14.2

4.5.14.1 Luminous Intensity Element

The required `LuminousIntensity` element is the parent of the luminous intensity data. Elements are detailed in Table 21.

Table 21: Luminous Intensity Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute Photometry	`AbsolutePhotometry`	xs:boolean	Yes	4.5.14.1.1
Symmetry	`Symm`	xs:string	Optional	4.5.14.1.2
Multiplier	`Multiplier`	xs:decimal	Optional	4.5.14.1.3
Number Measured	`NumberMeasured`	xs:int	Yes	4.5.14.1.4
Number Horz	`NumberHorz`	xs:int	Yes	4.5.14.1.5
Number Vert	`NumberVert`	xs:int	Yes	4.5.14.1.6
Intensity Data	`IntData`	XML Element	Yes	4.5.14.1.7

4.5.14.1.1 Absolute Photometry Element

The required `AbsolutePhotometry` element, if true, indicates that the luminous intensity measurements were performed using absolute photometry.

4.5.14.1.2 Symmetry Element

The optional `Symm` element identifies the horizontal symmetry type. Valid values for `CIE_C` and `IES_C` gonioradiometer types only are shown in Table 22.

Table 22: Symmetry Types

Type	Description
`Symm_None`	No horizontal symmetry
`Symm_Bi_0`	Symmetric about the 0-180 degree plane
`Symm_Bi_90`	Symmetric about the 90-270 degree plane
`Symm_Quad`	Symmetric in each quadrant
`Symm_Full`	Symmetric in all vertical planes
`Symm_Arbitrary`	No horizontal or vertical symmetry

If the `Symm` element is not present, the default value is `Symm_None`.

4.5.14.1.3 Multiplier Element

The optional `Multiplier` element, if present, indicates a floating-point multiplier that must be applied to the luminous intensity measurements.

If the `Multiplier` element is not present, the default value is 1.0.

4.5.14.1.4 Number Measured Element

The required `NumberMeasured` element specifies the number of luminous intensity measurements.

4.5.14.1.5 Number Horz Element

The required `NumberHorz` element specifies the number of horizontal angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.14.1.6 Number Vert Element

The required `NumberVert` element specifies the number of vertical angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.14.1.7 Intensity Data Element

The required `IntData` element specifies the luminous intensity data (in candela) for the specified horizontal and vertical angles (in degrees). The element contains the value to be reported and there are attributes for the horizontal and vertical angles this value occurs at. For example:

```
<IntData h="0.0" v="65.0">44</IntData>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the luminous intensity value.

NOTE: The `Multiplier` element enables luminous intensity values to be reported in candela per kilolumen.

Multiple `IntData` elements are allowed.

4.5.14.2 Luminous Flux Element

The optional `LuminousFlux` element specifies the luminous flux in lumens.

4.5.15 Radiant Data Element

The optional `RadiantData` element is the parent of radiant data. Elements are detailed in Table 23.

Table 23: Radiant Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Minimum Wavelength	`MinWavelength`	xs:decimal	Yes	4.5.15.1
Maximum Wavelength	`MaxWavelength`	xs:decimal	Yes	4.5.15.2
Radiant Intensity	`RadiantIntensity`	XML Element	Yes	4.5.15.3
Radiant Flux	`RadiantFlux`	xs:decimal	Optional	4.5.15.4

4.5.15.1 Minimum Wavelength Element

The required `MinWavelength` element specifies the minimum wavelength of the radiant intensity measurements in nanometers.

4.5.15.2 Maximum Wavelength Element

The required `MaxWavelength` element specifies the maximum wavelength of the radiant intensity measurements in nanometers.

4.5.15.3 Radiant Intensity Element

The required `RadiantIntensity` element is the parent of the radiant intensity data. Elements are detailed in Table 24.

Table 24: Radiant Intensity Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	`Absolute`	xs:boolean	Optional	4.5.15.3.1
Symmetry	`Symm`	xs:string	Optional	4.5.15.3.2
Multiplier	`Multiplier`	xs:decimal	Optional	4.5.15.3.3
Number Measured	`NumberMeasured`	xs:int	Yes	4.5.15.3.4
Number Horz	`NumberHorz`	xs:int	Yes	4.5.15.3.5
Number Vert	`NumberVert`	xs:int	Yes	4.5.15.3.6
Intensity Data	`IntData`	XML Element	Yes	4.5.15.3.7

4.5.15.3.1 Absolute Element

The optional `Absolute` element, if true, indicates that the radiant intensity measurements were performed using absolute radiometry.

If the `Absolute` element is not present, the default value is true.

4.5.15.3.2 Symmetry Element

The optional `Symm` element identifies the horizontal symmetry type. Valid values for `CIE_C` and `IES_C` gonioradiometer types only are shown in Table 25.

Table 25: Symmetry Types

Type	Description
`Symm_None`	No horizontal symmetry
`Symm_Bi_0`	Symmetric about the 0-180 degree plane
`Symm_Bi_90`	Symmetric about the 90-270 degree plane
`Symm_Quad`	Symmetric in each quadrant
`Symm_Full`	Symmetric in all vertical planes
`Symm_Arbitrary`	No horizontal or vertical symmetry

If the `Symm` element is not present, the default value is `Symm_None`.

4.5.15.3.3 Multiplier Element

The optional `Multiplier` element, if present, indicates a floating-point multiplier that must be applied to the radiant intensity measurements.

If the `Multiplier` element is not present, the default value is 1.0.

4.5.15.3.4 Number Measured Element

The required `NumberMeasured` element specifies the number of radiant intensity measurements.

4.5.15.3.5 Number Horz Element

The required `NumberHorz` element specifies the number of horizontal angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.15.3.6 Number Vert Element

The required `NumberVert` element specifies the number of vertical angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.15.3.7 Intensity Data Element

The required `IntData` element specifies the radiant intensity data (in watts per steradian) for the specified horizontal and vertical angles (in degrees). The element contains the value to be reported, and there are attributes for the horizontal and vertical angles this value occurs at. For example:

```
<IntData h="0.0" v="65.0">44</IntData>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the radiant intensity value.

NOTE: The `Multiplier` element enables radiant intensity values to be reported in microwatts or milliwatts per steradian.

Multiple `IntData` elements are allowed.

4.5.15.4 Radiant Flux Element

The optional `RadiantFlux` element specifies the radiant flux in watts.

4.5.16 Photon Data Element

The optional `PhotonData` element is the parent of photon data. Elements are detailed in Table 26.

Table 26: Photon Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Minimum Wavelength	`MinWavelength`	xs:decimal	Yes	4.5.16.1
Maximum Wavelength	`MaxWavelength`	xs:decimal	Yes	4.5.16.2
Photon Intensity	`PhotonIntensity`	XML Element	Yes	4.5.16.3
Photon Flux	`PhotonFlux`	xs:decimal	Optional	4.5.16.4

4.5.16.1 Minimum Wavelength Element

The required `MinWavelength` element specifies the minimum wavelength of the photon measurements in nanometers.

4.5.16.2 Maximum Wavelength Element

The required `MaxWavelength` element specifies the maximum wavelength of the photon measurements in nanometers.

4.5.16.3 Photon Intensity Element

The required `PhotonIntensity` element is the parent of the photon intensity data. Elements are detailed in Table 27.

Table 27: Photon Intensity Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	Absolute	xs:boolean	Optional	4.5.16.3.1
Symmetry	Symm	xs:string	Optional	4.5.16.3.2
Multiplier	Multiplier	xs:decimal	Optional	4.5.16.3.3
Number Measured	NumberMeasured	xs:int	Yes	4.5.16.3.4
Number Horz	NumberHorz	xs:int	Yes	4.5.16.3.5
Number Vert	NumberVert	xs:int	Yes	4.5.16.3.6
Intensity Data	IntData	XML Element	Yes	4.5.16.3.7

4.5.16.3.1 Absolute Element

The optional Absolute element, if true, indicates that the photon intensity measurements were performed using absolute radiometry.

If the Absolute element is not present, the default value is true.

4.5.16.3.2 Symmetry Element

The optional Symm element identifies the horizontal symmetry type. Valid values for CIE_C and IES_C gonioradiometer types only are shown in Table 28.

Table 28: Symmetry Types

Type	Description
Symm_None	No horizontal symmetry
Symm_Bi_0	Symmetric about the 0-180 degree plane
Symm_Bi_90	Symmetric about the 90-270 degree plane
Symm_Quad	Symmetric in each quadrant
Symm_Full	Symmetric in all vertical planes
Symm_Arbitrary	No horizontal or vertical symmetry

If the Symm element is not present, the default value is Symm_None.

4.5.16.3.3 Multiplier Element

The optional Multiplier element, if present, indicates a floating-point multiplier that must be applied to the photon intensity measurements.

If the Multiplier element is not present, the default value is 1.0.

4.5.16.3.4 Number Measured Element

The required NumberMeasured element specifies the number of photon intensity measurements.

4.5.16.3.5 Number Horz Element

The required NumberHorz element specifies the number of horizontal angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.16.3.6 Number Vert Element

The required NumberVert element specifies the number of vertical angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.16.3.7 Intensity Data Element

The required `IntData` element specifies the photon intensity data (in micromoles per steradian per second) for the specified horizontal and vertical angles (in degrees). The element contains the value to be reported and there are attributes for the horizontal and vertical angles this value occurs at. For example:

```
<IntData h="0.0" v="65.0">44</IntData>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the photon intensity value.

Multiple `IntData` elements are allowed.

4.5.16.4 Photon Flux Element

The optional `PhotonFlux` element specifies the photon flux in micromoles per second (µmol/sec).

4.5.17 Spectral Data Element

The optional `SpectralData` element is the parent of spectroradiometric data. Elements are detailed in Table 29.

Table 29: Spectral Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Spectral Intensity	`EmitterSpectral`	XML Element	Optional	4.5.17.1
Angular Spectral	`AngularSpectral`	XML Element	Optional	4.5.17.2

4.5.17.1 Emitter Spectral Element

The optional `EmitterSpectral` element is the parent of the emitter spectral data. Elements are detailed in Table 30.

Multiple `EmitterSpectral` elements are allowed.

Table 30: Emitter Spectral Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Emitter Name	`EmitterName`	xs:string	Optional	4.5.17.1.1
Number Wavelength	`NumberWavelength`	xs:int	Yes	4.5.17.1.2
Multiplier	`Multiplier`	xs:decimal	Optional	4.5.17.1.3
Normalized	`Normalized`	xs:boolean	Optional	4.5.17.1.4
Timestamp	`Timestamp`	xs:int	Optional	4.5.17.1.5
Power Data	`PwrData`	XML Element	Yes	4.5.17.1.6
Quantum	`Quantum`	xs:boolean	Optional	4.5.17.1.7

4.5.17.1.1 Emitter Name Element

The optional `EmitterName` element specifies the emitter name. For example, a multichannel theatrical luminaire may have separate color channels identified as “red,” “green,” “blue,” and “amber.”

4.5.17.1.2 Number Wavelength Element

The required `NumberWavelength` element specifies the number of wavelengths.

4.5.17.1.3 Multiplier Element

The optional `Multiplier` element, if present, indicates a floating-point multiplier that must be applied to the spectral power measurements.

If the `Multiplier` element is not present, the default value is 1.0.

4.5.17.1.4 Normalized Element

The optional `Normalized` element, if true, indicates that the spectral power data values have been normalized such that the maximum value is 1.0.

4.5.17.1.5 Timestamp Element

The optional `Timestamp` element is intended for luminous flux and color maintenance tests. The value represents the number of hours of operation from when the test procedure commenced.

4.5.17.1.6 Power Data Element

The required `PwrData` element specifies the emitter spectral data. The element contains the value to be reported (in watts per nanometer) and there is an attribute for the wavelength this value occurs at (in nanometers). For example:

```
<PwrData  w="555.0">0.053</PwrData>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the spectral power value.

NOTE: The `Multiplier` element enables spectral power values to be reported in microwatts or milliwatts per nanometer.

NOTE: If `Normalized` is true and `Multiplier` is not present, the spectral power data value is unitless.

Multiple `PwrData` elements are allowed.

4.5.17.1.7 Quantum Element

The optional `Quantum` element, if true, indicates that the spectral power data values are reported in micromoles per second per nanometer (µmol/sec-nm) rather than watts per nanometer. The emitter spectral data then represents a spectral quantum distribution (SQD) rather than a spectral power distribution (SPD).

NOTE: A normalized SPD can be converted to a normalized SQD by multiplying each spectral power data value by λ / λ_{max}, where λ is the value wavelength and λ_{max} is the peak value wavelength, and renormalizing as required.

4.5.17.2 Angular Spectral Element

The optional `AngularSpectral` element is the parent of the angular spectral radiant intensity data. Elements are detailed in Table 31.

Table 31: Angular Spectral Intensity Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	Absolute	xs:boolean	Optional	4.5.17.2.1
Symmetry	Symm	xs:string	Optional	4.5.17.2.2
Multiplier	Multiplier	xs:decimal	Optional	4.5.17.2.3
Number Measured	NumberMeasured	xs:int	Yes	4.5.17.2.4
Number Horz	NumberHorz	xs:int	Yes	4.5.17.2.5
Number Vert	NumberVert	xs:int	Yes	4.5.17.2.6
Number Wavelength	NumberWavelength	xs:int	Yes	4.5.17.2.7
Intensity Data	IntData	XML Element	Yes	4.5.17.2.8

4.5.17.2.1 Absolute Element

The optional Absolute element, if true, indicates that the angular spectral intensity measurements were performed using absolute radiometry.

If the Absolute element is not present, the default value is true.

4.5.17.2.2 Symmetry Element

The optional Symm element identifies the horizontal symmetry type. Valid values for CIE_C and IES_C gonioradiometer types only are shown in Table 32.

Table 32: Symmetry Types

Type	Description
Symm_None	No horizontal symmetry
Symm_Bi_0	Symmetric about the 0-180 degree plane
Symm_Bi_90	Symmetric about the 90-270 degree plane
Symm_Quad	Symmetric in each quadrant
Symm_Full	Symmetric in all vertical planes
Symm_Arbitrary	No horizontal or vertical symmetry

If the Symm element is not present, the default value is Symm_None.

4.5.17.2.3 Multiplier Element

The optional Multiplier element, if present, indicates a floating-point multiplier that must be applied to the angular spectral intensity measurements.

If the Multiplier element is not present, the default value is 1.0.

4.5.17.2.4 Number Measured Element

The required NumberMeasured element specifies the number of angular spectral intensity measurements.

4.5.17.2.5 Number Horz Element

The required NumberHorz element specifies the number of horizontal angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.17.2.6 Number Vert Element

The required `NumberVert` element specifies the number of vertical angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.17.2.7 Number Wavelength Element

The required `NumberWavelength` element specifies the number of wavelengths.

4.5.17.2.8 Intensity Data Element

The required `IntData` element specifies the spectral radiant intensity data (in watts per steradian per nanometer) for the specified horizontal and vertical angles (in degrees). The element contains the value to be reported and there are attributes for the horizontal and vertical angles and wavelength (in nanometers) this value occurs at. For example:

```
<IntData h="0.0" v="65.0" w="555.0">0.023</IntData>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the angular spectral intensity value.

NOTE: The `Multiplier` element enables angular spectral intensity values to be reported in microwatts or milliwatts per steradian per nanometer.

Multiple `IntData` elements are allowed.

4.5.18 Angular Color Element

The optional `AngularColor` element is the parent of angular color data. Elements are detailed in Table 33.

Table 33: Angular Color Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	`Absolute`	xs:boolean	Optional	4.5.18.1
Symmetry	`Symm`	xs:string	Optional	4.5.18.2
Multiplier	`Multiplier`	xs:decimal	Optional	4.5.18.3
Number Measured	`NumberMeasured`	xs:int	Yes	4.5.18.4
Number Horz	`NumberHorz`	xs:int	Yes	4.5.18.5
Number Vert	`NumberVert`	xs:int	Yes	4.5.18.6
Color Data	`ColorData`	XML Element	Yes	4.5.18.7

4.5.18.1 Absolute Element

The optional `Absolute` element, if true, indicates that the angular color measurements were performed using absolute photometry.

If the `Absolute` element is not present, the default value is true.

4.5.18.2 Symmetry Element

The optional `Symm` element identifies the horizontal symmetry type. Valid values for `CIE_C` and `IES_C` gonioradiometer types only are shown in Table 34.

Table 34: Symmetry Types

Type	Description

Symm_None	No horizontal symmetry
Symm_Bi_0	Symmetric about the 0-180 degree plane
Symm_Bi_90	Symmetric about the 90-270 degree plane
Symm_Quad	Symmetric in each quadrant
Symm_Full	Symmetric in all vertical planes
Symm_Arbitrary	No horizontal or vertical symmetry

If the Symm element is not present, the default value is Symm_None.

4.5.18.3 Multiplier Element

The optional Multiplier element, if present, indicates a floating-point multiplier that must be applied to the luminous intensity (CIE Y) measurements.

If the Multiplier element is not present, the default value is 1.0.

4.5.18.4 Number Measured Element

The required NumberMeasured element specifies the number of angular color measurements.

4.5.18.5 Number Horz Element

The required NumberHorz element specifies the number of horizontal angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.18.6 Number Vert Element

The required NumberVert element specifies the number of vertical angles. The value shall be zero if the measurement coordinate system does not consist of a set of planes.

4.5.18.7 Color Data Element

The required ColorData element specifies the CIE *xy* chromaticity coordinates and luminous intensity data (CIE Y, stated in candela) for the specified horizontal and vertical angles (in degrees). The element contains the value to be reported, and there are attributes for the horizontal and vertical angles, and CIE *xy* chromaticity coordinates this value occurs at. For example:

```
<ColorData h="0.0" v="65.0" x="0.435" y="0.401">65.0</ColorData>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the angular luminous intensity value.

NOTE: The Multiplier element enables luminous intensity values to be reported in candela per kilolumen.

Multiple ColorData elements are allowed.

4.5.19 Illuminance Data Element

The optional IllumData element is the parent of illuminance data. This element contains information that is specific to the illuminance data. Elements are detailed in Table 35.

Table 35: Illuminance Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	Absolute	xs:boolean	Optional	4.5.19.1
Multiplier	Multiplier	xs:decimal	Optional	4.5.19.2
Number Planes	NumberPlanes	xs:int	Yes	4.5.19.3

Plane Data	PlaneData	XML Element	Yes	4.5.19.4

4.5.19.1 Absolute Element

The optional Absolute element, if true, indicates that the illuminance measurements were performed using absolute photometry.

If the Absolute element is not present, the default value is true.

4.5.19.2 Multiplier Element

The optional Multiplier element, if present, indicates a floating-point multiplier that must be applied to the illuminance measurements.

If the Multiplier element is not present, the default value is 1.0.

4.5.19.3 Number Planes Element

The required NumberPlanes element specifies the number of measurement planes.

4.5.19.4 Plane Data Element

The required PlaneData element specifies the illuminance data for the specified measurement plane. Elements are detailed in Table 36.

Multiple PlaneData elements are allowed.

Table 36: Plane Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Plane Normal	PlaneNormal	XML Element	Optional	4.5.19.4.1
Number Measured	NumberMeasured	xs:int	Yes	4.5.19.4.2
Illuminance	Illum	XML Element	Yes	4.5.19.4.3

4.5.19.4.1 Plane Normal Element

The optional PlaneNormal element specifies coordinates of the unit plane normal with respect to the luminaire dimensions coordinate system. For example:

```
<PlaneNormal x="-1.0" y="0.0" z="0.0"/>
```

NOTE: The plane can be arbitrarily oriented with respect to the emitter.

If absent, the unit plane normal coordinates are assumed to be aligned with zenith:

```
<PlaneNormal x="0.0" y="0.0" z="1.0"/>
```

4.5.19.4.2 Number Measured Element

The required NumberMeasured element specifies the number of illuminance measurements for the specified plane.

4.5.19.4.3 Illuminance Element

The required Illum element specifies illuminance data (in candela per square meter) for the specified position. The element contains the value to be reported, and there are attributes for the plane position (in meters) this value occurs at. For example:

```
<Illum x="0.0" y="1.5" z="1.2">55</Illum>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the illuminance value.

NOTE: The `Multiplier` element enables illuminance values to be reported in candela per square meter per kilolumen.

Multiple `Illum` elements are allowed.

4.5.20 Irradiance Data Element

The optional `IrradData` element is the parent of irradiance data. This element contains information that is specific to the irradiance data. Elements are detailed in Table 37.

Table 37: Irradiance Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	`Absolute`	xs:boolean	Optional	4.5.20.1
Multiplier	`Multiplier`	xs:decimal	Optional	4.5.20.2
Minimum Wavelength	`MinWavelength`	xs:decimal	Yes	4.5.20.3
Maximum Wavelength	`MaxWavelength`	xs:decimal	Yes	4.5.20.4
Number Planes	`NumberPlanes`	xs:int	Yes	4.5.20.5
Plane Data	`PlaneData`	XML Element	Yes	4.5.20.6

4.5.20.1 Absolute Element

The optional `Absolute` element, if true, indicates that the irradiance measurements were performed using absolute photometry.

If the `Absolute` element is not present, the default value is true.

4.5.20.2 Multiplier Element

The optional `Multiplier` element, if present, indicates a floating-point multiplier that must be applied to the irradiance measurements.

If the `Multiplier` element is not present, the default value is 1.0.

4.5.20.3 Minimum Wavelength Element

The required `MinWavelength` element specifies the minimum wavelength of the irradiance measurements in nanometers.

4.5.20.4 Maximum Wavelength Element

The required `MaxWavelength` element specifies the maximum wavelength of the irradiance measurements in nanometers.

4.5.20.5 Number Planes Element

The required `NumberPlanes` element specifies the number of measurement planes.

4.5.20.6 Plane Data Element

The required `PlaneData` element specifies the irradiance data for the specified measurement plane. Elements are detailed in Table 38.

Multiple `PlaneData` elements are allowed.

Table 38: Plane Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Plane Normal	`PlaneNormal`	XML Element	Optional	4.5.20.6.1
Number Measured	`NumberMeasured`	xs:int	Yes	4.5.20.6.2
Irradiance	`Irrad`	XML Element	Yes	4.5.20.6.3

4.5.20.6.1 Plane Normal Element

The optional `PlaneNormal` element specifies coordinates of the unit plane normal with respect to the luminaire dimensions coordinate system. For example:

```
<PlaneNormal x="-1.0" y="0.0" z="0.0"/>
```

NOTE: The plane can be arbitrarily oriented with respect to the emitter.

If absent, the unit plane normal coordinates are assumed to be aligned with zenith:

```
<PlaneNormal x="0.0" y="0.0" z="1.0"/>
```

4.5.20.6.2 Number Measured Element

The required `NumberMeasured` element specifies the number of irradiance measurements for the specified plane.

4.5.20.6.3 Irradiance Element

The required `Irrad` element specifies irradiance data (in watts per square meter) for the specified position. The element contains the value to be reported, and there are attributes for the plane position (in meters) this value occurs at. For example:

```
<Irrad x="0.0" y="1.5" z="1.2">55</Irrad>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the irradiance value.

NOTE: The `Multiplier` element enables irradiance values to be reported in microwatts or milliwatts per square meter.

Multiple `Irrad` elements are allowed.

4.5.21 Photon Flux Density Data Element

The optional `PFDData` element is the parent of photon flux density data. This element contains information that is specific to the photon flux density data. Elements are detailed in Table 39.

Table 39: Photon Flux Density Data Fields

Element Description	Element Name	Data Type	Required	Document Section

Absolute	Absolute	xs:boolean	Optional	4.5.21.1
Multiplier	Multiplier	xs:decimal	Optional	4.5.21.2
Minimum Wavelength	MinWavelength	xs:decimal	Yes	4.5.21.3
Maximum Wavelength	MaxWavelength	xs:decimal	Yes	4.5.20.4
Number Planes	NumberPlanes	xs:int	Yes	4.5.20.5
Plane Data	PlaneData	XML Element	Yes	4.5.20.6

4.5.21.1 Absolute Element

The optional Absolute element, if true, indicates that the irradiance measurements were performed using absolute photometry.

If the Absolute element is not present, the default value is true.

4.5.21.2 Multiplier Element

The optional Multiplier element, if present, indicates a floating-point multiplier that must be applied to the photon flux density measurements.

If the Multiplier element is not present, the default value is 1.0.

4.5.21.3 Minimum Wavelength Element

The required MinWavelength element specifies the minimum wavelength of the photon flux density measurements in nanometers.

4.5.21.4 Maximum Wavelength Element

The required MaxWavelength element specifies the maximum wavelength of the photon flux density measurements in nanometers.

4.5.21.5 Number Planes Element

The required NumberPlanes element specifies the number of measurement planes.

4.5.21.6 Plane Data Element

The required PlaneData element specifies the photon flux density data for the specified measurement plane. Elements are detailed in Table 40.

Multiple PlaneData elements are allowed.

Table 40: Plane Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Plane Normal	PlaneNormal	XML Element	Optional	4.5.21.6.1
Number Measured	NumberMeasured	xs:int	Yes	4.5.21.6.2
Photon Flux Density	PFD	XML Element	Yes	4.5.21.6.3

4.5.21.6.1 Plane Normal Element

The optional PlaneNormal element specifies coordinates of the unit plane normal with respect to the luminaire dimensions coordinate system. For example:

```
<PlaneNormal x="-1.0" y="0.0" z="0.0"/>
```

NOTE: The plane can be arbitrarily oriented with respect to the emitter.

If absent, the unit plane normal coordinates are assumed to be aligned with zenith:

```
<PlaneNormal x="0.0" y="0.0" z="1.0"/>
```

4.5.21.6.2 Number Measured Element

The required `NumberMeasured` element specifies the number of photon flux density measurements for the specified plane.

4.5.21.6.3 Photon Flux Density Element

The required `PFD` element specifies photon flux density data (in micromoles per second per square meter) for the specified position. The element contains the value to be reported, and there are attributes for the plane position (in meters) this value occurs at. For example:

```
<PFD x="0.0" y="1.5" z="1.2">55</PFD>
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the photon flux density value.

NOTE: The `Multiplier` element enables photon flux density values to be reported in microwatts or milliwatts per square meter.

Multiple `PFD` elements are allowed.

4.5.22 Spectral Irradiance Data Element

The optional `SpecIrradData` element is the parent of spectral irradiance data. This element contains information that is specific to the spectral irradiance data. Elements are detailed in Table 41.

Table 41: Spectral Irradiance Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Absolute	`Absolute`	xs:boolean	Optional	4.5.22.1
Multiplier	`Multiplier`	xs:decimal	Optional	4.5.22.2
Number Planes	`NumberPlanes`	xs:int	Yes	4.5.22.3
Plane Data	`PlaneData`	XML Element	Yes	4.5.22.4

4.5.22.1 Absolute Element

The optional `Absolute` element, if true, indicates that the spectral irradiance measurements were performed using absolute photometry.

If the `Absolute` element is not present, the default value is true.

4.5.22.2 Multiplier Element

The optional `Multiplier` element, if present, indicates a floating-point multiplier that must be applied to the spectral irradiance measurements.

If the `Multiplier` element is not present, the default value is 1.0.

4.5.22.3 Number Planes Element

The required `NumberPlanes` element specifies the number of measurement planes.

4.5.22.4 Plane Data Element

The required `PlaneData` element specifies the spectral irradiance data for the specified measurement plane. Elements are detailed in Table 42.

Multiple `PlaneData` elements are allowed.

Table 42: Plane Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Plane Normal	`PlaneNormal`	XML Element	Optional	4.5.22.4.1
Number Measured	`NumberMeasured`	xs:int	Yes	4.5.22.4.2
Number Wavelength	`NumberWavelength`	xs:int	Yes	4.5.22.4.3
Spectral Irradiance	`SIrrad`	XML Element	Yes	4.5.22.4.4

4.5.22.4.1 Plane Normal Element

The optional `PlaneNormal` element specifies coordinates of the unit plane normal with respect to the luminaire dimensions coordinate system. For example:

```
<PlaneNormal x="-1.0" y="0.0" z="0.0"/>
```

NOTE: The plane can be arbitrarily oriented with respect to the emitter.

If absent, the unit plane normal coordinates are assumed to be aligned with zenith:

```
<PlaneNormal x="0.0" y="0.0" z="1.0"/>
```

4.5.22.4.2 Number Measured Element

The required `NumberMeasured` element specifies the number of spectral irradiance measurements for the specified plane.

4.5.22.4.3 Number Wavelength Element

The required `NumberWavelength` element specifies the number of wavelengths.

4.5.22.4.4 Spectral Irradiance Element

The required `SIrrad` element specifies spectral irradiance data (in watts per square meter per nanometer) for the specified position. The element contains the value to be reported, and there are attributes for the plane position (in meters) and wavelength (in nanometers) this value occurs at. For example:

```
<SIrrad x="0.0" y="1.5" z="1.2" w="555.0">55</SIrrad >
```

NOTE: Scientific notation (e.g., 1.23E-2) is allowed for the spectral irradiance value.

NOTE: The `Multiplier` element enables spectral irradiance values to be reported in microwatts or milliwatts per square meter per nanometer.

Multiple `SIrrad` elements are allowed.

4.5.23 Channels Element

A luminaire may have multiple emitters with different spectral power distributions, such as a theatrical luminaire with red, green, blue, and amber light-emitting diodes. If the intensity of each emitter can be independently controlled (that is, dimmed) without significantly changing the spatial intensity distribution, a “channel multiplier” can be applied to the measured or simulated intensity distribution to represent the intensity distribution when the channel is tested at a specified correlated color temperature.

The optional `Channels` element is the parent of the emitter channels data. Elements are detailed in Table 43.

Table 43: Channels Fields

Element Description	Element Name	Data Type	Required	Document Section
Number Channels	`NumberChannels`	xs:int	Yes	4.5.23.1
Channel Multiplier	`ChannelMult`	XML Element	Yes	4.5.23.2

4.5.23.1 Number Channels Element

The required `NumberChannels` element specifies the number of independent emitter channels.

4.5.23.2 Channel Multiplier Element

The required `ChannelMult` element specifies an independent emitter channel multiplier that is applied to the emitter intensity values or flux value. For example:

```
<ChannelMult   name="red">0.63</ChannelMult>
```

where the channel names should be the same as emitter spectral names (Section 4.5.17.1.1) if multiple `EmitterSpectral` elements are present.

Multiple `ChannelMult` elements are allowed.

4.5.24 Emission Areas Element

The optional `EmissionAreas` element is the parent of emission areas data. Elements are detailed in Table 44.

NOTE: For cylindrical shapes, the planar emission faces are orthographically projected onto the cylindrical face.

Table 44: Emission Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Top Face	`TopFace`	XML Element	Optional	4.5.24.1
Bottom Face	`BottomFace`	XML Element	Optional	4.5.24.2
C0 Face	`C0Face`	XML Element	Optional	4.5.24.3
C90 Face	`C90Face`	XML Element	Optional	4.5.24.4
C180 Face	`C180Face`	XML Element	Optional	4.5.24.5
C270 Face	`C270Face`	XML Element	Optional	4.5.24.6

4.5.24.1 Top Face Element

The optional `TopFace` element is the parent of the top face emission areas data. Elements are detailed in Table 45.

Table 45: Top Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Number Top	NumberTop	xs:int	Yes	4.5.24.1.1
Top Area	TopArea	XML Element	Yes	4.5.24.1.2

4.5.24.1.1 Number Top Element

The required NumberTop element specifies the number of top face emission areas.

4.5.24.1.2 Top Area Element

The required TopArea element is the parent of the top face emission area data. Elements are detailed in Table 46.

Multiple TopArea elements are allowed.

Table 46: Top Face Emission Area Fields

Element Description	Element Name	Data Type	Required	Document Section
Length	Length	xs:decimal	Yes	4.5.24.1.2.1
Width	Width	xs:decimal	Yes	4.5.24.1.2.2
Length Offset	LengthOffset	xs:decimal	Yes	4.5.24.1.2.3
Width Offset	WidthOffset	xs:decimal	Yes	4.5.24.1.2.4
Circular	Circular	xs:boolean	Optional	4.5.24.1.2.5

4.5.24.1.2.1 Length Element

The required Length element specifies the length of the top face emission area in meters.

4.5.24.1.2.2 Width Element

The required Width element specifies the width of the top face emission area in meters.

4.5.24.1.2.3 Length Offset Element

The required LengthOffset element specifies the offset of the top face emission area from the geometric centre of the luminaire along the length (y) axis in meters.

4.5.24.1.2.4 Width Offset Element

The required WidthOffset element specifies the offset of the top face emission area from the geometric centre of the luminaire along the width (x) axis in meters.

4.5.24.1.2.5 Circular Element

The optional Boolean Circular element, if true, indicates that the top face emission area is circular rather than rectangular. (If the length and width element values are not equal, the area is considered to be elliptical.)

4.5.24.2 Bottom Face Element

The optional BottomFace element is the parent of the bottom face emission areas data. Elements are detailed in Table 47.

Table 47: Bottom Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Number Bottom	NumberBottom	xs:int	Yes	4.5.24.2.1
Bottom Area	BottomArea	XML Element	Yes	4.5.24.2.2

4.5.24.2.1 Number Bottom Element

The required `NumberBottom` element specifies the number of bottom face emission areas.

4.5.24.2.2 Bottom Area Element

The required `BottomArea` element is the parent of the bottom face emission area data. Elements are detailed in Table 48.

Multiple `BottomArea` elements are allowed.

Table 48: Bottom Face Emission Area Fields

Element Description	Element Name	Data Type	Required	Document Section
Length	`Length`	xs:decimal	Yes	4.5.24.2.2.1
Width	`Width`	xs:decimal	Yes	4.5.24.2.2.2
Length Offset	`LengthOffset`	xs:decimal	Yes	4.5.24.2.2.3
Width Offset	`WidthOffset`	xs:decimal	Yes	4.5.24.2.2.4
Circular	`Circular`	xs:boolean	Optional	4.5.24.2.2.5

4.5.24.2.2.1 Length Element

The required `Length` element specifies the length of the bottom face emission area in meters.

4.5.24.2.2.2 Width Element

The required `Width` element specifies the width of the bottom face emission area in meters.

4.5.24.2.2.3 Length Offset Element

The required `LengthOffset` element specifies the offset of the bottom face emission area from the geometric centre of the luminaire along the length (y) axis in meters.

4.5.24.2.2.4 Width Offset Element

The required `WidthOffset` element specifies the offset of the bottom face emission area from the geometric centre of the luminaire along the width (x) axis in meters.

4.5.24.2.2.5 Circular Element

The optional Boolean `Circular` element, if true, indicates that the bottom face emission area is circular rather than rectangular. (If the length and width element values are not equal, the area is considered to be elliptical.)

4.5.24.3 C0 Face Element

The optional `C0Face` element is the parent of the C0 face emission areas data. Elements are detailed in Table 49.

Table 49: C0 Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Number C0	`NumberC0`	xs:int	Yes	4.5.24.3.1
C0 Area	`C0Area`	XML Element	Yes	4.5.24.3.2

4.5.24.3.1 Number C0 Element

The required `NumberC0` element specifies the number of C0 face emission areas.

4.5.24.3.2 C0 Area Element

The required `C0Area` element is the parent of the C0 face emission area data. Elements are detailed in Table 50.

Multiple `C0Area` elements are allowed.

Table 50: C0 Face Emission Area Fields

Element Description	Element Name	Data Type	Required	Document Section
Length	`Length`	xs:decimal	Yes	4.5.24.3.2.1
Height	`Height`	xs:decimal	Yes	4.5.24.3.2.2
Length Offset	`LengthOffset`	xs:decimal	Yes	4.5.24.3.2.3
Height Offset	`HeightOffset`	xs:decimal	Yes	4.5.24.3.2.4
Circular	`Circular`	xs:boolean	Optional	4.5.24.3.2.5

4.5.24.3.2.1 Length Element

The required `Length` element specifies the length of the C0 face emission area in meters.

4.5.24.3.2.2 Height Element

The required `Height` element specifies the height of the C0 face emission area in meters.

4.5.24.3.2.3 Length Offset Element

The required `LengthOffset` element specifies the offset of the C0 face emission area from the geometric centre of the luminaire along the length (y) axis in meters.

4.5.24.3.2.4 Height Offset Element

The required `HeightOffset` element specifies the offset of the C0 face emission area from the geometric centre of the luminaire along the height (z) axis in meters.

4.5.24.3.2.5 Circular Element

The optional Boolean `Circular` element, if true, indicates that the C0 face emission area is circular rather than rectangular. (If the length and width element values are not equal, the area is considered to be elliptical.)

4.5.24.4 C90 Face Element

The optional `C90Face` element is the parent of the C90 face emission areas data. Elements are detailed in Table 51.

Table 51: C90 Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Number C90	`NumberC90`	xs:int	Yes	4.5.24.4.1
C90 Area	`C90Area`	XML Element	Yes	4.5.24.4.2

4.5.24.4.1 Number C90 Element

The required `NumberC90` element specifies the number of C90 face emission areas.

4.5.24.4.2 C90 Area Element

The required `C90Area` element is the parent of the C90 face emission area data. Elements are detailed in Table 52.

Multiple C90Area elements are allowed.

Table 52: C90 Face Emission Area Fields

Element Description	Element Name	Data Type	Required	Document Section
Width	Width	xs:decimal	Yes	4.5.24.4.2.1
Height	Height	xs:decimal	Yes	4.5.24.4.2.3
Width Offset	WidthOffset	xs:decimal	Yes	4.5.24.4.2.3
Height Offset	HeightOffset	xs:decimal	Yes	4.5.24.4.2.4
Circular	Circular	xs:boolean	Optional	4.5.24.4.2.5

4.5.24.4.2.1 Width Element

The required Width element specifies the width of the C90 face emission area in meters.

4.5.24.4.2.2 Height Element

The required Height element specifies the height of the C90 face emission area in meters.

4.5.24.4.2.3 Width Offset Element

The required WidthOffset element specifies the offset of the C90 face emission area from the geometric centre of the luminaire along the width (x) axis in meters.

4.5.24.4.2.4 Height Offset Element

The required HeightOffset element specifies the offset of the C90 face emission area from the geometric centre of the luminaire along the height (z) axis in meters.

4.5.24.4.2.5 Circular Element

The optional Boolean Circular element, if true, indicates that the C90 face emission area is circular rather than rectangular. (If the length and width element values are not equal, the area is considered to be elliptical.)

4.5.24.5 C180 Face Element

The optional C180Face element is the parent of the C180 face emission areas data.
Elements are detailed in Table 53.

Table 53: C180 Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Number C180	NumberC180	xs:int	Yes	4.5.24.5.1
C180 Area	C180Area	XML Element	Yes	4.5.24.5.2

4.5.24.5.1 Number C180 Element

The required NumberC180 element specifies the number of C180 face emission areas.

4.5.24.5.2 C180 Area Element

The required C180Area element is the parent of the C180 face emission area data. Elements are detailed in Table 54.

Multiple C180Area elements are allowed.

Table 54: C180 Face Emission Area Fields

Element Description	Element Name	Data Type	Required	Document Section

Length	Length	xs:decimal	Yes	4.5.24.5.2.1
Height	Height	xs:decimal	Yes	4.5.24.5.2.2
Length Offset	LengthOffset	xs:decimal	Yes	4.5.24.5.2.3
Height Offset	HeightOffset	xs:decimal	Yes	4.5.24.5.2.4
Circular	Circular	xs:boolean	Optional	4.5.24.5.2.5

4.5.24.5.2.1 Length Element

The required Length element specifies the length of the C180 face emission area in meters.

4.5.24.5.2.2 Height Element

The required Height element specifies the height of the C180 face emission area in meters.

4.5.24.5.2.3 Length Offset Element

The required LengthOffset element specifies the offset of the C180 face emission area from the geometric centre of the luminaire along the length (y) axis in meters.

4.5.24.5.2.4 Height Offset Element

The required HeightOffset element specifies the offset of the C180 face emission area from the geometric centre of the luminaire along the height (z) axis in meters.

4.5.24.5.2.5 Circular Element

The optional Boolean Circular element, if true, indicates that the C180 face emission area is circular rather than rectangular. (If the length and width element values are not equal, the area is considered to be elliptical.)

4.5.24.6 C270 Face Element

The optional C270Face element is the parent of the C270 face emission areas data. Elements are detailed in Table 55.

Table 55: C270 Face Fields

Element Description	Element Name	Data Type	Required	Document Section
Number C0	NumberC270	xs:int	Yes	4.5.24.6.1
C270 Area	C270Area	XML Element	Yes	4.5.24.6.2

4.5.24.6.1 Number C270 Element

The required NumberC270 element specifies the number of C270 face emission areas.

4.5.24.6.2 C270 Area Element

The required C270Area element is the parent of the C270 face emission area data. Elements are detailed in Table 56.

Multiple C270Area elements are allowed.

Table 56: C270 Face Emission Area Fields

Element Description	Element Name	Data Type	Required	Document Section
Width	Width	xs:decimal	Yes	4.5.24.6.2.1
Height	Height	xs:decimal	Yes	4.5.24.6.2.2
Width Offset	WidthOffset	xs:decimal	Yes	4.5.24.6.2.3
Height Offset	HeightOffset	xs:decimal	Yes	4.5.24.6.2.4
Circular	Circular	xs:boolean	Optional	4.5.24.6.2.5

4.5.24.6.2.1 Width Element

The required `Width` element specifies the width of the C270 face emission area in meters.

4.5.24.6.2.2 Height Element

The required `Height` element specifies the height of the C270 face emission area in meters.

4.5.24.6.2.3 Width Offset Element

The required `WidthOffset` element specifies the offset of the C270 face emission area from the geometric centre of the luminaire along the width (x) axis in meters.

4.5.24.6.2.4 Height Offset Element

The required `HeightOffset` element specifies the offset of the C270 face emission area from the geometric centre of the luminaire along the height (z) axis in meters.

4.5.24.6.2.5 Circular Element

The optional Boolean `Circular` element, if true, indicates that the C270 face emission area is circular rather than rectangular. (If the length and width element values are not equal, the area is considered to be elliptical.)

4.5.25 Emitter Centre Element

The optional `EmitterCenter` element is the parent of emitter centre data. Elements are detailed in Table 57.

If the `EmitterCenter` element is absent, the emitter centre is assumed to be coincident with the geometric centre.

Table 57: Emitter Centre Fields

Element Description	Element Name	Data Type	Required	Document Section
Length Offset	`LengthOffset`	xs:decimal	Yes	4.5.25.1
WidthOffset	`WidthOffset`	xs:decimal	Yes	4.5.25.2
Height Offset	`HeightOffset`	xs:decimal	Yes	4.5.25.3

4.5.25.1 Length Offset Element

The required `LengthOffset` element specifies the offset of the emitter centre from the geometric centre of the luminaire along the length (y) axis in meters.

4.5.25.2 Width Offset Element

The required `WidthOffset` element specifies the offset of the emitter centre from the geometric centre of the luminaire along the width (x) axis in meters.

4.5.25.3 Height Offset Element

The required `HeightOffset` element specifies the offset of the emitter centre from the geometric centre of the luminaire along the height (z) axis in meters.

4.5.26 Regulatory Element

The optional `Regulatory` element is the parent of regulatory. Elements are detailed in Table 58.

Table 58: Regulatory Fields

Element Description	Element Name	Data Type	Required	Document Section
Input Wattage	InputWattage	xs:string	Optional	4.5.5
Power Factor	PowerFactor	xs:string	Optional	4.5.6
Ballast Factor	BallastFactor	xs:string	Optional	4.5.7
Color Temperature	ColorTemperature	xs:string	Optional	4.5.9
CIE_CRI	CIE_CRI	xs:string	Optional	4.5.10.1
IES_TM30	IES_TM30	xs:string	Optional	4.5.10.2
Duv	Duv	xs:string	Optional	4.5.11
S/P Ratio	SPRatio	xs:string	Optional	4.5.12
Luminous Intensity	LuminousIntensity	xs:string	Optional	4.5.14.1.6
Luminous Flux	LuminousFlux	xs:string	Optional	4.5.14.2
Radiant Intensity	RadiantIntensity	xs:string	Optional	4.5.15.3.5
Radiant Flux	RadiantFlux	xs:string	Optional	4.5.15.4
Photon Intensity	PhotonIntensity	xs:string	Optional	4.5.16.3.5
Photon Flux	PhotonFlux	xs:string	Optional	4.5.16.4
Spectral Power	SpectralPower	xs:string	Optional	4.5.17.1.5
Spectral Intensity	SpectralIntensity	xs:string	Optional	4.5.17.2.7
Angular Color	AngularColor	xs:string	Optional	4.5.18.5
Illuminance	Illuminance	xs:string	Optional	4.5.19.2.4
Irradiance	Irradiance	xs:string	Optional	4.5.20.4.4
Photon Flux Density	PhotonFluxDensity	xs:string	Optional	4.5.21.4.4
Spectral Irradiance	SpectralIrradiance	xs:string	Optional	4.5.22.2.5

Each optional `Regulatory` element shall be identified as having measured, nominal, or rated values, as listed in Table 59.

Table 59: Regulatory Value Types

Type	Description
Measured	Measured value(s)
Nominal	Nominal value(s)
Rated	Rated value(s)

A “rated” value is the value of a quantity used for specification purposes, established for a specified set of operating conditions of the product.

A “nominal” value is an approximate quantity value used to designate or identify a product.

If a `Regulatory` element is absent, its values are assumed to be measured or calculated from measured data.

4.6 Custom Data Element

The optional `CustomData` element is the parent of custom data. Elements are detailed in Table 60.

The intent of the `CustomData` element is to provide a means of including custom data within the luminaire optical data document. For example, a company or government agency may require additional information that cannot be represented within the base XML schema (Section 4.7).

Multiple `CustomData` elements are allowed.

Table 60: Custom Data Fields

Element Description	Element Name	Data Type	Required	Document Section
Name	`Name`	xs:string	Yes	4.6.1
Unique Identifier	`UniqueIdentifier`	xs:string	Yes	4.6.2
Any Data	`[Not applicable]`	XML Element	Optional	4.6.3

4.6.1 Name Element

The required `Name` element specifies the name describing the custom data, for example "`Italian CAM`".

4.6.2 Unique Identifier Element

The required `UniqueIdentifier` element contains a Universally Unique Identifier (UUID) as defined by RFC 4122. 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:

E1EC2128-3AEB-1069-A24E-98712B54306F

The purpose of this UUID is to prevent name collisions between different instances of the `Name` element.

4.6.3 AnyData Element

The base XML schema (Section 4.7) allows an arbitrary sequence of XML elements within the `CustomData` element using an `<any>` declaration with an `##any` namespace attribute to instruct a validating parser to ignore the element sequence for validation purposes.

4.7 XML Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema   xmlns:xs="http://www.w3.org/2001/XMLSchema">

  <!-- Common attribute definitions -->
  <xs:attribute  name="angle"  type="xs:decimal"/>
  <xs:attribute  name="h"  type="xs:decimal"/>
  <xs:attribute  name="v"  type="xs:decimal"/>
  <xs:attribute  name="w"  type="xs:decimal"/>
  <xs:attribute  name="x"  type="xs:decimal"/>
  <xs:attribute  name="y"  type="xs:decimal"/>
  <xs:attribute  name="z"  type="xs:decimal"/>

  <!-- Common simple element definitions -->
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  <xs:element  name="HeightOffset"  type="xs:decimal"/>
  <xs:element  name="Length"  type="xs:decimal"/>
  <xs:element  name="LengthOffset"  type="xs:decimal"/>
  <xs:element  name="MaxWavelength"  type="xs:decimal"/>
  <xs:element  name="MeasurementEquipment"  type="xs:string"/>
  <xs:element  name="MinWavelength"  type="xs:decimal"/>
  <xs:element  name="Multiplier"  type="xs:float"/>
  <xs:element  name="NumberHorz"  type="xs:int"/>
  <xs:element  name="NumberMeasured"  type="xs:int"/>
```

```
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<xs:element  name="NumberVert"  type="xs:int"/>
<xs:element  name="NumberWavelength"  type="xs:int"/>
<xs:element  name="Width"  type="xs:decimal"/>
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<!-- Common element definitions -->
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      <xs:attribute  ref="v"/>
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      <xs:attribute  ref="y"/>
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    </xs:extension>
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    <xs:enumeration  value="Nominal"/>
    <xs:enumeration  value="Rated"/>
  </xs:restriction>
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  <xs:restriction  base="xs:string">
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      <xs:enumeration   value="Symm_Bi_90"/>
      <xs:enumeration    value="Symm_Quad"/>
      <xs:enumeration    value="Symm_Full"/>
      <xs:enumeration   value="Symm_Arbitrary"/>
    </xs:restriction>
  </xs:simpleType>

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              <xs:element name="GTIN" type="xs:integer"
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              <xs:element  name="Description"  type="xs:string"/>
              <xs:element  name="Laboratory"  type="xs:string"/>
              <xs:element  name="ReportNumber"  type="xs:string"/>
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                  minOccurs="0"/>
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                    <xs:enumeration   value="IES_A"/>
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                    <xs:enumeration  value="CUSTOM"/>
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```

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                <xs:element   ref="NumberVert"/>
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                <xs:element   ref="NumberHorz"/>
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```

```
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                <xs:element   ref="NumberHorz"/>
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```

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        <xs:complexType>
          <xs:sequence>
            <xs:element  ref="Length"/>
            <xs:element  ref="Width"/>
            <xs:element  ref="LengthOffset"/>
            <xs:element  ref="WidthOffset"/>
            <xs:element ref="Circular"
                minOccurs="0"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element  name="BottomFace"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="NumberBottom"
          type="xs:int"/>
      <xs:element name="BottomArea"
          maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element  ref="Length"/>
            <xs:element  ref="Width"/>
            <xs:element  ref="LengthOffset"/>
            <xs:element  ref="WidthOffset"/>
            <xs:element ref="Circular"
                minOccurs="0"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element  name="C0Face"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element  name="NumberC0"  type="xs:int"/>
      <xs:element name="C0Area"
          maxOccurs="unbounded">
        <xs:complexType>
         <xs:sequence>
            <xs:element  ref="Length"/>
            <xs:element  ref="Height"/>
            <xs:element  ref="LengthOffset"/>
            <xs:element  ref="HeightOffset"/>
           <xs:element ref="Circular"
               minOccurs="0"/>
         </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
```

```
  </xs:complexType>
</xs:element>
<xs:element  name="C90Face"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element  name="NumberC90"  type="xs:int"/>
      <xs:element name="C90Area"
          maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element  ref="Width"/>
            <xs:element  ref="Height"/>
            <xs:element  ref="WidthOffset"/>
            <xs:element  ref="HeightOffset"/>
            <xs:element ref="Circular"
                minOccurs="0"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element  name="C180Face"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="NumberC180"
          type="xs:int"/>
      <xs:element name="C180Area"
          maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element  ref="Length"/>
            <xs:element  ref="Height"/>
            <xs:element  ref="LengthOffset"/>
            <xs:element  ref="HeightOffset"/>
            <xs:element ref="Circular"
                minOccurs="0"/>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element  name="C270Face"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="NumberC270"
          type="xs:int"/>
      <xs:element name="C270Area"
          maxOccurs="unbounded">
        <xs:complexType>
          <xs:sequence>
            <xs:element  ref="Width"/>
            <xs:element  ref="Height"/>
            <xs:element  ref="WidthOffset"/>
            <xs:element  ref="HeightOffset"/>
            <xs:element ref="Circular"
                minOccurs="0"/>
```

```
                </xs:sequence>
              </xs:complexType>
            </xs:element>
          </xs:sequence>
        </xs:complexType>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element  name="EmitterCenter"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element  ref="LengthOffset"/>
      <xs:element  ref="WidthOffset"/>
      <xs:element  ref="HeightOffset"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
<xs:element  name="Regulatory"  minOccurs="0">
  <xs:complexType>
    <xs:sequence>
      <xs:element name="InputWattage"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="PowerFactor"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="BallastFactor"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="ColorTemperature"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="CIE_CRI"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="IES_TM30"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element  name="Duv"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="SPRatio"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="LuminousIntensity"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="LuminousFlux"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="RadiantIntensity"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="RadiantFlux"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="PhotonIntensity"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="PhotonFlux"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="SpectralPower"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="SpectralIntensity"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="AngularColor"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element name="Illuminance"
          type="RegulatoryValue"   minOccurs="0"/>
      <xs:element  name="Irradiance"
```

```
                        type="RegulatoryValue"   minOccurs="0"/>
                    <xs:element name="PhotonFluxDensity"
                        type="RegulatoryValue"   minOccurs="0"/>
                    <xs:element name="SpectralIrradiance"
                        type="RegulatoryValue"   minOccurs="0"/>
                  </xs:sequence>
                </xs:complexType>
              </xs:element>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
        <xs:element name="CustomData" minOccurs="0"
            maxOccurs="unbounded">
          <xs:complexType>
            <xs:sequence>
              <xs:element  name="Name"  type="xs:string"/>
              <xs:element  name="UniqueIdentifier"  type="xs:string"/>
              <xs:any namespace="##any" processContents="skip"
                  minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
          </xs:complexType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

4.8 JSON Document Format

JSON is a minimalist data-interchange format that is widely used for Internet client-server communications. Unlike the rich semantics of XML with its many data types, JSON allows only name/value pairs and ordered lists.

The advantage of the XML document format in representing luminaire optical data is that the documents can be validated using the associated schema (Section 4.7); the advantage of the JSON document format is that its ordered lists can be used to compactly represent data arrays, such as luminous intensity and photon flux density. In particular, JSON documents tend to be an order of magnitude smaller than their equivalent XML documents.

4.8.1 XML to JSON Mapping

Mapping XML elements to JSON name-value pairs is straightforward. For example, the XML complex element:

```
<Equipment>
  <Gonioradiometer>
    <Type>CIE_C</Type>
  <Gonioradiometer>
</Equipment>
```

becomes in JSON:

```
"Equipment": {
  "Gonioradiometer":  {
    "Type":  "CIE_C"
  }
}
```

Where multiple XML elements are allowed, these can be represented in JSON as arrays. For example:

```
<Comment>This  is  a  comment</Comment>
<Comment>This  is  another  comment</Comment>
```

becomes:

```
"Comment":  {
  "This is  a  comment",
  "This  is  another  comment"
}
```

4.8.1.1 Multiple XML Elements without Attributes

Multiple XML elements without attributes that can be represented as JSON arrays are:

Table 61: Multiple XML Elements without Attributes

Section	Element Name
4.2.11	Comment
4.2.12	Reference
4.4.1.2	MeasurementEquipment
4.4.2.1	MeasurementEquipment
4.4.3.1	MeasurementEquipment
4.5	Emitter
4.5.12.2.4	MeasUncertainty

4.5.17.1	EmitterSpectral
4.5.18.2	PlaneData
4.5.19.4	PlaneData
4.5.20.4	PlaneData
4.5.23.1.2	TopArea
4.5.23.2.2	BottomArea
4.5.23.3.2	C0Area
4.5.23.4.2	C90Area
4.5.23.5.2	C180Area
4.5.23.6.2	C270Area
4.5.25	Regulatory
4.6	CustomData

4.8.1.2 Multiple XML Elements with Attributes

Multiple XML elements with attributes that can be represented as JSON arrays are:

4.8.1.3 Tilt Element

A typical Tilt Angles XML element (Section 4.5.8) is:

```
<TiltAngles>
  <NumberAngles>3</NumberAngles>
  <Tilt  angle="0.0">1.00</Tilt>
  <Tilt   angle="10.0">0.90</Tilt>
  <Tilt   angle="20.0">0.80</Tilt>
</TiltAngles>
```

The equivalent JSON elements are:

```
"TiltAngles": {
  "NumberAngles": 3,
  "TiltArray": {
    "Angle": [0.0, 10.0, 20.0],
    "Mult": [1.00, 0.90, 0.80]
  }
}
```

4.8.1.4 Intensity Data Element

A typical Luminous Intensity Data XML element (Section 4.5.14.1) is:

```
<LuminousIntensity>
  <AbsolutePhotometry>true</AbsolutePhotometry>
  <Symm>Symm_Full</Symm>
  <NumberMeasured>95</NumberMeasured>
  <NumberHorz>5</NumberHorz>
  <NumberVert>19</NumberVert>
  …
  <IntData  h="0.0"  v="60.0">53</IntData>
  <IntData  h="0.0"  v="65.0">44</IntData>
  …
</LuminousIntensity>
```

If the `Symm` type is `Symm_Arbitrary` and `NumberHorz` is zero and `NumberVert` is zero (that is, the measurement coordinate system does not consist of a set of planes), the equivalent JSON elements are:

```
"LuminousIntensity": {
  "AbsolutePhotometry": true,
  "Symm": "Symm_Arbitrary",
  "NumberMeasured": 95,
  "NumberHorz": 0,
  "NumberVert": 0,
  "IntDataNoSymm": [
    …
    [0.0, 60.0, 53],
    [5.0, 65.0, 44],
    …
  ]
}
```

Otherwise, horizontal symmetry allows the intensity data to be expressed more compactly as:

```
"LuminousIntensity": {
  "AbsolutePhotometry": true,
  "Symm": "Symm_Full",
  "NumberMeasured": 95,
  "NumberHorz": 5,
  "NumberVert": 19,
  "IntDataSymm": {
    "h": [0.0],
    "v": [ …, 60.0, 65.0, … ],
    "IntData": [
       [ …, 53, 44, … ],
       …
       [ …, 50, 43, … ]
    ]
  }
}
```

where "IntData" is a two-dimensional array with "NumberHorz" rows and "NumberVert" columns. That is, it is ordered by "NumberHorz" and "NumberVert".

Radiant intensity and photon intensity data elements (Sections 4.5.15.3, and 4.5.16.3) can be similarly expressed.

4.8.1.5 Power Data Element

A typical Emitter Spectral XML element (Section 4.5.17.1) is:

```
<EmitterSpectral>
  <NumberWavelength>61</NumberWavelength>
  …
  <PwrData  w="555.0">0.053</PwrData>
  …
</EmitterSpectral>
```

The equivalent JSON elements are:

```
"EmitterSpectral": {
  "NumberWavelength": 61,
  "PwrDataArray": {
    "w": […, 555.0, …],
    "PwrData": […, 0.053, …]
  }
```

```
}
```

4.8.1.6 Angular Spectral Intensity Data Element

A typical Angular Spectral Intensity Data XML element (Section 4.5.17.2) is:

```
<AngularSpectral>
  <Symm>Symm_Full</Symm>
  <NumberMeasured>19</NumberMeasured>
  <NumberHorz>1</NumberHorz>
  <NumberVert>19</NumberVert>
  <NumberWavelength>81</NumberWavelength>
  …
  <IntData  h="0.0"  v="60.0"  w="555.0">0.023</IntData>
  <IntData  h="0.0"  v="60.0"  w="560.0">0.031</IntData>
  …
</AngularSpectral>
```

If the `Symm` type is `Symm_Arbitrary` and `NumberHorz` is zero and `NumberVert` is zero (that is, the measurement coordinate system does not consist of a set of planes), the equivalent JSON elements are:

```
"AngularSpectral":   {
  "Symm": "Symm_Arbitrary",
  "NumberMeasured": 19,
  "NumberHorz":  0,
  "NumberVert":  0,
  "NumberWavelength": 81,
  "IntDataNoSymm": [
    …
    [0.0,  60.0,  555.0,  0.023],
    [0.0,  60.0,  555.0,  0.031],
    …
  ]
}
```

Otherwise, horizontal symmetry allows the intensity data to be expressed more compactly as:

```
"AngularSpectral": {
  "Symm": "Symm_Full",
  "NumberMeasured": 19,
  "NumberHorz":  1,
  "NumberVert":  19,
  "NumberWavelength": 81,
  "IntDataSymm": {
    "h":  [0.0],
    "v":  […,  60.0,  …],
    "w":  […,  555.0,  560.0,  …],
    "IntData":  [
      [
        …
        [ …,  0.023,  0.031,  … ],
        …
      ]
    ]
  }
}
```

where “IntData” is a three-dimensional array ordered by “NumberHorz”, “NumberVert”, and “NumberWavelength”.

4.8.1.7 Angular Color Data Element

A typical Angular Color Data XML element (Section 4.5.18) is:

```
<AngularColor>
  <Symm>Symm_Full</Symm>
  <NumberMeasured>19</NumberMeasured>
  <NumberHorz>1</NumberHorz>
  <NumberVert>19</NumberVert>
  …
  <ColorData  h="0.0"  v="60.0"  x="0.3135"  y="0.3293">55</ColorData>
  <ColorData  h="0.0"  v="65.0"  y="0.3129"  y="0.3290">52</ColorData>
  …
</AngularColor>
```

If the Symm type is Symm_Arbitrary and NumberHorz is zero and NumberVert is zero (that is, the measurement coordinate system does not consist of a set of planes), the equivalent JSON elements are:

```
"AngularColor":  {
  "Symm": "Symm_Arbitrary",
  "NumberMeasured": 19,
  "NumberHorz":  0,
  "NumberVert":  0,
  "NumberWavelength": 81,
  "ColorDataNoSymm": [
    …
    [0.0,  60.0,  0.3135,  0.3293,  55],
    [0.0,  65.0,  0.3129,  0.3290,  52],
    …
  ]
}
```

Otherwise, horizontal symmetry allows the color data to be expressed more compactly as:

```
"AngularColor":  {
  "Symm": "Symm_Full",
  "NumberMeasured": 19,
  "NumberHorz":  1,
  "NumberVert": 19,
  "ColorDataSymm":  {
    "h":  [0.0],
    "v":  […,  60.0,  65.0,  …],
    "ColorData":  [
      [
        …
        [0.3135,  0.3293,  55],
        [0.3129,  0.3290,  52],
        …
      ]
    ]
  }
}
```

where “IntData” is a two-dimensional array ordered by “NumberHorz” and “NumberVert”.

4.8.1.8 Plane Normal Element

A typical Plane Normal XML element (Sections 4.5.18.2.1, 4.5.19.4.1, 4.5.20.4.1, and 4.5.21.2.1) is:

```
<PlaneNormal x="1.0" y="0.0" z="0.0"/>
```

The equivalent JSON element is:

```
"PlaneNormal": [1.0,0.0,0.0]
```

4.8.1.9 Illuminance Data Element

A typical Illuminance Data element (Section 4.5.18) is:

```
<IllumData>
  <NumberPlanes>1</NumberPlanes>
  <PlaneData>
    <NumberMeasured>128</NumberMeasured>
    …
    <Illum x="0.0" y="1.5" z="1.2">55</Illum>
    …
  </PlaneData>
</IllumData>
```

If the illuminance measurements are not on a rectangular grid, the equivalent JSON elements are:

```
"IllumData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "NumberMeasured": 128,
    "IllumNoSymm": [
      …
      [0.0,1.5,1.2,55],
      …
    ]
  ]
}
```

Otherwise, symmetry allows the illuminance data to be expressed more compactly as:

```
"IllumData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "IllumSymm": {
      "x": […, 0.0, …],
      "y”: […, 1.5, …],
      "z": […, 1.2, …],
      "Illum": [
        [
          …
          […, 55, …]
          …
        ]
      ]
    }
  ]
```

```
}
```

where "Illum" is a three-dimensional array ordered by "x", "y", and "z".

4.8.1.10 Irradiance Data Element

A typical Irradiance Data element (Section 4.5.19) is:

```
<IrradData>
  <NumberPlanes>1</NumberPlanes>
  <PlaneData>
    <NumberMeasured>128</NumberMeasured>
    …
    <Irrad  x="0.0"  y="1.5"  z="1.2">55</Irrad>
    …
  </PlaneData>
</IrradData>
```

If the irradiance measurements are not on a rectangular grid, the equivalent JSON elements are:

```
"IrradData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "NumberMeasured": 128,
    "IrradNoSymm": [
      …
      [0.0,1.5,1.2,55],
      …
    ]
  ]
}
```

Otherwise, symmetry allows the irradiance data to be expressed more compactly as:

```
"IrradData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "IrradSymm": {
      "x": […, 0.0, …],
      "y": […, 1.5, …],
      "z": […, 1.2, …],
      "Irrad": [
        [
          …
          […, 55, …]
          …
        ]
      ]
    }
  ]
}
```

where "Irrad" is a three-dimensional array ordered by "x", "y", and "z".

4.8.1.11 Photon Flux Density Data Element

A typical Photon Flux Density Data element (Section 4.5.20) is:

```
<PFDData>
  <NumberPlanes>1</NumberPlanes>
  <PlaneData>
    <NumberMeasured>128</NumberMeasured>
    …
    <PFD  x="0.0"  y="1.5"  z="1.2">55</PFD>
    …
  </PlaneData>
</PFDData>
```

If the photon flux density measurements are not on a rectangular grid, the equivalent JSON elements are:

```
"PFDData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "NumberMeasured": 128,
    "PFDNoSymm": [
      …
      [0.0,1.5,1.2,55],
      …
    ]
  ]
}
```

Otherwise, symmetry allows the photon flux density data to be expressed more compactly as:

```
"PFDData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "PFDSymm": {
      "x": […, 0.0, …],
      "y": […, 1.5, …],
      "z": […, 1.2, …],
      "PFD": [
        [
          …
          […, 55, …]
          …
        ]
      ]
    }
  ]
}
```

where "PFD" is a three-dimensional array ordered by "x", "y", and "z".

4.8.1.12 Spectral Irradiance Data Element

A typical Spectral Irradiance Data element (Section 4.5.21) is:

```
<SpecIrradData>
  <NumberPlanes>1</NumberPlanes>
  <PlaneData>
    <NumberMeasured>128</NumberMeasured>
    …
    <SIrrad  x="0.0"  y="1.5"  z="1.2"  w="555.0">55</SIrrad>
```

```
    …
   </PlaneData>
 </SpecIrradData>
```

If the irradiance measurements are not on a rectangular grid, the equivalent JSON elements are:

```
"SpecIrradData": {
  "NumberPlanes": 1,
  "PlaneData": [
    "NumberMeasured": 128,
    "SpecIrradNoSymm": [
      …
      [0.0, 1.5, 1.2, 555.0, 55],
      …
    ]
  ]
}
```

Otherwise, symmetry allows the irradiance data to be expressed more compactly as:

```
"SpecIrradData": {
  "NumberPlanes": 1,
  "PlaneData”: [
    "SpecIrradSymm": {
      "x": […, 0.0, …],
      "y”: […, 1.5, …],
      "z": […, 1.2, …],
      "w": […, 555.0, …],
      "SIrrad": [
        [
          [
            …
            […, 55, …]
            …
          ]
        ]
      ]
    }
  ]
}
```

where “SIrrad” is a four-dimensional array ordered by “x”, “y”, “z”, and “w”.

4.8.1.13 Channels Element

A typical Channels element (Section 4.5.22) is:

```
<Channels>
  <NumChannels>3</NumChannels>
  <ChannelMult   name="red">0.21</ChannelMult>
  <ChannelMult   name="green">0.72</ChannelMult>
  <ChannelMult   name="blue">0.08</ChannelMult>
</Channels>
```

The equivalent JSON elements are:

```
"Channels": {
```

```
  "NumChannels":  3,
  "ChannelMult":  [
    {  "Name"="red",  "ChannelMult"=0.21  },
    {  "Name"="green",  "ChannelMult"=0.72  },
    {  "Name"="blue",  "ChannelMult"=0.08  }
  ]
}
```

4.8.2 JSON Schema

```
{
  "$schema": "http://json-schema.org/draft/2019-09/schema#",
  "type": "object",
  "properties":  {
    "Version":  {
      "type":  "number"
    },
    "Header":  {
      "type":  "object",
      "properties":  {
        "Manufacturer": {
          "type":  "string"
        },
        "CatalogNumber": {
          "type":  "string"
        },
        "GTIN": {
          "type":  "number"
        },
        "Description": {
          "type":  "string"
        },
        "Laboratory": {
          "type":  "string"
        },
        "ReportNumber": {
          "type":  "string"
        },
        "ReportDate": {
          "type":  "string",
          "pattern":    "(^([0-9]{4}-[0-9]{2}-[0-9]{2})$|UNKNOWN)"
        },
        "DocumentCreator": {
          "type": "string"
        },
        "DocumentCreationDate": {
          "type": "string",
          "pattern":   "^([0-9]{4}-[0-9]{2}-[0-9]{2})$"
        },
        "UniqueIdentifier": {
          "type": "string"
        },
        "Comments": {
          "type":  "array",
          "items": {
            "type":  "string"
          }
        },
        "Reference": {
          "type":  "array",
          "items": {
```

```
          "type": "string"
        }
      },
      "MoreInfoURI": {
        "type": "string"
      }
    },
    "required": [
      "Description", "Laboratory", "ReportNumber", "ReportDate"
    ]
  },
  "Luminaire": {
    "type": "object",
    "properties": {
      "Dimensions": {
        "type": "object",
        "properties": {
          "Length": {
            "type": "number"
          },
          "Width": {
            "type": "number"
          },
          "Height": {
            "type": "number"
          }
        },
        "required": ["Length", "Width", "Height"]
      },
      "Shape": {
        "type": "string",
        "enum": ["Align_X", "Align_Y", "Align_Z"]
      },
      "NumEmitter": {
        "type": "integer"
      }
    },
    "required": ["Dimensions", "NumEmitter"]
  },
  "Equipment": {
    "type": "object",
    "properties": {
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  "oneOf": [
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    },
```

```
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    },
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      "PlaneData"
    ]
  },
  "SpecIrradData": {
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    "properties": {
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        "type":  "boolean"
      },
      "Multiplier": {
        "type":  "number"
      },
      "NumberPlanes": {
        "type":  "integer"
      },
      "PlaneData": {
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        "properties": {
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                "type":  "array",
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                }
              },
              "y": {
                "type":  "array",
                "items": {
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                }
              },
              "z": {
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                }
              },
              "w": {
```

```
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                      "items": {
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                        "items": {
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                "required": ["x", "y", "z", "SIrrad"]
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            }
          }
        },
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          },
          {
            "required": ["NumberMeasured", "SpecIrradNoSymm"]
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        ]
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        "ChannelMult": {
          "type": "array",
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        "items": {
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            "ChannelMult": {
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            }
          },
          "required": ["name", "ChannelMult"]
        }
      }
    },
    "required": ["NumChannels", "ChannelMult"]
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  "EmissionAreas": {
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    "properties": {
      "TopFace": {
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        "properties": {
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                "type": "boolean"
              }
            },
            "required": [
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              "Width",
              "LengthOffset",
              "WidthOffset"
            ]
          }
        },
        "required": ["NumberTop", "TopArea"]
      },
      "BottomFace": {
        "type": "object",
        "properties": {
          "NumberBottom": {
            "type": "integer"
          },
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```

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            }
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            "LengthOffset",
            "WidthOffset"
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    },
    "required": ["NumberBottom", "BottomArea"]
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    "properties": {
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      },
      "C0Area": {
        "type": "object",
        "properties": {
          "Length": {
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          "Circular": {
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          }
        },
        "required": [
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          "Height",
          "LengthOffset",
          "HeightOffset"
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```
        ]
      }
    },
    "required": ["NumberC0", "C0Area"]
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  "C90Face": {
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    "properties": {
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        "properties": {
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          },
          "Height": {
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          },
          "WidthOffset": {
            "type": "integer"
          },
          "HeightOffset": {
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          },
          "Circular": {
            "type": "boolean"
          }
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          "Height",
          "WidthOffset",
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  },
  "C180Face": {
    "type": "object",
    "properties": {
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        "type": "integer"
      },
      "C180Area": {
        "type": "object",
        "properties": {
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          },
          "Height": {
            "type": "integer"
          },
          "LengthOffset": {
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          "HeightOffset": {
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```

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        }
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    "C270Face": {
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      "properties": {
        "NumberC270": {
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        },
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          },
          "required": [
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            "Height",
            "WidthOffset",
            "HeightOffset"
          ]
        }
      },
      "required": ["NumberTop", "TopArea"]
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  }
},
"EmitterCenter": {
  "type": "object",
  "properties": {
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    },
    "HeightOffset": {
```

```
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    },
    "required": [
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  },
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    "properties": {
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        "enum": ["Measured", "Nominal", "Rated"]
      },
      "PowerFactor": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
      },
      "BallastFactor": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
      },
      "ColorTemperature": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
      },
      "CIE_CRI": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
      },
      "IES_TM30": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
      },
      "Duv": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
      },
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        "enum": ["Measured", "Nominal", "Rated"]
      },
      "LuminousFlux": {
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        "enum": ["Measured", "Nominal", "Rated"]
      },
      "RadiantIntensity": {
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        "enum": ["Measured", "Nominal", "Rated"]
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      "RadiantFlux": {
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        "enum": ["Measured", "Nominal", "Rated"]
      },
      "PhotonIntensity": {
        "type": "string",
        "enum": ["Measured", "Nominal", "Rated"]
```

```
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                  "enum": ["Measured", "Nominal", "Rated"]
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                  "enum": ["Measured", "Nominal", "Rated"]
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                "SpectralIntensity": {
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                  "enum": ["Measured", "Nominal", "Rated"]
                },
                "AngularColor": {
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                  "enum": ["Measured", "Nominal", "Rated"]
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                "Illuminance": {
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                  "enum": ["Measured", "Nominal", "Rated"]
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                "Irradiance": {
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            }
          },
          "required": ["Quantity", "Description", "InputWattage"]
        }
      },
      "CustomData": {
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          "properties": {
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              "type": "string"
            },
            "UniqueIdentifier": {
              "type": "string"
            }
          },
          "required": ["Name", "UniqueIdentifier"],
          "additionalProperties": true
        }
      }
    },
    "required": ["Header", "Emitter"]
}
```

Annex A Sample Luminous (Photometric) Documents

A.1 Sample Luminous (Photometric) XML Document

```
<?xml version="1.1"?>
<CIE2xx>
  <Version>1.1</Version>
  <Header>
    <Manufacturer>Academy Lighting</Manufacturer>
    <CatalogNumber>XET 55529</CatalogNumber>
    <Description>LED 2' x 4' Troffer</Description>
    <Laboratory>Apex Analytics</Laboratory>
    <ReportNumber>APEX-091101-004</ReportNumber>
    <ReportDate>2009-11-01</ReportDate>
    <DocumentCreator>Apex Analytics</DocumentCreator>
    <UniqueIdentifier>21EC2020-3AEA-4069-A2DD-08002B30309D
        </UniqueIdentifier>
    <Comment>Ambient temperature 25 degrees C.</Comment>
  </Header>
  <Luminaire>
    <Dimensions>
      <Length>1.20</Length>
      <Width>0.60</Width>
      <Height>0.10</Height>
    </Dimensions>
    <NumEmitter>1</NumEmitter>
  </Luminaire>
  <Equipment>
    <Gonioradiometer>
      <Type>IES_C</Type>
      <MeasurementEquipment>LightLab</MeasurementEquipment>
    </Gonioradiometer>
    <IntegratingSphere>
      <MeasurementEquipment>LabSphere</MeasurementEquipment>
    </IntegratingSphere>
  </Equipment>
  <Emitter>
    <Quantity>1</Quantity>
    <Description>Integral LED module</Description>
    <CatalogNumber>Not applicable</CatalogNumber>
    <RatedLumens>0.0</RatedLumens>
    <InputWattage>35.4</InputWattage>
    <ColorTemperature>
      <FixedCCT>4000</FixedCCT>
    </ColorTemperature>
    <ColorRendering>
      <CIE_CRI>
        <Ra>92</Ra>
        <R9>85</R9>
      </CIE_CRI>
      <IES_TM30>
        <Rf>60</Rf>
        <Rg>95</Rg>
      </IES_TM30>
    </ColorRendering>
    <LuminousData>
      <LuminousIntensity>
        <AbsolutePhotometry>true</AbsolutePhotometry>
```

```
        <Symm>Symm_Full</Symm>
        <NumberMeasured>19</NumberMeasured>
        <NumberHorz>1</NumberHorz>
        <NumberVert>19</NumberVert>
        <IntData  h="0.0"  v="0.0">109</IntData>
        <IntData  h="0.0"  v="5.0">109</IntData>
        <IntData  h="0.0"  v="10.0">108</IntData>
        <IntData  h="0.0"  v="15.0">107</IntData>
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        <IntData  h="0.0"  v="30.0">95</IntData>
        <IntData  h="0.0"  v="35.0">89</IntData>
        <IntData  h="0.0"  v="40.0">83</IntData>
        <IntData  h="0.0"  v="45.0">77</IntData>
        <IntData  h="0.0"  v="50.0">71</IntData>
        <IntData  h="0.0"  v="55.0">63</IntData>
        <IntData  h="0.0"  v="60.0">53</IntData>
        <IntData  h="0.0"  v="65.0">44</IntData>
        <IntData  h="0.0"  v="70.0">36</IntData>
        <IntData  h="0.0"  v="75.0">29</IntData>
        <IntData  h="0.0"  v="80.0">22</IntData>
        <IntData  h="0.0"  v="85.0">16</IntData>
        <IntData  h="0.0"  v="90.0">13</IntData>
      </LuminousIntensity>
      <LuminousFlux>1000.0</LuminousFlux>
    </LuminousData>
    <Channels>
      <NumChannels>3</NumChannels>
      <ChannelMult   name="red">0.21</ChannelMult>
      <ChannelMult   name="green">0.72</ChannelMult>
      <ChannelMult   name="blue">0.08</ChannelMult>
    </Channels>
    <EmissionAreas>
      <BottomFace>
        <NumberBottom>2</NumberBottom>
        <BottomArea>
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          <Width>0.60</Width>
          <LengthOffset>-0.1</LengthOffset>
          <WidthOffset>0.0</WidthOffset>
        </BottomArea>
        <BottomArea>
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          <Width>0.60</Width>
          <LengthOffset>0.1</LengthOffset>
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        </BottomArea>
      </BottomFace>
    </EmissionAreas>
    <EmitterCenter>
      <LengthOffset>0.00</LengthOffset>
      <WidthOffset>0.00</WidthOffset>
      <HeightOffset>-0.05</HeightOffset>
    </EmitterCenter>
  </Emitter>
</CIE2xx>
```

A.2 Sample Luminous (Photometric) JSON Document


```
{
  "Version": 1.1,
  "Header": {
    "Manufacturer": "Academy Lighting",
    "CatalogNumber": "XET 55529",
    "Description": "LED 2' x 4' Troffer",
    "Laboratory": "Apex Analytics",
    "ReportNumber": "APEX-091101-004",
    "ReportDate": "2009-11-01",
    "DocumentCreator": "Apex Analytics",
    "UniqueIdentifier": "21EC2020-3AEA-4069-A2DD-08002B30309D",
    "Comment": [
      "Ambient temperature 25 degrees C."
    ]
  },
  "Luminaire": {
    "Dimensions": {
      "Length": 1.20,
      "Width": 0.60,
      "Height": 0.10
    },
    "NumEmitter": 1
  },
  "Equipment": {
    "Gonioradiometer": {
      "Type": "IES_C",
      "MeasurementEquipment": [
        "LightLab"
      ]
    },
    "IntegratingSphere": {
      "MeasurementEquipment": [
        "LabSphere"
      ]
    }
  },
  "Emitter": [
    {
      "Quantity": 1,
      "Description": "Integral LED module",
      "CatalogNumber": "Not applicable",
      "RatedLumens": 0.0,
      "InputWattage": 35.4,
      "ColorTemperature": {
        "FixedCCT": 4000
      },
      "ColorRendering": {
        "CIE_CRI": {
          "Ra": 92,
          "R9": 85
        },
        "IES_TM30": {
          "Rf": 60,
          "Rg": 95
        }
      },
      "LuminousData": {
```

```
        "LuminousIntensity": {
          "AbsolutePhotometry": true,
          "Symm": "Symm_Full",
          "NumberMeasured": 19,
          "NumberHorz": 1,
          "NumberVert": 19,
          "h": [ 0.0 ],
          "v": [ 0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0, 35.0,
          40.0, 45.0, 50.0, 55.0, 60.0, 65.0, 70.0, 75.0, 80.0,
          85.0, 90.0 ],
          "IntDataSymm": [ 109, 109, 108, 107, 104, 100, 95, 89, 83,
          77, 71, 63, 53, 44, 36, 29, 22, 16, 13 ]
        },
        "LuminousFlux": 1000.0
      },
      "Channels": {
        "NumChannels": 3,
        "ChannelMult": [
          {
            "name": "red",
            "mult": 0.21
          },
          {
            "name": "green",
            "mult": 0.72
          },
          {
            "name": "blue",
            "mult": 0.08
          }
        ]
      },
      "EmissionAreas": {
        "BottomFace": {
          "NumberBottom": 2,
          "BottomArea": [
            {
              "Length": 0.50,
              "Width": 0.60,
              "LengthOffset": -0.1,
              "WidthOffset": 0.0
            },
            {
              "Length": 0.50,
              "Width": 0.60,
              "LengthOffset": 0.1,
              "WidthOffset": 0.0
            }
          ]
        }
      },
      "EmitterCenter": {
        "LengthOffset": 0.00,
        "WidthOffset": 0.00,
        "HeightOffset": -0.05
      }
    }
  ]
}
```

Annex B Photon Flux (Informative)

Visible light is typically defined in terms of either lumens (luminous flux) or watts (radiant flux). Horticulturalists, however, measure electromagnetic radiation over the range of 280 nm to 800 nm in terms of photons per second.

Each photon has a “quantum” of energy that is inversely proportional to its wavelength. Thus, the number of photons per second can be expressed in watts if you know the wavelength of each photon (or, more practically, all the photons that have the same wavelength).

Plant photosynthesis, however, depends on a chlorophyll molecule absorbing a single photon, regardless of its wavelength between, approximately 400 nm and 700 nm. Thus, horticulturalists are not concerned with the photon’s energy. They instead measure “photon flux” in terms of micromoles (6.022×10^{17}) photons per second. If the wavelength range is 400 nm to 700 nm, this is Photosynthetically Active Radiation (PAR).

Plants also respond to ultraviolet radiation (280 nm to 400 nm) and “far-red” radiation (700 nm to 800 nm). Depending on the application, horticultural measurements may be reported in terms of radiant flux or photon flux.

A comprehensive list of horticultural lighting metrics is provided in ANSI/ASABE S640 JUL2017, Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms).