INTERNATIONAL STANDARD

IEC 61182-2

First edition
2006-09

Printed board assembly products – Manufacturing description data and transfer methodology –

Part 2:
Generic requirements

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PRINTED BOARD ASSEMBLY PRODUCTS – MANUFACTURING DESCRIPTION DATA AND TRANSFER METHODOLOGY –

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FOREWORD

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International Standard IEC 61182-2 has been prepared by IEC technical committee 93: Design automation.

The text of this standard is based on the following documents:

CDV	Report on voting
93/211/CDV	93/231/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this standard may be issued at a later date.

PRINTED BOARD ASSEMBLY PRODUCTS – MANUFACTURING DESCRIPTION DATA AND TRANSFER METHODOLOGY –

Part 2: Generic requirements

1 Scope and object

This part of IEC 61182 specifies the XML Schema that represents the intelligent data file format used to describe printed board and printed board assembly products with details sufficient for tooling, manufacturing, assembly, and inspection requirements. This format may be used for transmitting information between a printed board designer and a manufacturing or assembly facility. The data is most useful when the manufacturing cycle includes computer-aided processes and numerical control machines.

The data can be defined in either English or International System of Units (SI) units.

1.1 Focus and intent

The generic format requirements are provided in a series of standards focused on printed board manufacturing, assembly, and inspection testing. This standard series consists of a generic standard (IEC 61182-2) that contains all the general requirements. There are four sectional standards that are focused on the XML details necessary to accumulate information in the single file, that addresses the needs of the design, fabrication, assembly and test disciplines producing a particular product.

The sectional standards (IEC 61182-2-1 through IEC 61182-2-4) paraphrase the important requirements and provide suggested usage and examples for the topic covered by the sectional standard.

1.2 Notation

Although the data would be contained in a single file, the file can have different purposes as described in Clause 4. The XML Schema used for this standard follows the notations set forth by the W3C and is as follows:

element – Element appears exactly one time

element? – element may appear 0 or 1 times

element* – element may appear 0 or more times

element+ – element may appear 1 or more times

Any IEC 61182-2 file is composed of a high level element IEC 61182-2 that contains up to six sub-elements:

Content – information about the contents of the 258X file

LogisticHeader – information pertaining to the order and supply data

HistoryRec – change information of the file

Bom – Bill of Materials (Material List) information

Ecad – Computer Aided Design (engineering) information

Avl – Approved Vendors List information

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60194, *Printed board design, manufacture and assembly – Terms and definitions*

IEC 61188-5-1, *Printed boards and printed board assemblies – Design and use – Part 5-1: Attachment (land/joint) considerations – Generic requirements*

IEC 61188-5-2, *Printed boards and printed board assemblies – Design and use – Part 5-2: Attachment (land/joint) considerations – Discrete components*

IEC 61188-5-3, *Printed boards and printed board assemblies – Part 5-3: Sectional design and use requirements – Attachment (land/joint) considerations – Components with Gull-wing leads on two sides*[1]

IEC 61188-5-4, *Printed boards and printed board assemblies – Design and use – Part 5-4: Sectional requirements – Attachment (land/joint) consideration – Components with J leads on two sides*[2]

IEC 61188-5-5, *Printed boards and printed board assemblies – Design and use – Part 5-5: Sectional requirements – Attachment (land/joint) considerations – Components with Gull-wing leads on four sides*[2]

IEC 61188-5-6, *Printed boards and printed board assemblies – Design and use – Part 5-6: Attachment (land/joint) considerations – Chip carriers with J-leads on four sides*

IEC 61188-5-8, *Printed boards and printed board assemblies – Design and use – Part 5-8 : Sectional Requirement – Attachment (land/joint) considerations – Area array components (BGA, FBGA, CGA, LGA)*[2]

3 Documentation conventions

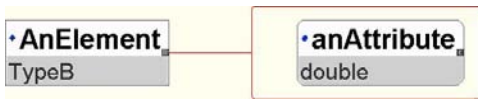
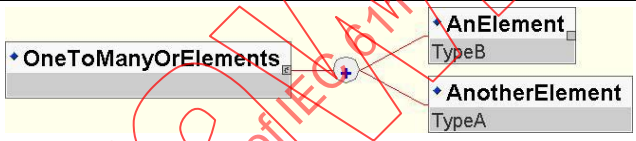
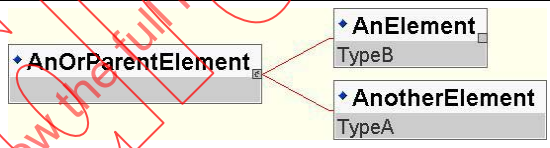
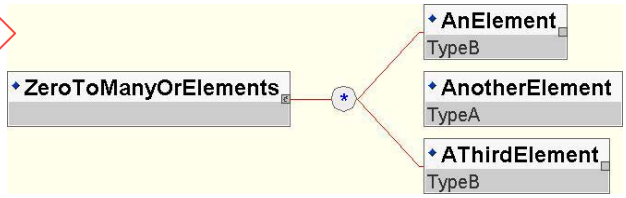
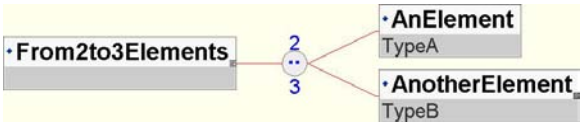
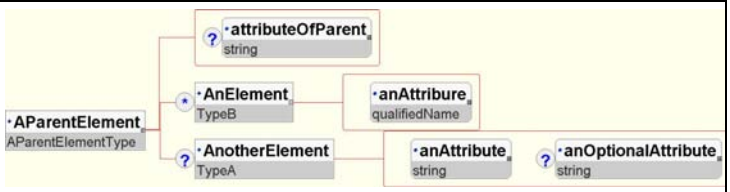
The XML file format standard and the XML Schema definition language standard, as defined by the World Wide Web Consortium (W3C), have been adopted by IEC for use in the IEC 61182 series of standards.

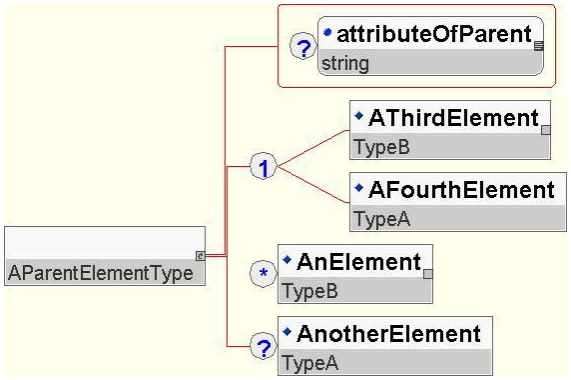
In addition to the text based schema notation, this document provides graphical representation of the structure of the file format. The XML diagrams are designed to effectively illustrate the structure and cardinality of elements and attributes that make up any IEC 61182-2 file. The notation in the graphics does not provide a complete visualization of the schema definition for the file format, but it does provide a good top down overview. Should there be any conflict between the graphical notation and the schema notation, the authoritative definition is the schema notation.

Table 1 provides an overview of the graphical notation used in the document.

[1] To be published.

Table 1– Graphical notation overview

This diagram depicts an element named AnElement that is of type TypeB. There is one attribute, named anAttribute, that is of type double. The attribute is required.	
Example: <AnElement anAttribute="14.44e-3"/> Note that all attribute values must be enclosed in quotes, regardless of type.	
This diagram depicts an element with two attributes. The attribute anAttribute is required. The "?" in the circle indicates that the second attribute, anOptionalAttribute, is optional. Both attributes are of type string.	
Examples: <AnotherElement anAttribute="red" anOptionalAttribute="a string" /> <AnotherElement anAttribute="blue" />	
The element OneToManyOrElements is the parent of an unordered list of one or more instances of the elements AnElement and AnothertElement. The "+" indicates the occurrence is one to many and the angled lines indicate this is a choice relationship ("|") between the children elements.	
< OneToManyOrParentElement>…	
The absence of an occurrence bubble declares that one and only one occurrence are allowed. The AnOrParentElement can have one of AnElement or AnotherElement as a child element.	
The '*' in the occurrence bubble indicates the choice is from 0 to many.	
This diagram depicts an element, From2to3Elements. The element has no type and no attributes. It can have from 2 to 3 sub-elements of either AnElement or AnotherElement.	
This diagram depicts an element, AParentElement, of type AParentElementType. This element has one attribute, attributeOfParent, which is optional. The lines with square corners indicate that occurrences of AnElement and AnotherElement must appear in the order by the illustration on the right where the top element is addressed first and AnotherElement is addressed secondly.	

This diagram depicts a type, AParentElementType, that contains a sequence starting with one of AThirdElement or AFourth element followed by 0-n AnElement and an optional final AnotherElement.	

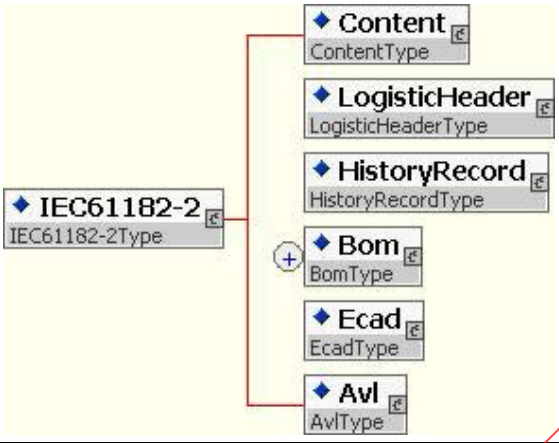
4 Requirements

The XML Schema contained in this document describes the structure of a generic computer-aided manufacturing IEC 61182-2 exchange format. The document specifies data elements specifically designed to establish the information exchange related to the data needed by printed board manufacturing, and assembly including inspection of those products.

The XML Schema defines the configuration of mandatory and optional elements, as well as mandatory and optional attributes. The Top Level (TopElement) of the schema contains six major elements. The schema notation specifies that the 6 top-level elements are required to appear in the order shown in Figure 1. The order of appearance in the file is significant. For instance, the appearance of graphics on a layer is dependent on the order of appearance in the file. The order is also important because elements often reference information that is defined elsewhere in the file in order to eliminate redundancy within the file. The file is structured to allow all references to be resolved in one pass.

An implementation of the XML Schema must be able to facilitate the reading and/or writing of all characteristics defined within the requirements stated in the Mode function of this standard. Some tools may have only read capability; some may have only write capability. Some tools may have both read/write capability. All schema defined in the standard as mandatory (1-1, 1-n occurrences) **shall** be executed as appropriate. Tool providers **shall** identify their capability by Mode Level (Full, Design 1, 2 or 3, Fabrication 1, 2, or 3, etc.) plus 2581R (read-only); 2581W (write-only); or 2581RW (read and write).

Each element has a specific function or task. Accordingly, the information interchange for a specific purpose is possible only if that element is populated. The ability to select those characteristics that are appropriate for a given task makes the schema a robust methodology for defining only those areas and characteristics that are necessary to produce a given product. Figure 1 shows the children elements of the Top Element IEC 61182-2.



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
IEC 61182-2	IEC 61182-2 Type	**The generic name of the file used to describe design, fabrication, assembly, and test information in accordance with IEC 61182-2 .**	**1-1**
Content	ContentType	The `Content` element defines the function of the file, and references the major sections of the product description (i.e. Step, Layer, Bom and Avl). In addition, there are six dictionaries indicated in Content that would contain the pre-descibed information needed for the file details.	**1-1**
LogisticHeader	LogisticHeaderType	The `LogisticHeader` describes information pertaining to ordering and delivery, by identifying individuals and locations responsible for these functions.	**1-1**
HistoryRecord	HistoryRecordType	The `HistoryRecord` element provides a sequential change number for the IEC 61182-2 file. The number is changed every time the controlled version of the IEC 61182-2 file is modified. Also identified are the change approval conditions.	**1-1**
Bom	BomType	The `Bill of Materials` for the board is a list of all the different components to be used for the assembly of the board, arranged by their OEM Design Number (ODN) and the materials used to fabricate the printed board.	**1-n**
Ecad	EcadType	The `Ecad` section describes the Computer Aided Design data of the job, including all the graphical description of the layers, component location, panel design, etc.	**1-1**
Avl	AvlType	The `AVL` element contains the list of matching manufacturer's part numbers (MPNs) and vendor information of certain component parts. Approved vendors of printed board materials may also be included.	**1-1**

Figure 1 – The IEC 61182-2 children element

IEC 1669/06

4.1 Rules concerning the use of XML and XML Schema

The rules required to define syntax and semantics of the 61182-2-X file format notation have been simplified by the adoption of the W3C standards for XML Schema and XML file formats. These two standards are well-specified by the W3C. The popularity of these standards has lead to the development of many commercial and open source software tools and libraries that conform to the W3C standards.

A IEC 61182-2 file begins with the <61182-2-X revision = "1.0"> tag and end with the </61182-2-X> tag. The content between these tags must match the .xsd definition of the 61182-2-X element as defined by the IEC 61182-2-1 through IEC 61182-2-4 XML Schema.

4.1.1 File readability and uniformity

A valid IEC 61182-2-1 through IEC 61182-2-4 file must conform to the W3C Canonical XML format. The format is defined by the http://www.w3.org/TR/xml-c14n specification. Software tools exist that will take malformed XML and automatically generate Canonical XML.

4.1.2 File markers

An optional checksum can be appended following the </61182-2-X > tag. The checksum is an MD5 message digest algorithm (see Internet RFC 1321: http://www.ietf.org/rfc/rfc1321.txt) that is base64 encoded. The checksum starts with the "<" character of the <258X> tag and ending with the ">" character of the closing </61182-2-X > tag. The checksum follows immediately after the ">" character of the closing </61182-2-X > tag.

The digest provides a 128-bit checksum of the 61182-2-X file contents. The MD5 signature must be base64 encoded (see IETF RFC 1421 for the base64 algorithm) to convert the MD5 signature to a US-ASCII, base64 string. An end of line character will indicate the end of the base64 encoded MD5 signature.

4.1.3 File extension

The file extension for a 61182-2-X file is .cvg.

4.1.4 File remarks

The 61182-2-X format permits file remarks using the standard XML commenting notation. They are only to be used to support debugging software. A parser may ignore and discard remarks when reading a 61182-2-X file. File remarks are never to be used to represent design or manufacturing information.

4.1.5 Character set definition

The XML standard uses the Unicode character set. This character set covers the characters used in hundreds of written languages. The XML standard allows several of the Unicode encoding formats to be used in an XML file. IEC 61182-2-1 through IEC 61182-2-4 requires the use of the UTF-8 character encoding of the Unicode character set. Although comments and user assigned names may be in any language of choice, all qualified names or enumerated string names **shall** be in English only.

4.2 Data organization and identification rules

The 61182-2-X standards use a namespace mechanism for XML instance files that is similar to the XML namespace mechanism that was created for managing XML meta-data namespaces. The instance file namespace mechanism prevents collisions between the names used by the different products within a single file. This partitioning of namespaces is necessary because any of the 61182-2-X files may contain information describing an arbitrary collection of products. (Boards, assemblies, or panels that are products allowed in an IEC 61182-2-X file.) For example, a file could contain descriptions for building multiple electronic assemblies that are manufactured on separate panels. This mechanism also prepares the way for a distributed database of 61182-2-X design data in which the data can be trusted to be universally unambiguous.

4.2.1 Naming elements within a 61182-2-X file

The capability of Unique namespaces was created to allow a panel to be defined in the single 61182-2-X file that contains multiple unique boards. Since two boards may reuse the same identifier, for example "U1", "R1", it must be possible to separate names in the file into namespaces. The 61182-2-X namespace implementation borrows the notation used by XML namespaces and makes the 61182-2-X standard format consistent with conventional XML usage.

There are two types of names used to name top-level objects (element instances) in a 61182-2-X file. The first type of name is a `qualifiedName` type. This type includes a prefix in the name that corresponds to a namespace within the 61182-2-X file. The prefix and the globally unique identity of the `Namespace` are declared in the `Namespace` element. The second type of name is a `shortName` type. This type is required to be unique within the 61182-2-X file. The syntax restrictions on short names and qualified names assure that all names will be unique as top-level names within 61182-2-X file.

4.2.2 The use of XML elements and types

A comprehensive overview of XML Schema can be found in the W3C XML Schema Primer. This section briefly describes the decisions that were made in the development of the 61182-2-X schema. Reviewing the Primer is recommended prior to reading this section.

The XML Schema defines a namespace mechanism that can be used when defining element names. The W3C also provides a set of general purpose element and attribute types, such as xsd:string, xsd:double, and xsd:datetime. The 61182-2-X format uses these standard types, however the documentation of the 61182-2-X standard has been defined without the use of a namespace prefix for element names within a 61182-2-X file.

Each of the schema elements has a prefix, "`xsd:`", which is associated with the XML Schema namespace through the declaration, `xmlns:xsd= "`http://www.w3.org/2000/08/XMLSchema"`, that appears in the schema element. The prefix `xsd:` is used by convention to denote the XML Schema namespace, although any prefix can be used. The same prefix, and hence the same association, also appears on the names of built-in simple types, for example `xsd:`string. The purpose of the association is to identify the elements and simple types as belonging to the vocabulary of the XML Schema language rather than the vocabulary of the schema author.

In XML Schema, there is a basic difference between complex types that allow elements in their content and may carry attributes, and simple types that cannot have element content and cannot carry attributes. There is also a major distinction between definitions that create new types (both simple and complex), and declarations that enable elements and attributes with specific names and types (both simple and complex) to appear in document instances.

New complex types are defined using the `complexType` element and such definitions typically contain a set of element declarations, element references, and attribute declarations. The declarations are not themselves types, but rather an association between a name and constraints that govern the appearance of that name in documents governed by the associated schema. Elements are declared using the "element," and attributes are declared using the "attribute."

4.2.3 Attribute base types (governing templates)

The attribute basic types (SimpleTypes) provided by XML Schema are defined by the W3C. They are easy to distinguish from the 61182-2-X types because the W3C type is always prefixed with "xsd:". The W3C datatypes are defined in http://www.w3.org/2000/10/XMLSchema (XML Schema Part 2).

Table 2 defines those W3C basic types that are used to define attributes in the 61182-2-X schema. The xsd:string type is constrained to create specific base types for special purpose strings, such as `qualifiedName` and `shortName`. The rules for special number types and the date format are also defined. Table 3 defines those basic types that have been standardized for use within the 61182-2-X format.

Table 2 – Governing template basic types defined by W3C

xsd:string	**A W3C standard data type for a Unicode character string. The characters are from the UTF-8 character set as defined in http://www.ietf.org/rfc/rfc2279.txt.**
xsd:double	**A W3C standard data type for a binary floating-point number. The W3C definition of xsd:double is in http://www.w3.org/TR/xmlschema-2/.** **The xsd:double is a number where the value can be positive, negative, integer or floating point, with at least 7 digits of precision. Numbers are assumed to be positive but can be explicitly designated as positive by preceding the number with a '+' (ASCII decimal 43) character. Negative numbers must be explicitly designated as negative by a preceding '–' (ASCII decimal 45) character. An internal representation of an IEEE double precision floating-point number is assumed. This range of values for IEEE doubles is defined as 3.4x10-38 ≤ value ≤ 3.4x10+38. The format for representing a double is the same as the format used in the computer languages C, Perl, Python, or TCL. For example, all the following are legal numbers:** 1.005 ; 0.01; .01; -2.334e-33; .224e-2
xsd:nonNegativeInteger	**A W3C standard data type for non-negative integer numbers. The W3C definition of xsd:nonNegativeInteger is in http://www.w3.org/TR/xmlschema-2/.** **The range of values allowed are 0 ≤ value ≤ 2147483647 (the non-negative values that fit in a 32 bit signed integer).**
xsd:positiveInteger	**A W3C standard data type for positive integer numbers. The W3C definition of xsd:positiveInteger is in http://www.w3.org/TR/xmlschema-2/.** **The range of values allowed are 1 ≤ value ≤ 2147483647 (the positive values that fit in a 32 bit signed integer).**
xsd:dateTime	**The W3C standard data type for the current date and time is xsd:dateTime. (See http://www.w3.org/TR/NOTE-datetime-970915.html.) The following formats from the W3C specification are recommended for 61182-2-X files:** **Complete date plus hours, minutes and seconds:** **YYYY-MM-DDThh:mm:ssTZD (e.g. 1997-07-16T19:20:30.4536+01:00)** **Complete date plus hours, minutes, seconds and a decimal fraction of a Second:** **YYYY-MM-DDThh:mm:ss.sTZD (e.g. 1997-07-16T19:20:30.45+01:00)** where: **YYYY = four-digit year** **MM = two-digit month (01=January, etc.)** **DD = two-digit day of month (01 through 31)** **Hh = two digits of hour (00 through 23) (am/pm NOT allowed)** **Mm = two digits of minute (00 through 59)** **Ss = two digits of second (00 through 59)** **S = one or more digits representing a decimal fraction of a second** **TZD = time zone designator (Z or +hh:mm or –hh:mm)**
xsd:anyURI	**A W3C standard data type for hyperlinks. The W3C definition of xsd:anyURI is in http://www.w3.org/TR/xmlschema-2/.**
xsd:unsignedByte	**The W3C standard for an unsigned byte (an unsigned 8 bit integer with a value between 0-255.) The W3C definition of xsd:unsignedByte is in http://www.w3.org/TR/xmlschema-2/.**
xsd:base64Binary	**The data is encoded using base64. (see IETF *RFC 1421* for the base64 algorithm and http://www.w3.org/TR/xmlschema-2/#base64Binary)**

Table 3 – Governing template basic types defined by IEC 61182-2-X

qualifiedName	The `qualifiedName` data type is a data type defined for the 61182-2-X series. The type is a restricted xsd:string data type where the pattern of the string must match the regular expression "[a-zA-Z][a-zA-Z0-9_-]*:.+". The definition of the qualifiedName data type is: <xsd:simpleType name = "qualifiedName"> <xsd:restriction base = "xsd:string"> <xsd:pattern value = "[a-zA-Z][a-zA-Z0-9_-]*:.+"/> </xsd:restriction> </xsd:simpleType> An example of a string that matches the pattern is: "prefix:name". The "prefix" is a `Namespace` name. The "name" is the name of an object within the Namespace.
nonNegativeDouble	The `nonNegativeDouble` data type is defined for the 61182-2-X series. The type restricts an xsd:double to positive numbers, inclusive of 0. The non-negative range of values for IEEE doubles is defined as 0.0 ≤ value ≤ 3.4×10^{38}.
pinName	The `pinName` data type is a data type defined for the 61182-2-X series. The type is a restricted xsd:string. The definition of the pinName data type is: <xsd:simpleType name = "pinName"> <xsd:restriction base = "xsd:string"/> </xsd:simpleType>
xpath	The xpath data type is a data type defined for the 61182-2-X series. The type is a restricted xsd:string data type where the pattern of the string must be a legal Xpath as defined in W3C http://www.w3.org/TR/xpath.
shortName	The `shortName` data type is a data type defined for the 61182-2-X series. The type is a restricted xsd:string data type where the pattern of the string must match the regular expression "[a-zA-Z][a-zA-Z0-9_-]*". The xsd definition of the shortName data type is: <xsd:simpleType name = "shortName"> <xsd:restriction base = "xsd:string"> <xsd:pattern value = "[a-zA-Z][a-zA-Z0-9_-]*"/> </xsd:restriction> </xsd:simpleType> An example of a string that matches the pattern is "bob_24"
mimeType	The `mimeType` data type is a restricted xsd:string type that matches IETF MIME type definitions. (e.g. text/html, application/postscript).

The 61182-2-X file supports two types of qualified names. One is a basic qualifiedName; the second is a complete qualifiedName as shown in Table 3.

A basic qualifiedName is composed of at least one letter, followed by any number of letters, numbers, underscores, or hyphens. To form a complete qualifiedName, one can optionally prefix a basic qualifiedName with a colon delimited path, where each step along the path is constructed the same way as the basic qualified name. This permits sorting of sort names into a hierarchy (see Table 3).

Examples of basic qualified names are:

"KarenSingleBoard"
"MultilayerStrategy"
"StandardPrimitiveShapes"

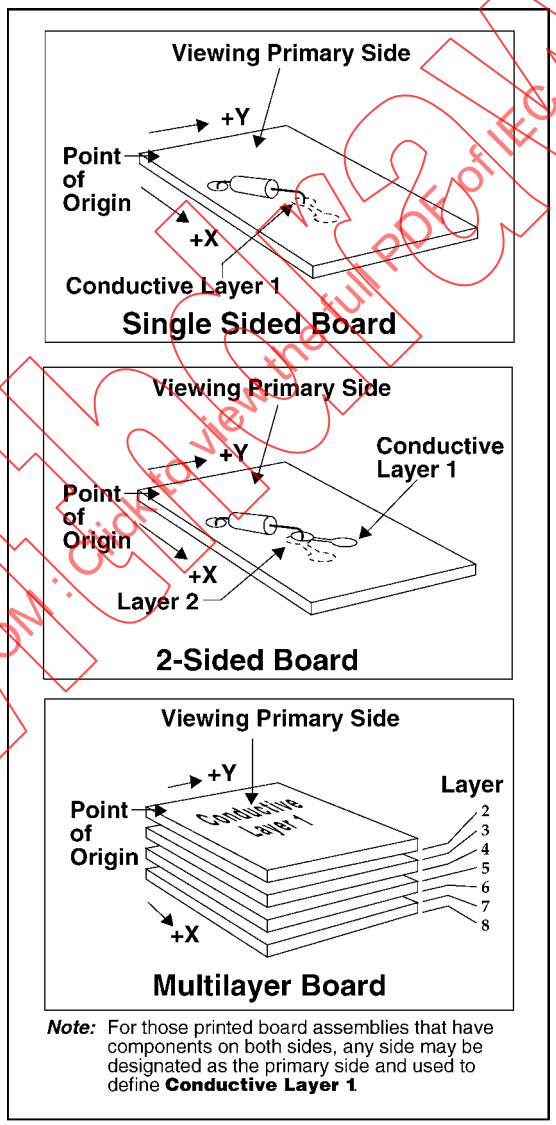
Examples of complete qualified names are:

"Set1:KarenSingleBoard"
"Set1:MultilayerStrategy"
"Set1:StandardPrimitiveShapes"

4.2.4 Coordinate system and transformation rules

Any geometry defined in a 61182-2-X file is defined in a Cartesian coordinate system. The x coordinates become more positive going from left to right (west to east). The y coordinates become more positive going from bottom to top (south to north). The primary side (TOP) of the board, coupon, or panel is in the x-y plane of the coordinate system with the primary side facing up.

The illustration in Figure 2 provides a perspective drawing of a board and a coordinate system. Each product in a 61182-2-X file is defined relative to a local coordinate system for the product. The point of origin of the product is located at (0,0) in the local coordinate system.



IEC 1670/06

Figure 2 – Printed board viewing

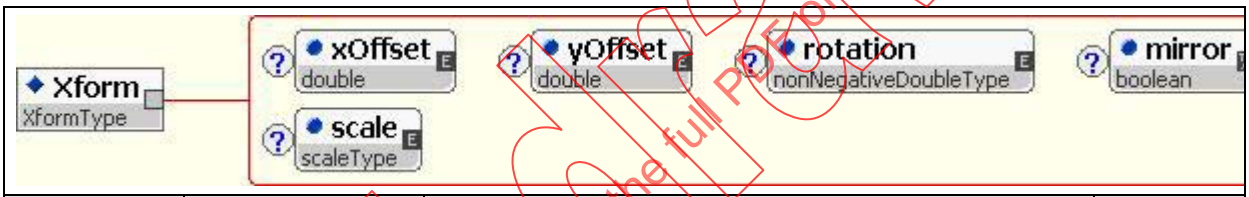
4.3 Transformation characteristics (Xform)

The `Xform` element defines a transformation that may be used throughout this specification to define a modification of the original stored data in the Dictionaries, the location and orientation of physical features. `Features`, `Shapes`, `Primitives` or other graphics in the file may be manipulated relative to their local Cartesian coordinate system by the values set in the transform. The `Xform` element can define a modification of the pre-defined feature's point of origin, and then apply rotation, mirroring, scaling and location (x and y) of the image.

The units of measure are defined in the `CadHeader` as an attribute that describes the details of all the features in the `Ecad` section.In addition, units of measure are also defined in each of the Dictionaries that contain graphical information. These are `DictionaryStandard`, `DictionaryUser`, `DictionaryFont`, and `DictionaryLineDesc`. When a pre-defined image from one of the dictionaries is used in the `Ecad` section, the units of measure must match.

The order of the transformation **shall** always follow the order of the fields in the description. This would be to 1) modify the origin; 2) apply rotation; 3) mirror image; and 4) scale. See Table 4.

Table 4 – Xform characteristics



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined target that can be scaled, mirror imaged or rotated.	0-1
xOffset	double	The x offset of a previously defined shape relative to its original point of origin in order to define a new origin used for rotation, mirroring, scaling and location. The `CadHeader` defines the units of measure.	**0-1**
yOffset	double	The y offset of a previously defined shape relative to its original point of origin in order to define a new origin used for rotation, mirroring, scaling and location. The `CadHeader` defines the units of measure.	**0-1**
rotation	nonNegativeDouble Type	Defines the rotation of a shape about the local origin in degrees. Positive rotation is always counter-clockwise as viewed from the board TOP (primary side). Degree accuracy is expressed as a two place decimal i.e. 45.15; 62.34	**0-1**
mirror	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE equals that the image is mirrored; FALSE indicates that it is not.	**0-1**
scale	scaleType	An attribute that defines a "double" dimension whose minExclusiveValue=0.0 representing the multiplication factor of all x and y dimensions. The scale factor does not apply to angular values.	**0-1**

4.3.1 The x and y Offset attributes

The `xOffset` and `yOffset` attributes are of type xsd:double. They define the x and y offset of a shape relative to the origin of a Cartesian coordinate system. The definition of shapes can be nested and the x and y attributes are always interpreted relative to the local coordinate system of the shape to which the transformation applies. The default value for x and y is 0.0.

4.3.2 The rotation attribute

The `rotation` attribute is of type `nonNegativeDouble` that defines the rotation of a shape about the local origin. The interpretation of the value is set globally in the file to units of degrees. The `Units` element in the `Ecad Header` element specifies the units of measure. The range of the rotation parameter for DEGREES is 0.00 to 360.00 expressed as a `nonNegativeDouble` with an accuracy of a two place decimal. Positive rotation is always counter-clockwise as viewed from the board TOP (primary side), even if the component that is being rotated is on the board BOTTOM (secondary side). Rotation defaults to 0.0, and can be applied to text, or any physical shape.

4.3.3 The mirror attribute

The `mirror` attribute is of data type `boolean`. This type is an enumerated string indicating TRUE or FALSE. The default value for MIRROR is FALSE. When mirror is set to TRUE it indicates that all x dimensions are set to a –x value. The proper interpretation of the mirror and rotate attributes are shown in Figure 3. The example shows a unique artwork (14-pin DIP device) placed on the top and bottom of a board at 90.00° rotations.

4.3.4 The scale attribute

The `scale` attribute is of data type `scaleType`. The `scale` attribute is a “double” that must have a value greater than zero. All x and y dimensions of a geometry are multiplied by the scale attribute. The scale factor does not apply to angular values. The default value is 1.0.

4.3.5 The x and y Location attributes

The `xLocation` and `yLocation` attributes are of type xsd:double. They define the x and y position where a feature, component, text or other shape is placed. The `xLocation` and `yLocation` coordinate positions a shape by its original origin or its modified origin (x and y Offset) relative to the origin of the image upon which the feature, component etc. is to be located. Mirroring, rotating, and scaling may all apply to the location of the shape as indicated by the `Xform`.

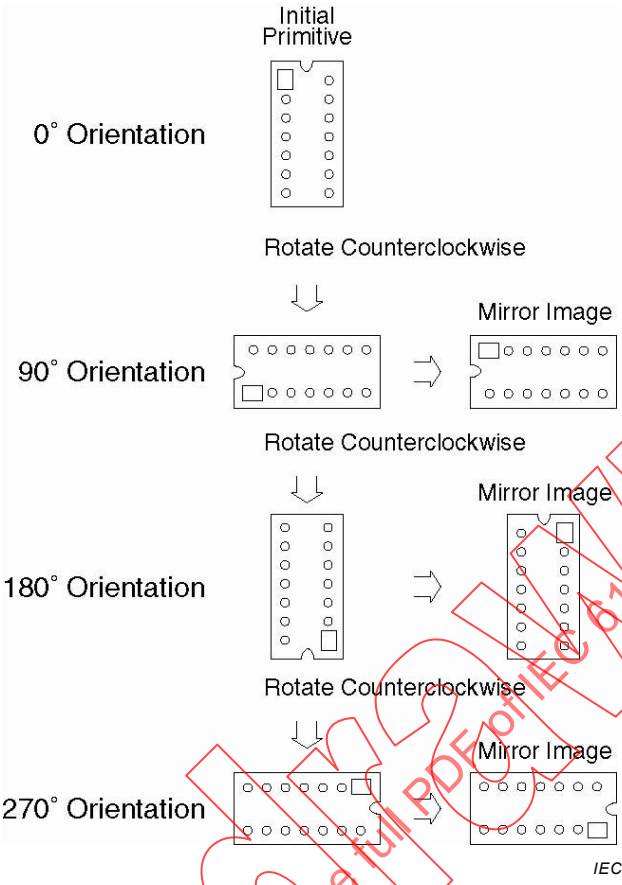


Figure 3 – Mirror and rotation diagram

4.4 Substitution groups

The IEC 61182-2-X uses the concept of substitution within the XML Schema. Various groups of elements have been identified in the body of the standard and have been designated as having a specific focus or purpose. Within the schema, these substitution groups are provided with a name. When a group exists and if they are required according to the instances of the schema, it is mandatory that the substitution name be replaced by one of the acceptable descriptions identified within the group.

Often a schema needs to specify that one of several different XML Elements can be used with equal validity. For example, in every case where a `Triangle` can be used, it is also permissible to use a `Diamond`, `Hexagon`, `Octagon`, `Oval`, or one of several others: even though these shapes are quite different, they are equivalent as far as the schema is concerned. IEC 61182-2-X handles this by using “substitution groups.”

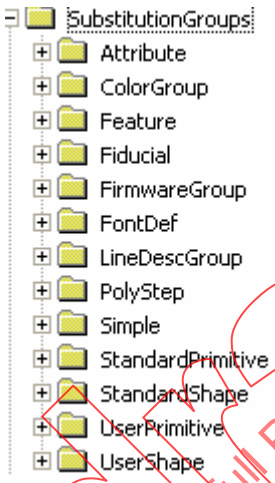
A substitution group consists of two types of elements: a “head”, and elements which may substitute for the head. Furthermore, when the head is denoted as ABSTRACT, the substitution is required, rather than optional. In IEC 61182-2-X, the heads of all substitution groups are ABSTRACT. Thus, it means that a valid instance document is not allowed to contain a `StandardPrimitive` element, but instead, (where `StandardPrimitive` is called for in the schema) a `Triangle`, `Diamond`, `Hexagon`, etc. must be used.

It should be noted that the head of one substitution group may be used within a different substitution group. As an example, the `StandardPrimitive` element is part of the `StandardShape` substitution group, which in turn is part of the `Feature` substitution group. This means that a `Triangle`, `Diamond`, `Hexagon`, etc may be used wherever a `Feature` or `StandardShape` is called for, as well as wherever a `StandardPrimitive` is called for.

61182-2-X features several dictionaries that permit specifying some type of information (such as a `StandardPrimitive` or a `LineDesc`) one time, and to reuse that definition as often as necessary. Some substitution groups in IEC 61182-2-X are present to enable specifying either a dictionary entry or the same kind of information defined in specific detail within the body of the file. Any predefined image contained in the Dictionaries must have a unique "id". It is the "id" name that is used to instantiate information from any of the dictionaries.

There are 13 substitution groups within the 61182-2-X schema. These are shown in Table 5.

Table 5 – Substitution groups



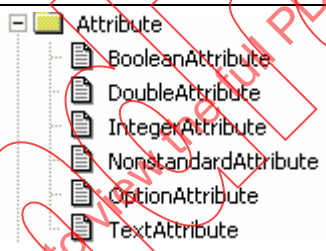
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Attribute	ABSTRACT	A substitution group that permits the substitution of the `Attribute` element when it is a child of the parent `Component`, `LogicalNet`, `Set`, or `Step` elements.	4
ColorGroup	ABSTRACT	A substitution group that permits the substitution of the `Color` element when it is a child of the parent `FinishType`, `Set`, or `Text` Elements.	3
Feature	ABSTRACT	A substitution group that permits the substitution of the `Feature` element when it is a child of the parent `Set` element.	1
Fiducial	ABSTRACT	A substitution group that permits the substitution of the `Fiducial` element when it is a child of the parent `Set` element.	1
FirmwareGroup	ABSTRACT	A substitution group that permits the substitution of the `FirmwareGroup` element when it is a child of the parent `Firmware` element.	1
FontDef	ABSTRACT	A substitution group that permits the substitution of the `FontDef` element when it is a child of the parent `EntryFont` element.	1
LineDescGroup	ABSTRACT	A substitution group that permits the substitution of the `LineDescGroup` element when it is a child of the parent `Outline`, `Polyline`, or `Set` elements.	3
PolyStep	ABSTRACT	A substitution group that permits the substitution of the `PolyStep` element when it is a child of the parent `Polyline` or `Polygon` elements.	2
Simple	ABSTRACT	A substitution group that permits the substitution of the `Simple` element when it is a child of the parent `DfxMeasurement`, `Glyph`, or `Slot` elements.	3
StandardPrimitive	ABSTRACT	A substitution group that permits the substitution of the `StandardPrimitive` element when it is a child of the parent `EntryStandard` element.	1

StandardShape	ABSTRACT	A substitution group that permits the substitution of the `StandardShape` element when it is a child of the parent `LayerPad` or `Pad` elements.	2
UserPrimitive	ABSTRACT	A substitution group that permits the substitution of the `UserPrimitive` element when it is a child of the parent `EntryUser` element.	1
UserShape	ABSTRACT	A substitution group that permits the substitution or classification of a higher level substitution group. The `UserShape` element may be used to further classify `Feature`. In so doing, `UserShape` can be substituted by a `UserPrimitive` or `UserPrimitiveRef`.	0

4.4.1 Attribute

The `Attribute` substitution group consists of various attributes that may be used within the body of the 61182-2-X standard. Attributes are optional and are used within the `Component`, `LogicalNet`, `Set`, and `Step` elements. Attributes contain legacy data that has not yet become a more formal part of 61182-2-X. The long range intention is to deprecate all Attributes and to incorporate their information elsewhere in 61182-2-X files. There are five kinds of standard Attributes that hold different types of data, and a `NonstandardAttribute` which can contain any type of data. The standard attributes are constrained to have specific names. See Table 6.

Table 6 – `Attribute` substitution group



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
BooleanAttribute	ABSTRACT	A substitution for `Attribute` identified as an enumerated string that may be any of the following: smd | gold_plating | n_electric | nomenclature | tear_drop | pattern_fill | drill_noopt | foot_down | et_align | full_plane | out_orig | net_point | test_point | imp_line | non_tp | patch | shave | mount_hole | tooling_hole | is_capped | lpol_surf | critical_net | critical_tp | orbotech_plot_stamp | skip_indicator | out_mirror | lpol_done | cu_base | out_drill_full | out_drill_optional | out_rout_optional | array_with_rotation | out_break | out_scale | break_away | center_fiducial | comp_ign_spacing | no_tp_under | no_hole_under | no_trace_under | no_copper_shape_under | no_uncap_via_under | no_text_under | no_fiducial_check | thvpad_required | label_clearance | guard_comp | needs_guarding | ind_orient_req | is_burried | is_shadowed | is_wirebonded | spo_shape_stretch | toep_nochk_o_side | no_pop | comp_ignore | hp3070_test | drc_bend_keepout | drc_board | drc_mech | drc_etch_lyrs_all | drc_comp_keepin | drc_tp_keepin | drc_route_keepin | drc_comp_keepout | drc_tp_keepout | drc_trace_keepout | drc_pad_keepout | drc_plane_keepout | drc_via_keepout | drc_route_keepout | drc_comp_height | vcut | hatch | hatch_border | hatch_serrated_border | dxf_dimension	0-n

DoubleAttribute	ABSTRACT	A substitution for `Attribute` identified as an enumerated string that may be any of the following: pitch | string_angle | spacing_req | board_thickness | out_x_scale | out_y_scale | out_comp | eda_layers | et_adjacency | layer_dielectric | fill_dx | fill_dy | image_dx | image_dy | local_fiducial_dist | comp_height | comp_htol_plus | comp_htol_minus | comp_weight | spo_shape_rotate | spo_move_center | spo_w_val | spo_w_fact | spo_h_val | spo_h_fact | spo_s_val | spo_s_fact | spo_p_val | spo_p_fact | toep_spacing_req | hp3070_tol_pos | hp3070_tol_neg | hp3070_hi_value | hp3070_lo_value | hp3070_seriesr | gencad_device_ptol | gencad_device_ntol | drc_max_height | drc_min_height | net_length_min | net_length_max | dpair_gap | eclass_voltage_swing | eclass_impedance | eclass_rise_time | eclass_min_stub_length | eclass_max_stub_length | min_line_width | ar_pad_drill_top_min | ar_pad_drill_top_max | ar_pad_drill_inner_min | ar_pad_drill_inner_max | ar_pad_drill_bottom_min | ar_pad_drill_bottom_max | ar_sm_pad_top_min | ar_sm_pad_top_max | ar_sm_pad_bottom_min | ar_sm_pad_bottom_max | ar_sm_drill_top_min | ar_sm_drill_top_max | ar_sm_drill_bottom_min | ar_sm_drill_bottom_max	0-n
IntegerAttribute	ABSTRACT	A substitution for `Attribute` identified as an enumerated string that may be any of the following: drill_flag | rout_chain | rout_flag | pilot_hole | out_flag | extended | feed | speed | cut_line | aoi_drcu | aoi_drbm | aoi_cpcu | aoi_cpbm | aoi_value | orig_surf | eda_dimension_id | output_dcode | design_origin_x | design_origin_y | out_drill_order | out_rout_order | num_local_fiducials | src_orientation | rot_correction | drc_min_space | drc_min_width | drc_add_rad | eclass_max_via_count | testpoint_count	0-n
NonstandardAttribute	ABSTRACT	A substitution for `Attribute` identified as string data that may be any characteristics that the owner or user of the file deems necessary to help clarify the issues of the `Component`, `LogicalNet`, `Set` or `Step` elements.	0-n
OptionAttribute	ABSTRACT	A substitution for `Attribute` identified as an enumerated string that may be any of the following: drill | via_type | comp | drill_stage | drill_sr_zero | pad_usage | primary_side | out_angle | out_polarity | layer_hdi_type | fs_direction_top | fs_direction_bottom | smt_direction_top | smt_direction_bottom | viacap_layer | wheel_type | comp_type | comp_type2 | comp_mount_type | comp_polarity | otherside_keepout | spo_w_mode | spo_h_mode | spo_s_mode | spo_p_mode | drc_assembly_lyrs | sip	0-n
TextAttribute	ABSTRACT	A substitution for `Attribute` identified as an enumerated string that may be any of the following: bit | geometry | fiducial_rdlist | area_name | source_llayer | fiducial_name | string | color | customer | comment | technology | global_camtek_aoiset | drc_route_keepin_lyr | drc_comp_keepin_lyr | drc_tp_keepin_lyr | drc_route_keepout_lyr | drc_via_keepout_lyr | drc_trace_keepout_lyr | drc_plane_keepout_lyr | drc_pad_keepout_lyr | drc_comp_keepout_lyr | drc_comp_height_lyr | drc_tp_keepout_lyr | inp_file | eda_layers | out_name | assembly_proc_top | assembly_proc_bottom | all_eda_layers | fab_drc | hdi_drc | hdi_drc | spo_shape | user_bom_rev | machine_pkg | hp3070_device | hp3070_value | hp3070_type | hp3070_fail_msg | hp3070_common_pin | hp3070_contact_pin | hp3070_contact_pin | hp3070_comment | gencad_device_type | gencad_device_style | gencad_device_value | drc_ref_des | drc_etch_lyrs | drc_etch_lyrs_bit | cad_part_override | diff_pair | net_type | electrical_class | eclass_individual_parallel_min_jog_list | eclass_individual_parallel_max_length_list | eclass_individual_parallel_dist_list | eclass_accumulative_parallel_max_length_list | eclass_accumulative_parallel_dist_list | station | variant_list | comp_variant_list | current_variant	0-n

4.4.2 ColorGroup

The ColorGroup substitution group consists of various colors that may be used within the body of the 61182-2-X standard. Color may be predefined and named in the DictionaryColor. Color is used by the FinishType, Set, or Text elements. It is referred to in the body of the file by its "Color ID" or by the three attributes that make up color (red, green, blue). See Table 7.

Table 7 – ColorGroup substitution group

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Color	ColorType	The description of a specific color using the three attributes of red, green, and blue.	0-n
ColorRef	ColorRefType	The id of a previously defined color stored in the DictionaryColor.	0-n

4.4.3 Feature

The Feature substitution consists of two major substitution groups. Where Feature is called for, an instance must substitute a graphic allowed by either the StandardShape or UserShape substitution groups. See Table 8

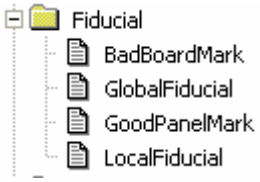
Table 8 – Feature substitution group

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
StandardShape	ABSTRACT	A substitution group that occurs in the 61182-2-X schema and permits the substitution of the StandardShape element when it is a child of the parent LayerPad or Pad elements.	0-n
UserShape	ABSTRACT	A substitution group that occurs in the 61182-2-X schema and permits the substitution or classification of a higher level substitution group. The UserShape element may be used to further classify Feature. In so doing UserShape can be substituted by a UserPrimitive or UserPrimitiveRef.	0-n

4.4.4 Fiducial

The Fiducial substitution group consists of three elements that may be used to replace the Fiducial element. When the Fiducial element is substituted, it **shall** be by either a BadBoardMark, GlobalFiducial, GoodPanelMark, or LocalFiducial pad type. The Fiducial elements contain an Xform and a substitution capability to a StandardShape. An optional Pin attribute allows reference to a component pin. See Table 9

Table 9 – `Fiducial` substitution group



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
BadBoardMark	PadType	A set of Standard Shapes used as an aid to the board assembler by defining those boards in a panel that did not pass inspection or electrical test. The fiducial shape is positioned near each board in the assembly panel array and covered over to signify that the board is defective.	0-n
GlobalFiducial	PadType	A set of Standard Shapes used in the description, arrangement or positioning of a group of features on an individual board, assembly, or panel.	0-n
GoodPanelMark	PadType	A single Standard Shape used to define a panel where all boards on the panel are good. The fiducial is positioned once on the panel and enables reduction in inspection time.	0-n
LocalFiducial	PadType	A set of fiducials (usually a pair) used in the description and arrangement of features related to a specific component on a board, assembly, or panel which aide in the location/positioning process.	0-n

4.4.5 FirmwareGroup

The `FirmwareGroup` substitution group consists of the description element for the firmware that defines the data to be added to a component through the `RefDes` element of a particular `BomItem`. The information may be provided as a `CachedFirmware` element or as a reference to the firmware which has been stored and identified with an "id" in the `DictionaryFirmware`. See Table 10.

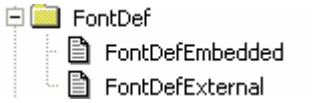
Table 10 – `FirmwareGroup` substitution group

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
CachedFirmware	CachedFirmwareType	An element that identifies the firmware needed for a particular component in the Bill of Material. The information is in a `hexEncodeBinary` format.	0-n
FirmwareRef	FirmwareType	An element that references `CachedFirmware` stored in the `DictionaryFirmware` through the callout of the firmware "id"	0-n

4.4.6 FontDef

The `FontDef` substitution group consists of the description of a font that is different than the standard Helvetica and which is contained in the `DictionaryFont`. Fonts in the dictionary have an "id" which is called out when a `FontRef` is instantiated. `FontRef` is used by the element `Text`, which is called for in `SilkScreen` and `AssemblyDrawing`. `Text` can also be substituted whenever a `UserPrimitive`, `UserShape` or `Feature` is called for. See Table 11.

Table 11 – FontDef substitution group



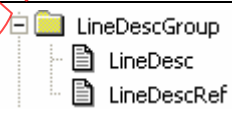
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
FontDefEmbedded	FontDef Embedded Type	A description of a font using individual characters that are defined in accordance with the Glyph element and are contained in the DictionaryFont. Fonts must be predefined and may not be instantiated as part of the data in the file.	0-n
FontDefExternal	FontDef ExternalType	A reference to an external font description through the instantiation of a URN. The font is named and the reference is contained in the DictionaryFont. The appropriate character set is defined by the URN. External Fonts must be predefined and may not be instantiated as part of the data in the file.	0-n

The term "Uniform Resource Name" (URN) refers to the subset of URI that are required to remain globally unique and persistent even when the resource ceases to exist or becomes unavailable. A URI can be further classified as a locator, a name, or both. The term "Uniform Resource Locator" (URL) refers to the subset of URI that identify resources via a representation of their primary access mechanism (e.g. their network "location"), rather than identifying the resource by name or by some other attribute(s) of that resource.

4.4.7 LineDescGroup

The LineDescGroup substitution specifies the LineWidth and LineEnd characteristics of any feature that requires that definition. Line descriptions are a part of the Outline, Polyline and Set element definitions. The substitution is also instantiated by the substitution group Simple which calls for Arc, Line, Outline and Polyline. See Table 12.

Table 12 – LineDescGroup substitution group



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LineDesc	LineDescType	An element that identifies the LineEnd and LineWidth characteristics	0-n
LineDescRef	LineDescRef Type	A reference to a LineDesc that is contained in the DictionaryLineDesc and identified by its unique “id”. The units for the dictionary are defined and must be consistent with the units of the CadHeader when referenced from the Ecad section.	0-n

4.4.8 PolyStep

The Polystep substitution consists of defining either a Line or an Arc as the continuation of a Polyline or Polygon description. The location information is interpreted as being the point to which the curve (Arc), or segment (Line) is drawn. The substitution may take place anywhere within the file where the elements Polyline and Outline occur. This action includes the dictionaries where graphic descriptions are predefined. The Units of measure must be consistent with the Units parameter of the three dictionaries where this substitution can take place; DictionaryStandard, DictionaryUser, and DictionaryFont. See Table 13.

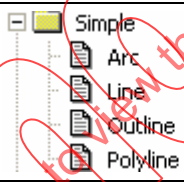
Table 13 – Polystep substitution group

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
PolyStepCurve	PolyStepCurve Type	The continuation of the linear description of a Polyline or Polygon if the next portion to be defined is an arc. The end point of the arc is defined as well as the location of the radius. CounterClockwise is the default direction	0-n
PolyStepSegment	PolyStep SegmentType	The continuation of the linear description of a Polyline or Polygon if the next portion to be defined is a line segment. The end point of the line is defined.	0-n

4.4.9 Simple

The Simple substitution consists of defining an Arc, Line, Outline or Polyline. The Simple substitution is called for in the DfxMeasurement, Glyph, and Slot elements. Simple is also identified as a UserPrimitive, UserShape, or Feature and the four elements may be substituted when called for in conjunction with those descriptions. When predefined in the DictionaryUser, or DictionaryFont the Units must match those of the dictionary. See Table 14.

Table 14 – Simple substitution group

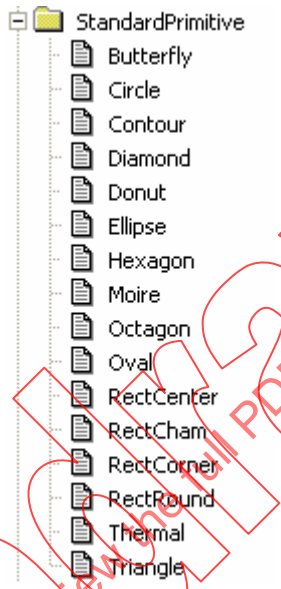


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Arc	ArcType	Arc elements are curves (defined by three sets of coordinates: startX, startY, endX, endY and centerX, centerY. The width of the arc is applied when the arc is instantiated or predefined.	0-n
Line	LineType	Line elements are individual line segments. The lineWidth and lineEnd conditions are defined when the line is instantiated or pre-defined. The lineEnd default is ROUND.	0-n
Outline	OutlineType	Outline has Polygon and LineDesc as children elements. The characteristics of the Polygon must be a closed shape. The point of origin of the shape is identified as the 0:0 coordinate. The element includes the start of the polygon definition (PolyBegin) and the appropriate number of PolySteps to complete the closed shape. The lineWidth is defined at a time when the Outline is instantiated or predefined.	0-n
Polyline	PolylineType	The Polyline element consists of a series of lines that define a particular grouping configuration. These line segments do NOT result in a closed shape, however they can be pre-defined and re-used as needed. The lineWidth and lineEnd of the Polyline are defined at the time the Polyline is instantiated or predefined.	0-n

4.4.10 StandardPrimitive

There are sixteen Standard Primitives defined in the 61182-2-X structure. Any of the primitive shapes may be a candidate for substitution when `StandardPrimitive` is called for in the schema. The names of the various shapes indicate their type; each has its attributes that identify the physical requirements. Any `StandardPrimitive` may be predefined, provided a unique "id", and contained in the `DictionaryStandard`. All `StandardPrimitive` shapes are developed in accordance with their description requirements in the preferred orientation of this standard. See Table 15.

Table 15 – Standard primitive substitution group



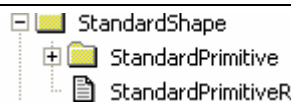
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Butterfly	ButterflyType	A primitive shape (either ROUND or SQUARE) that has two quadrants of the Cartesian coordinate system removed (0° to 90° and 180° to 270°).	0-n
Circle	CircleType	A primitive shape that defines a round object where the circular shape consists of a diameter.	0-n
Contour	ContourType	A closed primitive shape that has as its children a polygon and optional cutout(s) The sequence of connected edges that form the polygon may be straight or circular.	0-n
Diamond	DiamondType	A primitive shape with four equal sides that are extended from its horizontal center to its vertical center. The lines converge into a point both horizontally and vertically. The overall description of the shape is controlled by the width (distance between vertical point) and the height (distance between horizontal point).	0-n
Donut	DonutType	A round, square, hexagon, or octagon shaped primitive consisting of an outer diamer and inner diameter that define physical characteristics of the donut.	0-n
Ellipse	EllipseType	An elliptical primitive shape that follows the standard ellipse characteristics and is defined by a width and height dimension, establishing the overall limits of the feature.	0-n
Hexagon	HexagonType	A six-sided primitive shape with all sides being equal in length and with all angles between adjacent sides being equal. The orientation of the Hexagon is with one of its points facing North. Only the dimension across the points is required.	0-n

Moire	MoireType	A series of circles, each consisting of a smaller diameter than the previous.The details of the `Moire` is defined by the number of rings, their center line spacing, and the ring width. The pattern may also contain a crosshair representing its point of origin. Restrictions apply so that `ringWidth` is smaller than `ringGap`.	0-n
Octagon	OctagonType	An eight-sided primitive shape with all sides being equal in length and with all angles between adjacent sides being equal. The orientation of the `Octagon` is with one of its points facing north. Only the dimension across the points is required.	0-n
Oval	OvalType	A rectangular primitive shape with a complete radius (180° arc) at each end. The limits of the feature are controlled by the length and width of the oval across the outer extremities.	0-n
RectCenter	RectCenterType	The characteristics of a rectangle defined by a width and height dimension consistent with a horizontal position on the Cartesian coordinate system. The center point is the point of origin and is used to locate the `RectCenter`. A "`square`" is a `RectCenter` with the width and height equal.	0-n
RectCham	RectChamType	A rectangle with one or more corners chamfered. The user has the option to define any of the corners as containing the chamfer as well as the chamfered dimensions. All chamfers (or opportunities for chamfers) must be identical in size.	0-n
RectCorner	RectCornerType	A constraining rectangular area (bounding box) that describes a rectangle consistent with a horizontal position on the Cartesian coordinate system. The point of origin is the lower left corner. A Square positioned by its corners is a `RectCorner` that is defined by having the X and Y offset be equal.	0-n
RectRound	RectRoundType	A rectangle with one or more corners rounded. The user has the option to define any of the corners as containing the radius as well as the radiused dimensions. All corners (or opportunities for corners) must be identical in size.	0-n
Thermal	ThermalType	A primitive shape consisting either of ROUND, SQUARE, HEXAGON, or OCTAGON configuration that historically defines the removal of material from a plane or conductive fill area in accordance to the shape attribute description.	0-n
Triangle	TriangleType	A primitive isosceles triangular shape that has two equal sides and a base. The feature is defined by a base and height dimension.	0-n

4.4.11 StandardShape

The `StandardShape` substitution group permits the substitution of any of the `Standard Primitive` shapes in accordance with their individual descriptions. A predefined `StandardPrimitive` may also be instantiated by its unique "`id`" when the feature is contained in the `DictionaryStandard`. When a reference is made to the dictionary predefined primitive, the `Units` must match. See Table 16.

Table 16 – StandardShape substitution group



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Standard Primitive	ABSTRACT	A substitution group that permits the substitution of the `StandardPrimitive` element with any of the sixteen standard primitive types.	0-n
StandardPrimitive Ref	StandardPrimitive RefType	A reference to a predefined `StandardPrimitive`, contained in the `DictionaryPrimitive`. The reference is by its unique "id". The units of the referenced predefined primitive and the `Ecad` section where it is to be instantiated must match.	0-n

4.4.12 UserPrimitive

The `UserPrimitive` substitution group consists of any simple graphic feature (`Arc, Line, Outline or Polyline`), as well as `text` or `UserSpecial` shapes. The `UserSpecial` element is a collection of `Features` (which are any of the permitted graphics used in the 61182-2-X file). `UserSpecial` permits the definition of logos, special targets, drawing formats or other graphics needed by a particular design. `UserPrimitives` can be predefined, assigned a unique "id" and contained in the `DictionaryUser`. The `DictionaryUser` defines the `Units` used to describe the graphic shapes. See Table 17.

Table 17 – `UserPrimitive` substitution group

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Simple	ABSTRACT	A substitution consists of defining an `Arc, Line, Outline or Polyline`. The `Simple` substitution is called for in the schema in `DfxMeasurement, Glyph,` and `Slot` elements and may be defined in any other graphics.	0-n
Text	TextType	The text element defines text strings, fonts, and the bounding box containing the text. Also included are Xform to position, mirror or rotate the text.	0-n
UserSpecial	UserSpecial Type	The `UserSpecial` element has all the capabilities allowed by the standard. The characteristic uses the substitution group "Feature" and may develop any combination of graphical shapes.	0-n

4.4.13 UserShape

The `UserShape` substitution group permits the substitution of any of the `UserPrimitive` shapes in accordance with their individual descriptions. A predefined `UserPrimitive` may also be instantiated by its unique "id" when the feature is contained in the `DictionaryUser`. When a reference is made to the dictionary predefined primitive, the `Units` must match. See Table 18.

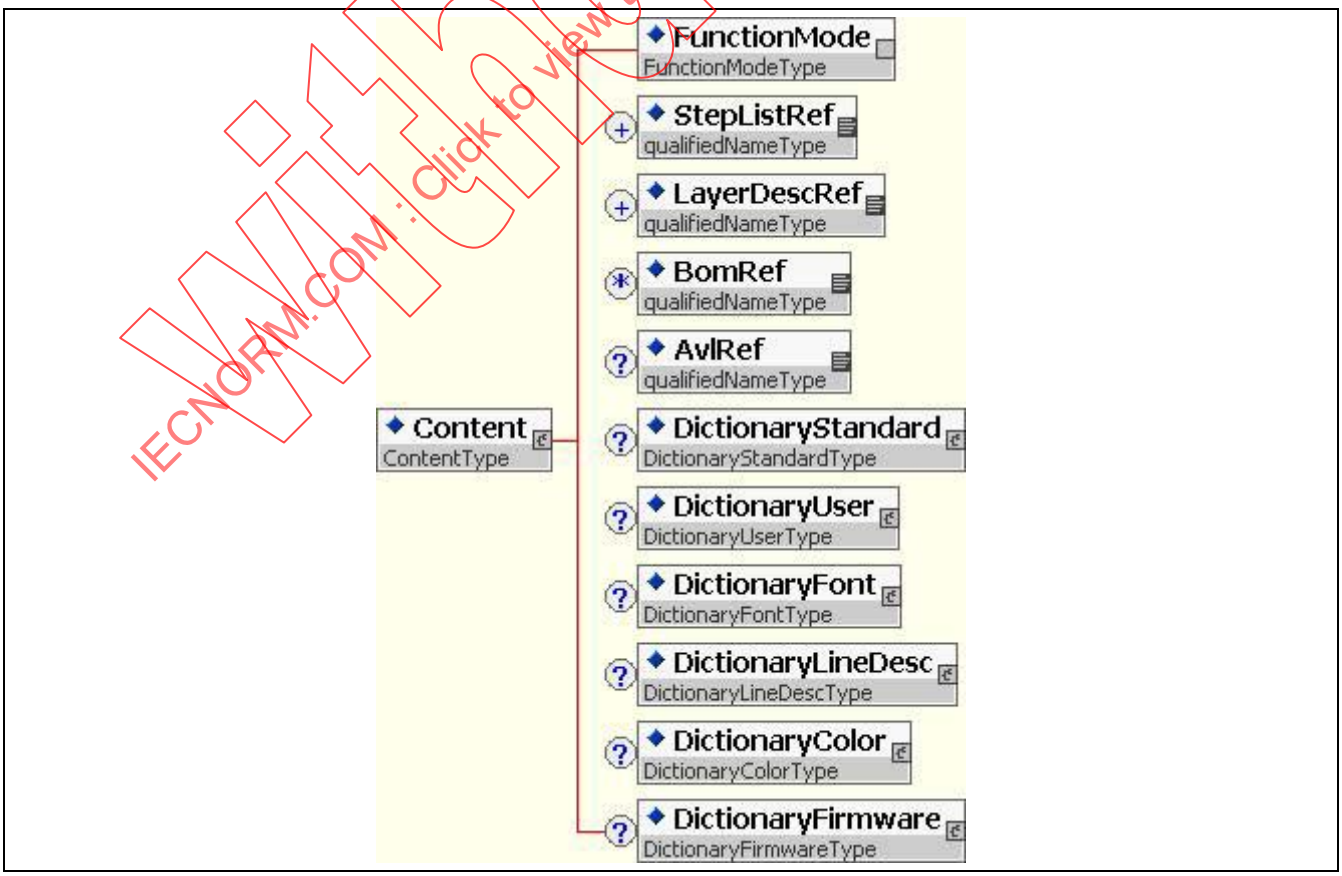
Table 18 – UserShape substitution group

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
UserPrimitive	ABSTRACT	A substitution group that occurs in the 61182-2-X schema and permits the substitution of the `UserPrimitive` element with any of the user primitive description or types.	0-n
UserPrimitiveRef	UserPrimitive RefType	A reference to a predefined `UserPrimitive`, contained in the `DictionaryUser`. The reference is by its unique "id". The units of the referenced predefined primitive and the Ecad section where it is to be instantiated must match.	0-n

5 Content

The `Content` sub-element provides the information about the contents of the IEC 61182-2-X file. See Table 19. The `Content` schema identifies the depth and breadth of information in the file. The `Content` sub-elements include references to the `FunctionMode`, `StepsListRef`, `LayersDescRef`, `BomRef`, and `AvlRef` included in the file, plus six Dictionaries: `DictionaryStandard`, `DictionaryUser`, `DictionaryFont`, `DictionaryLineDesc`, `DictionaryColor`, and `DictionaryFirmware`.

Table 19 – `Content` sub-element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Content	ContentType	The `Content` element defines the function of the file, and references the major sections of the product description (i.e. Step, Layer, Bom and Avl). In addition, there are six dictionaries indicated in Content that would contain the pre-descibed information needed for the file details.	**1-1**
FunctionMode	FunctionModeType	The function that the file is intended to perform between trading partners.	1-1
StepListRef	qualifiedNameType	A reference to all the `StepLists` that are included in the 61182-2-X file.	1-n
LayerDescRef	qualifiedNameType	A reference to all the LayerLists that are included in the IPC-61182-2-X file.	1-n
BomRef	qualifiedNameType	A reference to all the `BomData` included in the file. There may be several `Bom` elements.	0-n
AvlRef	qualifiedNameType	A reference to the `Avl` portion of the file. This file contains the approved vendor list for all items contained in the `BomData`.	0-1
DictionaryStandard	Dictionary StandardType	An element that contains substitution group information using predefined descriptions of standard primitives identified by the 61182-2-X standard and described by the user for reuse in the file.	0-1
DictionaryUser	DictionaryUser Type	An element that contains substitution group information using predefined descriptions of user primitives identified by the 61182-2-X standard and described by the user for reuse in the file.	0-1
DictionaryFont	DictionaryFont Type	An element that contains substitution group information regarding font descriptions as predefined Glyphs or references to external URN's for character sets that differ from the Helvetica standard.	0-1
DictionaryLineDesc	DictionaryLine DescType	An element that contains substitution group information using line description criteria, predefined by the user for reuse in the file.	0-1
DictionaryColor	DictionaryColor Type	An element that contains substitution group information using color description criteria, predefined by the user for reuse in the file.	0-1
DictionaryFirmware	DictionaryFirmwareType	An element that contains substitution group information using firmware description criteria, predefined by the user for reuse in the file.	0-1

5.1 Content: FunctionMode

The `FunctionMode` element defines the global mode of the file (see Table 20). There are five valid values for the `mode` attribute. These are:

FULL – everything in the IEC 61182-2 standard job is included

DESIGN (IEC 61182-2-1) – file carries mostly Design start or complete description

FABRICATION (IEC 61182-2-2) – file carries mostly Fabrication information

ASSEMBLY (IEC 61182-2-3) – file carries mostly Assembly information

TEST (IEC 61182-2-4) – file carries mostly testing information for bare board or assembly

Table 20 – File segmentation and function apportionment

Name	Full	Design			Fabrication			Assembly			Test		
		1	2	3	1	2	3	1	2	3	1	2	3
Hierarchical layer/stack instance files	Y	N	Y	N	N	N	N	N	N	N	N	N	N
Hierarchical conductor routing files	Y	N	Y	N	N	N	N	N	N	N	N	N	N
BOM (Components and Materials)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
AVL (Components and Materials)	Y	N	Y	Y	N	Y	Y	Y	Y	Y	N	N	Y
Component Packages	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y
Land Patterns	Y	N	Y	Y	N	N	Y	N	Y	Y	N	Y	Y
Device Descriptions	Y	Y	Y	Y	N	N	N	N	N	Y	N	N	Y
Component Descriptions	Y	Y	Y	Y	N	N	N	Y	Y	Y	N	Y	Y
Soldermask; Solder Paste Legend Layers	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Drilling and Routing Layers	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Documentation Layers	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Net List	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	N	Y
Outer Copper Layers	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Inner Layers	Y	N	N	Y	Y	Y	Y	N	Y	Y	N	N	Y
Miscellaneous Image Layers	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y
DFX Analysis	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Each `FunctionMode` has a specific purpose defined for the industry. The `FunctionMode` element has three attributes. The first is `mode`, which can be the enumerated strings of DESIGN, FABRICATION, ASSEMBLY, TEST and FULL. In many instances, the testing function is already included in fabrication and assembly modes consisting of bare board testing for fabrication, and in-circuit testing for assembly. Nevertheless, there are times when companies wish to outsource the testing activity. Therefore it is important to identify the various testing modes.

In order to define additional granularity, `FunctionMode` has a second attribute, `level`, that defines the data complexity needed for each of the mode condition. The attribute `level` is a positive integer however only the numbers 1, 2 or 3 are presently allowed since each mode has only three levels. When identifying FULL as the mode, the level should be set at 1. The levels encompass their own file details in order to identify that they are associated with an individual mode. Thus, the required file content for level 1 of the DESIGN mode is not the same as a level 1 for the ASSEMBLY mode.

The `FunctionMode` element has a third attribute. The attribute is `comment` which, as string data, permits the users of the 61182-2-X file to enhance the `FunctionMode` descriptions with additional information. See Table 21.

5.1.1 FULL mode

The `FULL` mode identifier incorporates a total of fifteen functions. Each function is represented and available in the file. The order of the details in the file is not significant as several elements may be used to address any given function. Hierarchical padstack and route information reflects original design intent that may be altered in the representation of the flattened fabrication data. For FABRICATION and ASSEMBLY, flattened data **shall** be used.

5.1.2 DESIGN mode

The `DESIGN` mode consists of three levels of complexity. Each level performs a different function consisting of an original design starting from scratch to completed design that had already been converted to manufacturing data, or a completed design that is still in the CAD format structure.

5.1.3 FABRICATION mode

The `FABRICATION` mode consists of three levels of complexity. Each level describes information in a layered format, from very simplistic data to that where the customer has dictated very specific materials and material stack-up structures.

5.1.4 ASSEMBLY mode

The `ASSEMBLY` mode consists of three levels of complexity. Each level describes a concept of more complete information. The simplest level is mainly bill of material data as well as external copper layers. In its most complete form, the assembly information describes the component approved vendor listing for aliases and substitution in sufficient detail to ensure proper assembly.

5.1.5 TEST mode

The `Test` mode consists of three levels of complexity. Each level describes a specific function for testing information that must be contained within a file. In its simplest mode, the data describes information to allow bare board testing. In its most complex mode, there is information on in-circuit test, impedance control, and dielectric withstanding voltage conditions.

5.2 Function levels

The IEC 61182-2 is limited to be organized as one of thirteen function levels. The `level` attribute, when associated with the `mode` attribute, defines the complexity and detail of the file content.

The `level` attribute consists of a positive integer and identifies complexity with respect to the characteristics for mode-DESIGN, mode-FABRICATION, mode-ASSEMBLY, and mode-TEXT. A mode-FULL consists of all the elements for an 61182-2 file and has only one (1) level value. For all other modes, the `level` attribute relates to the type of mode and is apportioned as one of three levels.

Table 21 – Content – FunctionMode

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
FunctionMode	FunctionMode Type	The function that the file is intended to perform between trading partners.	1-1
mode	modeType	Defines type of mode that the file is intended to serve.	1-1
level	positiveInteger	A numerical value of 1, 2, or 3 used to define the complexity of the mode.	1-1
comment	string	Any appropriate comment to help clarify the intended use of the file.	0-1

5.2.1 FULL Mode Level 1

The FULL mode level 1 requirements are shown as follows. The characteristics represent the most complete state possible.

Layer Stack: Instances of multilayer structure at a single point site defining the characteristics that exist at a particular point including land description or reference, non-pad description or reference, thermal connections or reference, and holes (through-hole, buried, blind, and microvias). LayerStacks are for reference to the construction of the original design.

Conductor Route: Original CAD data files describing conductive patterns and features used to interconnect electronic components in accordance with the original schematic capture file and component library descriptions.

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Device Descriptions: Device characterization including the electronic or electromechanical part number, as well as its value, tolerance, and pin ID consisting of a name and function.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a specific land pattern, a component package style, and a device if the component is electronic.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing (DFM) processes run against it. The results of these are referenced in the `Analysis` element.

5.2.2 Design Levels

The Design Level requirements have a variety of element combinations. Each combination is identified by its `mode` and `level` in combination. There are three Design Level descriptions starting with Design Level 1, Design Level 2 and Design Level 3. The following subclauses show the content of each of the three design levels. It should be noted that when the elements that represent the design mode are available in any of the fabrication or assembly file structures, the information should be treated as original input and reference and can be used for analysis and checking, however ASSEMBLY and FABRICATION elements take precedence.

5.2.2.1 Design Level 1

This level represents the original OEM design as was used to lay out a PCB from the design schematic, layout design rules, and component information. The characteristics represent designing from scratch, taking OEM input and developing the board. Design Level 1 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components and their relation to their logical net description.

Device Descriptions: Device characterization including the electronic or electromechanical part number, as well as its value, tolerance, and pin ID consisting of a name and function.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a specific land pattern, a component package style, and a device if the component is electronic.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of logical nets that includes the physical net points of the components, the location, side, as well as additional information required for bare board electrical testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the Analysis element.

5.2.2.2 Design Level 2

This level provides information that is used to modify an existing design using the original CAD data information since the changes impact the electrical characteristics that should be maintained. The characteristics represent modifying a design where the Fabrication and Assembly file has been archived by the OEM. Design Level 2 requirements are shown as follows:

Layer Stack: Instances of multilayer structure at a single point site defining the characteristics that exist at a particular point including land description or reference, non-pad description or reference, thermal connections or reference, and holes (through-hole, buried, blind, and microvias). LayerStacks are for reference to the construction of the original design.

Conductor Route: Original CAD data files describing conductive patterns and features used to interconnect electronic components in accordance with the original schematic capture file and component library descriptions.

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Device Descriptions: Device characterization including the electronic or electromechanical part number, as well as its value, tolerance, and pin ID consisting of a name and function.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a specific land pattern, a component package style, and a device if the component is electronic.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.2.3 Design Level 3

This information is used to modify an existing or archived design where the original hierarchical information was not maintained or may not be compatible with the design system. The characteristics represent modifying a design using the original CAD data information since the changes impact the electrical characteristics that should be maintained. Design Level 3 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Device Descriptions: Device characterization including the electronic or electromechanical part number, as well as its value, tolerance, and pin ID consisting of a name and function.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a specific land pattern, a component package style, and a device if the component is electronic.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.3 Fabrication Levels

The Fabrication Level requirements have a variety of element combinations. Each combination is identified by its `mode` and `level` in combination. There are three Fabrication Level descriptions starting with Fabrication Level 1, Fabrication Level 2 and Fabrication Level 3. The following sections show the content of each of the three fabrication levels.

5.2.3.1 Fabrication Level 1

This information represents single, double-sided, or multilayer PCB graphical data. There is no electrical connectivity or performance data included. This level replaces PCB fabrication Gerber data. This level presents the fabrication print notes and material construction information in a machine-readable ASCII file format. The level is for build to documentation instructions. Electrical testing is derived from the conductive images. The characteristics represent single or double sided boards, built to documentation. Fabrication Level 1 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.3.2 Fabrication Level 2

This information represents single, double-sided, or multilayer PCB's where electrical connectivity or performance data is included. This replaces the PCB Gerber and IEC 61182-7. This level presents the fabrication print notes and material construction information in a machine-readable ASCII file format. The boards defined may include buried and blind vias with electrical opens and shorts testing and complete stack up definition. Fabrication Level 2 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.3.3 Fabrication Level 3

This information represents single, double-sided, or multilayer PCB's where electrical connectivity, performance data, and embedded passive information is included. This file level replaces the existing PCB fabrication Gerber and IEC 61182-7 data. This level presents the fabrication print notes and material construction information in a machine-readable ASCII file format. These descriptions represent complex printed boards intended to perform a circuit function. Also included is a complete description of core, prepreg and sometimes reinforcement. Fabrication Level 3 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive (resistive or capacitive) material layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.4 Assembly Levels

The Assembly Level requirements have a variety of element combinations. Each combination is identified by its `mode` and `level` in combination. There are three Assembly Level descriptions starting with Assembly Level 1, Assembly Level 2 and Assemblyy Level 3. The following sections show the content of each of the three assembly levels.

5.2.4.1 Assembly Level 1

This information represents pure assembly. There is no Design for Manufacturing (DFM) analysis of the bare board only assembly functions. Parts are provided on a consignment basis, however an Approved Vendor List (AVL) is still required that includes the part number of parts in the consignment. There is no analysis of the data to improve the design. There are no added value services. The requirements are to build to print. Assembly Level 1 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, assembly, and test information.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a component package style, and a Bom item.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.4.2 Assembly Level 2

The information provided represents assemblies that are to be built to print. Parts are procured by Electronic Manufacturing Services (EMS) companies. There is limited DFM analysis, Automated Optical Inspection (AOI), and Flying probe testing. Assembly Level 2 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a component package style, and a Bom item.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.4.3 Assembly Level 3

This level of information represents a full service assembly process. This includes full Design for Excellence (DFX) and customer feed back. Procurement of parts is required as well as an analysis of component substitution. Customer contact provides design improvement recommendations. Full testing, including in-circuit, automatic optical inspection (AOI), Automatic X-ray Inspection (AXI), functional testing and some stress or burn-in testing is a part of this level. DFA can include assignment of parts to specific machines. Assembly Level 3 requirements are shown as follows.

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Device Descriptions: Device characterization including the electronic or electromechanical part number, as well as its value, tolerance, and pin ID consisting of a name and function.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a component package style, and a Bom item.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.5 Test Levels

TheTest Level requirements have a variety of element combinations. Each combination is identified by its `mode` and `level` in combination. There are three Test Level descriptions starting with Test Level 1, Test Level 2 and Test Level 3. The following sections show the content of each of the three test levels.

5.2.5.1 Test Level 1

This information provides testing of the bare board only. It includes opens and shorts, impedance control and dielectric withstanding voltage testing. Test Level 1 requirements are shown as follows:

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.2.5.2 Test Level 2

The information provided includes capability for inspection, manual or using automated equipment such as AOI and AXI. It does not include electrical testing. Test Level 2 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a component package style, and a Bom item.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the Analysis element.

5.2.5.3 Test Level 3

The information available is for full electrical testing. It includes in-circuit as well as functional testing requirements and boundary scan (self test) analysis. Test Level 3 requirements are shown as follows:

Bom: Bill of Material information that describes, in sufficient detail, the component descriptions of the printed board, as well as the materials used for board fabrication, assembly, and test.

Avl: An approved vendor list for each item as defined by the OEM and modified accordingly by the board fabricator and the board assembler to reflect the materials and components used in the final electronic assembly.

Component Packages: Physical outlines of mechanical dimensions for electronic and mechanical components, their pins, (lands), and their relation to their logical net description.

Land Patterns: Combinations of lands used on outer layers that are grouped into a pattern so that they coincide with the mounting pins (IO's) of electronic or electromechanical components. The information is through a reference to the individual land for each pin of a device. Land patterns are for reference only to provide a grouping of lands related to a particular component.

Device Descriptions: Device characterization including the electronic or electromechanical part number, as well as its value, tolerance, and pin ID consisting of a name and function.

Component Descriptions: Consists of the components and their instances on the electronic assembly, including a reference to a component package style, and a Bom item.

Masking Layer: Images for soldermask on external layers of a printed circuit board (top and bottom) as well as legend marking to be incorporated on top of soldermask material.

Drilling Routing: Information on hole forming, either through mechanical drilling, laser ablation, or chemical mechanism and the relationship of the conductor routing layer.

Documentation Layers: Information on the details for finishes, tolerances, and other details necessary to complete the full disclosure of the printed board structure and/or assembly.

Net List: A list of physical nets that includes the physical net points, the location, side, as well as additional information required for bare board electrical testing.

Outer Conductive: External copper geometries and features used for electronic probing or component attachment. They may be defined as positive or negative.

Inner Layers: Image description for innerlayers of multilayered PCB's where the description indicates the conductive pattern as well as plated-through holes contained within a layerset. These characteristics are also used to describe embedded passive layers.

Image Layers: Miscellaneous image layers that may be extracted from the originating CAD system that provide supplementary details for either printed circuit board fabrication or printed circuit board assembly processes and testing.

Analysis: Any of the CAD data can have Design for Manufacturing processes run against it. The results of these are referenced in the `Analysis` element.

5.3 Content: StepListRef

`StepListRef` references the names of `Steps` used in the description of the Printed Circuit Assembly (PCA) itself. In manufacturing, this basic `Step` is often step and repeated (nested) inside a larger step (called array, or sub-panel). This array step can be further nested into another step (called a production panel). The `Ecad` element always contains at least one `Step`, but may contain several, some basic ones and others nesting previous steps.

The `StepsListRef` element, as it appears in the `Contents` schema, references the job `StepList` names and thus the `Steps` that are included in the 61182-2 file. All the graphical data of a 61182-2 job are located inside `Steps` that can be nested inside each other (PCB/Sub Panel/Panel, etc.). `Steps` are referenced in the `Content` schema (`StepsListRef`) as a `qualifiedName` that relates to the details in the `Ecad` schema.

Table 22 – Content – StepListRef

StepListRef qualifiedNameType			
Attribute/ Element Name	**Attribute/ Element Type**	**Description**	**Occur-rence**
StepListRef	qualifiedName Type	A list of the names of the existing steps contained within the file. This feature is a method of checking completeness in file transfer.	1-1

5.4 Content: LayerDescRef

`Layers`, as the name implies, are sheets of two-dimensional data that, when laid on top of each other, create the Printed Circuit Assembly (unpopulated PCB and components). The `Layer` element appears in the 61182-2 file as a sub-element of the `LayerDesc` element.

The LayerDescRef element, as it appears in the Contents schema, references a job's LayerDesc names included in the 61182-2 file. See Table 23

Table 23 – Content – LayerDescRef

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LayerDescRef	qualifiedName Type	A list of the names of the existing layer descriptions contained within the file. This feature is a method of checking completeness in file transfer.	1-1

5.5 Content: BomRef

The BOM section describes the Bill of Materials for the board. A bill of materials is a list of all the different components, materials, mechanical parts, or programmable software used in the electronic product. Components are arranged by the OEMDesignNumber or an alternate; materials for board fabrication or component attachment are arranged by their appropriate identifier. Each part number has a list of attributes and is accompanied by a list of the various specific uses or locations on the electronic product, each with its unique name.

Each BomRef element, as it appears in the Contents schema, references one of the potentially many Bom categories and the number of items included in each category in the 61182-2 file. See Table 24.

Table 24 – Content – BomRef

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
BomRef	qualifiedNameTy pe	A list of BOM items that are arranged by the category description contained as an attribute of each BomItem, i.e., ELECTRICAL | PROGRAMMABLE | MECHANICAL | MATERIAL. This feature identifies the specific number of BomItems as well as the category to which they pertain, and is a method of checking completeness in file transfer.	0-n

5.6 Content: AvlRef

The Avl section describes the Approved Vendor Lists for the materials used to fabricate the board and the assembly. The BOM (bill of material) lists include all the different components to be used on the board, arranged by their appropriate part number, and material used to fabricate the board arranged by the part number of the material. There are also BOMs for the material used that are consumed by the fabrication and assembly processes. Each BOM has a corresponding list of approved vendors if the customer wishes to restrict the components and materials used for the electronic assembly to a specific supplier(s). There **shall** be only one Avl section in a 61182-2 file. It **shall** provide the names of each of the approved suppliers and **shall** correlate them with the BOM that contains the material/component descriptions.

The Avl is used by the customer, the fabricator and the assembler to coordinate the relationship with the bills of materials described in the 61182-2 file. See Table 25.

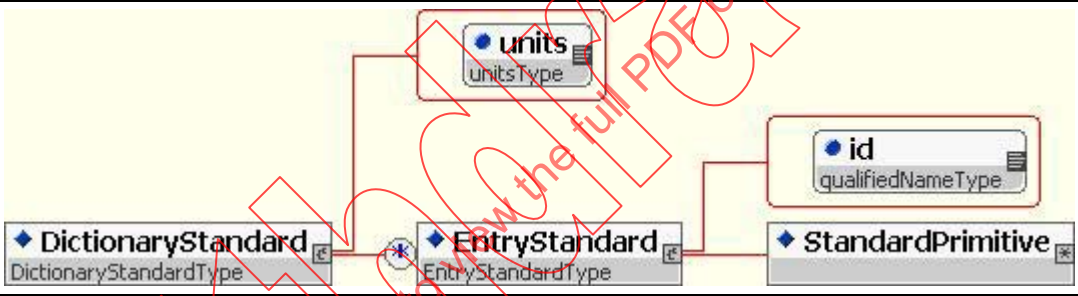
Table 25 – Content – AvlRef

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
AvlRef	qualifiedName Type	A reference to the single Approved Vendor List for all the suppliers identified and the total number in the 61182-2 file. This feature is a method of checking completeness in file transfer.	0-1

5.7 Content: DictionaryStandard

The `DictionaryStandard` is intended to provide lookup information on predefined Standard Primitives. The `DictionaryStandard` is maintained as part of a substitution group schema. The intent is to have graphic descriptions available that are identified by their characteristics and a specific name (id). They may be reused throughout the file as appropriate. The name (id) of a `StandardPrimitive` must be unique within the `DictionaryStandard`. See Table 26.

Table 26 – Content –DictionaryStandard



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
DictionaryStandard	Dictionary StandardType	An element that contains substitution group information using predefined descriptions of standard primitives identified by the 61182-2 standard and described by the user for reuse in the file.	0-1
units	unitsType	An enumerated string that may be one of the following: MILLIMETER | MICRON | INCH.	1-1
EntryStandard	EntryStandard Type	An element that establishes the individual characteristic associated with a StandardPrimitive substitution shape that has been identified by the user of the 61182-2 file.	0-n
Id	qualifiedName Type	The unique qualified name description assigned as an id for any `StandardPrimitive` for XML Schema substitution.	1-1
StandardPrimitive	ABSTRACT	Any standard primitive that is part of the substitution group that permits the substitution of the `StandardShape` element.	1-n

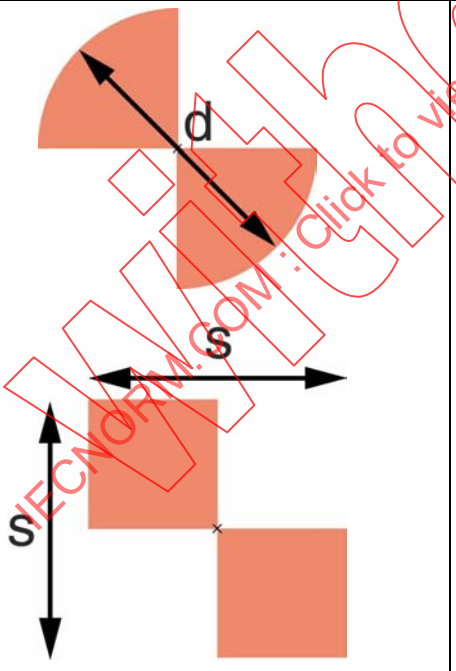
The organization of the `DictionaryStandard` is accomplished in accordance with the substitution group description criteria. The `StandardPrimitive` description may be any of sixteen standard shapes according to the specific characteristics identified in the following paragraphs. The `StandardPrimitiveRef` function is used in the body of the 61182-2 file when a specific `StandardPrimitive` has been predefined, assigned a name, and the unique "id" is referenced in the file. This feature permits the use of either a predefined `StandardPrimitive`, or defining the details of a `StandardPrimitive` within the file. The description in the file must contain all the features of a particular primitive shape under the rules of the particular shape definition.

5.7.1 StandardPrimitive: Butterfly

A `Butterfly` is a `StandardPrimitive` shape that may have the external periphery either round or square with two quadrants of the Cartesian coordinate system removed (0 to 90° and 180 to 270°). The round shape is defined by its diameter; the square shape is defined by an equal side dimension. The `Butterfly` is positioned by its point of origin, which is at the center of the `Butterfly`. See Table 27.

Table 27 – StandardPrimitive – Butterfly

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Butterfly	ButterflyType	A primitive shape (either ROUND or SQUARE) that has two quadrants of the Cartesian coordinate system removed (0 to 90° and 180 to 270°).	1-1
shape	butterflyShape Type	The inner and outer shapes are one of ROUND or SQUARE: ROUND: The inner and outer shapes are like circleDef. SQUARE: The inner and outer shapes are like RectCenterDef with height and width of each shape being equal.	1-1
diameter	nonNegative DoubleType	The diameter applies to the circular butterfly and is the outer boundary of the butterfly.	0-1
side	nonNegative DoubleType	The width along the x-axis and the height along the y-axis of a square.	0-1



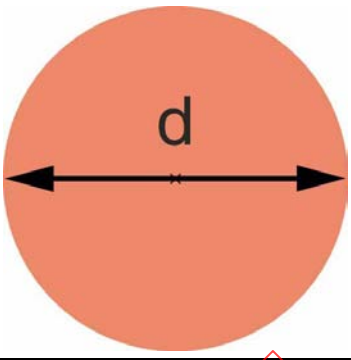

```
<DictionaryStandard units = "MILLIMETER">
    </EntryStandard>
    <EntryStandard id = "Butterfly1">
        <Butterfly shape = "ROUND" diameter = "3.2"/>
    </EntryStandard>
    <EntryStandard id = "Butterfly2">
        <Butterfly shape = "SQUARE" side = "1.8"/>
    </EntryStandard>
</DictionaryStandard>
```

5.7.2 StandardPrimitive: Circle

A `Circle` is a `StandardPrimitive` shape that defines a circle by the diameter of the circle. The point of origin is the center of a circle. See Table 28

Table 28 – StandardPrimitive – Circle

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Circle	CircleType	An embedded element that defines a circular shape consisting of a diameter.	0-n
diameter	nonNegative DoubleType	The diameter of the circle.	0-n

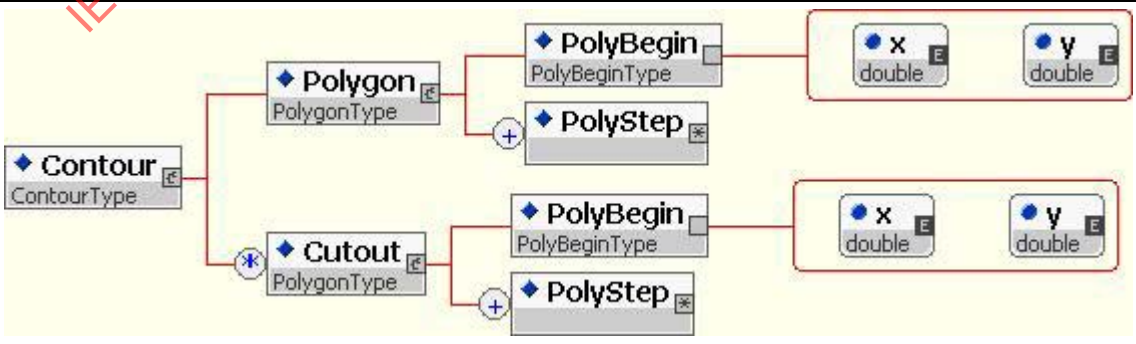



```
<DictionaryStandard units = "MILLIMETER">
        </EntryStandard>
        <EntryStandard id = "Circle1">
                <Circle diameter = "3.6"/>
        </EntryStandard>
        <EntryStandard id = "Circle2">
                <Circle diameter = "4.0"/>
        </EntryStandard>
</DictionaryStandard>
```

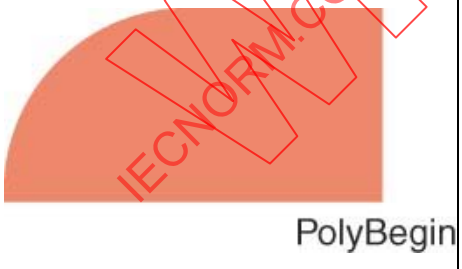
5.7.3 StandardPrimitive: Contour

The `Contour` element is a `StandardPrimitive` shape that defines a sequence of connected edges that form a polygon. An edge can be straight or circular. The `polygon` is a closed shape whose edges do not cross. This same characteristic is also true for `cutout`, which represents the absence of material inside the polygon shape. The coordinates of the `polygon`, `cutout`, and subsequent cutouts are defined relative to the local coordinate system of the original `polygon`. The point of origin may be a centroid of the `polygon` or one of the corners that sets the 0/0 coordinate. This is the point used to place the `polygon` or to rotate the image. The `cutout` uses the same coordinates. See Table 29.

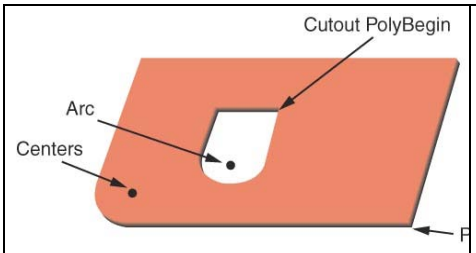
Table 29 – StandardPrimitive – Contour



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Contour	ContourType	A sequence of connected edges that form a polygon. An edge can be straight or circular.	1-1
Polygon	PolygonType	A closed shape whose edges do not cross, the coordinates of which are defined relative to the local coordinate system of the polygon.	1-1
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the `PolyBegin` element to signify that the shape is closed.	1-n
Cutout	CutoutType	A polygon closed shape whose edges do not cross, which adopts the coordinates of the original polygon, however represents the absence of material within the original polygon shape.	0-n
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the `PolyBegin` element to signify that the shape is closed.	1-n




```
<DictionaryStandard units = "MILLIMETER">
   </EntryStandard>
   <EntryStandard id = "Contour1">
      <Contour>
         <Polygon>
            <PolyBegin x = "0.00" y = "0.00"/>
            <PolyStepSegment x = "0.00" y = "7.00"/>
            <PolyStepSegment x = "-8.00" y = "7.00"/>
            <PolyStepCurve x = "-15.00" y = "0.00" centerX = "-8.00"
                centerY = "0.00"/>
            <PolyStepSegment x = "0.00" y = "0.00"/>
         </Polygon>
      </Contour>
   </EntryStandard>
</DictionaryStandard>
```

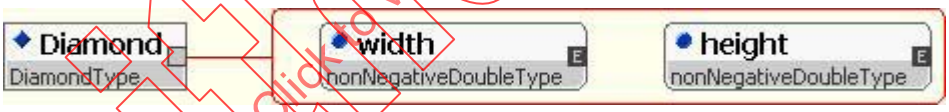



```
<EntryStandard id = "Contour2">
    <Contour>
      <Polygon>
        <PolyBegin x = "0.00" y = "0.00"/>
        <PolyStepSegment x = "-14.00" y = "0.00"/>
        <PolyStepCurve x = "-3.00" y = "3.00" centerX = "-14.00"
            centerY = "3.00" clockwise = "TRUE"/>
        <PolyStepSegment x = "-17.00" y = "7.00"/>
        <PolyStepSegment x = "0.00" y = "7.00"/>
        <PolyStepSegment x = "0.00" y = "0.00"/>
      </Polygon>
      <Cutout>
        <PolyBegin x = "-10.00" y = "5.00"/>
        <PolyStepSegment x = "-13.00" y = "5.00"/>
        <PolyStepSegment x = "-13.00" y = "3.00"/>
        <PolyStepCurve x = "-10.00" y = "3.00" centerX = "-11.50"
            centerY = "3.00"/>
        <PolyStepSegment x = "-10.00" y = "5.00"/>
      </Cutout>
    </Contour>
</EntryStandard>
```

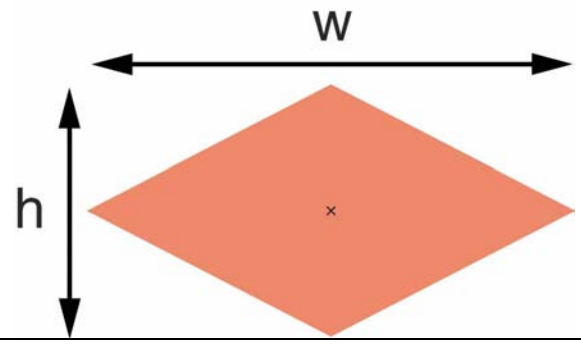
5.7.4 StandardPrimitive: Diamond

A `Diamond` is a 4-sided `StandardPrimitive` shape. The lengths of the sides of a diamond are always equal. A height and a width dimension specify the diamond. The first line defining the outline of the diamond is drawn between the point that is ½ the height dimension along the positive y-axis and the point that is ½ the width dimension along the x-axis. The same process is used to draw the other three lines of the diamond in each of the remaining quadrants. The `Diamond` is positioned with one of its corners facing the North direction. See Table 30.

Table 30 – StandardPrimitive – Diamond



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Diamond	DiamondType	A primitive shape with four equal sides that are extended from its horizontal center to its vertical center. The lines converge into a point both horizontally and vertically. The overall description of the shape is controlled by the width (distance between vertical point) and the height (distance between horizontal point).	1-1
width	nonNegative DoubleType	The length of the diamond along, and centered on, the x-axis.	1-1
height	nonNegative DoubleType	The length of the diamond along, and centered on, the y-axis.	1-1



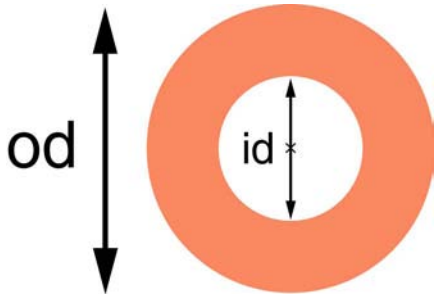

```
<EntryStandard id = "Diamond1">
      <Diamond width = "10.40" height = "6.20"/>
</EntryStandard>
<EntryStandard id = "Diamond2">
      <Diamond width = "6.00" height = "8.60"/>
</EntryStandard>
```

5.7.5 StandardPrimitive: Donut

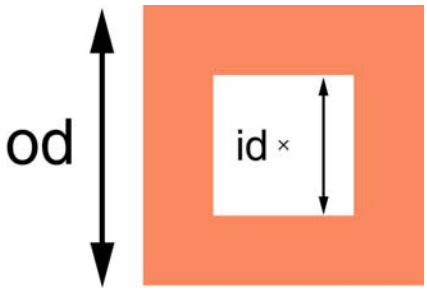
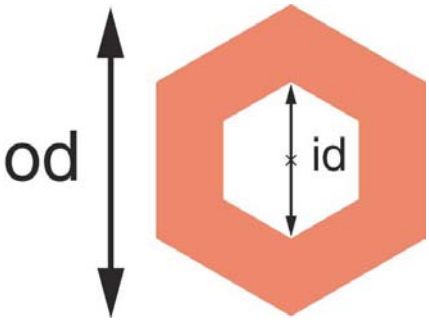
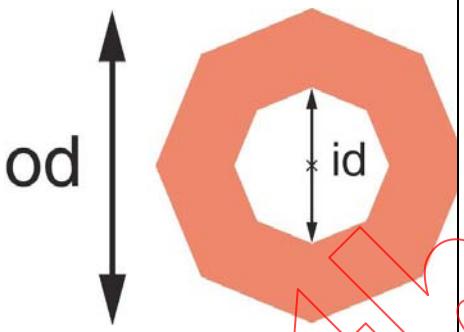
A `Donut` is a `StandardPrimitive` shape composed of two concentric identical shapes. The shapes are the same but of different sizes with the outer diameter (OD) being larger than the inner diameter (ID). The shapes must be identical and may be square, round, hexagonal, or octagonal. The center of a `Donut` is also the point of origin of the primitive. The hexagonal and octagonal shapes are defined with a point of the shape facing the North direction. See Table 31.

Table 31 – StandardPrimitive – Donut

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Donut	DonutType	A round, square, hexagon, or octagon shape consisting of an outer diamer and inner diameter that define physical characteristics of the donut.	1-1
shape	donutShape Type	The inner and outer shapes are one of ROUND, SQUARE , HEXAGON or OCTAGON: ROUND – The inner and outer shapes are like a circle. SQUARE – The inner and outer shapes are like a RectCenter with height and width of each shape being equal. HEXAGON – The inner and outer shapes are like a Hexagon. OCTAGON – The inner and outer shapes are like an Octagon.	1-1
outerDiameter	nonNegative DoubleType	The outer boundary of the filled region. The meaning based on donutShape: ROUND –The diameter of the circle is the outer boundary of the donut. The center of the circle is at the origin of the donut. SQUARE –The width along the x-axis and the height along the y-axis of a square at the inner boundary of the donut. The center of the square is at the origin. HEXAGON – The point-to-point measurement on the x-axis of the hexagon that forms the outer boundary of the donut. OCTAGON – The point-to-point measurement on the x-axis of the octagon that forms the outer boundary of the donut.	1-1
innerDiameter	nonNegative DoubleType	The inner boundary of the filled region. The meaning based on donutShape : ROUND – The diameter of the circle is the inner boundary of the donut. The center of the circle is at the origin of the donut. SQUARE – The width along the x-axis and height along the y-axis of a square at the inner boundary of the donut. The center of the square is at the origin. HEXAGON – The point-to-point measurement on the x-axis of the hexagon that forms the inner boundary of the donut. OCTAGON – the point-to-point measurement on the x-axis of the octagon that forms the inner boundary of the donut.	1-1



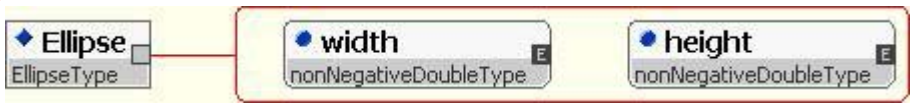

```
<EntryStandard id = "Donut1">
    <Donut shape = "ROUND" outerDiameter = "6.8" innerDiameter = "4.8"/>
</EntryStandard>
<EntryStandard id = "Donut2">
    <Donut shape = "ROUND" outerDiameter = "8.6" innerDiameter = "7.4"/>
</EntryStandard>
```

	<EntryStandard id = "Donut3"> <Donut shape = "SQUARE" outerDiameter = "6.8" innerDiameter = "5.0"/> </EntryStandard> <EntryStandard id = "Donut4"> <Donut shape = "SQUARE" outerDiameter = "8.20" innerDiameter = "6.20"/> </EntryStandard>
	<EntryStandard id = "Donut5"> <Donut shape = "HEXAGON" outerDiameter = "12.40" innerDiameter = "10.20"/> </EntryStandard> <EntryStandard id = "Donut6"> <Donut shape = "HEXAGON" outerDiameter = "10.00" innerDiameter = "8.00"/> </EntryStandard>
	<EntryStandard id = "Donut7"> <Donut shape = "OCTAGON" outerDiameter = "11.60" innerDiameter = "10.00"/> </EntryStandard> <EntryStandard id = "Donut8"> <Donut shape = "OCTAGON" outerDiameter = "12.00" innerDiameter = "10.00"/> </EntryStandard>

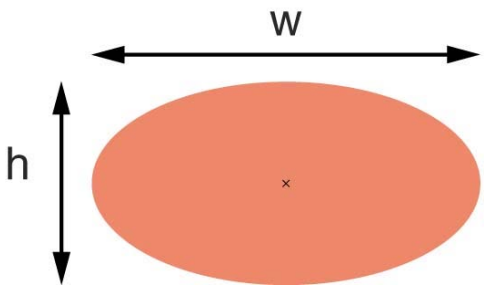
5.7.6 StandardPrimitive: Ellipse

The `Ellipse` is a `StandardPrimitive` shape that is an ellipse with the standard ellipse characteristics. The shape is defined by the width and height dimension. The `Ellipse` is positioned with its point of origin at the center of the `width` and `height` dimensions. See Table 32.

Table 32 – StandardPrimitive – Ellipse



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Ellipse	EllipseType	An elliptical shape that follows the standard ellipse characteristics and is defined by a width and height dimension, establishing the overall limits of the feature.	1-1
width	nonNegative DoubleType	The height of the ellipse on the y-axis.	1-1
height	nonNegative DoubleType	The width of the ellipse on the x-axis.	1-1

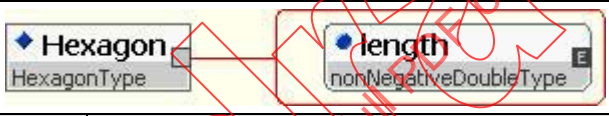



```
<EntryStandard id = "Ellipse1">
     <Ellipse width = "12.60" height = "6.20"/>
</EntryStandard>
<EntryStandard id = "Ellipse2">
     <Ellipse width = "6.20" height = "12.60"/>
</EntryStandard>
<EntryStandard id = "Ellipse3">
     <Ellipse width = "14.80" height = "4.20"/>
</EntryStandard>
<EntryStandard id = "Ellipse4">
     <Ellipse width = "10.60" height = "14.20"/>
</EntryStandard>
```

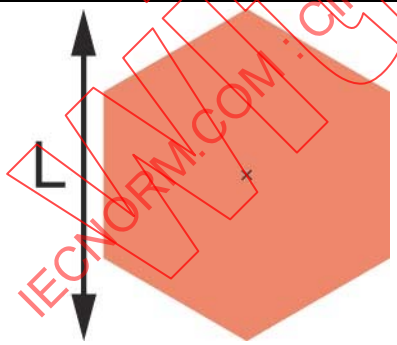
5.7.7 StandardPrimitive: Hexagon

A `Hexagon` is a six-sided `StandardPrimitive` shape with each of the sides being equal in length and with all angles between adjacent sides also being equal. The orientation of the hexagon is in accordance with one of its points facing the North direction. Only one dimension is required and that is the length across the points. `Rotation` is accomplished using `Xform` at the time the hexagon is instantiated. See Table 33.

Table 33 – StandardPrimitive – Hexagon



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Hexagon	HexagonType	A six-sided primitive shape with all sides being equal and which is defined by the length (L) across the points. The position of the octagon is in accordance with one of the points facing North.	0-1
length	nonNegative DoubleType	The length (L) between any two opposing corner points of the hexagon.	1-1

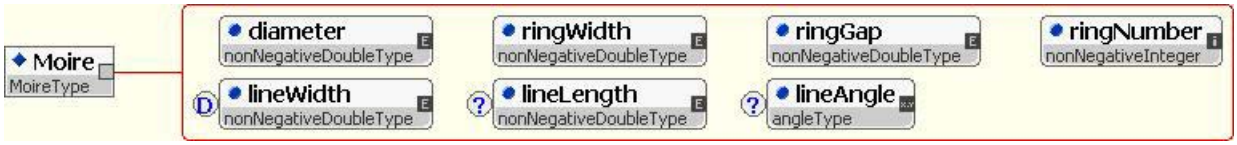



```
<EntryStandard id = "Hexagon1">
      <Hexagon length = "12.8"/>
</EntryStandard>
<EntryStandard id = "Hexagon2">
      <Hexagon length = "11.8"/>
</EntryStandard>
<EntryStandard id = "Hexagon3">
     <Hexagon length = "10.8"/>
</EntryStandard>
<EntryStandard id = "hexagon4">
     <Hexagon length = "9.8"/>
</EntryStandard>
```

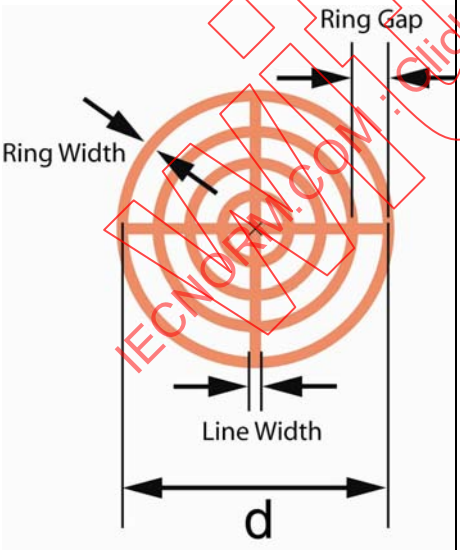
5.7.8 StandardPrimitive: Moire

The `Moire` is a primitive shape that consists of a series of circles each with a smaller diameter. The `Moire` is used as an assist in image registration. The `Moire` may be only circles or may also contain a crosshair line to assist in human acknowledgement of moiré alignment. The shape is defined by the number of rings, their center line spacing and the ring line width. The line spacing must be larger than the line width. The crosshair lines can also be described. The `Moire` pattern is positioned using its point of origin which is the center of the ring pattern. See Table 34.

Table 34 – StandardPrimitive – Moire



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Moire	MoireType	A series of circles, each consisting of a smaller diameter the shape of which is defined by the number of rings, their center line spacing, and the ring width. The pattern may also contain a crosshair representing its point of origin.	1-1
diameter	nonNegative DoubleType	The diameter of the center of the outermost circle.	1-1
ringWidth	nonNegative DoubleType	The width of the line used for each circle.	1-1
ringGap	nonNegative DoubleType	The gap between circle lines as defined by the dimension between the centerlines of each circle location. The gap between centerlines must be larger than the `ringWidth` so that there is a clearance between individual rings.	1-1
ringNumber	nonNegative Integer	The number of rings.	1-1
lineWidth	nonNegative DoubleType	The line width used to develop a crosshair across the moiré. The default is 0.	0-1
lineLength	nonNegative DoubleType	The length of the line for both the horizontal and vertical cross-hair.	0-1
lineAngle	angleType	The angle at which the crosshair may be rotated. Rotation is always counter-clockwise. The default is 0° and can be oriented up to 90°.	0-1

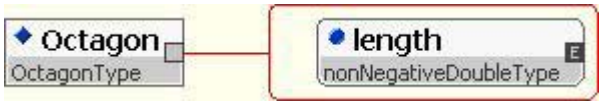



```
<EntryStandard id = "Moire1">
    <Moire diameter = "8.4" ringWidth = "0.3" ringGap = "0.6" ringNumber = "5"
            lineWidth = "0.3" lineLength = "8.2" lineAngle = "0"/>
</EntryStandard>
<EntryStandard id = "Moire2">
    <Moire diameter = "6.0" ringWidth = "0.2" ringGap = "0.4" ringNumber = "4"
            lineWidth = "0.2" lineLength = "5.8" lineAngle = "45"/>
</EntryStandard>
```

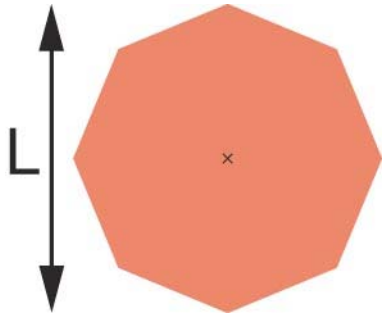

5.7.9 StandardPrimitive: Octagon

An `Octagon` is an eight-sided `StandardPrimitive` shape with each of the sides being equal in length and with all angles between adjacent sides also being equal. The orientation of the `Octagon` is in accordance with one of its points facing the North direction. Only one dimension is required and that is the length across the points. `Rotation` is accomplished using `Xform` at the time the `Octagon` is instanced. See Table 35

Table 35 – StandardPrimitive – Octagon



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Octagon	OctagonType	An eight-sided primitive shape with all sides being equal and which is defined by the length (L) across the points. The position of the octagon is in accordance with one of its points facing north.	0-1
length	nonNegative DoubleType	The length (L) between any two opposing corner points of the octagon.	0-1

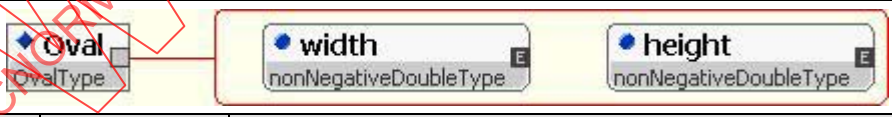



```
<EntryStandard id = "Octagon1">
      <Octagon length = "12.8"/>
</EntryStandard>
<EntryStandard id = "Octagon2">
      <Octagon length = "11.8"/>
</EntryStandard>
<EntryStandard id = "Octagon3">
      <Octagon length = "10.8"/>
</EntryStandard>
<EntryStandard id = "Octagon4">
      <Octagon length = "9.8"/>
</EntryStandard>
```

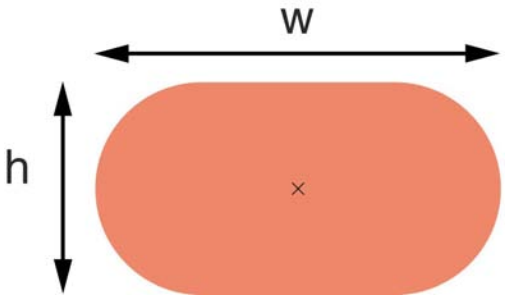
5.7.10 StandardPrimitive: Oval

An `Oval` is a `StandardPrimitive` shape that defines a rectangle with a complete radius (180° arc) at each end. The base rectangle is defined by a width attribute and a height attribute with the center of the rectangle being centered on both the height and width dimensions. The center of the `Oval` rectangle is the point of origin of the shape. The rectangle is defined with edges parallel to the x-axis and y-axis relative to the local coordinate system. Rotation is about the point of origin. The `Oval` is defined with the radius located along the y-axis sides. The radius on the ends of the oval shaped rectangle is always equal to ½ the height. See Table 36

Table 36 – StandardPrimitive – Oval



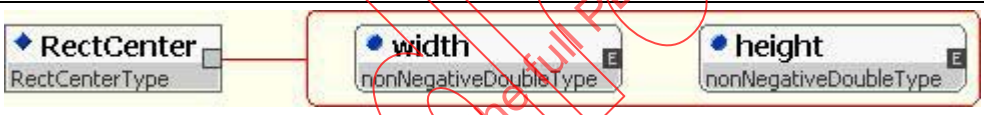
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Oval	OvalType	A rectangle defined by a width and height attribute with the center of the rectangle being centered on both the height and width dimensions.	1-1
width	nonNegative DoubleType	The length of the rectangle about the x-axis.	1-1
height	nonNegative DoubleType	The length of the rectangle about the y-axis. It is an error to define a height greater than the width.	1-1

	<EntryStandard id = "Oval1"> <Oval width = "10.6" height = "6.4"/> </EntryStandard> <EntryStandard id = "Oval2"> <Oval width = "8.4" height = "8.4"/> </EntryStandard> <EntryStandard id = "Oval3"> <Oval width = "16.4" height = "5.6"/> </EntryStandard> <EntryStandard id = "Oval4"> <Oval width = "14.8" height = "6.8"/> </EntryStandard>

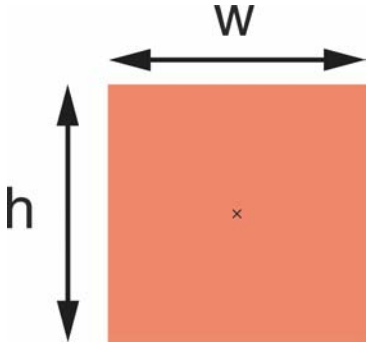
5.7.11 StandardPrimitive: RectCenter

A `RectCenter` is a primitive shape that defines a rectangle by a `width` attribute and a `height` attribute with the center of the rectangle being centered on both the height and width dimensions. The center of the `RectCenter` rectangle is the point of origin of the shape. The rectangle is defined with edges parallel to the x-axis and y-axis relative to the local coordinate system. Rotation is about the point of origin. The `RectCenter` is also used to represent a square shape. The characteristics of the square would be to have the width and height equal. See Table 37.

Table 37 – StandardPrimitive – RectCenter



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
RectCenter	RectCenter Type	The characteristics of a rectangle defined by a width and height dimension consistent with a horizontal position on the Cartesian coordinate system	1-1
width	nonNegative DoubleType	The length of the rectangle about the x-axis.	1-1
height	nonNegative DoubleType	The length of the rectangle about the y-axis.	1-1

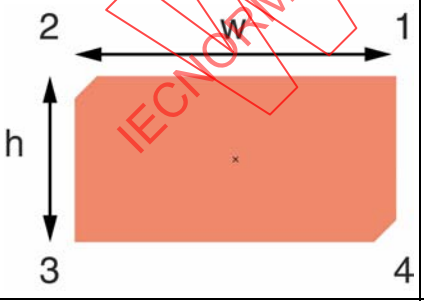
	<EntryStandard id = "RectangleC1"> <RectCenter width = "16.8" height = "6.4"/> </EntryStandard> <EntryStandard id = "RectangleC2"> <RectCenter width = "6.4" height = "12.8"/> </EntryStandard> <EntryStandard id = "RectangleC3"> <RectCenter width = "10.4" height = "6.4"/> </EntryStandard>
	<EntryStandard id = "RectangleSquare1"> <RectCenter width = "8.4" height = "8.4"/> </EntryStandard> <EntryStandard id = "RectangleSquare2"> <RectCenter width = "10.0" height = "10.0"/> </EntryStandard> <EntryStandard id = "RectangleSquare3"> <RectCenter width = "4.8" height = "4.8"/> </EntryStandard>

5.7.12 StandardPrimitive: RectCham

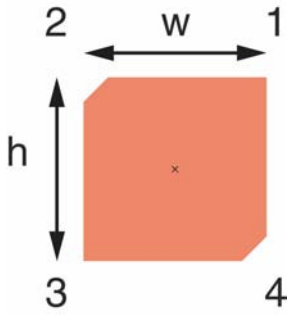
A `RectCham` is a `StandardPrimitive` shape that defines a rectangle with chamfered corners. The base rectangle is defined by a `width` attribute and a `height` attribute with the center of the rectangle being centered on both the height and width dimensions. The center of the `RectCham` rectangle is the point of origin of the shape. The rectangle is defined with edges parallel to the x-axis and y-axis relative to the local coordinate system. Rotation is about the point of origin. The `RectCham` is also used to represent a square shape with chamfered corners. The characteristics of the square would be to have the width and height equal. See Table 38.

Table 38 – StandardPrimitive –RectCham

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
RectCham	RectChamType	A rectangle with one or more corners chamfered. The user has the option to define any of the corners as containing the chamfer as well as the chamfered dimensions. All chamfers (or opportunities for chamfers) must be identical in size.	1-1
width	nonNegative DoubleType	The length of the rectangle about the x-axis.	1-1
height	nonNegative DoubleType	The length of the rectangle about the y-axis.	1-1
chamfer	nonNegative DoubleType	The length measured from each corner that defines 4 points along the width and 4 points along the height. The corners are clipped between the points at each corner. The resulting chamfers are always cut at 45° relative to the local coordinate system. It is an error to define the value of chamfer to be greater than ½ the height or ½ the width.	1-1
upperRight	boolean	The upper right corner (1).	0-1
upperLeft	boolean	The upper left corner (2).	0-1
lowerLeft	boolean	The lower left corner (3).	0-1
lowerRight	boolean	The lower right corner (4).	0-1




```
<EntryStandard id = "ChamferedRect1">
   <RectCham width = "12.6" height = "8.4" chamfer = "2.0" upperLeft =
        "TRUE" lowerRight = "TRUE"/>
</EntryStandard>
<EntryStandard id = "ChamferedRect2">
    <RectCham width = "10.6" height = "6.2" chamfer = "2.0" upperRight
        = "TRUE" upperLeft = "TRUE" lowerLeft = "TRUE" lowerRight =
        "TRUE"/>
</EntryStandard>
```




```
<EntryStandard id = "ChamferedSquare1">
      <RectCham width = "8.4" height = "8.4" chamfer = "2.0" upperRight =
       "TRUE" lowerLeft = "TRUE"/>
</EntryStandard>
<EntryStandard id = "ChamferedSquare2">
       <RectCham width = "6.6" height = "6.6" chamfer = "1.8" upperRight =
       "TRUE" upperLeft = "TRUE" lowerLeft = "TRUE" lowerRight = "TRUE"/>
</EntryStandard>
```

5.7.13 StandardPrimitive: RectCorner

A `RectCorner` is a `StandardPrimitive` shape that defines a rectangle. The element describes the lower left and upper right corners of the rectangle. The point of origin of a `RectCorner` rectangle is (0, 0). This can be coincident with attribute `lowerLeftX` and `lowerLeftY`, the lower left corner of the rectangle, but there is no requirement for that location to be at (0, 0). The rectangle is defined with edges parallel to the x-axis and y-axis relative to the local coordinate system. Rotation is about the point of origin, not about the lower left or upper right corners. See Table 39.

Table 39 – StandardPrimitive – RectCorner

Attribute/ Element Name	Attribute / Element Type	Description	Occur-rence
RectCorner	RectCornerType	A constraining rectangular area (bounding box) that describes a rectangle consistent with a horizontal position on the Cartesian coordinate system.	1-1
lowerLeftX	double	The lower left hand x dimension of the rectangular area encompassing the text.	1-1
lowerLeftY	double	The lower left hand y dimension of the rectangular area encompassing the text.	1-1
upperRightX	double	The upper right hand x dimension of the the rectangular area encompassing the text.	1-1
upperRightY	double	The upper right hand y dimension of the rectangular area encompassing the text.	1-1


```
<EntryStandard id = "CorneredRectangle1">
    <RectCorner lowerLeftX = "0.0" lowerLeftY = "0.0"
        upperRightX = "12.6" upperRightY = "6.8"/>
</EntryStandard>
<EntryStandard id = "CorneredRectangle2">
    <RectCorner lowerLeftX = "-6.4" lowerLeftY = "-3.2"
        upperRightX = "6.4" upperRightY = "3.2"/>
</EntryStandard>
```

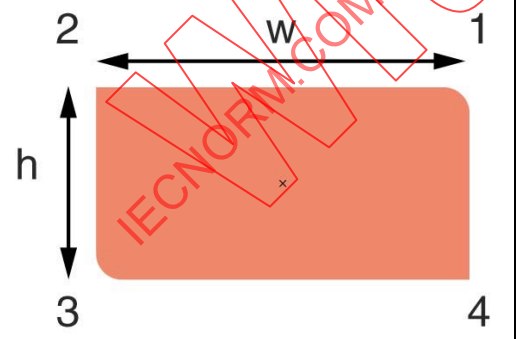

```
<EntryStandard id = "CorneredSquare1">
    <RectCorner lowerLeftX = "0.0" lowerLeftY = "0.0"
        upperRightX = "8.4" upperRightY = "8.4"/>
</EntryStandard>
<EntryStandard id = "CorneredSquare2">
    <RectCorner lowerLeftX = "-4.6" lowerLeftY = "-4.6"
        upperRightX = "4.6" upperRightY = "4.6"/>
</EntryStandard>
```

5.7.14 StandardPrimitive: RectRound

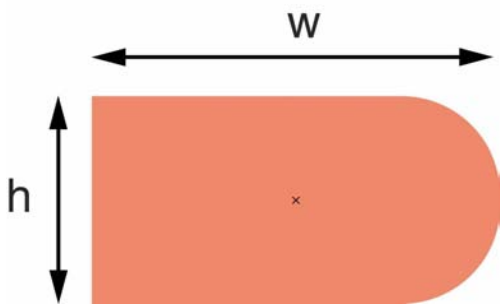
A `RectRound` is a `StandardPrimitive` shape that defines a rectangle with radius corners. The base rectangle is defined by a width attribute and a height attribute with the center of the rectangle being centered on both the height and width dimensions. The center of the `RectRound` rectangle is the point of origin of the shape. The rectangle is defined with edges parallel to the x-axis and y-axis relative to the local coordinate system. Rotation is about the point of origin. The `RectRound` is also used to represent a square shape with rounded corners. The characteristics of the square would be to have the width and height equal. See Table 40.

Table 40 – StandardPrimitive – RectRound

Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
RectRound	RectRoundType	A rectangle with one or more corners rounded. The user has the option to define any of the corners as containing the radius as well as the radiused dimensions. All corners (or opportunities for corners) must be identical in size.	1-1
width	nonNegative DoubleType	The length of the rectangle about the x-axis.	1-1
height	nonNegative DoubleType	The length of the rectangle about the y-axis.	1-1
radius	nonNegative DoubleType	The radius to be trimmed from the four corners of the rectangle. It is an error to define a radius that is greater than ½ the height value or ½ the width value.	1-1
upperRight	boolean	The upper right corner (1).	0-1
upperLeft	boolean	The upper left corner (2).	0-1
lowerLeft	boolean	The lower left corner (3).	0-1
lowerRight	boolean	The lower right corner (4).	0-1




```
<EntryStandard id = "RoundedDshape1">
    <RectRound width = "10.2" height = "6.4" radius = "3.2"
        upperRight = "TRUE" lowerRight = "TRUE"/>
</EntryStandard>
```




```
<EntryStandard id = "RoundedDshape2">
    <RectRound width = "4.8" height = "4.8" radius = "2.4"
        upperRight = "TRUE" lowerRight = "TRUE"/>
</EntryStandard>
```

5.7.15 StandardPrimitive: Thermal

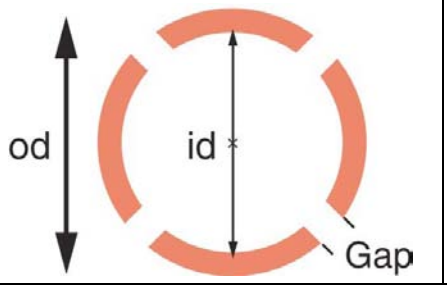
A `Thermal` is a `StandardPrimitive` shape that historically was used to remove material from a plane, conductive filled area or around a plated through hole. The `Thermal` shapes include square, round, hexagonal, or octagonal, and have varying numbers of spokes. The center of a thermal is the point of origin of the primitive.

A spokeless thermal can be used for non-functional lands on an innerlayer plane, where the land is not connected to the plane. IEC 61182-2 defines these using the `Thermal` element with a spoke count of zero. These are similar to a Donut except that they remove material. Many thermal primitive configurations can be generated using different spoke numbers and end types. See Table 41.

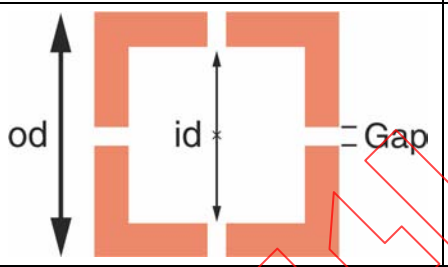
Table 41 – StandardPrimitive –Thermal

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Thermal	ThermalType	A primitive shape consisting either of ROUND, SQUARE, HEXAGON, or OCTAGON configuration that defines the removal of material from a plane or conductive fill area in accordance to the shape attribute description.	1-1
shape	thermalShape Type	The shape of the thermal. One of ROUND | SQUARE | OCTAGON. ROUND: The inner and outer shapes are like Circle. SQUARE: The inner and outer shapes are like RectCenter with height and width of each shape being equal. HEXAGON: The inner and outer shapes are like Hexagon. OCTAGON: The inner and outer shapes are like Octagon.	1-1
outerDiameter	nonNegative DoubleType	The outer boundary of the filled region. The meaning based on the shape attribute: ROUND: The diameter of the circle is the outer boundary of the thermal. The center of the circle is at the origin of the thermal. SQUARE: The width along the x-axis and the height along the y-axis of a square at the inner boundary of the thermal. The center of the square is at the origin. HEXAGON: The point-to-point measurement (L) on the x-axis of the hexagon that forms the outer boundary of the thermal. OCTAGON: The point-to-point (L) measurement on the x-axis of the octagon that forms the outer boundary of the thermal.	1-1
innerDiameter	nonNegative DoubleType	The inner boundary of the filled region. The meaning based on the shape attribute: ROUND: The diameter of the circle is the inner boundary of the thermal. The center of the circle is at the origin of the thermal. SQUARE: The width along the x-axis and the height along the y-axis of a square at the inner boundary of the thermal The center of the square is at the origin. HEXAGON: The point-to-point measurement on the x-axis of the hexagon that forms the inner boundary of the thermal. OCTAGON: The point-to-point measurement on the x-axis of the octagon that forms the inner boundary of the thermal.	1-1

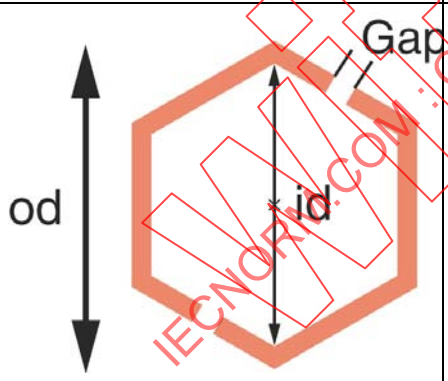
spokeCount	spokeCount Type	The number of cutouts allowed in the inner and outer shapes. ROUND: must be 0, 2, 3, or 4 (the default is 4) SQUARE: must be 0, 2, or 4 (the default is 4) HEXAGON: must be 0, 2, or 3 (the default is 3) OCTAGON: must be 0, 2, or 4 (the default is 4) If the `spokeCount` is defined as 0 (zero), the other three optional parameters do not apply. The spokeless thermal has a shape like a donut shape.	0-1
gap	nonNegative DoubleType	The minimum distance between the sides of a spoke cut. The default value is the `innerDiameter` subtracted from the `outerDiameter`.	0-1
spokeStartAngle	angleType	The angle in counterclockwise direction from the x-axis at which the first spoke is cut. The default angle is 45° counterclockwise from the x-axis.	1-1



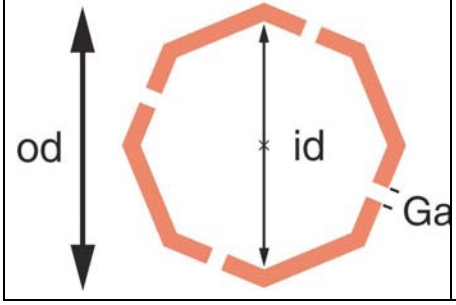

```
<EntryStandard id = "ThermalRound1">
    <Thermal shape = "ROUND" outerDiameter = "10.6" innerDiameter = "6.0."
      spokeCount = "4" gap = "2.0" spokeStartAngle = "45.00"/>
</EntryStandard>
<EntryStandard id = "ThermalRound2">
    <Thermal shape = "ROUND" outerDiameter = "12.0" innerDiameter = "8.0"
      spokeCount = "4" gap = "2.0" spokeStartAngle = "0.00"/>
</EntryStandard>
```



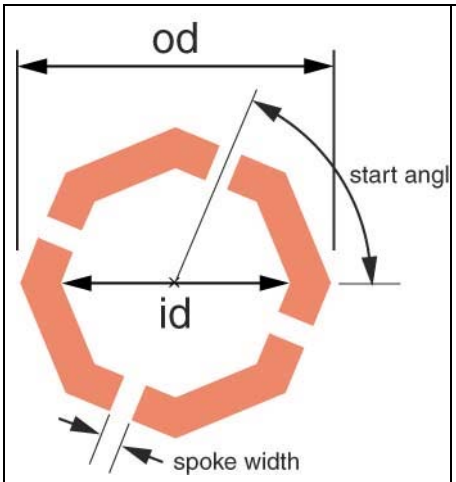

```
<EntryStandard id = "ThermalSquare1">
    <Thermal shape = "SQUARE" outerDiameter = "10.8" innerDiameter = "6.0"
      spokeCount = "4" gap = "2.4" spokeStartAngle = "0.00"/>
</EntryStandard>
<EntryStandard id = "ThermalSquare2">
    <Thermal shape = "SQUARE" outerDiameter = "12.8" innerDiameter = "8.0"
      spokeCount = "4" gap = "2.4" spokeStartAngle = "0.00"/>
</EntryStandard>>
```




```
<EntryStandard id = "ThermalHex1">
    <Thermal shape = "HEXAGON" outerDiameter = "10.8" innerDiameter = "6.4"
      spokeCount = "4" gap = "2.0" spokeStartAngle = "45.00"/>
</EntryStandard>
<EntryStandard id = "ThermalHex2">
    <Thermal shape = "HEXAGON" outerDiameter = "12.0" innerDiameter =
      "8.0" spokeCount = "4" gap = "2.0" spokeStartAngle = "45.00"/>
</EntryStandard>
```




```
<EntryStandard id = "ThermalOct1">
    <Thermal shape = "OCTAGON" outerDiameter = "10.6" innerDiameter = "6.6"
    spokeCount = "4" gap = "2.0" spokeStartAngle = "60.00"/>
</EntryStandard>
<EntryStandard id = "ThermalOct2">
    <Thermal shape = "OCTAGON" outerDiameter = "12.0" innerDiameter = "8.0"
    spokeCount = "4" gap = "2.0" spokeStartAngle = "60.00"/>
</EntryStandard>
```

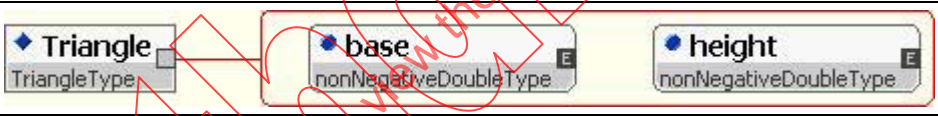



```
<EntryStandard id = "ThermalOct3">
      <Thermal shape = "OCTAGON" outerDiameter = "10.6" innerDiameter = "6.0"
      spokeCount = "4" gap ="2.0" spokeStartAngle = "60.00"/>
 </EntryStandard>
 <EntryStandard id = "ThermalOct4">
      <Thermal shape = "OCTAGON" outerDiameter = "12.0" innerDiameter = "7.6"
      spokeCount = "2" gap = "2.2" spokeStartAngle = "60.00"/>
 </EntryStandard>
```

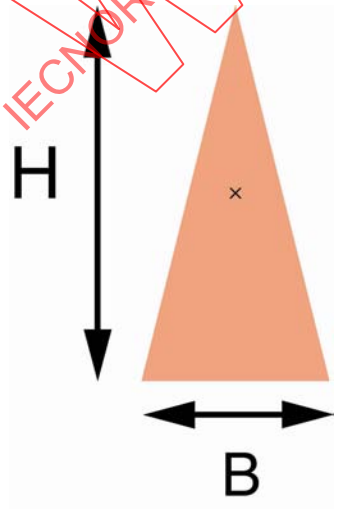
5.7.16 StandardPrimitive: Triangle

The `Triangle` is a `StandardPrimitive` shape that is an isosceles triangle that has two equal sides and a base. The shape is defined by the base and height dimension. The triangle is positioned with its point of origin which is at the center of the base and height dimensions. See Table 42.

Table 42 – StandardPrimitive – Triangle



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Triangle	TriangleType	A primitive shape defined by a base and height dimension.	1-1
base	nonNegative DoubleType	The distance between the two corner points of the base of the triangle with the point of origin at the center of the base and height dimensions.	1-1
height	nonNegative DoubleType	The triangle height.	1-1

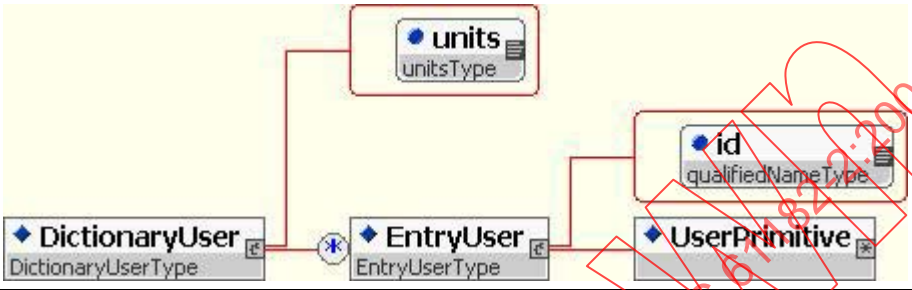



```
<EntryStandard id = "Triangle1">
      <Triangle base = "4.0" height = "8.0"/>
</EntryStandard>
<EntryStandard id = "Triangle2">
      <Triangle base = "4.0" height = "6.0"/>
</EntryStandard>
<EntryStandard id = "Triangle3">
      <Triangle base = "4.0" height = "12.0"/>
</EntryStandard>
<EntryStandard id = "Triangle4">
      <Triangle base = "8.0" height = "4.0"/>
</EntryStandard>
```

5.8 Content: DictionaryUser

The DictionaryUser is intended to provide lookup information on predefined UserPrimitives. The DictionaryUser is maintained as part of a substitution group schema. The intent is to have graphic descriptions available that are identified by their characteristics and a specific name (id). They may be reused throughout the file as appropriate. The name (id) of a UserPrimitive must be unique within the DictionaryUser. See Table 43.

Table 43 – Content – DictionaryUser



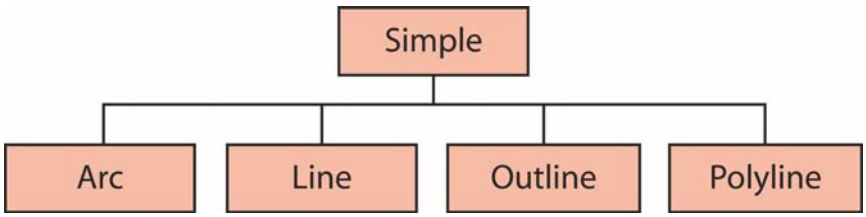
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
DictionaryUser	DictionaryUser Type	An element that contains substitution group information using predefined descriptions of user primitives identified by the 61182-2 standard and described by the user for reuse in the file.	0-1
units	unitsType	An enumerated string that may be one of the following: MILLIMETER | MICRON | INCH.	1-1
EntryUser	EntryUserType	An element that establishes the individual characteristic associated with a UserPrimitive substitution shape that has been identified by the user of the 61182-2 file.	0-n
id	qualifiedName Type	The unique qualified name description assigned as an id for any StandardPrimitive for XML Schema substitution.	1-1
UserPrimitive	ABSTRACT	Any user primitive that is part of the substitution group that permits the substitution of the user primitives (arc, line, Outline, Polygon), a text string, or UserSpecial shape.	1-n

The organization of the DictionaryUser is accomplished in accordance with the substitution group description criteria. The UserPrimitive description may be any of four simple shapes according to the specific characteristics identified in the following paragraphs plus text strings or user combinations of primitives to develop UserSpecial graphics for such items as logos, targets, drawing formats, etc. The UserPrimitiveRef function is used in the body of the 61182-2 file when a specific UserPrimitive has been predefined, assigned a name, and this unique "id" is referenced in the file. This feature permits the use of either a predefined UserPrimitive or defining the details of a UserPrimitive within the file. The description in the file must contain all the features of a particular primitive shape under the rules of the particular shape definition.

5.8.1 UserPrimitive, Simple

An abstract type identifying a substitution set of pre-defined simple primitive shapes that may be any one of four geometries. Each of the simple primitives must have a unique name within the DictionaryUser section. See Table 44.

Table 44 – UserPrimitive – Simple

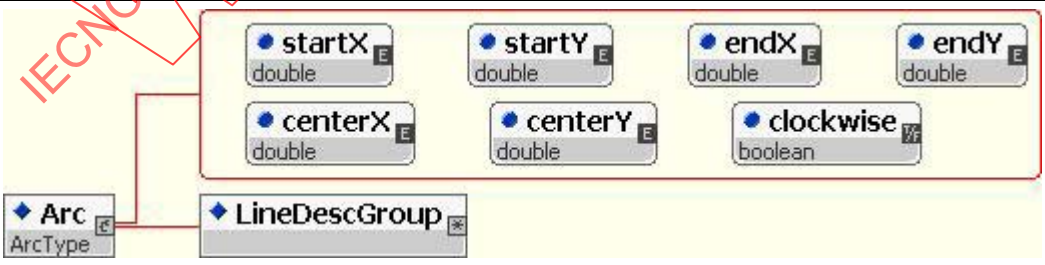


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Arc	ArcType	The Arc element represents an arc. Arcs are curves (defined by three sets of coordinates: startX, startY, endX, endY, and centerX, centerY. The width of the arc is defined as a substitution group for LineDesc or applied when the Arc is instantiated.	0-n
Line	LineType	The Line element is used to describe an individual line segment. The lineWidth and lineEnd conditions are defined as a substitution group for LineDesc or applied when the line segment is instantiated. The lineEnd default is ROUND.	0-n
Outline	OutlineType	The Outline element is that of a Polygon and represents a closed shape. The point of origin of the shape is identified as the 0:0 coordinate. The element includes the start of the polygon definition (PolyBegin) and the appropriate number of PolySteps to complete the closed shape. The lineWidth is defined as a substitution group for LineDesc or applied when the Outline is instantiated.	0-n
Polyline	PolylineType	The Polyline element consists of a series of lines that define a particular grouping configuration. These line segments do not result in a closed shape, however they can be predefined and reused as needed. The lineWidth and lineEnd of the Polyline are defined as a substitution group for LineDesc or applied at the time the Polyline is instantiated.	0-n

5.8.1.1 UserPrimitive, Simple: Arc

Each Arc entry (EntryUser) in the DictionaryPrim **shall** have a unique id and consist of the characteristics shown in Table 45.

Table 45 – UserPrimitive – Simple: Arc



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Arc	ArcType	The Arc element represents an arc. Arcs are curves (defined by three sets of coordinates: startX, startY, endX, endY and centerX, centerY. The width of the arc is set by the LineDesc substitution group or applied when the Arc is instantiated.	0-n
startX	double	Beginning x-coordinate of the Arc.	1-1
startY	double	Beginning y-coordinate of the Arc.	1-1

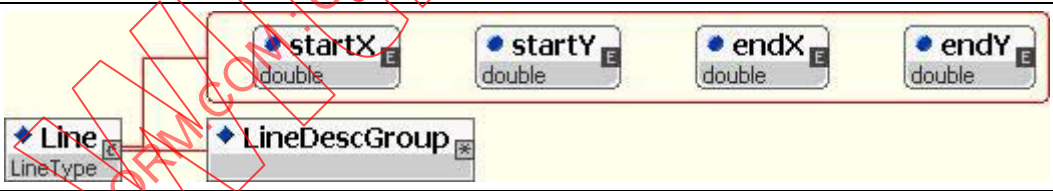
endX	double	Ending x-coordinate of the Arc.	1-1
endY	double	Ending y-coordinate of the Arc.	1-1
centerX	double	The X location for the origin of the radius of the circular Arc.	1-1
centerY	double	The Y location for the origin of the radius of the circular Arc.	1-1
clockwise	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE equals that the Arc is in a clockwise direction; FALSE is the default indicating a counterclockwise direction.	0-1
LineDescGroup	ABSTRACT	A substitution group that specifies the LineWidth and LineEnd characteristics of the Arc by reference to a predefined LineDesc or specified when the Arc is instantiated.	1-1

```
<EntryUser id = "Arc1">
      <Arc startX = "8.0" startY = "0.0" endX = "-8.0" endY = "0.0" centerX = "0.0" centerY = "0.0" clockwise = "FALSE">
        <LineDescRef id = "MediumLine"/>
    </Arc>
</EntryUser>
<EntryUser id = "Arc2">
    <Arc startX = "0.0" startY = "0.0" endX = "12.0" endY = "0.0" centerX = "6.0" centerY = "0.0" clockwise = "TRUE">
        <LineDescRef id = "HeavyLine"/>
    </Arc>
</EntryUser>
<EntryUser id = "Arc3">
    <Arc startX = "-8.0" startY = "0.0" endX = "0.0" endY = "8.0" centerX = "0.0" centerY = "0.0" clockwise = "TRUE">
        <LineDesc lineEnd = "ROUND" lineWidth = "1.0"/>
    </Arc>
 </EntryUser>
```

5.8.1.2 UserPrimitive, Simple: Line

Each Line entry (EntryUser) in the DictionaryUser **shall** have a unique id and consist of the characteristics shown in Table 46.

Table 46 – UserPrimitive – Simple: Line



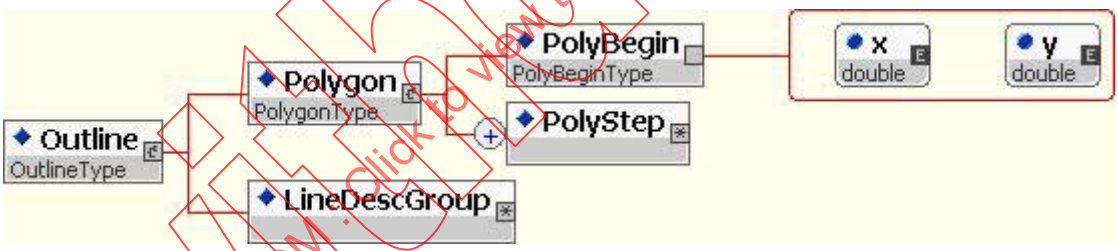
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Line	LineType	The Line element is used to describe an individual line segment. The lineWidth and lineEnd conditions are defined by the LineDescGroup or when the line is instantiated. The lineEnd default is ROUND.	0-n
startX	double	Beginning x-coordinate of the Line.	1-1
startY	double	Beginning y-coordinate of the Line.	1-1
endX	double	Ending x-coordinate of the Line.	1-1
endY	double	Ending y-coordinate of the Line.	1-1
LineDescGroup	ABSTRACT	A substitution group that specifies the LineWidth and LineEnd characteristics of the Line by reference to a predefined LineDesc or specified when the Line is instantiated.	1-1

```
<EntryUser id = "Line1">
    <Line startX = "0.0" startY = "0.0" endX = "12.6" endY = "9.4">
        <LineDesc lineEnd = "ROUND" lineWidth = "1.0"/>
    </Line>
</EntryUser>
<EntryUser id = "Line2">
    <Line startX = "3.6" startY = "4.8" endX = "-4.8" endY = "-3.6">
        <LineDescRef id = "MediumLine"/>
    </Line>
</EntryUser>
<EntryUser id = "Line3">
    <Line startX = "0.0" startY = "0.0" endX = "12.8" endY = "0.0">
        <LineDescRef id = "HeavyLine"/>
    </Line>
</EntryUser>
<EntryUser id = "Line4">
    <Line startX = "12.8" startY = "2.4" endX = "-10.2" endY = "1.2">
        <LineDesc lineEnd = "SQUARE" lineWidth = "0.8"/>
    </Line>
</EntryUser>
```

5.8.1.3 UserPrimitive, Simple: Outline

Each `Outline` entry (`EntryUser`) in the `DictionaryUser` **shall** have a unique id and consist of the following characteristics. The `Outline` element consists of the characteristics shown in Table 47 using a `Polygon` shape to represent a closed shaped group of lines.

Table 47 UserPrimitive – Simple: Outline



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Outline	OutlineType	An element that has as its sub-elements the `Polygon` and `LineDesc` elements in order to define a closed shape that has a line width.	0-n
Polygon	PolygonType	The standard description for the `Polygon` characteristic must be a closed shape. The point of origin of the shape is identified as the 0:0 coordinate. The element includes the start of the polygon definition (`PolyBegin`) and the appropriate number of PolySteps to complete the closed shape. The lineWidth is through the `LineDesc` substitution group or defined at a time when the `Polygon` is instantiated.	0-n
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon line.	1-1
y	double	The Y starting point of the first polygon line.	1-1

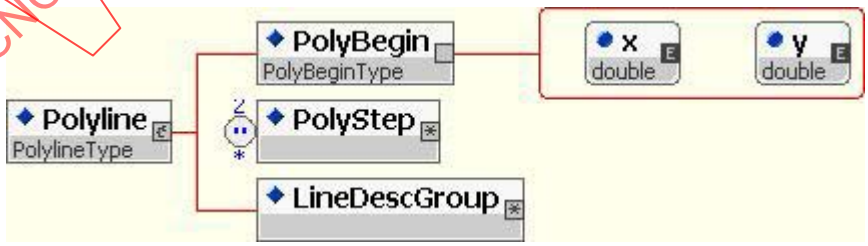
PolyStep	ABSTRACT	The PolyStep element is a substitution group that defines a circular (PolyStepCurve) or straight line (PolyStepSegment) continuation of the polygon. The polystep direction may be clockwise or counterclockwise which must be consistent when any Arc description is used as one of the PolyStep elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the PolyBegin element to signify that the shape is closed.	2-n
LineDescGroup	ABSTRACT	A substitution group that specifies the LineWidth and LineEnd characteristics of the Line by reference to a predefined LineDesc or specified when the Outline is instantiated.	1-1

```
<EntryUser id = "Outline1">
    <Outline>
        <Polygon>
            <PolyBegin x = "0.0" y = "6.4"/>
            <PolyStepSegment x = "12.6" y = "6.4"/>
            <PolyStepCurve x = "14.8" y = "4.2" centerX = "12.6" centerY = "4.2" clockwise = "TRUE"/>
            <PolyStepSegment x = "14.8" y = "0.0"/>
            <PolyStepSegment x = "0.0" y = "0.0"/>
            <PolyStepSegment x = "0.0" y = "6.4"/>
        </Polygon>
        <LineDescRef id = "FineLine"/>
    </Outline>
</EntryUser>
<EntryUser id = "Outline2">
    <Outline>
        <Polygon>
            <PolyBegin x = "-10.4" y = "-2.0"/>
            <PolyStepSegment x = "-10.4" y = "0.0"/>
            <PolyStepCurve x = "10.4" y = "0.0" centerX = "0.0" centerY = "0.0" clockwise = "TRUE"/>
            <PolyStepSegment x = "10.4" y = "-2.0"/>
            <PolyStepSegment x = "0.0" y = "-6.0"/>
            <PolyStepSegment x = "-10.4" y = "-2.0"/>
        </Polygon>
        <LineDesc lineEnd = "ROUND" lineWidth = "0.2"/>
    </Outline>
</EntryUser>
```


5.8.1.4 UserPrimitive, Simple: PolyLine

Each PolyLine entry (Entryuser) in the DictionaryUser **shall** have a unique id and consist of the characteristics shown in Table 48. The PolyLine characteristics represent an open shaped group of lines.

Table 48 UserPrimitive – Simple: PolyLine



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Polyline	PolylineType	The Polyline element consists of a series of lines that define a particular grouping configuration. These line segments do not result in a closed shape however they can be pre-defined and re-used as needed. The lineWidth and lineEnd are defined by the substitution group LineDescGroup or are defined at the time the Polyline is instantiated.	0-n
PolyBegin	PolyBeginType	The PolyBegin element defines the starting point of the polyline.	1-1

x	double	The X starting point of the first polyline line segment.	1-1
y	double	The Y starting point of the first polyline line segment.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polyline. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross.	2-n
LineDescGroup	ABSTRACT	A substitution group that specifies the `LineWidth` and `LineEnd` characteristics of the `Line` by reference to a predefined `LineDesc` or specified when the `polyline` is instantiated.	1-1

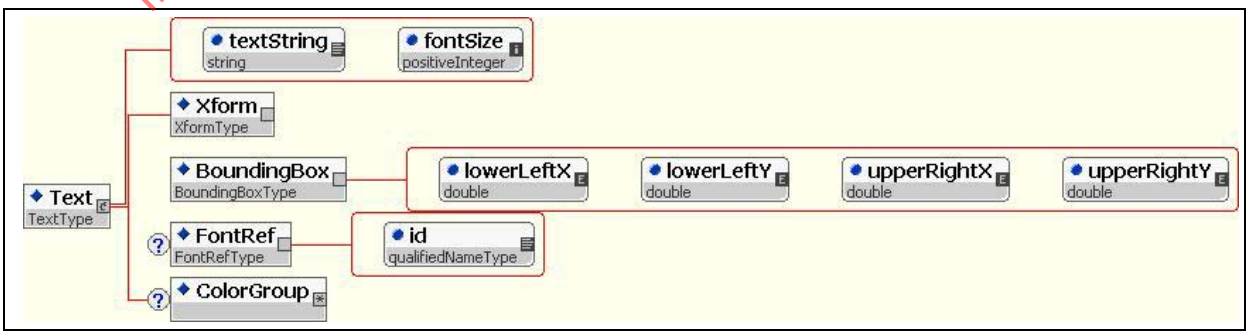
```
<EntryUser id = "Polyline1">
    <Polyline>
        <PolyBegin x = "0.0" y = "0.0"/>
        <PolyStepSegment x = "4.0" y = "0.0"/>
        <PolyStepCurve x = "4.0" y = "6.0" centerX = "4.0" centerY = "3.0" clockwise = "FALSE"/>
        <PolyStepCurve x = "4.0" y = "12.0" centerX = "4.0" centerY = "9.0" clockwise = "TRUE"/>
        <LineDescRef id = "HeavyLine"/>
    </Polyline>
</EntryUser>
<EntryUser id = "Polyline2">
    <Polyline>
        <PolyBegin x = "3.2" y = "2.2"/>
        <PolyStepSegment x = "8.8" y = "10.4"/>
        <PolyStepCurve x = "8.8" y = "16.4" centerX = "8.8" centerY = "13.4" clockwise = "TRUE"/>
        <PolyStepSegment x = "6.0" y = "16.4"/>
        <PolyStepSegment x = "6.0" y = "10.0"/>
        <LineDesc lineEnd = "ROUND" lineWidth = "0.5"/>
    </Polyline>
</EntryUser>
```

5.8.2 UserPrimitive: Text

When text is to be drawn on a product or a drawing the definition includes a bounding rectangle for the text. The `lowerLeftX` and `lowerLeftY` coordinate and the `upperRightX` and `upperRightY` coordinate define the `BoundingBox` rectangle. All portions of the text, including the line width of the strokes of the text, must fit within the `BoundingBox` rectangle. Any portion of a character exceeding the perimeter of the `BoundingBox` rectangle will be clipped at the boundaries of the `BoundingBox` rectangle.

Each `Text` entry (`EntryUser`) in the `DictionaryUser` **shall** have a unique id and consist of the characteristics shown in Table 49.

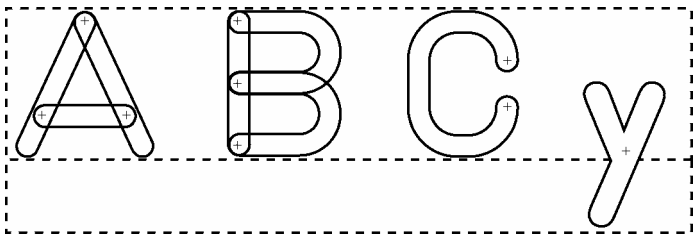
Table 49 – UserPrimitive –Text



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Text	TextType	A pre-defined string of text that may be referenced and instantiated within the 61182-2 file, including specific transformation.	0-n
textString	string	The text phrase (case-sensitive) in accordance with the language element of the `Header` element.	1-1
fontSize	positive Integer	A dimensional characteristic in terms of an integer that defines the font size	1-1
Xform	XformType	An element that provides the ability to reset the point of origin of the text box, then scale, mirror image or rotate the text box after the text box origin has been placed at an X and Y location. See 3.3	1-1
Boundingbox	BoundingBox Type	A constraining rectangular area (bounding box) that encompasses the entire text string including upper and lower case characters.	1-1
lowerLeftX	double	The lower left hand x dimension of the rectangular area encompassing the text.	1-1
lowerLeftY	double	The lower left hand y dimension of the rectangular area encompassing the text.	1-1
UpperRightX	double	The upper right hand x dimension of the the rectangular area encompassing the text.	1-1
UpperRightY	double	The upper right hand y dimension of the rectangular area encompassing the text.	1-1
FontRef	FontRefType	An element that is optional to reference a predefined font by its id, if the standard Helvetica font is not being instantiated.	0-1
id	qualifiedName Type	The identification of the `FontDef` stored in the `DictionaryFont`.	1-1
ColorGroup	ABSTRACT	An optional substitution group that permits assigning a particular color through instantiating the three basic colors or by providing a reference to a predefined `Color` in `DictionaryColor`.	0-1

The following diagram and the requirments describe the general case for how text is to be drawn. There are two variations on the use of text. This makes `Text` an element that is incorporated as a layer feature or in a `Package` description. When used in this manner, all the characteristics of `Xform` and the `BoundingBox` apply. The other form of text is as a simple `string` attribute. This is where the word `text` is used to add extra information to a particular element and therefore does not require the special features for `location`, `font`, and `Xform`.

When `text` is used as an element, the attribute `textString` should be defined to be enclosed in the textbox as illustrated in Figure 4. This includes upper and lower case letters, as well as all line widths, line descriptions, and line ends. Anything outside the clipping box will be clipped. The clipping boundary is necessary because fonts vary between computer systems and application implementations.



IEC 1672/06

Figure 4 – Bounding rectangle to round end character relationships

5.8.2.1 Text restrictions

Text character dimensions are constrained by the bounding rectangle as illustrated in Figure 5. Character height is expressed by the `fontSize` attribute. Incremental units of the `BoundingBox` follow the `Units` element used by the file; this sets the limits (left and right xy coordinates) of the bounding rectangle. Both upper and lower case letters must be inside the `BoundingBox` rectangle. Included in this requirement are the extensions of such descending letters as lower case “g,” “q,” “y,” “j,” and “p.”

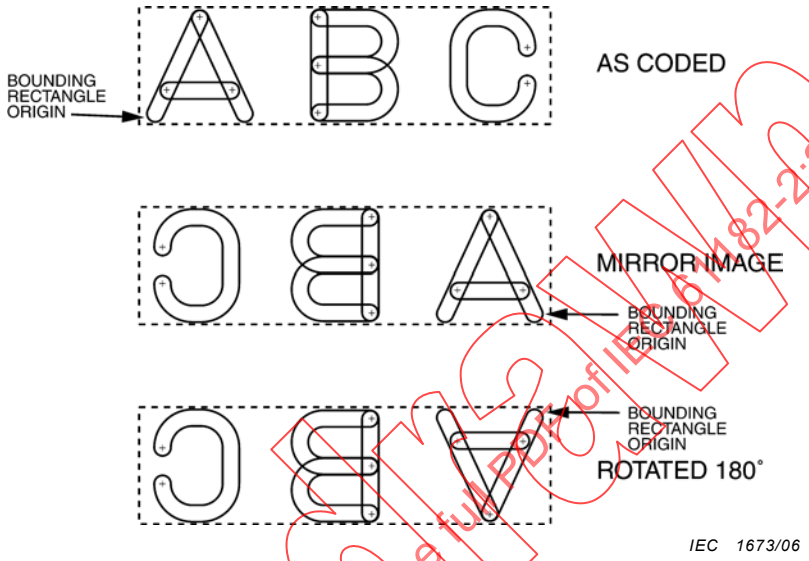


Figure 5 – Text transformation examples

5.8.2.2 Text rotation

The bounding rectangle of `Text` is defined relative to the local coordinate system. The `xLocation` and `yLocation` of `Xform` is applied to the bounding rectangle and the text contained within the rectangle to locate the `Text`. The bounding rectangle must be mirrored if required before it is rotated. The text is drawn relative to the bounding rectangle.

The example shown in Figure 6 indicates a `BoundingBox` rectangle that has been rotated 30° about the lower left xy coordinate.

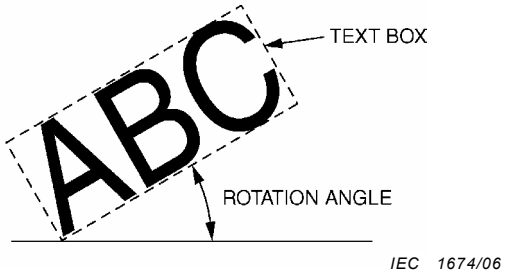
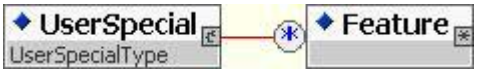


Figure 6 – Rotation Angle

5.8.3 UserPrimitive: UserSpecial

Each `UserSpecial` entry (`EntryUser`) in the `DictionaryUser` **shall** have a unique id and consist of the characteristics shown in Table 50. The `UserSpecial` may be any combination of `StandardShapes` or `UserShapes`, and is used to develop logos, targets, drawing formats or other combination of shapes.

Table 50 – UserPrimitive – UserSpecial

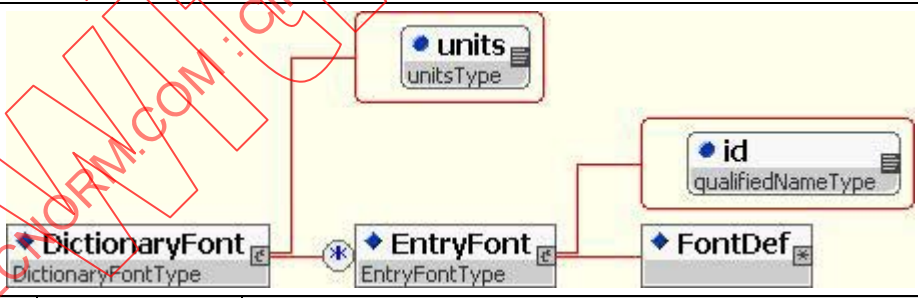


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
UserSpecial	UserSpecialType	A combination of primitive shapes that may be organized in any orientation needed to represent the users needs for defining a special graphic shape.	0-n
Feature	ABSTRACT	A substitution group consisting of any graphic allowed by either the `StandardShape` or `UserShape` substitution groups.	0-n
StandardShape	ABSTRACT	A substitution group that permits the substitution of the `StandardShape` element. The `StandardShape` element may be used to further classify `Feature`. In so doing, `StandardShape` can be substituted by a `StandardPrimitive` or `StandardPrimitiveRef`.	0-n
UserShape	ABSTRACT	A substitution group that permits the substitution or classification of a higher level substitution group. The `UserShape` element may be used to further classify `Feature`. In so doing, `UserShape` can be substituted by a `UserPrimitive` or `UserPrimitiveRef`.	0-n

5.9 Content: DictionaryFont

The `DictionaryFont` is intended to provide lookup information on predefined font descriptions when the standard Helvetica font is not used. The `DictionaryFont` is maintained as part of a substitution group schema. The intent is to have font descriptions available that are identified by their characteristics and a specific name (id). The reference is to individual `Glyph` characters or to a known font through reference to a URN. Font descriptions may be reused throughout the file as appropriate. The name (id) of a `FontDef` must be unique within the `DictionaryFont`. See Table 51

Table 51 – Content – DictionaryFont



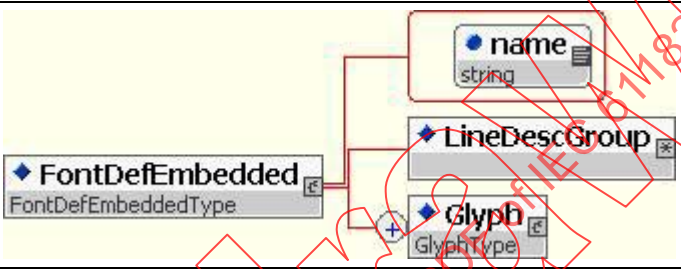
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
DictionaryFont	dictionaryFont Type	An element that consists of all the named font descriptions within the 61182-2 file.	0-n
units	unitsType	An enumerated string that may be one of the following: MILLIMETER | MICRON | INCH.	1-1
EntryFont	EntryFontType	An element that establishes the individual characteristic associated with a font substitution character or characters that have been identified by the user in the 61182-2 file.	0-n
id	qualifiedName Type	The unique qualified name description assigned as an id for any `EntryFont` for XML Schema substitution.	1-1
FontDef	ABSTRACT	A part of the substitution group that permits the substitution of individual `Glyphs` (`EmbeddedFontDef`) or known font types through reference of a URN (`ExternalFontDef`).	1-n

The organization of the Dictionaryfont is accomplished in accordance with the substitution group description criteria. The FontDef description may be any character represented as a Glyph according to the specific characteristics identified in the following paragraphs. FontDef may also be a know font through reference of a URN. The FontRef function is used in the body of the 61182-2 file when a specific font has been predefined, assigned a name, and the unique "id" is referenced in the file. This feature permits the substitution of the standard Helvetica font; Font descriptions are only contained in the DictionaryFont and are not instantiated in the body of the 61182-2 file.

5.9.1 FontDefEmbedded

The FontDefEmbedded element is used to capture individual characters and store them in the DictionaryFont. See Table 52.

Table 52 – FontDetEmbedded element

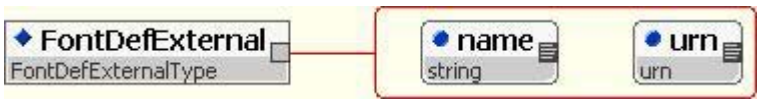


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
FontDefEmbedded	FontDefEmbeddeType	A substitution for FontDef that identifies an individual Glyph character by a specific name and the Glyph characteristics.	0-n
name	string	A unique name related to the charCode of the Glyph character.	0-n
LineDescGroup	ABSTRACT	A substitution group that specifies the LineWidth and LineEnd characteristics of the Font by reference to a predefined LineDesc or specified when the font is instantiated.	1-1
Glyph	GlyphType	The element that contains the description of all the character definitions defined in the user developed font.	1-n

5.9.2 FontDefExternal

The FontDefExternal element is used to capture known font characters and store the reference in the DictionaryFont. See Table 53.

Table 53 FontDetExternal element

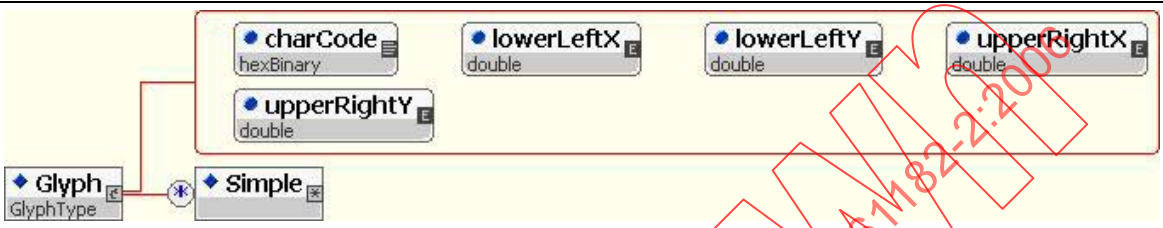


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
FontDefExternal	FontDefExternal Type	A substitution for FontDef that identifies a known group of characters through their font style.	0-n
name	string	A unique name related to the character set of a known font.	0-n
urn	urn	A specific urn that makes reference to a known font that has the appropriate permission to use the font substitution in a 61182-2 file.	1-1

5.9.3 FontDef: Glyph

The Glyph character set is a group of user defined characters that will be reference by the text command in the file. Glyph permits the user to define a special set of characters that need description as a part of the 61182-2 file. Each character is in a BoundingBox that contains all the line strokes needed to completely define each character in the set. The point of origin is the lower left hand corner of the BoundingBox. The lowerLeftX and lowerLeftY point of origin will be used to position, rotate or mirror image all Glyph characters. See Table 54.

Table 54 – FontDet – Glyph



Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
Glyph	GlyphType	The element that contains the description of all the character definitions defined in the user developed font.	0-n
charCode	hexBinary	A code used by the user to identify a special character.	0-1
lowerLeftX	double	The lower left hand x dimension of the rectangular area encompassing the character.	1-1
lowerLeftY	double	The lower left hand y dimension of the rectangular area encompassing the character.	1-1
upperRightX	double	The upper right hand x dimension of the the rectangular area encompassing the character.	1-1
upperRightY	double	The upper right hand y dimension of the rectangular area encompassing the text character.	1-1
Simple	ABSTRACT	A substitution set of simple primitive shapes that may be any one of four geometries: Arc, Line, Outline, or PolyLine. The LineWidth and LineEnd characteristics are established by the Simple substitution	0-n

5.9.4 FontDef: Glyph combination

The developers of individual Glyph characters are encouraged to consider the manner in which the characters will be used. Since the BoundingBox surrounding the character must entirely encompass the Glyph, it is important to leave room in the BoundingBox so that the spacing between characters is consistent with the character style.

Using individual Glyph characters does not present a problem, however Glyph combinations should match the style of Glyph chosen by the user. Since it is mostly the Text element that instantiates fonts, the Glyph BoundingBox must fit into the Text BoundingBox. This is a simple strategy when all the Glyph characters are of a similar height. In this instance the “Y” dimensional differences between Glyph characters bounding boxes and Text bounding boxes should be identical in order to keep the Glyph characters within the Text box. Under those circumstances, only the spacing between characters needs to be considered.

As an example consider the word simple instantiated in capital letters or lower case. When instantiating a Text string, the Glyph for “SIMPLE” would only require equal bounding boxes in the character height even though the character “I” would have a smaller character width than the character “M”. A different strategy for Glyph development must be used if the Text string were to call for “Simple”. Since character height is different, it is recommended that the

Glyph BoundingBox consider its location position in a Text BoundingBox according to the rule that all characters must be inside the Text box.

Figure 7 shows an example of Glyph bounding boxes related to the Text BoundingBox. The characters line up even though they are positioned on the lower y-coordinate. They were designed along a construction line to have this condition occur.

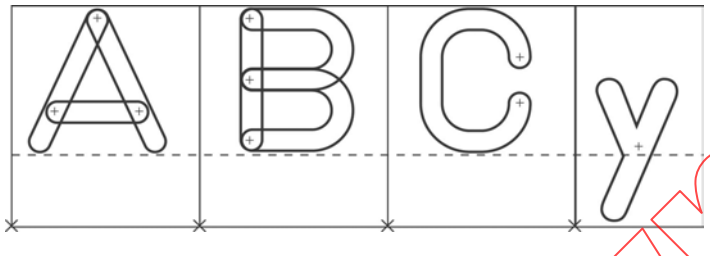
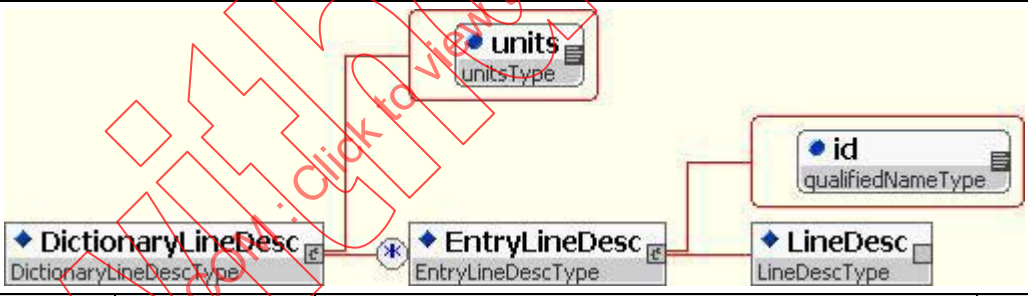


Figure 7 – Glyph bounding rectangles to Text bounding box relationships

5.10 Content: DictionaryLineDesc

The DictionarylineDesc is intended to provide lookup information on predefined line descriptions. The DictionarylineDesc is maintained as part of a substitution group schema. The intent is to have line descriptions available that are identified by their characteristics and a specific name (id). They may be reused throughout the file as appropriate. The name (id) of a LineDesc must be unique within the DictionaryLineDesc. See Table 55.

Table 55 – Content – DictionaryLineDesc



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
DictionaryLineDesc	DictionaryLine DescType	An element that contains substitution group information using line description criteria, predefined by the user for reuse in the file.	0-1
units	unitsType	An enumerated string that may be one of the following: MILLIMETER | MICRON | INCH.	1-1
EntryLineDesc	EntryLineDesc Type	An element that establishes the individual characteristic associated with a line description substitution group that has been identified by the user of the 61182-2 file.	0-n
id	qualifiedName Type	The unique qualified name description assigned as an id for any LineDesc for XML Schema substitution.	1-1
LineDesc	LineDescType	An element that defines the LineEnd and LineWidth characteristics to become part of the substitution group for defining line descriptions.	1-n

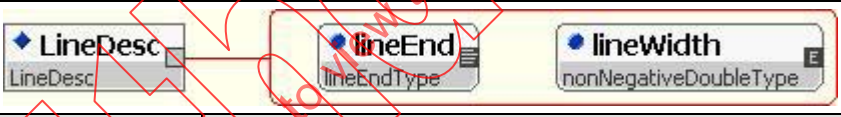
```
<DictionaryLineDesc units = "MILLIMETER">
    <EntryLineDesc id = "FineLine">
        <LineDesc lineEnd = "ROUND" lineWidth = "0.05"/>
    </EntryLineDesc>
    <EntryLineDesc id = "MediumLine">
        <LineDesc lineEnd = "NONE" lineWidth = "0.15"/>
    </EntryLineDesc>
        <EntryLineDesc id = "HeavyLine">
        <LineDesc lineEnd = "SQUARE" lineWidth = "0.30"/>
    </EntryLineDesc>
</DictionaryLineDesc>
```

The organization of the DictionaryLineDesc is accomplished in accordance with the substitution group description criteria. The lineDesc description defines the LineEnd and LineWidth according to the specific characteristics identified in the following paragraphs. The LineDescRef function is used in the body of the 61182-2 file when a specific LineDesc has been predefined, assigned a name, and the unique "id" is referenced in the file. This feature permits the use of either a predefined LineDesc, or defining the details of a LineDesc within the file. The description in the file must contain all the features of a line description under the rules of the LineDesc definition.

5.10.1 LineDesc

The LineDesc element is used throughout the 61182-2 file to establish the characteristics of lineEnd and lineWidth descriptions. The LineDesc definition is according to the following characteristics. See Table 56.

Table 56 – LineDesc element

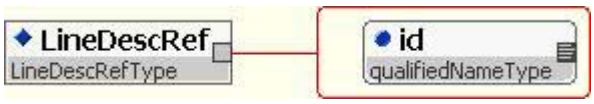


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LineDesc	LineDesc	An element that defines the characteristics of a line. The Units are defined when the LineDesc is instantiated; Units is a part of the characteristics when LineDesc is contained in the DictionaryLineDesc.	1-n
lineEnd	lineEndType	A description of the line ends used in any graphic description. The lineEnd description is an enumerated string that may be ROUND | SQUARE | NONE.	1-1
lineWidth	nonNegative DoubleType	A dimensional characteristic that defines the nominal lineWidth of a Line, Polyline, or Arc element. The dimensions are in the same category as all dimensions contained in the 61182-2 file.	1-1

5.10.2 LineDescRef

The LineDescRef element is used throughout the 61182-2 file to establish the relationship to a previously defined LineDesc. The Units of the predefined LineDesc must match the Units of the Ecad section in which it is instantiated. The LineDescRef definition is according to the following characteristics. See Table 57

Table 57 – LineDescRef element

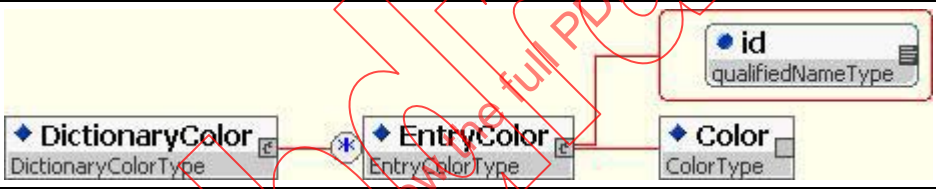


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LineDescRef	LineDescRef Type	An element used to reference a previously defined `LineDesc`, contained in the `DictionaryLineDesc`.	1-n
id	qualifiedName Type	The identification of the `LineDesc` being referenced from the `DictionaryLineDesc`.	1-1

5.11 Content: DictionaryColor

The `DictionaryColor` is intended to provide lookup information on predefined `Color` descriptions. The `DictionaryColor` is maintained as part of a substitution group schema. The intent is to have color descriptions available that are identified by their three color hues and intensity characteristics and a specific name (id). They may be reused throughout the file as appropriate. The name (id) of a `color` must be unique within the `DictionaryColor`. See Table 58.

Table 58 – Content – DictionaryColor



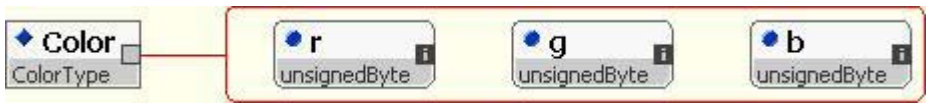
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
DictionaryColor	DictionaryColorType	An element that contains substitution group information using color description criteria, predefined by the user for reuse in the file.	0-1
EntryColor	EntryColorType	An element that establishes the individual characteristic associated with a color substitution that has been identified by the user in the 61182-2 file.	0-n
id	qualifiedNameType	The qualified description name assigned as an id standard for XML Schema color substitution.	1-1
Color	ColorType	A specific color identified through the instantiation of the three color spectrum as a part of the schema within the 61182-2 file.	1-n

The organization of the `DictionaryColor` is accomplished in accordance with the substitution group description criteria. The `Color` description may be any combination of the three color hues (red, green and blue) at the appropriate intensity according to the specific characteristics identified in the following paragraphs. The `colorRef` function is used in the body of the 61182-2 file when a specific `Color` has been predefined, assigned a name, and the unique "id" is referenced in the file. This feature permits the use of either a predefined `Color`, or defining the details of a `Color` within the file. The description in the file must contain all the features of a particular `Color` under the rules of the particular `color` definition.

5.11.1 Color

`Color` is defined by three values that represent the red, green and blue components of the composite color. If r, g, and b are all set to 0, the color is black. If all values are 255 then the color is white. The attributes of a `Color` element are defined in Table 59.

Table 59 – Color element

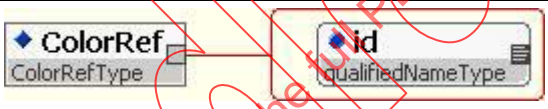


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Color	ColorType	The specific description of the color represented by the three attributes.	1-1
r	unsignedByte	Defines the red color intensity as a value between 0 and 255.	1-1
g	unsignedByte	Defines the green color intensity as a value between 0 and 255.	1-1
b	unsignedByte	Defines the blue color intensity as a value between 0 and 255.	1-1

5.11.2 ColorRef

The `ColorRef` element is used throughout the 61182-2 file to establish the relationship to a previously defined `Color`. The `ColorRef` definition is according to the characteristics shown in Table 60.

Table 60 – ColorRef element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
ColorRef	ColorRefType	The specific reference to a predefined color represented by the three attributes and contained in the `DictionaryColor`.	1-1
id	qualifiedNameType	The qualified description name assigned as an `id` standard for XML Schema color substitution.	1-1

5.12 Content: DictionaryFirmware

The `DictionaryFirmware` is intended to provide lookup information on predefined `CachedFirmware`. The `DictionaryFirmware` is maintained as part of a substitution group schema. The intent is to have firmware descriptions available that are identified by their characteristics and a specific name (id). They may be reused throughout the file as appropriate. The name (id) of a `CachedFirmware` must be unique within the `DictionaryFirmware`. See Table 61.

Table 61 – Content – DictionaryFirmware

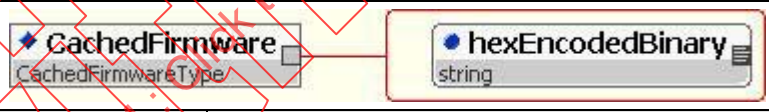
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
DictionaryFirmware	DictionaryFirmwareType	An element that consists of all the named CachedFirmware within the 61182-2 file.	0-n
EntryFirmware	EntryFirmware Type	An element that establishes the individual characteristic associated with a Firmware entry substitution that has been identified by the user in the 61182-2 file.	0-n
id	qualifiedName Type	The qualified description name assigned as an id for XML Schema substitution of firmware.	1-1
CachedFirmware	CachedFirmwareType	Any CachedFirmware identified and contained in the DictionaryFirmware as a part of the schema within the 61182-2 file.	1-n

The organization of the DictionaryFirmware is accomplished in accordance with the substitution group description criteria. The CachedFirmware description may be any hexEncodedBinary string according to the specific characteristics identified in the following paragraphs. The FirmwareRef function is used in the body of the 61182-2 file when a specific CachedFirmware has been predefined, assigned a name, and the unique "id" is referenced in the file. This feature permits the use of either a predefined CachedFirmware, or defining the details of the Firmware associated with a particular Component identified by reference designator in the Step section within the file. The description in the file must contain all the features of a particular Firmware under the rules of the particular encoded definition.

5.12.1 CachedFirmware

The CachedFirmware element is used to describe firmware that will be contained in the DictionaryFirmware. The details are in accordance to the characteristics in Table 62.

Table 62 – CachedFirmware element

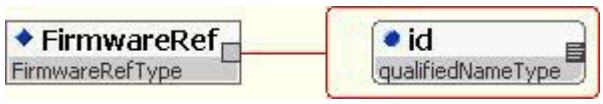


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
CachedFirmware	CachedFirmware Type	The firmware description needed by a particular component that becomes part of the predefined firmware in the DictionaryFirmware.	1-1
hexEncodedBinary	string	An attribute defining the binary code that **shall** be added to a particular component and which is contained in the DictionaryFirmware.	1-1

5.12.2 FirmwareRef

The FirmwareRef element is used throughout the 61182-2 file to establish the relationship to a previously defined CashedFirmware. The FirmwareRef definition is according to the characteristics in Table 63.

Table 63 – FirmwareRef element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
FirmwareRef	FirmwareRefType	The specific reference to firmware previously defined and contained in the `DictionaryFirmware`.	1-1
id	qualifiedNameType	The qualified name of `CachedFirmware` contained in the `DictionaryFirmware`.	1-1

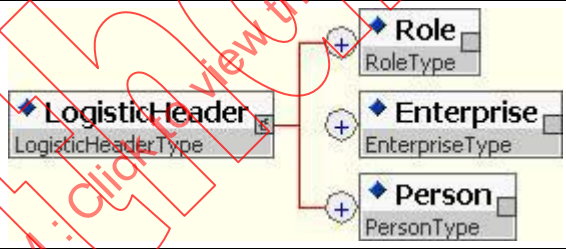
6 Logistic header

The `LogisticHeader` element consists of information about the owner of the 61182-2 file. It can be used for configuration management or contact information. The enterprise is also linked to the Bill of Material and the Approved Vendor List.

6.1 LogisticHeader

The `LogisticHeader` describes information pertaining to ordering and delivery. This includes the role played by the individual providing ordering and delivery information, the title of the person responsible and the address and particulars of the enterprise. See Table 64.

Table 64 LogisticHeader element



Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
LogisticHeader	LogisticHeaderType	The `LogisticHeader` describes information pertaining to ordering and delivery.	1-1
Role	RoleType	Defines the type of activity within the enterprise.	1-n
Enterprise	EnterpriseType	Provides information about the company identified in the BOM or Avl schema.	1-n
Person	PersonType	Identifies the person involved in sending receiving or having anything to do in the trading partner relationship.	1-n

```
<LogisticHeader>
  <Role name = "OWNER" description = "IPC Staff" publicKey = "x6d8rf7xd90mJHR13" authority = "25XX standard development"/>
  <Enterprise id = "IPC" name = "IPC Incorporated – Association Connecting Electronincs Industries" code = "57834" codeType = "CAGE"
        address1 = "2215 Sanders Road" city = "Northbrook" stateProvince = "Illinois" country = "US" postalCode = "60062" phone =
        "+1-847-790-5339" fax = "+1-847-509-9798" email = "Dieterbergman@ipc.org" url = "www.ipc.org"/>
  <Person name = "Dieter W. Bergman" enterpriseRef = "IPC" title = "Director Technology Transfer" email = "Bergdi@ipc.org" phone =
        "847-790-5339" fax = "847-509-9798" mailstop = "2nd Floor " roleRef = "Owner"/>
</LogisticHeader>
```

6.2 Role

A `Role` element declares a type of activity within an `Enterprise`. The attribute values of the `Role` based on the requirements of the activities performed by the role. See Table 65.

Table 65 – Role element

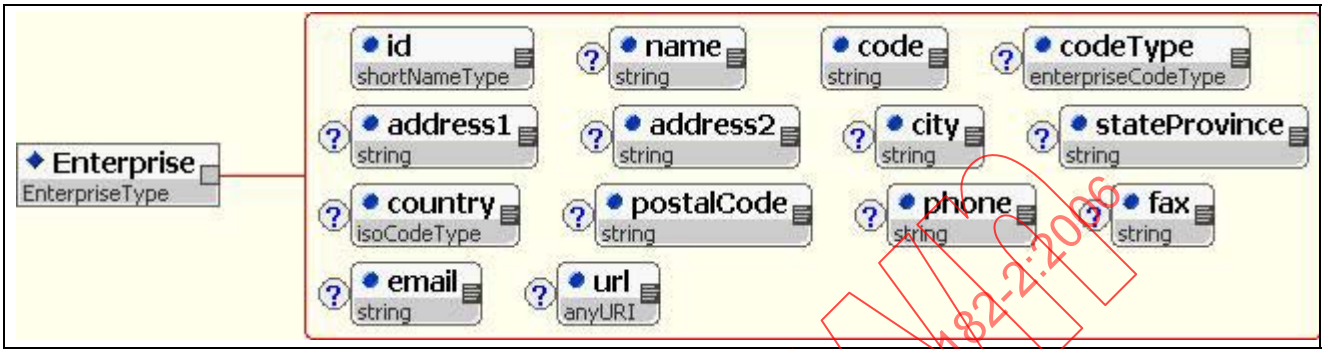
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Role	RoleType	Defines the type of activity within the enterprise.	1-n
Name	shortNameType	The name uniquely identifies a role type used by the enterprise. The name is a `shortName` data type (a restricted xsd:string) that must be unique within the global (top level) namespace of the 61182-2 file. The standard IPC role types are defined as follows: SENDER: Identifies the person sending out the 61182-2 file. OWNER: Identifies the person who maintains the configuration management of the 61182-2 file and has the right to increment the file history number of the 61182-2 file. RECEIVER: Identifies the person receiving the 61182-2 file. DESIGNER: Identifies the designer of the product described in the 61182-2 file. ENGINEER: Identifies the engineer who is responsible for the product described in the 61182-2 file. BUYER: Identifies the person who is responsible for payment. CUSTOMERSERVICE: Identifies the customer service representative who is responsible for the account. DELIVERTO: Identifies the person in the receiving department who takes possession of the shipment in the name of the enterprise. BILLTO: Identifies the person in the billing or purchasing department to whom the billing should be addressed.	1-1
description	string	The `description` attribute defines a role within an enterprise. (The `description` is optional if the IPC definition is to be used.)	0-1
publicKey	base64Binary	The `publicKey` attribute of a role holds the public encryption key if one exists for the role. The key is base64 encoded. (See IETF *RFC 1421* for the base64 algorithm) If a role `publicKey` is present it can be used instead of a `Person`/`publicKey` to encrypt data. The role's `publicKey` is used to encrypt data so only that someone with access to the role's private key can access the data.	0-1
authority	string	The access level associated with this role as defined by the system referenced by `externalConfigurationControlEntryPoint`	0-1

```
<LogisticHeader>
    <Role name = “ENGINEER” description = “responsible for data in file”/>
    <Role name = “BUYER” description = “responsible for ordering data”/>
    <Role name = “DESIGNER” description = “responsible for design description in file”/>
</LogisticHeader>
```

6.3 Enterprise

The `Enterprise` element provides information about an enterprise that will be referenced within the 61182-2 file. The attributes of the `Enterprise` element are defined in Table 66.

Table 66 – Enterprise element



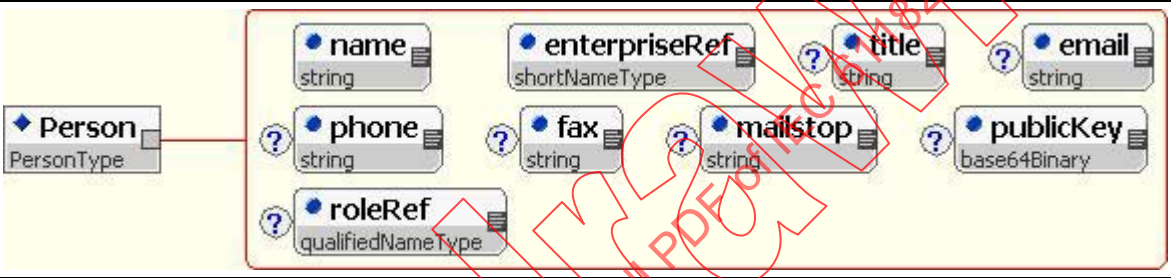
Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
Enterprise	EnterpriseType	Provides information about the company identified in the `Bom` or `Avl` schema.	1-n
id	shortNameType	The id uniquely identifies an enterprise throughout the 61182-2 file. The id is a `shortName` data type (a restricted xsd: string) that must be unique within the global (top-level) namespace of the 61182-2 file. (Suggest “XYZ”, “ACME”…).	1-1
name	string	The full name of the enterprise.	0-1
code	string	Value of a CAGE or DUNS code. If no CAGE or DUNS code is available use “NONE” as the value of the code attribute.	1-1
codeType	enterpriseCodeType	One of DUNS or CAGE. The default is DUNS. If the DUNS codeType is selected, then the `code` attribute of `Enterprise` is the D-U-N-S Number of the enterprise. (see the reference to D&B D-U-N-S Number at http://www.dnb.com/) If the CAGE `codeType` is used then the CAGE code of the `Enterprise` is in the code attribute of Enterprise. (see http://www.dscc.dla.mil/offices/sourcedev/cage.html).	0-1
address1	string	The street address of the `Enterprise`.	0-1
address2	string	Additional address information for the `Enterprise`.	0-1
city	string	The `city`.	0-1
stateProvince	string	The state or province.	0-1
country	isoCodeType	The two-letter ISO country code from the ISO 3166 standard. (see ftp://info.ripe.net/iso3166-countrycodes). The default country is “US.”	0-1
postalCode	string	The postal code.	0-1
phone	string	The general phone number for the `Enterprise`.	0-1
fax	string	The phone number of the `Enterprise` fax machine.	0-1
email	string	The email address for the `Enterprise`.	0-1
url	anyURI	The Internet HTTP Web address of the `Enterprise`.	0-1

```
<LogisticHeader>
    <Role name = “ENGINEER” description = “responsible for data in file”/>
    <Enterprise id = “Acme” name = “Acme Tool and Die Company Inc.” code = “1433” codeType = “DUNNS” address1 = “7347 Concorde Ave.” address2 = “suite 42” city = “Camden” stateProvince = “NJ” country = “US” postalCode = “08780” phone = “609-458-5943” fax = “609-458-5900” email = “AcmeCorp@mindspring.com” url = “www.Acmeproducts.com”/>
    <Enterprise Id = “Masters” name = “Master Spring Manufacturer” code = “NONE” address1 = “3793 Varembe Ave.” address2 = “Room 412” city = “Geneva” stateProvince = “Switzerland” country = “CH” phone = “+ 49-22-47 64 84” email = “masters@swisscom.ch”/>
</LogisticHeader>
```

6.4 Person

The `Person` element provides information about a person who will be referenced within the 61182-2 file. The attributes of a `Person` element are defined in Table 67.

Table 67 – Person element



Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
Person	PersonType	Identifies the person involved in sending receiving or having anything to do in the trading partner relationship.	1-n
name	string	A string that uniquely identifies the person throughout the 61182-2 file. The `Name` must be unique within the global (top-level) namespace of the 61182-2 file. It may be the full legal name or a known abbreviation.	1-1
enterpriseRef	shortNameType	The `shortName` of the person’s company or enterprise. If no enterprise exists, the term “SELF” should be used.	1-1
title	string	The job title of the person.	0-1
email	string	The email address of the person.	0-1
phone	string	The phone number of the person.	0-1
fax	string	The fax machine phone number of the person.	0-1
mailstop	string	The mail stop within the `Enterprise`, however this may be an alternate address from the `Enterprise` should the mail be directed somewhere else. In that event, the `Enterprise` **shall** be named, but contain no address or contact information.	0-1
publicKey	base64Binary	The `publicKey` attribute of a person holds the public encryption key if one exists for the person. The key is base64 encoded. (see IETF *RFC 1421* for the base64 algorithm) The person’s `publicKey` is used to encrypt data so only that person can access the data.	0-1
roleRef	qualifiedNameType	A reference to the role and identified responsibility of the person.	0-1

```
<LogisticHeader>
        <Person name = “Dilbert” enterpriseRef = “Acme” email = jdilbert@acme.com phone = “(301) 555-1212”/>
        <Person name = “John Jones” enterpriseRef = “Philco Corp” title = “Consultant” email = jones@aol.com phone = “(301) 555-1212” mailstop = “37 Stringer Rd., Overland, OH, 56432” roleRef = JJ Engineer” />
</LogisticHeader>
```

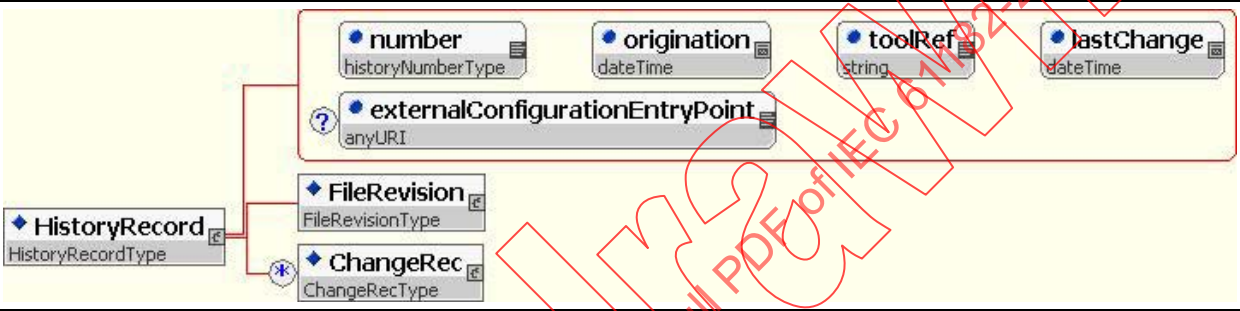
7 History record

The History Record element consists of changes performed on the file throughout its history. Several attributes are defined as part of the `History` as well as two elements. These are file revision and change records elements.

7.1 HistoryRecord

The `HistoryRecord` element provides a sequential change number for the 61182-2 file. The number is changed every time the controlled version of the 61182-2 file is modified. Only the file owner is allowed to change the value of `HistoryRecord/number`. The attributes of a `HistoryRecord` element are defined in Table 68.

Table 68 HistoryRecord element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
HistoryRecord	HistoryRecordType	The `HistoryRecord` element provides a sequential change number for the 61182-2 file. The number is changed every time the controlled version of the 61182-2 file is modified. Also identified are the change approval conditions.	**1-1**
number	historyNumberType	The revision number of the 61182-2 file. The content of this number is defined and controlled by the file owner.	1-1
origination	dateTime	The timestamp recorded when the 61182-2 file was first created.	1-1
toolRef	string	A reference to the tool used to create the original file.	1-1
lastChange	dateTime	The timestamp recorded when the History number was last incremented.	1-1
externalConfiguration EntryPoint	anyURI	A URI referencing a configuration control system that “owns” the 61182-2 file contents.	0-1
FileRevision	FileRevisionType	An element that tracks the changes that have been made to an 61182-2 file. The revision identifier does not necessarily track the revision of the product but does establish the sequence and software tools used to make the changes.	1-1
ChangeRec	ChangeRecType	An element that is required to manage the configuration of the changes made to the product during its development phases and its final configuration in the field.	0-n

```
<HistoryRecord number = "Example1" origination = "2004-02-11T12:53" toolRef = "Dieter Laptop Dell Latitude" lastChange =
                "2004-02-13T13:24:00">
  <FileRevision fileRevisionId = "Example1" comment = "Primitive layout positioning">
    <SoftwarePackage name = "Manual Interpretation" vendor = "IPC" revision = "none">
      <Certification certificationStatus = "ALPHA" certificationCategory = "DETAILEDDRAWING"/>
    </SoftwarePackage>
  </FileRevision>
</HistoryRecord>
```

7.2 FileRevision

The `FileRevision` element tracks changes to the 61182-2 file. The revision identifier does not necessarily track the revision of the product. The purpose of the `FileRevision` is to track which software tools were used to make changes to the file and the sequence in which the changes were made. See Table 69.

Table 69 FileRevision element

Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
FileRevision	FileRevision Type	An element that tracks the changes that have been made to an 61182-2 file. The revision identifier does not necessarily track the revision of the product but does establish the sequence and software tools used to make the changes.	1-1
fileRevisionID	string	An identifier for the revision. This value may be supplied by a revision control system such as RCS, CVS, or SCCS.	1-1
comment	string	A short description of the revision, such as a changes statement entered by RCS or SCCS.	1-1
label	string	A label that can be applied to a branch head. The label can be used to associate a file revision of special significance.	0-1
SoftwarePackage	Software PackageType	A nested element, the software package that wrote this revision of the file.	1-1

7.3 SoftwarePackage

The `SoftwarePackage` element is the description of the software package that was used to create the revision to the file. This includes the revision of the software that wrote the file as well as the vendor name and platform model. Also added to the `SoftwarePackage` schema is any certification that has occurred of the software's ability to meet the requirements of the 61182-2 standard. See Table 70.

Table 70 SoftwarePackage element

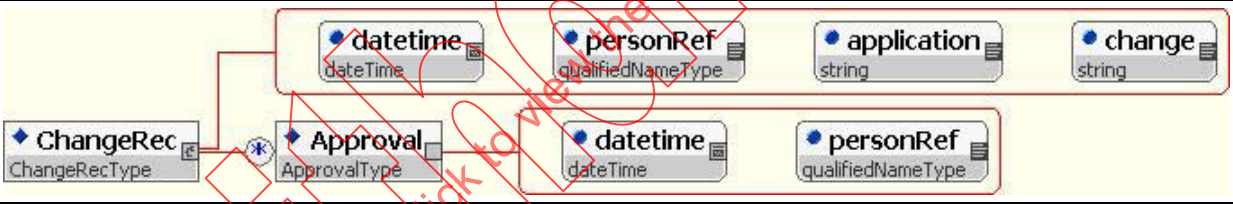
Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
SoftwarePackage	SoftwarePackage Type	A nested element, the software package that wrote this revision of the file.	1-1
name	string	The name of the software package that wrote the revision to the file.	1-1
vendor	string	The tool providers name both system and software package.	1-1
revision	string	The revision of the software that wrote the file.	1-1
model	string	The model of the software or release number.	0-1
Certification	CertificationType	The different certifications that the tool or software package has acquired.	1-n

certificationStatus	certification StatusType	An enumerated string that defines the status as one of four types. ALPHA | BETA | CERTIFIED | SELFTEST.	1-1
certificationCategory	certification CategoryType	The various categories that exist for certification of the type of activities related to building electronic assemblies. An enumerated string consisting of: ASSEMBLYDRAWING | ASSEMBLYFIXTUREGENERATION | ASSEMBLYPANEL | ASSEMBLYPREPTOOLS | ASSEMBLYTESTFIXTUREGENERATION | ASSEMBLYTESTGENERATION | BOARDFABRICATION | BOARDFIXTUREGENERATION | BOARDPANEL | BOARDTESTGENERATION | COMPONENTPLACEMENT | DETAILEDDRAWING | FABRICATIONDRAWING | GENERALASSEMBLY | GLUEDOT | MECHANICALHARDWARE | MULTIBOARDPARTLIST | PHOTOTOOLS | SCHEMATICDRAWINGS | SINGLEBOARDPARTLIST | SOLDERSTENCILPASTE | SPECSOURCECONTROLDRAWING.	0-1

7.4 ChangeRec

The `ChangeRec` element is the information needed for configuration management of the changes made to the product that the data file represents. The characteristics are stored by the `datecode` that the change record was executed. The information can also be used to obtain approval of a suggested change. See Table 71.

Table 71 – ChangeRec element



Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
ChangeRec	ChangeRecType	An element that is required to manage the configuration of the changes made to the product during its development phases and its final configuration in the field.	0-n
datetime	dateTime	The timestamp recorded when the change was made to the file.	0-n
personRef	qualifiedNameType	The pointer to the person listed in the `LogisticHeader`.	1-1
application	string	The effectivity of the change indicating when it becomes active, such as after so many completed units.	1-1
change	string	A short description of the change.	1-1
Approval	approvalType	The approval of a suggested change by the fabricator or assembler	0-n
datetime	dateTime	The timestamp recorded when the change was made to the file.	0-n
personRef	qualifiedNameType	The pointer to the person listed in the `LogisticHeader`.	1-1

8 BOM (Material List)

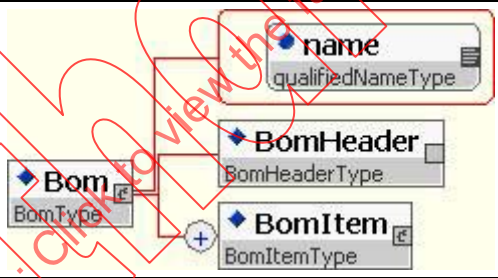
This clause describes the Bill of Materials for the printed board and printed board assembly. A bill of materials is a list of all the different materials and components to be used in the manufacture of the electronic assembly. The information is arranged by a specific category of material or components and then by the OEM Design Number (ODN). This is the number assigned by the owner of the file. Each ODN has a list of attributes and is accompanied by a list of the various specific uses of the materials or components on the electronic assembly, each with its private name or reference designator.

The `BOM` dataset represents the list of materials or components found on a particular board, keyed by the OEM Design Number (ODN). The original `BOM` is delivered by the owner of the file (OEM, EMS, etc.) in the early stages of the design. The Bom element is composed of the `BomHeader` and the `BomData`

For example, ODN **348324-001** can be of package **pqfp100**, has an Internal Part Number (IPN) **30020A** and may have four occurrences on the board, labelled **U14**, **U15**, **U75**, **U76**. Each occurrence is called a Reference Designator (RefDes for short).

The 61182-2 file can contain several `BOM` elements. Each one has a `BomHeader` sub-element with board and date/time information. The main data resides in the sub-element `BomData`. See Table 72.

Table 72 – Bom element



Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
Bom	BomType	The `Bom` element describes the Bill of Materials for the printed board and printed board assembly. A bill of materials is a list of all the different materials and components to be used in the manufacture of the electronic assembly.	1-1
name	qualifiedNameType	The name string that identifies the specific `Bom` section. This name is referenced in the `AvlDataHeader` element.	1-1
BomHeader	BomHeaderType	A nested element containing identification and logistical information about the `Bom`.	1-1
BomItem	BomItemType	The individual elements that define the details of each of the items in the `Bom`.	1-n

```
<Bom name = "TestBoard1">
<BomHeader assembly = "Karens Design" revision = "Prototype" stepListRef = "KarensBoard"/>
    <BomItem OEMDesignNumberRef = "Fabricated" quantity = "1" numberIO = "4" category = "ELECTRICAL"    description = "Card
                Edge Connector">
      <RefDes name = "J1" populate = "FALSE"/>
      <Characteristics category = "ELECTRICAL"/>
    </BomItem>
    <BomItem OEMDesignNumberRef = "Sample1234" quantity = "1" numberIO = "8" category = "ELECTRICAL" internalPartNumber =
                "Molex 354892" description = "Biforcated Thru-hole connector" packageRef = "Connector1">
      <RefDes name = "J2" populate = "TRUE"/>
      <Characteristics category = "ELECTRICAL"/>
    </BomItem>
    <BomItem OEMDesignNumberRef = "SOIC129867" quantity = "1" numberIO = "8" category = "ELECTRICAL" internalPartNumber =
                "Phillips IC2436" description = "SOIC 1.27 pitch" packageRef = "SOIC12">
      <RefDes name = "U1" populate = "TRUE"/>
      <Characteristics category = "ELECTRICAL">
        <Textual definitionSource = "Pretested Logic" textualCharacteristicName = "Per Supplier Data Sheet"/>
      </Characteristics>
    </BomItem>
    <BomItem OEMDesignNumberRef = "CAP 24A1846" quantity = "1" numberIO = "2" category = "ELECTRICAL" internalPartNumber =
      "Phillips Cap1235" description = "3225 Surface Mount Capacitor" packageRef = "Capacitor1">
      <RefDes name = "C1" populate = "TRUE"/>
      <Characteristics category = "ELECTRICAL">
        <Measured measuredCharacteristicName = "Capacitance" measuredCharacteristicValue = "20 Microfarads"
          engineeringUnitOfMeasure = "Microfarads" engineeringNegativeTolerance = "3 microfarads" engineering
          PositiveTolerance = "3 microfarads"/>
```

8.1 BOM Header

Each Bom in the 61182-2 file has a BomHeader element. This is a mandatory requirement as a part of the Bom element. Table 73 provides the characteristics that are necessary to properly describe a Bom.

Table 73 – BomHeader element

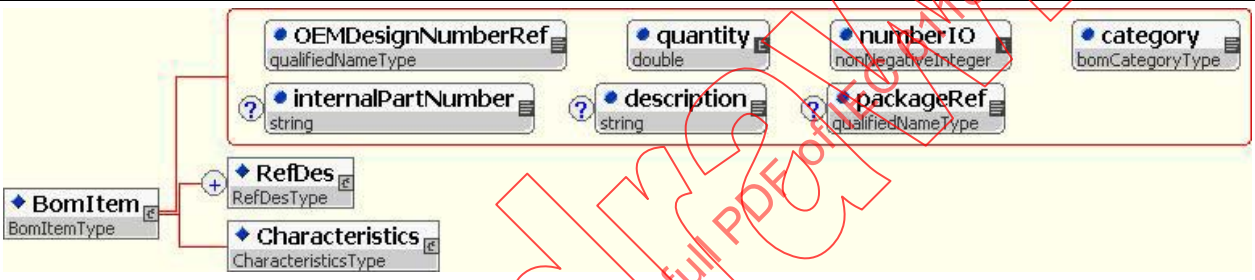
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
BomHeader	BomHeaderType	A nested element containing identification and logistical information about the Bom.	1-1
assembly	qualifiedNameType	Electronic assembly name as parsed from the Bom file.	1-1
revision	string	Revision as parsed from the Bom file.	1-1
affecting	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). True equals that the current BOM was used in the assembly merge process in the job and therefore was the affecting one. This is due to the fact that there can be multiple BOMs in a job, but only one has been used to affect the current top and bottom component placements sections.	0-1
stepListRef	qualifiedNameType	Identification of specific steps used to help describe the BomItem within the category of materials	1-1

8.2 BomItem

Each `BomItem` is a part of the `BomItem` list. A `BomItem` consists of a variety of attributes. `BomItem` contains the reference to the OEM Design Number (ODN), the line item of the ODN, a quantity of parts required, and optional `internalPartNumber` (IPN), description of the `bomItem` and a reference to the package type (`packageRef`). The `BomItem` also contains three additional elements that include the list of reference designators (`RefDes`) associated with the `BomItem`, a list of detail descriptions related to the `BomItem` (`DescList`), and FirmWare (`Firmware`) associated with programming a part that needs those characteristics. `Multiple RefDes` lists may be maintained since there may be several reference designator file locations.

The attributes are shown in theTable 74 and are a mandatory part of the `Bom` section of the 61182-2 file.

Table 74 – BomItem



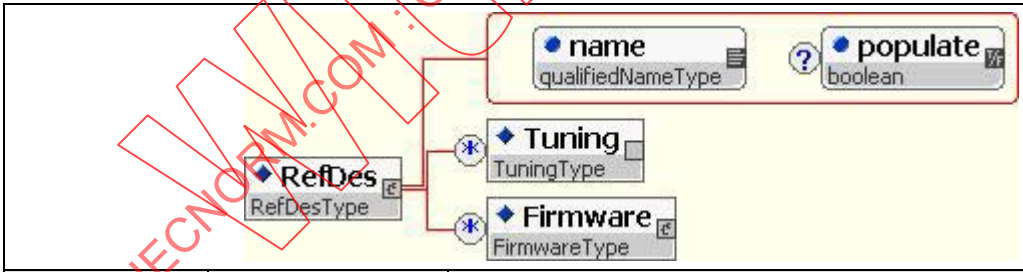
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
BomItem	BomItemType	The individual elements that define the details of each of the items in the `Bom`.	1-n
OEMDesignNumberRef	qualifiedNameType	A qualified name referencing the OEM part number data.	1-1
quantity	double	The count of the instances of this item in the assembly.	1-1
numberIO	nonNegativeInteger	The number of input/output determinations on the lineItem.	0-n
category	bomCategoryType	The category of the bomItem as an enumerated string being either ELECTRICAL | PROGRAMMABLE | MECHANICAL | MATERIAL	1-1
internalPartNumber	string	Internal or warehouse stock part identifier.	1-1
description	string	The description of the BomItem.	0-1
packageRef	qualifiedNameType	The name assigned to the package describing the physical outlines, documentation, and land patterns features related to package pin assignment.	0-1
RefDes	RefDesType	A nested element containing the reference designator strings for the individual parts identified in the file for a one to one relationship with the quantity listed for the `BomItem`.	1-n
Characteristics	CharacteristicsType	A nested element containing descriptive strings that can be linked together and also a reference to a describing line in an external file.	1-1

```
<Bom name = "TestBoard1">
    <BomHeader assembly = "Karens Design" revision = "Prototype" stepListRef = "KarensBoard"/>
     <BomItem OEMDesignNumberRef = "Fabricated" quantity = "1" numberIO = "4" category = "ELECTRICAL"  description = "Card Edge
                Connector">
        <RefDes name = "J1" populate = "FALSE"/>
        <Characteristics category = "ELECTRICAL"/>
     </BomItem>
     <BomItem OEMDesignNumberRef = "Sample1234" quantity = "1" numberIO = "8" category = "ELECTRICAL"     internalPartNumber =
              "Molex 354892" description = "Biforcated Thru-hole connector" packageRef = "Connector1">
        <RefDes name = "J2" populate = "TRUE"/>
        <Characteristics category = "ELECTRICAL"/>
     </BomItem>
     <BomItem OEMDesignNumberRef = "SOIC129867" quantity = "1" numberIO = "8" category = "ELECTRICAL" internalPartNumber =
               "Phillips IC2436" description = "SOIC 1.27 pitch" packageRef = "SOIC12">
        <RefDes name = "U1" populate = "TRUE"/>
        <Characteristics category = "ELECTRICAL">
           <Textual definitionSource = "Pretested Logic" textualCharacteristicName = "Per Supplier Data Sheet"/>
        </Characteristics>
     </BomItem>
     <BomItem OEMDesignNumberRef = "CAP 24A1846" quantity = "1" numberIO = "2" category = "ELECTRICAL" internalPartNumber =
               "Phillips Cap1235" description = "3225 Surface Mount Capacitor" packageRef = "Capacitor1">
        <RefDes name = "C1" populate = "TRUE"/>
        <Characteristics category = "ELECTRICAL">
           <Measured measuredCharacteristicName = "Capacitance" measuredCharacteristicValue = "20     Microfarads"
                     engineeringUnitOfMeasure = "Microfarads" engineeringNegativeTolerance = "3 microfarads"
              engineeringPositiveTolerance = "3 microfarads"/>
        </Characteristics>
     </BomItem>
```

8.2.1 RefDes

The `RefDes` is an element that represents the specific reference designator associated with a component that becomes a part of the electronic assembly. This is a mandatory requirement for all `BomItems` that have a reference designator associated with their ELECTRICAL descriptions. In this instance, the standard set of reference designator letters **shall** be used. i.e. R = Resistor, C = Capacitor, CR = Diode etc. The prefix letter M **shall** be used for all MECHANICAL parts, P **shall** be used for all Process MATERIAL `bomItems`, and S for all Software PROGRAMMABLE `bomItems`. See Table 75.

Table 75 – RefDes element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
RefDes	RefDesType	A nested element containing the reference designator strings for the individual parts identified in the file for a one to one relationship with the quantity listed for the `BomItem`.	0-1
name	qualifiedNameType	The name of the reference designator used.	1-n
populate	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). True equals that the `RefDes` was populated; False indicates that it was not. TRUE is the default.	0-1
Tuning	TuningType	A number of conditions that determine any adjustment that is needed for a particular `BomItem`.	0-n
Firmware	FirmwareType	A nested element containing descriptive strings that can be linked together to describe the software implementation for an individual `BomItem`.	0-n

8.2.1.1 Tuning

The `Tuning` element represents conditions that determine any adjustment that is needed for a particular `BomItem`. See Table 76.

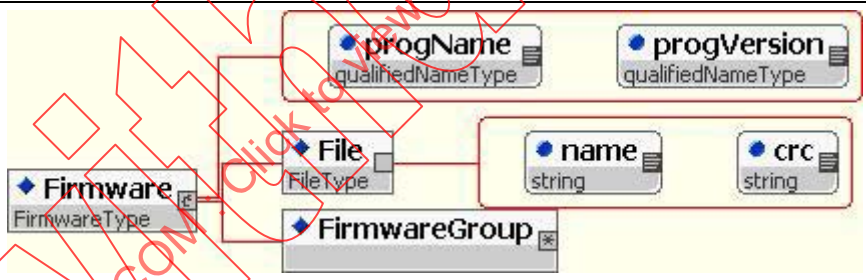
Table 76 – Tuning element

Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Tuning	TuningType	A number of conditions that determine any adjustment that is needed for a particular `BomItem`.	0-n
value	qualifiedNameType	The value of the tuning characteristics and its relationship to the other prescribed values.	1-1
comments	string	Any instructions or comments needed to prescribe the proper tuning.	0-n

8.2.1.2 Firmware

A nested element containing descriptive strings that can be linked together to describe the software implementation for an individual `BomItem` and associates the characteristics of the specific reference designators to which the programmable information is to be included. See Table 77.

Table 77 Firmware element

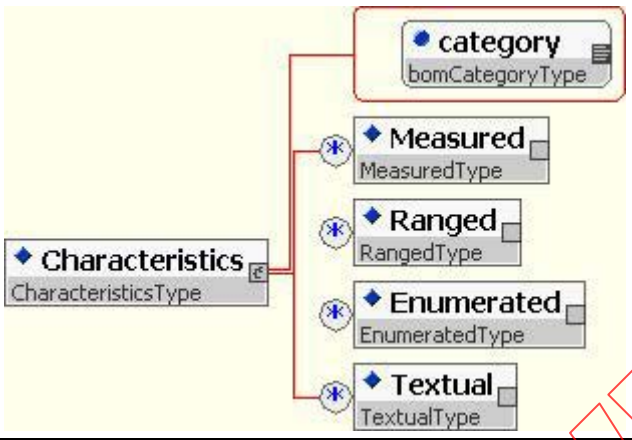


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Firmware	FirmwareType	A nested element containing descriptive strings that can be linked together to describe the software implementation for an individual `BomItem`.	0-n
progName	qualifiedNameType	Name of the program to be embedded in the BomItem.	0-1
progVersion	qualifiedNameType	Version of program or revision status.	0-1
File	FileType	Computer file containing the program code to be inserted.	1-1
name	string	Name of the file.	1-1
crc	string	Certification status to verify correct program elements.	1-1
FirmwareGroup	ABSTRACT	A substitution group that specifies the `CachedFirmware` which has been stored by the user in the `DictionaryFirmware`.	0-1

8.2.2 Characteristics

A group of specific characteristics applicable to a particular `BomItem`; they all relate to one of the categories to which the `BomItem` belongs. Each characteristic has its own level of requirements and are defined under the major element `Characteristics`. See Table 78.

Table 78 – Characteristics element

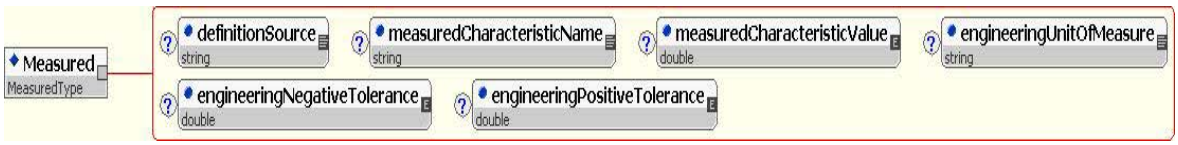


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Characteristics	CharacteristicsType	A nested element containing descriptive strings that can be linked together and also a reference to a describing line in an external file.	1-1
category	bomCategoryType	Defines the type of material or component category to which the `BomItem` belongs.	1-1
Measured	MeasuredType	A nested element containing descriptive strings that can be linked together to describe the measurable characteristics for an individual `BomItem`.	0-n
Ranged	RangedType	A nested element containing descriptive strings that can be linked together to describe the tolerances or ranges of variation that can be applied to the characteristics for an individual `BomItem`.	0-n
Enumerated	EnumeratedType	A nested element containing descriptive strings that can be linked together to describe those values that define the numerical characteristics and the source for that information for an individual `BomItem`.	0-n
Textual	TextualType	A nested element containing descriptive strings that can be linked together to describe any textual characteristics and their source for an individual `BomItem`.	0-n

8.2.2.1 Measured

The `Measured` elements are those properties that when linked together describe the measurable characteristics for an individual `BomItem`. These characteristics provide the nominal value and also include the tolerances on the measurement. See Table 79

Table 79 Measured element



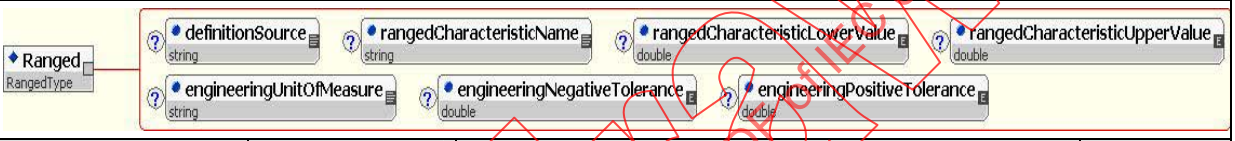
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Measured	MeasuredType	A nested element containing descriptive strings that can be linked together to describe the measurable characteristics for an individual `BomItem`.	0-n
definitionSource	string	The source of the information about the measurements.	0-1
measured CharacteristicName	string	A unique name applied to the characteristic (e.g. capacitance)	0-1

measured CharacteristicValue	double	The value of the measured property at its nominal or target value.	0-1
engineeringUnitOf Measure	string	The engineering unit of measure.	0-1
engineeringNegative Tolerance	double	The negative tolerance on the value identified.	0-1
engineeringPositive Tolerance	double	The positive tolerance on the value identified.	0-1

8.2.2.2 Ranged

The `Ranged` elements are those properties that when linked together describe the ranges that a `BomItem` must meet. These range characteristics include the upper and lower limit of the range as well as the tolerances on the measurement. These values are compared against those that have been measured to ascertain that the `BomItem` is within specifications. See Table 80.

Table 80 – Ranged element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Ranged	RangedType	A nested element containing descriptive strings that can be linked together to describe the tolerances or ranges of variation that can be applied to the characteristics for an individual `BomItem`.	0-n
definitionSource	string	The source of the information about the measurement ranges.	0-1
rangedCharacteristic Name	string	A unique name applied to the characteristic.	0-1
rangedCharacteristicL owerValue	double	The lower value of a ranged characteristic.	0-1
rangedCharacteristic UpperValue	double	The upper value of a ranged characteristic.	0-1
engineeringUnitOfMe asure	string	The engineering unit of measure.	0-1
engineeringNegativeT olerance	double	Any negative tolerance that can may be applied to the range in order to affix the target value of the `BomItem`.	0-1
engineeringPositiveT olerance	double	Any positive tolerance that can may be applied to the range in order to affix the target value of the `BomItem`.	0-1

8.2.2.3 Enumerated

The `Enumerated` elements are those properties that, when linked together, describe the enumerated value of a `BomItem` as well as the source of that information. See Table 81.

Table 81 – Enumerated element

Attribute/ Element Name	Attribute / Element Type	Description	Occur-rence
Enumerated	EnumeratedType	A nested element containing descriptive strings that can be linked together to describe those values that define the numerical characteristics and the source for that information for an individual `BomItem`.	0-n
definitionSource	string	The source of the information about the enumerated value.	0-1
enumeratedCharacteristicName	string	A unique name applied to the characteristic.	0-1
enumeratedCharacteristicValue	string	The enumerated value identified for the `BomItem`.	0-1

8.2.2.4 Textual

The `Textual` elements are those properties that when linked together describe the textual value of a `BomItem` as well as the source of that information. See Table 82.

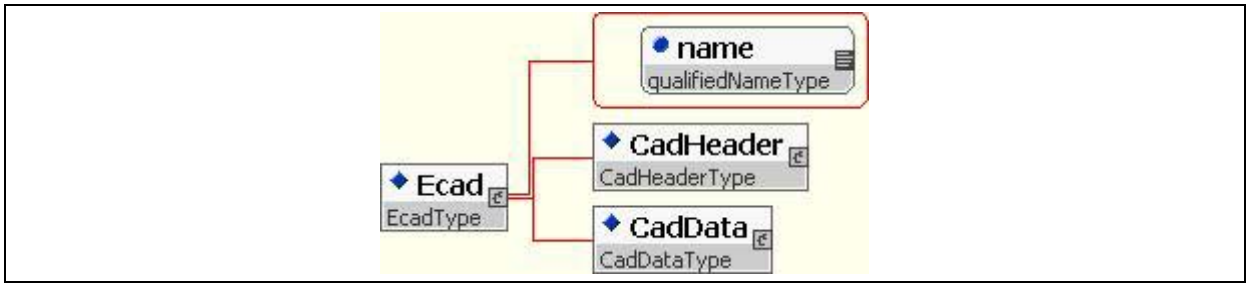
Table 82 – Textual element

Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
Textual	TextualType	A nested element containing descriptive strings that can be linked together to describe any textual characteristics and their source for an individual `BomItem`.	0-n
definitionSource	string	The source of the information about the textual value.	0-1
textualCharacteristicName	string	A unique name applied to the characteristic.	0-1
textualCharacteristicValue	string	The textual value identified for the `BomItem`.	0-1

9 Electronic computer aided design (ecad)

The `Ecad` section describes the Computer Aided Design data of the job, including all the graphical description of the layers, component location, panel design, etc. In most cases, the `Ecad` section is by far the largest body of data inside the 61182-2 file. To understand how the `Ecad` section is organized, it is important to be familiar with the `Layers` and `Step` elements. See Table 83.

Table 83 – Ecad

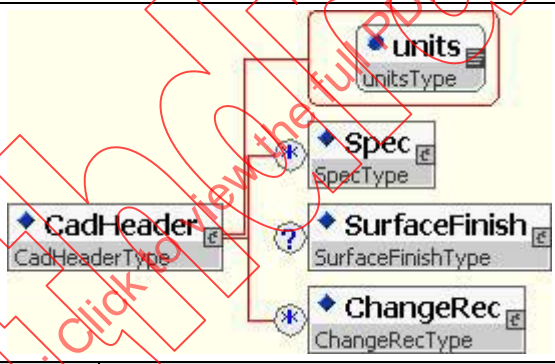


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Ecad	EcadType	The Ecad section describes the Computer Aided Design data of the job, including all the graphical description of the layers, component location, panel design, etc.	1-1
name	qualifiedNameType	The qualified name related to identify the specific Ecad information based on the electronic assembly(s) in the 61182-2 file.	1-1
CadHeader	CadHeaderType	A nested element containing identification and information about the description of the data in the file.	1-1
CadData	CadDataType	A nested element containing the actual Cad data describing the printed board and printed board assembly characteristics.	1-1

9.1 CadHeader

The CadHeader element is mandatory. Inside the CadHeader there are general attributes that describe the board and its format. Thickness should be in inches (imperial) or mm (metric) depending on units. The thickness attribute is the overall thickness of the board used to mount the components, including all plating and over-plating. See Table 84.

Table 84 – CadHeader element



Attribute/ Element Name	Attribute / Element Type	Description	Occur-rence
CadHeader	CadHeaderType	A nested element containing identification and information about the description of the data in the file.	1-1
units	unitsType	An enumerated string that may be one of the following: MILLIMETER | MICRON | INCH.	1-1
Spec	SpecType	Contains the values for conductor width and spacing in addition to other attributes.	0-n
SurfaceFinish	SurfaceFinishType	The list of potential surface finishes for the printed board.	0-1
ChangeRec	ChangeRecType	A nested element containing identification and information about the description of the data in the Ecad section of the file.	0-n

9.1.1 Spec

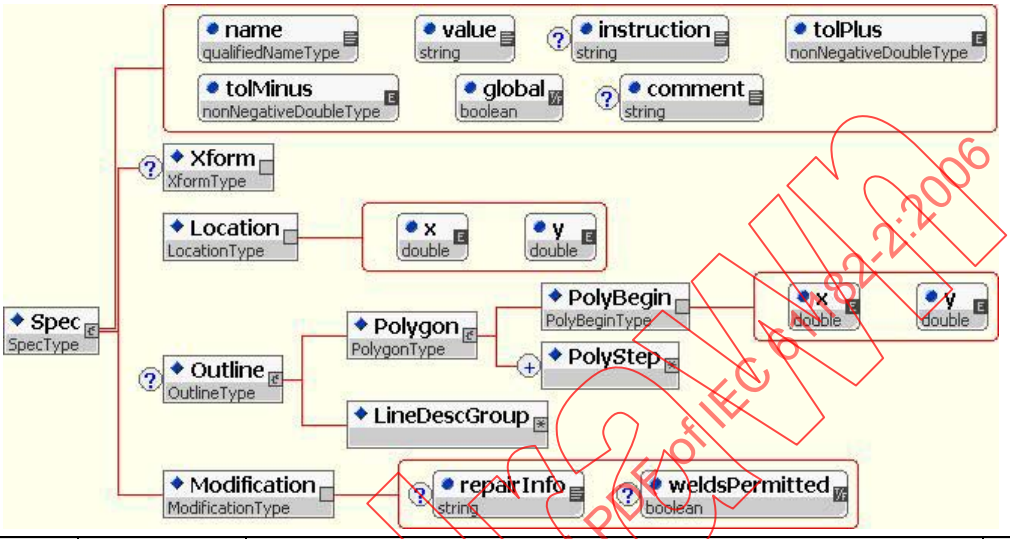
The Spec element contains various values for

- width, spacing, component spacing, component to edge, etc.;
- impedance, capacitance and resistance values;
- dimensions between edge/feature/hole to edge/feature/hole.

An optional `comment` can point to a `Spec` and version. An optional `instruction` can explain the measurement method, net and pin names or the type of elements between which the measurement has to be taken.

Up to two sub-elements describe the `Location` of the `Spec` measurement. See Table 85.

Table 85 – Spec element



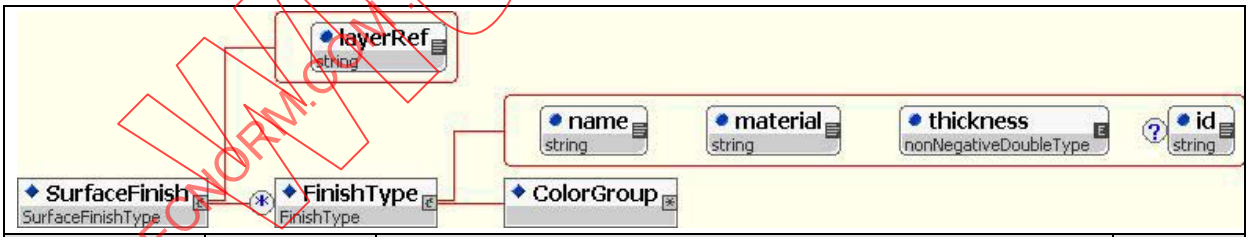
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Spec	SpecType	Contains the values for conductor width and spacing in addition to other attributes.	0-n
name	qualifiedNameType	The qualified name of the specification and indicating to which product in the file the specification pertains.	1-1
value	string	The value to be assigned to the property of the product being assessed	1-1
instruction	string	Any special instructions needed to apply the specification characteristics to the product	0-1
tolPlus	nonNegativeDoubleType	The positive tolerance to determine the upper specification limit.	1-1
tolMinus	nonNegativeDoubleType	The negative tolerance to determine the lower specification limit.	1-1
global	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE equals that conditions apply to the entire `Ecad` data as global characteristics; False indicates that they do not.	1-1
comment	string	Any comment needed to help clarify the issues pertaining to the specification limits.	0-1
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined area that can be scaled, mirror imaged or rotated. See 3.3	0-1
Location	LocationType	The image defined by `Outline` or a pre-defined image is located to identify where the specification applies. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location to which the specification applies	1-1
y	double	The y coordinate of the location to which the specification applies	1-1
Outline	OutlineType	A nested element containing a specific area(s) to which the specification(s). The `Outline` is a closed polygon configuration	0-1

Polygon	PolygonType	The standard description for the Polygon characteristic must be a closed shape. The point of origin of the shape is identified as the 0:0 coordinate. The element includes the start of the polygon definition (PolyBegin) and the appropriate number of PolyStep's to complete the closed shape. The lineWidth is through the LineDesc substitution group or defined at a time when the Polygon is instantiated.	0-n
PolyBegin	PolyBeginType	The PolyBegin element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon line.	1-1
y	double	The Y starting point of the first polygon line.	1-1
PolyStep	ABSTRACT	The PolyStep element is a substitution group that defines a circular (PolyStepCurve) or straight line (PolyStepSegment) continuation of the polygon. The polystep direction may be clockwise or counterclockwise which must be consistent when any Arc description is used as one of the PolyStep elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the PolyBegin element to signify that the shape is closed.	1-n
LineDescGroup	ABSTRACT	A substitution group that specifies the LineWidth and LineEnd characteristics of the Line by reference to a predefined LineDesc or specified when the Outline is instantiated.	1-1
Modification	Modification Type	An element that defines the acceptable modifications that may be accomplished to the final physical product.	
repairInfo	string	Information on the type of repairs permitted to the printed board.	0-1
weldsPermitted	boolean	An enumerated string that defines whether welds are permitted and may be one of the following YES; NO; or UNKNOWN.	0-1

9.1.2 SurfaceFinish

The SurfaceFinish element contains a list of potential surface finish choices and a name of a layer to which the finishes pertains. Location attributes can also be referenced by the name of the attribute to where the finish needs to be applied. These are usually in the form of polygons, each having an attribute that points to the right finish type by its id. See Table 86.

Table 86 – SurfaceFinish element

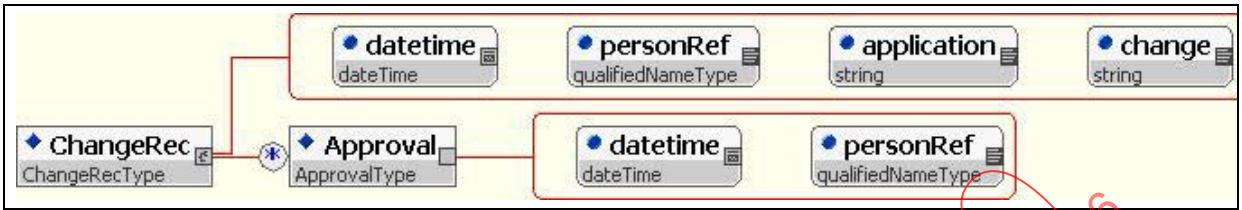


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
SurfaceFinish	SurfaceFinish Type	The list of potential surface finishes for the printed board.	0-1
layerRef	string	Description of the layer to which the surface finish applies.	1-1
FinishType	FinishType	A nested element that describes the surface finish type.	0-n
name	string	The name of the surface finish.	1-1
material	string	The material designation or reference to a specification.	1-1
thickness	nonNegative DoubleType	The maximum thickness that the surface finish needs to be after final application.	1-1
id	string	A special "id" given to the surface finish to allow it to be selectively applied to a location on a specific layer.	0-1
ColorGroup	ABSTRACT	An element that is a substitution group which can be used to define a particular Color for the surface finish, either in the body of the file or by reference to a predefined Color contained in DictionaryColor.	0-1

9.1.3 ChangeRec

The ChangeRec element contains the ChangeRec elements specifying deviations requested by the manufacturer and approved by the customer (OEM, EMS, other). See Table 87.

Table 87 – ChangeRec element



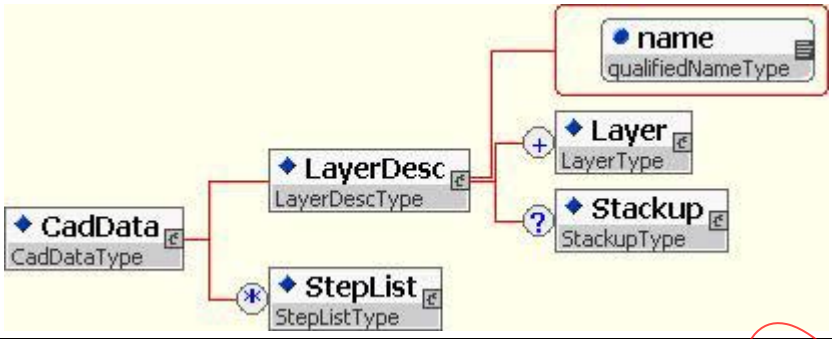
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
ChangeRec	**ChangeRecType**	**A nested element containing identification and information about the description of the data in the Ecad section of the file.**	0-n
datetime	**dateTime**	**The standard date and time indication of the change request.**	1-1
personRef	**qualifiedNameType**	**The name of the person to whom the request was made.**	1-1
application	**string**	**The effectivity of the change and exactly where the change was to be made.**	1-1
change	**string**	**A detailed description of the change, including a reference to a URL if graphic descriptions are involved.**	1-1
Approval	**ApprovalType**	**A nested element that signifies who approved the change requested by the manufacturer.**	0-n
datetime	dateTime	The standard date and time indication of the change approval.	1-1
personRef	qualifiedNameType	The name of the person who approved the change request.	1-1

9.2 CadData/LayerDesc

The CadData element is the three-dimensional structure of the design that is retrieved from the Cad system as a group of layers. The information is contained in the LayerDesc element. The layers are listed in the correct order inside LayerDesc. This includes name, context, type, side, polarity, span, and DrillToolList that define each layer. CAD data layers are required in 61182-2 to successfully hold ECAD layout information. These layers are not necessarily physical layers, but the myriad of layers that can be represented in the Ecad data but not actually fabricated into the bare board. See Table 88.

Layers, as the name implies, are sheets of two-dimensional data which, when laid on top of each other, create the Printed Circuit Assembly (unpopulated PCB and components). Some layers are physical layers that are laminated together to form the board. Other layers represent masks, films or phototools used to expose the board in a process that applies materials selectively on the outer layers of the boards. Some layers contain only drawings and annotations, which are not put physically on the board but can be used to further define it. These layers are organized in the 61182-2 file by their specific type.

Table 88 – CadData/LayerDesc elements

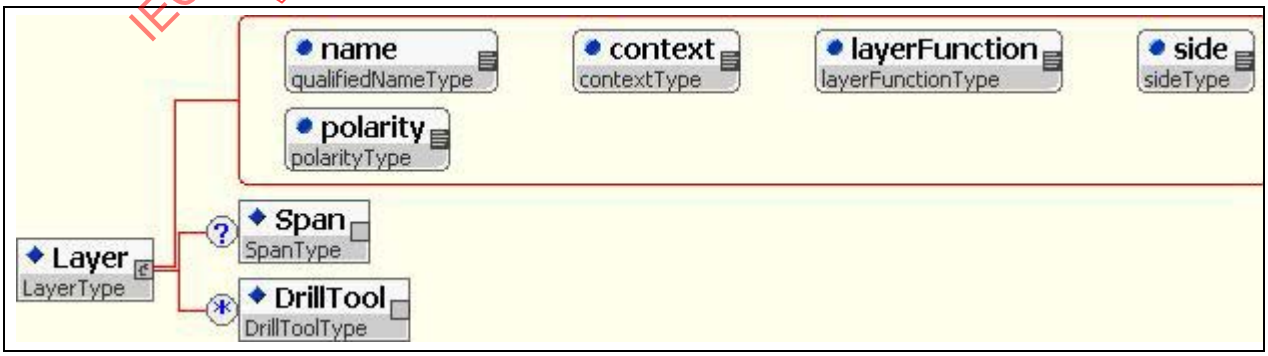


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
CadData	CadDataType	A nested element containing the actual Cad data describing the printed board and printed board assembly characteristics.	1-1
LayerDesc	LayerDescType	Defines the type of layers contained in the list. This may be any one of the following enumerated strings: BOARD | BOARDPANEL | ASSEMBLY | ASSEMBLYARRAY | COUPON | DOCUMENTATION | TOOLING | MISCELLANEOUS.	1-1
name	qualifiedNameType	The unique identification of the Layer grouping and how it applies to the total structure.	1-1
Layer	LayerType	A nested element containing the different layer information represented in the CAD data base which describes the electronic assembly to be manufactured.	1-n
Stackup	StackupType	A nested element containing the construction information for the printed board.	0-1
StepList	StepListType	The element that signifies the collection of layers, each with their own profile as is used to describe the printed circuit board assembly sub-panel or other conditions in the file.	0-n

9.2.1 Layer

The Layer element describes the characteristics of specific layers. The layers may be for the board or the assembly and may be individual characterization or those of the board fabrication panel and the assembly array of boards in the assembly panel. There are also documentation, tooling and miscellaneous layers. See Table 89.

Table 89 – Layer element



Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
Layer	LayerType	A nested element containing the different layer information represented in the CAD data base which describes the electronic assembly to be manufactured.	1-n
name	qualifiedNameType	The identification of the Cad data element identifying a particular layer.	1-1
context	contextType	The main use of the layer is en enumerated string and may be noted as BOARD | BOARDPANEL | ASSEMBLY | ASSEMBLYARRAY | COUPON | DOCUMENTATION | TOOLING | MISCELLANEOUS. This type element matches the layerListCategory element. However mixing of types within a category is permitted in order to help identify the layer characteristics.	1-1
layerFunction	layerFunctionType	The type of layer and its main use as established by the following: The function of the layer. One of: LEGEND | GLUE | SOLDERMASK | BOARDOUTLINE | COATINGCOND | COATINGNONCOND | CONDUCTOR | COURTYARD | DIELBASE | DIELCORE | DIELPREG | DIELADHV | SOLDERBUMP | PASTEMASK | HOLEFILL | PIN | COMPONENT | RESISTIVE | CAPACITIVE | PROBE | REWORK | FIXTURE | GRAPHIC | DRILL_ROUTE | LANDPATTERN | OTHER.	1-1
side	sideType	A fixed field parameter that defines the side of the layer. The fixed attribute is one of the following TOP | BOTTOM | BOTH | INTERNAL | ALL | NOTAPPLICABLE.	1-1
polarity	polarityType	Applies for layers of type signal, power_ground or mixed. In such layers, positive means that the layer features represent copper. NEGATIVE means that the layer features represent laminate. For example, on a negative power_round layer, features represent clearances. All other layers should be defined as positive. POSITIVE is the default.	1-1
Span	SpanType	A nested element where the field may be added to layers of type drill and route that are either buried or blind. In such a case, it represents the start and end board layers between which drilling/routing is done. If the drill layer is going through the board, it is required not to include a span subsection.	0-1
DrillTool	DrillToolType	A nested element containing drill tool and tolerance data.	0-n

There are eight context values for layers:

BOARD for all the 'important' layers representing the graphics of the board itself.

BOARDPANEL for all the 'important' layers representing the graphics of the board panel itself.

ASSEMBLY for all the 'important' layers representing the graphics of the assembly itself.

ASSEMBLYARRAY for all the 'important' layers representing the graphics of the assembly array panel itself.

DOCUMENTATION for all the 'important' layers representing the documentation of the board or the assembly.

TOOLING for all the 'important' layers representing the tooling used on the board or the assembly.

COUPON for test coupons that are embedded in the design of the board or assembly.

MISCELLANEOUS, for all the remaining layers that do not have a home in any of the other context identification.

A layer type can take one of 26 discrete values, as specified in the XML Schema, each representing a different usage for the layer. Some systems may use color coding to distinguish layers by type (Green for solder mask, white for silk screen, etc.).

The side of the layer can take one of 6 discrete values, as specified in the XML Schema. This attribute can be stored in the layer but no special action is required by the viewer, as the order of the layers always defines the side.

The polarity of the layer is mostly relevant for copper layers (signal, power and ground, mixed). Polarity defines whether the graphical features on the layer define copper (positive) or laminate (negative). In most cases, signal layers are positive and power and ground layers are negative, although there can be exceptions. It is used when determining the image conductivity.

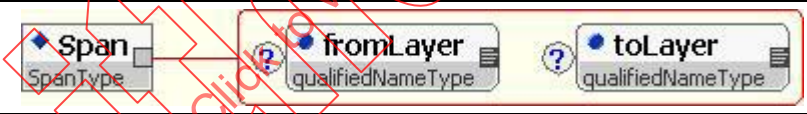
When combining layers such as BOARD and COUPONS layers on the same PANEL the layer construction must be identical between those elements being instantiated on the same panel.

The viewer should always display the graphical features but store the layer polarity as an attribute.

9.2.1.1 Span

The Span element is relevant only for layers of type drill (holes drilled in the board) and rout (final cut around the outline of the board). The span defines the layers through which the drill/rout is done. Span **shall not** be used for holes that are drilled through the entire board; The Span element is used to define drilling for board construction subsets, or sequential lamination processes. See Table 90.

Table 90 – Span element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Span	SpanType	A nested element where the field may be added to layers of type drill and route that are either buried or blind. In such a case, it represents the start and end board layers between which drilling/routing is done. If the drill layer is going through the board, it is required not to include a span subsection.	0-1
fromLayer	qualifiedNameType	The identification of the starting layer where the drilling or routing information applies.	0-1
toLayer	qualifiedNameType	The identification of the ending layer where the drilling or routing information applies.	0-1

9.2.1.2 DrillTool

The DrillTool is the list of elements and their tolerances used in the drill and rout layers of the final printed board or printed board panel See Table 91.

Table 91 – DrillTool element

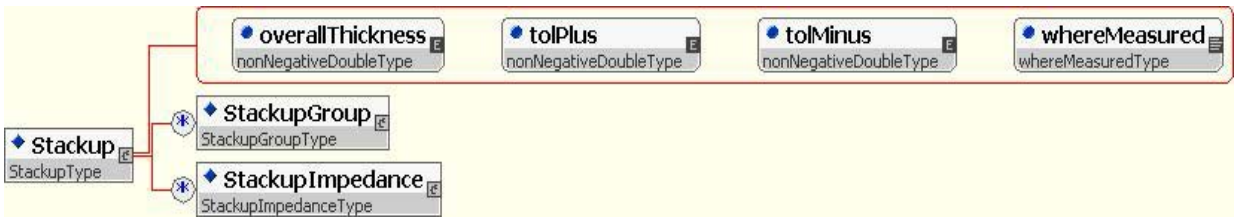
Attribute / Element Name	Attribute/ Element Type	Description	Occur-rence
DrillTool	DrillToolType	A nested element containing drill tool and tolerance data.	0-n
number	double	A unique number assigned by the user to the drill or router bit.	1-1
name	qualifiedNameType	A unique name assigned by the user to identify the type of hole as to whether it is plated, or non-plated or whether the routing path is completed or only partial.	1-1
type	drillType	An enumerated string that defines the type of drill. The applicable names are: CARBIDE | ROUTER | LASER | FLATNOSE | EXTENSION.	1-1
tolPlus	nonNegativeDouble Type	The permitted variation on the positive side of the nominal drill size.	1-1
tolMinus	nonNegativeDouble Type	The permitted variation on the negative side of the nominal drill size.	1-1
bitUnit	bitUnitType	The type of identification given to the drill or router bit as to its diameter and is an enumerated string. The applicable names are: FRACTION | WIREGAUGE | LETTER | METRIC.	0-1
finishSize	nonNegativeDouble Type	A numerical range description of the finished hole or routing slot size.	1-1
drillSize	string	The size of the drill or router bit used to produce the holes or routing path. The information may be a drill number, or fraction depending on the size standardization of the fabricator.	1-1

Typically, a hole is drilled through the whole board, thus no `span` is defined. However, in more complex designs, a subset of the layers is drilled separately, and then laminated with the rest of the layers. The drills are then called blind or buried vias. Separate layers will contain the holes of these kinds and the `span` for these layers is set accordingly.

9.2.2 Stackup

The `Stackup` element represents the construction for the printed board. The `Stackup` element consists of several sub-elements that help to define various sections of the construction permitting the description of core material or prepreg definition. These are accomplished in the `StackupGroup` element. See Table 92.

Table 92 Stackup element

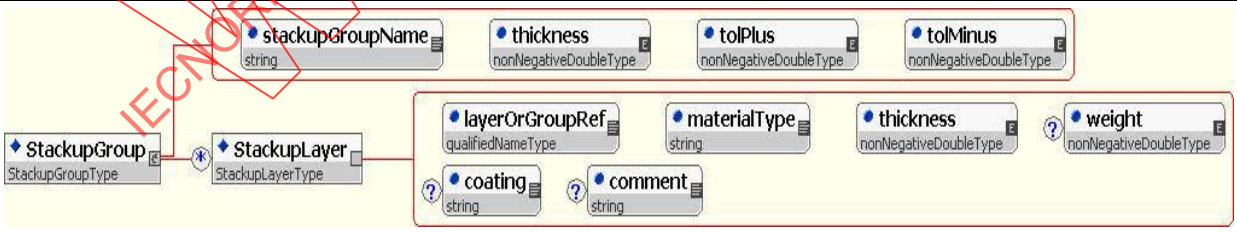


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Stackup	StackupType	A nested element containing the construction information for the printed board.	0-1
overallThickness	nonNegativeDouble Type	Describes the overall nominal thickness of the finished printed board including all plating and coatings.	1-1
tolPlus	nonNegativeDouble Type	The plus tolerance that may be applied to the nominal thickness to set the printed board upper control limit.	1-1
tolMinus	nonNegativeDouble Type	The minus tolerance that may be applied to the nominal thickness to set the printed board lower control limit.	1-1
whereMeasured	whereMeasuredType	An enumerated string that may be one of the following: LAMINATE | METAL | MASK | OTHER that defines the location on the printed board, panel, or assembly where the overall thickness is to be measured.	1-1
StackupGroup	StackupGroupType	A nested element containing information of the printed board construction.	0-n
StackupImpedance	StackupImpedance Type	A nested element containing information on those areas that are sensitive to impedance matching and must therefore be controlled to achieve the desired results.	0-n

9.2.2.1 StackupGroup

The `StackupGroup` represents all the layers of the printed board and defines the order of their occurrence in the board construction. Individual layers may be identified as layer pairs. In this manner, the user has the ability to define the characterization of the multilayer construction as well as preparing layer prelamination sequences. The order, however, must be in accordance with the description of the final board. See Table 93.

Table 93 – StackupGroup



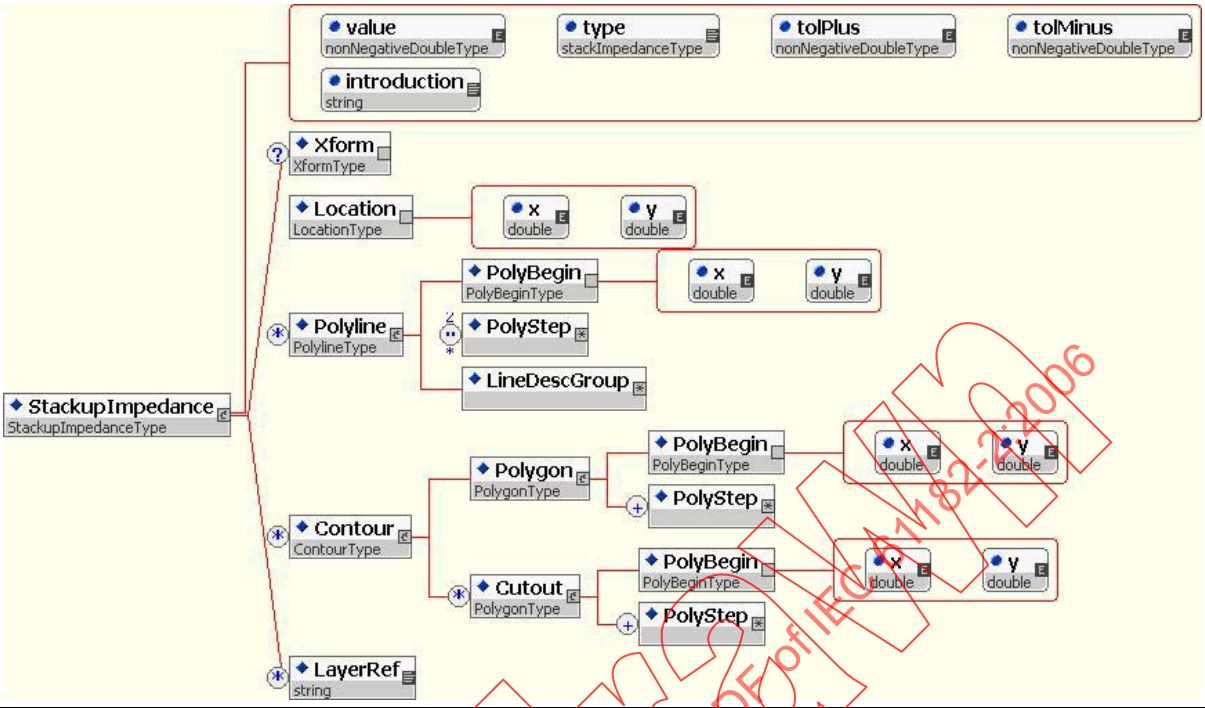
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
StackupGroup	StackupGroupType	A nested element containing information of the printed board construction.	0-n
StackupGroupName	string	A unique name assigned to an individual or group of layers that make up the printed board. The name must be unique so that when a group becomes nested in the over all board it is referenced in the proper order of occurrence in the stackup.	1-1
thickness	nonNegativeDouble Type	The nominal thickness of the stackup group. If the stackup group represents the total board rather than a subset, the thickness must match the information provided in the stackup element attributes.	1-1

tolPlus	nonNegativeDouble Type	The plus tolerance that may be applied to the nominal thickness to set the stackupGroup upper control limit.	1-1
tolMinus	nonNegativeDouble Type	The minus tolerance that may be applied to the nominal thickness to set the stackupGroup lower control limit.	1-1
StackupLayer	StackupLayerType	A nested element containing in all the layer formation as to how the printed board is constructed. If layer pairs are produced separately possibly containing buried vias they are defined as a separate group and then positioned in the appropriate order of their occurrence in the stackup.	0-n
LayerOrGroupRef	qualifiedNameType	A reference to an individual layer or a group that has been previously identified. A single sheet of copper foil may be a named layer and would thus apply to the group, as would a layer pair of copper clad laminate purchased from a laminator.	1-1
materialType	string	Identification of the material in the stackup. The material may be conductive or nonconductive, film, adhesive, prepreg, copper foil or metal core.	1-1
thickness	nonNegativeDouble Type	The thickness of the particular material being defined. The thickness matches nominal thickness of a predefined StackupGroup.	1-1
weight	nonNegativeDouble Type	An optional attribute mostly used to define starting copper foil or metal cores which are measured in ounces.	0-1
coating	string	An optional attribute used to define special coating used in the stackup, such as adhesives, solder mask or selective conformal coating.	0-1
comment	string	An optional attribute used to provide any special instructions about the layering or stackup of a multilayer single-sided, or double-sided printed board.	0-1

9.2.2.2 StackupImpedance

The `StackupImpedance` element defines the circuits that have impedance control requirements. See Table 94.

Table 94 – StackupImpedance element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
StackupImpedance	StackupImpedance Type	A nested element containing information on those areas that are sensitive to impedance matching and must therefore be controlled to achieve the desired results.	0-n
value	nonNegativeDouble Type	The numeric value in Z ohms trying to be achieved for the circuit that is defined in the StackupImpedance element.	1-1
type	StackImpedance Type	The enumerated string that defines the type as being either MICROSTRIP | DIFFERENTIAL_PAIR | EMBEDDED_MICROSTRIP | EDGE_COUPLED_STRIPLINE | DECOUPLED_EMBEDDED_MICROSTRIP | RAMBUS | COPLANAR_WAVEGUIDE_MICROSTRIP | COPLANAR_WAVEGUIDE_STRIPLINE | EDGE_COUPLED_COPLANAR_WAVEGUIDE_STRIPLINE | EDGE_COUPLED_COPLANAR_WAVEGUIDE_MICROSTRIP that requires the impedance control.	1-1
tolPlus	nonNegativeDouble Type	The plus tolerance on the nominal number established as the value for the impedance circuitry.	1-1
tolMinus	nonNegativeDouble Type	The minus tolerance on the nominal number established as the value for the impedance circuitry.	1-1
introduction	string	The details required to identify the source and receptor of the signals that need the control and whether the construction is a Stripline, Embedded Stripline, microstrip, dual microstrip or some other configuration.	1-1
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined area that can be scaled, mirror imaged or rotated. See 3.3. The details provide where the impedance is critical	0-1
Location	LocationType	The image defined by `Polyline` or `Contour` or a pre-defined image is located to identify where the impedance applies. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location to which the impedance applies	1-1
y	double	The y coordinate of the location to which the impedance applies	1-1

Polyline	PolylineType	A particular conductor that can be defined as a continuous circuit on a particular layer of reference where the conductor width or dielectric separation are part of the impedance calculations. The polyBegin and polyStep attributes are provided.	0-n
PolyBegin	PolyBeginType	The PolyBegin element defines the starting point of the polyline.	1-1
x	double	The X starting point of the first polyline line segment.	1-1
y	double	The Y starting point of the first polyline line segment.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross.	2-n
LineDescGroup	ABSTRACT	A substitution group that specifies the `LineWidth` and `LineEnd` characteristics of the `Line` by reference to a predefined `LineDesc` or specified when the `Polyline` is instantiated.	1-1
Contour	ContourType	A sequence of connected edges that form a polygon. An edge can be straight or circular.	0-n
Polygon	PolygonType	A closed shape whose edges do not cross, the coordinates of which are defined relative to the local coordinate system of the polygon.	1-1
PolyBegin	PolyBeginType	The PolyBegin element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the PolyBegin element to signify that the shape is closed.	1-n
Cutout	CutoutType	A polygon closed shape whose edges do not cross, which adopts the coordinates of the original polygon, however represents the absence of material within the original polygon shape.	0-n
PolyBegin	PolyBeginType	The PolyBegin element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the `PolyBegin` element to signify that the shape is closed.	1-n
LayerRef	string	A reference to the layer being described in the elements.	0-n

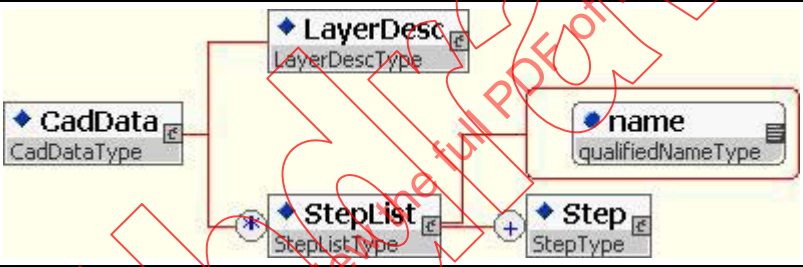
9.3 CadData/StepList

The `CadData StepList` represent a collection of layers, each with a profile that defines its outer shape. The basic step is the Printed Circuit Assembly (PCA) itself. In manufacturing, this basic step is often step and repeated (nested) inside a larger step (called array, or sub-panel). This array step can be further nested into another step; called a production panel. The `Ecad` element always contains at least one `Step`, but may contain several, some basic ones and others nesting previous steps.

The CAD `Step` tag can be repeated multiple times inside a job to represent several job Steps and their optional panelization. Each Step contains all the relevant information including `Datum`, `Profile`, `StepRepeatList`, `LayerAttributeList`, `PackageList`, `ComponentList`, `VplComponentList`, `LogicalNetList` and `LayerFeatureList`. See Table 96.

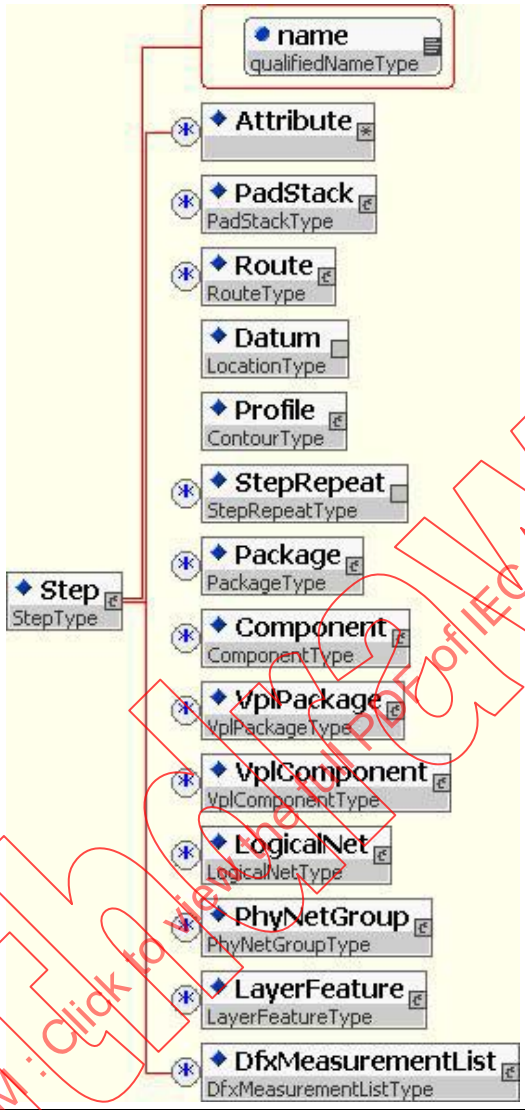
All steps inside an `Ecad` element share the exact same layer structure, since they are 'cut' from the same basic panel. Each `layer`, in the list of layers, exists in every step, although in each `step` it may contain different graphical information or be empty.

Table 95 – CadData StepList



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
CadData	CadDataType	A nested element containing the actual Cad data describing the printed board and printed board assembly characteristics.	1-1
LayerDesc	LayerDescType	Defines the type of layers contained in the list. This may be any one of the following enumerated strings: BOARD | BOARDPANEL | ASSEMBLY | ASSEMBLYARRAY | COUPON | DOCUMENTATION | TOOLING | MISCELLANEOUS.	1-1
StepList	StepListType	The element that signifies the collection of layers, each with their own profile as is used to describe the printed circuit board assembly sub-panel or other conditions in the file.	0-n
name	qualifiedNameType	The name assigned by the user for the collection of layers identified in the `StepList`.	1-1
Step	StepType	The `Step` element consists of multiple sub-elements each intended to help describe the different steps needed in the board fabrication, or assembling the electronic product.	1-n

Table 96 – Step



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Step	StepType	The `Step` element consists of multiple sub-elements each intended to help describe the different steps needed in the board fabrication, or assembling the electronic product.	1-n
name	qualifiedName Type	The name assigned by the user for the individual Steps used to make up the layers identified in a particular `StepList`.	1-1
Attribute	ABSTRACT	A substitution group that consists of various attributes that may be used within the body of the 61182-2 standard. Attributes are optional and are used within the Component, `LogicalNet`, `Set`, and `Step` elements. Attributes contain legacy data that has not yet become a more formal part of 61182-2 : the long range intention is to deprecate all Attributes and to incorporate their information elsewhere in 61182-2 files. There are five kinds of standard `Attribute` that hold different types of data, and a `NonstandardAttribute` which can contain any type of data. The standard attributes are constrained to have specific names.	0-n

PadStack	PadStackType	A nested element containing a list of all the PadStack configurations taken from the CAD file as a description of the original design of the board or panel and their application to the electronic product. The data is redundant when layered fabrication is defined in the file, and serves the purpose of archiving CAD data used for reference.	0-n
Route	RouteType	The individual route segment list captured from the CAD system. The data is redundant when layered fabrication is defined in the file, and serves the purpose of archiving CAD data used for reference.	0-n
Datum	LocationType	The Datum element defines the location of the point of origin for the individual Step file. The name of the StepList helps to associate the datum between boards and panels or arrays.	1-1
Profile	ContourType	The profile of all the elements in the Step established as a Contour.	1-1
StepRepeat	StepRepeat Type	A nested element list containing the Step and Repeat functions that impact the information of the electronic product.	0-n
Package	PackageType	Generic component package descriptions for use by the Step file schemas.	0-n
Component	Component Type	A nested element list of component descriptions and their application to the electronic product. Each component references a package style from the Package section.	0-n
VplPackage	VplPackage Type	A nested element list of package types and CAD library descriptions and their application to the electronic product.	0-n
VplComponent	VplComponent Type	A nested element list of component descriptions combined with any External Vendor Parts Library (EVPL) Database. Each component references a package style from the VplPackage section.	0-n
LogicalNet	LogicalNetType	A nested element list of logical net descriptions and their application to the electronic product.	0-n
PhyNetGroup	PhyNetGroup Type	A nested element list of physical net descriptions and their application to the electronic product.	0-n
LayerFeature	LayerFeature Type	A nested element list of all the features associated with a specific layer and their application to the electronic product.	0-n
DfxMeasurementList	DfxMeasure-mentListType	A nested element list of the recommended modifications of the design features, indicating the measurements made of the physical conditions that might be considered as manufacturing improvements.	0-n

9.3.1 Attribute

The Attribute substitution group consists of various attributes that may be used in association with the Step. There are five kinds of standard Attribute that hold different types of data, and a NonstandardAttribute which can contain any type of data. The standard attributes are constrained to have specific names. There may be from one to many occurrences each with a unique name within the Step named identified file. See Table 97.

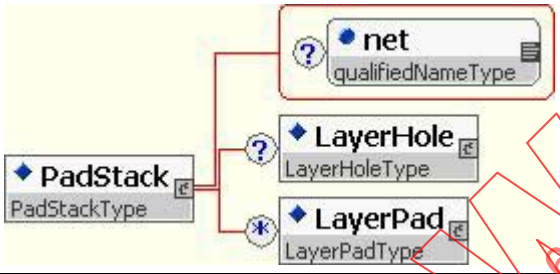
Table 97 – Attribute substitution group

Attribute			
Attribute/ Element Name	**Attribute/ Element Type**	**Description**	**Occur-rence**
Attribute	ABSTRACT	A substitution group that may be any of a group of enumerated string description or a unique string for a condition not addressed by the standard attributes.	0-n

9.3.2 PadStack

The `PadStack` element consists of multiple padstacks taken from the CAD system and is intended to preserve the data from the layout system. The information noted pertains to the `CadProperty` of which the padstack is a part. The relationship is identified by the `CadProperty` unique name and is the original design file from the CAD system. The data becomes redundant when the individual layered features are defined and is then for reference only. See Table 98.

Table 98 – PadStack element

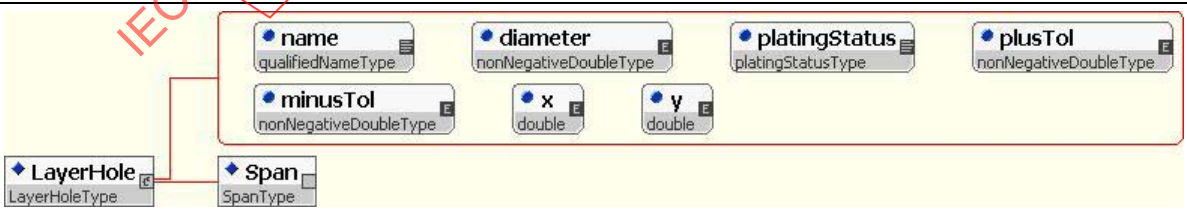


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
PadStack	PadStackType	A nested element containing a list of all the `PadStack` configurations taken from the CAD file as a description of the original design of the board or panel and its application to the electronic product. The data is redundant when layered fabrication is defined in the file, and therefore is for reference only.	0-n
net	qualifiedNameType	The name attached to the electrical description of the conductive hole pattern.	0-1
LayerHole	layerHoleType	The hole description of the padstack including all of its attributes.	0-1
LayerPad	layerPadType	A nested element defining the pad(s) that the hole traverses indicating location and layer reference for different pad sizes.	0-n

9.3.2.1 LayerHole

The `LayerHole` element associated with a padstack identifies the distance through which the hole transcends as a span between individual layers. See Table 99.

Table 99 – LayHole element



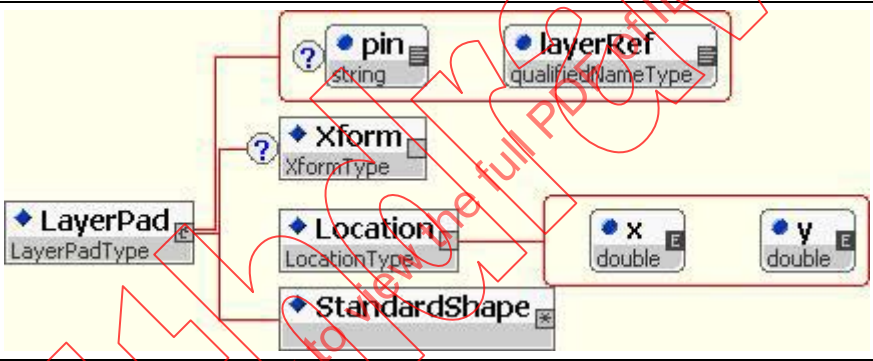
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LayerHole	LayerHoleType	The hole description of the padstack including all its attributes.	0-1
name	qualifiedNameType	A unique identification of a particular hole.	1-1
diameter	nonNegativeDouble Type	The nominal diameter of the hole in the as-finished state.	1-1
platingStatus	platingStatusType	The type of hole defined as an enumerated string indicating PLATED | NONPLATED | VIA.	1-1

plusTol	nonNegativeDouble Type	The plus tolerance that defines the variation permitted from the nominal hole-diameter.	1-1
minusTol	nonNegativeDouble Type	The minus tolerance that defines the variation permitted from the nominal hole-diameter.	1-1
x	double	The x-location of the hole.	1-1
y	double	The y-location of the hole.	1-1
Span	SpanType	A nested element where the field may be added to layers of type drill and route that are either buried or blind. In such a case, it represents the start and end board layers between which drilling/routing is done. If the drill layer is going through the board, it is required not to be included in a span subsection.	1-1

9.3.2.2 LayerPad

The `LayerPad` element is a group of specific graphic features that become part of the padstack with a description of the pin to which the padstack applies and the layer on which the individual pad is located. See Table 100.

Table 100 LayerPad element

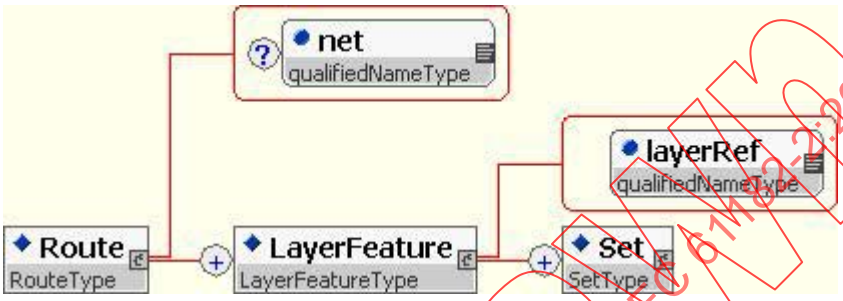


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LayerPad	LayerPadType	A nested element defining the pad(s) that the hole traverses indicating location and layer reference for different pad sizes	0-n
pin	string	Identification of the electrical connection to specific pins of electronic components.	0-1
layerRef	qualifiedNameType	A reference to the appropriate layer to which the attribute applies.	1-1
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined pad that can be scaled, mirror imaged or rotated. See 3.3	0-1
Location	LocationType	The location of the image defined by the `StandardShape` or a pre-defined `StandardShape` of the pad. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the pad.	1-1
y	double	The y coordinate of the location of the pad.	1-1
StandardShape	ABSTRACT	A substitution group that may call for any `StandardPrimitive`, instantiated by describing their unique features or by referencing a predefined primitive contained in the `DictionaryStandard`.	1-1

9.3.3 Route

The Route element consists of multiple routes taken from the CAD system and is intended to preserve the data from the layout system. Each Route is referenced to a particular Net and a layer on which the route or net occurs as taken from the CAD system. The data becomes redundant when the individual layered features are defined and is then for reference only. The Route element uses the same characteristics of the Step description as defined in the LayerFeature schema (see 8.3.13). See Table 101.

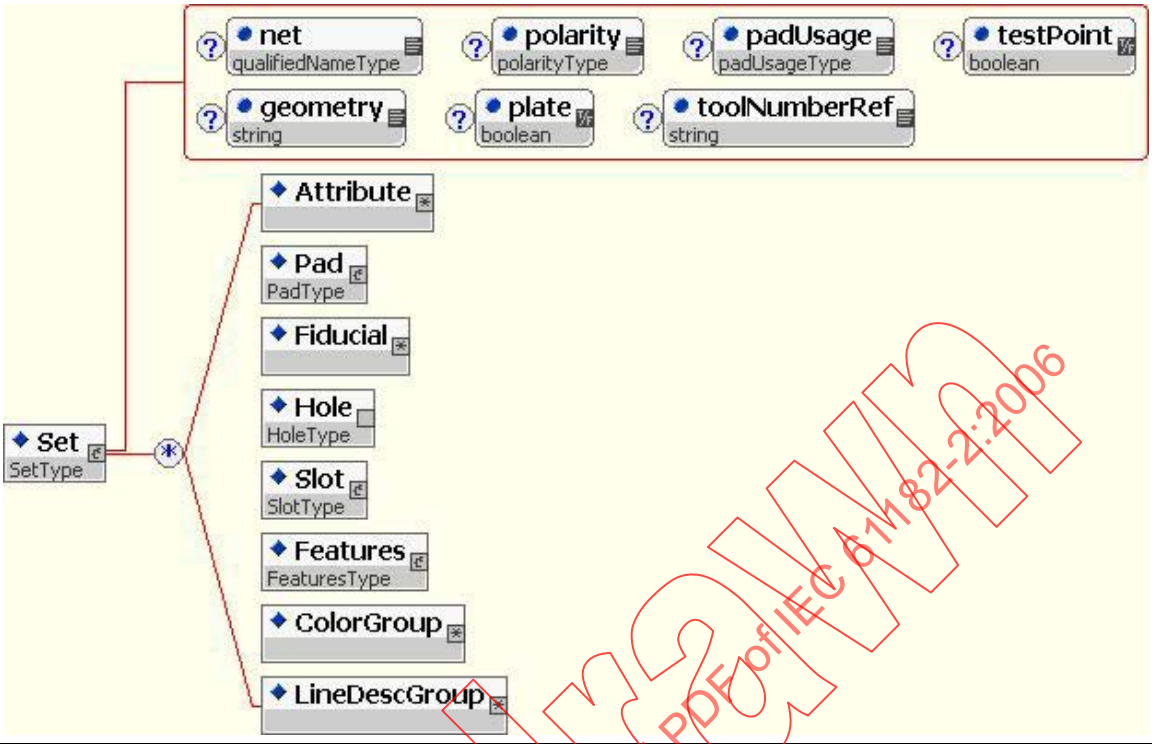
Table 101 – Route element



Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Route	RouteType	The individual route segment list captured from the CAD system. The data is redundant when layered fabrication is defined in the file, and therefore is for reference only.	0-n
net	qualifiedNameType	Each route is linked to a particular net which is defined in the Cad system and matches the padstacks that are associated with the net.	0-1
LayerFeature	LayerFeatureType	The standard 61182-2 Step characteristics for layer features related to the route taken from the Cad system.	1-n
layerRef	qualifiedNameType	A reference to a specific conductive layer where the route exists.	1-1
Set	SetType	The multiple Set elements and attributes defined in 8.3.13 LayerFeature used to define specific features associated with a conductive layer.	1-n

A specific set of graphical descriptions for a particular set of graphical shapes. These shapes are applied defining the conductive pattern of the printed board. See Table 102.

Table 102 – Set



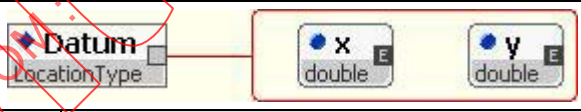
Attribute / Element Name	Attribute/ Element Type	Description	Occur-rence
Set	SetType	The multiple Set elements and attributes defined in 8.3.1 used to define specific features associated with a conductive layer.	1-n
net	qualifiedNameType	The electrical relationship of any feature that has conductivity checked in the `PhyNetPoint` descriptions. This attribute is left blank if the `Set` descriptions are for other than printed board fabrication or assembly conductivity.	0-1
polarity	polarityType	`Polarity` indicates whether the information described in the `Set` is POSITIVE | NEGATIVE. A NEGATIVE connotation can be used to describe the removal of a dark field to the specific dimensions described for another attribute. Thus, a surface that contains islands may have the islands described in a negative format.	0-1
padUsage	padUsageType	An indication as to the usage of any pad that becomes a part of the `LayerFeature Set`. The descriptions are enumerated strings and must be one of the following: TOE | VIA | GLOBAL_FIDUCIAL | LOCAL_FIDUCIAL | TOOLING_HOLE | NONE.	0-1
testPoint	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE indicates that the feature is a candidate for a test point used for either in-circuit or functional testing. FALSE indicates that it is not.	0-1
geometry	string	An identification to describe the overall geometry of the features contained in the `Set` and their particular application to the electronic product.	0-1
plate	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE indicates that the feature is plated in a secondary operation . FALSE indicates that it is not.	0-1
toolNumberRef	string	A reference to the tool number defined in the `DrillTool` instance of the `Layer` section. This feature is used to associate the tool with features that are part of the `Set`.	0-1

Attribute	ABSTRACT	A substitution group that may be any of a group of enumerated string descriptions or a unique string for a condition not addressed by the standard attributes. The `Attribute` is associated with the `LayerFeature Set`.	0-n
Pad	PadType	A series of pads that are associated with the `LayerFeature Set`.	0-n
Fiducial	ABSTRACT	A substitution that consists of four elements that may be used to replace the fiducial element. When the `Fiducial` element is substituted it **shall** be by a `Global`, `Local`, `BadBoardMark`, or `GoodPanelMark`.	0-n
Hole	HoleType	A series of holes associated with the `LayerFeature Set`.	0-n
Slot	SlotType	A series of slots associated with the `LayerFeature Set`.	0-n
Features	FeaturesType	An embedded element that defines a substitution group of any predefined `StandardShape` or `UserShape` that may be instantiated as a part of the `LayerFeature Set`.	0-n
ColorGroup	ABSTRACT	A substitution group that permits assigning a particular color through instantiating the three basic colors or by providing a reference to a predefined `Color` in `DictionaryColor`.	0-n
LineDescGroup	ABSTRACT	A substitution group that specifies the `LineWidth` and `LineEnd` characteristics of a `Feature` that requires that description. If a predefined feature is instantiated the presents of a `LineDescGroup` will override the previously defined `LineDesc`.	0-n

9.3.4 Datum

The `Datum` element of the `Step` schema (`StepType/Datum`) defines the location of the point of origin for the individual `Step` file. The name of the `StepList` helps to associate the datum between boards and panels or arrays. See Table 103.

Table 103 – Datum element

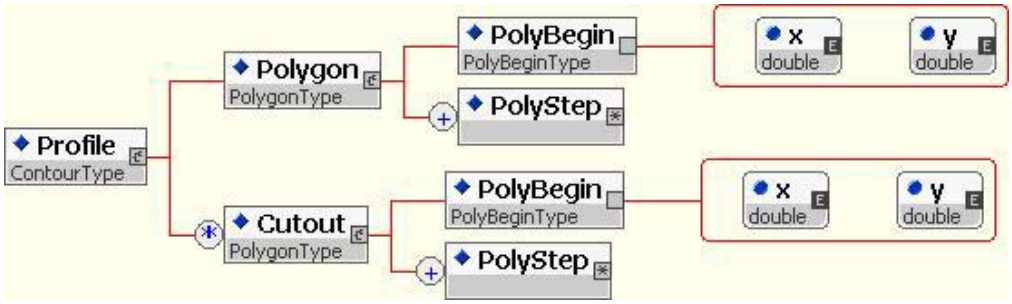


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Datum	LocationType	A nested element containing the datum origin for the overall Step.	1-1
x	double	The X location of the datum.	1-1
y	double	The Y location of the datum.	1-1

9.3.5 Profile

The `Profile` element of the `Step` schema (`StepTypeProfile`) defines the exact periphery of the board or assembly and therefore all the characteristics of the `Step` element. See Table 104.

Table 104 – Profile element



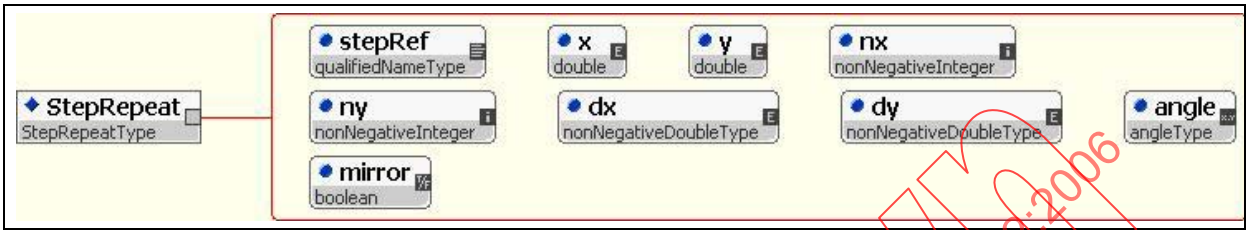
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Profile	ContourType	The profile is a `contourType` and thus describes the periphery that encompasses all the elements in the `Step`.	1-1
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the PolyBegin element to signify that the shape is closed.	1.n
Cutout	CutoutType	A polygon closed shape whose edges do not cross, which adopts the coordinates of the original polygon, however represents the absence of material within the original polygon shape.	0-n
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the PolyBegin element to signify that the shape is closed.	1-n

```
<Step name = "KarensSingleBoard">
    <Datum x = "10.00" y = "10.00"/>
      <Profile>
        <Polygon>
          <PolyBegin x = "0.00" y = "10.00"/>
          <PolyStepSegment x = "0.00" y = "90.00"/>
          <PolyStepCurve x = "10.00" y = "100.00" centerX = "10.00" centerY = "90.00" clockwise = "TRUE"/>
          <PolyStepSegment x = "200.00" y = "100.00"/>
          <PolyStepSegment x = "200.00" y = "50.00"/>
          <PolyStepSegment x = "150.00" y = "50.00"/>
          <PolyStepSegment x = "150.00" y = "0.00"/>
          <PolyStepSegment x = "10.00" y = "0.00"/>
          <PolyStepCurve x = "0.00" y = "10.00" centerX = "10.00" centerY = "10.00" clockwise = "TRUE"/>
        </Polygon>
      </Profile>
  </Step>
```

9.3.6 StepRepeat

The `StepRepeat` elements provides information for steps representing panels or assembly arrays. Coupons may also use this feature to step the coupon description on the borders of the panel. The layer descriptions of any `Board` and `Coupon` combined in a `Panel` description must be of the same construction. See Table 105.

Table 105 – StepRepeat element



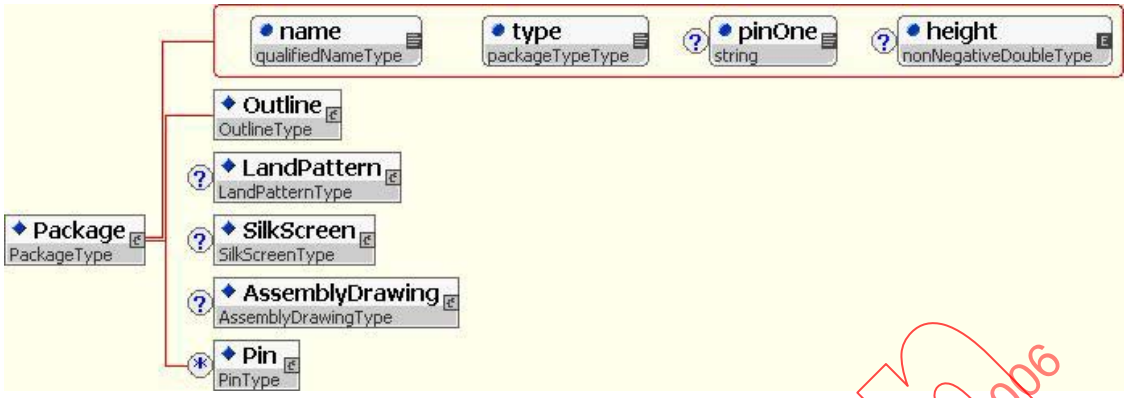
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
StepRepeat	StepRepeatType	A nested element list containing the Step and Repeat functions that impact the information of the electronic product.	0-n
stepRef	qualifiedNameType	A reference to the step that should be replicated on the panel.	1-1
x	double	The X point of origin where the first step should be placed in relationship to the datum. This may be coincident or may be offset from the datum of the particular step.	1-1
y	double	The Y point of origin where the first step should be placed in relationship to the datum. This may be coincident or may be offset from the datum of the particular step.	1-1
nx	nonNegativeInteger	The number of times that the referenced step should be repeated in the X direction.	1-1
ny	nonNegativeInteger	The number of times that the referenced step should be repeated in the Y direction.	1-1
dx	nonNegativeDouble Type	The dimensional distance in the positive X direction as a step from the first position point of origin (not necessarily from the datum).	1-1
dy	nonNegativeDouble Type	The dimensional distance in the positive Y direction as a step from the first position point of origin (not necessarily from the datum).	1-1
angle	angleType	A unique angle to allow rotation of the `StepRepeat` image description where “0°” is as defined with the angle descriptions being counterclockwise (i.e. 45° 90°) from the horizontal zero angle.	1-1
mirror	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE equals that the image is mirrored; FALSE indicates that it is not.	1-1

```
<Step name = "KarensAssemblyPanel">
   <Datum x = "0.00" y = "0.00"/>
      <Profile>
         <Polygon>
            <PolyBegin x = "0.00" y = "0.00"/>
            <PolyStepSegment x = "0.00" y = "427.00"/>
            <PolyStepSegment x = "260.00" y = "427.00"/>
            <PolyStepSegment x = "260.00" y = "0.00"/>
            <PolyStepSegment x = "0.00" y = "0.00"/>
         </Polygon>
      </Profile>
      <StepRepeat stepRef = "KarensSingleBoard" x = "110.00" y = "20.00" nx = "1" ny = "1" dx = "120.00" dy = "207.00" angle =
                  "90.00" mirror = "FALSE"/>
       <LayerFeature layerRef = "1-Top Signal">
         <Set polarity = "POSITIVE">
         <GlobalFiducial>
            <Location x = "250.00" y = "10.00"/>
            <Circle diameter = "1.00"/>
         </GlobalFiducial>
         <GlobalFiducial>
            <Location x = "250.00" y = "417.00"/>
            <Circle diameter = "1.00"/>
         </GlobalFiducial>
         <GlobalFiducial>
            <Location x = "10.00" y = "10.00"/>
            <Circle diameter = "1.00"/>
         </GlobalFiducial>
         <BadBoardMark>
            <Location x = "190.00" y = "5.00"/>
            <Circle diameter = "1.50"/>
         </BadBoardMark>
         <BadBoardMark>
            <Location x = "70.00" y = "5.00"/>
            <Circle diameter = "1.00"/>
         </BadBoardMark>
         <BadBoardMark>
            <Location x = "190.00" y = "213.00"/>
            <Circle diameter = "1.00"/>
         </BadBoardMark>
         <BadBoardMark>
            <Location x = "70.00" y = "213.00"/>
            <Circle diameter = "1.00"/>
         </BadBoardMark>
         <GoodPanelMark>
            <Location x = "250.00" y = "213.00"/>
            <Donut shape = "ROUND" outerDiameter = "1.50" innerDiameter = "0.80"/>
         </GoodPanelMark>
      </Set>
   </LayerFeature>
</Step>
```


9.3.7 Package

The `Package` element descriptions define the package shape (`Outline`), library descriptions including land patterns, silk screen information, assembly drawing details, and pin identification. The `Package` element defines all the physical description of all the packages used by the `Component` element inside the `Step`. See Table 106. The names assigned to the package should be consistent with the naming convention established in IPC-7350 series of parts and land pattern descriptions. (See Annex A)

Table 106 – Package element

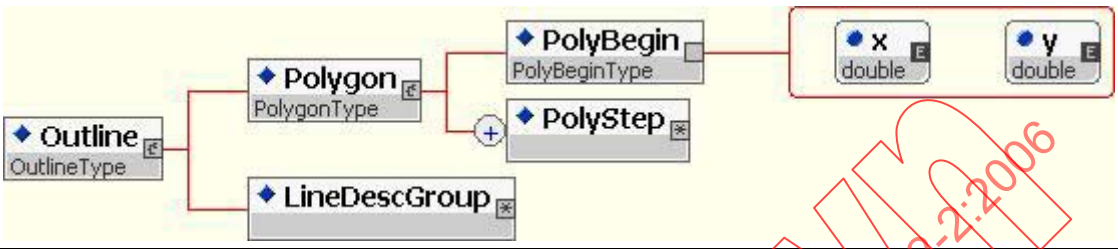


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Package	PackageType	Generic component package descriptions for use by the `Step` file schemas.	0-n
name	qualifiedName Type	A unique name assigned to the physical and graphical description of a part in accordance with the IPC-7351 Naming Convention for Packages and Land Patterns.	1-1
type	PackageType Type	A specific body construction indicated as an enumerated string using one of the following naming conventions: AXIAL_LEADED | BARE_DIE | CERAMIC_BGA | CERAMIC_DIP | CERAMIC_FLATPACK | CERAMIC_QUAD_FLATPACK | CERAMIC_SIP | CHIP | CHIP_SCALE | CHOKE_SWITCH_SM | COIL | CONNECTOR_SM | CONNECTOR_TH | EMBEDDED | FLIPCHIP | HERMETIC_HYBRED | LEADLESS_CERAMIC_CHIP_CARRIER | MCM | MELF | FINEPITCH_BGA | MOLDED | NETWORK | PGA | PLASTIC_BGA | PLASTIC_CHIP_CARRIER | PLASTIC_DIP | PLASTIC_SIP | POWER_TRANSISTOR | RADIAL_LEADED | RECTANGULAR_QUAD_FLATPACK | RELAY_SM | RELAY_TH | SOD123 | SOIC | SOJ | SOPIC | SOT143 | SOT23 | SOT52 | SOT89 | SQUARE_QUAD_FLATPACK | SSOIC | SWITCH_TH | TANTALUM | TO_TYPE | TRANSFORMER | TRIMPOT_SM | TRIMPOT_TH | OTHER	1-1
pinOne	string	A description of Pin one of the part in accordance with its relationship to the original orientation as stored. Pin one moves with the change in orientation.	0-1
height	double	A description of the component height in terms of the mounting surface to the highest protrusion of the `Package`. The units are in the `Units` set by the `Cadheader`.	0-1
Outline	OutlineType	A nested element that defines the physical outline of the part as seen from the top, related to the graphical image that appears on the assembly. Includes body and pin profiles if applicable. The outline is an enclosed polygon type.	1-1
LandPattern	LandPattern Type	A nested element that defines the surface land pattern consisting of Lands in a particular pattern that matches the footprint of the component outline. The point of origin of the `LandPattern` and `Outline` are identical.	0-1
SilkScreen	SilkScreen Type	A nested element that defines the symbolization and legend required to be placed on the board for the particular package. Includes location of the reference designator or other `Text`. The point of origin of the image is the same as the origin of the `LandPattern` and `Outline`.	0-1
AssemblyDrawing	Assembly DrawingType	A nested element that defines the graphics required for the assembly drawing. The images relate to the component body outline and any text needed. The point of origin for the assembly drawing is the same as the images of the `Outline`, LandPattern, and `SilkScreen` schema.	0-1
Pin	PinType	A nested element that defines the pin relationship of all the pins that are a part of the package style related to the land pattern description.	0-n

9.3.7.1 Outline

A nested element that defines the physical outlines of the part related to the graphical image that appears on the assembly. The `Outline` includes the body of the part, the `Pin` element and the `Pin` element includes the `Pin` profiles. These are combined to describe the component. See Table 107.

Table 107 – Outline element

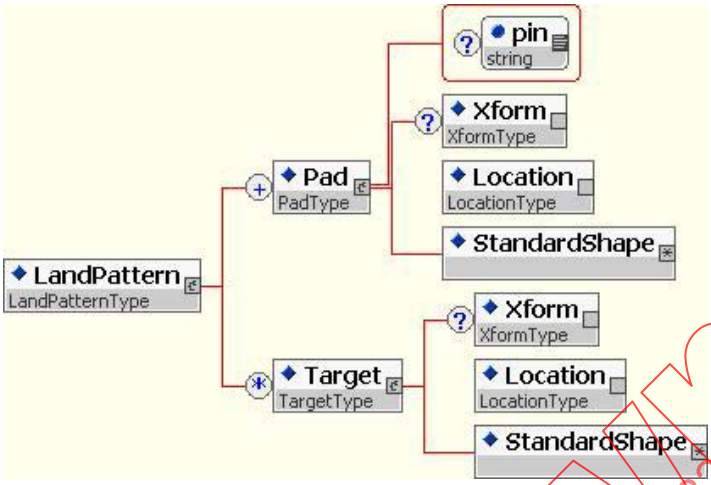


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Outline	OutlineType	A nested element that defines the physical outlines of the part viewed from the top, related to the graphical image that appears on the assembly. Includes the body only. `Pin` profiles are defined by the Pin element. The `Outline` is an enclosed polygon type.	1-1
Polygon	PolygonType	A closed shape whose edges do not cross, the coordinates of which are defined relative to the local coordinate system of the polygon.	1-1
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the `PolyBegin` element to signify that the shape is closed.	1-n
LineDescGroup	ABSTRACT	A substitution group that specifies the `LineWidth` and `LineEnd` characteristics of the `Outline`. The `LineDesc` may also have been predefined in the `DictionaryLineDesc` and instantiated from the dictionary.	1-1

9.3.7.2 LandPattern

The `LandPattern` element consists of those characteristics that define the pattern to which surface mount components are attached. The embedded elements include both the `Pad` description and the potential for providing a target, usually indicating `pinOne`. Land pattern descriptions should be used wherever a relationship to component pins needs to be established. This information is redundant when layers for component attachment are defined. See Table 108

Table 108 – LandPattern element

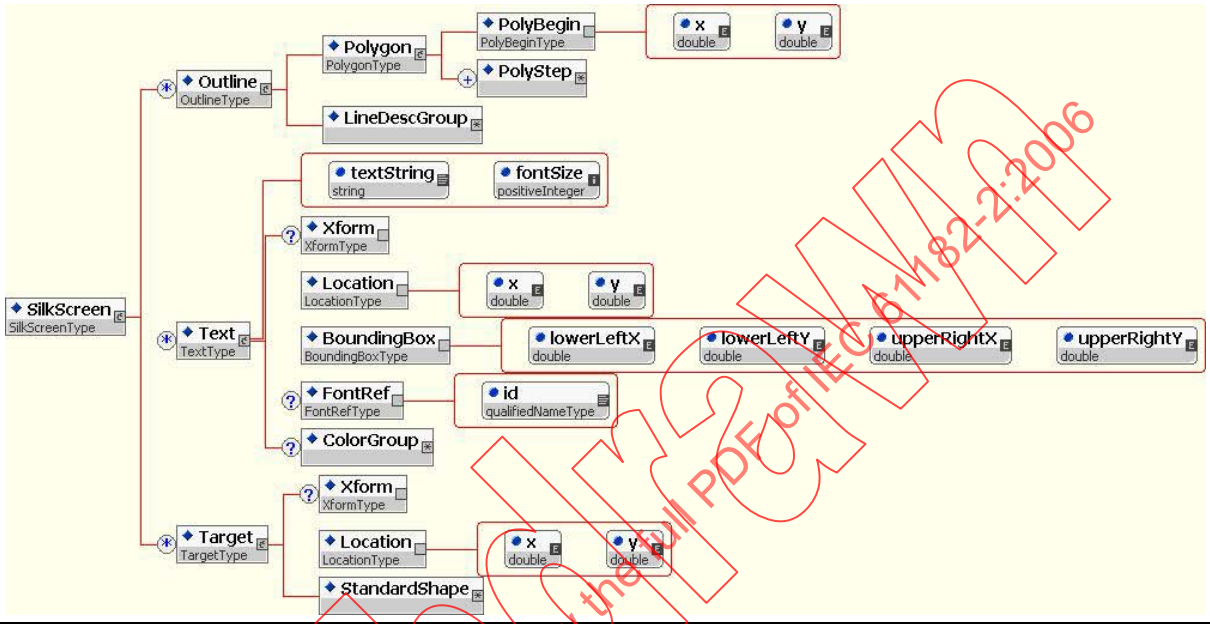


Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
LandPattern	LandPatternType	A nested element that defines the surface land pattern consisting of Pads in a particular pattern that matches the footprint of the component.	0-1
Pad	PadType	A nested element defining the pad to be located as part of the land pattern.	1-n
pin	string	A description relating the Pad to a specific pin of the component being mounted on the particular land pattern.	0-1
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined pad that can be scaled, mirror imaged or rotated. See 3.3	0-1
Location	LocationType	The location of the image defined by the standard shape or a pre-defined standard shape of the pad. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the pad.	1-1
y	double	The y coordinate of the location of the pad.	1-1
StandardShape	ABSTRACT	A substitution group that permits the substitution of any of the `StandardPrimitive` shapes in accordance with their individual descriptions. A predefined `StandardPrimitive` may also be instantiated by its unique “id” when the feature is contained in the DictionaryStandard. When a reference is made to the dictionary predefined primitive the `Units` must match.	1-1
Target	TargetType	A nested element defining the target to be located as part of the land pattern.	0-n
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined target that can be scaled, mirror imaged or rotated. See 3.3	0-1
Location	LocationType	The location of the image defined by the standard shape or a pre-defined standard shape of the target. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the target.	1-1
y	double	The y coordinate of the location of the target.	1-1
StandardShape	ABSTRACT	A substitution group that permits the substitution of any of the `StandardPrimitive` shapes in accordance with their individual descriptions. A predefined `StandardPrimitive` may also be instantiated by its unique “id” when the feature is contained in the `DictionaryStandard`. When a reference is made to the dictionary predefined primitive the `Units` must match.	1-1

9.3.7.3 SilkScreen

The `SilkScreen` element defines the symbolization and legend required to be placed on the board for the particular package. The `SilkScreen` descriptions include location of the reference designator or other `Text`. The point of origin of the image is the same as the origin of the `LandPattern` and `Outline`. See Table 109.

Table 109 – SilkScreen element



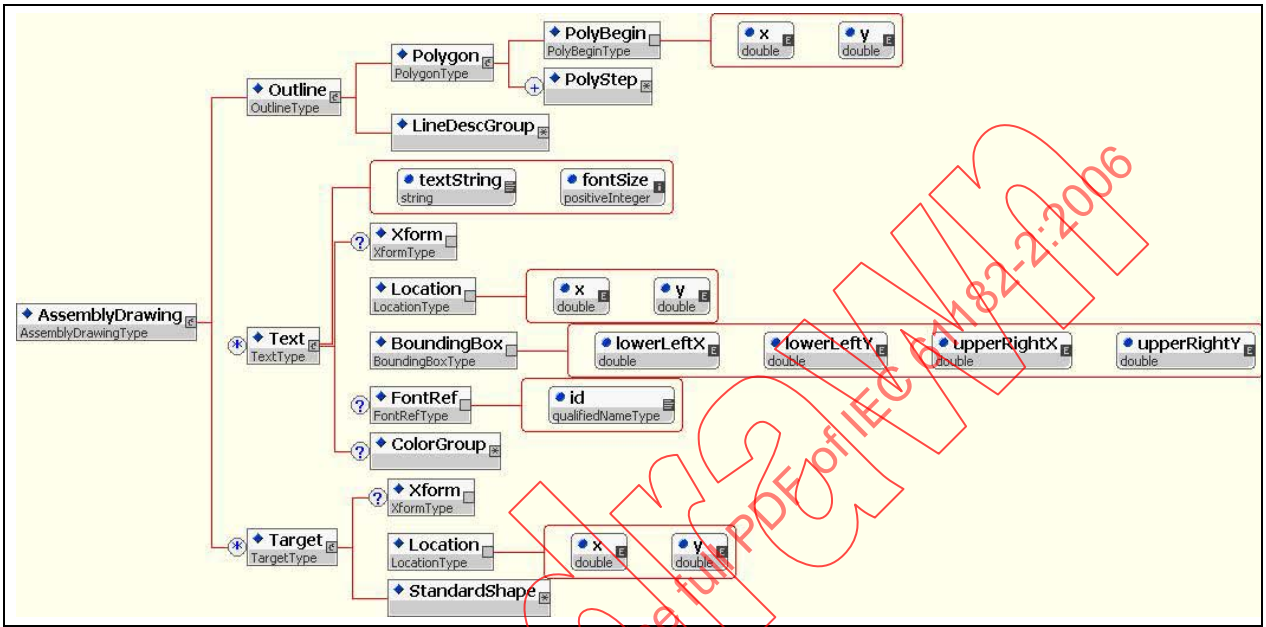
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
SilkScreen	SilkScreenType	A nested element that defines the symbolization and legend required to be placed on the board for the particular package. Includes location of the reference designator or other `Text`. The point of origin of the image is the same as the origin of the `LandPattern` and `Outline`.	0-1
Outline	OutlineType	A nested element that defines the outlines of the part related to the graphical image that appears on the board. The outline is an enclosed polygon type.	0-n
Polygon	PolygonType	A closed shape whose edges do not cross, the coordinates of which are defined relative to the local coordinate system of the polygon.	1-1
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge.	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the `PolyBegin` element to signify that the shape is closed.	1-n
LineDescGroup	ABSTRACT	A substitution group that specifies the `LineWidth` and `LineEnd` characteristics of the `Outline`. The `LineDesc` may also have been predefined in the `DictionaryLineDesc` and instantiated from the dictionary.	1-1

Text	TextType	A nested element that defines the text to be silkscreened onto the surface of the printed board.	0-n
textString	string	The text phrase (case-sensitive) in accordance with the language element of the `Header` element representing the specific characters to be silkscreened onto the board surface.	1-1
fontSize	positiveInteger	A dimensional characteristic in terms of an integer that defines the font size	1-1
Xform	XformType	An element that provides the ability to reset the point of origin of the text box, then scale, mirror image or rotate the text box after the text box origin has been placed at an X and Y location. See 3.3	0-1
Location	LocationType	The location of the point of origin of the `BoundingBox` used to contain the text or a predefined text contained in the `DictionaryUser`. The textbox may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the point of origin (lowerLeftX) of the `BoundingBox`.	1-1
y	double	The y coordinate of the location of the point of origin (lowerLeftY) of the `BoundingBox`.	1-1
Boundingbox	BoundingBoxType	A constraining rectangular area (bounding box) that encompasses the entire text string including upper and lower case characters.	1-1
lowerLeftX	double	The lower left hand x dimension of the rectangular area encompassing the text.	1-1
lowerLeftY	double	The lower left hand y dimension of the rectangular area encompassing the text.	1-1
upperRightX	double	The upper right hand x dimension of the the rectangular area encompassing the text.	1-1
upperRightY	double	The upper right hand y dimension of the rectangular area encompassing the text.	1-1
FontRef	FontRefType	An element that is optional to reference a predefined font by its id, if the standard Helvetica font is not being instantiated.	0-1
id	qualifiedNameType	The identification of the `FontDef` stored in the `DictionaryFont`.	1-1
ColorGroup	ABSTRACT	An optional substitution group that permits assigning a particular color through instantiating the three basic colors or by providing a reference to a predefined `Color` in `DictionaryColor`.	0-1
Target	TargetType	A nested element defining the target to be located as part of the land pattern.	0-n
Xform	XformType	A nested element describing the location and mirroring, rotation or scaling of the `StandardShape` used to define the `Target` in order to have it be consistent within the silk screen image description.	0-1
Location	LocationType	The location of the image defined by the standard shape or a pre-defined standard shape of the target. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the target.	1-1
y	double	The y coordinate of the location of the target.	1-1
StandardShape	ABSTRACT	A substitution group that permits the substitution of any of the `StandardPrimitive` shapes in accordance with their individual descriptions. A predefined `StandardPrimitive` may also be instantiated by its unique “id” when the feature is contained in the DictionaryStandard. When a reference is made to the dictionary predefined primitive the Units must match.	1-1

9.3.7.4 AssemblyDrawing

The `AssemblyDrawing` element reuses the same embedded elements and attributes as defined for the `Silkscreen` characteristics. The construction schemas are repeated to aid the reader in interpretation of the library structure. See Table 110.

Table 110 – AssemblyDrawing element



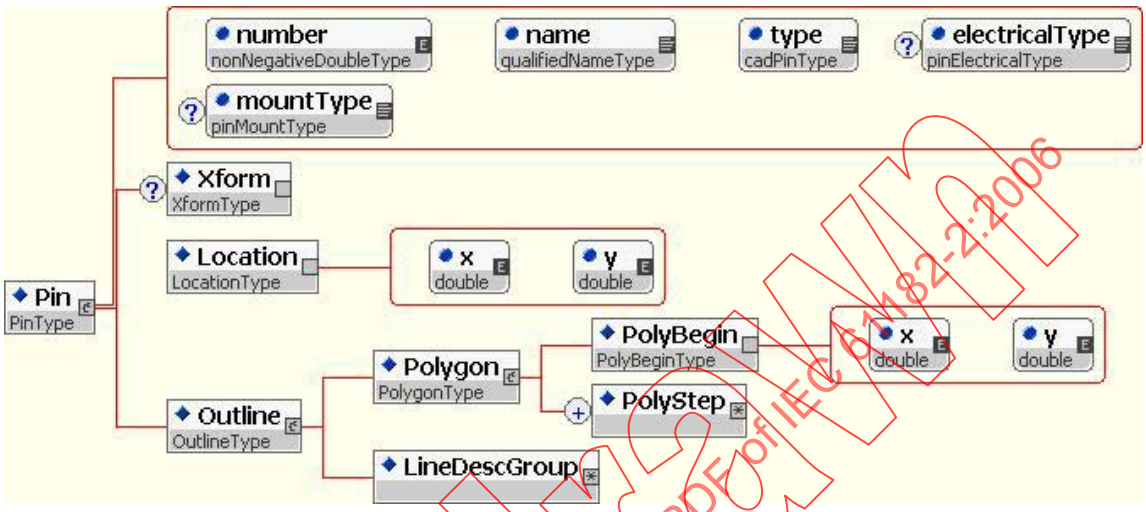
Attribute/ Element Name	Attribute/ Element Type	Description	Occurrence
AssemblyDrawing	Assembly DrawingType	A nested element that defines the graphics required for the assembly drawing. The images relate to the component body outline and any text needed. The point of origin for the assembly drawing is the same as the images of the outline, land pattern, and silk screen schema.	0-1
Outline	OutlineType	A nested element that defines the the outlines of the part related to the graphical image that appears on the board. The `Outline` is an enclosed polygon type.	0-1
Polygon	PolygonType	A closed shape whose edges do not cross, the coordinates of which are defined relative to the local coordinate system of the polygon	1-1
PolyBegin	PolyBeginType	The `PolyBegin` element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge	1-1
PolyStep	ABSTRACT	The `PolyStep` element is a substitution group that defines a circular (`PolyStepCurve`) or straight line (`PolyStepSegment`) continuation of the polygon. The `polystep` direction may be clockwise or counterclockwise which must be consistent when any `Arc` description is used as one of the `PolyStep` elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the `PolyBegin` element to signify that the shape is closed.	1-n
LineDescGroup	ABSTRACT	A substitution group that specifies the `LineWidth` and `LineEnd` characteristics of the `Outline`. The `LineDesc` may also have been predefined in the `DictionaryLineDesc` and instantiated from the dictionary.	1-1
Text	TextType	A nested element that defines the text to be silkscreened onto the surface of the printed board.	0-n

textString	string	The text phrase (case-sensitive) in accordance with the language element of the Header element representing the specific characters to be silkscreened onto the board surface.	1-1
fontSize	positiveInteger	A dimensional characteristic in terms of an integer that defines the font size	1-1
Xform	XformType	An element that provides the ability to reset the point of origin of the text box, then scale, mirror image or rotate the text box after the text box origin has been placed at an X and Y location. See 3.3	0-1
Location	LocationType	The location of the point of origin of the `BoundingBox` used to contain the text or a predefined text contained in the `DictionaryUser`. The textbox may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the point of origin (lowerLeftX) of the `BoundingBox`.	1-1
y	double	The y coordinate of the location of the point of origin (lowerLeftY) of the `BoundingBox`.	1-1
Boundingbox	BoundingBox Type	A constraining rectangular area (bounding box) that encompasses the entire text string including upper and lower case characters.	1-1
lowerLeftX	double	The lower left hand x dimension of the rectangular area encompassing the text.	1-1
lowerLeftY	double	The lower left hand y dimension of the rectangular area encompassing the text.	1-1
UpperRightX	double	The upper right hand x dimension of the the rectangular area encompassing the text.	1-1
UpperRightY	double	The upper right hand y dimension of the rectangular area encompassing the text.	1-1
FontRef	FontRefType	An element that is optional to reference a predefined font by its id, if the standard Helvetica font is not being instantiated.	0-1
id	qualifiedName Type	The identification of the `FontDef` stored in the `DictionaryFont`.	1-1
ColorGroup	ABSTRACT	An optional substitution group that permits assigning a particular color through instantiating the three basic colors or by providing a reference to a predefined `Color` in `DictionaryColor`.	0-1
Target	TargetType	A nested element defining the target to be located as part of the land pattern.	0-n
Xform	XformType	A nested element describing the location and mirroring, rotation or scaling of the `StandardShape` used to define the `Target` in order to have it be consistent within the AssemblyDrawing description.	0-1
Location	LocationType	The location of the image defined by the standard shape or a pre-defined standard shape of the pad. The image may have been reorientated by the Xform.	1-1
x	double	The x coordinate of the location of the target.	1-1
y	double	The y coordinate of the location of the target.	1-1
StandardShape	ABSTRACT	A substitution group that permits the substitution of any of the `StandardPrimitive` shapes in accordance with their individual descriptions. A predefined `StandardPrimitive` may also be instantiated by its unique “id” when the feature is contained in the `DictionaryStandard`. When a reference is made to the dictionary predefined primitive the `Units` must match.	1-1

9.3.7.5 Pin

The Pin element represents a set of Pin characteristics that are attached to each component package. Each Pin has a number, name, type, electricalType and mountType. Each Pin also contains its relative location and outline. See Table 111.

Table 111 – Pin element



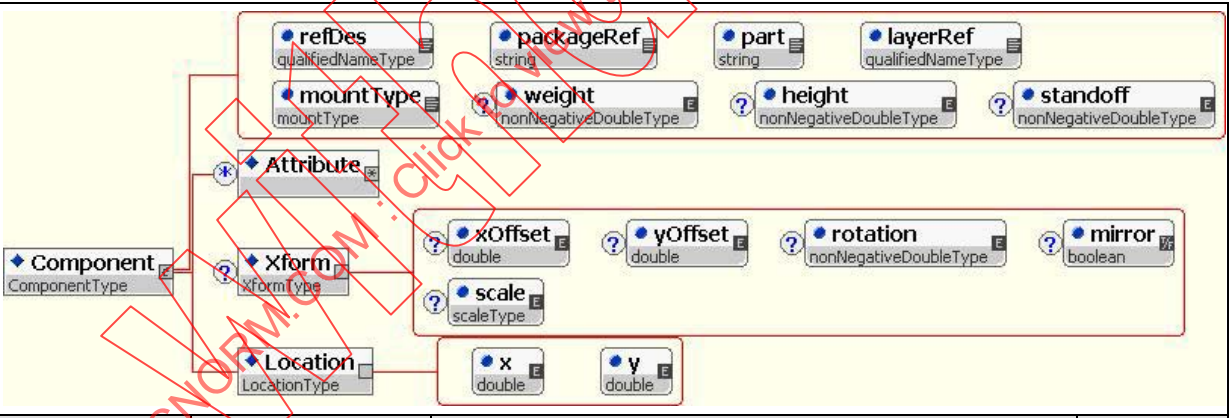
Attribute/ Element Name	Attribute/ Element Type	Description	Occur-rence
Pin	PinType	A nested element that defines the pin relationship of all the pins that are a part of the package style related to the land pattern description.	0-n
number	nonNegativeDouble Type	A specific number for the Pin being described. The number is usually an integer, however may require more granularity thus the type is identified as a nonNegativeDouble.	1-1
name	qualifiedNameType	A unique name assigned by the user to describe the Pin at a particular location.	1-1
type	cadPinType	An enumerated string that defines the type of Pin as being one of the following: THRU | BLIND | SURFACE.	1-1
electricalType	pinElectricalType	The electrical type enumerated string that defines the Pin as one of three possible conditions. These are: ELECTRICAL | MECHANICAL | UNDEFINED.	0-1
mountType	pinMountType	An enumerated string that defines the mounting characteristics of the Pins and may be any one of the following: SURFACE_MOUNT_PIN | SURFACE_MOUNT_PAD | THROUGH_HOLE_PIN | THROUGH_HOLE_HOLE | PRESSFIT | NONBOARD | HOLE | UNDEFINED	0-1
Xform	XformType	An element that provides the ability to reset the point of origin of the graphic outline pin shape, then scale, mirror image or rotate the shape it has been placed at an X and Y location. See 3.3	0-1
Location	LocationType	The location of the image defined by the pin shape or a pre-defined standard shape of the Pin. The image may have been reorientated by the Xform.	1-1
x	double	The X location of the Pin defined by its centroid.	1-1
y	double	The Y location of the Pin defined by its centroid.	1-1
Outline	OutlineType	A nested element that defines the the outlines of the part related to the graphical image that appears on the board. The Outline is an enclosed polygon type.	1-1

Polygon	PolygonType	A closed shape whose edges do not cross, the coordinates of which are defined relative to the local coordinate system of the polygon	1-1
PolyBegin	PolyBeginType	The PolyBegin element defines the starting point of the polygon.	1-1
x	double	The X starting point of the first polygon edge.	1-1
y	double	The Y starting point of the first polygon edge	1-1
PolyStep	ABSTRACT	The PolyStep element is a substitution group that defines a circular (PolyStepCurve) or straight line (PolyStepSegment) continuation of the polygon. The Polystep direction may be clockwise or counterclockwise which must be consistent when any Arc description is used as one of the PolyStep elements. Straight or curved line segments must not cross. The final X and final Y coordinate must match those of the PolyBegin element to signify that the shape is closed.	1-n
LineDescGroup	ABSTRACT	A substitution group that specifies the LineWidth and LineEnd characteristics of the Outline. The LineDesc may also have been predefined in the DictionaryLineDesc and instantiated from the dictionary.	1-1

9.3.8 Component

The Component section contains all the Component elements that were read from the originating CAD system and were captured in the Component element descriptions. See Table 112.

Table 112 – Component element



Attribute / Element Name	Attribute/ Element Type	Description	Occur-rence
Component	ComponentType	A nested element list of component descriptions and their application to the electronic product.	0-n
refDes	qualifiedNameType	A unique name assigned to the particular component.	1-1
packageRef	string	A reference to the package style used to house the component.	1-1
part	string	A part description of the part or its electrical/mechanical characteristics.	1-1
layerRef	qualifiedNameType	The reference to the layer to which the component should be attached as identified by the layer name including defining a reference to an internal layer for embedded component attachment.	1-1
mountType	mountType	The mount type as defined by an enumerated string which may be one of the following: SMT | THMT | OTHER. This attribute can be used to modify the Package description i.e. a through-hole mount modified to be surface mounted.	1-1

weight	nonNegativeDouble Type	The weight of the particular component in grams.	0-1
height	nonNegativeDouble Type	The height that the top protrusion of the component body is above the surface of the printed board in units assigned in the `CadHeader`.	0-1
standoff	nonNegativeDouble Type	The standoff clearance between the body and the printed board in units assigned in the `CadHeader`.	0-1
Attribute	ABSTRACT	A substitution group that may be any of a group of enumerated string descriptions or a unique string for a condition not addressed by the standard attributes. The `Attribute` is associated with the `Component` description.	0-n
Xform	XformType	An element that provides the ability to reset the point of origin of a predefined area that can be scaled, mirror imaged or rotated. The image may also by located by the Xform. See 3.3.	1-1
xOffset	double	The x offset of a previously defined shape relative to its original point of origin in order to define a new origin used for rotation, mirroring, scaling and location. The `CadHeader` defines the units of measure.	**0-1**
yOffset	double	The y offset of a previously defined shape relative to its original point of origin in order to define a new origin used for rotation, mirroring, scaling and location. The `CadHeader` defines the units of measure.	**0-1**
rotation	nonNegativeDouble Type	Defines the rotation of a shape about the local origin in degrees. Positive rotation is always counter-clockwise as viewed from the board TOP (primary side). Degree accuracy is expressed as a two place decimal i.e. 45,15; 62,34	**0-1**
mirror	boolean	An enumerated string as either TRUE or FALSE (part of the 3WC standard). TRUE equals that the image is mirrored; FALSE indicates that it is not.	**0-1**
scale	scaleType	An attribute that defines a “double” dimension whose minExclusiveValue=0,0 representing the multiplication factor of all x and y dimensions. The scale factor does not apply to angular values.	**0-1**
Location	LocationType	The location of the component defined by the `packageRef` or a pre-defined standard shape of the `Package`. The image may have been reorientated by the Xform.	**1-1**
x	double	The x coordinate upon which a features’ point-of-origin is located, relative to the point of origin of the product on which a component is positioned in accordance with the Cartesian coordinate system. The `CadHeader` defines the units of measure.	**1-1**
y	double	The x coordinate upon which a features’ point-of-origin is located, relative to the point of origin of the product on which a component is positioned in accordance with the Cartesian coordinate system. The `CadHeader` defines the units of measure.	**1-1**

9.3.9 VplPackage

The `VplPackage` element represents information for each component as a new package description that may differ from the original EDA package, thus affecting the shape or the location of the components on the electronic assembly. The details of the `VplPackage` descriptions contain data regarding other possible matching packages for each component. It should be noted that only one package could be set as chosen for a particular component. See Table 113.