



MTConnect® Standard
Part 4.1 – Cutting Tools
Version 1.6.0

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MTConnect Specification and Materials

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1 Purpose of This Document

- 2 This document, *MTConnect Standard: Part 4.1 - Cutting Tools* of the MTConnect Standard,
3 establishes the rules and terminology to be used by designers to describe the function
4 and operation of cutting tools used within manufacturing and to define the data that is pro-
5 vided by an *Agent* from a piece of equipment. This part of the Standard also defines the
6 structure for the XML document that is returned from an *Agent* in response to a probe
7 request.
- 8 The data associated with these cutting tools will be retrieved from multiple sources that
9 are responsible for providing their knowledge of an *MTConnect Asset*.

10 2 Terminology and Conventions

11 Refer to Section 2 of *MTConnect Standard Part 1.0 - Overview and Fundamentals* for a
12 dictionary of terms, reserved language, and document conventions used in the MTConnect
13 Standard.

14 2.1 Glossary

15 CDATA

16 General meaning:

17 An abbreviation for Character Data.

18 CDATA is used to describe a value (text or data) published as part of an XML ele-
19 ment.

20 For example, "This is some text" is the CDATA in the XML element:

21 <Message ...>This is some text</Message>

22 Appears in the documents in the following form: CDATA

23 NMOKEN

24 The data type for XML identifiers.

25 Note: The identifier must start with a letter, an underscore "_" or a colon. The next
26 character must be a letter, a number, or one of the following ".", "-", "_", ":". The
27 identifier must not have any spaces or special characters.

28 Appears in the documents in the following form: NMOKEN.

29 XML

30 Stands for eXtensible Markup Language.

31 XML defines a set of rules for encoding documents that both a human-readable and
32 machine-readable.

33 XML is the language used for all code examples in the MTConnect Standard.

34 Refer to <http://www.w3.org/XML> for more information about XML.

35 Agent

36 Refers to an MTConnect Agent.

37 Software that collects data published from one or more piece(s) of equipment, orga-
38 nizes that data in a structured manner, and responds to requests for data from client

39 software systems by providing a structured response in the form of a *Response Document*
40 that is constructed using the *semantic data models* defined in the Standard.

41 Appears in the documents in the following form: *Agent*.

42 **Asset**

43 General meaning:

44 Typically referred to as an *MTConnect Asset*.

45 An *MTConnect Asset* is something that is used in the manufacturing process, but is
46 not permanently associated with a single piece of equipment, can be removed from
47 the piece of equipment without compromising its function, and can be associated
48 with other pieces of equipment during its lifecycle.

49 Used to identify a storage area in an Agent:

50 See description of *buffer*.

51 Used as an Information Model:

52 Used to describe an *Information Model* that contains the rules and terminology that
53 describe information that may be included in electronic documents representing *MT-*
54 *Connect Assets*.

55 The *Asset Information Models* defines the structure for the *Assets Response Document*.
56

57 Individual *Information Models* describe the structure of the *Asset Documents* rep-
58 resent each type of *MTConnect Asset*. Appears in the documents in the following
59 form: *Asset Information Models* or (asset type) *Information Model*.

60 Used when referring to an MTConnect Asset:

61 Refers to the information related to an *MTConnect Asset* or a group of *MTConnect*
62 *Assets*.

63 Appears in the documents in the following form: *Asset* or *Assets*.

64 Used as an XML container or element:

- 65 • When used as an XML container that consists of one or more types of *Asset*
66 XML elements.

67 Appears in the documents in the following form: *Assets*.

- 68 • When used as an abstract XML element. It is replaced in the XML document
69 by types of *Asset* elements representing individual *Asset* entities.

70 Appears in the documents in the following form: *Asset*.

71 Used to describe information stored in an Agent:

72 Identifies an electronic document published by a data source and stored in the *assets*
73 *buffer* of an *Agent*.

74 Appears in the documents in the following form: *Asset Document*.

75 Used as an XML representation of an *MTConnect Response Document*:

76 Identifies an electronic document encoded in XML and published by an *Agent* in
77 response to a *Request* for information from a client software application relating to
78 *MTConnect Assets*.

79 Appears in the documents in the following form: `MTConnectAssets`.

80 Used as an *MTConnect Request*:

81 Represents a specific type of communications request between a client software ap-
82 plication and an *Agent* regarding *MTConnect Assets*.

83 Appears in the documents in the following form: *Asset Request*.

84 Used as part of an *HTTP Request*:

85 Used in the path portion of an *HTTP Request Line*, by a client software applica-
86 tion, to initiate an *Asset Request* to an *Agent* to publish an `MTConnectAssets`
87 document.

88 Appears in the documents in the following form: `asset`.

89 ***Asset Document***

90 An electronic document published by an *Agent* in response to a *Request* for infor-
91 mation from a client software application relating to Assets.

92 ***Attribute***

93 A term that is used to provide additional information or properties for an element.

94 Appears in the documents in the following form: `attribute`.

95 ***buffer***

96 General meaning:

97 A section of an *Agent* that provides storage for information published from pieces
98 of equipment.

99 Used relative to *Streaming Data*:

100 A section of an *Agent* that provides storage for information relating to individual
101 pieces of *Streaming Data*.

102 Appears in the documents in the following form: `buffer`.

103 Used relative to *MTConnect Assets*:

104 A section of an *Agent* that provides storage for *Asset Documents*.

105 Appears in the documents in the following form: `assets buffer`.

106 ***Data Entity***

107 A primary data modeling element that represents all elements that either describe
108 data items that may be reported by an *Agent* or the data items that contain the actual
109 data published by an *Agent*.

110 Appears in the documents in the following form: *Data Entity*.

111 ***Document***

112 General meaning:

113 A piece of written, printed, or electronic matter that provides information.

114 Used to represent an *MTConnect Document*:

115 Refers to printed or electronic document(s) that represent a *Part(s)* of the MTCon-
116 nect Standard.

117 Appears in the documents in the following form: *MTConnect Document*.

118 Used to represent a specific representation of an *MTConnect Document*:

119 Refers to electronic document(s) associated with an *Agent* that are encoded using
120 XML; *Response Documents* or *Asset Documents*.

121 Appears in the documents in the following form: *MTConnect XML Document*.

122 Used to describe types of information stored in an *Agent*:

123 In an implementation, the electronic documents that are published from a data source
124 and stored by an *Agent*.

125 Appears in the documents in the following form: *Asset Document*.

126 Used to describe information published by an *Agent*:

127 A document published by an *Agent* based upon one of the *semantic data models*
128 defined in the MTConnect Standard in response to a request from a client.

129 Appears in the documents in the following form: *Response Document*.

130 ***Equipment Metadata***

131 See *Metadata*

132 ***HTTP Request***

133 In the MTConnect Standard, a communications command issued by a client soft-
134 ware application to an *Agent* requesting information defined in the *HTTP Request*
135 *Line*.

136 Appears in the documents in the following form: *HTTP Request*.

137 ***HTTP Request Line***

138 In the MTConnect Standard, the first line of an *HTTP Request* describing a specific
139 *Response Document* to be published by an *Agent*.

140 Appears in the documents in the following form: *HTTP Request Line*.

141 ***Information Model***

142 The rules, relationships, and terminology that are used to define how information is
143 structured.

144 For example, an information model is used to define the structure for each *MTCon-*
145 *nnect Response Document*; the definition of each piece of information within those
146 documents and the relationship between pieces of information.

147 Appears in the documents in the following form: *Information Model*.

148 ***MTConnect Document***

149 See *Document*.

150 ***MTConnect Request***

151 A communication request for information issued from a client software application
152 to an *Agent*.

153 Appears in the documents in the following form: *MTConnect Request*.

154 ***MTConnect XML Document***

155 See *Document*.

156 ***Request***

157 A communications method where a client software application transmits a message
158 to an *Agent*. That message instructs the *Agent* to respond with specific information.

159 Appears in the documents in the following form: *Request*.

160 ***Response Document***

161 See *Document*.

162 ***semantic data model***

163 A methodology for defining the structure and meaning for data in a specific logical
164 way.

165 It provides the rules for encoding electronic information such that it can be inter-
166 preted by a software system.

167 Appears in the documents in the following form: *semantic data model*.

168 *Streaming Data*

169 The values published by a piece of equipment for the *Data Entities* defined by the
170 *Equipment Metadata*.

171 Appears in the documents in the following form: *Streaming Data*.

172 ***Valid Data Value***

173 One or more acceptable values or constrained values that can be reported for a *Data*
174 *Entity*.

175 Appears in the documents in the following form: *Valid Data Value(s)*.

176 *XML Schema*

177 In the MTConnect Standard, an instantiation of a schema defining a specific docu-
178 ment encoded in XML.

179 2.2 Acronyms

180 *AMT*

181 The Association for Manufacturing Technology

182 2.3 MTConnect References

183 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Overview and Fundamentals*. Version 1.5.0.
184

185 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Devices Information Model*. Ver-
186 sion 1.5.0.

187 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Streams Information Model*. Ver-
188 sion 1.5.0.

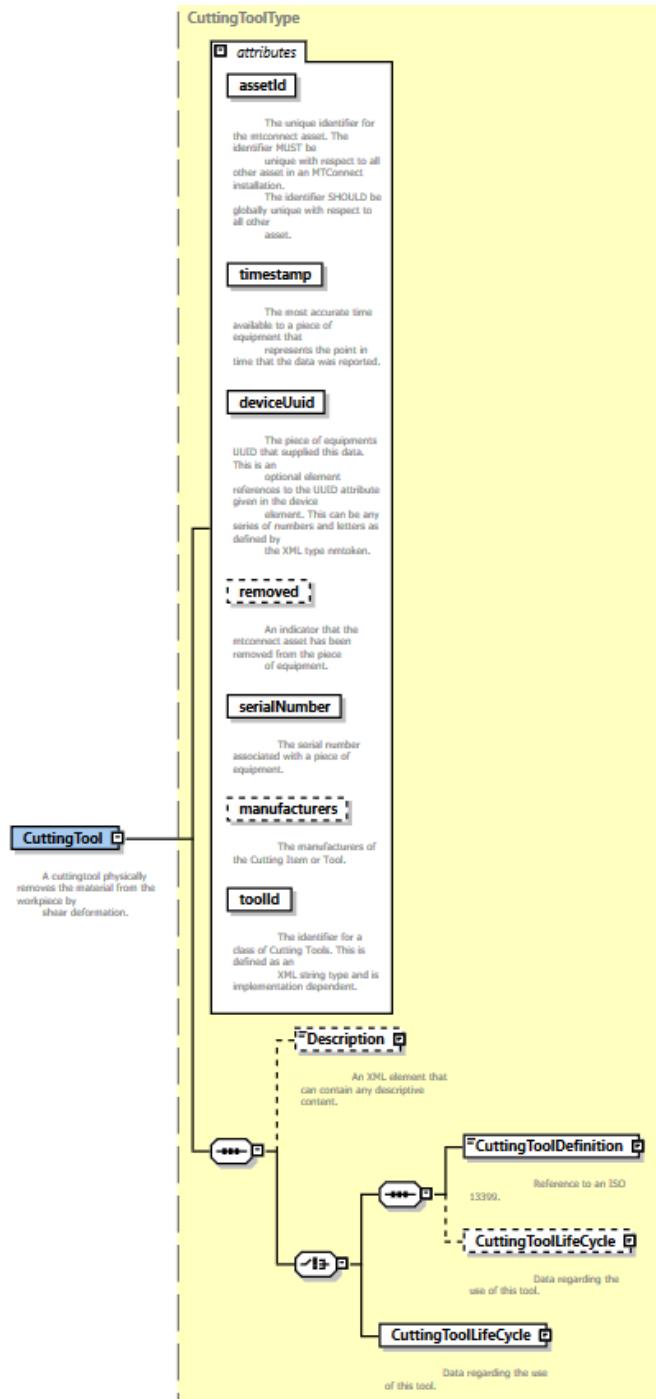
189 [MTConnect Part 4.1] *MTConnect Standard: Part 4.1 - Cutting Tools*. Version 1.5.0.

190 3 Cutting Tool and Cutting Tool Archetype

191 There are two *Information Models* used to represent a cutting tool, *CuttingToolArchetype*
192 and *CuttingTool*. The *CuttingToolArchetype* represent the static cutting tool
193 geometries and nominal values as one would expect from a tool catalog and the *Cut-
194 tingTool* represents the use or application of the tool on the shop floor with actual
195 measured values and process data. In Version 1.3.0 of the MTConnect Standard it was de-
196 cided to separate out these two concerns since not all pieces of equipment will have access
197 to both sets of information. In this way, a generic definition of the cutting tool can coexist
198 with a specific assembly *Information Model* with minimal redundancy of data.

199 3.1 XML Schema Structure for CuttingTool and CuttingToolArchetype

200 The *Figure 1* shows the *XML Schema* that applies to both the *CuttingTool Information
201 Model* and the *CuttingToolArchetype Information Model*.

**Figure 1:** Cutting Tool Schema

202 Note: The use of the XML element `CuttingToolDefinition` has been **DEP-**
 203 **RECATED** in the `CuttingTool` schema, but remains in the `Cutting-`
 204 `ToolArchetype` schema.

205 The following sections contain the definitions of `CuttingTool` and `CuttingToolArchetype`
 206 and describe their unique components. The following are the common entities for both el-
 207 ements.

208 3.2 Common Attributes for CuttingTool and CuttingToolArchetype

Table 1: Attributes for CuttingTool and CuttingToolArchetype

Attribute	Description	Occurrence
<code>timestamp</code>	The time this <i>MTConnect Asset</i> was last modified. Always given in UTC. The <code>timestamp</code> MUST be provided in UTC (Universal Time Coordinate, also known as GMT). This is the time the <i>Asset</i> data was last modified. <code>timestamp</code> is a required attribute.	1
<code>assetId</code>	The unique identifier of the instance of this tool. This will be the same as the <code>toolId</code> and <code>serialNumber</code> in most cases. The <code>assetId</code> SHOULD be the combination of the <code>toolId</code> and <code>serialNumber</code> as in <code>toolId</code> , <code>serialNumber</code> or an equivalent implementation dependent identification scheme. <code>assetId</code> is a required attribute. <code>assetId</code> is a permanent identifier that will be associated with an <i>MTConnect Asset</i> for its entire life.	1
<code>serialNumber</code>	The unique identifier for this assembly. This is defined as an XML string type and is implementation dependent. <code>serialNumber</code> is a required attribute.	1

Continuation of Table 1		
Attribute	Description	Occurrence
toolId	The identifier for a class of Cutting Tools. This is defined as an XML string type and is implementation dependent. toolId is a required attribute.	1
deviceUuid	A reference to the Device's uuid that created the Asset information. The deviceUuid MUST be an NMTOKEN XML type.	1
manufacturers	An optional attribute referring to the manufacturer(s) of this Cutting Tool, for this element, this will reference the Tool Item and Adaptive Items specifically. The Cutting Items manufacturers' will be an attribute of the CuttingItem elements. The representation will be a comma (,) delimited list of manufacturer names. This can be any series of numbers and letters as defined by the XML type string.	0..1
removed	This is an indicator that the Cutting Tool has been removed from the piece of equipment. removed is a required attribute. If the <i>MTConnect Asset</i> is marked as removed, it will not be visible to the client application unless the includeRemoved=true parameter is provided in the URL. If this attribute is not present it MUST be assumed to be false. The value is an xsi:boolean type and MUST be true or false.	0..1

209 **3.3 Common Elements for CuttingTool and CuttingToolArchetype**

Table 2: Common Elements for CuttingTool and CuttingToolArchetype

Element	Description	Occurrence
Description	An element that can contain any descriptive content. This can contain configuration information and manufacturer specific details. This element is defined to contain mixed content and XML elements can be added to extend the descriptive semantics of MTConnect Standard.	0..1

210 **3.3.1 Description Element for CuttingTool and CuttingToolArchetype**

211 Description **MAY** contain mixed content, meaning that an additional XML element
 212 or plain text may be provided as part of the content of the description tag. Currently
 213 Description contains no attributes.

214 4 CuttingToolArchetype Information Model

215 The CuttingToolArchetype *Information Model* will have the identical structure as
 216 the CuttingTool *Information Model* illustrated in *Figure 1*, except for a few entities.
 217 The CuttingTool will no longer carry the CuttingToolDefinition, this **MUST**
 218 only appear in the CuttingToolArchetype. The CuttingToolArchetype **MUST**
 219 **NOT** have measured values and **MUST NOT** have any of the following items: Cutter-
 220 Status, ToolLife values, Location, or a ReconditionCount.

221 MTConnect Standard will adopt the ISO 13399 structure when formulating the vocabulary
 222 for Cutting Tool geometries and structure to be represented in the CuttingToolArchetype.
 223 The nominal values provided in the CuttingToolLifeCycle section are only con-
 224 cerned with two aspects of the Cutting Tool, the Cutting Tool and the Cutting Item. The
 225 Tool Item, Adaptive Item, and Assembly Item will only be covered in the Cutting-
 226 ToolDefinition section of this document since this section contains the full ISO
 227 13399 information about a Cutting Tool.



Figure 2: Cutting Tool Parts

228 The *Figure 2* illustrates the parts of a Cutting Tool. The Cutting Tool is the aggregate of
 229 all the components and the Cutting Item is the part of the tool that removes the material
 230 from the workpiece. These are the primary focus of the MTConnect Standard.

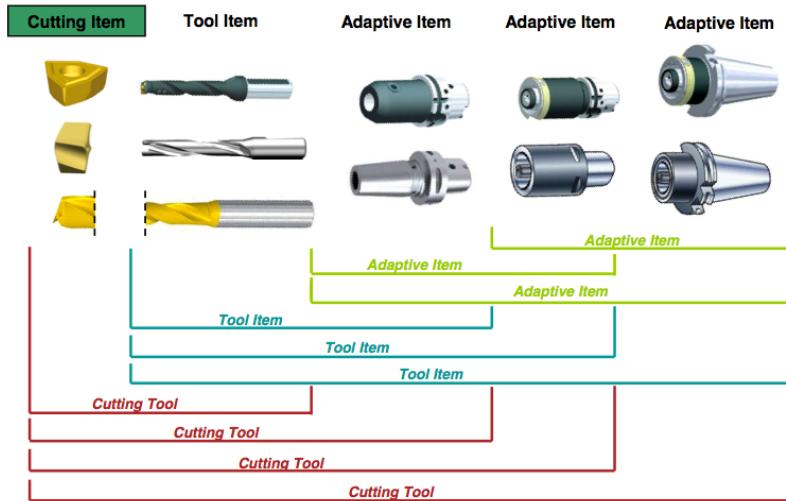


Figure 3: Cutting Tool Composition

231 *Figure 3* provides another view of the composition of a Cutting Tool. The Adaptive Items
 232 and Tool Items will be used for measurements, but will not be modeled as separate entities.
 233 When we are referencing the Cutting Tool we are referring to the entirety of the assembly
 234 and when we provide data regarding the Cutting Item we are referencing each individual
 235 item as illustrated on the left of the previous diagram.

236 *Figure 4* and *Figure 5* further illustrates the components of the Cutting Tool. As we
 237 compose the Tool Item, Cutting Item, Adaptive Item, we get a Cutting Tool. The Tool Item,
 238 Adaptive Item, and Assembly Item will only be in the CuttingToolDefinition
 239 section that will contain the full ISO 13399 information.

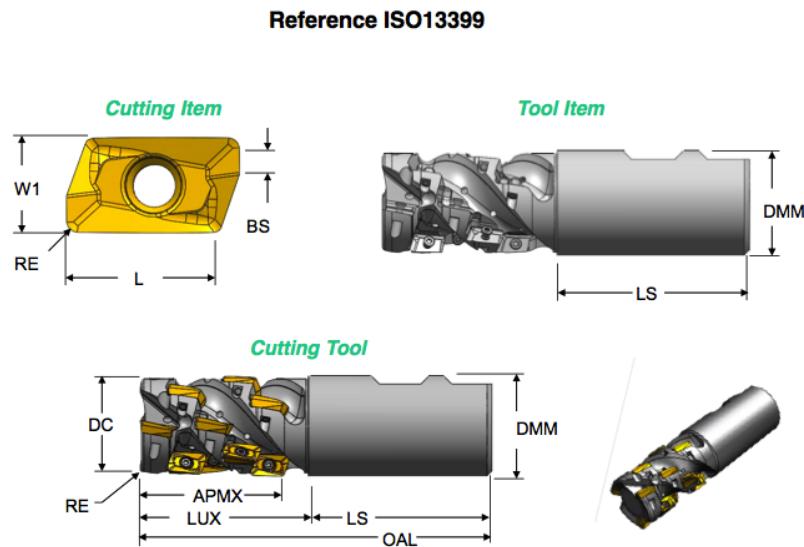


Figure 4: Cutting Tool, Tool Item, and Cutting Item

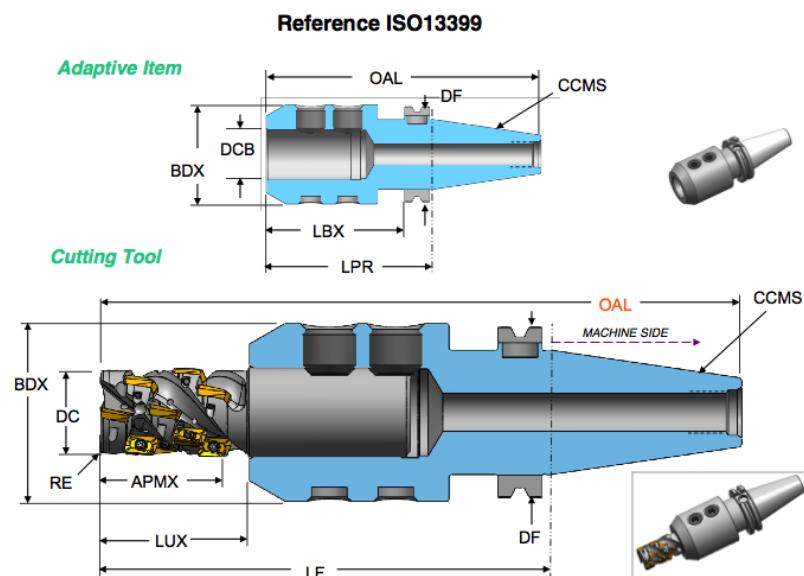


Figure 5: Cutting Tool, Tool Item, and Cutting Item 2

240 *Figure 4* and *Figure 5* use the ISO 13399 codes for each of the measurements. These
 241 codes will be translated into the MTConnect Standard vocabulary as illustrated below.
 242 The measurements will have a maximum, minimum, and nominal value representing the
 243 tolerance of allowable values for this dimension. See below for a full discussion.

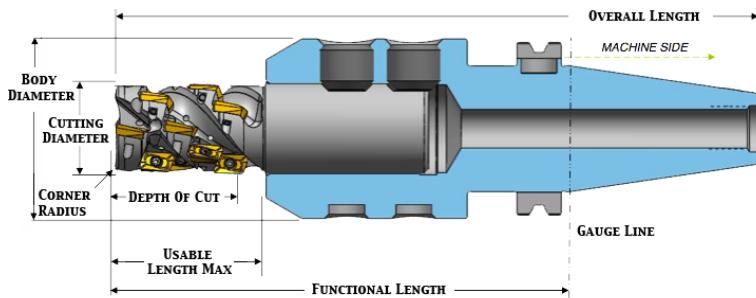


Figure 6: Cutting Tool Measurements

244 The MTConnect Standard will not define the entire geometry of the Cutting Tool, but will
 245 provide the information necessary to use the tool in the manufacturing process. Addi-
 246 tional information can be added to the definition of the Cutting Tool by means of schema
 247 extensions.

248 Additional diagrams will reference these dimensions by their codes that will be defined in
 249 the measurement tables. The codes are consistent with the codes used in ISO 13399 and
 250 have been standardized. MTConnect Standard will use the full text name for clarity in the
 251 XML document.

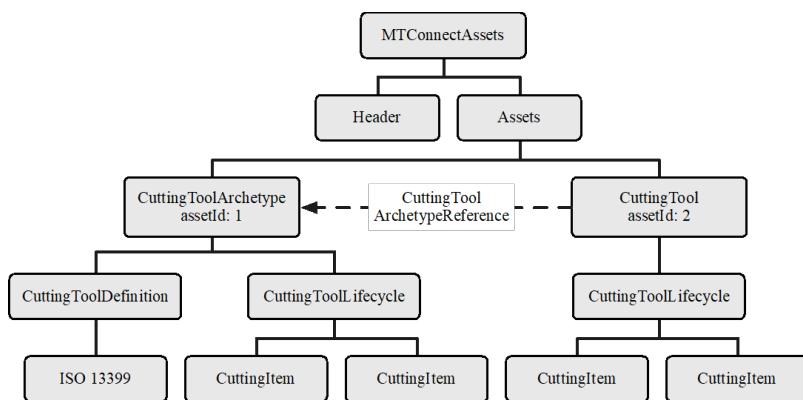


Figure 7: Cutting Tool Asset Structure

252 The structure of the MTConnectAssets header is defined in *MTConnect Standard Part*
 253 *1.0 - Overview and Fundamentals* of the Standard. A finite number of *MTConnect Assets*
 254 will be stored in the *Agent*. This finite number is implementation specific and will depend
 255 on memory and storage constraints. The standard will not prescribe the number or capacity
 256 requirements for an implementation.

257 4.1 Attributes for CuttingToolArchetype

258 Refer to *Section 3.2 - Common Attributes for CuttingTool and CuttingToolArchetype* for a
 259 full description of the attributes for CuttingToolArchetype *Information Model*.

260 4.2 Elements for CuttingToolArchetype

261 The elements associated with CuttingToolArchetype are given in *Table 3*. Each
 262 element will be described in more detail below and any possible values will be presented
 263 with full definitions. The elements **MUST** be provided in the following order as prescribed
 264 by XML. At least one of CuttingToolDefinition or CuttingToolLifeCycle
 265 **MUST** be supplied.

Table 3: Elements for CuttingToolArchetype

Element	Description	Occurrence
Description	An element that can contain any descriptive content. This can contain configuration information and manufacturer specific details. This element is defined to contain mixed content and XML elements can be added to extend the descriptive semantics of MTConnect Standard.	0..1
CuttingToolDefinition	Reference to an ISO 13399.	0..1
CuttingToolLifeCycle	Data regarding the use of this tool. The archetype will only contain nominal values.	0..1

266 4.2.1 CuttingToolDefinition Element for CuttingToolArchetype

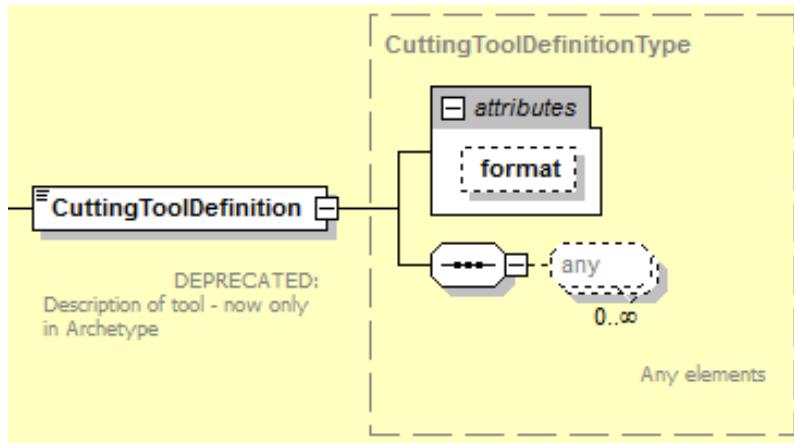


Figure 8: CuttingToolDefinition Schema

267 The CuttingToolDefinition contains the detailed structure of the Cutting Tool.
 268 The information contained in this element will be static during its lifecycle. Currently we
 269 are referring to the external ISO 13399 standard to provide the complete definition and
 270 composition of the Cutting Tool as defined in *Section 6.1 - CuttingToolLifeCycle*.

271 4.2.1.1 Attributes for CuttingToolDefinition

Table 4: Attributes for CuttingToolDefinition

Attribute	Description	Occurrence
format	<p>Identifies the expected representation of the enclosed data.</p> <p>format is an optional attribute.</p> <p>Valid values of format are – XML, EXPRESS, TEXT, or UNDEFINED.</p> <p>If format is not specified, the assumed format is XML.</p>	0..1

272 4.2.1.1.1 format Attribute for CuttingToolDefinition

273 The format attribute describes the expected representation of the enclosed data. If no
 274 value is given, the assumed format will be XML.

Table 5: Values for format attribute of CuttingToolDefinition

Value	Description
XML	The default value for the definition. The content will be an XML document.
EXPRESS	The document will conform to the ISO 10303 Part 21 standard.
TEXT	The document will be a text representation of the tool data.
UNDEFINED	The document will be provided in an undefined format.

275 **4.2.1.2 Elements for CuttingToolDefinition**

276 The only acceptable Cutting Tool definition at present is defined by the ISO 13399 stan-
 277 dard. Additional formats **MAY** be considered in the future.

278 **4.2.1.3 ISO13399 Standard**

279 The ISO 13399 data **MUST** be presented in either XML (ISO 10303-28) or EXPRESS
 280 format (ISO 10303-21). An *XML Schema* will be preferred as this will allow for easier
 281 integration with the MTConnect Standard XML tools. EXPRESS will also be supported,
 282 but software tools will need to be provided or made available for handling this data repre-
 283 sentation.

284 There will be the root element of the ISO13399 document when XML is used. When
 285 EXPRESS is used the XML element will be replaced by the text representation.

286 **4.2.2 CuttingToolLifeCycle Element for CuttingToolArchetype**

287 Refer to *Section 6 - Common Entity CuttingToolLifeCycle* for a complete description of
 288 *CuttingToolLifeCycle* element.

289 5 CuttingTool Information model

290 The CuttingTool *Information Model* illustrated in *Figure 1* has the identical struc-
 291 ture as the CuttingToolArchetype *Information Model* except for the XML ele-
 292 ment CuttingToolDefinition that has been **DEPRECATED** in the Cutting-
 293 Tool schema.

294 5.1 Attributes for CuttingTool

295 Refer to *Section 3.2 - Common Attributes for CuttingTool and CuttingToolArchetype* for a
 296 full description of the *Attributes for CuttingTool Information Model*.

297 5.2 Elements for CuttingTool

298 The elements associated with CuttingTool are given below. The elements **MUST** be
 299 provided in the order shown in *Table 6* as prescribed by XML.

Table 6: Elements for CuttingTool

Element	Description	Occurrence
Description	An element that can contain any descriptive content. This can contain configuration information and manufacturer specific details. This element is defined to contain mixed content and XML elements can be added to extend the descriptive semantics of MTConnect Standard.	0..1
CuttingToolDefinition	DEPRECATED for CuttingTool in Version 1.3.0. Reference to an ISO 13399.	0..1

Continuation of Table 6		
Element	Description	Occurrence
CuttingToolLifeCycle	Data regarding the use of this tool.	0..1
CuttingToolArchetypeReference	The content of this XML element is the assetId of the CuttingToolArchetype document. It MAY also contain a source attribute that gives the URL of the archetype data as well.	0..1

300 5.2.1 CuttingToolLifeCycle Elements for CuttingTool Only

301 The following CuttingToolLifeCycle elements are used only in the Cutting-
 302 Tool *Information Model* and are not part of the CuttingToolArchetype *Information Model*. Refer to *Section 6 - Common Entity CuttingToolLifeCycle* for a complete
 304 description of the remaining elements for CuttingToolLifeCycle that are common
 305 in both *Information Models*. Refer also to the CuttingToolLifeCycle schema illus-
 306 trated in *Figure 14*.

307 5.2.1.1 CutterStatus Element for CuttingToolLifeCycle

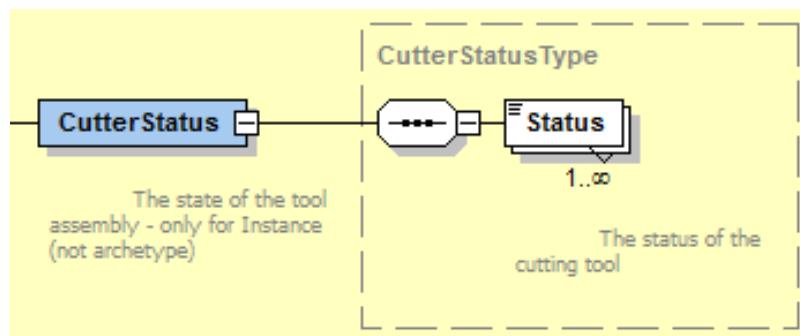


Figure 9: CutterStatus Schema

308 The elements of the CutterStatus element can be a combined set of Status ele-
 309 ments. The *MTConnect Standard* allows any set of statuses to be combined, but only
 310 certain combinations make sense. A CuttingTool **SHOULD** not be both NEW and

311 USED at the same time. There are no rules in the schema to enforce this, but this is left to
 312 the implementer. The following combinations **MUST NOT** occur:

- 313 • NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.
- 314 • UNKNOWN **MUST NOT** be used with any other status.
- 315 • ALLOCATED and UNALLOCATED **MUST NOT** be used together.
- 316 • AVAILABLE and UNAVAILABLE **MUST NOT** be used together.
- 317 • If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be AVAIL-
 318 ABLE.
- 319 • All other combinations are allowed.

Table 7: Elements for CutterStatus

Element	Description	Occurrence
Status	The status of the Cutting Tool. There can be multiple Status elements.	1..*

320 **5.2.1.1.1 Status Element for CutterStatus**

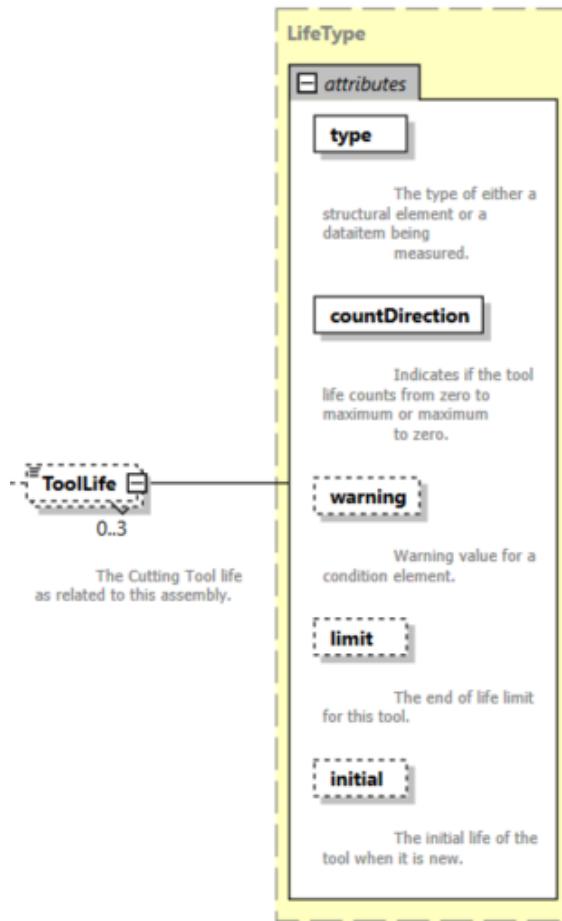
321 One of the values for the status of the CuttingTool.

Table 8: Values for Status Element of CutterStatus

Value	Description
NEW	A new tool that has not been used or first use. Marks the start of the tool history.
AVAILABLE	Indicates the tool is available for use. If this is not present, the tool is currently not ready to be used.
UNAVAILABLE	Indicates the tool is unavailable for use in metal removal. If this is not present, the tool is currently not ready to be used.

Continuation of Table 8	
Value	Description
ALLOCATED	Indicates if this tool is has been committed to a piece of equipment for use and is not available for use in any other piece of equipment. If this is not present, this tool has not been allocated for this piece of equipment and can be used by another piece of equipment.
UNALLOCATED	Indicates this Cutting Tool has not been committed to a process and can be allocated.
MEASURED	The tool has been measured.
RECONDITIONED	The Cutting Tool has been reconditioned. See ReconditionCount for the number of times this cutter has been reconditioned.
USED	The Cutting Tool is in process and has remaining tool life.
EXPIRED	The Cutting Tool has reached the end of its useful life.
BROKEN	Premature tool failure.
NOT_REGISTERED	This Cutting Tool cannot be used until it is entered into the system.
UNKNOWN	The Cutting Tool is an indeterminate state. This is the default value.

322 5.2.1.2 ToolLife Element for CuttingToolLifeCycle

**Figure 10:** ToolLife Schema

323 The value is the current value for the **ToolLife**. The value **MUST** be a number. **ToolLife**
 324 is an option element which can have three types, either minutes for time based, part
 325 count for parts based, or wear based using a distance measure. One **ToolLife** element
 326 can appear for each type, but there cannot be two entries of the same type. Additional
 327 types can be added in the future.

328 **5.2.1.2.1 Attributes for ToolLife**

329 ToolLife has the following attributes that can be used to indicate the behavior of the
 330 tool life management mechanism.

Table 9: Attributes for ToolLife

Attribute	Description	Occurrence
type	The type of tool life being accumulated. MINUTES, PART_COUNT, or WEAR. type is a required attribute.	1
countDirection	Indicates if the tool life counts from zero to maximum or maximum to zero. The value MUST be one of UP or DOWN. countDirection is a required attribute.	1
warning	The point at which a tool life warning will be raised. warning is an optional attribute.	0..1
limit	The end of life limit for this tool. If the countDirection is DOWN, the point at which this tool should be expired, usually zero. If the countDirection is UP, this is the upper limit for which this tool should be expired. limit is an optional attribute.	0..1
initial	The initial life of the tool when it is new. initial is an optional attribute.	0..1

331 **5.2.1.2.2 type Attribute for ToolLife**

332 The value of type must be one of the following:

Table 10: Values for type of ToolLife

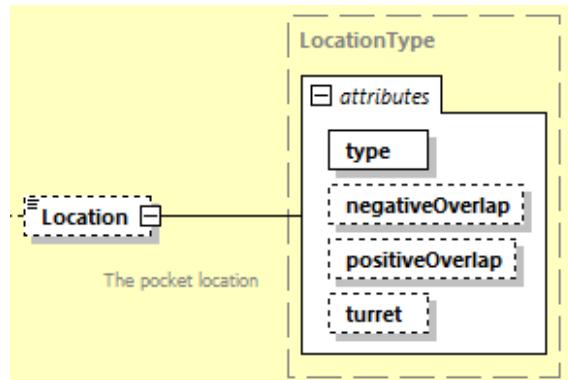
Value	Description
MINUTES	The tool life measured in minutes. All units for minimum, maximum, and nominal MUST be provided in minutes.
PART_COUNT	The tool life measured in parts. All units for minimum, maximum, and nominal MUST be provided as the number of parts.
WEAR	The tool life measured in tool wear. Wear MUST be provided in millimeters as an offset to nominal. All units for minimum, maximum, and nominal MUST be given as millimeter offsets as well. The standard will only consider dimensional wear at this time.

333 **5.2.1.2.3 countDirection Attribute for ToolLife**

334 The value of countDirection must be one of the following:

Table 11: Values for countDirection

Value	Description
UP	The tool life counts up from zero to the maximum.
DOWN	The tool life counts down from the maximum to zero.

335 **5.2.1.3 Location Element for CuttingToolLifeCycle****Figure 11:** Location Schema

336 Location element identifies the specific location where a tool resides in a piece of equip-

337 ment tool storage or in a tool crib. This can be any series of numbers and letters as defined
 338 by the XML type NMTOKEN. When a POT or STATION type is used, the value **MUST**
 339 be a numeric value. If a negativeOverlap or the positiveOverlap is provided,
 340 the tool reserves additional locations on either side, otherwise if they are not given, no
 341 additional locations are required for this tool. If the pot occupies the first or last location,
 342 a rollover to the beginning or the end of the index-able values may occur. For example, if
 343 there are 64 pots and the tool is in pot 64 with a positiveOverlap of 1, the first pot
 344 **MAY** be occupied as well.

345 **5.2.1.3.1 Attributes for Location**

Table 12: Attributes for Location

Attribute	Description	Occurrence
type	The type of location being identified. type MUST be one of POT, STATION, or CRIB. type is a required attribute.	1
positiveOverlap	The number of locations at higher index value from this location. positiveOverlap is a optional attribute.	0..1
negativeOverlap	The number of location at lower index values from this location. negativeOverlap is an optional attribute.	0..1

346 **5.2.1.3.2 type Attribute for Location**

347 The type of location being identified.

Table 13: Values for type of Location

Value	Description
POT	The number of the pot in the tool handling system.
STATION	The tool location in a horizontal turning machine.
CRIB	The location with regard to a tool crib.

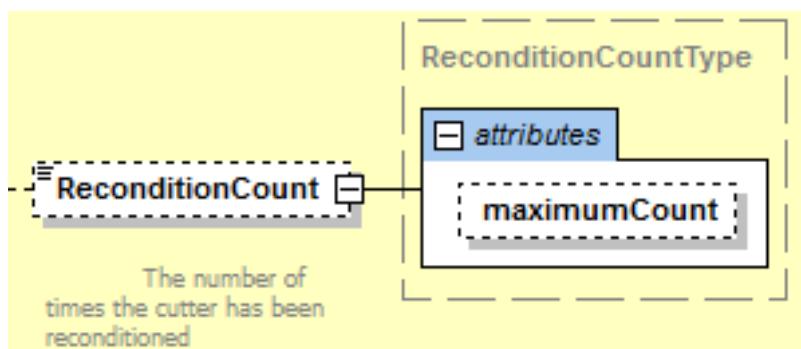
348 **5.2.1.3.3 positiveOverlap Attribute for Location**

349 The number of locations at higher index values that the CuttingTool occupies due to
 350 interference. The value **MUST** be an integer. If not provided it is assumed to be 0.

351 **5.2.1.3.4 negativeOverlap Attribute for Location**

352 The number of locations at lower index values that the CuttingTool occupies due to
 353 interference. The value **MUST** be an integer. If not provided it is not assumed to be 0.

354 The tool number assigned in the part program and is used for cross referencing this tool
 355 information with the process parameters. The value **MUST** be an integer.

356 **5.2.1.4 ReconditionCount Element for CuttingToolLifeCycle****Figure 12:** ReconditionCount Schema

357 This element **MUST** contain an integer value as the CDATA that represents the number of
 358 times the cutter has been reconditioned.

359 **5.2.1.4.1 Attributes for ReconditionCount****Table 14:** Attributes for ReconditionCount

Attribute	Description	Occurrence
maximumCount	The maximum number of times this tool may be reconditioned. maximumCount is a optional attribute.	0..1

360 5.2.2 CuttingToolArchetypeReference Element for Cutting Tool

361



Figure 13: CuttingToolArcheTypeReference Schema

362 This optional element references another *MTConnect Asset* document providing the static
 363 geometries and nominal values for all the measurements. This reduces the amount of data
 364 duplication as well as providing a mechanism for asset definitions to be provided before
 365 complete measurement has occurred.

366 5.2.2.1 source Attribute for CuttingToolArcheTypeReference

Table 15: Attributes for CuttingToolArchetypeReference

Attribute	Description	Occurrence
source	<p>The URL of the <i>CuttingToolArchetype Information Model</i>.</p> <p>This MUST be a fully qualified URL as in http://example.com/asset/A213155</p>	0..1

367 **6 Common Entity CuttingToolLifeCycle**

368 **6.1 CuttingToolLifeCycle**

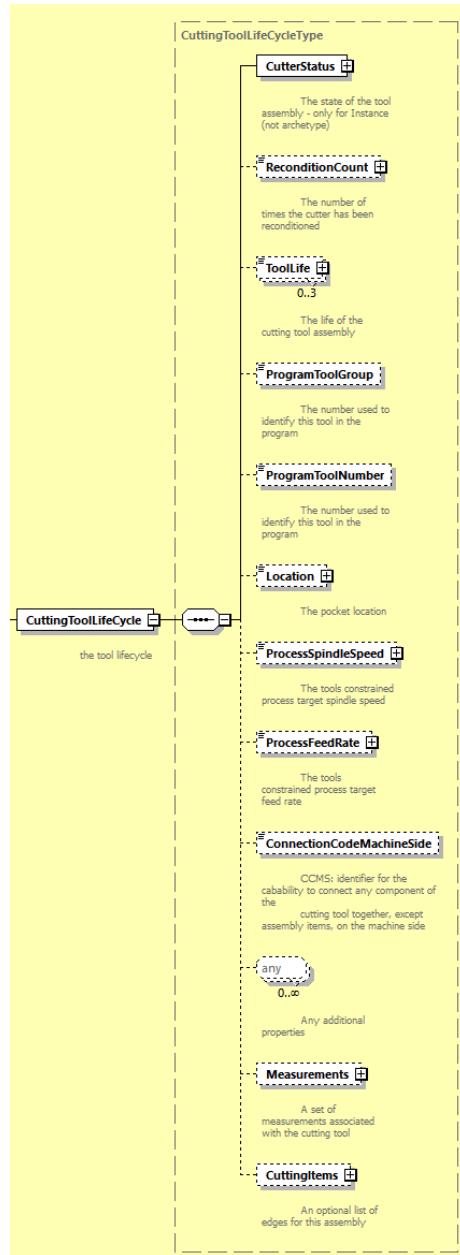
369 The life cycle refers to the data pertaining to the application or the use of the tool. This
370 data is provided by various pieces of equipment (i.e. machine tool, presetter) and statistical
371 process control applications. Life cycle data will not remain static, but will change
372 periodically when a tool is used or measured. The life cycle has three conceptual parts;
373 CuttingTool and CuttingItem identity, properties, and measurements. A measurement
374 is defined as a constrained value that is reported in defined units and as a W3C
375 floating point format.

376 The CuttingToolLifeCycle contains data for the entire tool assembly. The specific
377 CuttingItems that are part of the CuttingToolLifeCycle are contained in the
378 CuttingItems element. Each Cutting Item has similar properties as the assembly;
379 identity, properties, and Measurements.

380 The units for all Measurements have been predefined in the *MTConnect Standard* and
381 will be consistent with *MTConnect Standard: Part 2.0 - Devices Information Model* and
382 *MTConnect Standard: Part 3.0 - Streams Information Model*. This means that all lengths
383 and distances will be given in millimeters and all angular measures will be given in degrees.
384 Quantities like ProcessSpindleSpeed will be given in RPM, the same as the
385 ROTARY_VELOCITY in *MTConnect Standard: Part 3.0 - Streams Information Model*.

386 **6.1.1 XML Schema Structure for CuttingToolLifeCycle**

387 The CuttingToolLifeCycle schema shown in *Figure 14* is used in both the CuttingToolArchetype and CuttingTool *Information Models*. The only difference
388 is that the elements CutterStatus, ToolLife, Location, and Recondition-
389 Count are used only in the CuttingTool *Information Model*.

**Figure 14:** CuttingToolLifeCycle Schema

391 6.2 Elements for CuttingToolLifeCycle

392 The elements associated with this Cutting Tool are given in *Table 16*. The elements **MUST**
 393 be provided in the following order as prescribed by XML.

Table 16: Elements for CuttingToolLifeCycle

Element	Description	Occurrence
CutterStatus	<p>The status of this assembly.</p> <p>CutterStatus can be one of the following values: NEW, AVAILABLE, UNAVAILABLE, ALLOCATED, UNALLOCATED, MEASURED, RECONDITIONED, NOT_REGISTERED, USED, EXPIRED, BROKEN, or UNKNOWN.</p> <p>MUST only be used in the <i>CuttingTool Information Model</i>.</p>	1
ReconditionCount	<p>The number of times this cutter has been reconditioned.</p> <p>MUST only be used in the <i>CuttingTool Information Model</i>.</p>	0..1
ToolLife	<p>The Cutting Tool life as related to this assembly.</p> <p>MUST only be used in the <i>CuttingTool Information Model</i>.</p>	0..1
Location	<p>The Pot or Spindle this tool currently resides in.</p> <p>MUST only be used in the <i>CuttingTool Information Model</i>.</p>	0..1

Continuation of Table 16		
Element	Description	Occurrence
ProgramToolGroup	The tool group this tool is assigned in the part program.	0..1
ProgramToolNumber	The number of the tool as referenced in the part program.	0..1
ProcessSpindleSpeed	The constrained process spindle speed for this tool.	0..1
ProcessFeedRate	The constrained process feed rate for this tool in mm/s.	0..1
ConnectionCodeMachineSide	Identifier for the capability to connect any component of the Cutting Tool together, except Assembly Items, on the machine side. Code: CCMS	0..1
Measurements	A collection of measurements for the tool assembly.	0..1
CuttingItems	An optional set of individual Cutting Items.	0..1
xs:any	Any additional properties not in the current document model. MUST be in separate XML namespace.	0..n

394 6.2.1 ProgramToolGroup Element for CuttingToolLifeCycle

395 The optional identifier for the group of Cutting Tools when multiple tools can be used
 396 interchangeably. This is defined as an XML string type and is implementation dependent.

397 6.2.2 ProgramToolNumber Element for CuttingToolLifeCycle

398 The tool number assigned in the part program and is used for cross referencing this tool
 399 information with the process parameters. The value **MUST** be an integer.

400 6.2.3 ProcessSpindleSpeed Element for CuttingToolLifeCycle

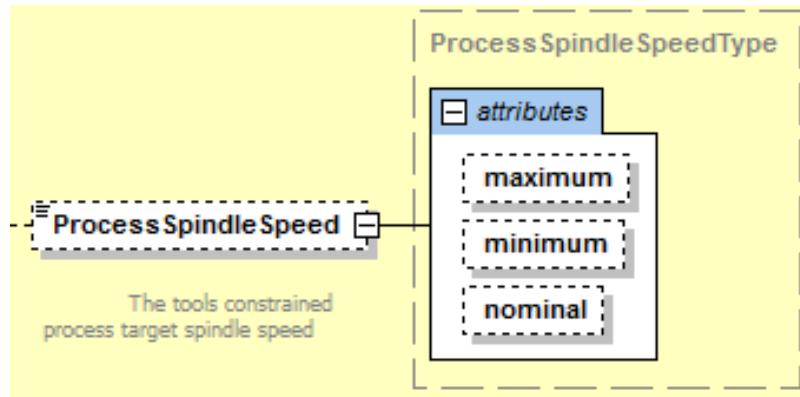


Figure 15: ProcessSpindleSpeed Schema

401 The **ProcessSpindleSpeed** **MUST** be specified in revolutions/minute (RPM). The
 402 CDATA **MAY** contain the nominal process target spindle speed if available. The maximum
 403 and minimum speeds **MAY** be provided as attributes. If **ProcessSpindleSpeed** is
 404 provided, at least one value of maximum, nominal, or minimum **MUST** be specified.

405 6.2.3.1 Attributes for ProcessSpindleSpeed

Table 17: Attributes for ProcessSpindleSpeed

Attribute	Description	Occurrence
maximum	The upper bound for the tool's target spindle speed. maximum is an optional attribute.	0..1
minimum	The lower bound for the tools spindle speed. minimum is a optional attribute.	0..1
nominal	The nominal speed the tool is designed to operate at. nominal is an optional attribute.	0..1

406 6.2.4 ProcessFeedRate Element for CuttingToolLifeCycle

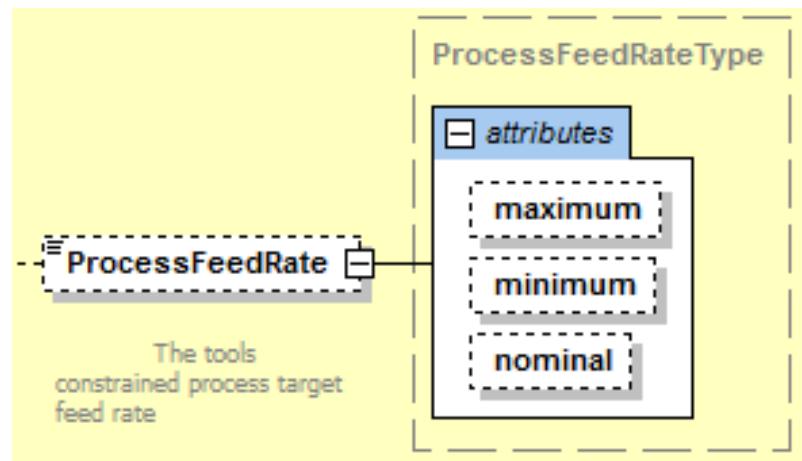


Figure 16: ProcessFeedRate Schema

407 The `ProcessFeedRate` **MUST** be specified in millimeters/second (mm/s). The CDATA
 408 **MAY** contain the nominal process target feed rate if available. The maximum and mini-
 409 mum rates **MAY** be provided as attributes. If `ProcessFeedRate` is provided, at least
 410 one value of maximum, nominal, or minimum **MUST** be specified.

411 **6.2.4.1 Attributes for ProcessFeedRate**

Table 18: Attributes for ProcessFeedRate

Attribute	Description	Occurrence
<code>maximum</code>	The upper bound for the tool's process target feedrate. <code>maximum</code> is an optional attribute.	0..1
<code>minimum</code>	The lower bound for the tools feedrate. <code>minimum</code> is a optional attribute.	0..1
<code>nominal</code>	The nominal feedrate the tool is designed to operate at. <code>nominal</code> is an optional attribute.	0..1

412 **6.2.5 ConnectionCodeMachineSide Element for CuttingToolLifeCy-**
413 **cle**

414 This is an optional identifier for implementation specific connection component of the
415 Cutting Tool on the machine side. Code: CCMS. The CDATA **MAY** be any valid string
416 according to the referenced connection code standards.

417 **6.2.6 xs:any Element for CuttingToolLifeCycle**

418 Utilizing *XML Schema* 1.1, extension points are available where an additional element
419 can be added to the document without being part of a substitution group. The new ele-
420 ments **MUST NOT** be part of the *MTConnect namespace* and **MUST NOT** be one of the
421 predefined elements mentioned above.

422 This allows additional properties to be defined for *CuttingTool* without having to
423 change the definition of the definition of the *CuttingTool* or modify the standard, but
424 requires *XML Schema* Version 1.1.

425 **6.2.7 Measurements Element for CuttingToolLifeCycle**

426 The *Measurements* element is a collection of one or more constrained scalar values
427 associated with this *Cutting Tool*. The XML element **MUST** be a type extension of the
428 base types *CommonMeasurement* or *AssemblyMeasurement*. The following sec-
429 tion defines the abstract *Measurement* type used in both *CuttingToolLifeCycle*
430 and *CuttingItem*. This subsequent sections describe the *AssemblyMeasurement*
431 types followed by the *CuttingItemMeasurement* types.

432 A *Measurement* is specific to the tool management policy at a particular shop. The tool
433 zero reference point or gauge line will be different depending on the particular implemen-
434 tation and will be assumed to be consistent within the shop. *MTConnect Standard* does
435 not standardize the manufacturing process or the definition of the zero point.

436 6.2.8 Measurement

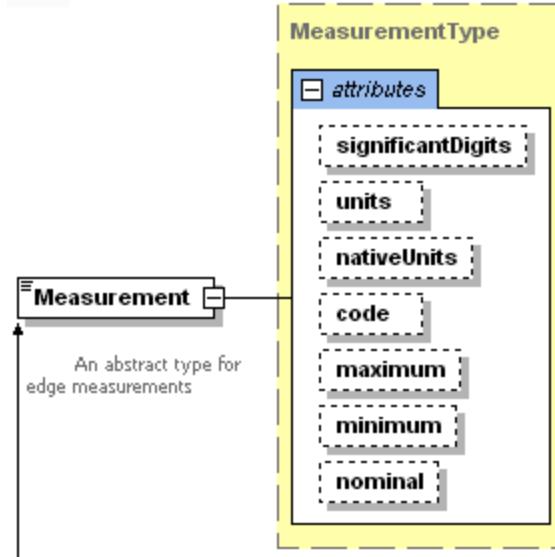


Figure 17: Measurement Schema

437 A Measurement **MUST** be a scalar floating-point value that **MAY** be constrained to a
 438 maximum and minimum value. Since the *CuttingToolLifeCycle*'s main responsi-
 439 bility is to track aspects of the tool that change over its use in the shop, *MTConnect* repre-
 440 sents the current value of the Measurement **MUST** be in the CDATA (text between the
 441 start and end element) as the most current valid value.

442 The minimum and maximum **MAY** be supplied if they are known or relevant to the
 443 Measurement. A nominal value **MAY** be provided to show the reference value for
 444 this Measurement.

445 There are three abstract subtypes of Measurement: CommonMeasurement, Assem-
 446 blyMeasurement, and CuttingItemMeasurement. These abstract types **MUST**
 447 **NOT** appear in an *MTConnectAssets* document, but are used in the schema as a way
 448 to separate which measurements **MAY** appear in the different sections of the document.
 449 Only subtypes that have extended these types **MAY** appear in the *MTConnectAssets*
 450 XML.

451 Measurements in the *CuttingToolLifeCycle* section **MUST** refer to the en-
 452 tire assembly and not to an individual *CuttingItem*. *CuttingItem* measurements
 453 **MUST** be located in the measurements associated with the individual *CuttingItem*.

454 Measurements **MAY** provide an optional units attribute to reinforce the given units.
 455 The units **MUST** always be given in the predefined *MTConnect* units. If units are

456 provided, they are only for documentation purposes. `nativeUnits` **MAY** optionally be
 457 provided to indicate the original units provided for the measurements.

458 **6.2.8.1 Attributes for Measurement**

Table 19: Attributes for Measurement

Attribute	Description	Occurrence
<code>code</code>	A shop specific code for this measurement. ISO 13399 codes MAY be used for these codes as well. <code>code</code> is a optional attribute.	0..1
<code>maximum</code>	The maximum value for this measurement. Exceeding this value would indicate the tool is not usable. <code>maximum</code> is a optional attribute.	0..1
<code>minimum</code>	The minimum value for this measurement. Exceeding this value would indicate the tool is not usable. <code>minimum</code> is a optional attribute.	0..1
<code>nominal</code>	The as advertised value for this measurement. <code>nominal</code> is a optional attribute.	0..1
<code>significantDigits</code>	The number of significant digits in the reported value. This is used by applications to determine accuracy of values. This MAY be specified for all numeric values. <code>significantDigits</code> is a optional attribute.	0..1

Continuation of Table 19		
Attribute	Description	Occurrence
units	The units for the measurements. MTConnect Standard defines all the units for each measurement, so this is mainly for documentation sake. See <i>MTConnect Standard: Part 2.0 - Devices Information Model</i> 7.2.2.5 for the full list of units. units is a optional attribute.	0..1
nativeUnits	The units the measurement was originally recorded in. This is only necessary if they differ from units. See <i>MTConnect Standard: Part 2.0 - Devices Information Model</i> Section 7.2.2.6 for the full list of units. nativeUnits is a optional attribute.	0..1

459 6.2.8.2 Measurement Subtypes for CuttingToolLifeCycle

460 These Measurements for CuttingTool are specific to the entire assembly and **MUST**
 461 **NOT** be used for the Measurement pertaining to a CuttingItem. *Figure 18* and *Fig-
 462 ure 19* will be used to reference the assembly specific Measurements.

463 The Code in *Table 20* will refer to the acronyms in the diagrams. We will be referring to
 464 many diagrams to disambiguate all measurements of the CuttingTool and Cuttin-
 465 gItem.

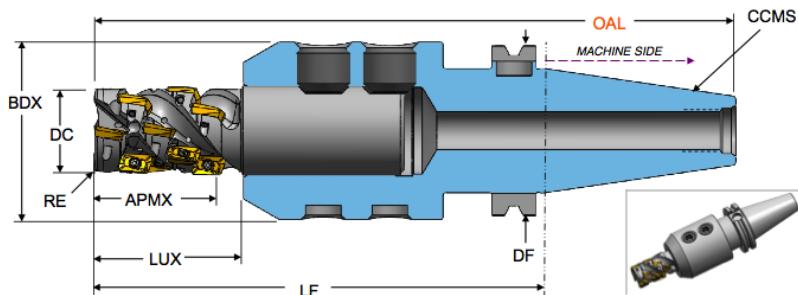
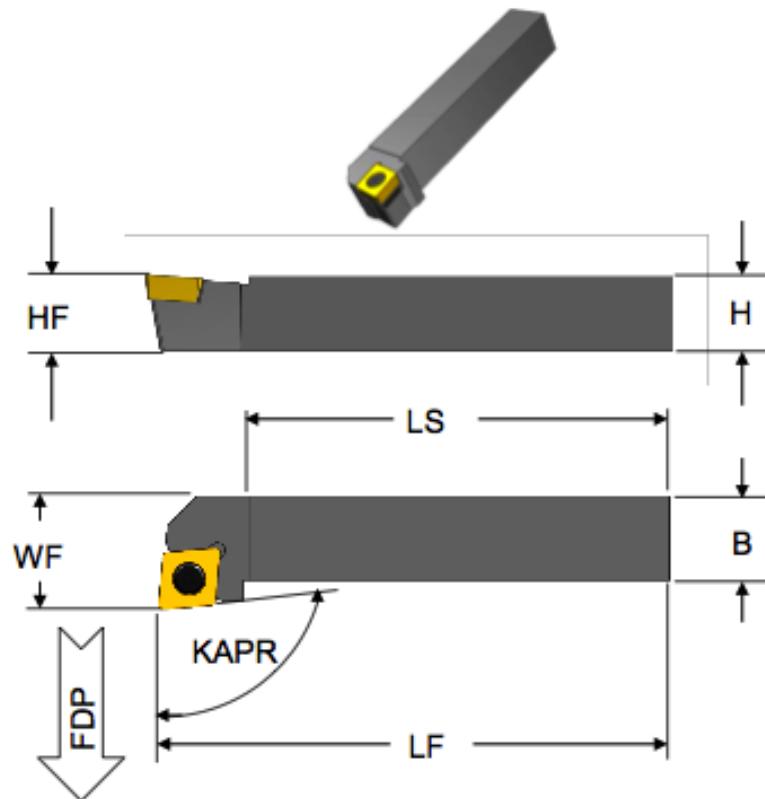


Figure 18: Cutting Tool Measurement Diagram 1

**Figure 19:** Cutting Tool Measurement Diagram 2**Table 20:** Measurement Subtypes for CuttingTool

Measurement Subtype	Code	Description	Units
BodyDiameterMax	BDX	The largest diameter of the body of a Tool Item.	MILLIMETER

Continuation of Table 20			
Measurement Subtype	Code	Description	Units
BodyLengthMax	LBX	The distance measured along the X axis from that point of the item closest to the workpiece, including the Cutting Item for a Tool Item but excluding a protruding locking mechanism for an Adaptive Item, to either the front of the flange on a flanged body or the beginning of the connection interface feature on the machine side for cylindrical or prismatic shanks.	MILLIMETER
DepthOfCutMax	APMX	The maximum engagement of the cutting edge or edges with the workpiece measured perpendicular to the feed motion.	MILLIMETER
CuttingDiameterMax	DC	The maximum diameter of a circle on which the defined point Pk of each of the master inserts is located on a Tool Item. The normal of the machined peripheral surface points towards the axis of the Cutting Tool.	MILLIMETER
FlangeDiameterMax	DF	The dimension between two parallel tangents on the outside edge of a flange.	MILLIMETER
OverallToolLength	OAL	The largest length dimension of the Cutting Tool including the master insert where applicable.	MILLIMETER

Continuation of Table 20			
Measurement Subtype	Code	Description	Units
ShankDiameter	DMM	The dimension of the diameter of a cylindrical portion of a Tool Item or an Adaptive Item that can participate in a connection.	MILLIMETER
ShankHeight	H	The dimension of the height of the shank.	MILLIMETER
ShankLength	LS	The dimension of the length of the shank.	MILLIMETER
UsableLengthMax	LUX	Maximum length of a Cutting Tool that can be used in a particular cutting operation including the non-cutting portions of the tool.	MILLIMETER
ProtrudingLength	LPR	The dimension from the yz-plane to the furthest point of the Tool Item or Adaptive Item measured in the -X direction.	MILLIMETER
Weight	WT	The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.	GRAM

Continuation of Table 20			
Measurement Subtype	Code	Description	Units
FunctionalLength	LF	The distance from the gauge plane or from the end of the shank to the furthest point on the tool, if a gauge plane does not exist, to the cutting reference point determined by the main function of the tool. The CuttingTool functional length will be the length of the entire tool, not a single Cutting Item. Each CuttingItem can have an independent FunctionalLength represented in its measurements.	MILLIMETER

466 6.2.9 CuttingItems Element for CuttingToolLifeCycle

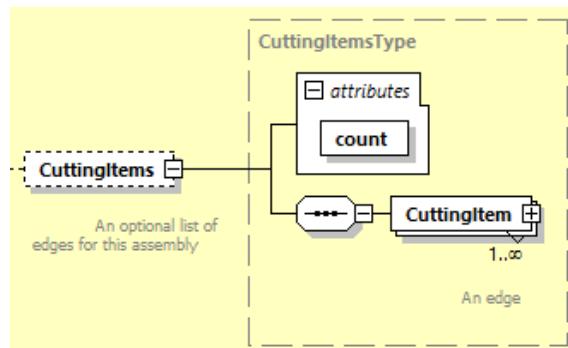


Figure 20: CuttingItems Schema

467 An optional collection of CuttingItems that **SHOULD** be provided for each indepen-
 468 dent edge or insert. If the CuttingItems are not present; it indicates there is no specific
 469 information with respect to each of the CuttingItems. This does not imply there are no
 470 CuttingItems – there **MUST** be at least one CuttingItem – but there is no specific
 471 information.

472 **6.2.9.1 Attributes for CuttingItems****Table 21:** Attributes for CuttingItems

Attribute	Description	Occurrence
count	The number of Cutting Item. count is a required attribute.	1

473 **6.2.10 CuttingItem**

474 A CuttingItem is the portion of the tool that physically removes the material from the
 475 workpiece by shear deformation. The Cutting Item can be either a single piece of mate-
 476 rial attached to the CuttingItem or it can be one or more separate pieces of material
 477 attached to the CuttingItem using a permanent or removable attachment. A Cut-
 478 tingItem can be comprised of one or more cutting edges. CuttingItems include:
 479 replaceable inserts, brazed tips and the cutting portions of solid CuttingTools.

480 MTConnect Standard considers CuttingItems as part of the CuttingTool. A Cut-
 481 tingItems **MUST NOT** exist in MTConnect unless it is attached to a CuttingTool.
 482 Some of the measurements, such as FunctionalLength, **MUST** be made with refer-
 483 ence to the entire CuttingTool to be meaningful.

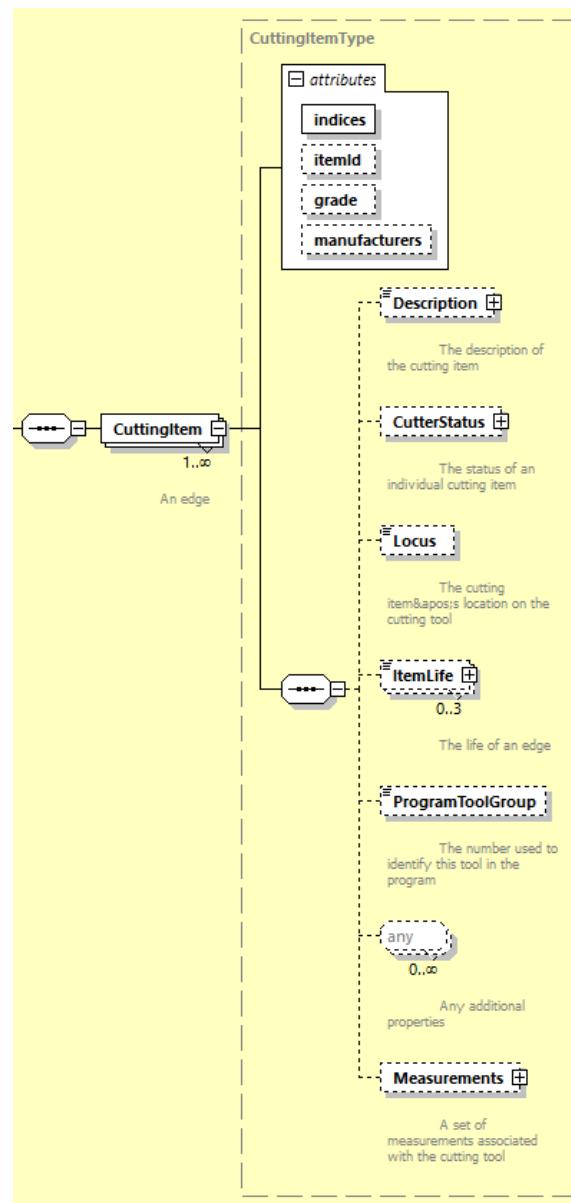


Figure 21: CuttingItem Schema

484 **6.2.10.1 Attributes for CuttingItem****Table 22:** Attributes for CuttingItem

Attribute	Description	Occurrence
indices	The number or numbers representing the individual Cutting Item or items on the tool. indices is a required attribute.	1
itemId	The manufacturer identifier of this Cutting Item. itemId is an optional attribute.	0..1
manufacturers	The manufacturers of the Cutting Item or Tool. manufacturers is an optional attribute.	0..1
grade	The material composition for this Cutting Item. grade is an optional attribute.	0..1

485 **6.2.10.1.1 indices Attribute for CuttingItem**

486 An identifier that indicates the CuttingItem or CuttingItems these data are as-
 487 sociated with. The value **MUST** be a single number ("1") or a comma separated set of
 488 individual elements ("1,2,3,4"), or as a inclusive range of values as in ("1-10") or any
 489 combination of ranges and numbers as in "1-4,6-10,22". There **MUST NOT** be spaces or
 490 non-integer values in the text representation.

491 Indices **SHOULD** start numbering with the inserts or CuttingItem furthest from the
 492 gauge line and increasing in value as the items get closer to the gauge line. Items at the
 493 same distance **MAY** be arbitrarily numbered.

494 **6.2.10.1.2 itemId Attribute for CuttingItem**

495 The manufactures' identifier for this CuttingItem that **MAY** be its catalog or reference
 496 number. The value **MUST** be an XML NMTOKEN value of numbers and letters.

497 **6.2.10.1.3 manufacturers Attribute for CuttingItem**

498 This optional element references the manufacturers of this tool. At this level the manufac-

499 turers will reference the CuttingItem specifically. The representation will be a comma
 500 (,) delimited list of manufacturer names. This can be any series of numbers and letters as
 501 defined by the XML type string.

502 **6.2.10.1.4 grade Attribute for CuttingItem**

503 This provides an implementation specific designation for the material composition of this
 504 CuttingItem.

505 **6.2.10.2 Elements for CuttingItem**

Table 23: Elements for CuttingItem

Element	Description	Occurrence
Description	A free-form description of the Cutting Item.	0..1
Locus	A free form description of the location on the Cutting Tool.	0..1
ItemLife	The life of this Cutting Item.	0..3
Measurements	A collection of measurements relating to this Cutting Item.	0..1
CutterStatus	The status of this item. CutterStatus MUST one of the following values: NEW, AVAILABLE, UNAVAILABLE, ALLOCATED, UNALLOCATED, MEASURED, RECONDITIONED, NOT_REGISTERED, USED, EXPIRED, BROKEN, or UNKNOWN.	0..1
ProgramToolGroup	The tool group the part program assigned this item.	0..1

506 **6.2.10.2.1 Description Element for CuttingItem**

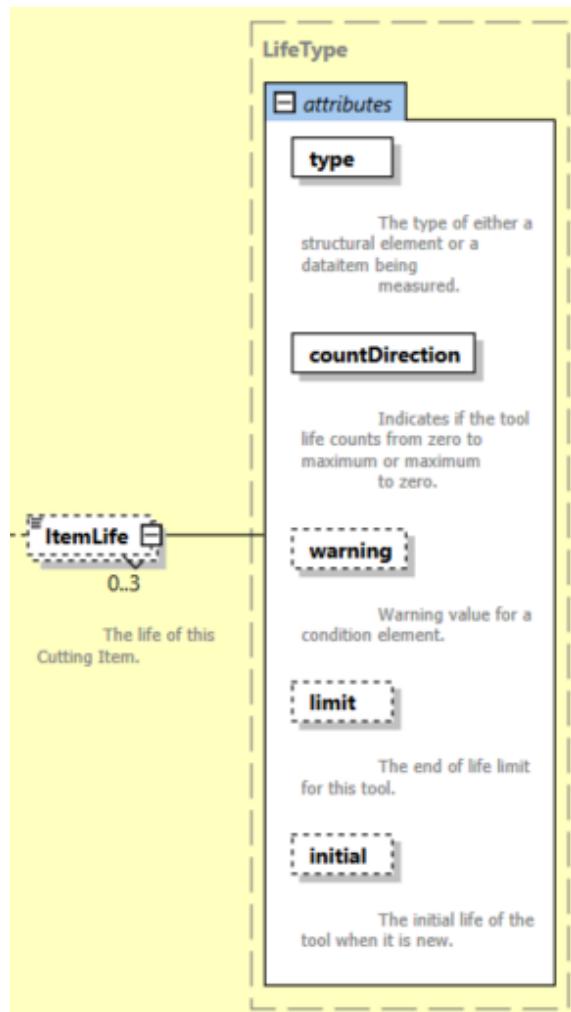
507 An optional free form text description of this CuttingItem.

508 **6.2.10.2.2 Locus Element for CuttingItem**

509 Locus represents the location of the CuttingItem with respect to the Cutting Tool.
510 For clarity, the words FLUTE, INSERT, and CARTRIDGE **SHOULD** be used to assist in
511 noting the location of a CuttingItem. The Locus **MAY** be any free form text, but
512 **SHOULD** adhere to the following rules:

- 513 • The location numbering **SHOULD** start at the furthest CuttingItem (#1) and
514 work it's way back to the Cutting Item closest to the gauge line.
- 515 • Flutes **SHOULD** be identified as such using the word FLUTE:. For example: FLUTE:
516 1, INSERT: 2 - would indicate the first flute and the second furthest insert from the
517 end of the tool on that flute.
- 518 • Other designations such as CARTRIDGE **MAY** be included, but should be identified
519 using upper case and followed by a colon (:).

520 6.2.10.2.3 ItemLife Element for CuttingItem

**Figure 22:** ItemLife Schema

521 The value is the current value for the ToolLife. The value **MUST** be a number. Tool-
 522 Life is an option element which can have three types, either minutes for time based, part
 523 count for parts based, or wear based using a distance measure. One tool life can appear for
 524 each type, but there cannot be two entries of the same type. Additional types can be added
 525 in the future.

526 **6.2.10.2.4 Attributes for ItemLife**

527 These is an optional attribute that can be used to further classify the operation type.

Table 24: Attributes for ItemLife

Attribute	Description	Occurrence
type	The type of tool life being accumulated. <i>Valid Data Values:</i> MINUTES, PART_COUNT, or WEAR. type is a required attribute.	1
countDirection	Indicates if the tool life counts from zero to maximum or maximum to zero. The value MUST be one of UP or DOWN. countDirection is a required attribute.	1
warning	The point at which a tool life warning will be raised. warning is an optional attribute.	0..1
limit	The end of life limit for this tool. If the countDirection is DOWN, the point at which this tool should be expired, usually zero. If the countDirection is UP, this is the upper limit for which this tool should be expired. limit is an optional attribute.	0..1
initial	The initial life of the tool when it is new. initial is an optional attribute.	0..1

528 **6.2.10.2.5 type Attribute for ItemLife**

529 The value of type must be one of the following:

Table 25: Values for type of ItemLife

Value	Description
MINUTES	The tool life measured in minutes. All units for minimum, maximum, and nominal MUST be provided in minutes.
PART_COUNT	The tool life measured in parts. All units for minimum, maximum, and nominal MUST be provided as the number of parts.
WEAR	The tool life measured in tool wear. Wear MUST be provided in millimeters as an offset to nominal. All units for minimum, maximum, and nominal MUST be given as millimeter offsets as well.

530 **6.2.10.2.6 countDirection Attribute for ItemLife**

531 The value of type must be one of the following:

Table 26: Values for countDirection

Value	Description
UP	The tool life counts up from zero to the maximum.
DOWN	The tool life counts down from the maximum to zero.

532 **6.2.10.3 Measurement Subtypes for CuttingItem**533 These Measurements for CuttingItem are specific to an individual glscuttingitem
534 and **MUST NOT** be used for the Measurements pertaining to an assembly. The *Fig-*
535 *ure 23 , Figure 24 , Figure 25* and *Figure 26* will be used to for reference for the Cut-
536 tingItem specific Measurements .537 The Code in *Table 27* will refer to the acronym in the diagram. We will be referring to
538 many diagrams to disambiguate all Measurements of the CuttingTools and Cut-
539 tingItems. We will present a few here; please refer to Appendix B for additional
540 reference material.

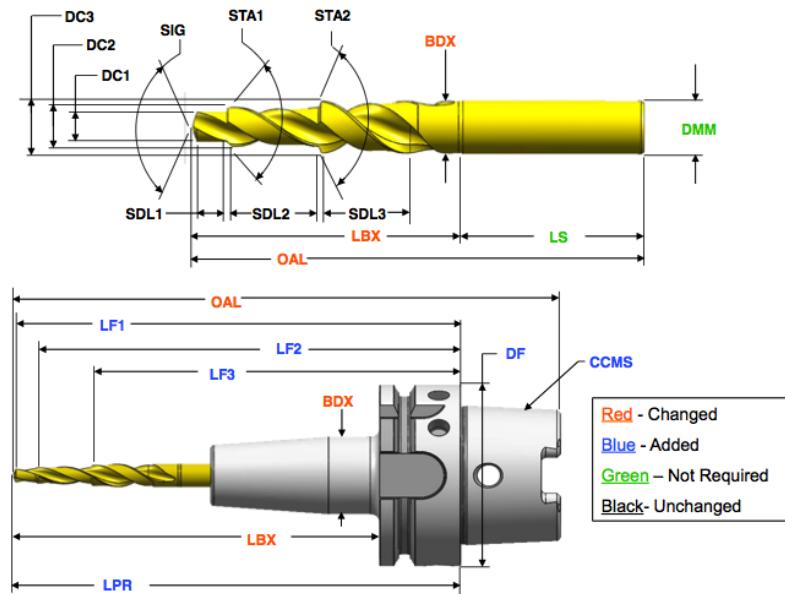


Figure 23: Cutting Tool

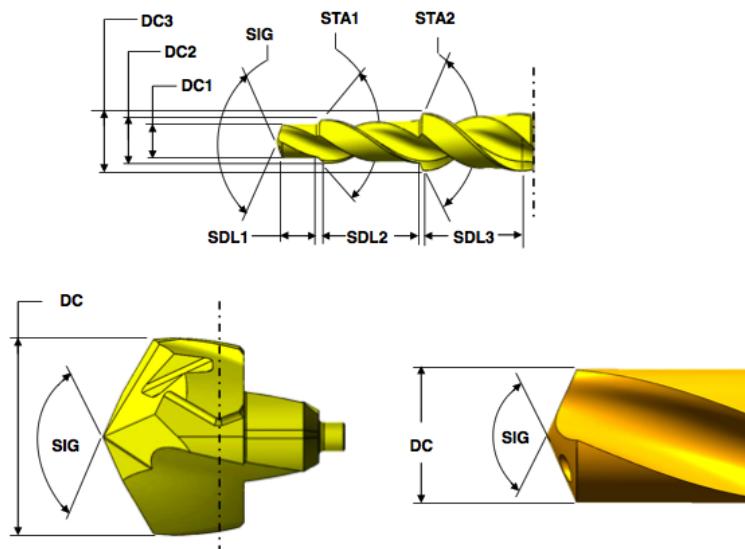
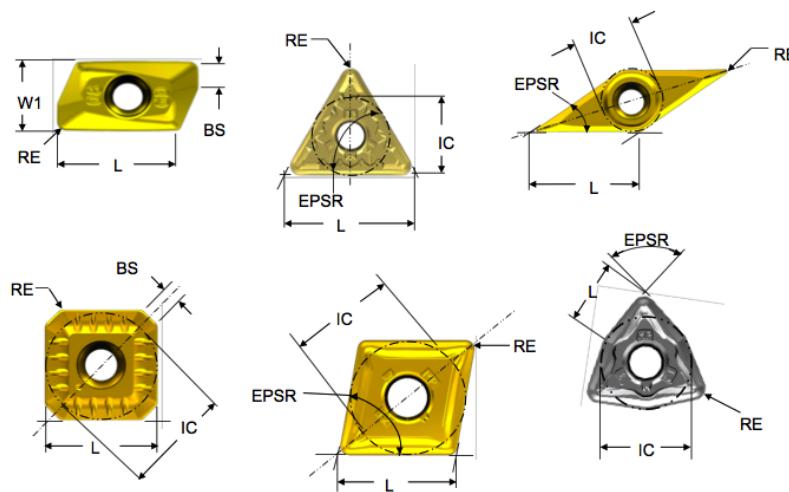
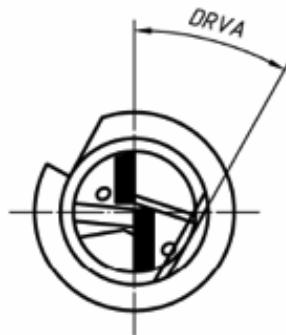


Figure 24: Cutting Item

**Figure 25:** Cutting Item Measurement Diagram 3**Figure 26:** Cutting Item Drive Angle

541 The CuttingItem Measurements in *Table 27* will refer the *Figure 23* , *Figure 24* ,
 542 *Figure 25* and *Figure 26* .

Table 27: Measurement Subtypes for CuttingItem

Measurement Subtype	Code	Description	Units
CuttingReferencePoint	CRP	The theoretical sharp point of the Cutting Tool from which the major functional dimensions are taken.	MILLIMETER

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
CuttingEdgeLength	L	The theoretical length of the cutting edge of a Cutting Item over sharp corners.	MILLIMETER
DriveAngle	DRVA	Angle between the driving mechanism locator on a Tool Item and the main cutting edge.	DEGREE
FlangeDiameter	DF	The dimension between two parallel tangents on the outside edge of a flange.	MILLIMETER
FunctionalWidth	WF	The distance between the cutting reference point and the rear backing surface of a turning tool or the axis of a boring bar.	MILLIMETER
InscribedCircleDiameter	IC	The diameter of a circle to which all edges of a equilateral and round regular insert are tangential.	MILLIMETER
PointAngle	SIG	The angle between the major cutting edge and the same cutting edge rotated by 180 degrees about the tool axis.	DEGREE
ToolCuttingEdgeAngle	KAPR	The angle between the tool cutting edge plane and the tool feed plane measured in a plane parallel the xy-plane.	DEGREE

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
ToolLeadAngle	PSIR	The angle between the tool cutting edge plane and a plane perpendicular to the tool feed plane measured in a plane parallel the xy-plane.	DEGREE
ToolOrientation	N/A	The angle of the tool with respect to the workpiece for a given process. The value is application specific.	DEGREE
WiperEdgeLength	BS	The measure of the length of a wiper edge of a Cutting Item.	MILLIMETER
StepDiameterLength	SDLx	The length of a portion of a stepped tool that is related to a corresponding cutting diameter measured from the cutting reference point of that cutting diameter to the point on the next cutting edge at which the diameter starts to change.	MILLIMETER
StepIncludedAngle	STAx	The angle between a major edge on a step of a stepped tool and the same cutting edge rotated 180 degrees about its tool axis.	DEGREE

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
CuttingDiameter	DCx	The diameter of a circle on which the defined point Pk located on this Cutting Tool. The normal of the machined peripheral surface points towards the axis of the Cutting Tool.	MILLIMETER
CuttingHeight	HF	The distance from the basal plane of the Tool Item to the cutting point.	MILLIMETER
CornerRadius	RE	The nominal radius of a rounded corner measured in the X Y-plane.	MILLIMETER
Weight	WT	The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.	GRAM
FunctionalLength	LFx	The distance from the gauge plane or from the end of the shank of the Cutting Tool, if a gauge plane does not exist, to the cutting reference point determined by the main function of the tool. This measurement will be with reference to the Cutting Tool and MUST NOT exist without a Cutting Tool.	MILLIMETER
ChamferFlatLength	BCH	The flat length of a chamfer.	MILLIMETER
ChamferWidth	CHW	The width of the chamfer.	MILLIMETER

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
InsertWidth	W1	W1 is used for the insert width when an inscribed circle diameter is not practical.	MILLIMETER

543 Appendices

544 A Bibliography

- 545 Engineering Industries Association. *EIA Standard - EIA-274-D*, Interchangeable Variable,
 546 Block Data Format for Positioning, Contouring, and Contouring/Positioning Numerically
 547 Controlled Machines. Washington, D.C. 1979.
- 548 ISO TC 184/SC4/WG3 N1089. *ISO/DIS 10303-238*: Industrial automation systems and
 549 integration Product data representation and exchange Part 238: Application Protocols: Ap-
 550 plication interpreted model for computerized numerical controllers. Geneva, Switzerland,
 551 2004.
- 552 International Organization for Standardization. *ISO 14649*: Industrial automation sys-
 553 tems and integration – Physical device control – Data model for computerized numerical
 554 controllers – Part 10: General process data. Geneva, Switzerland, 2004.
- 555 International Organization for Standardization. *ISO 14649*: Industrial automation sys-
 556 tems and integration – Physical device control – Data model for computerized numerical
 557 controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.
- 558 International Organization for Standardization. *ISO 6983/1* – Numerical Control of ma-
 559 chines – Program format and definition of address words – Part 1: Data format for posi-
 560 tioning, line and contouring control systems. Geneva, Switzerland, 1982.
- 561 Electronic Industries Association. *ANSI/EIA-494-B-1992*, 32 Bit Binary CL (BCL) and
 562 7 Bit ASCII CL (ACL) Exchange Input Format for Numerically Controlled Machines.
 563 Washington, D.C. 1992.
- 564 National Aerospace Standard. *Uniform Cutting Tests* - NAS Series: Metal Cutting Equip-
 565 ment Specifications. Washington, D.C. 1969.
- 566 International Organization for Standardization. *ISO 10303-11*: 1994, Industrial automa-
 567 tion systems and integration Product data representation and exchange Part 11: Descrip-
 568 tion methods: The EXPRESS language reference manual. Geneva, Switzerland, 1994.
- 569 International Organization for Standardization. *ISO 10303-21*: 1996, Industrial automa-
 570 tion systems and integration – Product data representation and exchange – Part 21: Imple-
 571 mentation methods: Clear text encoding of the exchange structure. Geneva, Switzerland,
 572 1996.
- 573 H.L. Horton, F.D. Jones, and E. Oberg. *Machinery's Handbook*. Industrial Press, Inc.

574 New York, 1984.

575 International Organization for Standardization. *ISO 841-2001: Industrial automation sys-*
576 *tems and integration - Numerical control of machines - Coordinate systems and motion*
577 *nomenclature.* Geneva, Switzerland, 2001.

578 *ASME B5.59-2 Version 9c: Data Specification for Properties of Machine Tools for Milling*
579 *and Turning.* 2005.

580 *ASME/ANSI B5.54: Methods for Performance Evaluation of Computer Numerically Con-*
581 *trolled Machining Centers.* 2005.

582 OPC Foundation. *OPC Unified Architecture Specification, Part 1: Concepts Version 1.00.*
583 July 28, 2006.

584 International Organization for Standardization. *ISO 13399: Cutting tool data representa-*
585 *tion and exchange.* Geneva, Switzerland, 2000.

586 B Additional Illustrations

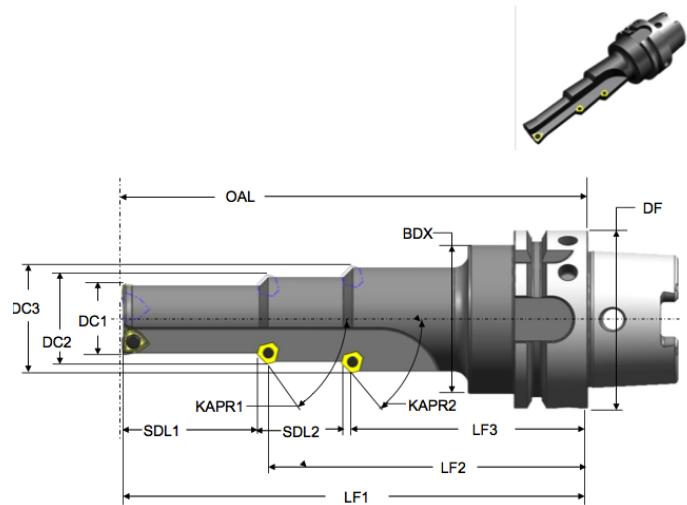


Figure 27: Cutting Tool Measurement Diagram 1
(Cutting Tool, Cutting Item, and Assembly Item – ISO 13399)

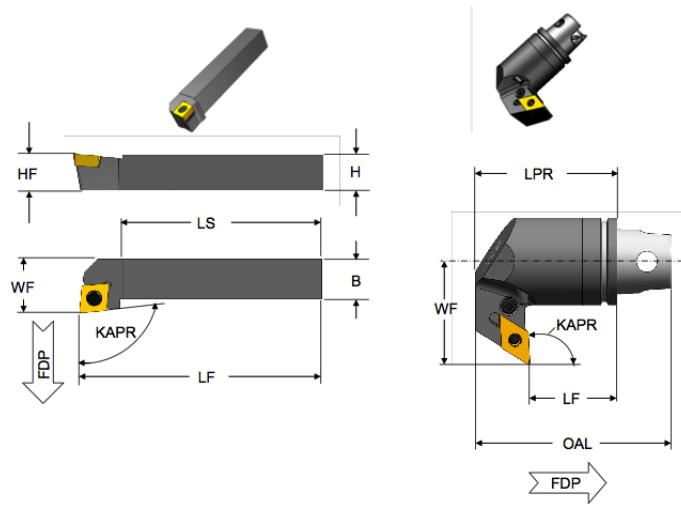


Figure 28: Cutting Tool Measurement Diagram 2
(Cutting Tool, Cutting Item, and Assembly Item – ISO 13399)

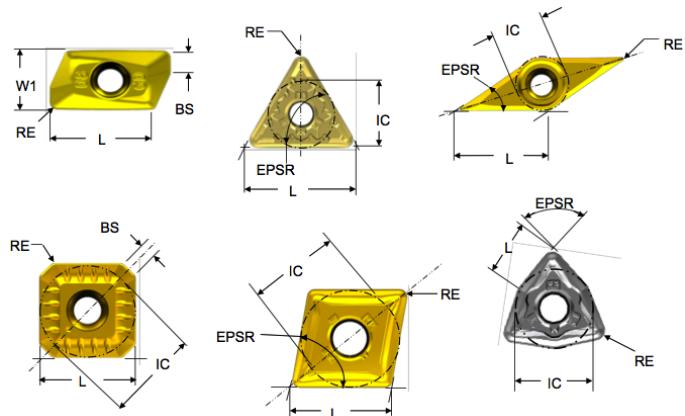


Figure 29: Cutting Tool Measurement Diagram 3
(Cutting Item – ISO 13399)

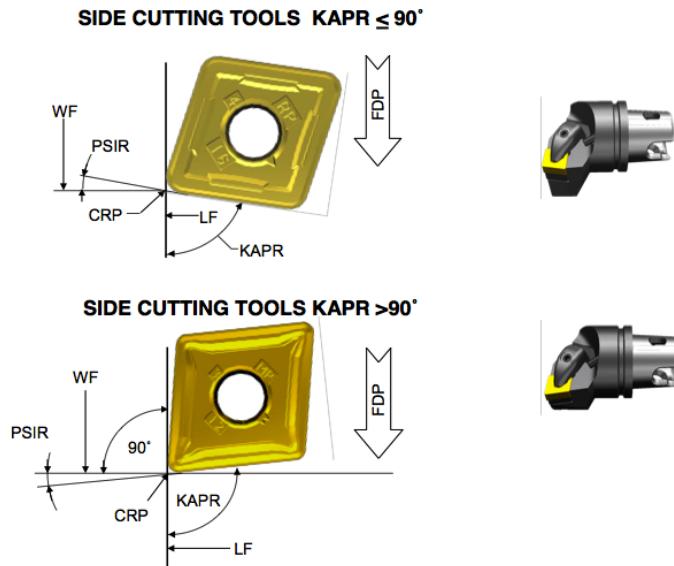


Figure 30: Cutting Tool Measurement Diagram 4
(Cutting Item – ISO 13399)

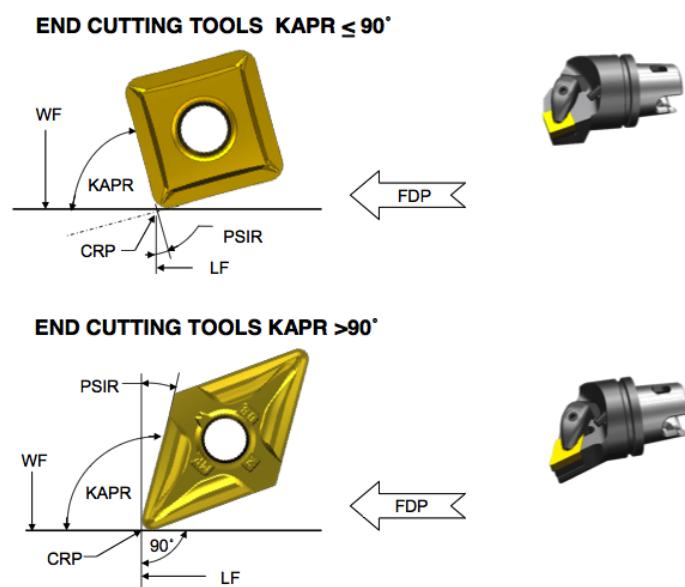


Figure 31: Cutting Tool Measurement Diagram 5
(Cutting Item – ISO 13399)

BCH = CHAMFER FLAT LENGTH
CHW = CHAMFER WIDTH

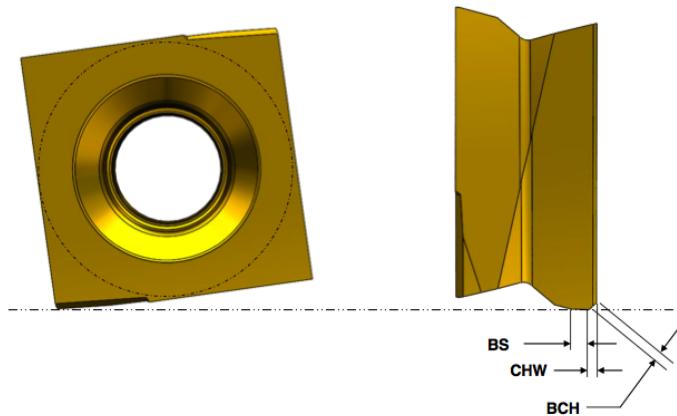


Figure 32: Cutting Tool Measurement Diagram 6
(Cutting Item – ISO 13399)

587 C Cutting Tool Example

588 C.1 Shell Mill

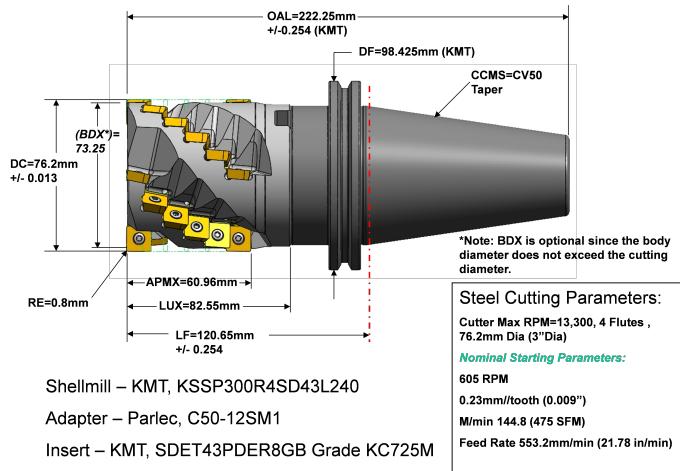


Figure 33: Shell Mill Side View

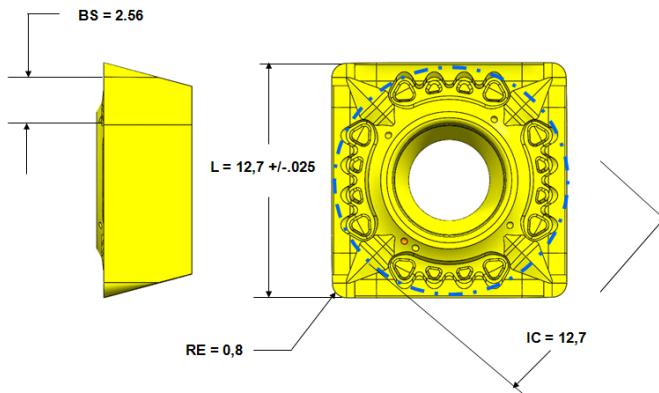


Figure 34: Indexable Insert Measurements

Example 1: Example for Indexable Insert Measurements

```

589 1 <?xml version="1.0" encoding="UTF-8"?>
590 2 <MTConnectAssets
591 3 xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
592 4 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
593 5 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
594 6 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
595 7 http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
596 8   <Header creationTime="2011-05-11T13:55:22"
597 9     assetBufferSize="1024" sender="localhost"
```

```

598 10    assetCount="2" version="1.2" instanceId="1234"/>
599 11    <Assets>
600 12      <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240">
601 13        timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
602 14        manufacturers="KMT, Parlec">
603 15          <CuttingToolLifeCycle>
604 16            <CutterStatus><Status>NEW</Status></CutterStatus>
605 17            <ProcessSpindleSpeed maximum="13300"
606 18              nominal="605">10000</ProcessSpindleSpeed>
607 19            <ProcessFeedRate
608 20              nominal="9.22">9.22</ProcessSpindleSpeed>
609 21            <ConnectionCodeMachineSide>CV50
610 22            </ConnectionCodeMachineSide>
611 23            <Measurements>
612 24              <BodyDiameterMax code="BDX">73.25
613 25              </BodyDiameterMax>
614 26              <OverallToolLength nominal="222.25"
615 27                minimum="221.996" maximum="222.504"
616 28                  code="OAL">222.25</OverallToolLength>
617 29              <UsableLengthMax code="LUX" nominal="82.55">82.55
618 30              </UsableLengthMax>
619 31              <CuttingDiameterMax code="DC" nominal="76.2"
620 32                maximum="76.213" minimum="76.187">76.2
621 33              </CuttingDiameterMax>
622 34              <BodyLengthMax code="LF" nominal="120.65"
623 35                maximum="120.904" minimum="120.404">120.65
624 36              </BodyLengthMax>
625 37              <DepthOfCutMax code="APMX"
626 38                nominal="60.96">60.95</DepthOfCutMax>
627 39              <FlangeDiameterMax code="DF"
628 40                nominal="98.425">98.425</FlangeDiameterMax>
629 41            </Measurements>
630 42            <CuttingItems count="24">
631 43              <CuttingItem indices="1-24" itemId="SDET43PDER8GB"
632 44                manufacturers="KMT" grade="KC725M">
633 45                <Measurements>
634 46                  <CuttingEdgeLength code="L" nominal="12.7"
635 47                    minimum="12.675" maximum="12.725">12.7
636 48                    </CuttingEdgeLength>
637 49                  <WiperEdgeLength code="BS" nominal=
638 50                    "2.56">2.56</WiperEdgeLength>
639 51                  <InscribedCircleDiameter code="IC"
640 52                    nominal="12.7">12.7
641 53                  </InscribedCircleDiameter>
642 54                  <CornerRadius code="RE" nominal="0.8">
643 55                    0.8</CornerRadius>
644 56                  </Measurements>
645 57                  </CuttingItem>
646 58            </CuttingItems>
647 59            </CuttingToolLifeCycle>
648 60          </CuttingTool>

```

```
649 61    </Assets>
650 62  </MTConnectAssets>
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651 C.2 Step Drill

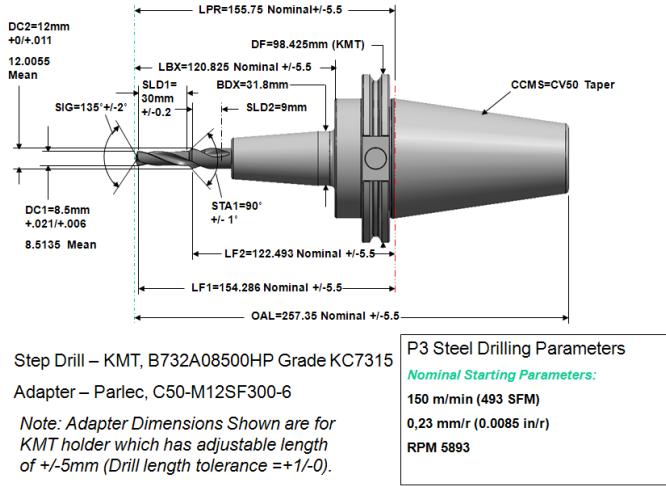


Figure 35: Step Mill Side View

Example 2: Example for Step Mill Side View

```

652 1 <?xml version="1.0" encoding="UTF-8"?>
653 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
654 3 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
655 4 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
656 5 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
657 6 http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
658 7   <Header creationTime="2011-05-
659 8     _11T13:55:22" assetBufferSize="1024"
660 9     sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
661 10  <Assets>
662 11    <CuttingTool serialNumber="1" toolId="B732A08500HP"
663 12      timestamp="2011-05-11T13:55:22" assetId="B732A08500HP_"
664 13      manufacturers="KMT, Parlec">
665 14        <Description>
666 15          Step Drill - KMT, B732A08500HP Grade KC7315
667 16          Adapter - Parlec, C50-M12SF300-6
668 17        </Description>
669 18        <CuttingToolLifeCycle>
670 19          <CutterStatus><Status>NEW</Status></CutterStatus>
671 20          <ProcessSpindleSpeed nominal="5893">5893</ProcessSpindleSpeed>
672 21          <ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
673 22          <ConnectionCodeMachineSide>CV50 Taper</ConnectionCodeMachineSide>
674 23        <Measurements>
675 24          <BodyDiameterMax code="BDX">31.8</BodyDiameterMax>
676 25          <BodyLengthMax code="LBX" nominal="120.825" maximum="126.325"
677 26            minimum="115.325">120.825</BodyLengthMax>
678 27          <ProtrudingLength code="LPR" nominal="155.75" maximum="161.25"
679 28            minimum="150.26">155.75</ProtrudingLength>
```

```

680 29      <FlangeDiameterMax code="DF"
681 30          nominal="98.425">98.425</FlangeDiameterMax>
682 31      <OverallToolLength nominal="257.35" minimum="251.85"
683 32          maximum="262.85" code="OAL">257.35</OverallToolLength>
684 33      </Measurements>
685 34      <CuttingItems count="2">
686 35          <CuttingItem indices="1" manufacturers="KMT" grade="KC7315">>
687 36              <Measurements>
688 37                  <CuttingDiameter code="DC1" nominal="8.5" maximum="8.521"
689 38                      minimum="8.506">8.5135</CuttingDiameter>
690 39                  <StepIncludedAngle code="STA1" nominal="90" maximum="91"
691 40                      minimum="89">90</StepIncludedAngle>
692 41                  <FunctionalLength code="LF1" nominal="154.286"
693 42                      minimum="148.786"
694 43                      maximum="159.786">154.286</FunctionalLength>
695 44                  <StepDiameterLength code="SDL1"
696 45                      nominal="9">9</StepDiameterLength>
697 46                  <PointAngle code="SIG" nominal="135" minimum="133"
698 47                      maximum="137">135</PointAngle>
699 48              </Measurements>
700 49          </CuttingItem>
701 50          <CuttingItem indices="2" manufacturers="KMT" grade="KC7315">>
702 51              <Measurements>
703 52                  <CuttingDiameter code="DC2" nominal="12" maximum="12.011"
704 53                      minimum="12">12</CuttingDiameter>
705 54                  <FunctionalLength code="LF2" nominal="122.493"
706 55                      maximum="127.993"
707 56                      minimum="116.993">122.493</FunctionalLength>
708 57                  <StepDiameterLength code="SDL2"
709 58                      nominal="9">9</StepDiameterLength>
710 59              </Measurements>
711 60          </CuttingItem>
712 61      </CuttingItems>
713 62      </CuttingToolLifeCycle>
714 63  </CuttingTool>
715 64  </Assets>
716 65 </MTConnectAssets>

```

717 C.3 Shell Mill with Individual Loci

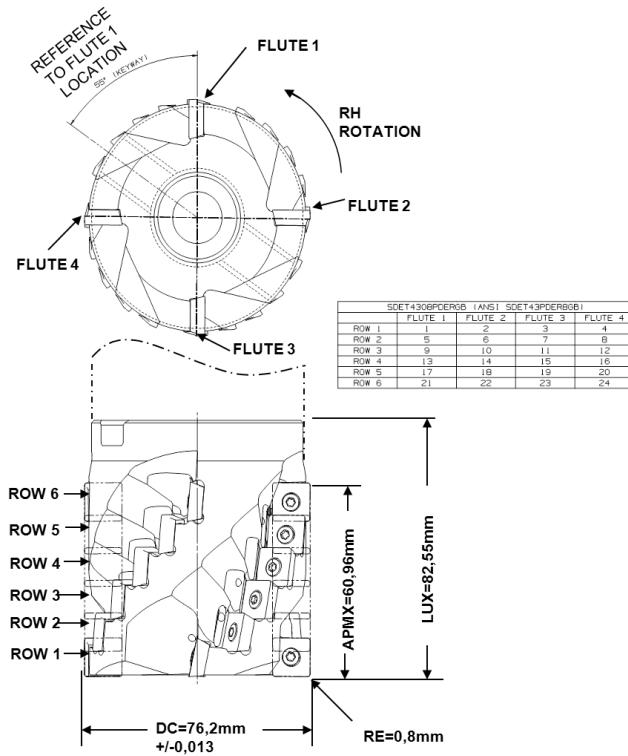


Figure 36: Shell Mill with Explicate Loci

Example 3: Example for Shell Mill with Explicate Loci

```

718 1 <?xml version="1.0" encoding="UTF-8"?>
719 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
720 3   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
721 4   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
722 5   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
723 6   http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
724 7   <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
725 8   sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
726 9   <Assets>
727 10  <CuttingTool serialNumber="1" toolID="KSSP300R4SD43L240"
728 11    timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
729 12    manufacturers="KMT, Parlec">
730 13      <Description>Keyway: 55 degrees</Description>
731 14      <CuttingToolLifeCycle>
732 15        <CutterStatus><Status>NEW</Status></CutterStatus>
733 16        <Measurements>
734 17          <UsableLengthMax code="LUX"
735 18            nominal="82.55">82.55</UsableLengthMax>
736 19          <CuttingDiameterMax code="DC" nominal="76.2" maximum="76.213"
```

```
737 20      minimum="76.187">76.2</CuttingDiameterMax>
738 21      <DepthOfCutMax code="APMX" nominal="60.96">60.95</DepthOfCutMax>
739 22  </Measurements>
740 23  <CuttingItems count="24">
741 24      <CuttingItem indices="1" itemId="SDET43PDER8GB"
742 25      manufacturers="KMT">
743 26          <Locus>FLUTE: 1, ROW: 1</Locus>
744 27          <Measurements>
745 28              <DriveAngle code="DRVA" nominal="55">55</DriveAngle>
746 29          </Measurements>
747 30      </CuttingItem>
748 31      <CuttingItem indices="2-24" itemId="SDET43PDER8GB"
749 32      manufacturers="KMT">
750 33          <Locus>FLUTE: 2-4, ROW: 1; FLUTE: 1-4, ROW 2-6</Locus>
751 34          </CuttingItem>
752 35      </CuttingItems>
753 36      </CuttingToolLifeCycle>
754 37  </CuttingTool>
755 38  </Assets>
756 39 </MTConnectAssets>
```

757 C.4 Drill with Individual Loci

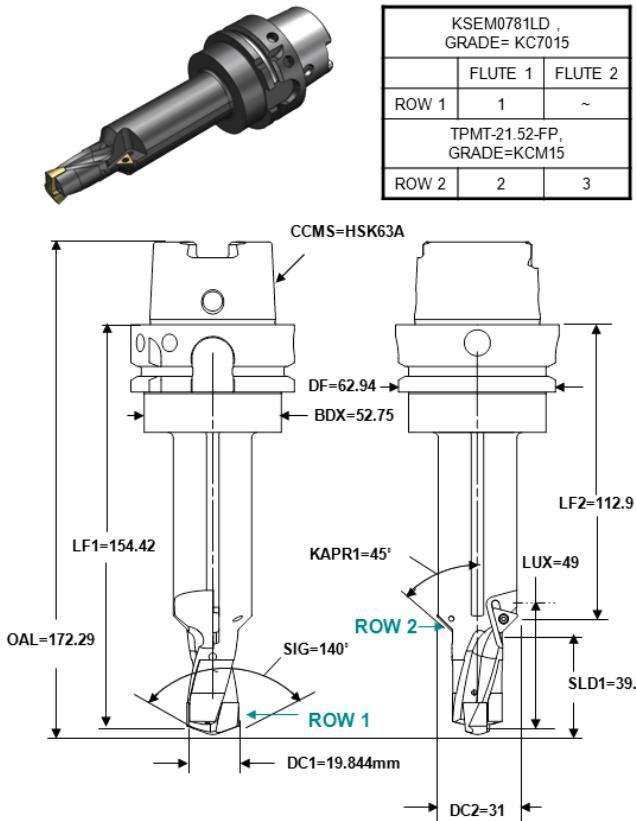


Figure 37: Step Drill with Explicate Loci

Example 4: Example for Step Drill with Explicate Loci

```

758 1 <?xml version="1.0" encoding="UTF-8"?>
759 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
760 3   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
761 4   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
762 5   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
763 6   http://mtconnect.org/schemas/MTConnectAssets\1.2.xsd">
764 7   <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
765 8     sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
766 9   <Assets>
767 10    <CuttingTool serialNumber="1" toolId="KSEM0781LD"
768 11      timestamp="2011-05-11T13:55:22" assetId="KSEM0781LD.1" manufacturers="KMT">
769 12      <CuttingToolLifeCycle>
770 13        <CutterStatus><Status>NEW</Status></CutterStatus>
771 14        <ConnectionCodeMachineSide>HSK63A</ConnectionCodeMachineSide>
772 15        <Measurements>
773 16          <BodyDiameterMax code="BDX">52.75</BodyDiameterMax>
774 17          <OverallToolLength nominal="172.29"

```

```

775 18      code="OAL">172.29</OverallToolLength>
776 19      <UsableLengthMax code="LUX" nominal="49">49</UsableLengthMax>
777 20      <FlangeDiameterMax code="DF"
778 21          nominal="62.94">62.94</FlangeDiameterMax>
779 22      </Measurements>
780 23      <CuttingItems count="3">
781 24          <CuttingItem indices="1" itemId="KSEM0781LD" manufacturers="KMT"
782 25              grade="KC7015">
783 26              <Locus>FLUTE: 1, ROW: 1</Locus>
784 27              <Measurements>
785 28                  <FunctionalLength code="LF1" nominal="154.42">154.42</FunctionalLength>
786 29                  <CuttingDiameter code="DC1" nominal="19.844">19.844</CuttingDiameter>
787 30                  <PointAngle code="SIG" nominal="140">140</PointAngle>
788 31                  <ToolCuttingEdgeAngle code="KAPR1" nominal="45">45</ToolCuttingEdgeAngle>
789 32                  <StepDiameterLength code="SLD1" nominal="39.8">39.8</StepDiameterLength>
790 33          </Measurements>
791 34      </CuttingItem>
792 35      <CuttingItem indices="2-3" itemId="TPMT-21.52-FP"
793 36          manufacturers="KMT" grade="KCM15">
794 37          <Locus>FLUTE: 1-2, ROW: 2</Locus>
795 38          <Measurements>
796 39              <FunctionalLength code="LF2" nominal="112.9">119.2</FunctionalLength>
797 40              <CuttingDiameter code="DC2" nominal="31">31</CuttingDiameter>
798 41          </Measurements>
799 42      </CuttingItem>
800 43  </CuttingItems>
801 44      </CuttingToolLifeCycle>
802 45  </CuttingTool>
803 46  </Assets>
804 47  </MTConnectAssets>

```

805 C.5 Shell Mill with Different Inserts on First Row

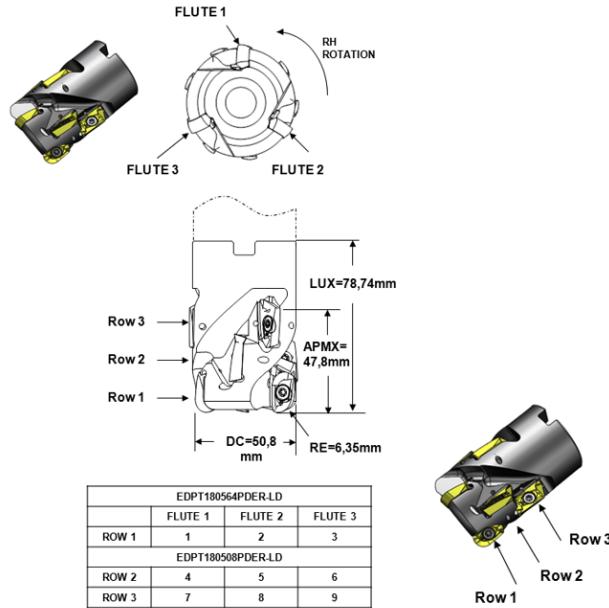


Figure 38: Shell Mill with Different Inserts on First Row

Example 5: Example for Shell Mill with Different Inserts on First Row

```

806 1 <?xml version="1.0" encoding="UTF-8"?>
807 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
808 3   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
809 4   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
810 5   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
811 6   http://mtconnect.org/schemas/MTConnectAssets\1.2.xsd">
812 7   <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
813 8     sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
814 9   <Assets>
815 10    <CuttingTool serialNumber="1" toolId="XXX" timestamp="2011-05-11T13:55:22"
816 11      assetId="XXX.1" manufacturers="KMT">
817 12        <CuttingToolLifeCycle>
818 13          <CutterStatus><Status>NEW</Status></CutterStatus>
819 14          <Measurements>
820 15            <DepthOfCutMax code="APMX" nominal="47.8">47.8</DepthOfCutMax>
821 16            <CuttingDiameterMax code="DC"
822 17              nominal="50.8">50.8</CuttingDiameterMax>
823 18            <UsableLengthMax code="LUX"
824 19              nominal="78.74">78.74</UsableLengthMax>
825 20          </Measurements>
826 21          <CuttingItems count="9">
827 22            <CuttingItem indices="1-3" itemId="EDPT180564PDER-LD"
828 23              manufacturers="KMT">
829 24              <Locus>FLUTE: 1-3, ROW: 1</Locus>

```

```
830 25      <Measurements>
831 26          <CornerRadius code="RE" nominal="6.25">6.35</CornerRadius>
832 27      </Measurements>
833 28  </CuttingItem>
834 29      <CuttingItem indices="4-9" itemId="EDPT180508PDER-LD"
835 30          manufacturers="KMT">
836 31              <Locus>FLANGE: 1-4, ROW: 2-3</Locus>
837 32          </CuttingItem>
838 33      </CuttingItems>
839 34  </CuttingToolLifeCycle>
840 35      </CuttingTool>
841 36  </Assets>
842 37 </MTConnectAssets>
```