MTConnect® Standard
Part 4.1 – Cutting Tools

Version 1.4.0

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MTConnect® Specification and Materials

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1 Purpose of This Document

1

2 This document, *Part 4.1 – Cutting Tools* of the MTConnect® Standard, establishes the rules and
3 terminology to be used by designers to describe the function and operation of Cutting Tools used
4 within manufacturing and to define the data that is provided by an *MTConnect Agent* from a
5 piece of equipment. This part of the Standard also defines the structure for the XML document
6 that is returned from an *MTConnect Agent* in response to a `Probe` request.

7 The data associated with these Cutting Tools will be retrieved from multiple sources that are
8 responsible for providing their knowledge of an *MTConnect Asset*.

9

2 Terminology and Conventions

Refer to *Section 2* of *Part 1 - Overview and Functionality* for a dictionary of terms, reserved language, and document conventions used in the MTConnect Standard.

3 Cutting Tool and Cutting Tool Archetype

13

14 There are two *Information Models* used to represent a Cutting Tool, a
15 `CuttingToolArchetype` and a `CuttingTool`. The `CuttingToolArchetype`
16 represent the static Cutting Tool geometries and nominal values as one would expect from a tool
17 catalog and the `CuttingTool` represents the use or application of the tool on the shop floor
18 with actual measured values and process data. In Version 1.3.0 of the MTConnect Standard it
19 was decided to separate out these two concerns since not all pieces of equipment will have access
20 to both pieces of information. In this way, a generic definition of the Cutting Tool can coexist
21 with a specific assembly information model with minimal redundancy of data.

22

3.1 XML Schema Structure for `CuttingTool` and `CuttingToolArchetype`

The following figure shows the XML schema that applies to both the `CuttingTool` *Information Model* and the `CuttingToolArchetype` *Information Model*.
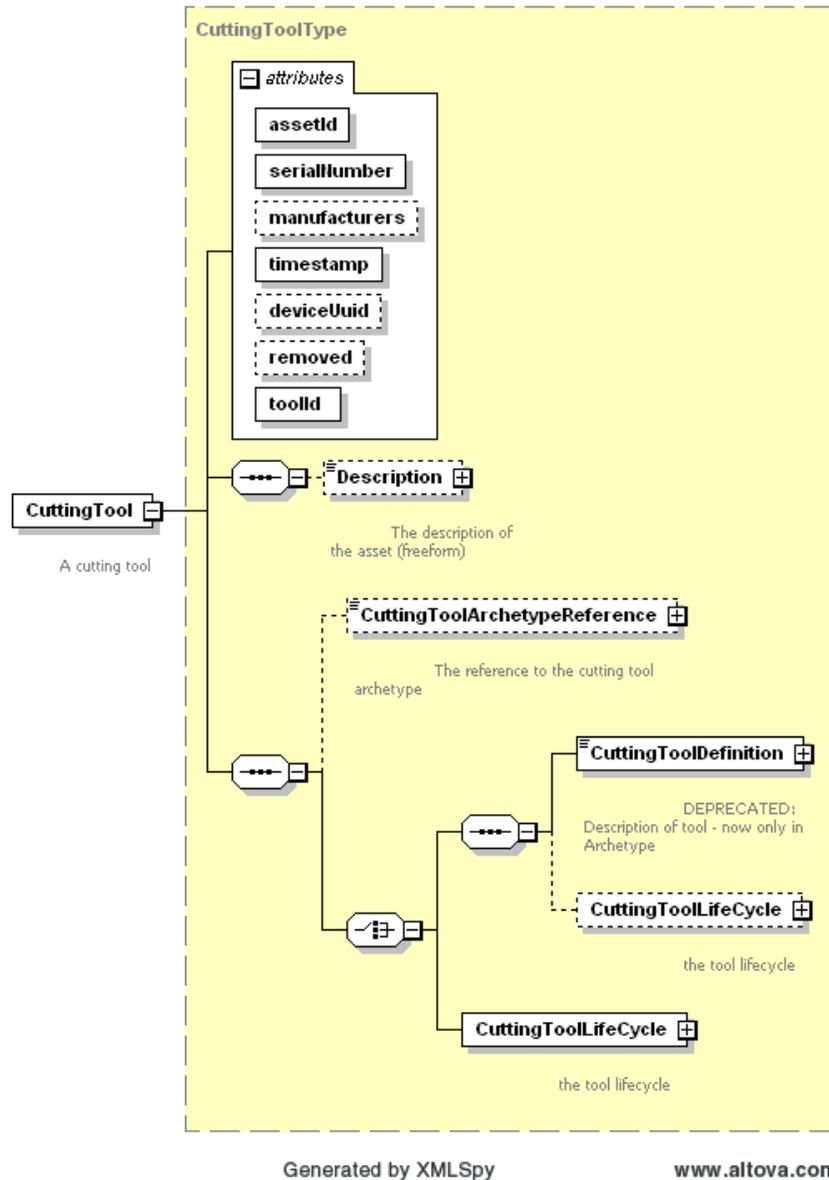
Figure 1: `CuttingTool` Schema

Note: The use of the XML element `CuttingToolDefinition` has been **DEPRECATED** in the `CuttingTool` schema, but remains in the `CuttingToolArchetype` schema.

34   The following sections contain the definitions of `CuttingTool` and
35   `CuttingToolArchetype` and describe their unique components. The following are the
36   common entities for both elements.

37   3.2   Common Attributes for `CuttingTool` and `CuttingToolArchetype`

Attribute	Description	Occurrence
timestamp	The time this *MTConnect Asset* was last modified. Always given in UTC. The timestamp **MUST** be provided in UTC (Universal Time Coordinate, also known as GMT). This is the time the *Asset* data was last modified. `timestamp` is a required attribute.	1
assetId	The unique identifier of the instance of this tool. This will be the same as the `toolId` and `serialNumber` in most cases. The `assetId` **SHOULD** be the combination of the `toolId` and `serialNumber` as in `toolId.serialNumber` or an equivalent implementation dependent identification scheme. `assetId` is a required attribute. `assetId` is a permanent identifier that will be associated with an *MTConnect Asset* for its entire life.	1
serialNumber	The unique identifier for this assembly. This is defined as an XML string type and is implementation dependent. `serialNumber` is a required attribute.	1
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	The piece of equipment UUID that supplied this data. This optional element references to the UUID attribute given in the `Device` element. This can be any series of numbers and letters as defined by the XML type NMTOKEN.	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

Attribute	Description	Occurrence
removed	This is an indicator that the Cutting Tool has been removed from the piece of equipment. removed is an optional attribute. If the *MTConnect Asset* 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

38

3.3 Common Elements for `CuttingTool` and `CuttingToolArchetype`

40

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 the MTConnect Standard.	0..1

41

3.3.1 `Description` Element for `CuttingTool` and `CuttingToolArchetype`

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

4 `CuttingToolArchetype` *Information Model*

48 The `CuttingToolArchetype` *Information Model* will have the identical structure as the
49 `CuttingTool` *Information Model* illustrated in *Figure 1*, except for a few entities. The
50 `CuttingTool` will no longer carry the `CuttingToolDefinition`, this **MUST** only
51 appear in the `CuttingToolArchetype`. The `CuttingToolArchetype` **MUST NOT**
52 have measured values and **MUST NOT** have any of the following items: `CutterStatus`,
53 `ToolLife` values, `Location`, or a `ReconditionCount`.

54 MTConnect Standard will adopt the ISO 13399 structure when formulating the vocabulary for
55 Cutting Tool geometries and structure to be represented in the `CuttingToolArchetype`.
56 The nominal values provided in the `CuttingToolLifeCycle` section are only concerned
57 with two aspects of the Cutting Tool, the Cutting Tool and the Cutting Item. The Tool Item,
58 Adaptive Item, and Assembly Item will only be covered in the `CuttingToolDefinition`
59 section of this document since this section contains the full ISO 13399 information about a
60 Cutting Tool.
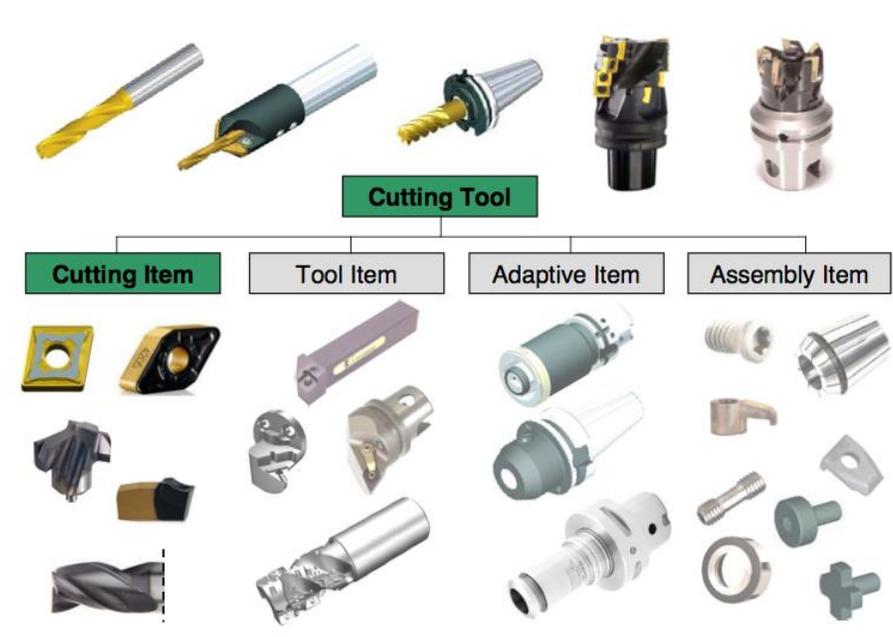
61

62 **Figure 2: Cutting Tool Parts**

63

64

65 The previous diagram illustrates the parts of a Cutting Tool. The Cutting Tool is the aggregate of
66 all the components and the Cutting Item is the part of the tool that removes the material from the
67 workpiece. These are the primary focus of the MTConnect Standard.

68
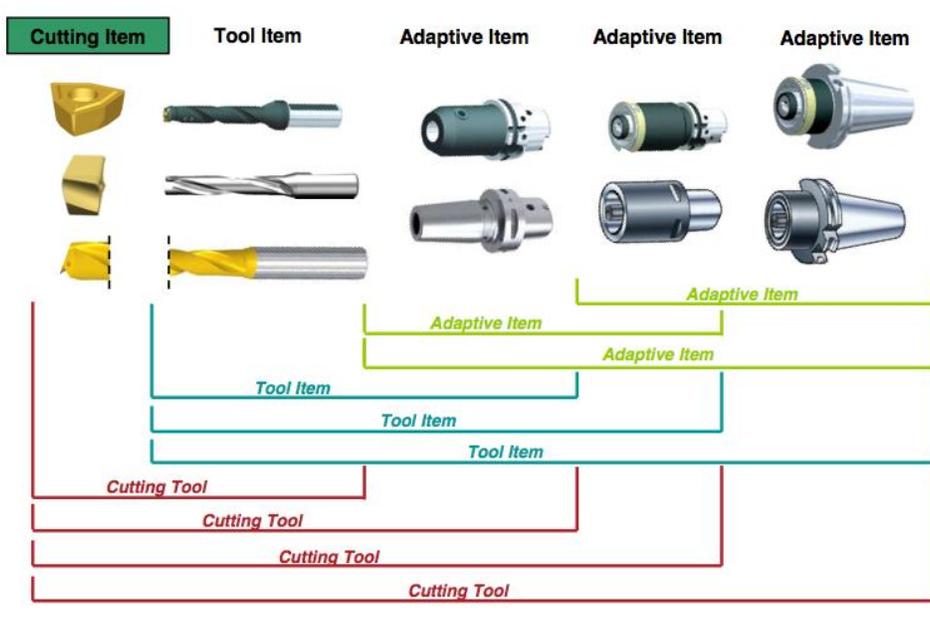
69 **Figure 3: Cutting Tool Composition**

70

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

76

77 *Figures 4* and *5* further illustrates the components of the Cutting Tool. As we compose the Tool
78 Item, Cutting Item, Adaptive Item, we get a Cutting Tool. The Tool Item, Adaptive Item, and
79 Assembly Item will only be in the `CuttingToolDefinition` section that will contain the
80 full ISO 13399 information.

81
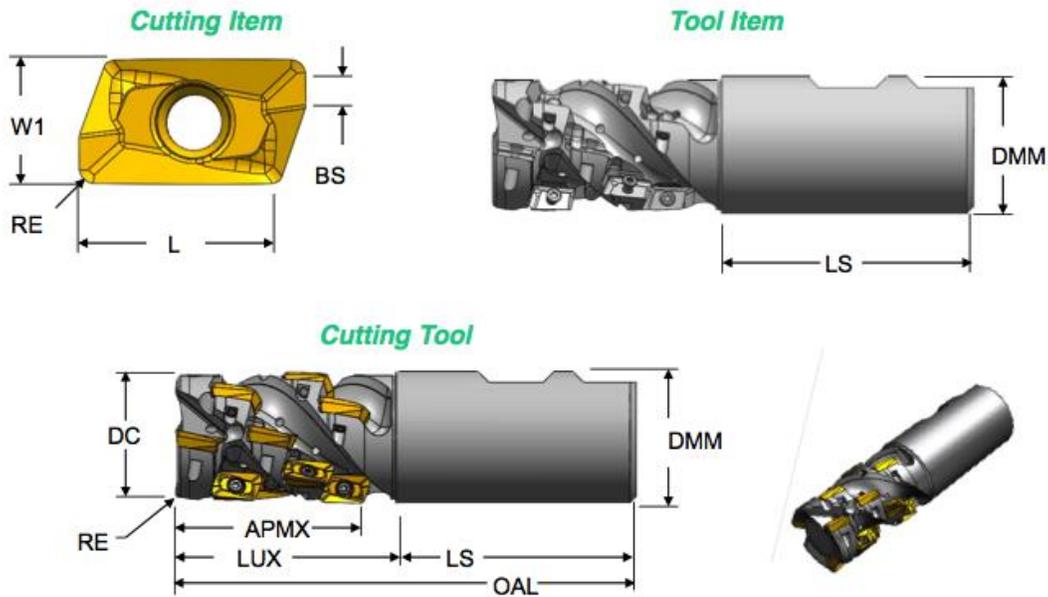
82   **Figure 4: Cutting Tool, Tool Item and Cutting Item**

83
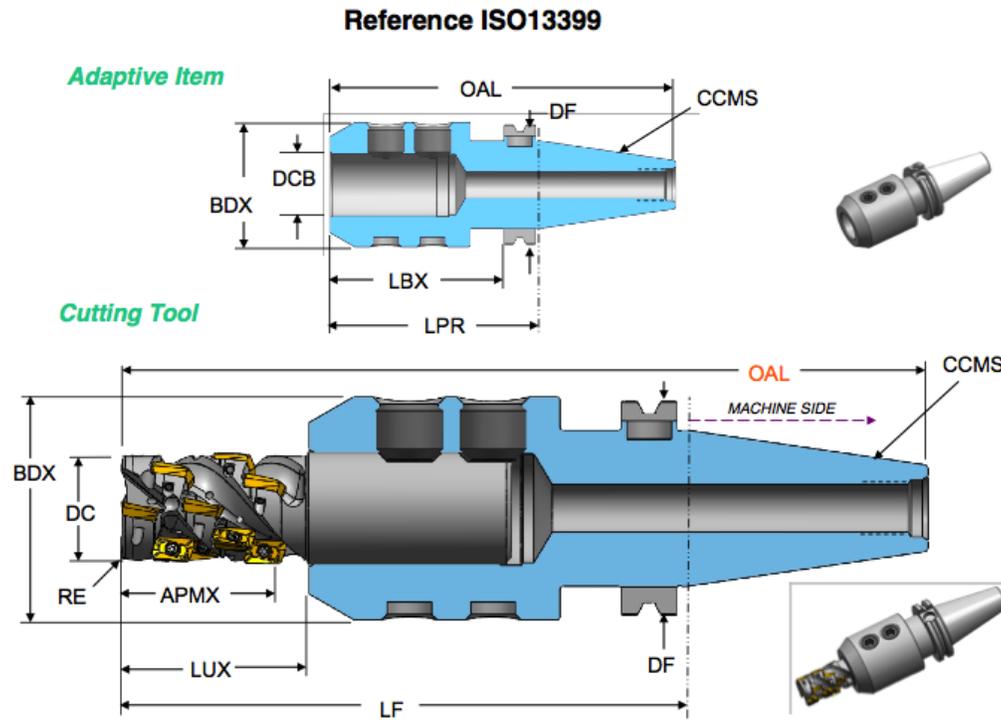
Figure 5: Cutting Tool, Tool Item and Cutting Item

The above diagrams use the ISO 13399 codes for each of the measurements. These codes will be translated into the MTConnect Standard vocabulary as illustrated below. The measurements will have a maximum, minimum, and nominal value representing the tolerance of allowable values for this dimension. See below for a full discussion.

92
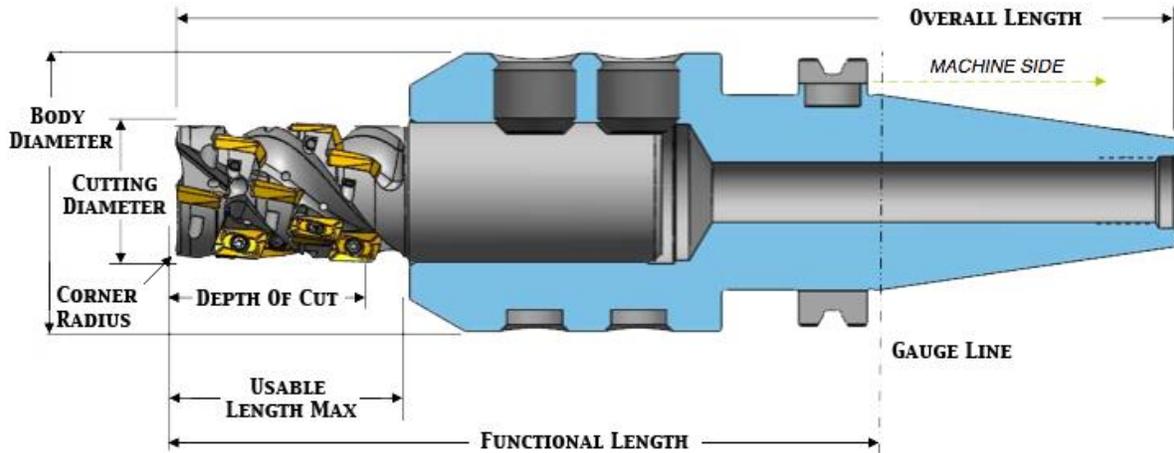
Figure 6: Cutting Tool Measurements

94 The MTConnect Standard will not define the entire geometry of the Cutting Tool, but will
95 provide the information necessary to use the tool in the manufacturing process. Additional
96 information can be added to the definition of the Cutting Tool by means of schema extensions.

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

100
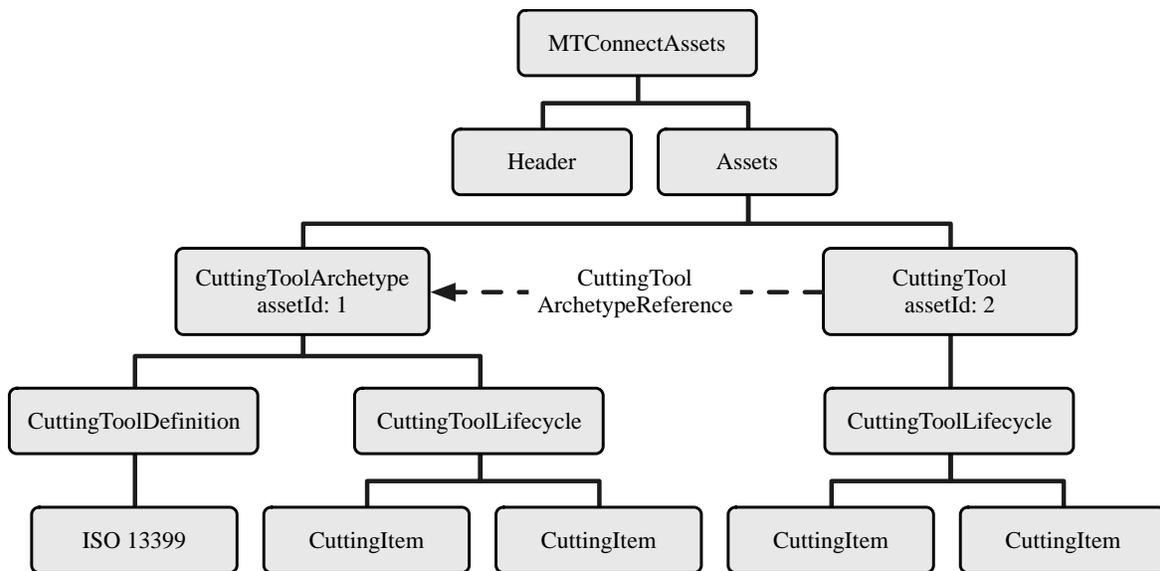
Figure 7: Cutting Tool Asset Structure

102

103

104 The structure of the `MTConnectAssets` header is defined in *Part 1 - Overview and*
105 *Fundamentals* of the Standard. A finite number of *MTConnect Assets* will be stored in the
106 M*TConnect Agent*. This finite number is implementation specific and will depend on memory
107 and storage constraints. The standard will not prescribe the number or capacity requirements for
108 an implementation.

4.1 Attributes for `CuttingToolArchetype`

110 Refer to *Section 3.2* for a full description of the attributes for `CuttingToolArchetype`
111 *Information Model*.

4.2 Elements for `CuttingToolArchetype`

113 The elements associated with `CuttingToolArchetype` are given below. Each element will
114 be described in more detail below and any possible values will be presented with full definitions.
115 The elements **MUST** be provided in the following order as prescribed by XML. At least one of
116 `CuttingToolDefinition` or `CuttingToolLifeCycle` **MUST** be supplied.

117

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

118

119

120 **4.2.1 CuttingToolDefinition Element for**
121 **CuttingToolArchetype**

122

123
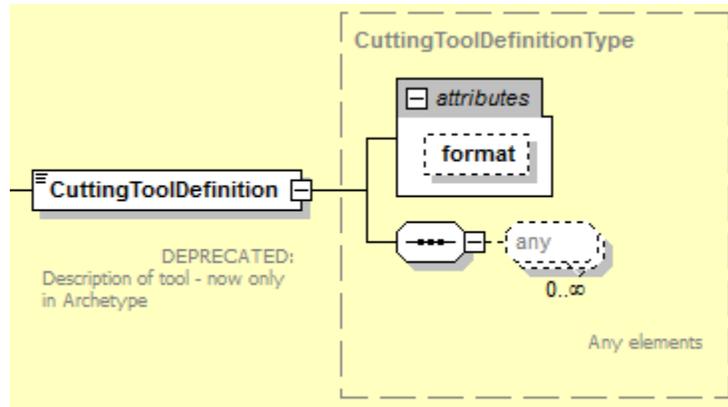
Figure 8: CuttingToolDefinition Schema

125

126 The CuttingToolDefinition contains the detailed structure of the Cutting Tool. The
127 information contained in this element will be static during its lifecycle. Currently we are
128 referring to the external ISO 13399 standard to provide the complete definition and composition
129 of the Cutting Tool as defined in *Section 6.1* of this document.

130 **4.2.1.1 Attributes for CuttingToolDefinition**

131

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

132

133

134 #### 4.2.1.1.1 `format` Attribute for `CuttingToolDefinition`

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

Value	Description
`XML`	The default value for the definition. The content will be an XML document.
`EXPRESS`	The document will confirm 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.

137

138 ### 4.2.1.2 Elements for `CuttingToolDefinition`

139 The only acceptable Cutting Tool definition at present is defined by the ISO 13399 standard.
140 Additional formats **MAY** be considered in the future.

141 ### 4.2.1.3 ISO 13399 Standard

142 The ISO 13399 data **MUST** be presented in either XML (ISO 10303-28) or EXPRESS format
143 (ISO 10303-21). An XML schema will be preferred as this will allow for easier integration with
144 the MTConnect Standard XML tools. EXPRESS will also be supported, but software tools will
145 need to be provided or made available for handling this data representation.

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

148 ## 4.2.2 `CuttingToolLifeCycle` Element for `CuttingToolArchetype`

149 Refer to *Section 6 – Common Entity `CuttingToolLifeCycle`* for a complete description of
150 `CuttingToolLifeCycle` element.

5 `CuttingTool` *Information Model*

The `CuttingTool` *Information Model* illustrated in *Figure 1* has the identical structure as the `CuttingToolArchetype` *Information Model* except for the XML element `CuttingToolDefinition` that has been **DEPRECATED** in the `CuttingTool` schema.

5.1 Attributes for `CuttingTool`

Refer to *Section 3.2* for a full description of the attributes for `CuttingTool` *Information Model*.

5.2 Elements for `CuttingTool`

The elements associated with `CuttingTool` are given below. The elements **MUST** be provided in the following order as prescribed by XML.

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~~
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

5.2.1 `CuttingToolLifeCycle` Elements for `CuttingTool` Only

The following `CuttingToolLifeCycle` elements are used only in the `CuttingTool` *Information Model* and are not part of the `CuttingToolArchetype` *Information Model*. Refer to *Section 6* for a complete description of the remaining elements for `CuttingToolLifeCycle` that are common in both *Information Models*. Refer also to the `CuttingToolLifeCycle` schema illustrated in *Figure 12*.

169 **5.2.1.1** **CutterStatus Element for CuttingToolLifeCycle**

170
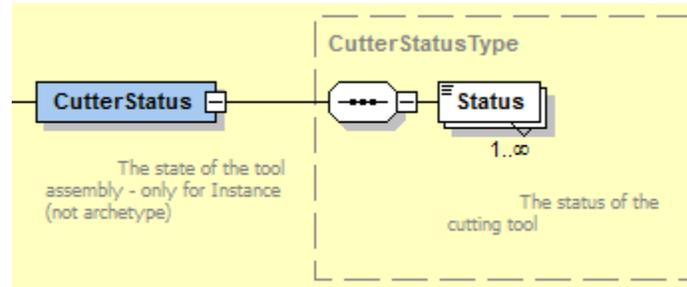
172 **Figure 9: CutterStatus Schema**

173 The elements of the CutterStatus element can be a combined set of Status elements. The
174 MTConnect Standard allows any set of statuses to be combined, but only certain combinations
175 make sense. A Cutting Tool **SHOULD** not be both NEW and USED at the same time. There are
176 no rules in the schema to enforce this, but this is left to the implementer. The following
177 combinations **MUST NOT** occur:

178 • NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.
179 • UNKNOWN **MUST NOT** be used with any other status.
180 • ALLOCATED and UNALLOCATED **MUST NOT** be used together.
181 • AVAILABLE and UNAVAILABLE **MUST NOT** be used together.
182 • If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be
183   AVAILABLE.
184 • All other combinations are allowed.

185

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

186

187 **5.2.1.1.1** **Status Element for CutterStatus**

188 One of the values for the status of the Cutting Tool.

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.

Value	Description
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.
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.

189

190 **5.2.1.2 `ToolLife` Element for `CuttingToolLifeCycle`**

191
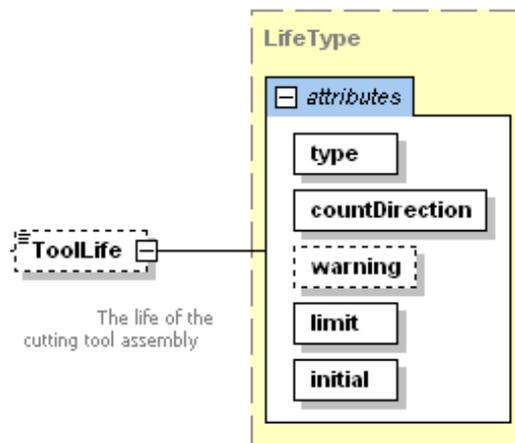
192

193 **Figure 10: `ToolLife` Schema**

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

198 **5.2.1.2.1   Attributes for `ToolLife`**

199 `ToolLife` has the following attributes that can be used to indicate the behavior of the tool life
200 management mechanism.

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 a required attribute.	0..1
initial	The initial life of the tool when it is new. `initial` is a required attribute.	0..1

201

202 **5.2.1.2.2   `type` Attribute for `ToolLife`**

203 The value of `type` must be one of the following:

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.

Value	Description
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.

204

5.2.1.2.3   `countDirection` Attribute for `ToolLife`

206   The value of `type` must be one of the following:

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

207

5.2.1.3 `Location` Element for `CuttingToolLifeCycle`

209

210
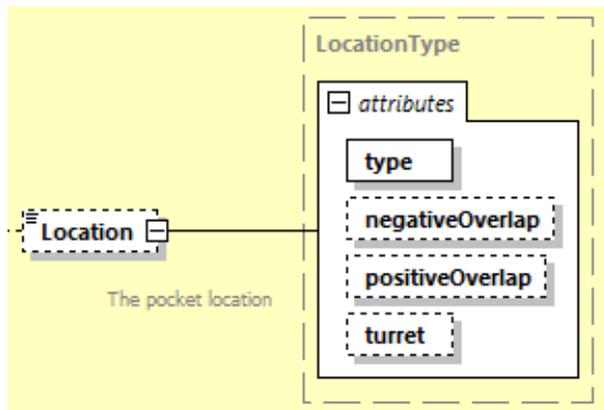
Figure 11: `Location` Schema

212

213   `Location` element identifies the specific location where a tool resides in a piece of equipment
214   tool storage or in a tool crib. This can be any series of numbers and letters as defined by the
215   XML type NMTOKEN. When a POT or STATION type is used, the value **MUST** be a numeric
216   value. If a `negativeOverlap` or the `positiveOverlap` is provided, the tool reserves
217   additional locations on either side, otherwise if they are not given, no additional locations are
218   required for this tool. If the pot occupies the first or last location, a rollover to the beginning or
219   the end of the index-able values may occur. For example, if there are 64 pots and the tool is in
220   pot 64 with a `positiveOverlap` of 1, the first pot **MAY** be occupied as well.

221 **5.2.1.3.1 Attributes for `Location`**

222

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 an optional attribute.	0..1
negativeOverlap	The number of location at lower index values from this location. negativeOverlap is an optional attribute.	0..1

223

224 **5.2.1.3.2 `Type` Attribute for `Location`**

225 The type of location being identified.

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.

226

227 **5.2.1.3.3 `positiveOverlap` Attribute for `Location`**

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

230 **5.2.1.3.4 `negativeOverlap` Attribute for `Location`**

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

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

235

236 **5.2.1.4 ReconditionCount Element for CuttingToolLifeCycle**

237
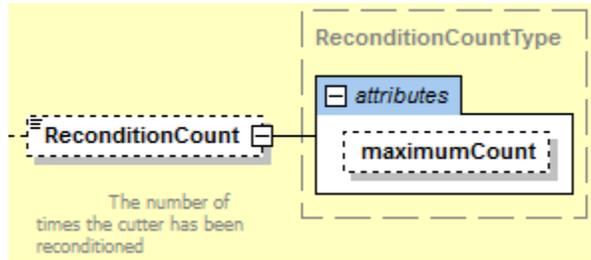
238

239 **Figure 12: ReconditionCount Schema**

240

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

243 **5.2.1.4.1 Attributes for ReconditionCount**

244

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

245

246 **5.2.2 CuttingToolArchetypeReference Element for**
247 **CuttingTool**

248

249 Generated by XMLSpy   www.altova.com

250 **Figure 13: CuttingToolArchetypeReference Schema**

251

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

256 **5.2.2.1 Source Attribute for `CuttingToolArchetypeReference`**

257

Attribute	Description	Occurrence
Source	The URL of the `CuttingToolArchetype` *Information Model*. This **MUST** be a fully qualified URL as in http://example.com/asset/A213155	0..1

258

6 Common Entity `CuttingToolLifeCycle`

6.1 `CuttingToolLifeCycle`

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

The `CuttingToolLifeCycle` contains data for the entire tool assembly. The specific Cutting Items that are part of the `CuttingToolLifeCycle` are contained in the `CuttingItems` element. Each Cutting Item has similar properties as the assembly; identity, properties, and measurements.

The units for all measurements have been predefined in the MTConnect Standard and will be consistent with *Part 2 – Devices Information Model* and *Part 3 – Streams Information Model* of the Standard. This means that all lengths and distances will be given in millimeters and all angular measures will be given in degrees. Quantities like `ProcessSpindleSpeed` will be given in RPM, the same as the `RotaryVelocity` in *Part 3 – Streams Information Model*.

277 6.1.1 XML Schema Structure for `CuttingToolLifeCycle`

278 The `CuttingToolLifeCycle` schema shown in *Figure 12* is used in both the
279 `CuttingToolArchetype` and `CuttingTool` *Information Models*. The only difference is
280 that the elements `CutterStatus`, `ToolLife`, `Location`, and `ReconditionCount` are
281 used only in the `CuttingTool` *Information Model*.
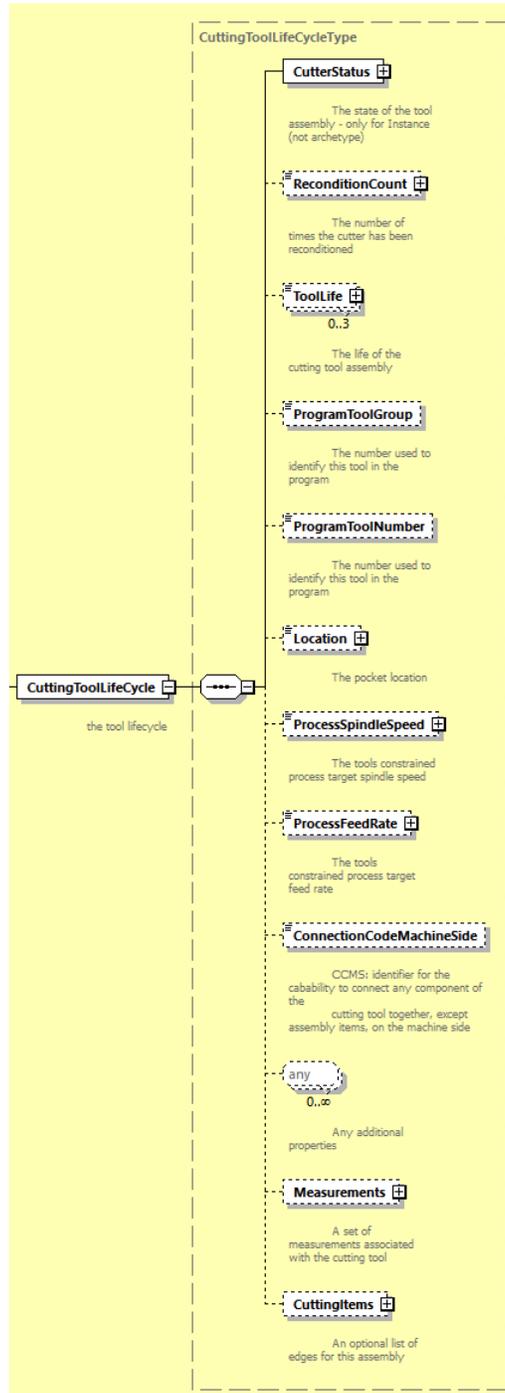
282

283 **Figure 14: `CuttingToolLifeCycle` Schema**

284 **6.2 Elements for `CuttingToolLifeCycle`**

285 The elements associated with this Cutting Tool are given below. Each element will be described
286 in more detail below and any possible values will be presented with full definitions. The
287 elements **MUST** be provided in the following order as prescribed by XML.

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

288

289   **6.2.1**   `ProgramToolGroup` **Element for** `CuttingToolLifeCycle`

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

292   **6.2.2**   `ProgramToolNumber` **Element for** `CuttingToolLifeCycle`

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

295   **6.2.3**   `ProcessSpindleSpeed` **Element for** `CuttingToolLifeCycle`
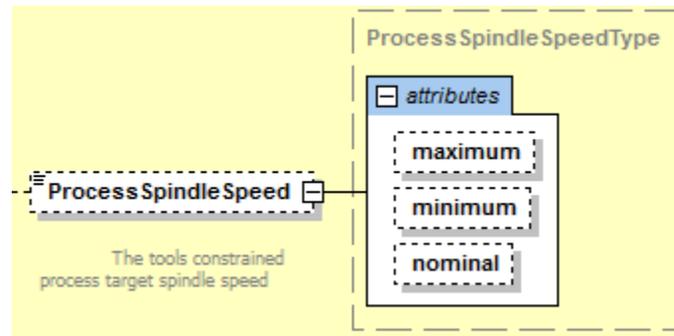
297   **Figure 15: `ProcessSpindleSpeed` Schema**

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

303   **6.2.3.1   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 an optional attribute.	0..1
`nominal`	The nominal speed the tool is designed to operate at. `nominal` is an optional attribute.	0..1

307 ## 6.2.4 **`ProcessFeedRate`** Element for **`CuttingToolLifeCycle`**

308
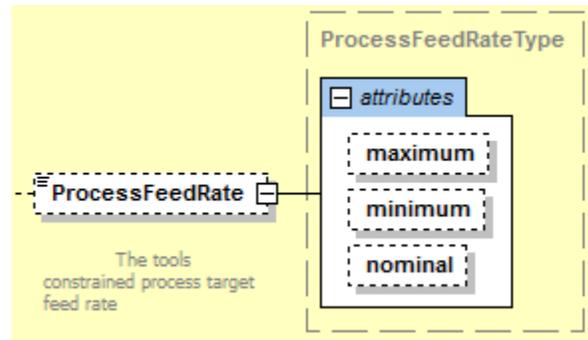
310 **Figure 16: `ProcessFeedRate` Schema**

311

312 The `ProcessFeedRate` **MUST** be specified in millimeters/second (mm/s). The CDATA
313 **MAY** contain the nominal process target feed rate if available. The maximum and minimum
314 rates **MAY** be provided as attributes. If `ProcessFeedRate` is provided, at least one value of
315 `maximum`, `nominal`, or `minimum` **MUST** be specified.

316 ### 6.2.4.1 Attributes for **`ProcessFeedRate`**

317

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

318

319 ## 6.2.5 **`ConnectionCodeMachineSide`** Element for
320 **`CuttingToolLifeCycle`**

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

324 6.2.6 `xs:any` Element for `CuttingToolLifeCycle`

325 Utilizing the new capability in XMLSchema 1.1, we are now able to add extension points where
326 an additional element can be added to the document without being part of a substitution group.
327 The new elements have the restriction that they **MUST NOT** be part of the MTConnect
328 namespace and **MUST NOT** be one of the predefined elements mentioned above.

329 This will allow users to add additional properties to the Cutting Tool without having to change
330 the definition of the Cutting Tool or modify the standard. We will begin making use of this
331 capability in Version 1.3 of MTConnect Standard which will necessitate upgrading to Version 1.1
332 of XMLSchema.

333 6.2.7 `Measurements` Element for `CuttingToolLifeCycle`

334 The `Measurements` element is a collection of one or more constrained scalar values associated
335 with this Cutting Tool. The contents **MUST** be a subtype of `CommonMeasurement` or
336 `AssemblyMeasurement`. The following section will define the abstract `Measurement`
337 type used in both `CuttingToolLifeCycle` and `CuttingItem`. This section will then
338 describe the `AssemblyMeasurement` types. The `CuttingItemMeasurement` types will
339 be described at the end of the `CuttingItem` section.

340 A measurement is specific to a process and a machine tool at a particular shop. The tool zero
341 reference point or gauge line will be different depending on the particular implementation and
342 will be assumed to be consistent within the shop. MTConnect Standard does not standardize the
343 manufacturing process or the definition of the zero point.

344 6.2.8 `Measurement`
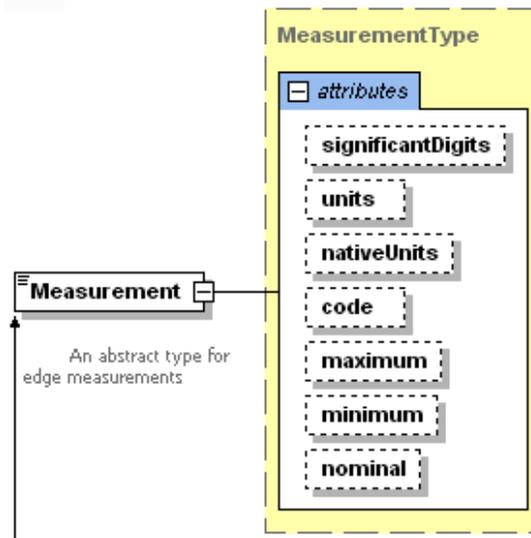
345

346 **Figure 17: `Measurement` Schema**

347

348 A measurement **MUST** be a scalar floating-point value that **MAY** be constrained to a maximum
349 and minimum value. Since the `CuttingToolLifeCycle`'s main responsibility is to track
350 aspects of the tool that change over its use in the shop, MTConnect represents the current value
351 of the measurement **MUST** be in the `CDATA` (text between the start and end element) as the most
352 current valid value.

353 The `minimum` and `maximum` **MAY** be supplied if they are known or relevant to the
354 measurement. A `nominal` value **MAY** be provided to show the reference value for this
355 measurement.

356 There are three subtypes of `Measurement`: `CommonMeasurement`,
357 `AssemblyMeasurement`, and `CuttingItemMeasurement`. These abstract types
358 **MUST NOT** appear in an `MTConnectAssets` document, but are used in the schema as a way
359 to separate which measurements **MAY** appear in the different sections of the document. Only
360 subtypes that have extended these types **MAY** appear in the `MTConnectAssets` XML.

361 Measurements in the `CuttingToolLifeCycle` section **MUST** refer to the entire assembly
362 and not to an individual Cutting Item. Cutting Item measurements **MUST** be located in the
363 measurements associated with the individual Cutting Item.

364 Measurements **MAY** provide an optional `units` attribute to reinforce the given units. The units
365 **MUST** always be given in the predefined MTConnect units. If `units` are provided, they are
366 only for documentation purposes. `nativeUnits` **MAY** optionally be provided to indicate the
367 original units provided for the measurements.

368 **6.2.8.1 Attributes for `Measurement`**
369

Attribute	Description	Occurrence
`code`	A shop specific code for this measurement. ISO 13399 codes **MAY** be used for these codes as well. `code` is an optional attribute.	0..1
`maximum`	The maximum value for this measurement. Exceeding this value would indicate the tool is not usable. `maximum` is an optional attribute.	0..1
`minimum`	The minimum value for this measurement. Exceeding this value would indicate the tool is not usable. `minimum` is an optional attribute.	0..1
`nominal`	The as advertised value for this measurement. `nominal` is an optional attribute.	0..1

Attribute	Description	Occurrence
significantDigits	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. significantDigits is an optional attribute.	0..1
units	The units for the measurements. MTConnect Standard defines all the units for each measurement, so this is mainly for documentation sake. See *MTConnect Part 2 – Devices Information Model Section 7.2.2.5* for the full list of units. units is an optional attribute.	0..1
nativeUnits	The units the measurement was originally recorded in. This is only necessary if they differ from units. See *MTConnect Part 2 – Devices Information Model Section 7.2.2.6* for the full list of units. nativeUnits is an optional attribute.	0..1

370

6.2.8.2 **Measurement** Subtypes for **CuttingToolLifeCycle**

372 These measurements for CuttingTool are specific to the entire assembly and **MUST NOT** be
373 used for the measurement pertaining to a CuttingItem. The following diagram will be used
374 to reference the assembly specific measurements.

375 The Code in the following table will refer to the acronyms in the diagrams. We will be referring
376 to many diagrams to disambiguate all measurements of the CuttingTool and
377 CuttingItem.

378
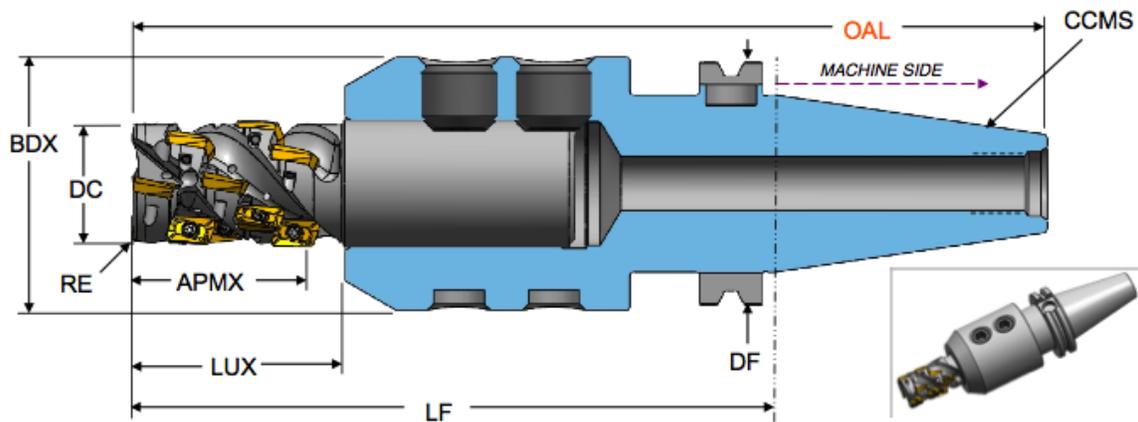
Figure 18: Cutting Tool Measurement Diagram 1
(Cutting Item, Tool Item, and Adaptive Item – ISO 13399)

381

382
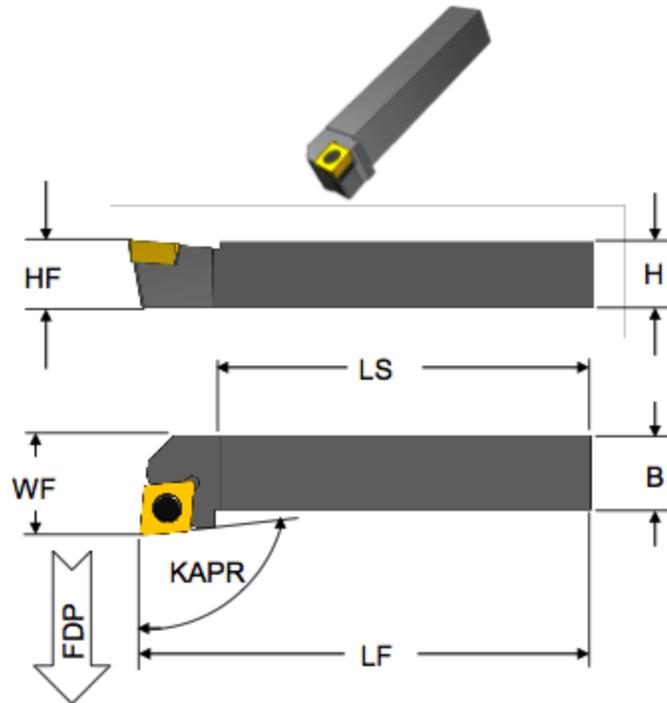
Figure 19: Cutting Tool Measurement Diagram 2
(Cutting Item, Tool Item, and Adaptive Item – ISO 13399)

Measurement	Code	Description	Units
BodyDiameterMax	BDX	The largest diameter of the body of a Tool Item.	mm
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.	mm
DepthOfCutMax	APMX	The maximum engagement of the cutting edge or edges with the workpiece measured perpendicular to the feed motion.	mm
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.	mm
FlangeDiameterMax	DF	The dimension between two parallel tangents on the outside edge of a flange.	mm

Measurement	Code	Description	Units
OverallToolLength	OAL	The largest length dimension of the Cutting Tool including the master insert where applicable.	mm
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.	mm
ShankHeight	H	The dimension of the height of the shank.	mm
ShankLength	LS	The dimension of the length of the shank.	mm
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.	mm
ProtrudingLength	LPR	The dimension from the yz-plane to the furthest point of the Tool Item or Adaptive Item measured in the -X direction.	mm
Weight	WT	The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.	grams
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.	mm

386

6.2.9 CuttingItems Element for CuttingToolLifeCycle

388
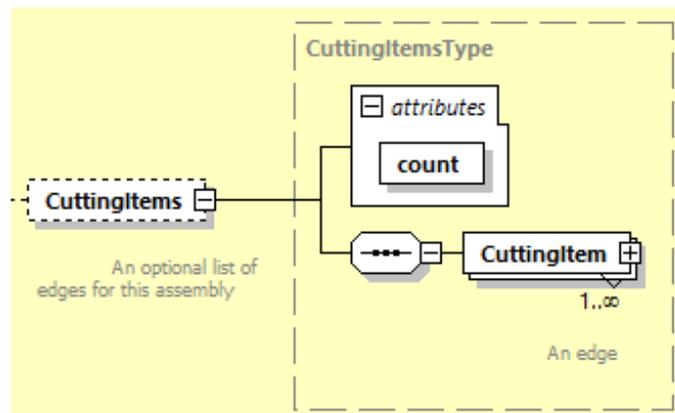
Figure 20: CuttingItems Schema

390

391 An optional collection of Cutting Items that **SHOULD** be provided for each independent edge or
392 insert. If the `CuttingItems` are not present; it indicates there is no specific information with
393 respect to each of the Cutting Items. This does not imply there are no Cutting Items – there
394 **MUST** be at least one Cutting Item – but there is no specific information.

395 **6.2.9.1 Attributes for `CuttingItems`**

396

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

397

6.2.10 `CuttingItem`

399 A Cutting Item is the portion of the tool that physically removes the material from the workpiece
400 by shear deformation. The Cutting Item can be either a single piece of material attached to the
401 Tool Item or it can be one or more separate pieces of material attached to the Tool Item using a
402 permanent or removable attachment. A Cutting Item can be comprised of one or more cutting
403 edges. Cutting Items include: replaceable inserts, brazed tips and the cutting portions of solid
404 Cutting Tools.

405

406 MTConnect Standard considers Cutting Items as part of the Cutting Tool. A Cutting Item **MUST**
407 **NOT** exist in MTConnect unless it is attached to a Cutting Tool. Some of the measurements,
408 such as `FunctionalLength`, **MUST** be made with reference to the entire Cutting Tool to be
409 meaningful.
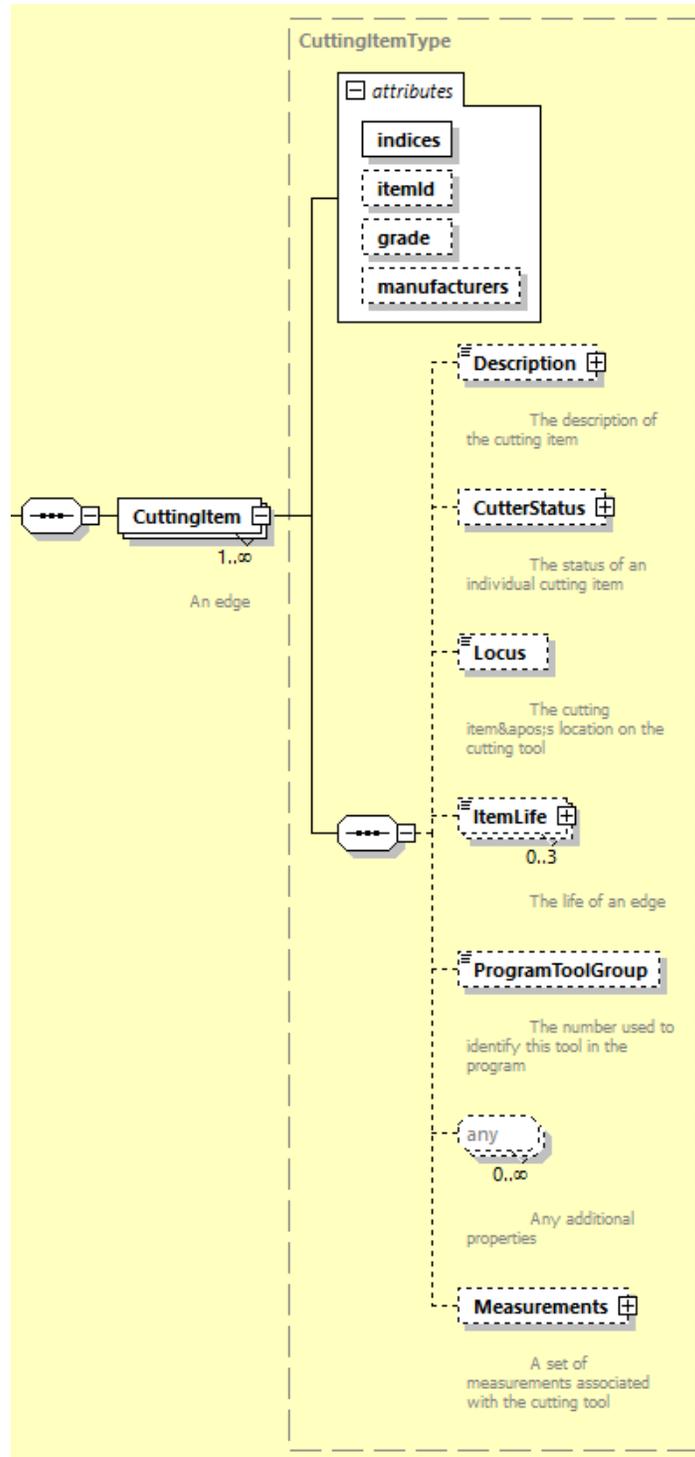
410

411 **Figure 21: `CuttingItem` Schema**

412 **6.2.10.1 Attributes for `CuttingItem`**

413

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. `manufacturers` is an optional attribute.	0..1
`grade`	The material composition for this Cutting Item. `grade` is an optional attribute.	0..1

414

415 **6.2.10.1.1 `Indices` Attribute for `CuttingItem`**

416 An identifier that indicates the Cutting Item or items these data are associated with. The value
417 **MUST** be a single number ("1") or a comma separated set of individual elements ("1,2,3,4"), or
418 as a inclusive range of values as in ("1-10") or any combination of ranges and numbers as in "1-
419 4,6-10,22". There **MUST NOT** be spaces or non-integer values in the text representation.

420 Indices **SHOULD** start numbering with the inserts or Cutting Item furthest from the gauge line
421 and increasing in value as the items get closer to the gauge line. Items at the same distance **MAY**
422 be arbitrarily numbered.

423 **6.2.10.1.2 `itemId` Attribute for `CuttingItem`**

424 The manufactures' identifier for this Cutting Item that **MAY** be its catalog or reference number.
425 The value **MUST** be an XML NMTOKEN value of numbers and letters.

426 **6.2.10.1.3 `manufacturers` Attribute for `CuttingItem`**

427 This optional element references the manufacturers of this tool. At this level the manufacturers
428 will reference the Cutting Item specifically. The representation will be a comma (`,`) delimited
429 list of manufacturer names. This can be any series of numbers and letters as defined by the XML
430 type `string`.

431 **6.2.10.1.4 `grade` Attribute for `CuttingItem`**

432 This provides an implementation specific designation for the material composition of this
433 Cutting Item.

434 **6.2.10.2 Elements for `CuttingItem`**

435

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

436

437 **6.2.10.2.1 `Description` Element for `CuttingItem`**

438 An optional free form text description of this Cutting Item.

439 **6.2.10.2.2 `Locus` Element for `CuttingItem`**

440 Locus represents the location of the Cutting Item with respect to the Cutting Tool. For clarity,
441 the words FLUTE, INSERT, and CARTRIDGE **SHOULD** be used to assist in noting the location
442 of a Cutting Item. The Locus **MAY** be any free form text, but **SHOULD** adhere to the following
443 rules:

444   1. The location numbering **SHOULD** start at the furthest Cutting Item (#1) and work it's
445   way back to the Cutting Item closest to the gauge line.

446   2. Flutes **SHOULD** be identified as such using the word FLUTE:. For example:
447   FLUTE: 1, INSERT: 2 - would indicate the first flute and the second furthest
448   insert from the end of the tool on that flute.

449   3. Other designations such as CARTRIDGE **MAY** be included, but should be identified
450   using upper case and followed by a colon (:).

451

452 **6.2.10.2.3 `ItemLife` Element for `CuttingItem`**

453

454
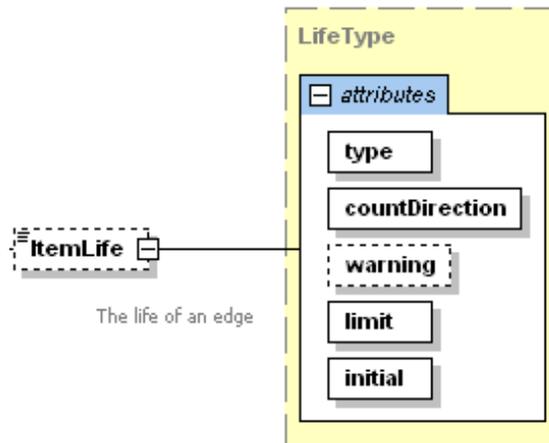
Figure 22: Item Life

456

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

461 **6.2.10.2.4   Attributes for `ItemLife`**

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

Attribute	Description	Occurrence
type	The type of tool life being accumulated. *Valid Data Values*: 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 values **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

Attribute	Description	Occurrence
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

463

6.2.10.2.5 `type` Attribute for `ItemLife`

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

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 supplied 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.

466

6.2.10.2.6 `countDirection` Attribute for `ItemLife`

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

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

469

6.2.10.3 `Measurement` Subtypes for `CuttingItem`

471 These measurements for CuttingItem are specific to an individual Cutting Item and **MUST**
472 **NOT** be used for the measurement pertaining to an assembly. The following diagram will be
473 used to for reference for the Cutting Item specific measurements.

474　The Code in the following table will refer to the acronym in the diagram. We will be referring to
475　many diagrams to disambiguate all measurements of the Cutting Tools and Items. We will
476　present a few here; please refer to *Appendix B* for additional reference material.

477
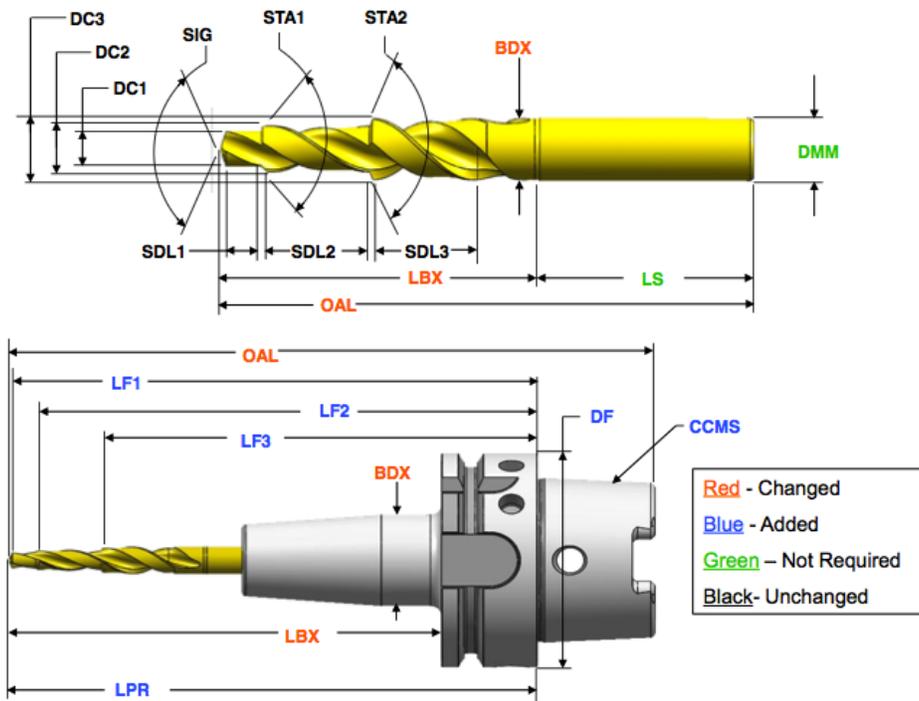
478　**Figure 23: Cutting Tool**

479
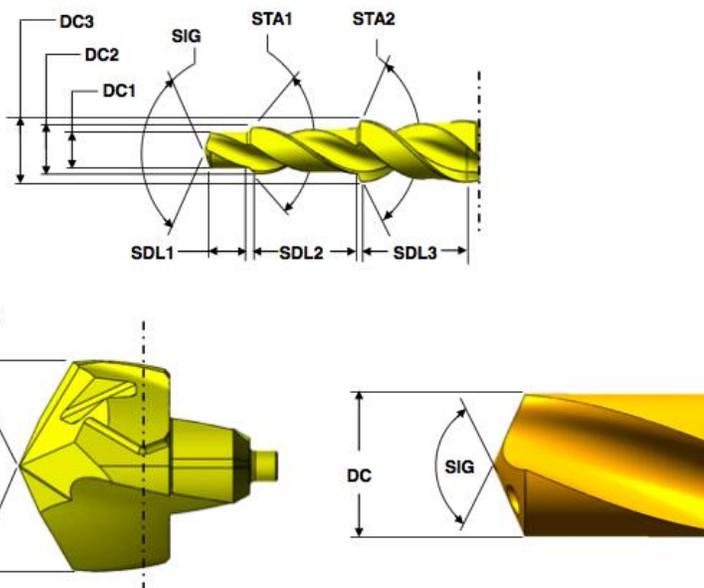
480

481　**Figure 24: Cutting Item**

482
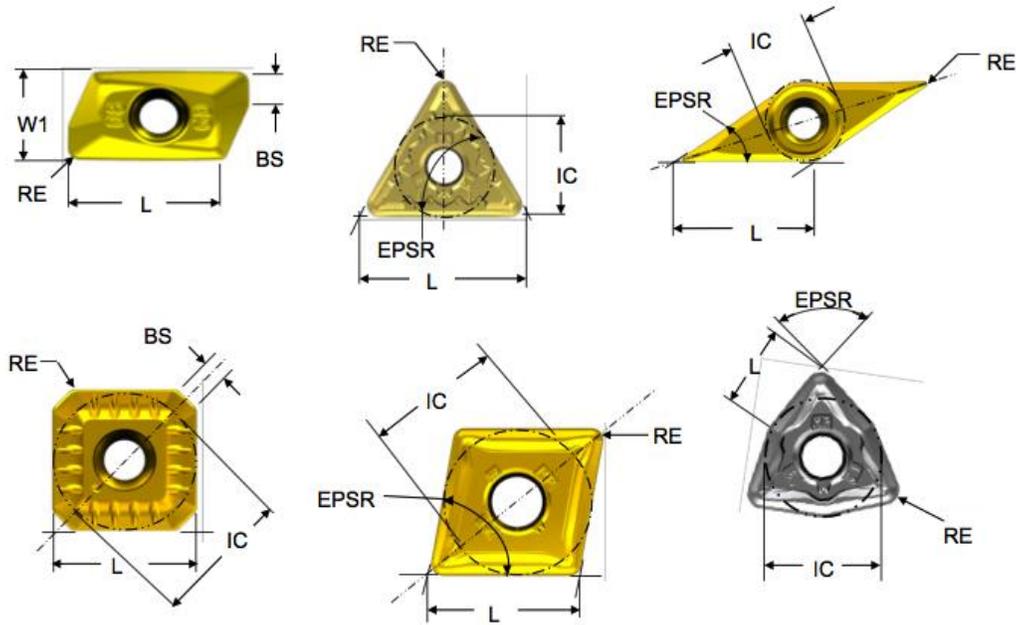
Figure 25: Cutting Item Measurement Diagram 3
(Cutting Item – ISO 13399)

485

486
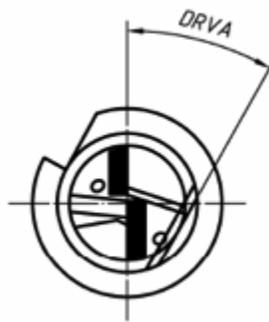
Figure 26: Cutting Item Drive Angle
(Cutting Item – ISO 13399)

489

490   The following `CuttingItem Measurements` will refer the diagram above.

491

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

Measurement Subtype	Code	Description	Units
CuttingEdgeLength	L	The theoretical length of the cutting edge of a Cutting Item over sharp corners.	mm
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.	mm
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.	mm
IncribedCircleDiameter	IC	The diameter of a circle to which all edges of a equilateral and round regular insert are tangential.	mm
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
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.	mm
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.	mm
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
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.	mm

Measurement Subtype	Code	Description	Units
CuttingHeight	HF	The distance from the basal plane of the Tool Item to the cutting point.	mm
CornerRadius	RE	The nominal radius of a rounded corner measured in the X Y-plane.	mm
Weight	WT	The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.	grams
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.	mm
ChamferFlatLength	BCH	The flat length of a chamfer.	mm
ChamferWidth	CHW	The width of the chamfer	mm
InsertWidth	W1	W1 is used for the insert width when an inscribed circle diameter is not practical.	mm

Appendices

A. Bibliography

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3. International Organization for Standardization. *ISO 14649*: Industrial automation systems and integration – Physical device control – Data model for computerized numerical controllers – Part 10: General process data. Geneva, Switzerland, 2004.

4. International Organization for Standardization. *ISO 14649*: Industrial automation systems and integration – Physical device control – Data model for computerized numerical controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.

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6. Electronic Industries Association. *ANSI/EIA-494-B-1992*, 32 Bit Binary CL (BCL) and 7 Bit ASCII CL (ACL) Exchange Input Format for Numerically Controlled Machines. Washington, D.C. 1992.

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10. H.L. Horton, F.D. Jones, and E. Oberg. *Machinery's handbook*. Industrial Press, Inc. New York, 1984.

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

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

530   13. *ASME/ANSI B5.54: Methods for Performance Evaluation of Computer Numerically*
531   *Controlled Lathes and Turning Centers. 2005.*

532   14. OPC Foundation. *OPC Unified Architecture Specification, Part 1: Concepts Version 1.00.*
533   *July 28, 2006.*

534   15. International Organization for Standardization. *ISO 13399*: *Cutting Tool data*
535   *representation and exchange*. Geneva, Switzerland, 2000.

536

537 # B. Additional Illustrations

538

539
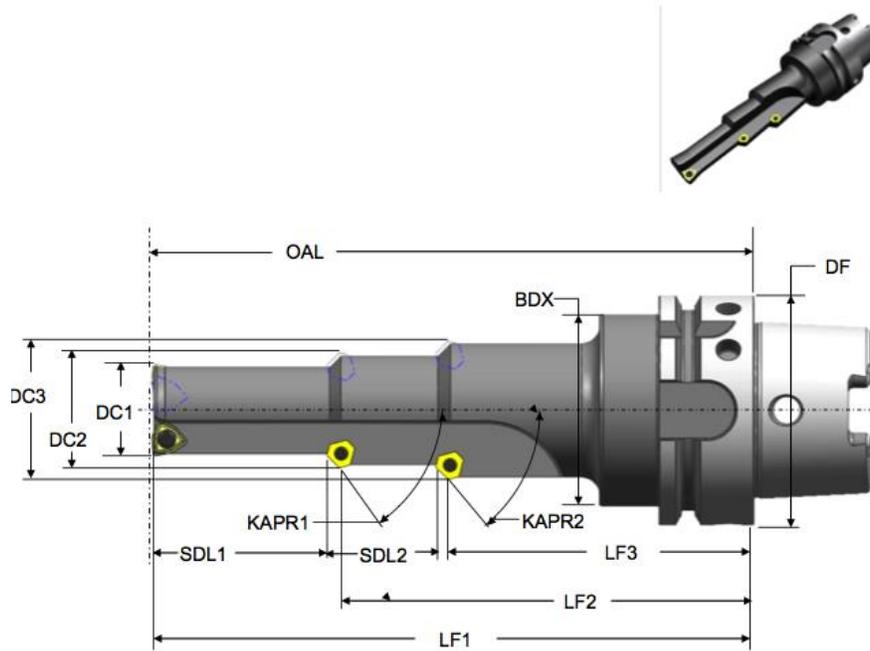
540 **Figure 27: Cutting Tool Measurement Diagram 1**
541 **(Cutting Tool, Cutting Item, and Assembly Item – ISO 13399)**

542
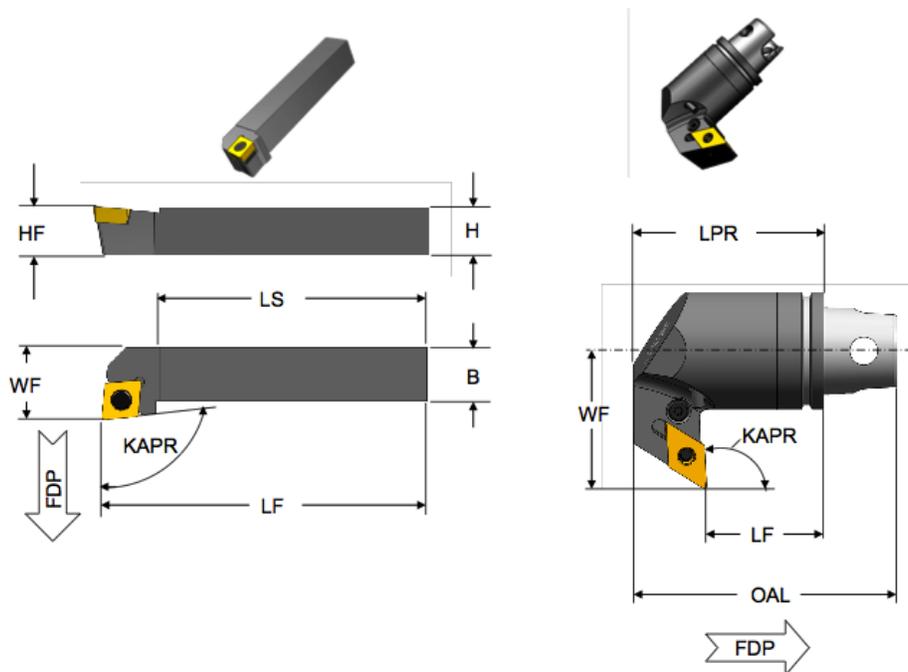
543 **Figure 28: Cutting Tool Measurement Diagram 2**
544 **(Cutting Tool, Cutting Item, and Assembly Item – ISO 13399)**

545
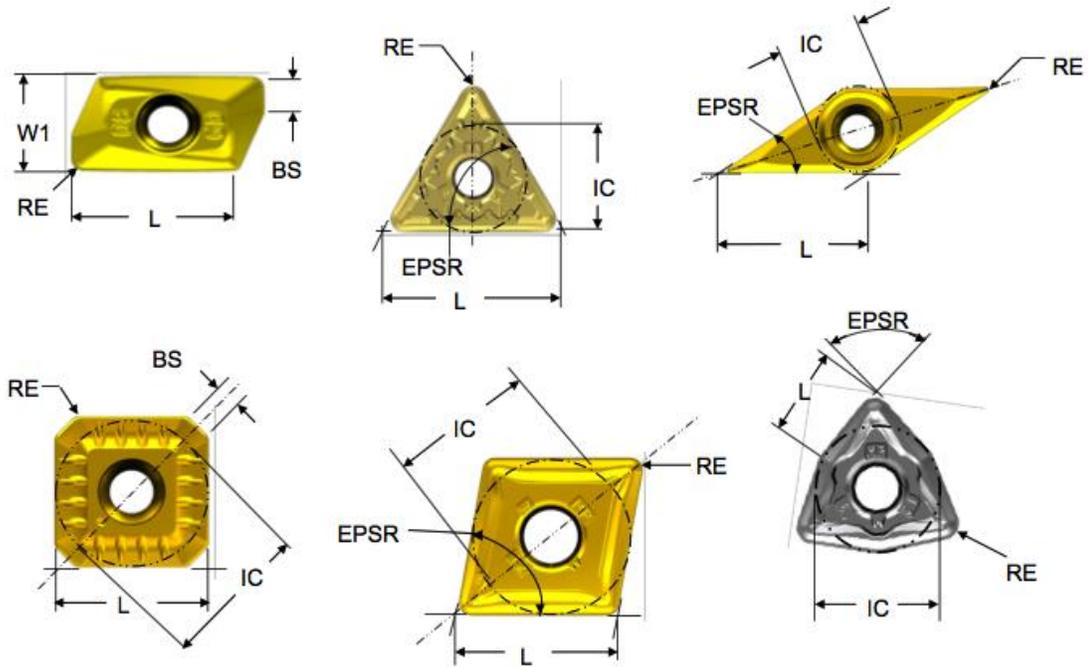
Figure 29: Cutting Item Measurement Diagram 3
(Cutting Item – ISO 13399)

548
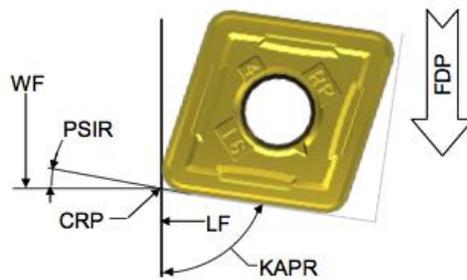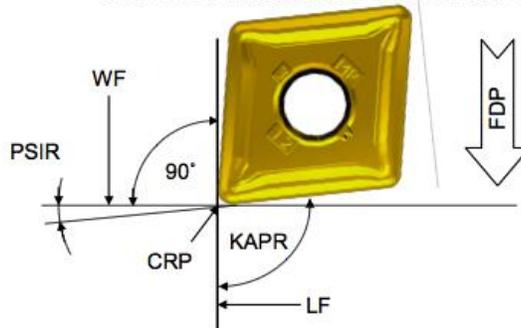
Figure 30: Cutting Item Measurement Diagram 4
(Cutting Item – ISO 13399)

END CUTTING TOOLS KAPR ≤ 90˚

END CUTTING TOOLS KAPR >90˚

551
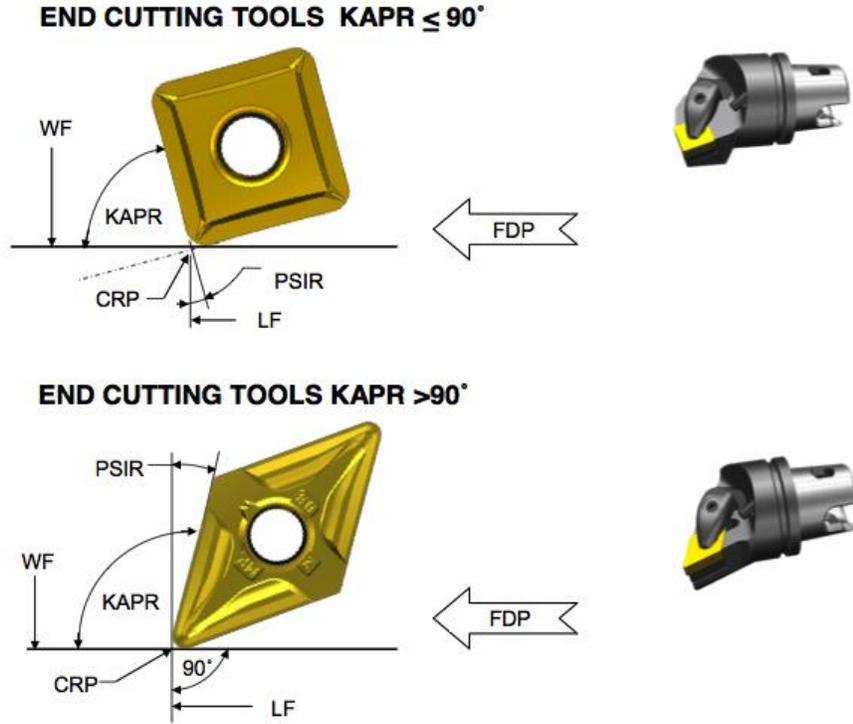
Figure 31: Cutting Item Measurement Diagram 5
(Cutting Item – ISO 13399)

BCH = CHAMFER FLAT LENGTH
CHW = CHAMFER WIDTH

554
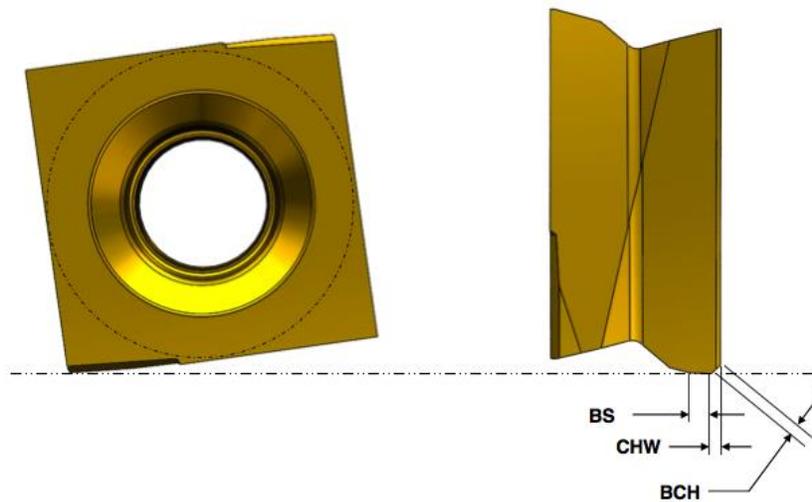
Figure 32: Cutting Item Measurement Diagram 6
(Cutting Item – ISO 13399)

557 # C. Cutting Tool Example

558 ## C.1 Shell Mill

559

OAL=222.25mm +/-0.254 (KMT)

DF=98.425mm (KMT)

CCMS=CV50 Taper

(BDX*)= 73.25

DC=76.2mm +/- 0.013

APMX=60.96mm

LUX=82.55mm

RE=0.8mm

LF=120.65mm +/- 0.254

*Note: BDX is optional since the body diameter does not exceed the cutting diameter.

Shellmill – KMT, KSSP300R4SD43L240

Adapter – Parlec, C50-12SM1

Insert – KMT, SDET43PDER8GB Grade KC725M

Steel Cutting Parameters:

Cutter Max RPM=13,300, 4 Flutes , 76.2mm Dia (3"Dia)

Nominal Starting Parameters:

605 RPM

0.23mm//tooth (0.009")

M/min 144.8 (475 SFM)

Feed Rate 553.2mm/min (21.78 in/min)

560

561 **Figure 33: Shell Mill Side View**

562

BS = 2.56

L = 12,7 +/-.025

RE = 0,8

IC = 12,7

563
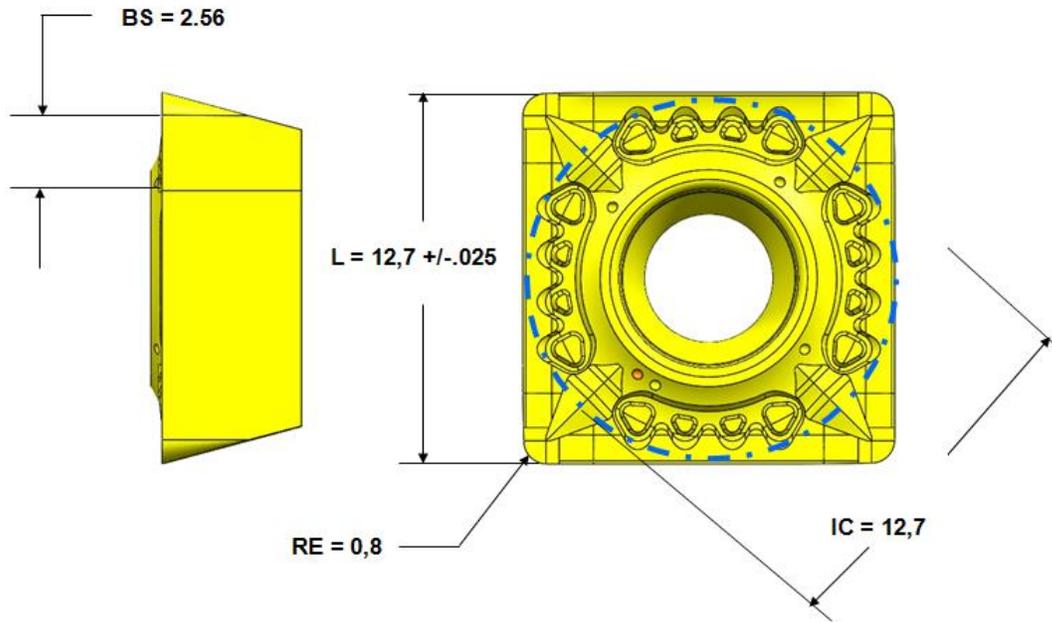
Figure 34: Indexable Insert Measurements

564

565

```
566  <?xml version="1.0" encoding="UTF-8"?>
567  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
568     xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
569     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
570     xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
571     http://mtconnect.org/schemas/MTConnectAssets_1.2.xsd">
572     <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
573     sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
574     <Assets>
575      <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240" timestamp="2011-
576     05-11T13:55:22" assetId="KSSP300R4SD43L240.1" manufacturers="KMT,Parlec">
577       <CuttingToolLifeCycle>
578        <CutterStatus><Status>NEW</Status></CutterStatus>
579        <ProcessSpindleSpeed maximum="13300"
580     nominal="605">10000</ProcessSpindleSpeed>
581        <ProcessFeedRate nominal="9.22">9.22</ProcessSpindleSpeed>
582        <ConnectionCodeMachineSide>CV50</ConnectionCodeMachineSide>
583        <Measurements>
584         <BodyDiameterMax code="BDX">73.25</BodyDiameterMax>
585         <OverallToolLength nominal="222.25" minimum="221.996"
586     maximum="222.504" code="OAL">222.25</OverallToolLength>
587         <UsableLengthMax code="LUX" nominal="82.55">82.55</UsableLengthMax>
588         <CuttingDiameterMax code="DC" nominal="76.2" maximum="76.213"
589     minimum="76.187">76.2</CuttingDiameterMax>
```

```
590        <BodyLengthMax code="LF" nominal="120.65" maximum="120.904"
591    minimum="120.404">120.65</BodyLengthMax>
592        <DepthOfCutMax code="APMX" nominal="60.96">60.95</DepthOfCutMax>
593        <FlangeDiameterMax code="DF"
594    nominal="98.425">98.425</FlangeDiameterMax>
595      </Measurements>
596      <CuttingItems count="24">
597        <CuttingItem indices="1-24" itemId="SDET43PDER8GB" manufacturers="KMT"
598    grade="KC725M">
599          <Measurements>
600            <CuttingEdgeLength code="L" nominal="12.7" minimum="12.675"
601    maximum="12.725">12.7</CuttingEdgeLength>
602            <WiperEdgeLength code="BS" nominal="2.56">2.56</WiperEdgeLength>
603            <IncribedCircleDiameter code="IC"
604    nominal="12.7">12.7</IncribedCircleDiameter>
605            <CornerRadius code="RE" nominal="0.8">0.8</CornerRadius>
606          </Measurements>
607        </CuttingItem>
608      </CuttingItems>
609     </CuttingToolLifeCycle>
610    </CuttingTool>
611    </Assets>
612  </MTConnectAssets>
613
```

614   **C.2 Step Drill**

Step Drill – KMT, B732A08500HP Grade KC7315

Adapter – Parlec, C50-M12SF300-6

Note: Adapter Dimensions Shown are for KMT holder which has adjustable length of +/-5mm (Drill length tolerance =+1/-0).
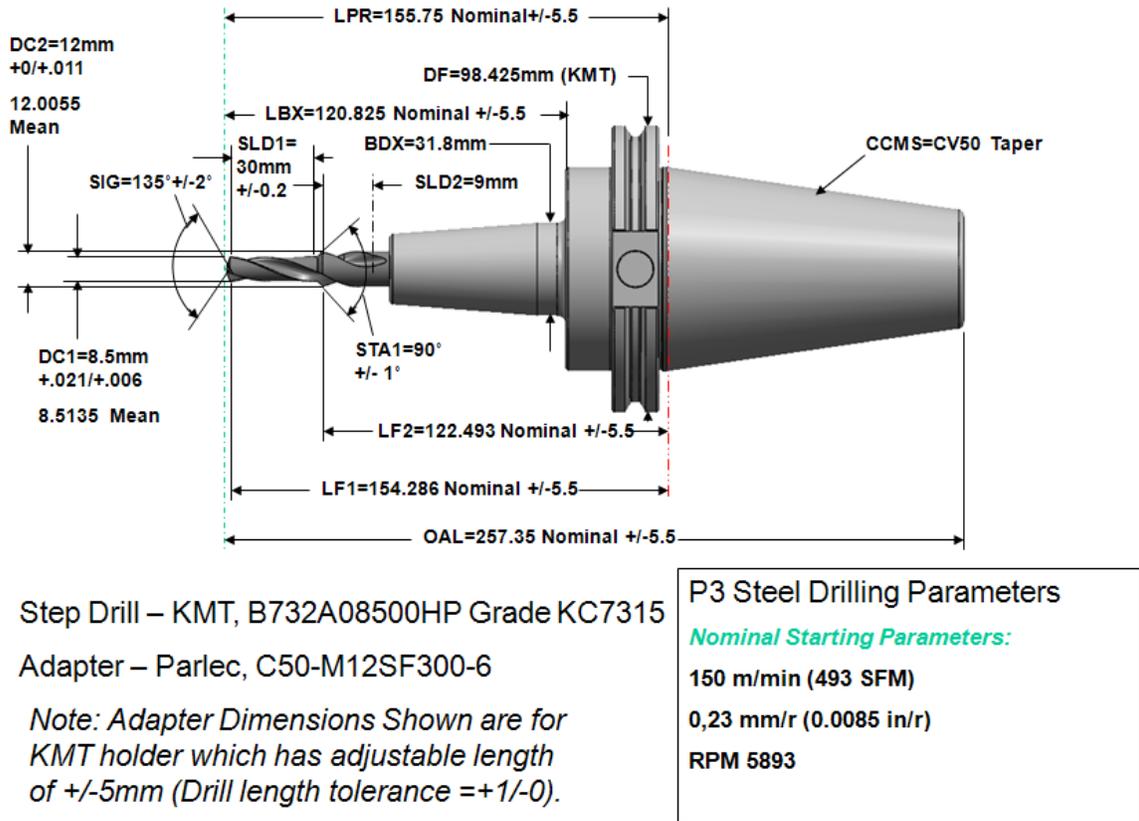
615

616   **Figure 35: Step Drill Side View**

617

```xml
618  <?xml version="1.0" encoding="UTF-8"?>
619  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
620     xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
621     xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
622     xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
623     http://mtconnect.org/schemas/MTConnectAssets_1.2.xsd">
624     <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
625     sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
626     <Assets>
627      <CuttingTool serialNumber="1 " toolId="B732A08500HP" timestamp="2011-05-
628     11T13:55:22" assetId="B732A08500HP " manufacturers="KMT,Parlec">
629       <Description>
630         Step Drill – KMT, B732A08500HP Grade KC7315
631         Adapter – Parlec, C50-M12SF300-6
632       </Description>
633       <CuttingToolLifeCycle>
634         <CutterStatus><Status>NEW</Status></CutterStatus>
```

```
635        <ProcessSpindleSpeed nominal="5893">5893</ProcessSpindleSpeed>
636        <ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
637        <ConnectionCodeMachineSide>CV50 Taper</ConnectionCodeMachineSide>
638        <Measurements>
639         <BodyDiameterMax code="BDX">31.8</BodyDiameterMax>
640         <BodyLengthMax code="LBX" nominal="120.825" maximum="126.325"
641     minimum="115.325">120.825</BodyLengthMax>
642         <ProtrudingLength code="LPR" nominal="155.75" maximum="161.25"
643     minimum="150.26">155.75</ProtrudingLength>
644         <FlangeDiameterMax code="DF"
645     nominal="98.425">98.425</FlangeDiameterMax>
646         <OverallToolLength nominal="257.35" minimum="251.85" maximum="262.85"
647     code="OAL">257.35</OverallToolLength>
648        </Measurements>
649        <CuttingItems count="2">
650         <CuttingItem indices="1" manufacturers="KMT" grade="KC7315">>
651          <Measurements>
652           <CuttingDiameter code="DC1" nominal="8.5" maximum="8.521"
653     minimum="8.506">8.5135</CuttingDiameter>
654           <StepIncludedAngle code="STA1" nominal="90" maximum="91"
655     minimum="89">90</StepIncludedAngle>
656           <FunctionalLength code="LF1" nominal="154.286" minimum="148.786"
657     maximum="159.786">154.286</FunctionalLength>
658           <StepDiameterLength code="SDL1" nominal="9">9</StepDiameterLength>
659           <PointAngle code="SIG" nominal="135" minimum="133"
660     maximum="137">135</PointAngle>
661          </Measurements>
662         </CuttingItem>
663         <CuttingItem indices="2" manufacturers="KMT" grade="KC7315">>
664          <Measurements>
665           <CuttingDiameter code="DC2" nominal="12" maximum="12.011"
666     minimum="12">12</CuttingDiameter>
667           <FunctionalLength code="LF2" nominal="122.493" maximum="127.993"
668     minimum="116.993">122.493</FunctionalLength>
669           <StepDiameterLength code="SDL2" nominal="9">9</StepDiameterLength>
670          </Measurements>
671         </CuttingItem>
672        </CuttingItems>
673       </CuttingToolLifeCycle>
674      </CuttingTool>
675     </Assets>
676   </MTConnectAssets>
```

677 C.3 Shell Mill with Individual Loci

678
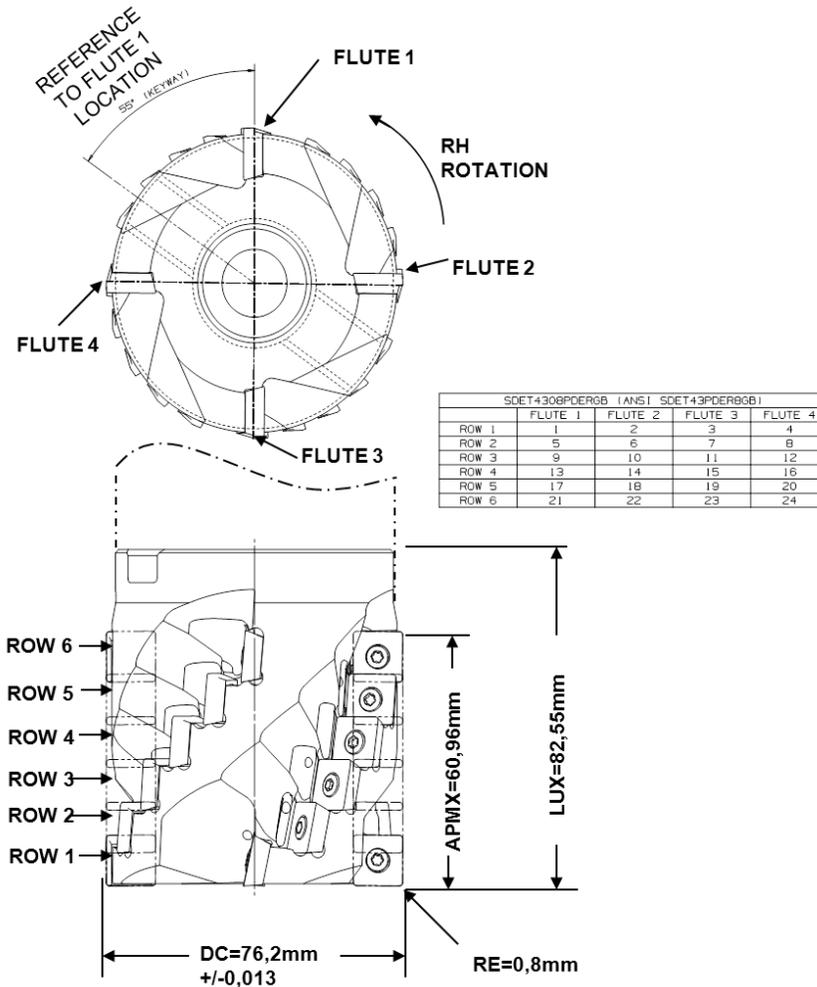
Figure 36: Shell Mill with Explicate Loci

680

681 <?xml version="1.0" encoding="UTF-8"?>

682 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
683 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
684 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
685 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
686 http://mtconnect.org/schemas/MTConnectAssets_1.2.xsd">

687 <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024" sender="localhost"
688 assetCount="2" version="1.2" instanceId="1234"/>

689 <Assets>

```
690    <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240" timestamp="2011-05-
691  11T13:55:22" assetId="KSSP300R4SD43L240.1" manufacturers="KMT,Parlec">

692      <Description>Keyway: 55 degrees</Description>

693      <CuttingToolLifeCycle>

694        <CutterStatus><Status>NEW</Status></CutterStatus>

695        <Measurements>

696          <UsableLengthMax code="LUX" nominal="82.55">82.55</UsableLengthMax>

697          <CuttingDiameterMax code="DC" nominal="76.2" maximum="76.213"
698  minimum="76.187">76.2</CuttingDiameterMax>

699          <DepthOfCutMax code="APMX" nominal="60.96">60.95</DepthOfCutMax>

700        </Measurements>

701        <CuttingItems count="24">

702          <CuttingItem indices="1" itemId="SDET43PDER8GB" manufacturers="KMT">

703            <Locus>FLUTE: 1, ROW: 1</Locus>

704          <Measurements>

705            <DriveAngle code="DRVA" nominal="55">55</DriveAngle>

706          </Measurements>

707          </CuttingItem>

708          <CuttingItem indices="2-24" itemId="SDET43PDER8GB" manufacturers="KMT">

709            <Locus>FLUTE: 2-4, ROW: 1; FLUTE: 1-4, ROW 2-6</Locus>

710          </CuttingItem>

711        </CuttingItems>

712      </CuttingToolLifeCycle>

713    </CuttingTool>

714  </Assets>

715 </MTConnectAssets>

716
```

717   C.4 Drill with Individual Loci

718
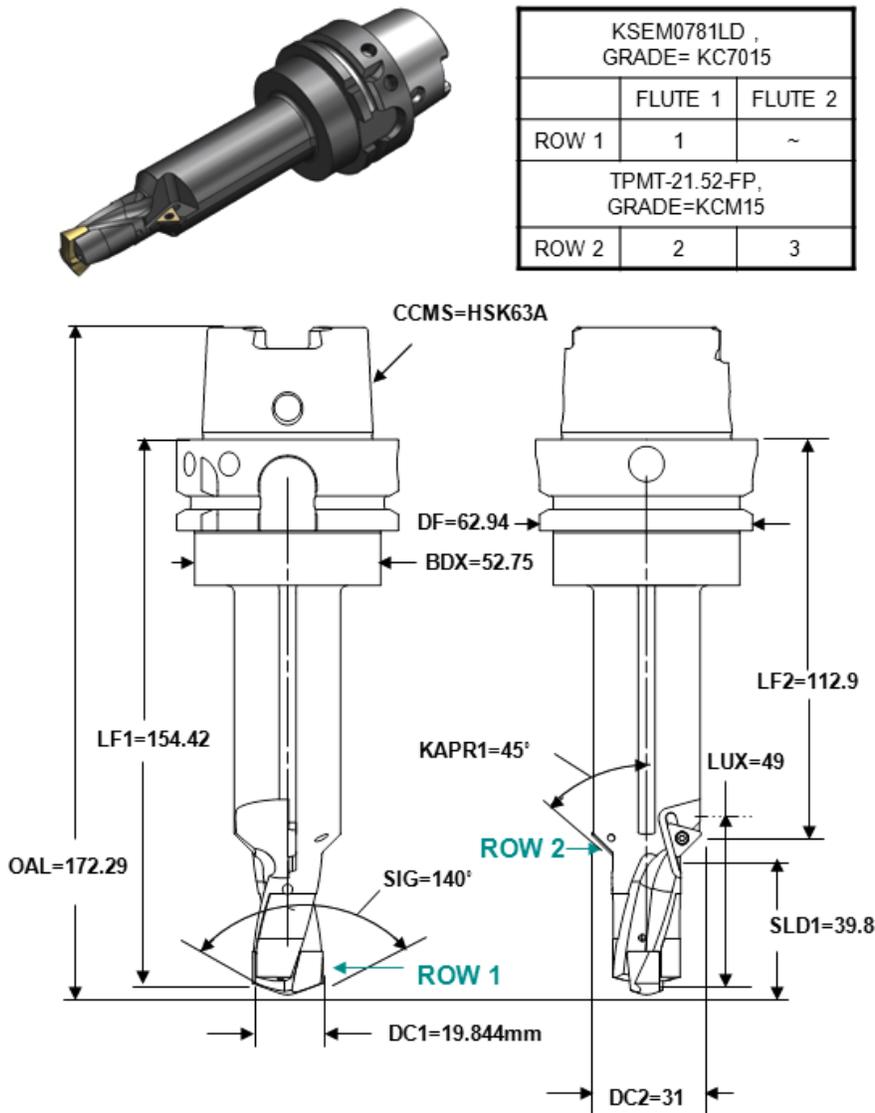
719   Figure 37: Step Drill with Explicate Loci

720

721   <?xml version="1.0" encoding="UTF-8"?>

722   <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
723   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
724   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
725   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
726   http://mtconnect.org/schemas/MTConnectAssets_1.2.xsd">

727   <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024" sender="localhost"
728   assetCount="2" version="1.2" instanceId="1234"/>

```
729    <Assets>

730    <CuttingTool serialNumber="1" toolId="KSEM0781LD" timestamp="2011-05-11T13:55:22"
731    assetId="KSEM0781LD.1" manufacturers="KMT">

732      <CuttingToolLifeCycle>

733        <CutterStatus><Status>NEW</Status></CutterStatus>

734        <ConnectionCodeMachineSide>HSK63A</ConnectionCodeMachineSide>

735        <Measurements>

736          <BodyDiameterMax code="BDX">52.75</BodyDiameterMax>

737          <OverallToolLength nominal="172.29" code="OAL">172.29</OverallToolLength>

738          <UsableLengthMax code="LUX" nominal="49">49</UsableLengthMax>

739          <FlangeDiameterMax code="DF" nominal="62.94">62.94</FlangeDiameterMax>

740        </Measurements>

741        <CuttingItems count="3">

742          <CuttingItem indices="1" itemId="KSEM0781LD" manufacturers="KMT"
743    grade="KC7015">

744            <Locus>FLUTE: 1, ROW: 1</Locus>

745            <Measurements>

746          <FunctionalLength code="LF1" nominal="154.42">154.42</FunctionalLength>

747          <CuttingDiameter code="DC1" nominal="19.844">19.844</CuttingDiameter>

748          <PointAngle code="SIG" nominal="140">140</PointAngle>

749          <ToolCuttingEdgeAngle code="KAPR1" nominal="45">45</ToolCuttingEdgeAngle>

750          <StepDiameterLength code="SLD1" nominal="39.8">39.8</StepDiameterLength>

751            </Measurements>

752          </CuttingItem>

753          <CuttingItem indices="2-3" itemId="TPMT-21.52-FP" manufacturers="KMT"
754    grade="KCM15">

755            <Locus>FLUTE: 1-2, ROW: 2</Locus>

756            <Measurements>

757          <FunctionalLength code="LF2" nominal="112.9">119.2</FunctionalLength>

758          <CuttingDiameter code="DC2" nominal="31">31</CuttingDiameter>
```

759   </Measurements>

760   </CuttingItem>

761   </CuttingItems>

762   </CuttingToolLifeCycle>

763   </CuttingTool>

764   </Assets>

765 </MTConnectAssets>

766

C.5 Shell Mill with Different Inserts on First Row

768
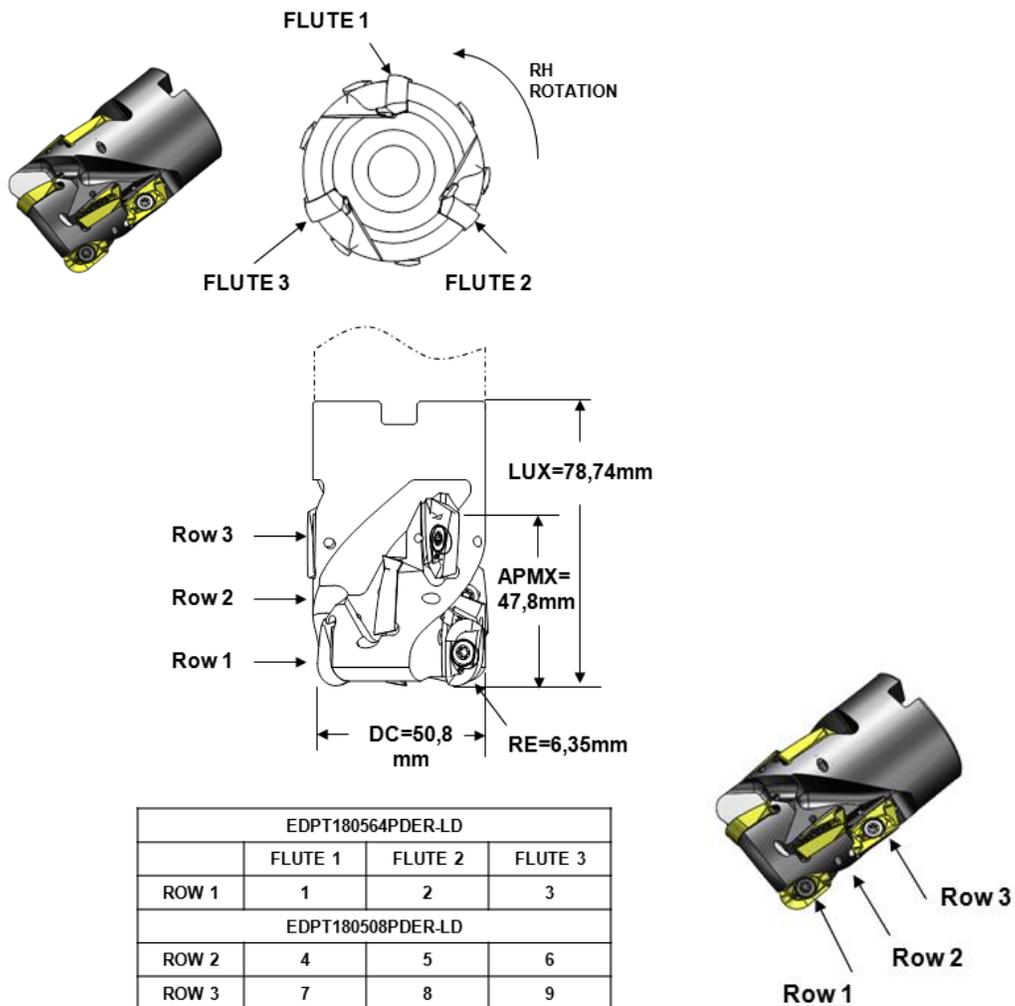
Figure 38: Shell Mill with Different Inserts on First Row

770

```
771    <?xml version="1.0" encoding="UTF-8"?>

772    <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
773    xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
774    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
775    xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
776    http://mtconnect.org/schemas/MTConnectAssets_1.2.xsd">

777      <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024" sender="localhost"
778    assetCount="2" version="1.2" instanceId="1234"/>

779      <Assets>

780        <CuttingTool serialNumber="1" toolId="XXX" timestamp="2011-05-11T13:55:22"
781    assetId="XXX.1" manufacturers="KMT">

782          <CuttingToolLifeCycle>

783            <CutterStatus><Status>NEW</Status></CutterStatus>

784            <Measurements>

785              <DepthOfCutMax code="APMX" nominal="47.8">47.8</DepthOfCutMax>

786              <CuttingDiameterMax code="DC" nominal="50.8">50.8</CuttingDiameterMax>

787              <UsableLengthMax code="LUX" nominal="78.74">78.74</UsableLengthMax>

788            </Measurements>

789            <CuttingItems count="9">

790            <CuttingItem indices="1-3" itemId="EDPT180564PDER-LD" manufacturers="KMT">

791              <Locus>FLUTE: 1-3, ROW: 1</Locus>

792              <Measurements>

793                <CornerRadius code="RE" nominal="6.25">6.35</CornerRadius>

794              </Measurements>

795            </CuttingItem>

796            <CuttingItem indices="4-9" itemId="EDPT180508PDER-LD" manufacturers="KMT">

797              <Locus>FLANGE: 1-4, ROW: 2-3</Locus>

798            </CuttingItem>

799            </CuttingItems>

800          </CuttingToolLifeCycle>

801        </CuttingTool>
```

802   </Assets>

803   </MTConnectAssets>

804