



MTConnect[®] Standard
Part 4.0 – Asset Information Model
Version 2.2.0

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The normative XMI is located at the following URL: [MTConnectSysMLModel.xml](#)

Table of Contents

1	Purpose of This Document	2
2	Terminology and Conventions	3
2.1	General Terms	3
2.2	Information Model Terms	10
2.3	Protocol Terms	11
2.4	HTTP Terms	13
2.5	XML Terms	15
2.6	MTConnect Terms	16
2.7	Acronyms	17
2.8	MTConnect References	29
3	Asset Information Model	30
3.1	Asset	30
3.1.1	Value Properties of Asset	31
3.1.2	Part Properties of Asset	32
4	Cutting Tool Asset Information Model	33
4.1	Cutting Tool	35
4.1.1	CuttingTool	35
4.1.2	CuttingToolArchetype	38
4.1.3	CuttingToolArchetypeReference	39
4.1.4	CuttingToolDefinition	40
4.2	Cutting Tool Life Cycle	41
4.2.1	CuttingToolLifeCycle	42
4.2.2	ToolLife	44
4.2.3	Location	46
4.2.4	ReconditionCount	48
4.2.5	ProcessSpindleSpeed	49
4.2.6	ProcessFeedRate	50
4.2.7	Status	51
4.2.8	Measurement	52
4.3	Cutting Item	53
4.3.1	CuttingItem	54
4.3.2	CuttingItems	57
4.3.3	ItemLife	57
4.4	Cutting Tool Measurement Subtypes	58
4.4.1	BodyDiameterMax	59
4.4.2	BodyLengthMax	59
4.4.3	DepthOfCutMax	59
4.4.4	CuttingDiameterMax	60

4.4.5	FlangeDiameterMax	61
4.4.6	OverallToolLength	61
4.4.7	ShankDiameter	61
4.4.8	ShankHeight	61
4.4.9	ShankLength	61
4.4.10	UsableLengthMax	62
4.4.11	ProtrudingLength	62
4.4.12	FunctionalLength	62
4.4.13	Weight	63
4.5	Cutting Item Measurement Subtypes	63
4.5.1	FunctionalLength	64
4.5.2	CuttingReferencePoint	64
4.5.3	CuttingEdgeLength	65
4.5.4	DriveAngle	65
4.5.5	FlangeDiameter	65
4.5.6	FunctionalWidth	66
4.5.7	IncribedCircleDiameter	67
4.5.8	PointAngle	67
4.5.9	ToolCuttingEdgeAngle	67
4.5.10	ToolLeadAngle	67
4.5.11	ToolOrientation	68
4.5.12	StepDiameterLength	68
4.5.13	StepIncludedAngle	68
4.5.14	WiperEdgeLength	68
4.5.15	CuttingDiameter	69
4.5.16	CuttingHeight	69
4.5.17	CornerRadius	69
4.5.18	Weight	69
4.5.19	ChamferFlatLength	70
4.5.20	ChamferWidth	70
4.5.21	InsertWidth	70
5	Files Asset Information Model	71
5.1	Files	71
5.1.1	AbstractFile	71
5.1.2	File	74
5.1.3	FileArchetype	76
5.1.4	FileProperty	76
5.1.5	FileComment	77
5.1.6	FileLocation	77
5.1.7	Destination	78

6	Raw Material Asset Information Model	79
6.1	Raw Material	79
6.1.1	RawMaterial	79
6.1.2	Material	84
7	QIF Asset Information Model	86
7.1	QIF	86
7.1.1	QIFDocument	86
7.1.2	QIFDocumentWrapper	86
8	Component Configuration Parameters	89
8.1	ComponentConfigurationParameters	89
8.1.1	Part Properties of ComponentConfigurationParameters	90
8.2	ParameterSet	90
8.2.1	Value Properties of ParameterSet	90
8.2.2	Part Properties of ParameterSet	90
8.3	Parameter	91
8.3.1	Value Properties of Parameter	91
9	Profile	93
9.1	DataTypes	93
9.2	boolean	93
9.3	ID	93
9.4	string	93
9.5	float	93
9.6	datetime	94
9.7	integer	94
9.8	xlinktype	94
9.9	xslang	94
9.10	SECOND	94
9.11	IDREF	94
9.12	xlinkhref	94
9.13	x509	95
9.14	int32	95
9.15	int64	95
9.16	version	95
9.17	uint32	95
9.18	uint64	95
9.19	binary	95
9.20	double	96
9.21	Stereotypes	96
9.22	organizer	96
9.23	deprecated	96

9.24 extensible 96
 9.25 informative 96
 9.26 valueType 96
 9.27 normative 96
 9.28 observes 97

Appendices 99

A Bibliography 99
 B XML Schema Diagrams 101
 B.1 Assets Schema Diagrams 101
 B.2 CuttingTool Schema Diagrams 101
 B.3 CuttingToolLifeCycle Schema Diagrams 101
 B.4 CuttingItem Schema Diagrams 102
 B.5 ISO 13399 Diagrams 102
 B.6 Cutting Tool Examples 102
 B.7 File Schema Diagrams 116
 B.8 RawMaterial Schema Diagrams 116
 B.9 QIFDocumentWrapper Schema Diagrams 116

Table of Figures

Figure 1: Asset	31
Figure 2: Cutting Tool Parts	33
Figure 3: Cutting Tool Composition	34
Figure 4: Cutting Tool, Tool Item, and Cutting Item	35
Figure 5: Cutting Tool, Tool Item, and Cutting Item 2	36
Figure 6: CuttingTool	36
Figure 7: CuttingToolLifeCycle	41
Figure 8: CuttingItem	54
Figure 9: Cutting Tool Measurement 1	59
Figure 10:Cutting Tool Measurement 2	60
Figure 11:Cutting Tool	63
Figure 12:Cutting Item	64
Figure 13:Cutting Item Measurement	65
Figure 14:Cutting Item Drive Angle	66
Figure 15:Files	72
Figure 16:RawMaterial	81
Figure 17:QIFDocumentWrapper	87
Figure 18:ComponentConfigurationParameters	89
Figure 19:DataTypes	93
Figure 20:Stereotypes	98
Figure 21:Cutting Tool Measurement 3	102
Figure 22:Cutting Tool Measurement 4	103
Figure 23:Cutting Tool Measurement 5	104
Figure 24:Cutting Tool Measurement 6	105
Figure 25:Cutting Tool Measurement 7	106
Figure 26:Cutting Tool Measurement 8	107
Figure 27:Shell Mill Side View	108
Figure 28:Indexable Insert Measurements	109
Figure 29:Step Mill Side View	110
Figure 30:Shell Mill with Explicate Loci	111
Figure 31:Step Drill with Explicate Loci	113
Figure 32:Shell Mill with Different Inserts on First Row	115

List of Tables

Table 1: Value Properties of Asset	31
Table 2: Part Properties of Asset	32
Table 3: Value Properties of CuttingTool	36
Table 4: Part Properties of CuttingTool	37
Table 5: Value Properties of CuttingToolArchetype	38
Table 6: Part Properties of CuttingToolArchetype	39
Table 7: Value Properties of CuttingToolArchetypeReference	40
Table 8: Value Properties of CuttingToolDefinition	40
Table 9: Value Properties of CuttingToolLifeCycle	42
Table 10: Part Properties of CuttingToolLifeCycle	43
Table 11: Value Properties of ToolLife	45
Table 12: Value Properties of Location	47
Table 13: Value Properties of ReconditionCount	49
Table 14: Value Properties of ProcessSpindleSpeed	49
Table 15: Value Properties of ProcessFeedRate	50
Table 16: Value Properties of Measurement	52
Table 17: Value Properties of CuttingItem	54
Table 18: Part Properties of CuttingItem	56
Table 19: Value Properties of CuttingItems	57
Table 20: Value Properties of ItemLife	58
Table 21: Value Properties of AbstractFile	72
Table 22: Part Properties of AbstractFile	74
Table 23: Value Properties of File	75
Table 24: Part Properties of File	76
Table 25: Value Properties of FileProperty	77
Table 26: Value Properties of FileComment	77
Table 27: Value Properties of FileLocation	78
Table 28: Value Properties of Destination	78
Table 29: Value Properties of RawMaterial	80
Table 30: Part Properties of RawMaterial	83
Table 31: Value Properties of Material	84
Table 32: Value Properties of QIFDocumentWrapper	87
Table 33: Part Properties of QIFDocumentWrapper	88
Table 34: Part Properties of ComponentConfigurationParameters	90
Table 35: Value Properties of ParameterSet	90
Table 36: Part Properties of ParameterSet	91
Table 37: Value Properties of Parameter	91

1 **1 Purpose of This Document**

2 This document, *MTCConnect Standard: Part 4.0 - Asset Information Model* of the MTCon-
3 nect Standard, details information that is common to all types of *Assets*. Part 4.0 of the
4 MTCConnect Standard provide semantic models for entities that are used in the manufactur-
5 ing process, but are not considered to be a piece of equipment. These entities are defined
6 as *Assets*. These assets may be removed from a piece of equipment without detriment to
7 the function of the equipment and can be associated with other pieces of equipment dur-
8 ing their lifecycle. The data associated with these assets may be retrieved from multiple
9 sources that are each responsible for providing their knowledge of the asset.

10 2 Terminology and Conventions

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

13 2.1 General Terms

14 ***adapter***

15 optional piece of hardware or software that transforms information provided by a
16 piece of equipment into a form that can be received by an *agent*.

17 ***agent***

18 software that collects data published from one or more piece(s) of equipment, or-
19 ganizes that data in a structured manner, and responds to requests for data from
20 client software systems by providing a structured response in the form of a *response*
21 *document* that is constructed using the *semantic data model* of a Standard.

22 ***alarm limit***

23 limit used to trigger warning or alarm indicators.

24 ***application***

25 software or a program that is specific to the solution of an application problem.
26 *Ref ISO/IEC 20944-1:2013*

27 ***archetype***

28 *archetype* provides the requirements, constraints, and common properties for a type
29 of *Asset*.

30 ***asset buffer***

31 *buffer* for *Assets*.

32 ***attachment***

33 connection by which one thing is associated with another.

34 ***buffer***

35 section of an *agent* that provides storage for information published from pieces of
36 equipment.

37 ***cartesian coordinate system***

38 3D orthogonal coordinate system [(ISO/IEC 19794-5:2011)en].

39 ***characteristic***

40 control placed on an element of a *feature* such as its size, location, or form, which
41 may be a specification limit, a nominal with tolerance, or some other numerical or
42 non-numerical control. *Ref QIF 3.0 3.4.29. Ref AS9102-B.*

43 ***client***

44 *application* that sends *request* for information to an *agent*.

45 Note: Examples include software applications or a function that imple-
46 ments the *request* portion of an *interface interaction model*.

47 ***combined standard uncertainty***

48 *standard uncertainty* of the result of a measurement when that result is obtained
49 from the values of a number of other quantities, equal to the positive square root of a
50 sum of terms, the terms being the variances or covariances of these other quantities
51 weighted according to how the measurement result varies with changes in these
52 quantities. *Ref JCGM 100:2008 2.3.4*

53 ***controlled vocabulary***

54 restricted set of values that may be published for an observation.

55 ***data dictionary***

56 listing of standardized terms and definitions used in *MTCConnect Information Model*.

57 ***data model***

58 organizes elements of data and standardizes how they relate to one another and to
59 the properties of real-world entities.

60 ***data set***

61 *key-value pairs* where each entry is uniquely identified by the *key*.

62 ***data source***

63 piece of equipment that can produce data that is published to an *agent*.

64 ***deprecated***

65 indication that specific content in an *MTCConnect Document* is currently usable but
66 is regarded as being obsolete or superseded.

67 ***deprecation warning***

68 indication that specific content in an *MTConnect Document* may be changed to *depre-*
69 *recated* in a future release of the standard.

70 ***document***

71 piece of written, printed, or electronic matter that provides information or evidence
72 that serves as an official record.

73 ***electric current***

74 rate of flow of electric charge.

75 ***element***

76 constituent part or a basic unit of identifiable and definable data.

77 ***extensible***

78 ability for an implementer to extend *MTConnect Information Model* by adding con-
79 tent not currently addressed in the MTConnect Standard.

80 ***feature***

81 topological entity(ies) or design requirements related to a geometric model. *Ref QIF*
82 *3.0-3.4.59*

83 ***force***

84 push or pull on a mass which results in an acceleration.

85 ***heartbeat***

86 function that indicates to a *client* that the communications connection to an *agent* is
87 still viable during times when there is no new data available to report often referred
88 to as a “keep alive” message.

89 ***higher level***

90 nested element that is above a lower level element.

91 ***implementation***

92 specific instantiation of the MTConnect Standard.

93 ***information model***

94 rules, relationships, and terminology that are used to define how information is struc-
95 tured.

96 ***instance***

97 describes a set of *streaming data* in an *agent*. Each time an *agent* is restarted with
98 an empty *buffer*, data placed in the *buffer* represents a new *instance* of the *agent*.

99 ***interaction model***

100 model that defines how information is exchanged across an *interface* to enable in-
101 teractions between independent systems.

102 ***interface***

103 means by which communication is achieved between independent systems.

104 ***key***

105 unique identifier in a *key-value pair* association.

106 ***key-value pair***

107 association between an identifier referred to as the *key* and a value which taken
108 together create a *key-value pair*.

109 ***location***

110 place or named space associated with an object or that can be occupied by an object.

111 ***lower camel case***

112 first word is lowercase and the remaining words are capitalized and all spaces be-
113 tween words are removed.

114 ***lower level***

115 nested element that is below a higher level element.

116 ***lower limit***

117 lower conformance boundary for a variable.

118 ***lower warning***

119 lower boundary indicating increased concern and supervision may be required.

120 ***major***

121 identifier representing a consistent set of functionalities defined by the MTConnect
122 Standard.

123 ***maximum***

124 numeric upper constraint.

125 ***message***

126 communication in writing, in speech, or by signals.

127 ***metadata***

128 data that provides information about other data.

129 ***minimum***

130 numeric lower constraint.

131 ***minor***

132 identifier representing a specific set of functionalities defined by the MTConnect
133 Standard.

134 ***nominal***

135 ideal or desired value for a variable.

136 ***organize***

137 act of containing and owning one or more elements.

138 ***organizer***

139 entity that *organizes* one or more elements.

140 ***parameter***

141 variable that must be given a value during the execution of a program or a commu-
142 nications command.

143 ***part***

144 discrete item that has both defined and measurable physical characteristics including
145 mass, material, and features, and is created by applying one or more manufacturing
146 process steps to a workpiece

147 ***pascal case***

148 first letter of each word is capitalized and the remaining letters are in lowercase. All
149 space is removed between letters

150 ***persistence***

151 method for retaining or restoring information.

152 ***position***

153 *location* that is represented by a point in space relative to a reference.

154 ***probe***

155 instrument commonly used for measuring the physical geometrical characteristics
156 of an object.

157 ***profile***

158 extends a reference metamodel (such as Unified Modeling Language (UML)) by
159 allowing to adapt or customize the metamodel with constructs that are specific to a
160 particular domain, platform, or a software development method.

161 ***requester***

162 entity that initiates a *request* for information in a communications exchange.

163 ***reset***

164 act of reverting back the accumulated value or statistic to their initial value.

165 Note: An *Observation* with a *data set* representation removes all *key-*
166 *value pairs*, setting the *data set* to an empty set.

167 ***responder***

168 entity that responds to a *request* for information in a communications exchange.

169 ***response document***

170 electronic *document* published by an *MTCConnect Agent* in response to a *probe re-*
171 *quest, current request, sample request* or *asset request*.

172 ***revision***

173 supplemental identifier representing only organizational or editorial changes to a
174 *minor* version document with no changes in the functionality described in that doc-
175 ument.

176 ***schema***

177 definition of the structure, rules, and vocabularies used to define the information
178 published in an electronic document.

179 ***semantic data model***

180 methodology for defining the structure and meaning for data in a specific logical
181 way that can be interpreted by a software system.

182 ***sensing element***

183 mechanism that provides a signal or measured value.

184 ***sequence number***

185 primary key identifier used to manage and locate a specific piece of *streaming data*
186 in an *agent*.

187 ***specification limit***

188 limit defining a range of values designating acceptable performance for a variable.

189 ***spindle***

190 mechanism that provides rotational capabilities to a piece of equipment.

191 Note: Typically used for either work holding, materials or cutting tools.

192 ***standard***

193 *document* established by consensus that provides rules, guidelines, or characteristics
194 for activities or their results.. *Ref ISO/IEC Guide 2:2004*

195 ***standard uncertainty***

196 *uncertainty* of the result of a measurement expressed as a standard deviation. *Ref JCGM*
197 *100:2008 2.3.1*

198 ***stereotype***

199 defines how an existing UML metaclass may be extended as part of a *profile*.

200 ***subtype***

201 secondary or subordinate type of categorization or classification of information.

202 ***table***

203 two dimensional set of values given by a set of *key-value pairs table entries*.

204 ***table cell***

205 subdivision of a *table entry* representing a singular value.

206 ***table entry***

207 subdivision of a *table* containing a set of *key-value pairs* representing *table cells*.

208 ***top level***

209 element that represents the most significant physical or logical functions of a piece
210 of equipment.

211 ***type***

212 classification or categorization of information.

213 ***uncertainty***

214 uncertainty (of measurement) parameter, associated with the result of a measure-
215 ment, that characterizes the dispersion of the values that could reasonably be at-
216 tributed to the measurand. *Ref JCGM 100:2008 2.2.3*

217 Note: Use of the term uncertainty refers to uncertainty of measurement.

218 ***upper limit***

219 upper conformance boundary for a variable.

220 ***upper warning***

221 upper boundary indicating increased concern and supervision may be required.

222 ***version***

223 unique identifier of the administered item. *Ref ISO/IEC 11179-:2015*

224 **2.2 Information Model Terms**

225 ***Asset Information Model***

226 *information model* that provides semantic models for *Assets*.

227 ***Device Information Model***

228 *information model* that describes the physical and logical configuration for a piece
229 of equipment and the data that may be reported by that equipment.

230 ***Error Information Model***

231 *information model* that describes the *response document* returned by an *agent* when
232 it encounters an error while interpreting a *request* for information from a *client* or
233 when an *agent* experiences an error while publishing the *response* to a *request* for
234 information.

235 ***MTCConnect Information Model***

236 *information model* that defines the semantics of the MTCConnect Standard.

237 ***Observation Information Model***

238 *information model* that describes the *streaming data* reported by a piece of equip-
239 ment.

240 2.3 Protocol Terms

241 ***asset request***

242 *HTTP Request* to the *agent* regarding *Assets*.

243 ***current request***

244 *request* to an *agent* to produce an *MtConnectStreams Response Document* contain-
245 ing the *Observation Information Model* for a snapshot of the latest observations at
246 the moment of the *request* or at a given *sequence number*.

247 ***data streaming***

248 method for an *agent* to provide a continuous stream of information in response to a
249 single *request* from a *client*.

250 ***MtConnect Request***

251 *request* for information issued from a *client* to an *MtConnect Agent*.

252 ***MtConnect Response Document***

253 *response document* published by an *MtConnect Agent*.

254 ***MtConnectAssets Response Document***

255 *response document* published by an *MtConnect Agent* in response to an *asset re-*
256 *quest*.

257 ***MtConnectDevices Response Document***

258 *response document* published by an *MtConnect Agent* in response to a *probe re-*
259 *quest*.

260 ***MtConnectErrors Response Document***

261 *response document* published by an *MtConnect Agent* whenever it encounters an
262 error while interpreting an *MtConnect Request*.

263 ***MtConnectStreams Response Document***

264 *response document* published by an *MtConnect Agent* in response to a *current re-*
265 *quest* or a *sample request*.

266 ***probe request***

267 *request* to an *agent* to produce an *MtConnectDevices Response Document* contain-
268 ing the *Device Information Model*.

269 protocol

270 set of rules that allow two or more entities to transmit information from one to the
271 other.

272 publish

273 sending of messages in a *publish and subscribe* pattern.

274 publish and subscribe

275 asynchronous communication method in which messages are exchanged between
276 applications without knowing the identity of the sender or recipient.

277 Note: In the MTConnect Standard, a communications messaging pattern
278 that may be used to publish *streaming data* from an *agent*.

279 request

280 communications method where a *client* transmits a message to an *agent*. That mes-
281 sage instructs the *agent* to respond with specific information.

282 request and response

283 communications pattern that supports the transfer of information between an *agent*
284 and a *client*.

285 response

286 response *interface* which responds to a *request*.

287 sample request

288 *request* to an *agent* to produce an *MTConnectStreams Response Document* contain-
289 ing the *Observation Information Model* for a set of timestamped observations made
290 by *Components*.

291 streaming data

292 observations published by a piece of equipment defined by the equipment metadata.

293 subscribe

294 receiving messages in a *publish and subscribe* pattern.

295 transport protocol

296 set of capabilities that provide the rules and procedures used to transport information
297 between an *agent* and a client software application through a physical connection.

298 2.4 HTTP Terms

299 **HTTP Body**

300 data bytes transmitted in an HTTP transaction message immediately following the
301 headers. *Ref IETF:RFC-2616*

302 **HTTP Error Message**

303 response provided by an *agent* indicating that an *HTTP Request* is incorrectly for-
304 matted or identifies that the requested data is not available from the *agent*. *Ref IETF:RFC-*
305 *2616*

306 **HTTP Header**

307 header of either an *HTTP Request* from a *client* or an *HTTP Response* from an *agent*.
308 *Ref IETF:RFC-2616*

309 **HTTP Header Field**

310 components of the header section of request and response messages in an HTTP
311 transaction. *Ref IETF:RFC-2616*

312 **HTTP Message**

313 consist of requests from client to server and responses from server to client. *Ref IETF:RFC-*
314 *2616*

315 Note: In MTConnect Standard, it describes the information that is ex-
316 changed between an *agent* and a *client*.

317 **HTTP Messaging**

318 *interface* for information exchange functionality. *Ref IETF:RFC-2616*

319 **HTTP Method**

320 portion of a command in an *HTTP Request* that indicates the desired action to be
321 performed on the identified resource; often referred to as verbs. *Ref IETF:RFC-*
322 *2616*

323 **HTTP Query**

324 portion of a request for information that more precisely defines the specific informa-
325 tion to be published in response to the request. *Ref IETF:RFC-2616*

326 **HTTP Request**

327 request message from a client to a server includes, within the first line of that mes-
328 sage, the method to be applied to the resource, the identifier of the resource, and the
329 protocol version in use. *Ref IETF:RFC-2616*

330 Note: In MTConnect Standard, a request issued by a *client* to an *agent*
331 requesting information defined in the *HTTP Request Line*.

332 ***HTTP Request Line***

333 begins with a method token, followed by the Request-URI and the protocol version,
334 and ending with CRLF. A CRLF is allowed in the definition of TEXT only as part
335 of a header field continuation. *Ref IETF:RFC-2616*

336 Note: the first line of an *HTTP Request* describing a specific *response*
337 *document* to be published by an *agent*.

338 ***HTTP Request Method***

339 indicates the method to be performed on the resource identified by the Request-URI.
340 *Ref IETF:RFC-2616*

341 ***HTTP Request URI***

342 Uniform Resource Identifier that identifies the resource upon which to apply the
343 request. *Ref IETF:RFC-2616*

344 ***HTTP Response***

345 after receiving and interpreting a request message, a server responds with an HTTP
346 response message. *Ref IETF:RFC-2616*

347 Note: In MTConnect Standard, the information published from an *agent*
348 in reply to an *HTTP Request*.

349 ***HTTP Server***

350 server that accepts *HTTP Request* from *client* and publishes *HTTP Response* as a
351 reply to those *HTTP Request*. *Ref IETF:RFC-2616*

352 ***HTTP Status Code***

353 3-digit integer result code of the attempt to understand and satisfy the request.
354 *Ref IETF:RFC-2616*

355 ***HTTP Version***

356 version of the HTTP protocol. *Ref IETF:RFC-2616*

357 2.5 XML Terms

358 ***abstract element***

359 element that defines a set of common characteristics that are shared by a group of
360 elements. An abstract entity cannot appear in a document. In a specific implemen-
361 tation, an abstract entity is replaced by a derived element that is itself not an abstract
362 entity. The characteristics for the derived element are inherited from the abstract
363 entity.

364 ***attribute***

365 additional information or property for an *element*.

366 ***child element***

367 *element* of a data modeling structure that illustrates the relationship between itself
368 and the higher-level *parent element* within which it is contained.

369 ***document body***

370 portion of the content of an *MTCConnect Response Document* that is defined by the
371 relative *MTCConnect Information Model*. The *document body* contains the *structural*
372 *elements* and *Observations* or *DataItems* reported in a *response document*.

373 ***document header***

374 portion of the content of an *MTCConnect Response Document* that provides infor-
375 mation from an *agent* defining version information, storage capacity, protocol, and
376 other information associated with the management of the data stored in or retrieved
377 from the *agent*.

378 ***element name***

379 descriptive identifier contained in both the `start-tag` and `end-tag` of an XML
380 element that provides the name of the element.

381 ***namespace***

382 organizes information into logical groups.

383 ***parent element***

384 *element* of a data modeling structure that illustrates the relationship between itself
385 and the lower-level *child element*.

386 ***root element***

387 first *structural element* provided in a *response document* encoded using XML.

388 ***structural element***

389 *element* that organizes information that represents the physical and logical parts and
390 sub-parts of a piece of equipment.

391 ***XML Document***

392 structured text file encoded using Extensible Markup Language (XML).

393 ***XML Schema***

394 *schema* defining a specific document encoded in XML.

395 **2.6 MTConnect Terms**396 ***Asset***

397 asset that is used by the manufacturing process to perform tasks.

398 Note 1 to entry: An *Asset* relies upon an *Device* to provide observations
399 and information about itself and the *Device* revises the information to
400 reflect changes to the *Asset* during their interaction. Examples of *Assets*
401 are cutting tools, Part Information, Manufacturing Processes, Fixtures,
402 and Files.

403 Note 2 to entry: A singular `assetId`, *Asset* uniquely identifies an
404 *Asset* throughout its lifecycle and is used to track and relate the *Asset* to
405 other *Devices* and entities.

406 Note 3 to entry: *Assets* are temporally associated with a device and can
407 be removed from the device without damage or alteration to its primary
408 functions.

409 ***Component***

410 engineered system part of a *Device* composed of zero or more *Components*

411 ***Composition***

412 *Component* belonging to a *Component* and not composed of any *Components*.

413 ***Configuration***

414 configuration for a *Component*

415 ***DataItem***

416 observable observed by a *Component* that may make *Observations*

417 ***Device***

418 *Component* not belonging to any *Component* that may have assets

419 ***MTCConnect Agent***

420 *agent* for the *MTCConnect Information Model*.

421 ***MTCConnect Document***

422 *document* that represents a Part(s) of the MTCConnect Standard.

423 ***MTCConnect Event***

424 observation of either a state or discrete value of the *Component*.

425 ***MTCConnect Interface***

426 *interaction model* for interoperability between pieces of equipment.

427 ***Observation***

428 observation that provides telemetry data for a *DataItem*.

429 **2.7 Acronyms**

430 ***2D***

431 two-dimensional

432 ***3D***

433 three-dimensional

434 ***AI***

435 artificial intelligence

436 ***ALM***

437 application lifecycle management

438 ***AMT***

439 The Association for Manufacturing Technology

440 ***ANSI***

441 American National Standards Institute

442	AP
443	Application Protocol
444	API
445	application programming interface
446	ASME
447	American Society of Mechanical Engineers
448	ASTM
449	American Society for Testing and Materials
450	AWS
451	American Welding Society
452	BDD
453	block definition diagram
454	BOM
455	bill of materials
456	BST
457	Board on Standardization and Testing
458	C&R
459	cause and remedy
460	CA
461	certificate authority
462	CAD
463	computer-aided design
464	CAE
465	computer-aided engineering
466	CAI
467	computer-aided inspection
468	CAM
469	computer-aided manufacturing

470	CAx
471	computer-aided technologies
472	CDATA
473	Character Data
474	CFD
475	computational fluid dynamics
476	CM
477	configuration management
478	CMS
479	coordinate-measurement system
480	CNC
481	Computer Numerical Controller
482	CNRI
483	Corporation for National Research Initiatives
484	CPM
485	Core Product Model
486	CPM2
487	Revised Core Product Model
488	CPSC
489	Consumer Product Safety Commission
490	cUAV
491	configurable unmanned aerial vehicle
492	DARPA
493	Defense Advanced Research Projects Agency
494	DER
495	designated-engineering representative
496	DFM
497	design for manufacturing

498	<i>DLA</i>
499	Defense Logistics Agency
500	<i>DMC</i>
501	digital manufacturing certificate
502	<i>DMSC</i>
503	Dimensional Metrology Standards Consortium
504	<i>DNS</i>
505	Domain Name System
506	<i>DoD</i>
507	U.S. Department of Defense
508	<i>DOI</i>
509	Distributed Object Identifier
510	<i>DRM</i>
511	digital rights management
512	<i>ECR</i>
513	engineering change request
514	<i>ERP</i>
515	enterprise resource planning
516	<i>FAA</i>
517	Federal Aviation Administration
518	<i>FAIR</i>
519	first article inspection reporting
520	<i>FDA</i>
521	Food and Drug Administration
522	<i>FEA</i>
523	finite-element analysis
524	<i>GD&T</i>
525	geometric dimensions and tolerances

526	<i>GID</i>
527	global identifier
528	<i>HMI</i>
529	Human Machine Interface
530	<i>HTML</i>
531	Hypertext Markup Language
532	<i>HTTP</i>
533	Hypertext Transfer Protocol
534	<i>HTTPS</i>
535	Hypertext Transfer Protocol over Secure Sockets Layer
536	<i>I/O</i>
537	in-out
538	<i>ID</i>
539	identifier
540	<i>IEEE</i>
541	Institute of Electrical and Electronics Engineers
542	<i>IIoT</i>
543	industrial internet of things
544	<i>INCOSE</i>
545	International Council on Systems Engineering
546	<i>IP</i>
547	intellectual property
548	<i>ISO</i>
549	International Standards Organization
550	<i>ISS</i>
551	International Space Station
552	<i>ISV</i>
553	Independent Software Vendor

- 554 ***IT***
- 555 information technology
- 556 ***ITU-T***
- 557 Telecommunication Standardization Sector of the International Telecommunication
- 558 Union
- 559 ***JSON***
- 560 JavaScript Object Notation
- 561 ***JT***
- 562 Jupiter Tessellation
- 563 ***LHS***
- 564 Lifecycle Handler System
- 565 ***LIFT***
- 566 Lifecycle Information Framework and Technology
- 567 ***LOI***
- 568 Lifecycle Object Identifier
- 569 ***MAC***
- 570 media access control
- 571 ***MADE***
- 572 Manufacturing Automation and Design Engineering
- 573 ***MBD***
- 574 model-based definition
- 575 ***MBE***
- 576 Model-Based Enterprise
- 577 ***MBI***
- 578 model-based inspection
- 579 ***MBM***
- 580 model-based manufacturing

581	<i>MBSD</i>
582	model-based standards development
583	<i>MBSE</i>
584	model-based systems engineering
585	<i>MEDALS</i>
586	Military Engineering Data Asset Locator System
587	<i>MES</i>
588	manufacturing execution system
589	<i>MOI</i>
590	manufacturing object identifier
591	<i>MOM</i>
592	Message Orienged Middleware
593	<i>MQTT</i>
594	Message Queuing Telemetry Transport
595	<i>MTC</i>
596	Manufacturing Technology Centre
597	<i>NASA</i>
598	National Aeronautics and Space Administration
599	<i>NC</i>
600	numerical control
601	<i>NIST</i>
602	National Institute of Standards and Technology
603	<i>NMTOKEN</i>
604	Name Token
605	<i>NNMI</i>
606	National Network of Manufacturing Innovation
607	<i>NSF</i>
608	National Science Foundation

609	<i>NTSC</i>
610	National Transportation Safety Board
611	<i>OASIS</i>
612	Organization for the Advancement of Structured Information Standards
613	<i>ODI</i>
614	Open Data Institute
615	<i>OEM</i>
616	original equipment manufacturer
617	<i>OOI</i>
618	Ocean Observatories Initiative
619	<i>OPC</i>
620	OLE for Process Control
621	<i>OSLC</i>
622	Open Services for Lifecycle Collaboration
623	<i>OSTP</i>
624	Office of Science and Technology Policy
625	<i>OT</i>
626	operational technology
627	<i>OWL</i>
628	Ontology Web Language
629	<i>PDF</i>
630	Portable Document Format
631	<i>PDM</i>
632	product-data management
633	<i>PDQ</i>
634	product-data quality
635	<i>PHM</i>
636	prognosis and health monitoring

637	<i>PI</i>	
638		principal investigator
639	<i>PLC</i>	
640		Programmable Logic Controller
641	<i>PLCS</i>	
642		Product Life Cycle Support
643	<i>PLM</i>	
644		product lifecycle management
645	<i>PLOT</i>	
646		product lifecycle of trust
647	<i>PMI</i>	
648		product and manufacturing information
649	<i>PMS</i>	
650		Production Management System
651	<i>PRC</i>	
652		Product Representation Compact
653	<i>PSI</i>	
654		Physical Science Informatics
655	<i>PTAB</i>	
656		Primary Trustworthy Digital Repository Authorization Body Ltd.
657	<i>QIF</i>	
658		Quality Information Framework
659	<i>QMS</i>	
660		quality management system
661	<i>QName</i>	
662		Qualified Name
663	<i>RDF</i>	
664		Resource Description Framework

665	REST
666	Representational State Transfer
667	RII
668	receiving and incoming inspection
669	S/MIME
670	Secure/Multipurpose Internet Mail Extensions
671	SaaS
672	software-as-a-service
673	SAML
674	Security Assertion Markup Language
675	SC
676	Standards Committee
677	SCADA
678	Supervisory Control And Data Acquisition
679	SDO
680	Standards Development Organization
681	SFTP
682	Secure File Transfer Protocol
683	SKOS
684	Simple Knowledge Organization System
685	SLH
686	system lifecycle handler
687	SLR
688	systematic literature review
689	SME
690	small-to-medium enterprise
691	SMOPAC
692	Smart Manufacturing Operations Planning and Control

693	<i>SMS Test Bed</i>
694	Smart Manufacturing Systems Test Bed
695	<i>SOA</i>
696	service-oriented architecture
697	<i>SPMM</i>
698	semantic-based product metamodel
699	<i>SSL</i>
700	Secure Sockets Layer
701	<i>STEP</i>
702	Standard for the Exchange of Product Model Data
703	<i>STEP AP242</i>
704	Standard for the Exchange of Product Model Data Application Protocol 242
705	<i>STL</i>
706	Stereolithography
707	<i>SysML</i>
708	Systems Modeling Language
709	<i>TCP/IP</i>
710	Transmission Control Protocol/Internet Protocol
711	<i>TDP</i>
712	technical data package
713	<i>TLS</i>
714	Transport Layer Security
715	<i>TSM</i>
716	Total System Model
717	<i>UA</i>
718	Unified Architecture
719	<i>UAL</i>
720	Unified Architecture Language

721	<i>UML</i>
722	Unified Modeling Language
723	<i>URI</i>
724	Uniform Resource Identifier
725	<i>URL</i>
726	Uniform Resource Locator
727	<i>URN</i>
728	Uniform Resource Name
729	<i>UTC</i>
730	Coordinated Universal Time
731	<i>UUID</i>
732	Universally Unique Identifier
733	<i>V&V</i>
734	verification and validation
735	<i>W3C</i>
736	World Wide Web Consortium
737	<i>WSN</i>
738	Wirth Syntax Notation
739	<i>WWW</i>
740	World Wide Web
741	<i>X.509-PKI</i>
742	Public Key Infrastructure
743	<i>X.509-PMI</i>
744	Privilege Management Infrastructure
745	<i>XML</i>
746	Extensible Markup Language
747	<i>XPath</i>
748	XML Path Language
749	<i>XSD</i>
750	XML Schema Definitions

751 **2.8 MTConnect References**

- 752 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Fundamentals*. Version 2.0.
- 753 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Device Information Model*. Ver-
754 sion 2.0.
- 755 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Observation Information Model*.
756 Version 2.0.
- 757 [MTConnect Part 4.0] *MTConnect Standard: Part 4.0 - Asset Information Model*. Ver-
758 sion 2.0.

759

760 3 Asset Information Model

761 The MTConnect Standard supports a simple distributed storage mechanism that allows ap-
762 plications and equipment to share and exchange complex information models in a similar
763 way to a distributed data store. The *Asset Information Model* associates each `MTConnect-`
764 `tAssets` entity with a unique identifier and allows for some predefined mechanisms to
765 find, create, request, update, and delete these electronic documents in a way that provides
766 for consistency across multiple pieces of equipment.

767 The protocol provides a limited mechanism of accessing *Assets* using the following prop-
768 erties: `assetId`, asset type (element name of asset root), and the piece of equipment
769 associated with the asset. These access strategies will provide the following services and
770 answer the following questions: What assets are from a particular piece of equipment?
771 What are the assets of a particular type? What asset is stored for a given `assetId`?

772 Although these mechanisms are provided, an *agent* should not be considered a data store
773 or a system of reference. The *agent* is providing an ephemeral storage capability that will
774 temporarily manage the data for applications wishing to communicate and manage data
775 as needed by the various processes. An application cannot rely on an *agent* for long term
776 persistence or durability since the *agent* is only required to temporarily store the asset data
777 and may require another system to provide the source data upon initialization. An *agent* is
778 always providing the best-known equipment centric view of the data given the limitations
779 of that piece of equipment.

780 The MTConnect Standard has two data item types to support change notification when an
781 *Asset* is added, updated or removed. `AssetChanged` states the `assetId` of the *Asset*
782 that has been added or updated. `AssetRemoved` states the `assetId` of the *Asset* that
783 has been removed. See *MTConnect Standard: Part 3.0 - Observation Information Model*
784 for more details.

785 3.1 Asset

786 abstract *Asset*.

787 It is used in the manufacturing process, but is not permanently associated with a single
788 piece of equipment. It can be removed from the piece of equipment without compromising
789 its function, and can be associated with other pieces of equipment during its lifecycle.

790 Note: See *Section B.1 - Assets Schema Diagrams* for XML schema.

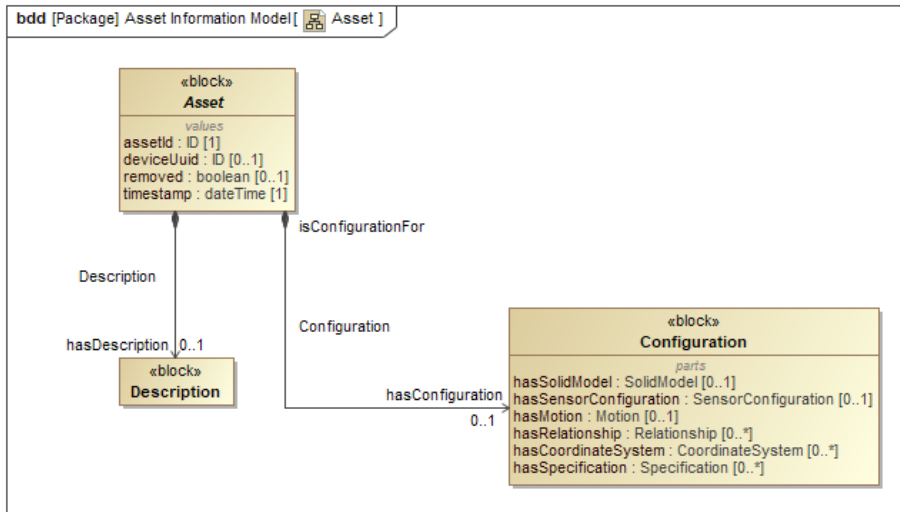


Figure 1: Asset

791 **3.1.1 Value Properties of Asset**

792 *Table 1* lists the Value Properties of Asset.

Value Property name	Value Property type	Multiplicity
assetId	ID	1
deviceUuid	ID	0..1
removed	boolean	0..1
timestamp	datetime	1
hash	string	0..1

Table 1: Value Properties of Asset

793 Descriptions for Value Properties of Asset:

- 794 • assetId
- 795 unique identifier for an Asset.
- 796 • deviceUuid
- 797 associated piece of equipment’s Universally Unique Identifier (UUID) that supplied
- 798 the Asset’s data.
- 799 It references to the uuid property of the Device defined in *MTConnect Standard:*
- 800 *Part 2.0 - Device Information Model.*

- 801 • removed
- 802 indicator that the `Asset` has been removed from the piece of equipment.
- 803 • timestamp
- 804 time the `Asset` data was last modified.
- 805 • hash
- 806 condensed message digest from a secure one-way hash function. *Ref FIPS PUB*
- 807 *180-4*

808 3.1.2 Part Properties of Asset

809 *Table 2* lists the Part Properties of `Asset`.

Part Property name	Multiplicity
Description	0..1
Configuration	0..1

Table 2: Part Properties of `Asset`

810 Descriptions for Part Properties of `Asset`:

- 811 • Description
- 812 descriptive content.
- 813 This can contain configuration information and manufacturer specific details.
- 814 • Configuration
- 815 technical information about an entity describing its physical layout, functional char-
- 816 acteristics, and relationships with other entities.
- 817 See `Configuration` in *MTCConnect Standard: Part 2.0 - Device Information*
- 818 *Model*.

819 4 Cutting Tool Asset Information Model

820 There are two *information models* used to represent a cutting tool, `CuttingToolArchetype`
 821 and `CuttingTool`. The `CuttingToolArchetype` represents the static cutting tool
 822 geometries and nominal values as one would expect from a tool catalog and the `Cut-`
 823 `tingTool` represents the use or application of the tool on the shop floor with actual
 824 measured values and process data. In Version 1.3.0 of the MTConnect Standard it was de-
 825 cided to separate out these two concerns since not all pieces of equipment will have access
 826 to both sets of information. In this way, a generic definition of the cutting tool can coexist
 827 with a specific assembly *information model* with minimal redundancy of data.

828 MTConnect Standard will adopt the ISO 13399 structure when formulating the vocabulary
 829 for Cutting Tool geometries and structure to be represented in the `CuttingToolArchetype`.
 830 The nominal values provided in the `CuttingToolLifeCycle` section are only con-
 831 cerned with two aspects of the Cutting Tool; the Cutting Tool and the cutting item. The
 832 tool item, Adaptive Item, and Assembly Item will only be covered in the `Cutting-`
 833 `ToolDefinition` section of this document since this section contains the full ISO
 834 13399 information about a Cutting Tool.



Figure 2: Cutting Tool Parts

835 The Figure 2 illustrates the parts of a Cutting Tool. The Cutting Tool is the aggregate of all
 836 the components and the cutting item is the part of the tool that removes the material from
 837 the workpiece. These are the primary focus of the MTConnect Standard.

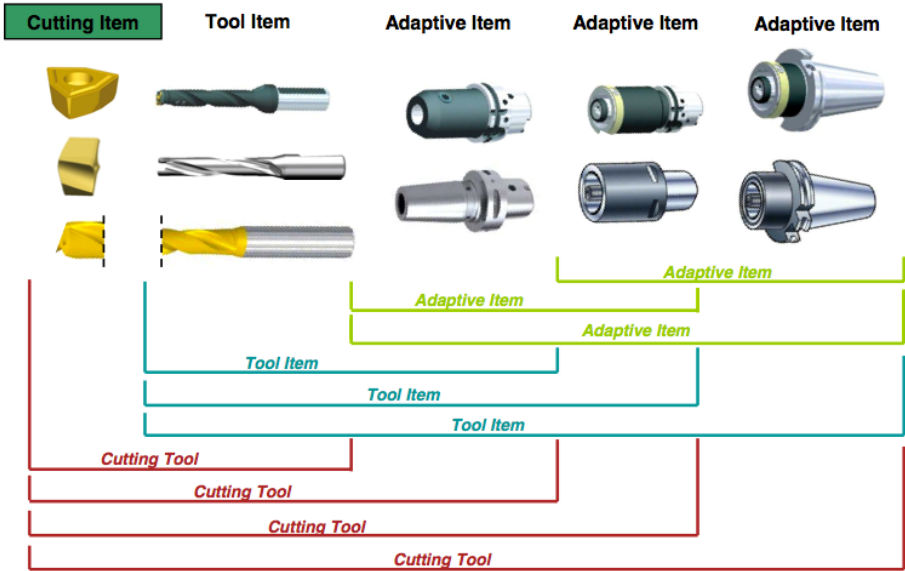


Figure 3: Cutting Tool Composition

838 Figure 3 provides another view of the composition of a Cutting Tool. The Adaptive Items
 839 and tool items will be used for measurements, but will not be modeled as separate entities.
 840 When we are referencing the Cutting Tool we are referring to the entirety of the assembly
 841 and when we provide data regarding the cutting item we are referencing each individual
 842 item as illustrated on the left of the previous diagram.

843 Figure 4 and Figure 5 further illustrates the components of the Cutting Tool. As we com-
 844 pose the tool item, cutting item, Adaptive Item, we get a Cutting Tool. The tool item,
 845 Adaptive Item, and Assembly Item will only be in the CuttingToolDefinition section that will contain the full ISO 13399
 846 information. These figures also use the ISO 13399 codes for each of the measurements. These codes will be translated into the MTConnect
 847 Standard vocabulary as illustrated below. The measurements will have a maximum, mini-
 848 mum, and nominal value representing the tolerance of allowable values for this dimension.
 849

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

854 Additional diagrams will reference these dimensions by their codes that will be defined in
 855 the measurement tables. The codes are consistent with the codes used in ISO 13399 and
 856 have been standardized. MTConnect Standard will use the full text name for clarity in the
 857 response documents.

Reference ISO13399

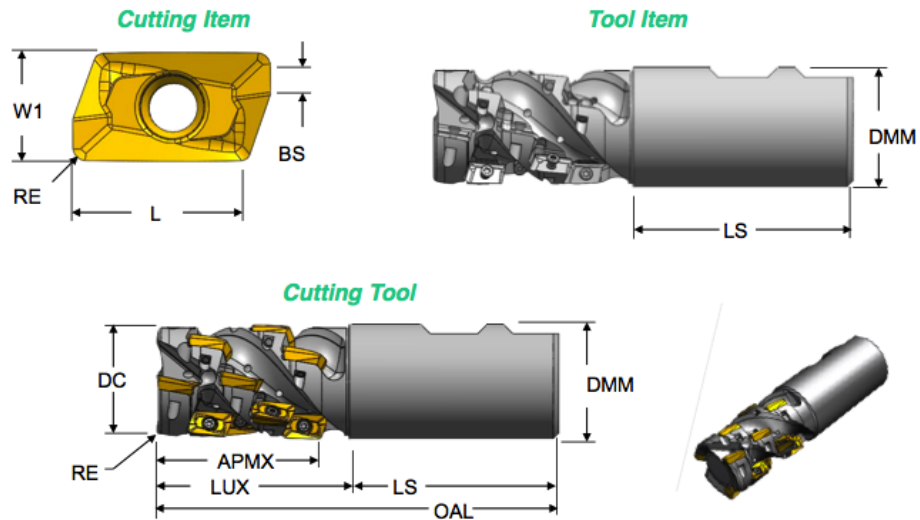


Figure 4: Cutting Tool, Tool Item, and Cutting Item

858 **4.1 Cutting Tool**

859 This section provides semantic information for the `CuttingTool` and `CuttingToolArchetype`
 860 models.

861 Note: See *Section B.2 - CuttingTool Schema Diagrams* for XML schema.

862 **4.1.1 CuttingTool**

863 Asset that physically removes the material from the workpiece by shear deformation.

864 **4.1.1.1 Value Properties of CuttingTool**

865 *Table 3* lists the Value Properties of `CuttingTool`.

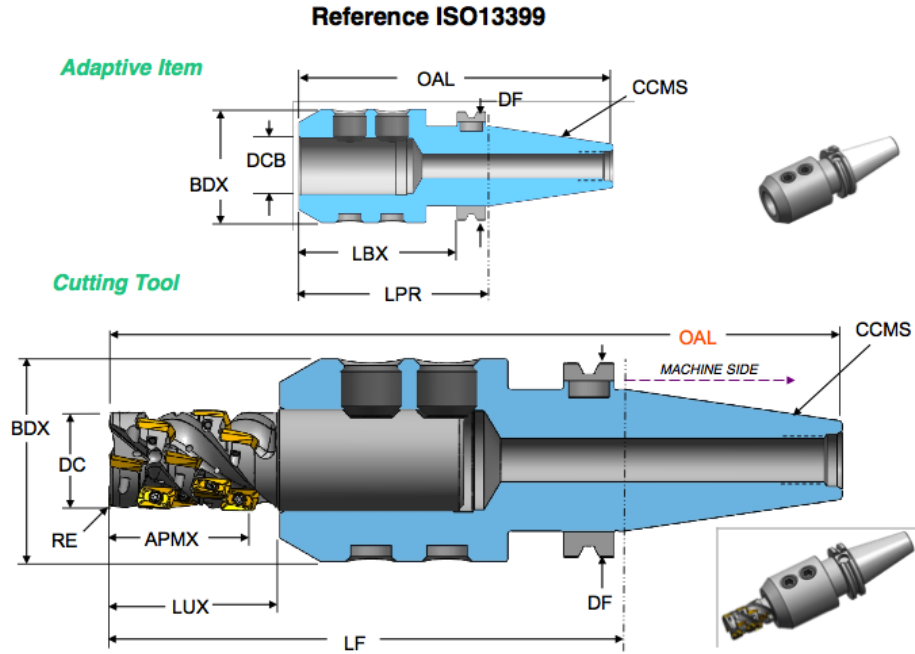


Figure 5: Cutting Tool, Tool Item, and Cutting Item 2

Value Property name	Value Property type	Multiplicity
manufacturers	string	0..*
serialNumber	string	1
toolId	string	1

Table 3: Value Properties of CuttingTool

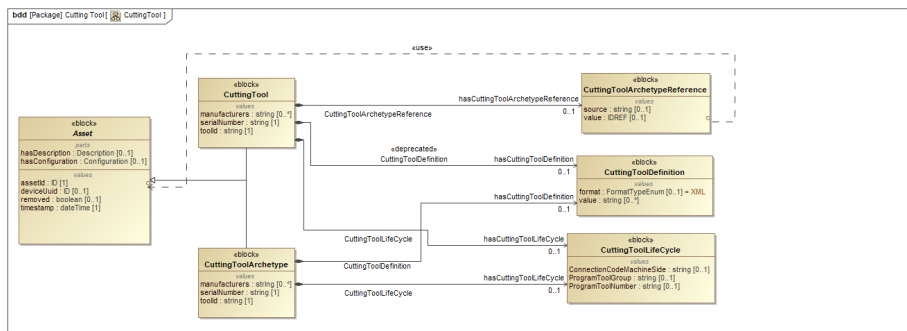


Figure 6: CuttingTool

866 Descriptions for Value Properties of CuttingTool:

- 867 • manufacturers
- 868 manufacturers of the cutting tool.
- 869 This will reference the tool item and adaptive items specifically. The cutting items
- 870 manufacturers' will be a property of CuttingItem.

871 Note: In XML, the representation **MUST** be a comma(,) delimited list of

872 manufacturer names. See *Section B.2 - CuttingTool Schema Diagrams*.

- 873 • serialNumber
- 874 unique identifier for this assembly.
- 875 • toolId
- 876 identifier for a class of cutting tools.

877 **4.1.1.2 Part Properties of CuttingTool**

878 *Table 4* lists the Part Properties of CuttingTool.

Part Property name	Multiplicity
CuttingToolLifeCycle	0..1
CuttingToolArchetypeReference	0..1
<<deprecated>> CuttingToolDefinition	0..1

Table 4: Part Properties of CuttingTool

879 Descriptions for Part Properties of CuttingTool:

- 880 • CuttingToolLifeCycle
- 881 data regarding the application or use of the tool.
- 882 This data is provided by various pieces of equipment (i.e. machine tool, presetter)
- 883 and statistical process control applications. Life cycle data will not remain static,
- 884 but will change periodically when a tool is used or measured.
- 885 See *Section 4.2.1 - CuttingToolLifeCycle*.
- 886 • CuttingToolArchetypeReference
- 887 reference information about the `assetId` and/or the URL of the data source of
- 888 CuttingToolArchetype.

- 889 • `CuttingToolDefinition`
- 890 detailed structure of the cutting tool which is static during its lifecycle. *Ref ISO*
- 891 *13399.*
- 892 **DEPRECATED** in *Version 1.3.0* for `CuttingTool`.

893 4.1.2 CuttingToolArchetype

894 Asset that describes the static cutting tool geometries and nominal values as one would
 895 expect from a tool catalog.

896 4.1.2.1 Value Properties of CuttingToolArchetype

897 *Table 5* lists the Value Properties of `CuttingToolArchetype`.

Value Property name	Value Property type	Multiplicity
manufacturers	string	0..*
serialNumber	string	1
toolId	string	1

Table 5: Value Properties of `CuttingToolArchetype`

898 Descriptions for Value Properties of `CuttingToolArchetype`:

- 899 • `manufacturers`
- 900 manufacturers of the cutting tool.
- 901 This will reference the tool item and adaptive items specifically. The cutting items
- 902 manufacturers' will be a property of `CuttingItem`.

903 Note: In XML, the representation will be a comma(,) delimited list of
 904 manufacturer names. See *Section B.2 - CuttingTool Schema Diagrams*.

- 905 • `serialNumber`
- 906 unique identifier for this assembly.
- 907 • `toolId`
- 908 identifier for a class of cutting tools.

909 4.1.2.2 Part Properties of CuttingToolArchetype

910 *Table 6* lists the Part Properties of CuttingToolArchetype.

Part Property name	Multiplicity
CuttingToolDefinition	0..1
CuttingToolLifeCycle	0..1

Table 6: Part Properties of CuttingToolArchetype

911 Descriptions for Part Properties of CuttingToolArchetype:

- 912 • CuttingToolDefinition
- 913 detailed structure of the cutting tool which is static during its lifecycle. *Ref ISO*
- 914 *13399.*
- 915 **DEPRECATED** in *Version 2.1.0* for CuttingToolArchetype.
- 916 • CuttingToolLifeCycle
- 917 data regarding the application or use of the tool.
- 918 This data is provided by various pieces of equipment (i.e. machine tool, presetter)
- 919 and statistical process control applications. Life cycle data will not remain static,
- 920 but will change periodically when a tool is used or measured.
- 921 See *Section 4.2.1 - CuttingToolLifeCycle.*

922 4.1.3 CuttingToolArchetypeReference

923 reference information about the `assetId` and/or the URL of the data source of Cut-
924 tingToolArchetype.

925 The value of CuttingToolArchetypeReference **MUST** be IDREF. See *Section 9.11*
926 *- IDREF.*

927 4.1.3.1 Value Properties of CuttingToolArchetypeReference

928 *Table 7* lists the Value Properties of CuttingToolArchetypeReference.

Value Property name	Value Property type	Multiplicity
source	string	0..1

Table 7: Value Properties of CuttingToolArchetypeReference

929 Descriptions for Value Properties of CuttingToolArchetypeReference:

930 • source

931 Uniform Resource Locator (URL) of the CuttingToolArchetype *information*
932 *model*.

933 4.1.4 CuttingToolDefinition

934 detailed structure of the cutting tool which is static during its lifecycle. *Ref ISO 13399*.

935 The value of CuttingToolDefinition **MUST** be a list of string of size 0..*.

936 4.1.4.1 Value Properties of CuttingToolDefinition

937 *Table 8* lists the Value Properties of CuttingToolDefinition.

Value Property name	Value Property type	Multiplicity
format	FormatTypeEnum	0..1

Table 8: Value Properties of CuttingToolDefinition

938 Descriptions for Value Properties of CuttingToolDefinition:

939 • format

940 identifies the expected representation of the enclosed data.

941 FormatTypeEnum Enumeration:

942 – EXPRESS

943 document will confirm to the ISO 10303 Part 21 standard.

944 – TEXT

945 document will be a text representation of the tool data.

- 946 – UNDEFINED
- 947 document will be provided in an undefined format.
- 948 – XML
- 949 default value for the definition. The content will be an XML document.

950 4.2 Cutting Tool Life Cycle

951 This section provides semantic information for the CuttingToolLifeCycle model.

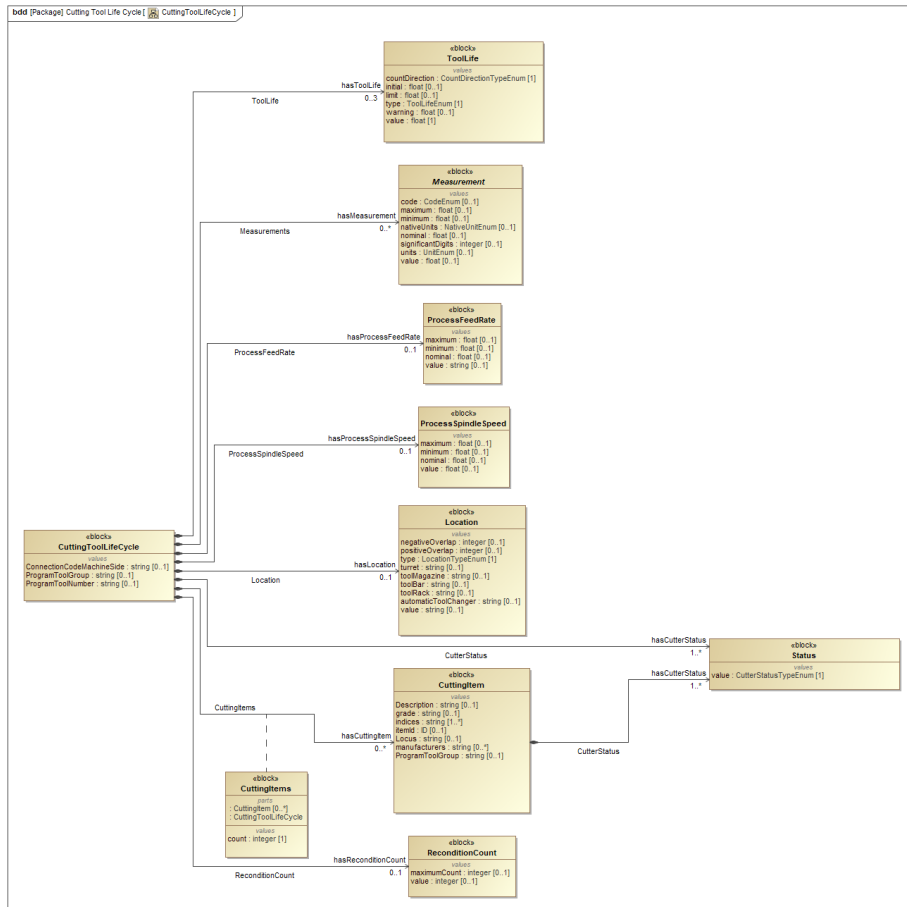


Figure 7: CuttingToolLifeCycle

952 Note: See Section B.3 - CuttingToolLifeCycle Schema Diagrams for XML
 953 schema.

954 **4.2.1 CuttingToolLifeCycle**

955 data regarding the application or use of the tool.

956 This data is provided by various pieces of equipment (i.e. machine tool, presetter) and
957 statistical process control applications. Life cycle data will not remain static, but will
958 change periodically when a tool is used or measured.

959 **4.2.1.1 Value Properties of CuttingToolLifeCycle**

960 *Table 9* lists the Value Properties of CuttingToolLifeCycle.

Value Property name	Value Property type	Multiplicity
ConnectionCodeMachineSide	string	0..1
ProgramToolGroup	string	0..1
ProgramToolNumber	string	0..1

Table 9: Value Properties of CuttingToolLifeCycle

961 Descriptions for Value Properties of CuttingToolLifeCycle:

- 962 • ConnectionCodeMachineSide
963 identifier for the capability to connect any component of the cutting tool together,
964 except Assembly Items, on the machine side. Code: CCMS
- 965 • ProgramToolGroup
966 tool group this tool is assigned in the part program.
- 967 • ProgramToolNumber
968 number of the tool as referenced in the part program.

969 **4.2.1.2 Part Properties of CuttingToolLifeCycle**

970 *Table 10* lists the Part Properties of CuttingToolLifeCycle.

Part Property name	Multiplicity
ProcessFeedRate	0..1
ToolLife	0..3
ProcessSpindleSpeed	0..1
Status (organized by CutterStatus)	1..*
CuttingItem (organized by CuttingItems)	0..*
Measurement (organized by Measurements)	0..*
ReconditionCount	0..1
Location	0..1

Table 10: Part Properties of CuttingToolLifeCycle

971 Descriptions for Part Properties of CuttingToolLifeCycle:

972 • ProcessFeedRate

973 constrained process feed rate for the tool in mm/s.

974 The value **MAY** contain the nominal process target feed rate if available. If Pro-
975 cessFeedRate is provided, at least one value of maximum, nominal, or min-
976 imum **MUST** be specified.

977 See Section 4.2.6 - *ProcessFeedRate*.

978 • ToolLife

979 cutting tool life as related to the assembly.

980 See Section 4.2.2 - *ToolLife*.

981 • ProcessSpindleSpeed

982 constrained process spindle speed for the tool in revolutions/minute.

983 The value **MAY** contain the nominal process target spindle speed if available. If
984 ProcessSpindleSpeed is provided, at least one value of maximum, nomi-
985 nal, or minimum **MUST** be specified.

986 See Section 4.2.5 - *ProcessSpindleSpeed*.

987 • Status

988 status of the cutting tool.

989 CutterStatus provides the status of the assembly and *organize* one or more
990 Status entities. See Section 4.2.7 - *Status*.

991 The following combinations of Status entities **MUST NOT** occur for a Cut-
992 terStatus:

- 993 – NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.
- 994 – UNKNOWN **MUST NOT** be used with any other status.
- 995 – ALLOCATED and UNALLOCATED **MUST NOT** be used together.
- 996 – AVAILABLE and UNAVAILABLE **MUST NOT** be used together.
- 997 – If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be
- 998 AVAILABLE.

- 999 • CuttingItem
- 1000 part of of the tool that physically removes the material from the workpiece by shear
- 1001 deformation.
- 1002 CuttingItems groups one or more CuttingItem entities. See *Section 4.3.1 -*
- 1003 *CuttingItem* and *Section 4.3 - Cutting Item* for more detail.

- 1004 • Measurement
- 1005 constrained scalar value associated with a cutting tool.
- 1006 Measurements groups one or more Measurement subtypes. See *Section 4.2.8*
- 1007 – *Measurement*.

- 1008 • ReconditionCount
- 1009 number of times the cutter has been reconditioned.
- 1010 See *Section 4.2.4 - ReconditionCount*.

- 1011 • Location
- 1012 location of the pot or spindle the cutting tool currently resides in.
- 1013 If negativeOverlap or positiveOverlap is provided, the tool reserves ad-
- 1014 ditional locations on either side, otherwise if they are not given, no additional loca-
- 1015 tions are required for this tool.
- 1016 If the pot occupies the first or last location, a rollover to the beginning or the end of
- 1017 the indexable values may occur. For example, if there are 64 pots and the tool is in
- 1018 pot 64 with a positiveOverlap of 1, the first pot **MAY** be occupied as well.
- 1019 See *Section 4.2.3 - Location* for more detail.

1020 4.2.2 ToolLife

1021 cutting tool life as related to the assembly.

1022 ToolLife **MUST** be defined only for the CuttingToolLifeCycle of Cutting-
 1023 Tool and **MUST NOT** be defined for the CuttingToolLifeCycle of Cutting-
 1024 ToolArchetype.

1025 The value of ToolLife **MUST** be float.

1026 **4.2.2.1 Value Properties of ToolLife**

1027 *Table 11* lists the Value Properties of ToolLife.

Value Property name	Value Property type	Multiplicity
countDirection	CountDirectionTypeEnum	1
initial	float	0..1
limit	float	0..1
type	ToolLifeEnum	1
warning	float	0..1

Table 11: Value Properties of ToolLife

1028 Descriptions for Value Properties of ToolLife:

- 1029 • countDirection
- 1030 indicates if the tool life counts from zero to maximum or maximum to zero.
- 1031 CountDirectionTypeEnum Enumeration:
- 1032 – DOWN
- 1033 tool life counts down from the maximum to zero.
- 1034 – UP
- 1035 tool life counts up from zero to the maximum.

- 1036 • initial
- 1037 initial life of the tool when it is new.

- 1038 • limit
- 1039 end of life limit for the tool.

- 1040 • type
- 1041 type of tool life being accumulated.
- 1042 ToolLifeEnum Enumeration:

- 1043 – MINUTES
 1044 tool life measured in minutes.
 1045 All units for minimum, maximum, and nominal **MUST** be provided in min-
 1046 utes.
- 1047 – PART_COUNT
 1048 tool life measured in parts.
 1049 All units for minimum, maximum, and nominal **MUST** be provided as the
 1050 number of parts.
- 1051 – WEAR
 1052 tool life measured in tool wear.
 1053 Wear **MUST** be provided in millimeters as an offset to nominal. All units for
 1054 minimum, maximum, and nominal **MUST** be given as millimeter offsets as
 1055 well. The standard will only consider dimensional wear at this time.
- 1056 • warning
 1057 point at which a tool life warning will be raised.

1058 4.2.3 Location

- 1059 location of the pot or spindle the cutting tool currently resides in.
- 1060 If `negativeOverlap` or `positiveOverlap` is provided, the tool reserves additional
 1061 locations on either side, otherwise if they are not given, no additional locations are required
 1062 for this tool.
- 1063 If the pot occupies the first or last location, a rollover to the beginning or the end of the
 1064 indexable values may occur. For example, if there are 64 pots and the tool is in pot 64 with
 1065 a `positiveOverlap` of 1, the first pot **MAY** be occupied as well.
- 1066 Location **MUST** be defined only for the `CuttingToolLifeCycle` of `Cutting-`
 1067 `Tool` and **MUST NOT** be defined for the `CuttingToolLifeCycle` of `Cutting-`
 1068 `ToolArchetype`.
- 1069 The value of `Location` **MUST** be string.

1070 4.2.3.1 Value Properties of Location

- 1071 *Table 12* lists the Value Properties of `Location`.

Value Property name	Value Property type	Multiplicity
negativeOverlap	integer	0..1
positiveOverlap	integer	0..1
type	LocationTypeEnum	1
turret	string	0..1
toolMagazine	string	0..1
toolBar	string	0..1
toolRack	string	0..1
automaticToolChanger	string	0..1

Table 12: Value Properties of Location

1072 Descriptions for Value Properties of Location:

1073 • negativeOverlap

1074 number of locations at lower index values from this location.

1075 • positiveOverlap

1076 number of locations at higher index value from this location.

1077 • type

1078 type of location being identified.

1079 When a POT or STATION type is used, value of Location **MUST** be a numeric
1080 value.

1081 LocationTypeEnum Enumeration:

1082 – CRIB

1083 location with regard to a tool crib.

1084 – END_EFFECTOR

1085 location associated with an end effector.

1086 – EXPIRED_POT

1087 location for a tool that is no longer usable and is awaiting removal from a tool
1088 magazine or turret.

1089 – POT

1090 number of the pot in the tool handling system.

1091 – REMOVAL_POT

1092 location for a tool removed from a tool magazine or turret awaiting transfer to
1093 a location outside of the piece of equipment.

- 1094 – RETURN_POT
 1095 location for a tool removed from a *spindle* or turret and awaiting return to a
 1096 tool magazine.
- 1097 – SPINDLE
 1098 location associated with a *spindle*.
- 1099 – STAGING_POT
 1100 location for a tool awaiting transfer to a tool magazine or turret from outside
 1101 of the piece of equipment.
- 1102 – STATION
 1103 tool location in a horizontal turning machine.
- 1104 – TRANSFER_POT
 1105 location for a tool awaiting transfer from a tool magazine to spindle or a turret.
- 1106 • turret
 1107 turret associated with a tool.
- 1108 • toolMagazine
 1109 tool magazine associated with a tool.
- 1110 • toolBar
 1111 tool bar associated with a tool.
- 1112 • toolRack
 1113 tool rack associated with a tool.
- 1114 • automaticToolChanger
 1115 automatic tool changer associated with a tool.

1116 **4.2.4 ReconditionCount**

1117 number of times the cutter has been reconditioned.

1118 ReconditionCount **MUST** be defined only for the CuttingToolLifeCycle of
 1119 CuttingTool and **MUST NOT** be defined for the CuttingToolLifeCycle of
 1120 CuttingToolArchetype.

1121 The value of ReconditionCount **MUST** be integer.

1122 4.2.4.1 Value Properties of ReconditionCount

1123 *Table 13* lists the Value Properties of ReconditionCount.

Value Property name	Value Property type	Multiplicity
maximumCount	integer	0..1

Table 13: Value Properties of ReconditionCount

1124 Descriptions for Value Properties of ReconditionCount:

- 1125 • maximumCount
- 1126 maximum number of times the tool may be reconditioned.

1127 4.2.5 ProcessSpindleSpeed

1128 constrained process spindle speed for the tool in revolutions/minute.

1129 The value **MAY** contain the nominal process target spindle speed if available. If `ProcessSpindleSpeed` is provided, at least one value of maximum, nominal, or minimum **MUST** be specified.

1132 The value of `ProcessSpindleSpeed` **MUST** be float.

1133 4.2.5.1 Value Properties of ProcessSpindleSpeed

1134 *Table 14* lists the Value Properties of ProcessSpindleSpeed.

Value Property name	Value Property type	Multiplicity
maximum	float	0..1
minimum	float	0..1
nominal	float	0..1

Table 14: Value Properties of ProcessSpindleSpeed

1135 Descriptions for Value Properties of ProcessSpindleSpeed:

- 1136 • maximum
- 1137 upper bound for the tool's target spindle speed.

- 1138 • minimum
- 1139 lower bound for the tools spindle speed.
- 1140 • nominal
- 1141 nominal speed the tool is designed to operate at.

1142 4.2.6 ProcessFeedRate

- 1143 constrained process feed rate for the tool in mm/s.
- 1144 The value **MAY** contain the nominal process target feed rate if available. If `Process-`
- 1145 `FeedRate` is provided, at least one value of maximum, nominal, or minimum **MUST**
- 1146 be specified.
- 1147 The value of `ProcessFeedRate` **MUST** be string.

1148 4.2.6.1 Value Properties of ProcessFeedRate

1149 *Table 15* lists the Value Properties of `ProcessFeedRate`.

Value Property name	Value Property type	Multiplicity
maximum	float	0..1
minimum	float	0..1
nominal	float	0..1

Table 15: Value Properties of `ProcessFeedRate`

1150 Descriptions for Value Properties of `ProcessFeedRate`:

- 1151 • maximum
- 1152 upper bound for the tool’s process target feedrate.
- 1153 • minimum
- 1154 lower bound for the tool’s feedrate.
- 1155 • nominal
- 1156 nominal feedrate the tool is designed to operate at.

1157 4.2.7 Status

1158 status of the cutting tool.

1159 CutterStatusTypeEnum Enumeration:

- 1160 • ALLOCATED
- 1161 tool is has been committed to a piece of equipment for use and is not available for
- 1162 use in any other piece of equipment.
- 1163 • AVAILABLE
- 1164 tool is available for use.
- 1165 If this is not present, the tool is currently not ready to be used.
- 1166 • BROKEN
- 1167 premature tool failure.
- 1168 • EXPIRED
- 1169 tool has reached the end of its useful life.
- 1170 • MEASURED
- 1171 tool has been measured.
- 1172 • NEW
- 1173 new tool that has not been used or first use.
- 1174 Marks the start of the tool history.
- 1175 • NOT_REGISTERED
- 1176 tool cannot be used until it is entered into the system.
- 1177 • RECONDITIONED
- 1178 tool has been reconditioned.
- 1179 • UNALLOCATED
- 1180 tool has not been committed to a process and can be allocated.
- 1181 • UNAVAILABLE
- 1182 tool is unavailable for use in metal removal.
- 1183 • UNKNOWN
- 1184 tool is an indeterminate state. This is the default value.

- 1185 • USED
- 1186 tool is in process and has remaining tool life.

1187 4.2.8 Measurement

1188 constrained scalar value associated with a cutting tool.

1189 A Measurement is specific to the tool management policy at a particular shop. The tool
 1190 zero reference point or gauge line will be different depending on the particular implemen-
 1191 tation and will be assumed to be consistent within the shop. MTConnect Standard does
 1192 not standardize the manufacturing process or the definition of the zero point.

1193 The value of Measurement **MUST** be float.

1194 4.2.8.1 Value Properties of Measurement

1195 *Table 16* lists the Value Properties of Measurement.

Value Property name	Value Property type	Multiplicity
code	CodeEnum	0..1
maximum	float	0..1
minimum	float	0..1
nativeUnits	NativeUnitEnum	0..1
nominal	float	0..1
significantDigits	integer	0..1
units	UnitEnum	0..1

Table 16: Value Properties of Measurement

1196 Descriptions for Value Properties of Measurement:

- 1197 • code
- 1198 shop specific code for the measurement.
- 1199 ISO 13399 codes **MAY** be used for these codes as well.
- 1200 See *Section 4.4 - Cutting Tool Measurement Subtypes* and *Section 4.5 - Cutting*
 1201 *Item Measurement Subtypes* for details on Measurement types and their respec-
 1202 tive code values.

- 1203 • maximum
- 1204 maximum value for the measurement.
- 1205 • minimum
- 1206 minimum value for the measurement.
- 1207 • nativeUnits
- 1208 units the measurement was originally recorded in. See *MTConnect Standard: Part*
- 1209 *2.0 - Device Information Model* for the complete list of nativeUnits.
- 1210 The value of nativeUnits **MUST** be one of the NativeUnitEnum enumera-
- 1211 tion.
- 1212 • nominal
- 1213 as advertised value for the measurement.
- 1214 • significantDigits
- 1215 number of significant digits in the reported value.
- 1216 • units
- 1217 units for the measurements. See *MTConnect Standard: Part 2.0 - Device Informa-*
- 1218 *tion Model* for the complete list of units.
- 1219 The value of units **MUST** be one of the UnitEnum enumeration.

1220 4.3 Cutting Item

1221 A CuttingItem is the portion of the tool that physically removes the material from the
 1222 workpiece by shear deformation. The cutting item can be either a single piece of mate-
 1223 rial attached to the CuttingTool or it can be one or more separate pieces of material
 1224 attached to the CuttingTool using a permanent or removable attachment. A Cuttin-
 1225 gItem can be comprised of one or more cutting edges. Cutting items include: replaceable
 1226 inserts, brazed tips and the cutting portions of solid CuttingTools.

1227 MTConnect Standard considers CuttingItems as part of the CuttingTool. A Cut-
 1228 tingItems **MUST NOT** exist in MTConnect unless it is attached to a CuttingTool.
 1229 Some of the measurements, such as FunctionalLength, **MUST** be made with refer-
 1230 ence to the entire CuttingTool to be meaningful.

1231 Note: See *Section B.4 - CuttingItem Schema Diagrams* for XML schema.

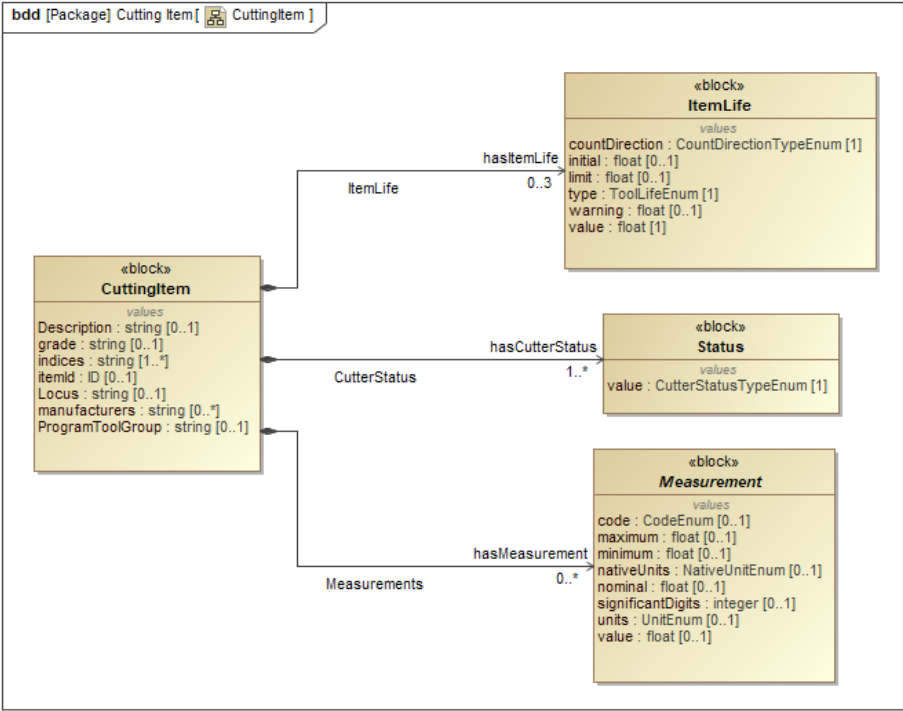


Figure 8: CuttingItem

1232 **4.3.1 CuttingItem**

1233 part of of the tool that physically removes the material from the workpiece by shear defor-
 1234 mation.

1235 **4.3.1.1 Value Properties of CuttingItem**

1236 *Table 17* lists the Value Properties of CuttingItem.

Value Property name	Value Property type	Multiplicity
Description	string	0..1
grade	string	0..1
indices	string	1..*
itemId	ID	0..1
Locus	string	0..1
manufacturers	string	0..*
ProgramToolGroup	string	0..1

Table 17: Value Properties of CuttingItem

1237 Descriptions for Value Properties of CuttingItem:

- 1238 • Description
1239 free-form description of the cutting item.
- 1240 • grade
1241 material composition for this cutting item.
- 1242 • indices
1243 number or numbers representing the individual cutting item or items on the tool.
1244 Indices **SHOULD** start numbering with the inserts or CuttingItem furthest from
1245 the gauge line and increasing in value as the items get closer to the gauge line. Items
1246 at the same distance **MAY** be arbitrarily numbered.
- 1247 Note: In XML, the representation **MUST** be a single number (“1”) or a
1248 comma separated set of individual elements (“1,2,3,4”), or as a inclusive
1249 range of values as in (“1-10”) or any combination of ranges and numbers
1250 as in “1-4,6-10,22”. There **MUST NOT** be spaces or non-integer values
1251 in the text representation.
- 1252 • itemId
1253 manufacturer identifier of this cutting item.
- 1254 • Locus
1255 free form description of the location on the cutting tool.
1256 For clarity, the words FLUTE, INSERT, and CARTRIDGE **SHOULD** be used to
1257 assist in noting the location of a CuttingItem. Locus **MAY** be any free form
1258 string, but **SHOULD** adhere to the following rules:
- 1259 – The location numbering **SHOULD** start at the furthest CuttingItem and
1260 work it’s way back to the CuttingItem closest to the gauge line.
- 1261 – Flutes **SHOULD** be identified as such using the word FLUTE:. For example:
1262 FLUTE: 1, INSERT: 2 - would indicate the first flute and the second furthest
1263 insert from the end of the tool on that flute.
- 1264 – Other designations such as CARTRIDGE **MAY** be included, but should be
1265 identified using upper case and followed by a colon (:).
- 1266 • manufacturers
1267 manufacturers of the cutting item.
1268 This will reference the tool item and adaptive items specifically. The cutting items
1269 manufacturers’ will be a property of CuttingItem.

1270 Note: In XML, the representation **MUST** be a comma(,) delimited list of
1271 manufacturer names. See *Section B.4 - CuttingItem Schema Diagrams*.

1272 • ProgramToolGroup

1273 tool group this item is assigned in the part program.

1274 4.3.1.2 Part Properties of CuttingItem

1275 *Table 18* lists the Part Properties of CuttingItem.

Part Property name	Multiplicity
Status (organized by CutterStatus)	1..*
ItemLife	0..3
Measurement (organized by Measurements)	0..*

Table 18: Part Properties of CuttingItem

1276 Descriptions for Part Properties of CuttingItem:

1277 • Status

1278 status of the cutting tool.

1279 CutterStatus provides the status of the assembly and *organize* one or more
1280 Status entities. See *Section 4.2.7 - Status*.

1281 The following combinations of Status entities **MUST NOT** occur for a Cut-
1282 terStatus:

1283 – NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.

1284 – UNKNOWN **MUST NOT** be used with any other status.

1285 – ALLOCATED and UNALLOCATED **MUST NOT** be used together.

1286 – AVAILABLE and UNAVAILABLE **MUST NOT** be used together.

1287 – If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be
1288 AVAILABLE.

1289 CutterStatus **MUST** be defined only for the CuttingToolLifeCycle of
1290 CuttingTool and **MUST NOT** be defined for the CuttingToolLifeCycle
1291 of CuttingToolArchetype.

1292 • ItemLife

1293 life of a CuttingItem.

1294 See *Section 4.3.3 - ItemLife*.

- 1295 • Measurement
- 1296 constrained scalar value associated with a cutting tool.
- 1297 Measurements groups one or more Measurement subtypes. See *Section 4.2.8*
- 1298 - *Measurement*.

1299 4.3.2 CuttingItems

1300 CuttingItems groups one or more CuttingItem entities. See *Section 4.3.1 - CuttingItem* and *Section 4.3 - Cutting Item* for more detail.

1302 4.3.2.1 Value Properties of CuttingItems

1303 *Table 19* lists the Value Properties of CuttingItems.

Value Property name	Value Property type	Multiplicity
count	integer	1

Table 19: Value Properties of CuttingItems

1304 Descriptions for Value Properties of CuttingItems:

- 1305 • count
- 1306 number of CuttingItem organized by CuttingItems.

1307 4.3.3 ItemLife

1308 life of a CuttingItem.

1309 The value of ItemLife **MUST** be float.

1310 4.3.3.1 Value Properties of ItemLife

1311 *Table 20* lists the Value Properties of ItemLife.

Value Property name	Value Property type	Multiplicity
countDirection	CountDirectionTypeEnum	1
initial	float	0..1
limit	float	0..1
type	ToolLifeEnum	1
warning	float	0..1

Table 20: Value Properties of ItemLife

1312 Descriptions for Value Properties of ItemLife:

- 1313 • countDirection
- 1314 indicates if the item life counts from zero to maximum or maximum to zero.
- 1315 The value of countDirection **MUST** be one of the CountDirectionType-
- 1316 Enum enumeration.
- 1317 • initial
- 1318 initial life of the item when it is new.
- 1319 • limit
- 1320 end of life limit for this item.
- 1321 • type
- 1322 type of item life being accumulated.
- 1323 The value of type **MUST** be one of the ToolLifeEnum enumeration.
- 1324 • warning
- 1325 point at which a item life warning will be raised.

1326 4.4 Cutting Tool Measurement Subtypes

1327 This section lists the Measurement subtypes for CuttingTool.

1328 These Measurement subtypes for CuttingTool are specific to the entire assembly
 1329 and **MUST NOT** be used for the Measurement pertaining to a CuttingItem. Fig-
 1330 ure 9 and Figure 10 will be used to reference the assembly specific Measurement sub-
 1331 types.

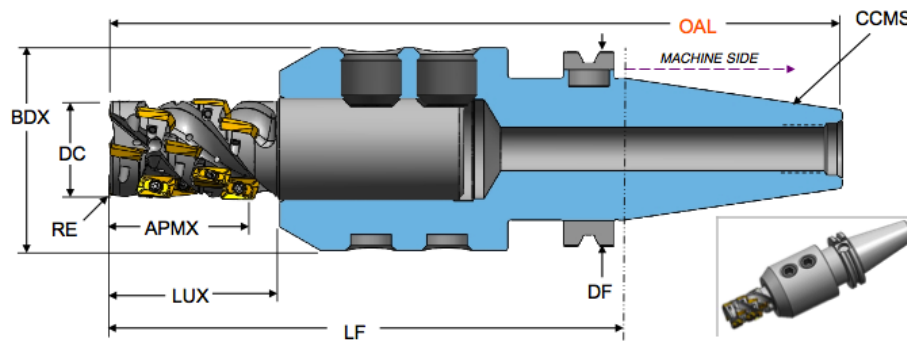


Figure 9: Cutting Tool Measurement 1

1332 4.4.1 BodyDiameterMax

1333 largest diameter of the body of a tool item.

1334 The code of BodyDiameterMax **MUST** be BDX.

1335 The units of BodyDiameterMax **MUST** be MILLIMETER.

1336 4.4.2 BodyLengthMax

1337 distance measured along the X axis from that point of the item closest to the workpiece,
 1338 including the cutting item for a tool item but excluding a protruding locking mechanism
 1339 for an adaptive item, to either the front of the flange on a flanged body or the beginning of
 1340 the connection interface feature on the machine side for cylindrical or prismatic shanks.

1341 The code of BodyLengthMax **MUST** be LBX.

1342 The units of BodyLengthMax **MUST** be MILLIMETER.

1343 4.4.3 DepthOfCutMax

1344 maximum engagement of the cutting edge or edges with the workpiece measured perpen-
 1345 dicular to the feed motion.

1346 The code of DepthOfCutMax **MUST** be APMX.

1347 The units of DepthOfCutMax **MUST** be MILLIMETER.

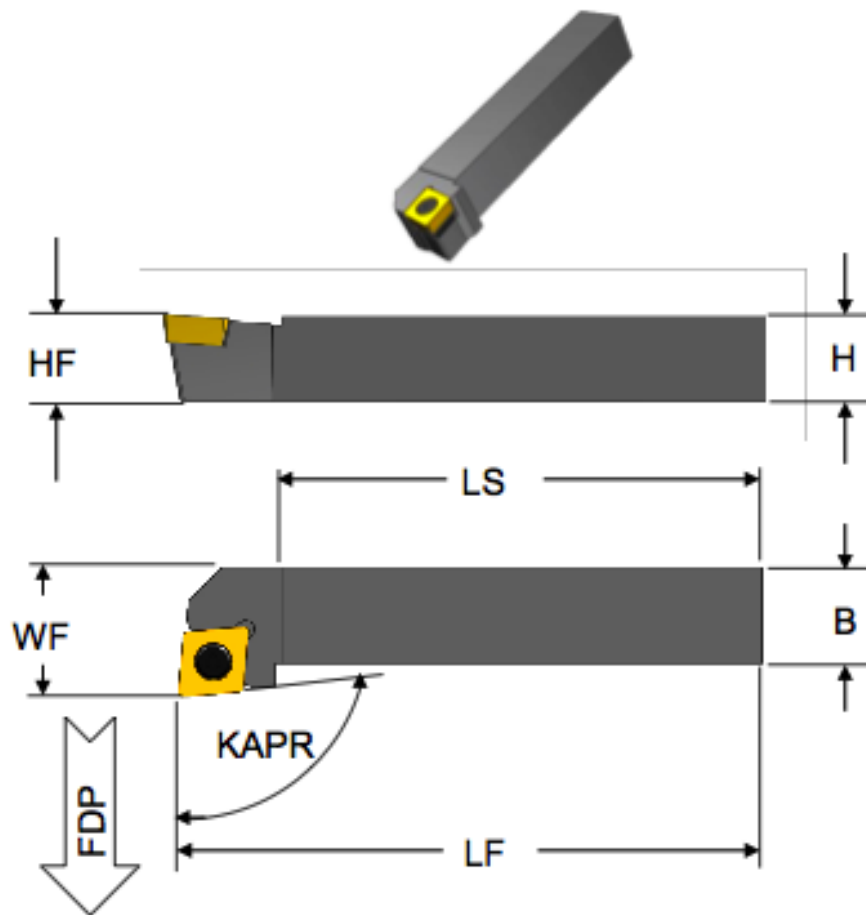


Figure 10: Cutting Tool Measurement 2

1348 4.4.4 CuttingDiameterMax

1349 maximum diameter of a circle on which the defined point Pk of each of the master inserts
 1350 is located on a tool item.

1351 The normal of the machined peripheral surface points towards the axis of the cutting tool.

1352 The code of CuttingDiameterMax **MUST** be DC.

1353 The units of CuttingDiameterMax **MUST** be MILLIMETER.

1354 4.4.5 FlangeDiameterMax

1355 dimension between two parallel tangents on the outside edge of a flange.

1356 The code of `FlangeDiameterMax` **MUST** be DF.

1357 The units of `FlangeDiameterMax` **MUST** be MILLIMETER.

1358 4.4.6 OverallToolLength

1359 largest length dimension of the cutting tool including the master insert where applicable.

1360 The code of `OverallToolLength` **MUST** be OAL.

1361 The units of `OverallToolLength` **MUST** be MILLIMETER.

1362 4.4.7 ShankDiameter

1363 dimension of the diameter of a cylindrical portion of a tool item or an adaptive item that
1364 can participate in a connection.

1365 The code of `ShankDiameter` **MUST** be DMM.

1366 The units of `ShankDiameter` **MUST** be MILLIMETER.

1367 4.4.8 ShankHeight

1368 dimension of the height of the shank.

1369 The code of `ShankHeight` **MUST** be H.

1370 The units of `ShankHeight` **MUST** be MILLIMETER.

1371 4.4.9 ShankLength

1372 dimension of the length of the shank.

1373 The code of ShankLength **MUST** be LS.

1374 The units of ShankLength **MUST** be MILLIMETER.

1375 **4.4.10 UsableLengthMax**

1376 maximum length of a cutting tool that can be used in a particular cutting operation includ-
1377 ing the non-cutting portions of the tool.

1378 The code of UsableLengthMax **MUST** be LUX.

1379 The units of UsableLengthMax **MUST** be MILLIMETER.

1380 **4.4.11 ProtrudingLength**

1381 dimension from the yz-plane to the furthest point of the tool item or adaptive item mea-
1382 sured in the -X direction.

1383 The code of ProtrudingLength **MUST** be LPR.

1384 The units of ProtrudingLength **MUST** be MILLIMETER.

1385 **4.4.12 FunctionalLength**

1386 distance from the gauge plane or from the end of the shank to the furthest point on the
1387 tool, if a gauge plane does not exist, to the cutting reference point determined by the main
1388 function of the tool.

1389 The CuttingTool functional length will be the length of the entire tool, not a single
1390 cutting item. Each CuttingItem can have an independent FunctionalLength rep-
1391 resented in its measurements.

1392 The code of FunctionalLength **MUST** be LF.

1393 The units of FunctionalLength **MUST** be MILLIMETER.

1394 **4.4.13 Weight**

- 1395 total weight of the cutting tool in grams.
- 1396 The force exerted by the mass of the cutting tool.
- 1397 The code of Weight **MUST** be WT.
- 1398 The units of Weight **MUST** be GRAM.

1399 **4.5 Cutting Item Measurement Subtypes**

- 1400 This section lists the Measurement subtypes for CuttingItem.
- 1401 These Measurement subtypes for CuttingItem are specific to an individual CuttingItem and **MUST NOT** be used for the Measurement pertaining to an assembly.
- 1402 Figures below will be used to for reference for the CuttingItem specific Measurement types.
- 1404

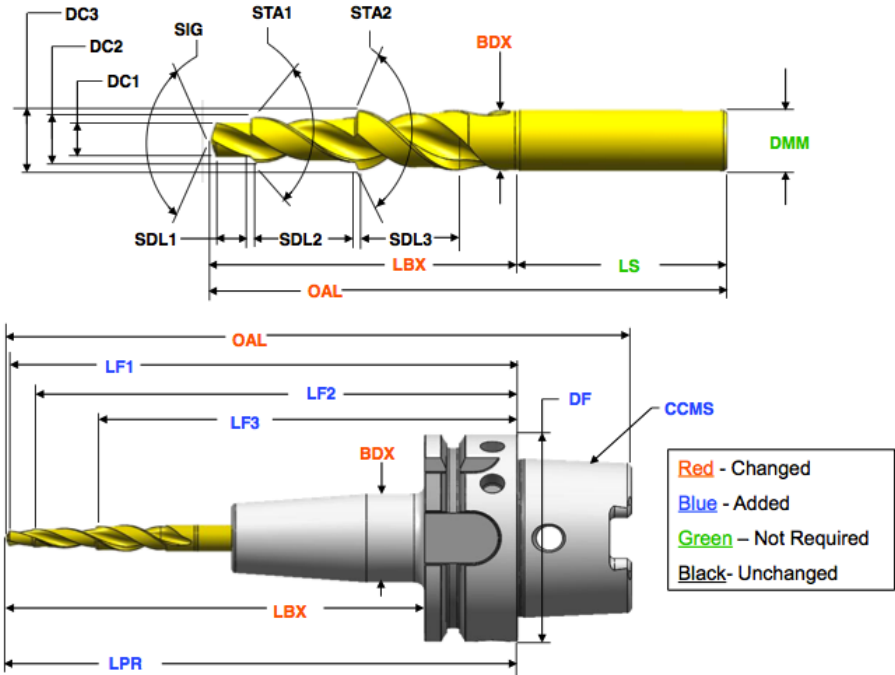


Figure 11: Cutting Tool

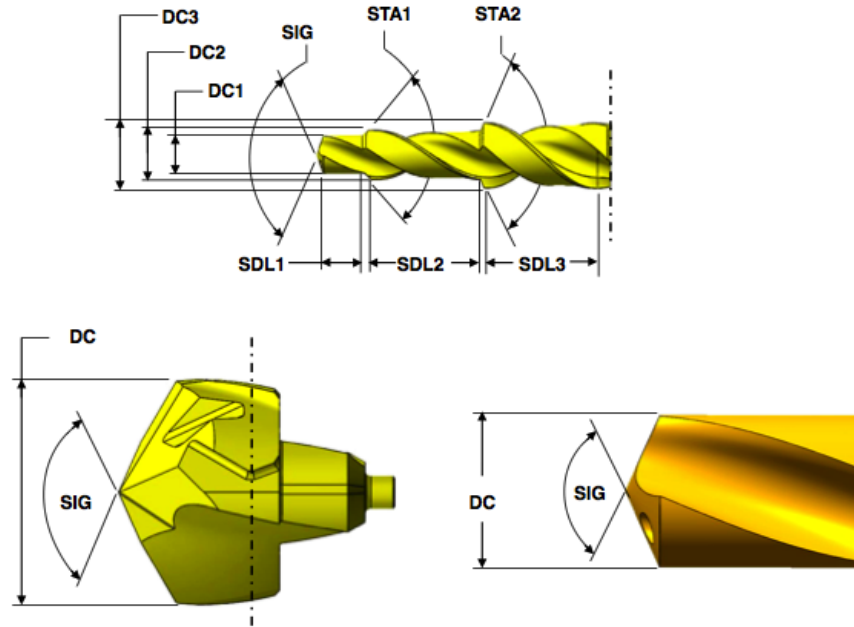


Figure 12: Cutting Item

1405 **4.5.1 FunctionalLength**

1406 distance from the gauge plane or from the end of the shank of the cutting tool, if a gauge
 1407 plane does not exist, to the cutting reference point determined by the main function of the
 1408 tool.

1409 This measurement will be with reference to the cutting tool and **MUST NOT** exist without
 1410 a cutting tool.

1411 The code of FunctionalLength **MUST** be LFX.

1412 The units of FunctionalLength **MUST** be MILLIMETER.

1413 **4.5.2 CuttingReferencePoint**

1414 theoretical sharp point of the cutting tool from which the major functional dimensions are
 1415 taken.

1416 The code of CuttingReferencePoint **MUST** be CRP.

1417 The units of CuttingReferencePoint **MUST** be MILLIMETER.

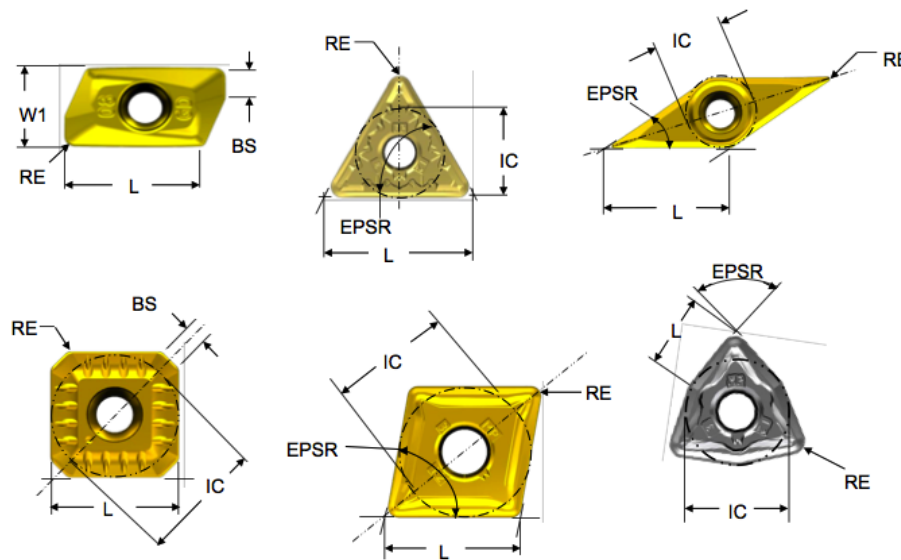


Figure 13: Cutting Item Measurement

1418 4.5.3 CuttingEdgeLength

1419 theoretical length of the cutting edge of a cutting item over sharp corners.

1420 The code of CuttingEdgeLength **MUST** be L.

1421 The units of CuttingEdgeLength **MUST** be MILLIMETER.

1422 4.5.4 DriveAngle

1423 angle between the driving mechanism locator on a tool item and the main cutting edge.

1424 The code of DriveAngle **MUST** be DRVA.

1425 The units of DriveAngle **MUST** be DEGREE.

1426 4.5.5 FlangeDiameter

1427 dimension between two parallel tangents on the outside edge of a flange.

1428 The code of FlangeDiameter **MUST** be DF.

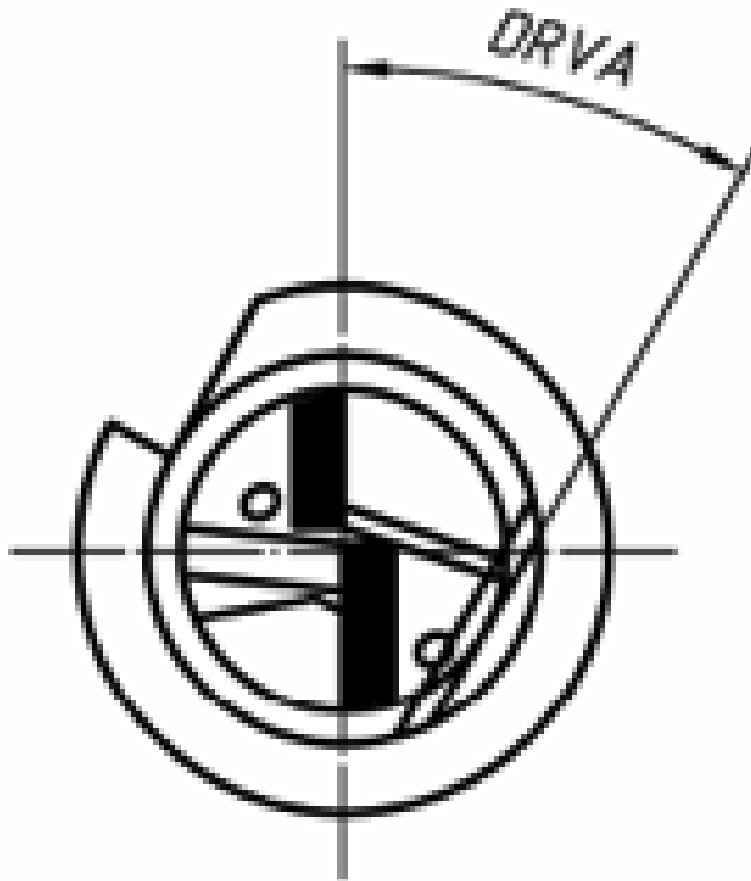


Figure 14: Cutting Item Drive Angle

1429 The units of FlangeDiameter **MUST** be MILLIMETER.

1430 **4.5.6 FunctionalWidth**

1431 distance between the cutting reference point and the rear backing surface of a turning tool
1432 or the axis of a boring bar.

1433 The code of FunctionalWidth **MUST** be WF.

1434 The units of FunctionalWidth **MUST** be MILLIMETER.

1435 **4.5.7 IncribedCircleDiameter**

1436 diameter of a circle to which all edges of a equilateral and round regular insert are tangen-
1437 tial.

1438 The code of `IncribedCircleDiameter` **MUST** be IC.

1439 The units of `IncribedCircleDiameter` **MUST** be MILLIMETER.

1440 **4.5.8 PointAngle**

1441 angle between the major cutting edge and the same cutting edge rotated by 180 degrees
1442 about the tool axis.

1443 The code of `PointAngle` **MUST** be SIG.

1444 The units of `PointAngle` **MUST** be DEGREE.

1445 **4.5.9 ToolCuttingEdgeAngle**

1446 angle between the tool cutting edge plane and the tool feed plane measured in a plane
1447 parallel the xy-plane.

1448 The code of `ToolCuttingEdgeAngle` **MUST** be KAPR.

1449 The units of `ToolCuttingEdgeAngle` **MUST** be DEGREE.

1450 **4.5.10 ToolLeadAngle**

1451 angle between the tool cutting edge plane and a plane perpendicular to the tool feed plane
1452 measured in a plane parallel the xy-plane.

1453 The code of `ToolLeadAngle` **MUST** be PSIR.

1454 The units of `ToolLeadAngle` **MUST** be DEGREE.

1455 4.5.11 ToolOrientation

1456 angle of the tool with respect to the workpiece for a given process.

1457 The value is application specific.

1458 The code is N/A for ToolOrientation.

1459 The units of ToolOrientation **MUST** be DEGREE.

1460 4.5.12 StepDiameterLength

1461 length of a portion of a stepped tool that is related to a corresponding cutting diameter
1462 measured from the cutting reference point of that cutting diameter to the point on the next
1463 cutting edge at which the diameter starts to change.

1464 The code of StepDiameterLength **MUST** be SDLx.

1465 The units of StepDiameterLength **MUST** be MILLIMETER.

1466 4.5.13 StepIncludedAngle

1467 angle between a major edge on a step of a stepped tool and the same cutting edge rotated
1468 180 degrees about its tool axis.

1469 The code of StepIncludedAngle **MUST** be STAx.

1470 The units of StepIncludedAngle **MUST** be DEGREE.

1471 4.5.14 WiperEdgeLength

1472 measure of the length of a wiper edge of a cutting item.

1473 The code of WiperEdgeLength **MUST** be BS.

1474 The units of WiperEdgeLength **MUST** be MILLIMETER.

1475 4.5.15 CuttingDiameter

- 1476 diameter of a circle on which the defined point Pk located on this cutting tool.
- 1477 The normal of the machined peripheral surface points towards the axis of the cutting tool.
- 1478 The code of CuttingDiameter **MUST** be DCx.
- 1479 The units of CuttingDiameter **MUST** be MILLIMETER.

1480 4.5.16 CuttingHeight

- 1481 distance from the basal plane of the tool item to the cutting point.
- 1482 The code of CuttingHeight **MUST** be HF.
- 1483 The units of CuttingHeight **MUST** be MILLIMETER.

1484 4.5.17 CornerRadius

- 1485 nominal radius of a rounded corner measured in the X Y-plane.
- 1486 The code of CornerRadius **MUST** be RE.
- 1487 The units of CornerRadius **MUST** be MILLIMETER.

1488 4.5.18 Weight

- 1489 total weight of the cutting tool in grams.
- 1490 The force exerted by the mass of the cutting tool.
- 1491 The code of Weight **MUST** be WT.
- 1492 The units of Weight **MUST** be GRAM.

1493 4.5.19 ChamferFlatLength

1494 flat length of a chamfer.

1495 The code of ChamferFlatLength **MUST** be BCH.

1496 The units of ChamferFlatLength **MUST** be MILLIMETER.

1497 4.5.20 ChamferWidth

1498 width of the chamfer.

1499 The code of ChamferWidth **MUST** be CHW.

1500 The units of ChamferWidth **MUST** be MILLIMETER.

1501 4.5.21 InsertWidth

1502 W1 is used for the insert width when an inscribed circle diameter is not practical.

1503 The code of InsertWidth **MUST** be W1.

1504 The units of InsertWidth **MUST** be MILLIMETER.

1505 **5 Files Asset Information Model**

1506 Manufacturing processes require various documents, programs, setup sheets, and digital
1507 media available at the device for a given process. The `File` and `FileArchetype` As-
1508 sets provide a mechanism to communicate specific “Files” that are relevant to a process
1509 where the media is located on a server and represented by a Universal Resource Locator
1510 (URL).

1511 The `FileArchetype` contains metadata common to all `File` Assets for a certain
1512 purpose. The `FileAsset` references the file specific to a given device or set of devices.
1513 The `FileAsset` does not hold the contents of the file, it contains a reference to the
1514 location (URL) used to access the information. The metadata associated with the `File`
1515 provides semantic information about the representation (mime-type) and the application
1516 associated with the `File`. The application of the file is an extensible controlled vocabulary
1517 with common manufacturing uses provided.

1518 **5.1 Files**

1519 This section provides semantic information for the `File` model.

1520 Note: See *Section B.7 - File Schema Diagrams* for XML schema.

1521 **5.1.1 AbstractFile**

1522 `abstractAsset` that contains the common properties of the `File` and `FileArchetype`
1523 types.

1524 **5.1.1.1 Value Properties of AbstractFile**

1525 *Table 21* lists the Value Properties of `AbstractFile`.

Value Property name	Value Property type	Multiplicity
name	string	1
mediaType	string	1
applicationCategory	ApplicationCategoryEnum	1
applicationType	ApplicationTypeEnum	1

Table 21: Value Properties of AbstractFile

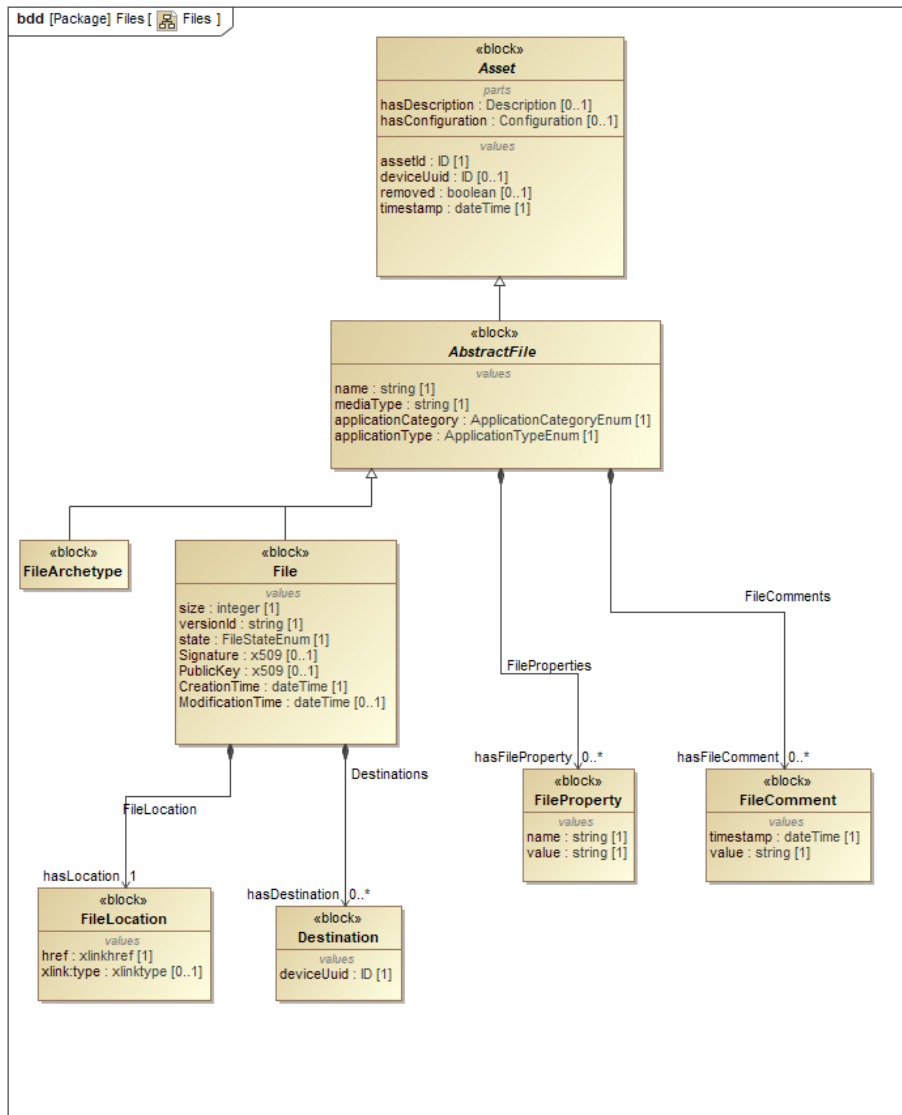


Figure 15: Files

1526 Descriptions for Value Properties of AbstractFile:

- 1527 • name
- 1528 name of the file.
- 1529 • mediaType
- 1530 mime type of the file.
- 1531 • applicationCategory
- 1532 category of application that will use this file.
- 1533 ApplicationCategoryEnum Enumeration:
 - 1534 – ASSEMBLY
 - 1535 files regarding the fully assembled product.
 - 1536 – DEVICE
 - 1537 device related files.
 - 1538 – HANDLING
 - 1539 files relating to the handling of material.
 - 1540 – INSPECTION
 - 1541 files related to the quality inspection.
 - 1542 – MAINTENANCE
 - 1543 files relating to equipment maintenance.
 - 1544 – PART
 - 1545 files relating to a part.
 - 1546 – PROCESS
 - 1547 files related to the manufacturing process.
 - 1548 – SETUP
 - 1549 files related to the setup of a process.
- 1550 • applicationType
- 1551 type of application that will use this file.
- 1552 ApplicationTypeEnum Enumeration:
 - 1553 – DATA
 - 1554 generic data.
 - 1555 – DESIGN
 - 1556 computer aided design files or drawings.

- 1557 – DOCUMENTATION
- 1558 documentation regarding a category of file.
- 1559 – INSTRUCTIONS
- 1560 user instructions regarding the execution of a task.
- 1561 – LOG
- 1562 data related to the history of a machine or process.
- 1563 – PRODUCTION_PROGRAM
- 1564 machine instructions to perform a process.

1565 **5.1.1.2 Part Properties of AbstractFile**

1566 *Table 22* lists the Part Properties of AbstractFile.

Part Property name	Multiplicity
FileProperty (organized by FileProperties)	0..*
FileComment (organized by FileComments)	0..*

Table 22: Part Properties of AbstractFile

1567 Descriptions for Part Properties of AbstractFile:

- 1568 • FileProperty
- 1569 key-value pair providing additional metadata about a File.
- 1570 FileProperties groups one or more FileProperty entities for a File. See
- 1571 *Section 5.1.4 - FileProperty.*
- 1572 • FileComment
- 1573 remark or interpretation for human interpretation associated with a File or FileArchetype.
- 1574 FileComments groups one or more FileComment entities for a File. See
- 1575 *Section 5.1.5 - FileComment.*

1576 **5.1.2 File**

1577 AbstractFile type that provides information about the File instance and its URL.

1578 **5.1.2.1 Value Properties of File**

1579 *Table 23* lists the Value Properties of File.

Value Property name	Value Property type	Multiplicity
size	integer	1
versionId	string	1
state	FileStateEnum	1
Signature	x509	0..1
PublicKey	x509	0..1
CreationTime	datetime	1
ModificationTime	datetime	0..1

Table 23: Value Properties of File

1580 Descriptions for Value Properties of File:

- 1581 • size
- 1582 size of the file in bytes.
- 1583 • versionId
- 1584 version identifier of the file.
- 1585 • state
- 1586 state of the file.
- 1587 FileStateEnum Enumeration:
- 1588 – EXPERIMENTAL
- 1589 used for processes other than production or otherwise defined.
- 1590 – PRODUCTION
- 1591 used for production processes.
- 1592 – REVISION
- 1593 content is modified from PRODUCTION or EXPERIMENTAL.
- 1594 • Signature
- 1595 secure hash of the file.
- 1596 • PublicKey
- 1597 public key used to verify the signature.
- 1598 • CreationTime
- 1599 time the file was created.
- 1600 • ModificationTime
- 1601 time the file was modified.

1602 5.1.2.2 Part Properties of File

1603 *Table 24* lists the Part Properties of File.

Part Property name	Multiplicity
FileLocation	1
Destination (organized by Destinations)	0..*

Table 24: Part Properties of File

1604 Descriptions for Part Properties of File:

- 1605 • FileLocation
- 1606 URL reference to the file location.
- 1607 See *Section 5.1.6 - FileLocation*.
- 1608 • Destination
- 1609 reference to the target Device for this File.
- 1610 Destinations groups one or more Destination entities. See *Section 5.1.7 -*
- 1611 *Destination*.

1612 5.1.3 FileArchetype

1613 AbstractFile type that provides information common to all versions of a file.

1614 5.1.4 FileProperty

1615 key-value pair providing additional metadata about a File.

1616 The value of FileProperty **MUST** be string.

1617 5.1.4.1 Value Properties of FileProperty

1618 *Table 25* lists the Value Properties of FileProperty.

Value Property name	Value Property type	Multiplicity
name	string	1

Table 25: Value Properties of FileProperty

1619 Descriptions for Value Properties of FileProperty:

- 1620 • name
 1621 name of the FileProperty.

1622 5.1.5 FileComment

1623 remark or interpretation for human interpretation associated with a File or FileArchetype.

1624 The value of FileComment **MUST** be string.

1625 5.1.5.1 Value Properties of FileComment

1626 *Table 26* lists the Value Properties of FileComment.

Value Property name	Value Property type	Multiplicity
timestamp	datetime	1

Table 26: Value Properties of FileComment

1627 Descriptions for Value Properties of FileComment:

- 1628 • timestamp
 1629 time the comment was made.

1630 5.1.6 FileLocation

1631 URL reference to the file location.

1632 5.1.6.1 Value Properties of FileLocation

1633 *Table 27* lists the Value Properties of FileLocation.

Value Property name	Value Property type	Multiplicity
href	xlink:href	1
xlink:type	xlink:type	0..1

Table 27: Value Properties of FileLocation

1634 Descriptions for Value Properties of FileLocation:

- 1635 • href
- 1636 URL reference to the file.
- 1637 href is of type xlink:href from the W3C XLink specification.
- 1638 • xlink:type
- 1639 type of href for the xlink href type.
- 1640 **MUST** be locator referring to a URL .

1641 5.1.7 Destination

1642 reference to the target Device for this File.

1643 5.1.7.1 Value Properties of Destination

1644 *Table 28* lists the Value Properties of Destination.

Value Property name	Value Property type	Multiplicity
deviceUuid	ID	1

Table 28: Value Properties of Destination

1645 Descriptions for Value Properties of Destination:

- 1646 • deviceUuid
- 1647 uuid of the target device or application.

1648 **6 Raw Material Asset Information Model**

1649 Raw material represents the source of material for immediate use and sources of material
1650 that may or may not be used during the manufacturing process.

1651 The `RawMaterialAsset` holds the references to the content stored in the actual `Raw-`
1652 `Material` container or derived about the `RawMaterial` by the system during opera-
1653 tion.

1654 **6.1 Raw Material**

1655 This section provides semantic information for the `RawMaterial` model.

1656 Note: See *Section B.8 - RawMaterial Schema Diagrams* for XML schema.

1657 **6.1.1 RawMaterial**

1658 Asset that represents raw material.

1659 **6.1.1.1 Value Properties of RawMaterial**

1660 *Table 29* lists the Value Properties of `RawMaterial`.

Value Property name	Value Property type	Multiplicity
name	string	0..1
containerType	string	0..1
processKind	string	0..1
serialNumber	string	0..1
HasMaterial	boolean	0..1
Form	FormEnum	1
ManufacturingDate	datetime	0..1
FirstUseDate	datetime	0..1
LastUseDate	datetime	0..1
InitialVolume	CUBIC_MILLIMETER	0..1
InitialDimension	MILLIMETER	0..3
InitialQuantity	integer	0..1
CurrentVolume	CUBIC_MILLIMETER	0..1
CurrentDimension	MILLIMETER	0..3
CurrentQuantity	integer	0..1

Table 29: Value Properties of RawMaterial

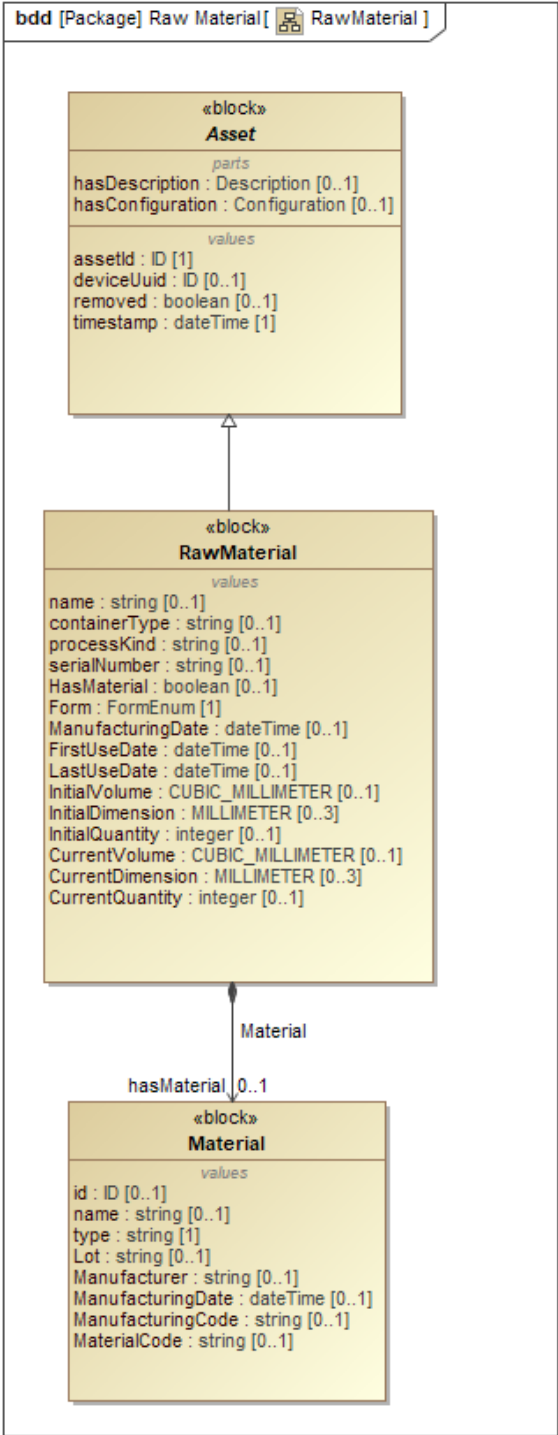


Figure 16: RawMaterial

1661 Descriptions for Value Properties of RawMaterial:

- 1662 • name
- 1663 name of the raw material.
- 1664 Examples: Container1 and AcrylicContainer.
- 1665 • containerType
- 1666 type of container holding the raw material.
- 1667 Examples: Pallet, Canister, Cartridge, Tank, Bin, Roll, and Spool.
- 1668 • processKind
- 1669 ISO process type supported by this raw material.
- 1670 Examples include: VAT_POLYMERIZATION, BINDER_JETTING, MATERIAL_EXTRUSION,
- 1671 MATERIAL_JETTING, SHEET_LAMINATION, POWDER_BED_FUSION and DI-
- 1672 RECTED_ENERGY_DEPOSITION.
- 1673 • serialNumber
- 1674 serial number of the raw material.
- 1675 • HasMaterial
- 1676 Material has existing usable volume.
- 1677 • Form
- 1678 form of the raw material.
- 1679 FormEnum Enumeration:
 - 1680 – BAR
 - 1681 – BLOCK
 - 1682 – CASTING
 - 1683 – FILAMENT
 - 1684 – GAS
 - 1685 – GEL
 - 1686 – LIQUID
 - 1687 – POWDER
 - 1688 – SHEET
- 1689 • ManufacturingDate
- 1690 date the raw material was created.

- 1691 • FirstUseDate
- 1692 date raw material was first used.
- 1693 • LastUseDate
- 1694 date raw material was last used.
- 1695 • InitialVolume
- 1696 amount of material initially placed in raw material when manufactured.
- 1697 • InitialDimension
- 1698 dimension of material initially placed in raw material when manufactured.
- 1699 • InitialQuantity
- 1700 quantity of material initially placed in raw material when manufactured.
- 1701 • CurrentVolume
- 1702 amount of material currently in raw material.
- 1703 • CurrentDimension
- 1704 dimension of material currently in raw material.
- 1705 • CurrentQuantity
- 1706 quantity of material currently in raw material.

1707 **6.1.1.2 Part Properties of RawMaterial**

1708 *Table 30* lists the Part Properties of RawMaterial.

Part Property name	Multiplicity
Material	0..1

Table 30: Part Properties of RawMaterial

1709 Descriptions for Part Properties of RawMaterial:

- 1710 • Material
- 1711 material used as the RawMaterial.
- 1712 See *Section 6.1.2 - Material*.

1713 6.1.2 Material

1714 material used as the RawMaterial.

1715 6.1.2.1 Value Properties of Material

1716 *Table 31* lists the Value Properties of Material.

Value Property name	Value Property type	Multiplicity
id	ID	0..1
name	string	0..1
type	string	1
Lot	string	0..1
Manufacturer	string	0..1
ManufacturingDate	datetime	0..1
ManufacturingCode	string	0..1
MaterialCode	string	0..1

Table 31: Value Properties of Material

1717 Descriptions for Value Properties of Material:

- 1718 • id
- 1719 unique identifier for the material.
- 1720 • name
- 1721 name of the material.
- 1722 **Examples:** ULTM9085, ABS, 4140.
- 1723 • type
- 1724 type of material.
- 1725 **Examples:** Metal, Polymer, Wood, 4140, Recycled, Prestine and Used.
- 1726 • Lot
- 1727 manufacturer's lot code of the material.
- 1728 • Manufacturer
- 1729 name of the material manufacturer.

- 1730 • ManufacturingDate
- 1731 manufacturing date of the material from the material manufacturer.
- 1732 • ManufacturingCode
- 1733 lot code of the raw feed stock for the material, from the feed stock manufacturer.
- 1734 • MaterialCode
- 1735 American Society for Testing and Materials (ASTM) standard code that the material
- 1736 complies with.

1737 **7 QIF Asset Information Model**

1738 The Quality Information Framework (QIF) is an American National Standards Institute
1739 (ANSI) accredited standard developed by the Digital Metrology Standards Consortium
1740 (DMSC) standards development organization. The DMSC is an A-liaison to the Interna-
1741 tional Standards Organization (ISO) Technical Committee (TC) 184. QIF addresses the
1742 needs of the metrology community to have a semantic information model for the exchange
1743 of metrology data throughout the verification lifecycle from product design to execution,
1744 analysis, and reporting.

1745 The MTConnect *QIF Asset Information Model* provides a wrapper around a QIF document
1746 (i.e., a dataset conforming to the QIF Information model) in its native XML representation.
1747 The MTConnect standard does not alter or extend the QIF standard and regards the QIF
1748 standard as a passthrough.

1749 Information about the QIF standards is at the following location: <https://qifstandards.org>

1750 **7.1 QIF**

1751 This section provides semantic information for the `QIFDocumentWrapper` model.

1752 Note: See *Section B.9 - QIFDocumentWrapper Schema Diagrams* for XML
1753 schema.

1754 **7.1.1 QIFDocument**

1755 QIF Document as given by the QIF standard.

1756 **7.1.2 QIFDocumentWrapper**

1757 Asset that carries the QIF Document.

1758 **7.1.2.1 Value Properties of QIFDocumentWrapper**

1759 *Table 32* lists the Value Properties of `QIFDocumentWrapper`.

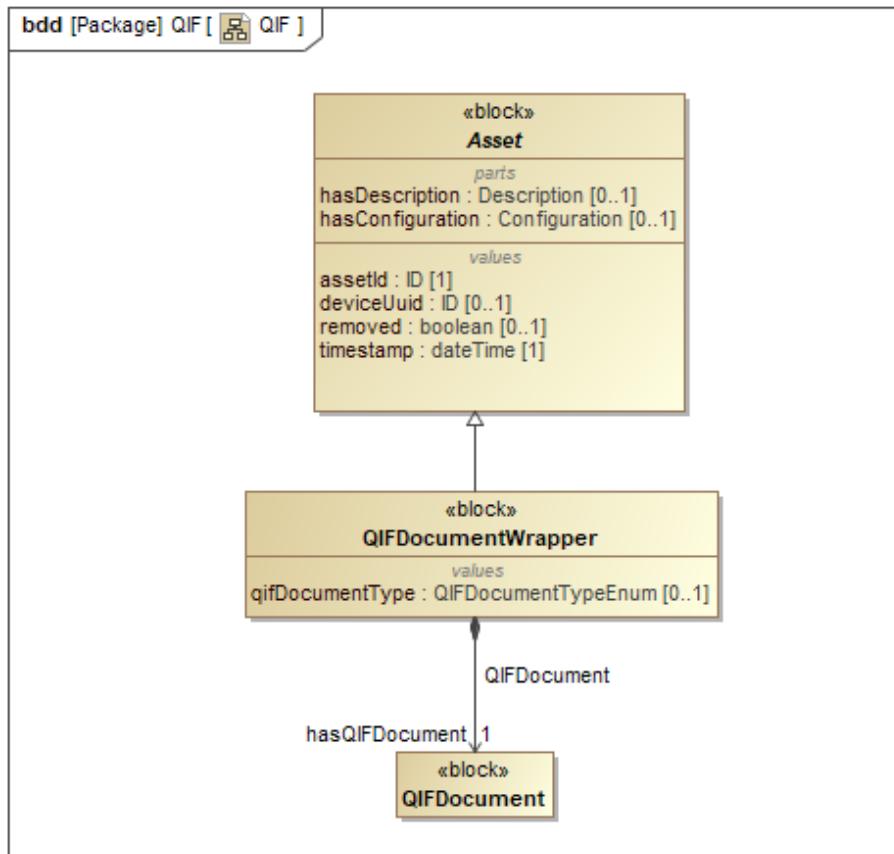


Figure 17: QIFDocumentWrapper

Value Property name	Value Property type	Multiplicity
qifDocumentType	QIFDocumentTypeEnum	0..1

Table 32: Value Properties of QIFDocumentWrapper

1760 Descriptions for Value Properties of QIFDocumentWrapper:

- 1761 • qifDocumentType
- 1762 contained QIF Document type as defined in the QIF Standard.

1763 QIFDocumentTypeEnum Enumeration:

- 1764 – MEASUREMENT_RESOURCE
- 1765 – PLAN
- 1766 – PRODUCT
- 1767 – RESULTS

- 1768 – RULES
- 1769 – STATISTICS

1770 **7.1.2.2 Part Properties of QIFDocumentWrapper**

1771 *Table 33* lists the Part Properties of QIFDocumentWrapper.

Part Property name	Multiplicity
QIFDocument	1

Table 33: Part Properties of QIFDocumentWrapper

1772 Descriptions for Part Properties of QIFDocumentWrapper:

- 1773 • QIFDocument
- 1774 QIF Document as given by the QIF standard.

1775 8 Component Configuration Parameters

1776 This section provides semantic information for the ComponentConfigurationPa-
 1777 rameters model.

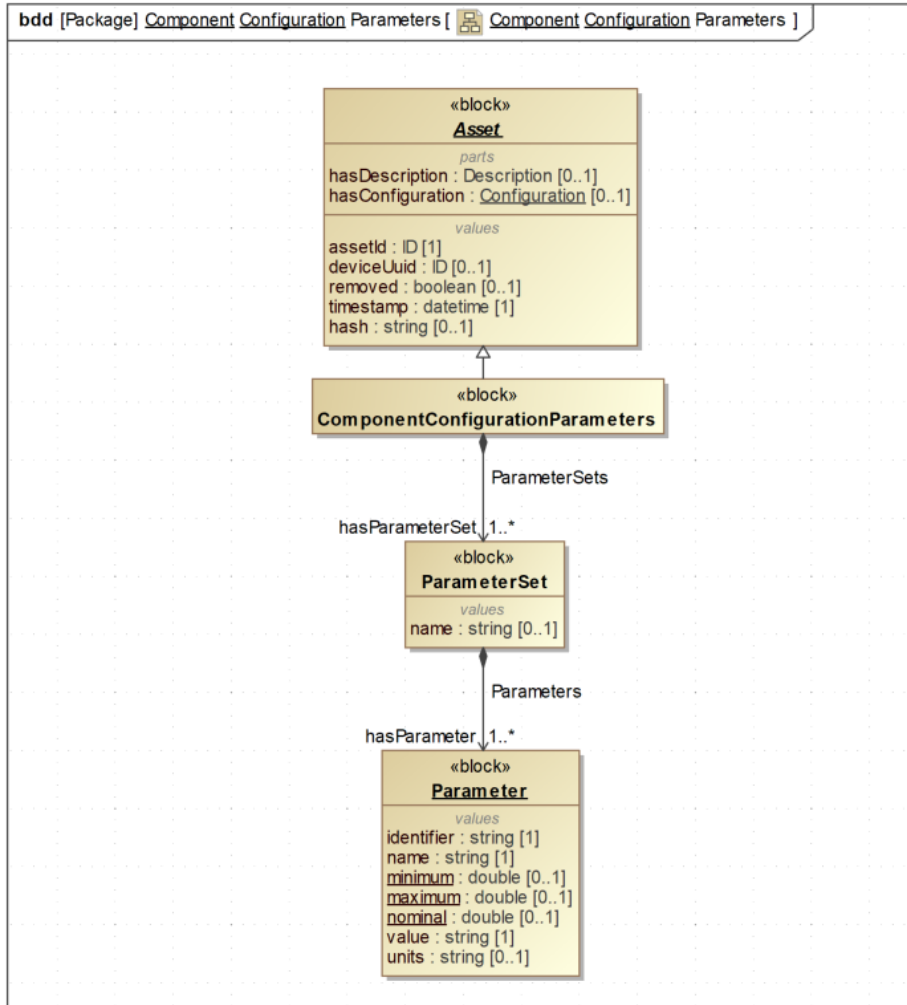


Figure 18: ComponentConfigurationParameters

1778 8.1 ComponentConfigurationParameters

1779 set of parameters that govern the functionality of the related Component.

1780 8.1.1 Part Properties of ComponentConfigurationParameters

1781 *Table 34* lists the Part Properties of ComponentConfigurationParameters.

Part Property name	Multiplicity
ParameterSet (organized by ParameterSets)	1..*

Table 34: Part Properties of ComponentConfigurationParameters

1782 Descriptions for Part Properties of ComponentConfigurationParameters:

1783 • ParameterSet

1784 set of parameters defining the configuration of a Component.

1785 8.2 ParameterSet

1786 set of parameters defining the configuration of a Component.

1787 8.2.1 Value Properties of ParameterSet

1788 *Table 35* lists the Value Properties of ParameterSet.

Value Property name	Value Property type	Multiplicity
name	string	0..1

Table 35: Value Properties of ParameterSet

1789 Descriptions for Value Properties of ParameterSet:

1790 • name

1791 name of the parameter set if more than one exists.

1792 8.2.2 Part Properties of ParameterSet

1793 *Table 36* lists the Part Properties of ParameterSet.

Part Property name	Multiplicity
Parameter (organized by Parameters)	1..*

Table 36: Part Properties of ParameterSet

1794 Descriptions for Part Properties of ParameterSet:

- 1795 • Parameter
- 1796 property defining a configuration of a Component.

1797 8.3 Parameter

1798 property defining a configuration of a Component.

1799 The value of Parameter **MUST** be string.

1800 8.3.1 Value Properties of Parameter

1801 *Table 37* lists the Value Properties of Parameter.

Value Property name	Value Property type	Multiplicity
identifier	string	1
name	string	1
minimum	double	0..1
maximum	double	0..1
nominal	double	0..1
units	string	0..1

Table 37: Value Properties of Parameter

1802 Descriptions for Value Properties of Parameter:

- 1803 • identifier
- 1804 internal identifier, register, or address.
- 1805 • name
- 1806 descriptive name.

- 1807 • minimum
- 1808 minimal allowed value.
- 1809 • maximum
- 1810 maximum allowed value.
- 1811 • nominal
- 1812 nominal value.
- 1813 • units
- 1814 engineering units.
- 1815 units **SHOULD** be SI or MTConnect Units.

1816 9 Profile

1817 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML)
 1818 metamodel for the MTConnect domain using additional data types and *stereotypes*.

1819 9.1 DataTypes

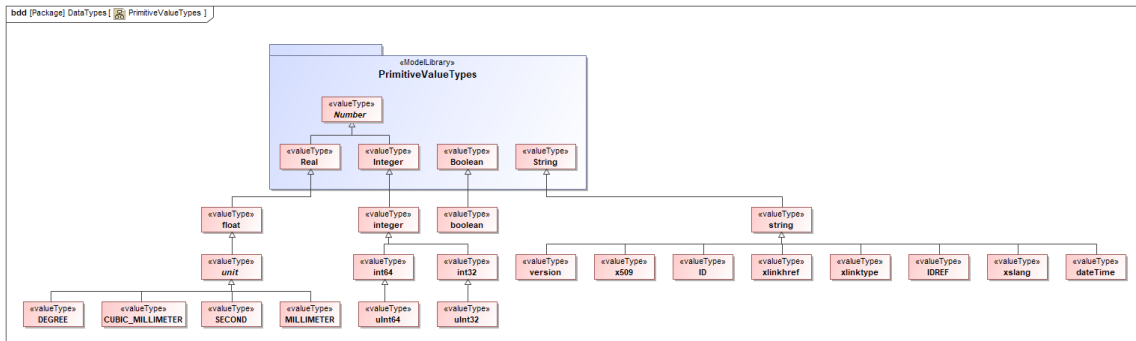


Figure 19: DataTypes

1820 9.2 boolean

1821 primitive type.

1822 9.3 ID

1823 string that represents an identifier (ID).

1824 9.4 string

1825 primitive type.

1826 9.5 float

1827 primitive type.

1828 9.6 datetime

1829 string that represents timestamp in ISO 8601 format.

1830 9.7 integer

1831 primitive type.

1832 9.8 xlinktype

1833 string that represents the type of an XLink element. See <https://www.w3.org/TR/xlink11/>.

1835 9.9 xslang

1836 string that represents a language tag. See <http://www.ietf.org/rfc/rfc4646.txt>.

1838 9.10 SECOND

1839 float that represents time in seconds.

1840 9.11 IDREF

1841 string that represents a reference to an ID.

1842 9.12 xlinkhref

1843 string that represents the locator attribute of an XLink element. See <https://www.w3.org/TR/xlink11/>.

1845 9.13 x509

1846 string that represents an x509 data block. *Ref ISO/IEC 9594-8:2020.*

1847 9.14 int32

1848 32-bit integer.

1849 9.15 int64

1850 64-bit integer.

1851 9.16 version

1852 series of four numeric values, separated by a decimal point, representing a *major*, *minor*,
1853 and *revision* number of the MTConnect Standard and the revision number of a specific
1854 *schema*.

1855 9.17 uint32

1856 32-bit unsigned integer.

1857 9.18 uint64

1858 64-bit unsigned integer.

1859 9.19 binary

1860 base-2 numeral system or binary numeral system represented by two digits: “0” and “1”.

1861 9.20 double

1862 primitive type.

1863 9.21 Stereotypes

1864 9.22 organizer

1865 element that *organizes* other elements of a type.

1866 9.23 deprecated

1867 element that has been deprecated.

1868 9.24 extensible

1869 enumeration that can be extended.

1870 9.25 informative

1871 element that is descriptive and non-normative.

1872 9.26 valueType

1873 extends SysML <<ValueType>> to include `Class` as a value type.

1874 9.27 normative

1875 element that has been added to the standard.

1876 **9.28** **observes**

1877 association in which a *Component* makes *Observations* about an observable *DataItem*.

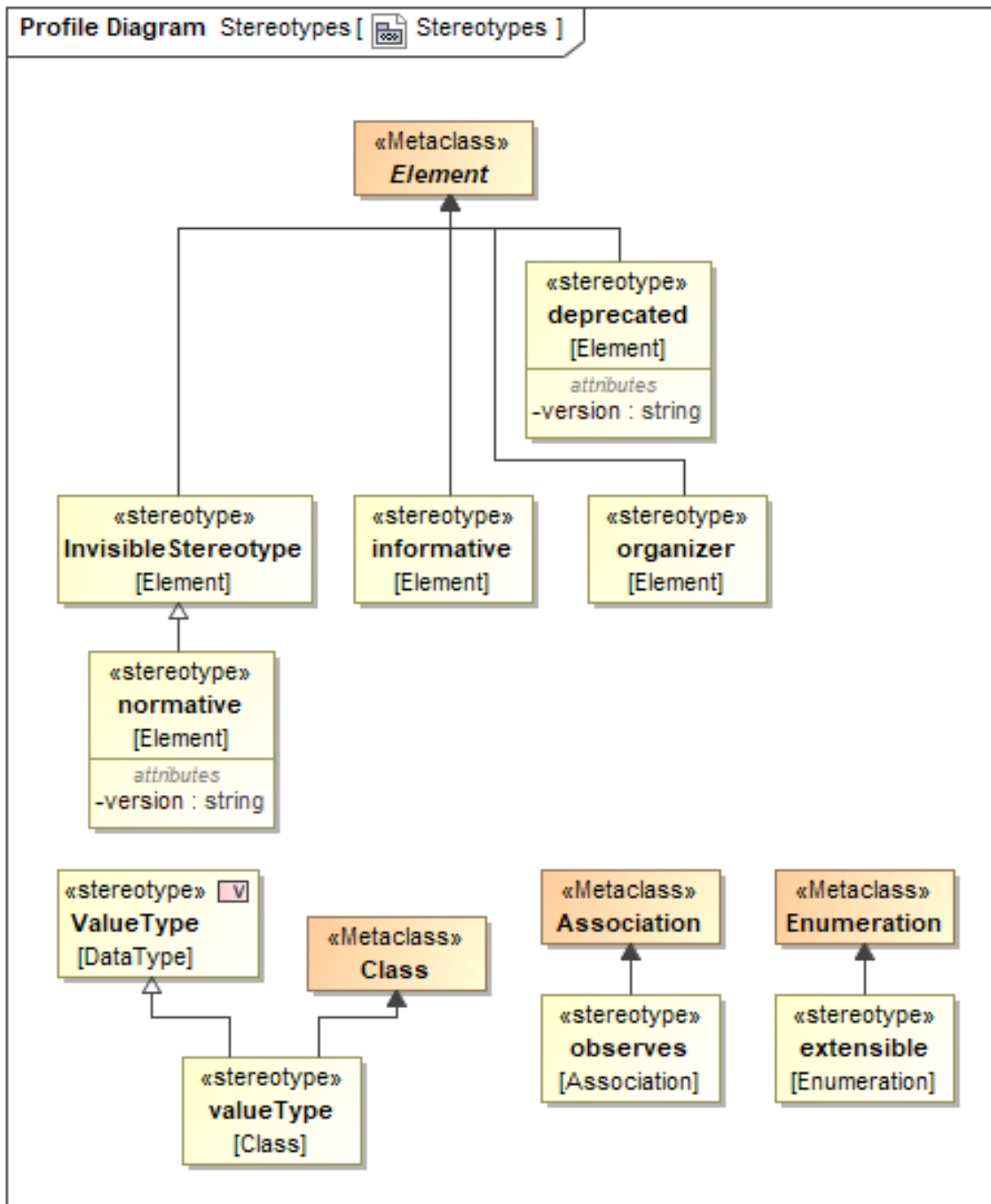


Figure 20: Stereotypes

1878 Appendices

1879 A Bibliography

1880 Engineering Industries Association. EIA Standard - EIA-274-D, Interchangeable Variable,
1881 Block Data Format for Positioning, Contouring, and Contouring/Positioning Numerically
1882 Controlled Machines. Washington, D.C. 1979.

1883 ISO TC 184/SC4/WG3 N1089. ISO/DIS 10303-238: Industrial automation systems and
1884 integration Product data representation and exchange Part 238: Application Protocols: Ap-
1885 plication interpreted model for computerized numerical controllers. Geneva, Switzerland,
1886 2004.

1887 International Organization for Standardization. ISO 14649: Industrial automation sys-
1888 tems and integration – Physical device control – Data model for computerized numerical
1889 controllers – Part 10: General process data. Geneva, Switzerland, 2004.

1890 International Organization for Standardization. ISO 14649: Industrial automation sys-
1891 tems and integration – Physical device control – Data model for computerized numerical
1892 controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.

1893 International Organization for Standardization. ISO 6983/1 – Numerical Control of ma-
1894 chines – Program format and definition of address words – Part 1: Data format for posi-
1895 tioning, line and contouring control systems. Geneva, Switzerland, 1982.

1896 Electronic Industries Association. ANSI/EIA-494-B-1992, 32 Bit Binary CL (BCL) and
1897 7 Bit ASCII CL (ACL) Exchange Input Format for Numerically Controlled Machines.
1898 Washington, D.C. 1992.

1899 National Aerospace Standard. Uniform Cutting Tests - NAS Series: Metal Cutting Equip-
1900 ment Specifications. Washington, D.C. 1969.

1901 International Organization for Standardization. ISO 10303-11: 1994, Industrial automa-
1902 tion systems and integration Product data representation and exchange Part 11: Descrip-
1903 tion methods: The EXPRESS language reference manual. Geneva, Switzerland, 1994.

1904 International Organization for Standardization. ISO 10303-21: 1996, Industrial automa-
1905 tion systems and integration – Product data representation and exchange – Part 21: Imple-
1906 mentation methods: Clear text encoding of the exchange structure. Geneva, Switzerland,
1907 1996.

1908 H.L. Horton, F.D. Jones, and E. Oberg. Machinery's Handbook. Industrial Press, Inc.

- 1909 New York, 1984.
- 1910 International Organization for Standardization. ISO 841-2001: Industrial automation sys-
1911 tems and integration - Numerical control of machines - Coordinate systems and motion
1912 nomenclature. Geneva, Switzerland, 2001.
- 1913 ASME B5.57: Methods for Performance Evaluation of Computer Numerically Controlled
1914 Lathes and Turning Centers, 1998.
- 1915 ASME/ANSI B5.54: Methods for Performance Evaluation of Computer Numerically Con-
1916 trolled Machining Centers. 2005.
- 1917 OPC Foundation. OPC Unified Architecture Specification, Part 1: Concepts Version 1.00.
1918 July 28, 2006.
- 1919 IEEE STD 1451.0-2007, Standard for a Smart Transducer Interface for Sensors and Ac-
1920 tuators – Common Functions, Communication Protocols, and Transducer Electronic Data
1921 Sheet (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The In-
1922 stitute of Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH99684,
1923 October 5, 2007.
- 1924 IEEE STD 1451.4-1994, Standard for a Smart Transducer Interface for Sensors and Ac-
1925 tuators – Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet
1926 (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The Institute of
1927 Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH95225, December
1928 15, 2004.

1929 **B XML Schema Diagrams**

1930 See XML schemas for the MTConnect standard here: <https://schemas.mtconnect.org/>.

1932 **B.1 Assets Schema Diagrams**

1933 See Asset element in MTConnectAssets schema.

1934 See Description element in MTConnectAssets schema.

1935 **B.2 CuttingTool Schema Diagrams**

1936 See CuttingTool element in MTConnectAssets schema.

1937 See CuttingToolDefinition element in MTConnectAssets schema.

1938 See CuttingToolArchetypeReference element in MTConnectAssets schema.

1939 **B.3 CuttingToolLifeCycle Schema Diagrams**

1940 See CuttingToolLifeCycle element in MTConnectAssets schema.

1941 See CutterStatus element in MTConnectAssets schema.

1942 See Location element in MTConnectAssets schema.

1943 See Measurement element in MTConnectAssets schema.

1944 See ProcessFeedRate element in MTConnectAssets schema.

1945 See ProcessSpindleSpeed element in MTConnectAssets schema.

1946 See ReconditionCount element in MTConnectAssets schema.

1947 See ToolLife element in MTConnectAssets schema.

1948 **B.4 CuttingItem Schema Diagrams**

1949 See CuttingItems element in MTConnectAssets schema.

1950 See CuttingItem element in MTConnectAssets schema.

1951 See ItemLife element in MTConnectAssets schema.

1952 **B.5 ISO 13399 Diagrams**

1953 **B.5.1 Measurement Diagrams**

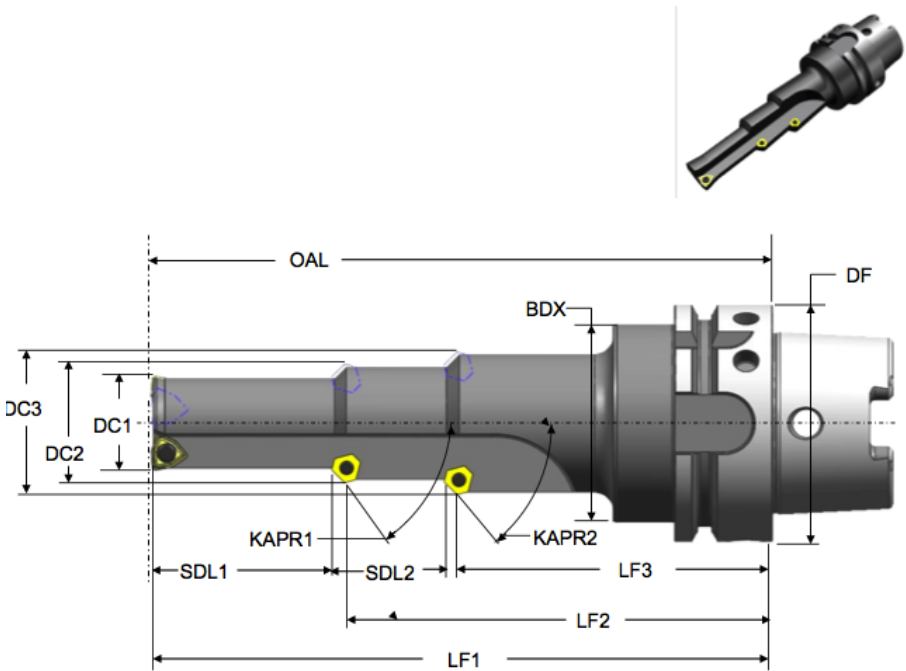


Figure 21: Cutting Tool Measurement 3

1954 **B.6 Cutting Tool Examples**

1955 **B.6.1 Shell Mill**

Example 1: Example for Indexable Insert Measurements

```
1956 1 <?xml version="1.0" encoding="UTF-8"?>
```

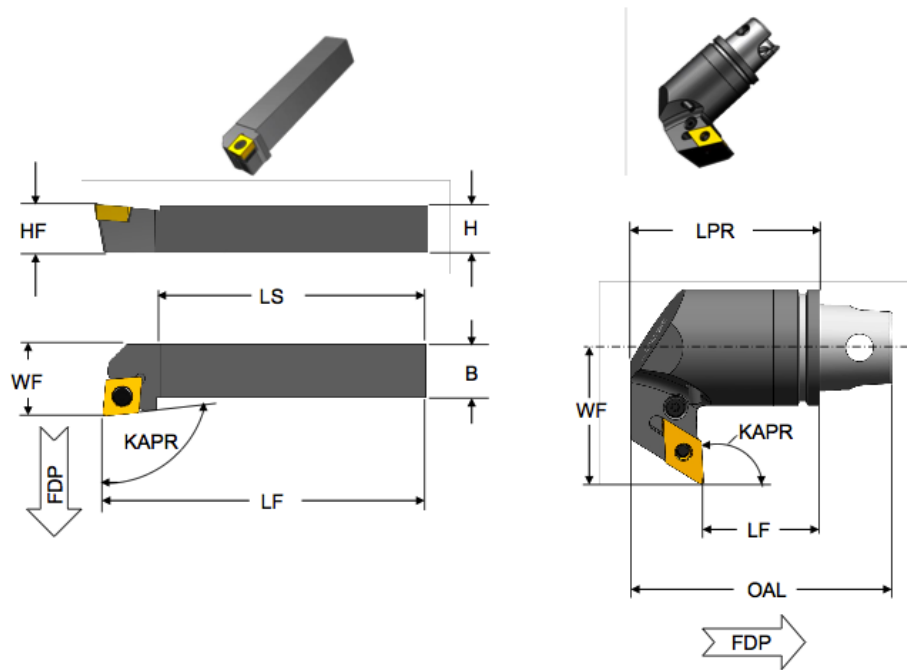


Figure 22: Cutting Tool Measurement 4

```

1957 2 <MTConnectAssets
1958 3 xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
1959 4 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
1960 5 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
1961 6 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
1962 7 http://mtconnect.org/schemas/MTConnectAssets\textunderscore 1.2.xsd"
1963 >
1964 8 <<Header_creationTime="2011-05-11T13:55:22"
1965 9 <<assetBufferSize="1024"<_sender="localhost"
1966 10 <<assetCount="2"<_version="1.2"<_instanceId="1234"/>
1967 11 <<Assets>
1968 12 <<CuttingTool_serialNumber="1"<_toolId="KSSP300R4SD43L240"
1969 13 <<timestamp="2011-05-11T13:55:22"<_assetId="KSSP300R4SD43L240.1"
1970 14 <<manufacturers="KMT,Parlec">
1971 15 <<<CuttingToolLifeCycle>
1972 16 <<<CutterStatus><Status>NEW</Status></CutterStatus>
1973 17 <<<ProcessSpindleSpeed_maximum="13300"
1974 18 <<nominal="605">10000</ProcessSpindleSpeed>
1975 19 <<<ProcessFeedRate
1976 20 <<nominal="9.22">9.22</ProcessSpindleSpeed>
1977 21 <<<ConnectionCodeMachineSide>CV50
1978 22 <<</ConnectionCodeMachineSide>
1979 23 <<<Measurements>
1980 24 <<<<<BodyDiameterMax_code="BDX">73.25
1981 25 <<<<</BodyDiameterMax>
1982 26 <<<<<OverallToolLength_nominal="222.25"

```

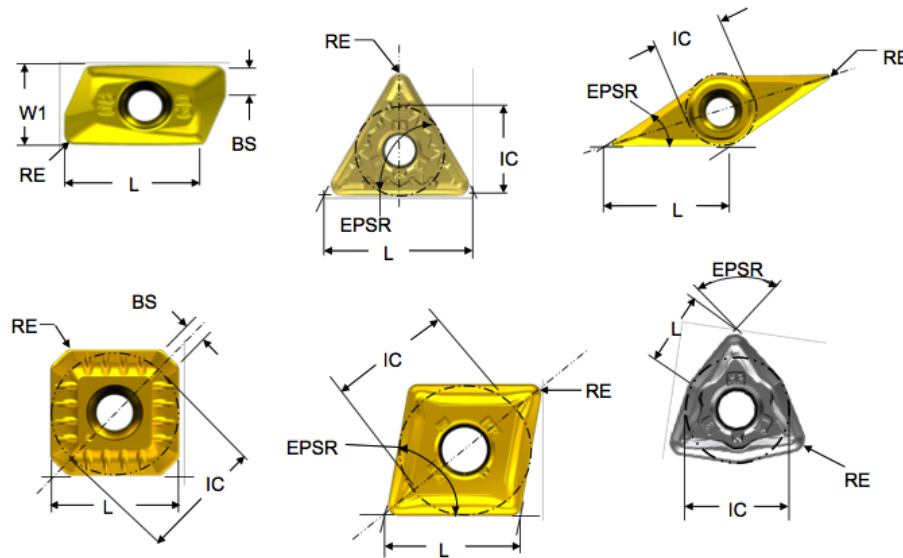


Figure 23: Cutting Tool Measurement 5

```

1983 27 _____minimum="221.996" _maximum="222.504"
1984 28 _____code="OAL">222.25</OverallToolLength>
1985 29 _____<UsableLengthMax_code="LUX" _nominal="82.55">82.55
1986 30 _____</UsableLengthMax>
1987 31 _____<CuttingDiameterMax_code="DC" _nominal="76.2"
1988 32 _____maximum="76.213" _minimum="76.187">76.2
1989 33 _____</CuttingDiameterMax>
1990 34 _____<BodyLengthMax_code="LF" _nominal="120.65"
1991 35 _____maximum="120.904" _minimum="120.404">120.65
1992 36 _____</BodyLengthMax>
1993 37 _____<DepthOfCutMax_code="APMX"
1994 38 _____nominal="60.96">60.95</DepthOfCutMax>
1995 39 _____<FlangeDiameterMax_code="DF"
1996 40 _____nominal="98.425">98.425</FlangeDiameterMax>
1997 41 _____</Measurements>
1998 42 _____<CuttingItems_count="24">
1999 43 _____<CuttingItem_indices="1-24" _itemId="SDET43PDER8GB"
2000 44 _____manufacturers="KMT" _grade="KC725M">
2001 45 _____<Measurements>
2002 46 _____<CuttingEdgeLength_code="L" _nominal="12.7"
2003 47 _____minimum="12.675" _maximum="12.725">12.7
2004 48 _____</CuttingEdgeLength>
2005 49 _____<WiperEdgeLength_code="BS" _nominal=
2006 50 _____"2.56">2.56</WiperEdgeLength>
2007 51 _____<IncribedCircleDiameter_code="IC"
2008 52 _____nominal="12.7">12.7
2009 53 _____</IncribedCircleDiameter>
2010 54 _____<CornerRadius_code="RE" _nominal="0.8">
2011 55 _____0.8</CornerRadius>

```

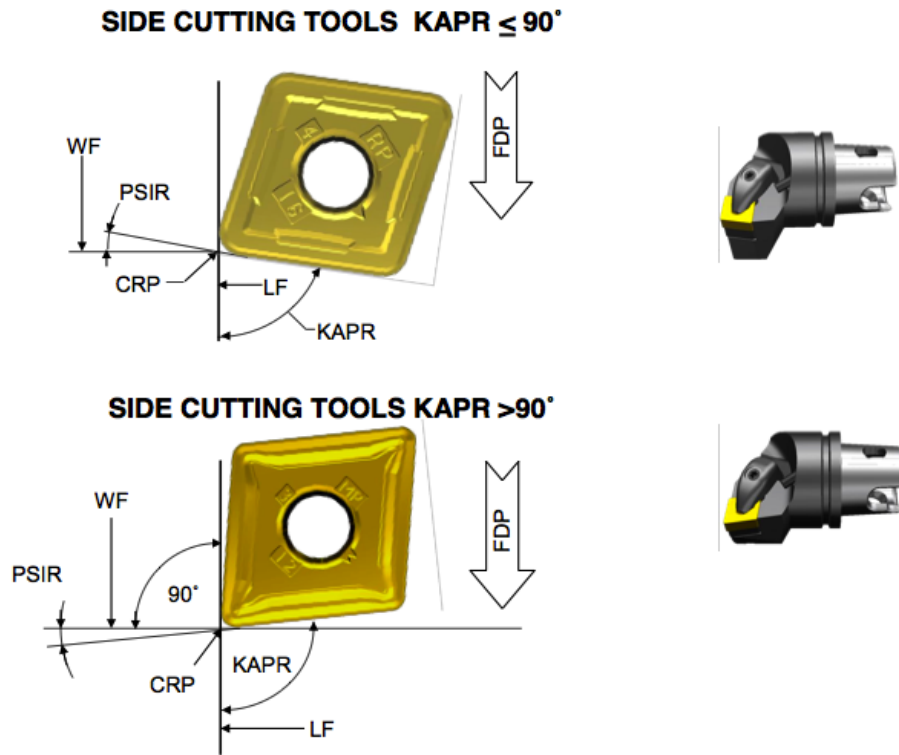


Figure 24: Cutting Tool Measurement 6

```

2012 56 <<<<<<</Measurements>
2013 57 <<<<<<</CuttingItem>
2014 58 <<<<<<</CuttingItems>
2015 59 <<<<<<</CuttingToolLifeCycle>
2016 60 <<<<<<</CuttingTool>
2017 61 <<<<<<</Assets>
2018 62 <<<<<<</MTConnectAssets>

```

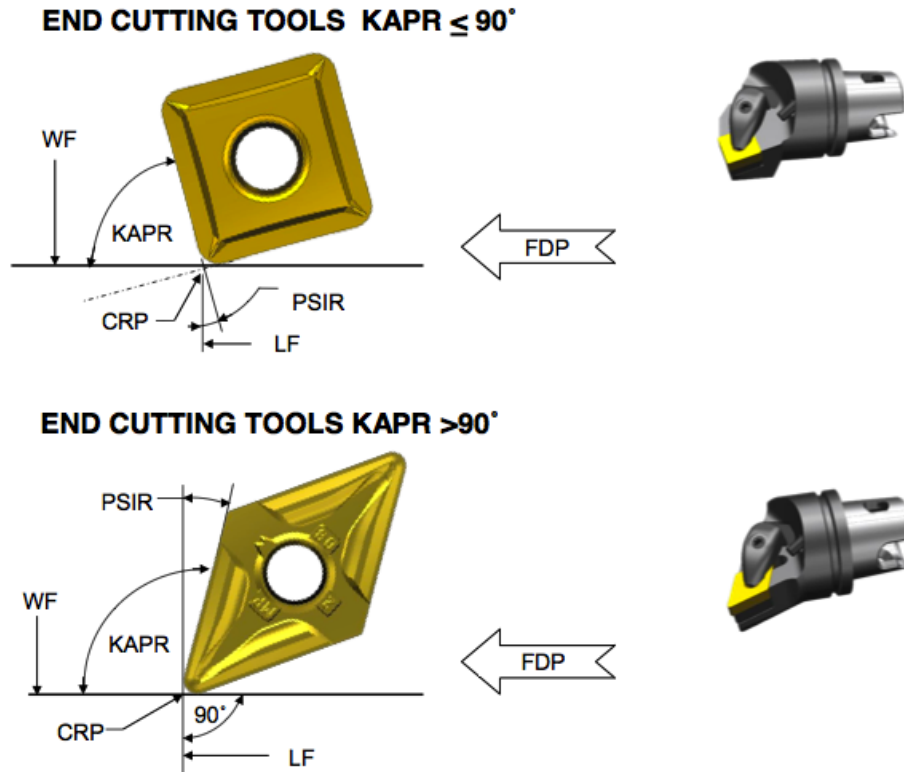



Figure 25: Cutting Tool Measurement 7

2019 **B.6.2 Step Drill**

Example 2: Example for Step Mill Side View

```

2020 1 <?xml version="1.0" encoding="UTF-8"?>
2021 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2022 3 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2023 4 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2024 5 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2025 6 http://mtconnect.org/schemas/MTConnectAssets\textunderscore_1.2.xsd"
2026 7 >
2027 8 <Header creationTime="2011-05-
2028 9 11T13:55:22" assetBufferSize="1024"
2029 10 sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2030 11 />
2031 12 <Assets>
2032 13 <CuttingTool serialNumber="1_" toolId="B732A08500HP"
2033 14 timestamp="2011-05-11T13:55:22" assetId="B732A08500HP_"
2034 15 manufacturers="KMT,Parlec">
2035 16 <Description>
2036 17 Step Drill - KMT, B732A08500HP Grade KC7315
2037 Adapter - Parlec, C50-M12SF300-6
2038 </Description>

```

BCH = CHAMFER FLAT LENGTH
 CHW = CHAMFER WIDTH

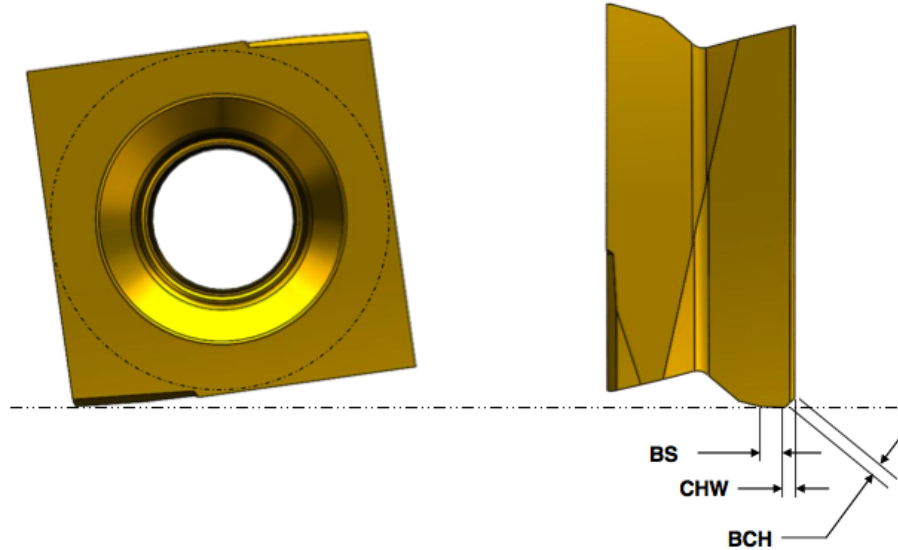


Figure 26: Cutting Tool Measurement 8

```

2039 18      <CuttingToolLifeCycle>
2040 19      <CutterStatus><Status>NEW</Status></CutterStatus>
2041 20      <ProcessSpindleSpeed nominal="5893">5893</
2042 ProcessSpindleSpeed>
2043 21      <ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
2044 22      <ConnectionCodeMachineSide>CV50 Taper</
2045 ConnectionCodeMachineSide>
2046 23      <Measurements>
2047 24      <BodyDiameterMax code="BDX">31.8</BodyDiameterMax>
2048 25      <BodyLengthMax code="LBX" nominal="120.825" maximum="
2049 126.325"
2050 26      minimum="115.325">120.825</BodyLengthMax>
2051 27      <ProtrudingLength code="LPR" nominal="155.75" maximum="
2052 161.25"
2053 28      minimum="150.26">155.75</ProtrudingLength>
2054 29      <FlangeDiameterMax code="DF"
2055 30      nominal="98.425">98.425</FlangeDiameterMax>
2056 31      <OverallToolLength nominal="257.35" minimum="251.85"
2057 32      maximum="262.85" code="OAL">257.35</OverallToolLength>
2058 33      </Measurements>
2059 34      <CuttingItems count="2">
2060 35      <CuttingItem indices="1" manufacturers="KMT" grade="KC7315
2061 36      ">>
2062 36      <Measurements>
    
```

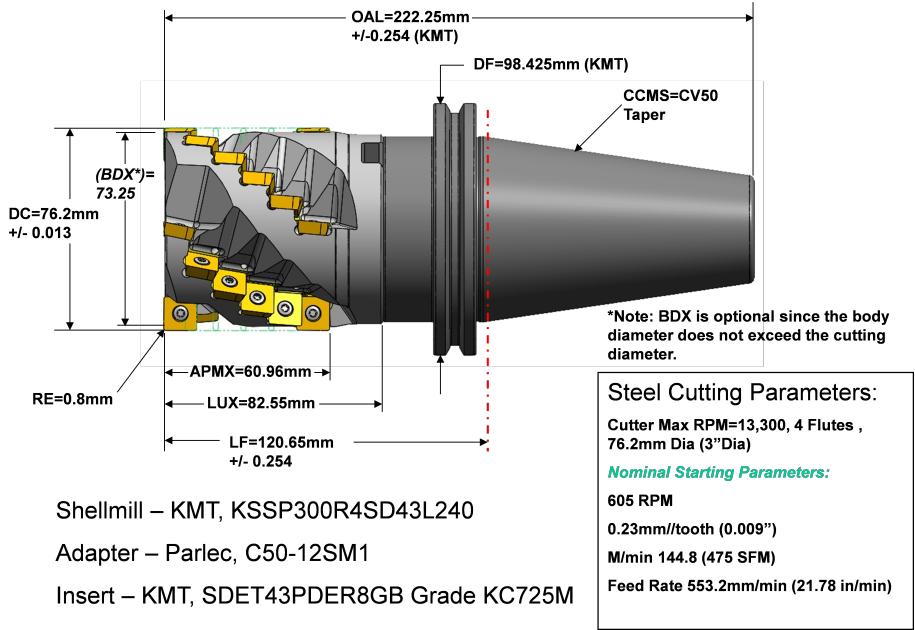


Figure 27: Shell Mill Side View

```

2063 37      <CuttingDiameter code="DC1" nominal="8.5" maximum="
2064 38      8.521"
2065 39      minimum="8.506">8.5135</CuttingDiameter>
2066 40      <StepIncludedAngle code="STA1" nominal="90" maximum="
2067 41      91"
2068 42      minimum="89">90</StepIncludedAngle>
2069 43      <Functionallength code="LF1" nominal="154.286"
2070 44      minimum="148.786"
2071 45      maximum="159.786">154.286</Functionallength>
2072 46      <StepDiameterLength code="SDL1"
2073 47      nominal="9">9</StepDiameterLength>
2074 48      <PointAngle code="SIG" nominal="135" minimum="133"
2075 49      maximum="137">135</PointAngle>
2076 50      </Measurements>
2077 51      </CuttingItem>
2078 52      <CuttingItem indices="2" manufacturers="KMT" grade="KC7315
2079 53      ">>
2080 54      <Measurements>
2081 55      <CuttingDiameter code="DC2" nominal="12" maximum="
2082 56      12.011"
2083 57      minimum="12">12</CuttingDiameter>
2084 58      <Functionallength code="LF2" nominal="122.493"
2085 59      maximum="127.993"
2086 60      minimum="116.993">122.493</Functionallength>
2087 61      <StepDiameterLength code="SDL2"
2088 62      nominal="9">9</StepDiameterLength>
2089 63      </Measurements>
    
```

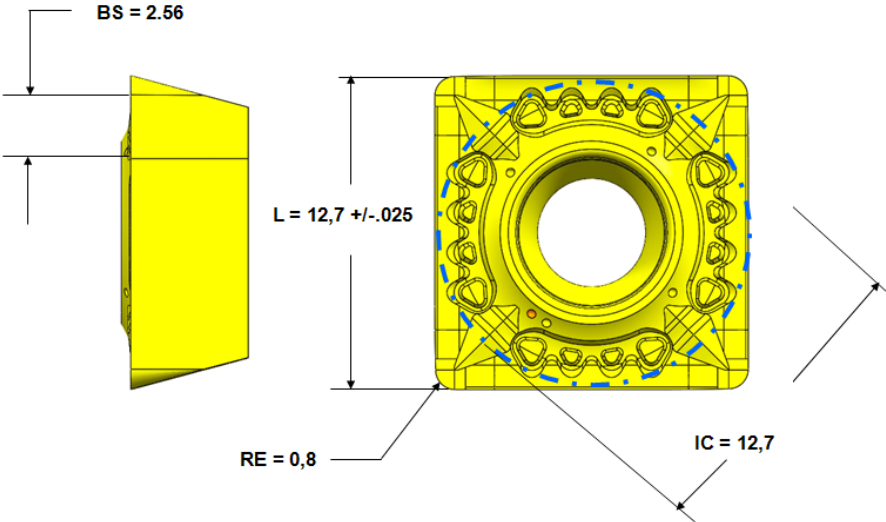
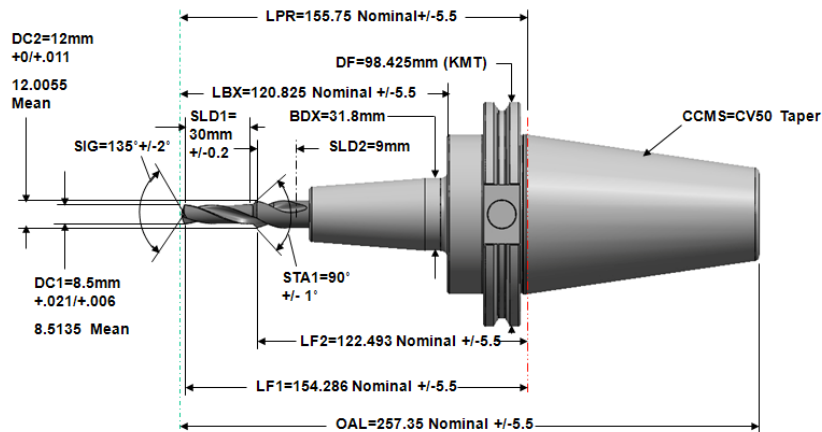


Figure 28: Indexable Insert Measurements

```
2090 60      </CuttingItem>  
2091 61      </CuttingItems>  
2092 62      </CuttingToolLifeCycle>  
2093 63      </CuttingTool>  
2094 64      </Assets>  
2095 65      </MTConnectAssets>
```



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).

P3 Steel Drilling Parameters

Nominal Starting Parameters:

150 m/min (493 SFM)

0,23 mm/r (0.0085 in/r)

RPM 5893

Figure 29: Step Mill Side View

2096 B.6.3 Shell Mill with Individual Loci

Example 3: Example for Shell Mill with Explicate Loci

```

2097 1 <?xml version="1.0" encoding="UTF-8"?>
2098 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2099 3 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2100 4 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2101 5 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2102 6 http://mtconnect.org/schemas/MTConnectAssets\textunderscore_1.2.xsd"
2103 >
2104 7 <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
2105 8 sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2106 />
2107 9 <Assets>
2108 10 <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
2109 11 timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
2110 12 manufacturers="KMT,Parlec">
2111 13 <Description>Keyway: 55 degrees</Description>
2112 14 <CuttingToolLifeCycle>
2113 15 <CutterStatus><Status>NEW</Status></CutterStatus>
2114 16 <Measurements>
2115 17 <UsableLengthMax code="LUX"
2116 18 nominal="82.55">82.55</UsableLengthMax>
2117 19 <CuttingDiameterMax code="DC" nominal="76.2" maximum="
2118 20 76.213"
2119 20 minimum="76.187">76.2</CuttingDiameterMax>

```

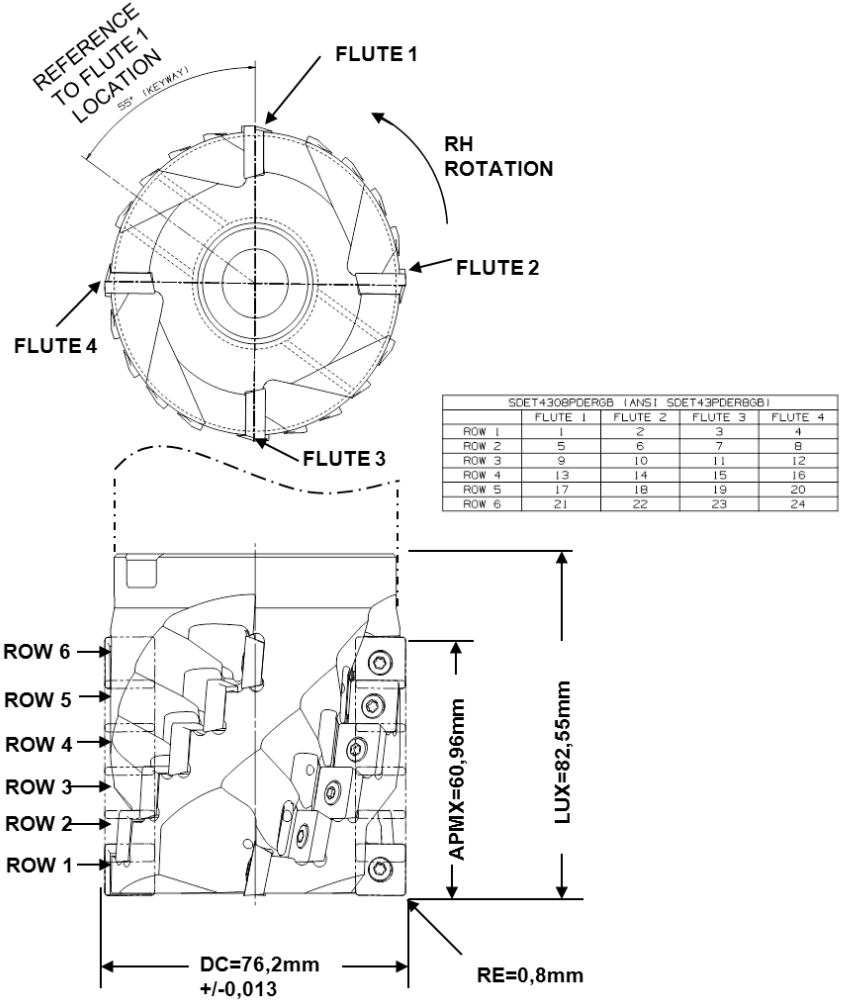


Figure 30: Shell Mill with Explicite Loci

```

2120 21      <DepthOfCutMax code="APMX" nominal="60.96">60.95</
2121          DepthOfCutMax>
2122 22      </Measurements>
2123 23      <CuttingItems count="24">
2124 24          <CuttingItem indices="1" itemId="SDET43PDER8GB"
2125 25              manufacturers="KMT">
2126 26              <Locus>FLUTE: 1, ROW: 1</Locus>
2127 27              <Measurements>
2128 28                  <DriveAngle code="DRVA" nominal="55">55</DriveAngle>
2129 29              </Measurements>
2130 30          </CuttingItem>
2131 31          <CuttingItem indices="2-24" itemId="SDET43PDER8GB"
2132 32              manufacturers="KMT">
2133 33              <Locus>FLUTE: 2-4, ROW: 1; FLUTE: 1-4, ROW 2-6</Locus>
2134 34          </CuttingItem>

```

```
2135 35      </CuttingItems>
2136 36      </CuttingToolLifeCycle>
2137 37      </CuttingTool>
2138 38      </Assets>
2139 39 </MTCConnectAssets>
```

2140 B.6.4 Drill with Individual Loci

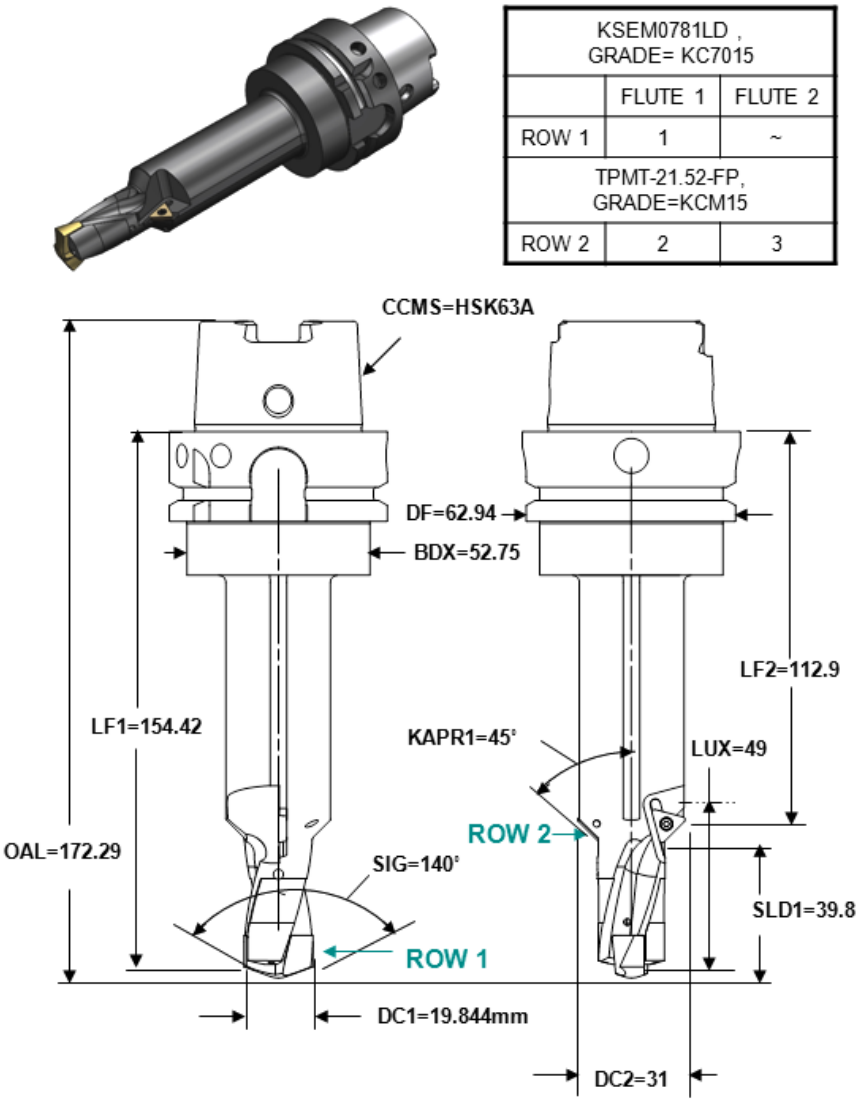


Figure 31: Step Drill with Explicate Loci

Example 4: Example for Step Drill with Explicate Loci

```

2141 1 <?xml version="1.0" encoding="UTF-8"?>
2142 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2143 3 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2144 4 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2145 5 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2146 6 http://mtconnect.org/schemas/MTConnectAssets\textunderscore_1.2.xsd"
2147 7 >
2148 7 <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"

```



```

2149 8   sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2150    />
2151 9   <Assets>
2152 10  <CuttingTool serialNumber="1" toolId="KSEM0781LD"
2153 11  timestamp="2011-05-11T13:55:22" assetId="KSEM0781LD.1"
2154    manufacturers="KMT">
2155 12  <CuttingToolLifeCycle>
2156 13  <CutterStatus><Status>NEW</Status></CutterStatus>
2157 14  <ConnectionCodeMachineSide>HSK63A</ConnectionCodeMachineSide
2158  >
2159 15  <Measurements>
2160 16  <BodyDiameterMax code="BDX">52.75</BodyDiameterMax>
2161 17  <OverallToolLength nominal="172.29"
2162 18  code="OAL">172.29</OverallToolLength>
2163 19  <UsableLengthMax code="LUX" nominal="49">49</
2164    UsableLengthMax>
2165 20  <FlangeDiameterMax code="DF"
2166 21  nominal="62.94">62.94</FlangeDiameterMax>
2167 22  </Measurements>
2168 23  <CuttingItems count="3">
2169 24  <CuttingItem indices="1" itemId="KSEM0781LD" manufacturers
2170    ="KMT"
2171 25  grade="KC7015">
2172 26  <Locus>FLUTE: 1, ROW: 1</Locus>
2173 27  <Measurements>
2174 28  <FunctionalLength code="LF1" nominal="154.42">154.42</
2175  FunctionalLength>
2176 29  <CuttingDiameter code="DC1" nominal="19.844">19.844</
2177    CuttingDiameter>
2178 30  <PointAngle code="SIG" nominal="140">140</PointAngle>
2179 31  <ToolCuttingEdgeAngle code="KAPR1" nominal="45">45</
2180    ToolCuttingEdgeAngle>
2181 32  <StepDiameterLength code="SLD1" nominal="39.8">39.8</
2182    StepDiameterLength>
2183 33  </Measurements>
2184 34  </CuttingItem>
2185 35  <CuttingItem indices="2-3" itemId="TPMT-21.52-FP"
2186 36  manufacturers="KMT" grade="KCM15">
2187 37  <Locus>FLUTE: 1-2, ROW: 2</Locus>
2188 38  <Measurements>
2189 39  <FunctionalLength code="LF2" nominal="112.9">112.9</
2190  FunctionalLength>
2191 40  <CuttingDiameter code="DC2" nominal="31">31</
2192    CuttingDiameter>
2193 41  </Measurements>
2194 42  </CuttingItem>
2195 43  </CuttingItems>
2196 44  </CuttingToolLifeCycle>
2197 45  </CuttingTool>
2198 46  </Assets>
2199 47  </MTConnectAssets>

```

2200 B.6.5 Shell Mill with Different Inserts on First Row

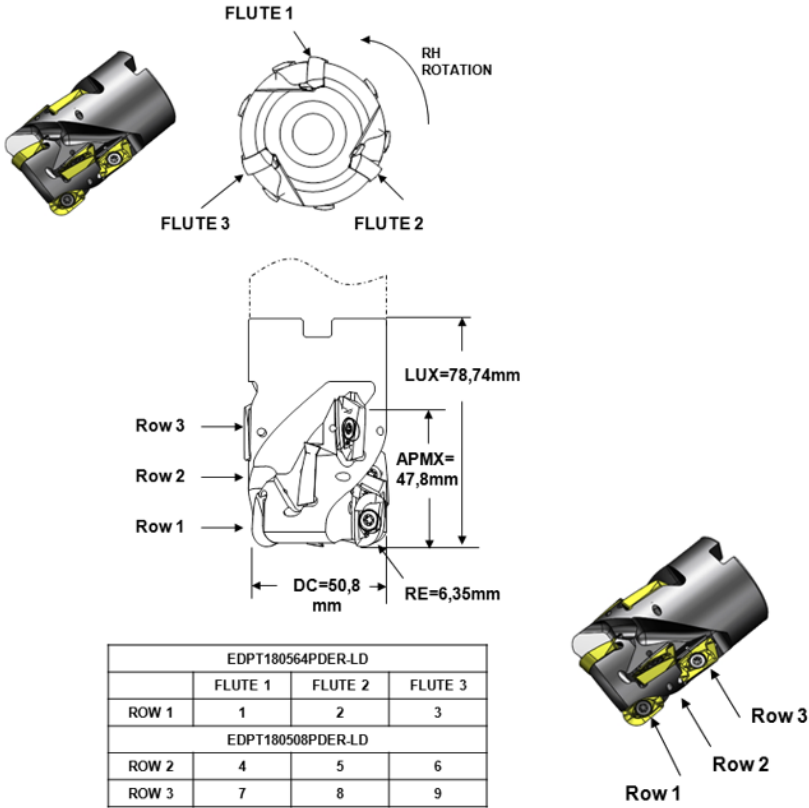


Figure 32: Shell Mill with Different Inserts on First Row

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

```

2201 1 <?xml version="1.0" encoding="UTF-8"?>
2202 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2203 3 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2204 4 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2205 5 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2206 6 http://mtconnect.org/schemas/MTConnectAssets\textunderscore_1.2.xsd"
2207 >
2208 7 <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
2209 8 sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2210 />
2211 9 <Assets>
2212 10 <CuttingTool serialNumber="1" toolId="XXX" timestamp="2011-05-11
2213 T13:55:22"
2214 11 assetId="XXX.1" manufacturers="KMT">
2215 12 <CuttingToolLifeCycle>
2216 13 <CutterStatus><Status>NEW</Status></CutterStatus>
2217 14 <Measurements>

```

```

2218 15      <DepthOfCutMax code="APMX" nominal="47.8">47.8</
2219      DepthOfCutMax>
2220 16      <CuttingDiameterMax code="DC"
2221 17      nominal="50.8">50.8</CuttingDiameterMax>
2222 18      <UsableLengthMax code="LUX"
2223 19      nominal="78.74">78.74</UsableLengthMax>
2224 20      </Measurements>
2225 21      <CuttingItems count="9">
2226 22      <CuttingItem indices="1-3" itemId="EDPT180564PDER-LD"
2227 23      manufacturers="KMT">
2228 24      <Locus>FLUTE: 1-3, ROW: 1</Locus>
2229 25      <Measurements>
2230 26      <CornerRadius code="RE" nominal="6.25">6.35</
2231      CornerRadius>
2232 27      </Measurements>
2233 28      </CuttingItem>
2234 29      <CuttingItem indices="4-9" itemId="EDPT180508PDER-LD"
2235 30      manufacturers="KMT">
2236 31      <Locus>FLANGE: 1-4, ROW: 2-3</Locus>
2237 32      </CuttingItem>
2238 33      </CuttingItems>
2239 34      </CuttingToolLifeCycle>
2240 35      </CuttingTool>
2241 36      </Assets>
2242 37      </MTConnectAssets>

```

2243 B.7 File Schema Diagrams

2244 See File element in MTConnectAssets schema.

2245 B.8 RawMaterial Schema Diagrams

2246 See RawMaterial element in MTConnectAssets schema.

2247 B.9 QIFDocumentWrapper Schema Diagrams

2248 See QIFDocumentWrapper element in MTConnectAssets schema.