



MTConnect® Standard

Part 4.0 – Asset Information Model

Version 2.1.0

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MTConnect Specification and Materials

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The normative XMI is located at the following URL: MTConnectSysMLModel.xml

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1 Purpose of This Document

2 This document, *MTConnect 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 MTConnect 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 19794-5:2011en].

39 ***client***

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

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

43 ***controlled vocabulary***

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

45 ***data dictionary***

46 listing of standardized terms and definitions used in *MTConnect Information Model*.

47 ***data model***

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

50 ***data set***

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

52 ***data source***

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

54 ***deprecated***

55 indication that specific content in an *MTConnect Document* is currently usable but
56 is regarded as being obsolete or superseded.

57 ***deprecation warning***

58 indication that specific content in an *MTConnect Document* may be changed to *dep-
59 recated* in a future release of the standard.

60 ***document***

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

63 ***electric current***

64 rate of flow of electric charge.

65 ***element***

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

67 ***extensible***

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

70 ***force***

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

72 ***heartbeat***

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

76 ***higher level***

77 nested element that is above a lower level element.

78 ***implementation***

79 specific instantiation of the MTConnect Standard.

80 ***information model***

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

83 ***instance***

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

86 ***interaction model***

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

89 ***interface***

90 means by which communication is achieved between independent systems.

91 ***key***

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

93 ***key-value pair***

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

96 ***lower camel case***

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

99 ***lower level***

100 nested element that is below a higher level element.

101 ***lower limit***

102 lower conformance boundary for a variable.

103 ***lower warning***

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

105 ***major***

106 identifier representing a consistent set of functionalities defined by the MTConnect
107 Standard.

108 ***maximum***

109 numeric upper constraint.

110 ***message***

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

112 ***metadata***

113 data that provides information about other data.

114 ***minimum***

115 numeric lower constraint.

116 ***minor***

117 identifier representing a specific set of functionalities defined by the MTConnect
118 Standard.

119 ***nominal***

120 ideal or desired value for a variable.

121 ***organize***

122 act of containing and owning one or more elements.

123 ***organizer***

124 entity that *organizes* one or more elements.

125 **parameter**

126 variable that must be given a value during the execution of a program or a commu-
127 niques command.

128 **part**

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

132 **pascal case**

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

135 **persistence**

136 method for retaining or restoring information.

137 **probe**

138 instrument commonly used for measuring the physical geometrical characteristics
139 of an object.

140 **profile**

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

144 **requester**

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

146 **reset**

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

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

150 **responder**

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

152 **response document**

153 electronic *document* published by an *MTConnect Agent* in response to a *probe re-*
154 *quest*, *current request*, *sample request* or *asset request*.

155 ***revision***

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

159 ***schema***

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

162 ***semantic data model***

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

165 ***sensing element***

166 mechanism that provides a signal or measured value.

167 ***sequence number***

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

170 ***specification limit***

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

172 ***spindle***

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

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

175 ***standard***

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

178 ***stereotype***

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

180 ***subtype***

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

182 ***table***

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

184 **table cell**

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

186 **table entry**

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

188 **top level**

189 element that represents the most significant physical or logical functions of a piece
190 of equipment.

191 **type**

192 classification or categorization of information.

193 **upper limit**

194 upper conformance boundary for a variable.

195 **upper warning**

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

197 **version**

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

199 2.2 Information Model Terms

200 **Asset Information Model**

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

202 **Device Information Model**

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

205 **Error Information Model**

206 *information model* that describes the *response document* returned by an *agent* when
207 it encounters an error while interpreting a *request* for information from a *client* or
208 when an *agent* experiences an error while publishing the *response* to a *request* for
209 information.

210 **MTConnect Information Model**

211 *information model* that defines the semantics of the MTConnect Standard.

212 ***Observation Information Model***

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

215 **2.3 Protocol Terms**

216 ***asset request***

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

218 ***current request***

219 *request* to an *agent* to produce an *MTConnectStreams Response Document* contain-
220 ing the *Observation Information Model* for a snapshot of the latest observations at
221 the moment of the *request* or at a given *sequence number*.

222 ***data streaming***

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

225 ***MTConnect Request***

226 *request* for information issued from a *client* to an *MTConnect Agent*.

227 ***MTConnect Response Document***

228 *response document* published by an *MTConnect Agent*.

229 ***MTConnectAssets Response Document***

230 *response document* published by an *MTConnect Agent* in response to an *asset re-*
231 *quest*.

232 ***MTConnectDevices Response Document***

233 *response document* published by an *MTConnect Agent* in response to a *probe re-*
234 *quest*.

235 ***MTConnectErrors Response Document***

236 *response document* published by an *MTConnect Agent* whenever it encounters an
237 error while interpreting an *MTConnect Request*.

238 ***MTConnectStreams Response Document***

239 *response document* published by an *MTConnect Agent* in response to a *current re-*
240 *quest* or a *sample request*.

241 ***probe request***

242 *request* to an *agent* to produce an *MTConnectDevices Response Document* contain-
 243 ing the *Device Information Model*.

244 ***protocol***

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

247 ***publish***

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

249 ***publish and subscribe***

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

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

254 ***request***

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

257 ***request and response***

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

260 ***response***

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

262 ***sample request***

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

266 ***streaming data***

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

268 ***subscribe***

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

270 ***transport protocol***

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

273 2.4 HTTP Terms

274 ***HTTP Body***

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

277 ***HTTP Error Message***

278 response provided by an *agent* indicating that an *HTTP Request* is incorrectly for-
 279 matted or identifies that the requested data is not available from the *agent*. *Ref IETF:RFC-*
 280 *2616*

281 ***HTTP Header***

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

284 ***HTTP Header Field***

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

287 ***HTTP Message***

288 consist of requests from client to server and responses from server to client. *Ref IETF:RFC-*
 289 *2616*

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

292 ***HTTP Messaging***

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

294 ***HTTP Method***

295 portion of a command in an *HTTP Request* that indicates the desired action to be
 296 performed on the identified resource; often referred to as verbs. *Ref IETF:RFC-*
 297 *2616*

298 ***HTTP Query***

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

301 ***HTTP Request***

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

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

307 ***HTTP Request Line***

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

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

313 ***HTTP Request Method***

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

316 ***HTTP Request URI***

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

319 ***HTTP Response***

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

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

324 ***HTTP Server***

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

327 ***HTTP Status Code***

328 3-digit integer result code of the attempt to understand and satisfy the request.
329 *Ref IETF:RFC-2616*

330 ***HTTP Version***

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

332 2.5 XML Terms

333 ***abstract element***

334 element that defines a set of common characteristics that are shared by a group of
 335 elements. An abstract entity cannot appear in a document. In a specific implemen-
 336 tation, an abstract entity is replaced by a derived element that is itself not an abstract
 337 entity. The characteristics for the derived element are inherited from the abstract
 338 entity.

339 ***attribute***

340 additional information or property for an *element*.

341 ***child element***

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

344 ***document body***

345 portion of the content of an *MTConnect Response Document* that is defined by the
 346 relative *MTConnect Information Model*. The *document body* contains the *structural*
 347 *elements* and *Observations* or *DataItems* reported in a *response document*.

348 ***document header***

349 portion of the content of an *MTConnect Response Document* that provides infor-
 350 mation from an *agent* defining version information, storage capacity, protocol, and
 351 other information associated with the management of the data stored in or retrieved
 352 from the *agent*.

353 ***element name***

354 descriptive identifier contained in both the *start-tag* and *end-tag* of an XML
 355 element that provides the name of the element.

356 ***namespace***

357 organizes information into logical groups.

358 ***parent element***

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

361 ***root element***

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

363 ***structural element***

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

366 ***XML Document***

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

368 ***XML Schema***

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

370 **2.6 MTConnect Terms**

371 ***Asset***

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

373 Note 1 to entry: An *Asset* relies upon an *Device* to provide observations
374 and information about itself and the *Device* revises the information to
375 reflect changes to the *Asset* during their interaction. Examples of *Assets*
376 are cutting tools, Part Information, Manufacturing Processes, Fixtures,
377 and Files.

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

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

384 ***Component***

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

386 ***Composition***

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

388 ***Configuration***

389 configuration for a *Component*

390 ***DataItem***

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

392 **Device**

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

394 **MTConnect Agent**

395 *agent* for the *MTConnect Information Model*.

396 **MTConnect Document**

397 *document* that represents a Part(s) of the MTConnect Standard.

398 **MTConnect Event**

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

400 **MTConnect Interface**

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

402 **Observation**

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

404 2.7 Acronyms

405 **2D**

406 two-dimensional

407 **3D**

408 three-dimensional

409 **AI**

410 artificial intelligence

411 **ALM**

412 application lifecycle management

413 **AMT**

414 The Association for Manufacturing Technology

415 **ANSI**

416 American National Standards Institute

417 **AP**

418 Application Protocol

419 **API**

420 application programming interface

421 **ASME**

422 American Society of Mechanical Engineers

423 **ASTM**

424 American Society for Testing and Materials

425 **AWS**

426 American Welding Society

427 **BDD**

428 block definition diagram

429 **BOM**

430 bill of materials

431 **BST**

432 Board on Standardization and Testing

433 **C&R**

434 cause and remedy

435 **CA**

436 certificate authority

437 **CAD**

438 computer-aided design

439 **CAE**

440 computer-aided engineering

441 **CAI**

442 computer-aided inspection

443 **CAM**

444 computer-aided manufacturing

445 **CAx**
446 computer-aided technologies

447 **CDATA**
448 Character Data

449 **CFD**
450 computational fluid dynamics

451 **CM**
452 configuration management

453 **CMS**
454 coordinate-measurement system

455 **CNC**
456 Computer Numerical Controller

457 **CNRI**
458 Corporation for National Research Initiatives

459 **CPM**
460 Core Product Model

461 **CPM2**
462 Revised Core Product Model

463 **CPSC**
464 Consumer Product Safety Commission

465 **cUAV**
466 configurable unmanned aerial vehicle

467 **DARPA**
468 Defense Advanced Research Projects Agency

469 **DER**
470 designated-engineering representative

471 **DFM**
472 design for manufacturing

473 **DLA**

474 Defense Logistics Agency

475 **DMC**

476 digital manufacturing certificate

477 **DMSC**

478 Dimensional Metrology Standards Consortium

479 **DNS**

480 Domain Name System

481 **DoD**

482 U.S. Department of Defense

483 **DOI**

484 Distributed Object Identifier

485 **DRM**

486 digital rights management

487 **ECR**

488 engineering change request

489 **ERP**

490 enterprise resource planning

491 **FAA**

492 Federal Aviation Administration

493 **FAIR**

494 first article inspection reporting

495 **FDA**

496 Food and Drug Administration

497 **FEA**

498 finite-element analysis

499 **GD&T**

500 geometric dimensions and tolerances

501 **GID**
502 global identifier

503 **HMI**
504 Human Machine Interface

505 **HTML**
506 Hypertext Markup Language

507 **HTTP**
508 Hypertext Transfer Protocol

509 **HTTPS**
510 Hypertext Transfer Protocol over Secure Sockets Layer

511 **I/O**
512 in-out

513 **ID**
514 identifier

515 **IEEE**
516 Institute of Electrical and Electronics Engineers

517 **IIoT**
518 industrial internet of things

519 **INCOSE**
520 International Council on Systems Engineering

521 **IP**
522 intellectual property

523 **ISO**
524 International Standards Organization

525 **ISS**
526 International Space Station

527 **ISV**
528 Independent Software Vendor

529 **IT**

530 information technology

531 **ITU-T**

532 Telecommunication Standardization Sector of the International Telecommunication
533 Union

534 **JSON**

535 JavaScript Object Notation

536 **JT**

537 Jupiter Tesselation

538 **LHS**

539 Lifecycle Handler System

540 **LIFT**

541 Lifecycle Information Framework and Technology

542 **LOI**

543 Lifecycle Object Identifier

544 **MAC**

545 media access control

546 **MADE**

547 Manufacturing Automation and Design Engineering

548 **MBD**

549 model-based definition

550 **MBE**

551 Model-Based Enterprise

552 **MBI**

553 model-based inspection

554 **MBM**

555 model-based manufacturing

556 ***MBSD***

557 model-based standards development

558 ***MBSE***

559 model-based systems engineering

560 ***MEDALS***

561 Military Engineering Data Asset Locator System

562 ***MES***

563 manufacturing execution system

564 ***MOI***

565 manufacturing object identifier

566 ***MOM***

567 Message Oriented Middleware

568 ***MQTT***

569 Message Queuing Telemetry Transport

570 ***MTC***

571 Manufacturing Technology Centre

572 ***NASA***

573 National Aeronautics and Space Administration

574 ***NC***

575 numerical control

576 ***NIST***

577 National Institute of Standards and Technology

578 ***NMTOKEN***

579 Name Token

580 ***NNMI***

581 National Network of Manufacturing Innovation

582 ***NSF***

583 National Science Foundation

584 **NTSC**

585 National Transportation Safety Board

586 **OASIS**

587 Organization for the Advancement of Structured Information Standards

588 **ODI**

589 Open Data Institute

590 **OEM**

591 original equipment manufacturer

592 **OOI**

593 Ocean Observatories Initiative

594 **OPC**

595 OLE for Process Control

596 **OSLC**

597 Open Services for Lifecycle Collaboration

598 **OSTP**

599 Office of Science and Technology Policy

600 **OT**

601 operational technology

602 **OWL**

603 Ontology Web Language

604 **PDF**

605 Portable Document Format

606 **PDM**

607 product-data management

608 **PDQ**

609 product-data quality

610 **PHM**

611 prognosis and health monitoring

612 ***PI***

613 principal investigator

614 ***PLC***

615 Programmable Logic Controller

616 ***PLCS***

617 Product Life Cycle Support

618 ***PLM***

619 product lifecycle management

620 ***PLOT***

621 product lifecycle of trust

622 ***PMI***

623 product and manufacturing information

624 ***PMS***

625 Production Management System

626 ***PRC***

627 Product Representation Compact

628 ***PSI***

629 Physical Science Informatics

630 ***PTAB***

631 Primary Trustworthy Digital Repository Authorization Body Ltd.

632 ***QIF***

633 Quality Information Framework

634 ***QMS***

635 quality management system

636 ***QName***

637 Qualified Name

638 ***RDF***

639 Resource Description Framework

- 640 ***REST***
641 Representational State Transfer
- 642 ***RII***
643 receiving and incoming inspection
- 644 ***S/MIME***
645 Secure/Multipurpose Internet Mail Extensions
- 646 ***SaaS***
647 software-as-a-service
- 648 ***SAML***
649 Security Assertion Markup Language
- 650 ***SC***
651 Standards Committee
- 652 ***SCADA***
653 Supervisory Control And Data Acquisition
- 654 ***SDO***
655 Standards Development Organization
- 656 ***SFTP***
657 Secure File Transfer Protocol
- 658 ***SKOS***
659 Simple Knowledge Organization System
- 660 ***SLH***
661 system lifecycle handler
- 662 ***SLR***
663 systematic literature review
- 664 ***SME***
665 small-to-medium enterprise
- 666 ***SMOPAC***
667 Smart Manufacturing Operations Planning and Control

668 **SMS Test Bed**

669 Smart Manufacturing Systems Test Bed

670 **SOA**

671 service-oriented architecture

672 **SPMM**

673 semantic-based product metamodel

674 **SSL**

675 Secure Sockets Layer

676 **STEP**

677 Standard for the Exchange of Product Model Data

678 **STEP AP242**

679 Standard for the Exchange of Product Model Data Application Protocol 242

680 **STL**

681 Stereolithography

682 **SysML**

683 Systems Modeling Language

684 **TCP/IP**

685 Transmission Control Protocol/Internet Protocol

686 **TDP**

687 technical data package

688 **TLS**

689 Transport Layer Security

690 **TSM**

691 Total System Model

692 **UA**

693 Unified Architecture

694 **UAL**

695 Unified Architecture Language

696 ***UML***
697 Unified Modeling Language
698 ***URI***
699 Uniform Resource Identifier
700 ***URL***
701 Uniform Resource Locator
702 ***URN***
703 Uniform Resource Name
704 ***UTC***
705 Coordinated Universal Time
706 ***UUID***
707 Universally Unique Identifier
708 ***V&V***
709 verification and validation
710 ***W3C***
711 World Wide Web Consortium
712 ***WSN***
713 Wirth Syntax Notation
714 ***WWW***
715 World Wide Web
716 ***X.509-PKI***
717 Public Key Infrastructure
718 ***X.509-PMI***
719 Privilege Management Infrastructure
720 ***XML***
721 Extensible Markup Language
722 ***XPath***
723 XML Path Language
724 ***XSD***
725 XML Schema Definitions

726 2.8 MTConnect References

- 727 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Fundamentals*. Version 2.0.
- 728 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Device Information Model*. Ver-
729 sion 2.0.
- 730 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Observation Information Model*.
731 Version 2.0.
- 732 [MTConnect Part 4.0] *MTConnect Standard: Part 4.0 - Asset Information Model*. Ver-
733 sion 2.0.

734

735 3 Asset Information Model

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

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

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

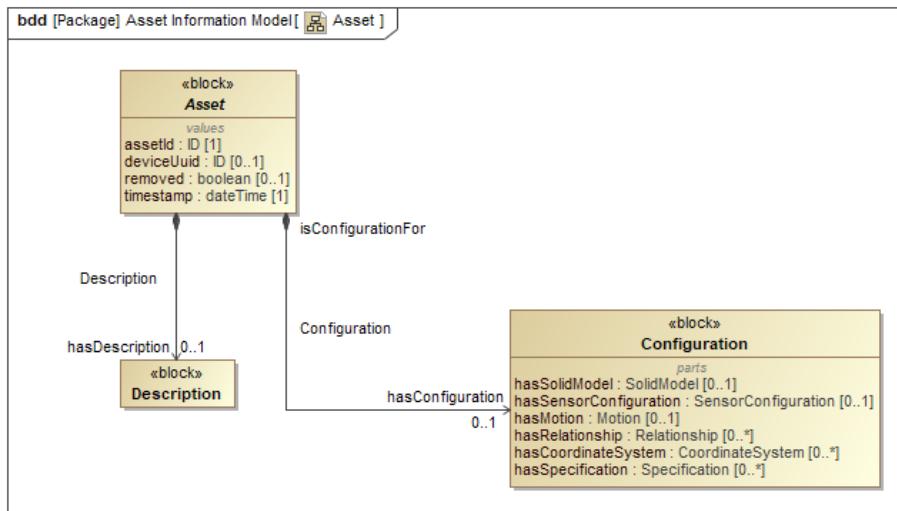
755 The MTConnect Standard has two data item types to support change notification when an
 756 *Asset* is added, updated or removed. AssetChanged states the assetId of the *Asset*
 757 that has been added or updated. AssetRemoved states the assetId of the *Asset* that
 758 has been removed. See *MTConnect Standard: Part 3.0 - Observation Information Model*
 759 for more details.

760 3.1 Asset

761 abstract *Asset*.

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

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

**Figure 1:** Asset

766 3.1.1 Value Properties of Asset

767 *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

Table 1: Value Properties of Asset

768 Descriptions for Value Properties of Asset:

- 769 • assetId
- 770 unique identifier for an Asset.
- 771 • deviceUuid
- 772 associated piece of equipment's Universally Unique Identifier (UUID) that supplied
- 773 the Asset's data.
- 774 It references to the `uuid` property of the Device defined in *MTConnect Standard: Part 2.0 - Device Information Model*.
- 776 • removed
- 777 indicator that the Asset has been removed from the piece of equipment.

- 778 • timestamp
 779 time the Asset data was last modified.

780 3.1.2 Part Properties of Asset

781 *Table 2* lists the Part Properties of Asset.

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

Table 2: Part Properties of Asset

782 Descriptions for Part Properties of Asset:

- 783 • Description
 784 descriptive content.
 785 This can contain configuration information and manufacturer specific details.
- 786 • Configuration
 787 technical information about an entity describing its physical layout, functional char-
 788 acteristics, and relationships with other entities.
 789 See Configuration in *MTConnect Standard: Part 2.0 - Device Information Model*.
 790

791 4 Cutting Tool Asset Information Model

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

800 MTConnect Standard will adopt the ISO 13399 structure when formulating the vocabulary
 801 for Cutting Tool geometries and structure to be represented in the `CuttingToolArchetype`.
 802 The nominal values provided in the `CuttingToolLifeCycle` section are only con-
 803 cerned with two aspects of the Cutting Tool; the Cutting Tool and the cutting item. The
 804 tool item, Adaptive Item, and Assembly Item will only be covered in the `Cutting-
 805 ToolDefinition` section of this document since this section contains the full ISO
 806 13399 information about a Cutting Tool.



Figure 2: Cutting Tool Parts

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

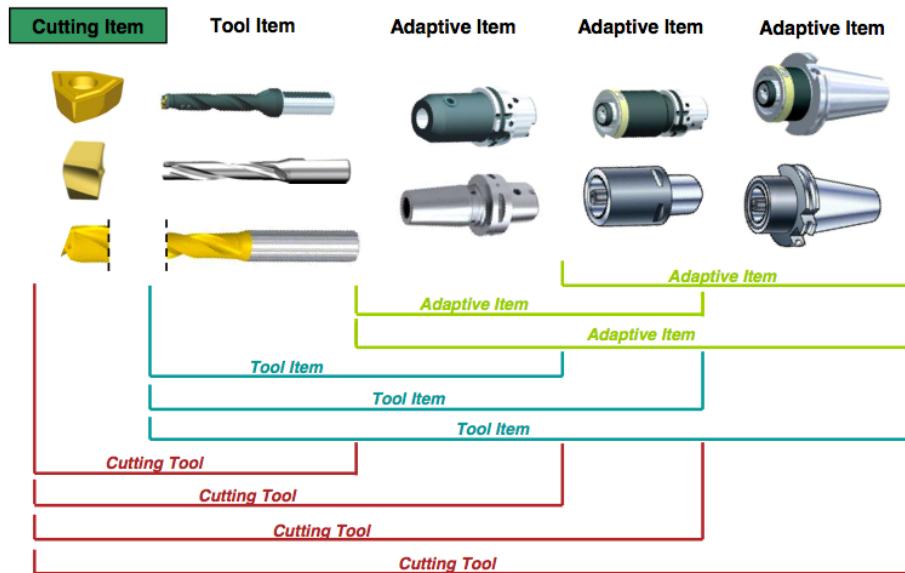


Figure 3: Cutting Tool Composition

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

815 Figure 4 and Figure 5 further illustrates the components of the Cutting Tool. As we com-
 816 pose the tool item, cutting item, Adaptive Item, we get a Cutting Tool. The tool item,
 817 Adaptive Item, and Assembly Item will only be in the `CuttingToolDefinition` sec-
 818 tion that will contain the full ISO 13399 information. These figures also use the ISO 13399
 819 codes for each of the measurements. These codes will be translated into the MTConnect
 820 Standard vocabulary as illustrated below. The measurements will have a maximum, mini-
 821 mum, and nominal value representing the tolerance of allowable values for this dimension.

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

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

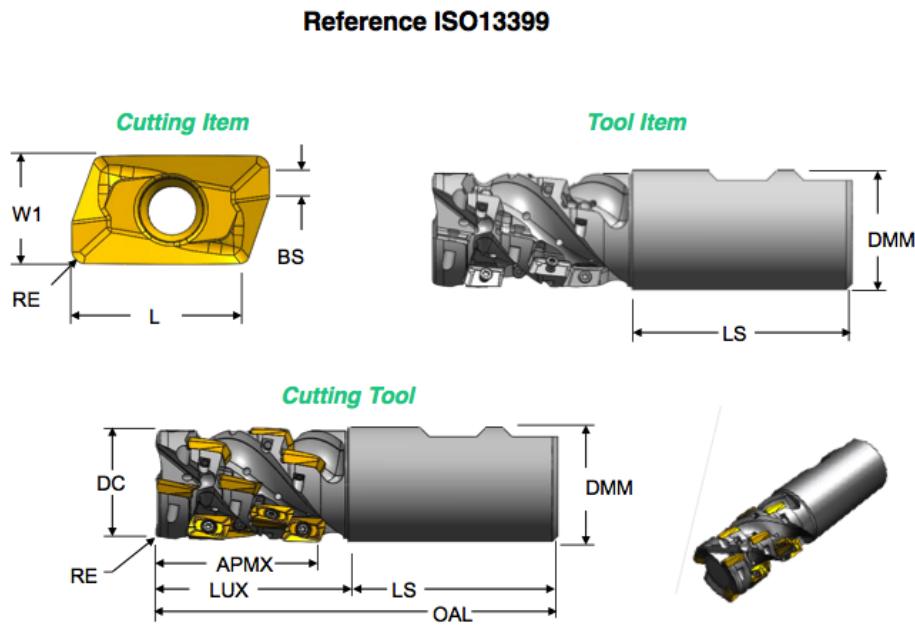


Figure 4: Cutting Tool, Tool Item, and Cutting Item

830 4.1 Cutting Tool

831 This section provides semantic information for the `CuttingTool` and `CuttingToolArchetype`
832 models.

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

834 4.1.1 CuttingTool

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

836 4.1.1.1 Value Properties of CuttingTool

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

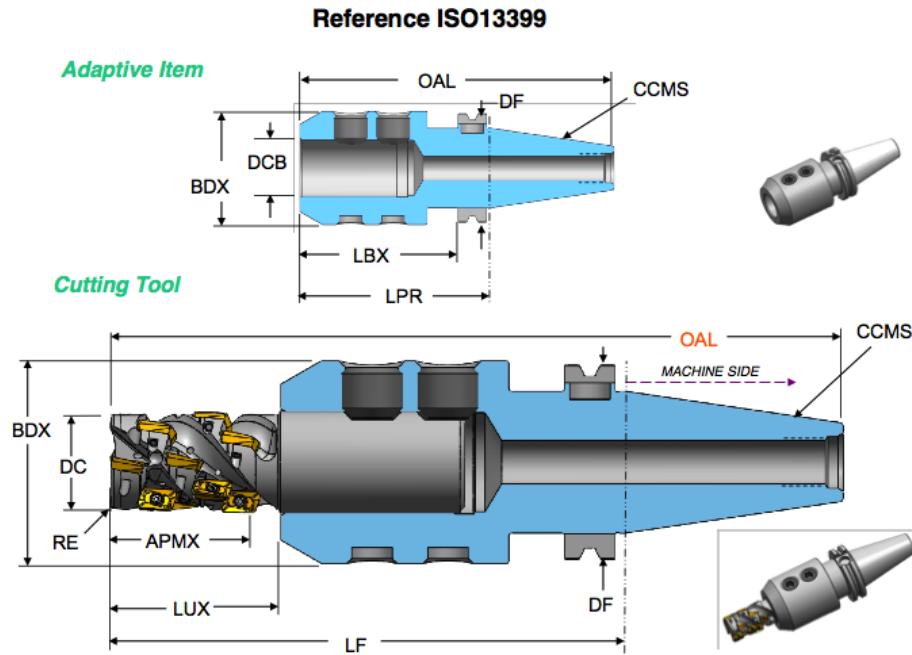


Figure 5: Cutting Tool, Tool Item, and Cutting Item 2

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

Table 3: Value Properties of CuttingTool

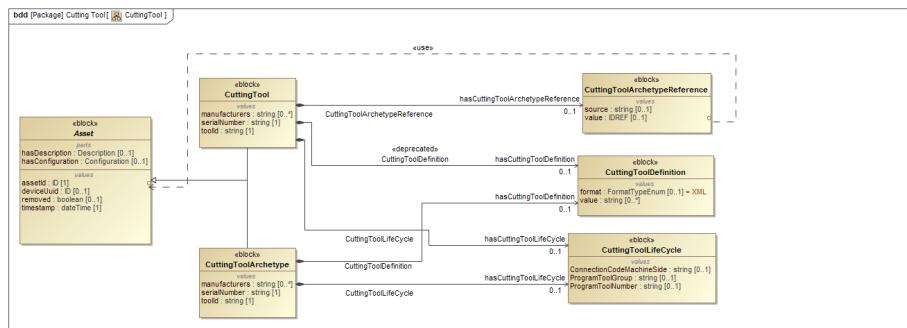


Figure 6: CuttingTool

838 Descriptions for Value Properties of CuttingTool:

- 839 • manufacturers
 840 manufacturers of the cutting tool.
 841 This will reference the tool item and adaptive items specifically. The cutting items
 842 manufacturers' will be a property of CuttingItem.
- 843 Note: In XML, the representation **MUST** be a comma(,) delimited list of
 844 manufacturer names. See *Section B.2 - CuttingTool Schema Diagrams*.
- 845 • serialNumber
 846 unique identifier for this assembly.
 847 • toolId
 848 identifier for a class of cutting tools.

849 **4.1.1.2 Part Properties of CuttingTool**

850 *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

851 Descriptions for Part Properties of CuttingTool:

- 852 • CuttingToolLifeCycle
 853 data regarding the application or use of the tool.
 854 This data is provided by various pieces of equipment (i.e. machine tool, presetter)
 855 and statistical process control applications. Life cycle data will not remain static,
 856 but will change periodically when a tool is used or measured.
 857 See *Section 4.2.1 - CuttingToolLifeCycle*.
 858 • CuttingToolArchetypeReference
 859 reference information about the assetId and/or the URL of the data source of
 860 CuttingToolArchetype.

- 861 • <>deprecated>> CuttingToolDefinition
 862 detailed structure of the cutting tool which is static during its lifecycle. *Ref ISO*
 863 *13399.*
 864 **DEPRECATED** in *Version 1.3.0* for CuttingTool.

865 4.1.2 CuttingToolArchetype

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

868 4.1.2.1 Value Properties of CuttingToolArchetype

869 *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

870 Descriptions for Value Properties of CuttingToolArchetype:

- 871 • manufacturers
 872 manufacturers of the cutting tool.
 873 This will reference the tool item and adaptive items specifically. The cutting items
 874 manufacturers' will be a property of CuttingItem.

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

- 877 • serialNumber
 878 unique identifier for this assembly.
 879 • toolId
 880 identifier for a class of cutting tools.

881 **4.1.2.2 Part Properties of CuttingToolArchetype**

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

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

Table 6: Part Properties of CuttingToolArchetype

883 Descriptions for Part Properties of CuttingToolArchetype:

- 884 • <<deprecated>> CuttingToolDefinition

885 detailed structure of the cutting tool which is static during its lifecycle. *Ref ISO
886 13399.*

887 **DEPRECATED** in Version 2.1.0 for CuttingToolArchetype.

- 888 • CuttingToolLifeCycle

889 data regarding the application or use of the tool.

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

893 See *Section 4.2.1 - CuttingToolLifeCycle*.

894 **4.1.3 CuttingToolArchetypeReference**

895 reference information about the assetId and/or the URL of the data source of Cut-
896 tingToolArchetype.

897 The value of CuttingToolArchetypeReference **MUST** be IDREF. See *Section 8.1.10
898 - IDREF*.

899 **4.1.3.1 Value Properties of CuttingToolArchetypeReference**

900 *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

901 Descriptions for Value Properties of CuttingToolArchetypeReference:

- 902 • source
 903 Uniform Resource Locator (URL) of the CuttingToolArchetype *information*
 904 *model*.

905 **4.1.4 <>deprecated>>CuttingToolDefinition**

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

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

908 **4.1.4.1 Value Properties of CuttingToolDefinition**

909 *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

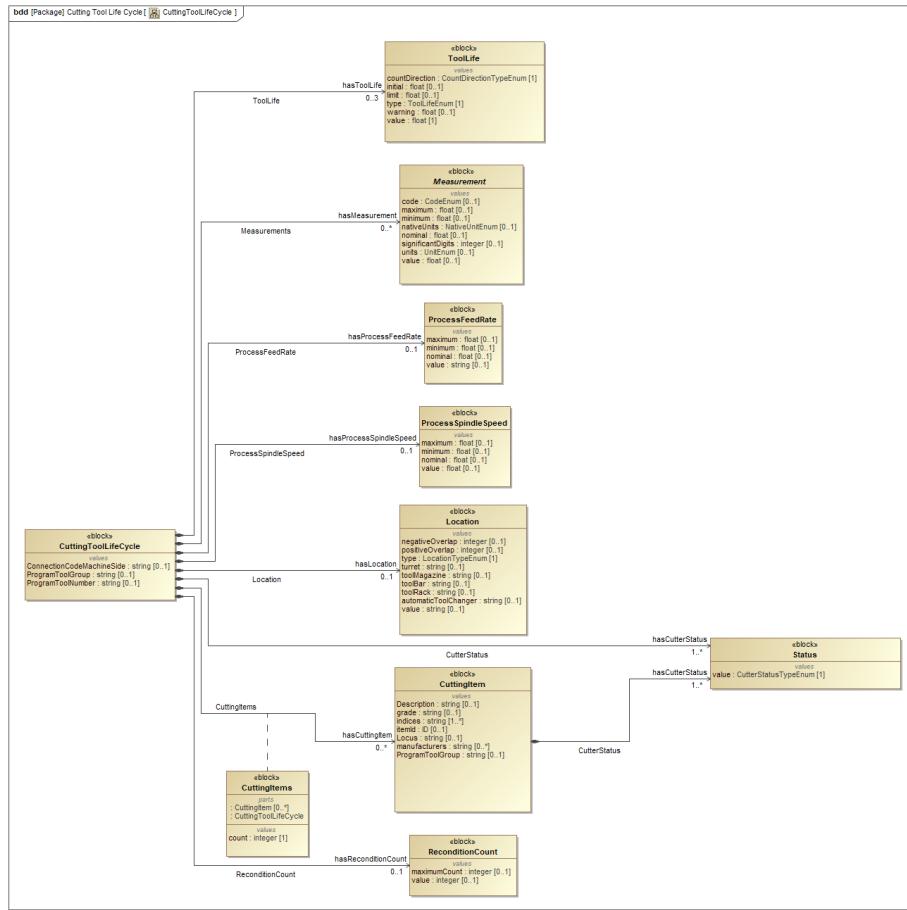
910 Descriptions for Value Properties of CuttingToolDefinition:

- 911 • format
 912 identifies the expected representation of the enclosed data.

913 **4.2 Cutting Tool Life Cycle**

914 This section provides semantic information for the CuttingToolLifeCycle model.

915 Note: See *Section B.3 - CuttingToolLifeCycle Schema Diagrams* for XML
 916 schema.

**Figure 7: CuttingToolLifeCycle****917 4.2.1 CuttingToolLifeCycle**

918 data regarding the application or use of the tool.

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

922 4.2.1.1 Value Properties of CuttingToolLifeCycle

923 *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

924 Descriptions for Value Properties of CuttingToolLifeCycle:

- 925 • ConnectionCodeMachineSide
- 926 identifier for the capability to connect any component of the cutting tool together,
927 except Assembly Items, on the machine side. Code: CCMS
- 928 • ProgramToolGroup
- 929 tool group this tool is assigned in the part program.
- 930 • ProgramToolNumber
- 931 number of the tool as referenced in the part program.

932 **4.2.1.2 Part Properties of CuttingToolLifeCycle**

933 *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

934 Descriptions for Part Properties of CuttingToolLifeCycle:

- 935 • ProcessFeedRate
- 936 constrained process feed rate for the tool in mm/s.

937 The value **MAY** contain the nominal process target feed rate if available. If `ProcessFeedRate`
 938 is provided, at least one value of maximum, nominal, or minimum
 939 **MUST** be specified.

940 See *Section 4.2.6 - ProcessFeedRate*.

941 • `ToolLife`
 942 cutting tool life as related to the assembly.

943 See *Section 4.2.2 - ToolLife*.

944 • `ProcessSpindleSpeed`
 945 constrained process spindle speed for the tool in revolutions/minute.

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

949 See *Section 4.2.5 - ProcessSpindleSpeed*.

950 • `Status`
 951 status of the cutting tool.

952 `CutterStatus` provides the status of the assembly and *organize* one or more
 953 Status entities. See *Section 4.2.7 - Status*.

954 The following combinations of Status entities **MUST NOT** occur for a `CutterStatus`:
 955

- 956 – NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.
- 957 – UNKNOWN **MUST NOT** be used with any other status.
- 958 – ALLOCATED and UNALLOCATED **MUST NOT** be used together.
- 959 – AVAILABLE and UNAVAILABLE **MUST NOT** be used together.
- 960 – If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be
 961 AVAILABLE.

962 • `CuttingItem`
 963 part of the tool that physically removes the material from the workpiece by shear
 964 deformation.

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

967 • `Measurement`
 968 constrained scalar value associated with a cutting tool.
 969 Measurements groups one or more Measurement subtypes. See *Section 4.2.8*
 970 - *Measurement*.

971 • ReconditionCount
 972 number of times the cutter has been reconditioned.
 973 See *Section 4.2.4 - ReconditionCount*.
 974 • Location
 975 location of the pot or spindle the cutting tool currently resides in.
 976 If negativeOverlap or positiveOverlap is provided, the tool reserves ad-
 977 ditional locations on either side, otherwise if they are not given, no additional loca-
 978 tions are required for this tool.
 979 If the pot occupies the first or last location, a rollover to the beginning or the end of
 980 the indexable values may occur. For example, if there are 64 pots and the tool is in
 981 pot 64 with a positiveOverlap of 1, the first pot **MAY** be occupied as well.
 982 See *Section 4.2.3 - Location* for more detail.

983 4.2.2 ToolLife

984 cutting tool life as related to the assembly.

985 ToolLife **MUST** be defined only for the CuttingToolLifeCycle of Cutting-
 986 Tool and **MUST NOT** be defined for the CuttingToolLifeCycle of Cutting-
 987 ToolArchetype.

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

989 4.2.2.1 Value Properties of ToolLife

990 *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

991 Descriptions for Value Properties of ToolLife:

- 992 • countDirection
- 993 indicates if the tool life counts from zero to maximum or maximum to zero.
- 994 CountDirectionTypeEnum Enumeration:
- 995 – DOWN
- 996 tool life counts down from the maximum to zero.
- 997 – UP
- 998 tool life counts up from zero to the maximum.
- 999 • initial
- 1000 initial life of the tool when it is new.
- 1001 • limit
- 1002 end of life limit for the tool.
- 1003 • type
- 1004 type of tool life being accumulated.
- 1005 ToolLifeEnum Enumeration:
- 1006 – MINUTES
- 1007 tool life measured in minutes.
- 1008 All units for minimum, maximum, and nominal **MUST** be provided in minutes.
- 1009
- 1010 – PART_COUNT
- 1011 tool life measured in parts.
- 1012 All units for minimum, maximum, and nominal **MUST** be provided as the
- 1013 number of parts.
- 1014 – WEAR
- 1015 tool life measured in tool wear.
- 1016 Wear **MUST** be provided in millimeters as an offset to nominal. All units for
- 1017 minimum, maximum, and nominal **MUST** be given as millimeter offsets as
- 1018 well. The standard will only consider dimensional wear at this time.
- 1019 • warning
- 1020 point at which a tool life warning will be raised.

1021 4.2.3 Location

1022 location of the pot or spindle the cutting tool currently resides in.

1023 If negativeOverlap or positiveOverlap is provided, the tool reserves additional
1024 locations on either side, otherwise if they are not given, no additional locations are required
1025 for this tool.

1026 If the pot occupies the first or last location, a rollover to the beginning or the end of the
1027 indexable values may occur. For example, if there are 64 pots and the tool is in pot 64 with
1028 a positiveOverlap of 1, the first pot **MAY** be occupied as well.

1029 Location **MUST** be defined only for the CuttingToolLifeCycle of Cutting-
1030 Tool and **MUST NOT** be defined for the CuttingToolLifeCycle of Cutting-
1031 ToolArchetype.

1032 The value of Location **MUST** be string.

1033 4.2.3.1 Value Properties of Location

1034 *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

1035 Descriptions for Value Properties of Location:

- 1036 • negativeOverlap
1037 number of locations at lower index values from this location.
- 1038 • positiveOverlap
1039 number of locations at higher index value from this location.

- 1040 • type
1041 type of location being identified.
1042 When a POT or STATION type is used, value of Location **MUST** be a numeric
1043 value.
1044 LocationTypeEnum Enumeration:
1045 - CRIB
1046 location with regard to a tool crib.
1047 - END_EFFECTOR
1048 location associated with an end effector.
1049 - EXPIRED_POT
1050 location for a tool that is no longer usable and is awaiting removal from a tool
1051 magazine or turret.
1052 - POT
1053 number of the pot in the tool handling system.
1054 - REMOVAL_POT
1055 location for a tool removed from a tool magazine or turret awaiting transfer to
1056 a location outside of the piece of equipment.
1057 - RETURN_POT
1058 location for a tool removed from a *spindle* or turret and awaiting return to a
1059 tool magazine.
1060 - SPINDLE
1061 location associated with a *spindle*.
1062 - STAGING_POT
1063 location for a tool awaiting transfer to a tool magazine or turret from outside
1064 of the piece of equipment.
1065 - STATION
1066 tool location in a horizontal turning machine.
1067 - TRANSFER_POT
1068 location for a tool awaiting transfer from a tool magazine to spindle or a turret.
1069 • turret
1070 turret associated with a tool.
1071 • toolMagazine
1072 tool magazine associated with a tool.

- 1073 • toolBar
 1074 tool bar associated with a tool.
- 1075 • toolRack
 1076 tool rack associated with a tool.
- 1077 • automaticToolChanger
 1078 automatic tool changer associated with a tool.

1079 4.2.4 ReconditionCount

1080 number of times the cutter has been reconditioned.

1081 ReconditionCount **MUST** be defined only for the CuttingToolLifeCycle of
 1082 CuttingTool and **MUST NOT** be defined for the CuttingToolLifeCycle of
 1083 CuttingToolArchetype.

1084 The value of ReconditionCount **MUST** be integer.

1085 4.2.4.1 Value Properties of ReconditionCount

1086 *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

1087 Descriptions for Value Properties of ReconditionCount:

- 1088 • maximumCount
 1089 maximum number of times the tool may be reconditioned.

1090 4.2.5 ProcessSpindleSpeed

1091 constrained process spindle speed for the tool in revolutions/minute.

1092 The value **MAY** contain the nominal process target spindle speed if available. If Process
 1093 SpindleSpeed is provided, at least one value of maximum, nominal, or min-
 1094 imum **MUST** be specified.

1095 The value of ProcessSpindleSpeed **MUST** be float.

1096 **4.2.5.1 Value Properties of ProcessSpindleSpeed**

1097 *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

1098 Descriptions for Value Properties of ProcessSpindleSpeed:

- 1099 • maximum
 1100 upper bound for the tool's target spindle speed.
- 1101 • minimum
 1102 lower bound for the tools spindle speed.
- 1103 • nominal
 1104 nominal speed the tool is designed to operate at.

1105 **4.2.6 ProcessFeedRate**

1106 constrained process feed rate for the tool in mm/s.

1107 The value **MAY** contain the nominal process target feed rate if available. If Process-
 1108 FeedRate is provided, at least one value of maximum, nominal, or minimum **MUST**
 1109 be specified.

1110 The value of ProcessFeedRate **MUST** be string.

1111 **4.2.6.1 Value Properties of ProcessFeedRate**

1112 *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

1113 Descriptions for Value Properties of ProcessFeedRate:

- 1114 • maximum
- 1115 upper bound for the tool's process target feedrate.
- 1116 • minimum
- 1117 lower bound for the tool's feedrate.
- 1118 • nominal
- 1119 nominal feedrate the tool is designed to operate at.

1120 **4.2.7 Status**

1121 status of the cutting tool.

1122 CutterStatusTypeEnum Enumeration:

- 1123 • ALLOCATED

1124 tool is has been committed to a piece of equipment for use and is not available for
1125 use in any other piece of equipment.
- 1126 • AVAILABLE

1127 tool is available for use.
- 1128 If this is not present, the tool is currently not ready to be used.
- 1129 • BROKEN

1130 premature tool failure.

- 1131 • EXPIRED
 - 1132 tool has reached the end of its useful life.
- 1133 • MEASURED
 - 1134 tool has been measured.
- 1135 • NEW
 - 1136 new tool that has not been used or first use.
- 1137 Marks the start of the tool history.
- 1138 • NOT_REGISTERED
 - 1139 tool cannot be used until it is entered into the system.
- 1140 • RECONDITIONED
 - 1141 tool has been reconditioned.
- 1142 • UNALLOCATED
 - 1143 tool has not been committed to a process and can be allocated.
- 1144 • UNAVAILABLE
 - 1145 tool is unavailable for use in metal removal.
- 1146 • UNKNOWN
 - 1147 tool is an indeterminate state. This is the default value.
- 1148 • USED
 - 1149 tool is in process and has remaining tool life.

1150 4.2.8 Measurement

- 1151 constrained scalar value associated with a cutting tool.
- 1152 A Measurement is specific to the tool management policy at a particular shop. The tool
 - 1153 zero reference point or gauge line will be different depending on the particular implemen-
 - 1154 tation and will be assumed to be consistent within the shop. MTConnect Standard does
 - 1155 not standardize the manufacturing process or the definition of the zero point.
- 1156 The value of Measurement **MUST** be float.

1157 **4.2.8.1 Value Properties of Measurement**

1158 *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

1159 Descriptions for Value Properties of Measurement:

- 1160 • code

1161 shop specific code for the measurement.

1162 ISO 13399 codes **MAY** be used for these codes as well.

1163 See *Section 4.4 - Cutting Tool Measurement Subtypes* and *Section 4.5 - Cutting*
 1164 *Item Measurement Subtypes* for details on Measurement types and their respec-
 1165 tive code values.

- 1166 • maximum

1167 maximum value for the measurement.

- 1168 • minimum

1169 minimum value for the measurement.

- 1170 • nativeUnits

1171 units the measurement was originally recorded in. See *MTConnect Standard: Part*
 1172 *2.0 - Device Information Model* for the complete list of nativeUnits.

1173 The value of nativeUnits **MUST** be one of the NativeUnitEnum enumera-
 1174 tion.

- 1175 • nominal

1176 as advertised value for the measurement.

- 1177 • significantDigits

1178 number of significant digits in the reported value.

1179 • units
 1180 units for the measurements. See *MTConnect Standard: Part 2.0 - Device Information Model* for the complete list of units.
 1181
 1182 The value of units **MUST** be one of the UnitEnum enumeration.

1183 4.3 Cutting Item

1184 A CuttingItem is the portion of the tool that physically removes the material from the
 1185 workpiece by shear deformation. The cutting item can be either a single piece of mate-
 1186 rial attached to the CuttingTool or it can be one or more separate pieces of material
 1187 attached to the CuttingTool using a permanent or removable attachment. A Cuttin-
 1188 gItem can be comprised of one or more cutting edges. Cutting items include: replaceable
 1189 inserts, brazed tips and the cutting portions of solid CuttingTools.
 1190 MTConnect Standard considers CuttingItems as part of the CuttingTool. A Cut-
 1191 tingItems **MUST NOT** exist in MTConnect unless it is attached to a CuttingTool.
 1192 Some of the measurements, such as FunctionalLength, **MUST** be made with refer-
 1193 ence to the entire CuttingTool to be meaningful.

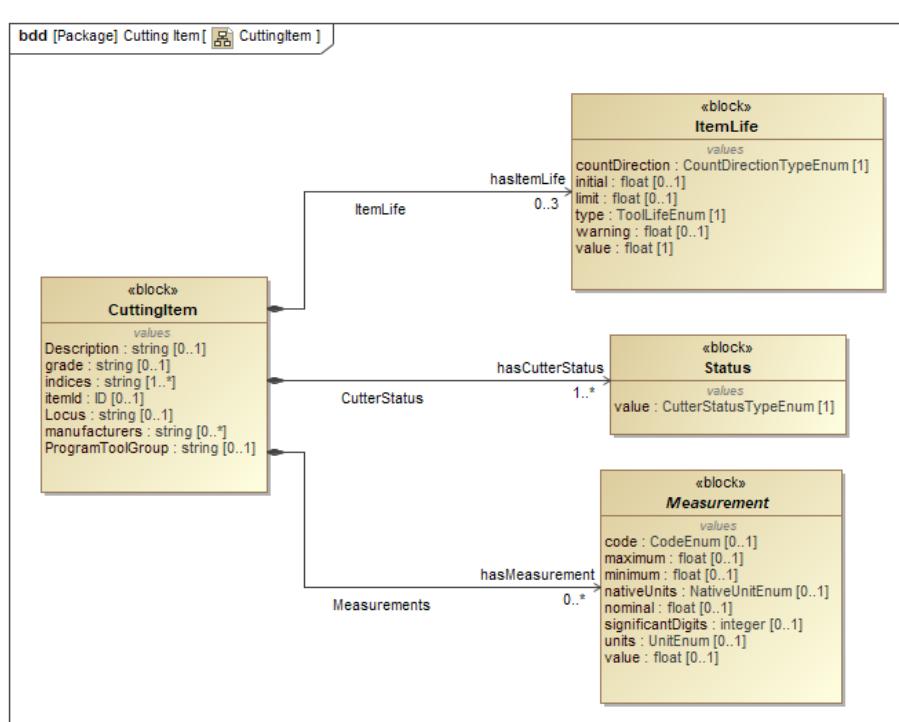


Figure 8: CuttingItem

1194 Note: See *Section B.4 - CuttingItem Schema Diagrams* for XML schema.

1195 **4.3.1 CuttingItem**

1196 part of the tool that physically removes the material from the workpiece by shear deformation.
 1197

1198 **4.3.1.1 Value Properties of CuttingItem**

1199 *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

1200 Descriptions for Value Properties of CuttingItem:

1201 • Description

1202 free-form description of the cutting item.

1203 • grade

1204 material composition for this cutting item.

1205 • indices

1206 number or numbers representing the individual cutting item or items on the tool.

1207 Indices **SHOULD** start numbering with the inserts or CuttingItem furthest from
 1208 the gauge line and increasing in value as the items get closer to the gauge line. Items
 1209 at the same distance **MAY** be arbitrarily numbered.

1210 Note: In XML, the representation **MUST** be a single number (“1”) or a
 1211 comma separated set of individual elements (“1,2,3,4”), or as a inclusive

1212 range of values as in (“1-10”) or any combination of ranges and numbers
 1213 as in “1-4,6-10,22”. There **MUST NOT** be spaces or non-integer values
 1214 in the text representation.

1215 • itemId
 1216 manufacturer identifier of this cutting item.

1217 • Locus
 1218 free form description of the location on the cutting tool.

1219 For clarity, the words FLUTE, INSERT, and CARTRIDGE **SHOULD** be used to
 1220 assist in noting the location of a CuttingItem. Locus **MAY** be any free form
 1221 string, but **SHOULD** adhere to the following rules:

- 1222 – The location numbering **SHOULD** start at the furthest CuttingItem and
 1223 work it's way back to the CuttingItem closest to the gauge line.
- 1224 – Flutes **SHOULD** be identified as such using the word FLUTE:. For example:
 1225 FLUTE: 1, INSERT: 2 - would indicate the first flute and the second furthest
 1226 insert from the end of the tool on that flute.
- 1227 – Other designations such as CARTRIDGE **MAY** be included, but should be
 1228 identified using upper case and followed by a colon (:).

1229 • manufacturers
 1230 manufacturers of the cutting item.

1231 This will reference the tool item and adaptive items specifically. The cutting items
 1232 manufacturers' will be a property of CuttingItem.

1233 Note: In XML, the representation **MUST** be a comma(,) delimited list of
 1234 manufacturer names. See *Section B.4 - CuttingItem Schema Diagrams*.

1235 • ProgramToolGroup
 1236 tool group this item is assigned in the part program.

1237 4.3.1.2 Part Properties of CuttingItem

1238 *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

1239 Descriptions for Part Properties of CuttingItem:

1240 • Status

1241 status of the cutting tool.

1242 CutterStatus provides the status of the assembly and *organize* one or more
1243 Status entities. See *Section 4.2.7 - Status*.

1244 The following combinations of Status entities **MUST NOT** occur for a Cut-
1245 terStatus:

1246 – NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.

1247 – UNKNOWN **MUST NOT** be used with any other status.

1248 – ALLOCATED and UNALLOCATED **MUST NOT** be used together.

1249 – AVAILABLE and UNAVAILABLE **MUST NOT** be used together.

1250 – If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be
1251 AVAILABLE.

1252 CutterStatus **MUST** be defined only for the CuttingToolLifeCycle of
1253 CuttingTool and **MUST NOT** be defined for the CuttingToolLifeCycle
1254 of CuttingToolArchetype.

1255 • ItemLife

1256 life of a CuttingItem.

1257 See *Section 4.3.3 - ItemLife*.

1258 • Measurement

1259 constrained scalar value associated with a cutting tool.

1260 Measurements groups one or more Measurement subtypes. See *Section 4.2.8*
1261 – *Measurement*.

1262 4.3.2 CuttingItems

1263 CuttingItems groups one or more CuttingItem entities. See *Section 4.3.1 - CuttingItem*
 1264 and *Section 4.3 - Cutting Item* for more detail.

1265 4.3.2.1 Value Properties of CuttingItems

1266 *Table 19* lists the Value Properties of CuttingItems.

Value Property name	Value Property type	Multiplicity
count	integer	1

Table 19: Value Properties of CuttingItems

1267 Descriptions for Value Properties of CuttingItems:

- 1268 • count
 1269 number of CuttingItem organized by CuttingItems.

1270 4.3.3 ItemLife

1271 life of a CuttingItem.

1272 The value of ItemLife **MUST** be float.

1273 4.3.3.1 Value Properties of ItemLife

1274 *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

1275 Descriptions for Value Properties of ItemLife:

- 1276 • `countDirection`
- 1277 indicates if the item life counts from zero to maximum or maximum to zero.
- 1278 The value of `countDirection` **MUST** be one of the `CountDirectionType-`
1279 `Enum` enumeration.
- 1280 • `initial`
- 1281 initial life of the item when it is new.
- 1282 • `limit`
- 1283 end of life limit for this item.
- 1284 • `type`
- 1285 type of item life being accumulated.
- 1286 The value of `type` **MUST** be one of the `ToolLifeEnum` enumeration.
- 1287 • `warning`
- 1288 point at which a item life warning will be raised.

1289 4.4 Cutting Tool Measurement Subtypes

1290 This section lists the `Measurement` subtypes for `CuttingTool`.

1291 These `Measurement` subtypes for `CuttingTool` are specific to the entire assembly
1292 and **MUST NOT** be used for the `Measurement` pertaining to a `CuttingItem`. Figure
1293 9 and Figure 10 will be used to reference the assembly specific `Measurement` sub-
1294 types.

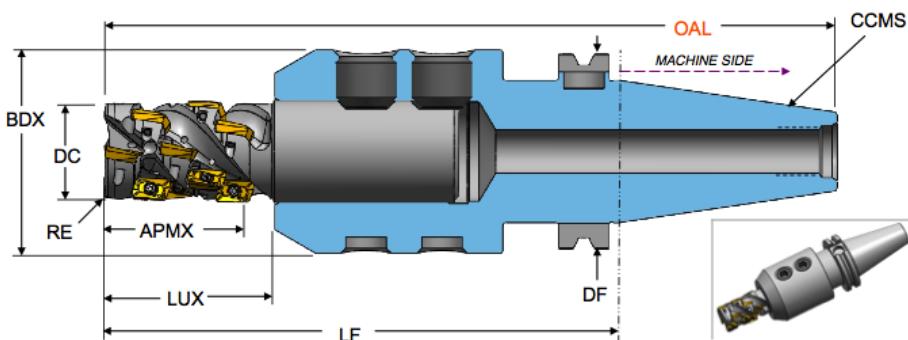


Figure 9: Cutting Tool Measurement 1

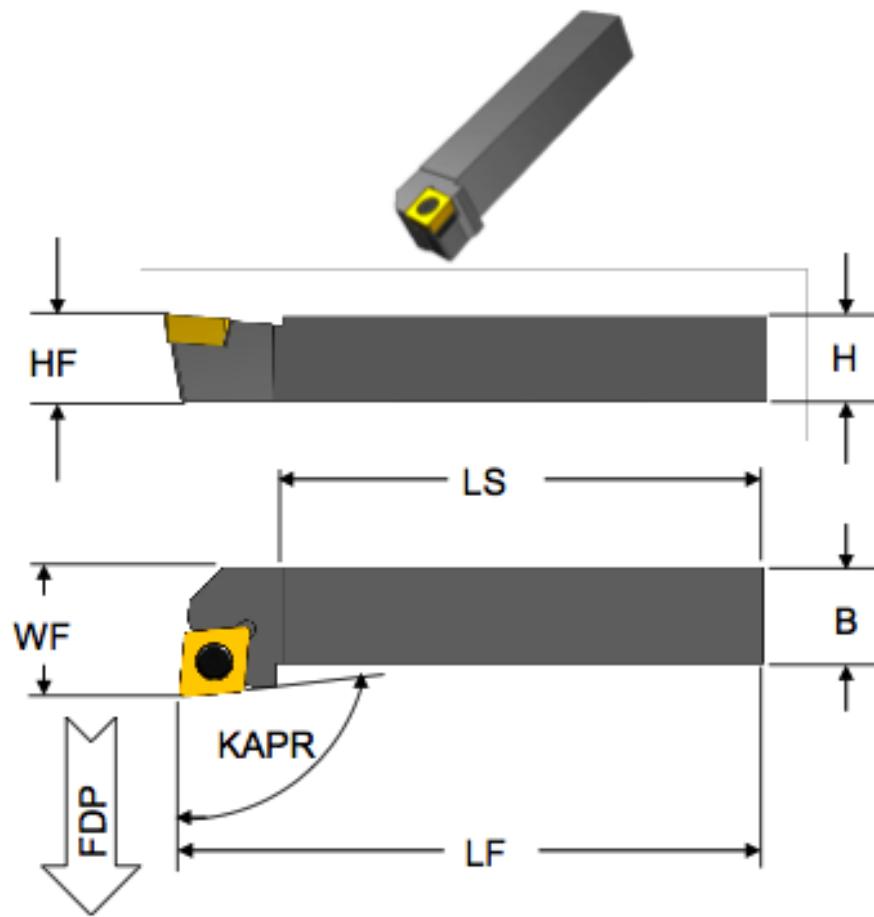


Figure 10: Cutting Tool Measurement 2

1295 4.4.1 BodyDiameterMax

1296 largest diameter of the body of a tool item.

1297 The code of BodyDiameterMax **MUST** be BDX.

1298 The units of BodyDiameterMax **MUST** be MILLIMETER.

1299 4.4.2 BodyLengthMax

1300 distance measured along the X axis from that point of the item closest to the workpiece,
 1301 including the cutting item for a tool item but excluding a protruding locking mechanism
 1302 for an adaptive item, to either the front of the flange on a flanged body or the beginning of

1303 the connection interface feature on the machine side for cylindrical or prismatic shanks.

1304 The code of BodyLengthMax **MUST** be LBX.

1305 The units of BodyLengthMax **MUST** be MILLIMETER.

1306 4.4.3 DepthOfCutMax

1307 maximum engagement of the cutting edge or edges with the workpiece measured perpendicular to the feed motion.

1309 The code of DepthOfCutMax **MUST** be APMX.

1310 The units of DepthOfCutMax **MUST** be MILLIMETER.

1311 4.4.4 CuttingDiameterMax

1312 maximum diameter of a circle on which the defined point Pk of each of the master inserts
1313 is located on a tool item.

1314 The normal of the machined peripheral surface points towards the axis of the cutting tool.

1315 The code of CuttingDiameterMax **MUST** be DC.

1316 The units of CuttingDiameterMax **MUST** be MILLIMETER.

1317 4.4.5 FlangeDiameterMax

1318 dimension between two parallel tangents on the outside edge of a flange.

1319 The code of FlangeDiameterMax **MUST** be DF.

1320 The units of FlangeDiameterMax **MUST** be MILLIMETER.

1321 4.4.6 OverallToolLength

1322 largest length dimension of the cutting tool including the master insert where applicable.

1323 The code of OverallToolLength **MUST** be OAL.

1324 The units of OverallToolLength **MUST** be MILLIMETER.

1325 4.4.7 ShankDiameter

1326 dimension of the diameter of a cylindrical portion of a tool item or an adaptive item that
1327 can participate in a connection.

1328 The code of ShankDiameter **MUST** be DMM.

1329 The units of ShankDiameter **MUST** be MILLIMETER.

1330 4.4.8 ShankHeight

1331 dimension of the height of the shank.

1332 The code of ShankHeight **MUST** be H.

1333 The units of ShankHeight **MUST** be MILLIMETER.

1334 4.4.9 ShankLength

1335 dimension of the length of the shank.

1336 The code of ShankLength **MUST** be LS.

1337 The units of ShankLength **MUST** be MILLIMETER.

1338 4.4.10 UsableLengthMax

1339 maximum length of a cutting tool that can be used in a particular cutting operation includ-
1340 ing the non-cutting portions of the tool.

1341 The code of UsableLengthMax **MUST** be LUX.

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

1343 4.4.11 ProtrudingLength

1344 dimension from the *yz*-plane to the furthest point of the tool item or adaptive item mea-
1345 sured in the *-X* direction.

1346 The code of **ProtrudingLength** **MUST** be LPR.

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

1348 4.4.12 FunctionalLength

1349 distance from the gauge plane or from the end of the shank to the furthest point on the
1350 tool, if a gauge plane does not exist, to the cutting reference point determined by the main
1351 function of the tool.

1352 The **CuttingTool** functional length will be the length of the entire tool, not a single
1353 cutting item. Each **CuttingItem** can have an independent **FunctionalLength** rep-
1354 resented in its measurements.

1355 The code of **FunctionalLength** **MUST** be LF.

1356 The units of **FunctionalLength** **MUST** be MILLIMETER.

1357 4.4.13 Weight

1358 total weight of the cutting tool in grams.

1359 The force exerted by the mass of the cutting tool.

1360 The code of **Weight** **MUST** be WT.

1361 The units of **Weight** **MUST** be GRAM.

1362 4.5 Cutting Item Measurement Subtypes

1363 This section lists the **Measurement** subtypes for **CuttingItem**.

1364 These **Measurement** subtypes for **CuttingItem** are specific to an individual Cut-

1365 tingItem and **MUST NOT** be used for the Measurement pertaining to an assembly.
 1366 Figures below will be used to for reference for the CuttingItem specific Measure-
 1367 ment types.

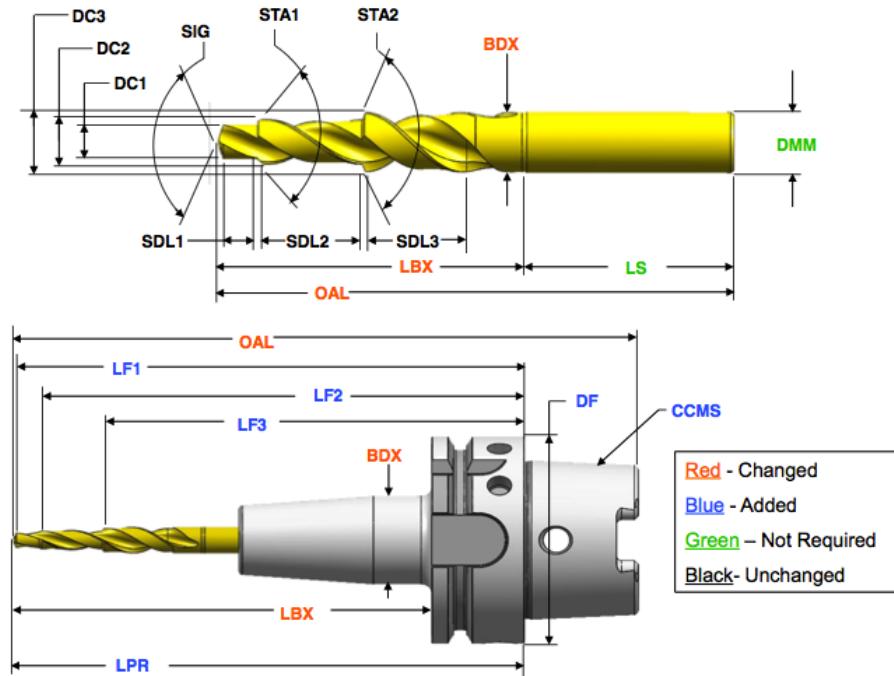


Figure 11: Cutting Tool

1368 4.5.1 FunctionalLength

1369 distance from the gauge plane or from the end of the shank of the cutting tool, if a gauge
 1370 plane does not exist, to the cutting reference point determined by the main function of the
 1371 tool.

1372 This measurement will be with reference to the cutting tool and **MUST NOT** exist without
 1373 a cutting tool.

1374 The code of FunctionalLength **MUST** be LFx.

1375 The units of FunctionalLength **MUST** be MILLIMETER.

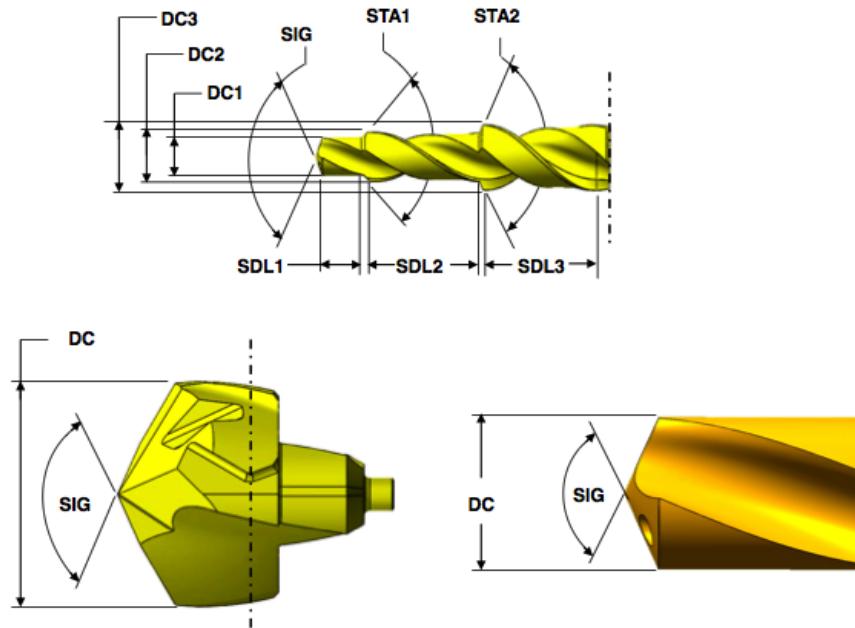


Figure 12: Cutting Item

1376 4.5.2 CuttingReferencePoint

1377 theoretical sharp point of the cutting tool from which the major functional dimensions are
1378 taken.

1379 The code of CuttingReferencePoint **MUST** be CRP.

1380 The units of CuttingReferencePoint **MUST** be MILLIMETER.

1381 4.5.3 CuttingEdgeLength

1382 theoretical length of the cutting edge of a cutting item over sharp corners.

1383 The code of CuttingEdgeLength **MUST** be L.

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

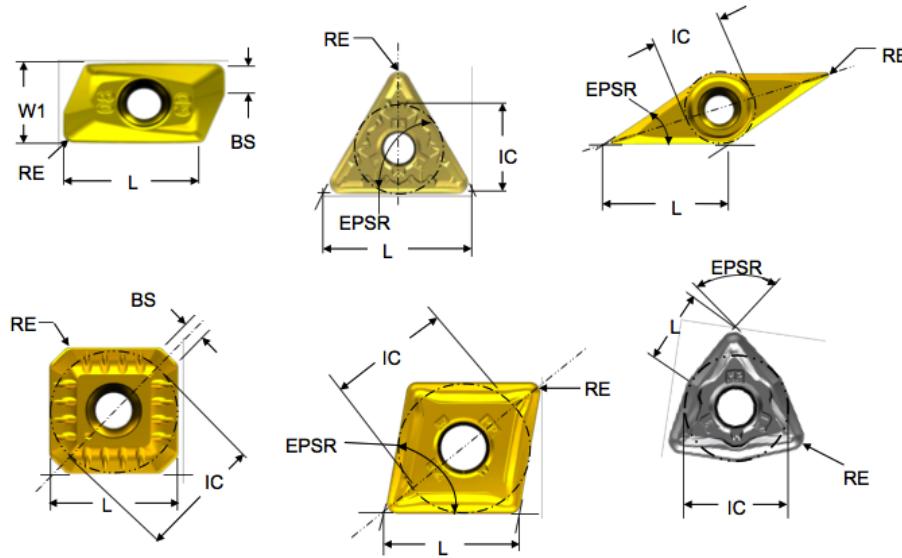


Figure 13: Cutting Item Measurement

1385 4.5.4 DriveAngle

1386 angle between the driving mechanism locator on a tool item and the main cutting edge.

1387 The code of DriveAngle **MUST** be DRVA.

1388 The units of DriveAngle **MUST** be DEGREE.

1389 4.5.5 FlangeDiameter

1390 dimension between two parallel tangents on the outside edge of a flange.

1391 The code of FlangeDiameter **MUST** be DF.

1392 The units of FlangeDiameter **MUST** be MILLIMETER.

1393 4.5.6 FunctionalWidth

1394 distance between the cutting reference point and the rear backing surface of a turning tool
1395 or the axis of a boring bar.

1396 The code of FunctionalWidth **MUST** be WF.

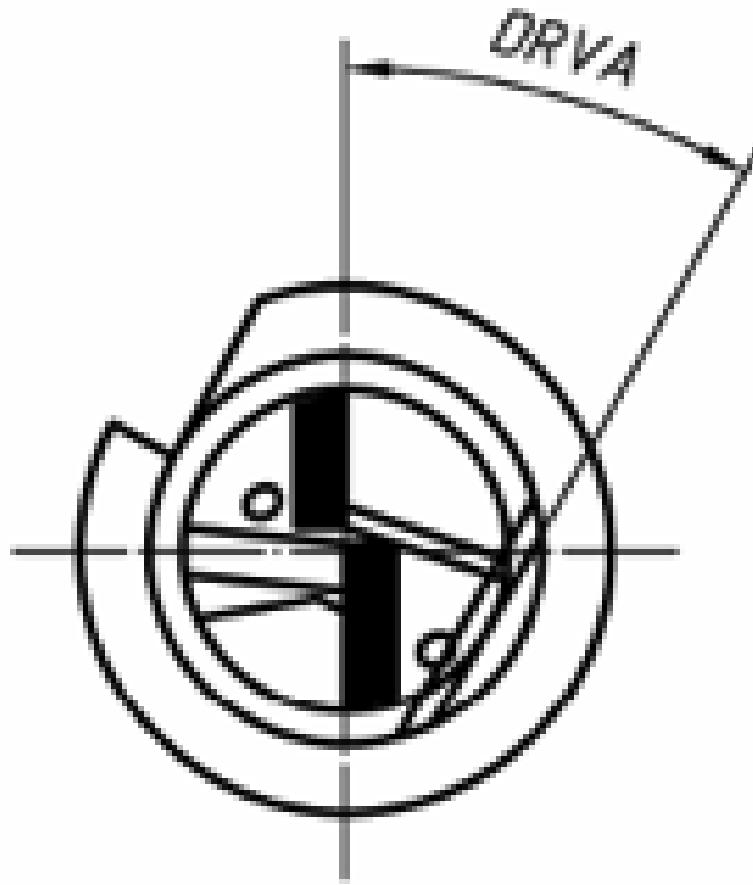


Figure 14: Cutting Item Drive Angle

1397 The units of FunctionalWidth **MUST** be MILLIMETER.

1398 4.5.7 IncribedCircleDiameter

1399 diameter of a circle to which all edges of a equilateral and round regular insert are tangent.
1400 tial.

1401 The code of IncribedCircleDiameter **MUST** be IC.

1402 The units of IncribedCircleDiameter **MUST** be MILLIMETER.

1403 4.5.8 PointAngle

1404 angle between the major cutting edge and the same cutting edge rotated by 180 degrees
1405 about the tool axis.

1406 The code of PointAngle **MUST** be SIG.

1407 The units of PointAngle **MUST** be DEGREE.

1408 4.5.9 ToolCuttingEdgeAngle

1409 angle between the tool cutting edge plane and the tool feed plane measured in a plane
1410 parallel the xy-plane.

1411 The code of ToolCuttingEdgeAngle **MUST** be KAPR.

1412 The units of ToolCuttingEdgeAngle **MUST** be DEGREE.

1413 4.5.10 ToolLeadAngle

1414 angle between the tool cutting edge plane and a plane perpendicular to the tool feed plane
1415 measured in a plane parallel the xy-plane.

1416 The code of ToolLeadAngle **MUST** be PSIR.

1417 The units of ToolLeadAngle **MUST** be DEGREE.

1418 4.5.11 ToolOrientation

1419 angle of the tool with respect to the workpiece for a given process.

1420 The value is application specific.

1421 The code is N/A for ToolOrientation.

1422 The units of ToolOrientation **MUST** be DEGREE.

1423 4.5.12 StepDiameterLength

1424 length of a portion of a stepped tool that is related to a corresponding cutting diameter
1425 measured from the cutting reference point of that cutting diameter to the point on the next
1426 cutting edge at which the diameter starts to change.

1427 The code of StepDiameterLength **MUST** be SDLx.

1428 The units of StepDiameterLength **MUST** be MILLIMETER.

1429 4.5.13 StepIncludedAngle

1430 angle between a major edge on a step of a stepped tool and the same cutting edge rotated
1431 180 degrees about its tool axis.

1432 The code of StepIncludedAngle **MUST** be STAx.

1433 The units of StepIncludedAngle **MUST** be DEGREE.

1434 4.5.14 WiperEdgeLength

1435 measure of the length of a wiper edge of a cutting item.

1436 The code of WiperEdgeLength **MUST** be BS.

1437 The units of WiperEdgeLength **MUST** be MILLIMETER.

1438 4.5.15 CuttingDiameter

1439 diameter of a circle on which the defined point Pk located on this cutting tool.

1440 The normal of the machined peripheral surface points towards the axis of the cutting tool.

1441 The code of CuttingDiameter **MUST** be DCx.

1442 The units of CuttingDiameter **MUST** be MILLIMETER.

1443 4.5.16 CuttingHeight

1444 distance from the basal plane of the tool item to the cutting point.

1445 The code of CuttingHeight **MUST** be HF.

1446 The units of CuttingHeight **MUST** be MILLIMETER.

1447 4.5.17 CornerRadius

1448 nominal radius of a rounded corner measured in the X Y-plane.

1449 The code of CornerRadius **MUST** be RE.

1450 The units of CornerRadius **MUST** be MILLIMETER.

1451 4.5.18 Weight

1452 total weight of the cutting tool in grams.

1453 The force exerted by the mass of the cutting tool.

1454 The code of Weight **MUST** be WT.

1455 The units of Weight **MUST** be GRAM.

1456 4.5.19 ChamferFlatLength

1457 flat length of a chamfer.

1458 The code of ChamferFlatLength **MUST** be BCH.

1459 The units of ChamferFlatLength **MUST** be MILLIMETER.

1460 4.5.20 ChamferWidth

1461 width of the chamfer.

1462 The code of ChamferWidth **MUST** be CHW.

1463 The units of ChamferWidth **MUST** be MILLIMETER.

1464 4.5.21 InsertWidth

1465 W1 is used for the insert width when an inscribed circle diameter is not practical.

1466 The code of InsertWidth **MUST** be W1.

1467 The units of InsertWidth **MUST** be MILLIMETER.

1468 5 Files Asset Information Model

1469 Manufacturing processes require various documents, programs, setup sheets, and digital
1470 media available at the device for a given process. The File and FileArchetype As-
1471 sets provide a mechanism to communicate specific “Files” that are relevant to a process
1472 where the media is located on a server and represented by a Universal Resource Locator
1473 (URL).

1474 The FileArchetype contains metadata common to all File Assets for a certain
1475 purpose. The File Asset references the file specific to a given device or set of devices.
1476 The File Asset does not hold the contents of the file, it contains a reference to the
1477 location (URL) used to access the information. The metadata associated with the File
1478 provides semantic information about the representation (mime-type) and the application
1479 associated with the File. The application of the file is an extensible controlled vocabulary
1480 with common manufacturing uses provided.

1481 5.1 Files

1482 This section provides semantic information for the File model.

1483 Note: See *Section B.7 - File Schema Diagrams* for XML schema.

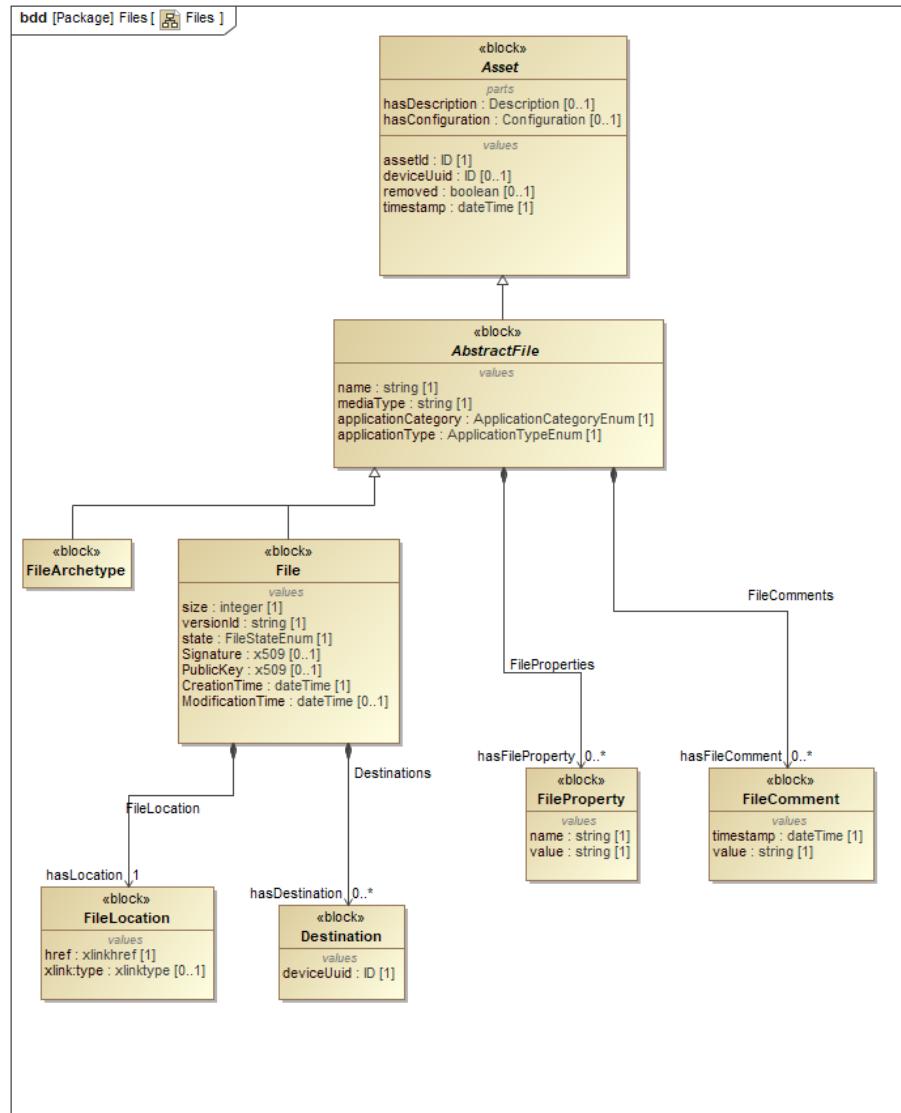
1484 5.1.1 AbstractFile

1485 abstract Asset that contains the common properties of the File and FileArchetype
1486 types.

1487 5.1.1.1 Value Properties of AbstractFile

1488 *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

1489 Descriptions for Value Properties of `AbstractFile`:

- 1490 • `name`
1491 name of the file.
1492 • `mediaType`
1493 mime type of the file.
1494 • `applicationCategory`
1495 category of application that will use this file.

1496 `ApplicationCategoryEnum` Enumeration:

- 1497 – ASSEMBLY
1498 files regarding the fully assembled product.
1499 – DEVICE
1500 device related files.
1501 – HANDLING
1502 files relating to the handling of material.
1503 – INSPECTION
1504 files related to the quality inspection.
1505 – MAINTENANCE
1506 files relating to equipment maintenance.
1507 – PART
1508 files relating to a part.
1509 – PROCESS
1510 files related to the manufacturing process.
1511 – SETUP
1512 files related to the setup of a process.

- 1513 • `applicationType`
1514 type of application that will use this file.

1515 `ApplicationTypeEnum` Enumeration:

- 1516 – DATA
1517 generic data.
1518 – DESIGN
1519 computer aided design files or drawings.

- 1520 - DOCUMENTATION
 1521 documentation regarding a category of file.
 1522 - INSTRUCTIONS
 1523 user instructions regarding the execution of a task.
 1524 - LOG
 1525 data related to the history of a machine or process.
 1526 - PRODUCTION_PROGRAM
 1527 machine instructions to perform a process.

1528 **5.1.1.2 Part Properties of AbstractFile**

1529 *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

1530 Descriptions for Part Properties of AbstractFile:

- 1531 • FileProperty
 1532 key-value pair providing additional metadata about a File.
 1533 FileProperties groups one or more FileProperty entities for a File. See
 1534 *Section 5.1.4 - FileProperty*.
 1535 • FileComment
 1536 remark or interpretation for human interpretation associated with a File or FileArchetype.
 1537 FileComments groups one or more FileComment entities for a File. See
 1538 *Section 5.1.5 - FileComment*.

1539 **5.1.2 File**

1540 AbstractFile type that provides information about the File instance and its URL.

1541 **5.1.2.1 Value Properties of File**

1542 *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

1543 Descriptions for Value Properties of File:

- 1544 • size
size of the file in bytes.
- 1546 • versionId
version identifier of the file.
- 1548 • state
state of the file.
- 1550 FileStateEnum Enumeration:
 - 1551 – EXPERIMENTAL
used for processes other than production or otherwise defined.
 - 1553 – PRODUCTION
used for production processes.
 - 1555 – REVISION
content is modified from PRODUCTION or EXPERIMENTAL.
- 1557 • Signature
secure hash of the file.
- 1559 • PublicKey
public key used to verify the signature.
- 1561 • CreationTime
time the file was created.
- 1563 • ModificationTime
time the file was modified.

1565 **5.1.2.2 Part Properties of File**

1566 *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

1567 Descriptions for Part Properties of File:

1568 • FileLocation

1569 URL reference to the file location.

1570 See *Section 5.1.6 - FileLocation*.

1571 • Destination

1572 reference to the target Device for this File.

1573 Destinations groups one or more Destination entities. See *Section 5.1.7 - Destination*.

1574

1575 **5.1.3 FileArchetype**

1576 AbstractFile type that provides information common to all versions of a file.

1577 **5.1.4 FileProperty**

1578 key-value pair providing additional metadata about a File.

1579 The value of FileProperty **MUST** be string.

1580 **5.1.4.1 Value Properties of FileProperty**

1581 *Table 25* lists the Value Properties of FileProperty.

Value Property name	Value Property type	Multiplicity
name	string	1

Table 25: Value Properties of FileProperty

1582 Descriptions for Value Properties of FileProperty:

- 1583 • name
 1584 name of the FileProperty.

1585 5.1.5 FileComment

1586 remark or interpretation for human interpretation associated with a File or FileArchetype.
 1587 The value of FileComment **MUST** be string.

1588 5.1.5.1 Value Properties of FileComment

1589 *Table 26* lists the Value Properties of FileComment.

Value Property name	Value Property type	Multiplicity
timestamp	datetime	1

Table 26: Value Properties of FileComment

1590 Descriptions for Value Properties of FileComment:

- 1591 • timestamp
 1592 time the comment was made.

1593 5.1.6 FileLocation

1594 URL reference to the file location.

1595 5.1.6.1 Value Properties of FileLocation

1596 *Table 27* lists the Value Properties of FileLocation.

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

Table 27: Value Properties of FileLocation

1597 Descriptions for Value Properties of FileLocation:

- 1598 • href
 - 1599 URL reference to the file.
 - 1600 href is of type xlink:href from the W3C XLink specification.
- 1601 • xlink:type
 - 1602 type of href for the xlink href type.
 - 1603 **MUST** be locator referring to a URL .

1604 5.1.7 Destination

1605 reference to the target Device for this File.

1606 5.1.7.1 Value Properties of Destination

1607 *Table 28* lists the Value Properties of Destination.

Value Property name	Value Property type	Multiplicity
deviceUuid	ID	1

Table 28: Value Properties of Destination

1608 Descriptions for Value Properties of Destination:

- 1609 • deviceUuid
 - 1610 uuid of the target device or application.

1611 6 Raw Material Asset Information Model

1612 Raw material represents the source of material for immediate use and sources of material
1613 that may or may not be used during the manufacturing process.

1614 The RawMaterial Asset holds the references to the content stored in the actual Raw-
1615 Material container or derived about the RawMaterial by the system during opera-
1616 tion.

1617 6.1 Raw Material

1618 This section provides semantic information for the RawMaterial model.

1619 Note: See *Section B.8 - RawMaterial Schema Diagrams* for XML schema.

1620 6.1.1 RawMaterial

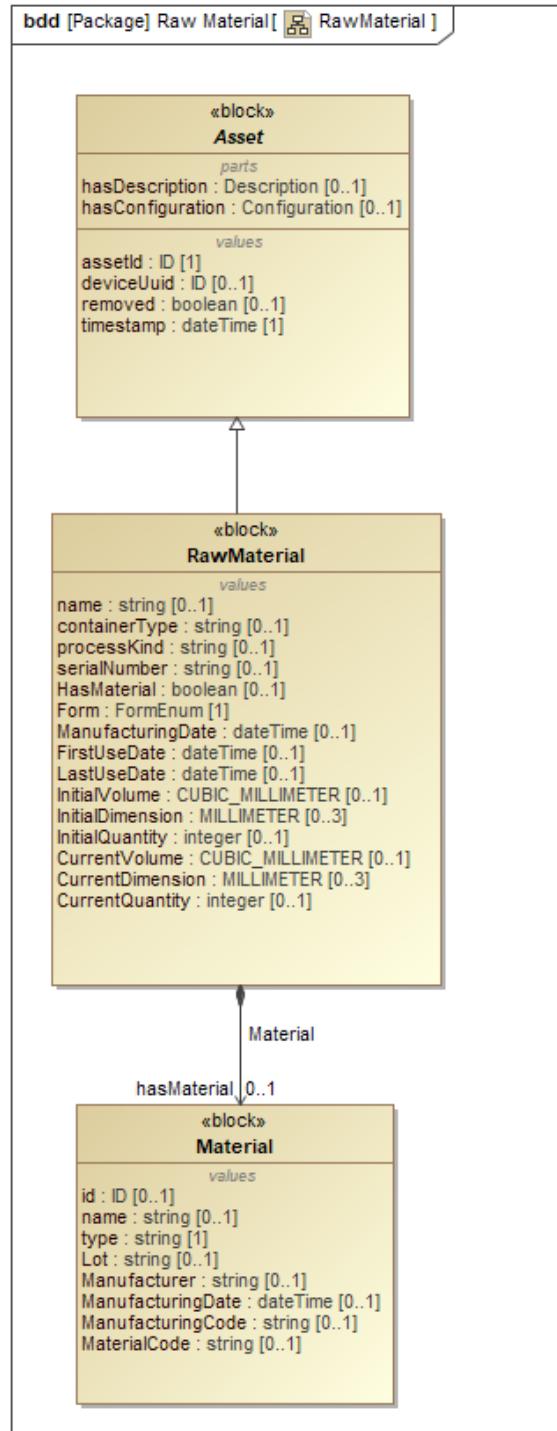
1621 Asset that represents raw material.

1622 6.1.1.1 Value Properties of RawMaterial

1623 *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

1624 Descriptions for Value Properties of RawMaterial:

1625 • name

1626 name of the raw material.

1627 Examples: Container1 and AcrylicContainer.

1628 • containerType

1629 type of container holding the raw material.

1630 Examples: Pallet, Canister, Cartridge, Tank, Bin, Roll, and Spool.

1631 • processKind

1632 ISO process type supported by this raw material.

1633 Examples include: VAT_POLYMERIZATION, BINDER_JETTING, MATERIAL_EXTRUSION,
1634 MATERIAL_JETTING, SHEET_LAMINATION, POWDER_BED_FUSION and DI-
1635 RECTED_ENERGY_DEPOSITION.

1636 • serialNumber

1637 serial number of the raw material.

1638 • HasMaterial

1639 Material has existing usable volume.

1640 • Form

1641 form of the raw material.

1642 FormEnum Enumeration:

1643 – BAR

1644 – BLOCK

1645 – CASTING

1646 – FILAMENT

1647 – GAS

1648 – GEL

1649 – LIQUID

1650 – POWDER

1651 – SHEET

1652 • ManufacturingDate

1653 date the raw material was created.

- 1654 • FirstUseDate
 1655 date raw material was first used.
- 1656 • LastUseDate
 1657 date raw material was last used.
- 1658 • InitialVolume
 1659 amount of material initially placed in raw material when manufactured.
- 1660 • InitialDimension
 1661 dimension of material initially placed in raw material when manufactured.
- 1662 • InitialQuantity
 1663 quantity of material initially placed in raw material when manufactured.
- 1664 • CurrentVolume
 1665 amount of material currently in raw material.
- 1666 • CurrentDimension
 1667 dimension of material currently in raw material.
- 1668 • CurrentQuantity
 1669 quantity of material currently in raw material.

1670 **6.1.1.2 Part Properties of RawMaterial**

1671 *Table 30* lists the Part Properties of RawMaterial.

Part Property name	Multiplicity
Material	0..1

Table 30: Part Properties of RawMaterial

1672 Descriptions for Part Properties of RawMaterial:

- 1673 • Material
 1674 material used as the RawMaterial.
 1675 See *Section 6.1.2 - Material*.

1676 6.1.2 Material

1677 material used as the RawMaterial.

1678 6.1.2.1 Value Properties of Material

1679 *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

1680 Descriptions for Value Properties of Material:

1681 • id

1682 unique identifier for the material.

1683 • name

1684 name of the material.

1685 Examples: ULM9085, ABS, 4140.

1686 • type

1687 type of material.

1688 Examples: Metal, Polymer, Wood, 4140, Recycled, Prestine and Used.

1689 • Lot

1690 manufacturer's lot code of the material.

1691 • Manufacturer

1692 name of the material manufacturer.

- 1693 • ManufacturingDate
- 1694 manufacturing date of the material from the material manufacturer.
- 1695 • ManufacturingCode
- 1696 lot code of the raw feed stock for the material, from the feed stock manufacturer.
- 1697 • MaterialCode
- 1698 American Society for Testing and Materials (ASTM) standard code that the material
- 1699 complies with.

1700 7 QIF Asset Information Model

1701 The Quality Information Framework (QIF) is an American National Standards Institute
1702 (ANSI) accredited standard developed by the Digital Metrology Standards Consortium
1703 (DMSC) standards development organization. The DMSC is an A-liaison to the Interna-
1704 tional Standards Organization (ISO) Technical Committee (TC) 184. QIF addresses the
1705 needs of the metrology community to have a semantic information model for the exchange
1706 of metrology data throughout the verification lifecycle from product design to execution,
1707 analysis, and reporting.

1708 The MTConnect QIF Asset Information Model provides a wrapper around a QIF document
1709 (i.e., a dataset conforming to the QIF Information model) in its native XML representation.
1710 The MTConnect standard does not alter or extend the QIF standard and regards the QIF
1711 standard as a passthrough.

1712 Information about the QIF standards is at the following location: <https://qifstandards.org>

1713 7.1 QIF

1714 This section provides semantic information for the `QIFDocumentWrapper` model.

1715 Note: See *Section B.9 - QIFDocumentWrapper Schema Diagrams* for XML
1716 schema.

1717 7.1.1 QIFDocument

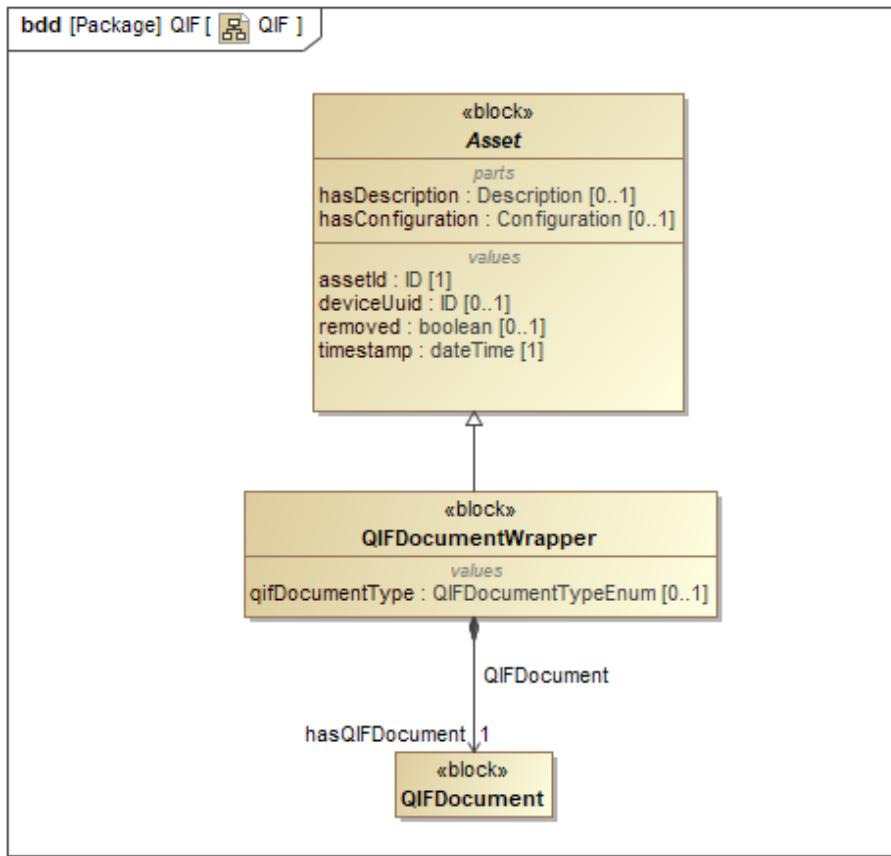
1718 QIF Document as given by the QIF standard.

1719 7.1.2 QIFDocumentWrapper

1720 Asset that carries the QIF Document.

1721 7.1.2.1 Value Properties of QIFDocumentWrapper

1722 *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

1723 Descriptions for Value Properties of QIFDocumentWrapper:

- 1724 • qifDocumentType
 1725 contained QIF Document type as defined in the QIF Standard.
 1726 QIFDocumentTypeEnum Enumeration:
 1727 – MEASUREMENT_RESOURCE
 1728 – PLAN
 1729 – PRODUCT
 1730 – RESULTS

- 1731 – RULES
 1732 – STATISTICS

1733 **7.1.2.2 Part Properties of QIFDocumentWrapper**

1734 *Table 33* lists the Part Properties of QIFDocumentWrapper.

Part Property name	Multiplicity
QIFDocument	1

Table 33: Part Properties of QIFDocumentWrapper

1735 Descriptions for Part Properties of QIFDocumentWrapper:

- 1736 • QIFDocument
 1737 QIF Document as given by the QIF standard.

1738 8 Profile

1739 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML) 1740 metamodel for the MTConnect domain using additional data types and *stereotypes*.

1741 8.1 DataTypes

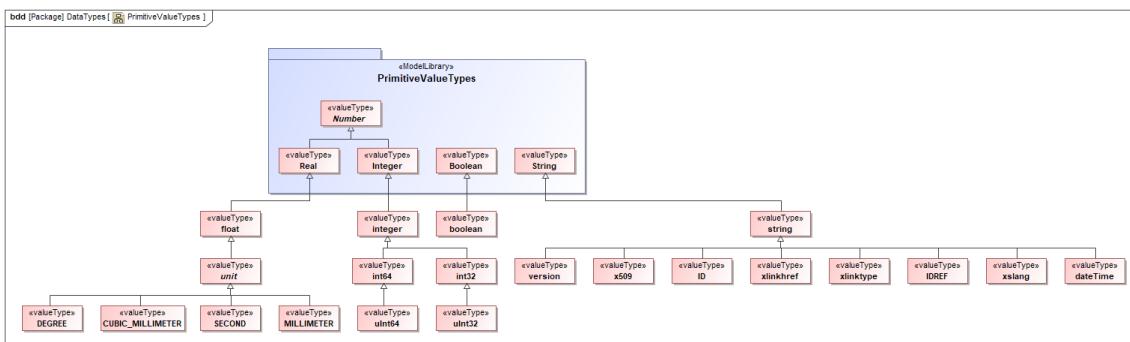


Figure 18: DataTypes

1742 8.1.1 boolean

1743 primitive type.

1744 8.1.2 ID

1745 string that represents an identifier (ID).

1746 8.1.3 string

1747 primitive type.

1748 8.1.4 float

1749 primitive type.

1750 **8.1.5 datetime**

1751 string that represents timestamp in ISO 8601 format.

1752 **8.1.6 integer**

1753 primitive type.

1754 **8.1.7 xlinktype**

1755 string that represents the type of an XLink element. See <https://www.w3.org/TR/xlink11/>.

1757 **8.1.8 xslang**

1758 string that represents a language tag. See <http://www.ietf.org/rfc/rfc4646.txt>.

1760 **8.1.9 SECOND**

1761 float that represents time in seconds.

1762 **8.1.10 IDREF**

1763 string that represents a reference to an ID.

1764 **8.1.11 xlinkhref**

1765 string that represents the locator attribute of an XLink element. See <https://www.w3.org/TR/xlink11/>.

1767 **8.1.12 x509**

1768 string that represents an x509 data block. *Ref ISO/IEC 9594-8:2020.*

1769 **8.1.13 int32**

1770 32-bit integer.

1771 **8.1.14 int64**

1772 64-bit integer.

1773 **8.1.15 version**

1774 series of four numeric values, separated by a decimal point, representing a *major*, *minor*,
1775 and *revision* number of the MTConnect Standard and the revision number of a specific
1776 *schema*.

1777 **8.1.16 uint32**

1778 32-bit unsigned integer.

1779 **8.1.17 uint64**

1780 64-bit unsigned integer.

1781 **8.2 Stereotypes**

1782 **8.2.1 organizer**

1783 element that *organizes* other elements of a type.

1784 8.2.2 deprecated

1785 element that has been deprecated.

1786 8.2.3 extensible

1787 enumeration that can be extended.

1788 8.2.4 informative

1789 element that is descriptive and non-normative.

1790 8.2.5 valueType

1791 extends SysML <<ValueType>> to include Class as a value type.

1792 8.2.6 normative

1793 element that has been added to the standard.

1794 8.2.7 observes

1795 association in which a *Component* makes *Observations* about an observable *DataItem*.

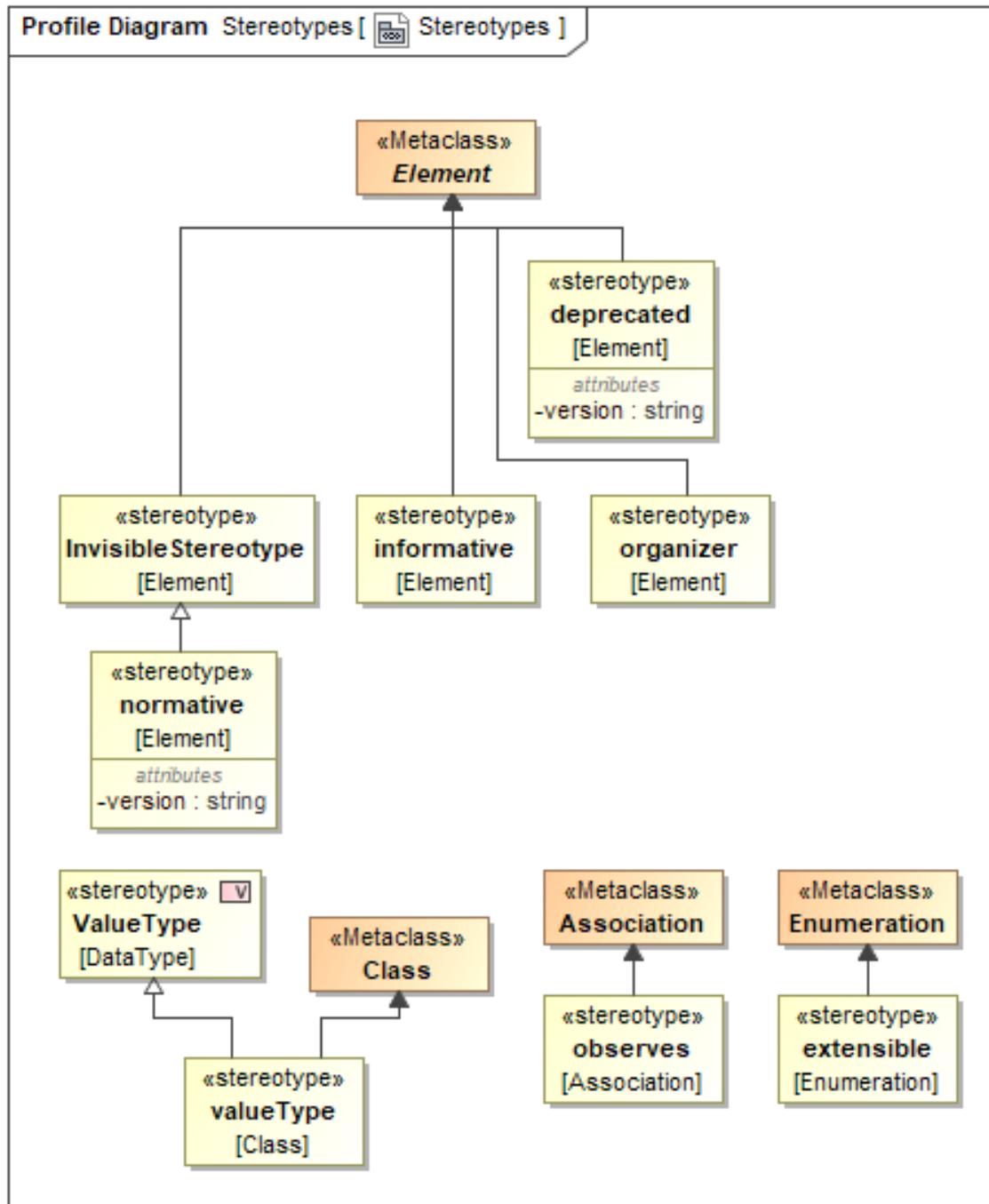


Figure 19: Stereotypes

1796 Appendices

1797 A Bibliography

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- 1805 International Organization for Standardization. ISO 14649: Industrial automation sys- 1806 tems and integration – Physical device control – Data model for computerized numerical 1807 controllers – Part 10: General process data. Geneva, Switzerland, 2004.
- 1808 International Organization for Standardization. ISO 14649: Industrial automation sys- 1809 tems and integration – Physical device control – Data model for computerized numerical 1810 controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.
- 1811 International Organization for Standardization. ISO 6983/1 – Numerical Control of ma- 1812 chines – Program format and definition of address words – Part 1: Data format for posi- 1813 tioning, line and contouring control systems. Geneva, Switzerland, 1982.
- 1814 Electronic Industries Association. ANSI/EIA-494-B-1992, 32 Bit Binary CL (BCL) and 1815 7 Bit ASCII CL (ACL) Exchange Input Format for Numerically Controlled Machines. 1816 Washington, D.C. 1992.
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- 1828 International Organization for Standardization. ISO 841-2001: Industrial automation sys-
1829 tems and integration - Numerical control of machines - Coordinate systems and motion
1830 nomenclature. Geneva, Switzerland, 2001.
- 1831 ASME B5.57: Methods for Performance Evaluation of Computer Numerically Controlled
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1834 trolled Machining Centers. 2005.
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1836 July 28, 2006.
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1838 tuators – Common Functions, Communication Protocols, and Transducer Electronic Data
1839 Sheet (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The In-
1840 stitute of Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH99684,
1841 October 5, 2007.
- 1842 IEEE STD 1451.4-1994, Standard for a Smart Transducer Interface for Sensors and Ac-
1843 tuators – Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet
1844 (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The Institute of
1845 Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH95225, December
1846 15, 2004.

1847 B XML Schema Diagrams

1848 See XML schemas for the MTConnect standard here: <https://schemas.mtconnect.org/>.

1850 B.1 Assets Schema Diagrams

1851 See Asset element in MTConnectAssets schema.

1852 See Description element in MTConnectAssets schema.

1853 B.2 CuttingTool Schema Diagrams

1854 See CuttingTool element in MTConnectAssets schema.

1855 See CuttingToolDefinition element in MTConnectAssets schema.

1856 See CuttingToolArchetypeReference element in MTConnectAssets schema.

1857 B.3 CuttingToolLifeCycle Schema Diagrams

1858 See CuttingToolLifeCycle element in MTConnectAssets schema.

1859 See CutterStatus element in MTConnectAssets schema.

1860 See Location element in MTConnectAssets schema.

1861 See Measurement element in MTConnectAssets schema.

1862 See ProcessFeedRate element in MTConnectAssets schema.

1863 See ProcessSpindleSpeed element in MTConnectAssets schema.

1864 See ReconditionCount element in MTConnectAssets schema.

1865 See ToolLife element in MTConnectAssets schema.

1866 B.4 CuttingItem Schema Diagrams

1867 See CuttingItems element in MTConnectAssets schema.

1868 See CuttingItem element in MTConnectAssets schema.

1869 See ItemLife element in MTConnectAssets schema.

1870 B.5 ISO 13399 Diagrams

1871 B.5.1 Measurement Diagrams

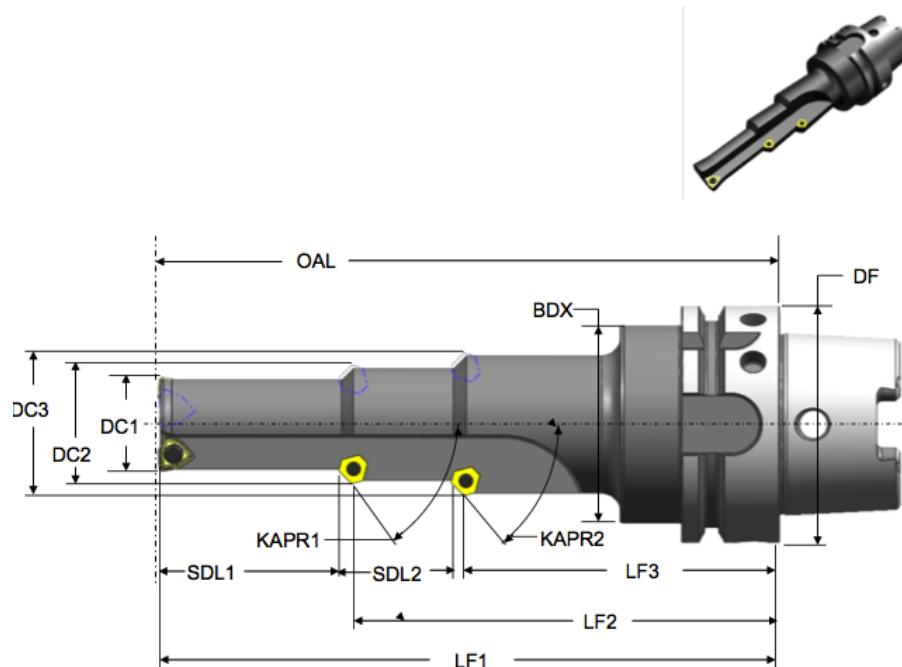


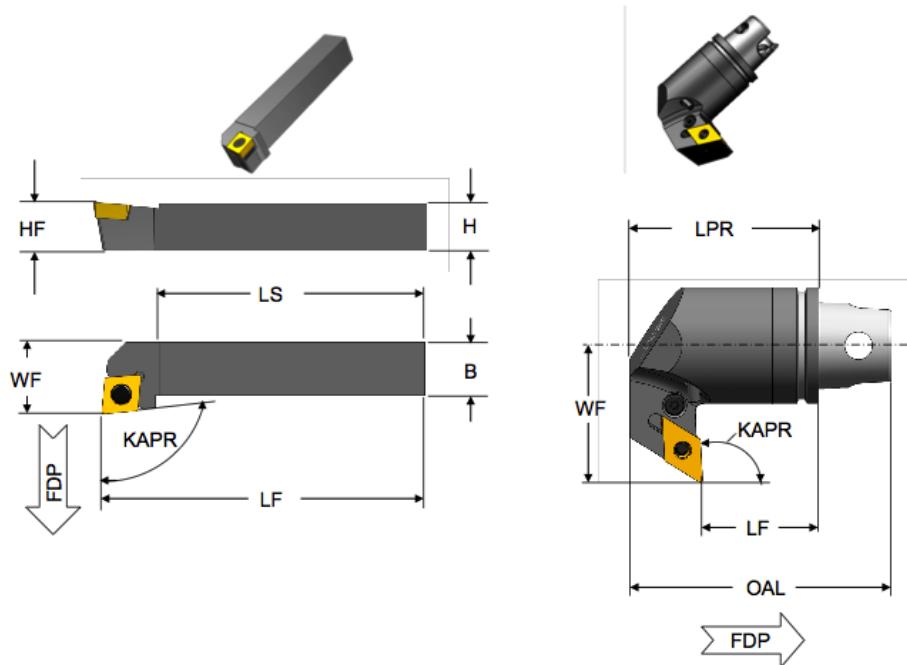
Figure 20: Cutting Tool Measurement 3

1872 B.6 Cutting Tool Examples

1873 B.6.1 Shell Mill

Example 1: Example for Indexable Insert Measurements

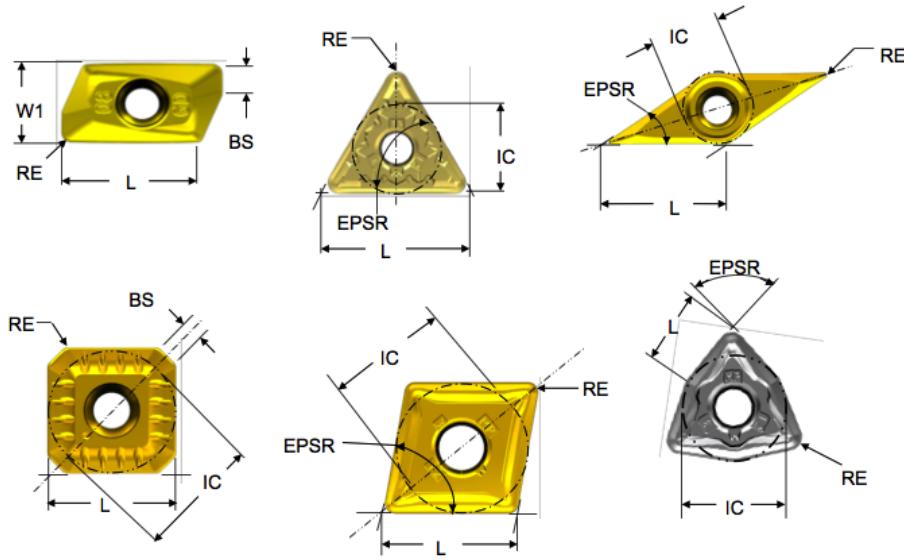
1874 1 <?xml version="1.0" encoding="UTF-8"?>

**Figure 21:** Cutting Tool Measurement 4

```

1875 2 <MTConnectAssets
1876 3 xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
1877 4 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
1878 5 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
1879 6 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
1880 7 http://mtconnect.org/schemas/MTConnectAssets\textunderscore 1.2.xsd"
1881      >
1882 8   <Header creationTime="2011-05-11T13:55:22"
1883 9     assetBufferSize="1024" sender="localhost"
1884 10    assetCount="2" version="1.2" instanceId="1234" />
1885 11    <Assets>
1886 12      <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
1887 13        timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
1888 14        manufacturers="KMT, Parlec">
1889 15          <CuttingToolLifeCycle>
1890 16            <CutterStatus><Status>NEW</Status></CutterStatus>
1891 17            <ProcessSpindleSpeed maximum="13300"
1892 18              nominal="605">10000</ProcessSpindleSpeed>
1893 19            <ProcessFeedRate
1894 20              nominal="9.22">9.22</ProcessFeedRate>
1895 21            <ConnectionCodeMachineSide>CV50
1896 22            </ConnectionCodeMachineSide>
1897 23          <Measurements>
1898 24            <BodyDiameterMax code="BDX">73.25
1899 25            </BodyDiameterMax>
1900 26            <OverallToolLength nominal="222.25"

```

**Figure 22:** Cutting Tool Measurement 5

```

1901 27 <minimum="221.996" maximum="222.504"
1902 28 <code="OAL">222.25</OverallToolLength>
1903 29 <UsableLengthMax_code="LUX" nominal="82.55">82.55
1904 30 </UsableLengthMax>
1905 31 <CuttingDiameterMax_code="DC" nominal="76.2"
1906 32 <maximum="76.213" minimum="76.187">76.2
1907 33 </CuttingDiameterMax>
1908 34 <BodyLengthMax_code="LF" nominal="120.65"
1909 35 <maximum="120.904" minimum="120.404">120.65
1910 36 </BodyLengthMax>
1911 37 <DepthOfCutMax_code="APMX"
1912 38 <nominal="60.96">60.95</DepthOfCutMax>
1913 39 <FlangeDiameterMax_code="DF"
1914 40 <nominal="98.425">98.425</FlangeDiameterMax>
1915 41 </Measurements>
1916 42 <CuttingItems_count="24">
1917 43 <CuttingItem_indices="1-24" itemId="SDET43PDER8GB"
1918 44 <manufacturers="KMT" grade="KC725M">
1919 45 <Measurements>
1920 46 <CuttingEdgeLength_code="L" nominal="12.7"
1921 47 <minimum="12.675" maximum="12.725">12.7
1922 48 </CuttingEdgeLength>
1923 49 <WiperEdgeLength_code="BS" nominal=
1924 50 <maximum="2.56">2.56</WiperEdgeLength>
1925 51 <InscribedCircleDiameter_code="IC"
1926 52 <nominal="12.7">12.7
1927 53 </InscribedCircleDiameter>
1928 54 <CornerRadius_code="RE" nominal="0.8">
1929 55 <maximum="0.8">0.8</CornerRadius>

```

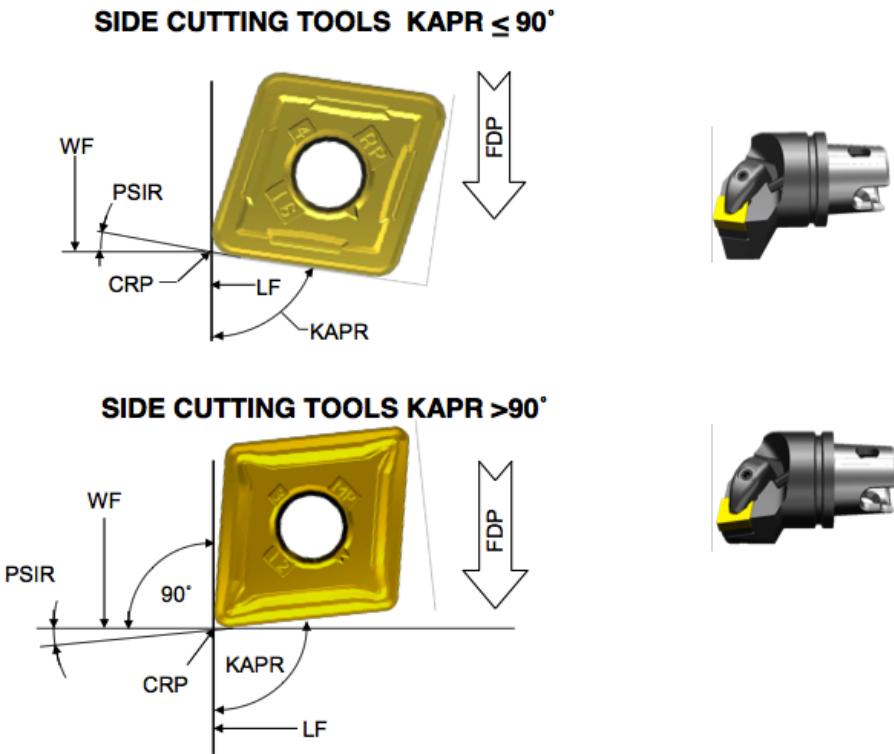


Figure 23: Cutting Tool Measurement 6

```

1930 56  
```

`</Measurements>`

```

1931 57  
```

`</CuttingItem>`

```

1932 58  
```

`</CuttingItems>`

```

1933 59  
```

`</CuttingToolLifeCycle>`

```

1934 60  
```

`</CuttingTool>`

```

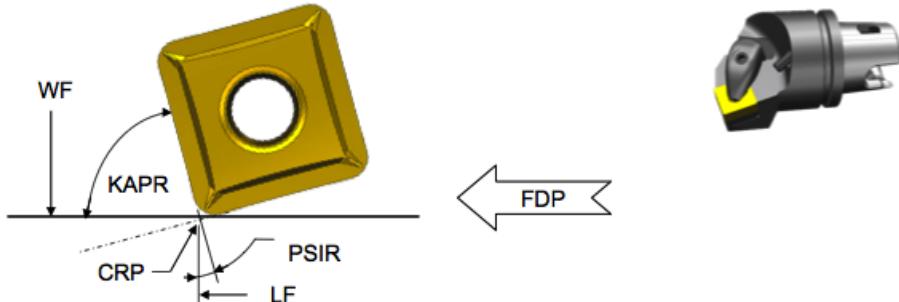
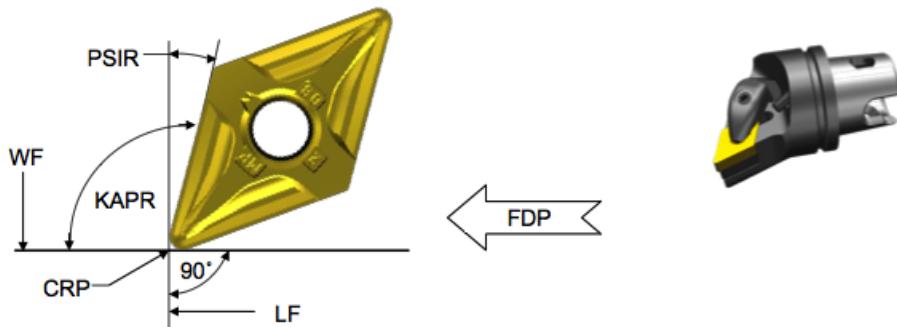
1935 61  
```

`</Assets>`

```

1936 62  
```

`</MTConnectAssets>`

END CUTTING TOOLS KAPR $\leq 90^\circ$ **END CUTTING TOOLS KAPR >90°****Figure 24:** Cutting Tool Measurement 7**1937 B.6.2 Step Drill****Example 2:** Example for Step Mill Side View

```

1938 1  <?xml version="1.0" encoding="UTF-8"?>
1939 2  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
1940 3  xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
1941 4  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
1942 5  xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
1943 6  http://mtconnect.org/schemas/MTConnectAssets\textunderscore1.2.xsd"
1944 7  >
1945 7  <Header creationTime="2011-05-
1946 8  ..11T13:55:22" assetBufferSize="1024"
1947 9  sender="localhost" assetCount="2" version="1.2" instanceId="1234"
1948 10 />
1949 <Assets>
1950 11 <CuttingTool serialNumber="1_" toolId="B732A08500HP"
1951 12 timestamp="2011-05-11T13:55:22" assetId="B732A08500HP_"
1952 13 manufacturers="KMT, Parlec">
1953 14 <Description>
1954 15     Step Drill - KMT, B732A08500HP Grade KC7315
1955 16     Adapter - Parlec, C50-M12SF300-6
1956 17 </Description>
```

BCH = CHAMFER FLAT LENGTH
 CHW = CHAMFER WIDTH

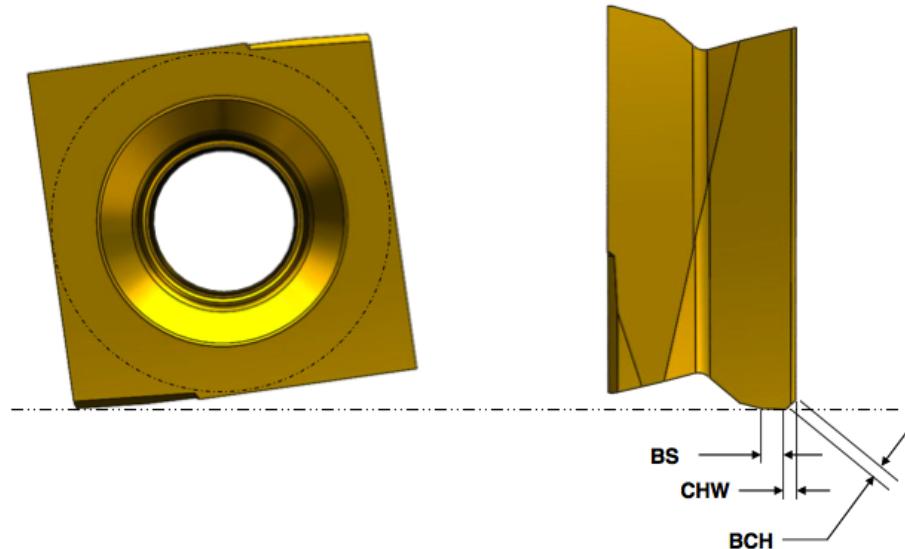


Figure 25: Cutting Tool Measurement 8

```

1957 18      <CuttingToolLifeCycle>
1958 19        <CutterStatus><Status>NEW</Status></CutterStatus>
1959 20        <ProcessSpindleSpeed nominal="5893">5893</
1960 ProcessSpindleSpeed>
1961 21        <ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
1962 22        <ConnectionCodeMachineSide>CV50 Taper</
1963 ConnectionCodeMachineSide>
1964 23        <Measurements>
1965 24          <BodyDiameterMax code="BDX">31.8</BodyDiameterMax>
1966 25          <BodyLengthMax code="LBX" nominal="120.825" maximum="
1967           126.325"
1968 26          minimum="115.325">120.825</BodyLengthMax>
1969 27          <ProtrudingLength code="LPR" nominal="155.75" maximum="
1970           161.25"
1971 28          minimum="150.26">155.75</ProtrudingLength>
1972 29          <FlangeDiameterMax code="DF"
1973 30           nominal="98.425">98.425</FlangeDiameterMax>
1974 31          <OverallToolLength nominal="257.35" minimum="251.85"
1975 32           maximum="262.85" code="OAL">257.35</OverallToolLength>
1976 33        </Measurements>
1977 34        <CuttingItems count="2">
1978 35          <CuttingItem indices="1" manufacturers="KMT" grade="KC7315
1979           " ">>
1980 36          <Measurements>
```

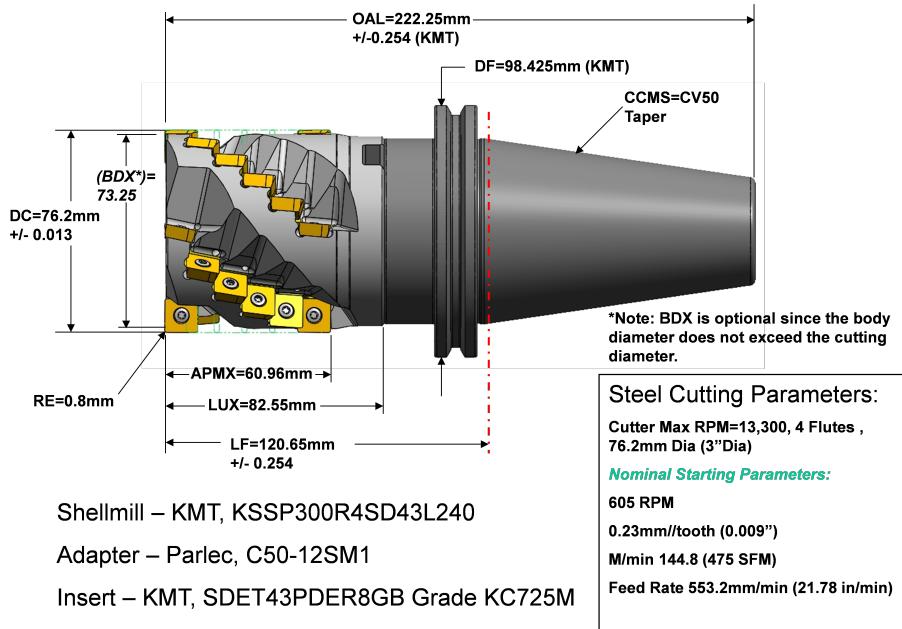


Figure 26: Shell Mill Side View

1981	37	<CuttingDiameter code="DC1" nominal="8.5" maximum="
1982	8.521"	minimum="8.506">8.5135</CuttingDiameter>
1983	38	<StepIncludedAngle code="STA1" nominal="90" maximum="
1984	39	91"
1985		minimum="89">90</StepIncludedAngle>
1986	40	<FunctionalLength code="LF1" nominal="154.286"
1987	41	minimum="148.786"
1988	42	maximum="159.786">154.286</FunctionalLength>
1989	43	<StepDiameterLength code="SDL1"
1990	44	nominal="9">9</StepDiameterLength>
1991	45	<PointAngle code="SIG" nominal="135" minimum="133"
1992	46	maximum="137">135</PointAngle>
1993	47	</Measurements>
1994	48	</CuttingItem>
1995	49	<CuttingItem indices="2" manufacturer="KMT" grade="KC7315
1996	50	">>
1997		<Measurements>
1998	51	<CuttingDiameter code="DC2" nominal="12" maximum="
1999	52	minimum="12">12</CuttingDiameter>
2000	12.011"	<FunctionalLength code="LF2" nominal="122.493"
2001	53	maximum="127.993"
2002	54	minimum="116.993">122.493</FunctionalLength>
2003	55	<StepDiameterLength code="SDL2"
2004	56	nominal="9">9</StepDiameterLength>
2005	57	</Measurements>
2006	58	
2007	59	

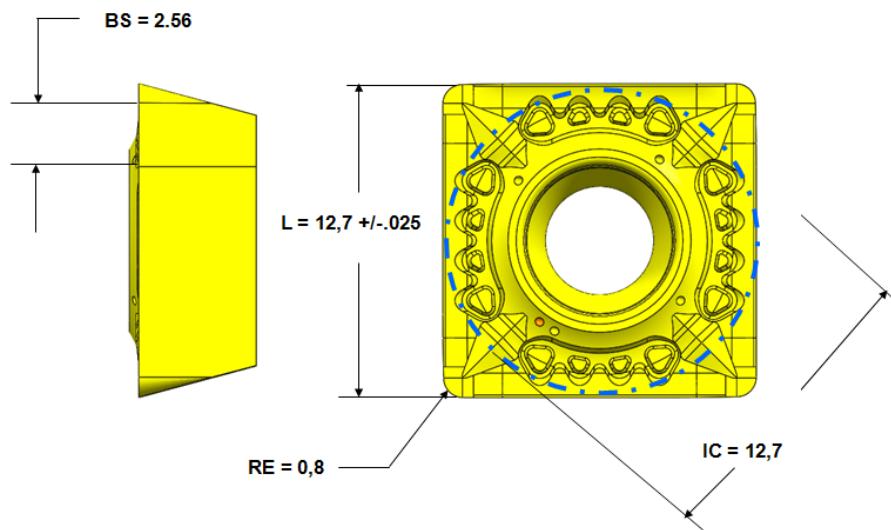
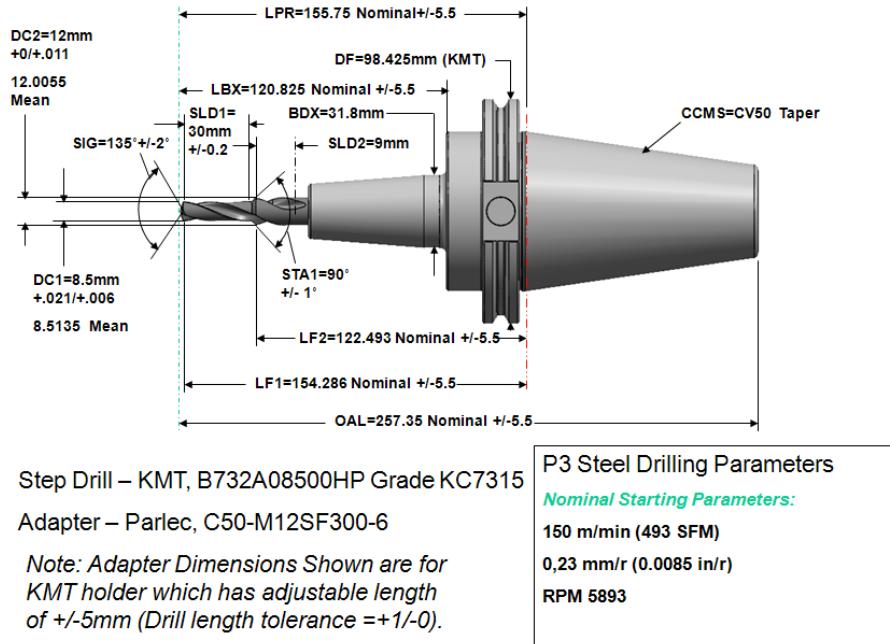


Figure 27: Indexable Insert Measurements

```
2008 60      </CuttingItem>
2009 61      </CuttingItems>
2010 62      </CuttingToolLifeCycle>
2011 63      </CuttingTool>
2012 64      </Assets>
2013 65      </MTConnectAssets>
```

**Figure 28: Step Mill Side View**

2014 B.6.3 Shell Mill with Individual Loci

Example 3: Example for Shell Mill with Explicate Loci

```

2015 1 <?xml version="1.0" encoding="UTF-8"?>
2016 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2017 3   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2018 4   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2019 5   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2020 6   http://mtconnect.org/schemas/MTConnectAssets\textunderscore1.2.xsd"
2021 7   >
2022 8 <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
2023 9   sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2024 10  />
2025 11 <Assets>
2026 12   <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
2027 13     timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
2028 14     manufacturers="KMT,Parlec">
2029 15     <Description>Keyway: 55 degrees</Description>
2030 16     <CuttingToolLifeCycle>
2031 17       <CutterStatus><Status>NEW</Status></CutterStatus>
2032 18     <Measurements>
2033 19       <UsableLengthMax code="LUX"
2034 20         nominal="82.55">82.55</UsableLengthMax>
2035 21       <CuttingDiameterMax code="DC" nominal="76.2" maximum=
2036 22         76.213"
2037 23         minimum="76.187">76.2</CuttingDiameterMax>
```

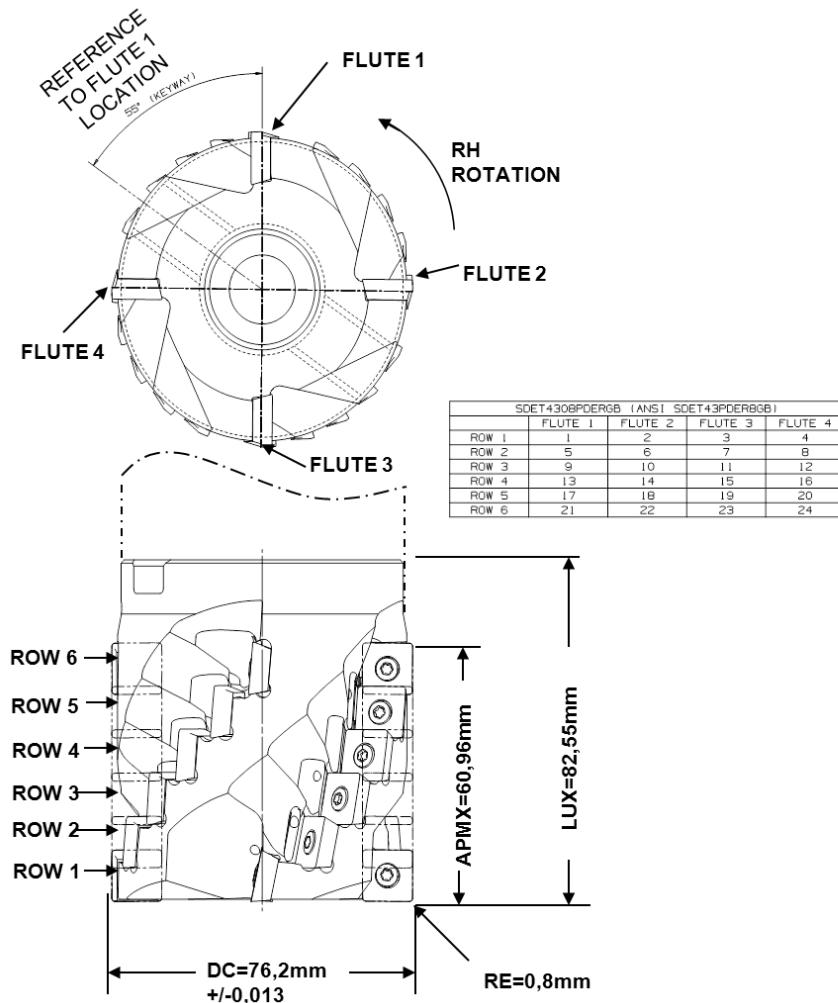


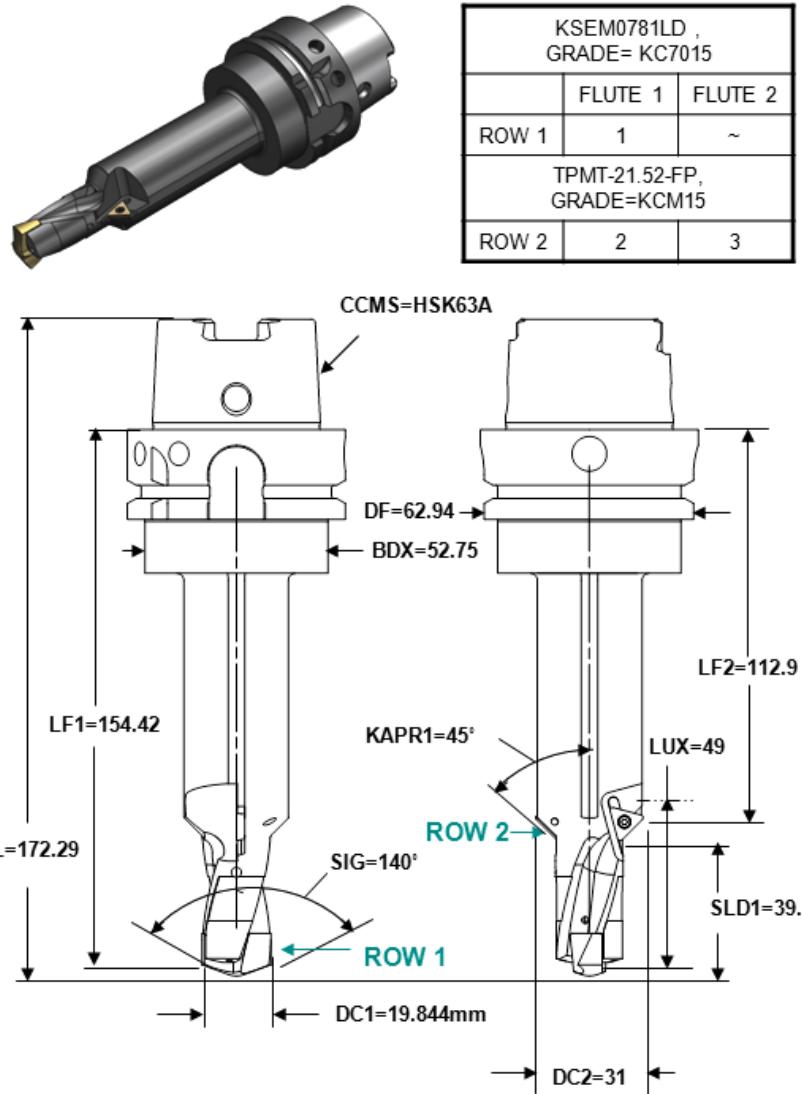
Figure 29: Shell Mill with Explicate Loci

```

2038 21 <DepthOfCutMax code="APMX" nominal="60.96">60.95</
2039                               DepthOfCutMax>
2040 22 </Measurements>
2041 23 <CuttingItems count="24">
2042 24   <CuttingItem indices="1" itemId="SDET43PDER8GB"
2043 25     manufacturers="KMT">
2044 26     <Locus>FLUTE: 1, ROW: 1</Locus>
2045 27     <Measurements>
2046 28       <DriveAngle code="DRVA" nominal="55">55</DriveAngle>
2047 29     </Measurements>
2048 30   </CuttingItem>
2049 31   <CuttingItem indices="2-24" itemId="SDET43PDER8GB"
2050 32     manufacturers="KMT">
2051 33     <Locus>FLUTE: 2-4, ROW: 1; FLUTE: 1-4, ROW 2-6</Locus>
2052 34   </CuttingItem>

```

```
2053 35      </CuttingItems>
2054 36      </CuttingToolLifeCycle>
2055 37      </CuttingTool>
2056 38      </Assets>
2057 39  </MTConnectAssets>
```

2058 **B.6.4 Drill with Individual Loci****Figure 30:** Step Drill with Explicate Loci**Example 4:** Example for Step Drill with Explicate Loci

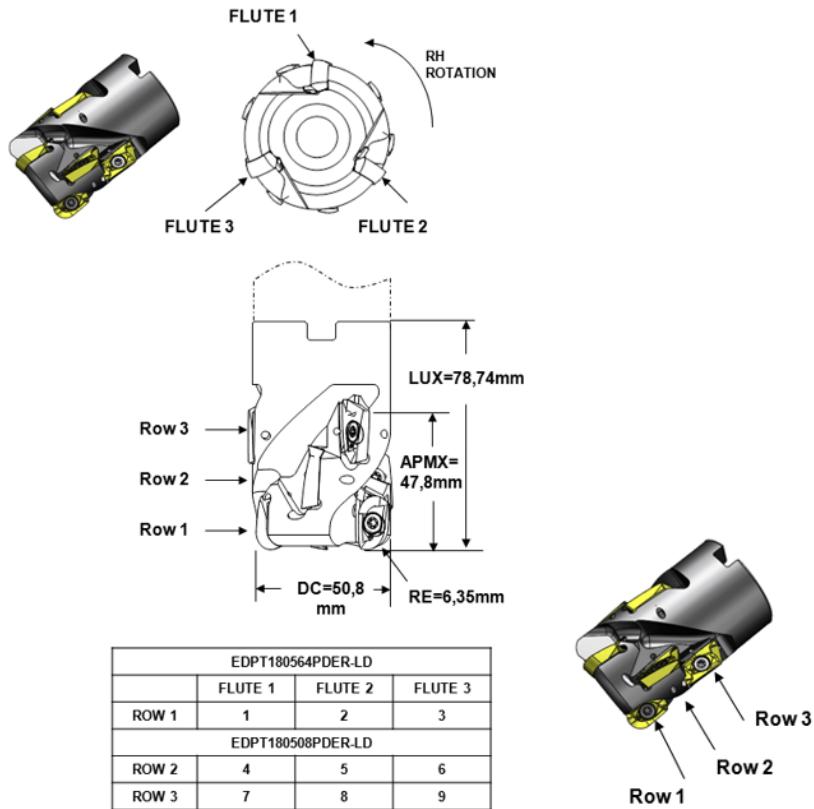
```

2059 1 <?xml version="1.0" encoding="UTF-8"?>
2060 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2061 3   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2062 4   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2063 5   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2064 6   http://mtconnect.org/schemas/MTConnectAssets\textunderscore1.2.xsd"
2065 7   >
2066 7   <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"

```

```

2067 8    sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2068  />
2069 9    <Assets>
2070 10   <CuttingTool serialNumber="1" toolId="KSEM0781LD"
2071 11     timestamp="2011-05-11T13:55:22" assetId="KSEM0781LD.1"
2072 12       manufacturers="KMT">
2073 13         <CuttingToolLifeCycle>
2074 14           <CutterStatus><Status>NEW</Status></CutterStatus>
2075 14           <ConnectionCodeMachineSide>HSK63A</ConnectionCodeMachineSide
2076  >
2077 15         <Measurements>
2078 16           <BodyDiameterMax code="BDX">52.75</BodyDiameterMax>
2079 17           <OverallToolLength nominal="172.29"
2080 18             code="OAL">172.29</OverallToolLength>
2081 19             <UsableLengthMax code="LUX" nominal="49">49</
2082 19               UsableLengthMax>
2083 20             <FlangeDiameterMax code="DF"
2084 21               nominal="62.94">62.94</FlangeDiameterMax>
2085 22         </Measurements>
2086 23         <CuttingItems count="3">
2087 24           <CuttingItem indices="1" itemId="KSEM0781LD" manufacturers
2088 24             ="KMT"
2089 25             grade="KC7015">
2090 26               <Locus>FLUTE: 1, ROW: 1</Locus>
2091 27                 <Measurements>
2092 28                   <FunctionalLength code="LF1" nominal="154.42">154.42</
2093 28                     FunctionalLength>
2094 29                   <CuttingDiameter code="DC1" nominal="19.844">19.844</
2095 29                     CuttingDiameter>
2096 30                   <PointAngle code="SIG" nominal="140">140</PointAngle>
2097 31                   <ToolCuttingEdgeAngle code="KAPR1" nominal="45">45</
2098 31                     ToolCuttingEdgeAngle>
2099 32                   <StepDiameterLength code="SLD1" nominal="39.8">39.8</
2100 32                     StepDiameterLength>
2101 33                 </Measurements>
2102 34           </CuttingItem>
2103 35           <CuttingItem indices="2-3" itemId="TPMT-21.52-FP"
2104 36             manufacturers="KMT" grade="KCM15">
2105 37               <Locus>FLUTE: 1-2, ROW: 2</Locus>
2106 38                 <Measurements>
2107 39                   <FunctionalLength code="LF2" nominal="112.9">119.2</
2108 39                     FunctionalLength>
2109 40                   <CuttingDiameter code="DC2" nominal="31">31</
2110 40                     CuttingDiameter>
2111 41                 </Measurements>
2112 42           </CuttingItem>
2113 43         </CuttingItems>
2114 44       </CuttingToolLifeCycle>
2115 45     </CuttingTool>
2116 46   </Assets>
2117 47 </MTConnectAssets>
```

2118 **B.6.5 Shell Mill with Different Inserts on First Row****Figure 31:** Shell Mill with Different Inserts on First Row**Example 5:** Example for Shell Mill with Different Inserts on First Row

```

2119 1 <?xml version="1.0" encoding="UTF-8"?>
2120 2 <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
2121 3   xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
2122 4   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2123 5   xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
2124 6   http://mtconnect.org/schemas/MTConnectAssets\textunderscore_1.2.xsd"
2125 7   >
2126 8     <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
2127 9     sender="localhost" assetCount="2" version="1.2" instanceId="1234"
2128 10    />
2129 11    <Assets>
2130 12      <CuttingTool serialNumber="1" toolId="XXX" timestamp="2011-05-11
2131 13        T13:55:22"
2132 14        assetId="XXX.1" manufacturers="KMT">
2133 15          <CuttingToolLifeCycle>
2134 16            <CutterStatus><Status>NEW</Status></CutterStatus>
2135 17            <Measurements>
```

```

2136 15      <DepthOfCutMax code="APMX" nominal="47.8">47.8</
2137 16      DepthOfCutMax>
2138 17          <CuttingDiameterMax code="DC"
2139 18              nominal="50.8">50.8</CuttingDiameterMax>
2140 19          <UsableLengthMax code="LUX"
2141 20              nominal="78.74">78.74</UsableLengthMax>
2142 21      </Measurements>
2143 22      <CuttingItems count="9">
2144 23          <CuttingItem indices="1-3" itemId="EDPT180564PDER-LD"
2145 24              manufacturers="KMT">
2146 25                  <Locus>FLUTE: 1-3, ROW: 1</Locus>
2147 26                  <Measurements>
2148 27                      <CornerRadius code="RE" nominal="6.25">6.35</
2149 28      CornerRadius>
2150 29          </Measurements>
2151 30      </CuttingItem>
2152 31      <CuttingItem indices="4-9" itemId="EDPT180508PDER-LD"
2153 32          manufacturers="KMT">
2154 33                  <Locus>FLANGE: 1-4, ROW: 2-3</Locus>
2155 34          </CuttingItem>
2156 35      </CuttingItems>
2157 36      </CuttingToolLifeCycle>
2158 37      </CuttingTool>
2159 38  </Assets>
2160 39 </MTConnectAssets>

```

2161 B.7 File Schema Diagrams

2162 See `File` element in `MTConnectAssets` schema.

2163 B.8 RawMaterial Schema Diagrams

2164 See `RawMaterial` element in `MTConnectAssets` schema.

2165 B.9 QIFDocumentWrapper Schema Diagrams

2166 See `QIFDocumentWrapper` element in `MTConnectAssets` schema.