



MTConnect[®] Standard

Part 2.0 – Device Information Model

Version 2.5.0

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

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1 1 Purpose of This Document

2 This document, *MTConnect Standard: Part 2.0 - Device Information Model* of the MT-
3 Connect Standard, establishes the rules and terminology to be used by designers to de-
4 scribe the function and operation of a piece of equipment and to define the data that is
5 provided by an *agent* from the equipment. The *Device Information Model* also defines the
6 structure for the *response document* that is returned from an *agent* in response to a *probe*
7 *request*.

8 In the MTConnect Standard, equipment represents any tangible property that is used in the
9 operations of a manufacturing facility. Examples of equipment are machine tools, ovens,
10 sensor units, workstations, software applications, and bar feeders.

11 Note: See *MTConnect Standard: Part 3.0 - Observation Information Model*
12 of the MTConnect Standard for details on the *response document* that are
13 returned from an *agent* in response to a *sample request* or *current request*.

14 2 Terminology and Conventions

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

17 2.1 General Terms

18 ***adapter***

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

21 ***agent***

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

26 ***alarm limit***

27 limit used to trigger warning or alarm indicators.

28 ***application***

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

31 ***archetype***

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

34 ***asset buffer***

35 *buffer* for *Assets*.

36 ***attachment***

37 connection by which one thing is associated with another.

38 ***buffer***

39 section of an *agent* that provides storage for information published from pieces of
40 equipment.

41 ***cartesian coordinate system***

42 3D orthogonal coordinate system [(ISO/IEC 19794-5:2011en).

43 ***characteristic***

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

47 ***client***

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

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

51 ***combined standard uncertainty***

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

57 ***condition activation***

58 state transition from Normal to either Warning or Fault.

59 ***controlled vocabulary***

60 restricted set of values for a given property.

61 ***data dictionary***

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

63 ***data model***

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

66 ***data set***

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

68 ***data source***

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

70 ***deprecated***

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

73 ***deprecation warning***

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

76 ***document***

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

79 ***electric current***

80 rate of flow of electric charge.

81 ***element***

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

83 ***extensible***

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

86 ***feature***

87 topological entity(ies) or design requirements related to a geometric model. *Ref QIF*
88 *3.0-3.4.59*

89 ***force***

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

91 ***heartbeat***

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

95 ***higher level***

96 nested element that is above a lower level element.

97 ***implementation***

98 specific instantiation of the MTConnect Standard.

99 ***information model***

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

102 ***instance***

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

105 ***interaction model***

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

108 ***interface***

109 means by which communication is achieved between independent systems.

110 ***key***

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

112 ***key-value pair***

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

115 ***location***

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

117 ***lower camel case***

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

120 ***lower level***

121 nested element that is below a higher level element.

122 ***lower limit***

123 lower conformance boundary for a variable.

124 ***lower warning***

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

126 ***major***

127 identifier representing a consistent set of functionalities defined by the MTConnect
128 Standard.

129 ***maximum***

130 numeric upper constraint.

131 ***message***

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

133 ***metadata***

134 data that provides information about other data.

135 ***minimum***

136 numeric lower constraint.

137 ***minor***

138 identifier representing a specific set of functionalities defined by the MTConnect
139 Standard.

140 ***nominal***

141 ideal or desired value for a variable.

142 ***organize***

143 act of containing and owning one or more elements.

144 ***organizer***

145 entity that *organizes* one or more elements.

146 ***parameter***

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

149 ***part***

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

153 ***pascal case***

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

156 ***patch***

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

160 ***persistence***

161 method for retaining or restoring information.

162 ***position***

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

164 ***probe***

165 instrument commonly used for measuring the physical geometrical characteristics
166 of an object.

167 ***profile***

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

171 ***requester***

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

173 ***reset***

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

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

177 ***responder***

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

179 ***response document***

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

182 ***schema***

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

185 ***semantic data model***

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

188 ***sensing element***

189 mechanism that provides a signal or measured value.

190 ***sequence number***

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

193 ***specification limit***

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

195 ***spindle***

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

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

198 ***standard***

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

201 ***standard uncertainty***

202 *uncertainty* of the result of a measurement expressed as a standard deviation. *Ref JCGM*
203 *100:2008 2.3.1*

204 ***stereotype***

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

206 ***subtype***

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

208 ***table***

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

210 ***table cell***

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

212 ***table entry***

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

214 ***top level***

215 element that represents the most significant physical or logical functions of a piece
216 of equipment.

217 ***type***

218 classification or categorization of information.

219 ***uncertainty***

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

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

224 ***upper limit***

225 upper conformance boundary for a variable.

226 ***upper warning***

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

228 ***version***

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

230 **2.2 Information Model Terms**

231 ***Asset Information Model***

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

233 ***Device Information Model***

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

236 ***Error Information Model***

237 *information model* that describes the *response document* returned by an *agent* when
 238 it encounters an error while interpreting a *request* for information from a *client* or
 239 when an *agent* experiences an error while publishing the *response* to a *request* for
 240 information.

241 ***MTConnect Information Model***

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

243 ***Observation Information Model***

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

246 2.3 Protocol Terms

247 ***asset request***

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

249 ***current request***

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

253 ***data streaming***

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

256 ***MTConnect Request***

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

258 ***MTConnect Response Document***

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

260 ***MTConnectAssets Response Document***

261 *response document* published by an *MTConnect Agent* in response to an *asset re-*
 262 *quest*.

263 ***MTConnectDevices Response Document***

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

266 ***MTConnectErrors Response Document***

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

269 ***MTConnectStreams Response Document***

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

272 ***probe request***

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

275 ***protocol***

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

278 ***publish***

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

280 ***publish and subscribe***

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

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

285 ***request***

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

288 ***request and response***

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

291 ***response***

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

293 ***sample request***

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

297 ***streaming data***

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

299 ***subscribe***

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

301 ***transport protocol***

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

304 2.4 HTTP Terms

305 **HTTP Body**

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

308 **HTTP Error Message**

309 response provided by an *agent* indicating that an *HTTP Request* is incorrectly for-
310 matted or identifies that the requested data is not available from the *agent*. *Ref IETF:RFC-*
311 *2616*

312 **HTTP Header**

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

315 **HTTP Header Field**

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

318 **HTTP Message**

319 consist of requests from client to server and responses from server to client. *Ref IETF:RFC-*
320 *2616*

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

323 **HTTP Messaging**

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

325 **HTTP Method**

326 portion of a command in an *HTTP Request* that indicates the desired action to be
327 performed on the identified resource; often referred to as verbs. *Ref IETF:RFC-*
328 *2616*

329 **HTTP Query**

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

332 **HTTP Request**

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

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

338 ***HTTP Request Line***

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

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

344 ***HTTP Request Method***

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

347 ***HTTP Request URI***

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

350 ***HTTP Response***

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

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

355 ***HTTP Server***

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

358 ***HTTP Status Code***

359 3-digit integer result code of the attempt to understand and satisfy the request.
360 *Ref IETF:RFC-2616*

361 ***HTTP Version***

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

363 2.5 XML Terms

364 ***abstract element***

365 element that defines a set of common characteristics that are shared by a group of
366 elements. An abstract entity cannot appear in a document. In a specific implemen-
367 tation, an abstract entity is replaced by a derived element that is itself not an abstract
368 entity. The characteristics for the derived element are inherited from the abstract
369 entity.

370 ***attribute***

371 additional information or property for an *element*.

372 ***child element***

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

375 ***document body***

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

379 ***document header***

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

384 ***element name***

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

387 ***namespace***

388 organizes information into logical groups.

389 ***parent element***

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

392 ***root element***

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

394 ***structural element***

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

397 ***XML Document***

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

399 ***XML Schema***

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

401 **2.6 MTConnect Terms**

402 ***Asset***

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

404 Note 1 to entry: An *Asset* relies upon an *Device* to provide observations
405 and information about itself and the *Device* revises the information to
406 reflect changes to the *Asset* during their interaction. Examples of *Assets*
407 are cutting tools, Part Information, Manufacturing Processes, Fixtures,
408 and Files.

409 Note 2 to entry: A singular `assetId` uniquely identifies an *Asset* through-
410 out its lifecycle and is used to track and relate the *Asset* to other *Devices*
411 and entities.

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

415 ***Component***

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

417 ***Composition***

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

419 ***Configuration***

420 configuration for a *Component*

421 ***DataItem***

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

423 ***Device***

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

425 ***MTConnect Agent***

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

427 ***MTConnect Document***

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

429 ***MTConnect Event***

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

431 ***MTConnect Interface***

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

433 ***Observation***

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

435 **2.7 Acronyms**

436 ***2D***

437 two-dimensional

438 ***3D***

439 three-dimensional

440 ***AI***

441 artificial intelligence

442 ***ALM***

443 application lifecycle management

444 ***AMT***

445 The Association for Manufacturing Technology

446 ***ANSI***

447 American National Standards Institute

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

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

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

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

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

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

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

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

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

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

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

757 2.8 MTConnect References

- 758 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Fundamentals*. Version 2.0.
- 759 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Device Information Model*. Ver-
760 sion 2.0.
- 761 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Observation Information Model*.
762 Version 2.0.
- 763 [MTConnect Part 4.0] *MTConnect Standard: Part 4.0 - Asset Information Model*. Ver-
764 sion 2.0.

765

766 3 Device Information Model

767 The *Device Information Model* provides a representation of the physical and logical con-
 768 figuration for a piece of equipment used for a manufacturing process or for any other
 769 purpose. It also provides the definition of data that may be reported by that equipment.

770 Using information defined in the *Device Information Model*, a software application can
 771 determine the configuration and reporting capabilities of a piece of equipment. To do this,
 772 the software application issues a *probe request* (defined in *MTConnect Standard Part 1.0 -*
 773 *Fundamentals*) to an *agent* associated with a piece of equipment. An *agent* responds to the
 774 *probe request* with an *MTConnectDevices Response Document* that contains information
 775 describing both the physical and logical structure of the piece of equipment and a detailed
 776 description of each *Observation* that can be reported by the *agent* associated with the
 777 piece of equipment. This information allows the client software application to interpret
 778 the document and to extract the data with the same meaning, value, and context that it had
 779 at its original source.

780 The *MTConnectDevices Response Document* is comprised of two sections: `Header` and
 781 `Devices`.

782 The `Header` section contains protocol related information as defined in *MTConnect Stan-*
 783 *dard Part 1.0 - Fundamentals*.

784 The `Devices` section of the *MTConnectDevices Response Document* contains a `Device`
 785 entity for each piece of equipment described in the document. Each `Device` is comprised
 786 of two primary types of entities - *Components* and *DataItems*.

787 *Components* organize information that represents the physical and logical parts and sub-
 788 parts of a piece of equipment (See *Section 4.1 - Components* for more details).

789 *DataItems* describe data that can be reported by a piece of equipment. In the *Device Infor-*
 790 *mation Model*, *DataItems* are defined as `DataItem` entities (See *Section 6.5 - DataItem*
 791 *Types*).

792 The *Components* and *DataItems* in the *MTConnectDevices Response Document* provide
 793 information representing the physical and logical structure for a piece of equipment and
 794 the types of data that the piece of equipment can report relative to that structure. The *MT-*
 795 *ConnectDevices Response Document* does not contain values for the data types reported
 796 by the piece of equipment. The *MTConnectStreams Response Document* defined in *MT-*
 797 *Connect Standard: Part 3.0 - Observation Information Model* provides the data values that
 798 are reported by the piece of equipment.

799 Note: The MTConnect Standard also defines the information model for assets.
 800 An asset is something that is used in the manufacturing process, but is not
 801 permanently associated with a single piece of equipment, can be removed
 802 from the piece of equipment without compromising its function, and can be
 803 associated with other pieces of equipment during its lifecycle. See *MTConnect*
 804 *Standard: Part 4.0 - Asset Information Model* for more details on assets.

805 3.1 Device

806 Component composed of a piece of equipment that produces observations about itself.

807 A Device *organizes* its parts as Component entities.

808 A Device **MUST** have a name and uuid to identify itself.

809 A Device **MUST** have the following DataItems: Availability, AssetChanged,
 810 and AssetRemoved.

811 See *Section 4.1 - Components* for more details on the properties of Device.

812 See *Section 3.1.2 - Part Properties of Device* for a list of *top level* Compo-
 813 nent types for a Device.

814 3.1.1 Value Properties of Device

815 *Table 1* lists the Value Properties of Device.

Value Property name	Value Property type	Multiplicity
<<deprecated>> iso841Class	string	0..1
uuid	UUID	1
mtconnectVersion	string	0..1
name	string	1
hash	string	0..1

Table 1: Value Properties of Device

816 Descriptions for Value Properties of Device:

- 817 • <<deprecated>> iso841Class

818 **DEPRECATED** in *MTConnect Version 1.2*.

819 • `mtconnectVersion`

820 MTConnect version of the *Device Information Model* used to configure the informa-
821 tion to be published for a piece of equipment in an *MTConnect Response Document*.

822 • `hash`

823 condensed message digest from a secure one-way hash function. *Ref FIPS PUB*
824 *180-4*

825 3.1.2 Part Properties of Device

826 Table 2 lists the Part Properties of Device.

Part Property name	Multiplicity
Auxiliary (organized by <<organizer>> Auxiliaries)	0..*
Controller (organized by <<organizer>> Controllers)	0..*
Interface (organized by <<organizer>> Interfaces)	0..*
Resource (organized by <<organizer>> Resources)	0..*
Structure (organized by <<organizer>> Structures)	0..*
System (organized by <<organizer>> Systems)	0..*
Axis (organized by <<organizer>> Axes)	0..*
Adapter (organized by <<organizer>> Adapters)	0..*

Table 2: Part Properties of Device

827 Descriptions for Part Properties of Device:

828 • `Auxiliary`

829 abstract `Component` composed of removable part(s) of a piece of equipment that
830 provides supplementary or extended functionality.

831 • `Controller`

832 System that provides regulation or management of a system or component. *Ref ISO*
833 *16484-5:2017*

834 • `Interface`

835 abstract `Component` that coordinates actions and activities between pieces of equip-
836 ment.

- 837 • Resource
- 838 abstract Component composed of material or personnel involved in a manufactur-
- 839 ing process.
- 840 • Structure
- 841 Component composed of part(s) comprising the rigid bodies of the piece of equip-
- 842 ment.
- 843 • System
- 844 abstract Component that is permanently integrated into the piece of equipment.
- 845 • Axis
- 846 abstract Component composed of a motion system that provides linear or rota-
- 847 tional motion for a piece of equipment.
- 848 • Adapter
- 849 Component that provides information about the data source for an *MTConnect*
- 850 Agent.

851 3.1.3 Commonly Observed DataItem Types for Device

852 Table 3 lists the Commonly Observed DataItem Types for Device.

Commonly Observed DataItem Types	Multiplicity
Availability	1
AssetChanged	1
AssetRemoved	1

Table 3: Commonly Observed DataItem Types for Device

853 4 Components Model

854 MTConnectDevices provides the physical and logical architecture of a piece of equip-
 855 ment. Figure 1 provides an overview of the entities used in an example of an MTCon-
 856 nectDevices entity.

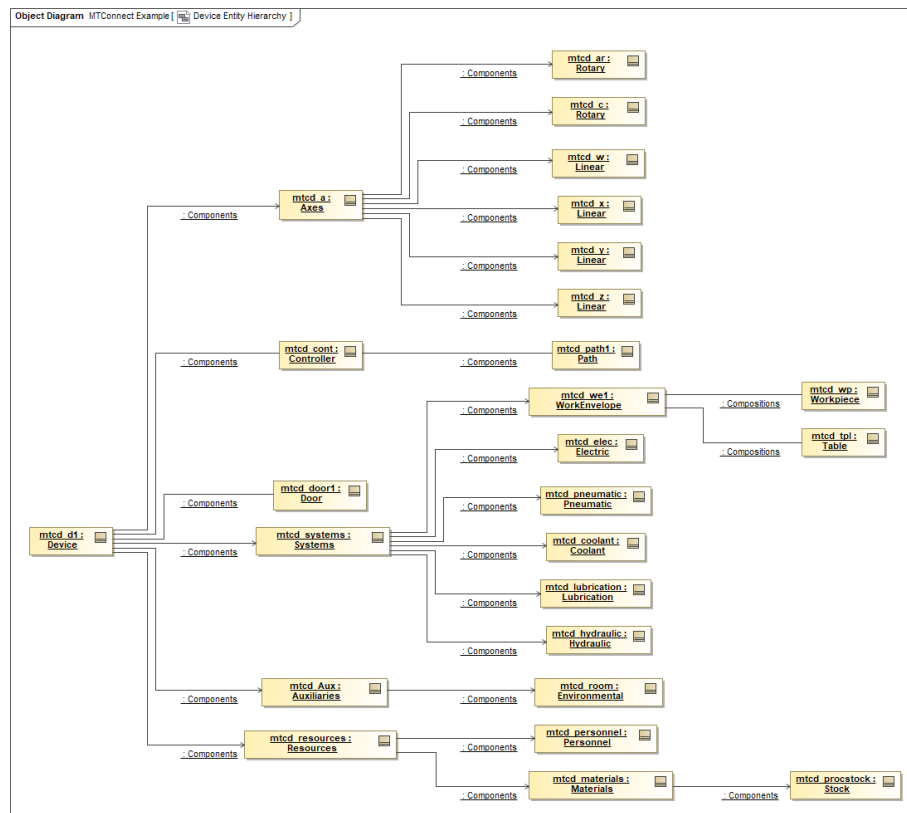


Figure 1: Device Entity Hierarchy Example

857 Note 1 to entry: See *Example 3* for the XML representation of the same ex-
 858 ample.

859 Note 2 to entry: Example above only shows the Component and Composi-
 860 tion level hierarchy. For a complete semantics on each kind see *Section 4.1*
 861 - *Components* and *Section 5.1 - Compositions*.

862 A variety of entities are defined to describe a piece of equipment. Some of these entities
 863 **MUST** always be defined for an MTConnectDevices entity, while others are optional
 864 and **MAY** be used, as required, to provide additional structure.

865 The first, or highest level, entity defined for an MTConnectDevices entity is De-
 866 vices. Devices is used to group one or more pieces of equipment into a single docu-
 867 ment. Devices **MUST** always be defined for an MTConnectDevices entity.

868 Device is the next entity defined for the MTConnectDevices entity. A separate De-
 869 vice entity is used to identify each piece of equipment for an MTConnectDevices
 870 entity. Each Device provides information on the physical and logical structure of the
 871 piece of equipment and the data associated with that equipment. Device can also repre-
 872 sent any logical grouping of pieces of equipment that function as a unit or any other data
 873 source that provides data through an *agent*.

874 One or more Device entities **MUST** always be defined for an MTConnectDevices
 875 entity.

876 Components is the next entity defined for the MTConnectDevices entity. Com-
 877 ponents is used to group information describing lower level physical parts or logical
 878 functions of a piece of equipment.

879 Component is the next level of entity defined for the MTConnectDevices entity.
 880 Component is both an abstract type entity and an *organizer* type entity.

881 As an abstract entity, Component will always be realized by a specific Component type
 882 defined in *Section 4.3 - Component Types*. Each Component can also be used to organize
 883 information describing *lower level* entities or *DataItems* associated with the Component.

884 If *lower level* entities are described, these entities are by definition child Component
 885 entities of a parent Component. At this next level, the *lower level* child Component
 886 entities are grouped by Components.

887 A Component **MAY** be further decomposed into Composition entities that are grouped
 888 by Compositions. These describe the lowest level basic structural or functional build-
 889 ing blocks contained within a Component. Data provided for a Component provides
 890 more specific meaning when it is associated with one of the Composition entities of
 891 the Component. The different Composition types that **MAY** be defined for the MT-
 892 ConnectDevices entity are defined in *Section 5.1 - Compositions*.

893 This parent-child relationship can continue to any depth required to fully define a piece of
 894 equipment.

895 Note: See Figure 1 for an example.

896 4.1 Components

897 This section provides semantic information for the Component entity. Figure 2 shows
898 the Component model.

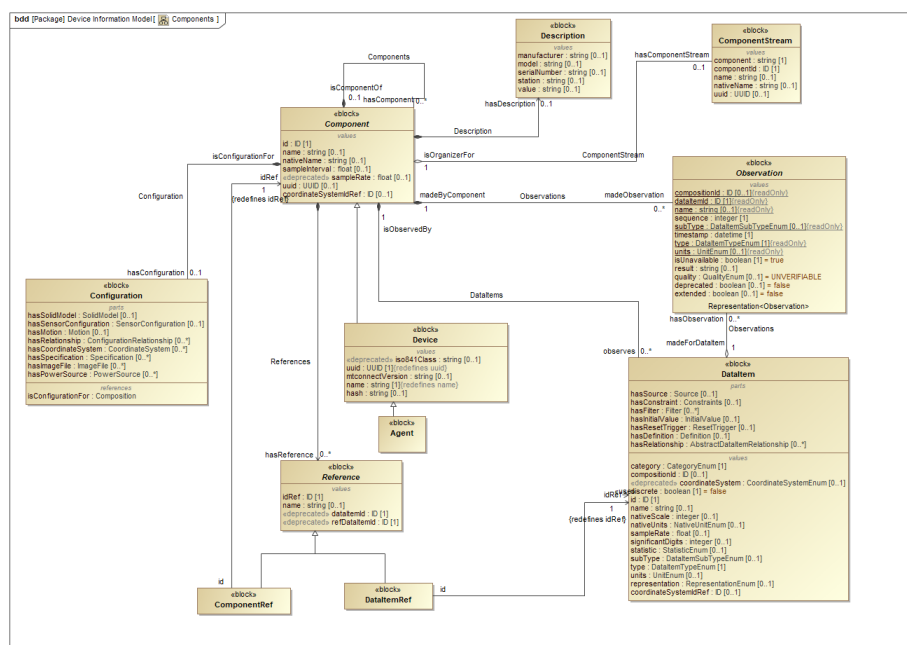


Figure 2: Components

899 Note: See *Section B.1 - Components Schema Diagrams* for XML schema.

900 4.1.1 Component

901 logical or physical entity that provides a capability.

902 Component is an abstract entity and will be realized by specific Component types for
903 an MTConnectDevices entity. See *Section 4.3 - Component Types* for more details on
904 the Component types.

905 Component also provides structure for describing the *lower level* entities associated with
906 it.

907 At least one of Component, DataItem, or Reference entities **MUST** be provided
908 for a Component.

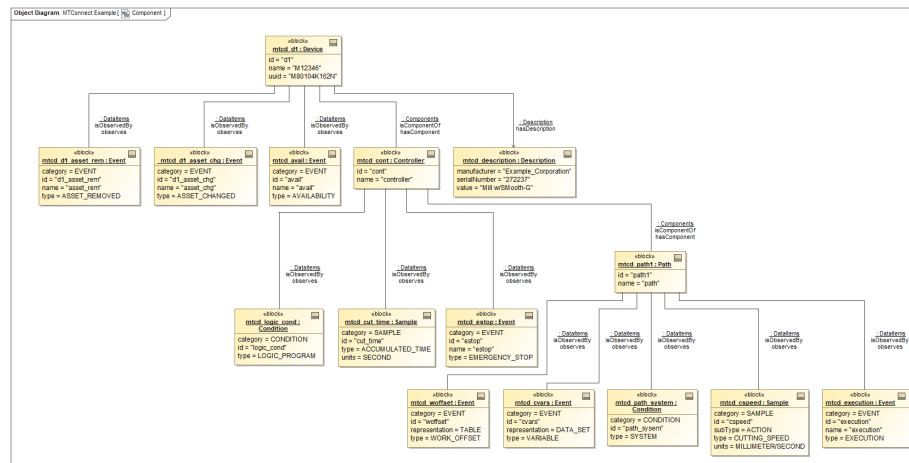


Figure 3: Component Example

Note: See *Example 4* for the XML representation of the same example.

4.1.1.1 Value Properties of Component

Table 4 lists the Value Properties of Component.

Value Property name	Value Property type	Multiplicity
id	ID	1
name	string	0..1
nativeName	string	0..1
sampleInterval	float	0..1
<<deprecated>> sampleRate	float	0..1
uuid	UUID	0..1
coordinateSystemIdRef	ID	0..1

Table 4: Value Properties of Component

Descriptions for Value Properties of Component:

- id
unique identifier for the Component.
- name
name of the Component.
When provided, name **MUST** be unique for all child Component entities of a parent Component.

- 919 • `nativeName`
920 common name associated with `Component`.
- 921 • `sampleInterval`
922 interval in milliseconds between the completion of the reading of the data associated
923 with the `Component` until the beginning of the next sampling of that data.
924 This information may be used by client software applications to understand how
925 often information from a `Component` is expected to be refreshed.
926 The refresh rate for data from all child `Component` entities will be the same as for
927 the parent `Component` element unless specifically overridden by another sam-
928 pleInterval provided for the child `Component`.
- 929 • `<<deprecated>> sampleRate`
930 **DEPRECATED** in *MTConnect Version 1.2*. Replaced by `sampleInterval`.
- 931 • `uuid`
932 universally unique identifier for the `Component`.
- 933 • `coordinateSystemIdRef`
934 specifies the `CoordinateSystem` for this `Component` and its children.

935 4.1.1.2 Reference Properties of Component

936 *Table 5* lists the Reference Properties of `Component`.

Reference Property name	Multiplicity
<code>ComponentStream</code>	0..1

Table 5: Reference Properties of `Component`

937 Descriptions for Reference Properties of `Component`:

- 938 • `ComponentStream`
939 organizes the data associated with each `Component` entity defined for a `Device`
940 in the associated *MTConnectDevices Response Document*.
941 `ComponentStream` *organizes* the `Observation` entities associated with the
942 `Component`.
943 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Com-
944 ponentStream model.

945 Note 1 to entry: In the XML representation, `ComponentStream` enti-
 946 ties **MUST NOT** appear in the *MTConnectDevices Response Document*.

947 Note 2 to entry: In the XML representation, `ComponentStream` enti-
 948 ties **MUST** appear only in the *MTConnectStreams Response Document*.

949 **4.1.1.3 Part Properties of Component**

950 *Table 6* lists the Part Properties of Component.

Part Property name	Multiplicity
Description	0..1
Composition (organized by Compositions)	0..*
Component (organized by Components)	0..*
Configuration	0..1
DataItem (organized by DataItems)	0..*
Observation (organized by Observations)	0..*
Reference (organized by References)	0..*

Table 6: Part Properties of Component

951 Descriptions for Part Properties of Component:

- 952 • Description
 953 descriptive content.
 954 See *Section 4.1.2 - Description*.
- 955 • Composition
 956 functional part of a piece of equipment contained within a Component.
 957 `Compositions` groups one or more `Composition` entities. See *Section 5.1 -*
 958 *Compositions*.
- 959 • Component
 960 logical or physical entity that provides a capability.
 961 `Components` groups one or more `Component` entities.
- 962 • Configuration
 963 technical information about an entity describing its physical layout, functional char-
 964 acteristics, and relationships with other entities.
 965 See *Section 8.1 - Configurations*.

- 966 • `DataItem`
 967 information reported about a piece of equipment.
 968 `DataItems` groups one or more `DataItem` entities. See *Section 6.1 - DataItems*.
- 969 • `Observation`
 970 abstract entity that provides telemetry data for a `DataItem` at a point in time.
 971 `Observations` groups one or more `Observations` made by the Component
 972 entity.
 973 Component make `Observations` about observed `DataItems`.
 974 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Ob-
 975 servation model.
- 976 Note 1 to entry: In the XML representation, `Observation` entities
 977 **MUST NOT** appear in the *MTConnectDevices Response Document*.
- 978 Note 2 to entry: In the XML representation, `Observation` entities
 979 **MUST** appear only in the *MTConnectStreams Response Document*.
- 980 • `Reference`
 981 pointer to information that is associated with another entity defined elsewhere in the
 982 `MTConnectDevices` entity for a piece of equipment.
 983 `References` groups one or more `Reference` entities associated with the Com-
 984 ponent. See *Section 7.1 - References*.

985 4.1.2 Description

986 descriptive content.

987 Note 1 to entry: See Figure 3 for an example.

988 Note 2 to entry: See *Example 4* for the XML representation of the same ex-
 989 ample.

990 The value of `Description` **MUST** be string.

991 4.1.2.1 Value Properties of Description

992 *Table 7* lists the Value Properties of `Description`.

Value Property name	Value Property type	Multiplicity
manufacturer	string	0..1
model	string	0..1
serialNumber	string	0..1
station	string	0..1

Table 7: Value Properties of Description

993 Descriptions for Value Properties of Description:

- 994 • `manufacturer`
995 name of the manufacturer of the physical or logical part of a piece of equipment
996 represented by this element.
- 997 • `model`
998 model description of the physical part or logical function of a piece of equipment
999 represented by this element.
- 1000 • `serialNumber`
1001 serial number associated with a piece of equipment.
- 1002 • `station`
1003 identifier where a manufacturing function takes place.

1004 4.2 Devices

1005 This section provides semantic information for the `Device` types.

1006 4.2.1 Agent

1007 `Device` composed of an *MTConnect Agent* and all its connected data sources.

1008 An Agent **MUST** be provided by all *MTConnect Agent* implementations.

1009 An Agent **MUST** provide notifications when devices are added or changed.

1010 An Agent **MUST** provide connection information for each data source currently supply-
1011 ing data to the *MTConnect Agent*.

1012 An Agent **MAY** provide information about telemetry relating to data sources.

1013 An Agent **MAY** provide information about the *MTConnect Agent* resource utilization.

1014 4.3 Component Types

1015 This section provides semantic information for the types of Component.

1016 Note: In the XML representation, Component entities are defined into two
1017 major categories:

1018 • *top level* Component entities that *organizes* the most significant physi-
1019 cal or logical functions of a piece of equipment (see *Section 3.1.2 - Part*
1020 *Properties of Device*). They **MAY** also be used as *lower level* Com-
1021 ponent entities; as required. See *Section 4.4 - Component Organizer*
1022 *Types*.

1023 • *lower level* Component entities composed of the sub-parts of the parent
1024 Component to provide more clarity and granularity to the physical or
1025 logical structure of the *top level* Component entities.

1026 This section provides guidance for the most common relationships between Component
1027 types. However, all Component types **MAY** be used in any configuration, as required, to
1028 fully describe a piece of equipment.

1029 As described in *Section 4.1 - Components*, Component is an abstract entity and will be
1030 always realized by a specific Component type.

1031 4.3.1 Adapter

1032 Component that provides information about the data source for an *MTConnect Agent*.

1033 It **MAY** contain connectivity state of the data source and additional telemetry about the
1034 data source and source-specific information.

1035 4.3.2 Amplifier

1036 leaf `Component` composed of an electronic component or circuit that amplifies power,
1037 electric current, or voltage.

1038 4.3.2.1 Part Properties of Amplifier

1039 *Table 8* lists the Part Properties of `Amplifier`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 8: Part Properties of `Amplifier`

1040 Descriptions for Part Properties of `Amplifier`:

- 1041 • `Composition`
1042 functional part of a piece of equipment contained within a `Component`.
- 1043 • `Component`
1044 logical or physical entity that provides a capability.

1045 4.3.3 Auxiliary

1046 abstract `Component` composed of removable part(s) of a piece of equipment that pro-
1047 vides supplementary or extended functionality.

1048 4.3.3.1 Deposition

1049 `Auxiliary` that manages the addition of material or state change of material being per-
1050 formed in an additive manufacturing process.

1051 For example, this could describe the portion of a piece of equipment that manages a mate-
1052 rial extrusion process or a vat polymerization process.

1053 **4.3.3.2 Loader**

1054 Auxiliary that provides movement and distribution of materials, parts, tooling, and
1055 other items to or from a piece of equipment.

1056 **4.3.3.2.1 BarFeeder**

1057 Loader that delivers bar stock to a piece of equipment.

1058 **4.3.3.3 ToolingDelivery**

1059 Auxiliary that manages, positions, stores, and delivers tooling within a piece of equip-
1060 ment.

1061 **4.3.3.3.1 GangToolBar**

1062 ToolingDelivery composed of a tool mounting mechanism that holds any number of
1063 tools.

1064 Tools are located in Station entities. Tools are positioned for use in the manufacturing
1065 process by linearly positioning the GangToolBar.

1066 **4.3.3.3.2 AutomaticToolChanger**

1067 ToolingDelivery composed of a tool delivery mechanism that moves tools between
1068 a ToolMagazine and a *spindle* a Turret.

1069 AutomaticToolChanger may also transfer tools between a location outside of a piece
1070 of equipment and a ToolMagazine or Turret.

1071 **4.3.3.3.3 ToolMagazine**

1072 ToolingDelivery composed of a tool storage mechanism that holds any number of
1073 tools.

1074 Tools are located in Pots. Pots are moved into position to transfer tools into or out of the
1075 ToolMagazine by an AutomaticToolChanger.

1076 **4.3.3.3.4 ToolRack**

1077 ToolingDelivery composed of a linear or matrixed tool storage mechanism that holds
1078 any number of tools.

1079 Tools are located in Station entities.

1080 **4.3.3.3.5 Turret**

1081 ToolingDelivery composed of a tool mounting mechanism that holds any number of
1082 tools.

1083 Tools are positioned for use in the manufacturing process by rotating the Turret.

1084 **4.3.3.4 WasteDisposal**

1085 Auxiliary that removes manufacturing byproducts from a piece of equipment.

1086 **4.3.4 Axis**

1087 abstract Component composed of a motion system that provides linear or rotational mo-
1088 tion for a piece of equipment.

1089 In robotics, the term *Axis* is synonymous with *Joint*. A *Joint* is the connection between
1090 two parts of the structure that move in relation to each other.

1091 Linear and Rotary components **MUST** have name that **MUST** follow the conventions
1092 described below. Use the `nativeName` for the manufacturer's name of the axis if it
1093 differs from the assigned name.

1094 MTConnect has two high-level classes for automation equipment as follows: (1) Equip-
1095 ment that controls cartesian coordinate axes and (2) Equipment that controls articulated
1096 axes. There are ambiguous cases where some machines exhibit both characteristics; when
1097 this occurs, the primary control system's configuration determines the classification.

1098 Examples of cartesian coordinate equipment are CNC Machine Tools, Coordinate mea-
1099 surement machines, as specified in ISO 841, and 3D Printers. Examples of articulated
1100 automation equipment are Robotic systems as specified in ISO 8373.

1101 The following sections define the designation of names for the axes and additional guid-

1102 ance when selecting the correct scheme to use for a given piece of equipment.

1103 **4.3.4.1 Cartesian Coordinate Naming Conventions**

1104 A Three-Dimensional Cartesian Coordinate control system organizes its axes orthogonally
1105 relative to a machine coordinate system where the manufacturer of the equipment specifies
1106 the origin.

1107 Axes name **SHOULD** comply with ISO 841, if possible.

1108 **4.3.4.1.1 Linear Motion**

1109 A piece of equipment **MUST** represent prismatic motion using a `Linear` axis and assign
1110 its name using the designations X, Y, and Z. A `Linear` axis name **MUST** append a
1111 monotonically increasing suffix when there are more than one parallel axes; for example,
1112 X2, X3, and X4.

1113 **4.3.4.1.2 Rotary Motion**

1114 MTConnect **MUST** assign the name to `Rotary` axes exhibiting rotary motion using A,
1115 B, and C. A `Rotary` axis name **MUST** append a monotonically increasing suffix when
1116 more than one `Rotary` axis rotates around the same `Linear` axis; for example, A2, A3,
1117 and A4.

1118 **4.3.4.2 Articulated Machine Control Systems**

1119 An articulated control system's axes represent the connecting linkages between two ad-
1120 jacent rigid members of an assembly. The `Linear` axis represents prismatic motion,
1121 and the `Rotary` axis represents the rotational motion of the two related members. The
1122 control organizes the axes in a kinematic chain from the mounting surface (base) to the
1123 end-effector or tooling.

1124 **4.3.4.3 Articulated Machine Axis Names**

1125 The axes of articulated machines represent forward kinematic relationships between me-
1126 chanical linkages. Each axis is a connection between linkages, also referred to as joints,
1127 and **MUST** be named using a J followed by a monotonically increasing number; for ex-
1128 ample, J1, J2, J3. The numbering starts at the base axis connected or closest to the

1129 mounting surface, J_1 , incrementing to the mechanical interface, J_n , where n is the num-
 1130 ber of the last axis. The chain forms a parent-child relationship with the parent being the
 1131 axis closest to the base.

1132 A machine having an axis with more than one child **MUST** number each branch using its
 1133 numeric designation followed by a branch number and a monotonically increasing number.
 1134 For example, if J_2 has two children, the first child branch **MUST** be named $J_2.1.1$ and
 1135 the second child branch $J_2.2.1$. A child of the first branch **MUST** be named $J_2.1.2$,
 1136 incrementing to $J_2.1.n$, where $J_2.1.n$ is the number of the last axis in that branch.

1137 **4.3.4.4 Linear**

1138 *Axis* that provides prismatic motion along a fixed axis.

1139 **4.3.4.5 Part Properties of Linear**

1140 *Table 9* lists the Part Properties of *Linear*.

Part Property name	Multiplicity
observesLoad	0..1
observesTemperature	0..1
observesAxisFeedrateActual	0..1

Table 9: Part Properties of Linear

1141 Descriptions for Part Properties of *Linear*:

- 1142 • Load
- 1143 actual versus the standard rating of a piece of equipment.
- 1144 • Temperature
- 1145 degree of hotness or coldness measured on a definite scale.
- 1146 • *AxisFeedrate.Actual*
- 1147 measured or reported value of an observation.

1148 **4.3.4.6 Rotary**

1149 *Axis* that provides rotation about a fixed axis.

1150 4.3.4.7 Part Properties of Rotary

1151 *Table 10* lists the Part Properties of Rotary.

Part Property name	Multiplicity
observesLoad	0..1
observesTemperature	0..1
observesRotaryVelocity	0..1
observesAxisFeedrate	0..1

Table 10: Part Properties of Rotary

1152 Descriptions for Part Properties of Rotary:

- 1153 • Load
- 1154 actual versus the standard rating of a piece of equipment.
- 1155 • Temperature
- 1156 degree of hotness or coldness measured on a definite scale.
- 1157 • RotaryVelocity
- 1158 rotational speed of a rotary axis.
- 1159 • AxisFeedrate
- 1160 feedrate of a linear axis.

1161 4.3.4.8 <<deprecated>>Spindle

1162 Component that provides an axis of rotation for the purpose of rapidly rotating a part or
1163 a tool to provide sufficient surface speed for cutting operations.

1164 Spindle was **DEPRECATED** in *MTConnect Version 1.1* and was replaced by Ro-
1165 taryMode.

1166 4.3.5 Ballscrew

1167 leaf Component composed of a mechanical structure that transforms rotary motion into
1168 linear motion.

1169 4.3.5.1 Part Properties of Ballscrew

1170 *Table 11* lists the Part Properties of Ballscrew.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 11: Part Properties of Ballscrew

1171 Descriptions for Part Properties of Ballscrew:

- 1172 • Composition
- 1173 functional part of a piece of equipment contained within a Component.
- 1174 • Component
- 1175 logical or physical entity that provides a capability.

1176 4.3.6 Belt

1177 leaf Component composed of an endless flexible band that transmits motion for a piece
1178 of equipment or conveys materials and objects.

1179 4.3.6.1 Part Properties of Belt

1180 *Table 12* lists the Part Properties of Belt.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 12: Part Properties of Belt

1181 Descriptions for Part Properties of Belt:

- 1182 • Composition
- 1183 functional part of a piece of equipment contained within a Component.
- 1184 • Component
- 1185 logical or physical entity that provides a capability.

1186 4.3.7 Brake

1187 leaf `Component` that slows or stops a moving object by the absorption or transfer of the
 1188 energy of momentum, usually by means of friction, electrical force, or magnetic force.

1189 4.3.7.1 Part Properties of Brake

1190 *Table 13* lists the Part Properties of Brake.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 13: Part Properties of Brake

1191 Descriptions for Part Properties of Brake:

- 1192 • `Composition`
- 1193 functional part of a piece of equipment contained within a `Component`.
- 1194 • `Component`
- 1195 logical or physical entity that provides a capability.

1196 4.3.8 Chain

1197 leaf `Component` composed of interconnected series of objects that band together and are
 1198 used to transmit motion for a piece of equipment or to convey materials and objects.

1199 4.3.8.1 Part Properties of Chain

1200 *Table 14* lists the Part Properties of Chain.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 14: Part Properties of Chain

1201 Descriptions for Part Properties of Chain:

- 1202 • `Composition`
- 1203 functional part of a piece of equipment contained within a `Component`.
- 1204 • `Component`
- 1205 logical or physical entity that provides a capability.

1206 **4.3.9 Chopper**

- 1207 leaf `Component` that breaks material into smaller pieces.

1208 **4.3.9.1 Part Properties of Chopper**

- 1209 *Table 15* lists the Part Properties of Chopper.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 15: Part Properties of Chopper

- 1210 Descriptions for Part Properties of Chopper:

- 1211 • `Composition`
- 1212 functional part of a piece of equipment contained within a `Component`.
- 1213 • `Component`
- 1214 logical or physical entity that provides a capability.

1215 **4.3.10 Chuck**

- 1216 leaf `Component` composed of a mechanism that holds a part or stock material in place.

1217 **4.3.11 Chute**

- 1218 leaf `Component` composed of an inclined channel that conveys material.

1219 4.3.11.1 Part Properties of Chute

1220 *Table 16* lists the Part Properties of Chute.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 16: Part Properties of Chute

1221 Descriptions for Part Properties of Chute:

- 1222 • Composition
- 1223 functional part of a piece of equipment contained within a Component.
- 1224 • Component
- 1225 logical or physical entity that provides a capability.

1226 4.3.12 CircuitBreaker

1227 leaf Component that interrupts an electric circuit.

1228 4.3.12.1 Part Properties of CircuitBreaker

1229 *Table 17* lists the Part Properties of CircuitBreaker.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 17: Part Properties of CircuitBreaker

1230 Descriptions for Part Properties of CircuitBreaker:

- 1231 • Composition
- 1232 functional part of a piece of equipment contained within a Component.
- 1233 • Component
- 1234 logical or physical entity that provides a capability.

1235 4.3.13 Clamp

1236 leaf `Component` that strengthens, support, or fastens objects in place.

1237 4.3.13.1 Part Properties of Clamp

1238 *Table 18* lists the Part Properties of `Clamp`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 18: Part Properties of `Clamp`

1239 Descriptions for Part Properties of `Clamp`:

- 1240 • `Composition`
- 1241 functional part of a piece of equipment contained within a `Component`.
- 1242 • `Component`
- 1243 logical or physical entity that provides a capability.

1244 4.3.14 Compressor

1245 leaf `Component` composed of a pump or other mechanism that reduces volume and in-
 1246 creases pressure of gases in order to condense the gases to drive pneumatically powered
 1247 pieces of equipment.

1248 4.3.14.1 Part Properties of Compressor

1249 *Table 19* lists the Part Properties of `Compressor`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 19: Part Properties of `Compressor`

1250 Descriptions for Part Properties of `Compressor`:

- 1251 • `Composition`
- 1252 functional part of a piece of equipment contained within a `Component`.
- 1253 • `Component`
- 1254 logical or physical entity that provides a capability.

1255 4.3.15 CoolingTower

1256 leaf `Component` composed of a heat exchange system that uses a fluid to transfer heat to
 1257 the atmosphere.

1258 4.3.15.1 Part Properties of CoolingTower

1259 *Table 20* lists the Part Properties of `CoolingTower`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 20: Part Properties of `CoolingTower`

1260 Descriptions for Part Properties of `CoolingTower`:

- 1261 • `Composition`
- 1262 functional part of a piece of equipment contained within a `Component`.
- 1263 • `Component`
- 1264 logical or physical entity that provides a capability.

1265 4.3.16 Door

1266 `Component` composed of a mechanical mechanism or closure that can cover a physical
 1267 access portal into a piece of equipment allowing or restricting access to other parts of the
 1268 equipment.

1269 The closure can be opened or closed to allow or restrict access to other parts of the equip-
 1270 ment.

1271 Door **MUST** have DoorState data item to indicate if the door is OPEN, CLOSED, or
 1272 UNLATCHED. A Component **MAY** contain multiple Door entities.

1273 4.3.16.1 Commonly Observed DataItem Types for Door

1274 Table 21 lists the Commonly Observed DataItem Types for Door.

Commonly Observed DataItem Types	Multiplicity
DoorState	1

Table 21: Commonly Observed DataItem Types for Door

1275 4.3.17 Drain

1276 leaf Component that allows material to flow for the purpose of drainage from, for exam-
 1277 ple, a vessel or tank.

1278 4.3.17.1 Part Properties of Drain

1279 Table 22 lists the Part Properties of Drain.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 22: Part Properties of Drain

1280 Descriptions for Part Properties of Drain:

- 1281 • Composition
- 1282 functional part of a piece of equipment contained within a Component.
- 1283 • Component
- 1284 logical or physical entity that provides a capability.

1285 4.3.18 Encoder

1286 leaf Component that measures position.

1287 **4.3.18.1 Part Properties of Encoder**

1288 *Table 23* lists the Part Properties of Encoder.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 23: Part Properties of Encoder

1289 Descriptions for Part Properties of Encoder:

- 1290 • Composition
- 1291 functional part of a piece of equipment contained within a Component.
- 1292 • Component
- 1293 logical or physical entity that provides a capability.

1294 **4.3.19 Environmental**

1295 Component that observes the surroundings of another Component.

1296 Note: Environmental **SHOULD** be organized by Auxillaries, Sys-
 1297 tems or Parts depending on the relationship to the Component.

1298 **4.3.20 ExpiredPot**

1299 leaf Component that is a Pot for a tool that is no longer usable for removal from a
 1300 ToolMagazine or Turret.

1301 **4.3.20.1 Part Properties of ExpiredPot**

1302 *Table 24* lists the Part Properties of ExpiredPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 24: Part Properties of ExpiredPot

1303 Descriptions for Part Properties of ExpiredPot:

- 1304 • Composition
- 1305 functional part of a piece of equipment contained within a Component.
- 1306 • Component
- 1307 logical or physical entity that provides a capability.

1308 4.3.21 ExposureUnit

1309 leaf Component that emits a type of radiation.

1310 4.3.21.1 Part Properties of ExposureUnit

1311 *Table 25* lists the Part Properties of ExposureUnit.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 25: Part Properties of ExposureUnit

1312 Descriptions for Part Properties of ExposureUnit:

- 1313 • Composition
- 1314 functional part of a piece of equipment contained within a Component.
- 1315 • Component
- 1316 logical or physical entity that provides a capability.

1317 4.3.22 ExtrusionUnit

1318 leaf `Component` that dispenses liquid or powered materials.

1319 4.3.22.1 Part Properties of ExtrusionUnit

1320 *Table 26* lists the Part Properties of `ExtrusionUnit`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 26: Part Properties of `ExtrusionUnit`

1321 Descriptions for Part Properties of `ExtrusionUnit`:

- 1322 • `Composition`
- 1323 functional part of a piece of equipment contained within a `Component`.
- 1324 • `Component`
- 1325 logical or physical entity that provides a capability.

1326 4.3.23 Fan

1327 leaf `Component` that produces a current of air.

1328 4.3.23.1 Part Properties of Fan

1329 *Table 27* lists the Part Properties of `Fan`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 27: Part Properties of `Fan`

1330 Descriptions for Part Properties of `Fan`:

- 1331 • `Composition`
- 1332 functional part of a piece of equipment contained within a `Component`.
- 1333 • `Component`
- 1334 logical or physical entity that provides a capability.

1335 **4.3.24 Filter**

- 1336 leaf `Component` through which liquids or gases are passed to remove suspended impuri-
- 1337 ties or to recover solids.

1338 **4.3.24.1 Part Properties of Filter**

- 1339 *Table 28* lists the Part Properties of `Filter`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 28: Part Properties of `Filter`

- 1340 Descriptions for Part Properties of `Filter`:

- 1341 • `Composition`
- 1342 functional part of a piece of equipment contained within a `Component`.
- 1343 • `Component`
- 1344 logical or physical entity that provides a capability.

1345 **4.3.25 Galvanomotor**

- 1346 leaf `Component` composed of an electromechanical actuator that produces deflection of
- 1347 a beam of light or energy in response to electric current through its coil in a magnetic field.

1348 **4.3.25.1 Part Properties of Galvanomotor**

- 1349 *Table 29* lists the Part Properties of `Galvanomotor`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 29: Part Properties of Galvanomotor

1350 Descriptions for Part Properties of Galvanomotor:

- 1351 • Composition
- 1352 functional part of a piece of equipment contained within a Component.
- 1353 • Component
- 1354 logical or physical entity that provides a capability.

1355 4.3.26 Gripper

1356 leaf Component that holds a part, stock material, or any other item in place.

1357 4.3.26.1 Part Properties of Gripper

1358 *Table 30* lists the Part Properties of Gripper.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 30: Part Properties of Gripper

1359 Descriptions for Part Properties of Gripper:

- 1360 • Composition
- 1361 functional part of a piece of equipment contained within a Component.
- 1362 • Component
- 1363 logical or physical entity that provides a capability.

1364 4.3.27 Hopper

1365 leaf `Component` composed of a chamber or bin in which materials are stored temporarily,
 1366 typically being filled through the top and dispensed through the bottom.

1367 4.3.27.1 Part Properties of Hopper

1368 *Table 31* lists the Part Properties of `Hopper`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 31: Part Properties of `Hopper`

1369 Descriptions for Part Properties of `Hopper`:

- 1370 • `Composition`
- 1371 functional part of a piece of equipment contained within a `Component`.
- 1372 • `Component`
- 1373 logical or physical entity that provides a capability.

1374 4.3.28 LinearPositionFeedback

1375 leaf `Component` that measures linear motion or position.

1376 **DEPRECATION WARNING** : May be deprecated in the future. Recommend using
 1377 `Encoder`.

1378 4.3.28.1 Part Properties of LinearPositionFeedback

1379 *Table 32* lists the Part Properties of `LinearPositionFeedback`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 32: Part Properties of LinearPositionFeedback

1380 Descriptions for Part Properties of LinearPositionFeedback:

- 1381 • Composition
- 1382 functional part of a piece of equipment contained within a Component.
- 1383 • Component
- 1384 logical or physical entity that provides a capability.

1385 4.3.29 Lock

1386 Component that physically prohibits a Device or Component from opening or oper-
1387 ating.

1388 4.3.29.1 Commonly Observed DataItem Types for Lock

1389 Table 33 lists the Commonly Observed DataItem Types for Lock.

Commonly Observed DataItem Types	Multiplicity
LockState	0..1

Table 33: Commonly Observed DataItem Types for Lock

1390 4.3.30 Motor

1391 leaf Component that converts electrical, pneumatic, or hydraulic energy into mechanical
1392 energy.

1393 4.3.30.1 Part Properties of Motor

1394 Table 34 lists the Part Properties of Motor.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 34: Part Properties of Motor

1395 Descriptions for Part Properties of Motor:

- 1396 • Composition
- 1397 functional part of a piece of equipment contained within a Component.
- 1398 • Component
- 1399 logical or physical entity that provides a capability.

1400 4.3.31 Oil

1401 leaf Component composed of a viscous liquid.

1402 4.3.31.1 Part Properties of Oil

1403 *Table 35* lists the Part Properties of Oil.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 35: Part Properties of Oil

1404 Descriptions for Part Properties of Oil:

- 1405 • Composition
- 1406 functional part of a piece of equipment contained within a Component.
- 1407 • Component
- 1408 logical or physical entity that provides a capability.

1409 4.3.32 Part

1410 abstract Component composed of a *part* being processed by a piece of equipment.

1411 4.3.32.1 PartOccurrence

1412 Part that exists at a specific place and time, such as a specific instance of a bracket at a
1413 specific timestamp.

1414 PartId **MUST** be defined for PartOccurrence.

Example 1: XML Device Model Example for PartOccurrence and ComponentData

```

1415 1 <Parts id="partOccSet">
1416 2   <Components>
1417 3     <PartOccurrence id="partOccur">
1418 4       <DataItems>
1419 5         <DataItem id="partSet" category="EVENT"
1420         representation="TABLE" type="COMPONENT\
1421         textunderscore_DATA">
1422 6           <Definition>
1423 7             <EntryDefinitions>
1424 8               <EntryDefinition keyType="
1425               PART\textunderscore_
1426               UNIQUE\textunderscore_ID"
1427               />
1428 9             </EntryDefinitions>
1429 10            <CellDefinitions>
1430 11              <CellDefinition key="
1431              partNumber" type="PART\
1432              textunderscore_KIND\
1433              textunderscore_ID"
1434              subType="PART\
1435              textunderscore_NUMBER"/>
1436 12              <CellDefinition key="batchId
1437              " type="PART\
1438              textunderscore_GROUP\
1439              textunderscore_ID"
1440              subType="BATCH"/>
1441 13              <CellDefinition key="
1442              quantity" type="PART\
1443              textunderscore_COUNT"
1444              subType="TARGET"/>
1445 14              <CellDefinition key="
1446              actualCompleteTime" type=
1447              "PROCESS\textunderscore_
1448              TIME" subType="COMPLETE"
1449              />

```

```

1450 15          <CellDefinition key="
1451          partState" type="PROCESS\
1452          textunderscore_STATE"/>
1453 16          </CellDefinitions>
1454 17        </Definition>
1455 18      </DataItem>
1456 19    </DataItems>
1457 20  </PartOccurrence>
1458 21 </Components>
1459 22 </Parts>

```

Example 2: XML Streams Response Example for PartOccurrence and ComponentData

```

1460 1  <?xml version="1.0" encoding="UTF-8"?>
1461 2  <?xml-stylesheet type="text/xsl" href="/styles/Streams.xsl"?>
1462 3  <MTConnectStreams>
1463 4    <Streams>
1464 5      <DeviceStream name="VMC-3Axis" uuid="test\textunderscore_27MAY">
1465 6        <ComponentStream component="PartOccurrence" name="partSet"
1466 6        componentId="partOccur">
1467 7          <Events>
1468 8            <ComponentDataTable dataItemId="partSet" timestamp="
1469 8            2020-10-28T19:45:43.070010Z" sequence="95" count="2">
1470 9              <Entry key="part1">
1471 10                <Cell key="actualStartTime">2009-06-15T00
1472 10                :00:00.000000</Cell>
1473 11                <Cell key="partId">part1</Cell>
1474 12                <Cell key="partName">SomeName</Cell>
1475 13                <Cell key="uniqueID">abc-123</Cell>
1476 14              </Entry>
1477 15              <Entry key="part2">
1478 16                <Cell key="actualStartTime">2009-06-15T00
1479 16                :00:00.007925</Cell>
1480 17                <Cell key="partId">part2</Cell>
1481 18                <Cell key="partName">AnotherName</Cell>
1482 19                <Cell key="uniqueID">def-123</Cell>
1483 20              </Entry>
1484 21            </ComponentDataTable>
1485 22          </Events>
1486 23        </ComponentStream>
1487 24      </DeviceStream>
1488 25    </Streams>
1489 26  </MTConnectStreams>

```

1490 4.3.32.2 Commonly Observed DataItem Types for PartOccurrence

1491 *Table 36* lists the Commonly Observed DataItem Types for PartOccurrence.

Commonly Observed DataItem Types	Multiplicity
PartId	1
PartUniqueId	0..1
PartGroupId	0..1
PartKindId	0..1
PartCount	0..1
PartStatus	0..1
ProcessOccurrenceId	0..1
ProcessTime	0..1
User	0..1

Table 36: Commonly Observed DataItem Types for PartOccurrence

1492 4.3.32.2.1 FeatureOccurrence

1493 Component that provides information related to an individual *feature*.

1494 4.3.32.3 Part Properties of FeatureOccurrence

1495 *Table 37* lists the Part Properties of FeatureOccurrence.

Part Property name	Multiplicity
observesFeaturePersisitentId	0..1
observesFeatureMeasurement	0..1
observesMeasurementType	0..1
observesCharacteristicPersistentId	0..1
observesCharacteristicStatus	0..1
observesUncertainty	0..1
observesUncertaintyType	0..1
observesMeasurementUnits	0..1
observesMeasurementValue	0..1

Table 37: Part Properties of FeatureOccurrence

1496 Descriptions for Part Properties of FeatureOccurrence:

- 1497 • FeaturePersisitentId
- 1498 Universally Unique Identifier (UUID) of a *feature*. *Ref ISO 10303 AP 242/239*.
- 1499 • FeatureMeasurement

1500 tabular representation of assessing elements of a *feature*.
 1501 FeatureMeasurement **MAY** include a *characteristic* in which case it **MAY**
 1502 include a CHARACTERISTIC_STATUS.

- 1503 • MeasurementType
 1504 class of measurement being performed. *Ref QIF 3:2018 Section 6.3*
 1505 Examples: POINT, RADIUS, ANGLE, LENGTH, etc.
- 1506 • CharacteristicPersistentId
 1507 UUID of the *characteristic*.
- 1508 • CharacteristicStatus
 1509 pass/fail result of the measurement.
- 1510 • Uncertainty
 1511 *uncertainty* specified by UncertaintyType.
- 1512 • UncertaintyType
 1513 method used to compute *standard uncertainty*.
- 1514 • MeasurementUnits
 1515 engineering units of the measurement.
- 1516 • MeasurementValue
 1517 measurement based on the measurement type.

1518 4.3.33 Path

1519 Component that organizes an independent operation or function within a Controller.

1520 For many types of equipment, Path organizes a set of Axes, one or more Program el-
 1521 ements, and the data associated with the motion of a control point as it moves through
 1522 space. However, it **MAY** also represent any independent function within a Controller
 1523 that has unique data associated with that function.

1524 Path **SHOULD** provide an Execution data item to define the operational state of the
 1525 Controller of the piece of equipment.

1526 If the Controller is capable of performing more than one independent operation or
 1527 function simultaneously, a separate Path **MUST** be used to organize the data associated
 1528 with each independent operation or function.

1529 4.3.33.1 Part Properties of Path

1530 *Table 38* lists the Part Properties of Path.

Part Property name	Multiplicity
observesProgram	0..1
observesPathFeedrateOverrideProgrammed	0..1
observesPathFeedrateOverrideRapid	0..1
observesRotaryVelocityOverride	0..1
observesPathFeedrate	0..1
observesPartCount	0..1

Table 38: Part Properties of Path

1531 Descriptions for Part Properties of Path:

- 1532 • Program
- 1533 name of the logic or motion program being executed by the Controller compo-
- 1534 nent.
- 1535 • PathFeedrateOverride.Programmed
- 1536 directive value without offsets and adjustments.
- 1537 • PathFeedrateOverride.Rapid
- 1538 performing an operation faster or in less time than nominal rate.
- 1539 • RotaryVelocityOverride
- 1540 percentage change to the velocity of the programmed velocity for a Rotary axis.
- 1541 This command represents a percentage change to the velocity calculated by a logic
- 1542 or motion program or set by a switch for a Rotary type axis.
- 1543 • PathFeedrate
- 1544 feedrate for the axes, or a single axis, associated with a Path component.
- 1545 • PartCount
- 1546 aggregate count of parts.

1547 4.3.33.2 Commonly Observed DataItem Types for Path

1548 *Table 39* lists the Commonly Observed DataItem Types for Path.

Commonly Observed DataItem Types	Multiplicity
Execution	0..1

Table 39: Commonly Observed DataItem Types for Path**1549 4.3.34 Pot**

1550 leaf Component composed of a tool storage location associated with a ToolMagazine
 1551 or AutomaticToolChanger.

1552 4.3.34.1 Part Properties of Pot

1553 Table 40 lists the Part Properties of Pot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 40: Part Properties of Pot

1554 Descriptions for Part Properties of Pot:

- 1555 • Composition
- 1556 functional part of a piece of equipment contained within a Component.
- 1557 • Component
- 1558 logical or physical entity that provides a capability.

1559 4.3.35 <<deprecated>>Power

1560 Power was **DEPRECATED** in *MTConnect Version 1.1* and was replaced by Avail-
 1561 ability data item type.

1562 4.3.36 PowerSupply

1563 leaf Component that provides power to electric mechanisms.

1564 **4.3.36.1 Part Properties of PowerSupply**

1565 *Table 41* lists the Part Properties of PowerSupply.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 41: Part Properties of PowerSupply

1566 Descriptions for Part Properties of PowerSupply:

- 1567 • *Composition*
- 1568 functional part of a piece of equipment contained within a *Component*.
- 1569 • *Component*
- 1570 logical or physical entity that provides a capability.

1571 **4.3.37 Process**

1572 abstract *Component* composed of a manufacturing process being executed on a piece of
1573 equipment.

1574 **4.3.37.1 ProcessOccurrence**

1575 *Process* that takes place at a specific place and time, such as a specific instance of part-
1576 milling occurring at a specific timestamp.

1577 *ProcessOccurrenceId* **MUST** be defined for *ProcessOccurrence*.

1578 **4.3.37.2 Commonly Observed DataItem Types for ProcessOccurrence**

1579 *Table 42* lists the Commonly Observed DataItem Types for *ProcessOccurrence*.

Commonly Observed DataItem Types	Multiplicity
ProcessOccurrenceId	1
ProcessAggregateId	0..1
ProcessTime	0..1
ProcessKindId	0..1
User	0..1
Program	0..1
PartUniqueId	0..1

Table 42: Commonly Observed DataItem Types for ProcessOccurrence

1580 4.3.38 Pulley

1581 leaf `Component` composed of a mechanism or wheel that turns in a frame or block and
 1582 serves to change the direction of or to transmit force.

1583 4.3.38.1 Part Properties of Pulley

1584 *Table 43* lists the Part Properties of `Pulley`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 43: Part Properties of Pulley

1585 Descriptions for Part Properties of `Pulley`:

- 1586 • `Composition`
 1587 functional part of a piece of equipment contained within a `Component`.
- 1588 • `Component`
 1589 logical or physical entity that provides a capability.

1590 4.3.39 Pump

1591 leaf `Component` that raises, drives, exhausts, or compresses fluids or gases by means of
 1592 a piston, plunger, or set of rotating vanes.

1593 **4.3.39.1 Part Properties of Pump**

1594 *Table 44* lists the Part Properties of Pump.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 44: Part Properties of Pump

1595 Descriptions for Part Properties of Pump:

- 1596 • Composition
- 1597 functional part of a piece of equipment contained within a Component.
- 1598 • Component
- 1599 logical or physical entity that provides a capability.

1600 **4.3.40 Reel**

1601 leaf Component composed of a rotary storage unit for material.

1602 **4.3.40.1 Part Properties of Reel**

1603 *Table 45* lists the Part Properties of Reel.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 45: Part Properties of Reel

1604 Descriptions for Part Properties of Reel:

- 1605 • Composition
- 1606 functional part of a piece of equipment contained within a Component.
- 1607 • Component
- 1608 logical or physical entity that provides a capability.

1609 4.3.41 RemovalPot

1610 leaf `Component` that is a `Pot` for a tool that has to be removed from a `ToolMagazine`
 1611 or `Turret` to a location outside of the piece of equipment.

1612 4.3.41.1 Part Properties of RemovalPot

1613 *Table 46* lists the Part Properties of `RemovalPot`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 46: Part Properties of `RemovalPot`

1614 Descriptions for Part Properties of `RemovalPot`:

- 1615 • `Composition`
 1616 functional part of a piece of equipment contained within a `Component`.
- 1617 • `Component`
 1618 logical or physical entity that provides a capability.

1619 4.3.42 Resource

1620 abstract `Component` composed of material or personnel involved in a manufacturing
 1621 process.

1622 4.3.42.1 Material

1623 `Resource` composed of material that is consumed or used by the piece of equipment for
 1624 production of parts, materials, or other types of goods.

1625 4.3.42.1.1 Stock

1626 `Material` that is used in a manufacturing process and to which work is applied in a
 1627 machine or piece of equipment to produce parts.

1628 Stock may be either a continuous piece of material from which multiple parts may be
 1629 produced or it may be a discrete piece of material that will be made into a part or a set of
 1630 parts.

1631 **4.3.42.2 Part Properties of Stock**

1632 *Table 47* lists the Part Properties of Stock.

Part Property name	Multiplicity
observesMaterial	0..1
observesLengthRemaining	0..1
observesLengthStandard	0..1

Table 47: Part Properties of Stock

1633 Descriptions for Part Properties of Stock:

- 1634 • Material
- 1635 identifier of a material used or consumed in the manufacturing process.
- 1636 • Length.Remaining
- 1637 remaining total length of an object.
- 1638 • Length.Standard
- 1639 standard or original length of an object.

1640 **4.3.42.3 Personnel**

1641 Resource composed of an individual or individuals who either control, support, or oth-
 1642 erwise interface with a piece of equipment.

1643 **4.3.42.4 Part Properties of Personnel**

1644 *Table 48* lists the Part Properties of Personnel.

Part Property name	Multiplicity
observesUserOperator	0..1
observesUserMaintenance	0..1

Table 48: Part Properties of Personnel

1645 Descriptions for Part Properties of Personnel:

- 1646 • `User.Operator`
1647 identifier of the person currently responsible for operating the piece of equipment.
- 1648 • `User.Maintenance`
1649 identifier of the person currently responsible for performing maintenance on the
1650 piece of equipment.

1651 4.3.43 ReturnPot

1652 leaf Component that is a Pot for a tool that has been removed from *spindle* or Turret
1653 and awaiting for return to a ToolMagazine.

1654 4.3.43.1 Part Properties of ReturnPot

1655 *Table 49* lists the Part Properties of ReturnPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 49: Part Properties of ReturnPot

1656 Descriptions for Part Properties of ReturnPot:

- 1657 • `Composition`
1658 functional part of a piece of equipment contained within a Component.
- 1659 • `Component`
1660 logical or physical entity that provides a capability.

1661 4.3.44 SensingElement

1662 leaf Component that provides a signal or measured value.

1663 4.3.44.1 Part Properties of SensingElement

1664 Table 50 lists the Part Properties of SensingElement.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 50: Part Properties of SensingElement

1665 Descriptions for Part Properties of SensingElement:

- 1666 • Composition
- 1667 functional part of a piece of equipment contained within a Component.
- 1668 • Component
- 1669 logical or physical entity that provides a capability.

1670 4.3.45 Sensor

1671 Component that responds to a physical stimulus and transmits a resulting impulse or
1672 value from a sensing unit.

1673 If modeling individual sensors, then sensor should be associated with the Component
1674 that the measured value is most closely associated.

1675 When modeled as an Auxiliary, sensor **SHOULD** represent an integrated sensor unit
1676 system that provides signal processing, conversion, and communications. A sensor unit
1677 may have multiple *sensing elements*.

1678 See SensorConfiguration for more details on the use and configuration of a Sen-
1679 sor.

1680 **4.3.45.1 <<deprecated>>Thermostat**

1681 Component composed of a sensor or an instrument that measures temperature.

1682 Thermostat was **DEPRECATED** in *MTConnect Version 1.2* and was replaced by
1683 Temperature.

1684 **4.3.45.2 <<deprecated>>Vibration**

1685 Component composed of a sensor or an instrument that measures the amount and/or
1686 frequency of vibration within a system.

1687 Vibration was **DEPRECATED** in *MTConnect Version 1.2* and was replaced by Dis-
1688 placement, Frequency etc.

1689 **4.3.46 Spreader**

1690 leaf Component that flattens or spreading materials.

1691 **4.3.46.1 Part Properties of Spreader**

1692 *Table 51* lists the Part Properties of Spreader.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 51: Part Properties of Spreader

1693 Descriptions for Part Properties of Spreader:

- 1694 • Composition
- 1695 functional part of a piece of equipment contained within a Component.
- 1696 • Component
- 1697 logical or physical entity that provides a capability.

1698 4.3.47 StagingPot

1699 leaf Component that is a Pot for a tool that is awaiting transfer to a ToolMagazine
1700 or Turret from outside of the piece of equipment.

1701 4.3.47.1 Part Properties of StagingPot

1702 Table 52 lists the Part Properties of StagingPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 52: Part Properties of StagingPot

1703 Descriptions for Part Properties of StagingPot:

- 1704 • Composition
- 1705 functional part of a piece of equipment contained within a Component.
- 1706 • Component
- 1707 logical or physical entity that provides a capability.

1708 4.3.48 Station

1709 leaf Component composed of a storage or mounting location for a tool associated with a
1710 Turret, GangToolBar, or ToolRack.

1711 4.3.48.1 Part Properties of Station

1712 Table 53 lists the Part Properties of Station.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 53: Part Properties of Station

1713 Descriptions for Part Properties of Station:

- 1714 • `Composition`
- 1715 functional part of a piece of equipment contained within a `Component`.
- 1716 • `Component`
- 1717 logical or physical entity that provides a capability.

1718 **4.3.49 StorageBattery**

- 1719 leaf `Component` composed of one or more cells in which chemical energy is converted
- 1720 into electricity and used as a source of power.

1721 **4.3.49.1 Part Properties of StorageBattery**

- 1722 *Table 54* lists the Part Properties of `StorageBattery`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 54: Part Properties of `StorageBattery`

- 1723 Descriptions for Part Properties of `StorageBattery`:

- 1724 • `Composition`
- 1725 functional part of a piece of equipment contained within a `Component`.
- 1726 • `Component`
- 1727 logical or physical entity that provides a capability.

1728 **4.3.50 Structure**

- 1729 `Component` composed of part(s) comprising the rigid bodies of the piece of equipment.

1730 **4.3.50.1 Link**

- 1731 `Structure` that provides a connection between `Component` entities.

1732 4.3.51 Switch

1733 leaf `Component` that turns on or off an electric current or makes or breaks a circuit.

1734 4.3.51.1 Part Properties of Switch

1735 *Table 55* lists the Part Properties of `Switch`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 55: Part Properties of Switch

1736 Descriptions for Part Properties of `Switch`:

- 1737 • `Composition`
- 1738 functional part of a piece of equipment contained within a `Component`.
- 1739 • `Component`
- 1740 logical or physical entity that provides a capability.

1741 4.3.52 System

1742 abstract `Component` that is permanently integrated into the piece of equipment.

1743 4.3.52.1 Actuator

1744 `Component` composed of a physical apparatus that moves or controls a mechanism or
1745 system.

1746 It takes energy usually provided by air, electric current, or liquid and converts the energy
1747 into some kind of motion.

1748 4.3.52.1.1 Hydraulic

1749 `System` that provides movement and distribution of pressurized liquid throughout the
1750 piece of equipment.

1751 **4.3.52.2 Part Properties of Hydraulic**

1752 *Table 56* lists the Part Properties of `Hydraulic`.

Part Property name	Multiplicity
observesPressure	0..1

Table 56: Part Properties of `Hydraulic`

1753 Descriptions for Part Properties of `Hydraulic`:

- 1754 • Pressure
- 1755 force per unit area measured relative to atmospheric pressure.
- 1756 Commonly referred to as gauge pressure.

1757 **4.3.52.2.1 Pneumatic**

1758 System that uses compressed gasses to actuate components or do work within the piece
1759 of equipment.

1760 Note: Actuation is usually performed using a cylinder.

1761 **4.3.52.3 Part Properties of Pneumatic**

1762 *Table 57* lists the Part Properties of `Pneumatic`.

Part Property name	Multiplicity
observesPressure	0..1

Table 57: Part Properties of `Pneumatic`

1763 Descriptions for Part Properties of `Pneumatic`:

- 1764 • Pressure
- 1765 force per unit area measured relative to atmospheric pressure.
- 1766 Commonly referred to as gauge pressure.

1767 **4.3.52.4 Controller**

1768 System that provides regulation or management of a system or component. *Ref ISO*
1769 *16484-5:2017*

1770 Typical types of controllers for a piece of equipment include CNC (Computer Numerical
1771 Control), PAC (Programmable Automation Control), IPC (Industrialized Computer), or IC
1772 (Imbedded Computer).

1773 Note: In XML representation, `Controller` is a *top level* element.

1774 **4.3.52.5 Part Properties of Controller**

1775 *Table 58* lists the Part Properties of `Controller`.

Part Property name	Multiplicity
Path	0..*
observesEmergencyStop	0..1
observesSystemCondition	0..1
observesControllerMode	0..1
observesCommunicationsCondition	0..1
observesLogicProgramCondition	0..1

Table 58: Part Properties of Controller

1776 Descriptions for Part Properties of `Controller`:

- 1777 • Path

1778 Component that organizes an independent operation or function within a Con-
1779 troller.

- 1780 • EmergencyStop

1781 state of the emergency stop signal for a piece of equipment, controller path, or any
1782 other component or subsystem of a piece of equipment.

- 1783 • System

1784 general purpose indication associated with an electronic component of a piece of
1785 equipment or a controller that represents a fault that is not associated with the oper-
1786 ator, program, or hardware.

- 1787 • `ControllerMode`
- 1788 current mode of the `Controller` component.
- 1789 • `Communications`
- 1790 indication that the piece of equipment has experienced a communications failure.
- 1791 • `LogicProgram`
- 1792 indication that an error occurred in the logic program or programmable logic controller (PLC) associated with a piece of equipment.
- 1793

1794 **4.3.52.6 Coolant**

1795 System that provides distribution and management of fluids that remove heat from a
1796 piece of equipment.

1797 **4.3.52.7 Part Properties of Coolant**

1798 *Table 59* lists the Part Properties of `Coolant`.

Part Property name	Multiplicity
<code>observesConcentration</code>	0..1

Table 59: Part Properties of `Coolant`

1799 Descriptions for Part Properties of `Coolant`:

- 1800 • `Concentration`
- 1801 percentage of one component within a mixture of components.

1802 **4.3.52.8 Dielectric**

1803 System that manages a chemical mixture used in a manufacturing process being performed at that piece of equipment.

1805 For example, this could describe the dielectric system for an EDM process or the chemical bath used in a plating process.

1807 **4.3.52.9 Electric**

1808 System composed of the main power supply for the piece of equipment that provides
1809 distribution of that power throughout the equipment.

1810 The electric system will provide all the data with regard to electric current, voltage, fre-
1811 quency, etc. that applies to the piece of equipment as a functional unit. Data regarding
1812 electric power that is specific to a Component will be reported for that specific Compo-
1813 nent.

1814 **4.3.52.10 Part Properties of Electric**

1815 *Table 60* lists the Part Properties of Electric.

Part Property name	Multiplicity
observesWattage	0..1

Table 60: Part Properties of Electric

1816 Descriptions for Part Properties of Electric:

- 1817 • Wattage
- 1818 power flowing through or dissipated by an electrical circuit or piece of equipment.

1819 **4.3.52.11 Enclosure**

1820 System composed of a structure that is used to contain or isolate a piece of equipment or
1821 area.

1822 Enclosure may provide information regarding access to the internal components of a
1823 piece of equipment or the conditions within the enclosure. For example, Door may be
1824 defined as a *lower level* Component or Composition entity of the Enclosure.

1825 **4.3.52.12 EndEffector**

1826 System composed of functions that form the last link segment of a piece of equipment.

1827 It is the part of a piece of equipment that interacts with the manufacturing process.

1828 **4.3.52.13 Feeder**

1829 System that manages the delivery of materials within a piece of equipment.

1830 For example, this could describe the wire delivery system for an EDM or welding process;
1831 conveying system or pump and valve system distributing material to a blending station; or
1832 a fuel delivery system feeding a furnace.

1833 **4.3.52.14 Lubrication**

1834 System that provides distribution and management of fluids used to lubricate portions of
1835 the piece of equipment.

1836 **4.3.52.15 ProcessPower**

1837 System composed of a power source associated with a piece of equipment that supplies
1838 energy to the manufacturing process separate from the Electric system.

1839 For example, this could be the power source for an EDM machining process, an electro-
1840 plating line, or a welding system.

1841 **4.3.52.16 Protective**

1842 System that provides functions used to detect or prevent harm or damage to equipment
1843 or personnel.

1844 Protective does not include the information relating to the Enclosure.

1845 **4.3.52.17 Heating**

1846 System that delivers controlled amounts of heat to achieve a target temperature at a spec-
1847 ified heating rate.

1848 Note: As an example, Energy Delivery Method can be either through Electric
1849 heaters or Gas burners.

1850 **4.3.52.18 Vacuum**

1851 System that evacuates gases and liquids from an enclosed and sealed space to a controlled
1852 negative pressure or a molecular density below the prevailing atmospheric level.

1853 **4.3.52.19 Cooling**

1854 System that extracts controlled amounts of heat to achieve a target temperature at a spec-
1855 ified cooling rate.

1856 Note: As an example, Energy Extraction Method can be via cooling water
1857 pipes running through the chamber.

1858 **4.3.52.20 Pressure**

1859 System that delivers compressed gas or fluid and controls the pressure and rate of pres-
1860 sure change to a desired target set-point.

1861 Note: For example, Delivery Method can be a Compressed Air or N2 tank
1862 that is piped via an inlet valve to the chamber.

1863 **4.3.52.21 WorkEnvelope**

1864 System composed of the physical process execution space within a piece of equipment.

1865 WorkEnvelope **MAY** provide information regarding the physical workspace and the
1866 conditions within that workspace.

1867 **4.3.52.22 AirHandler**

1868 system that circulates air or regulates airflow without altering temperature or humidity.

1869 **4.3.53 Table**

1870 leaf Component composed of a surface for holding an object or material.

1871 **4.3.53.1 Part Properties of Table**

1872 *Table 61* lists the Part Properties of Table.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 61: Part Properties of Table

1873 Descriptions for Part Properties of Table:

- 1874 • Composition
- 1875 functional part of a piece of equipment contained within a Component.
- 1876 • Component
- 1877 logical or physical entity that provides a capability.

1878 **4.3.54 Tank**

1879 leaf Component generally composed of an enclosed container.

1880 **4.3.54.1 Part Properties of Tank**

1881 *Table 62* lists the Part Properties of Tank.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 62: Part Properties of Tank

1882 Descriptions for Part Properties of Tank:

- 1883 • Composition
- 1884 functional part of a piece of equipment contained within a Component.
- 1885 • Component
- 1886 logical or physical entity that provides a capability.

1887 4.3.55 Tensioner

1888 leaf `Component` that provides or applies a stretch or strain to another mechanism.

1889 4.3.55.1 Part Properties of Tensioner

1890 *Table 63* lists the Part Properties of `Tensioner`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 63: Part Properties of `Tensioner`

1891 Descriptions for Part Properties of `Tensioner`:

- 1892 • `Composition`
- 1893 functional part of a piece of equipment contained within a `Component`.
- 1894 • `Component`
- 1895 logical or physical entity that provides a capability.

1896 4.3.56 TransferArm

1897 leaf `Component` that physically moves a tool from one location to another.

1898 4.3.56.1 Part Properties of TransferArm

1899 *Table 64* lists the Part Properties of `TransferArm`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 64: Part Properties of `TransferArm`

1900 Descriptions for Part Properties of `TransferArm`:

- 1901 • `Composition`
- 1902 functional part of a piece of equipment contained within a `Component`.
- 1903 • `Component`
- 1904 logical or physical entity that provides a capability.

1905 **4.3.57 TransferPot**

1906 leaf `Component` that is a `Pot` for a tool that is awaiting transfer from a `ToolMagazine`
 1907 to *spindle* or `Turret`.

1908 **4.3.57.1 Part Properties of TransferPot**

1909 *Table 65* lists the Part Properties of `TransferPot`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 65: Part Properties of `TransferPot`

1910 Descriptions for Part Properties of `TransferPot`:

- 1911 • `Composition`
- 1912 functional part of a piece of equipment contained within a `Component`.
- 1913 • `Component`
- 1914 logical or physical entity that provides a capability.

1915 **4.3.58 Transformer**

1916 leaf `Component` that transforms electric energy from a source to a secondary circuit.

1917 **4.3.58.1 Part Properties of Transformer**

1918 *Table 66* lists the Part Properties of `Transformer`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 66: Part Properties of Transformer

1919 Descriptions for Part Properties of Transformer:

- 1920 • Composition
- 1921 functional part of a piece of equipment contained within a Component.
- 1922 • Component
- 1923 logical or physical entity that provides a capability.

1924 4.3.59 Valve

1925 leaf Component that halts or controls the flow of a liquid, gas, or other material through

1926 a passage, pipe, inlet, or outlet.

1927 4.3.59.1 Part Properties of Valve

1928 Table 67 lists the Part Properties of Valve.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 67: Part Properties of Valve

1929 Descriptions for Part Properties of Valve:

- 1930 • Composition
- 1931 functional part of a piece of equipment contained within a Component.
- 1932 • Component
- 1933 logical or physical entity that provides a capability.

1934 4.3.60 Vat

1935 leaf `Component` generally composed of an open container.

1936 4.3.60.1 Part Properties of Vat

1937 *Table 68* lists the Part Properties of `Vat`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 68: Part Properties of `Vat`

1938 Descriptions for Part Properties of `Vat`:

- 1939 • `Composition`
- 1940 functional part of a piece of equipment contained within a `Component`.
- 1941 • `Component`
- 1942 logical or physical entity that provides a capability.

1943 4.3.61 Water

1944 leaf `Component` composed of H_2O .

1945 4.3.61.1 Part Properties of Water

1946 *Table 69* lists the Part Properties of `Water`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 69: Part Properties of `Water`

1947 Descriptions for Part Properties of `Water`:

- 1948 • `Composition`
- 1949 functional part of a piece of equipment contained within a `Component`.
- 1950 • `Component`
- 1951 logical or physical entity that provides a capability.

1952 4.3.62 Wire

- 1953 leaf `Component` composed of a string like piece or filament of relatively rigid or flexible
- 1954 material provided in a variety of diameters.

1955 4.3.62.1 Part Properties of Wire

- 1956 *Table 70* lists the Part Properties of `Wire`.

Part Property name	Multiplicity
<code>hasComposition</code>	0
<code>hasComponent</code>	0

Table 70: Part Properties of Wire

- 1957 Descriptions for Part Properties of `Wire`:

- 1958 • `Composition`
- 1959 functional part of a piece of equipment contained within a `Component`.
- 1960 • `Component`
- 1961 logical or physical entity that provides a capability.

1962 4.3.63 Workpiece

- 1963 leaf `Component` composed of an object or material on which a form of work is per-
- 1964 formed.

1965 4.3.63.1 Part Properties of Workpiece

- 1966 *Table 71* lists the Part Properties of `Workpiece`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 71: Part Properties of Workpiece

1967 Descriptions for Part Properties of Workpiece:

- 1968 • Composition
- 1969 functional part of a piece of equipment contained within a Component.
- 1970 • Component
- 1971 logical or physical entity that provides a capability.

1972 4.4 Component Organizer Types

1973 This section provides semantic information for the types of Component that are used to
 1974 *organize* other Component types.

1975 4.4.1 <<organizer>>Adapters

1976 Component that *organizes* Adapter types.

1977 4.4.2 <<organizer>>Auxiliaries

1978 Component that *organizes* Auxiliary types.

1979 4.4.3 <<organizer>>Axes

1980 Component that *organizes* Axis types.

1981 4.4.4 <<organizer>>Controllers

1982 Component that *organizes* Controller entities.

1983 4.4.5 <<organizer>>Interfaces

1984 Component that *organizes* Interface types.

1985 4.4.6 <<organizer>>Parts

1986 Component that *organizes* Part types.

1987 4.4.7 <<organizer>>Processes

1988 Component that *organizes* Process types.

1989 4.4.8 <<organizer>>Resources

1990 Component that *organizes* Resource types.

1991 4.4.8.1 <<organizer>>Materials

1992 Resources that *organizes* Material types.

1993 4.4.9 <<organizer>>Structures

1994 Component that *organizes* Structure types.

1995 4.4.10 <<organizer>>Systems

1996 Component that *organizes* System types.

1997 **5 Compositions Model**

1998 Composition entities are used to describe the lowest level physical building blocks of
 1999 a piece of equipment contained within a Component. By referencing a specific Com-
 2000 position entity, further clarification and meaning to data associated with a specific
 2001 Component can be achieved.

2002 Both Component and Composition entities are *lower level* entities representing the
 2003 sub-parts of the parent Component. However, there are distinct differences between
 2004 Component and Composition type entities.

2005 Component entities may be further defined with *lower level* Component entities and
 2006 may have associated *DataItems*.

2007 Composition entities represent the lowest level physical part of a piece of equipment.
 2008 They **MUST NOT** be further defined with *lower level* Component entities and they
 2009 **MUST NOT** have *DataItems* directly associated with them. They do provide additional
 2010 information that can be used to enhance the specificity of *DataItems* associated with the
 2011 parent Component.

2012 **5.1 Compositions**

2013 This section provides semantic information for the Composition entity.

2014 See Figure 2 for the Composition model diagram.

2015 Note: See *Example 5* for the XML representation of the same example.

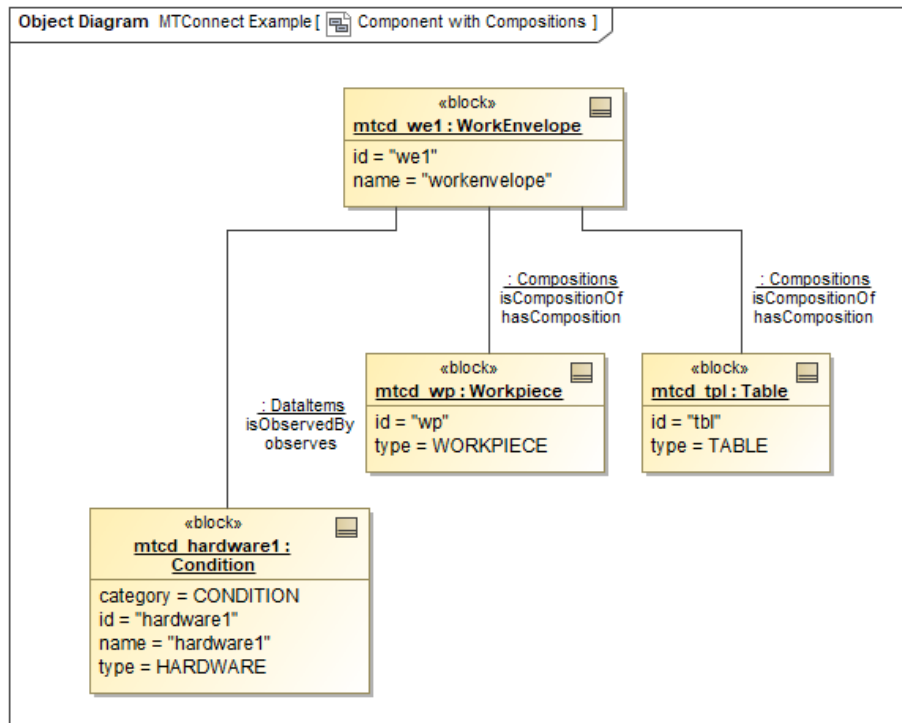
2016 **5.1.1 Composition**

2017 functional part of a piece of equipment contained within a Component.

2018 Composition **MUST NOT** have child Component, Composition, or DataItems
 2019 elements.

2020 **5.1.1.1 Value Properties of Composition**

2021 *Table 72* lists the Value Properties of Composition.

**Figure 4:** Component with Compositions Example

Value Property name	Value Property type	Multiplicity
id	ID	1
type	CompositionTypeEnum	1
name	string	0..1
uuid	UUID	0..1

Table 72: Value Properties of Composition

2022 Descriptions for Value Properties of Composition:

- 2023 • id
- 2024 unique identifier for the Composition element.
- 2025 • type
- 2026 type of Composition.
- 2027 The value of type **MUST** be one of the CompositionTypeEnum enumeration.
- 2028 • name
- 2029 name of the Composition element.

- 2030 • uuid
- 2031 universally unique identifier for the Composition.

2032 **5.1.1.2 Part Properties of Composition**

2033 *Table 73* lists the Part Properties of Composition.

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

Table 73: Part Properties of Composition

2034 Descriptions for Part Properties of Composition:

- 2035 • Description
- 2036 descriptive content.
- 2037 *See Section 4.1.2 - Description.*
- 2038 • Configuration
- 2039 technical information about an entity describing its physical layout, functional characteristics, and relationships with other entities.
- 2040
- 2041 *See Section 8 - Configurations Model.*

2042 6 DataItems Model

2043 For an `MTConnectDevices` entity, *DataItems* describe data that can be reported by a
 2044 piece of equipment and are associated with `Device` and `Component` entities. While the
 2045 *DataItems* describe the data that can be reported by a piece of equipment as an `MTCon-`
 2046 `nectDevices` entity, the actual data values are provided by the `MTConnectStreams`
 2047 entity in the *MTConnectStreams Response Document*. See *MTConnect Standard: Part 3.0*
 2048 - *Observation Information Model* for detail on the reported values.

2049 Each *DataItem* **SHOULD** be modeled for the `MTConnectDevices` entity such that it
 2050 is associated with the entity that the reported data directly applies.

2051 `DataItem` describes specific types of *DataItems* that represent a numeric value, a func-
 2052 tioning state, or a health status reported by a piece of equipment. `DataItem` provides a
 2053 detailed description for each *DataItem* that is reported; it defines the type of data being
 2054 reported and an array of optional attributes that further describe that data. The different
 2055 types of `DataItem` elements are defined in *Section 6.5 - DataItem Types*.

2056 6.1 DataItems

2057 This section provides semantic information for the `DataItem` entity. Figure 5 shows the
 2058 `DataItem` model.

2059 Note: See *Section B.2 - DataItems Schema Diagrams* for XML schema.

2060 6.1.1 DataItem

2061 information reported about a piece of equipment.

2062 6.1.1.1 Value Properties of DataItem

2063 *Table 74* lists the Value Properties of `DataItem`.

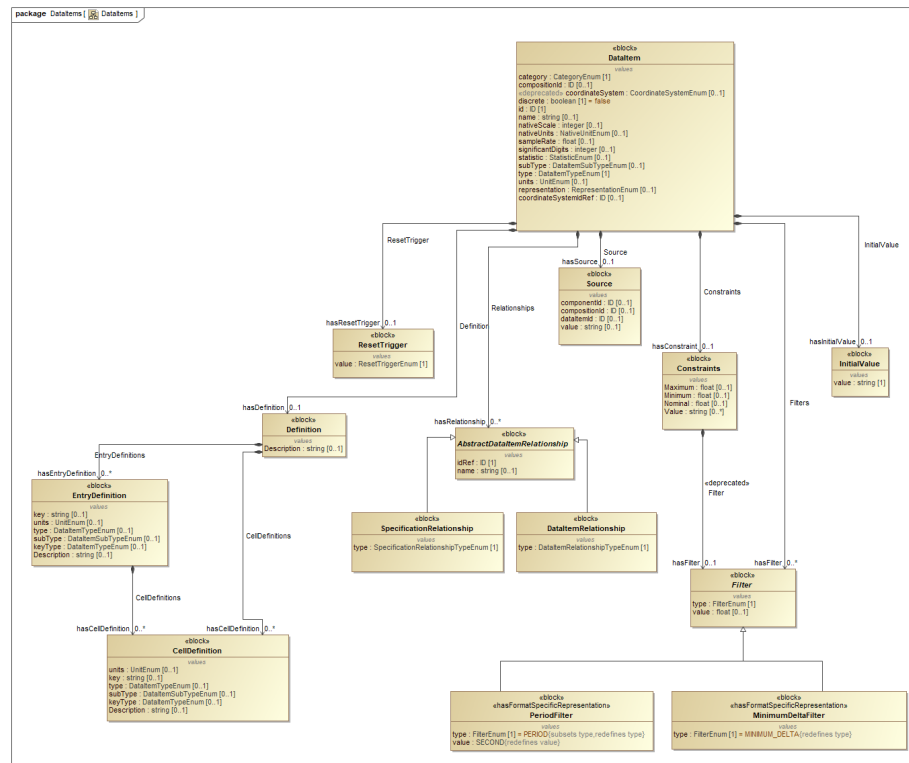


Figure 5: DataItems

Value Property name	Value Property type	Multiplicity
category	CategoryEnum	1
compositionId	ID	0..1
<<deprecated>> coordinateSystem	CoordinateSystemEnum	0..1
discrete	boolean	1
id	ID	1
name	string	0..1
nativeScale	integer	0..1
nativeUnits	NativeUnitEnum	0..1
sampleRate	float	0..1
significantDigits	integer	0..1
statistic	StatisticEnum	0..1
subType	DataItemSubTypeEnum	0..1
type	DataItemTypeEnum	1
units	UnitEnum	0..1
representation	RepresentationEnum	0..1
coordinateSystemIdRef	ID	0..1

Table 74: Value Properties of DataItem

2064 Descriptions for Value Properties of `DataItem`:

- 2065 • `category`
 2066 specifies the kind of information provided by a data item.
 2067 `CategoryEnum` Enumeration:
- 2068 – `CONDITION`
 2069 information about the health of a piece of equipment and its ability to function.
- 2070 – `EVENT`
 2071 discrete piece of information from the piece of equipment.
- 2072 – `SAMPLE`
 2073 continuously variable or analog data value.
 2074 A continuous value can be measured at any point-in-time and will always pro-
 2075 duce a result.
- 2076 • `compositionId`
 2077 identifier attribute of the `Composition` that the reported data is most closely as-
 2078 sociated.
- 2079 • `<<deprecated>> coordinateSystem`
 2080 for measured values relative to a coordinate system like `Position`, the coordinate
 2081 system used may be reported.
 2082 **DEPRECATED** in *Version 2.0*. Replaced by `coordinateSystemIdRef`.
- 2083 • `discrete`
 2084 indication signifying whether each value reported for the *Observation* is significant
 2085 and whether duplicate values are to be suppressed.
 2086 If a value is not defined for `discrete`, the default value **MUST** be `false`.
- 2087 • `id`
 2088 unique identifier for this data item.
- 2089 • `name`
 2090 name of the data item.
- 2091 • `nativeScale`
 2092 used to convert the reported value to represent the original measured value.

- 2093 • nativeUnits
- 2094 native units of measurement for the reported value of the data item.
- 2095 <<extensible>> NativeUnitEnum Enumeration:
- 2096 – AMPERE_HOUR
- 2097 electric charge in ampere hour.
- 2098 – BAR
- 2099 pressure in bar.
- 2100 – CENTIPOISE
- 2101 viscosity in centipoise.
- 2102 – CUBIC_FOOT
- 2103 geometric volume in cubic foot.
- 2104 – CUBIC_FOOT/HOUR
- 2105 change of geometric volume in cubic foot per hour.
- 2106 – CUBIC_FOOT/MINUTE
- 2107 change of geometric volume in cubic foot per minute.
- 2108 – DEGREE/MINUTE
- 2109 rotational velocity in degree per minute.
- 2110 – FAHRENHEIT
- 2111 temperature in Fahrenheit.
- 2112 – FOOT
- 2113 length in foot.
- 2114 – FOOT/MINUTE
- 2115 speed in foot per minute.
- 2116 – FOOT/SECOND
- 2117 speed in foot per second.
- 2118 – FOOT/SECOND²
- 2119 acceleration in foot per second squared.
- 2120 – FOOT_3D
- 2121 point in space identified by X, Y, and Z positions and represented by a space-
- 2122 delimited set of numbers each expressed in feet.
- 2123 – GALLON/MINUTE
- 2124 volumetric flow in gallon per minute.
- 2125 – GRAVITATIONAL_ACCELERATION
- 2126 acceleration relative to earth's gravity given in meter per second squared.

2127 Note 1 to entry: At different points on Earth's surface, the free-fall
2128 acceleration ranges from 9.764 to 9.834 m/s² (Wikipedia: Gravita-
2129 tional Acceleration). The constant can be customized depending on
2130 the location in the universe.

2131 Note 2 to entry: In the standard, it is assumed that Earth's average
2132 value of gravitational acceleration is 9.90665 m/s².

2133 – GRAVITATIONAL_FORCE
2134 MASS times GRAVITATIONAL_ACCELERATION (g).

2135 – HOUR
2136 time in hour.

2137 – INCH
2138 length in inch.

2139 – INCH/MINUTE
2140 speed in inch per minute.

2141 – INCH/REVOLUTION
2142 feedrate per revolution in inch per revolution.

2143 – INCH/SECOND
2144 speed in inch per second.

2145 – INCH/SECOND²
2146 acceleration in inch per second squared.

2147 – INCH_3D
2148 point in space identified by X, Y, and Z positions and represented by a space-
2149 delimited set of numbers each expressed in inches.

2150 – INCH_POUND
2151 torque in inch pound.

2152 – KELVIN
2153 temperature in Kelvin.

2154 – KILOWATT
2155 power in kilowatt.

2156 – KILOWATT_HOUR
2157 energy in kilowatt-hour.

2158 – LITER/MINUTE
2159 volumetric flow in liter per minute.

2160 – MICROMETER
2161 length in micrometer.

- 2162 – MICROTorr
- 2163 pressure in microtorr.
- 2164 – MILLIMETER/MINUTE
- 2165 speed in millimeter per minute.
- 2166 – MILLIMETER_MERCURY
- 2167 pressure in millimeter of mercury (mmHg).
- 2168 – MINUTE
- 2169 time in minute.
- 2170 – OTHER
- 2171 unsupported unit.
- 2172 – PASCAL/MINUTE
- 2173 pressurization rate in pascal per minute.
- 2174 – POUND
- 2175 mass in pound.
- 2176 – POUND / INCH²
- 2177 pressure in pound per square inch (PSI).
- 2178 – Radian
- 2179 angle in radian.
- 2180 – Radian/MINUTE
- 2181 angular velocity in radian per minute.
- 2182 – Radian/SECOND
- 2183 angular velocity in radian per second.
- 2184 – Radian/SECOND²
- 2185 angular acceleration in radian per second squared.
- 2186 – RANKINE
- 2187 temperature in Rankine.
- 2188 – SQUARE_INCH
- 2189 geometric area in inch squared.
- 2190 – TORR
- 2191 pressure in torr.

- 2192 • sampleRate
- 2193 rate at which successive samples of a data item are recorded by a piece of equipment.
- 2194 • significantDigits
- 2195 number of significant digits in the reported value.

- 2196 • `statistic`
- 2197 type of statistical calculation performed on a series of data samples to provide the
- 2198 reported data value.
- 2199 `StatisticEnum` Enumeration:
- 2200 – `AVERAGE`
- 2201 mathematical average value calculated for the data item during the calculation
- 2202 period.
- 2203 – `<<deprecated>> KURTOSIS`
- 2204 **DEPRECATED** in *Version 1.6*. `~~`A measure of the “peakedness” of a prob-
- 2205 ability distribution; i.e., the shape of the distribution curve.`~~`
- 2206 – `MAXIMUM`
- 2207 maximum or peak value recorded for the data item during the calculation pe-
- 2208 riod.
- 2209 – `MEDIAN`
- 2210 middle number of a series of numbers.
- 2211 – `MINIMUM`
- 2212 minimum value recorded for the data item during the calculation period.
- 2213 – `MODE`
- 2214 number in a series of numbers that occurs most often.
- 2215 – `RANGE`
- 2216 difference between the maximum and minimum value of a data item during the
- 2217 calculation period. Also represents Peak-to-Peak measurement in a waveform.
- 2218 – `ROOT_MEAN_SQUARE`
- 2219 mathematical Root Mean Square (RMS) value calculated for the data item dur-
- 2220 ing the calculation period.
- 2221 – `STANDARD_DEVIATION`
- 2222 statistical Standard Deviation value calculated for the data item during the cal-
- 2223 culation period.
- 2224 • `subType`
- 2225 sub-categorization of the `type`.
- 2226 `<<extensible>> DataItemSubTypeEnum` Enumeration:
- 2227 – `ABORTED`
- 2228 actions or activities that were attempted, but terminated before they could be
- 2229 completed.

- 2230 – ABSOLUTE
- 2231 relating to or derived in the simplest manner from the fundamental units or
- 2232 measurements.
- 2233 – ACTION
- 2234 indication of the operating state of a mechanism.
- 2235 – ACTIVE
- 2236 relating to logic or motion program currently executing.
- 2237 – ACTIVITY
- 2238 phase or segment of a recipe or program.
- 2239 – ACTUAL
- 2240 reported value of an observation.
- 2241 – ALL
- 2242 all actions, items, or activities being counted independent of the outcome.
- 2243 – <<deprecated>> ALTERNATING
- 2244 measurement of alternating voltage or current. If not specified further in statis-
- 2245 tic, defaults to RMS voltage.
- 2246 **DEPRECATED** in *Version 1.6*.
- 2247 – AUXILIARY
- 2248 when multiple locations on a piece of bar stock being feed by a bar feeder are
- 2249 referenced as the indication of whether the end of that piece of bar stock has
- 2250 been reached.
- 2251 – A_SCALE
- 2252 A-Scale weighting factor on the frequency scale.
- 2253 – BAD
- 2254 actions, items, or activities being counted that do not conform to specification
- 2255 or expectation.
- 2256 – BATCH
- 2257 group of parts produced in a batch.
- 2258 – BINARY
- 2259 observed as a binary data type.
- 2260 – BOOLEAN
- 2261 observed as a boolean data type.
- 2262 – BRINELL
- 2263 scale to measure the resistance to deformation of a surface.
- 2264 – B_SCALE
- 2265 B-Scale weighting factor on the frequency scale.

- 2266 – COMMANDED
- 2267 directive value including adjustments such as an offset or overrides.
- 2268 – COMPLETE
- 2269 associated with the completion of an activity or event.
- 2270 – CONSUMED
- 2271 amount of material consumed from an object or container during a manufacturing process.
- 2272
- 2273 – CONTROL
- 2274 state of the enabling signal or control logic that enables or disables the function or operation of the entity.
- 2275
- 2276 – C_SCALE
- 2277 C-Scale weighting factor on the frequency scale.
- 2278 – DELAY
- 2279 elapsed time of a temporary halt of action.
- 2280 – DETECT
- 2281 indicated by the presence or existence of something.
- 2282 – <<deprecated>> DIRECT
- 2283 DC current or voltage.
- 2284 **DEPRECATED** in *Version 1.6*.
- 2285 – DRY_RUN
- 2286 setting or operator selection used to execute a test mode to confirm the execution of machine functions.
- 2287
- 2288 – D_SCALE
- 2289 D-Scale weighting factor on the frequency scale.
- 2290 – ENDED
- 2291 boundary when an activity or an event terminates.
- 2292 – ENUMERATED
- 2293 observed as a set containing a restricted number of discrete values where each discrete value is named and unique. *Ref ISO 21961:2003, 013*
- 2294
- 2295 – EXPIRATION
- 2296 relating to the expiration or end of useful life for a material or other physical item.
- 2297
- 2298 – FAILED
- 2299 actions or activities that were attempted , but failed to complete or resulted in an unexpected or unacceptable outcome.
- 2300

- 2301 – FIRST_USE
- 2302 relating to the first use of a material or other physical item.
- 2303 – GAS
- 2304 fluid that has no definite shape or volume.
- 2305 – GATEWAY
- 2306 Gateway for the Component network.
- 2307 – GOOD
- 2308 actions, items, or activities being counted that conform to specification or ex-
- 2309 pectation.
- 2310 – HEAT_TREAT
- 2311 material heat number.
- 2312 – INCREMENTAL
- 2313 relating to or derived from the last observation.
- 2314 – INSTALL_DATE
- 2315 date the hardware or software was installed.
- 2316 – IPV4_ADDRESS
- 2317 IPV4 network address of the Component.
- 2318 – IPV6_ADDRESS
- 2319 IPV6 network address of the Component.
- 2320 – ISO_STEP_EXECUTABLE
- 2321 reference to a ISO 10303 Executable.
- 2322 – JOG
- 2323 relating to momentary activation of a function or a movement.
- 2324 **DEPRECATION WARNING:** May be deprecated in the future.
- 2325 – LATERAL
- 2326 indication of the position of a mechanism that may move in a lateral direction.
- 2327 – LEEB
- 2328 scale to measure the elasticity of a surface.
- 2329 – LENGTH
- 2330 reference to a length type tool offset variable.
- 2331 – LICENSE
- 2332 license code to validate or activate the hardware or software.
- 2333 – LINE
- 2334 state of the power source.

- 2335 – LINEAR
- 2336 direction of motion of a linear motion.
- 2337 – LIQUID
- 2338 fluid that has a definite volume but no definite shape.
- 2339 – LOADED
- 2340 indication that the subparts of a piece of equipment are under load.
- 2341 – LOT
- 2342 group of parts tracked as a lot.
- 2343 – MACHINE_AXIS_LOCK
- 2344 setting or operator selection that changes the behavior of the controller on a
- 2345 piece of equipment.
- 2346 – MAC_ADDRESS
- 2347 Media Access Control Address. The unique physical address of the network
- 2348 hardware.
- 2349 – MAIN
- 2350 relating to the primary logic or motion program currently being executed.
- 2351 – MAINTENANCE
- 2352 relating to maintenance on the piece of equipment.
- 2353 – MANUAL_UNCLAMP
- 2354 indication of the state of an operator controlled interlock that can inhibit the
- 2355 ability to initiate an unclamp action of an electronically controlled chuck.
- 2356 – MANUFACTURE
- 2357 related to the production of a material or other physical item.
- 2358 – MANUFACTURER
- 2359 corporate identity for the maker of the hardware or software.
- 2360 – MAXIMUM
- 2361 maximum value.
- 2362 – MEASURED
- 2363 that has *uncertainty*.
- 2364 – MINIMUM
- 2365 minimum value.
- 2366 – MODEL
- 2367 model info of the hardware or software.
- 2368 – MOHS
- 2369 scale to measure the resistance to scratching of a surface.

- 2370 – MOTION
- 2371 indication of the open or closed state of a mechanism.
- 2372 – NO_SCALE
- 2373 no weighting factor on the frequency scale.
- 2374 – OPERATING
- 2375 piece of equipment that is powered or performing any activity.
- 2376 – OPERATION
- 2377 step of a discrete manufacturing process.
- 2378 – OPERATOR
- 2379 relating to the person currently responsible for operating the piece of equip-
- 2380 ment.
- 2381 – OPTIONAL_STOP
- 2382 setting or operator selection that changes the behavior of the controller on a
- 2383 piece of equipment.
- 2384 – ORDER_NUMBER
- 2385 authorization of a process occurrence.
- 2386 – OVERRIDE
- 2387 overridden value.
- 2388 – PART
- 2389 amount included in the *part*.
- 2390 – PART_FAMILY
- 2391 group of parts having similarities in geometry, manufacturing process, and/or
- 2392 functions.
- 2393 – PART_NAME
- 2394 word or set of words by which a part is known, addressed, or referred to.
- 2395 – PART_NUMBER
- 2396 particular part design or model.
- 2397 – POWERED
- 2398 piece of equipment is powered and functioning or Component that are re-
- 2399 quired to remain on are powered.
- 2400 – PRIMARY
- 2401 main or principle.
- 2402 – PROBE
- 2403 position provided by a measurement probe.
- 2404 **DEPRECATION WARNING:** May be deprecated in the future.

- 2405 – PROCESS
- 2406 relating to production of a part or product on a piece of equipment.
- 2407 – PROCESS_NAME
- 2408 word or set of words by which a process being executed (process occurrence)
- 2409 by the device is known, addressed, or referred to.
- 2410 – PROCESS_PLAN
- 2411 process plan that a process occurrence belongs to.
- 2412 – PROCESS_STEP
- 2413 step in the process plan that this occurrence corresponds to.
- 2414 – PROGRAMMED
- 2415 directive value without offsets and adjustments.
- 2416 – RADIAL
- 2417 reference to a radial type tool offset variable.
- 2418 – RAPID
- 2419 performing an operation faster or in less time than nominal rate.
- 2420 – RAW_MATERIAL
- 2421 material that is used to produce parts.
- 2422 – RECIPE
- 2423 process as part of product production; can be a subprocess of a larger process.
- 2424 – RELEASE_DATE
- 2425 date the hardware or software was released for general use.
- 2426 – REMAINING
- 2427 remaining measure or count of an action, object or activity.
- 2428 – REQUEST
- 2429 *request* by an Interface for a task.
- 2430 – RESPONSE
- 2431 *response* by an Interface to a *request* for a task.
- 2432 – ROCKWELL
- 2433 scale to measure the resistance to deformation of a surface.
- 2434 – ROTARY
- 2435 direction of a rotary motion using the right hand rule convention.
- 2436 – SCHEDULE
- 2437 identity of a control program that is used to specify the order of execution of
- 2438 other programs.

- 2439 – SEGMENT
- 2440 phase of a recipe process.
- 2441 – SERIAL_NUMBER
- 2442 serial number that uniquely identifies a specific part.
- 2443 – SET_UP
- 2444 relating to the preparation of a piece of equipment for production or restoring
- 2445 the piece of equipment to a neutral state after production.
- 2446 – SHORE
- 2447 scale to measure the resistance to deformation of a surface.
- 2448 – SINGLE_BLOCK
- 2449 setting or operator selection that changes the behavior of the controller on a
- 2450 piece of equipment.
- 2451 – SOLID
- 2452 matter that has a definite shape and a definite volume.
- 2453 – STANDARD
- 2454 standard measure of an object or an action.
- 2455 – START
- 2456 boundary when an activity or an event commences.
- 2457 – SUBNET_MASK
- 2458 SubNet mask for the Component network.
- 2459 – SWITCHED
- 2460 indication of the activation state of a mechanism represented by a Composi-
- 2461 tion.
- 2462 – TARGET
- 2463 goal of the operation or process.
- 2464 – TARGET_COMPLETION
- 2465 relating to the end or completion of an activity or event.
- 2466 – TOOL_CHANGE_STOP
- 2467 setting or operator selection that changes the behavior of the controller on a
- 2468 piece of equipment.
- 2469 – USEABLE
- 2470 remaining usable measure of an object or action.
- 2471 – UUID
- 2472 universally unique identifier as specified in ISO 11578 or RFC 4122.

- 2473 – VERSION
- 2474 version of the hardware or software.
- 2475 – VERTICAL
- 2476 indication of the position of a mechanism that may move in a vertical direction.
- 2477 – VICKERS
- 2478 scale to measure the resistance to deformation of a surface.
- 2479 – VLAN_ID
- 2480 layer2 Virtual Local Network (VLAN) ID for the Component network.
- 2481 – WASTE
- 2482 amount discarded.
- 2483 – WIRELESS
- 2484 identifies whether the connection type is wireless.
- 2485 – WORKING
- 2486 piece of equipment performing any activity, the equipment is active and per-
- 2487 forming a function under load or not.

- 2488 • type
- 2489 type of data being measured. See *Section 6.5 - DataItem Types*.
- 2490 The value of type **MUST** be one of the DataItemTypeEnum enumeration.

- 2491 • units
- 2492 unit of measurement for the reported value of the data item.
- 2493 <<extensible>> UnitEnum Enumeration:

- 2494 – AMPERE
- 2495 electric current in ampere.
- 2496 – CELSIUS
- 2497 temperature in degree Celsius.
- 2498 – COULOMB
- 2499 electric charge in coulomb.
- 2500 – COUNT
- 2501 count of something.
- 2502 – COUNT/SECOND
- 2503 frequency in count per second.
- 2504 – CUBIC_METER
- 2505 geometric volume in meter.

- 2506 – CUBIC_MILLIMETER
- 2507 geometric volume in millimeter.
- 2508 – CUBIC_MILLIMETER/SECOND
- 2509 change of geometric volume per second.
- 2510 – CUBIC_MILLIMETER/SECOND²
- 2511 change in geometric volume per second squared.
- 2512 – DECIBEL
- 2513 sound level in decibel.
- 2514 – DEGREE
- 2515 angle in degree.
- 2516 – DEGREE/SECOND
- 2517 angular velocity in degree per second.
- 2518 – DEGREE/SECOND²
- 2519 angular acceleration in degree per second squared.
- 2520 – DEGREE_3D
- 2521 space-delimited, floating-point representation of the angular rotation in degrees
- 2522 around the X, Y, and Z axes relative to a cartesian coordinate system respec-
- 2523 tively in order as A, B, and C.
- 2524 If any of the rotations is not known, it **MUST** be zero (0).
- 2525 – GRAM
- 2526 mass in gram.
- 2527 – GRAM/CUBIC_METER
- 2528 density in gram per cubic meter.
- 2529 – HERTZ
- 2530 frequency in cycles per second.
- 2531 – JOULE
- 2532 energy in joule.
- 2533 – KILOGRAM
- 2534 mass in kilogram.
- 2535 – LITER
- 2536 volume in liter.
- 2537 – LITER/SECOND
- 2538 volumetric flow in liter per second.
- 2539 – METER/SECOND²
- 2540 acceleration in meter per second squared.

2541	– MICRO_RADIAN
2542	tilt in micro radian.
2543	– MILLIGRAM
2544	mass in milligram.
2545	– MILLIGRAM/CUBIC_MILLIMETER
2546	density in milligram per cubic millimeter.
2547	– MILLILITER
2548	volume in milliliter.
2549	– MILLIMETER
2550	length in millimeter.
2551	– MILLIMETER/REVOLUTION
2552	feedrate per revolution in millimeter per revolution.
2553	– MILLIMETER/SECOND
2554	speed in millimeter per second.
2555	– MILLIMETER/SECOND ²
2556	acceleration in millimeter per second squared.
2557	– MILLIMETER_3D
2558	point in space identified by X, Y, and Z positions and represented by a space-
2559	delimited set of numbers each expressed in millimeters.
2560	– NEWTON
2561	force in newton.
2562	– NEWTON_METER
2563	torque in newton-meter.
2564	– OHM
2565	electrical resistance in ohm.
2566	– OHM_METER
2567	resistivity in ohm-meter.
2568	– PASCAL
2569	pressure or stress in pascal.
2570	– PASCAL/SECOND
2571	pressurization rate in pascal per second.
2572	– PASCAL_SECOND
2573	viscosity in pascal-second.
2574	– PERCENT
2575	amount in or for every hundred.

- 2576 – PH
- 2577 acidity or alkalinity of a solution in pH.
- 2578 – REVOLUTION/MINUTE
- 2579 rotational velocity in revolution per minute.
- 2580 – REVOLUTION/SECOND
- 2581 rotational velocity in revolution per second.
- 2582 – REVOLUTION/SECOND²
- 2583 rotational acceleration in revolution per second squared.
- 2584 – SECOND
- 2585 time in second.
- 2586 – SIEMENS/METER
- 2587 electrical conductivity in siemens per meter.
- 2588 – SQUARE_MILLIMETER
- 2589 geometric area in millimeter.
- 2590 – UNIT_VECTOR_3D
- 2591 3D Unit Vector.
- 2592 Space delimited list of three floating point numbers.
- 2593 – VOLT
- 2594 electric potential, electric potential difference or electromotive force in volt.
- 2595 – VOLT_AMPERE
- 2596 apparent power in an electrical circuit, equal to the product of root-mean-square (RMS) voltage and RMS current (commonly referred to as VA) in volt-
- 2597 square (RMS) voltage and RMS current (commonly referred to as VA) in volt-
- 2598 ampere.
- 2599 – VOLT_AMPERE_REACTIVE
- 2600 reactive power in an AC electrical circuit (commonly referred to as VAR) in
- 2601 volt-ampere-reactive.
- 2602 – WATT
- 2603 power in watt.
- 2604 – WATT_SECOND
- 2605 electrical energy in watt-second
- 2606 • `representation`
- 2607 description of a means to interpret data consisting of multiple data points or samples
- 2608 reported as a single value.
- 2609 If `representation` is not specified, it **MUST** be determined to be `VALUE`.
- 2610 `RepresentationEnum` Enumeration:

- 2611 – DATA_SET
- 2612 reported value(s) are represented as a set of *key-value pairs*.
- 2613 Each reported value in the *data set* **MUST** have a unique key.
- 2614 – <<deprecated>> DISCRETE
- 2615 **DEPRECATED** as representation type in *MTConnect Version 1.5*. Re-
- 2616 placed by the discrete.
- 2617 – TABLE
- 2618 two dimensional set of *key-value pairs* where the Entry represents a row, and
- 2619 the value is a set of *key-value pair* Cell elements.
- 2620 A *table* follows the same behavior as the *data set* for change tracking, clearing,
- 2621 and history. When an Entry changes, all Cell elements update as a single
- 2622 unit following the behavior of a *data set*.
- 2623 Note: It is best to use Variable if the Cell entities represent mul-
- 2624 tiple semantic types.
- 2625 Each Entry in the *table* **MUST** have a unique key. Each Cell of each En-
- 2626 try in the *table* **MUST** have a unique key.
- 2627 See Representation in *MTConnect Standard: Part 3.0 - Observation In-*
- 2628 formation Model, for a description of Entry and Cell elements.
- 2629 – TIME_SERIES
- 2630 series of sampled data.
- 2631 The data is reported for a specified number of samples and each sample is
- 2632 reported with a fixed period.
- 2633 – VALUE
- 2634 measured value of the sample data.
- 2635 If no representation is specified for a data item, the representation
- 2636 **MUST** be determined to be VALUE.
- 2637 • coordinateSystemIdRef
- 2638 associated CoordinateSystem context for the DataItem.

2639 6.1.1.2 Reference Properties of DataItem

2640 Table 75 lists the Reference Properties of DataItem.

Reference Property name	Multiplicity
Observation (organized by Observations)	0..*

Table 75: Reference Properties of DataItem

2641 Descriptions for Reference Properties of DataItem:

- 2642 • **Observation**
2643 abstract entity that provides telemetry data for a DataItem at a point in time.
2644 Observations groups one or more Observation entities made for the DataItem
2645 entity.
2646 Component observes DataItem entities to create Observation entities for
2647 the DataItem entities.
2648 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Ob-
2649 servation model.

2650 Note 1 to entry: In the XML representation, Observation entities
2651 **MUST NOT** appear in the *MTConnectDevices Response Document*.

2652 Note 2 to entry: In the XML representation, Observation entities
2653 **MUST** appear only in the *MTConnectStreams Response Document*.

2654 6.1.1.3 Part Properties of DataItem

2655 Table 76 lists the Part Properties of DataItem.

Part Property name	Multiplicity
Source	0..1
Constraints	0..1
Filter (organized by Filters)	0..*
InitialValue	0..1
ResetTrigger	0..1
Definition	0..1
AbstractDataItemRelationship (organized by Relationships)	0..*

Table 76: Part Properties of DataItem

2656 Descriptions for Part Properties of DataItem:

- 2657 • Source
- 2658 identifies the Component, DataItem, or Composition from which a mea-
- 2659 sured value originates.
- 2660 See *Section 6.2.2 - Source*.
- 2661 • Constraints
- 2662 organizes a set of expected values that can be reported for a DataItem.
- 2663 Constraints organizes a set of expected values that can be reported for the
- 2664 DataItem. See *Section 6.2.7 - Constraints*.
- 2665 • Filter
- 2666 provides a means to control when an *agent* records updated information for a DataItem.
- 2667 Filters groups one or more Filter entities associated with the DataItem.
- 2668 • InitialValue
- 2669 starting value for a DataItem as well as the value to be set for the DataItem
- 2670 after a reset event.
- 2671 • ResetTrigger
- 2672 type of event that may cause a reset to occur.
- 2673 • Definition
- 2674 defines the meaning of Entry and Cell entities when the associated represen-
- 2675 tation is either DATA_SET or TABLE.
- 2676 See *Section 6.2.8 - Definition*.
- 2677 • AbstractDataItemRelationship
- 2678 association between a DataItem and another entity.
- 2679 Relationships groups one or more DataItemRelationship and Spec-
- 2680 ificationRelationship. See *Section 8.4 - Relationships*.

2681 6.2 Properties of DataItem

2682 This section provides additional semantic information for the Part Properties of DataItem.

2683 Note: See *Section B.2 - DataItems Schema Diagrams* for XML schema of the

2684 elements for DataItem.

2685 6.2.1 ResetTrigger

2686 type of event that may cause a reset to occur.

2687 ResetTriggerEnum Enumeration:

- 2688 • ACTION_COMPLETE
- 2689 observation of the DataItem that is measuring an action or operation is to be reset
- 2690 upon completion of that action or operation.
- 2691 • ANNUAL
- 2692 observation of the DataItem is to be reset at the end of a 12-month period.
- 2693 • DAY
- 2694 observation of the DataItem is to be reset at the end of a 24-hour period.
- 2695 • LIFE
- 2696 observation of the DataItem is not reset and accumulates for the entire life of the
- 2697 piece of equipment.
- 2698 • MAINTENANCE
- 2699 observation of the DataItem is to be reset upon completion of a maintenance
- 2700 event.
- 2701 • MONTH
- 2702 observation of the DataItem is to be reset at the end of a monthly period.
- 2703 • POWER_ON
- 2704 observation of the DataItem is to be reset when power was applied to the piece of
- 2705 equipment after a planned or unplanned interruption of power has occurred.
- 2706 • SHIFT
- 2707 observation of the DataItem is to be reset at the end of a work shift.
- 2708 • WEEK
- 2709 observation of the DataItem is to be reset at the end of a 7-day period.

2710 6.2.2 Source

2711 identifies the Component, DataItem, or Composition from which a measured value
2712 originates.

2713 The value of Source **MUST** be string.

2714 6.2.2.1 Value Properties of Source

2715 Table 77 lists the Value Properties of Source.

Value Property name	Value Property type	Multiplicity
componentId	ID	0..1
compositionId	ID	0..1
dataItemId	ID	0..1

Table 77: Value Properties of Source

2716 Descriptions for Value Properties of Source:

- 2717 • componentId
2718 identifier of the Component that represents the physical part of a piece of equip-
2719 ment where the data represented by the DataItem originated.
- 2720 • compositionId
2721 identifier of the Composition that represents the physical part of a piece of equip-
2722 ment where the data represented by the DataItem originated.
- 2723 • dataItemId
2724 identifier of the DataItem that represents the originally measured value of the data
2725 referenced by this DataItem.

2726 6.2.3 InitialValue

2727 starting value for a DataItem as well as the value to be set for the DataItem after a
2728 reset event.

2729 The value of InitialValue **MUST** be string.

2730 6.2.4 Filter

2731 provides a means to control when an *agent* records updated information for a `DataItem`.

2732 The value of `Filter` **MUST** be float.

2733 6.2.4.1 Value Properties of Filter

2734 *Table 78* lists the Value Properties of `Filter`.

Value Property name	Value Property type	Multiplicity
type	FilterEnum	1

Table 78: Value Properties of Filter

2735 Descriptions for Value Properties of `Filter`:

2736 • type

2737 type of `Filter`.

2738 `FilterEnum` Enumeration:

2739 – MINIMUM_DELTA

2740 new value **MUST NOT** be reported for a data item unless the measured value
2741 has changed from the last reported value by at least the delta given as the value
2742 of this element.

2743 The value of `Filter` **MUST** be an absolute value using the same units as the
2744 reported data.

2745 – PERIOD

2746 data reported for a data item is provided on a periodic basis. The `PERIOD` for
2747 reporting data is defined in the value of the `Filter`.

2748 The value of `Filter` **MUST** be an absolute value reported in seconds repre-
2749 senting the time between reported samples of the value of the data item.

2750 6.2.5 <<hasFormatSpecificRepresentation>>MinimumDeltaFilter

2751 new value **MUST NOT** be reported for a data item unless the measured value has changed
2752 from the last reported value by at least the delta given as the value of this element.

2753 The value of `Filter` **MUST** be an absolute value using the same units as the reported
 2754 data.

2755 **6.2.6 <<hasFormatSpecificRepresentation>>PeriodFilter**

2756 data reported for a data item is provided on a periodic basis. The `PERIOD` for reporting
 2757 data is defined in the value of the `Filter`.

2758 The value of `Filter` **MUST** be an absolute value reported in seconds representing the
 2759 time between reported samples of the value of the data item.

2760 The value of `PeriodFilter` **MUST** be `SECOND`. See *Section 9.1.9 - SECOND*.

2761 **6.2.7 Constraints**

2762 *organizes* a set of expected values that can be reported for a `DataItem`.

2763 **6.2.7.1 Value Properties of Constraints**

2764 *Table 79* lists the Value Properties of `Constraints`.

Value Property name	Value Property type	Multiplicity
Maximum	float	0..1
Minimum	float	0..1
Nominal	float	0..1
Value	string	0..*

Table 79: Value Properties of Constraints

2765 Descriptions for Value Properties of `Constraints`:

- 2766 • Maximum
- 2767 numeric upper constraint.
- 2768 If the data reported for a data item is a range of numeric values, the expected value
- 2769 reported **MAY** be described with an upper limit defined by this constraint.
- 2770 • Minimum

- 2771 numeric lower constraint.
- 2772 If the data reported for a data item is a range of numeric values, the expected value
- 2773 reported **MAY** be described with a lower limit defined by this constraint.
- 2774 • Nominal
- 2775 numeric target or expected value.
- 2776 • Value
- 2777 single data value that is expected to be reported for a `DataItem`.
- 2778 Value **MUST NOT** be used in conjunction with any other Constraint ele-
- 2779 ments.

2780 6.2.7.2 Part Properties of Constraints

2781 *Table 80* lists the Part Properties of Constraints.

Part Property name	Multiplicity
<<deprecated>> Filter	0..1

Table 80: Part Properties of Constraints

2782 Descriptions for Part Properties of Constraints:

- 2783 • Filter
- 2784 provides a means to control when an *agent* records updated information for a `DataItem`.
- 2785 **DEPRECATED** in *MTConnect Version 1.4*. Moved to the Filters. See *Sec-*
- 2786 *tion 6.2 - Properties of DataItem*.

2787 6.2.8 Definition

2788 defines the meaning of `Entry` and `Cell` entities when the associated representa-

2789 tion is either `DATA_SET` or `TABLE`.

2790 6.2.8.1 Part Properties of Definition

2791 *Table 81* lists the Part Properties of Definition.

Part Property name	Multiplicity
CellDefinition (organized by CellDefinitions)	0..*
EntryDefinition (organized by EntryDefinitions)	0..*

Table 81: Part Properties of Definition

2792 Descriptions for Part Properties of Definition:

- 2793 • CellDefinition
- 2794 semantic definition of a Cell.
- 2795 CellDefinitions groups one or more CellDefinition entities. See *Sec-*
- 2796 *tion 6.3.1 - CellDefinition.*
- 2797 • EntryDefinition
- 2798 semantic definition of an Entry.
- 2799 EntryDefinitions groups one or more EntryDefinition entities. See
- 2800 *Section 6.3.2 - EntryDefinition.*

2801 6.3 Properties of Definition

2802 This section provides semantic information for the elements of the Definition for a

2803 DataItem.

2804 6.3.1 CellDefinition

2805 semantic definition of a Cell.

2806 6.3.1.1 Value Properties of CellDefinition

2807 Table 82 lists the Value Properties of CellDefinition.

Value Property name	Value Property type	Multiplicity
units	UnitEnum	0..1
key	string	0..1
type	DataItemTypeEnum	0..1
subType	DataItemSubTypeEnum	0..1
keyType	DataItemTypeEnum	0..1

Table 82: Value Properties of CellDefinition

2808 Descriptions for Value Properties of CellDefinition:

- 2809 • units
- 2810 same as units. See *Section 6.1.1.1 - Value Properties of DataItem*.
- 2811 The value of units **MUST** be one of the UnitEnum enumeration.
- 2812 • key
- 2813 unique identification of the Cell in the Definition.
- 2814 The description applies to all Cell observations having this key.
- 2815 • type
- 2816 same as type. See *Section 6.5 - DataItem Types*.
- 2817 The value of type **MUST** be one of the DataItemTypeEnum enumeration.
- 2818 • subType
- 2819 same as subType. See *Section 6.1.1 - DataItem*.
- 2820 The value of subType **MUST** be one of the DataItemSubTypeEnum enumer-
- 2821 ation.
- 2822 • keyType
- 2823 type that defines the meaning of key.
- 2824 The value of keyType **MUST** be one of the DataItemTypeEnum enumeration.

2825 6.3.2 EntryDefinition

2826 semantic definition of an Entry.

2827 6.3.2.1 Value Properties of EntryDefinition

2828 *Table 83* lists the Value Properties of EntryDefinition.

Value Property name	Value Property type	Multiplicity
key	string	0..1
units	UnitEnum	0..1
type	DataItemTypeEnum	0..1
subType	DataItemSubTypeEnum	0..1
keyType	DataItemTypeEnum	0..1

Table 83: Value Properties of EntryDefinition

2829 Descriptions for Value Properties of EntryDefinition:

- 2830 • key
- 2831 unique identification of the Entry in the Definition.
- 2832 The description applies to all Entry observations having this key.
- 2833 • units
- 2834 same as units. See *Section 6.1.1.1 - Value Properties of DataItem*.
- 2835 The value of units **MUST** be one of the UnitEnum enumeration.
- 2836 • type
- 2837 same as type. See *Section 6.5 - DataItem Types*.
- 2838 The value of type **MUST** be one of the DataItemTypeEnum enumeration.
- 2839 • subType
- 2840 same as subType. See *Section 6.1.1 - DataItem*.
- 2841 The value of subType **MUST** be one of the DataItemSubTypeEnum enumeration.
- 2842 ation.
- 2843 • keyType
- 2844 type that defines the meaning of key.
- 2845 The value of keyType **MUST** be one of the DataItemTypeEnum enumeration.

2846 6.3.2.2 Part Properties of EntryDefinition

2847 *Table 84* lists the Part Properties of EntryDefinition.

Part Property name	Multiplicity
CellDefinition (organized by CellDefinitions)	0..*

Table 84: Part Properties of EntryDefinition

2848 Descriptions for Part Properties of EntryDefinition:

- 2849 • CellDefinition
- 2850 semantic definition of a Cell.
- 2851 CellDefinitions groups one or more CellDefinition entities if repre-
- 2852 sentation is TABLE. See *Section 6.3.1 - CellDefinition*.

2853 6.4 Relationship Types for DataItem

2854 This section provides semantic information for the types of AbstractDataItemRe-

2855 lationship that can be defined for a DataItem.

2856 6.4.1 AbstractDataItemRelationship

2857 association between a DataItem and another entity.

2858 AbstractDataItemRelationship is an abstract entity and hence will be realized

2859 by specific AbstractDataItemRelationship types in an MTConnectDevices

2860 entity. See *Section 6.4 - Relationship Types for DataItem*.

2861 6.4.1.1 Value Properties of AbstractDataItemRelationship

2862 Table 85 lists the Value Properties of AbstractDataItemRelationship.

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

Table 85: Value Properties of AbstractDataItemRelationship

2863 Descriptions for Value Properties of AbstractDataItemRelationship:

- 2864 • idRef
- 2865 reference to the related entity's id.
- 2866 • name
- 2867 descriptive name associated with this AbstractDataItemRelationship.

2868 6.4.2 SpecificationRelationship

2869 AbstractDataItemRelationship that provides a semantic reference to another
 2870 Specification described by type and idRef.

2871 6.4.2.1 Value Properties of SpecificationRelationship

2872 Table 86 lists the Value Properties of SpecificationRelationship.

Value Property name	Value Property type	Multiplicity
type	SpecificationRelationshipTypeEnum	1

Table 86: Value Properties of SpecificationRelationship

2873 Descriptions for Value Properties of SpecificationRelationship:

- 2874 • type
- 2875 specifies how the Specification is related.
- 2876 SpecificationRelationshipTypeEnum Enumeration:
- 2877 – LIMIT
- 2878 referenced Specification provides process limits.

2879 6.4.3 DataItemRelationship

2880 AbstractDataItemRelationship that provides a semantic reference to another
 2881 DataItem described by type.

2882 6.4.3.1 Value Properties of DataItemRelationship

2883 Table 87 lists the Value Properties of DataItemRelationship.

Value Property name	Value Property type	Multiplicity
type	DataItemRelationshipTypeEnum	1

Table 87: Value Properties of DataItemRelationship

2884 Descriptions for Value Properties of DataItemRelationship:

- 2885 • type
- 2886 specifies how the DataItem is related.
- 2887 DataItemRelationshipTypeEnum Enumeration:
- 2888 – ATTACHMENT
 - 2889 reference to a DataItem that associates the values with an external entity.
 - 2890 – COORDINATE_SYSTEM
 - 2891 referenced DataItem provides the id of the effective Coordinate System.
 - 2892 – LIMIT
 - 2893 referenced DataItem provides process limits.
 - 2894 – OBSERVATION
 - 2895 referenced DataItem provides the observed values.

2896 6.5 DataItem Types

2897 This section provides semantic information for the types of a DataItem.

2898 In the MTConnect Standard, DataItem are defined and organized based upon the cat-
2899 egory and type. The category provides a high level grouping for DataItems based
2900 on the kind of information that is reported by the data item.

2901 These categories are:

- 2902 • SAMPLE: A SAMPLE reports a continuously variable or analog data value.
- 2903 • EVENT: An EVENT reports information representing a functional state, with two or
2904 more discrete values, associated with a component or it contains a message. The
2905 data provided may be a numeric value or text.
- 2906 • CONDITION: A CONDITION reports information about the health of a piece of
2907 equipment and its ability to function.

The `type` specifies the specific kind of data that is reported. For some types of data items, a `subType` may also be used to differentiate between multiple data items of the same `type` where the information reported by the data item has a different, but related, meaning.

Many types of data items provide two forms of data: a value (reported as either a `SAMPLE` or `EVENT`) and a health status (reported as a `CONDITION`). These `DataItem` types **MAY** be defined in more than one category based on the data that they report.

6.5.1 Condition

abstract `DataItem` that is about an entity's status regarding its ability to operate or it provides an indication whether the data reported for the entity is within an expected range.

`Condition` is reported differently than `Sample` or `Event`. `Condition` **MUST** be reported as `Normal`, `Warning`, or `Fault`.

All `Samples` **MAY** have associated `Condition` states. `Condition` states indicate whether the value for the data is within an expected range and **MUST** be reported as `Normal`, or the value is unexpected or out of tolerance for the data and a `Warning` or `Fault` **MUST** be provided.

6.5.1.1 Value Properties of Condition

Table 88 lists the Value Properties of `Condition`.

Value Property name	Value Property type	Multiplicity
<code>category</code>	<code>CONDITION</code>	1
<code>type</code>	<code>ConditionEnum</code>	1

Table 88: Value Properties of Condition

Descriptions for Value Properties of `Condition`:

- `type`

<<extensible>> `ConditionEnum` Enumeration:

- `ACTUATOR`

indication of a fault associated with an actuator.

- 2931 – COMMUNICATIONS
- 2932 indication that the piece of equipment has experienced a communications fail-
- 2933 ure.
- 2934 – DATA_RANGE
- 2935 indication that the value of the data associated with a measured value or a
- 2936 calculation is outside of an expected range.
- 2937 – LOGIC_PROGRAM
- 2938 indication that an error occurred in the logic program or programmable logic
- 2939 controller (PLC) associated with a piece of equipment.
- 2940 – MOTION_PROGRAM
- 2941 indication that an error occurred in the motion program associated with a piece
- 2942 of equipment.
- 2943 – SYSTEM
- 2944 general purpose indication associated with an electronic component of a piece
- 2945 of equipment or a controller that represents a fault that is not associated with
- 2946 the operator, program, or hardware.

2947 6.5.2 Event

2948 abstract `DataItem` that is a discrete piece of information from a piece of equipment. It
 2949 does not have intermediate values that vary over time.

2950 An `Event` is information that, when provided at any specific point in time, represents the
 2951 current state of the piece of equipment.

2952 6.5.2.1 Value Properties of Event

2953 *Table 89* lists the Value Properties of `Event`.

Value Property name	Value Property type	Multiplicity
category	EVENT	1
type	EventEnum	1

Table 89: Value Properties of Event

2954 Descriptions for Value Properties of `Event`:

- 2955 • type

2956 <<extensible>> EventEnum Enumeration:

2957 – ACTIVATION_COUNT

2958 accumulation of the number of times a function has attempted to, or is planned

2959 to attempt to, activate or be performed.

2960 – ACTIVE_AXES

2961 set of axes currently associated with a Path or Controller.

2962 – ACTIVE_POWER_SOURCE

2963 active energy source for the Component.

2964 – ACTUATOR_STATE

2965 operational state of an apparatus for moving or controlling a mechanism or

2966 system.

2967 – ADAPTER_SOFTWARE_VERSION

2968 originator's software version of the *adapter*.

2969 – ADAPTER_URI

2970 Uniform Resource Identifier (URI) of the *adapter*.

2971 – <<deprecated>> ALARM

2972 **DEPRECATED:** Replaced with CONDITION category data items in Version

2973 1.1.0.

2974 – <<deprecated>> ALARM_LIMIT

2975 set of limits used to trigger warning or alarm indicators.

2976 **DEPRECATED** in Version 2.5. Replaced by ALARM_LIMITS.

2977 – ALARM_LIMITS

2978 set of limits used to trigger warning or alarm indicators.

2979 – APPLICATION

2980 application on a Component.

2981 – ASSET_CHANGED

2982 assetId of the *Asset* that has been added or changed.

2983 – ASSET_COUNT

2984 data set of the number of *Assets* of a given type for a *Device*.

2985 – ASSET_REMOVED

2986 assetId of the *Asset* that has been removed.

2987 – AVAILABILITY

2988 agent's ability to communicate with the data source.

- 2989 – `AXIS_COUPLING`
- 2990 describes the way the axes will be associated to each other.
- 2991 This is used in conjunction with `COUPLED_AXES` to indicate the way they are
- 2992 interacting.
- 2993 – `AXIS_FEEDRATE_OVERRIDE`
- 2994 value of a signal or calculation issued to adjust the feedrate of an individual
- 2995 linear type axis.
- 2996 – `AXIS_INTERLOCK`
- 2997 state of the axis lockout function when power has been removed and the axis
- 2998 is allowed to move freely.
- 2999 – `AXIS_STATE`
- 3000 state of a Linear or Rotary component representing an axis.
- 3001 – `BATTERY_STATE`
- 3002 present status of the battery.
- 3003 – `BLOCK`
- 3004 line of code or command being executed by a Controller entity.
- 3005 – `BLOCK_COUNT`
- 3006 total count of the number of blocks of program code that have been executed
- 3007 since execution started.
- 3008 – `CHARACTERISTIC_PERSISTENT_ID`
- 3009 UUID of the *characteristic*.
- 3010 – `CHARACTERISTIC_STATUS`
- 3011 pass/fail result of the measurement.
- 3012 – `CHUCK_INTERLOCK`
- 3013 state of an interlock function or control logic state intended to prevent the as-
- 3014 sociated Chuck component from being operated.
- 3015 – `CHUCK_STATE`
- 3016 operating state of a mechanism that holds a part or stock material during a
- 3017 manufacturing process.
- 3018 It may also represent a mechanism that holds any other mechanism in place
- 3019 within a piece of equipment.
- 3020 – `CLOCK_TIME`
- 3021 time provided by a timing device at a specific point in time.
- 3022 – `<<deprecated>> CODE`
- 3023 programmatic code being executed.
- 3024 **DEPRECATED** in *Version 1.1*.

- 3025 – COMPONENT_DATA
- 3026 Event that represents a Component where the EntryDefinition identifies the Component and the CellDefinitions define the Component's
- 3027 observed DataItems.
- 3028
- 3029 – COMPOSITION_STATE
- 3030 operating state of a mechanism represented by a Composition entity.
- 3031 – CONNECTION_STATUS
- 3032 status of the connection between an *adapter* and an *agent*.
- 3033 – CONTROLLER_MODE
- 3034 current mode of the Controller component.
- 3035 – CONTROLLER_MODE_OVERRIDE
- 3036 setting or operator selection that changes the behavior of a piece of equipment.
- 3037 – <<deprecated>> CONTROL_LIMIT
- 3038 set of limits used to indicate whether a process variable is stable and in control.
- 3039 **DEPRECATED** in Version 2.5. Replaced by CONTROL_LIMITS.
- 3040 – CONTROL_LIMITS
- 3041 set of limits used to indicate whether a process variable is stable and in control.
- 3042 – COUPLED_AXES
- 3043 set of associated axes.
- 3044 – CYCLE_COUNT
- 3045 accumulation of the number of times a cyclic function has attempted to, or is
- 3046 planned to attempt to execute.
- 3047 – DATE_CODE
- 3048 time and date code associated with a material or other physical item.
- 3049 – DEACTIVATION_COUNT
- 3050 accumulation of the number of times a function has attempted to, or is planned
- 3051 to attempt to, deactivate or cease.
- 3052 – DEVICE_ADDED
- 3053 UUID of new device added to an *MTConnect Agent*.
- 3054 – DEVICE_CHANGED
- 3055 UUID of the device whose *metadata* has changed.
- 3056 – DEVICE_REMOVED
- 3057 UUID of a device removed from an *MTConnect Agent*.
- 3058 – DEVICE_UUID
- 3059 identifier of another piece of equipment that is temporarily associated with a
- 3060 component of this piece of equipment to perform a particular function.

- 3061 – DIRECTION
- 3062 direction of motion.
- 3063 – DOOR_STATE
- 3064 operational state of a Door component or composition element.
- 3065 – EMERGENCY_STOP
- 3066 state of the emergency stop signal for a piece of equipment, controller path, or
- 3067 any other component or subsystem of a piece of equipment.
- 3068 – END_OF_BAR
- 3069 indication of whether the end of a piece of bar stock being feed by a bar feeder
- 3070 has been reached.
- 3071 – EQUIPMENT_MODE
- 3072 indication that a piece of equipment, or a sub-part of a piece of equipment, is
- 3073 performing specific types of activities.
- 3074 – EXECUTION
- 3075 operating state of a Component.
- 3076 – FEATURE_MEASUREMENT
- 3077 assessing elements of a *feature*.
- 3078 – FEATURE_PERSISTENT_ID
- 3079 UUID of a *feature*. *Ref ISO 10303 AP 242/239.*
- 3080 – FIRMWARE
- 3081 embedded software of a Component .
- 3082 – FIXTURE_ID
- 3083 identifier for the current workholding or part clamp in use by a piece of equip-
- 3084 ment.
- 3085 – FUNCTIONAL_MODE
- 3086 current intended production status of the Component.
- 3087 – HARDNESS
- 3088 hardness of a material.
- 3089 – HARDWARE
- 3090 hardware of a Component.
- 3091 – HOST_NAME
- 3092 name of the host computer supplying data.
- 3093 – LEAK_DETECT
- 3094 indication designating whether a leak has been detected.

- 3095 – LIBRARY
- 3096 software library on a Component
- 3097 – <<deprecated>> LINE
- 3098 current line of code being executed.
- 3099 **DEPRECATED** in *Version 1.4.0*.
- 3100 – LINE_LABEL
- 3101 identifier for a Block of code in a Program.
- 3102 – LINE_NUMBER
- 3103 position of a block of program code within a control program.
- 3104 – LOAD_COUNT
- 3105 accumulation of the number of times an operation has attempted to, or is
- 3106 planned to attempt to, load materials, parts, or other items.
- 3107 – LOCATION_ADDRESS
- 3108 structured information that allows the unambiguous determination of an object
- 3109 for purposes of identification and location. *Ref ISO 19160-4:2017*
- 3110 – LOCATION_NARRATIVE
- 3111 textual description of the location of an object or activity.
- 3112 – LOCATION_SPATIAL_GEOGRAPHIC
- 3113 absolute geographic location defined by two coordinates, longitude and lati-
- 3114 tude and an elevation.
- 3115 – LOCK_STATE
- 3116 state or operating mode of a Lock.
- 3117 – MAINTENANCE_LIST
- 3118 actions or activities to be performed in support of a piece of equipment.
- 3119 – MATERIAL
- 3120 identifier of a material used or consumed in the manufacturing process.
- 3121 – MATERIAL_LAYER
- 3122 identifies the layers of material applied to a part or product as part of an additive
- 3123 manufacturing process.
- 3124 – MEASUREMENT_TYPE
- 3125 class of measurement being performed. *Ref QIF 3:2018 Section 6.3*
- 3126 – MEASUREMENT_UNITS
- 3127 engineering units of the measurement.
- 3128 – MEASUREMENT_VALUE
- 3129 measurement based on the measurement type.

- 3130 – MESSAGE
- 3131 information to be transferred from a piece of equipment to a client software
- 3132 application.
- 3133 – MTCONNECT_VERSION
- 3134 reference version of the MTConnect Standard supported by the *adapter*.
- 3135 – NETWORK
- 3136 network details of a Component.
- 3137 – NETWORK_PORT
- 3138 number of the TCP/IP or UDP/IP port for the connection endpoint.
- 3139 – OPERATING_MODE
- 3140 state of Component or Composition that describes the automatic or man-
- 3141 ual operation of the entity.
- 3142 – OPERATING_SYSTEM
- 3143 Operating System (OS) of a Component.
- 3144 – OPERATOR_ID
- 3145 identifier of the person currently responsible for operating the piece of equip-
- 3146 ment.
- 3147 – PALLET_ID
- 3148 identifier for a pallet.
- 3149 – PART_COUNT
- 3150 aggregate count of parts.
- 3151 – PART_COUNT_TYPE
- 3152 interpretation of PART_COUNT.
- 3153 – PART_DETECT
- 3154 indication designating whether a part or work piece has been detected or is
- 3155 present.
- 3156 – PART_GROUP_ID
- 3157 identifier given to a collection of individual parts.
- 3158 – PART_ID
- 3159 identifier of a part in a manufacturing operation.
- 3160 – PART_INDEX
- 3161 sequence of a part in a group of parts.
- 3162 – PART_KIND_ID
- 3163 identifier given to link the individual occurrence to a class of parts, typically
- 3164 distinguished by a particular part design.

- 3165 – <<deprecated>> PART_NUMBER
- 3166 identifier of a part or product moving through the manufacturing process.
- 3167 **DEPRECATED** in *Version 1.7*. PART_NUMBER is now a subType of PART_KIND_ID.
- 3168 – PART_PROCESSING_STATE
- 3169 particular condition of the part occurrence at a specific time.
- 3170 – PART_STATUS
- 3171 state or condition of a part.
- 3172 – PART_UNIQUE_ID
- 3173 identifier given to a distinguishable, individual part.
- 3174 – PATH_FEEDRATE_OVERRIDE
- 3175 value of a signal or calculation issued to adjust the feedrate for the axes asso-
- 3176 ciated with a Path component that may represent a single axis or the coordi-
- 3177 nated movement of multiple axes.
- 3178 – PATH_MODE
- 3179 describes the operational relationship between a Path entity and another Path
- 3180 entity for pieces of equipment comprised of multiple logical groupings of con-
- 3181 trolled axes or other logical operations.
- 3182 – POWER_STATE
- 3183 indication of the status of the source of energy for an entity to allow it to per-
- 3184 form its intended function or the state of an enabling signal providing permis-
- 3185 sion for the entity to perform its functions.
- 3186 – <<deprecated>> POWER_STATUS
- 3187 status of the Component.
- 3188 **DEPRECATED** in *Version 1.1.0*.
- 3189 – PROCESS_AGGREGATE_ID
- 3190 identifier given to link the individual occurrence to a group of related occur-
- 3191 rences, such as a process step in a process plan.
- 3192 – PROCESS_KIND_ID
- 3193 identifier given to link the individual occurrence to a class of processes or
- 3194 process definition.
- 3195 – PROCESS_OCCURRENCE_ID
- 3196 identifier of a process being executed by the device.
- 3197 – PROCESS_STATE
- 3198 particular condition of the process occurrence at a specific time.
- 3199 – PROCESS_TIME
- 3200 time and date associated with an activity or event.

3201	– PROGRAM
3202	name of the logic or motion program being executed by the Controller
3203	component.
3204	– PROGRAM_COMMENT
3205	comment or non-executable statement in the control program.
3206	– PROGRAM_EDIT
3207	indication of the status of the Controller components program editing
3208	mode.
3209	A program may be edited while another is executed.
3210	– PROGRAM_EDIT_NAME
3211	name of the program being edited.
3212	This is used in conjunction with ProgramEdit when in ACTIVE state.
3213	– PROGRAM_HEADER
3214	non-executable header section of the control program.
3215	– PROGRAM_LOCATION
3216	URI for the source file associated with Program.
3217	– PROGRAM_LOCATION_TYPE
3218	defines whether the logic or motion program defined by Program is being
3219	executed from the local memory of the controller or from an outside source.
3220	– PROGRAM_NEST_LEVEL
3221	indication of the nesting level within a control program that is associated with
3222	the code or instructions that is currently being executed.
3223	– ROTARY_MODE
3224	current operating mode for a Rotary type axis.
3225	– ROTARY_VELOCITY_OVERRIDE
3226	percentage change to the velocity of the programmed velocity for a Rotary
3227	axis.
3228	– ROTATION
3229	three space angular displacement of an object or coordinate system relative to
3230	a <i>cartesian coordinate system</i> .
3231	– SENSOR_ATTACHMENT
3232	<i>attachment</i> between a sensor and an entity.
3233	– SENSOR_STATE
3234	detection result of a sensor.
3235	– SERIAL_NUMBER
3236	serial number associated with a Component, Asset, or Device.

- 3237 – <<deprecated>> SPECIFICATION_LIMIT
- 3238 set of limits defining a range of values designating acceptable performance for
- 3239 a variable.
- 3240 **DEPRECATED** in *Version 2.5*. Replaced by SPECIFICATION_LIMITS.
- 3241 – SPECIFICATION_LIMITS
- 3242 set of limits defining a range of values designating acceptable performance for
- 3243 a variable.
- 3244 – SPINDLE_INTERLOCK
- 3245 indication of the status of the spindle for a piece of equipment when power has
- 3246 been removed and it is free to rotate.
- 3247 – THICKNESS
- 3248 dimension between two surfaces of an object, usually the dimension of smallest
- 3249 measure, for example an additive layer, or a depth of cut.
- 3250 – TOOL_ASSET_ID
- 3251 identifier of an individual tool asset.
- 3252 – TOOL_CUTTING_ITEM
- 3253 references the `CuttingToolLifeCycle CuttingItem` index related to
- 3254 the indices of the currently active cutting tool edge.
- 3255 – TOOL_GROUP
- 3256 identifier for the tool group associated with a specific tool. Commonly used to
- 3257 designate spare tools.
- 3258 – <<deprecated>> TOOL_ID
- 3259 identifier of the tool currently in use for a given `Path`.
- 3260 **DEPRECATED** in *Version 1.2.0*. See `TOOL_NUMBER`.
- 3261 – TOOL_NUMBER
- 3262 identifier assigned by the `Controller` component to a cutting tool when in
- 3263 use by a piece of equipment.
- 3264 – TOOL_OFFSET
- 3265 reference to the tool offset variables applied to the active cutting tool.
- 3266 – TOOL_OFFSETS
- 3267 properties of each addressable tool offset.
- 3268 – TRANSFER_COUNT
- 3269 accumulation of the number of times an operation has attempted to, or is
- 3270 planned to attempt to, transfer materials, parts, or other items from one lo-
- 3271 cation to another.

- 3272 – TRANSLATION
- 3273 three space linear displacement of an object or coordinate system relative to a
- 3274 *cartesian coordinate system*.
- 3275 – UNCERTAINTY
- 3276 *uncertainty* specified by `UncertaintyType`.
- 3277 – UNCERTAINTY_TYPE
- 3278 method used to compute *standard uncertainty*.
- 3279 – UNLOAD_COUNT
- 3280 accumulation of the number of times an operation has attempted to, or is
- 3281 planned to attempt to, unload materials, parts, or other items.
- 3282 – USER
- 3283 identifier of the person currently responsible for operating the piece of equip-
- 3284 ment.
- 3285 – VALVE_STATE
- 3286 state of a valve is one of open, closed, or transitioning between the states.
- 3287 – VARIABLE
- 3288 data whose meaning may change over time due to changes in the operation of
- 3289 a piece of equipment or the process being executed on that piece of equipment.
- 3290 – WAIT_STATE
- 3291 indication of the reason that `Execution` is reporting a value of `WAIT`.
- 3292 – WIRE
- 3293 identifier for the type of wire used as the cutting mechanism in Electrical Dis-
- 3294 charge Machining or similar processes.
- 3295 – WORKHOLDING_ID
- 3296 identifier for the current workholding or part clamp in use by a piece of equip-
- 3297 ment.
- 3298 **DEPRECATION WARNING:** Recommend using `FIXTURE_ID` instead.
- 3299 – WORK_OFFSET
- 3300 reference to offset variables for a work piece or part.
- 3301 – WORK_OFFSETS
- 3302 properties of each addressable work offset.

3303 6.5.3 Sample

3304 abstract `DataItem` that is continuously changing or analog data value.

3305 This data can be measured at any point-in-time and will always produce a result.

3306 The units for Sample **MUST** always be specified.

3307 6.5.3.1 Value Properties of Sample

3308 Table 90 lists the Value Properties of Sample.

Value Property name	Value Property type	Multiplicity
category	SAMPLE	1
type	SampleEnum	1

Table 90: Value Properties of Sample

3309 Descriptions for Value Properties of Sample:

3310 • type

3311 <<extensible>> SampleEnum Enumeration:

3312 – ACCELERATION

3313 positive rate of change of velocity.

3314 – ACCUMULATED_TIME

3315 accumulated time for an activity or event.

3316 – <<deprecated>> AMPERAGE

3317 strength of electrical current.

3318 **DEPRECATED** in Version 1.6. Replaced by AMPERAGE_AC and AMPER-
3319 AGE_DC.

3320 – AMPERAGE_AC

3321 electrical current that reverses direction at regular short intervals.

3322 – AMPERAGE_DC

3323 electric current flowing in one direction only.

3324 – ANGLE

3325 angular position.

3326 – ANGULAR_ACCELERATION

3327 positive rate of change of angular velocity.

3328 – ANGULAR_DECELERATION

3329 negative rate of change of angular velocity.

- 3330 – ANGULAR_VELOCITY
- 3331 rate of change of angular position.
- 3332 – ASSET_UPDATE_RATE
- 3333 average rate of change of values for assets in the MTConnect streams.
- 3334 The average is computed over a rolling window defined by the implementation.
- 3335 – AXIS_FEEDRATE
- 3336 feedrate of a linear axis.
- 3337 – BATTERY_CAPACITY
- 3338 maximum rated charge a battery is capable of maintaining based on the battery
- 3339 discharging at a specified current over a specified time period.
- 3340 – BATTERY_CHARGE
- 3341 value of the battery’s present capacity expressed as a percentage of the battery’s
- 3342 maximum rated capacity.
- 3343 – CAPACITY_FLUID
- 3344 maximum amount of fluid that can be held by a container.
- 3345 – CAPACITY_SPATIAL
- 3346 maximum amount of material that can be held by a container.
- 3347 – CHARGE_RATE
- 3348 value of the current being supplied to the Component for the purpose of
- 3349 charging.
- 3350 – CONCENTRATION
- 3351 percentage of one component within a mixture of components.
- 3352 – CONDUCTIVITY
- 3353 ability of a material to conduct electricity.
- 3354 – CUTTING_SPEED
- 3355 speed difference (relative velocity) between the cutting mechanism and the
- 3356 surface of the workpiece it is operating on.
- 3357 – DECELERATION
- 3358 negative rate of change of velocity.
- 3359 – DENSITY
- 3360 volumetric mass of a material per unit volume of that material.
- 3361 – DEPOSITION_ACCELERATION_VOLUMETRIC
- 3362 rate of change in spatial volume of material deposited in an additive manufac-
- 3363 turing process.

3364	– DEPOSITION_DENSITY
3365	density of the material deposited in an additive manufacturing process per unit
3366	of volume.
3367	– DEPOSITION_MASS
3368	mass of the material deposited in an additive manufacturing process.
3369	– DEPOSITION_RATE_VOLUMETRIC
3370	rate at which a spatial volume of material is deposited in an additive manufac-
3371	turing process.
3372	– DEPOSITION_VOLUME
3373	spatial volume of material to be deposited in an additive manufacturing pro-
3374	cess.
3375	– DEW_POINT
3376	temperature at which moisture begins to condense, corresponding to saturation
3377	for a given absolute humidity.
3378	– DIAMETER
3379	dimension of a diameter.
3380	– DISCHARGE_RATE
3381	value of current being drawn from the Component.
3382	– DISPLACEMENT
3383	change in position of an object.
3384	– DISPLACEMENT_ANGULAR
3385	absolute value of the change in angular position around a vector
3386	– DISPLACEMENT_LINEAR
3387	absolute value of the change in position along a vector.
3388	– ELECTRICAL_ENERGY
3389	Wattage used or generated by a component over an interval of time.
3390	– EQUIPMENT_TIMER
3391	amount of time a piece of equipment or a sub-part of a piece of equipment has
3392	performed specific activities.
3393	– FILL_HEIGHT
3394	amount of a substance in a container.
3395	– FILL_LEVEL
3396	amount of a substance remaining compared to the planned maximum amount
3397	of that substance.
3398	– FLOW
3399	rate of flow of a fluid.

- 3400 – FOLLOWING_ERROR
- 3401 difference between actual and commanded position at any specific point in
- 3402 time during a motion.
- 3403 – FOLLOWING_ERROR_ANGULAR
- 3404 angular difference between the commanded encoder/resolver position and the
- 3405 actual encoder/resolver position at any specified point in time during a motion.
- 3406 – FOLLOWING_ERROR_LINEAR
- 3407 difference between the commanded encoder/resolver position and the actual
- 3408 encoder/resolver position at any specified point in time during a motion.
- 3409 – FREQUENCY
- 3410 number of occurrences of a repeating event per unit time.
- 3411 – <<deprecated>> GLOBAL_POSITION
- 3412 position in three-dimensional space.
- 3413 **DEPRECATED** in Version 1.1.
- 3414 – GRAVITATIONAL_ACCELERATION
- 3415 acceleration relative to Earth's gravity of 9.80665 METER/SECOND².
- 3416 – GRAVITATIONAL_FORCE
- 3417 force relative to earth's gravity.
- 3418 – HUMIDITY_ABSOLUTE
- 3419 amount of water vapor expressed in grams per cubic meter.
- 3420 – HUMIDITY_RELATIVE
- 3421 amount of water vapor present expressed as a percent to reach saturation at the
- 3422 same temperature.
- 3423 – HUMIDITY_SPECIFIC
- 3424 ratio of the water vapor present over the total weight of the water vapor and air
- 3425 present expressed as a percent.
- 3426 – LENGTH
- 3427 length of an object.
- 3428 – <<deprecated>> LEVEL
- 3429 level of a resource.
- 3430 **DEPRECATED** in *Version 1.2*. See FILL_LEVEL.
- 3431 – LINEAR_FORCE
- 3432 *force* applied to a mass in one direction only.
- 3433 – LOAD
- 3434 actual versus the standard rating of a piece of equipment.

- 3435 – MASS
- 3436 mass of an object(s) or an amount of material.
- 3437 – OBSERVATION_UPDATE_RATE
- 3438 average rate of change of values for data items in the MTConnect streams. The
- 3439 average is computed over a rolling window defined by the implementation.
- 3440 – OPENNESS
- 3441 percentage open where 100% is fully open and 0% is fully closed.
- 3442 – ORIENTATION
- 3443 angular position of a plane or vector relative to a *cartesian coordinate system*
- 3444 – PARTICLE_COUNT
- 3445 number of particles counted by their size or other characteristics.
- 3446 – PARTICLE_SIZE
- 3447 size of particles counted by their size or other characteristics.
- 3448 – PATH_FEEDRATE
- 3449 feedrate for the axes, or a single axis, associated with a `Path` component.
- 3450 – PATH_FEEDRATE_PER_REVOLUTION
- 3451 feedrate for the axes, or a single axis.
- 3452 – PATH_POSITION
- 3453 position of a control point associated with a `Controller` or a `Path`.
- 3454 – PH
- 3455 acidity or alkalinity of a solution.
- 3456 – POSITION
- 3457 point along an axis in a *cartesian coordinate system*.
- 3458 – POSITION_CARTESIAN
- 3459 point in a *cartesian coordinate system*.
- 3460 – POWER_FACTOR
- 3461 ratio of real power flowing to a load to the apparent power in that AC circuit.
- 3462 – PRESSURE
- 3463 force per unit area measured relative to atmospheric pressure.
- 3464 Commonly referred to as gauge pressure.
- 3465 – PRESSURE_ABSOLUTE
- 3466 force per unit area measured relative to a vacuum.
- 3467 – PRESSURIZATION_RATE
- 3468 change of pressure per unit time.

- 3469 – PROCESS_TIMER
- 3470 amount of time a piece of equipment has performed different types of activities
- 3471 associated with the process being performed at that piece of equipment.
- 3472 – RESISTANCE
- 3473 degree to which a substance opposes the passage of an electric current.
- 3474 – RESISTIVITY
- 3475 inability of a material to conduct electricity.
- 3476 – ROTARY_VELOCITY
- 3477 rotational speed of a rotary axis.
- 3478 – SETTLING_ERROR
- 3479 difference between actual and commanded position at the end of a motion.
- 3480 – SETTLING_ERROR_ANGULAR
- 3481 angular difference between the commanded encoder/resolver position, and the
- 3482 actual encoder/resolver position when motion is complete.
- 3483 – SETTLING_ERROR_LINEAR
- 3484 difference between the commanded encoder/resolver position, and the actual
- 3485 encoder/resolver position when motion is complete.
- 3486 – SOUND_LEVEL
- 3487 sound level or sound pressure level relative to atmospheric pressure.
- 3488 – <<deprecated>> SPINDLE_SPEED
- 3489 rotational speed of the rotary axis.
- 3490 **DEPRECATED** in *Version 1.2*. Replaced by ROTARY_VELOCITY.
- 3491 – STRAIN
- 3492 amount of deformation per unit length of an object when a load is applied.
- 3493 – TEMPERATURE
- 3494 degree of hotness or coldness measured on a definite scale.
- 3495 – TENSION
- 3496 force that stretches or elongates an object.
- 3497 – TILT
- 3498 angular displacement.
- 3499 – TORQUE
- 3500 turning force exerted on an object or by an object.
- 3501 – VELOCITY
- 3502 rate of change of position of a Component.

- 3503 – VISCOSITY
- 3504 fluid’s resistance to flow.
- 3505 – <<deprecated>> VOLTAGE
- 3506 electrical potential between two points.
- 3507 **DEPRECATED** in *Version 1.6*. Replaced by VOLTAGE_AC and VOLTAGE_DC.
- 3508 – VOLTAGE_AC
- 3509 electrical potential between two points in an electrical circuit in which the cur-
- 3510 rent periodically reverses direction.
- 3511 – VOLTAGE_DC
- 3512 electrical potential between two points in an electrical circuit in which the cur-
- 3513 rent is unidirectional.
- 3514 – VOLT_AMPERE
- 3515 apparent power in an electrical circuit, equal to the product of root-mean-
- 3516 square (RMS) voltage and RMS current (commonly referred to as VA).
- 3517 – VOLT_AMPERE_REACTIVE
- 3518 reactive power in an AC electrical circuit (commonly referred to as VAR).
- 3519 – VOLUME_FLUID
- 3520 fluid volume of an object or container.
- 3521 – VOLUME_SPATIAL
- 3522 geometric volume of an object or container.
- 3523 – WATTAGE
- 3524 power flowing through or dissipated by an electrical circuit or piece of equip-
- 3525 ment.
- 3526 – X_DIMENSION
- 3527 dimension of an entity relative to the X direction of the referenced coordinate
- 3528 system.
- 3529 – Y_DIMENSION
- 3530 dimension of an entity relative to the Y direction of the referenced coordinate
- 3531 system.
- 3532 – Z_DIMENSION
- 3533 dimension of an entity relative to the Z direction of the referenced coordinate
- 3534 system.

3535 7 References Model

3536 References *organizes* pointers to information defined elsewhere within the MTCon-
 3537 nectDevices entity for a piece of equipment. It is an efficient method to associate
 3538 information with an element without duplicating any of the data or structure.

3539 7.1 References

3540 This section provides semantic information for the Reference entity. Figure 6 shows
 3541 the Reference model.

3542 Reference may be modeled as part of a Device, Component or Interface type.

3543 Note: See *Section B.3 - References Schema Diagrams* for XML schema of
 3544 Reference and its types.

3545 7.1.1 Reference

3546 pointer to information that is associated with another entity defined elsewhere in the MT-
 3547 ConnectDevices entity for a piece of equipment.

3548 Reference is an abstract entity and will be realized by a specific Reference type for
 3549 an MTConnectDevices entity. See *Section 7.1.3 - ComponentRef* and *Section 7.1.2 -*
 3550 *DataItemRef*.

3551 7.1.1.1 Value Properties of Reference

3552 *Table 91* lists the Value Properties of Reference.

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

Table 91: Value Properties of Reference

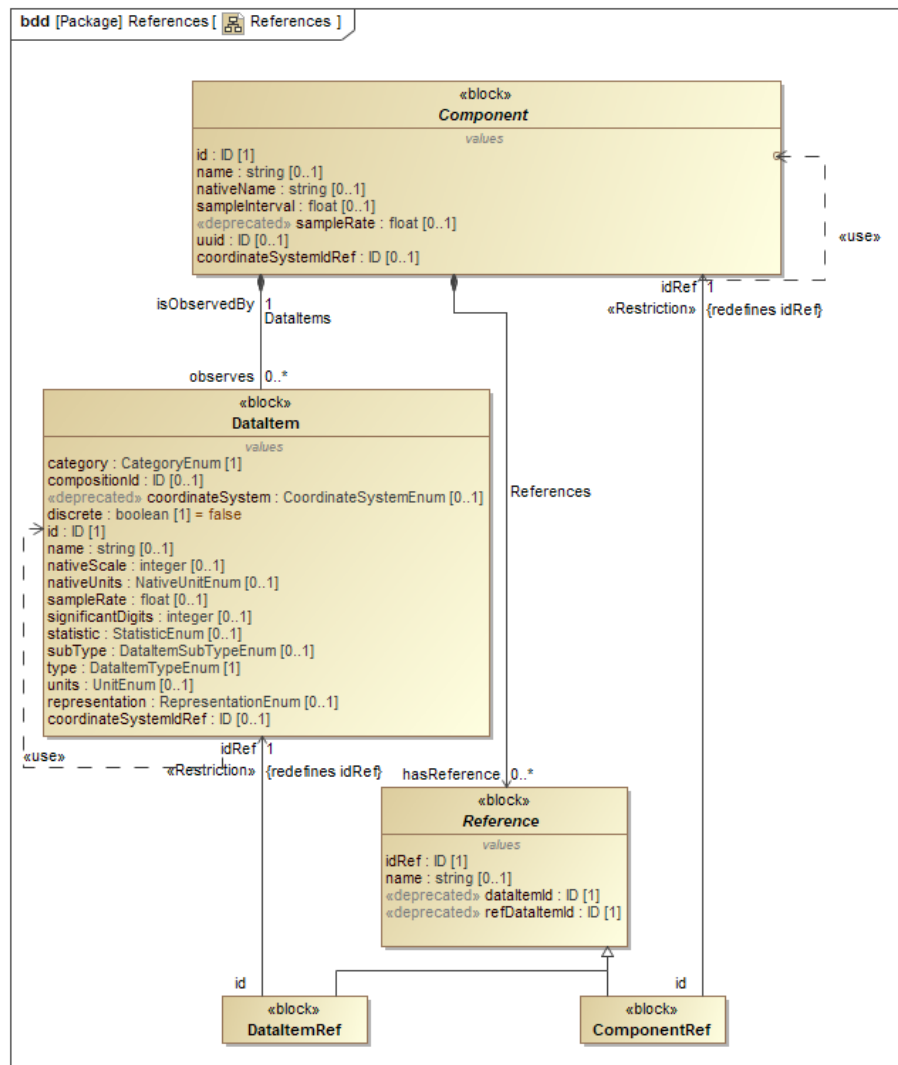


Figure 6: References

3553 Descriptions for Value Properties of Reference:

- 3554 • `idRef`
- 3555 pointer to the `id` of an entity that contains the information to be associated with this
- 3556 entity.
- 3557 • `name`
- 3558 name of an element or a piece of equipment.

3559 7.1.2 DataItemRef

3560 Reference that is a pointer to a `DataItem` associated with another entity defined for
3561 a piece of equipment.

3562 `DataItemRef` allows the data associated with a `DataItem` defined in another entity to
3563 be directly associated with this entity.

3564 7.1.3 ComponentRef

3565 Reference that is a pointer to all of the information associated with another entity de-
3566 fined for a piece of equipment.

3567 `ComponentRef` allows all of the information of (*lower level* `Component` entities that
3568 is associated with the other entity to be directly associated with this entity.

3569 8 Configurations Model

3570 This section provides semantic information for the Configuration entity that is used
3571 to model technical information about a Component.

3572 8.1 Configurations

3573 Figure 7 shows the abstract Configuration and its types.

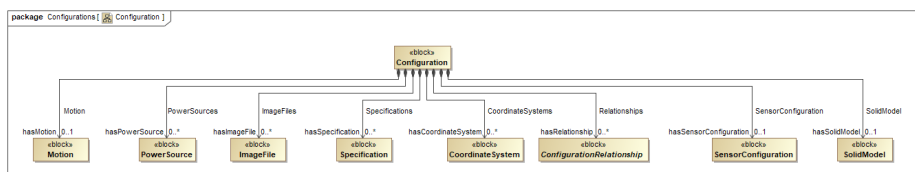


Figure 7: Configuration

3574 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3575 8.1.1 Configuration

3576 technical information about an entity describing its physical layout, functional character-
3577 istics, and relationships with other entities.

3578 8.1.1.1 Part Properties of Configuration

3579 Table 92 lists the Part Properties of Configuration.

Part Property name	Multiplicity
SolidModel	0..1
SensorConfiguration	0..1
Motion	0..1
ConfigurationRelationship (organized by Relationships)	0..*
CoordinateSystem (organized by CoordinateSystems)	0..*
Specification (organized by Specifications)	0..*
ImageFile (organized by ImageFiles)	0..*
PowerSource (organized by PowerSources)	0..*

Table 92: Part Properties of Configuration

3580 Descriptions for Part Properties of Configuration:

- 3581 • SolidModel
- 3582 references to a file with the three-dimensional geometry of the Component or
- 3583 Composition.
- 3584 See *Section 8.6 - SolidModel*.
- 3585 • SensorConfiguration
- 3586 configuration for a Sensor.
- 3587 See SensorConfiguration.
- 3588 • Motion
- 3589 movement of the component relative to a coordinate system.
- 3590 See *Section 8.3 - Motion*.
- 3591 • ConfigurationRelationship
- 3592 association between two pieces of equipment that function independently but to-
- 3593 gether perform a manufacturing operation.
- 3594 Relationships groups one or more ConfigurationRelationship types.
- 3595 See *Section 8.4 - Relationships*.
- 3596 • CoordinateSystem
- 3597 reference system that associates a unique set of n parameters with each point in an
- 3598 n-dimensional space. *Ref ISO 10303-218:2004*
- 3599 CoordinateSystems groups one or more CoordinateSystem entities. See
- 3600 *Section 8.2 - CoordinateSystems*.

- 3601 • Specification
- 3602 design characteristics for a piece of equipment.
- 3603 Specifications groups one or more Specification entities. See *Sec-*
- 3604 *tion 8.7 - Specifications.*
- 3605 • ImageFile
- 3606 reference to a file containing an image of the Component.
- 3607 ImageFiles groups one or more ImageFile entities. See *Section 8.8 - Image-*
- 3608 *Files.*
- 3609 • PowerSource
- 3610 potential energy sources for the Component.
- 3611 PowerSources groups one or more PowerSource entities. See *Section 8.9 -*
- 3612 *PowerSources.*

3613 8.2 CoordinateSystems

3614 This section provides semantic information for the CoordinateSystem entity.

3615 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3616 Note: See *Example 6* for the XML representation of the same example.

3617 8.2.1 CoordinateSystem

3618 reference system that associates a unique set of n parameters with each point in an n-

3619 dimensional space. *Ref ISO 10303-218:2004*

3620 At most only one of Origin or Transformation **MUST** be defined for a Coordi-

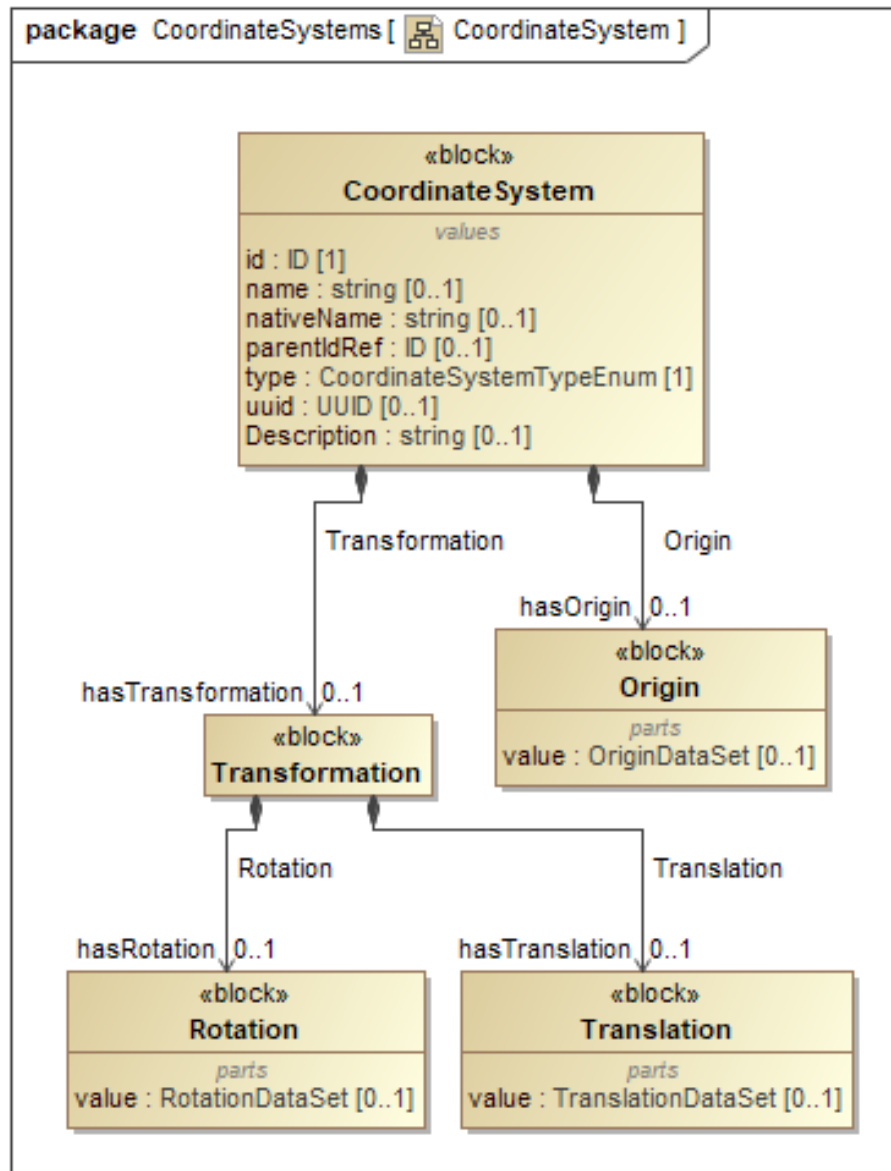
3621 nateSystem.

3622 8.2.1.1 Value Properties of CoordinateSystem

3623 *Table 93* lists the Value Properties of CoordinateSystem.

Value Property name	Value Property type	Multiplicity
id	ID	1
name	string	0..1
nativeName	string	0..1
parentIdRef	ID	0..1
type	CoordinateSystemTypeEnum	1
uuid	UUID	0..1
Description	string	0..1

Table 93: Value Properties of CoordinateSystem

**Figure 8:** CoordinateSystem

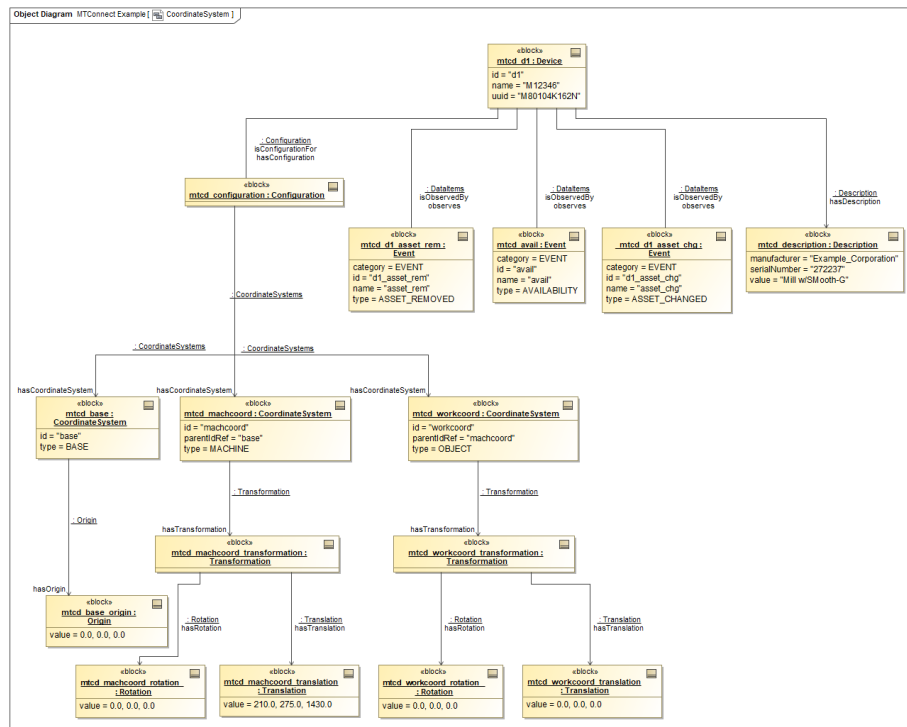


Figure 9: CoordinateSystem Example

3624 Descriptions for Value Properties of `CoordinateSystem`:

- 3625 • `id`
3626 unique identifier for the coordinate system.
- 3627 • `name`
3628 name of the coordinate system.
- 3629 • `nativeName`
3630 manufacturer's name or users name for the coordinate system.
- 3631 • `parentIdRef`
3632 pointer to the `id`.
- 3633 • `type`
3634 type of coordinate system.

3635 `CoordinateSystemTypeEnum` Enumeration:

- 3636 – `BASE`
3637 coordinate system referenced to the base mounting surface. *Ref ISO 9787:2013*
3638 A base mounting surface is a connection surface between the arm and its sup-
3639 porting structure. *Ref ISO 9787:2013*
3640 For non-robotic devices, it is the connection surface between the device and its
3641 supporting structure.
- 3642 – `CAMERA`
3643 coordinate system referenced to the sensor which monitors the site of the task.
3644 *Ref ISO 9787:2013*
- 3645 – `MACHINE`
3646 coordinate system referenced to the home position and orientation of the pri-
3647 mary axes of a piece of equipment.
- 3648 – `MECHANICAL_INTERFACE`
3649 coordinate system referenced to the mechanical interface. *Ref ISO 9787:2013*
- 3650 – `MOBILE_PLATFORM`
3651 coordinate system referenced to one of the components of a mobile platform.
3652 *Ref ISO 8373:2012*
- 3653 – `OBJECT`
3654 coordinate system referenced to the object. *Ref ISO 9787:2013*

- 3655 – TASK
- 3656 coordinate system referenced to the site of the task. *Ref ISO 9787:2013*
- 3657 – TOOL
- 3658 coordinate system referenced to the tool or to the end effector attached to the
- 3659 mechanical interface. *Ref ISO 9787:2013*
- 3660 – WORLD
- 3661 stationary coordinate system referenced to earth, which is independent of the
- 3662 robot motion. *Ref ISO 9787:2013*
- 3663 For non-robotic devices, stationary coordinate system referenced to earth, which
- 3664 is independent of the motion of a piece of equipment.

- 3665 • uuid
- 3666 UUID for the coordinate system.

- 3667 • Description
- 3668 natural language description of the `CoordinateSystem`.

3669 **8.2.1.2 Part Properties of `CoordinateSystem`**

3670 *Table 94* lists the Part Properties of `CoordinateSystem`.

Part Property name	Multiplicity
Origin	0..1
Transformation	0..1

Table 94: Part Properties of `CoordinateSystem`

3671 Descriptions for Part Properties of `CoordinateSystem`:

- 3672 • Origin
- 3673 coordinates of the origin position of a coordinate system.
- 3674 See *Section 8.2.2 - Origin*.

- 3675 • Transformation
- 3676 process of transforming to the origin position of the coordinate system from a parent
- 3677 coordinate system using `Translation` and `Rotation`.
- 3678 See *Section 8.2.3 - Transformation*.

3679 8.2.2 Origin

3680 coordinates of the origin position of a coordinate system.

3681 8.2.2.1 Part Properties of Origin

3682 *Table 95* lists the Part Properties of Origin.

Part Property name	Multiplicity
value	0..1

Table 95: Part Properties of Origin

3683 Descriptions for Part Properties of Origin:

- 3684 • OriginDataSet
- 3685 x-coordinate.

3686 8.2.3 Transformation

3687 process of transforming to the origin position of the coordinate system from a parent co-
3688 ordinate system using Translation and Rotation.

3689 At a minimum, a Translation or a Rotation **MUST** be defined for a Transfor-
3690 mation.

3691 8.2.3.1 Part Properties of Transformation

3692 *Table 96* lists the Part Properties of Transformation.

Part Property name	Multiplicity
Translation	0..1
Rotation	0..1

Table 96: Part Properties of Transformation

3693 Descriptions for Part Properties of Transformation:

- 3694 • Translation
- 3695 translations along X, Y, and Z axes are expressed as x,y, and z respectively within a
- 3696 3-dimensional vector.
- 3697 See *Section 8.2.5 - Translation*.
- 3698 • Rotation
- 3699 rotations about X, Y, and Z axes are expressed in A, B, and C respectively within a
- 3700 3-dimensional vector.
- 3701 See *Section 8.2.4 - Rotation*.

3702 8.2.4 Rotation

- 3703 rotations about X, Y, and Z axes are expressed in A, B, and C respectively within a 3-
- 3704 dimensional vector.

3705 8.2.4.1 Part Properties of Rotation

- 3706 *Table 97* lists the Part Properties of Rotation.

Part Property name	Multiplicity
value	0..1

Table 97: Part Properties of Rotation

- 3707 Descriptions for Part Properties of Rotation:

- 3708 • RotationDataSet
- 3709 rotation about X axis.

3710 8.2.5 Translation

- 3711 translations along X, Y, and Z axes are expressed as x,y, and z respectively within a 3-
- 3712 dimensional vector.

3713 8.2.5.1 Part Properties of Translation

- 3714 *Table 98* lists the Part Properties of Translation.

Part Property name	Multiplicity
value	0..1

Table 98: Part Properties of Translation

3715 Descriptions for Part Properties of Translation:

3716 • TranslationDataSet

3717 translation along X axis.

3718 8.3 Motion

3719 This section provides semantic information for the Motion entity.

3720 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3721 Note: See *Example 7* for the XML representation of the same example.

3722 8.3.1 Motion

3723 movement of the component relative to a coordinate system.

3724 Motion specifies the kinematic chain of the component entities.

3725 At most only one of Origin or Transformation **MUST** be defined for a Motion.

3726 8.3.1.1 Value Properties of Motion

3727 Table 99 lists the Value Properties of Motion.

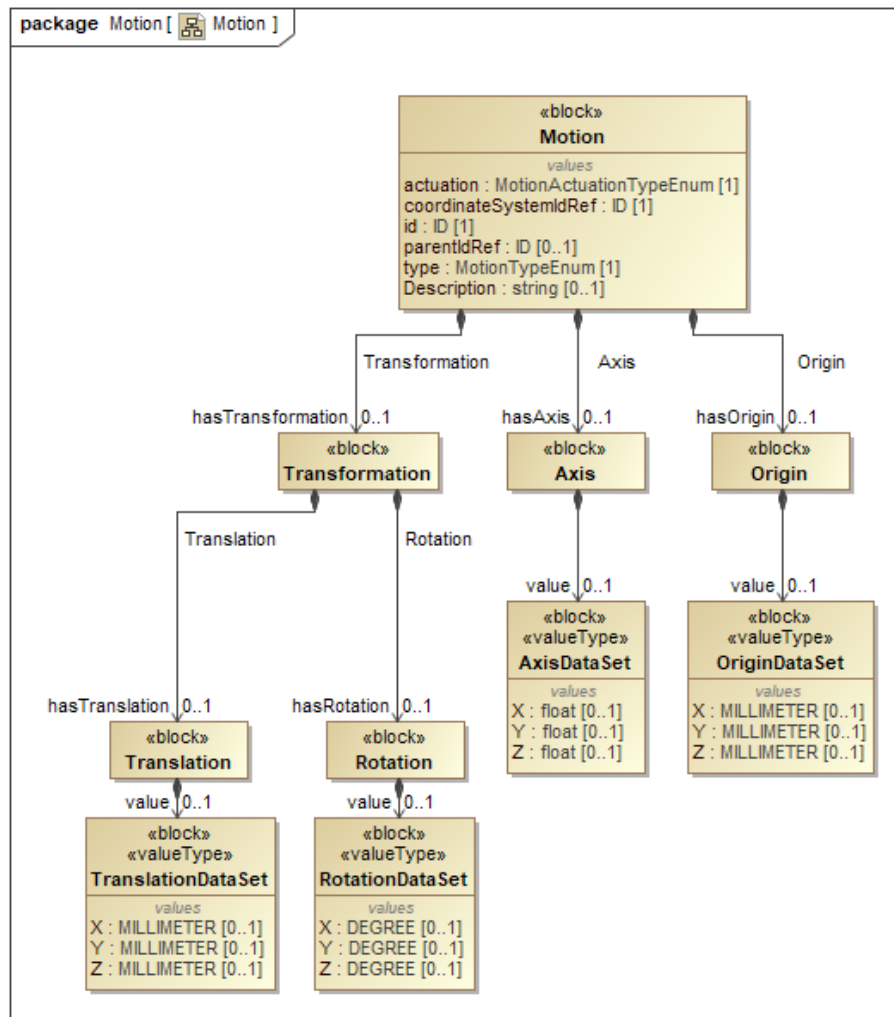


Figure 10: Motion

Value Property name	Value Property type	Multiplicity
actuation	MotionActuationTypeEnum	1
coordinateSystemIdRef	ID	1
id	ID	1
parentIdRef	ID	0..1
type	MotionTypeEnum	1

Table 99: Value Properties of Motion

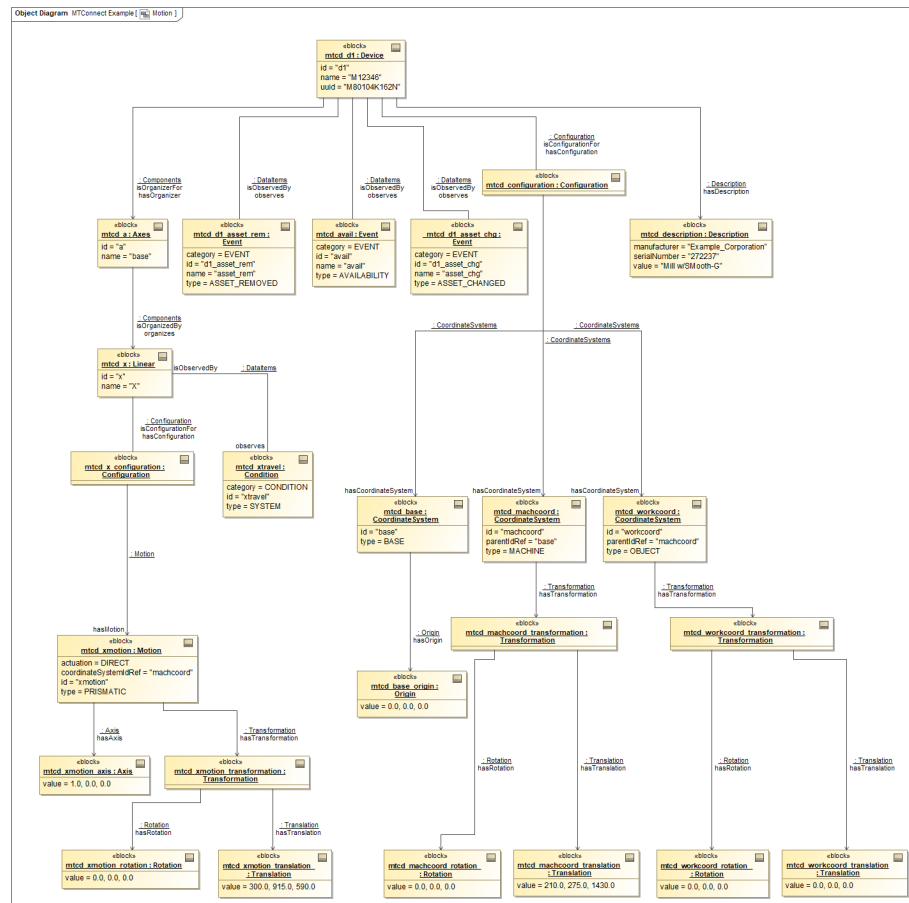


Figure 11: Motion Example

3728 Descriptions for Value Properties of Motion:

- 3729 • `actuation`
 3730 describes if this component is actuated directly or indirectly as a result of other
 3731 motion.
 3732 `MotionActuationTypeEnum` Enumeration:
 3733 – `DIRECT`
 3734 movement is initiated by the component.
 3735 – `NONE`
 3736 no actuation of this axis.
 3737 Note: Actuation of `NONE` can be either a derived `REVOLUTE` or
 3738 `PRISMATIC` motion or static `FIXED` relationship.
 3739 – `VIRTUAL`
 3740 motion is computed and is used for expressing an imaginary movement.
- 3741 • `coordinateSystemIdRef`
 3742 coordinate system within which the kinematic motion occurs.
- 3743 • `id`
 3744 unique identifier for this element.
- 3745 • `parentIdRef`
 3746 pointer to the `id`.
 3747 The kinematic chain connects all components using the parent relations. All motion
 3748 is connected to the motion of the parent. The first node in the chain will not have a
 3749 parent.
- 3750 • `type`
 3751 type of motion.
 3752 `MotionTypeEnum` Enumeration:
 3753 – `CONTINUOUS`
 3754 revolves around an axis with a continuous range of motion.
 3755 – `FIXED`
 3756 axis does not move.
 3757 – `PRISMATIC`
 3758 sliding linear motion along an axis with a fixed range of motion.
 3759 – `REVOLUTE`
 3760 rotates around an axis with a fixed range of motion.

3761 8.3.1.2 Part Properties of Motion

3762 *Table 100* lists the Part Properties of Motion.

Part Property name	Multiplicity
Axis	0..1
Origin	0..1
Transformation	0..1

Table 100: Part Properties of Motion

3763 Descriptions for Part Properties of Motion:

- 3764 • Axis
- 3765 axis along or around which the Component moves relative to a coordinate system.
- 3766 See *Section 4.3.4 - Axis*.
- 3767 • Origin
- 3768 coordinates of the origin position of a coordinate system.
- 3769 See *Section 8.2.2 - Origin*.
- 3770 • Transformation
- 3771 process of transforming to the origin position of the coordinate system from a parent
- 3772 coordinate system using Translation and Rotation.
- 3773 See *Section 8.2.3 - Transformation*.

3774 8.3.2 Axis

3775 axis along or around which the Component moves relative to a coordinate system.

3776 8.3.2.1 Part Properties of Axis

3777 *Table 101* lists the Part Properties of Axis.

Part Property name	Multiplicity
value	0..1

Table 101: Part Properties of Axis

3778 Descriptions for Part Properties of Axis:

- 3779 • AxisDataSet
 3780 x-component of Axis.

3781 8.4 Relationships

- 3782 This section provides semantic information for the ConfigurationRelationship
 3783 entity.

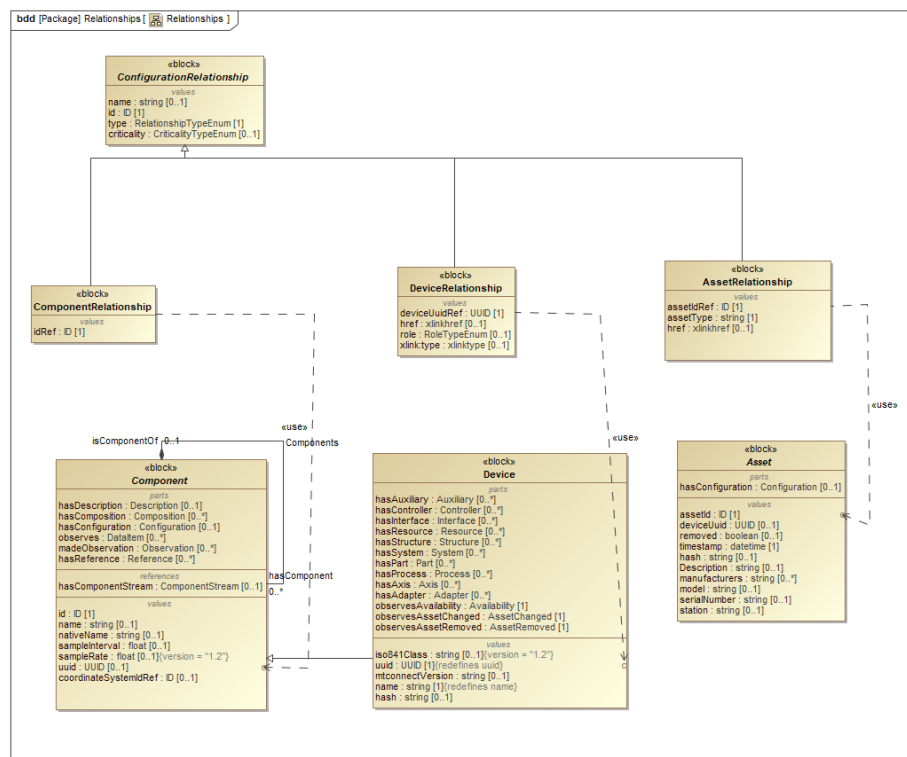


Figure 12: Relationships

- 3784 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

- 3785 Note: See *Example 8* for the XML representation of the same example.

3786 8.4.1 ConfigurationRelationship

- 3787 association between two pieces of equipment that function independently but together
 3788 perform a manufacturing operation.

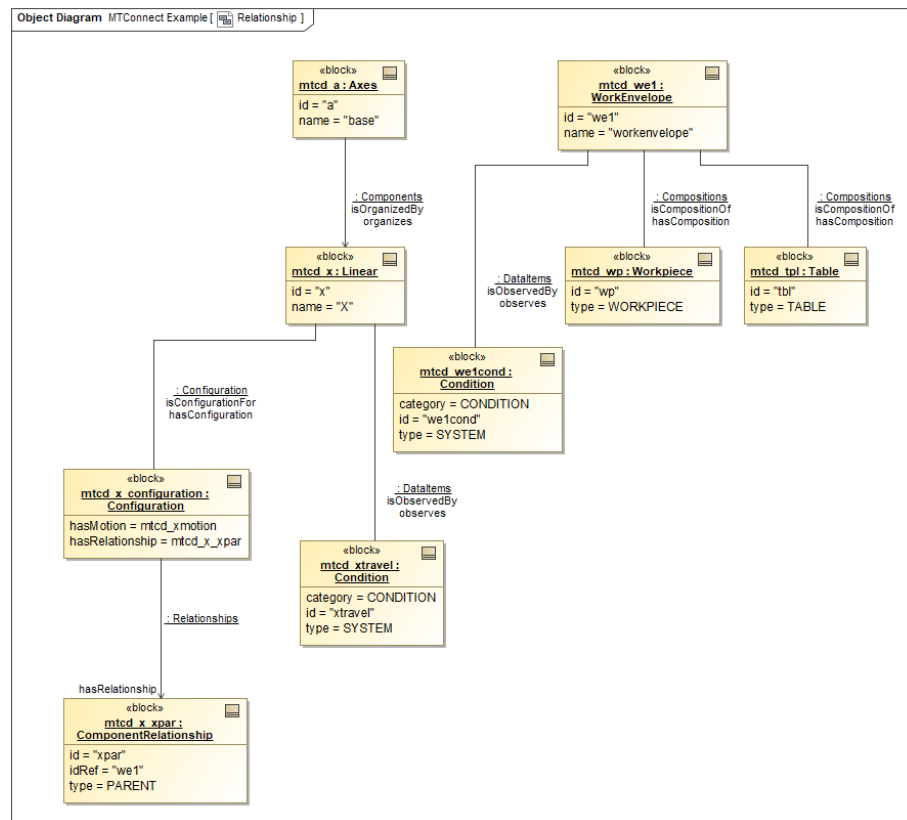


Figure 13: Relationship Example

3789 ConfigurationRelationship is an abstract entity and hence will be realized by
 3790 specific ConfigurationRelationship types in an MTConnectDevices entity.
 3791 See Section 8.4.2 - ComponentRelationship and Section 8.4.3 - DeviceRelationship.

3792 8.4.1.1 Value Properties of ConfigurationRelationship

3793 Table 102 lists the Value Properties of ConfigurationRelationship.

Value Property name	Value Property type	Multiplicity
name	string	0..1
id	ID	1
type	RelationshipTypeEnum	1
criticality	CriticalityTypeEnum	0..1

Table 102: Value Properties of ConfigurationRelationship

3794 Descriptions for Value Properties of ConfigurationRelationship:

- 3795 • `name`
- 3796 `name` associated with this `ConfigurationRelationship`.
- 3797 • `id`
- 3798 unique identifier for this `ConfigurationRelationship`.
- 3799 • `type`
- 3800 defines the authority that this piece of equipment has relative to the associated piece
- 3801 of equipment.
- 3802 `RelationshipTypeEnum` Enumeration:
- 3803 – `CHILD`
- 3804 functions as a child in the relationship with the associated element.
- 3805 – `PARENT`
- 3806 functions as a parent in the relationship with the associated element.
- 3807 – `PEER`
- 3808 functions as a peer which provides equal functionality and capabilities in the
- 3809 relationship with the associated element.
- 3810 • `criticality`
- 3811 defines whether the services or functions provided by the associated piece of equip-
- 3812 ment is required for the operation of this piece of equipment.
- 3813 `CriticalityTypeEnum` Enumeration:
- 3814 – `CRITICAL`
- 3815 services or functions provided by the associated element is required for the
- 3816 operation of this element.
- 3817 – `NONCRITICAL`
- 3818 services or functions provided by the associated element is not required for the
- 3819 operation of this element.

3820 8.4.2 ComponentRelationship

3821 `ConfigurationRelationship` that describes the association between two compo-
 3822 nents within a piece of equipment that function independently but together perform a ca-
 3823 pability or service within a piece of equipment.

3824 8.4.2.1 Value Properties of ComponentRelationship

3825 *Table 103* lists the Value Properties of ComponentRelationship.

Value Property name	Value Property type	Multiplicity
idRef	ID	1

Table 103: Value Properties of ComponentRelationship

3826 Descriptions for Value Properties of ComponentRelationship:

- 3827 • idRef
- 3828 reference to the associated Component.

3829 8.4.3 DeviceRelationship

3830 ConfigurationRelationship that describes the association between two pieces of
3831 equipment that function independently but together perform a manufacturing operation.

3832 8.4.3.1 Value Properties of DeviceRelationship

3833 *Table 104* lists the Value Properties of DeviceRelationship.

Value Property name	Value Property type	Multiplicity
deviceUuidRef	UUID	1
href	xlink:href	0..1
role	RoleTypeEnum	0..1
xlink:type	xlink:type	0..1

Table 104: Value Properties of DeviceRelationship

3834 Descriptions for Value Properties of DeviceRelationship:

- 3835 • deviceUuidRef
- 3836 reference to the uuid of the associated piece of equipment.
- 3837 • href
- 3838 URI identifying the *agent* that is publishing information for the associated piece of
- 3839 equipment.

- 3840 • `role`
- 3841 defines the services or capabilities that the referenced piece of equipment provides
- 3842 relative to this piece of equipment.
- 3843 `RoleTypeEnum` Enumeration:
- 3844 – `AUXILIARY`
- 3845 associated element performs the functions as an `Auxiliary` for this element.
- 3846 – `SYSTEM`
- 3847 associated element performs the functions of a `System` for this element.
- 3848 • `xlink:type`
- 3849 `xlink:type` **MUST** have a fixed value of `locator` as defined in W3C XLink
- 3850 1.1 *Ref <https://www.w3.org/TR/xlink11/>.*

3851 8.4.4 AssetRelationship

3852 `ConfigurationRelationship` that describes the association between a `Component`

3853 and an `Asset`.

3854 8.4.4.1 Value Properties of AssetRelationship

3855 *Table 105* lists the Value Properties of `AssetRelationship`.

Value Property name	Value Property type	Multiplicity
<code>assetIdRef</code>	ID	1
<code>assetType</code>	string	1
<code>href</code>	<code>xlink:href</code>	0..1

Table 105: Value Properties of `AssetRelationship`

3856 Descriptions for Value Properties of `AssetRelationship`:

- 3857 • `assetIdRef`
- 3858 uuid of the related `Asset`.
- 3859 • `assetType`
- 3860 type of `Asset` being referenced.
- 3861 • `href`
- 3862 URI reference to the associated `Asset`.

3863 8.5 Sensor

3864 This section provides semantic information for the `SensorConfiguration` entity.

3865 sensor is a unique type of a piece of equipment. A sensor is typically comprised of two
 3866 major components: a sensor unit that provides signal processing, conversion, and commu-
 3867 nications and the *sensing elements* that provides a signal or measured value.

3868 The sensor unit is modeled as a *lower level* `Component` called `Sensor`. The *sensing*
 3869 *element* may be modeled as a `Composition` element of a `Sensor` element and the
 3870 measured value would be modeled as a `DataItem` (See *Section 6.1 - DataItems* for more
 3871 information on `DataItem` elements). Each sensor unit may have multiple *sensing ele-*
 3872 *ments*; each representing the data for a variety of measured values.

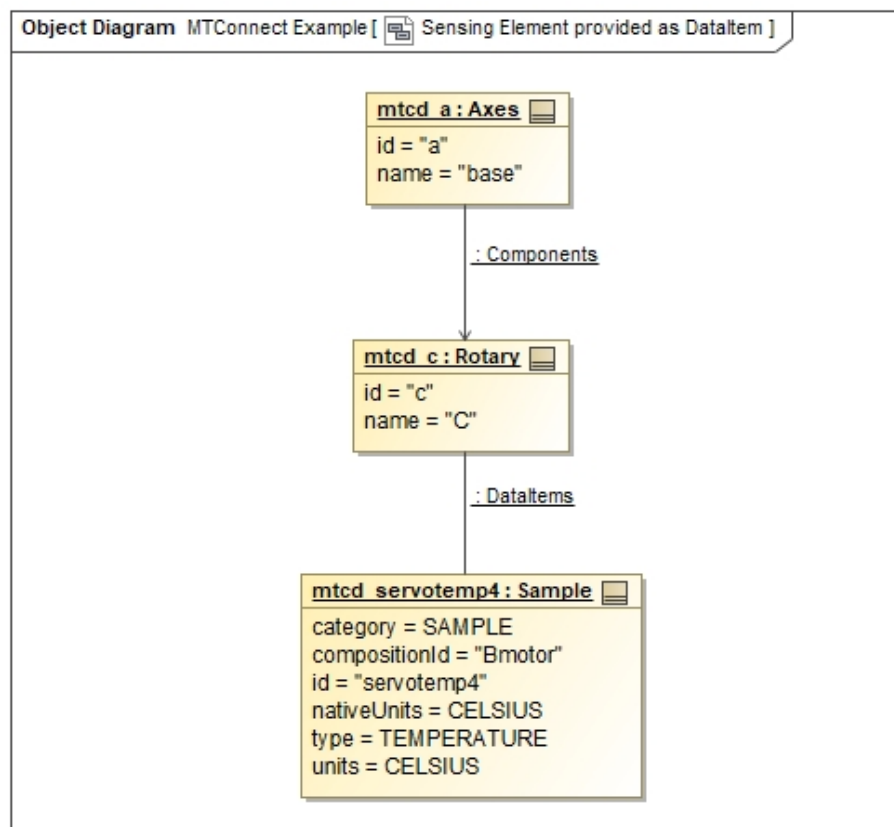


Figure 14: Sensing Element provided as a DataItem Example

3873 Note: See *Example 11* for an XML example.

3874 When a sensor unit is modeled as a `Component` or as a separate piece of equipment, it

3875 may provide additional configuration information for the sensor elements and the sensor
3876 unit itself.

3877 Note: If a `Sensor` provides vibration measurement data for the spindle on a
3878 piece of equipment, it could be modeled as a `Sensor` for rotary axis named
3879 C. See *Example 12* for an XML example.

3880 Note: If a `Sensor` provides measurement data for multiple `Component` el-
3881 ements within a piece of equipment and is not associated with any particular
3882 `Component`, it **MAY** be modeled as an independent `Component` and the
3883 data associated with measurements are associated with their associated `Com-`
3884 ponent entities. See *Example 13* for an XML example.

3885 Configuration data provides information required for maintenance and support of the
3886 sensor.

3887 When `Sensor` represents the sensor unit for multiple *sensing element(s)*, each sensing
3888 element is represented by a `Channel`. The sensor unit itself and each `Channel` repre-
3889 senting one *sensing element* **MAY** have its own configuration data.

3890 Note: See *Example 14* for an XML example.

3891 **8.5.1 SensorConfiguration**

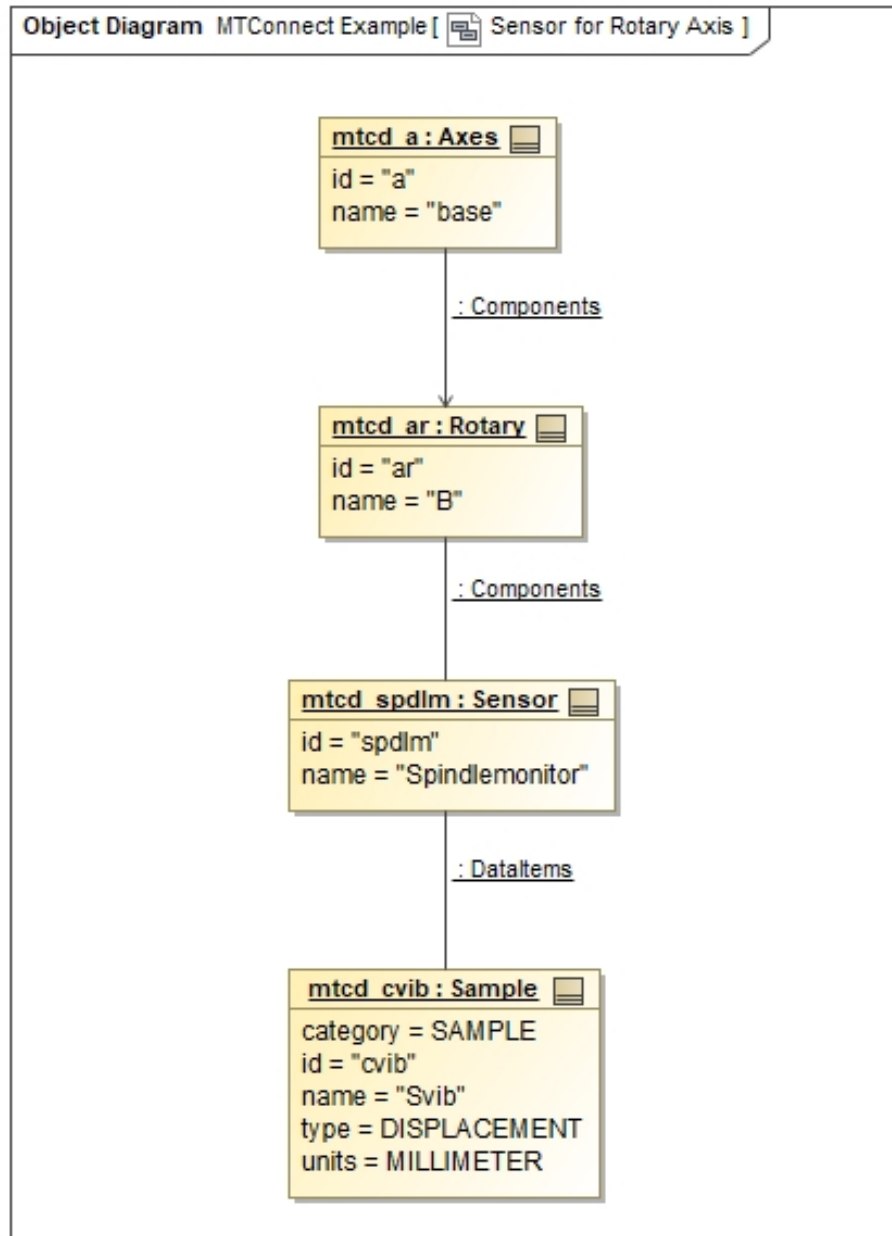
3892 configuration for a `Sensor`.

3893 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3894 **8.5.1.1 Value Properties of SensorConfiguration**

3895 *Table 106* lists the Value Properties of `SensorConfiguration`.

Value Property name	Value Property type	Multiplicity
CalibrationDate	datetime	0..1
CalibrationInitials	string	0..1
FirmwareVersion	string	1
NextCalibrationDate	datetime	0..1

Table 106: Value Properties of SensorConfiguration**Figure 15:** Sensor for Rotary Axis Example

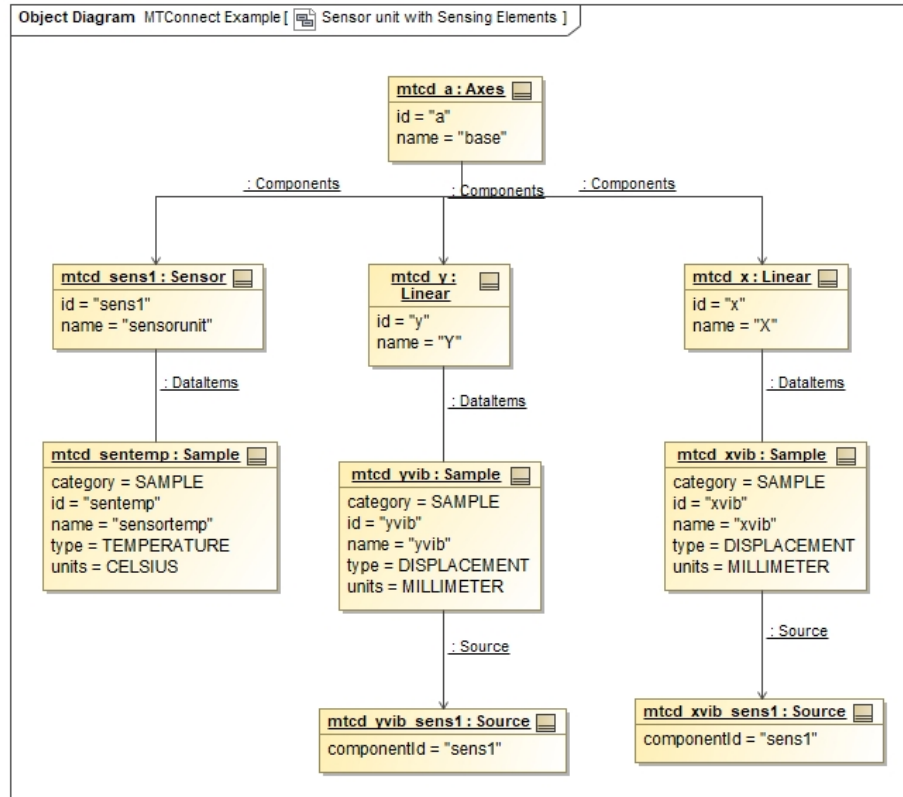


Figure 16: Sensor unit with Sensing Elements Example

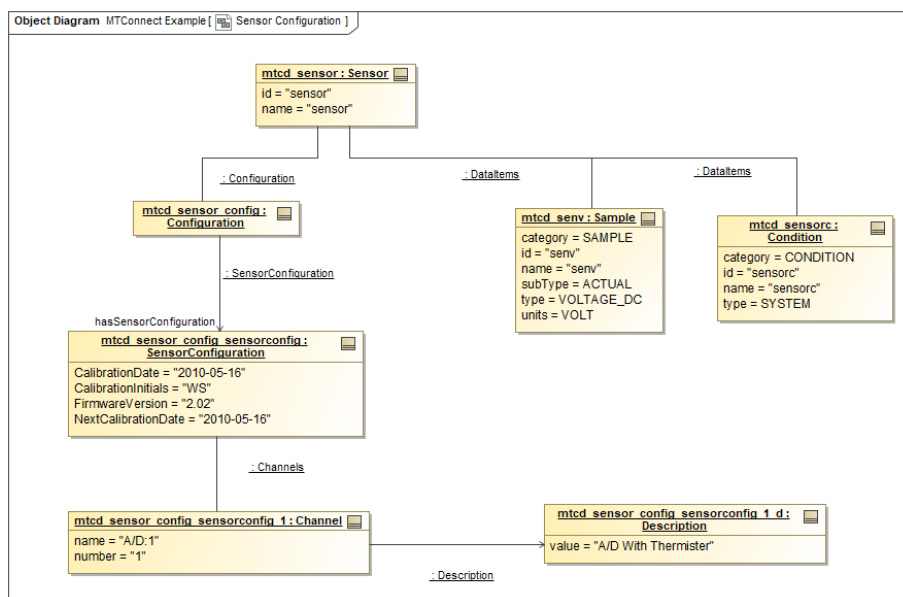


Figure 17: Sensor Configuration Example

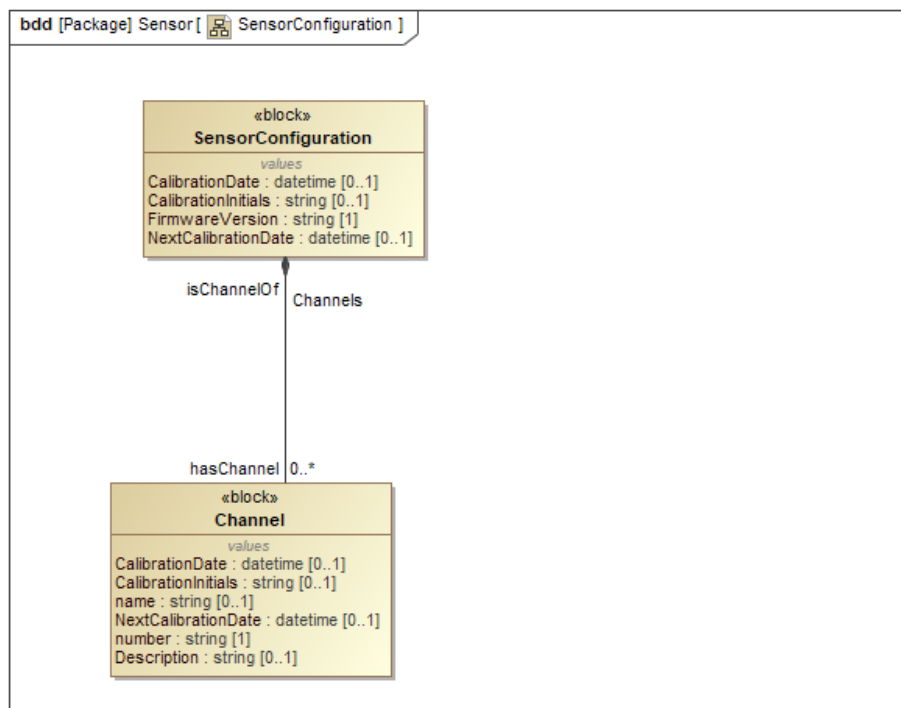


Figure 18: SensorConfiguration

3896 Descriptions for Value Properties of `SensorConfiguration`:

- 3897 • `CalibrationDate`
3898 Date upon which the sensor unit was last calibrated.
- 3899 • `CalibrationInitials`
3900 The initials of the person verifying the validity of the calibration data.
- 3901 • `FirmwareVersion`
3902 Version number for the sensor unit as specified by the manufacturer.
- 3903 • `NextCalibrationDate`
3904 Date upon which the sensor unit is next scheduled to be calibrated.

3905 **8.5.1.2 Part Properties of `SensorConfiguration`**

3906 *Table 107* lists the Part Properties of `SensorConfiguration`.

Part Property name	Multiplicity
Channel (organized by Channels)	0..*

Table 107: Part Properties of `SensorConfiguration`

3907 Descriptions for Part Properties of `SensorConfiguration`:

- 3908 • `Channel`
3909 *sensing element* of a `Sensor`.
- 3910 Channels groups one or more `Channel` entities. See `Channel`.

3911 **8.5.2 Channel**

3912 *sensing element* of a `Sensor`.

3913 When `Sensor` has multiple *sensing elements*, each *sensing element* is modeled as a
3914 `Channel` for the `Sensor`.

3915 **8.5.2.1 Value Properties of `Channel`**

3916 *Table 108* lists the Value Properties of `Channel`.

Value Property name	Value Property type	Multiplicity
CalibrationDate	datetime	0..1
CalibrationInitials	string	0..1
name	string	0..1
NextCalibrationDate	datetime	0..1
number	string	1

Table 108: Value Properties of Channel

3917 Descriptions for Value Properties of Channel:

- 3918 • CalibrationDate
- 3919 Date upon which the sensor unit was last calibrated to the sensor element.
- 3920 • CalibrationInitials
- 3921 The initials of the person verifying the validity of the calibration data.
- 3922 • name
- 3923 name of the specific *sensing element*.
- 3924 • NextCalibrationDate
- 3925 Date upon which the sensor element is next scheduled to be calibrated with the
- 3926 sensor unit.
- 3927 • number
- 3928 unique identifier that will only refer to a specific *sensing element*.

3929 8.6 SolidModel

3930 This section provides semantic information for the `SolidModel` entity.

3931 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

3932 Note: See *Example 9* for the XML representation of the same example.

3933 8.6.1 SolidModel

3934 references to a file with the three-dimensional geometry of the Component or Compo-
3935 sition.

3936 The geometry **MAY** have a transformation and a scale to position the Component with
3937 respect to the other Components. A geometry file can contain a set of assembled items, in
3938 this case, the SolidModel references the id of the assembly model file and the specific
3939 item within that file.

3940 The SolidModel **MAY** provide a translation, rotation, and scale to correctly place it
3941 relative to the other geometries in the machine. If the Component can move and has
3942 a Motion Configuration, the SolidModel will move when the Component or
3943 Composition moves.

3944 Either an href or a modelIdRef and an itemRef **MUST** be specified.

3945 8.6.1.1 Value Properties of SolidModel

3946 *Table 109* lists the Value Properties of SolidModel.

Value Property name	Value Property type	Multiplicity
id	ID	1
solidModelIdRef	ID	0..1
href	string	0..1
itemRef	string	0..1
mediaType	MediaTypeEnum	1
coordinateSystemIdRef	ID	0..1
nativeUnits	NativeUnitEnum	0..1
units	UnitEnum	0..1

Table 109: Value Properties of SolidModel

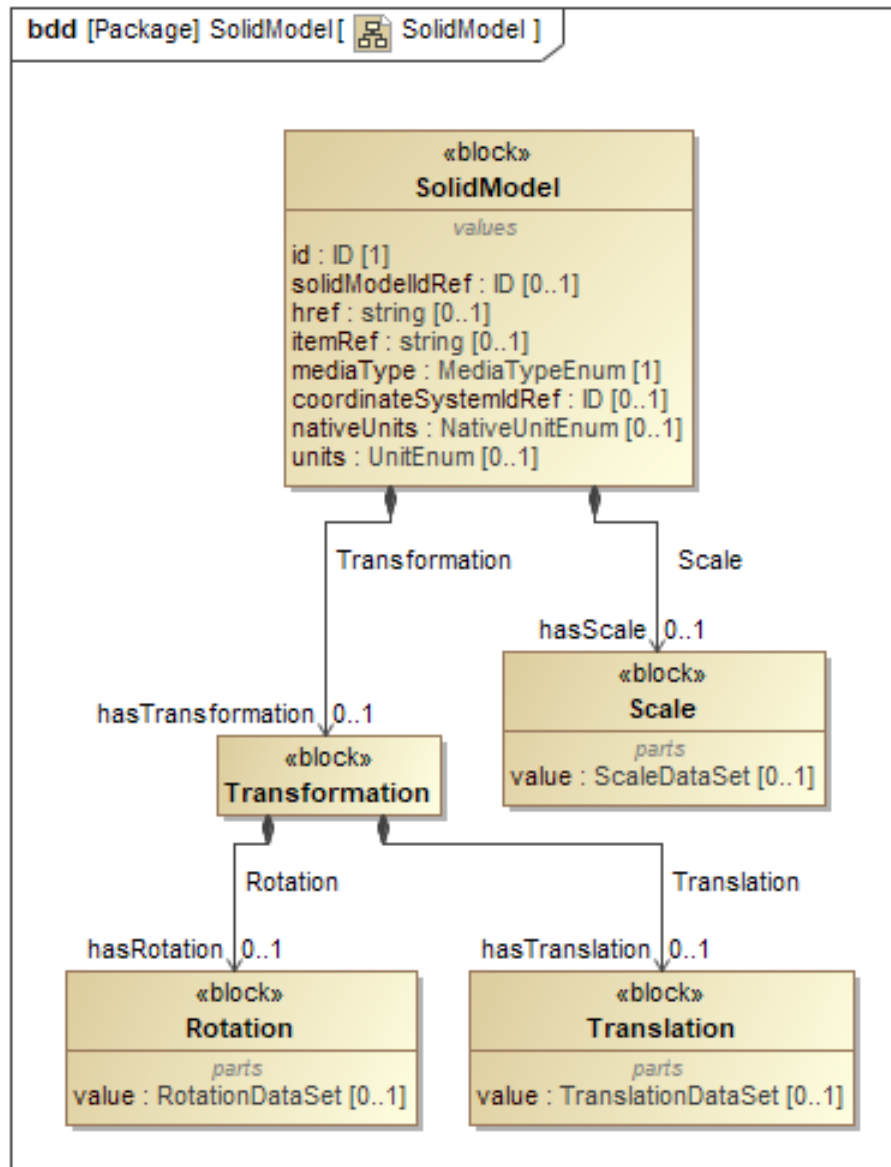
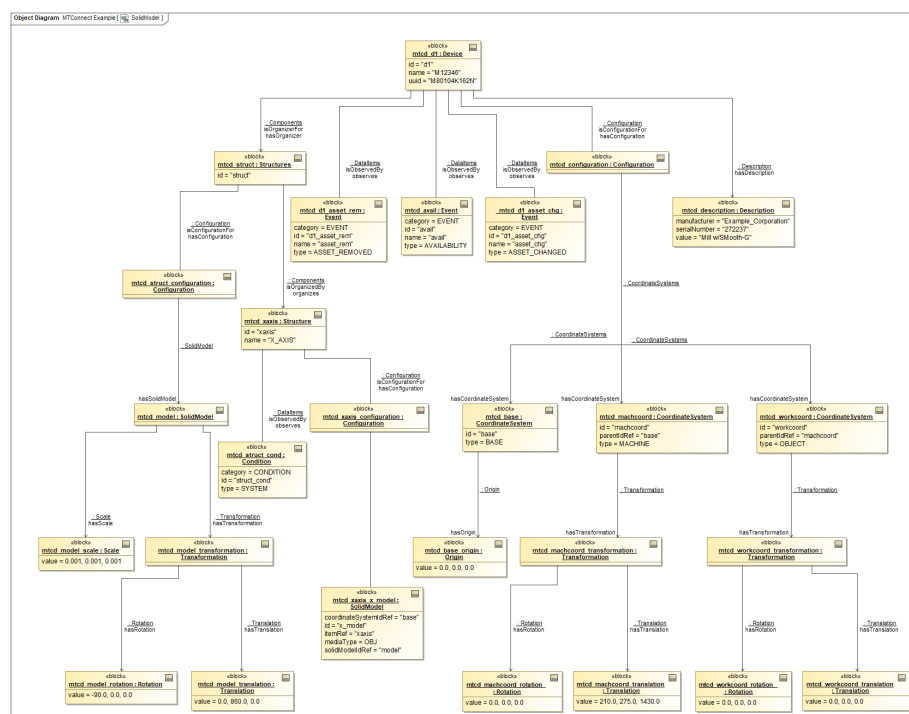


Figure 19: SolidModel



3947 Descriptions for Value Properties of SolidModel:

- 3948 • `id`
3949 unique identifier for this element.
- 3950 • `solidModelIdRef`
3951 associated model file if an item reference is used.
- 3952 • `href`
3953 Uniform Resource Locator (URL) giving the location of the `SolidModel`.
3954 If not present, the model referenced in the `solidModelIdRef` is used.
3955 `href` is of type `xlink:href` from the W3C XLink specification.
- 3956 • `itemRef`
3957 reference to the item within the model within the related geometry. A `solidModelIdRef` **MUST** be given.
3958
- 3959 Note: `Item` defined in ASME Y14.100 - A nonspecific term used to
3960 denote any unit or product, including materials, parts, assemblies, equip-
3961 ment, accessories, and computer software.
- 3962 • `mediaType`
3963 format of the referenced document.
3964 `MediaTypeEnum` Enumeration:
- 3965 – `3DS`
3966 Autodesk file format.
- 3967 – `ACIS`
3968 Dassault file format.
- 3969 – `COLLADA`
3970 ISO 17506.
- 3971 – `GDML`
3972 Geometry Description Markup Language.
- 3973 – `IGES`
3974 Initial Graphics Exchange Specification.
- 3975 – `OBJ`
3976 Wavefront OBJ file format.

- 3977 – STEP
- 3978 ISO 10303 STEP AP203 or AP242 format.
- 3979 – STL
- 3980 STereoLithography file format.
- 3981 – X_T
- 3982 Parasolid XT Siemens data interchange format.

- 3983 • coordinateSystemIdRef
- 3984 reference to the coordinate system for this SolidModel.

- 3985 • nativeUnits
- 3986 same as nativeUnits. See *Section 6.1.1 - DataItem*.
- 3987 The value of nativeUnits **MUST** be one of the NativeUnitEnum enumera-
- 3988 tion.

- 3989 • units
- 3990 same as units. See *Section 6.1.1 - DataItem*.
- 3991 The value of units **MUST** be one of the UnitEnum enumeration.

3992 **8.6.1.2 Part Properties of SolidModel**

3993 *Table 110* lists the Part Properties of SolidModel.

Part Property name	Multiplicity
Transformation	0..1
Scale	0..1

Table 110: Part Properties of SolidModel

3994 Descriptions for Part Properties of SolidModel:

- 3995 • Transformation
- 3996 process of transforming to the origin position of the coordinate system from a parent
- 3997 coordinate system using Translation and Rotation.
- 3998 See *Section 8.2.3 - Transformation*.

- 3999 • `Scale`
- 4000 either a single multiplier applied to all three dimensions or a three space multiplier
- 4001 given in the X, Y, and Z dimensions in the coordinate system used for the `Solid-`
- 4002 `Model`.
- 4003 See *Section 8.6.2 - Scale*.

4004 **8.6.2 Scale**

- 4005 either a single multiplier applied to all three dimensions or a three space multiplier given
- 4006 in the X, Y, and Z dimensions in the coordinate system used for the `SolidModel`.

4007 **8.6.2.1 Part Properties of Scale**

- 4008 *Table 111* lists the Part Properties of `Scale`.

Part Property name	Multiplicity
value	0..1

Table 111: Part Properties of Scale

- 4009 Descriptions for Part Properties of `Scale`:

- 4010 • `ScaleDataSet`
- 4011 multiplier for X axis.

4012 **8.7 Specifications**

- 4013 This section provides semantic information for the `Specification` entity.

- 4014 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

- 4015 Note: See *Example 10* for the XML representation of the same example.

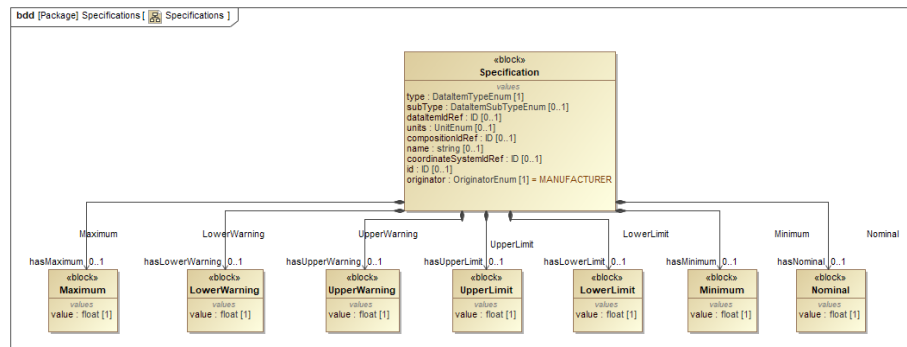


Figure 21: Specifications

8.7.1 Specification

design characteristics for a piece of equipment.

8.7.1.1 Value Properties of Specification

Table 112 lists the Value Properties of Specification.

Value Property name	Value Property type	Multiplicity
type	DataItemTypeEnum	1
subType	DataItemSubTypeEnum	0..1
dataItemIdRef	ID	0..1
units	UnitEnum	0..1
compositionIdRef	ID	0..1
name	string	0..1
coordinateSystemIdRef	ID	0..1
id	ID	0..1
originator	OriginatorEnum	1

Table 112: Value Properties of Specification

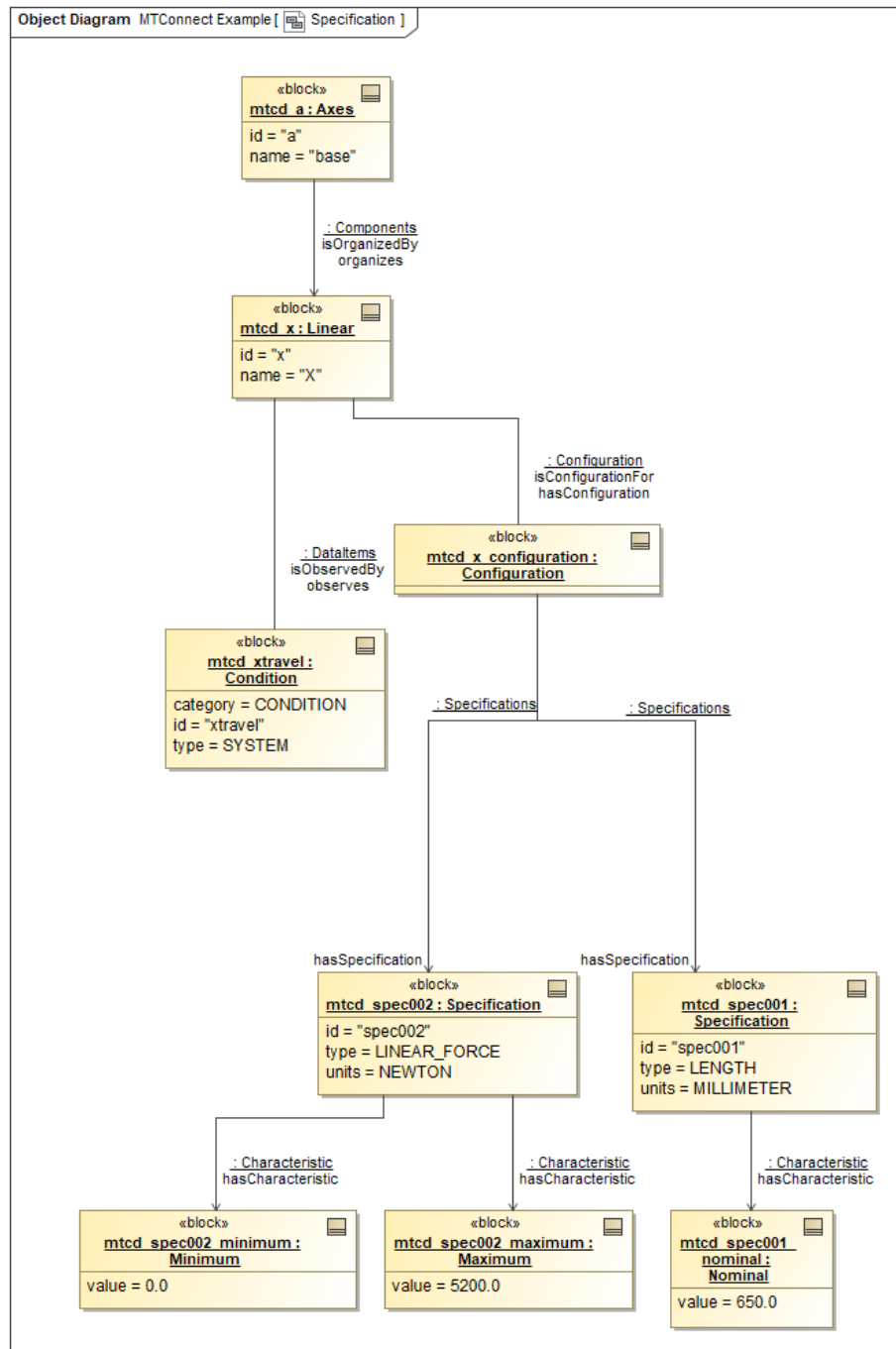


Figure 22: Specification Example

4020 Descriptions for Value Properties of Specification:

- 4021 • type
- 4022 same as type. See *Section 6.5 - DataItem Types*.
- 4023 The value of type **MUST** be one of the DataItemTypeEnum enumeration.
- 4024 • subType
- 4025 same as subType. See *Section 6.1.1 - DataItem*.
- 4026 The value of subType **MUST** be one of the DataItemSubTypeEnum enumer-
- 4027 ation.
- 4028 • dataItemIdRef
- 4029 reference to the id associated with this entity.
- 4030 • units
- 4031 same as units. See *Section 6.1.1 - DataItem*.
- 4032 The value of units **MUST** be one of the UnitEnum enumeration.
- 4033 • compositionIdRef
- 4034 reference to the id associated with this entity.
- 4035 • name
- 4036 name provides additional meaning and differentiates between Specification
- 4037 entities.
- 4038 • coordinateSystemIdRef
- 4039 references the CoordinateSystem for geometric Specification elements.
- 4040 • id
- 4041 unique identifier for this Specification.
- 4042 • originator
- 4043 reference to the creator of the Specification.
- 4044 OriginatorEnum Enumeration:
- 4045 – MANUFACTURER
- 4046 manufacturer of a piece of equipment or Component.
- 4047 – USER
- 4048 owner or implementer of a piece of equipment or Component.

4049 8.7.1.2 Part Properties of Specification

4050 *Table 113* lists the Part Properties of Specification.

Part Property name	Multiplicity
Maximum	0..1
UpperLimit	0..1
LowerWarning	0..1
LowerLimit	0..1
UpperWarning	0..1
Nominal	0..1
Minimum	0..1

Table 113: Part Properties of Specification

4051 Descriptions for Part Properties of Specification:

- 4052 • Maximum
- 4053 numeric upper constraint.
- 4054 • UpperLimit
- 4055 upper conformance boundary for a variable.
- 4056 Note: immediate concern or action may be required.
- 4057 • LowerWarning
- 4058 lower boundary indicating increased concern and supervision may be required.
- 4059 • LowerLimit
- 4060 lower conformance boundary for a variable.
- 4061 Note: immediate concern or action may be required.
- 4062 • UpperWarning
- 4063 upper boundary indicating increased concern and supervision may be required.
- 4064 • Nominal
- 4065 numeric target or expected value.
- 4066 • Minimum
- 4067 numeric lower constraint.

4068 8.7.2 ProcessSpecification

4069 Specification that provides information used to assess the conformance of a variable
4070 to process requirements.

4071 8.7.2.1 Part Properties of ProcessSpecification

4072 Table 114 lists the Part Properties of ProcessSpecification.

Part Property name	Multiplicity
SpecificationLimits	0..1
ControlLimits	0..1
AlarmLimits	0..1

Table 114: Part Properties of ProcessSpecification

4073 Descriptions for Part Properties of ProcessSpecification:

- 4074 • SpecificationLimits
4075 set of limits that define a range of values designating acceptable performance for a
4076 variable.
4077 See Section 8.7.5 - SpecificationLimits.
- 4078 • ControlLimits
4079 set of limits that is used to indicate whether a process variable is stable and in control.
4080 See Section 8.7.3 - ControlLimits.
- 4081 • AlarmLimits
4082 set of limits that is used to trigger warning or alarm indicators.
4083 See Section 8.7.4 - AlarmLimits.

4084 8.7.3 ControlLimits

4085 set of limits that is used to indicate whether a process variable is stable and in control.

4086 8.7.3.1 Part Properties of ControlLimits

4087 Table 115 lists the Part Properties of ControlLimits.

Part Property name	Multiplicity
UpperLimit	0..1
UpperWarning	0..1
LowerWarning	0..1
Nominal	0..1
LowerLimit	0..1

Table 115: Part Properties of ControlLimits

4088 Descriptions for Part Properties of ControlLimits:

- 4089 • UpperLimit
4090 upper conformance boundary for a variable.
- 4091 Note: immediate concern or action may be required.
- 4092 • UpperWarning
4093 upper boundary indicating increased concern and supervision may be required.
- 4094 • LowerWarning
4095 lower boundary indicating increased concern and supervision may be required.
- 4096 • Nominal
4097 numeric target or expected value.
- 4098 • LowerLimit
4099 lower conformance boundary for a variable.
- 4100 Note: immediate concern or action may be required.

4101 **8.7.4 AlarmLimits**

4102 set of limits that is used to trigger warning or alarm indicators.

4103 **8.7.4.1 Part Properties of AlarmLimits**

4104 *Table 116* lists the Part Properties of AlarmLimits.

Part Property name	Multiplicity
UpperLimit	0..1
UpperWarning	0..1
LowerLimit	0..1
LowerWarning	0..1

Table 116: Part Properties of AlarmLimits

4105 Descriptions for Part Properties of AlarmLimits:

4106 • UpperLimit

4107 upper conformance boundary for a variable.

4108 Note: immediate concern or action may be required.

4109 • UpperWarning

4110 upper boundary indicating increased concern and supervision may be required.

4111 • LowerLimit

4112 lower conformance boundary for a variable.

4113 Note: immediate concern or action may be required.

4114 • LowerWarning

4115 lower boundary indicating increased concern and supervision may be required.

4116 8.7.5 SpecificationLimits

4117 set of limits that define a range of values designating acceptable performance for a variable.

4118 8.7.5.1 Part Properties of SpecificationLimits

4119 *Table 117* lists the Part Properties of SpecificationLimits.

Part Property name	Multiplicity
UpperLimit	0..1
Nominal	0..1
LowerLimit	0..1

Table 117: Part Properties of SpecificationLimits

4120 Descriptions for Part Properties of SpecificationLimits:

4121 • UpperLimit

4122 upper conformance boundary for a variable.

4123 Note: immediate concern or action may be required.

4124 • Nominal

4125 numeric target or expected value.

4126 • LowerLimit

4127 lower conformance boundary for a variable.

4128 Note: immediate concern or action may be required.

4129 8.7.6 UpperWarning

4130 upper boundary indicating increased concern and supervision may be required.

4131 The value of UpperWarning **MUST** be float.

4132 8.7.7 UpperLimit

4133 upper conformance boundary for a variable.

4134 Note: immediate concern or action may be required.

4135 The value of UpperLimit **MUST** be float.

4136 8.7.8 Maximum

4137 numeric upper constraint.

4138 The value of Maximum **MUST** be float.

4139 8.7.9 LowerLimit

4140 lower conformance boundary for a variable.

4141 Note: immediate concern or action may be required.

4142 The value of LowerLimit **MUST** be float.

4143 8.7.10 LowerWarning

4144 lower boundary indicating increased concern and supervision may be required.

4145 The value of LowerWarning **MUST** be float.

4146 8.7.11 Minimum

4147 numeric lower constraint.

4148 The value of Minimum **MUST** be float.

4149 8.7.12 Nominal

4150 numeric target or expected value.

4151 The value of Nominal **MUST** be float.

4152 8.8 ImageFiles

4153 This section provides semantic information for the ImageFile entity.

4154 8.8.1 ImageFile

4155 reference to a file containing an image of the Component.

4156 8.8.1.1 Value Properties of ImageFile

4157 Table 118 lists the Value Properties of ImageFile.

Value Property name	Value Property type	Multiplicity
id	ID	1
href	string	1
mediaType	string	1
name	string	0..1

Table 118: Value Properties of ImageFile

4158 Descriptions for Value Properties of ImageFile:

- 4159 • id
- 4160 unique identifier of the image file.
- 4161 • href
- 4162 URL giving the location of the image file.
- 4163 • mediaType
- 4164 mime type of the image file.
- 4165 • name
- 4166 description of the image file.

4167 8.9 PowerSources

4168 This section provides semantic information for the PowerSource entity.

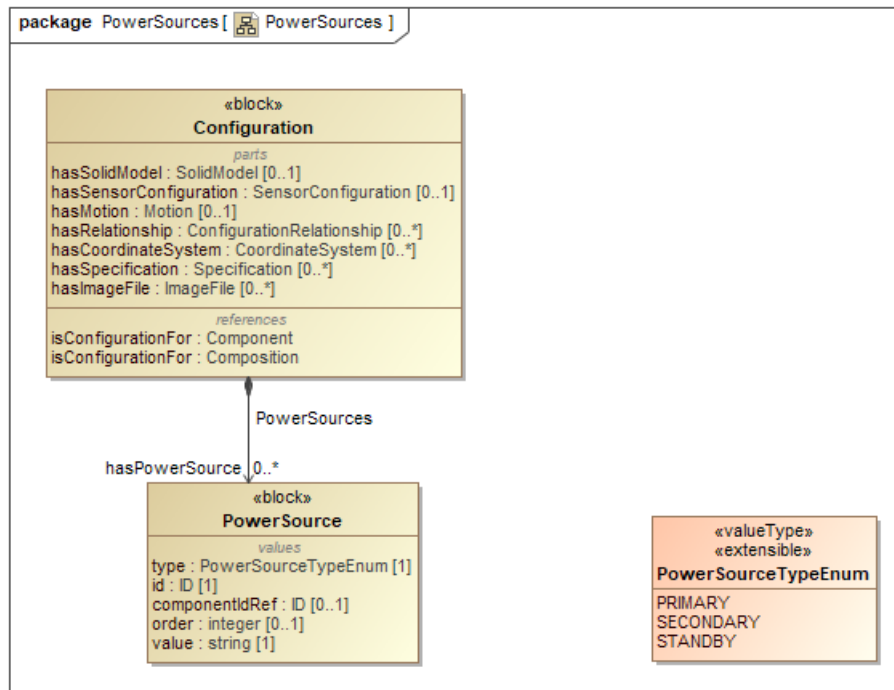


Figure 23: PowerSources

4169 8.9.1 PowerSource

4170 potential energy sources for the Component.

4171 The value of PowerSource **MUST** be string.

4172 8.9.1.1 Value Properties of PowerSource

4173 Table 119 lists the Value Properties of PowerSource.

Value Property name	Value Property type	Multiplicity
type	PowerSourceTypeEnum	1
id	ID	1
componentIdRef	ID	0..1
order	integer	0..1

Table 119: Value Properties of PowerSource

4174 Descriptions for Value Properties of PowerSource:

- 4175 • type
- 4176 type of the power source.
- 4177 <<extensible>> PowerSourceTypeEnum Enumeration:
- 4178 – PRIMARY
- 4179 main or principle.
- 4180 – SECONDARY
- 4181 alternate or not primary.
- 4182 – STANDBY
- 4183 held near at hand and ready for use and is uninterruptible.
- 4184 • id
- 4185 unique identifier for the power source.
- 4186 • componentIdRef
- 4187 reference to the Component providing observations about the power source.
- 4188 • order
- 4189 optional precedence for a given power source.

4190 9 Profile

4191 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML)
4192 metamodel for the MTConnect domain using additional data types and *stereotypes*.

4193 9.1 DataTypes

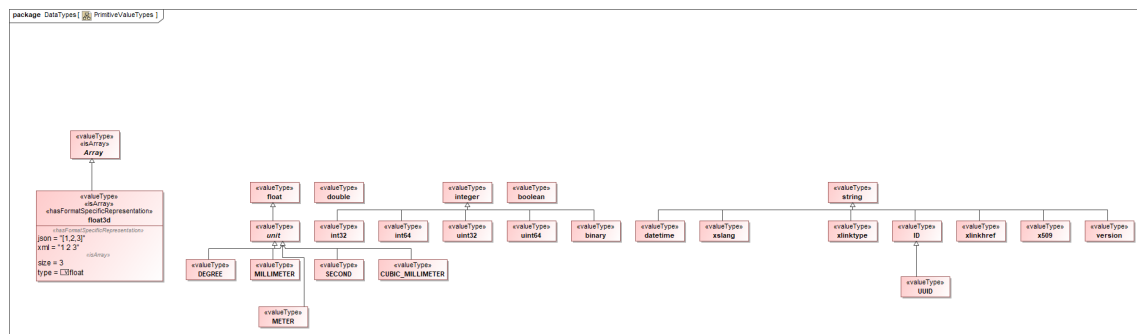


Figure 24: DataTypes

4194 9.1.1 boolean

4195 primitive type.

4196 9.1.2 ID

4197 string that represents an identifier (ID).

4198 **9.1.3 string**

4199 primitive type.

4200 **9.1.4 float**

4201 primitive type.

4202 9.1.5 datetime

4203 string that represents timestamp in ISO 8601 format.

4204 9.1.6 integer

4205 primitive type.

4206 9.1.7 xlinktype

4207 string that represents the type of an XLink element. See [https://www.w3.org/TR/](https://www.w3.org/TR/xlink11/)
4208 [xlink11/](https://www.w3.org/TR/xlink11/).

4209 9.1.8 xslang

4210 string that represents a language tag. See [http://www.ietf.org/rfc/rfc4646.](http://www.ietf.org/rfc/rfc4646.txt)
4211 [txt](http://www.ietf.org/rfc/rfc4646.txt).

4212 9.1.9 SECOND

4213 float that represents time in seconds.

4214 9.1.10 xlinkhref

4215 string that represents the locator attribute of an XLink element. See [https://www.w3.](https://www.w3.org/TR/xlink11/)
4216 [org/TR/xlink11/](https://www.w3.org/TR/xlink11/).

4217 9.1.11 x509

4218 string that represents an x509 data block. *Ref ISO/IEC 9594-8:2020.*

4219 9.1.12 int32

4220 32-bit integer.

4221 9.1.13 int64

4222 64-bit integer.

4223 9.1.14 version

4224 series of three numeric values, separated by a decimal point, representing a *major*, *minor*,
4225 and *patch* number of the MTConnect Standard.

4226 9.1.15 uint32

4227 32-bit unsigned integer.

4228 9.1.16 uint64

4229 64-bit unsigned integer.

4230 9.1.17 binary

4231 base-2 numeral system or binary numeral system represented by two digits: “0” and “1”.

4232 9.1.18 double

4233 primitive type.

4234 **9.1.19 Array**

4235 array.

4236 **9.1.20 <<hasFormatSpecificRepresentation>>float3d**

4237 array of size 3 and datatype float.

4238 **9.1.21 UUID**

4239 Universally Unique Identifier. *Ref IETF:RFC-4122*

4240 **9.1.22 METER**

4241 float that represents measurement in meter.

4242 **9.2 Stereotypes**

4243 **9.2.1 organizer**

4244 element that *organizes* other elements of a type.

4245 **9.2.2 deprecated**

4246 element that has been deprecated.

4247 **9.2.3 extensible**

4248 enumeration that can be extended.

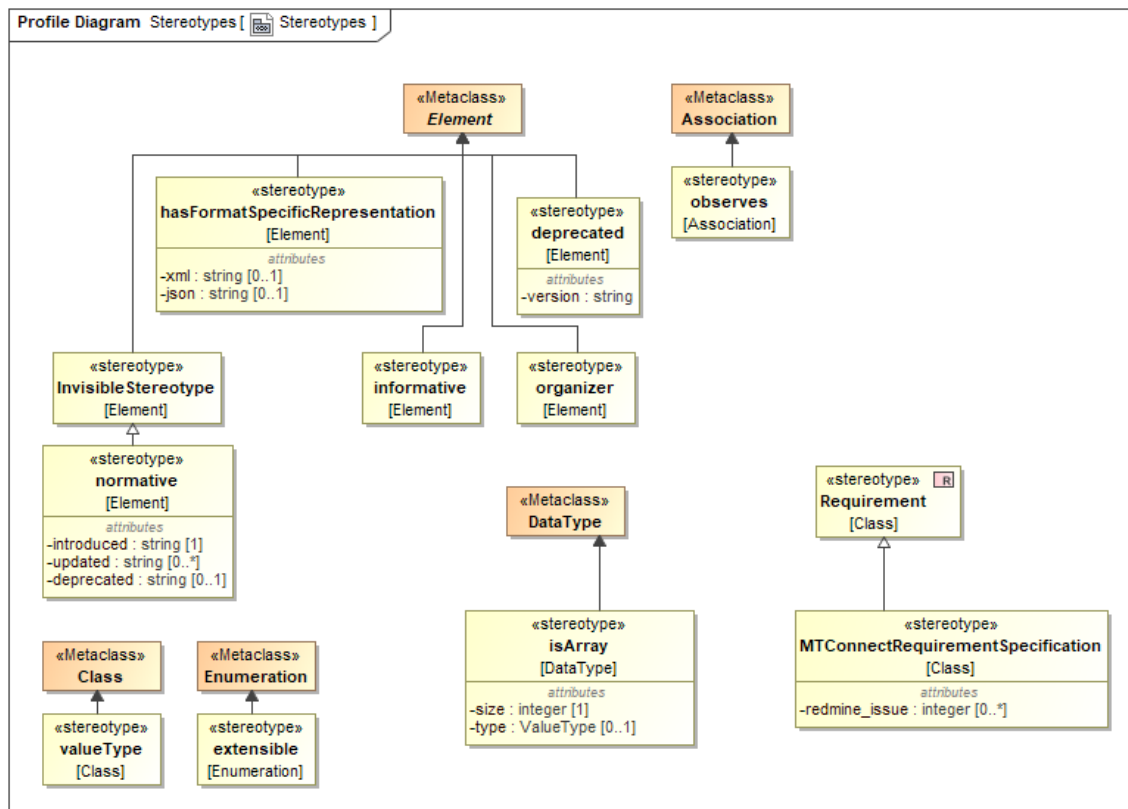


Figure 25: Stereotypes

4249 9.2.4 informative

4250 element that is descriptive and non-normative.

4251 9.2.5 normative

4252 element that has been added to the standard.

4253 9.2.6 observes

4254 association in which a *Component* makes *Observations* about an observable *DataItem*.

4255 9.2.7 satisfiedBy

4256 9.2.8 hasFormatSpecificRepresentation

4257 element that has format specific representation that might be different from the element's
4258 SysML representation.

4259 9.2.9 valueType

4260 extends `Class` to be used as a SysML `<<ValueType>>`.

4261 9.2.10 isArray

4262 datatype that is an array.

4263 9.2.11 MTConnectRequirementSpecification

4264 MTConnect Requirement.

4265 Appendices

4266 A Bibliography

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4268 Block Data Format for Positioning, Contouring, and Contouring/Positioning Numerically
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4271 integration Product data representation and exchange Part 238: Application Protocols: Ap-
4272 plication interpreted model for computerized numerical controllers. Geneva, Switzerland,
4273 2004.
- 4274 International Organization for Standardization. ISO 14649: Industrial automation sys-
4275 tems and integration – Physical device control – Data model for computerized numerical
4276 controllers – Part 10: General process data. Geneva, Switzerland, 2004.
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4278 tems and integration – Physical device control – Data model for computerized numerical
4279 controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.
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4298 tems and integration - Numerical control of machines - Coordinate systems and motion
4299 nomenclature. Geneva, Switzerland, 2001.
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4303 trolled Machining Centers. 2005.
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4305 July 28, 2006.
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4307 tuators – Common Functions, Communication Protocols, and Transducer Electronic Data
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4309 stitute of Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH99684,
4310 October 5, 2007.
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4312 tuators – Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet
4313 (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The Institute of
4314 Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH95225, December
4315 15, 2004.

4316 B XML Schema Diagrams

4317 See XML schemas for the MTConnect standard here: <https://schemas.mtconnect.org/>.
4318

4319 B.1 Components Schema Diagrams

4320 See `Components` element in `MTConnectDevices` schema.

4321 See `Description` element in `MTConnectDevices` schema.

4322 B.2 DataItems Schema Diagrams

4323 See `DataItems` element in `MTConnectDevices` schema.

4324 See `Source` element in `MTConnectDevices` schema.

4325 See `Constraints` element in `MTConnectDevices` schema.

4326 See `Filter` element in `MTConnectDevices` schema.

4327 See `Definition` element in `MTConnectDevices` schema.

4328 B.3 References Schema Diagrams

4329 See `References` element in `MTConnectDevices` schema.

4330 See `ComponentRef` element in `MTConnectDevices` schema.

4331 See `DataItemRef` element in `MTConnectDevices` schema.

4332 B.4 Configuration Schema Diagrams

4333 See `Configuration` element in `MTConnectDevices` schema.

4334 See `CoordinateSystem` element in `MTConnectDevices` schema.

- 4335 See Motion element in MTConnectDevices schema.
- 4336 See Relationships element in MTConnectDevices schema.
- 4337 See ComponentRelationship element in MTConnectDevices schema.
- 4338 See DeviceRelationship element in MTConnectDevices schema.
- 4339 See SensorConfiguration element in MTConnectDevices schema.
- 4340 See SolidModel element in MTConnectDevices schema.
- 4341 See Specifications element in MTConnectDevices schema.
- 4342 See ProcessSpecification element in MTConnectDevices schema.

4343 C XML Examples

4344 C.1 Device Entity Hierarchy Example

Example 3: Device Entity Hierarchy Example

```

4345 1 <Devices>
4346 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4347 3     <Components>
4348 4       <Axes id="a" name="base">
4349 5         <Components>
4350 6           <Linear id="x" name="X"/>
4351 7           <Linear id="y" name="Y"/>
4352 8           <Linear id="z" name="Z"/>
4353 9           <Rotary id="ar" name="B"/>
4354 10          <Linear id="w" name="Z3" nativeName="W"/>
4355 11          <Rotary id="c" name="C"/>
4356 12        </Components>
4357 13      </Axes>
4358 14      <Controller id="cont" name="controller">
4359 15        <Components>
4360 16          <Path id="path1" name="path"/>
4361 17        </Components>
4362 18      </Controller>
4363 19      <Door id="door1" name="door"/>
4364 20      <Systems id="systems" name="systems">
4365 21        <Components>
4366 22          <WorkEnvelope id="we1" name="workenv">
4367 23            <Compositions>
4368 24              <Composition type="WORKPIECE" id="wp"/>

```

```

4369 25      <Composition type="TABLE" id="tbl"/>
4370 26    </Compositions>
4371 27    </WorkEnvelope>
4372 28    <Electric id="elec" name="electric"/>
4373 29    <Hydraulic id="hydraulic" name="hydraulic"/>
4374 30    <Coolant id="coolant" name="coolant"/>
4375 31    <Pneumatic id="pneumatic" name="pneumatic"/>
4376 32    <Lubrication id="lubrication" name="lubrication"/>
4377 33  </Components>
4378 34  </Systems>
4379 35  <Auxiliaries id="Aux" name="auxiliaries">
4380 36    <Components>
4381 37      <Environmental id="room" name="environmental"/>
4382 38    </Components>
4383 39  </Auxiliaries>
4384 40  <Resources id="resources" name="resources">
4385 41    <Components>
4386 42      <Personnel id="personnel" name="personnel"/>
4387 43      <Materials id="materials" name="materials">
4388 44        <Components>
4389 45          <Stock id="procstock" name="stock"/>
4390 46        </Components>
4391 47      </Materials>
4392 48    </Components>
4393 49  </Resources>
4394 50  </Components>
4395 51 </Device>
4396 52 </Devices>

```

4397 C.2 Component Example

Example 4: Component Example

```

4398 1 <Devices>
4399 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4400 3     <Description manufacturer="Example\textunderscore_Corporation"
4401 4       serialNumber="272237"> Mill w/SMooth-G
4402 5     </Description>
4403 6   <DataItems>
4404 7     <DataItem category="EVENT" id="avail" name="avail" type="
4405 8     AVAILABILITY"/>
4406 8     <DataItem category="EVENT" id="d1\textunderscore_asset\
4407 9     textunderscore_chg" name="asset\textunderscore_chg" type="
4408 10    ASSET\textunderscore_CHANGED"/>
4409 9     <DataItem category="EVENT" id="d1\textunderscore_asset\
4410 10    textunderscore_rem" name="asset\textunderscore_rem" type="
4411 11    ASSET\textunderscore_REMOVED"/>
4412 10  </DataItems>

```

```

4413 11      <Components>
4414 12      <Controller id="cont" name="controller">
4415 13          <DataItems>
4416 14              <DataItem category="EVENT" id="estop" name="estop" type="
4417 EMERGENCY\textunderscore_STOP"/>
4418 15              <DataItem category="CONDITION" id="logic\textunderscore_cond"
4419 type="LOGIC\textunderscore_PROGRAM"/>
4420 16              <DataItem category="CONDITION" id="cont\textunderscore_system"
4421 type="SYSTEM"/>
4422 17              <DataItem category="SAMPLE" id="cut\textunderscore_time" type=
4423 "ACCUMULATED\textunderscore_TIME" units="SECOND"/>
4424 18          </DataItems>
4425 19      <Components>
4426 20          <Path id="path1" name="path">
4427 21              <DataItems>
4428 22                  <DataItem category="EVENT" id="execution" name="execution"
4429 type="EXECUTION"/>
4430 23                  <DataItem category="SAMPLE" id="cspeed" subType="ACTUAL"
4431 type="CUTTING\textunderscore_SPEED" units="MILLIMETER/
4432 SECOND"/>
4433 24                  <DataItem category="CONDITION" id="path\textunderscore_
4434 system" type="SYSTEM"/>
4435 25                  <DataItem category="EVENT" id="cvars" representation="DATA\
4436 textunderscore_SET" type="VARIABLE"/>
4437 26                  <DataItem category="EVENT" id="woffset" representation="
4438 TABLE" type="WORK\textunderscore_OFFSET"/>
4439 27              </DataItems>
4440 28          </Path>
4441 29      </Components>
4442 30  </Controller>
4443 31 </Components>
4444 32 </Device>
4445 33 </Devices>

```

4446 C.3 Component with Compositions Example

4447 In XML, Composition types are represented differently than Component types. For
4448 Component types, the element name is Pascal Case of the Component type name.
4449 Whereas, the element name for all Composition types is Composition and the type
4450 is defined by the type attribute of the element (see example below).

Example 5: Component with Compositions Example

```

4451 1 <WorkEnvelope id="we1" name="workenv">
4452 2   <DataItems>
4453 3     <DataItem category="CONDITION" id="hardware1" name="hardware1"
4454 type="HARDWARE"/>
4455 4   </DataItems>

```

```

4456 5    <Compositions>
4457 6    <Composition type="WORKPIECE" id="wp"/>
4458 7    <Composition type="TABLE" id="tbl"/>
4459 8    </Compositions>
4460 9    </WorkEnvelope>

```

4461 C.4 CoordinateSystem Example

Example 6: CoordinateSystem Example

```

4462 1    <Devices>
4463 2    <Device id="d1" name="M12346" uuid="M80104K162N">
4464 3        <Description manufacturer="Example\textunderscore_Corporation"
4465 4            serialNumber="272237"> Mill w/SMooth-G
4466 5        </Description>
4467 6        <DataItems>
4468 7            <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
4469 8            <DataItem category="EVENT" id="d1\textunderscore_asset\
4470 9                textunderscore_chg" name="asset\textunderscore_chg" type="
4471 10                ASSET\textunderscore_CHANGED"/>
4472 11            <DataItem category="EVENT" id="d1\textunderscore_asset\
4473 12                textunderscore_rem" name="asset\textunderscore_rem" type="
4474 13                ASSET\textunderscore_REMOVED"/>
4475 14        </DataItems>
4476 15        <Configuration>
4477 16            <CoordinateSystems>
4478 17                <CoordinateSystem id="base" type="BASE">
4479 18                    <Origin>0 0 0</Origin>
4480 19                </CoordinateSystem>
4481 20                <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef="
4482 21                    "base">
4483 22                    <Transformation>
4484 23                        <Translation>210 275 1430</Translation>
4485 24                        <Rotation>0 0 0</Rotation>
4486 25                    </Transformation>
4487 26                </CoordinateSystem>
4488 27                <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef="
4489 28                    machcoord">
4490 29                    <Transformation>
4491 30                        <Translation>0 0 0</Translation>
4492 31                        <Rotation>0 0 0</Rotation>
4493 32                    </Transformation>
4494 33                </CoordinateSystem>
4495 34            </CoordinateSystems>
4496 35        </Configuration>
4497 36    </Device>
4498 37 </Devices>

```

4499 C.5 Motion Example

Example 7: Motion Example

```

4500 1 <Devices>
4501 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4502 3     <Description manufacturer="Example\textunderscore_Corporation"
4503 4       serialNumber="272237"> Mill w/SMooth-G
4504 5     </Description>
4505 6     <DataItems>
4506 7       <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
4507 8       <DataItem category="EVENT" id="d1\textunderscore_asset\
4508         textunderscore_chg" name="asset\textunderscore_chg" type="
4509         ASSET\textunderscore_CHANGED"/>
4510 9       <DataItem category="EVENT" id="d1\textunderscore_asset\
4511         textunderscore_rem" name="asset\textunderscore_rem" type="
4512         ASSET\textunderscore_REMOVED"/>
4513 10    </DataItems>
4514 11    <Configuration>
4515 12      <CoordinateSystems>
4516 13        <CoordinateSystem id="base" type="BASE">
4517 14          <Origin>0 0 0</Origin>
4518 15        </CoordinateSystem>
4519 16        <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
4520          "base">
4521 17          <Transformation>
4522 18            <Translation>210 275 1430</Translation>
4523 19            <Rotation>0 0 0</Rotation>
4524 20          </Transformation>
4525 21        </CoordinateSystem>
4526 22        <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef="
4527          machcoord">
4528 23          <Transformation>
4529 24            <Translation>0 0 0</Translation>
4530 25            <Rotation>0 0 0</Rotation>
4531 26          </Transformation>
4532 27        </CoordinateSystem>
4533 28      </CoordinateSystems>
4534 29    </Configuration>
4535 30    <Components>
4536 31      <Axes id="a" name="base">
4537 32        <Components>
4538 33          <Linear id="x" name="X">
4539 34            <Configuration>
4540 35              <Motion id="xmotion" coordinateSystemIdRef="machcoord"
4541              type="PRISMATIC" actuation="DIRECT">
4542 36                <Transformation>
4543 37                  <Translaton>300 915 590</Translaton>
4544 38                  <Rotation>0 0 0</Rotation>
4545 39                </Transformation>
4546 40                <Axis>1.0 0 0</Axis>

```

```

4547 41          </Motion>
4548 42          </Configuration>
4549 43        </Linear>
4550 44        <DataItems>
4551 45          <DataItem id="xtravel" type="SYSTEM" category="CONDITION
4552 46        ">
4553 47          </DataItems>
4554 48        </Components>
4555 49      </Axes>
4556 50    </Components>
4557 51  </Device>
4558 52 </Devices>

```

4559 C.6 Relationship Example

Example 8: Relationship Example

```

4560 1  <Components>
4561 2    <Axes id="a" name="base">
4562 3      <Components>
4563 4        <Linear id="x" name="X">
4564 5          <Configuration>
4565 6            <Relationships>
4566 7              <ComponentRelationship id="xpar" type="PARENT" idRef="
4567 8            wel"/>
4568 9            </Relationships>
4569 10          </Configuration>
4570 11        </Linear>
4571 12      <DataItems>
4572 13        <DataItem id="xtravel" type="SYSTEM" category="CONDITION">
4573 14      </DataItems>
4574 15    </Components>
4575 16  </Axes>
4576 17 <Systems id="systems" name="systems">
4577 18   <Components>
4578 19     <WorkEnvelope id="wel" name="workenv">
4579 20       <Compositions>
4580 21         <Composition type="WORKPIECE" id="wp"/>
4581 22         <Composition type="TABLE" id="tbl"/>
4582 23       </Compositions>
4583 24     <DataItems>
4584 25       <DataItem id="welcond" type="SYSTEM" category="CONDITION">
4585 26     </DataItems>
4586 27   </WorkEnvelope>
4587 28 </Components>
4588 29 </Systems>
4589 30 </Components>

```

4590 C.7 SolidModel Example

Example 9: SolidModel Example

```

4591 1 <Devices>
4592 2   <Device id="d1" name="M12346" uuid="M80104K162N">
4593 3     <Description manufacturer="Example\textunderscore_Corporation"
4594 4       serialNumber="272237"> Mill w/SMooth-G
4595 5   </Description>
4596 6   <DataItems>
4597 7     <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
4598 8     <DataItem category="EVENT" id="d1\textunderscore_asset\
4599 9       textunderscore_chg" name="asset\textunderscore_chg" type="
4600 10      ASSET\textunderscore_CHANGED"/>
4601 11     <DataItem category="EVENT" id="d1\textunderscore_asset\
4602 12       textunderscore_rem" name="asset\textunderscore_rem" type="
4603 13      ASSET\textunderscore_REMOVED"/>
4604 14   </DataItems>
4605 15   <Configuration>
4606 16     <CoordinateSystems>
4607 17       <CoordinateSystem id="base" type="BASE">
4608 18         <Origin>0 0 0</Origin>
4609 19       </CoordinateSystem>
4610 20       <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
4611 21         "base">
4612 22         <Transformation>
4613 23           <Translation>210 275 1430</Translation>
4614 24           <Rotation>0 0 0</Rotation>
4615 25         </Transformation>
4616 26       </CoordinateSystem>
4617 27       <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef="
4618 28         machcoord">
4619 29         <Transformation>
4620 30           <Translation>0 0 0</Translation>
4621 31           <Rotation>0 0 0</Rotation>
4622 32         </Transformation>
4623 33       </CoordinateSystem>
4624 34     </CoordinateSystems>
4625 35   </Configuration>
4626 36   <Components>
4627 37     <Structures id="struct">
4628 38       <Configuration>
4629 39         <SolidModel id="model" mediaType="OBJ" href="/objs/mazak.
4630 40         obj" coordinateSystemIdRef="base">
4631 41         <Transformation>
4632 42           <Translation>0 860 0</Translation>
4633 43           <Rotation>-90 0 0</Rotation>
4634 44         </Transformation>
4635 45         <Scale>0.001 0.001 0.001</Scale>
4636 46       </SolidModel>
4637 47     </Configuration>

```

```

4638 41      <Components>
4639 42          <Structure id="xaxis" name="X\textunderscore_AXIS">
4640 43              <Configuration>
4641 44                  <SolidModel id="x\textunderscore_model" mediaType="OBJ
4642      " itemRef="xaxis" solidModelIdRef="model" coordinateSystemIdRef="
4643      base"/>
4644 45              </Configuration>
4645 46              <DataItems>
4646 47                  <DataItem type="SYSTEM" category="CONDITION" id="
4647      struct\textunderscore_cond"/>
4648 48              </DataItems>
4649 49          </Structure>
4650 50      </Components>
4651 51  </Structures>
4652 52  </Components>
4653 53  </Device>
4654 54  </Devices>

```

4655 C.8 Specification Example

Example 10: Specification Example

```

4656 1  <Components>
4657 2  <Axes id="a" name="base">
4658 3      <Components>
4659 4          <Linear id="x" name="X">
4660 5              <Configuration>
4661 6                  <Specifications>
4662 7                      <Specification id="spec001" type="LENGTH" units="
4663      MILLIMETER">
4664 8                          <Nominal>650</Nominal>
4665 9                      </Specification>
4666 10                     <Specification id="spec002" type="LINEAR\textunderscore_
4667      FORCE" units="NEWTON">
4668 11                         <Maximum>5200</Maximum>
4669 12                         <Minimum>0</Minimum>
4670 13                     </Specification>
4671 14                 </Specifications>
4672 15             </Configuration>
4673 16             <DataItems>
4674 17                 <DataItem id="xtravel" type="SYSTEM" category="CONDITION">
4675 18             </DataItems>
4676 19         </Linear>
4677 20     </Components>
4678 21 </Axes>
4679 22 </Components>

```


4680 C.9 Example of sensing element provided as data item associated with 4681 a Component

Example 11: Example of sensing element provided as data item associated with a Component

```

4682 1  <Components>
4683 2    <Axes id="a" name="base"
4684 3      <Components>
4685 4        <Rotary id="c" name="C">
4686 5          <DataItems>
4687 6            <DataItem type="TEMPERATURE" id="servotemp4"
4688 7              category="SAMPLE" nativeUnits="CELSIUS"
4689 8              compositionId="Bmotor" units="CELSIUS"/>
4690 9          </DataItems>
4691 10        </Rotary>
4692 11      </Components>
4693 12    </Axes>
4694 13  </Components>

```

4695 C.10 Example of Sensor for rotary axis

Example 12: Example of Sensor for rotary axis

```

4696 1  <Components>
4697 2    <Axes id="a" name="base"
4698 3      <Components>
4699 4        <Rotary id="ar" name="B">
4700 5          <Components>
4701 6            <Sensor id="spdlm" name="Spindlemonitor">
4702 7              <DataItems>
4703 8                <DataItem type="DISPLACEMENT" id="cvib"
4704 9                  category="SAMPLE" name="Svib"
4705 10                 units="MILLIMETER"/>
4706 11              </DataItems>
4707 12            </Sensor >
4708 13          </Components>
4709 14        </Rotary>
4710 15      </Components>
4711 16    </Axes>
4712 17  </Components>

```

4713 C.11 Example of sensor unit with sensing element

Example 13: Example of sensor unit with sensing element

```

4714 1 <Axes id="a" name="base"
4715 2   <Components>
4716 3   <Sensor id="sens1" name="Sensorunit">
4717 4     <DataItems>
4718 5     <DataItem type="TEMPERATURE" id="sentemp"
4719 6       category="SAMPLE" name="Sensortemp"
4720 7       units="CELSIUS"/>
4721 8     </DataItems>
4722 9   </Sensor >
4723 10  <Linear id="x" name="X">
4724 11    <DataItems>
4725 12    <DataItem type="DISPLACEMENT" id="xvib"
4726 13      category="SAMPLE" name="xvib"
4727 14      units="MILLIMETER">
4728 15      <Source componentId="sens1"/>
4729 16    </DataItem>
4730 17    </DataItems>
4731 18  </Rotary>
4732 19  <Linear id="y" name="Y">
4733 20    <DataItems>
4734 21    <DataItem type="DISPLACEMENT" id="yvib"
4735 22      category="SAMPLE" name="yvib"
4736 23      units="MILLIMETER">
4737 24      <Source componentId="sens1"/>
4738 25    </DataItem>
4739 26    </DataItems>
4740 27  </Linear>
4741 28  <Components>
4742 29 </Axes>

```

4743 C.12 Example of configuration data for Sensor**Example 14: Example of configuration data for Sensor**

```

4744 1 <Sensor id="sensor" name="sensor">
4745 2   <Configuration>
4746 3     <SensorConfiguration>
4747 4       <FirmwareVersion>2.02</FirmwareVersion>
4748 5       <CalibrationDate>2010-05-16</CalibrationDate>
4749 6       <NextCalibrationDate>2010-05-16</NextCalibrationDate>
4750 7       <CalibrationInitials>WS</CalibrationInitials>
4751 8     <Channels>
4752 9       <Channel number="1" name="A/D:1">
4753 10        <Description>A/D With Thermister</Description>
4754 11      </Channel>
4755 12    </Channels>
4756 13  </SensorConfiguration>

```

```
4757 14    </Configuration>
4758 15    <DataItems>
4759 16        <DataItem category="CONDITION" id="sensorc"
4760 17            name="sensorc" type="SYSTEM" />
4761 18        <DataItem category="SAMPLE" id="senv" name="sensorc"
4762 19            type="VOLTAGE\textunderscore_DC" units="VOLT" subType="ACTUAL"
4763            />
4764 20    </DataItems>
4765 21 </Sensor>
```