



MTConnect[®] Standard

Part 2.0 – Device Information Model

Version 2.1.0

Prepared for: MTConnect Institute

Prepared from: MTConnectSysMLModel.xml

Prepared on: January 14, 2023

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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 MTConnect References

18 [MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Fundamentals*. Version 2.0.

19 [MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Device Information Model*. Ver-
20 sion 2.0.

21 [MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Observation Information Model*.
22 Version 2.0.

23 [MTConnect Part 4.0] *MTConnect Standard: Part 4.0 - Asset Information Model*. Ver-
24 sion 2.0.

25

26 3 Device Information Model

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

30 Using information defined in the *Device Information Model*, a software application can
31 determine the configuration and reporting capabilities of a piece of equipment. To do this,
32 the software application issues a *probe request* (defined in *MTConnect Standard Part 1.0 -*
33 *Fundamentals*) to an *agent* associated with a piece of equipment. An *agent* responds to the
34 *probe request* with an *MTConnectDevices Response Document* that contains information
35 describing both the physical and logical structure of the piece of equipment and a detailed
36 description of each *Observation* that can be reported by the *agent* associated with the
37 piece of equipment. This information allows the client software application to interpret
38 the document and to extract the data with the same meaning, value, and context that it had
39 at its original source.

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

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

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

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

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

52 The *Components* and *DataItems* in the *MTConnectDevices Response Document* provide
53 information representing the physical and logical structure for a piece of equipment and
54 the types of data that the piece of equipment can report relative to that structure. The *MT-*
55 *ConnectDevices Response Document* does not contain values for the data types reported
56 by the piece of equipment. The *MTConnectStreams Response Document* defined in *MT-*
57 *Connect Standard: Part 3.0 - Observation Information Model* provides the data values that
58 are reported by the piece of equipment.

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

65 3.1 Device

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

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

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

69 A Device **MUST** have the following DataItems: Availability, AssetChanged,
 70 and AssetRemoved.

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

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

74 3.1.1 Value Properties of Device

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

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

Table 1: Value Properties of Device

76 Descriptions for Value Properties of Device:

- 77 • <<deprecated>> iso841Class
- 78 **DEPRECATED** in *MTConnect Version 1.2*.

- 79 • `mtconnectVersion`
- 80 MTConnect version of the *Device Information Model* used to configure the informa-
- 81 tion to be published for a piece of equipment in an *MTConnect Response Document*.

82 3.1.2 Part Properties of Device

83 *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

84 Descriptions for Part Properties of Device:

- 85 • **Auxiliary**
- 86 abstract Component composed of removable part(s) of a piece of equipment that
- 87 provides supplementary or extended functionality.
- 88 • **Controller**
- 89 System that provides regulation or management of a system or component. *Ref ISO*
- 90 *16484-5:2017*
- 91 • **Interface**
- 92 abstract Component that coordinates actions and activities between pieces of equip-
- 93 ment.
- 94 • **Resource**
- 95 abstract Component composed of material or personnel involved in a manufactur-
- 96 ing process.

- 97 • **Structure**
- 98 **Component** composed of part(s) comprising the rigid bodies of the piece of equip-
- 99 **ment.**
- 100 • **System**
- 101 **abstract Component** that is permanently integrated into the piece of equipment.
- 102 • **Axis**
- 103 **abstract Component** composed of a motion system that provides linear or rota-
- 104 **tional motion for a piece of equipment.**
- 105 • **Adapter**
- 106 **Component** that provides information about the data source for an *MTConnect*
- 107 **Agent.**

108 3.1.3 Commonly Observed DataItem Types for Device

109 *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

110 4 Components Model

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

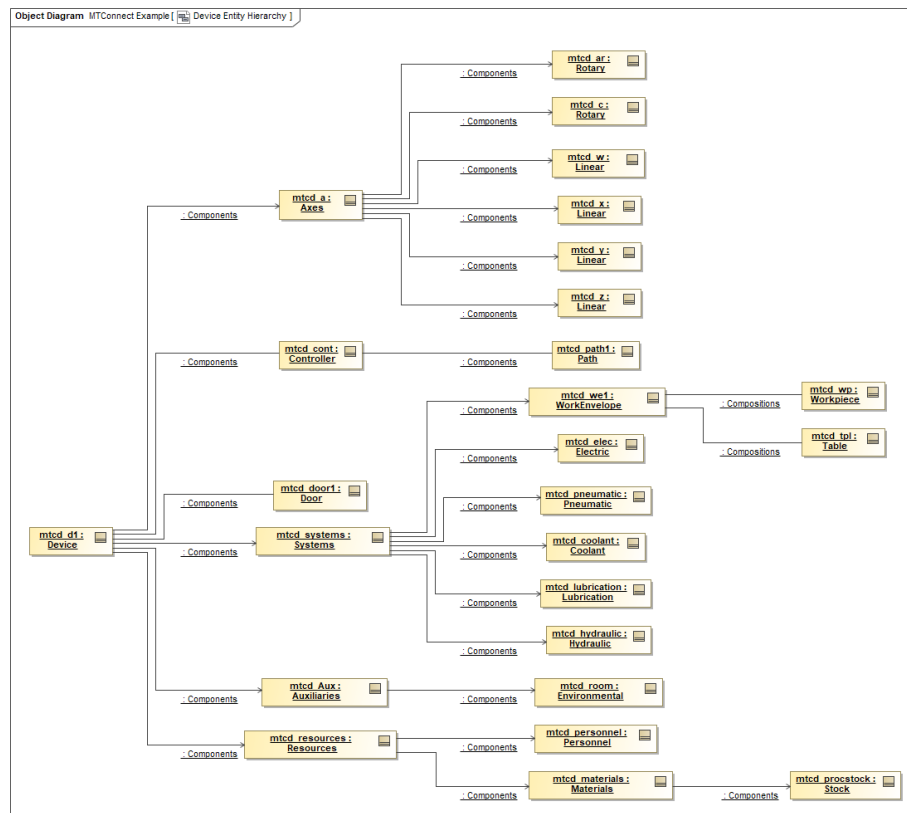


Figure 1: Device Entity Hierarchy Example

114 Note 1 to entry: See *Example 1* for the Extensible Markup Language (XML)
 115 representation of the same example.

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

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

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

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

131 One or more Device entities **MUST** always be defined for an MTConnectDevices
132 entity.

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

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

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

141 If *lower level* entities are described, these entities are by definition child Component
142 entities of a parent Component. At this next level, the *lower level* child Component
143 entities are grouped by Components.

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

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

152 Note: See Figure 1 for an example.

153 4.1 Components

154 This section provides semantic information for the Component entity. Figure 2 shows
 155 the Component model.

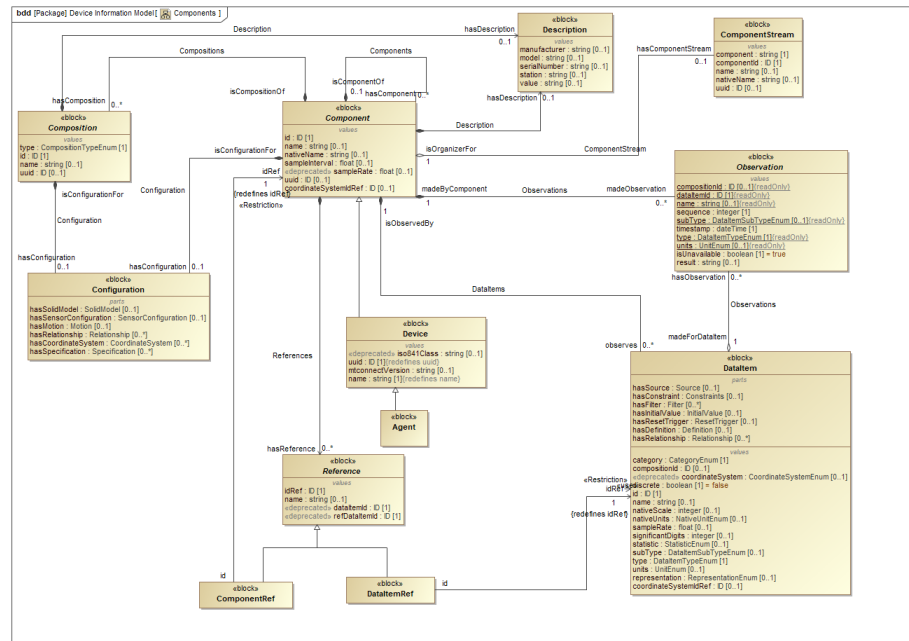


Figure 2: Components

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

157 4.1.1 Component

158 logical or physical entity that provides a capability.

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

162 Component also provides structure for describing the *lower level* entities associated with
 163 it.

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

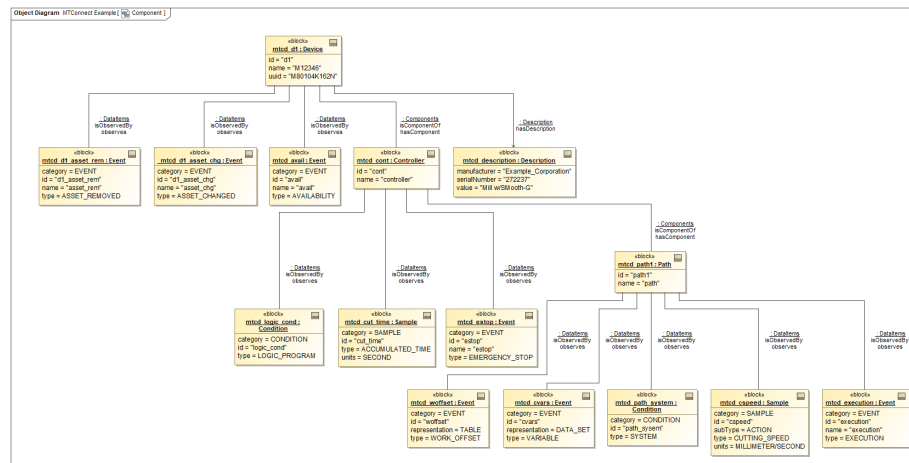


Figure 3: Component Example

Note: See *Example 2* 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	ID	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.

- 176 • `nativeName`
177 common name associated with `Component`.
- 178 • `sampleInterval`
179 interval in milliseconds between the completion of the reading of the data associated
180 with the `Component` until the beginning of the next sampling of that data.
181 This information may be used by client software applications to understand how
182 often information from a `Component` is expected to be refreshed.
183 The refresh rate for data from all child `Component` entities will be the same as for
184 the parent `Component` element unless specifically overridden by another sam-
185 pleInterval provided for the child `Component`.
- 186 • `<<deprecated>> sampleRate`
187 **DEPRECATED** in *MTConnect Version 1.2*. Replaced by `sampleInterval`, `Component`.
- 188 • `uuid`
189 universally unique identifier for the `Component`.
- 190 • `coordinateSystemIdRef`
191 specifies the `CoordinateSystem` for this `Component` and its children.

192 4.1.1.2 Reference Properties of Component

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

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

Table 5: Reference Properties of `Component`

194 Descriptions for Reference Properties of `Component`:

- 195 • `ComponentStream`
196 organizes the data associated with each `Component` entity defined for a `Device`
197 in the associated *MTConnectDevices Response Document*.
198 `ComponentStream` *organizes* the `Observation` entities associated with the
199 `Component`.
200 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Com-
201 ponentStream model.

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

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

206 4.1.1.3 Part Properties of Component

207 *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

208 Descriptions for Part Properties of Component:

- 209 • Description
 210 descriptive content.
 211 See *Section 4.1.2 - Description*.
- 212 • Composition
 213 functional part of a piece of equipment contained within a Component.
 214 `Compositions` groups one or more `Composition` entities. See *Section 5.1 -*
 215 *Compositions*.
- 216 • Component
 217 logical or physical entity that provides a capability.
 218 `Components` groups one or more `Component` entities.
- 219 • Configuration
 220 technical information about an entity describing its physical layout, functional char-
 221 acteristics, and relationships with other entities.
 222 See *Section 8.1 - Configurations*.

- 223 • `DataItem`
 224 information reported about a piece of equipment.
 225 `DataItems` groups one or more `DataItem` entities. See *Section 6.1 - DataItems*.
- 226 • `Observation`
 227 abstract entity that provides telemetry data for a `DataItem` at a point in time.
 228 `Observations` groups one or more `Observations` made by the Component
 229 entity.
 230 Component make `Observations` about observed `DataItems`.
 231 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Ob-
 232 servation model.
- 233 Note 1 to entry: In the XML representation, `Observation` entities
 234 **MUST NOT** appear in the *MTConnectDevices Response Document*.
- 235 Note 2 to entry: In the XML representation, `Observation` entities
 236 **MUST** appear only in the *MTConnectStreams Response Document*.
- 237 • `Reference`
 238 pointer to information that is associated with another entity defined elsewhere in the
 239 `MTConnectDevices` entity for a piece of equipment.
 240 `References` groups one or more `Reference` entities associated with the Com-
 241 ponent. See *Section 7.1 - References*.

242 4.1.2 Description

243 descriptive content.

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

245 Note 2 to entry: See *Example 2* for the XML representation of the same ex-
 246 ample.

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

248 4.1.2.1 Value Properties of Description

249 *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

250 Descriptions for Value Properties of Description:

- 251 • `manufacturer`
252 name of the manufacturer of the physical or logical part of a piece of equipment
253 represented by this element.
- 254 • `model`
255 model description of the physical part or logical function of a piece of equipment
256 represented by this element.
- 257 • `serialNumber`
258 serial number associated with a piece of equipment.
- 259 • `station`
260 station where the physical part or logical function of a piece of equipment is located
261 when it is part of a manufacturing unit or cell with multiple stations.

262 4.2 Devices

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

264 4.2.1 Agent

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

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

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

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

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

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

272 4.3 Component Types

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

274 Note: In the XML representation, Component entities are defined into two
275 major categories:

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

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

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

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

289 4.3.1 Actuator

290 Component composed of a physical apparatus that moves or controls a mechanism or
291 system.

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

294 4.3.2 Adapter

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

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

298 4.3.3 Amplifier

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

301 4.3.3.1 Part Properties of Amplifier

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

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 8: Part Properties of Amplifier

303 Descriptions for Part Properties of `Amplifier`:

- 304 • `Composition`
305 functional part of a piece of equipment contained within a `Component`.
- 306 • `Component`
307 logical or physical entity that provides a capability.

308 4.3.4 Auxiliary

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

311 **4.3.4.1 Deposition**

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

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

316 **4.3.4.2 Environmental**

317 Auxiliary that monitors, manages, or conditions the environment around or within a
318 piece of equipment.

319 **4.3.4.2.1 Heating**

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

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

324 **4.3.4.2.2 Vacuum**

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

327 **4.3.4.2.3 Cooling**

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

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

332 **4.3.4.2.4 Pressure**

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

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

337 **4.3.4.3 Loader**

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

340 **4.3.4.3.1 BarFeeder**

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

342 **4.3.4.4 ToolingDelivery**

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

345 **4.3.4.4.1 GangToolBar**

346 ToolingDelivery composed of a tool mounting mechanism that holds any number of
347 tools.

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

350 **4.3.4.4.2 AutomaticToolChanger**

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

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

355 **4.3.4.4.3 ToolMagazine**

356 ToolingDelivery composed of a tool storage mechanism that holds any number of
357 tools.

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

360 **4.3.4.4.4 ToolRack**

361 `ToolingDelivery` composed of a linear or matrixed tool storage mechanism that holds
362 any number of tools.

363 Tools are located in `Station` entities.

364 **4.3.4.4.5 Turret**

365 `ToolingDelivery` composed of a tool mounting mechanism that holds any number of
366 tools.

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

368 **4.3.4.5 WasteDisposal**

369 `Auxiliary` that removes manufacturing byproducts from a piece of equipment.

370 **4.3.5 Axis**

371 abstract `Component` composed of a motion system that provides linear or rotational mo-
372 tion for a piece of equipment.

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

375 `Linear` and `Rotary` components **MUST** have a `name` attribute that **MUST** follow
376 the conventions described below. Use the `nativeName` attribute for the manufacturer's
377 name of the axis if it differs from the assigned `name`.

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

382 Examples of cartesian coordinate equipment are `CNC Machine Tools`, `Coordinate mea-`

383 surement machines, as specified in ISO 841, and 3D Printers. Examples of articulated
384 automation equipment are Robotic systems as specified in ISO 8373.

385 The following sections define the designation of names for the axes and additional guid-
386 ance when selecting the correct scheme to use for a given piece of equipment.

387 **4.3.5.1 Cartesian Coordinate Naming Conventions**

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

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

392 **4.3.5.1.1 Linear Motion**

393 A piece of equipment **MUST** represent prismatic motion using a Linear axis Compo-
394 nent and assign its name using the designations X, Y, and Z. A Linear axis name
395 **MUST** append a monotonically increasing suffix when there are more than one parallel
396 axes; for example, X2, X3, and X4.

397 **4.3.5.1.2 Rotary Motion**

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

402 **4.3.5.2 Articulated Machine Control Systems**

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

408 **4.3.5.3 Articulated Machine Axis Names**

The axes of articulated machines represent forward kinematic relationships between mechanical linkages. Each axis is a connection between linkages, also referred to as joints, and **MUST** be named using a J followed by a monotonically increasing number; for example, J1, J2, J3. The numbering starts at the base axis connected or closest to the mounting surface, J1, incrementing to the mechanical interface, J_n, where n is the number of the last axis. The chain forms a parent-child relationship with the parent being the axis closest to the base.

A machine having an axis with more than one child **MUST** number each branch using its numeric designation followed by a branch number and a monotonically increasing number. For example, if J2 has two children, the first child branch **MUST** be named J2.1.1 and the second child branch J2.2.1. A child of the first branch **MUST** be named J2.1.2, incrementing to J2.1.n, where J2.1.n is the number of the last axis in that branch.

4.3.5.4 Linear

Axis that provides prismatic motion along a fixed axis.

4.3.5.5 Rotary

Axis that provides rotation about a fixed axis.

4.3.5.6 <<deprecated>>Spindle

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

Spindle was **DEPRECATED** in *MTConnect Version 1.1* and was replaced by RotaryMode.

4.3.6 Ballscrew

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

4.3.6.1 Part Properties of Ballscrew

Table 9 lists the Part Properties of Ballscrew.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 9: Part Properties of Ballscrew

435 Descriptions for Part Properties of Ballscrew:

- 436 • Composition
- 437 functional part of a piece of equipment contained within a Component.
- 438 • Component
- 439 logical or physical entity that provides a capability.

440 4.3.7 Belt

441 leaf Component composed of an endless flexible band that transmits motion for a piece

442 of equipment or conveys materials and objects.

443 4.3.7.1 Part Properties of Belt

444 *Table 10* lists the Part Properties of Belt.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 10: Part Properties of Belt

445 Descriptions for Part Properties of Belt:

- 446 • Composition
- 447 functional part of a piece of equipment contained within a Component.
- 448 • Component
- 449 logical or physical entity that provides a capability.

450 4.3.8 Brake

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

453 4.3.8.1 Part Properties of Brake

454 *Table 11* lists the Part Properties of `Brake`.

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

Table 11: Part Properties of `Brake`

455 Descriptions for Part Properties of `Brake`:

- 456 • `Composition`
 457 functional part of a piece of equipment contained within a `Component`.
- 458 • `Component`
 459 logical or physical entity that provides a capability.

460 4.3.9 Chain

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

463 4.3.9.1 Part Properties of Chain

464 *Table 12* lists the Part Properties of `Chain`.

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

Table 12: Part Properties of `Chain`

465 Descriptions for Part Properties of `Chain`:

- 466 • `Composition`
- 467 functional part of a piece of equipment contained within a `Component`.
- 468 • `Component`
- 469 logical or physical entity that provides a capability.

470 **4.3.10 Chopper**

471 leaf `Component` that breaks material into smaller pieces.

472 **4.3.10.1 Part Properties of Chopper**

473 *Table 13* lists the Part Properties of Chopper.

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

Table 13: Part Properties of Chopper

474 Descriptions for Part Properties of Chopper:

- 475 • `Composition`
- 476 functional part of a piece of equipment contained within a `Component`.
- 477 • `Component`
- 478 logical or physical entity that provides a capability.

479 **4.3.11 Chuck**

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

481 **4.3.12 Chute**

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

483 4.3.12.1 Part Properties of Chute

484 *Table 14* lists the Part Properties of Chute.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 14: Part Properties of Chute

485 Descriptions for Part Properties of Chute:

- 486 • Composition
- 487 functional part of a piece of equipment contained within a Component.
- 488 • Component
- 489 logical or physical entity that provides a capability.

490 4.3.13 CircuitBreaker

491 leaf Component that interrupts an electric circuit.

492 4.3.13.1 Part Properties of CircuitBreaker

493 *Table 15* lists the Part Properties of CircuitBreaker.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 15: Part Properties of CircuitBreaker

494 Descriptions for Part Properties of CircuitBreaker:

- 495 • Composition
- 496 functional part of a piece of equipment contained within a Component.
- 497 • Component
- 498 logical or physical entity that provides a capability.

499 4.3.14 Clamp

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

501 4.3.14.1 Part Properties of Clamp

502 *Table 16* lists the Part Properties of `Clamp`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 16: Part Properties of `Clamp`

503 Descriptions for Part Properties of `Clamp`:

- 504 • `Composition`
- 505 functional part of a piece of equipment contained within a `Component`.
- 506 • `Component`
- 507 logical or physical entity that provides a capability.

508 4.3.15 Compressor

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

512 4.3.15.1 Part Properties of Compressor

513 *Table 17* lists the Part Properties of `Compressor`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 17: Part Properties of `Compressor`

514 Descriptions for Part Properties of `Compressor`:

- 515 • `Composition`
- 516 functional part of a piece of equipment contained within a `Component`.
- 517 • `Component`
- 518 logical or physical entity that provides a capability.

519 **4.3.16 CoolingTower**

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

522 **4.3.16.1 Part Properties of CoolingTower**

523 *Table 18* lists the Part Properties of `CoolingTower`.

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

Table 18: Part Properties of `CoolingTower`

524 Descriptions for Part Properties of `CoolingTower`:

- 525 • `Composition`
- 526 functional part of a piece of equipment contained within a `Component`.
- 527 • `Component`
- 528 logical or physical entity that provides a capability.

529 **4.3.17 Door**

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

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

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

537 4.3.17.1 Commonly Observed DataItem Types for Door

538 Table 19 lists the Commonly Observed DataItem Types for Door.

Commonly Observed DataItem Types	Multiplicity
DoorState	1

Table 19: Commonly Observed DataItem Types for Door

539 4.3.18 Drain

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

542 4.3.18.1 Part Properties of Drain

543 Table 20 lists the Part Properties of Drain.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 20: Part Properties of Drain

544 Descriptions for Part Properties of Drain:

- 545 • Composition
 546 functional part of a piece of equipment contained within a Component.
- 547 • Component
 548 logical or physical entity that provides a capability.

549 4.3.19 Encoder

550 leaf Component that measures position.

551 4.3.19.1 Part Properties of Encoder

552 *Table 21* lists the Part Properties of Encoder.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 21: Part Properties of Encoder

553 Descriptions for Part Properties of Encoder:

- 554 • Composition
- 555 functional part of a piece of equipment contained within a Component.
- 556 • Component
- 557 logical or physical entity that provides a capability.

558 4.3.20 ExpiredPot

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

561 4.3.20.1 Part Properties of ExpiredPot

562 *Table 22* lists the Part Properties of ExpiredPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 22: Part Properties of ExpiredPot

563 Descriptions for Part Properties of ExpiredPot:

- 564 • Composition
- 565 functional part of a piece of equipment contained within a Component.
- 566 • Component
- 567 logical or physical entity that provides a capability.

568 4.3.21 ExposureUnit

569 leaf `Component` that emits a type of radiation.

570 4.3.21.1 Part Properties of ExposureUnit

571 *Table 23* lists the Part Properties of `ExposureUnit`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 23: Part Properties of `ExposureUnit`

572 Descriptions for Part Properties of `ExposureUnit`:

- 573 • `Composition`
574 functional part of a piece of equipment contained within a `Component`.
- 575 • `Component`
576 logical or physical entity that provides a capability.

577 4.3.22 ExtrusionUnit

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

579 4.3.22.1 Part Properties of ExtrusionUnit

580 *Table 24* lists the Part Properties of `ExtrusionUnit`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 24: Part Properties of `ExtrusionUnit`

581 Descriptions for Part Properties of `ExtrusionUnit`:

- 582 • `Composition`
- 583 functional part of a piece of equipment contained within a `Component`.
- 584 • `Component`
- 585 logical or physical entity that provides a capability.

586 **4.3.23 Fan**

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

588 **4.3.23.1 Part Properties of Fan**

589 *Table 25* lists the Part Properties of `Fan`.

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

Table 25: Part Properties of `Fan`

590 Descriptions for Part Properties of `Fan`:

- 591 • `Composition`
- 592 functional part of a piece of equipment contained within a `Component`.
- 593 • `Component`
- 594 logical or physical entity that provides a capability.

595 **4.3.24 Filter**

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

598 **4.3.24.1 Part Properties of Filter**

599 *Table 26* lists the Part Properties of `Filter`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 26: Part Properties of Filter

600 Descriptions for Part Properties of Filter:

- 601 • Composition
- 602 functional part of a piece of equipment contained within a Component.
- 603 • Component
- 604 logical or physical entity that provides a capability.

605 4.3.25 Galvanomotor

606 leaf Component composed of an electromechanical actuator that produces deflection of

607 a beam of light or energy in response to electric current through its coil in a magnetic field.

608 4.3.25.1 Part Properties of Galvanomotor

609 Table 27 lists the Part Properties of Galvanomotor.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 27: Part Properties of Galvanomotor

610 Descriptions for Part Properties of Galvanomotor:

- 611 • Composition
- 612 functional part of a piece of equipment contained within a Component.
- 613 • Component
- 614 logical or physical entity that provides a capability.

615 4.3.26 Gripper

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

617 4.3.26.1 Part Properties of Gripper

618 *Table 28* lists the Part Properties of `Gripper`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 28: Part Properties of `Gripper`

619 Descriptions for Part Properties of `Gripper`:

- 620 • `Composition`
- 621 functional part of a piece of equipment contained within a `Component`.
- 622 • `Component`
- 623 logical or physical entity that provides a capability.

624 4.3.27 Hopper

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

627 4.3.27.1 Part Properties of Hopper

628 *Table 29* lists the Part Properties of `Hopper`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 29: Part Properties of `Hopper`

629 Descriptions for Part Properties of `Hopper`:

- 630 • `Composition`
- 631 functional part of a piece of equipment contained within a `Component`.
- 632 • `Component`
- 633 logical or physical entity that provides a capability.

634 **4.3.28 LinearPositionFeedback**

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

636 **DEPRECATION WARNING** : May be deprecated in the future. Recommend using
 637 Encoder.

638 **4.3.28.1 Part Properties of LinearPositionFeedback**

639 *Table 30* lists the Part Properties of `LinearPositionFeedback`.

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

Table 30: Part Properties of `LinearPositionFeedback`

640 Descriptions for Part Properties of `LinearPositionFeedback`:

- 641 • `Composition`
- 642 functional part of a piece of equipment contained within a `Component`.
- 643 • `Component`
- 644 logical or physical entity that provides a capability.

645 **4.3.29 Lock**

646 `Component` that physically prohibits a `Device` or `Component` from opening or oper-
 647 ating.

648 4.3.29.1 Commonly Observed DataItem Types for Lock

649 *Table 31* lists the Commonly Observed DataItem Types for Lock.

Commonly Observed DataItem Types	Multiplicity
LockState	0..1

Table 31: Commonly Observed DataItem Types for Lock

650 4.3.30 Motor

651 leaf Component that converts electrical, pneumatic, or hydraulic energy into mechanical
652 energy.

653 4.3.30.1 Part Properties of Motor

654 *Table 32* lists the Part Properties of Motor.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 32: Part Properties of Motor

655 Descriptions for Part Properties of Motor:

- 656 • Composition
657 functional part of a piece of equipment contained within a Component.
- 658 • Component
659 logical or physical entity that provides a capability.

660 4.3.31 Oil

661 leaf Component composed of a viscous liquid.

662 4.3.31.1 Part Properties of Oil

663 *Table 33* lists the Part Properties of Oil.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 33: Part Properties of Oil

664 Descriptions for Part Properties of Oil:

- 665 • Composition
- 666 functional part of a piece of equipment contained within a Component.
- 667 • Component
- 668 logical or physical entity that provides a capability.

669 4.3.32 Part

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

671 4.3.32.1 PartOccurrence

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

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

675 4.3.32.2 Commonly Observed DataItem Types for PartOccurrence

676 *Table 34* 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 34: Commonly Observed DataItem Types for PartOccurrence

677 4.3.33 Path

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

679 For many types of equipment, Path organizes a set of Axes, one or more Program elements, and the data associated with the motion of a control point as it moves through
680 space. However, it **MAY** also represent any independent function within a Controller
681 that has unique data associated with that function.

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

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

688 4.3.33.1 Commonly Observed DataItem Types for Path

689 Table 35 lists the Commonly Observed DataItem Types for Path.

Commonly Observed DataItem Types	Multiplicity
Execution	0..1

Table 35: Commonly Observed DataItem Types for Path

690 4.3.34 Pot

691 leaf `Component` composed of a tool storage location associated with a `ToolMagazine`
 692 or `AutomaticToolChanger`.

693 4.3.34.1 Part Properties of Pot

694 *Table 36* lists the Part Properties of `Pot`.

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

Table 36: Part Properties of `Pot`

695 Descriptions for Part Properties of `Pot`:

- 696 • `Composition`
 697 functional part of a piece of equipment contained within a `Component`.
- 698 • `Component`
 699 logical or physical entity that provides a capability.

700 4.3.35 <<deprecated>>Power

701 `Power` was **DEPRECATED** in *MTConnect Version 1.1* and was replaced by Avail-
 702 ability data item type.

703 4.3.36 PowerSupply

704 leaf `Component` that provides power to electric mechanisms.

705 4.3.36.1 Part Properties of PowerSupply

706 *Table 37* lists the Part Properties of `PowerSupply`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 37: Part Properties of PowerSupply

707 Descriptions for Part Properties of PowerSupply:

- 708 • `Composition`
709 functional part of a piece of equipment contained within a `Component`.
710 • `Component`
711 logical or physical entity that provides a capability.

712 **4.3.37 Process**

713 abstract `Component` composed of a manufacturing process being executed on a piece of
714 equipment.

715 **4.3.37.1 ProcessOccurrence**

716 `Process` that takes place at a specific place and time, such as a specific instance of part-
717 milling occurring at a specific timestamp.

718 `ProcessOccurrenceId` **MUST** be defined for `ProcessOccurrence`.

719 **4.3.37.2 Commonly Observed DataItem Types for ProcessOccurrence**

720 *Table 38* 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 38: Commonly Observed DataItem Types for ProcessOccurrence

721 4.3.38 Pulley

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

724 4.3.38.1 Part Properties of Pulley

725 *Table 39* lists the Part Properties of `Pulley`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 39: Part Properties of Pulley

726 Descriptions for Part Properties of `Pulley`:

- 727 • `Composition`
 728 functional part of a piece of equipment contained within a `Component`.
- 729 • `Component`
 730 logical or physical entity that provides a capability.

731 4.3.39 Pump

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

734 4.3.39.1 Part Properties of Pump

735 *Table 40* lists the Part Properties of Pump.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 40: Part Properties of Pump

736 Descriptions for Part Properties of Pump:

- 737 • Composition
- 738 functional part of a piece of equipment contained within a Component.
- 739 • Component
- 740 logical or physical entity that provides a capability.

741 4.3.40 Reel

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

743 4.3.40.1 Part Properties of Reel

744 *Table 41* lists the Part Properties of Reel.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 41: Part Properties of Reel

745 Descriptions for Part Properties of Reel:

- 746 • Composition
- 747 functional part of a piece of equipment contained within a Component.
- 748 • Component
- 749 logical or physical entity that provides a capability.

750 4.3.41 RemovalPot

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

753 4.3.41.1 Part Properties of RemovalPot

754 Table 42 lists the Part Properties of RemovalPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 42: Part Properties of RemovalPot

755 Descriptions for Part Properties of RemovalPot:

- 756 • Composition
757 functional part of a piece of equipment contained within a Component.
- 758 • Component
759 logical or physical entity that provides a capability.

760 4.3.42 Resource

761 abstract Component composed of material or personnel involved in a manufacturing
762 process.

763 4.3.42.1 Material

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

766 4.3.42.1.1 Stock

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

769 `Stock` may be either a continuous piece of material from which multiple parts may be
 770 produced or it may be a discrete piece of material that will be made into a part or a set of
 771 parts.

772 **4.3.42.2 Personnel**

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

775 **4.3.43 ReturnPot**

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

778 **4.3.43.1 Part Properties of ReturnPot**

779 *Table 43* lists the Part Properties of `ReturnPot`.

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

Table 43: Part Properties of `ReturnPot`

780 Descriptions for Part Properties of `ReturnPot`:

- 781 • `Composition`
 782 functional part of a piece of equipment contained within a `Component`.
- 783 • `Component`
 784 logical or physical entity that provides a capability.

785 **4.3.44 SensingElement**

786 `leaf Component` that provides a signal or measured value.

787 4.3.44.1 Part Properties of SensingElement

788 *Table 44* lists the Part Properties of SensingElement.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 44: Part Properties of SensingElement

789 Descriptions for Part Properties of SensingElement:

- 790 • Composition
- 791 functional part of a piece of equipment contained within a Component.
- 792 • Component
- 793 logical or physical entity that provides a capability.

794 4.3.45 Sensor

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

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

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

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

804 4.3.45.1 <<deprecated>>Thermostat

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

806 Thermostat was **DEPRECATED** in *MTConnect Version 1.2* and was replaced by
807 Temperature.

808 **4.3.45.2 <<deprecated>>Vibration**

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

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

813 **4.3.46 Spreader**

814 leaf Component that flattens or spreading materials.

815 **4.3.46.1 Part Properties of Spreader**

816 *Table 45* lists the Part Properties of Spreader.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 45: Part Properties of Spreader

817 Descriptions for Part Properties of Spreader:

- 818 • Composition
819 functional part of a piece of equipment contained within a Component.
- 820 • Component
821 logical or physical entity that provides a capability.

822 **4.3.47 StagingPot**

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

825 **4.3.47.1 Part Properties of StagingPot**

826 *Table 46* lists the Part Properties of StagingPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 46: Part Properties of StagingPot

827 Descriptions for Part Properties of StagingPot:

- 828 • Composition
- 829 functional part of a piece of equipment contained within a Component.
- 830 • Component
- 831 logical or physical entity that provides a capability.

832 4.3.48 Station

833 leaf Component composed of a storage or mounting location for a tool associated with a

834 Turret, GangToolBar, or ToolRack.

835 4.3.48.1 Part Properties of Station

836 Table 47 lists the Part Properties of Station.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 47: Part Properties of Station

837 Descriptions for Part Properties of Station:

- 838 • Composition
- 839 functional part of a piece of equipment contained within a Component.
- 840 • Component
- 841 logical or physical entity that provides a capability.

842 4.3.49 StorageBattery

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

845 4.3.49.1 Part Properties of StorageBattery

846 *Table 48* lists the Part Properties of `StorageBattery`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 48: Part Properties of `StorageBattery`

847 Descriptions for Part Properties of `StorageBattery`:

- 848 • `Composition`
849 functional part of a piece of equipment contained within a `Component`.
- 850 • `Component`
851 logical or physical entity that provides a capability.

852 4.3.50 Structure

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

854 4.3.50.1 Link

855 `Structure` that provides a connection between `Component` entities.

856 4.3.51 Switch

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

858 4.3.51.1 Part Properties of Switch

859 *Table 49* lists the Part Properties of Switch.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 49: Part Properties of Switch

860 Descriptions for Part Properties of Switch:

- 861 • *Composition*
- 862 functional part of a piece of equipment contained within a *Component*.
- 863 • *Component*
- 864 logical or physical entity that provides a capability.

865 4.3.52 System

866 abstract *Component* that is permanently integrated into the piece of equipment.

867 4.3.52.1 Controller

868 *System* that provides regulation or management of a system or component. *Ref ISO*
869 *16484-5:2017*

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

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

874 4.3.52.2 Part Properties of Controller

875 *Table 50* lists the Part Properties of *Controller*.

Part Property name	Multiplicity
Path	0..*

Table 50: Part Properties of Controller

876 Descriptions for Part Properties of Controller:

877 • Path

878 Component that organizes an independent operation or function within a Con-
879 troller.

880 **4.3.52.3 Coolant**

881 System that provides distribution and management of fluids that remove heat from a
882 piece of equipment.

883 **4.3.52.4 Dielectric**

884 System that manages a chemical mixture used in a manufacturing process being per-
885 formed at that piece of equipment.

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

888 **4.3.52.5 Electric**

889 System composed of the main power supply for the piece of equipment that provides
890 distribution of that power throughout the equipment.

891 The electric system will provide all the data with regard to electric current, voltage, fre-
892 quency, etc. that applies to the piece of equipment as a functional unit. Data regard-
893 ing electric power that is specific to a Component will be reported for that specific
894 block(Component).

895 **4.3.52.6 Enclosure**

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

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

901 **4.3.52.7 EndEffector**

902 System composed of functions that form the last link segment of a piece of equipment.
903 It is the part of a piece of equipment that interacts with the manufacturing process.

904 **4.3.52.8 Feeder**

905 System that manages the delivery of materials within a piece of equipment.
906 For example, this could describe the wire delivery system for an EDM or welding process;
907 conveying system or pump and valve system distributing material to a blending station; or
908 a fuel delivery system feeding a furnace.

909 **4.3.52.9 Hydraulic**

910 System that provides movement and distribution of pressurized liquid throughout the
911 piece of equipment.

912 **4.3.52.10 Lubrication**

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

915 **4.3.52.11 Pneumatic**

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

918 Note: Actuation is usually performed using a cylinder.

919 **4.3.52.12 ProcessPower**

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

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

924 **4.3.52.13 Protective**

925 System that provides functions used to detect or prevent harm or damage to equipment
 926 or personnel.

927 `Protective` does not include the information relating to the `Enclosure`.

928 **4.3.52.14 WorkEnvelope**

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

930 `WorkEnvelope` **MAY** provide information regarding the physical workspace and the
 931 conditions within that workspace.

932 **4.3.53 Table**

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

934 **4.3.53.1 Part Properties of Table**

935 *Table 51* lists the Part Properties of `Table`.

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

Table 51: Part Properties of `Table`

936 Descriptions for Part Properties of `Table`:

- 937 • `Composition`
- 938 functional part of a piece of equipment contained within a `Component`.

- 939 • `Component`
- 940 logical or physical entity that provides a capability.

941 **4.3.54 Tank**

942 leaf `Component` composed of a receptacle or container that holds material.

943 **4.3.54.1 Part Properties of Tank**

944 *Table 52* lists the Part Properties of Tank.

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

Table 52: Part Properties of Tank

945 Descriptions for Part Properties of Tank:

- 946 • `Composition`
- 947 functional part of a piece of equipment contained within a `Component`.
- 948 • `Component`
- 949 logical or physical entity that provides a capability.

950 **4.3.55 Tensioner**

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

952 **4.3.55.1 Part Properties of Tensioner**

953 *Table 53* lists the Part Properties of `Tensioner`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 53: Part Properties of Tensioner

954 Descriptions for Part Properties of Tensioner:

- 955 • Composition
- 956 functional part of a piece of equipment contained within a Component.
- 957 • Component
- 958 logical or physical entity that provides a capability.

959 4.3.56 TransferArm

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

961 4.3.56.1 Part Properties of TransferArm

962 Table 54 lists the Part Properties of TransferArm.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 54: Part Properties of TransferArm

963 Descriptions for Part Properties of TransferArm:

- 964 • Composition
- 965 functional part of a piece of equipment contained within a Component.
- 966 • Component
- 967 logical or physical entity that provides a capability.

968 4.3.57 TransferPot

969 leaf Component that is a Pot for a tool that is awaiting transfer from a ToolMagazine
970 to *spindle* or Turret.

971 4.3.57.1 Part Properties of TransferPot

972 Table 55 lists the Part Properties of TransferPot.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 55: Part Properties of TransferPot

973 Descriptions for Part Properties of TransferPot:

- 974 • Composition
975 functional part of a piece of equipment contained within a Component.
- 976 • Component
977 logical or physical entity that provides a capability.

978 4.3.58 Transformer

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

980 4.3.58.1 Part Properties of Transformer

981 Table 56 lists the Part Properties of Transformer.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 56: Part Properties of Transformer

982 Descriptions for Part Properties of Transformer:

- 983 • `Composition`
- 984 functional part of a piece of equipment contained within a `Component`.
- 985 • `Component`
- 986 logical or physical entity that provides a capability.

987 **4.3.59 Valve**

988 leaf `Component` that halts or controls the flow of a liquid, gas, or other material through
 989 a passage, pipe, inlet, or outlet.

990 **4.3.59.1 Part Properties of Valve**

991 *Table 57* lists the Part Properties of `Valve`.

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

Table 57: Part Properties of Valve

992 Descriptions for Part Properties of `Valve`:

- 993 • `Composition`
- 994 functional part of a piece of equipment contained within a `Component`.
- 995 • `Component`
- 996 logical or physical entity that provides a capability.

997 **4.3.60 Vat**

998 leaf `Component` composed of a container that holds liquid or powdered materials.

999 **4.3.60.1 Part Properties of Vat**

1000 *Table 58* lists the Part Properties of `Vat`.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 58: Part Properties of Vat

1001 Descriptions for Part Properties of Vat:

- 1002 • Composition
- 1003 functional part of a piece of equipment contained within a Component.
- 1004 • Component
- 1005 logical or physical entity that provides a capability.

1006 4.3.61 Water

1007 leaf Component composed of H_2O .

1008 4.3.61.1 Part Properties of Water

1009 Table 59 lists the Part Properties of Water.

Part Property name	Multiplicity
hasComposition	0
hasComponent	0

Table 59: Part Properties of Water

1010 Descriptions for Part Properties of Water:

- 1011 • Composition
- 1012 functional part of a piece of equipment contained within a Component.
- 1013 • Component
- 1014 logical or physical entity that provides a capability.

1015 4.3.62 Wire

1016 leaf `Component` composed of a string like piece or filament of relatively rigid or flexible
1017 material provided in a variety of diameters.

1018 4.3.62.1 Part Properties of Wire

1019 *Table 60* lists the Part Properties of `Wire`.

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

Table 60: Part Properties of `Wire`

1020 Descriptions for Part Properties of `Wire`:

- 1021 • `Composition`
- 1022 functional part of a piece of equipment contained within a `Component`.
- 1023 • `Component`
- 1024 logical or physical entity that provides a capability.

1025 4.3.63 Workpiece

1026 leaf `Component` composed of an object or material on which a form of work is per-
1027 formed.

1028 4.3.63.1 Part Properties of Workpiece

1029 *Table 61* lists the Part Properties of `Workpiece`.

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

Table 61: Part Properties of `Workpiece`

1030 Descriptions for Part Properties of `Workpiece`:

- 1031 • Composition
- 1032 functional part of a piece of equipment contained within a Component.
- 1033 • Component
- 1034 logical or physical entity that provides a capability.

1035 **4.4 Component Organizer Types**

1036 This section provides semantic information for the types of Component that are used to
1037 *organize* other Component types.

1038 **4.4.1 <<organizer>>Adapters**

1039 Component that *organizes* Adapter types.

1040 **4.4.2 <<organizer>>Auxiliaries**

1041 Component that *organizes* Auxiliary types.

1042 **4.4.3 <<organizer>>Axes**

1043 Component that *organizes* Axis types.

1044 **4.4.4 <<organizer>>Controllers**

1045 Component that *organizes* Controller entities.

1046 **4.4.5 <<organizer>>Interfaces**

1047 Component that *organizes* Interface types.

1048 **4.4.6 <<organizer>>Parts**

1049 Component that *organizes* Part types.

1050 **4.4.7 <<organizer>>Processes**

1051 Component that *organizes* Process types.

1052 **4.4.8 <<organizer>>Resources**

1053 Component that *organizes* Resource types.

1054 **4.4.8.1 <<organizer>>Materials**

1055 Resources that *organizes* Material types.

1056 **4.4.9 <<organizer>>Structures**

1057 Component that *organizes* Structure types.

1058 **4.4.10 <<organizer>>Systems**

1059 Component that *organizes* System types.

1060 5 Compositions Model

1061 Composition entities are used to describe the lowest level physical building blocks of
 1062 a piece of equipment contained within a Component. By referencing a specific Com-
 1063 position entity, further clarification and meaning to data associated with a specific
 1064 Component can be achieved.

1065 Both Component and Composition entities are *lower level* entities representing the
 1066 sub-parts of the parent Component. However, there are distinct differences between
 1067 Component and Composition type entities.

1068 Component entities may be further defined with *lower level* Component entities and
 1069 may have associated *DataItems*.

1070 Composition entities represent the lowest level physical part of a piece of equipment.
 1071 They **MUST NOT** be further defined with *lower level* Component entities and they
 1072 **MUST NOT** have *DataItems* directly associated with them. They do provide additional
 1073 information that can be used to enhance the specificity of *DataItems* associated with the
 1074 parent Component.

1075 5.1 Compositions

1076 This section provides semantic information for the Composition entity.

1077 See Figure 2 for the Composition model diagram.

1078 Note: See *Example 3* for the XML representation of the same example.

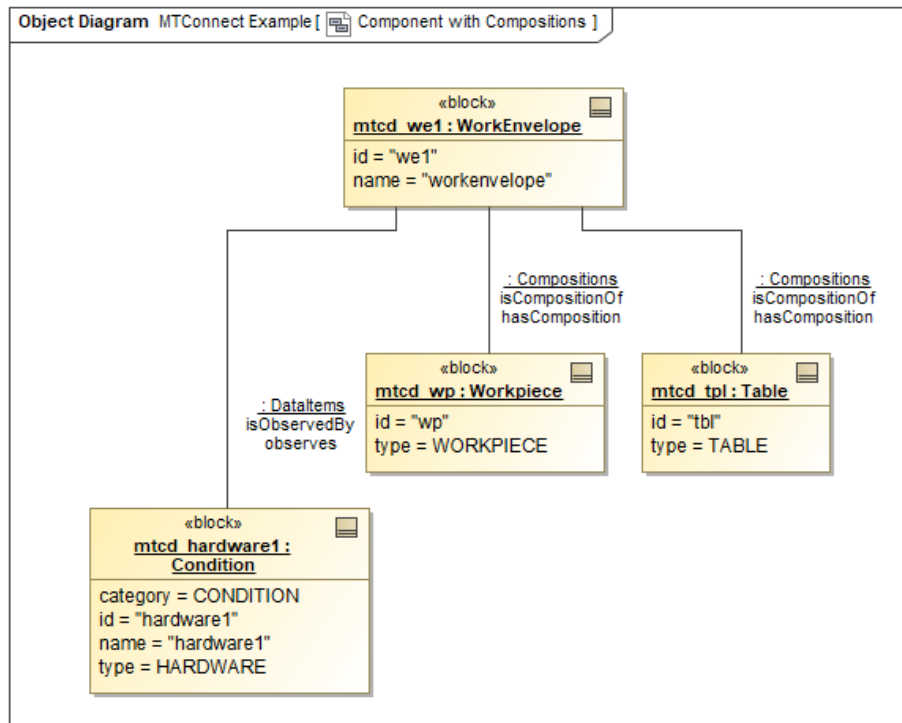
1079 5.1.1 Composition

1080 functional part of a piece of equipment contained within a Component.

1081 Composition **MUST NOT** have child Component, Composition, or DataItems
 1082 elements.

1083 5.1.1.1 Value Properties of Composition

1084 Table 62 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	ID	0..1

Table 62: Value Properties of Composition

1085 Descriptions for Value Properties of Composition:

- 1086 • id
- 1087 unique identifier for the Composition element.
- 1088 • type
- 1089 type of Composition.
- 1090 The value of type **MUST** be one of the CompositionTypeEnum enumeration.
- 1091 • name
- 1092 name of the Composition element.

- 1093 • uuid
- 1094 universally unique identifier for the Composition.

1095 **5.1.1.2 Part Properties of Composition**

1096 *Table 63* lists the Part Properties of Composition.

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

Table 63: Part Properties of Composition

1097 Descriptions for Part Properties of Composition:

- 1098 • Description
- 1099 descriptive content.
- 1100 See *Section 4.1.2 - Description*.
- 1101 • Configuration
- 1102 technical information about an entity describing its physical layout, functional characteristics, and relationships with other entities.
- 1103 See *Section 8 - Configurations Model*.
- 1104 See *Section 8 - Configurations Model*.

1105 6 DataItems Model

1106 For an MTConnectDevices entity, *DataItems* describe data that can be reported by a
 1107 piece of equipment and are associated with Device and Component entities. While the
 1108 *DataItems* describe the data that can be reported by a piece of equipment as an MTCon-
 1109 nectDevices entity, the actual data values are provided by the MTConnectStreams
 1110 entity in the *MTConnectStreams Response Document*. See *MTConnect Standard: Part 3.0*
 1111 - *Observation Information Model* for detail on the reported values.

1112 Each *DataItem* **SHOULD** be modeled for the MTConnectDevices entity such that it
 1113 is associated with the entity that the reported data directly applies.

1114 DataItem describes specific types of *DataItems* that represent a numeric value, a func-
 1115 tioning state, or a health status reported by a piece of equipment. DataItem provides a
 1116 detailed description for each *DataItem* that is reported; it defines the type of data being
 1117 reported and an array of optional attributes that further describe that data. The different
 1118 types of DataItem elements are defined in *Section 6.5 - DataItem Types*.

1119 6.1 DataItems

1120 This section provides semantic information for the DataItem entity. Figure 5 shows the
 1121 DataItem model.

1122 Note: See *Section B.2 - DataItems Schema Diagrams* for XML schema.

1123 6.1.1 DataItem

1124 information reported about a piece of equipment.

1125 6.1.1.1 Value Properties of DataItem

1126 Table 64 lists the Value Properties of DataItem.

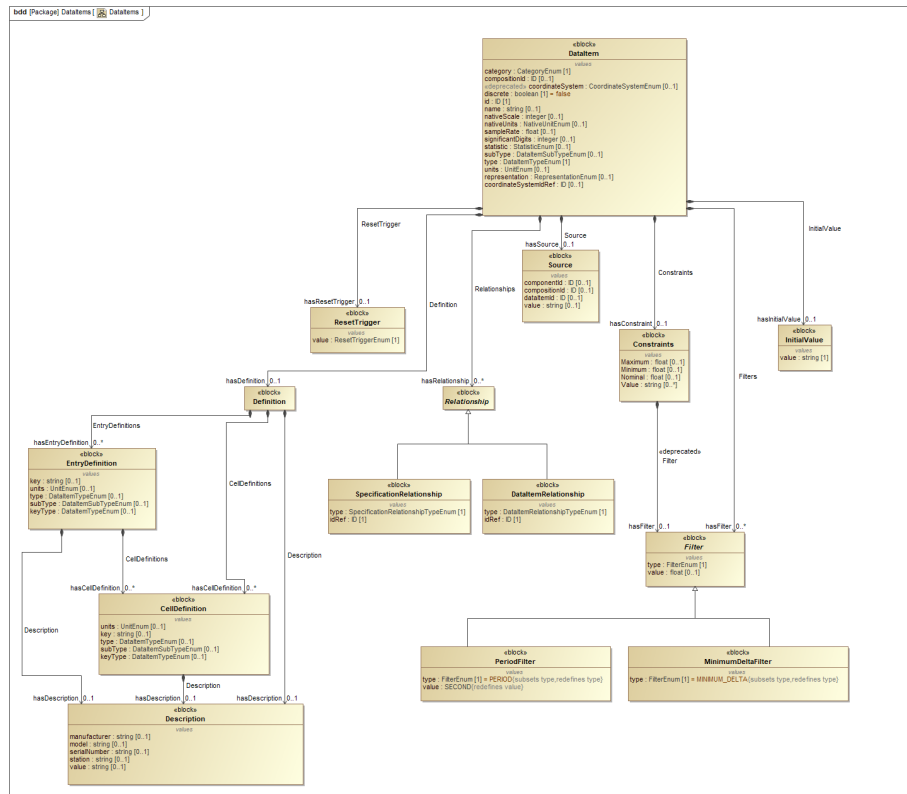


Figure 5: DataItems

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 64: Value Properties of DataItem

1127 Descriptions for Value Properties of DataItem:

- 1128 • `category`
- 1129 specifies the kind of information provided by a data item.
- 1130 CategoryEnum Enumeration:
- 1131 – `CONDITION`
- 1132 information about the health of a piece of equipment and its ability to function.
- 1133 – `EVENT`
- 1134 discrete piece of information from the piece of equipment.
- 1135 – `SAMPLE`
- 1136 continuously variable or analog data value.
- 1137 A continuous value can be measured at any point-in-time and will always pro-
- 1138 duce a result.
- 1139 • `compositionId`
- 1140 identifier attribute of the `Composition` that the reported data is most closely as-
- 1141 sociated.
- 1142 • `<<deprecated>> coordinateSystem`
- 1143 for measured values relative to a coordinate system like `Position`, the coordinate
- 1144 system used may be reported.
- 1145 **DEPRECATED** in *Version 2.0*. Replaced by `coordinateSystemIdRef`.
- 1146 • `discrete`
- 1147 indication signifying whether each value reported for the *Observation* is significant
- 1148 and whether duplicate values are to be suppressed.
- 1149 If a value is not defined for `discrete`, the default value **MUST** be `false`.
- 1150 • `id`
- 1151 unique identifier for this data item.
- 1152 • `name`
- 1153 name of the data item.
- 1154 • `nativeScale`
- 1155 used to convert the reported value to represent the original measured value.

1156 • nativeUnits
 1157 native units of measurement for the reported value of the data item.
 1158 <<extensible>> NativeUnitEnum Enumeration:

- 1159 – AMPERE_HOUR
 1160 electric charge in ampere hour.
- 1161 – BAR
 1162 pressure in Bar.
- 1163 – CENTIPOISE
 1164 measure of viscosity.
- 1165 – DEGREE/MINUTE
 1166 rotational velocity in degrees per minute.
- 1167 – FAHRENHEIT
 1168 temperature in Fahrenheit.
- 1169 – FOOT
 1170 feet.
- 1171 – FOOT/MINUTE
 1172 feet per minute.
- 1173 – FOOT/SECOND
 1174 feet per second.
- 1175 – FOOT/SECOND²
 1176 acceleration in feet per second squared.
- 1177 – FOOT_3D
 1178 point in space identified by X, Y, and Z positions and represented by a space-
 1179 delimited set of numbers each expressed in feet.
- 1180 – GALLON/MINUTE
 1181 gallons per minute.
- 1182 – GRAVITATIONAL_ACCELERATION
 1183 acceleration relative to earth's gravity given in METER/SECOND².

1184 Note 1 to entry: At different points on Earth's surface, the free-fall
 1185 acceleration ranges from 9.764 to 9.834 m/s² (Wikipedia: Gravitational
 1186 Acceleration). The constant can be customized depending on
 1187 the location in the universe.

1188 Note 2 to entry: In the standard, it is assumed that Earth's average
 1189 value of gravitational acceleration is 9.90665 m/s².

- 1190 – GRAVITATIONAL_FORCE
- 1191 *MASS* × *GRAVITATIONAL_ACCELERATION* (g) given in METER/SECOND².
- 1192 – HOUR
- 1193 measurement of time in hours.
- 1194 – INCH
- 1195 inches.
- 1196 – INCH/MINUTE
- 1197 inches per minute.
- 1198 – INCH/SECOND
- 1199 inches per second.
- 1200 – INCH/SECOND²
- 1201 acceleration in inches per second squared.
- 1202 – INCH_3D
- 1203 point in space identified by X, Y, and Z positions and represented by a space-
- 1204 delimited set of numbers each expressed in inches.
- 1205 – INCH_POUND
- 1206 measure of torque in inch pounds.
- 1207 – KELVIN
- 1208 measurement of temperature.
- 1209 – KILOWATT
- 1210 measurement in kilowatt.
- 1211 – KILOWATT_HOUR
- 1212 kilowatt hours which is 3.6 mega joules.
- 1213 – LITER/MINUTE
- 1214 measurement of rate of flow of a fluid.
- 1215 – MILLIMETER/MINUTE
- 1216 velocity in millimeters per minute.
- 1217 – MILLIMETER_MERCURY
- 1218 pressure in Millimeter of Mercury (mmHg).
- 1219 – MINUTE
- 1220 measurement of time in minutes.
- 1221 – OTHER
- 1222 unsupported unit.
- 1223 – PASCAL/MINUTE
- 1224 pascal per minute.

- 1225 – POUND
- 1226 US pounds.
- 1227 – POUND/INCH²
- 1228 pressure in pounds per square inch (PSI).
- 1229 – RADIANT
- 1230 angle in radians.
- 1231 – RADIANT/MINUTE
- 1232 velocity in radians per minute.
- 1233 – RADIANT/SECOND
- 1234 rotational acceleration in radian per second squared.
- 1235 – RADIANT/SECOND²
- 1236 rotational acceleration in radian per second squared.
- 1237 – TORR
- 1238 pressure in Torr.

- 1239 • `sampleRate`
- 1240 rate at which successive samples of a data item are recorded by a piece of equipment.

- 1241 • `significantDigits`
- 1242 number of significant digits in the reported value.

- 1243 • `statistic`
- 1244 type of statistical calculation performed on a series of data samples to provide the
- 1245 reported data value.
- 1246 StatisticEnum Enumeration:

- 1247 – AVERAGE
- 1248 mathematical average value calculated for the data item during the calculation
- 1249 period.
- 1250 – <<deprecated>> KURTOSIS
- 1251 **DEPRECATED** in *Version 1.6*. ~~A measure of the “peakedness” of a prob-
- 1252 ability distribution; i.e., the shape of the distribution curve.~~
- 1253 – MAXIMUM
- 1254 maximum or peak value recorded for the data item during the calculation pe-
- 1255 riod.
- 1256 – MEDIAN
- 1257 middle number of a series of numbers.

- 1258 – MINIMUM
- 1259 minimum value recorded for the data item during the calculation period.
- 1260 – MODE
- 1261 number in a series of numbers that occurs most often.
- 1262 – RANGE
- 1263 difference between the maximum and minimum value of a data item during the
- 1264 calculation period. Also represents Peak-to-Peak measurement in a waveform.
- 1265 – ROOT_MEAN_SQUARE
- 1266 mathematical Root Mean Square (RMS) value calculated for the data item dur-
- 1267 ing the calculation period.
- 1268 – STANDARD_DEVIATION
- 1269 statistical Standard Deviation value calculated for the data item during the cal-
- 1270 culation period.
- 1271 • subType
- 1272 sub-categorization of the data item type.
- 1273 <<extensible>> DataItemSubTypeEnum Enumeration:
- 1274 – ABORTED
- 1275 actions or activities that were attempted, but terminated before they could be
- 1276 completed.
- 1277 – ABSOLUTE
- 1278 relating to or derived in the simplest manner from the fundamental units or
- 1279 measurements.
- 1280 – ACTION
- 1281 indication of the operating state of a mechanism.
- 1282 – ACTIVE
- 1283 relating to logic or motion program currently executing.
- 1284 – ACTIVITY
- 1285 phase or segment of a recipe or program.
- 1286 – ACTUAL
- 1287 measured or reported value of an observation.
- 1288 – ALL
- 1289 all actions, items, or activities being counted independent of the outcome.
- 1290 – <<deprecated>> ALTERNATING
- 1291 measurement of alternating voltage or current. If not specified further in statis-
- 1292 tic, defaults to RMS voltage.
- 1293 **DEPRECATED** in *Version 1.6*.

- 1294 – AUXILIARY
- 1295 when multiple locations on a piece of bar stock being feed by a bar feeder are
- 1296 referenced as the indication of whether the end of that piece of bar stock has
- 1297 been reached.
- 1298 – A_SCALE
- 1299 A-Scale weighting factor on the frequency scale.
- 1300 – BAD
- 1301 actions, items, or activities being counted that do not conform to specification
- 1302 or expectation.
- 1303 – BATCH
- 1304 group of parts produced in a batch.
- 1305 – BRINELL
- 1306 scale to measure the resistance to deformation of a surface.
- 1307 – B_SCALE
- 1308 B-Scale weighting factor on the frequency scale.
- 1309 – COMMANDED
- 1310 directive value including adjustments such as an offset or overrides.
- 1311 – COMPLETE
- 1312 associated with the completion of an activity or event.
- 1313 – CONSUMED
- 1314 amount of material consumed from an object or container during a manufac-
- 1315 turing process.
- 1316 – CONTROL
- 1317 state of the enabling signal or control logic that enables or disables the function
- 1318 or operation of the entity.
- 1319 – C_SCALE
- 1320 C-Scale weighting factor on the frequency scale.
- 1321 – DELAY
- 1322 elapsed time of a temporary halt of action.
- 1323 – <<deprecated>> DIRECT
- 1324 DC current or voltage.
- 1325 **DEPRECATED** in *Version 1.6*.
- 1326 – DRY_RUN
- 1327 setting or operator selection used to execute a test mode to confirm the execu-
- 1328 tion of machine functions.

- 1329 – D_SCALE
- 1330 D-Scale weighting factor on the frequency scale.
- 1331 – ENDED
- 1332 boundary when an activity or an event terminates.
- 1333 – EXPIRATION
- 1334 relating to the expiration or end of useful life for a material or other physical
- 1335 item.
- 1336 – FAILED
- 1337 actions or activities that were attempted , but failed to complete or resulted in
- 1338 an unexpected or unacceptable outcome.
- 1339 – FIRST_USE
- 1340 relating to the first use of a material or other physical item.
- 1341 – GATEWAY
- 1342 Gateway for the Component network.
- 1343 – GOOD
- 1344 actions, items, or activities being counted that conform to specification or ex-
- 1345 pectation.
- 1346 – HEAT_TREAT
- 1347 material heat number.
- 1348 – INCREMENTAL
- 1349 relating to or derived from the last observation.
- 1350 – INSTALL_DATE
- 1351 date the hardware or software was installed.
- 1352 – IPV4_ADDRESS
- 1353 IPV4 network address of the Component.
- 1354 – IPV6_ADDRESS
- 1355 IPV6 network address of the Component.
- 1356 – ISO_STEP_EXECUTABLE
- 1357 reference to a ISO 10303 Executable.
- 1358 – JOG
- 1359 relating to momentary activation of a function or a movement.
- 1360 **DEPRECATION WARNING:** May be deprecated in the future.
- 1361 – LATERAL
- 1362 indication of the position of a mechanism that may move in a lateral direction.

- 1363 – LEEB
- 1364 scale to measure the elasticity of a surface.
- 1365 – LENGTH
- 1366 reference to a length type tool offset variable.
- 1367 – LICENSE
- 1368 license code to validate or activate the hardware or software.
- 1369 – LINE
- 1370 state of the power source.
- 1371 – LINEAR
- 1372 direction of motion of a linear motion.
- 1373 – LOADED
- 1374 indication that the subparts of a piece of equipment are under load.
- 1375 – LOT
- 1376 group of parts tracked as a lot.
- 1377 – MACHINE_AXIS_LOCK
- 1378 setting or operator selection that changes the behavior of the controller on a
- 1379 piece of equipment.
- 1380 – MAC_ADDRESS
- 1381 Media Access Control Address. The unique physical address of the network
- 1382 hardware.
- 1383 – MAIN
- 1384 relating to the primary logic or motion program currently being executed.
- 1385 – MAINTENANCE
- 1386 relating to maintenance on the piece of equipment.
- 1387 – MANUAL_UNCLAMP
- 1388 indication of the state of an operator controlled interlock that can inhibit the
- 1389 ability to initiate an unclamp action of an electronically controlled chuck.
- 1390 – MANUFACTURE
- 1391 related to the production of a material or other physical item.
- 1392 – MANUFACTURER
- 1393 corporate identity for the maker of the hardware or software.
- 1394 – MAXIMUM
- 1395 maximum value.
- 1396 – MINIMUM
- 1397 minimum value.

- 1398 – MOHS
- 1399 scale to measure the resistance to scratching of a surface.
- 1400 – MOTION
- 1401 indication of the open or closed state of a mechanism.
- 1402 – NO_SCALE
- 1403 no weighting factor on the frequency scale.
- 1404 – OPERATING
- 1405 piece of equipment that is powered or performing any activity.
- 1406 – OPERATION
- 1407 step of a discrete manufacturing process.
- 1408 – OPERATOR
- 1409 relating to the person currently responsible for operating the piece of equip-
- 1410 ment.
- 1411 – OPTIONAL_STOP
- 1412 setting or operator selection that changes the behavior of the controller on a
- 1413 piece of equipment.
- 1414 – ORDER_NUMBER
- 1415 authorization of a process occurrence.
- 1416 – OVERRIDE
- 1417 overridden value.
- 1418 – PART
- 1419 amount included in the *part*.
- 1420 – PART_FAMILY
- 1421 group of parts having similarities in geometry, manufacturing process, and/or
- 1422 functions.
- 1423 – PART_NAME
- 1424 word or set of words by which a part is known, addressed, or referred to.
- 1425 – PART_NUMBER
- 1426 particular part design or model.
- 1427 – POWERED
- 1428 piece of equipment is powered and functioning or Component that are re-
- 1429 quired to remain on are powered.
- 1430 – PRIMARY
- 1431 main or most important location of a piece of bar stock.

- 1432 – PROBE
- 1433 position provided by a measurement probe.
- 1434 **DEPRECATION WARNING:** May be deprecated in the future.
- 1435 – PROCESS
- 1436 relating to production of a part or product on a piece of equipment.
- 1437 – PROCESS_NAME
- 1438 word or set of words by which a process being executed (process occurrence)
- 1439 by the device is known, addressed, or referred to.
- 1440 – PROCESS_PLAN
- 1441 process plan that a process occurrence belongs to.
- 1442 – PROCESS_STEP
- 1443 step in the process plan that this occurrence corresponds to.
- 1444 – PROGRAMMED
- 1445 directive value without offsets and adjustments.
- 1446 – RADIAL
- 1447 reference to a radial type tool offset variable.
- 1448 – RAPID
- 1449 performing an operation faster or in less time than nominal rate.
- 1450 – RAW_MATERIAL
- 1451 material that is used to produce parts.
- 1452 – RECIPE
- 1453 process as part of product production; can be a subprocess of a larger process.
- 1454 – RELEASE_DATE
- 1455 date the hardware or software was released for general use.
- 1456 – REMAINING
- 1457 remaining measure or count of an action, object or activity.
- 1458 – REQUEST
- 1459 *request* by an Interface for a task.
- 1460 – RESPONSE
- 1461 *response* by an Interface to a *request* for a task.
- 1462 – ROCKWELL
- 1463 scale to measure the resistance to deformation of a surface.
- 1464 – ROTARY
- 1465 direction of a rotary motion using the right hand rule convention.

- 1466 – SCHEDULE
- 1467 identity of a control program that is used to specify the order of execution of
- 1468 other programs.
- 1469 – SEGMENT
- 1470 phase of a recipe process.
- 1471 – SERIAL_NUMBER
- 1472 serial number that uniquely identifies a specific part.
- 1473 – SET_UP
- 1474 relating to the preparation of a piece of equipment for production or restoring
- 1475 the piece of equipment to a neutral state after production.
- 1476 – SHORE
- 1477 scale to measure the resistance to deformation of a surface.
- 1478 – SINGLE_BLOCK
- 1479 setting or operator selection that changes the behavior of the controller on a
- 1480 piece of equipment.
- 1481 – STANDARD
- 1482 standard measure of an object or an action.
- 1483 – START
- 1484 boundary when an activity or an event commences.
- 1485 – SUBNET_MASK
- 1486 SubNet mask for the Component network.
- 1487 – SWITCHED
- 1488 indication of the activation state of a mechanism represented by a Composi-
- 1489 tion.
- 1490 – TARGET
- 1491 goal of the operation or process.
- 1492 – TARGET_COMPLETION
- 1493 relating to the end or completion of an activity or event.
- 1494 – TOOL_CHANGE_STOP
- 1495 setting or operator selection that changes the behavior of the controller on a
- 1496 piece of equipment.
- 1497 – USEABLE
- 1498 remaining usable measure of an object or action.
- 1499 – UUID
- 1500 universally unique identifier as specified in ISO 11578 or RFC 4122.

- 1501 – VERSION
- 1502 version of the hardware or software.
- 1503 – VERTICAL
- 1504 indication of the position of a mechanism that may move in a vertical direction.
- 1505 – VICKERS
- 1506 scale to measure the resistance to deformation of a surface.
- 1507 – VLAN_ID
- 1508 layer2 Virtual Local Network (VLAN) ID for the Component network.
- 1509 – WASTE
- 1510 amount discarded.
- 1511 – WIRELESS
- 1512 identifies whether the connection type is wireless.
- 1513 – WORKING
- 1514 piece of equipment performing any activity, the equipment is active and per-
- 1515 forming a function under load or not.

- 1516 • type
- 1517 type of data being measured. See *Section 6.5 - DataItem Types*.
- 1518 The value of type **MUST** be one of the DataItemTypeEnum enumeration.

- 1519 • units
- 1520 unit of measurement for the reported value of the data item.
- 1521 <<extensible>> UnitEnum Enumeration:

- 1522 – AMPERE
- 1523 amps.
- 1524 – CELSIUS
- 1525 degrees Celsius.
- 1526 – COULOMB
- 1527 electric charge in coulombs (C).
- 1528 – COUNT
- 1529 count of something.
- 1530 – COUNT/SECOND
- 1531 counts per second.
- 1532 – CUBIC_MILLIMETER
- 1533 geometric volume in millimeters.

- 1534 – CUBIC_MILLIMETER/SECOND
- 1535 change of geometric volume per second.
- 1536 – CUBIC_MILLIMETER/SECOND²
- 1537 change in geometric volume per second squared.
- 1538 – DECIBEL
- 1539 sound level.
- 1540 – DEGREE
- 1541 angle in degrees.
- 1542 – DEGREE/SECOND
- 1543 angular degrees per second.
- 1544 – DEGREE/SECOND²
- 1545 angular acceleration in degrees per second squared.
- 1546 – DEGREE_3D
- 1547 space-delimited, floating-point representation of the angular rotation in degrees
- 1548 around the X, Y, and Z axes relative to a cartesian coordinate system respec-
- 1549 tively in order as A, B, and C.
- 1550 If any of the rotations is not known, it **MUST** be zero (0).
- 1551 – GRAM
- 1552 gram.
- 1553 – GRAM/CUBIC_METER
- 1554 gram per cubic meter.
- 1555 – HERTZ
- 1556 frequency measured in cycles per second.
- 1557 – JOULE
- 1558 measurement of energy.
- 1559 – KILOGRAM
- 1560 kilograms.
- 1561 – LITER
- 1562 measurement of volume of a fluid.
- 1563 – LITER/SECOND
- 1564 liters per second.
- 1565 – METER/SECOND²
- 1566 acceleration in meters per second squared.
- 1567 – MICRO_RADIAN
- 1568 measurement of tilt.

- 1569 – MILLIGRAM
- 1570 milligram.
- 1571 – MILLIGRAM/CUBIC_MILLIMETER
- 1572 milligram per cubic millimeter.
- 1573 – MILLILITER
- 1574 milliliter.
- 1575 – MILLIMETER
- 1576 millimeters.
- 1577 – MILLIMETER/REVOLUTION
- 1578 millimeters per revolution.
- 1579 – MILLIMETER/SECOND
- 1580 millimeters per second.
- 1581 – MILLIMETER/SECOND²
- 1582 acceleration in millimeters per second squared.
- 1583 – MILLIMETER_3D
- 1584 point in space identified by X, Y, and Z positions and represented by a space-
- 1585 delimited set of numbers each expressed in millimeters.
- 1586 – NEWTON
- 1587 force in Newtons.
- 1588 – NEWTON_METER
- 1589 torque, a unit for force times distance.
- 1590 – OHM
- 1591 measure of electrical resistance.
- 1592 – PASCAL
- 1593 pressure in Newtons per square meter.
- 1594 – PASCAL/SECOND
- 1595 pascal per second.
- 1596 – PASCAL_SECOND
- 1597 measurement of viscosity.
- 1598 – PERCENT
- 1599 percentage.
- 1600 – PH
- 1601 measure of the acidity or alkalinity of a solution.
- 1602 – REVOLUTION/MINUTE
- 1603 revolutions per minute.

- 1604 – REVOLUTION/SECOND
- 1605 rotational velocity in revolution per second.
- 1606 – REVOLUTION/SECOND²
- 1607 revolutions per second squared.
- 1608 – SECOND
- 1609 measurement of time.
- 1610 – SIEMENS/METER
- 1611 measurement of electrical conductivity.
- 1612 – UNIT_VECTOR_3D
- 1613 3D Unit Vector.
- 1614 Space delimited list of three floating point numbers.
- 1615 – VOLT
- 1616 volts.
- 1617 – VOLT_AMPERE
- 1618 measurement of the apparent power in an electrical circuit, equal to the product
- 1619 of root-mean-square (RMS) voltage and RMS current (commonly referred to
- 1620 as VA).
- 1621 – VOLT_AMPERE_REACTIVE
- 1622 measurement of reactive power in an AC electrical circuit (commonly referred
- 1623 to as VAR).
- 1624 – WATT
- 1625 watts.
- 1626 – WATT_SECOND
- 1627 measurement of electrical energy, equal to one Joule.
- 1628 • `representation`
- 1629 description of a means to interpret data consisting of multiple data points or samples
- 1630 reported as a single value.
- 1631 If `representation` is not specified, it **MUST** be determined to be `VALUE`.
- 1632 RepresentationEnum Enumeration:
- 1633 – `DATA_SET`
- 1634 reported value(s) are represented as a set of *key-value pairs*.
- 1635 Each reported value in the *data set* **MUST** have a unique key.
- 1636 – `<<deprecated>> DISCRETE`
- 1637 **DEPRECATED** as a `representation` in *MTConnect Version 1.5*. Re-
- 1638 placed by the `discrete, DataItem` attribute of a `DataItem`.

- 1639 – TABLE
- 1640 two dimensional set of *key-value pairs* where the `Entry` represents a row, and
- 1641 the value is a set of *key-value pair* `Cell` elements.
- 1642 A *table* follows the same behavior as the *data set* for change tracking, clearing,
- 1643 and history. When an `Entry` changes, all `Cell` elements update as a single
- 1644 unit following the behavior of a *data set*.
- 1645 Note: It is best to use the `Variable DataItem` type if the `Cell`
- 1646 elements represent multiple semantic types.
- 1647 Each `Entry` in the *table* **MUST** have a unique key. Each `Cell` of each `En-`
- 1648 try in the *table* **MUST** have a unique key.
- 1649 See Representation in *MTConnect Standard: Part 3.0 - Observation In-*
- 1650 formation Model, for a description of `Entry` and `Cell` elements.
- 1651 – TIME_SERIES
- 1652 series of sampled data.
- 1653 The data is reported for a specified number of samples and each sample is
- 1654 reported with a fixed period.
- 1655 – VALUE
- 1656 measured value of the sample data.
- 1657 If no representation, `DataItem` is specified for a data item, the rep-
- 1658 resentation, `DataItem` **MUST** be determined to be `VALUE`.
- 1659 • `coordinateSystemIdRef`
- 1660 associated `CoordinateSystem` context for the `DataItem`.

1661 6.1.1.2 Reference Properties of `DataItem`

1662 *Table 65* lists the Reference Properties of `DataItem`.

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

Table 65: Reference Properties of `DataItem`

1663 Descriptions for Reference Properties of `DataItem`:

- 1664 • `Observation`
- 1665 abstract entity that provides telemetry data for a `DataItem` at a point in time.

1666 Observations groups one or more Observation entities made for the DataItem
1667 entity.

1668 Component observes DataItem entities to create Observation entities for
1669 the DataItem entities.

1670 See *MTConnect Standard: Part 3.0 - Observation Information Model* for the Ob-
1671 servation model.

1672 Note 1 to entry: In the XML representation, Observation entities
1673 **MUST NOT** appear in the *MTConnectDevices Response Document*.

1674 Note 2 to entry: In the XML representation, Observation entities
1675 **MUST** appear only in the *MTConnectStreams Response Document*.

1676 6.1.1.3 Part Properties of DataItem

1677 Table 66 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 66: Part Properties of DataItem

1678 Descriptions for Part Properties of DataItem:

1679 • Source
1680 identifies the Component, DataItem, or Composition from which a mea-
1681 sured value originates.

1682 See Section 6.2.2 - Source.

1683 • Constraints
1684 organizes a set of expected values that can be reported for a DataItem.
1685 Constraints organizes a set of expected values that can be reported for the
1686 DataItem. See Section 6.2.7 - Constraints.

- 1687 • **Filter**
- 1688 provides a means to control when an *agent* records updated information for a `DataItem`.
- 1689 **Filters** groups one or more `Filter` entities associated with the `DataItem`.
- 1690 • **InitialValue**
- 1691 starting value for a `DataItem` as well as the value to be set for the `DataItem`
- 1692 after a reset event.
- 1693 • **ResetTrigger**
- 1694 type of event that may cause a reset to occur.
- 1695 • **Definition**
- 1696 defines the meaning of `Entry` and `Cell` elements associated with the `DataItem`
- 1697 when the representation is either `DATA` or `TABLE`.
- 1698 See *Section 6.2.8 - Definition*.
- 1699 • **AbstractDataItemRelationship**
- 1700 association between a `DataItem` and another entity.
- 1701 **Relationships** groups one or more `DataItemRelationship` and `Spec-`
- 1702 *ificationRelationship*. See *Section 8.4 - Relationships*.

1703 6.2 Properties of `DataItem`

1704 This section provides additional semantic information for the Part Properties of `DataItem`.

1705 Note: See *Section B.2 - DataItems Schema Diagrams* for XML schema of the

1706 elements for `DataItem`.

1707 6.2.1 **ResetTrigger**

1708 type of event that may cause a reset to occur.

1709 `ResetTriggerEnum` Enumeration:

- 1710 • **ACTION_COMPLETE**
- 1711 observation of the `DataItem` that is measuring an action or operation is to be reset
- 1712 upon completion of that action or operation.

- 1713 • ANNUAL
- 1714 observation of the `DataItem` is to be reset at the end of a 12-month period.
- 1715 • DAY
- 1716 observation of the `DataItem` is to be reset at the end of a 24-hour period.
- 1717 • LIFE
- 1718 observation of the `DataItem` is not reset and accumulates for the entire life of the
- 1719 piece of equipment.
- 1720 • MAINTENANCE
- 1721 observation of the `DataItem` is to be reset upon completion of a maintenance
- 1722 event.
- 1723 • MONTH
- 1724 observation of the `DataItem` is to be reset at the end of a monthly period.
- 1725 • POWER_ON
- 1726 observation of the `DataItem` is to be reset when power was applied to the piece of
- 1727 equipment after a planned or unplanned interruption of power has occurred.
- 1728 • SHIFT
- 1729 observation of the `DataItem` is to be reset at the end of a work shift.
- 1730 • WEEK
- 1731 observation of the `DataItem` is to be reset at the end of a 7-day period.

1732 6.2.2 Source

- 1733 identifies the `Component`, `DataItem`, or `Composition` from which a measured value
- 1734 originates.
- 1735 The value of `Source` **MUST** be `string`.

1736 6.2.2.1 Value Properties of Source

- 1737 *Table 67* 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 67: Value Properties of Source

1738 Descriptions for Value Properties of Source:

- 1739 • `componentId`
1740 identifier of the `Component` that represents the physical part of a piece of equip-
1741 ment where the data represented by the `DataItem` originated.
- 1742 • `compositionId`
1743 identifier of the `Composition` that represents the physical part of a piece of equip-
1744 ment where the data represented by the `DataItem` originated.
- 1745 • `dataItemId`
1746 identifier of the `DataItem` that represents the originally measured value of the data
1747 referenced by this `DataItem`.

1748 6.2.3 InitialValue

1749 starting value for a `DataItem` as well as the value to be set for the `DataItem` after a
1750 reset event.

1751 The value of `InitialValue` **MUST** be string.

1752 6.2.4 Filter

1753 provides a means to control when an *agent* records updated information for a `DataItem`.

1754 The value of `Filter` **MUST** be float.

1755 6.2.4.1 Value Properties of Filter

1756 *Table 68* lists the Value Properties of `Filter`.

Value Property name	Value Property type	Multiplicity
type	FilterEnum	1

Table 68: Value Properties of Filter

1757 Descriptions for Value Properties of Filter:

- 1758 • type
- 1759 type of Filter.
- 1760 FilterEnum Enumeration:
- 1761 – MINIMUM_DELTA
- 1762 new value **MUST NOT** be reported for a data item unless the measured value
- 1763 has changed from the last reported value by at least the delta given as the value
- 1764 of this element.
- 1765 The value of Filter **MUST** be an absolute value using the same units as the
- 1766 reported data.
- 1767 – PERIOD
- 1768 data reported for a data item is provided on a periodic basis. The PERIOD for
- 1769 reporting data is defined in the value of the Filter.
- 1770 The value of Filter **MUST** be an absolute value reported in seconds repre-
- 1771 senting the time between reported samples of the value of the data item.

1772 6.2.5 MinimumDeltaFilter

- 1773 new value **MUST NOT** be reported for a data item unless the measured value has changed
- 1774 from the last reported value by at least the delta given as the value of this element.
- 1775 The value of Filter **MUST** be an absolute value using the same units as the reported
- 1776 data.

1777 6.2.6 PeriodFilter

- 1778 data reported for a data item is provided on a periodic basis. The PERIOD for reporting
- 1779 data is defined in the value of the Filter.
- 1780 The value of Filter **MUST** be an absolute value reported in seconds representing the
- 1781 time between reported samples of the value of the data item.

1782 The value of `PeriodFilter` **MUST** be `SECOND`. See *Section 9.1.9 - SECOND*.

1783 6.2.7 Constraints

1784 *organizes* a set of expected values that can be reported for a `DataItem`.

1785 6.2.7.1 Value Properties of Constraints

1786 *Table 69* 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 69: Value Properties of Constraints

1787 Descriptions for Value Properties of `Constraints`:

- 1788 • Maximum
- 1789 numeric upper constraint.
- 1790 If the data reported for a data item is a range of numeric values, the expected value
- 1791 reported **MAY** be described with an upper limit defined by this constraint.
- 1792 • Minimum
- 1793 numeric lower constraint.
- 1794 If the data reported for a data item is a range of numeric values, the expected value
- 1795 reported **MAY** be described with a lower limit defined by this constraint.
- 1796 • Nominal
- 1797 numeric target or expected value.
- 1798 • Value
- 1799 single data value that is expected to be reported for a `DataItem`.
- 1800 Value **MUST NOT** be used in conjunction with any other `Constraint` ele-
- 1801 ments.

1802 6.2.7.2 Part Properties of Constraints

1803 *Table 70* lists the Part Properties of Constraints.

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

Table 70: Part Properties of Constraints

1804 Descriptions for Part Properties of Constraints:

- 1805 • Filter
- 1806 provides a means to control when an *agent* records updated information for a `DataItem`.
- 1807 **DEPRECATED** in *MTConnect Version 1.4*. Moved to the Filters. See *Section 6.2 - Properties of DataItem*.
- 1808

1809 6.2.8 Definition

1810 defines the meaning of `Entry` and `Cell` elements associated with the `DataItem` when
 1811 the representation is either `DATA` or `TABLE`.

1812 6.2.8.1 Part Properties of Definition

1813 *Table 71* lists the Part Properties of Definition.

Part Property name	Multiplicity
<code>CellDefinition</code> (organized by <code>CellDefinitions</code>)	0..*
<code>Description</code>	0..1
<code>EntryDefinition</code> (organized by <code>EntryDefinitions</code>)	0..*

Table 71: Part Properties of Definition

1814 Descriptions for Part Properties of Definition:

- 1815 • `CellDefinition`
- 1816 semantic definition of a `Cell`.
- 1817 `CellDefinitions` groups one or more `CellDefinition` entities. See *Section 6.3.1 - CellDefinition*.
- 1818

- 1819 • Description
- 1820 descriptive content.
- 1821 See *Section 4.1.2 - Description*.
- 1822 • EntryDefinition
- 1823 semantic definition of an Entry.
- 1824 EntryDefinitions groups one or more EntryDefinition entities. See
- 1825 *Section 6.3.2 - EntryDefinition*.

1826 6.3 Properties of Definition

1827 This section provides semantic information for the elements of the Definition for a
 1828 DataItem.

1829 6.3.1 CellDefinition

1830 semantic definition of a Cell.

1831 6.3.1.1 Value Properties of CellDefinition

1832 Table 72 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 72: Value Properties of CellDefinition

1833 Descriptions for Value Properties of CellDefinition:

- 1834 • units
- 1835 same as DataItem units. See *Section 6.1.1.1 - Value Properties of DataItem*.
- 1836 The value of units **MUST** be one of the UnitEnum enumeration.

- 1837 • `key`
- 1838 unique identification of the `Cell` in the `Definition`.
- 1839 The description applies to all `Cell` observations having this `key`.
- 1840 • `type`
- 1841 same as `DataItem type`. See *Section 6.5 - DataItem Types*.
- 1842 The value of `type` **MUST** be one of the `DataItemTypeEnum` enumeration.
- 1843 • `subType`
- 1844 same as `DataItem subType`. See *Section 6.1.1 - DataItem*.
- 1845 The value of `subType` **MUST** be one of the `DataItemSubTypeEnum` enumer-
- 1846 ation.
- 1847 • `keyType`
- 1848 `DataItem type` that defines the meaning of the `key`.
- 1849 The value of `keyType` **MUST** be one of the `DataItemTypeEnum` enumeration.

1850 **6.3.1.2 Part Properties of CellDefinition**

1851 *Table 73* lists the Part Properties of `CellDefinition`.

Part Property name	Multiplicity
Description	0..1

Table 73: Part Properties of `CellDefinition`

1852 Descriptions for Part Properties of `CellDefinition`:

- 1853 • `Description`
- 1854 descriptive content.
- 1855 See *Section 4.1.2 - Description*.

1856 **6.3.2 EntryDefinition**

1857 semantic definition of an `Entry`.

6.3.2.1 Value Properties of EntryDefinition

Table 74 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 74: Value Properties of EntryDefinition

Descriptions for Value Properties of EntryDefinition:

- key
unique identification of the Entry in the Definition.
The description applies to all Entry observations having this key.
- units
same as DataItem units. See Section 6.1.1.1 - Value Properties of DataItem.
The value of units **MUST** be one of the UnitEnum enumeration.
- type
same as DataItem type. See Section 6.5 - DataItem Types.
The value of type **MUST** be one of the DataItemTypeEnum enumeration.
- subType
same as DataItem subType. See Section 6.1.1 - DataItem.
The value of subType **MUST** be one of the DataItemSubTypeEnum enumeration.
- keyType
DataItem type that defines the meaning of the key.
The value of keyType **MUST** be one of the DataItemTypeEnum enumeration.

6.3.2.2 Part Properties of EntryDefinition

Table 75 lists the Part Properties of EntryDefinition.

Part Property name	Multiplicity
Description	0..1
CellDefinition (organized by CellDefinitions)	0..*

Table 75: Part Properties of EntryDefinition

1879 Descriptions for Part Properties of EntryDefinition:

- 1880 • Description
- 1881 descriptive content.
- 1882 *See Section 4.1.2 - Description.*
- 1883 • CellDefinition
- 1884 semantic definition of a Cell.
- 1885 CellDefinitions groups one or more CellDefinition entities if the rep-
- 1886 resentation, DataItem of DataItem is TABLE. *See Section 6.3.1 - CellDef-*
- 1887 *inition.*

1888 6.4 Relationship Types for DataItem

1889 This section provides semantic information for the types of AbstractDataItemRe-
1890 lationship that can be defined for a DataItem.

1891 6.4.1 AbstractDataItemRelationship

1892 association between a DataItem and another entity.

1893 AbstractDataItemRelationship is an abstract entity and hence will be realized
1894 by specific AbstractDataItemRelationship types in an MTConnectDevices
1895 entity. *See Section 6.4 - Relationship Types for DataItem.*

1896 6.4.1.1 Value Properties of AbstractDataItemRelationship

1897 Table 76 lists the Value Properties of AbstractDataItemRelationship.

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

Table 76: Value Properties of AbstractDataItemRelationship

1898 Descriptions for Value Properties of AbstractDataItemRelationship:

- 1899 • idRef
- 1900 reference to the related entity's id.
- 1901 • name
- 1902 descriptive name associated with this AbstractDataItemRelationship.

1903 6.4.2 SpecificationRelationship

1904 AbstractDataItemRelationship that provides a semantic reference to another

1905 Specification described by the type and idRef property.

1906 6.4.2.1 Value Properties of SpecificationRelationship

1907 Table 77 lists the Value Properties of SpecificationRelationship.

Value Property name	Value Property type	Multiplicity
type	SpecificationRelationshipTypeEnum	1

Table 77: Value Properties of SpecificationRelationship

1908 Descriptions for Value Properties of SpecificationRelationship:

- 1909 • type
- 1910 specifies how the Specification is related.
- 1911 SpecificationRelationshipTypeEnum Enumeration:
- 1912 – LIMIT
- 1913 referenced Specification provides process limits.

1914 6.4.3 DataItemRelationship

1915 AbstractDataItemRelationship that provides a semantic reference to another
1916 DataItem described by the type property.

1917 6.4.3.1 Value Properties of DataItemRelationship

1918 Table 78 lists the Value Properties of DataItemRelationship.

Value Property name	Value Property type	Multiplicity
type	DataItemRelationshipTypeEnum	1

Table 78: Value Properties of DataItemRelationship

1919 Descriptions for Value Properties of DataItemRelationship:

- 1920 • type
- 1921 specifies how the DataItem is related.
- 1922 DataItemRelationshipTypeEnum Enumeration:
 - 1923 – ATTACHMENT
 - 1924 reference to a DataItem that associates the values with an external entity.
 - 1925 – COORDINATE_SYSTEM
 - 1926 referenced DataItem provides the id of the effective Coordinate System.
 - 1927 – LIMIT
 - 1928 referenced DataItem provides process limits.
 - 1929 – OBSERVATION
 - 1930 referenced DataItem provides the observed values.

1931 6.5 DataItem Types

1932 This section provides semantic information for the types of a DataItem.

1933 In the MTConnect Standard, DataItem elements are defined and organized based upon
1934 the category and type attributes. The category attribute provides a high level
1935 grouping for DataItem elements based on the kind of information that is reported by
1936 the data item.

1937 These categories are:

- 1938 • **SAMPLE:** A **SAMPLE** reports a continuously variable or analog data value.
- 1939 • **EVENT:** An **EVENT** reports information representing a functional state, with two or
- 1940 more discrete values, associated with a component or it contains a message. The
- 1941 data provided may be a numeric value or text.
- 1942 • **CONDITION:** A **CONDITION** reports information about the health of a piece of
- 1943 equipment and its ability to function.

1944 The `type` attribute specifies the specific kind of data that is reported. For some types of
 1945 data items, a `subType` attribute may also be used to differentiate between multiple data
 1946 items of the same `type` where the information reported by the data item has a different,
 1947 but related, meaning.

1948 Many types of data items provide two forms of data: a value (reported as either a **SAMPLE**
 1949 or **EVENT**) and a health status (reported as a **CONDITION**). These `DataItem` types **MAY**
 1950 be defined in more than one `category` based on the data that they report.

1951 6.5.1 Condition

1952 abstract `DataItem` that is about an entity's status regarding its ability to operate or it
 1953 provides an indication whether the data reported for the entity is within an expected range.

1954 `Condition` is reported differently than `Sample` or `Event`. `Condition` **MUST** be
 1955 reported as `Normal`, `Warning`, or `Fault`.

1956 All `Samples` **MAY** have associated `Condition` states. `Condition` states indicate
 1957 whether the value for the data is within an expected range and **MUST** be reported as
 1958 `Normal`, or the value is unexpected or out of tolerance for the data and a `Warning` or
 1959 `Fault` **MUST** be provided.

1960 6.5.1.1 Value Properties of Condition

1961 *Table 79* 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 79: Value Properties of `Condition`

1962 Descriptions for Value Properties of Condition:

1963 • type

1964 <<extensible>> ConditionEnum Enumeration:

1965 – ACTUATOR

1966 indication of a fault associated with an actuator.

1967 – COMMUNICATIONS

1968 indication that the piece of equipment has experienced a communications fail-
1969 ure.

1970 – DATA_RANGE

1971 indication that the value of the data associated with a measured value or a
1972 calculation is outside of an expected range.

1973 – LOGIC_PROGRAM

1974 indication that an error occurred in the logic program or programmable logic
1975 controller (PLC) associated with a piece of equipment.

1976 – MOTION_PROGRAM

1977 indication that an error occurred in the motion program associated with a piece
1978 of equipment.

1979 – SYSTEM

1980 general purpose indication associated with an electronic component of a piece
1981 of equipment or a controller that represents a fault that is not associated with
1982 the operator, program, or hardware.

1983 6.5.2 Event

1984 abstract DataItem that is a discrete piece of information from a piece of equipment. It
1985 does not have intermediate values that vary over time.

1986 An Event is information that, when provided at any specific point in time, represents the
1987 current state of the piece of equipment.

1988 6.5.2.1 Value Properties of Event

1989 Table 80 lists the Value Properties of Event.

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

Table 80: Value Properties of Event

1990 Descriptions for Value Properties of Event:

1991 • type

1992 <<extensible>> EventEnum Enumeration:

- 1993 – ACTIVATION_COUNT
1994 accumulation of the number of times a function has attempted to, or is planned
1995 to attempt to, activate or be performed.
- 1996 – ACTIVE_AXES
1997 set of axes currently associated with a Path or Controller.
- 1998 – ACTUATOR_STATE
1999 operational state of an apparatus for moving or controlling a mechanism or
2000 system.
- 2001 – ADAPTER_SOFTWARE_VERSION
2002 originator's software version of the *adapter*.
- 2003 – ADAPTER_URI
2004 Uniform Resource Identifier (URI) of the *adapter*.
- 2005 – <<deprecated>> ALARM
2006 **DEPRECATED:** Replaced with CONDITION category data items in Version
2007 1.1.0.
- 2008 – ALARM_LIMIT
2009 set of limits used to trigger warning or alarm indicators.
- 2010 – APPLICATION
2011 application on a Component.
- 2012 – ASSET_CHANGED
2013 assetId of the *Asset* that has been added or changed.
- 2014 – ASSET_COUNT
2015 *data set* of the number of *Assets* of a given type for a *Device*.
- 2016 – ASSET_REMOVED
2017 assetId of the *Asset* that has been removed.

- 2018 – AVAILABILITY
- 2019 *agent's* ability to communicate with the data source.
- 2020 – AXIS_COUPLING
- 2021 describes the way the axes will be associated to each other.
- 2022 This is used in conjunction with COUPLED_AXES to indicate the way they are
- 2023 interacting.
- 2024 – AXIS_FEEDRATE_OVERRIDE
- 2025 value of a signal or calculation issued to adjust the feedrate of an individual
- 2026 linear type axis.
- 2027 – AXIS_INTERLOCK
- 2028 state of the axis lockout function when power has been removed and the axis
- 2029 is allowed to move freely.
- 2030 – AXIS_STATE
- 2031 state of a Linear or Rotary component representing an axis.
- 2032 – BATTERY_STATE
- 2033 present status of the battery.
- 2034 – BLOCK
- 2035 line of code or command being executed by a Controller entity.
- 2036 – BLOCK_COUNT
- 2037 total count of the number of blocks of program code that have been executed
- 2038 since execution started.
- 2039 – CHUCK_INTERLOCK
- 2040 state of an interlock function or control logic state intended to prevent the as-
- 2041 sociated Chuck component from being operated.
- 2042 – CHUCK_STATE
- 2043 operating state of a mechanism that holds a part or stock material during a
- 2044 manufacturing process.
- 2045 It may also represent a mechanism that holds any other mechanism in place
- 2046 within a piece of equipment.
- 2047 – CLOCK_TIME
- 2048 time provided by a timing device at a specific point in time.
- 2049 – <<deprecated>> CODE
- 2050 programmatic code being executed.
- 2051 **DEPRECATED** in *Version 1.1*.
- 2052 – COMPOSITION_STATE
- 2053 operating state of a mechanism represented by a Composition entity.

- 2054 – CONNECTION_STATUS
- 2055 status of the connection between an *adapter* and an *agent*.
- 2056 – CONTROLLER_MODE
- 2057 current mode of the Controller component.
- 2058 – CONTROLLER_MODE_OVERRIDE
- 2059 setting or operator selection that changes the behavior of a piece of equipment.
- 2060 – CONTROL_LIMIT
- 2061 set of limits used to indicate whether a process variable is stable and in control.
- 2062 – COUPLED_AXES
- 2063 set of associated axes.
- 2064 – CYCLE_COUNT
- 2065 accumulation of the number of times a cyclic function has attempted to, or is
- 2066 planned to attempt to execute.
- 2067 – DATE_CODE
- 2068 time and date code associated with a material or other physical item.
- 2069 – DEACTIVATION_COUNT
- 2070 accumulation of the number of times a function has attempted to, or is planned
- 2071 to attempt to, deactivate or cease.
- 2072 – DEVICE_ADDED
- 2073 Universally Unique Identifier (UUID) of new device added to an *MTConnect*
- 2074 *Agent*.
- 2075 – DEVICE_CHANGED
- 2076 UUID of the device whose *metadata* has changed.
- 2077 – DEVICE_REMOVED
- 2078 UUID of a device removed from an *MTConnect Agent*.
- 2079 – DEVICE_UUID
- 2080 identifier of another piece of equipment that is temporarily associated with a
- 2081 component of this piece of equipment to perform a particular function.
- 2082 – DIRECTION
- 2083 direction of motion.
- 2084 – DOOR_STATE
- 2085 operational state of a Door component or composition element.
- 2086 – EMERGENCY_STOP
- 2087 state of the emergency stop signal for a piece of equipment, controller path, or
- 2088 any other component or subsystem of a piece of equipment.

- 2089 – END_OF_BAR
- 2090 indication of whether the end of a piece of bar stock being feed by a bar feeder
- 2091 has been reached.
- 2092 – EQUIPMENT_MODE
- 2093 indication that a piece of equipment, or a sub-part of a piece of equipment, is
- 2094 performing specific types of activities.
- 2095 – EXECUTION
- 2096 execution status of the Component.
- 2097 – FIRMWARE
- 2098 embedded software of a Component .
- 2099 – FIXTURE_ID
- 2100 identifier for a fixture.
- 2101 – FUNCTIONAL_MODE
- 2102 current intended production status of the Component.
- 2103 – HARDNESS
- 2104 hardness of a material.
- 2105 – HARDWARE
- 2106 hardware of a Component.
- 2107 – HOST_NAME
- 2108 name of the host computer supplying data.
- 2109 – LEAK_DETECT
- 2110 indication designating whether a leak has been detected.
- 2111 – LIBRARY
- 2112 software library on a Component
- 2113 – <<deprecated>> LINE
- 2114 current line of code being executed.
- 2115 **DEPRECATED** in *Version 1.4.0*.
- 2116 – LINE_LABEL
- 2117 identifier for a Block of code in a Program.
- 2118 – LINE_NUMBER
- 2119 position of a block of program code within a control program.
- 2120 – LOAD_COUNT
- 2121 accumulation of the number of times an operation has attempted to, or is
- 2122 planned to attempt to, load materials, parts, or other items.

- 2123 – LOCK_STATE
- 2124 state or operating mode of a Lock.
- 2125 – MAINTENANCE_LIST
- 2126 actions or activities to be performed in support of a piece of equipment.
- 2127 – MATERIAL
- 2128 identifier of a material used or consumed in the manufacturing process.
- 2129 – MATERIAL_LAYER
- 2130 identifies the layers of material applied to a part or product as part of an additive
- 2131 manufacturing process.
- 2132 – MESSAGE
- 2133 information to be transferred from a piece of equipment to a client software
- 2134 application.
- 2135 – MTCONNECT_VERSION
- 2136 reference version of the MTConnect Standard supported by the *adapter*.
- 2137 – NETWORK
- 2138 network details of a Component.
- 2139 – NETWORK_PORT
- 2140 number of the TCP/IP or UDP/IP port for the connection endpoint.
- 2141 – OPERATING_MODE
- 2142 state of Component or Composition that describes the automatic or man-
- 2143 ual operation of the entity.
- 2144 – OPERATING_SYSTEM
- 2145 Operating System (OS) of a Component.
- 2146 – OPERATOR_ID
- 2147 identifier of the person currently responsible for operating the piece of equip-
- 2148 ment.
- 2149 – PALLET_ID
- 2150 identifier for a pallet.
- 2151 – PART_COUNT
- 2152 aggregate count of parts.
- 2153 – PART_COUNT_TYPE
- 2154 interpretation of PART_COUNT.
- 2155 – PART_DETECT
- 2156 indication designating whether a part or work piece has been detected or is
- 2157 present.

- 2158 – PART_GROUP_ID
- 2159 identifier given to a collection of individual parts.
- 2160 – PART_ID
- 2161 identifier of a part in a manufacturing operation.
- 2162 – PART_KIND_ID
- 2163 identifier given to link the individual occurrence to a class of parts, typically
- 2164 distinguished by a particular part design.
- 2165 – <<deprecated>> PART_NUMBER
- 2166 identifier of a part or product moving through the manufacturing process.
- 2167 **DEPRECATED** in *Version 1.7*. PART_NUMBER is now a subType of PART_KIND_ID.
- 2168 – PART_PROCESSING_STATE
- 2169 particular condition of the part occurrence at a specific time.
- 2170 – PART_STATUS
- 2171 state or condition of a part.
- 2172 – PART_UNIQUE_ID
- 2173 identifier given to a distinguishable, individual part.
- 2174 – PATH_FEEDRATE_OVERRIDE
- 2175 value of a signal or calculation issued to adjust the feedrate for the axes asso-
- 2176 ciated with a Path component that may represent a single axis or the coordi-
- 2177 nated movement of multiple axes.
- 2178 – PATH_MODE
- 2179 describes the operational relationship between a Path entity and another Path
- 2180 entity for pieces of equipment comprised of multiple logical groupings of con-
- 2181 trolled axes or other logical operations.
- 2182 – POWER_STATE
- 2183 indication of the status of the source of energy for an entity to allow it to per-
- 2184 form its intended function or the state of an enabling signal providing permis-
- 2185 sion for the entity to perform its functions.
- 2186 – <<deprecated>> POWER_STATUS
- 2187 status of the Component.
- 2188 **DEPRECATED** in *Version 1.1.0*.
- 2189 – PROCESS_AGGREGATE_ID
- 2190 identifier given to link the individual occurrence to a group of related occur-
- 2191 rences, such as a process step in a process plan.
- 2192 – PROCESS_KIND_ID
- 2193 identifier given to link the individual occurrence to a class of processes or
- 2194 process definition.

- 2195 – PROCESS_OCCURRENCE_ID
- 2196 identifier of a process being executed by the device.
- 2197 – PROCESS_STATE
- 2198 particular condition of the process occurrence at a specific time.
- 2199 – PROCESS_TIME
- 2200 time and date associated with an activity or event.
- 2201 – PROGRAM
- 2202 name of the logic or motion program being executed by the Controller
- 2203 component.
- 2204 – PROGRAM_COMMENT
- 2205 comment or non-executable statement in the control program.
- 2206 – PROGRAM_EDIT
- 2207 indication of the status of the Controller components program editing
- 2208 mode.
- 2209 A program may be edited while another is executed.
- 2210 – PROGRAM_EDIT_NAME
- 2211 name of the program being edited.
- 2212 This is used in conjunction with ProgramEdit when in ACTIVE state.
- 2213 – PROGRAM_HEADER
- 2214 non-executable header section of the control program.
- 2215 – PROGRAM_LOCATION
- 2216 URI for the source file associated with Program.
- 2217 – PROGRAM_LOCATION_TYPE
- 2218 defines whether the logic or motion program defined by Program is being
- 2219 executed from the local memory of the controller or from an outside source.
- 2220 – PROGRAM_NEST_LEVEL
- 2221 indication of the nesting level within a control program that is associated with
- 2222 the code or instructions that is currently being executed.
- 2223 – ROTARY_MODE
- 2224 current operating mode for a Rotary type axis.
- 2225 – ROTARY_VELOCITY_OVERRIDE
- 2226 percentage change to the velocity of the programmed velocity for a Rotary
- 2227 axis.
- 2228 – ROTATION
- 2229 three space angular displacement of an object or coordinate system relative to
- 2230 a *cartesian coordinate system*.

- 2231 – SENSOR_ATTACHMENT
- 2232 *attachment* between a sensor and an entity.
- 2233 – SERIAL_NUMBER
- 2234 serial number associated with a Component, Asset, or Device.
- 2235 – SPECIFICATION_LIMIT
- 2236 set of limits defining a range of values designating acceptable performance for
- 2237 a variable.
- 2238 – SPINDLE_INTERLOCK
- 2239 indication of the status of the spindle for a piece of equipment when power has
- 2240 been removed and it is free to rotate.
- 2241 – TOOL_ASSET_ID
- 2242 identifier of an individual tool asset.
- 2243 – TOOL_GROUP
- 2244 identifier for the tool group associated with a specific tool. Commonly used to
- 2245 designate spare tools.
- 2246 – <<deprecated>> TOOL_ID
- 2247 identifier of the tool currently in use for a given Path.
- 2248 **DEPRECATED** in *Version 1.2.0*. See TOOL_ASSET_ID.
- 2249 – TOOL_NUMBER
- 2250 identifier assigned by the Controller component to a cutting tool when in
- 2251 use by a piece of equipment.
- 2252 – TOOL_OFFSET
- 2253 reference to the tool offset variables applied to the active cutting tool associated
- 2254 with a Path in a Controller type component.
- 2255 – TRANSFER_COUNT
- 2256 accumulation of the number of times an operation has attempted to, or is
- 2257 planned to attempt to, transfer materials, parts, or other items from one lo-
- 2258 cation to another.
- 2259 – TRANSLATION
- 2260 three space linear displacement of an object or coordinate system relative to a
- 2261 *cartesian coordinate system*.
- 2262 – UNLOAD_COUNT
- 2263 accumulation of the number of times an operation has attempted to, or is
- 2264 planned to attempt to, unload materials, parts, or other items.
- 2265 – USER
- 2266 identifier of the person currently responsible for operating the piece of equip-
- 2267 ment.

- 2268 – VALVE_STATE
- 2269 state of a valve is one of open, closed, or transitioning between the states.
- 2270 – VARIABLE
- 2271 data whose meaning may change over time due to changes in the operation of
- 2272 a piece of equipment or the process being executed on that piece of equipment.
- 2273 – WAIT_STATE
- 2274 indication of the reason that Execution is reporting a value of WAIT.
- 2275 – WIRE
- 2276 identifier for the type of wire used as the cutting mechanism in Electrical Dis-
- 2277 charge Machining or similar processes.
- 2278 – WORKHOLDING_ID
- 2279 identifier for the current workholding or part clamp in use by a piece of equip-
- 2280 ment.
- 2281 – WORK_OFFSET
- 2282 offset variables for a work piece or part associated with a Path in a Con-
- 2283 troller type component.

2284 6.5.3 Sample

- 2285 abstract DataItem that is continuously changing or analog data value.
- 2286 This data can be measured at any point-in-time and will always produce a result.
- 2287 The units for Sample **MUST** always be specified.

2288 6.5.3.1 Value Properties of Sample

2289 *Table 81* lists the Value Properties of Sample.

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

Table 81: Value Properties of Sample

2290 Descriptions for Value Properties of Sample:

- 2291 • type
- 2292 <<extensible>> SampleEnum Enumeration:
- 2293 – ACCELERATION
- 2294 positive rate of change of velocity.
- 2295 – ACCUMULATED_TIME
- 2296 accumulated time for an activity or event.
- 2297 – <<deprecated>> AMPERAGE
- 2298 strength of electrical current.
- 2299 **DEPRECATED** in *Version 1.6*. Replaced by AMPERAGE_AC and AMPER-
- 2300 AGE_DC.
- 2301 – AMPERAGE_AC
- 2302 electrical current that reverses direction at regular short intervals.
- 2303 – AMPERAGE_DC
- 2304 electric current flowing in one direction only.
- 2305 – ANGLE
- 2306 angular position.
- 2307 – ANGULAR_ACCELERATION
- 2308 positive rate of change of angular velocity.
- 2309 – ANGULAR_DECELERATION
- 2310 negative rate of change of angular velocity.
- 2311 – ANGULAR_VELOCITY
- 2312 rate of change of angular position.
- 2313 – ASSET_UPDATE_RATE
- 2314 average rate of change of values for assets in the MTConnect streams.
- 2315 The average is computed over a rolling window defined by the implementation.
- 2316 – AXIS_FEEDRATE
- 2317 feedrate of a linear axis.
- 2318 – BATTERY_CAPACITY
- 2319 maximum rated charge a battery is capable of maintaining based on the battery
- 2320 discharging at a specified current over a specified time period.
- 2321 – BATTERY_CHARGE
- 2322 value of the battery's present capacity expressed as a percentage of the battery's
- 2323 maximum rated capacity.
- 2324 – CAPACITY_FLUID
- 2325 fluid capacity of an object or container.

2326	– CAPACITY_SPATIAL
2327	geometric capacity of an object or container.
2328	– CHARGE_RATE
2329	value of the current being supplied to the Component for the purpose of
2330	charging.
2331	– CONCENTRATION
2332	percentage of one component within a mixture of components.
2333	– CONDUCTIVITY
2334	ability of a material to conduct electricity.
2335	– CUTTING_SPEED
2336	speed difference (relative velocity) between the cutting mechanism and the
2337	surface of the workpiece it is operating on.
2338	– DECELERATION
2339	negative rate of change of velocity.
2340	– DENSITY
2341	volumetric mass of a material per unit volume of that material.
2342	– DEPOSITION_ACCELERATION_VOLUMETRIC
2343	rate of change in spatial volume of material deposited in an additive manufac-
2344	turing process.
2345	– DEPOSITION_DENSITY
2346	density of the material deposited in an additive manufacturing process per unit
2347	of volume.
2348	– DEPOSITION_MASS
2349	mass of the material deposited in an additive manufacturing process.
2350	– DEPOSITION_RATE_VOLUMETRIC
2351	rate at which a spatial volume of material is deposited in an additive manufac-
2352	turing process.
2353	– DEPOSITION_VOLUME
2354	spatial volume of material to be deposited in an additive manufacturing pro-
2355	cess.
2356	– DEW_POINT
2357	temperature at which moisture begins to condense, corresponding to saturation
2358	for a given absolute humidity.
2359	– DIAMETER
2360	dimension of a diameter.

- 2361 – DISCHARGE_RATE
- 2362 value of current being drawn from the Component.
- 2363 – DISPLACEMENT
- 2364 change in position of an object.
- 2365 – DISPLACEMENT_ANGULAR
- 2366 absolute value of the change in angular position around a vector
- 2367 – DISPLACEMENT_LINEAR
- 2368 absolute value of the change in position along a vector.
- 2369 – ELECTRICAL_ENERGY
- 2370 Wattage used or generated by a component over an interval of time.
- 2371 – EQUIPMENT_TIMER
- 2372 amount of time a piece of equipment or a sub-part of a piece of equipment has
- 2373 performed specific activities.
- 2374 – FILL_LEVEL
- 2375 amount of a substance remaining compared to the planned maximum amount
- 2376 of that substance.
- 2377 – FLOW
- 2378 rate of flow of a fluid.
- 2379 – FOLLOWING_ERROR
- 2380 difference between actual and commanded position at any specific point in
- 2381 time during a motion.
- 2382 – FOLLOWING_ERROR_ANGULAR
- 2383 angular difference between the commanded encoder/resolver position and the
- 2384 actual encoder/resolver position at any specified point in time during a motion.
- 2385 – FOLLOWING_ERROR_LINEAR
- 2386 difference between the commanded encoder/resolver position and the actual
- 2387 encoder/resolver position at any specified point in time during a motion.
- 2388 – FREQUENCY
- 2389 number of occurrences of a repeating event per unit time.
- 2390 – <<deprecated>> GLOBAL_POSITION
- 2391 position in three-dimensional space.
- 2392 **DEPRECATED** in Version 1.1.
- 2393 – GRAVITATIONAL_ACCELERATION
- 2394 acceleration relative to Earth's gravity of 9.80665 METER/SECOND².
- 2395 – GRAVITATIONAL_FORCE
- 2396 force relative to earth's gravity.

- 2397 – HUMIDITY_ABSOLUTE
- 2398 amount of water vapor expressed in grams per cubic meter.
- 2399 – HUMIDITY_RELATIVE
- 2400 amount of water vapor present expressed as a percent to reach saturation at the
- 2401 same temperature.
- 2402 – HUMIDITY_SPECIFIC
- 2403 ratio of the water vapor present over the total weight of the water vapor and air
- 2404 present expressed as a percent.
- 2405 – LENGTH
- 2406 length of an object.
- 2407 – <<deprecated>> LEVEL
- 2408 level of a resource.
- 2409 **DEPRECATED** in *Version 1.2*. See `FILL_LEVEL`.
- 2410 – LINEAR_FORCE
- 2411 *force* applied to a mass in one direction only.
- 2412 – LOAD
- 2413 actual versus the standard rating of a piece of equipment.
- 2414 – MASS
- 2415 mass of an object(s) or an amount of material.
- 2416 – OBSERVATION_UPDATE_RATE
- 2417 average rate of change of values for data items in the MTConnect streams. The
- 2418 average is computed over a rolling window defined by the implementation.
- 2419 – OPENNESS
- 2420 percentage open where 100% is fully open and 0% is fully closed.
- 2421 – ORIENTATION
- 2422 angular position of a plane or vector relative to a *cartesian coordinate system*
- 2423 – PATH_FEEDRATE
- 2424 feedrate for the axes, or a single axis, associated with a `Path` component.
- 2425 – PATH_FEEDRATE_PER_REVOLUTION
- 2426 feedrate for the axes, or a single axis.
- 2427 – PATH_POSITION
- 2428 position of a control point associated with a `Controller` or a `Path`.
- 2429 – PH
- 2430 acidity or alkalinity of a solution.

- 2431 – POSITION
- 2432 point along an axis in a *cartesian coordinate system*.
- 2433 – POSITION_CARTESIAN
- 2434 point in a *cartesian coordinate system*.
- 2435 – POWER_FACTOR
- 2436 ratio of real power flowing to a load to the apparent power in that AC circuit.
- 2437 – PRESSURE
- 2438 force per unit area measured relative to atmospheric pressure.
- 2439 Commonly referred to as gauge pressure.
- 2440 – PRESSURE_ABSOLUTE
- 2441 force per unit area measured relative to a vacuum.
- 2442 – PRESSURIZATION_RATE
- 2443 change of pressure per unit time.
- 2444 – PROCESS_TIMER
- 2445 amount of time a piece of equipment has performed different types of activities
- 2446 associated with the process being performed at that piece of equipment.
- 2447 – RESISTANCE
- 2448 degree to which a substance opposes the passage of an electric current.
- 2449 – ROTARY_VELOCITY
- 2450 rotational speed of a rotary axis.
- 2451 – SETTLING_ERROR
- 2452 difference between actual and commanded position at the end of a motion.
- 2453 – SETTLING_ERROR_ANGULAR
- 2454 angular difference between the commanded encoder/resolver position, and the
- 2455 actual encoder/resolver position when motion is complete.
- 2456 – SETTLING_ERROR_LINEAR
- 2457 difference between the commanded encoder/resolver position, and the actual
- 2458 encoder/resolver position when motion is complete.
- 2459 – SOUND_LEVEL
- 2460 sound level or sound pressure level relative to atmospheric pressure.
- 2461 – <<deprecated>> SPINDLE_SPEED
- 2462 rotational speed of the rotary axis.
- 2463 **DEPRECATED** in *Version 1.2*. Replaced by ROTARY_VELOCITY.
- 2464 – STRAIN
- 2465 amount of deformation per unit length of an object when a load is applied.

- 2466 – TEMPERATURE
- 2467 degree of hotness or coldness measured on a definite scale.
- 2468 – TENSION
- 2469 force that stretches or elongates an object.
- 2470 – TILT
- 2471 angular displacement.
- 2472 – TORQUE
- 2473 turning force exerted on an object or by an object.
- 2474 – VELOCITY
- 2475 rate of change of position of a Component.
- 2476 – VISCOSITY
- 2477 fluid's resistance to flow.
- 2478 – <<deprecated>> VOLTAGE
- 2479 electrical potential between two points.
- 2480 **DEPRECATED** in *Version 1.6*. Replaced by VOLTAGE_AC and VOLTAGE_DC.
- 2481 – VOLTAGE_AC
- 2482 electrical potential between two points in an electrical circuit in which the cur-
- 2483 rent periodically reverses direction.
- 2484 – VOLTAGE_DC
- 2485 electrical potential between two points in an electrical circuit in which the cur-
- 2486 rent is unidirectional.
- 2487 – VOLT_AMPERE
- 2488 apparent power in an electrical circuit, equal to the product of root-mean-
- 2489 square (RMS) voltage and RMS current (commonly referred to as VA).
- 2490 – VOLT_AMPERE_REACTIVE
- 2491 reactive power in an AC electrical circuit (commonly referred to as VAR).
- 2492 – VOLUME_FLUID
- 2493 fluid volume of an object or container.
- 2494 – VOLUME_SPATIAL
- 2495 geometric volume of an object or container.
- 2496 – WATTAGE
- 2497 power flowing through or dissipated by an electrical circuit or piece of equip-
- 2498 ment.
- 2499 – X_DIMENSION
- 2500 dimension of an entity relative to the X direction of the referenced coordinate
- 2501 system.

- 2502 – Y_DIMENSION
- 2503 dimension of an entity relative to the Y direction of the referenced coordinate
- 2504 system.
- 2505 – Z_DIMENSION
- 2506 dimension of an entity relative to the Z direction of the referenced coordinate
- 2507 system.

2508 7 References Model

2509 References *organizes* pointers to information defined elsewhere within the MTCon-
 2510 nectDevices entity for a piece of equipment. It is an efficient method to associate
 2511 information with an element without duplicating any of the data or structure.

2512 7.1 References

2513 This section provides semantic information for the Reference entity. Figure 6 shows
 2514 the Reference model.

2515 Reference may be modeled as part of a Device, Component or Interface type.

2516 Note: See *Section B.3 - References Schema Diagrams* for XML schema of
 2517 Reference and its types.

2518 7.1.1 Reference

2519 pointer to information that is associated with another entity defined elsewhere in the MT-
 2520 ConnectDevices entity for a piece of equipment.

2521 Reference is an abstract entity and will be realized by a specific Reference type for
 2522 an MTConnectDevices entity. See *Section 7.1.3 - ComponentRef* and *Section 7.1.2 -*
 2523 *DataItemRef*.

2524 7.1.1.1 Value Properties of Reference

2525 Table 82 lists the Value Properties of Reference.

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

Table 82: Value Properties of Reference

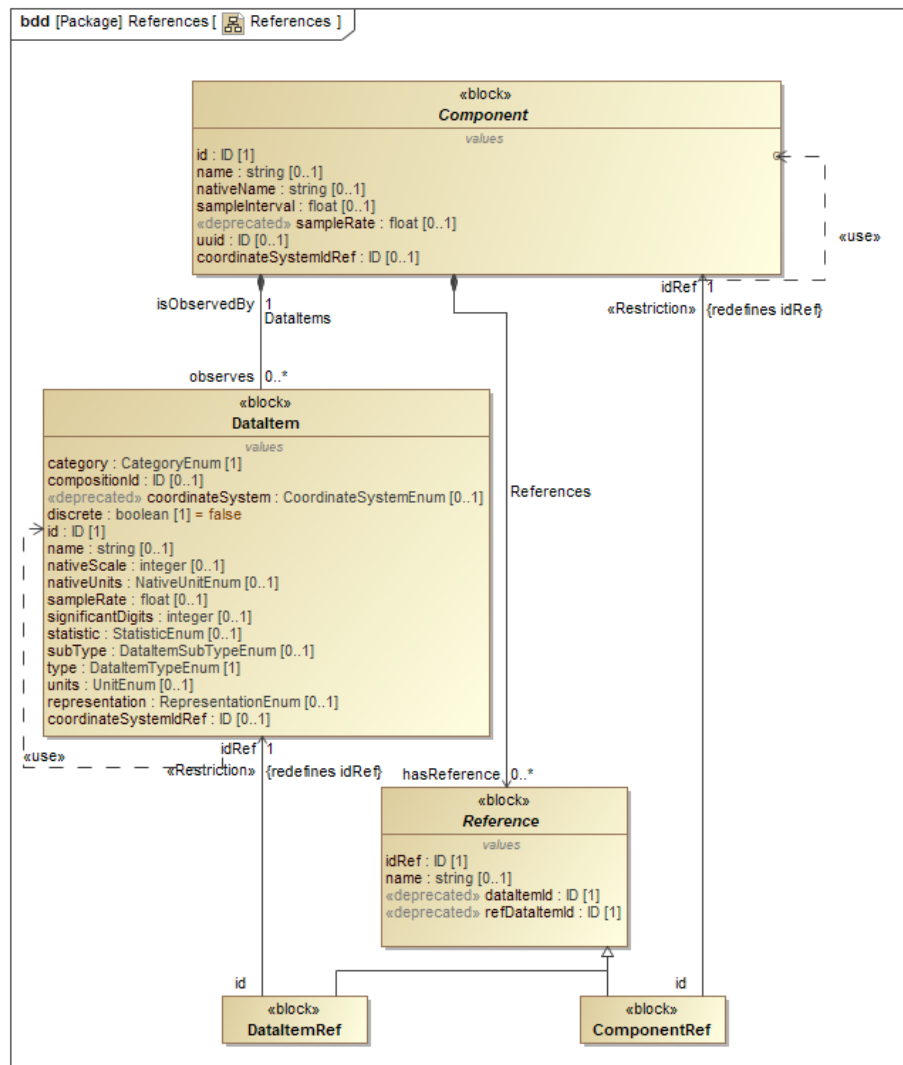


Figure 6: References

2526 Descriptions for Value Properties of Reference:

- 2527 • idRef
- 2528 pointer to the id of an entity that contains the information to be associated with this
- 2529 entity.
- 2530 • name
- 2531 name of an element or a piece of equipment.

2532 7.1.2 DataItemRef

2533 Reference that is a pointer to a `DataItem` associated with another entity defined for
2534 a piece of equipment.

2535 `DataItemRef` allows the data associated with a `DataItem` defined in another entity to
2536 be directly associated with this entity.

2537 7.1.3 ComponentRef

2538 Reference that is a pointer to all of the information associated with another entity de-
2539 fined for a piece of equipment.

2540 `ComponentRef` allows all of the information of (*lower level* `Component` entities that
2541 is associated with the other entity to be directly associated with this entity.

2542 8 Configurations Model

2543 This section provides semantic information for the Configuration entity that is used
2544 to model technical information about a Component.

2545 8.1 Configurations

2546 Figure 7 shows the abstract Configuration and its types.

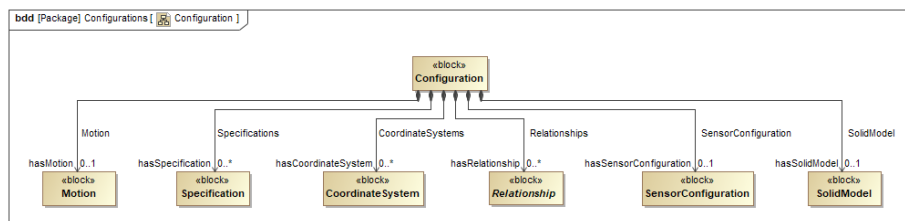


Figure 7: Configuration

2547 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2548 8.1.1 Configuration

2549 technical information about an entity describing its physical layout, functional character-
2550 istics, and relationships with other entities.

2551 8.1.1.1 Part Properties of Configuration

2552 Table 83 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..*

Table 83: Part Properties of Configuration

2553 Descriptions for Part Properties of Configuration:

- 2554 • SolidModel
- 2555 references to a file with the three-dimensional geometry of the Component or
- 2556 Composition.
- 2557 See *Section 8.6 - SolidModel*.
- 2558 • SensorConfiguration
- 2559 configuration for a Sensor.
- 2560 See SensorConfiguration.
- 2561 • Motion
- 2562 movement of the component relative to a coordinate system.
- 2563 See *Section 8.3 - Motion*.
- 2564 • ConfigurationRelationship
- 2565 association between two pieces of equipment that function independently but to-
- 2566 gether perform a manufacturing operation.
- 2567 Relationships groups one or more ConfigurationRelationship types.
- 2568 See *Section 8.4 - Relationships*.
- 2569 • CoordinateSystem
- 2570 reference system that associates a unique set of n parameters with each point in an
- 2571 n-dimensional space. *Ref ISO 10303-218:2004*
- 2572 CoordinateSystems groups one or more CoordinateSystem entities. See
- 2573 *Section 8.2 - CoordinateSystems*.
- 2574 • Specification
- 2575 design characteristics for a piece of equipment.

2576 Specifications groups one or more Specification entities. See *Sec-*
 2577 *tion 8.7 - Specifications.*

2578 8.2 CoordinateSystems

2579 This section provides semantic information for the CoordinateSystem entity.

2580 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2581 Note: See *Example 4* for the XML representation of the same example.

2582 8.2.1 CoordinateSystem

2583 reference system that associates a unique set of n parameters with each point in an n-
 2584 dimensional space. *Ref ISO 10303-218:2004*

2585 At most only one of Origin or Transformation **MUST** be defined for a Coordi-
 2586 nateSystem.

2587 8.2.1.1 Value Properties of CoordinateSystem

2588 *Table 84* 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
Description	string	0..1

Table 84: Value Properties of CoordinateSystem

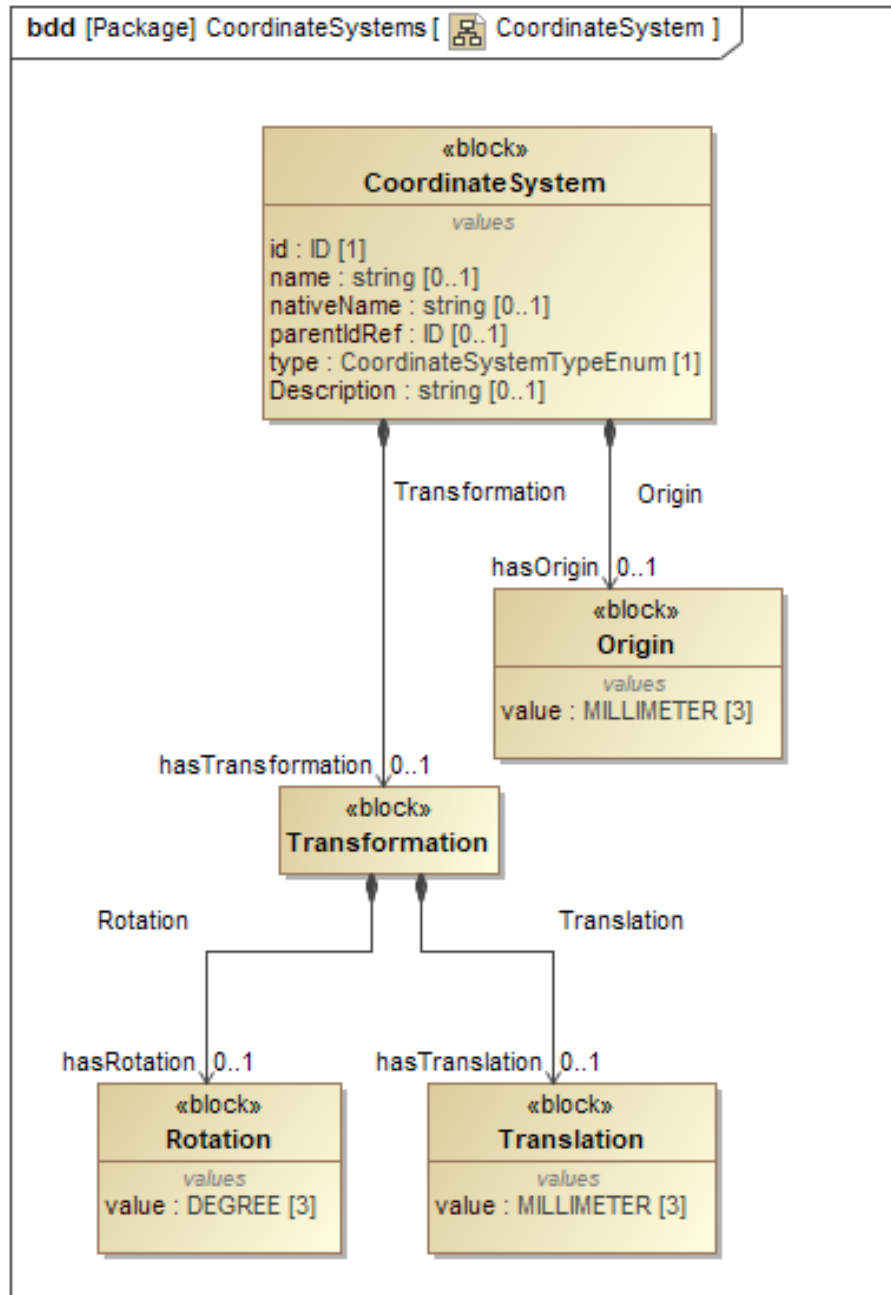


Figure 8: CoordinateSystem

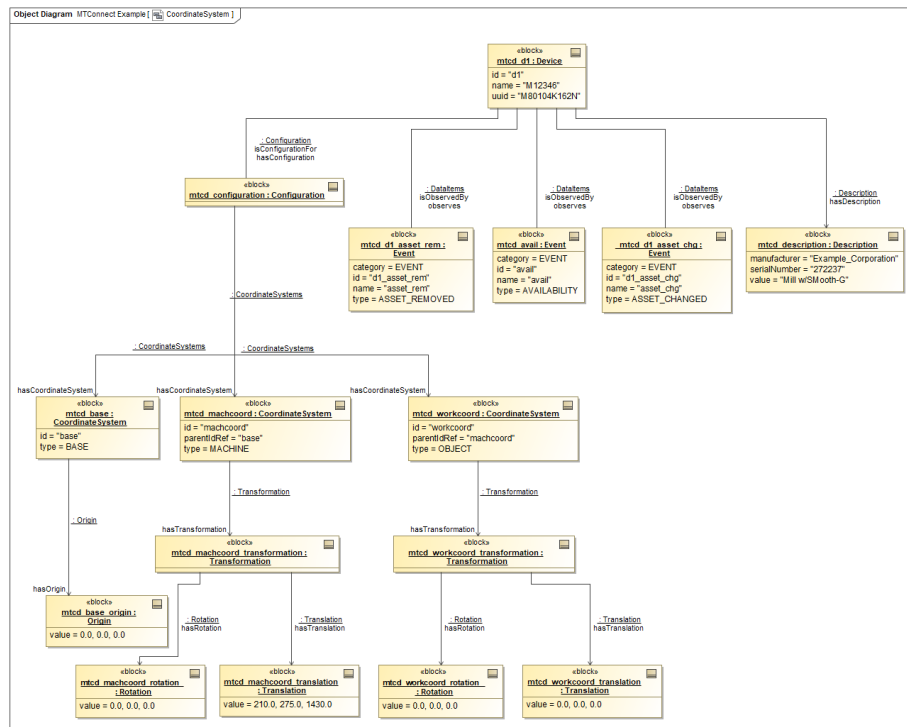


Figure 9: CoordinateSystem Example

2589 Descriptions for Value Properties of `CoordinateSystem`:

- 2590 • `id`
2591 unique identifier for this element.
- 2592 • `name`
2593 name of the coordinate system.
- 2594 • `nativeName`
2595 manufacturer's name or users name for the coordinate system.
- 2596 • `parentIdRef`
2597 pointer to the `id` attribute of the parent `CoordinateSystem`.
- 2598 • `type`
2599 type of coordinate system.

2600 `CoordinateSystemTypeEnum` Enumeration:

- 2601 – `BASE`
2602 coordinate system referenced to the base mounting surface. *Ref ISO 9787:2013*
2603 A base mounting surface is a connection surface between the arm and its sup-
2604 porting structure. *Ref ISO 9787:2013*
2605 For non-robotic devices, it is the connection surface between the device and its
2606 supporting structure.
- 2607 – `CAMERA`
2608 coordinate system referenced to the sensor which monitors the site of the task.
2609 *Ref ISO 9787:2013*
- 2610 – `MACHINE`
2611 coordinate system referenced to the home position and orientation of the pri-
2612 mary axes of a piece of equipment.
- 2613 – `MECHANICAL_INTERFACE`
2614 coordinate system referenced to the mechanical interface. *Ref ISO 9787:2013*
- 2615 – `MOBILE_PLATFORM`
2616 coordinate system referenced to one of the components of a mobile platform.
2617 *Ref ISO 8373:2012*
- 2618 – `OBJECT`
2619 coordinate system referenced to the object. *Ref ISO 9787:2013*

- 2620 – TASK
- 2621 coordinate system referenced to the site of the task. *Ref ISO 9787:2013*
- 2622 – TOOL
- 2623 coordinate system referenced to the tool or to the end effector attached to the
- 2624 mechanical interface. *Ref ISO 9787:2013*
- 2625 – WORLD
- 2626 stationary coordinate system referenced to earth, which is independent of the
- 2627 robot motion. *Ref ISO 9787:2013*
- 2628 For non-robotic devices, stationary coordinate system referenced to earth, which
- 2629 is independent of the motion of a piece of equipment.

- 2630 • Description
- 2631 natural language description of the `CoordinateSystem`.

2632 **8.2.1.2 Part Properties of `CoordinateSystem`**

2633 *Table 85* lists the Part Properties of `CoordinateSystem`.

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

Table 85: Part Properties of `CoordinateSystem`

2634 Descriptions for Part Properties of `CoordinateSystem`:

- 2635 • Origin
- 2636 coordinates of the origin position of a coordinate system.
- 2637 See *Section 8.2.2 - Origin*.
- 2638 • Transformation
- 2639 process of transforming to the origin position of the coordinate system from a parent
- 2640 coordinate system using `Translation` and `Rotation`.
- 2641 See *Section 8.2.3 - Transformation*.

2642 8.2.2 Origin

2643 coordinates of the origin position of a coordinate system.

2644 The value of `Origin` **MUST** be reported in `MILLIMETER_3D`.

2645 8.2.3 Transformation

2646 process of transforming to the origin position of the coordinate system from a parent co-
2647 ordinate system using `Translation` and `Rotation`.

2648 At a minimum, a `Translation` or a `Rotation` **MUST** be defined for a `Transfor-`
2649 `mation`.

2650 8.2.3.1 Part Properties of Transformation

2651 *Table 86* lists the Part Properties of `Transformation`.

Part Property name	Multiplicity
<code>Translation</code>	0..1
<code>Rotation</code>	0..1

Table 86: Part Properties of Transformation

2652 Descriptions for Part Properties of `Transformation`:

2653 • `Translation`
2654 translations along X, Y, and Z axes are expressed as x,y, and z respectively within a
2655 3-dimensional vector.

2656 See *Section 8.2.5 - Translation*.

2657 • `Rotation`
2658 rotations about X, Y, and Z axes are expressed in A, B, and C respectively within a
2659 3-dimensional vector.

2660 See *Section 8.2.4 - Rotation*.

2661 8.2.4 Rotation

2662 rotations about X, Y, and Z axes are expressed in A, B, and C respectively within a 3-
2663 dimensional vector.

2664 The value of `Rotation` **MUST** be reported in `DEGREE_3D`.

2665 8.2.5 Translation

2666 translations along X, Y, and Z axes are expressed as x,y, and z respectively within a 3-
2667 dimensional vector.

2668 The value of `Translation` **MUST** be reported in `MILLIMETER_3D`.

2669 8.3 Motion

2670 This section provides semantic information for the `Motion` entity.

2671 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2672 Note: See *Example 5* for the XML representation of the same example.

2673 8.3.1 Motion

2674 movement of the component relative to a coordinate system.

2675 `Motion` specifies the kinematic chain of the `component` entities.

2676 At most only one of `Origin` or `Transformation` **MUST** be defined for a `Motion`.

2677 8.3.1.1 Value Properties of Motion

2678 *Table 87* lists the Value Properties of `Motion`.

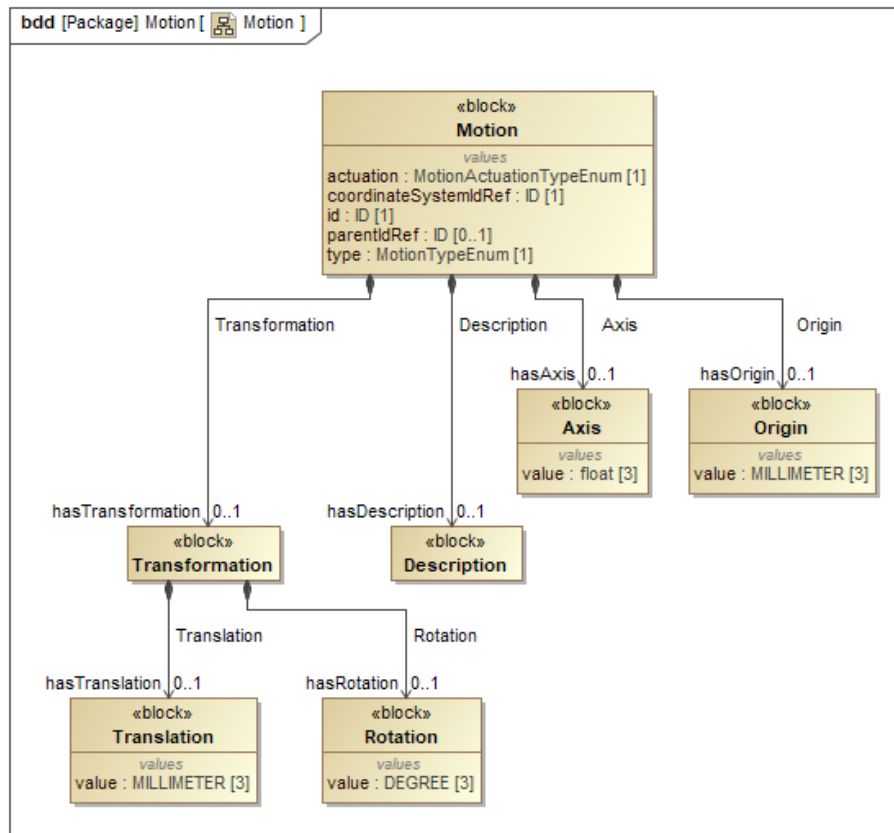


Figure 10: Motion

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

Table 87: Value Properties of Motion

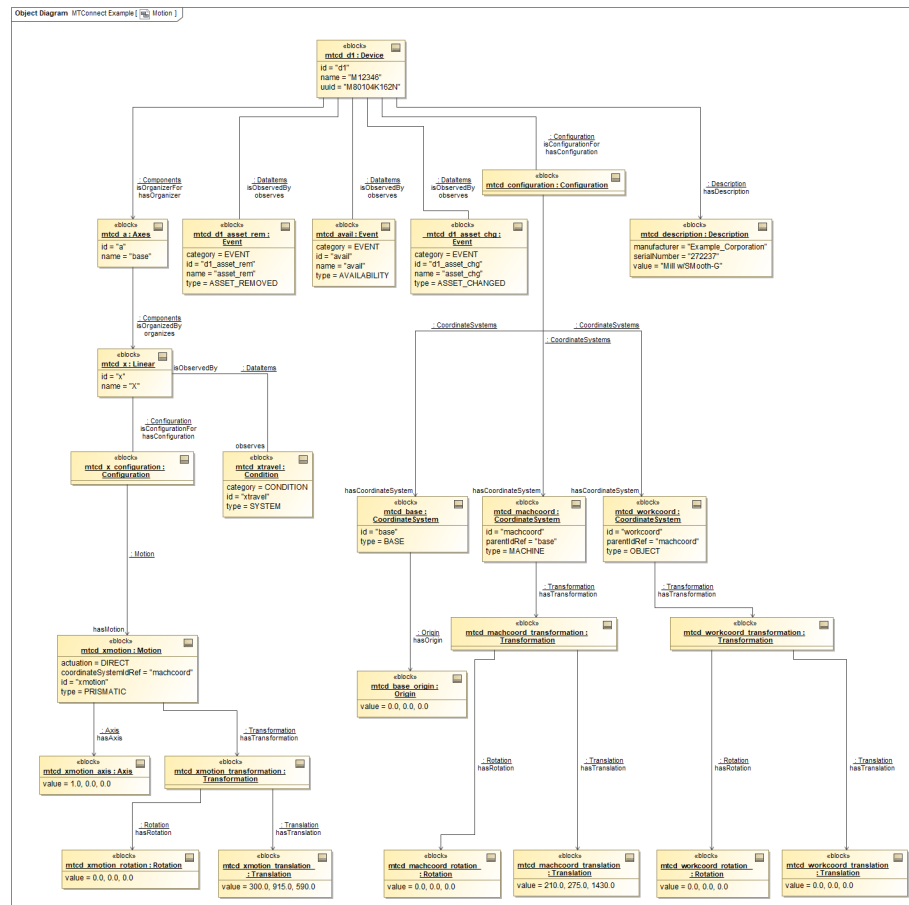


Figure 11: Motion Example

2679 Descriptions for Value Properties of Motion:

- 2680 • `actuation`
- 2681 describes if this component is actuated directly or indirectly as a result of other
- 2682 motion.
- 2683 `MotionActuationTypeEnum` Enumeration:
- 2684 – `DIRECT`
- 2685 movement is initiated by the component.
- 2686 – `NONE`
- 2687 no actuation of this axis.
- 2688 Note: Actuation of `NONE` can be either a derived `REVOLUTE` or
- 2689 `PRISMATIC` motion or static `FIXED` relationship.
- 2690 – `VIRTUAL`
- 2691 motion is computed and is used for expressing an imaginary movement.
- 2692 • `coordinateSystemIdRef`
- 2693 coordinate system within which the kinematic motion occurs.
- 2694 • `id`
- 2695 unique identifier for this element.
- 2696 • `parentIdRef`
- 2697 pointer to the `id` attribute of the parent `Motion`.
- 2698 The kinematic chain connects all components using the parent relations. All motion
- 2699 is connected to the motion of the parent. The first node in the chain will not have a
- 2700 parent.
- 2701 • `type`
- 2702 type of motion.
- 2703 `MotionTypeEnum` Enumeration:
- 2704 – `CONTINUOUS`
- 2705 revolves around an axis with a continuous range of motion.
- 2706 – `FIXED`
- 2707 axis does not move.
- 2708 – `PRISMATIC`
- 2709 sliding linear motion along an axis with a fixed range of motion.
- 2710 – `REVOLUTE`
- 2711 rotates around an axis with a fixed range of motion.

2712 8.3.1.2 Part Properties of Motion

2713 *Table 88* lists the Part Properties of Motion.

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

Table 88: Part Properties of Motion

2714 Descriptions for Part Properties of Motion:

- 2715 • Axis
- 2716 axis along or around which the Component moves relative to a coordinate system.
- 2717 See *Section 4.3.5 - Axis*.
- 2718 • Origin
- 2719 coordinates of the origin position of a coordinate system.
- 2720 See *Section 8.2.2 - Origin*.
- 2721 • Transformation
- 2722 process of transforming to the origin position of the coordinate system from a parent
- 2723 coordinate system using Translation and Rotation.
- 2724 See *Section 8.2.3 - Transformation*.
- 2725 • Description
- 2726 descriptive content.
- 2727 See *Section 4.1.2 - Description*.

2728 8.3.2 Axis

2729 axis along or around which the Component moves relative to a coordinate system.

2730 The value of Axis **MUST** be a list of float of size 3.

2731 8.4 Relationships

2732 This section provides semantic information for the ConfigurationRelationship
2733 entity.

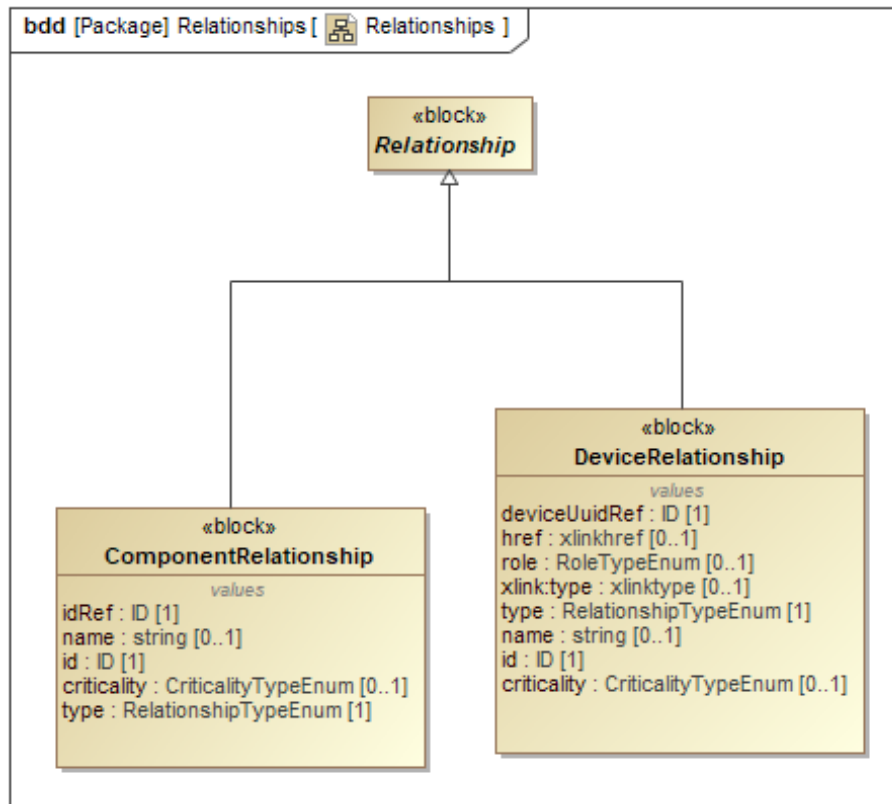


Figure 12: Relationships

2734 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2735 Note: See *Example 6* for the XML representation of the same example.

2736 8.4.1 ConfigurationRelationship

2737 association between two pieces of equipment that function independently but together
2738 perform a manufacturing operation.

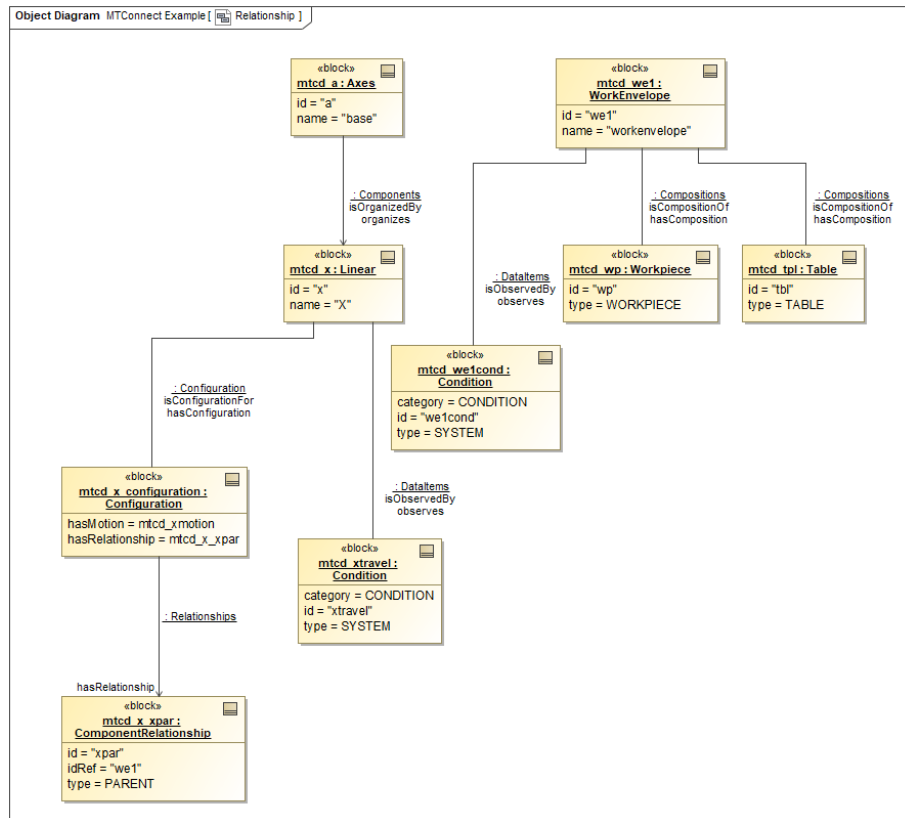


Figure 13: Relationship Example

2739 ConfigurationRelationship is an abstract entity and hence will be realized by
 2740 specific ConfigurationRelationship types in an MTConnectDevices entity.
 2741 See Section 8.4.2 - ComponentRelationship and Section 8.4.3 - DeviceRelationship.

2742 8.4.1.1 Value Properties of ConfigurationRelationship

2743 Table 89 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 89: Value Properties of ConfigurationRelationship

2744 Descriptions for Value Properties of ConfigurationRelationship:

- 2745 • `name`
- 2746 `name` associated with this `ConfigurationRelationship`.
- 2747 • `id`
- 2748 unique identifier for this `ConfigurationRelationship`.
- 2749 • `type`
- 2750 defines the authority that this piece of equipment has relative to the associated piece
- 2751 of equipment.
- 2752 `RelationshipTypeEnum` Enumeration:
- 2753 – `CHILD`
- 2754 functions as a child in the relationship with the associated element.
- 2755 – `PARENT`
- 2756 functions as a parent in the relationship with the associated element.
- 2757 – `PEER`
- 2758 functions as a peer which provides equal functionality and capabilities in the
- 2759 relationship with the associated element.
- 2760 • `criticality`
- 2761 defines whether the services or functions provided by the associated piece of equip-
- 2762 ment is required for the operation of this piece of equipment.
- 2763 `CriticalityTypeEnum` Enumeration:
- 2764 – `CRITICAL`
- 2765 services or functions provided by the associated element is required for the
- 2766 operation of this element.
- 2767 – `NONCRITICAL`
- 2768 services or functions provided by the associated element is not required for the
- 2769 operation of this element.

2770 8.4.2 ComponentRelationship

- 2771 `ConfigurationRelationship` that describes the association between two compo-
- 2772 nents within a piece of equipment that function independently but together perform a ca-
- 2773 pability or service within a piece of equipment.

2774 8.4.2.1 Value Properties of ComponentRelationship

2775 *Table 90* lists the Value Properties of ComponentRelationship.

Value Property name	Value Property type	Multiplicity
idRef	ID	1

Table 90: Value Properties of ComponentRelationship

2776 Descriptions for Value Properties of ComponentRelationship:

- 2777 • idRef
- 2778 reference to the associated Component.

2779 8.4.3 DeviceRelationship

2780 ConfigurationRelationship that describes the association between two pieces of
2781 equipment that function independently but together perform a manufacturing operation.

2782 8.4.3.1 Value Properties of DeviceRelationship

2783 *Table 91* lists the Value Properties of DeviceRelationship.

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

Table 91: Value Properties of DeviceRelationship

2784 Descriptions for Value Properties of DeviceRelationship:

- 2785 • deviceUuidRef
- 2786 reference to the uuid attribute of the Device element of the associated piece of
- 2787 equipment.
- 2788 • href
- 2789 URI identifying the *agent* that is publishing information for the associated piece of
- 2790 equipment.

- 2791 • `role`
- 2792 defines the services or capabilities that the referenced piece of equipment provides
- 2793 relative to this piece of equipment.
- 2794 `RoleTypeEnum` Enumeration:
- 2795 – `AUXILIARY`
- 2796 associated element performs the functions as an `Auxiliary` for this element.
- 2797 – `SYSTEM`
- 2798 associated element performs the functions of a `System` for this element.
- 2799 • `xlink:type`
- 2800 `xlink:type` **MUST** have a fixed value of `locator` as defined in W3C XLink
- 2801 1.1 Ref <https://www.w3.org/TR/xlink11/>.

2802 8.4.4 AssetRelationship

2803 `ConfigurationRelationship` that describes the association between a `Component`

2804 and an `Asset`.

2805 8.4.4.1 Value Properties of AssetRelationship

2806 *Table 92* 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 92: Value Properties of `AssetRelationship`

2807 Descriptions for Value Properties of `AssetRelationship`:

- 2808 • `assetIdRef`
- 2809 uuid of the related `Asset`.
- 2810 • `assetType`
- 2811 type of `Asset` being referenced.
- 2812 • `href`
- 2813 URI reference to the associated `Asset`.

2814 8.5 Sensor

2815 This section provides semantic information for the `SensorConfiguration` entity.

2816 sensor is a unique type of a piece of equipment. A sensor is typically comprised of two
 2817 major components: a sensor unit that provides signal processing, conversion, and commu-
 2818 nications and the *sensing elements* that provides a signal or measured value.

2819 The sensor unit is modeled as a *lower level* `Component` called `Sensor`. The *sensing*
 2820 *element* may be modeled as a `Composition` element of a `Sensor` element and the
 2821 measured value would be modeled as a `DataItem` (See *Section 6.1 - DataItems* for more
 2822 information on `DataItem` elements). Each sensor unit may have multiple *sensing ele-*
 2823 *ments*; each representing the data for a variety of measured values.

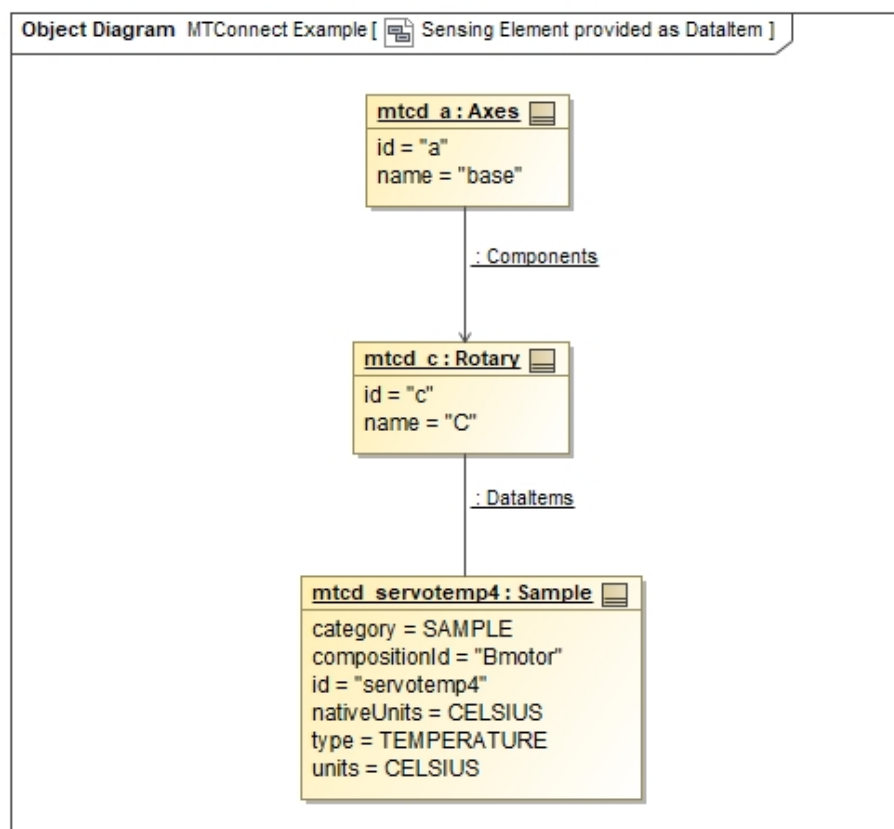


Figure 14: Sensing Element provided as a `DataItem` Example

2824 Note: See *Example 9* for an XML example.

2825 When a sensor unit is modeled as a `Component` or as a separate piece of equipment, it

2826 may provide additional configuration information for the sensor elements and the sensor
2827 unit itself.

2828 Note: If a `Sensor` provides vibration measurement data for the spindle on a
2829 piece of equipment, it could be modeled as a `Sensor` for rotary axis named
2830 C. See *Example 10* for an XML example.

2831 Note: If a `Sensor` provides measurement data for multiple `Component` el-
2832 ements within a piece of equipment and is not associated with any particular
2833 `Component`, it **MAY** be modeled as an independent `Component` and the
2834 data associated with measurements are associated with their associated `Com-`
2835 ponent entities. See *Example 11* for an XML example.

2836 Configuration data provides information required for maintenance and support of the
2837 sensor.

2838 When `Sensor` represents the sensor unit for multiple *sensing element(s)*, each sensing
2839 element is represented by a `Channel`. The sensor unit itself and each `Channel` repre-
2840 senting one *sensing element* **MAY** have its own configuration data.

2841 Note: See *Example 12* for an XML example.

2842 8.5.1 SensorConfiguration

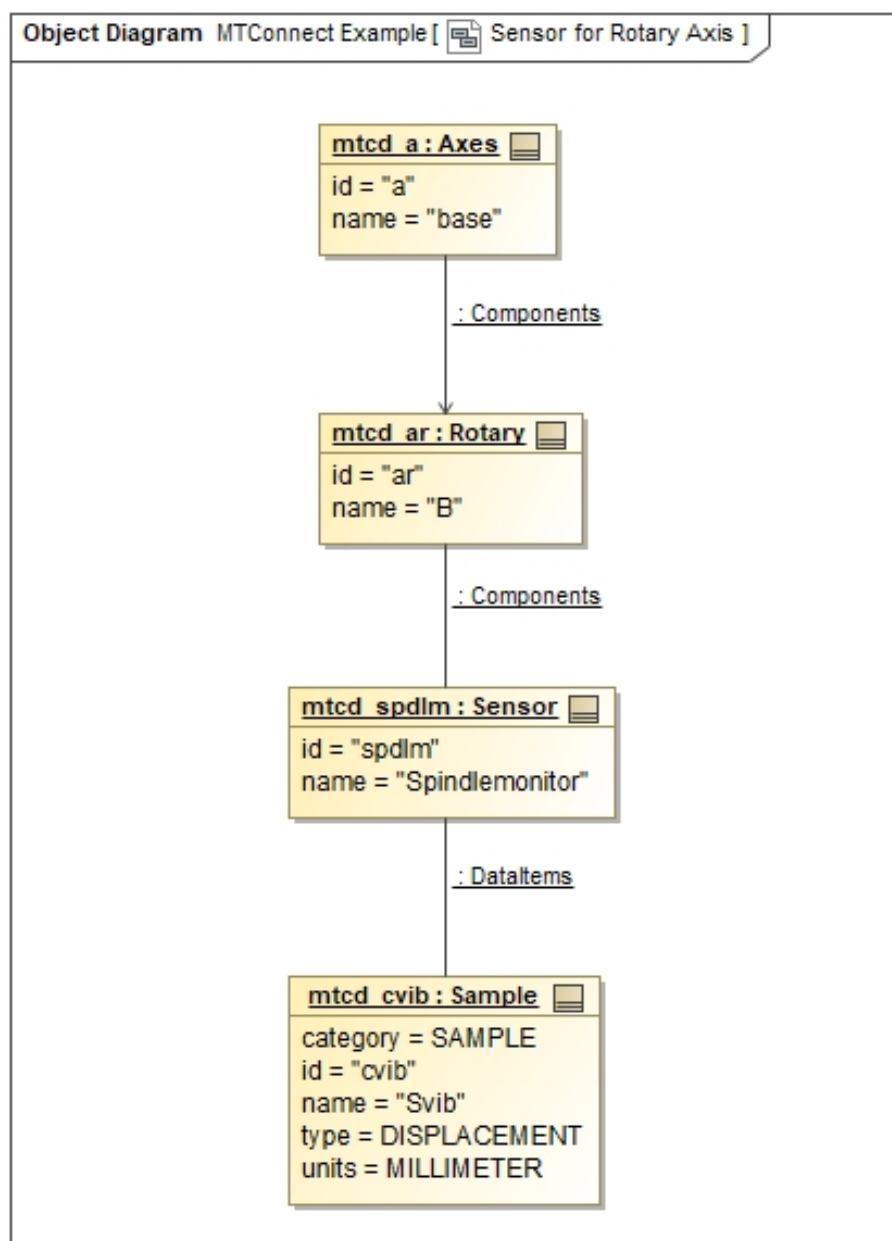
2843 configuration for a `Sensor`.

2844 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2845 8.5.1.1 Value Properties of SensorConfiguration

2846 *Table 93* 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 93: Value Properties of SensorConfiguration**Figure 15:** Sensor for Rotary Axis Example

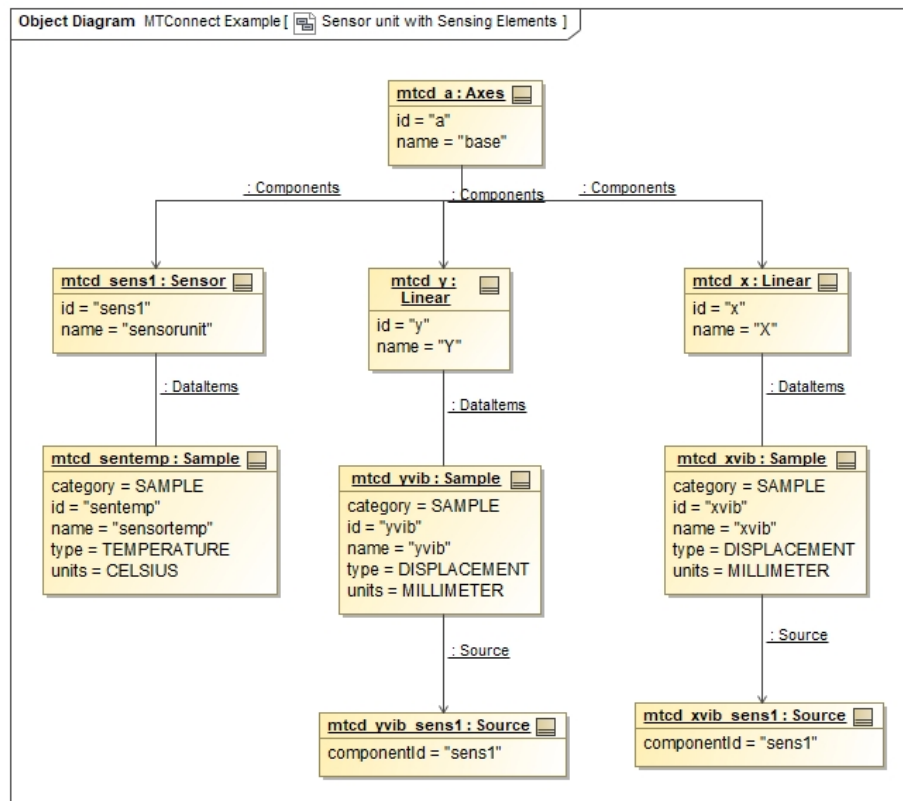


Figure 16: Sensor unit with Sensing Elements Example

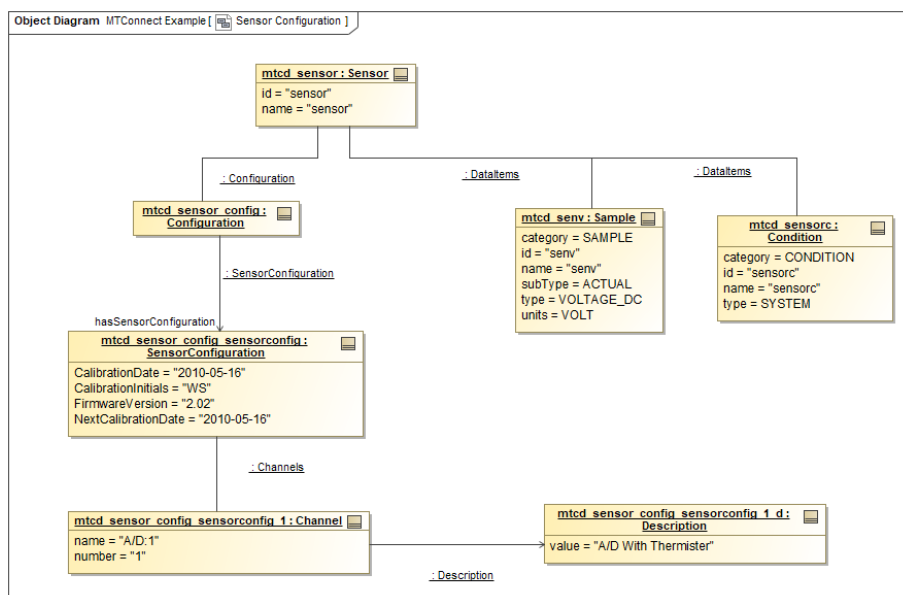
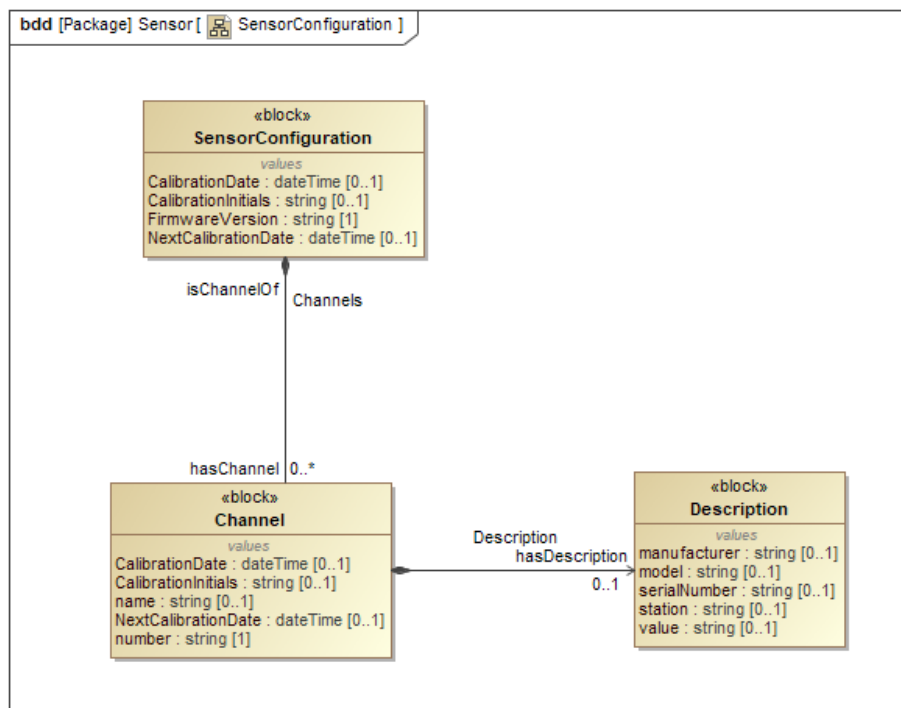


Figure 17: Sensor Configuration Example

**Figure 18:** SensorConfiguration

2847 Descriptions for Value Properties of SensorConfiguration:

- 2848 • CalibrationDate
- 2849 Date upon which the sensor unit was last calibrated.
- 2850 • CalibrationInitials
- 2851 The initials of the person verifying the validity of the calibration data.
- 2852 • FirmwareVersion
- 2853 Version number for the sensor unit as specified by the manufacturer.
- 2854 • NextCalibrationDate
- 2855 Date upon which the sensor unit is next scheduled to be calibrated.

2856 8.5.1.2 Part Properties of SensorConfiguration

2857 Table 94 lists the Part Properties of SensorConfiguration.

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

Table 94: Part Properties of SensorConfiguration

2858 Descriptions for Part Properties of SensorConfiguration:

- 2859 • Channel
- 2860 *sensing element* of a Sensor.
- 2861 Channels groups one or more Channel entities. See Channel.

2862 8.5.2 Channel

2863 *sensing element* of a Sensor.

2864 When Sensor has multiple *sensing elements*, each *sensing element* is modeled as a
2865 Channel for the Sensor.

2866 8.5.2.1 Value Properties of Channel

2867 Table 95 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 95: Value Properties of Channel

2868 Descriptions for Value Properties of Channel:

- 2869 • CalibrationDate
- 2870 Date upon which the sensor unit was last calibrated to the sensor element.
- 2871 • CalibrationInitials
- 2872 The initials of the person verifying the validity of the calibration data.
- 2873 • name
- 2874 name of the specific *sensing element*.
- 2875 • NextCalibrationDate
- 2876 Date upon which the sensor element is next scheduled to be calibrated with the
- 2877 sensor unit.
- 2878 • number
- 2879 unique identifier that will only refer to a specific *sensing element*.

2880 8.5.2.2 Part Properties of Channel

2881 *Table 96* lists the Part Properties of Channel.

Part Property name	Multiplicity
Description	0..1

Table 96: Part Properties of Channel

2882 Descriptions for Part Properties of Channel:

- 2883 • Description
- 2884 descriptive content.
- 2885 See *Section 4.1.2 - Description*.

2886 8.6 SolidModel

2887 This section provides semantic information for the SolidModel entity.

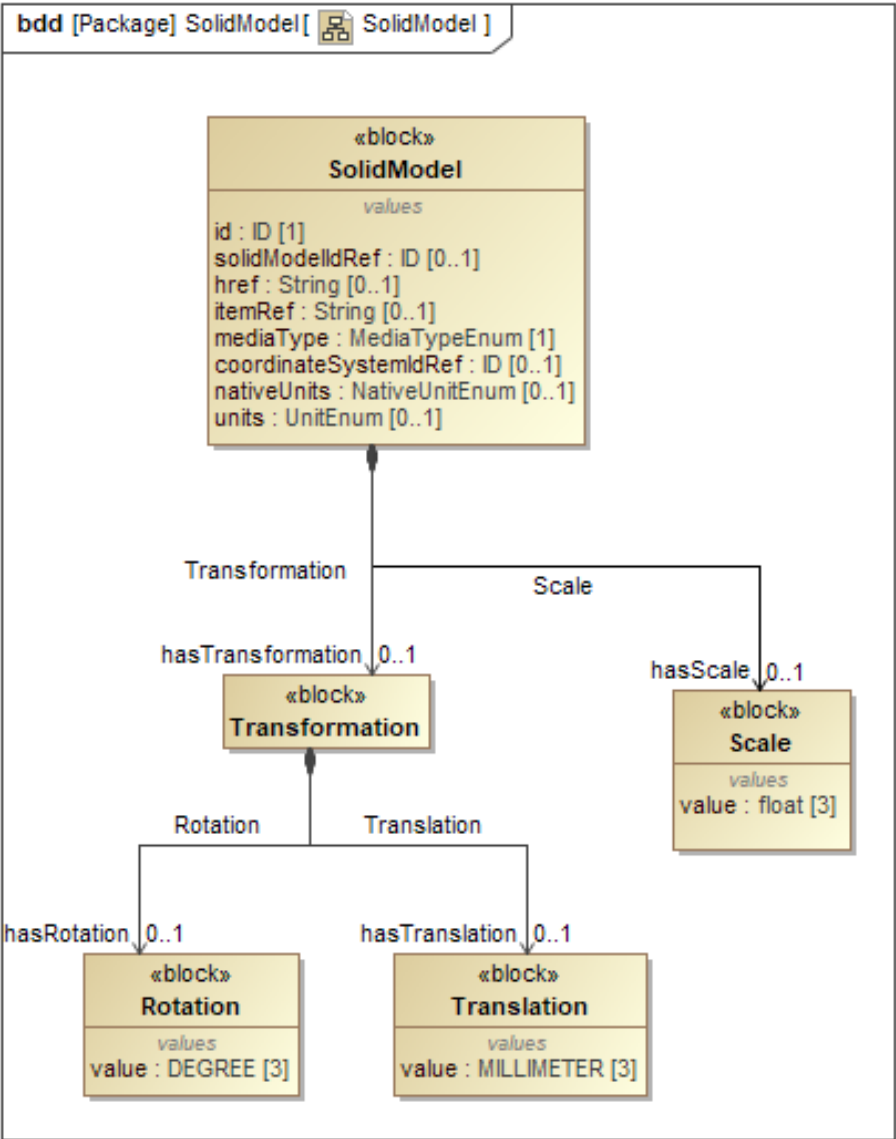


Figure 19: SolidModel

2888 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2889 Note: See *Example 7* for the XML representation of the same example.

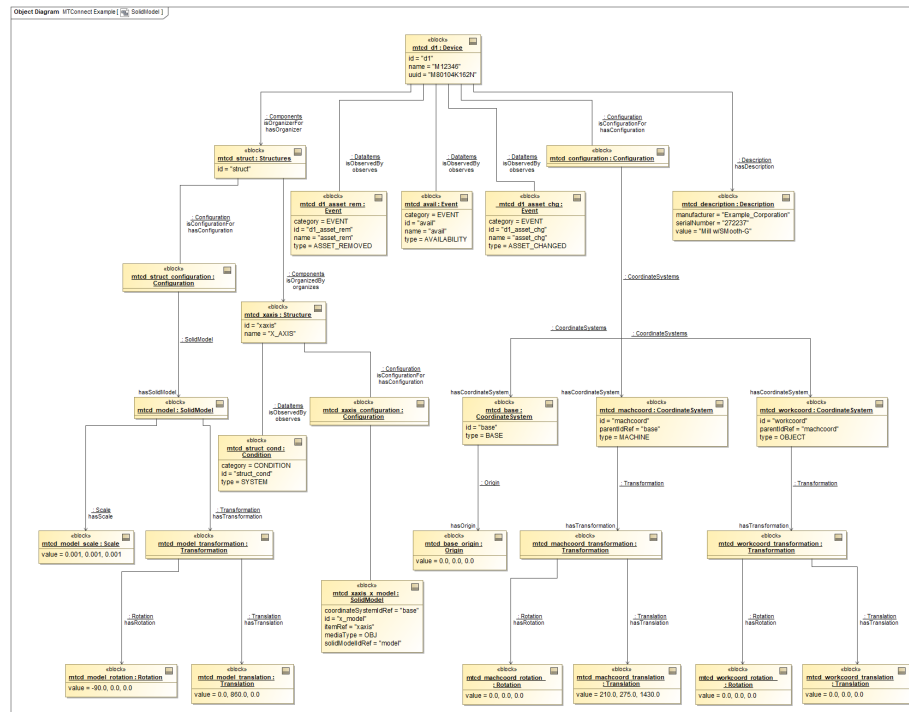


Figure 20: SolidModel Example

2890 8.6.1 SolidModel

2891 references to a file with the three-dimensional geometry of the Component or Compo-
2892 sition.

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

2897 The SolidModel **MAY** provide a translation, rotation, and scale to correctly place it
2898 relative to the other geometries in the machine. If the Component can move and has
2899 a Motion Configuration, the SolidModel will move when the Component or
2900 Composition moves.

2901 Either an href, SolidModel or a modelIdRef, SolidModel and an itemRef, SolidModel
2902 **MUST** be specified.

2903 8.6.1.1 Value Properties of SolidModel

2904 *Table 97* lists the Value Properties of `SolidModel`.

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

Table 97: Value Properties of `SolidModel`

2905 Descriptions for Value Properties of `SolidModel`:

- 2906 • id
- 2907 unique identifier for this element.
- 2908 • solidModelIdRef
- 2909 associated model file if an item reference is used.
- 2910 • mediaType
- 2911 format of the referenced document.
- 2912 MediaTypeEnum Enumeration:
- 2913 – 3DS
- 2914 Autodesk file format.
- 2915 – ACIS
- 2916 Dassault file format.
- 2917 – COLLADA
- 2918 ISO 17506.
- 2919 – GDML
- 2920 Geometry Description Markup Language.
- 2921 – IGES
- 2922 Initial Graphics Exchange Specification.
- 2923 – OBJ
- 2924 Wavefront OBJ file format.
- 2925 – STEP
- 2926 ISO 10303 STEP AP203 or AP242 format.

- 2927 – STL
- 2928 STereoLithography file format.
- 2929 – X_T
- 2930 Parasolid XT Siemens data interchange format.
- 2931 • coordinateSystemIdRef
- 2932 reference to the coordinate system for this SolidModel.
- 2933 • nativeUnits
- 2934 same as DataItem nativeUnits. See *Section 6.1.1 - DataItem*.
- 2935 The value of nativeUnits **MUST** be one of the NativeUnitEnum enumera-
- 2936 tion.
- 2937 • units
- 2938 same as DataItem units. See *Section 6.1.1 - DataItem*.
- 2939 The value of units **MUST** be one of the UnitEnum enumeration.

2940 **8.6.1.2 Part Properties of SolidModel**

2941 *Table 98* lists the Part Properties of SolidModel.

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

Table 98: Part Properties of SolidModel

2942 Descriptions for Part Properties of SolidModel:

- 2943 • Transformation
- 2944 process of transforming to the origin position of the coordinate system from a parent
- 2945 coordinate system using Translation and Rotation.
- 2946 See *Section 8.2.3 - Transformation*.
- 2947 • Scale
- 2948 either a single multiplier applied to all three dimensions or a three space multiplier
- 2949 given in the X, Y, and Z dimensions in the coordinate system used for the Solid-
- 2950 Model.
- 2951 See *Section 8.6.2 - Scale*.

2952 8.6.2 Scale

2953 either a single multiplier applied to all three dimensions or a three space multiplier given
 2954 in the X, Y, and Z dimensions in the coordinate system used for the `SolidModel`.

2955 The value of `Scale` **MUST** be a list of `float` of size 3.

2956 8.7 Specifications

2957 This section provides semantic information for the `Specification` entity.

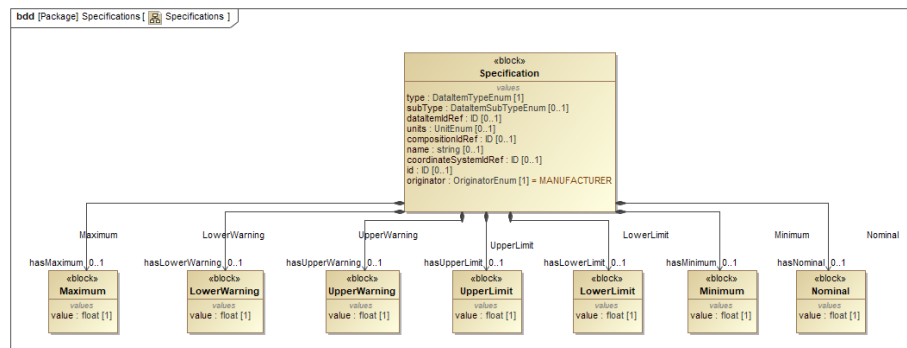


Figure 21: Specifications

2958 Note: See *Section B.4 - Configuration Schema Diagrams* for XML schema.

2959 Note: See *Example 8* for the XML representation of the same example.

2960 8.7.1 Specification

2961 design characteristics for a piece of equipment.

2962 8.7.1.1 Value Properties of Specification

2963 *Table 99* lists the Value Properties of `Specification`.

Value Property name	Value Property type	Multiplicity
type	DataTypeEnum	1
subType	DataTypeSubTypeEnum	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 99: Value Properties of Specification

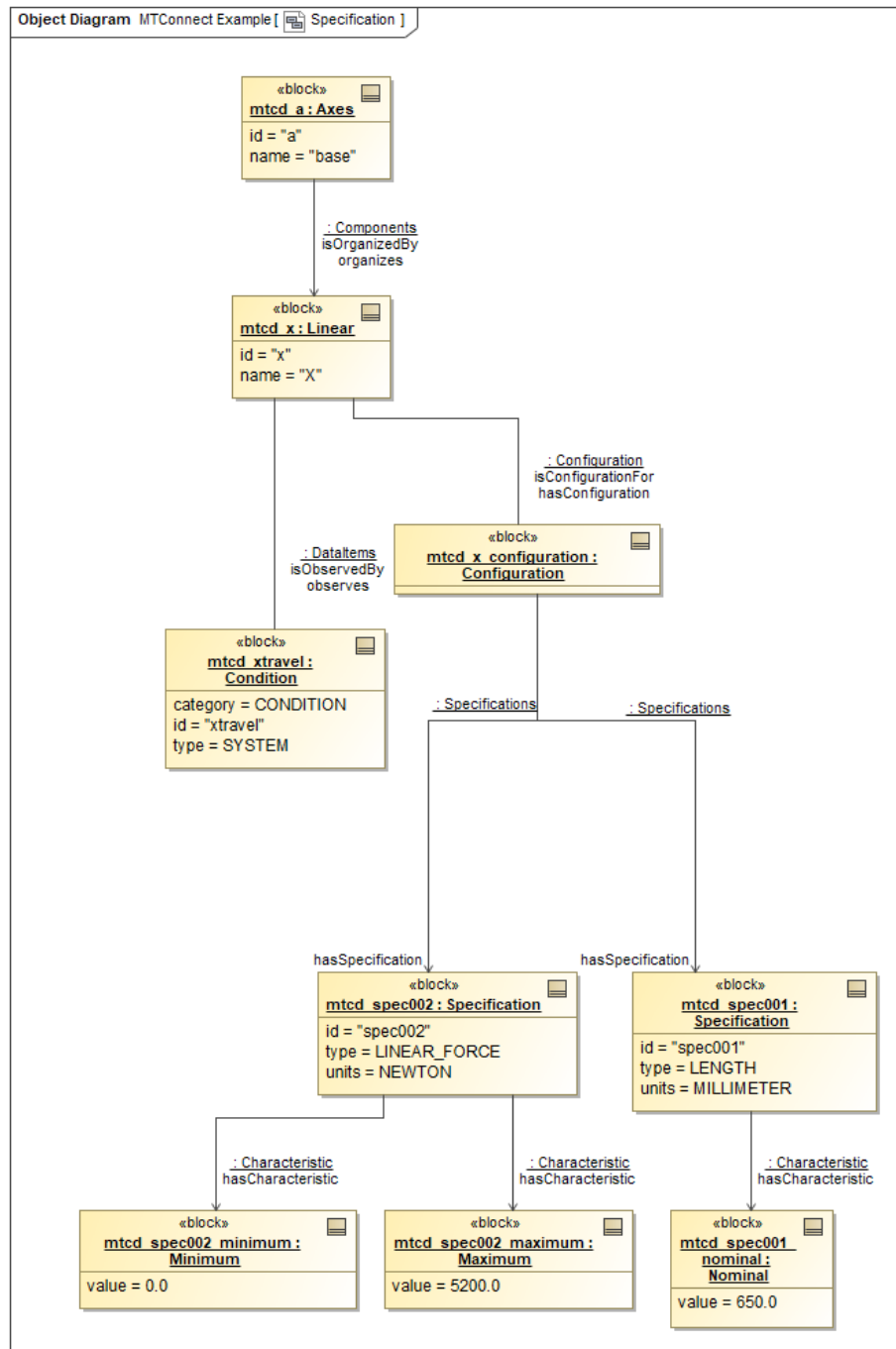


Figure 22: Specification Example

2964 Descriptions for Value Properties of Specification:

- 2965 • type
- 2966 same as DataItem type. See *Section 6.5 - DataItem Types*.
- 2967 The value of type **MUST** be one of the DataItemTypeEnum enumeration.
- 2968 • subType
- 2969 same as DataItem subType. See *Section 6.1.1 - DataItem*.
- 2970 The value of subType **MUST** be one of the DataItemSubTypeEnum enumer-
- 2971 ation.
- 2972 • dataItemIdRef
- 2973 reference to the id attribute of the DataItem associated with this element.
- 2974 • units
- 2975 same as DataItem units. See *Section 6.1.1 - DataItem*.
- 2976 The value of units **MUST** be one of the UnitEnum enumeration.
- 2977 • compositionIdRef
- 2978 reference to the id attribute of the Composition associated with this element.
- 2979 • name
- 2980 name provides additional meaning and differentiates between Specification
- 2981 elements.
- 2982 • coordinateSystemIdRef
- 2983 references the CoordinateSystem for geometric Specification elements.
- 2984 • id
- 2985 unique identifier for this Specification.
- 2986 • originator
- 2987 reference to the creator of the Specification.
- 2988 OriginatorEnum Enumeration:
- 2989 – MANUFACTURER
- 2990 manufacturer of a piece of equipment or Component.
- 2991 – USER
- 2992 owner or implementer of a piece of equipment or Component.

2993 8.7.1.2 Part Properties of Specification

2994 *Table 100* 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 100: Part Properties of Specification

2995 Descriptions for Part Properties of Specification:

- 2996 • Maximum
- 2997 numeric upper constraint.
- 2998 • UpperLimit
- 2999 upper conformance boundary for a variable.
- 3000 Note: immediate concern or action may be required.
- 3001 • LowerWarning
- 3002 lower boundary indicating increased concern and supervision may be required.
- 3003 • LowerLimit
- 3004 lower conformance boundary for a variable.
- 3005 Note: immediate concern or action may be required.
- 3006 • UpperWarning
- 3007 upper boundary indicating increased concern and supervision may be required.
- 3008 • Nominal
- 3009 numeric target or expected value.
- 3010 • Minimum
- 3011 numeric lower constraint.

3012 8.7.2 ProcessSpecification

3013 Specification that provides information used to assess the conformance of a variable
3014 to process requirements.

3015 8.7.2.1 Part Properties of ProcessSpecification

3016 Table 101 lists the Part Properties of ProcessSpecification.

Part Property name	Multiplicity
SpecificationLimits	0..1
ControlLimits	0..1
AlarmLimits	0..1

Table 101: Part Properties of ProcessSpecification

3017 Descriptions for Part Properties of ProcessSpecification:

- 3018 • SpecificationLimits
3019 set of limits that define a range of values designating acceptable performance for a
3020 variable.
3021 See Section 8.7.5 - SpecificationLimits.
- 3022 • ControlLimits
3023 set of limits that is used to indicate whether a process variable is stable and in control.
3024 See Section 8.7.3 - ControlLimits.
- 3025 • AlarmLimits
3026 set of limits that is used to trigger warning or alarm indicators.
3027 See Section 8.7.4 - AlarmLimits.

3028 8.7.3 ControlLimits

3029 set of limits that is used to indicate whether a process variable is stable and in control.

3030 8.7.3.1 Part Properties of ControlLimits

3031 Table 102 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 102: Part Properties of ControlLimits

3032 Descriptions for Part Properties of ControlLimits:

3033 • UpperLimit

3034 upper conformance boundary for a variable.

3035 Note: immediate concern or action may be required.

3036 • UpperWarning

3037 upper boundary indicating increased concern and supervision may be required.

3038 • LowerWarning

3039 lower boundary indicating increased concern and supervision may be required.

3040 • Nominal

3041 numeric target or expected value.

3042 • LowerLimit

3043 lower conformance boundary for a variable.

3044 Note: immediate concern or action may be required.

3045 8.7.4 AlarmLimits

3046 set of limits that is used to trigger warning or alarm indicators.

3047 8.7.4.1 Part Properties of AlarmLimits

3048 *Table 103* lists the Part Properties of AlarmLimits.

Part Property name	Multiplicity
UpperLimit	0..1
UpperWarning	0..1
LowerLimit	0..1
LowerWarning	0..1

Table 103: Part Properties of AlarmLimits

3049 Descriptions for Part Properties of AlarmLimits:

3050 • UpperLimit

3051 upper conformance boundary for a variable.

3052 Note: immediate concern or action may be required.

3053 • UpperWarning

3054 upper boundary indicating increased concern and supervision may be required.

3055 • LowerLimit

3056 lower conformance boundary for a variable.

3057 Note: immediate concern or action may be required.

3058 • LowerWarning

3059 lower boundary indicating increased concern and supervision may be required.

3060 8.7.5 SpecificationLimits

3061 set of limits that define a range of values designating acceptable performance for a variable.

3062 8.7.5.1 Part Properties of SpecificationLimits

3063 *Table 104* lists the Part Properties of SpecificationLimits.

Part Property name	Multiplicity
UpperLimit	0..1
Nominal	0..1
LowerLimit	0..1

Table 104: Part Properties of SpecificationLimits

3064 Descriptions for Part Properties of SpecificationLimits:

3065 • UpperLimit

3066 upper conformance boundary for a variable.

3067 Note: immediate concern or action may be required.

3068 • Nominal

3069 numeric target or expected value.

3070 • LowerLimit

3071 lower conformance boundary for a variable.

3072 Note: immediate concern or action may be required.

3073 8.7.6 UpperWarning

3074 upper boundary indicating increased concern and supervision may be required.

3075 The value of UpperWarning **MUST** be float.

3076 8.7.7 UpperLimit

3077 upper conformance boundary for a variable.

3078 Note: immediate concern or action may be required.

3079 The value of UpperLimit **MUST** be float.

3080 8.7.8 Maximum

3081 numeric upper constraint.

3082 The value of `Maximum` **MUST** be float.

3083 8.7.9 LowerLimit

3084 lower conformance boundary for a variable.

3085 Note: immediate concern or action may be required.

3086 The value of `LowerLimit` **MUST** be float.

3087 8.7.10 LowerWarning

3088 lower boundary indicating increased concern and supervision may be required.

3089 The value of `LowerWarning` **MUST** be float.

3090 8.7.11 Minimum

3091 numeric lower constraint.

3092 The value of `Minimum` **MUST** be float.

3093 8.7.12 Nominal

3094 numeric target or expected value.

3095 The value of `Nominal` **MUST** be float.

3096 9 Profile

3097 MTConnect Profile is a *profile* that extends the Systems Modeling Language (SysML)
 3098 metamodel for the MTConnect domain using additional data types and *stereotypes*.

3099 9.1 DataTypes

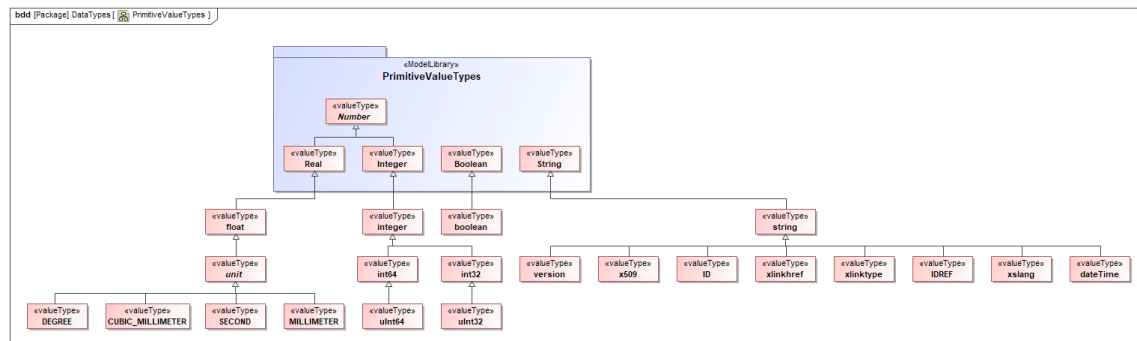


Figure 23: DataTypes

3100 9.1.1 boolean

3101 primitive type.

3102 9.1.2 ID

3103 string that represents an identifier (ID).

3104 9.1.3 string

3105 primitive type.

3106 9.1.4 float

3107 primitive type.

3108 9.1.5 datetime

3109 string that represents timestamp in ISO 8601 format.

3110 9.1.6 integer

3111 primitive type.

3112 9.1.7 xlinktype

3113 string that represents the type of an XLink element. See [https://www.w3.org/TR/](https://www.w3.org/TR/xlink11/)
3114 [xlink11/](https://www.w3.org/TR/xlink11/).

3115 9.1.8 xslang

3116 string that represents a language tag. See [http://www.ietf.org/rfc/rfc4646.](http://www.ietf.org/rfc/rfc4646.txt)
3117 [txt](http://www.ietf.org/rfc/rfc4646.txt).

3118 9.1.9 SECOND

3119 float that represents time in seconds.

3120 9.1.10 IDREF

3121 string that represents a reference to an ID.

3122 9.1.11 xlinkhref

3123 string that represents the locator attribute of an XLink element. See [https://www.w3.](https://www.w3.org/TR/xlink11/)
3124 [org/TR/xlink11/](https://www.w3.org/TR/xlink11/).

3125 9.1.12 x509

3126 string that represents an `x509` data block. *Ref ISO/IEC 9594-8:2020.*

3127 9.1.13 int32

3128 32-bit integer.

3129 9.1.14 int64

3130 64-bit integer.

3131 9.1.15 version

3132 series of four numeric values, separated by a decimal point, representing a *major*, *minor*,
3133 and *revision* number of the MTConnect Standard and the revision number of a specific
3134 *schema*.

3135 9.1.16 uint32

3136 32-bit unsigned integer.

3137 9.1.17 uint64

3138 64-bit unsigned integer.

3139 9.2 Stereotypes

3140 9.2.1 organizer

3141 element that *organizes* other elements of a type.

3142 9.2.2 deprecated

3143 element that has been deprecated.

3144 9.2.3 extensible

3145 enumeration that can be extended.

3146 9.2.4 informative

3147 element that is descriptive and non-normative.

3148 9.2.5 valueType

3149 extends SysML <<ValueType>> to include `Class` as a value type.

3150 9.2.6 normative

3151 element that has been added to the standard.

3152 9.2.7 observes

3153 association in which a *Component* makes *Observations* about an observable *DataItem*.

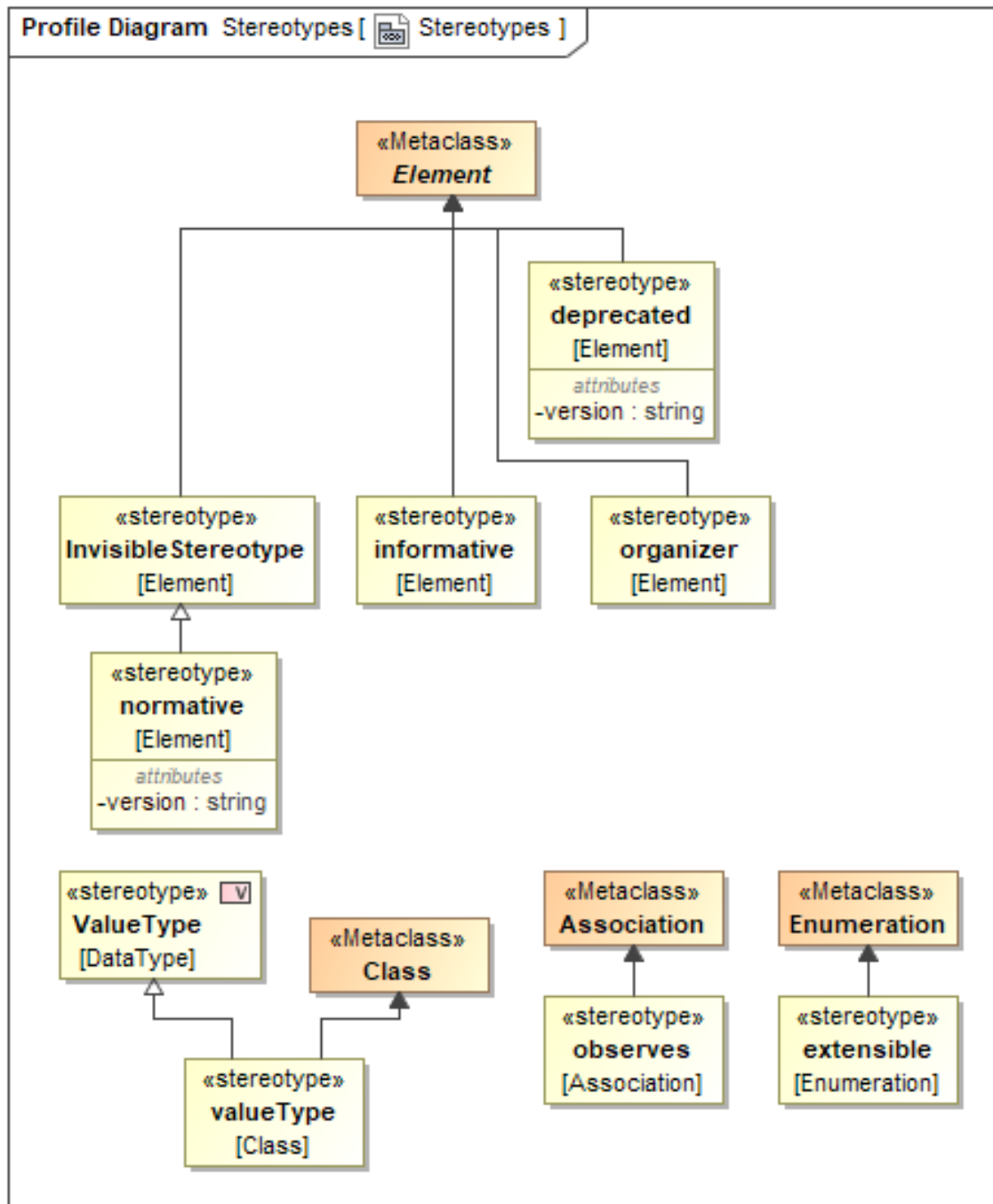


Figure 24: Stereotypes

3154 Appendices

3155 A Bibliography

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3192 trolled Machining Centers. 2005.
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3196 tuators – Common Functions, Communication Protocols, and Transducer Electronic Data
3197 Sheet (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The In-
3198 stitute of Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH99684,
3199 October 5, 2007.
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3201 tuators – Mixed-Mode Communication Protocols and Transducer Electronic Data Sheet
3202 (TEDS) Formats, IEEE Instrumentation and Measurement Society, TC-9, The Institute of
3203 Electrical and Electronics Engineers, Inc., New York, N.Y. 10016, SH95225, December
3204 15, 2004.

3205 **B XML Schema Diagrams**

3206 See XML schemas for the MTConnect standard here: <https://schemas.mtconnect.org/>.
3207

3208 **B.1 Components Schema Diagrams**

3209 See `Components` element in `MTConnectDevices` schema.

3210 See `Description` element in `MTConnectDevices` schema.

3211 **B.2 DataItems Schema Diagrams**

3212 See `DataItems` element in `MTConnectDevices` schema.

3213 See `Source` element in `MTConnectDevices` schema.

3214 See `Constraints` element in `MTConnectDevices` schema.

3215 See `Filter` element in `MTConnectDevices` schema.

3216 See `Definition` element in `MTConnectDevices` schema.

3217 **B.3 References Schema Diagrams**

3218 See `References` element in `MTConnectDevices` schema.

3219 See `ComponentRef` element in `MTConnectDevices` schema.

3220 See `DataItemRef` element in `MTConnectDevices` schema.

3221 **B.4 Configuration Schema Diagrams**

3222 See `Configuration` element in `MTConnectDevices` schema.

3223 See `CoordinateSystem` element in `MTConnectDevices` schema.

- 3224 See Motion element in MTConnectDevices schema.
- 3225 See Relationships element in MTConnectDevices schema.
- 3226 See ComponentRelationship element in MTConnectDevices schema.
- 3227 See DeviceRelationship element in MTConnectDevices schema.
- 3228 See SensorConfiguration element in MTConnectDevices schema.
- 3229 See SolidModel element in MTConnectDevices schema.
- 3230 See Specifications element in MTConnectDevices schema.
- 3231 See ProcessSpecification element in MTConnectDevices schema.

3232 C XML Examples

3233 C.1 Device Entity Hierarchy Example

Example 1: Device Entity Hierarchy Example

```

3234 1 <Devices>
3235 2   <Device id="d1" name="M12346" uuid="M80104K162N">
3236 3     <Components>
3237 4       <Axes id="a" name="base">
3238 5         <Components>
3239 6           <Linear id="x" name="X"/>
3240 7           <Linear id="y" name="Y"/>
3241 8           <Linear id="z" name="Z"/>
3242 9           <Rotary id="ar" name="B"/>
3243 10          <Linear id="w" name="Z3" nativeName="W"/>
3244 11          <Rotary id="c" name="C"/>
3245 12        </Components>
3246 13      </Axes>
3247 14      <Controller id="cont" name="controller">
3248 15        <Components>
3249 16          <Path id="path1" name="path"/>
3250 17        </Components>
3251 18      </Controller>
3252 19      <Door id="door1" name="door"/>
3253 20      <Systems id="systems" name="systems">
3254 21        <Components>
3255 22          <WorkEnvelope id="we1" name="workenv">
3256 23            <Compositions>
3257 24              <Composition type="WORKPIECE" id="wp"/>

```

```

3258 25      <Composition type="TABLE" id="tbl"/>
3259 26    </Compositions>
3260 27    </WorkEnvelope>
3261 28    <Electric id="elec" name="electric"/>
3262 29    <Hydraulic id="hydraulic" name="hydraulic"/>
3263 30    <Coolant id="coolant" name="coolant"/>
3264 31    <Pneumatic id="pneumatic" name="pneumatic"/>
3265 32    <Lubrication id="lubrication" name="lubrication"/>
3266 33  </Components>
3267 34  </Systems>
3268 35  <Auxiliaries id="Aux" name="auxiliaries">
3269 36    <Components>
3270 37      <Environmental id="room" name="environmental"/>
3271 38    </Components>
3272 39  </Auxiliaries>
3273 40  <Resources id="resources" name="resources">
3274 41    <Components>
3275 42      <Personnel id="personnel" name="personnel"/>
3276 43      <Materials id="materials" name="materials">
3277 44        <Components>
3278 45          <Stock id="procstock" name="stock"/>
3279 46        </Components>
3280 47      </Materials>
3281 48    </Components>
3282 49  </Resources>
3283 50  </Components>
3284 51 </Device>
3285 52 </Devices>

```

3286 C.2 Component Example

Example 2: Component Example

```

3287 1 <Devices>
3288 2   <Device id="d1" name="M12346" uuid="M80104K162N">
3289 3     <Description manufacturer="Example\textunderscore_Corporation"
3290 4       serialNumber="272237"> Mill w/SMooth-G
3291 5     </Description>
3292 6   <DataItems>
3293 7     <DataItem category="EVENT" id="avail" name="avail" type="
3294 8     AVAILABILITY"/>
3295 9     <DataItem category="EVENT" id="d1\textunderscore_asset\
3296 10    textunderscore_chg" name="asset\textunderscore_chg" type="
3297 11    ASSET\textunderscore_CHANGED"/>
3298 12    <DataItem category="EVENT" id="d1\textunderscore_asset\
3299 13    textunderscore_rem" name="asset\textunderscore_rem" type="
3300 14    ASSET\textunderscore_REMOVED"/>
3301 15  </DataItems>

```



```

3302 11      <Components>
3303 12      <Controller id="cont" name="controller">
3304 13          <DataItems>
3305 14              <DataItem category="EVENT" id="estop" name="estop" type="
3306 EMERGENCY\textunderscore_STOP"/>
3307 15              <DataItem category="CONDITION" id="logic\textunderscore_cond"
3308 type="LOGIC\textunderscore_PROGRAM"/>
3309 16              <DataItem category="CONDITION" id="cont\textunderscore_system"
3310 type="SYSTEM"/>
3311 17              <DataItem category="SAMPLE" id="cut\textunderscore_time" type="
3312 "ACCUMULATED\textunderscore_TIME" units="SECOND"/>
3313 18          </DataItems>
3314 19      <Components>
3315 20          <Path id="path1" name="path">
3316 21              <DataItems>
3317 22                  <DataItem category="EVENT" id="execution" name="execution"
3318 type="EXECUTION"/>
3319 23                  <DataItem category="SAMPLE" id="cspeed" subType="ACTUAL"
3320 type="CUTTING\textunderscore_SPEED" units="MILLIMETER/
3321 SECOND"/>
3322 24                  <DataItem category="CONDITION" id="path\textunderscore_
3323 system" type="SYSTEM"/>
3324 25                  <DataItem category="EVENT" id="cvars" representation="DATA\
3325 textunderscore_SET" type="VARIABLE"/>
3326 26                  <DataItem category="EVENT" id="woffset" representation="
3327 TABLE" type="WORK\textunderscore_OFFSET"/>
3328 27              </DataItems>
3329 28          </Path>
3330 29      </Components>
3331 30  </Controller>
3332 31 </Components>
3333 32 </Device>
3334 33 </Devices>

```

3335 C.3 Component with Compositions Example

3336 In XML, Composition types are represented differently than Component types. For
3337 Component types, the element name is Pascal Case of the Component type name.
3338 Whereas, the element name for all Composition types is Composition and the type
3339 is defined by the type attribute of the element (see example below).

Example 3: Component with Compositions Example

```

3340 1 <WorkEnvelope id="we1" name="workenv">
3341 2   <DataItems>
3342 3     <DataItem category="CONDITION" id="hardware1" name="hardware1"
3343 type="HARDWARE"/>
3344 4   </DataItems>

```

```

3345 5    <Compositions>
3346 6    <Composition type="WORKPIECE" id="wp"/>
3347 7    <Composition type="TABLE" id="tbl"/>
3348 8    </Compositions>
3349 9    </WorkEnvelope>

```

3350 C.4 CoordinateSystem Example

Example 4: CoordinateSystem Example

```

3351 1    <Devices>
3352 2    <Device id="d1" name="M12346" uuid="M80104K162N">
3353 3        <Description manufacturer="Example\textunderscore_Corporation"
3354 4            serialNumber="272237"> Mill w/SMooth-G
3355 5        </Description>
3356 6        <DataItems>
3357 7            <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
3358 8            <DataItem category="EVENT" id="d1\textunderscore_asset\
3359 9                textunderscore_chg" name="asset\textunderscore_chg" type="
3360                ASSET\textunderscore_CHANGED"/>
3361 9            <DataItem category="EVENT" id="d1\textunderscore_asset\
3362                textunderscore_rem" name="asset\textunderscore_rem" type="
3363                ASSET\textunderscore_REMOVED"/>
3364 10        </DataItems>
3365 11        <Configuration>
3366 12            <CoordinateSystems>
3367 13                <CoordinateSystem id="base" type="BASE">
3368 14                    <Origin>0 0 0</Origin>
3369 15                </CoordinateSystem>
3370 16                <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
3371                    "base">
3372 17                    <Transformation>
3373 18                        <Translation>210 275 1430</Translation>
3374 19                        <Rotation>0 0 0</Rotation>
3375 20                    </Transformation>
3376 21                </CoordinateSystem>
3377 22                <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef="
3378                    machcoord">
3379 23                    <Transformation>
3380 24                        <Translation>0 0 0</Translation>
3381 25                        <Rotation>0 0 0</Rotation>
3382 26                    </Transformation>
3383 27                </CoordinateSystem>
3384 28            </CoordinateSystems>
3385 29        </Configuration>
3386 30    </Device>
3387 31 </Devices>

```

3388 C.5 Motion Example

Example 5: Motion Example

```

3389 1 <Devices>
3390 2   <Device id="d1" name="M12346" uuid="M80104K162N">
3391 3     <Description manufacturer="Example\textunderscore_Corporation"
3392 4       serialNumber="272237"> Mill w/SMooth-G
3393 5   </Description>
3394 6   <DataItems>
3395 7     <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
3396 8     <DataItem category="EVENT" id="d1\textunderscore_asset\
3397       textunderscore_chg" name="asset\textunderscore_chg" type="
3398       ASSET\textunderscore_CHANGED"/>
3399 9     <DataItem category="EVENT" id="d1\textunderscore_asset\
3400       textunderscore_rem" name="asset\textunderscore_rem" type="
3401       ASSET\textunderscore_REMOVED"/>
3402 10  </DataItems>
3403 11  <Configuration>
3404 12    <CoordinateSystems>
3405 13      <CoordinateSystem id="base" type="BASE">
3406 14        <Origin>0 0 0</Origin>
3407 15      </CoordinateSystem>
3408 16      <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
3409        "base">
3410 17        <Transformation>
3411 18          <Translation>210 275 1430</Translation>
3412 19          <Rotation>0 0 0</Rotation>
3413 20        </Transformation>
3414 21      </CoordinateSystem>
3415 22      <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef="
3416        machcoord">
3417 23        <Transformation>
3418 24          <Translation>0 0 0</Translation>
3419 25          <Rotation>0 0 0</Rotation>
3420 26        </Transformation>
3421 27      </CoordinateSystem>
3422 28    </CoordinateSystems>
3423 29  </Configuration>
3424 30  <Components>
3425 31    <Axes id="a" name="base">
3426 32      <Components>
3427 33        <Linear id="x" name="X">
3428 34          <Configuration>
3429 35            <Motion id="xmotion" coordinateSystemIdRef="machcoord"
3430            type="PRISMATIC" actuation="DIRECT">
3431 36              <Transformation>
3432 37                <Translaton>300 915 590</Translaton>
3433 38                <Rotation>0 0 0</Rotation>
3434 39              </Transformation>
3435 40            <Axis>1.0 0 0</Axis>

```

```

3436 41          </Motion>
3437 42          </Configuration>
3438 43        </Linear>
3439 44        <DataItems>
3440 45          <DataItem id="xtravel" type="SYSTEM" category="CONDITION
3441 46        ">
3442 47          </DataItems>
3443 48        </Components>
3444 49      </Axes>
3445 50    </Components>
3446 51  </Device>
3447 52 </Devices>

```

3448 C.6 Relationship Example

Example 6: Relationship Example

```

3449 1 <Components>
3450 2   <Axes id="a" name="base">
3451 3     <Components>
3452 4       <Linear id="x" name="X">
3453 5         <Configuration>
3454 6           <Relationships>
3455 7             <ComponentRelationship id="xpar" type="PARENT" idRef="
3456 8           wel"/>
3457 9           </Relationships>
3458 10          </Configuration>
3459 11        </Linear>
3460 12      <DataItems>
3461 13        <DataItem id="xtravel" type="SYSTEM" category="CONDITION">
3462 14      </DataItems>
3463 15    </Components>
3464 16  </Axes>
3465 17 <Systems id="systems" name="systems">
3466 18   <Components>
3467 19     <WorkEnvelope id="wel" name="workenv">
3468 20       <Compositions>
3469 21         <Composition type="WORKPIECE" id="wp"/>
3470 22         <Composition type="TABLE" id="tbl"/>
3471 23       </Compositions>
3472 24     <DataItems>
3473 25       <DataItem id="welcond" type="SYSTEM" category="CONDITION">
3474 26     </DataItems>
3475 27   </WorkEnvelope>
3476 28 </Components>
3477 29 </Systems>
3478 30 </Components>

```

3479 C.7 SolidModel Example

Example 7: SolidModel Example

```

3480 1 <Devices>
3481 2   <Device id="d1" name="M12346" uuid="M80104K162N">
3482 3     <Description manufacturer="Example\textunderscore_Corporation"
3483 4       serialNumber="272237"> Mill w/SMooth-G
3484 5   </Description>
3485 6   <DataItems>
3486 7     <DataItem id="avail" type="AVAILABILITY" category="EVENT"/>
3487 8     <DataItem category="EVENT" id="d1\textunderscore_asset\
3488       textunderscore_chg" name="asset\textunderscore_chg" type="
3489       ASSET\textunderscore_CHANGED"/>
3490 9     <DataItem category="EVENT" id="d1\textunderscore_asset\
3491       textunderscore_rem" name="asset\textunderscore_rem" type="
3492       ASSET\textunderscore_REMOVED"/>
3493 10  </DataItems>
3494 11  <Configuration>
3495 12    <CoordinateSystems>
3496 13      <CoordinateSystem id="base" type="BASE">
3497 14        <Origin>0 0 0</Origin>
3498 15      </CoordinateSystem>
3499 16      <CoordinateSystem id="machcoord" type="MACHINE" parentIdRef=
3500        "base">
3501 17        <Transformation>
3502 18          <Translation>210 275 1430</Translation>
3503 19          <Rotation>0 0 0</Rotation>
3504 20        </Transformation>
3505 21      </CoordinateSystem>
3506 22      <CoordinateSystem id="workcoord" type="OBJECT" parentIdRef="
3507        machcoord">
3508 23        <Transformation>
3509 24          <Translation>0 0 0</Translation>
3510 25          <Rotation>0 0 0</Rotation>
3511 26        </Transformation>
3512 27      </CoordinateSystem>
3513 28    </CoordinateSystems>
3514 29  </Configuration>
3515 30  <Components>
3516 31    <Structures id="struct">
3517 32      <Configuration>
3518 33        <SolidModel id="model" mediaType="OBJ" href="/objs/mazak.
3519        obj" coordinateSystemIdRef="base">
3520 34          <Transformation>
3521 35            <Translation>0 860 0</Translation>
3522 36            <Rotation>-90 0 0</Rotation>
3523 37          </Transformation>
3524 38          <Scale>0.001 0.001 0.001</Scale>
3525 39        </SolidModel>
3526 40      </Configuration>

```

```

3527 41      <Components>
3528 42      <Structure id="xaxis" name="X\textunderscore_AXIS">
3529 43      <Configuration>
3530 44      <SolidModel id="x\textunderscore_model" mediaType="OBJ
3531      " itemRef="xaxis" solidModelIdRef="model" coordinateSystemIdRef="
3532      base"/>
3533 45      </Configuration>
3534 46      <DataItems>
3535 47      <DataItem type="SYSTEM" category="CONDITION" id="
3536      struct\textunderscore_cond"/>
3537 48      </DataItems>
3538 49      </Structure>
3539 50      </Components>
3540 51      </Structures>
3541 52      </Components>
3542 53      </Device>
3543 54      </Devices>

```

3544 C.8 Specification Example

Example 8: Specification Example

```

3545 1  <Components>
3546 2  <Axes id="a" name="base">
3547 3  <Components>
3548 4  <Linear id="x" name="X">
3549 5  <Configuration>
3550 6  <Specifications>
3551 7  <Specification id="spec001" type="LENGTH" units="
3552  MILLIMETER">
3553 8  <Nominal>650</Nominal>
3554 9  </Specification>
3555 10 <Specification id="spec002" type="LINEAR\textunderscore_
3556  FORCE" units="NEWTON">
3557 11 <Maximum>5200</Maximum>
3558 12 <Minimum>0</Minimum>
3559 13 </Specification>
3560 14 </Specifications>
3561 15 </Configuration>
3562 16 <DataItems>
3563 17 <DataItem id="xtravel" type="SYSTEM" category="CONDITION">
3564 18 </DataItems>
3565 19 </Linear>
3566 20 </Components>
3567 21 </Axes>
3568 22 </Components>

```

3569 C.9 Example of sensing element provided as data item associated with 3570 a Component

Example 9: Example of sensing element provided as data item associated with a Component

```

3571 1  <Components>
3572 2    <Axes id="a" name="base"
3573 3      <Components>
3574 4        <Rotary id="c" name="C">
3575 5          <DataItems>
3576 6            <DataItem type="TEMPERATURE" id="servotemp4"
3577 7              category="SAMPLE" nativeUnits="CELSIUS"
3578 8              compositionId="Bmotor" units="CELSIUS"/>
3579 9          </DataItems>
3580 10        </Rotary>
3581 11      </Components>
3582 12    </Axes>
3583 13  </Components>

```

3584 C.10 Example of Sensor for rotary axis

Example 10: Example of Sensor for rotary axis

```

3585 1  <Components>
3586 2    <Axes id="a" name="base"
3587 3      <Components>
3588 4        <Rotary id="ar" name="B">
3589 5          <Components>
3590 6            <Sensor id="spdlm" name="Spindlemonitor">
3591 7              <DataItems>
3592 8                <DataItem type="DISPLACEMENT" id="cvib"
3593 9                  category="SAMPLE" name="Svib"
3594 10                 units="MILLIMETER"/>
3595 11              </DataItems>
3596 12            </Sensor >
3597 13          </Components>
3598 14        </Rotary>
3599 15      </Components>
3600 16    </Axes>
3601 17  </Components>

```

3602 C.11 Example of sensor unit with sensing element

Example 11: Example of sensor unit with sensing element

```

3603 1 <Axes id="a" name="base"
3604 2   <Components>
3605 3   <Sensor id="sens1" name="Sensorunit">
3606 4     <DataItems>
3607 5     <DataItem type="TEMPERATURE" id="sentemp"
3608 6       category="SAMPLE" name="Sensortemp"
3609 7       units="CELSIUS"/>
3610 8     </DataItems>
3611 9   </Sensor >
3612 10  <Linear id="x" name="X">
3613 11    <DataItems>
3614 12    <DataItem type="DISPLACEMENT" id="xvib"
3615 13      category="SAMPLE" name="xvib"
3616 14      units="MILLIMETER">
3617 15      <Source componentId="sens1"/>
3618 16    </DataItem>
3619 17    </DataItems>
3620 18  </Rotary>
3621 19  <Linear id="y" name="Y">
3622 20    <DataItems>
3623 21    <DataItem type="DISPLACEMENT" id="yvib"
3624 22      category="SAMPLE" name="yvib"
3625 23      units="MILLIMETER">
3626 24      <Source componentId="sens1"/>
3627 25    </DataItem>
3628 26    </DataItems>
3629 27  </Linear>
3630 28  <Components>
3631 29 </Axes>

```

3632 C.12 Example of configuration data for Sensor**Example 12: Example of configuration data for Sensor**

```

3633 1 <Sensor id="sensor" name="sensor">
3634 2   <Configuration>
3635 3     <SensorConfiguration>
3636 4       <FirmwareVersion>2.02</FirmwareVersion>
3637 5       <CalibrationDate>2010-05-16</CalibrationDate>
3638 6       <NextCalibrationDate>2010-05-16</NextCalibrationDate>
3639 7       <CalibrationInitials>WS</CalibrationInitials>
3640 8     <Channels>
3641 9       <Channel number="1" name="A/D:1">
3642 10        <Description>A/D With Thermister</Description>
3643 11      </Channel>
3644 12    </Channels>
3645 13  </SensorConfiguration>

```



```
3646 14    </Configuration>
3647 15    <DataItems>
3648 16        <DataItem category="CONDITION" id="sensorc"
3649 17            name="sensorc" type="SYSTEM" />
3650 18        <DataItem category="SAMPLE" id="senv" name="sensorc"
3651 19            type="VOLTAGE\textunderscore_DC" units="VOLT" subType="ACTUAL"
3652 20            />
3653 21    </DataItems>
3654 22 </Sensor>
```