

MTConnect® Standard

Part 4 – Assets  
Version 1.2.0 – Draft A

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MTConnect® Specification

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# Overview

MTConnect® is a standard based on an open protocol for data integration. MTConnect® is not intended to replace the functionality of existing products, but it strives to enhance the data acquisition capabilities of devices and applications and move toward a plug-and-play environment to reduce the cost of integration.

MTConnect® is built upon the most prevalent standards in the manufacturing and software industry, maximizing the number of tools available for its implementation and providing the highest level of interoperability with other standards and tools in these industries.

To facilitate this level of interoperability, a number of objectives are being met. Foremost is the ability to transfer data via a standard protocol which includes:

* + A device identity (i.e. model number, serial number, calibration data, etc.).
  + The identity of all the independent components of the device.
  + Possibly a device’s design characteristics (i.e. axis length, maximum speeds, device thresholds, etc.).
  + Most importantly, data captured in real or near-real-time (i.e. current speed, position data, temperature data, program block, etc.) by a device that can be utilized by other devices or applications (e.g. utilized by maintenance diagnostic systems, management production information systems, CAM products, etc.).

The types of data that may need to be addressed in MTConnect® could include:

* + Physical and actual device design data
  + Measurement or calibration data
  + Near-real-time data from the device

To accommodate the vast amount of different types of devices and information that may come into play, MTConnect® will provide a common high-level vocabulary and structure.

The first version of MTConnect® will focus on a limited set of the characteristics mentioned above that were selected based on the fact that they can have an immediate affect on the efficiency of operations.

## MTConnect® Document Structure

The MTConnect® specification is subdivided using the following scheme:

Part 1: Overview and Protocol – Version 1.2.0, Draft

Part 2: Components and Data Items – Version 1.2.0, Draft

Part 3: Streams, Events, Samples, and Condition – Version 1.2.0, Draft

Part 4: Assets – Version 1.2.0, Draft

Extensions to the standard will be made according to this scheme and new sections will be added as new areas are addressed. Documents will be named as follows: MTC\_Part\_<Number>\_<Description>.doc. All documents will be developed in Microsoft® Word format and released in Adobe® PDF format. For example, this document is MTC\_Part\_1\_Overview.doc.

# Purpose of This Document

The four MTConnect® documents are intended to:

* define the MTConnect® standard;
* specify the requirements for compliance with the MTConnect® standard;
* provide engineers with sufficient information to implement Agents for their devices;
* provide developers with the necessary guidelines to use the standard to develop applications.

Part 2 of the MTConnect® standard focuses on structure and description of what information is available from the device. The actual device state is not provided in this section, but is covered in Part 3 covering Streams, Samples, Events, and Condition. The descriptive data is similar to the schema of the data, it describes the components available in a device and what data items are provided by each component.

This part also covers instructions on how a piece of equipment should be modeled, the structure of the component hierarchy, the names for each component (if restricted), and allowable data items for each of the component. Some components, like Linear axis, use the naming conventions as laid out in this document. This allows for a consistent meaning across devices.

## Terminology

**Adapter** An optional software component that connects the Agent to the Device.

**Agent** A process that implements the MTConnect® HTTP protocol, XML generation, and MTConnect protocol.

**Alarm** An alarm indicates an event that requires attention and indicates a deviation from normal operation.

**Application** A process or set of processes that access the MTConnect® Agent to perform some task.

**Attribute** A part of an element that provides additional information about that element. For example, the name element of the Device is given as <Device **name=“mill-1”**>...</Device>

**CDATA** The text in a simple content element. For example, *This is some text*, in <mt:Alarm ...>This is some text</mt:Alarm>.

**Component** A part of a device that can have sub-components and data items. A component is a basic building block of a device.

**Controlled Vocabulary** The value of an element or attribute is limited to a restricted set of possibilities. Examples of controlled vocabularies are country codes: US, JP, CA, FR, DE, etc…

**Current** A snapshot request to the Agent to retrieve the current values of all the data items specified in the path parameter. If no path parameter is given, then the values for all components are provided.

**Data Item** A data item provides the descriptive information regarding something that can be collected by the Agent.

**Device** A piece of equipment capable of performing an operation. A device is composed of a set of components that provide data to the application. The device is a separate entity with at least one Controller managing its operation.

**Discovery** Discovery is a service that allows the application to locate Agents for devices in the manufacturing environment. The discovery service is also referred to as the *Name Service.*

**Element** An XML element is the central building block of any XML Document. For example, in MTConnect® the Device element is specified as <**Device** >...</**Device**>

**Event** An event represents a change in state that occurs at a point in time. Note: An event does not occur at predefined frequencies.

**HTTP** Hyper-Text Transport Protocol. The protocol used by all web browsers and web applications.

**Instance** When used in software engineering, the word *instance* is used to define a single physical example of that type. In object-oriented models, there is the class that describes the thing and the instance that is an example of that thing.

**LDAP** Lightweight Directory Access Protocol, better known as Active Directory in Microsoft Windows. This protocol provides resource location and contact information in a hierarchal structure.

**MIME** Multipurpose Internet Mail Extensions. A format used for encoding multipart mail and http content with separate sections separated by a fixed boundary.

**Probe** A request to determine the configuration and reporting capabilities of the device.

**REST** REpresentational State Transfer. A software architecture where the client and server move through a series of state transitions based solely on the request from the client and the response from the server.

**Results** A general term for the Samples, Events, and Condition contained in a ComponentStream as a response from a sample or current request.

**Sample** A sample is a data point from within a continuous series of data points. An example of a Sample is the position of an axis.

**Socket** When used concerning interprocess communication, it refers to a connection between two end-points (usually processes). Socket communication most often uses TCP/IP as the underlying protocol.

**Stream** A collection of Events and Samples organized by devices and components.

**Service** An application that provides necessary functionality.

**Tag** Used to reference an instance of an XML element.

**TCP/IP** TCP/IP is the most prevalent stream-based protocol for interprocess communication. It is based on the IP stack (Internet Protocol) and provides the flow-control and reliable transmission layer on top of the IP routing infrastructure.

**URI** Universal Resource Identifier. This is the official name for a web address as seen in the address bar of a browser.

**UUID** Universally unique identifier.

**XPath** XPath is a language for addressing parts of an XML Document. See the XPath specification for more information. <http://www.w3.org/TR/xpath>

**XML** Extensible Markup Language. <http://www.w3.org/XML/>

**XML Schema** The definition of the XML structure and vocabularies used in the XML Document.

**XML Document** An instance of an XML Schema which has a single root element and conforms to the XML specification and schema.

**XML NMTOKEN** The data type for XML identifiers. It must start with a letter, an underscore “\_” or a colon “:” and then it **MUST** be followed by a letter, a number, or one of the following “.”, ”-“, ”\_”, “:”. An NMTOKEN cannot have any spaces or special characters.

## Terminology and Conventions

Please refer to Part 1 “Overview and Protocol” Section 2 for XML Terminology and Documentation conventions.

# Assets

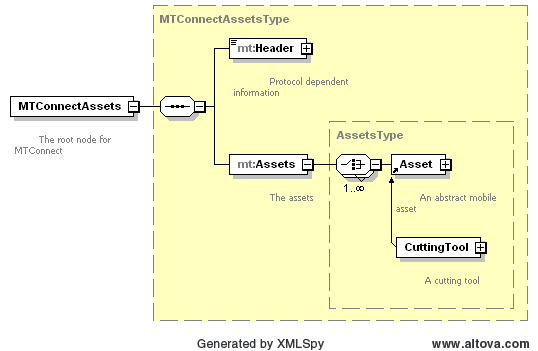


Figure 1: Assets Schema

An Asset is something that is associated with the manufacturing process that is not a component of a device, can be removed without detriment to the function of the device, and can be associated with other devices during their lifecycle. An is does not have computational capabilities, but may carry information in some media physically attached to the asset.

Concrete examples of Assets are things like Cutting Tools, Workholding, and Fixtures. Part 4 of the MTConnect standard will concern itself with the modeling of these assets and the management and communication of asset data using MTConnect.

At the top level of the MTConnectAssets document we have a standard header as documented in Part 1: Overview and Protocol and one or more assets. Each asset is required to have an assetId that serves as a unique identifier of that asset. The id allow the application to request the asset data from the agent, as prescribed in Part 1.

In the remain document, we will be discussing Cutting Tools as the first asset covered by the standard. The cutting tool must have an assetId that differs from all the other assets tracked by this agent. There **MUST** never be more than one asset provided by MTConnect with the same asset Id in the same agent.

## Cutting Tools

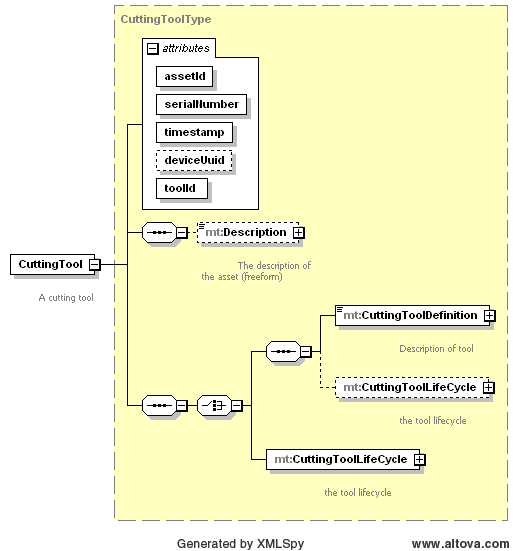


Figure 2: Cutting Tool Schema

A cutting tool, or cutter, is a type of asset that is used to remove material from a workpiece. A cutting tool may have one or more edges which provide a shear deformation of the material. The MTConnect standard will not define the entire geometry of the cutting tool, but will provide the information necessary to use the tool in the manufacturing process. Additional information can be added to the definition of the cutting tool by means of schema extensions.

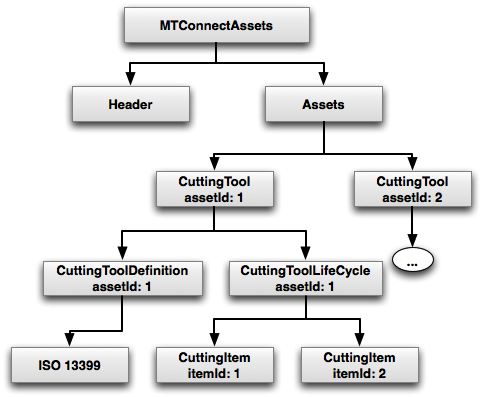


Figure : Cutting Tool Asset Structure

The structure of the MTConnectAssets document contains the standard MTConnectHeader as defined in *Part 1: Overview and Protocol* of the standard. A finite number of assets will be stored in the MTConnect agent. This finite number will be implementation specific and will depend on memory and storage constraints. The standard will not prescribe the number or capacity requirements for an implementation.

### CuttingTool attributes:

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| timestamp | The time this asset was last modified. Always given in UTC. | 1 |
| assetId | The unique identifier of the instance of this tool. This will be the same as the serial number in most cases. The suggested format is the combination of the toolId and the serialNumber. One example would be toolId.serialNumber | 1 |
| serialNumber | It **MUST** be an NMTOKEN XML type. | 1 |
| toolId | The identifier for class of cutting tool. | 1 |
| deviceUuid | The device’s uuid that supplied this data. | 1 |

### deviceUuid

This optional element References to the UUID atribute given in the device element. This can be any series of numbers and letters as defined by the XML type NMTOKEN.

### CuttingTool Elements

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

| **Element** | **Description** | **Occurrence** |
| --- | --- | --- |
| Description | An element that can contain any descriptive content. This can contain configuration information and manufacturer specific details. This element is defined to contain mixed content and XML elements can be added to extend the descriptive semantics of MTConnect. | 0..1 |
| CuttingToolDefinition | Reference to a ISO 13399 | 0..1 |
| CuttingToolLifeCycle | MTConnect data regarding the use phase of this tool. | 0..1 |

### Description

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

### CuttingToolDefinition

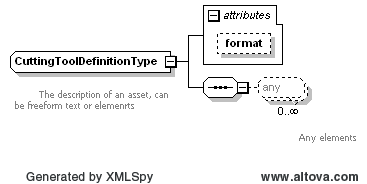


Figure 4: Cutting Tool Definition

The tool definition contains the ISO 13399 standard tool information.

### CuttingToolDefinition attributes:

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| format | Format – EXPRESS, XML, TEXT, or UNDEFINED. Default: XML | 0..1 |

#### format

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

| **Value** | **Description** |
| --- | --- |
| XML | The default value for the definition. The content will be an XML document. |
| EXPRESS | The document will confirm to the ISO 10303 standard. |
| TEXT | The document will be a text representation of the tool data. |
| UNDEFINED | The document will be provided in an undefined format. |

### CuttingToolDefinition Elements

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

| **Element** | **Description** | **Occurrence** |
| --- | --- | --- |
| ISO13399 | Not sure what this will be… | 1 |

### ISO 13399

The ISO 13399 data either in XML or EXPRESS format. An XML schema will be preferred. This is still an open issue.

### CuttingToolLifeCycle

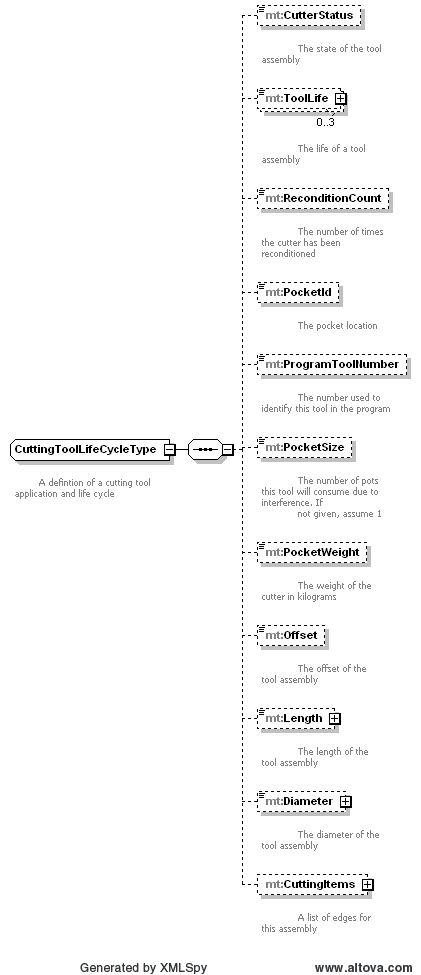


Figure 5: Cutting Tool Life Cycle

### CuttingToolLifeCycle Elements

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

| **Element** | **Description** | **Occurrence** |
| --- | --- | --- |
| CutterStatus | The status of the this assembly. Possible values are: NEW, RECONDITIONED, NOT\_REGISTERED, USED, EXPIRED, TAGGED\_OUT, BROKEN. | 0..1 |
| ToolLife | Tool life represents the amount of remaining or usage of the tool in either minutes (MINUTES) or in parts (PART\_COUNT). | 0..2 |
| ReconditionCount | The number of times this cutter has been reconditioned. | 0..1 |
| PocketId | The pocket identifier this tool now resides in. | 0..1 |
| ProgramToolNumber | The number of the tool as referenced in the part program. | 0..1 |
| PocketSize | The number of pots this tool will take. This may not be required here as it is in 13399 and will not change over the tools life. | 0..1 |
| PocketWeight | The weight of the cutter in kilograms. | 0..1 |
| Length | The measured length of the assembly. | 0..1 |
| Diameter | The measured diameter of the tool. | 0..1 |
| Offset | The computed offset of this tool. Do we need this? Is it the same as length? | 0..1 |
| CuttingItems | A set of individual cutting items. | 0..1 |

### CutterStatus

The value of the ToolStatus element can be one of the following or can be extended using the extended “x:[VALUE]” pattern where [VALUE] can be any uppercase word. The extended syntax MAY not be supported by applications, adhering to the following vocabulary is greatly encouraged.

| **Value** | **Description** |
| --- | --- |
| NEW | A new tool that has not been used or first use. Marks the start of the tool history. |
| RECONDITIONED | The cutting tool has been reconditioned. See ReconditionCount for the number of times this cutter has been reconditioned. |
| USED | The tool is in process and has remaining tool life. |
| EXPIRED | The cutting tool has reached the end of its useful life. |
| BROKEN | Premature tool failure. |
| TAGGED\_OUT | Removed from service of the machine. |
| NOT\_REGISTERED | This cutting tool cannot be used until it is entered into the system. |

### ToolLife

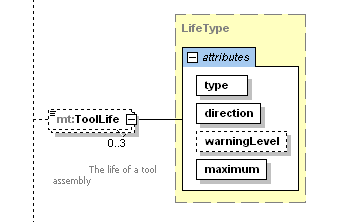


Figure 6: Tool Life

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

#### ToolLife attributes:

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

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| type | The type of tool life being accumulated. MINUTES, PART\_COUNT, or WEAR | 1 |
| direction | Indicates if the tool life counts from zero to maximum or maximum to zero, | 1 |
| warningLevel | The point at which a tool life warning will be raised. | 0..1 |
| maximum | The maximum limit of the tool life. | 0..1 |
| minimum | The minimum limit for the tool life | 0..1 |

##### ToolLife type attribute:

The value of type must be one of the following:

| **Value** | **Description** |
| --- | --- |
| MINUTES | The tool life measured in minutes. All units for minimum, maximum, and warningLevel **MUST** be provided in minutes. |
| PART\_COUNT | The tool life measured in parts. All units for minimum, maximum, and warningLevel **MUST** be provided supplied as the number of parts. |
| WEAR | The tool life measured in tool wear. Wear **MUST** be provided in millimeters as an offset to nominal. All units for minimum, maximum, and warningLevel **MUST** be given as millimeter offsets as well. |

##### ToolLife direction attribute:

The value of type must be one of the following:

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

### PocketId

This is the optional device specific pocket id providing the current pocket number this tool resides in. This can be any series of numbers and letters as defined by the XML type NMTOKEN.

### PocketSize

Number of Pot tool pocket locations that the assembly occupies due to interference. The value **MUST** be an integer.

### PocketWeight

The physical weight of the cutter. The CDATA for this element **MUST** be a floating point number representing the weight of the cutter in kilograms.

### ProgramNumber

The tool number that is assigned in the part program. The value **MUST** be an integer.

### ReconditionCount

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

### Length

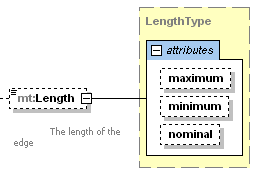


Figure 7: Cutting Item Length

The length of this cutting tool. The CDATA of the Length element contains the current measured value of the cutting item. All values **MUST** be given in millimeters.

#### Length attributes

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| maximum | The maximum length | 0..1 |
| minimum | The minimum length | 0..1 |
| nominal | The nominal length | 0..1 |

### Diameter

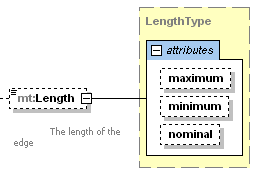


Figure 8: Cutting Item Diameter

The diameter of this cutting tool. The CDATA of the Diameter element contains the current measured value of the cutting item. All values **MUST** be given in millimeters.

#### Diameter attributes

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| maximum | The maximum diameter | 0..1 |
| minimum | The minimum diameter | 0..1 |
| nominal | The nominal diameter | 0..1 |

### CuttingItems

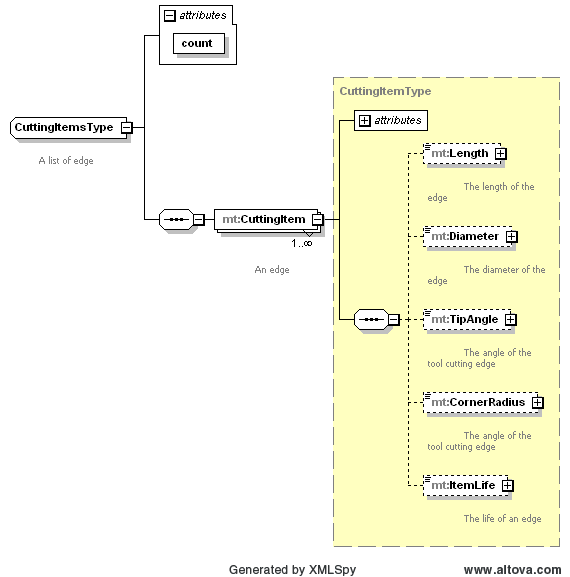


Figure 9: Cutting Items

The collection of cutting items.

#### CuttingItems attributes

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| count | The number of edges. | 1 |

### CuttingItem

A cutting item is the portion of the tool that physically removes the material from the workpiece by shear deformation. The cutting item can be either single piece of material attached to the tool item or it can be a separate piece of material attached to the tool item using a permanent or removable attachment.

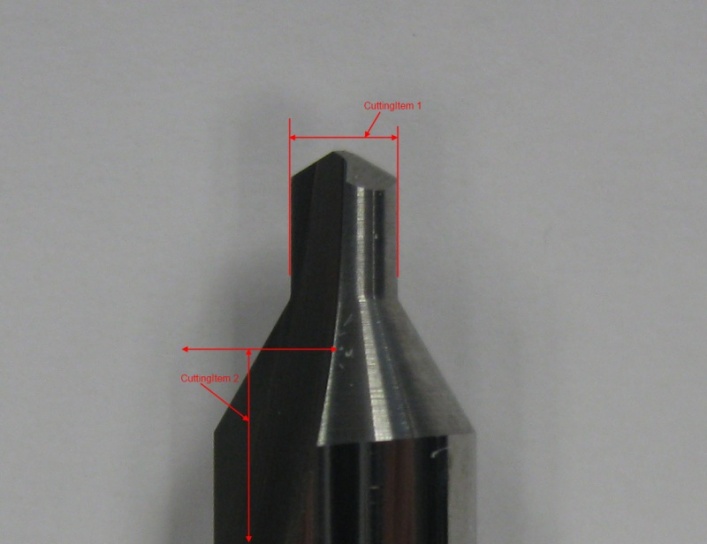
 



Figure 10: Cutting Item Examples

#### CuttingItem attributes

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| itemId | The unique identifier of this edge within this assembly | 1 |

An edge contains the following elements.

| **Element** | **Description** | **Occurrence** |
| --- | --- | --- |
| Length | The length of this edge in millimeters | 1 |
| Diameter | The diameter of the edge in millimeters | 1 |
| TipAngle | The angle of the tip of the edge in degrees. | 0..1 |
| CornerRadius | The corner radius of the edge in millimeters. | 0..1 |
| ItemLife | The life of this edge. | 0..3 |

### Length

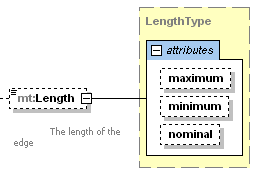


Figure 11: Cutting Item Length

The length of this cutting item. The CDATA of the Length element contains the current measured value of the cutting item. All values **MUST** be given in millimeters.

#### Length attributes

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| maximum | The maximum length | 0..1 |
| minimum | The minimum length | 0..1 |
| nominal | The nominal length | 0..1 |

### Diameter

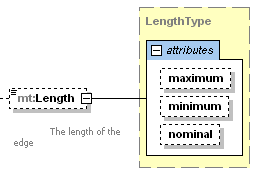


Figure 12: Cutting Item Diameter

The diameter of this cutting item. The CDATA of the Diameter element contains the current measured value of the cutting item. All values **MUST** be given in millimeters.

#### Diameter attributes

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| maximum | The maximum diameter | 0..1 |
| minimum | The minimum diameter | 0..1 |
| nominal | The nominal diameter | 0..1 |

### TipAngle

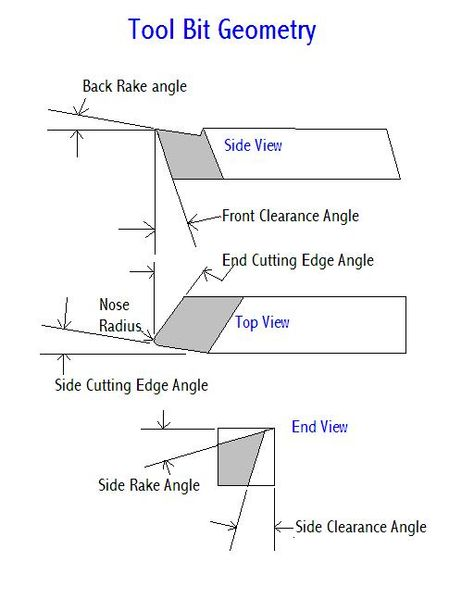


Figure 13: Cutting Item Geometry

The CDATA of the tip angle **MUST** be a floating point number representing the … ?

### CornerRadius

The corner radius of the cutting item **MUST** be a floating point number representing the radius of the cutting tool in millimeters. We need to indicate this on a picture to clarify.

### ItemLife:

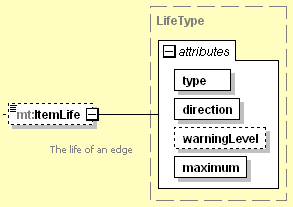


Figure 14: Item Life

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

#### ItemLife attributes:

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

| **Attribute** | **Description** | **Occurrence** |
| --- | --- | --- |
| type | The type of tool life being accumulated. MINUTES, PART\_COUNT, or WEAR | 1 |
| direction | Indicates if the tool life counts from zero to maximum or maximum to zero, | 1 |
| warningLevel | The point at which a tool life warning will be raised. | 0..1 |
| maximum | The maximum limit of the tool life. | 0..1 |
| minimum | The minimum limit for the tool life | 0..1 |

##### ItemLife type attribute:

The value of type must be one of the following:

| **Value** | **Description** |
| --- | --- |
| MINUTES | The tool life measured in minutes. All units for minimum, maximum, and warningLevel **MUST** be provided in minutes. |
| PART\_COUNT | The tool life measured in parts. All units for minimum, maximum, and warningLevel **MUST** be provided supplied as the number of parts. |
| WEAR | The tool life measured in tool wear. Wear **MUST** be provided in millimeters as an offset to nominal. All units for minimum, maximum, and warningLevel **MUST** be given as millimeter offsets as well. |

##### ItemLife direction attribute:

The value of type must be one of the following:

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

Appendices

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14. *ASME/ANSI B5.54: Methods for Performance Evaluation of Computer Numerically Controlled Lathes and Turning Centers. 2005.*
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17. Cutting Tool Example

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

<MTConnectAssets xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2 ../MTConnectAssets\_1.2.xsd" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:mt="urn:mtconnect.org:MTConnectAssets:1.2" xmlns="urn:mtconnect.org:MTConnectAssets:1.2">

<Header creationTime="2001-12-17T09:30:47Z" assetBufferSize="1024" sender="localhost" assetCount="10" version="1.2" instanceId="1234"/>

<Assets>

<CuttingTool serialNumber="213456" deviceUuid="AAA-BBB" toolId="111" timestamp="2001-12-17T09:30:47Z" assetId="111.213456">

<Description>Cutting tool ...</Description>

<CuttingToolDefinition format="XML">ISO 13399</CuttingToolDefinition>

<CuttingToolLifeCycle>

<CutterStatus>USED</CutterStatus>

<ToolLife maximum="5000" direction="DOWN" type="MINUTES" warningLevel="500">4500</ToolLife>

<PocketId>2</PocketId>

<ProgramToolNumber>12</ProgramToolNumber>

<PocketSize>1</PocketSize>

<CuttingItems count="0">

<CuttingItem itemId="0">

<Length maximum="5.55" nominal="5.5" minimum="5.22234">5.42234</Length>

<Diameter maximum="2.3" nominal="2.31" minimum="2.2">2.29888</Diameter>

<ItemLife maximum="5000" direction="DOWN" type="MINUTES" warningLevel="500">4500</ItemLife>

</CuttingItem>

</CuttingItems>

</CuttingToolLifeCycle>

</CuttingTool>

</Assets>

</MTConnectAssets>