MTConnect® Standard

Part 4.1 – Cutting Tools

Version 1.5.0

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MTConnect Specification and Materials

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1 Purpose of This Document

This document, *MTConnect Standard: Part 4.1 - Cutting Tools* of the MTConnect Standard, establishes the rules and terminology to be used by designers to describe the function and operation of cutting tools used within manufacturing and to define the data that is provided by an *Agent* from a piece of equipment. This part of the Standard also defines the structure for the XML document that is returned from an *Agent* in response to a `probe` request.

The data associated with these cutting tools will be retrieved from multiple sources that are responsible for providing their knowledge of an *MTConnect Asset*.

2 Terminology and Conventions

Refer to Section 2 of *MTConnect Standard Part 1.0 - Overview and Fundamentals* for a dictionary of terms, reserved language, and document conventions used in the MTConnect Standard.

2.1 Glossary

CDATA

General meaning:

An abbreviation for Character Data.

CDATA is used to describe a value (text or data) published as part of an XML element.

For example, "`This is some text`" is the CDATA in the XML element:

```
<Message ...>This is some text</Message>
```

Appears in the documents in the following form: CDATA

NMTOKEN

The data type for XML identifiers.

Note: The identifier must start with a letter, an underscore "_" or a colon. The next character must be a letter, a number, or one of the following ".", "-", "_", ":". The identifier must not have any spaces or special characters.

Appears in the documents in the following form: NMTOKEN.

XML

Stands for eXtensible Markup Language.

XML defines a set of rules for encoding documents that both a human-readable and machine-readable.

XML is the language used for all code examples in the MTConnect Standard.

Refer to http://www.w3.org/XML for more information about XML.

Agent

Refers to an MTConnect Agent.

Software that collects data published from one or more piece(s) of equipment, organizes that data in a structured manner, and responds to requests for data from client

software systems by providing a structured response in the form of a *Response Document* that is constructed using the *semantic data models* defined in the Standard.

Appears in the documents in the following form: *Agent*.

Asset

General meaning:

Typically referred to as an *MTConnect Asset*.

An *MTConnect Asset* is something that is used in the manufacturing process, but is not permanently associated with a single piece of equipment, can be removed from the piece of equipment without compromising its function, and can be associated with other pieces of equipment during its lifecycle.

Used to identify a storage area in an *Agent*:

See description of *buffer*.

Used as an *Information Model*:

Used to describe an *Information Model* that contains the rules and terminology that describe information that may be included in electronic documents representing *MTConnect Assets*.

The *Asset Information Models* defines the structure for the *Assets Response Document*.

Individual *Information Models* describe the structure of the *Asset Documents* represent each type of *MTConnect Asset*. Appears in the documents in the following form: *Asset Information Models* or (asset type) *Information Model*.

Used when referring to an *MTConnect Asset*:

Refers to the information related to an *MTConnect Asset* or a group of *MTConnect Assets*.

Appears in the documents in the following form: *Asset* or *Assets*.

Used as an XML container or element:

- When used as an XML container that consists of one or more types of `Asset` XML elements.

  Appears in the documents in the following form: `Assets`.
- When used as an abstract XML element. It is replaced in the XML document by types of `Asset` elements representing individual *Asset* entities.

  Appears in the documents in the following form: `Asset`.

Used to describe information stored in an *Agent*:

Identifies an electronic document published by a data source and stored in the *assets buffer* of an *Agent*.

Appears in the documents in the following form: *Asset Document*.

Used as an XML representation of an *MTConnect Response Document*:

Identifies an electronic document encoded in XML and published by an *Agent* in response to a *Request* for information from a client software application relating to *MTConnect Assets*.

Appears in the documents in the following form: `MTConnectAssets`.

Used as an *MTConnect Request*:

Represents a specific type of communications request between a client software application and an *Agent* regarding *MTConnect Assets*.

Appears in the documents in the following form: *Asset Request*.

Used as part of an *HTTP Request*:

Used in the path portion of an *HTTP Request Line*, by a client software application, to initiate an *Asset Request* to an *Agent* to publish an `MTConnectAssets` document.

Appears in the documents in the following form: `asset`.

Asset Document

An electronic document published by an *Agent* in response to a *Request* for information from a client software application relating to Assets.

Attribute

A term that is used to provide additional information or properties for an element.

Appears in the documents in the following form: attribute.

buffer

General meaning:

A section of an *Agent* that provides storage for information published from pieces of equipment.

Used relative to *Streaming Data*:

A section of an *Agent* that provides storage for information relating to individual pieces of *Streaming Data*.

Appears in the documents in the following form: *buffer*.

Used relative to *MTConnect Assets*:

A section of an *Agent* that provides storage for *Asset Documents*.

Appears in the documents in the following form: *assets buffer*.

Data Entity

A primary data modeling element that represents all elements that either describe data items that may be reported by an *Agent* or the data items that contain the actual data published by an *Agent*.

Appears in the documents in the following form: *Data Entity*.

Document

General meaning:

A piece of written, printed, or electronic matter that provides information.

Used to represent an *MTConnect Document*:

Refers to printed or electronic document(s) that represent a *Part*(s) of the MTConnect Standard.

Appears in the documents in the following form: *MTConnect Document*.

Used to represent a specific representation of an *MTConnect Document*:

Refers to electronic document(s) associated with an *Agent* that are encoded using XML; *Response Documents* or *Asset Documents*.

Appears in the documents in the following form: *MTConnect XML Document*.

Used to describe types of information stored in an *Agent*:

In an implementation, the electronic documents that are published from a data source and stored by an *Agent*.

Appears in the documents in the following form: *Asset Document*.

Used to describe information published by an *Agent*:

A document published by an *Agent* based upon one of the *semantic data models* defined in the MTConnect Standard in response to a request from a client.

Appears in the documents in the following form: *Response Document*.

Equipment Metadata

See *Metadata*

HTTP Request

In the MTConnect Standard, a communications command issued by a client software application to an *Agent* requesting information defined in the *HTTP Request Line*.

Appears in the documents in the following form: *HTTP Request*.

HTTP Request Line

In the MTConnect Standard, the first line of an *HTTP Request* describing a specific *Response Document* to be published by an *Agent*.

Appears in the documents in the following form: *HTTP Request Line*.

Information Model

The rules, relationships, and terminology that are used to define how information is structured.

For example, an information model is used to define the structure for each *MTConnect Response Document*; the definition of each piece of information within those documents and the relationship between pieces of information.

Appears in the documents in the following form: *Information Model*.

MTConnect Document

See *Document*.

MTConnect Request

A communication request for information issued from a client software application to an *Agent*.

Appears in the documents in the following form: *MTConnect Request*.

MTConnect XML Document

See *Document*.

Request

A communications method where a client software application transmits a message to an *Agent*. That message instructs the *Agent* to respond with specific information.

Appears in the documents in the following form: *Request*.

Response Document

See *Document*.

semantic data model

A methodology for defining the structure and meaning for data in a specific logical way.

It provides the rules for encoding electronic information such that it can be interpreted by a software system.

Appears in the documents in the following form: *semantic data model*.

Streaming Data

The values published by a piece of equipment for the *Data Entities* defined by the *Equipment Metadata*.

Appears in the documents in the following form: *Streaming Data*.

Valid Data Value

One or more acceptable values or constrained values that can be reported for a *Data Entity*.

Appears in the documents in the following form: *Valid Data Value*(s).

XML Schema

In the MTConnect Standard, an instantiation of a schema defining a specific document encoded in XML.

2.2 Acronyms

AMT

The Association for Manufacturing Technology

2.3 MTConnect References

[MTConnect Part 1.0] *MTConnect Standard Part 1.0 - Overview and Fundamentals*. Version 1.5.0.

[MTConnect Part 2.0] *MTConnect Standard: Part 2.0 - Devices Information Model*. Version 1.5.0.

[MTConnect Part 3.0] *MTConnect Standard: Part 3.0 - Streams Information Model*. Version 1.5.0.

[MTConnect Part 4.1] *MTConnect Standard: Part 4.1 - Cutting Tools*. Version 1.5.0.

3 Cutting Tool and Cutting Tool Archetype

There are two *Information Models* used to represent a cutting tool, `CuttingToolArchetype` and `CuttingTool`. The `CuttingToolArchetype` represent the static cutting tool geometries and nominal values as one would expect from a tool catalog and the `CuttingTool` represents the use or application of the tool on the shop floor with actual measured values and process data. In Version 1.3.0 of the MTConnect Standard it was decided to separate out these two concerns since not all pieces of equipment will have access to both sets of information. In this way, a generic definition of the cutting tool can coexist with a specific assembly *Information Model* with minimal redundancy of data.

3.1 XML Schema Structure for CuttingTool and CuttingToolArchetype

The *Figure 1* shows the XML schema that applies to both the `CuttingTool` *Information Model* and the `CuttingToolArchetype` *Information Model*.

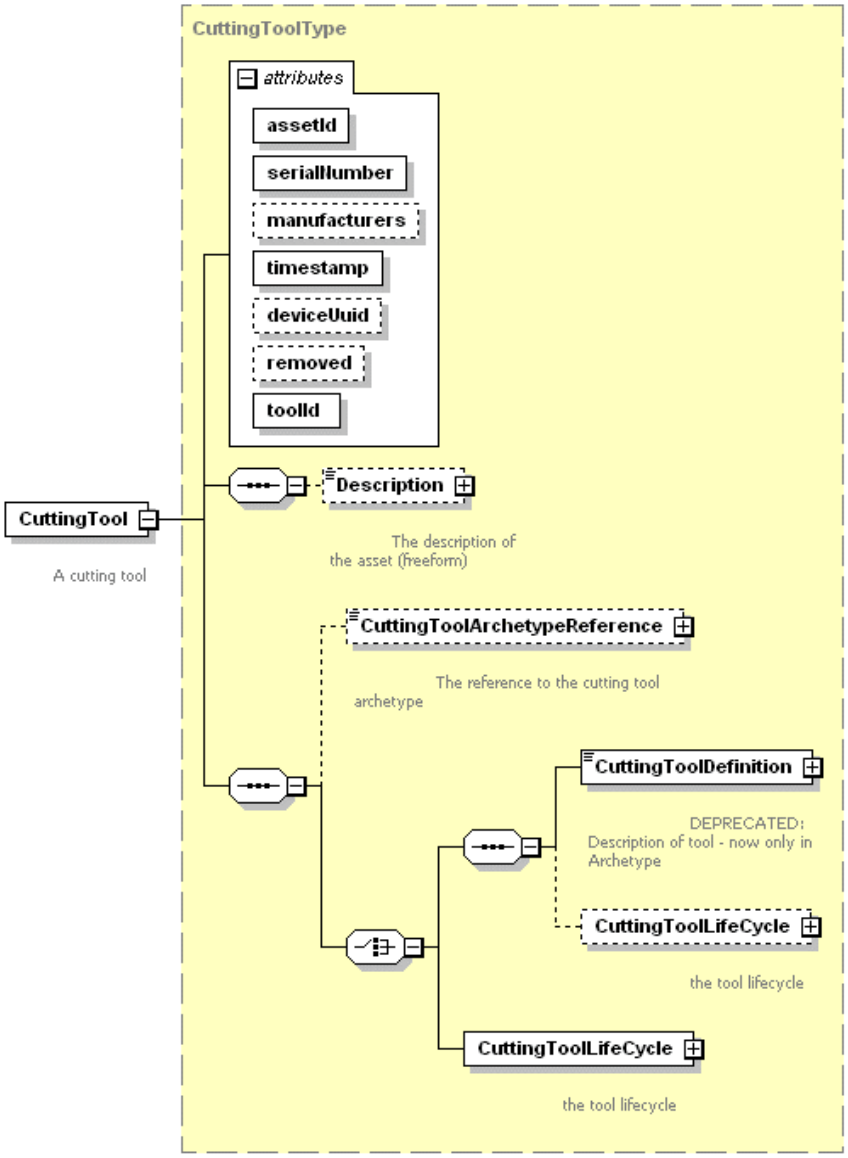


Figure 1: Cutting Tool Schema

Note: The use of the XML element `CuttingToolDefinition` has been **DEPRECATED** in the `CuttingTool` schema, but remains in the `CuttingToolArchetype` schema.

The following sections contain the definitions of `CuttingTool` and `CuttingToolArchetype` and describe their unique components. The following are the common entities for both elements.

3.2 Common Attributes for CuttingTool and CuttingToolArchetype

Table 1: Attributes for CuttingTool and CuttingToolArchetype

Attribute	Description	Occurrence
`timestamp`	The time this *MTConnect Asset* was last modified. Always given in UTC. The `timestamp` **MUST** be provided in UTC (Universal Time Coordinate, also known as GMT). This is the time the *Asset* data was last modified. `timestamp` is a required attribute.	1
`assetId`	The unique identifier of the instance of this tool. This will be the same as the `toolId` and `serialNumber` in most cases. The `assetId` **SHOULD** be the combination of the `toolId` and `serialNumber` as in `toolId`. `serialNumber` or an equivalent implementation dependent identification scheme. `assetId` is a required attribute. `assetId` is a permanent identifier that will be associated with an *MTConnect Asset* for its entire life.	1
`serialNumber`	The unique identifier for this assembly. This is defined as an XML string type and is implementation dependent. `serialNumber` is a required attribute.	1

Continuation of Table 1		
Attribute	Description	Occurrence
`toolId`	The identifier for a class of Cutting Tools. This is defined as an XML string type and is implementation dependent. `toolId` is a required attribute.	1
`deviceUuid`	The piece of equipments UUID that supplied this data. This is an optional element references to the UUID attribute given in the `Device` element. This can be any series of numbers and letters as defined by the XML type NMTOKEN.	1
`manufacturers`	An optional attribute referring to the manufacturer(s) of this Cutting Tool, for this element, this will reference the Tool Item and Adaptive Items specifically. The Cutting Items manufacturers' will be an attribute of the `CuttingItem` elements. The representation will be a comma (,) delimited list of manufacturer names. This can be any series of numbers and letters as defined by the XML type `string`.	0..1
`removed`	This is an indicator that the Cutting Tool has been removed from the piece of equipment. `removed` is a required attribute. If the *MTConnect Asset* is marked as removed, it will not be visible to the client application unless the `includeRemoved=true` parameter is provided in the URL. If this attribute is not present it **MUST** be assumed to be `false`. The value is an `xsi:boolean` type and **MUST** be `true` or `false`.	0..1

3.3 Common Elements for CuttingTool and CuttingToolArchetype

Table 2: Common Elements for CuttingTool and CuttingToolArchetype

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 Standard.	0..1

3.3.1 Description Element for CuttingTool and CuttingToolArchetype

`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 `Description` contains no attributes.

4 CuttingToolArchetype Information Model

The `CuttingToolArchetype` *Information Model* will have the identical structure as the `CuttingTool` *Information Model* illustrated in *Figure 1* , except for a few entities. The `CuttingTool` will no longer carry the `CuttingToolDefinition`, this **MUST** only appear in the `CuttingToolArchetype`. The `CuttingToolArchetype` **MUST NOT** have measured values and **MUST NOT** have any of the following items: `CutterStatus`, `ToolLife` values, `Location`, or a `ReconditionCount`.

MTConnect Standard will adopt the ISO 13399 structure when formulating the vocabulary for Cutting Tool geometries and structure to be represented in the `CuttingToolArchetype`. The nominal values provided in the `CuttingToolLifeCycle` section are only concerned with two aspects of the Cutting Tool, the Cutting Tool and the Cutting Item. The Tool Item, Adaptive Item, and Assembly Item will only be covered in the `CuttingToolDefinition` section of this document since this section contains the full ISO 13399 information about a Cutting Tool.

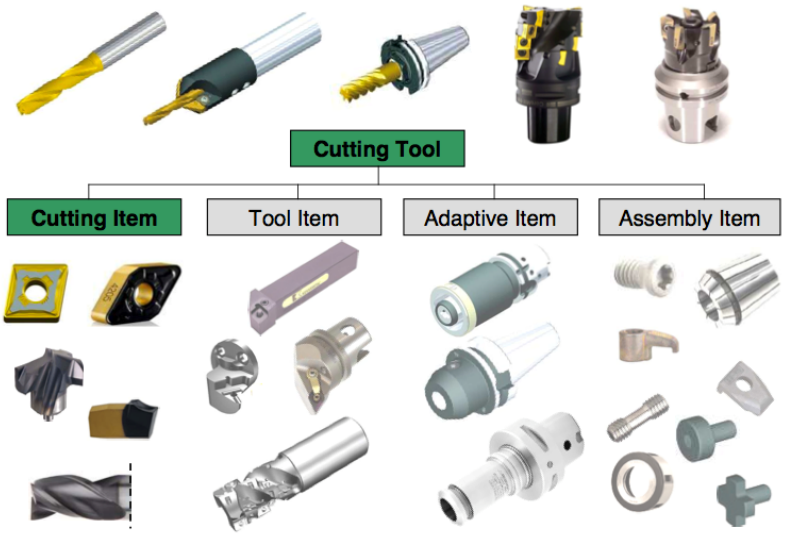


Figure 2: Cutting Tool Parts

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

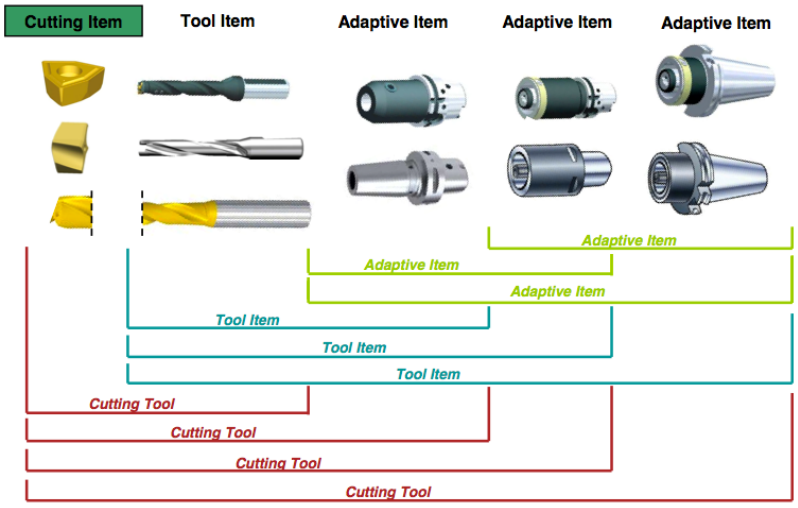


Figure 3: Cutting Tool Composition

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

Figure 4 and *Figure 5* further illustrates the components of the Cutting Tool. As we compose the Tool Item, Cutting Item, Adaptive Item, we get a Cutting Tool. The Tool Item, Adaptive Item, and Assembly Item will only be in the `CuttingToolDefinition` section that will contain the full ISO 13399 information.

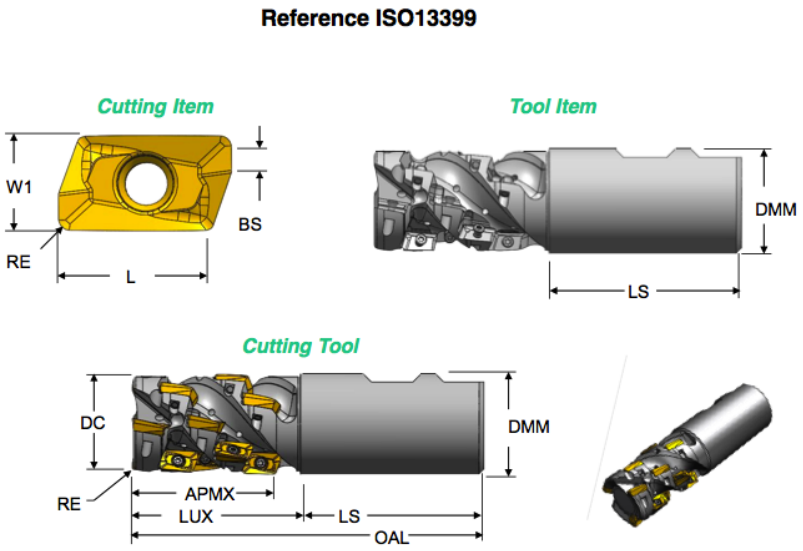


Figure 4: Cutting Tool, Tool Item, and Cutting Item

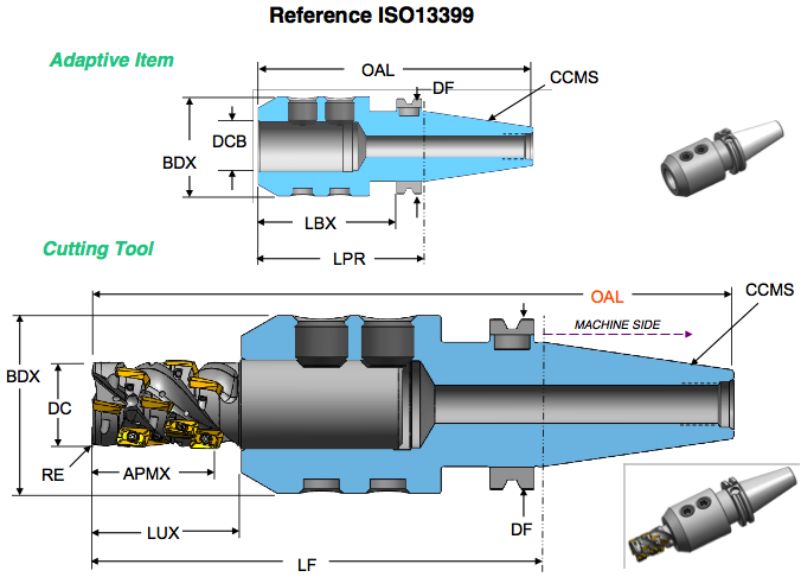


Figure 5: Cutting Tool, Tool Item, and Cutting Item 2

Figure 4 and *Figure 5* use the ISO 13399 codes for each of the measurements. These codes will be translated into the MTConnect Standard vocabulary as illustrated below. The measurements will have a maximum, minimum, and nominal value representing the tolerance of allowable values for this dimension. See below for a full discussion.

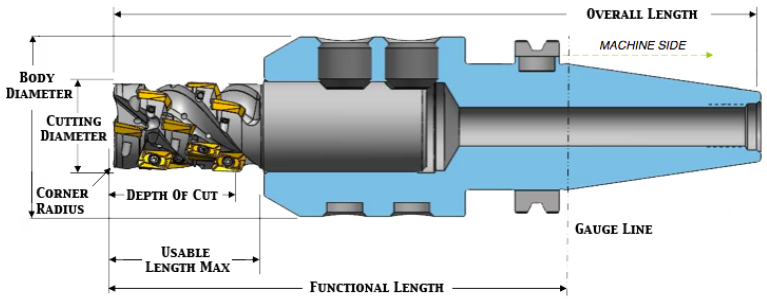


Figure 6: Cutting Tool Measurements

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.

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

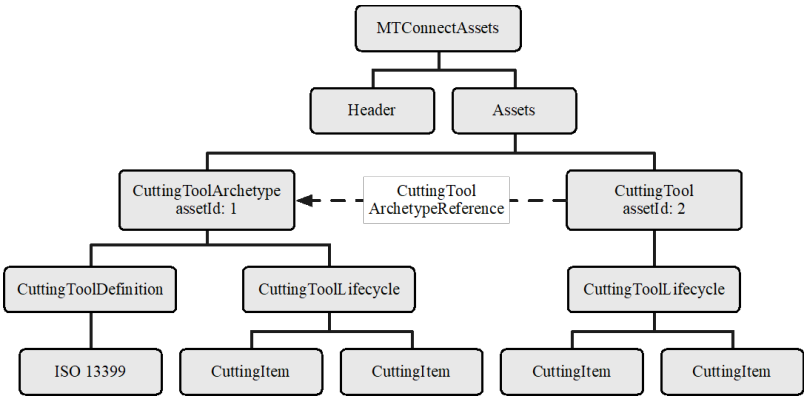


Figure 7: Cutting Tool Asset Structure

The structure of the `MTConnectAssets` header is defined in *MTConnect Standard Part 1.0 - Overview and Fundamentals* of the Standard. A finite number of *MTConnect Assets* will be stored in the *Agent*. This finite number is implementation specific and will depend on memory and storage constraints. The standard will not prescribe the number or capacity requirements for an implementation.

4.1 Attributes for CuttingToolArchetype

Refer to *Section 3.2 - Common Attributes for CuttingTool and CuttingToolArchetype* for a full description of the attributes for `CuttingToolArchetype` *Information Model*.

4.2 Elements for CuttingToolArchetype

The elements associated with `CuttingToolArchetype` are given in *Table 3*. 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.

Table 3: Elements for CuttingToolArchetype

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 Standard.	0..1
`CuttingToolDefinition`	Reference to an ISO 13399.	0..1
`CuttingToolLifeCycle`	Data regarding the use of this tool. The archetype will only contain nominal values.	0..1

4.2.1 CuttingToolDefinition Element for CuttingToolArchetype

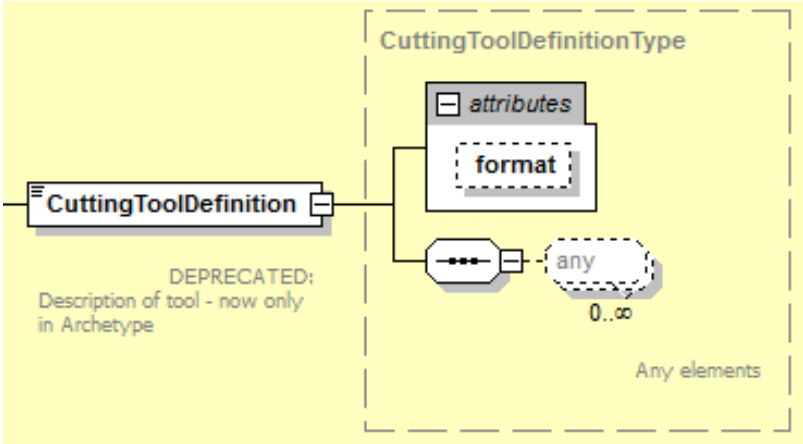


Figure 8: CuttingToolDefinition Schema

The `CuttingToolDefinition` contains the detailed structure of the Cutting Tool. The information contained in this element will be static during its lifecycle. Currently we are referring to the external ISO 13399 standard to provide the complete definition and composition of the Cutting Tool as defined in *Section 6.1 - CuttingToolLifeCycle*.

4.2.1.1 Attributes for CuttingToolDefinition

Table 4: Attributes for CuttingToolDefinition

Attribute	Description	Occurrence
`format`	Identifies the expected representation of the enclosed data. `format` is an optional attribute. Valid values of `format` are – `XML`, `EXPRESS`, `TEXT`, or `UNDEFINED`. If `format` is not specified, the assumed format is `XML`.	0..1

4.2.1.1.1 format Attribute for CuttingToolDefnition

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

Table 5: Values for format attribute of CuttingToolDefinition

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 Part 21 standard.
`TEXT`	The document will be a text representation of the tool data.
`UNDEFINED`	The document will be provided in an undefined format.

4.2.1.2 Elements for CuttingToolDefinition

The only acceptable Cutting Tool definition at present is defined by the ISO 13399 standard. Additional formats **MAY** be considered in the future.

4.2.1.3 ISO13399 Standard

The ISO 13399 data **MUST** be presented in either XML (ISO 10303-28) or EXPRESS format (ISO 10303-21). An XML schema will be preferred as this will allow for easier integration with the MTConnect Standard XML tools. EXPRESS will also be supported, but software tools will need to be provided or made available for handling this data representation.

There will be the root element of the ISO13399 document when XML is used. When EXPRESS is used the XML element will be replaced by the text representation.

4.2.2 CuttingToolLifeCycle Element for CuttingToolArchetype

Refer to *Section 6 - Common Entity CuttingToolLifeCycle* for a complete description of `CuttingToolLifeCycle` element.

5 CuttingTool Information model

The `CuttingTool` *Information Model* illustrated in *Figure 1* has the identical structure as the `CuttingToolArchetype` *Information Model* except for the XML element `CuttingToolDefinition` that has been **DEPRECATED** in the `CuttingTool` schema.

5.1 Attributes for CuttingTool

Refer to *Section 3.2 - Common Attributes for CuttingTool and CuttingToolArchetype* for a full description of the *Attributes* for `CuttingTool` *Information Model*.

5.2 Elements for CuttingTool

The elements associated with `CuttingTool` are given below. The elements **MUST** be provided in the order shown in *Table 6* as prescribed by XML.

Table 6: Elements for CuttingTool

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 Standard.	0..1
~~`CuttingToolDefinition`~~	**DEPRECATED** for `CuttingTool` in Version 1.3.0. ~~Reference to an ISO 13399.~~	~~0..1~~

Continuation of Table 6		
Element	Description	Occurrence
`CuttingToolLifeCycle`	Data regarding the use of this tool.	0..1
`CuttingToolArchetypeReference`	The content of this XML element is the `assetId` of the `CuttingToolArchetype` document. It **MAY** also contain a `source` attribute that gives the URL of the archetype data as well.	0..1

5.2.1 CuttingToolLifeCycle Elements for CuttingTool Only

The following `CuttingToolLifeCycle` elements are used only in the `CuttingTool` *Information Model* and are not part of the `CuttingToolArchetype` *Information Model*. Refer to *Section 6 - Common Entity CuttingToolLifeCycle* for a complete description of the remaining elements for `CuttingToolLifeCycle` that are common in both *Information Models*. Refer also to the `CuttingToolLifeCycle` schema illustrated in *Figure 14* .

5.2.1.1 CutterStatus Element for CuttingToolLifeCycle

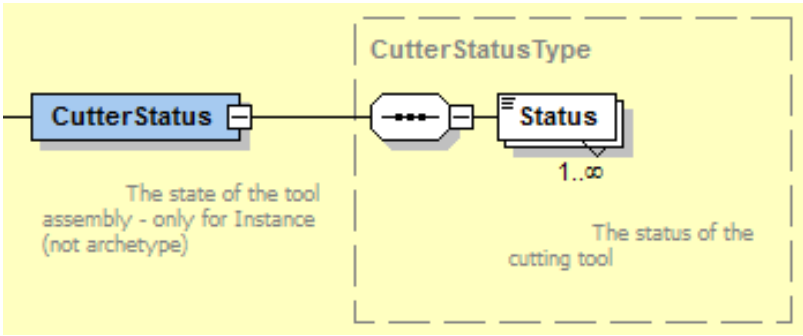


Figure 9: CutterStatus Schema

The elements of the `CutterStatus` element can be a combined set of `Status` elements. The *MTConnect Standard* allows any set of statuses to be combined, but only certain combinations make sense. A `CuttingTool` **SHOULD** not be both `NEW` and

USED at the same time. There are no rules in the schema to enforce this, but this is left to the implementer. The following combinations **MUST NOT** occur:

- NEW **MUST NOT** be used with USED, RECONDITIONED, or EXPIRED.
- UNKNOWN **MUST NOT** be used with any other status.
- ALLOCATED and UNALLOCATED **MUST NOT** be used together.
- AVAILABLE and UNAVAILABLE **MUST NOT** be used together.
- If the tool is EXPIRED, BROKEN, or NOT_REGISTERED it **MUST NOT** be AVAILABLE.
- All other combinations are allowed.

Table 7: Elements for CutterStatus

Element	Description	Occurrence
Status	The status of the Cutting Tool. There can be multiple Status elements.	1..*

5.2.1.1.1 Status Element for CutterStatus

One of the values for the status of the CuttingTool.

Table 8: Values for Status Element of CutterStatus

Value	Description
NEW	A new tool that has not been used or first use. Marks the start of the tool history.
AVAILABLE	Indicates the tool is available for use. If this is not present, the tool is currently not ready to be used.
UNAVAILABLE	Indicates the tool is unavailable for use in metal removal. If this is not present, the tool is currently not ready to be used.

Continuation of Table 8	
Value	Description
ALLOCATED	Indicates if this tool is has been committed to a piece of equipment for use and is not available for use in any other piece of equipment. If this is not present, this tool has not been allocated for this piece of equipment and can be used by another piece of equipment.
UNALLOCATED	Indicates this Cutting Tool has not been committed to a process and can be allocated.
MEASURED	The tool has been measured.
RECONDITIONED	The Cutting Tool has been reconditioned. See ReconditionCount for the number of times this cutter has been reconditioned.
USED	The Cutting 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.
NOT_REGISTERED	This Cutting Tool cannot be used until it is entered into the system.
UNKNOWN	The Cutting Tool is an indeterminate state. This is the default value.

5.2.1.2 ToolLife Element for CuttingToolLifeCycle

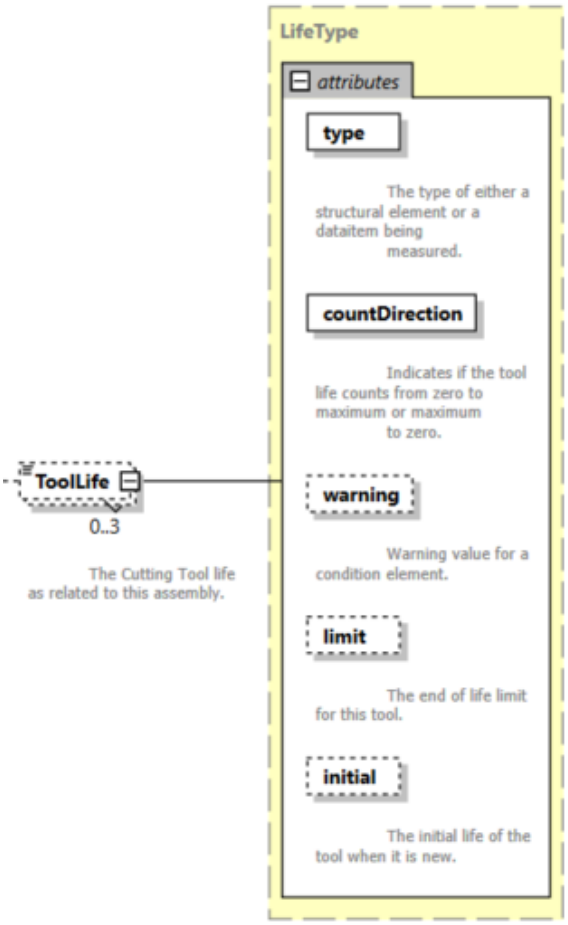


Figure 10: ToolLife Schema

The value is the current value for the `ToolLife`. The value **MUST** be a number. `ToolLife` 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 `ToolLife` element can appear for each type, but there cannot be two entries of the same type. Additional types can be added in the future.

5.2.1.2.1 Attributes for ToolLife

`ToolLife` has the following attributes that can be used to indicate the behavior of the tool life management mechanism.

Table 9: Attributes for ToolLife

Attribute	Description	Occurrence
`type`	The type of tool life being accumulated. `MINUTES`, `PART_COUNT`, or `WEAR`. `type` is a required attribute.	1
`countDirection`	Indicates if the tool life counts from zero to maximum or maximum to zero. The value **MUST** be one of `UP` or `DOWN`. `countDirection` is a required attribute.	1
`warning`	The point at which a tool life warning will be raised. `warning` is an optional attribute.	0..1
`limit`	The end of life limit for this tool. If the `countDirection` is `DOWN`, the point at which this tool should be expired, usually zero. If the `countDirection` is `UP`, this is the upper limit for which this tool should be expired. `limit` is an optional attribute.	0..1
`initial`	The initial life of the tool when it is new. `initial` is an optional attribute.	0..1

5.2.1.2.2 type Attribute for ToolLife

The value of `type` must be one of the following:

Table 10: Values for type of ToolLife

Value	Description
MINUTES	The tool life measured in minutes. All units for minimum, maximum, and nominal **MUST** be provided in minutes.
PART_COUNT	The tool life measured in parts. All units for minimum, maximum, and nominal **MUST** be provided 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 nominal **MUST** be given as millimeter offsets as well. The standard will only consider dimensional wear at this time.

5.2.1.2.3 countDirection Attribute for ToolLife

The value of `countDirection` must be one of the following:

Table 11: Values for countDirection

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

5.2.1.3 Location Element for CuttingToolLifeCycle

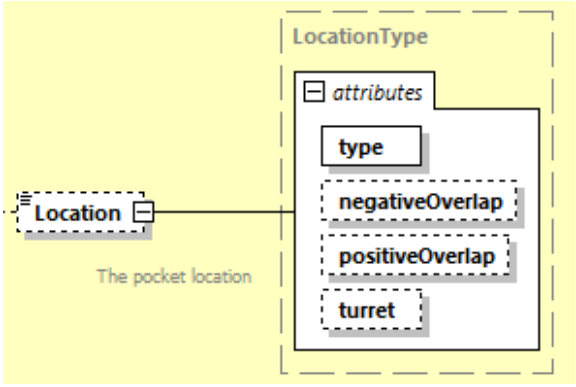


Figure 11: Location Schema

`Location` element identifies the specific location where a tool resides in a piece of equip-

ment tool storage or in a tool crib. This can be any series of numbers and letters as defined by the XML type NMTOKEN. When a `POT` or `STATION` type is used, the value **MUST** be a numeric value. If a `negativeOverlap` or the `positiveOverlap` is provided, the tool reserves additional locations on either side, otherwise if they are not given, no additional locations are required for this tool. If the pot occupies the first or last location, a rollover to the beginning or the end of the index-able values may occur. For example, if there are 64 pots and the tool is in pot 64 with a `positiveOverlap` of 1, the first pot **MAY** be occupied as well.

5.2.1.3.1 Attributes for Location

Table 12: Attributes for Location

Attribute	Description	Occurrence
`type`	The type of location being identified. `type` **MUST** be one of `POT`, `STATION`, or `CRIB`. `type` is a required attribute.	1
`positiveOverlap`	The number of locations at higher index value from this location. `positiveOverlap` is a optional attribute.	0..1
`negativeOverlap`	The number of location at lower index values from this location. `negativeOverlap` is an optional attribute.	0..1

5.2.1.3.2 type Attribute for Location

The type of location being identified.

Table 13: Values for type of Location

Value	Description
`POT`	The number of the pot in the tool handling system.
`STATION`	The tool location in a horizontal turning machine.
`CRIB`	The location with regard to a tool crib.

5.2.1.3.3 postiveOverlap Attribute for Location

The number of locations at higher index values that the `CuttingTool` occupies due to interference. The value **MUST** be an integer. If not provided it is assumed to be 0.

5.2.1.3.4 negativeOverlap Attribute for Location

The number of locations at lower index values that the `CuttingTool` occupies due to interference. The value **MUST** be an integer. If not provided it is not assumed to be 0.

The tool number assigned in the part program and is used for cross referencing this tool information with the process parameters. The value **MUST** be an integer.

5.2.1.4 ReconditionCount Element for CuttingToolLifeCycle

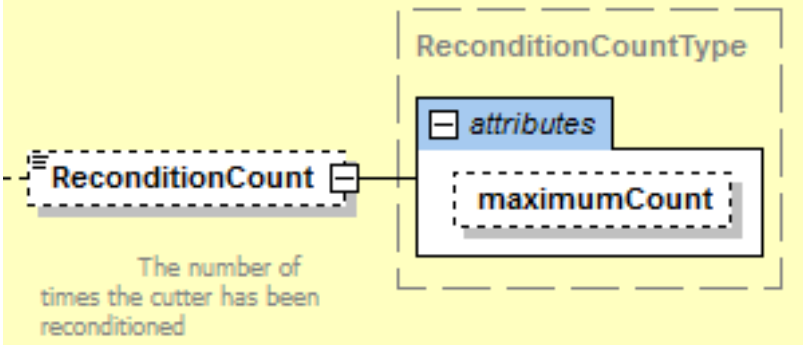


Figure 12: ReconditionCount Schema

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

5.2.1.4.1 Attributes for ReconditionCount

Table 14: Attributes for ReconditionCount

Attribute	Description	Occurrence
`maximumCount`	The maximum number of times this tool may be reconditioned. `maximumCount` is a optional attribute.	0..1

5.2.2 CuttingToolArchetypeReference Element for Cutting Tool

Figure 13: CuttingToolArcheTypeReference Schema

This optional element references another *MTConnect Asset* document providing the static geometries and nominal values for all the measurements. This reduces the amount of data duplication as well as providing a mechanism for asset definitions to be provided before complete measurement has occurred.

5.2.2.1 source Attribute for CuttingToolArcheTypeReference

Table 15: Attributes for CuttingToolArchetypeReference

Attribute	Description	Occurrence
`source`	The URL of the `CuttingToolArchetype` *Information Model*. This **MUST** be a fully qualified URL as in http://example.com/asset/A213155	0..1

6 Common Entity CuttingToolLifeCycle

6.1 CuttingToolLifeCycle

The life cycle refers to the data pertaining to the application or the use of the tool. This data is provided by various pieces of equipment (i.e. machine tool, presetter) and statistical process control applications. Life cycle data will not remain static, but will change periodically when a tool is used or measured. The life cycle has three conceptual parts; `CuttingTool` and `CuttingItem` identity, properties, and measurements. A measurement is defined as a constrained value that is reported in defined units and as a W3C floating point format.

The `CuttingToolLifeCycle` contains data for the entire tool assembly. The specific `CuttingItems` that are part of the `CuttingToolLifeCycle` are contained in the `CuttingItems` element. Each Cutting Item has similar properties as the assembly; identity, properties, and `Measurements`.

The units for all `Measurements` have been predefined in the *MTConnect Standard* and will be consistent with *MTConnect Standard: Part 2.0 - Devices Information Model* and *MTConnect Standard: Part 3.0 - Streams Information Model*. This means that all lengths and distances will be given in millimeters and all angular measures will be given in degrees. Quantities like `ProcessSpindleSpeed` will be given in RPM, the same as the `ROTARY_VELOCITY` in *MTConnect Standard: Part 3.0 - Streams Information Model*.

6.1.1 XML Schema Structure for CuttingToolLifeCycle

The `CuttingToolLifeCycle` schema shown in *Figure 14* is used in both the `CuttingToolArchetype` and `CuttingTool` *Information Models*. The only difference is that the elements `CutterStatus`, `ToolLife`, `Location`, and `ReconditionCount` are used only in the `CuttingTool` *Information Model*.

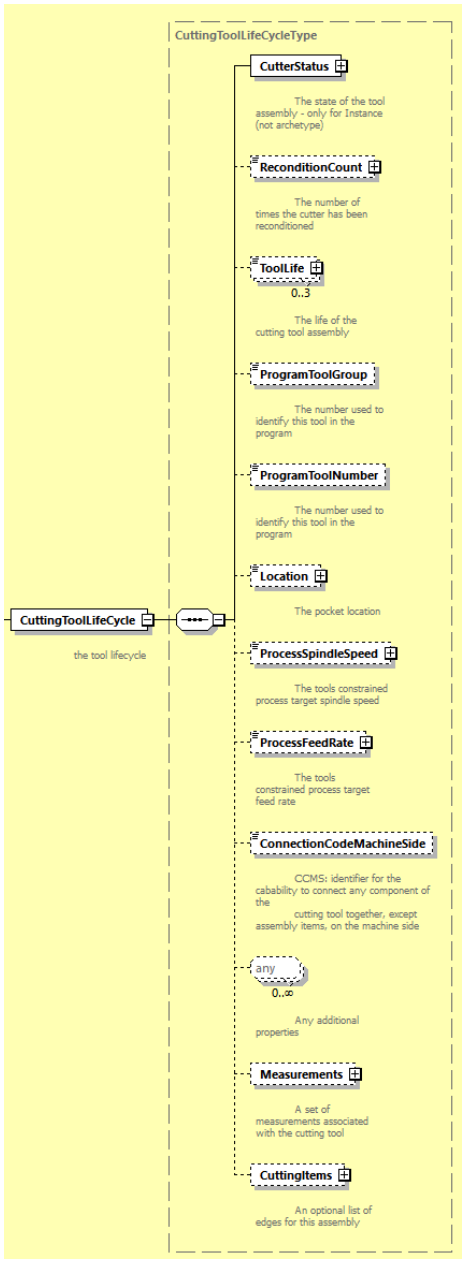


Figure 14: CuttingToolLifeCycle Schema

6.2 Elements for CuttingToolLifeCycle

The elements associated with this Cutting Tool are given in *Table 16*. The elements **MUST** be provided in the following order as prescribed by XML.

Table 16: Elements for CuttingToolLifeCycle

Element	Description	Occurrence
`CutterStatus`	The status of this assembly. `CutterStatus` can be one of the following values: `NEW`, `AVAILABLE`, `UNAVAILABLE`, `ALLOCATED`, `UNALLOCATED`, `MEASURED`, `RECONDITIONED`, `NOT_REGISTERED`, `USED`, `EXPIRED`, `BROKEN`, or `UNKNOWN`. **MUST** only be used in the `CuttingTool` *Information Model*.	1
`ReconditionCount`	The number of times this cutter has been reconditioned. **MUST** only be used in the `CuttingTool` *Information Model*.	0..1
`ToolLife`	The Cutting Tool life as related to this assembly. **MUST** only be used in the `CuttingTool` *Information Model*.	0..1
`Location`	The Pot or Spindle this tool currently resides in. **MUST** only be used in the `CuttingTool` *Information Model*.	0..1

Continuation of Table 16		
Element	Description	Occurrence
`ProgramToolGroup`	The tool group this tool is assigned in the part program.	0..1
`ProgramToolNumber`	The number of the tool as referenced in the part program.	0..1
`ProcessSpindleSpeed`	The constrained process spindle speed for this tool.	0..1
`ProcessFeedRate`	The constrained process feed rate for this tool in mm/s.	0..1
`ConnectionCodeMachineSide`	Identifier for the capability to connect any component of the Cutting Tool together, except Assembly Items, on the machine side. Code: `CCMS`	0..1
`Measurements`	A collection of measurements for the tool assembly.	0..1
`CuttingItems`	An optional set of individual Cutting Items.	0..1
`xs:any`	Any additional properties not in the current document model. **MUST** be in separate XML namespace.	0..n

6.2.1 ProgramToolGroup Element for CuttingToolLifeCycle

The optional identifier for the group of Cutting Tools when multiple tools can be used interchangeably. This is defined as an XML string type and is implementation dependent.

6.2.2 ProgramToolNumber Element for CuttingToolLifeCycle

The tool number assigned in the part program and is used for cross referencing this tool information with the process parameters. The value **MUST** be an integer.

400 6.2.3 ProcessSpindleSpeed Element for CuttingToolLifeCycle

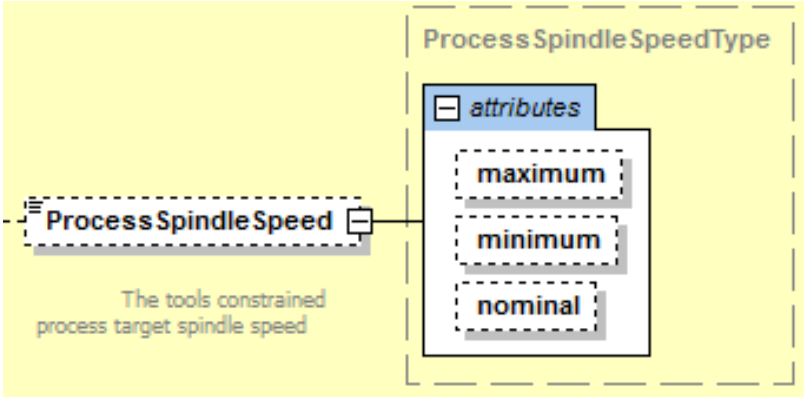


Figure 15: ProcessSpindleSpeed Schema

401 The `ProcessSpindleSpeed` **MUST** be specified in revolutions/minute (RPM). The
402 CDATA **MAY** contain the nominal process target spindle speed if available. The maximum
403 and minimum speeds **MAY** be provided as attributes. If `ProcessSpindleSpeed` is
404 provided, at least one value of `maximum`, `nominal`, or `minimum` **MUST** be specified.

405 6.2.3.1 Attributes for ProcessSpindleSpeed

Table 17: Attributes for ProcessSpindleSpeed

Attribute	Description	Occurrence
`maximum`	The upper bound for the tool's target spindle speed. `maximum` is an optional attribute.	0..1
`minimum`	The lower bound for the tools spindle speed. `minimum` is a optional attribute.	0..1
`nominal`	The nominal speed the tool is designed to operate at. `nominal` is an optional attribute.	0..1

406 6.2.4 ProcessFeedRate Element for CuttingToolLifeCycle

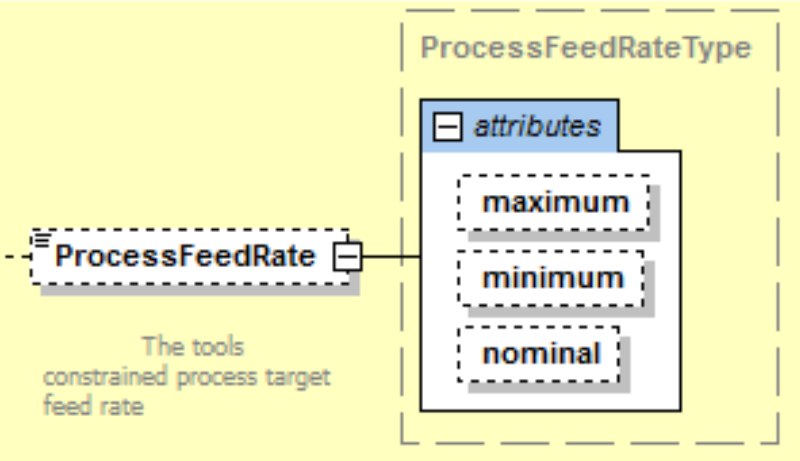


Figure 16: ProcessFeedRate Schema

407 The `ProcessFeedRate` **MUST** be specified in millimeters/second (mm/s). The CDATA
408 **MAY** contain the nominal process target feed rate if available. The maximum and mini-
409 mum rates MAY be provided as attributes. If `ProcessFeedRate` is provided, at least
410 one value of `maximum`, `nominal`, or `minimum` **MUST** be specified.

411 6.2.4.1 Attributes for ProcessFeedRate

Table 18: Attributes for ProcessFeedRate

Attribute	Description	Occurrence
`maximum`	The upper bound for the tool's process target feedrate. `maximum` is an optional attribute.	0..1
`minimum`	The lower bound for the tools feedrate. `minimum` is a optional attribute.	0..1
`nominal`	The nominal feedrate the tool is designed to operate at. `nominal` is an optional attribute.	0..1

6.2.5 ConnectionCodeMachineSide Element for CuttingToolLifeCycle

This is an optional identifier for implementation specific connection component of the Cutting Tool on the machine side. Code: `CCMS`. The CDATA **MAY** be any valid string according to the referenced connection code standards.

6.2.6 xs:any Element for CuttingToolLifeCycle

Utilizing the new capability in *XML Schema* Version 1.1, there are extension points where an additional element can be added to the document without being part of a substitution group. The new elements have the restriction that they **MUST NOT** be part of the *MTConnect namespace* and **MUST NOT** be one of the predefined elements mentioned above.

This allows one to add additional properties to the `CuttingTool` without having to change the definition of the `CuttingTool` or modify the standard. The new capabilities were introduced in Version 1.3 of the *MTConnect Standard* and necessitate using Version 1.1 of *XML Schema* to make use of this form of extensible properties.

6.2.7 Measurements Element for CuttingToolLifeCycle

The `Measurements` element is a collection of one or more constrained scalar values associated with this Cutting Tool. The XML element **MUST** be a type extension of the base types `CommonMeasurement` or `AssemblyMeasurement`. The following section defines the abstract `Measurement` type used in both `CuttingToolLifeCycle` and `CuttingItem`. This subsequent sections describe the `AssemblyMeasurement` types followed by the `CuttingItemMeasurement` types.

A `Measurement` is specific to the tool management policy at a particular shop. The tool zero reference point or gauge line will be different depending on the particular implementation and will be assumed to be consistent within the shop. *MTConnect Standard* does not standardize the manufacturing process or the definition of the zero point.

6.2.8 Measurement

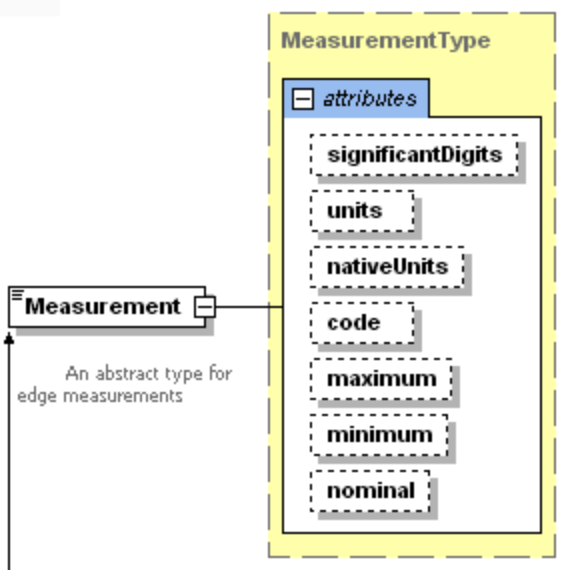


Figure 17: Measurement Schema

A `Measurement` **MUST** be a scalar floating-point value that **MAY** be constrained to a maximum and minimum value. Since the `CuttingToolLifeCycle`'s main responsibility is to track aspects of the tool that change over its use in the shop, *MTConnect* represents the current value of the `Measurement` **MUST** be in the CDATA (text between the start and end element) as the most current valid value.

The `minimum` and `maximum` **MAY** be supplied if they are known or relevant to the `Measurement`. A `nominal` value **MAY** be provided to show the reference value for this `Measurement`.

There are three abstract subtypes of `Measurement`: `CommonMeasurement`, `AssemblyMeasurement`, and `CuttingItemMeasurement`. These abstract types **MUST NOT** appear in an `MTConnectAssets` document, but are used in the schema as a way to separate which measurements **MAY** appear in the different sections of the document. Only subtypes that have extended these types **MAY** appear in the `MTConnectAssets` XML.

`Measurements` in the `CuttingToolLifeCycle` section **MUST** refer to the entire assembly and not to an individual `CuttingItem`. `CuttingItem` measurements **MUST** be located in the measurements associated with the individual `CuttingItem`.

`Measurements` **MAY** provide an optional `units` attribute to reinforce the given units. The units **MUST** always be given in the predefined MTConnect units. If `units` are

457 provided, they are only for documentation purposes. `nativeUnits` **MAY** optionally be
458 provided to indicate the original units provided for the measurements.

459 6.2.8.1 Attributes for Measurement

Table 19: Attributes for Measurement

Attribute	Description	Occurrence
`code`	A shop specific code for this measurement. ISO 13399 codes **MAY** be used for these codes as well. `code` is a optional attribute.	0..1
`maximum`	The maximum value for this measurement. Exceeding this value would indicate the tool is not usable. `maximum` is a optional attribute.	0..1
`minimum`	The minimum value for this measurement. Exceeding this value would indicate the tool is not usable. `minimum` is a optional attribute.	0..1
`nominal`	The as advertised value for this measurement. `nominal` is a optional attribute.	0..1
`significantDigits`	The number of significant digits in the reported value. This is used by applications to determine accuracy of values. This **MAY** be specified for all numeric values. `significantDigits` is a optional attribute.	0..1

Continuation of Table 19		
Attribute	Description	Occurrence
`units`	The units for the measurements. MTConnect Standard defines all the units for each measurement, so this is mainly for documentation sake. See MTConnect *MTConnect Standard: Part 2.0 - Devices Information Model* 7.2.2.5 for the full list of units. `units` is a optional attribute.	0..1
`nativeUnits`	The units the measurement was originally recorded in. This is only necessary if they differ from units. See *MTConnect Standard: Part 2.0 - Devices Information Model* Section 7.2.2.6 for the full list of units. `nativeUnits` is a optional attribute.	0..1

6.2.8.2 Measurement Subtypes for CuttingToolLifeCycle

These `Measurements` for `CuttingTool` are specific to the entire assembly and **MUST NOT** be used for the `Measurement` pertaining to a `CuttingItem`. *Figure 18* and *Figure 19* will be used to reference the assembly specific `Measurements`.

The Code in *Table 20* will refer to the acronyms in the diagrams. We will be referring to many diagrams to disambiguate all measurements of the `CuttingTool` and `CuttingItem`.

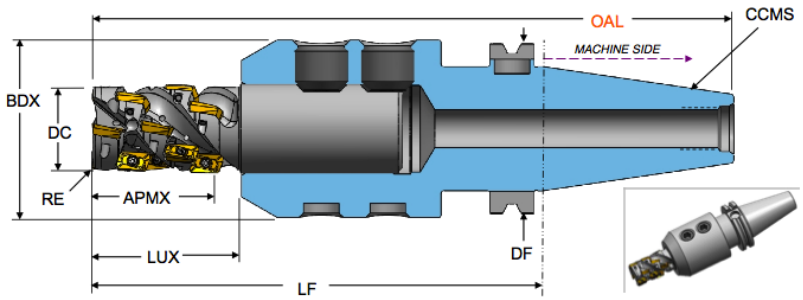


Figure 18: Cutting Tool Measurement Diagram 1

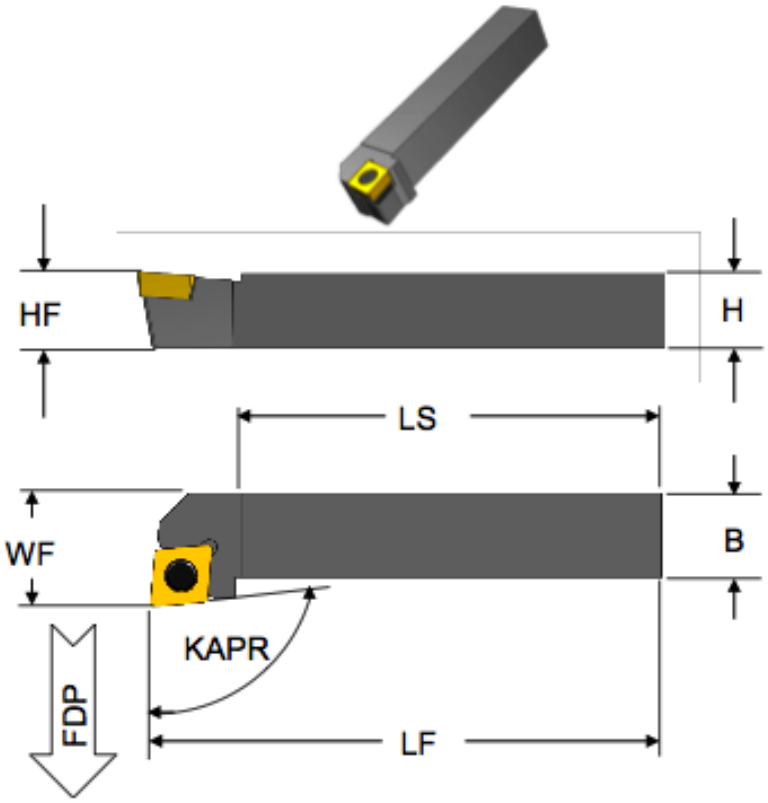


Figure 19: Cutting Tool Measurement Diagram 2

Table 20: Measurement Subtypes for CuttingTool

Measurement Subtype	Code	Description	Units
`BodyDiameterMax`	`BDX`	The largest diameter of the body of a Tool Item.	`MILLIMETER`

Continuation of Table 20			
Measurement Subtype	Code	Description	Units
BodyLengthMax	LBX	The distance measured along the X axis from that point of the item closest to the workpiece, including the Cutting Item for a Tool Item but excluding a protruding locking mechanism for an Adaptive Item, to either the front of the flange on a flanged body or the beginning of the connection interface feature on the machine side for cylindrical or prismatic shanks.	MILLIMETER
DepthOfCutMax	APMX	The maximum engagement of the cutting edge or edges with the workpiece measured perpendicular to the feed motion.	MILLIMETER
CuttingDiameterMax	DC	The maximum diameter of a circle on which the defined point Pk of each of the master inserts is located on a Tool Item. The normal of the machined peripheral surface points towards the axis of the Cutting Tool.	MILLIMETER
FlangeDiameterMax	DF	The dimension between two parallel tangents on the outside edge of a flange.	MILLIMETER
OverallToolLength	OAL	The largest length dimension of the Cutting Tool including the master insert where applicable.	MILLIMETER

Continuation of Table 20			
Measurement Subtype	Code	Description	Units
ShankDiameter	DMM	The dimension of the diameter of a cylindrical portion of a Tool Item or an Adaptive Item that can participate in a connection.	MILLIMETER
ShankHeight	H	The dimension of the height of the shank.	MILLIMETER
ShankLength	LS	The dimension of the length of the shank.	MILLIMETER
UsableLengthMax	LUX	Maximum length of a Cutting Tool that can be used in a particular cutting operation including the non-cutting portions of the tool.	MILLIMETER
ProtrudingLength	LPR	The dimension from the yz-plane to the furthest point of the Tool Item or Adaptive Item measured in the -X direction.	MILLIMETER
Weight	WT	The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.	GRAM

Continuation of Table 20			
Measurement Subtype	Code	Description	Units
FunctionalLength	LF	The distance from the gauge plane or from the end of the shank to the furthest point on the tool, if a gauge plane does not exist, to the cutting reference point determined by the main function of the tool. The CuttingTool functional length will be the length of the entire tool, not a single Cutting Item. Each CuttingItem can have an independent FunctionalLength represented in its measurements.	MILLIMETER

6.2.9 CuttingItems Element for CuttingToolLifeCycle

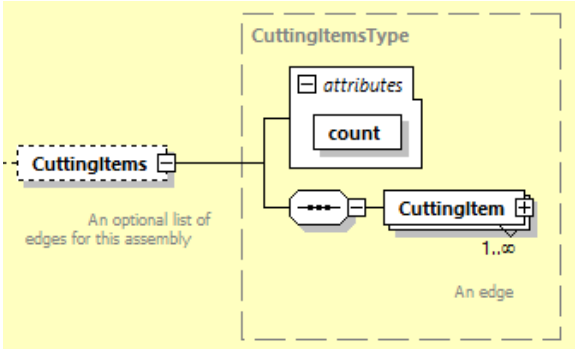


Figure 20: CuttingItems Schema

An optional collection of CuttingItems that **SHOULD** be provided for each independent edge or insert. If the CuttingItems are not present; it indicates there is no specific information with respect to each of the CuttingItems. This does not imply there are no CuttingItems – there **MUST** be at least one CuttingItem – but there is no specific information.

6.2.9.1 Attributes for CuttingItems

Table 21: Attributes for CuttingItems

Attribute	Description	Occurrence
`count`	The number of Cutting Item. `count` is a required attribute.	1

6.2.10 CuttingItem

A `CuttingItem` is the portion of the tool that physically removes the material from the workpiece by shear deformation. The Cutting Item can be either a single piece of material attached to the `CuttingItem` or it can be one or more separate pieces of material attached to the `CuttingItem` using a permanent or removable attachment. A `CuttingItem` can be comprised of one or more cutting edges. `CuttingItems` include: replaceable inserts, brazed tips and the cutting portions of solid `CuttingTools`.

MTConnect Standard considers `CuttingItems` as part of the `CuttingTool`. A `CuttingItems` **MUST NOT** exist in MTConnect unless it is attached to a `CuttingTool`. Some of the measurements, such as `FunctionalLength`, **MUST** be made with reference to the entire `CuttingTool` to be meaningful.

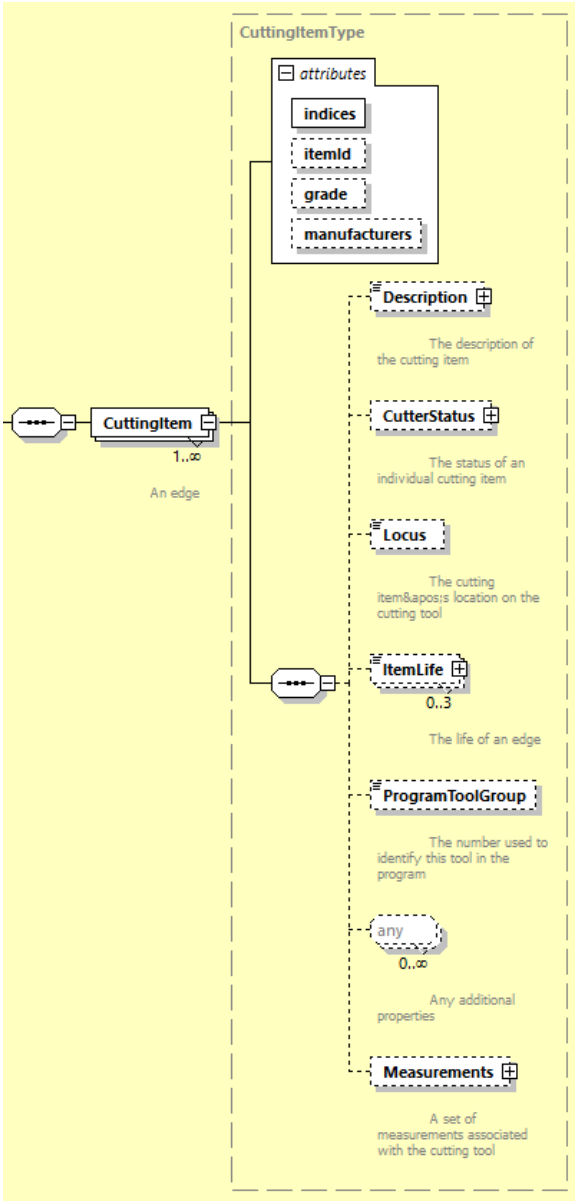


Figure 21: CuttingItem Schema

6.2.10.1 Attributes for CuttingItem

Table 22: Attributes for CuttingItem

Attribute	Description	Occurrence
`indices`	The number or numbers representing the individual Cutting Item or items on the tool. `indices` is a required attribute.	1
`itemId`	The manufacturer identifier of this Cutting Item. `itemId` is an optional attribute.	0..1
`manufacturers`	The manufacturers of the Cutting Item or Tool. `manufacturers` is an optional attribute.	0..1
`grade`	The material composition for this Cutting Item. `grade` is an optional attribute.	0..1

6.2.10.1.1 indices Attribute for CuttingItem

An identifier that indicates the `CuttingItem` or `CuttingItems` these data are associated with. The value **MUST** be a single number ("1") or a comma separated set of individual elements ("1,2,3,4"), or as a inclusive range of values as in ("1-10") or any combination of ranges and numbers as in "1-4,6-10,22". There **MUST NOT** be spaces or non-integer values in the text representation.

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

6.2.10.1.2 itemId Attribute for CuttingItem

The manufactures' identifier for this `CuttingItem` that **MAY** be its catalog or reference number. The value **MUST** be an XML NMTOKEN value of numbers and letters.

6.2.10.1.3 manufacturers Attribute for CuttingItem

This optional element references the manufacturers of this tool. At this level the manufac-

turers will reference the CuttingItem specifically. The representation will be a comma (,) delimited list of manufacturer names. This can be any series of numbers and letters as defined by the XML type string.

6.2.10.1.4 grade Attribute for CuttingItem

This provides an implementation specific designation for the material composition of this CuttingItem.

6.2.10.2 Elements for CuttingItem

Table 23: Elements for CuttingItem

Element	Description	Occurrence
Description	A free-form description of the Cutting Item.	0..1
Locus	A free form description of the location on the Cutting Tool.	0..1
ItemLife	The life of this Cutting Item.	0..3
Measurements	A collection of measurements relating to this Cutting Item.	0..1

6.2.10.2.1 Description Element for CuttingItem

An optional free form text description of this CuttingItem.

6.2.10.2.2 Locus Element for CuttingItem

Locus represents the location of the CuttingItem with respect to the Cutting Tool. For clarity, the words FLUTE, INSERT, and CARTRIDGE **SHOULD** be used to assist in noting the location of a CuttingItem. The Locus **MAY** be any free form text, but **SHOULD** adhere to the following rules:

- The location numbering **SHOULD** start at the furthest CuttingItem (#1) and work it's way back to the Cutting Item closest to the gauge line.
- Flutes **SHOULD** be identified as such using the word FLUTE:. For example: FLUTE:

1, INSERT: 2 - would indicate the first flute and the second furthest insert from the end of the tool on that flute.

- Other designations such as CARTRIDGE **MAY** be included, but should be identified using upper case and followed by a colon (:).

6.2.10.2.3 ItemLife Element for CuttingItem

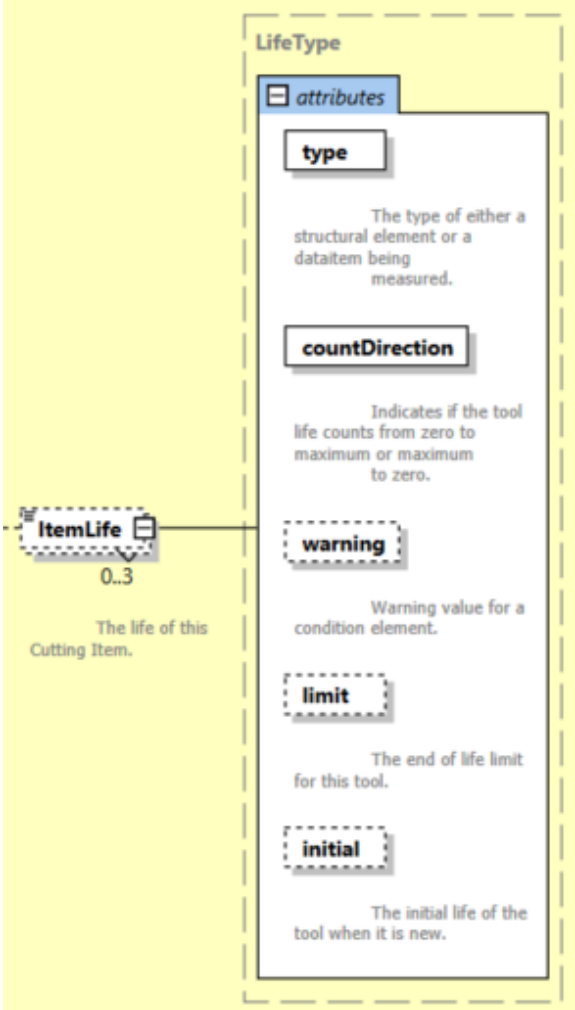


Figure 22: ItemLife Schema

The value is the current value for the ToolLife. The value **MUST** be a number. ToolLife 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.

6.2.10.2.4 Attributes for ItemLife

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

Table 24: Attributes for ItemLife

Attribute	Description	Occurrence
`type`	The type of tool life being accumulated. *Valid Data Values*: `MINUTES`, `PART_COUNT`, or `WEAR`. `type` is a required attribute.	1
`countDirection`	Indicates if the tool life counts from zero to maximum or maximum to zero. The value **MUST** be one of `UP` or `DOWN`. `countDirection` is a required attribute.	1
`warning`	The point at which a tool life warning will be raised. `warning` is an optional attribute.	0..1
`limit`	The end of life limit for this tool. If the `countDirection` is `DOWN`, the point at which this tool should be expired, usually zero. If the `countDirection` is `UP`, this is the upper limit for which this tool should be expired. `limit` is an optional attribute.	0..1
`initial`	The initial life of the tool when it is new. `initial` is an optional attribute.	0..1

6.2.10.2.5 type Attribute for ItemLife

The value of type must be one of the following:

Table 25: Values for type of ItemLife

Value	Description
MINUTES	The tool life measured in minutes. All units for minimum, maximum, and nominal **MUST** be provided in minutes.
PART_COUNT	The tool life measured in parts. All units for minimum, maximum, and nominal **MUST** be provided 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 nominal **MUST** be given as millimeter offsets as well.

6.2.10.2.6 countDirection Attribute for ItemLife

The value of type must be one of the following:

Table 26: Values for countDirection

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

6.2.10.3 Measurement Subtypes for CuttingItem

These Measurements for CuttingItem are specific to an individual glscuttingitem and **MUST NOT** be used for the Measurements pertaining to an assembly. The *Figure 23* , *Figure 24* , *Figure 25* and *Figure 26* will be used to for reference for the CuttingItem specific Measurements .

The Code in *Table 27* will refer to the acronym in the diagram. We will be referring to many diagrams to disambiguate all Measurements of the CuttingTools and CuttingItems. We will present a few here; please refer to Appendix B for additional reference material.

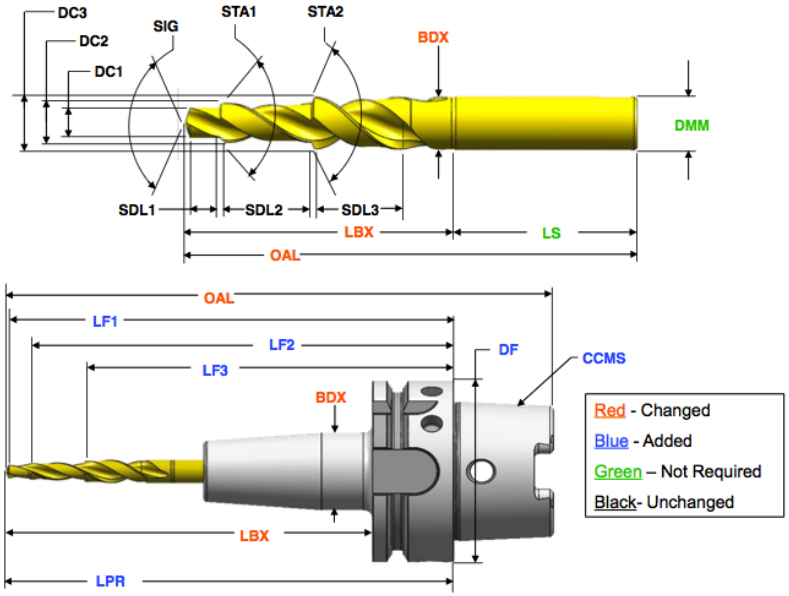


Figure 23: Cutting Tool

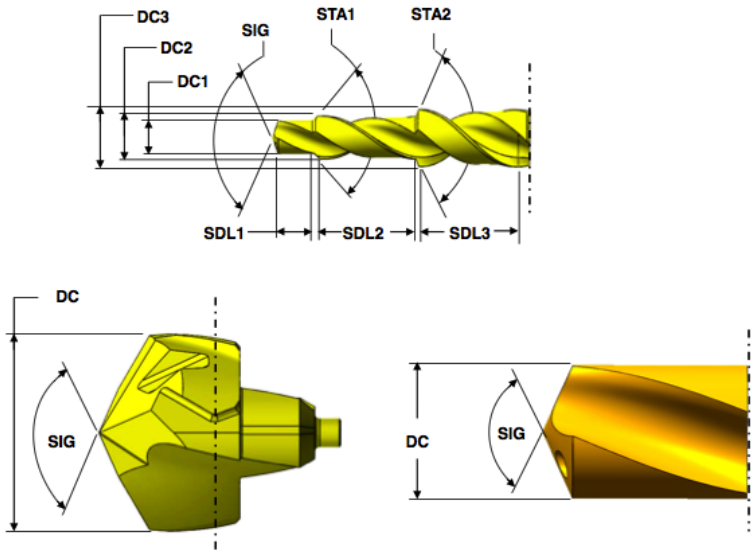


Figure 24: Cutting Item

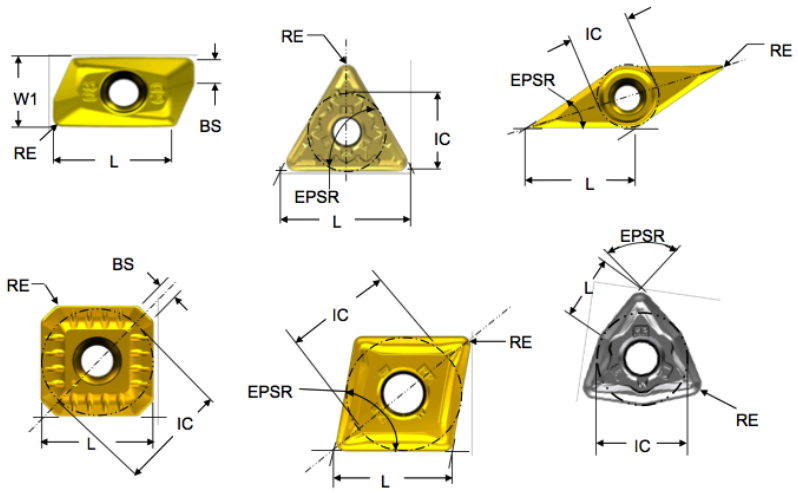


Figure 25: Cutting Item Measurement Diagram 3

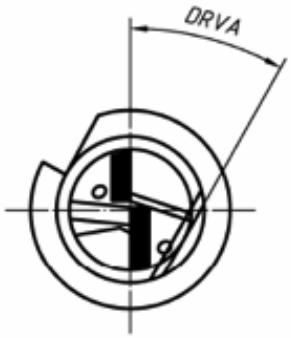


Figure 26: Cutting Item Drive Angle

542 The `CuttingItem Measurements` in *Table 27* will refer the *Figure 23* , *Figure 24* ,
543 *Figure 25* and *Figure 26* .

Table 27: Measurement Subtypes for CuttingItem

Measurement Subtype	Code	Description	Units
`CuttingReferencePoint`	`CRP`	The theoretical sharp point of the Cutting Tool from which the major functional dimensions are taken.	`MILLIMETER`

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
CuttingEdgeLength	L	The theoretical length of the cutting edge of a Cutting Item over sharp corners.	MILLIMETER
DriveAngle	DRVA	Angle between the driving mechanism locator on a Tool Item and the main cutting edge.	DEGREE
FlangeDiameter	DF	The dimension between two parallel tangents on the outside edge of a flange.	MILLIMETER
FunctionalWidth	WF	The distance between the cutting reference point and the rear backing surface of a turning tool or the axis of a boring bar.	MILLIMETER
IncribedCircleDiameter	IC	The diameter of a circle to which all edges of a equilateral and round regular insert are tangential.	MILLIMETER
PointAngle	SIG	The angle between the major cutting edge and the same cutting edge rotated by 180 degrees about the tool axis.	DEGREE
ToolCuttingEdgeAngle	KAPR	The angle between the tool cutting edge plane and the tool feed plane measured in a plane parallel the xy-plane.	DEGREE

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
ToolLeadAngle	PSIR	The angle between the tool cutting edge plane and a plane perpendicular to the tool feed plane measured in a plane parallel the xy-plane.	DEGREE
ToolOrientation	N/A	The angle of the tool with respect to the workpiece for a given process. The value is application specific.	DEGREE
WiperEdgeLength	BS	The measure of the length of a wiper edge of a Cutting Item.	MILLIMETER
StepDiameterLength	SDLx	The length of a portion of a stepped tool that is related to a corresponding cutting diameter measured from the cutting reference point of that cutting diameter to the point on the next cutting edge at which the diameter starts to change.	MILLIMETER
StepIncludedAngle	STAx	The angle between a major edge on a step of a stepped tool and the same cutting edge rotated 180 degrees about its tool axis.	DEGREE

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
CuttingDiameter	DCx	The diameter of a circle on which the defined point Pk located on this Cutting Tool. The normal of the machined peripheral surface points towards the axis of the Cutting Tool.	MILLIMETER
CuttingHeight	HF	The distance from the basal plane of the Tool Item to the cutting point.	MILLIMETER
CornerRadius	RE	The nominal radius of a rounded corner measured in the X Y-plane.	MILLIMETER
Weight	WT	The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.	GRAM
FunctionalLength	LFx	The distance from the gauge plane or from the end of the shank of the Cutting Tool, if a gauge plane does not exist, to the cutting reference point determined by the main function of the tool. This measurement will be with reference to the Cutting Tool and **MUST NOT** exist without a Cutting Tool.	MILLIMETER
ChamferFlatLength	BCH	The flat length of a chamfer.	MILLIMETER
ChamferWidth	CHW	The width of the chamfer.	MILLIMETER

Continuation of Table 27			
Measurement Subtype	Code	Description	Units
InsertWidth	W1	W1 is used for the insert width when an inscribed circle diameter is not practical.	MILLIMETER

Appendices

A Bibliography

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

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

International Organization for Standardization. *ISO 14649:* Industrial automation systems and integration – Physical device control – Data model for computerized numerical controllers – Part 10: General process data. Geneva, Switzerland, 2004.

International Organization for Standardization. *ISO 14649:* Industrial automation systems and integration – Physical device control – Data model for computerized numerical controllers – Part 11: Process data for milling. Geneva, Switzerland, 2000.

International Organization for Standardization. *ISO 6983/1* – Numerical Control of machines – Program format and definition of address words – Part 1: Data format for positioning, line and contouring control systems. Geneva, Switzerland, 1982.

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

National Aerospace Standard. *Uniform Cutting Tests* - NAS Series: Metal Cutting Equipment Specifications. Washington, D.C. 1969.

International Organization for Standardization. *ISO 10303-11:* 1994, Industrial automation systems and integration Product data representation and exchange Part 11: Description methods: The EXPRESS language reference manual. Geneva, Switzerland, 1994.

International Organization for Standardization. *ISO 10303-21:* 1996, Industrial automation systems and integration – Product data representation and exchange – Part 21: Implementation methods: Clear text encoding of the exchange structure. Geneva, Switzerland, 1996.

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

New York, 1984.

International Organization for Standardization. *ISO 841-2001:* Industrial automation systems and integration - Numerical control of machines - Coordinate systems and motion nomenclature. Geneva, Switzerland, 2001.

ASME B5.59-2 Version 9c: Data Specification for Properties of Machine Tools for Milling and Turning. 2005.

ASME/ANSI B5.54: Methods for Performance Evaluation of Computer Numerically Controlled Machining Centers. 2005.

OPC Foundation. *OPC Unified Architecture Specification, Part 1: Concepts Version 1.00.* July 28, 2006.

International Organization for Standardization. *ISO 13399: Cutting tool data representation and exchange*. Geneva, Switzerland, 2000.

B Additional Illustrations

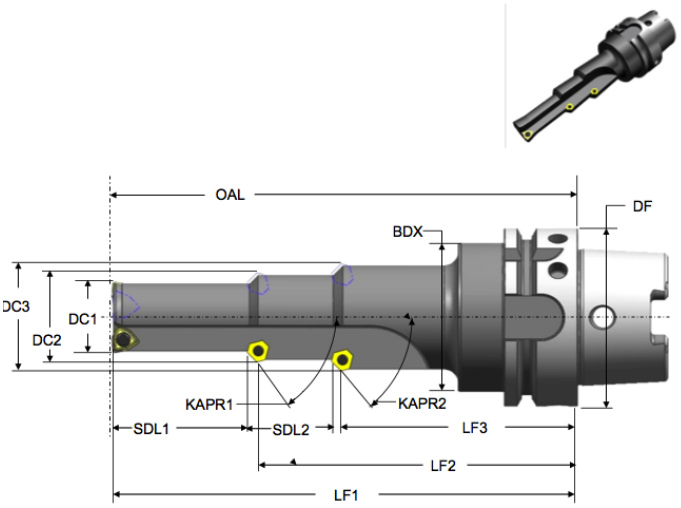


Figure 27: Cutting Tool Measurement Diagram 1
(Cutting Tool, Cutting Item, and Assembly Item – ISO 13399)

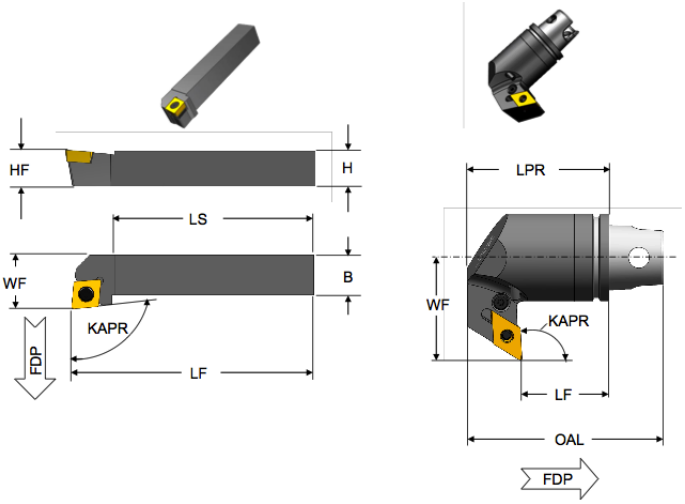


Figure 28: Cutting Tool Measurement Diagram 2
(Cutting Tool, Cutting Item, and Assembly Item – ISO 13399)

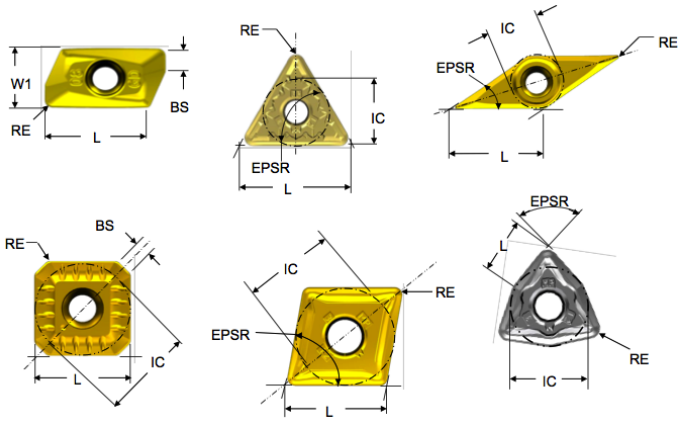


Figure 29: Cutting Tool Measurement Diagram 3
(Cutting Item – ISO 13399)

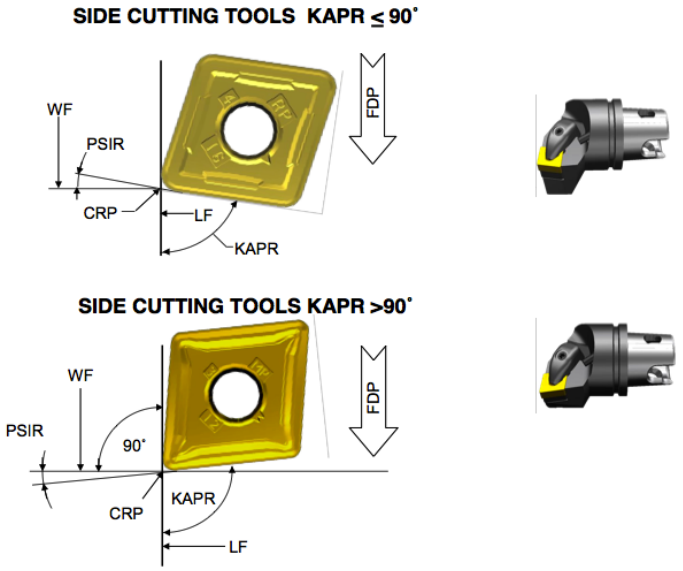


Figure 30: Cutting Tool Measurement Diagram 4
(Cutting Item – ISO 13399)

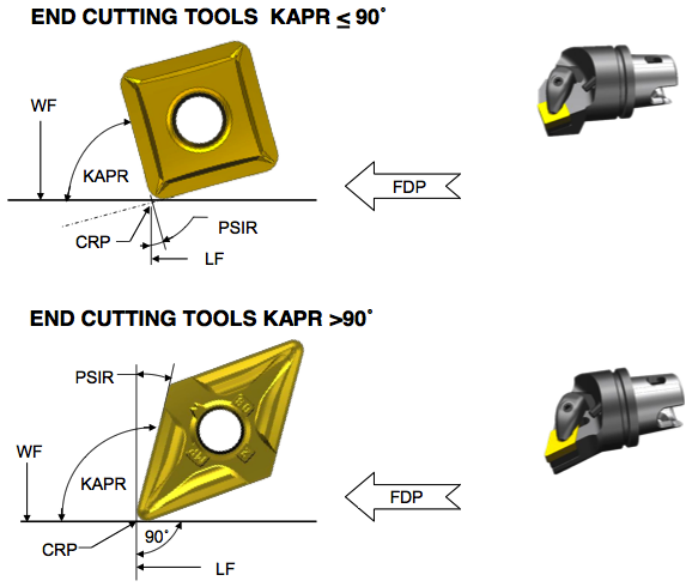


Figure 31: Cutting Tool Measurement Diagram 5
(Cutting Item – ISO 13399)

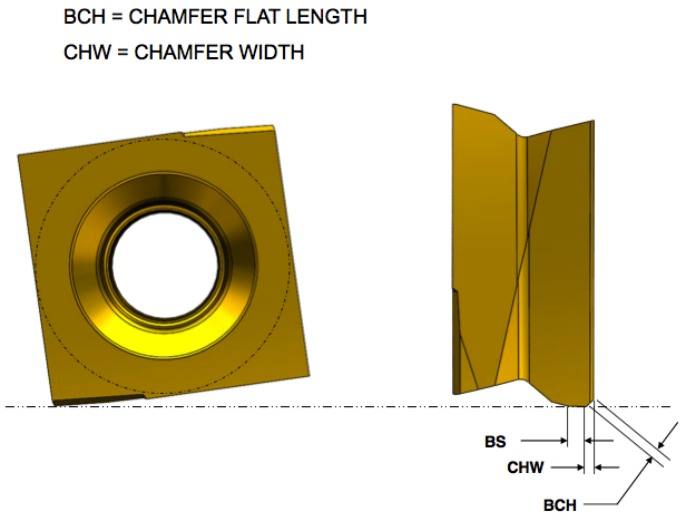


Figure 32: Cutting Tool Measurement Diagram 6
(Cutting Item – ISO 13399)

C Cutting Tool Example

C.1 Shell Mill

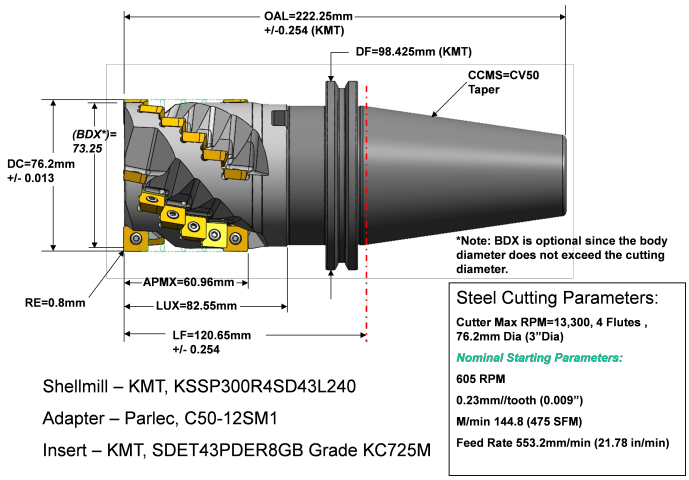


Figure 33: Shell Mill Side View

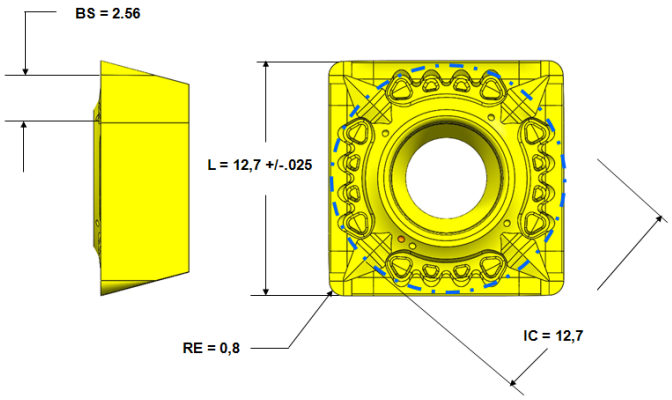


Figure 34: Indexable Insert Measurements

Example 1: Example for Indexable Insert Measurements

```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <MTConnectAssets
3 xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
4 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
5 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
6 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
7 http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
8   <Header creationTime="2011-05-11T13:55:22"
9   assetBufferSize="1024" sender="localhost"
```

```
599  10    assetCount="2" version="1.2" instanceId="1234"/>
600  11    <Assets>
601  12    <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
602  13    timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
603  14    manufacturers="KMT,Parlec">
604  15      <CuttingToolLifeCycle>
605  16      <CutterStatus><Status>NEW</Status></CutterStatus>
606  17      <ProcessSpindleSpeed maximum="13300"
607  18      nominal="605">10000</ProcessSpindleSpeed>
608  19      <ProcessFeedRate
609  20      nominal="9.22">9.22</ProcessSpindleSpeed>
610  21      <ConnectionCodeMachineSide>CV50
611  22      </ConnectionCodeMachineSide>
612  23      <Measurements>
613  24        <BodyDiameterMax code="BDX">73.25
614  25        </BodyDiameterMax>
615  26        <OverallToolLength nominal="222.25"
616  27          minimum="221.996" maximum="222.504"
617  28          code="OAL">222.25</OverallToolLength>
618  29        <UsableLengthMax code="LUX" nominal="82.55">82.55
619  30        </UsableLengthMax>
620  31        <CuttingDiameterMax code="DC" nominal="76.2"
621  32          maximum="76.213" minimum="76.187">76.2
622  33        </CuttingDiameterMax>
623  34        <BodyLengthMax code="LF" nominal="120.65"
624  35          maximum="120.904" minimum="120.404">120.65
625  36        </BodyLengthMax>
626  37        <DepthOfCutMax code="APMX"
627  38        nominal="60.96">60.95</DepthOfCutMax>
628  39        <FlangeDiameterMax code="DF"
629  40          nominal="98.425">98.425</FlangeDiameterMax>
630  41      </Measurements>
631  42      <CuttingItems count="24">
632  43        <CuttingItem indices="1-24" itemId="SDET43PDER8GB"
633  44          manufacturers="KMT" grade="KC725M">
634  45          <Measurements>
635  46            <CuttingEdgeLength code="L" nominal="12.7"
636  47              minimum="12.675" maximum="12.725">12.7
637  48            </CuttingEdgeLength>
638  49          <WiperEdgeLength code="BS" nominal=
639  50            "2.56">2.56</WiperEdgeLength>
640  51          <IncribedCircleDiameter code="IC"
641  52            nominal="12.7">12.7
642  53          </IncribedCircleDiameter>
643  54          <CornerRadius code="RE" nominal="0.8">
644  55            0.8</CornerRadius>
645  56        </Measurements>
646  57        </CuttingItem>
647  58      </CuttingItems>
648  59      </CuttingToolLifeCycle>
649  60      </CuttingTool>
```

```
650  61    </Assets>
651  62  </MTConnectAssets>
```

C.2 Step Drill

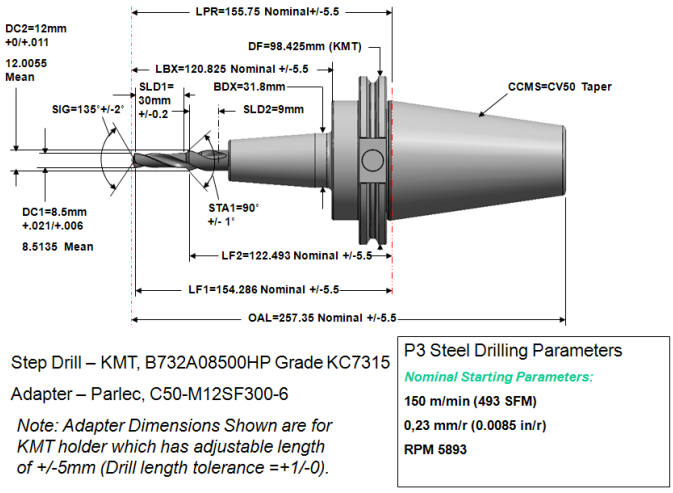


Figure 35: Step Mill Side View

Example 2: Example for Step Mill Side View

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
3  xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
4  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
5  xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
6  http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
7    <Header creationTime="2011-05-
8  ␣␣11T13:55:22" assetBufferSize="1024"
9    sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
10   <Assets>
11     <CuttingTool serialNumber="1␣" toolId="B732A08500HP"
12     timestamp="2011-05-11T13:55:22" assetId="B732A08500HP␣"
13     manufacturers="KMT,Parlec">
14       <Description>
15         Step Drill - KMT, B732A08500HP Grade KC7315
16         Adapter - Parlec, C50-M12SF300-6
17       </Description>
18       <CuttingToolLifeCycle>
19         <CutterStatus><Status>NEW</Status></CutterStatus>
20         <ProcessSpindleSpeed nominal="5893">5893</ProcessSpindleSpeed>
21         <ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
22         <ConnectionCodeMachineSide>CV50 Taper</ConnectionCodeMachineSide>
23         <Measurements>
24           <BodyDiameterMax code="BDX">31.8</BodyDiameterMax>
25           <BodyLengthMax code="LBX" nominal="120.825" maximum="126.325"
26           minimum="115.325">120.825</BodyLengthMax>
27           <ProtrudingLength code="LPR" nominal="155.75" maximum="161.25"
28           minimum="150.26">155.75</ProtrudingLength>
```

```
681  29            <FlangeDiameterMax code="DF"
682  30            nominal="98.425">98.425</FlangeDiameterMax>
683  31            <OverallToolLength nominal="257.35" minimum="251.85"
684  32            maximum="262.85" code="OAL">257.35</OverallToolLength>
685  33          </Measurements>
686  34          <CuttingItems count="2">
687  35            <CuttingItem indices="1" manufacturers="KMT" grade="KC7315">>
688  36              <Measurements>
689  37                <CuttingDiameter code="DC1" nominal="8.5" maximum="8.521"
690  38                minimum="8.506">8.5135</CuttingDiameter>
691  39                <StepIncludedAngle code="STA1" nominal="90" maximum="91"
692  40                minimum="89">90</StepIncludedAngle>
693  41                <FunctionalLength code="LF1" nominal="154.286"
694  42                minimum="148.786"
695  43                maximum="159.786">154.286</FunctionalLength>
696  44                <StepDiameterLength code="SDL1"
697  45                nominal="9">9</StepDiameterLength>
698  46                <PointAngle code="SIG" nominal="135" minimum="133"
699  47                maximum="137">135</PointAngle>
700  48              </Measurements>
701  49            </CuttingItem>
702  50            <CuttingItem indices="2" manufacturers="KMT" grade="KC7315">>
703  51              <Measurements>
704  52                <CuttingDiameter code="DC2" nominal="12" maximum="12.011"
705  53                minimum="12">12</CuttingDiameter>
706  54                <FunctionalLength code="LF2" nominal="122.493"
707  55                maximum="127.993"
708  56                minimum="116.993">122.493</FunctionalLength>
709  57                <StepDiameterLength code="SDL2"
710  58                nominal="9">9</StepDiameterLength>
711  59              </Measurements>
712  60            </CuttingItem>
713  61          </CuttingItems>
714  62        </CuttingToolLifeCycle>
715  63      </CuttingTool>
716  64    </Assets>
717  65  </MTConnectAssets>
```

C.3 Shell Mill with Individual Loci

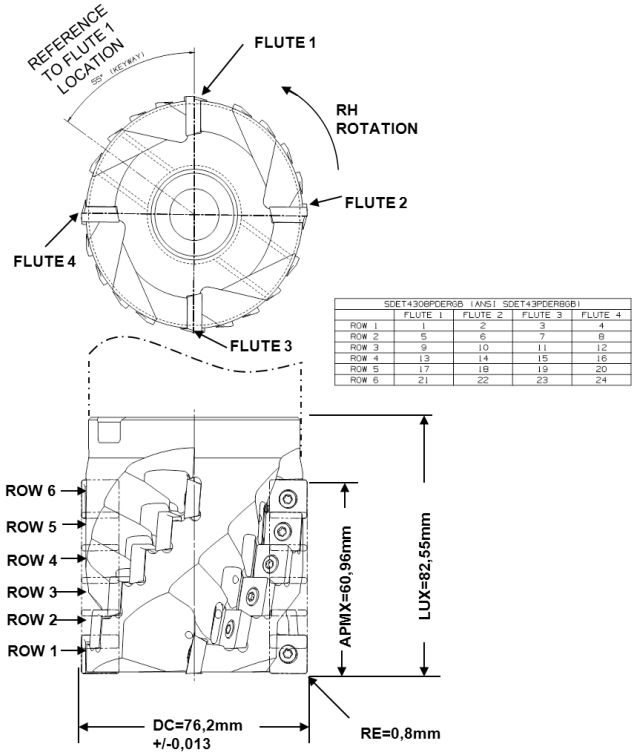


Figure 36: Shell Mill with Explicate Loci

Example 3: Example for Shell Mill with Explicate Loci

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
3  xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
4  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
5  xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
6  http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
7    <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
8    sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
9    <Assets>
10     <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
11     timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
12     manufacturers="KMT,Parlec">
13       <Description>Keyway: 55 degrees</Description>
14       <CuttingToolLifeCycle>
15         <CutterStatus><Status>NEW</Status></CutterStatus>
16         <Measurements>
17           <UsableLengthMax code="LUX"
18           nominal="82.55">82.55</UsableLengthMax>
19           <CuttingDiameterMax code="DC" nominal="76.2" maximum="76.213"
```

```
738  20          minimum="76.187">76.2</CuttingDiameterMax>
739  21          <DepthOfCutMax code="APMX" nominal="60.96">60.95</DepthOfCutMax>
740  22        </Measurements>
741  23        <CuttingItems count="24">
742  24          <CuttingItem indices="1" itemId="SDET43PDER8GB"
743  25          manufacturers="KMT">
744  26            <Locus>FLUTE: 1, ROW: 1</Locus>
745  27            <Measurements>
746  28             <DriveAngle code="DRVA" nominal="55">55</DriveAngle>
747  29            </Measurements>
748  30          </CuttingItem>
749  31          <CuttingItem indices="2-24" itemId="SDET43PDER8GB"
750  32          manufacturers="KMT">
751  33            <Locus>FLUTE: 2-4, ROW: 1; FLUTE: 1-4, ROW 2-6</Locus>
752  34          </CuttingItem>
753  35        </CuttingItems>
754  36      </CuttingToolLifeCycle>
755  37    </CuttingTool>
756  38  </Assets>
757  39 </MTConnectAssets>
```

C.4 Drill with Individual Loci

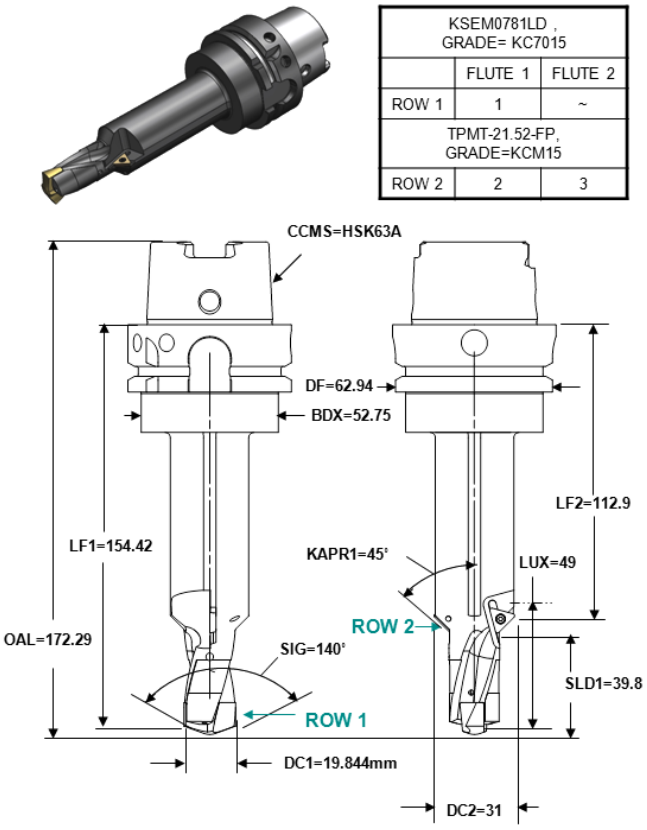


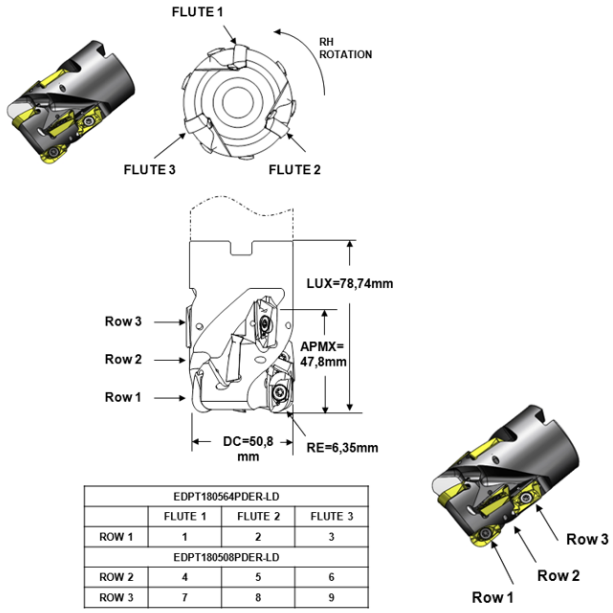
Figure 37: Step Drill with Explicate Loci

Example 4: Example for Step Drill with Explicate Loci

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
3  xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
4  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
5  xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
6  http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
7    <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
8    sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
9    <Assets>
10     <CuttingTool serialNumber="1" toolId="KSEM0781LD"
11     timestamp="2011-05-11T13:55:22" assetId="KSEM0781LD.1" manufacturers="KMT">
12       <CuttingToolLifeCycle>
13         <CutterStatus><Status>NEW</Status></CutterStatus>
14         <ConnectionCodeMachineSide>HSK63A</ConnectionCodeMachineSide>
15         <Measurements>
16           <BodyDiameterMax code="BDX">52.75</BodyDiameterMax>
17           <OverallToolLength nominal="172.29"
```

```
776  18            code="OAL">172.29</OverallToolLength>
777  19            <UsableLengthMax code="LUX" nominal="49">49</UsableLengthMax>
778  20            <FlangeDiameterMax code="DF"
779  21            nominal="62.94">62.94</FlangeDiameterMax>
780  22          </Measurements>
781  23          <CuttingItems count="3">
782  24            <CuttingItem indices="1" itemId="KSEM0781LD" manufacturers="KMT"
783  25            grade="KC7015">
784  26              <Locus>FLUTE: 1, ROW: 1</Locus>
785  27              <Measurements>
786  28           <FunctionalLength code="LF1" nominal="154.42">154.42</FunctionalLength>
787  29           <CuttingDiameter code="DC1" nominal="19.844">19.844</CuttingDiameter>
788  30           <PointAngle code="SIG" nominal="140">140</PointAngle>
789  31           <ToolCuttingEdgeAngle code="KAPR1" nominal="45">45</ToolCuttingEdgeAngle>
790  32           <StepDiameterLength code="SLD1" nominal="39.8">39.8</StepDiameterLength>
791  33              </Measurements>
792  34            </CuttingItem>
793  35            <CuttingItem indices="2-3" itemId="TPMT-21.52-FP"
794  36            manufacturers="KMT" grade="KCM15">
795  37              <Locus>FLUTE: 1-2, ROW: 2</Locus>
796  38              <Measurements>
797  39           <FunctionalLength code="LF2" nominal="112.9">119.2</FunctionalLength>
798  40           <CuttingDiameter code="DC2" nominal="31">31</CuttingDiameter>
799  41              </Measurements>
800  42            </CuttingItem>
801  43          </CuttingItems>
802  44        </CuttingToolLifeCycle>
803  45      </CuttingTool>
804  46    </Assets>
805  47  </MTConnectAssets>
```

C.5 Shell Mill with Different Inserts on First Row



EDPT180564PDER-LD			
	FLUTE 1	FLUTE 2	FLUTE 3
ROW 1	1	2	3
EDPT180508PDER-LD			
ROW 2	4	5	6
ROW 3	7	8	9

Figure 38: Shell Mill with Different Inserts on First Row

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

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
3  xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
4  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
5  xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
6  http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
7    <Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024"
8    sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
9    <Assets>
10     <CuttingTool serialNumber="1" toolId="XXX" timestamp="2011-05-11T13:55:22"
11     assetId="XXX.1" manufacturers="KMT">
12       <CuttingToolLifeCycle>
13         <CutterStatus><Status>NEW</Status></CutterStatus>
14         <Measurements>
15           <DepthOfCutMax code="APMX" nominal="47.8">47.8</DepthOfCutMax>
16           <CuttingDiameterMax code="DC"
17           nominal="50.8">50.8</CuttingDiameterMax>
18           <UsableLengthMax code="LUX"
19           nominal="78.74">78.74</UsableLengthMax>
20         </Measurements>
21         <CuttingItems count="9">
22           <CuttingItem indices="1-3" itemId="EDPT180564PDER-LD"
23           manufacturers="KMT">
24             <Locus>FLUTE: 1-3, ROW: 1</Locus>
```

```
831  25              <Measurements>
832  26                <CornerRadius code="RE" nominal="6.25">6.35</CornerRadius>
833  27              </Measurements>
834  28            </CuttingItem>
835  29            <CuttingItem indices="4-9" itemId="EDPT180508PDER-LD"
836  30            manufacturers="KMT">
837  31              <Locus>FLANGE: 1-4, ROW: 2-3</Locus>
838  32            </CuttingItem>
839  33          </CuttingItems>
840  34        </CuttingToolLifeCycle>
841  35      </CuttingTool>
842  36    </Assets>
843  37  </MTConnectAssets>
```