MTConnect® Standard
Part 4.1 – Cutting Tools
Version 1.7.0

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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 \textit{Response Document} that is constructed using the \textit{semantic data models} defined in the Standard. Appears in the documents in the following form: \textit{Agent}

\textbf{Asset}  

item, thing or entity that has potential or actual value to an organization \textit{Ref:ISO 55000:2014(en)}

Note 1 to entry: Value can be tangible or intangible, financial or non-financial, and includes consideration of risks and liabilities. It can be positive or negative at different stages of the asset life.

Note 2 to entry: Physical assets usually refer to equipment, inventory and properties owned by the organization. Physical assets are the opposite of intangible assets, which are non-physical assets such as leases, brands, digital assets, use rights, licences, intellectual property rights, reputation or agreements.

Note 3 to entry: A grouping of assets referred to as an asset system could also be considered as an asset.

\textbf{Attribute}  

A term that is used to provide additional information or properties for an element. Appears in the documents in the following form: \textit{attribute}.

\textbf{Child Element}  

A portion of a data modeling structure that illustrates the relationship between an element and the higher-level \textit{Parent Element} within which it is contained. Appears in the documents in the following form: \textit{Child Element}

\textbf{Component}  

General meaning:

A \textit{Structural Element} that represents a physical or logical part or subpart of a piece of equipment. Appears in the documents in the following form: \textit{Component}

\textit{Used in} \textit{Information Models}

A data modeling element used to organize the data being retrieved from a piece of equipment.
• When used as an XML container to organize `Lower Level` elements.
  Appears in the documents in the following form: Components.

• When used as an abstract XML element. Component is replaced in a data model by a type of `Component` element. Component is also an XML container used to organize `Lower Level` Component elements, [Data Entities] or both.
  Appears in the documents in the following form: Component.

**Current Request**

A [Current Request] is a [Request] to an [Agent] to produce an [MTConnectStreams Response Document] containing the [Observations Information Model] for a snapshot of the latest observations at the moment of the [Request] or at a given [sequence number].

**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].

**Devices Information Model**

A set of rules and terms that describes the physical and logical configuration for a piece of equipment and the data that may be reported by that equipment.
  Appears in the documents in the following form: [Devices Information Model].

**Equipment Metadata**

See [Metadata]

**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].

**Lower Level**

A nested element that is below a higher level element.
Metadata

Data that provides information about other data.

For example, Equipment Metadata defines both the Structural Elements that represent the physical and logical parts and sub-parts of each piece of equipment, the relationships between those parts and sub-parts, and the definitions of the Data Entities associated with that piece of equipment.

Appears in the documents in the following form: Metadata or Equipment Metadata.

MTConnect Agent

See definition for Agent.

MTConnect Asset

An MTConnect Asset is an Asset used by the manufacturing process to perform tasks.

Note 1 to entry: An MTConnect Asset relies upon an MTConnect Device to provide observations and information about itself and the MTConnect Device revises the information to reflect changes to the MTConnect Asset during their interaction. Examples of MTConnect Assets are Cutting Tools, Part Information, Manufacturing Processes, Fixtures, and Files.

Note 2 to entry: A singular assetId uniquely identifies an MTConnect Asset throughout its lifecycle and is used to track and relate the MTConnect Asset to other MTConnect Devices and entities.

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

MTConnect Device

An MTConnect Device is a piece of equipment or a manufacturing system that produces observations about itself and/or publishes data using the MTConnect Information Model.

MTConnect Information Model

See Information Model.

MTConnectDevices Response Document

A Response Document published by an MTConnect Agent in response to a Probe Request.
MTConnectStreams Response Document

A Response Document published by an MTConnect Agent in response to a Current Request or a Sample Request.

observation

The observed value of a property at a point in time.

Observations Information Model

An Information Model that describes the Streaming Data reported by a piece of equipment.

Parent Element

An XML element used to organize Lower Level child elements that share a common relationship to the Parent Element. Appears in the documents in the following form: Parent Element.

Probe Request

A Probe Request is a Request to an Agent to produce an MTConnectDevices Response Document containing the Devices Information Model.

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

An electronic document published by an MTConnect Agent in response to a Probe Request, Current Request, Sample Request, or Asset Request.

Sample Request

A Sample Request is a Request to an Agent to produce an MTConnectStreams Response Document containing the Observations Information Model for a set of timestamped observations made by Components.

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.
sequence number

The primary key identifier used to manage and locate a specific piece of Streaming Data in an Agent.

sequence number is a monotonically increasing number within an instance of an Agent.

Appears in the documents in the following form: sequence number.

Spindle

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

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

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.

Structural Element

General meaning:

An XML element that organizes information that represents the physical and logical parts and sub-parts of a piece of equipment.

Appears in the documents in the following form: Structural Element.

Used to indicate hierarchy of Components:

When used to describe a primary physical or logical construct within a piece of equipment.

Appears in the documents in the following form: Top Level Structural Element.

When used to indicate a Child Element which provides additional detail describing the physical or logical structure of a Top Level Structural Element.

Appears in the documents in the following form: Lower Level Structural Element.

Top Level

Structural Elements that represent the most significant physical or logical functions of a piece of equipment.

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).
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

3 Cutting Tool and Cutting Tool Archetype

There are two Information Models used to represent a cutting tool, CuttingToolArchetype and CuttingTool. The CuttingToolArchetype represents 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 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>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>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.</td>
<td>1</td>
</tr>
<tr>
<td>assetId</td>
<td>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.</td>
<td>1</td>
</tr>
<tr>
<td>serialNumber</td>
<td>The unique identifier for this assembly. This is defined as an XML string type and is implementation dependent. serialNumber is a required attribute.</td>
<td>1</td>
</tr>
<tr>
<td>Attribute</td>
<td>Description</td>
<td>Occurrence</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>toolId</td>
<td>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.</td>
<td>1</td>
</tr>
<tr>
<td>deviceUuid</td>
<td>A reference to the Device’s uuid that created the Asset information. The deviceUuid MUST be an NMTOKEN XML type.</td>
<td>1</td>
</tr>
<tr>
<td>manufacturers</td>
<td>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.</td>
<td>0..1</td>
</tr>
<tr>
<td>removed</td>
<td>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.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
3.3 Common Elements for CuttingTool and CuttingToolArchetype

Table 2: Common Elements for CuttingTool and CuttingToolArchetype

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>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.</td>
<td>0..1</td>
</tr>
</tbody>
</table>

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.
The 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.

The Figure 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.
Reference ISO13399

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

Reference ISO13399

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](image)

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](image)

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

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>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.</td>
<td>0..1</td>
</tr>
<tr>
<td>CuttingToolDefinition</td>
<td>Reference to an ISO 13399.</td>
<td>0..1</td>
</tr>
<tr>
<td>CuttingToolLifeCycle</td>
<td>Data regarding the use of this tool. The archetype will only contain nominal values.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
4.2.1 CuttingToolDefinition Element for CuttingToolArchetype

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

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>format</td>
<td>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.</td>
<td>0..1</td>
</tr>
</tbody>
</table>

4.2.1.1.1 format Attribute for CuttingToolDefinition

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XML</td>
<td>The default value for the definition. The content will be an XML document.</td>
</tr>
<tr>
<td>EXPRESS</td>
<td>The document will confirm to the ISO 10303 Part 21 standard.</td>
</tr>
<tr>
<td>TEXT</td>
<td>The document will be a text representation of the tool data.</td>
</tr>
<tr>
<td>UNDEFINED</td>
<td>The document will be provided in an undefined format.</td>
</tr>
</tbody>
</table>

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 7 has the identical structure as the CuttingToolArchetype [Information Model] except for the XML element CuttingToolDefinition that has been DEPRECATED in the Cutting-Tool 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>
<thead>
<tr>
<th>Table 6: Elements for CuttingTool</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Element</strong></td>
</tr>
<tr>
<td>Description</td>
</tr>
<tr>
<td>CuttingToolDefinition</td>
</tr>
</tbody>
</table>
Continuation of Table 6

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuttingToolLifeCycle</td>
<td>Data regarding the use of this tool.</td>
<td>0..1</td>
</tr>
<tr>
<td>CuttingToolArchetypeReference</td>
<td>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.</td>
<td>0..1</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td>The status of the Cutting Tool. There can be multiple Status elements.</td>
<td>1..*</td>
</tr>
</tbody>
</table>

**5.2.1.1 Status Element for CutterStatus**

One of the values for the status of the **CuttingTool**.

**Table 8: Values for Status Element of CutterStatus**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW</td>
<td>A new tool that has not been used or first use. Marks the start of the tool history.</td>
</tr>
<tr>
<td>AVAILABLE</td>
<td>Indicates the tool is available for use. If this is not present, the tool is currently not ready to be used.</td>
</tr>
<tr>
<td>UNAVAILABLE</td>
<td>Indicates the tool is unavailable for use in metal removal. If this is not present, the tool is currently not ready to be used.</td>
</tr>
<tr>
<td>Value</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ALLOCATED</td>
<td>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.</td>
</tr>
<tr>
<td>UNALLOCATED</td>
<td>Indicates this Cutting Tool has not been committed to a process and can be allocated.</td>
</tr>
<tr>
<td>MEASURED</td>
<td>The tool has been measured.</td>
</tr>
<tr>
<td>RECONDITIONED</td>
<td>The Cutting Tool has been reconditioned. See <code>ReconditionCount</code> for the number of times this cutter has been reconditioned.</td>
</tr>
<tr>
<td>USED</td>
<td>The Cutting Tool is in process and has remaining tool life.</td>
</tr>
<tr>
<td>EXPIRED</td>
<td>The Cutting Tool has reached the end of its useful life.</td>
</tr>
<tr>
<td>BROKEN</td>
<td>Premature tool failure.</td>
</tr>
<tr>
<td>NOT_REGISTERED</td>
<td>This Cutting Tool cannot be used until it is entered into the system.</td>
</tr>
<tr>
<td>UNKNOWN</td>
<td>The Cutting Tool is an indeterminate state. This is the default value.</td>
</tr>
</tbody>
</table>
5.2.1.2 ToolLife Element for CuttingToolLifeCycle

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**

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

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINUTES</td>
<td>The tool life measured in minutes. All units for minimum, maximum, and nominal MUST be provided in minutes.</td>
</tr>
<tr>
<td>PART_COUNT</td>
<td>The tool life measured in parts. All units for minimum, maximum, and nominal MUST be provided as the number of parts.</td>
</tr>
<tr>
<td>WEAR</td>
<td>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.</td>
</tr>
</tbody>
</table>

5.2.1.2.3 countDirection Attribute for ToolLife

The value of countDirection must be one of the following:

Table 11: Values for countDirection

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UP</td>
<td>The tool life counts up from zero to the maximum.</td>
</tr>
<tr>
<td>DOWN</td>
<td>The tool life counts down from the maximum to zero.</td>
</tr>
</tbody>
</table>

5.2.1.3 Location Element for CuttingToolLifeCycle
Location element identifies the specific location where a tool resides in a piece of equipment 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

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>type</td>
<td>The type of location being identified. type <strong>MUST</strong> be one of POT, STATION, CRIB, SPINDLE, TRANSFER_POT, RETURN_POT, STAGING_POT, REMOVAL_POT, EXPIRED_POT, or END_EFFECTOR. type is a required attribute.</td>
<td>1</td>
</tr>
<tr>
<td>positiveOverlap</td>
<td>The number of locations at higher index value from this location. positiveOverlap is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>negativeOverlap</td>
<td>The number of locations at lower index values from this location. negativeOverlap is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>turret</td>
<td>The turret associated with a tool. turret <strong>MUST</strong> be an XML NMTOKEN type.</td>
<td>0..1</td>
</tr>
<tr>
<td>toolMagazine</td>
<td>The tool magazine associated with a tool. toolMagazine <strong>MUST</strong> be an XML NMTOKEN type.</td>
<td>0..1</td>
</tr>
<tr>
<td>toolBar</td>
<td>The tool bar associated with a tool. toolBar <strong>MUST</strong> be an XML NMTOKEN type.</td>
<td>0..1</td>
</tr>
<tr>
<td>toolRack</td>
<td>The tool rack associated with a tool. toolRack <strong>MUST</strong> be an XML NMTOKEN type.</td>
<td>0..1</td>
</tr>
<tr>
<td>automaticToolChanger</td>
<td>The automatic tool changer associated with a tool. automaticToolChanger <strong>MUST</strong> be an XML NMTOKEN type.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
5.2.1.3.2 type Attribute for Location

The type of location being identified.

Table 13: Values for type of Location

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>POT</td>
<td>A location in a tool magazine.</td>
</tr>
<tr>
<td>STATION</td>
<td>A location in a turret, tool bar, or tool rack.</td>
</tr>
<tr>
<td>CRIB</td>
<td>A location within a tool crib.</td>
</tr>
<tr>
<td>SPINDLE</td>
<td>A location associated with a Spindle.</td>
</tr>
<tr>
<td>TRANSFER_POT</td>
<td>A location for a tool awaiting transfer from a tool magazine to spindle or a turret.</td>
</tr>
<tr>
<td>RETURN_POT</td>
<td>A location for a tool removed from a Spindle or turret and awaiting return to a tool magazine.</td>
</tr>
<tr>
<td>STAGING_POT</td>
<td>A location for a tool awaiting transfer to a tool magazine or turret from outside of the piece of equipment.</td>
</tr>
<tr>
<td>REMOVAL_POT</td>
<td>A location for a tool removed from a tool magazine or turret awaiting transfer to a location outside of the piece of equipment.</td>
</tr>
<tr>
<td>EXPIRED_POT</td>
<td>A location for a tool that is no longer useable and is awaiting removal from a tool magazine or turret.</td>
</tr>
<tr>
<td>END_EFFECTOR</td>
<td>A location associated with an end effector.</td>
</tr>
</tbody>
</table>

5.2.1.3.3 positiveOverlap 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

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximumCount</td>
<td>The maximum number of times this tool may be reconditioned. maximumCount is a optional attribute.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
5.2.2 CuttingToolArchetypeReference Element for Cutting Tool

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

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>source</td>
<td>The URL of the CuttingToolArchetype Information Model. This MUST be a fully qualified URL as in <a href="http://example.com/asset/A213155">http://example.com/asset/A213155</a></td>
<td>0..1</td>
</tr>
</tbody>
</table>
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 [4] 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>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>CutterStatus</td>
<td>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 <strong>Information</strong> Model.</td>
<td>1</td>
</tr>
<tr>
<td>ReconditionCount</td>
<td>The number of times this cutter has been reconditioned. MUST only be used in the CuttingTool <strong>Information</strong> Model</td>
<td>0..1</td>
</tr>
<tr>
<td>ToolLife</td>
<td>The Cutting Tool life as related to this assembly. MUST only be used in the CuttingTool <strong>Information</strong> Model</td>
<td>0..1</td>
</tr>
<tr>
<td>Location</td>
<td>The Pot or Spindle this tool currently resides in. MUST only be used in the CuttingTool <strong>Information</strong> Model</td>
<td>0..1</td>
</tr>
<tr>
<td>Element</td>
<td>Description</td>
<td>Occurrence</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>ProgramToolGroup</td>
<td>The tool group this tool is assigned in the part program.</td>
<td>0..1</td>
</tr>
<tr>
<td>ProgramToolNumber</td>
<td>The number of the tool as referenced in the part program.</td>
<td>0..1</td>
</tr>
<tr>
<td>ProcessSpindleSpeed</td>
<td>The constrained process spindle speed for this tool.</td>
<td>0..1</td>
</tr>
<tr>
<td>ProcessFeedRate</td>
<td>The constrained process feed rate for this tool in mm/s.</td>
<td>0..1</td>
</tr>
<tr>
<td>ConnectionCodeMachineSide</td>
<td>Identifier for the capability to connect any component of the Cutting Tool together, except Assembly Items, on the machine side. Code: CCMS</td>
<td>0..1</td>
</tr>
<tr>
<td>Measurements</td>
<td>A collection of measurements for the tool assembly.</td>
<td>0..1</td>
</tr>
<tr>
<td>CuttingItems</td>
<td>An optional set of individual Cutting Items.</td>
<td>0..1</td>
</tr>
<tr>
<td>xs:any</td>
<td>Any additional properties not in the current document model. MUST be in separate XML namespace.</td>
<td>0..n</td>
</tr>
</tbody>
</table>

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.
6.2.3 ProcessSpindleSpeed Element for CuttingToolLifeCycle

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

6.2.3.1 Attributes for ProcessSpindleSpeed

Table 17: Attributes for ProcessSpindleSpeed

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum</td>
<td>The upper bound for the tool’s target spindle speed. maximum is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>minimum</td>
<td>The lower bound for the tool’s spindle speed. minimum is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>nominal</td>
<td>The nominal speed the tool is designed to operate at. nominal is an optional attribute.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
6.2.4 ProcessFeedRate Element for CuttingToolLifeCycle

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

6.2.4.1 Attributes for ProcessFeedRate

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum</td>
<td>The upper bound for the tool’s process target feedrate. maximum is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>minimum</td>
<td>The lower bound for the tool’s feedrate. minimum is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>nominal</td>
<td>The nominal feedrate the tool is designed to operate at. nominal is an optional attribute.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
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 XML Schema 1.1, extension points are available where an additional element can be added to the document without being part of a substitution group. The new elements MUST NOT be part of the MTConnect namespace and MUST NOT be one of the predefined elements mentioned above.

This allows additional properties to be defined for CuttingTool without having to change the definition of the CuttingTool or modify the standard, but requires XML Schema Version 1.1.

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

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
provided, they are only for documentation purposes. `nativeUnits` may optionally be provided to indicate the original units provided for the measurements.

### 6.2.8.1 Attributes for Measurement

**Table 19:** Attributes for Measurement

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>A shop specific code for this measurement. ISO 13399 codes may be used for these codes as well. code is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>maximum</td>
<td>The maximum value for this measurement. Exceeding this value would indicate the tool is not usable. maximum is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>minimum</td>
<td>The minimum value for this measurement. Exceeding this value would indicate the tool is not usable. minimum is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>nominal</td>
<td>The as advertised value for this measurement. nominal is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>significantDigits</td>
<td>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 an optional attribute.</td>
<td>0..1</td>
</tr>
</tbody>
</table>
Continuation of Table 19

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>units</td>
<td>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. <strong>units</strong> is a optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>nativeUnits</td>
<td>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. <strong>nativeUnits</strong> is a optional attribute.</td>
<td>0..1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Measurement Subtype</th>
<th>Code</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>BodyDiameterMax</td>
<td>BDX</td>
<td>The largest diameter of the body of a Tool Item.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Measurement Subtype</td>
<td>Code</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>BodyLengthMax</td>
<td>LBX</td>
<td>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.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>DepthOfCutMax</td>
<td>APMX</td>
<td>The maximum engagement of the cutting edge or edges with the workpiece measured perpendicular to the feed motion.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>CuttingDiameterMax</td>
<td>DC</td>
<td>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.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>FlangeDiameterMax</td>
<td>DF</td>
<td>The dimension between two parallel tangents on the outside edge of a flange.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>OverallToolLength</td>
<td>OAL</td>
<td>The largest length dimension of the Cutting Tool including the master insert where applicable.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Measurement Subtype</td>
<td>Code</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>ShankDiameter</td>
<td>DMM</td>
<td>The dimension of the diameter of a cylindrical portion of a Tool Item or an Adaptive Item that can participate in a connection.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>ShankHeight</td>
<td>H</td>
<td>The dimension of the height of the shank.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>ShankLength</td>
<td>LS</td>
<td>The dimension of the length of the shank.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>UsableLengthMax</td>
<td>LUX</td>
<td>Maximum length of a Cutting Tool that can be used in a particular cutting operation including the non-cutting portions of the tool.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>ProtrudingLength</td>
<td>LPR</td>
<td>The dimension from the yz-plane to the farthest point of the Tool Item or Adaptive Item measured in the -X direction.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Weight</td>
<td>WT</td>
<td>The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.</td>
<td>GRAM</td>
</tr>
</tbody>
</table>
Continuation of Table 20

<table>
<thead>
<tr>
<th>Measurement Subtype</th>
<th>Code</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>FunctionalLength</td>
<td>LF</td>
<td>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.</td>
<td>MILLIMETER</td>
</tr>
</tbody>
</table>

6.2.9 CuttingItems Element for CuttingToolLifeCycle

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

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>count</td>
<td>The number of Cutting Item.</td>
<td>1</td>
</tr>
<tr>
<td>count</td>
<td>is a required attribute.</td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>indices</td>
<td>The number or numbers representing the individual Cutting Item or items on the tool. indices is a required attribute.</td>
<td>1</td>
</tr>
<tr>
<td>itemId</td>
<td>The manufacturer identifier of this Cutting Item. itemId is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>manufacturers</td>
<td>The manufacturers of the Cutting Item or Tool. manufacturers is an optional attribute.</td>
<td>0..1</td>
</tr>
<tr>
<td>grade</td>
<td>The material composition for this Cutting Item. grade is an optional attribute.</td>
<td>0..1</td>
</tr>
</tbody>
</table>

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-
Manufacturers 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

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>A free-form description of the Cutting Item.</td>
<td>0..1</td>
</tr>
<tr>
<td>Locus</td>
<td>A free form description of the location on the Cutting Tool.</td>
<td>0..1</td>
</tr>
<tr>
<td>ItemLife</td>
<td>The life of this Cutting Item.</td>
<td>0..3</td>
</tr>
<tr>
<td>Measurements</td>
<td>A collection of measurements relating to this Cutting Item.</td>
<td>0..1</td>
</tr>
<tr>
<td>CutterStatus</td>
<td>The status of this item.</td>
<td>0..1</td>
</tr>
<tr>
<td></td>
<td>CutterStatus <strong>MUST</strong> one of the following values: NEW, AVAILABLE, UNAVAILABLE, ALLOCATED, UNALLOCATED, MEASURED, RECONDITIONED, NOT_REGISTERED, USED, Expedited, BROKEN, or UNKNOWN.</td>
<td></td>
</tr>
<tr>
<td>ProgramToolGroup</td>
<td>The tool group the part program assigned this item.</td>
<td>0..1</td>
</tr>
</tbody>
</table>

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 its 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

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.

Figure 22: ItemLife Schema
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

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

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

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINUTES</td>
<td>The tool life measured in minutes. All units for minimum, maximum, and nominal <strong>MUST</strong> be provided in minutes.</td>
</tr>
<tr>
<td>PART_COUNT</td>
<td>The tool life measured in parts. All units for minimum, maximum, and nominal <strong>MUST</strong> be provided as the number of parts.</td>
</tr>
<tr>
<td>WEAR</td>
<td>The tool life measured in tool wear. Wear <strong>MUST</strong> be provided in millimeters as an offset to nominal. All units for minimum, maximum, and nominal <strong>MUST</strong> be given as millimeter offsets as well.</td>
</tr>
</tbody>
</table>

**6.2.10.2.6 countDirection Attribute for ItemLife**

The value of type must be one of the following:

**Table 26:** Values for countDirection

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>UP</td>
<td>The tool life counts up from zero to the maximum.</td>
</tr>
<tr>
<td>DOWN</td>
<td>The tool life counts down from the maximum to zero.</td>
</tr>
</tbody>
</table>

**6.2.10.3 Measurement Subtypes for CuttingItem**

These Measurements for CuttingItem are specific to an individual CuttingItem 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
The CuttingItem Measurements in Table 27 will refer the Figure 23, Figure 24, Figure 25 and Figure 26.

Table 27: Measurement Subtypes for CuttingItem

<table>
<thead>
<tr>
<th>Measurement Subtype</th>
<th>Code</th>
<th>Description</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuttingReferencePoint</td>
<td>CRP</td>
<td>The theoretical sharp point of the Cutting Tool from which the major functional dimensions are taken.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Measurement Subtype</td>
<td>Code</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>------------------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>CuttingEdgeLength</td>
<td>L</td>
<td>The theoretical length of the cutting edge of a Cutting Item over sharp corners.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>DriveAngle</td>
<td>DRVA</td>
<td>Angle between the driving mechanism locator on a Tool Item and the main cutting edge.</td>
<td>DEGREE</td>
</tr>
<tr>
<td>FlangeDiameter</td>
<td>DF</td>
<td>The dimension between two parallel tangents on the outside edge of a flange.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>FunctionalWidth</td>
<td>WF</td>
<td>The distance between the cutting reference point and the rear backing surface of a turning tool or the axis of a boring bar.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>IncribedCircleDiameter</td>
<td>IC</td>
<td>The diameter of a circle to which all edges of a equilateral and round regular insert are tangential.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>PointAngle</td>
<td>SIG</td>
<td>The angle between the major cutting edge and the same cutting edge rotated by 180 degrees about the tool axis.</td>
<td>DEGREE</td>
</tr>
<tr>
<td>ToolCuttingEdgeAngle</td>
<td>KAPR</td>
<td>The angle between the tool cutting edge plane and the tool feed plane measured in a plane parallel the xy-plane.</td>
<td>DEGREE</td>
</tr>
<tr>
<td>Measurement Subtype</td>
<td>Code</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>---------------------------</td>
<td>------</td>
<td>-----------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>ToolLeadAngle</td>
<td>PSIR</td>
<td>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.</td>
<td>DEGREE</td>
</tr>
<tr>
<td>ToolOrientation</td>
<td>N/A</td>
<td>The angle of the tool with respect to the workpiece for a given process. The value is application specific.</td>
<td>DEGREE</td>
</tr>
<tr>
<td>WiperEdgeLength</td>
<td>BS</td>
<td>The measure of the length of a wiper edge of a Cutting Item.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>StepDiameterLength</td>
<td>SDLx</td>
<td>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.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>StepIncludedAngle</td>
<td>STAx</td>
<td>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.</td>
<td>DEGREE</td>
</tr>
<tr>
<td>Measurement Subtype</td>
<td>Code</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Cutting Diameter</td>
<td>DCx</td>
<td>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.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Cutting Height</td>
<td>HF</td>
<td>The distance from the basal plane of the Tool Item to the cutting point.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Corner Radius</td>
<td>RE</td>
<td>The nominal radius of a rounded corner measured in the X Y-plane.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Weight</td>
<td>WT</td>
<td>The total weight of the Cutting Tool in grams. The force exerted by the mass of the Cutting Tool.</td>
<td>GRAM</td>
</tr>
<tr>
<td>Functional Length</td>
<td>LFx</td>
<td>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.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Chamfer Flat Length</td>
<td>BCH</td>
<td>The flat length of a chamfer.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Chamfer Width</td>
<td>CHW</td>
<td>The width of the chamfer.</td>
<td>MILLIMETER</td>
</tr>
<tr>
<td>Measurement Subtype</td>
<td>Code</td>
<td>Description</td>
<td>Units</td>
</tr>
<tr>
<td>---------------------</td>
<td>------</td>
<td>-------------</td>
<td>---------</td>
</tr>
<tr>
<td>InsertWidth</td>
<td>W1</td>
<td>W1 is used for the insert width when an inscribed circle diameter is not practical.</td>
<td>MILLIMETER</td>
</tr>
</tbody>
</table>
Appendices

Bibliography


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

Shellmill – KMT, KSSP300R4SD43L240
Adapter – Parlec, C50-12SM1
Insert – KMT, SDET43PD8R8GB Grade KC725M

Steel Cutting Parameters:
Cutter Max RPM=13,300, 4 Flutes, 76.2mm Dia (3"Dia)
Nominal Starting Parameters:
605 RPM
0.23mm/Tooth (0.009")
Mmin 144.0 (475 SFM)
Feed Rate 552.2mm/min (21.78 m/min)

Figure 34: Indexable Insert Measurements

Example 1: Example for Indexable Insert Measurements
<Assets>
  <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
    timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
    manufacturers="KMT,Parlec">  
    <CuttingToolLifeCycle>
      <CutterStatus><Status>NEW</Status></CutterStatus>
      <ProcessSpindleSpeed maximum="13300"
        nominal="605">10000</ProcessSpindleSpeed>
      <ProcessFeedRate
        nominal="9.22">9.22</ProcessFeedRate>
      <ConnectionCodeMachineSide>CV50</ConnectionCodeMachineSide>
    </CuttingToolLifeCycle>
  </CuttingTool>
</Assets>

<Measurements>
  <BodyDiameterMax code="BDX">73.25</BodyDiameterMax>
  <OverallToolLength nominal="222.25"
    minimum="221.996" maximum="222.504"
    code="OAL">222.25</OverallToolLength>
  <UsableLengthMax code="LUX" nominal="82.55">82.55</UsableLengthMax>
  <CuttingDiameterMax code="DC" nominal="76.2"
    maximum="76.213" minimum="76.187">76.2</CuttingDiameterMax>
  <BodyLengthMax code="LF" nominal="120.65"
    maximum="120.904" minimum="120.404">120.65</BodyLengthMax>
  <DepthOfCutMax code="APMX" nominal="60.96">60.95</DepthOfCutMax>
  <FlangeDiameterMax code="DF" nominal="98.425">98.425</FlangeDiameterMax>
</Measurements>

<CuttingItems count="24">
  <CuttingItem indices="1-24" itemId="SDET43PDER8GB"
    manufacturers="KMT" grade="KC725M">  
    <Measurements>
      <CuttingEdgeLength code="L" nominal="12.7"
        minimum="12.675" maximum="12.725">12.7</CuttingEdgeLength>
      <WiperEdgeLength code="BS" nominal="2.56">2.56</WiperEdgeLength>
      <IncribedCircleDiameter code="IC" nominal="12.7">12.7</IncribedCircleDiameter>
      <CornerRadius code="RE" nominal="0.8">0.8</CornerRadius>
    </Measurements>
  </CuttingItem>
</CuttingItems>
</Assets>
</MTConnectAssets>
C.2 Step Drill

Figure 35: Step Mill Side View

Example 2: Example for Step Mill Side View

```xml
<?xml version="1.0" encoding="UTF-8"?>
<MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
                 xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
                 xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
                 xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2 http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
           sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>

  <Assets>
    <CuttingTool serialNumber="1" toolId="B732A08500HP"
                  manufacturers="KMT,Parlec">
      <Description>
        Step Drill - KMT, B732A08500HP Grade KC7315
        Adapter - Parlec, C50-M12SF300-6
      </Description>
      <CuttingToolLifeCycle>
        <CutterStatus><Status>NEW</Status></CutterStatus>
        <ProcessSpindleSpeed nominal="5893">5893</ProcessSpindleSpeed>
        <ProcessFeedRate nominal="2.5">2.5</ProcessFeedRate>
      </CuttingToolLifeCycle>
      <Measurements>
        <BodyDiameterMax code="BDX">31.8</BodyDiameterMax>
        <BodyLengthMax code="LBX" nominal="120.825" maximum="126.325"
                        minimum="115.325">120.825</BodyLengthMax>
        <ProtrudingLength code="LPR" nominal="155.75" maximum="161.25"
                          minimum="150.26">155.75</ProtrudingLength>
      </Measurements>
    </CuttingTool>
  </Assets>
</MTConnectAssets>
```
<FlangeDiameterMax code="DF"
nominal="98.425">98.425</FlangeDiameterMax>
<OverallToolLength nominal="257.35" minimum="251.85"
maximum="262.85" code="OAL">257.35</OverallToolLength>
</Measurements>
<CuttingItems count="2">
  <CuttingItem indices="1" manufacturers="KMT" grade="KC7315">
    <Measurements>
      <CuttingDiameter code="DC1" nominal="8.5" maximum="8.521"
minimum="8.506">8.5135</CuttingDiameter>
      <StepIncludedAngle code="STA1" nominal="90" maximum="91"
minimum="89">90</StepIncludedAngle>
      <FunctionalLength code="LF1" nominal="154.286"
minimum="148.786" maximum="159.786">154.286</FunctionalLength>
      <StepDiameterLength code="SDL1" nominal="9">9</StepDiameterLength>
      <PointAngle code="SIG" nominal="135" minimum="133"
maximum="137">135</PointAngle>
    </Measurements>
  </CuttingItem>
  <CuttingItem indices="2" manufacturers="KMT" grade="KC7315">
    <Measurements>
      <CuttingDiameter code="DC2" nominal="12" maximum="12.011"
minimum="12">12</CuttingDiameter>
      <FunctionalLength code="LF2" nominal="122.493"
maximum="127.993" minimum="116.993">122.493</FunctionalLength>
      <StepDiameterLength code="SDL2" nominal="9">9</StepDiameterLength>
    </Measurements>
  </CuttingItem>
</CuttingItems>
</CuttingToolLifeCycle>
</CuttingTool>
</Assets>
</MTConnectAssets>
C.3 Shell Mill with Individual Loci

Example 3: Example for Shell Mill with Explicate Loci

```xml
<?xml version="1.0" encoding="UTF-8"?>
<MTConnectAssets xmlns:mt="urn:mtconnect.org:MTConnectAssets:1.2"
    xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2 http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
    sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
  <Assets>
    <CuttingTool serialNumber="1" toolId="KSSP300R4SD43L240"
    timestamp="2011-05-11T13:55:22" assetId="KSSP300R4SD43L240.1"
    manufacturers="KMT,Parlec">
      <Description>Keyway: 55 degrees</Description>
      <CuttingToolLifeCycle>
        <CutterStatus><Status>NEW</Status></CutterStatus>
        <Measurements>
          <UsableLengthMax code="LUX" nominal="82.55">82.55</UsableLengthMax>
          <CuttingDiameterMax code="DC" nominal="76.2" maximum="76.213">
            <DC>76.2mm</DC>
            <RE>6.8mm</RE>
            <LH>52.2mm</LH>
            <AP>50.3mm</AP>
            <DC>76.2mm</DC>
            <RE>6.8mm</RE>
            <LH>52.2mm</LH>
            <AP>50.3mm</AP>
          </CuttingDiameterMax>
        </Measurements>
      </CuttingToolLifeCycle>
    </CuttingTool>
  </Assets>
</MTConnectAssets>
```

Figure 36: Shell Mill with Explicate Loci
<CuttingDiameterMax minimum="76.187">76.2</CuttingDiameterMax>
<DepthOfCutMax code="APMX" nominal="60.96">60.95</DepthOfCutMax>

</Measurements>
<CuttingItems count="24">
  <CuttingItem indices="1" itemId="SDET43PDER8GB"
    manufacturers="KMT">
    <Locus>FLUTE: 1, ROW: 1</Locus>
    <Measurements>
      <DriveAngle code="DRVA" nominal="55">55</DriveAngle>
    </Measurements>
  </CuttingItem>
  <CuttingItem indices="2-24" itemId="SDET43PDER8GB"
    manufacturers="KMT">
    <Locus>FLUTE: 2-4, ROW: 1; FLUTE: 1-4, ROW 2-6</Locus>
  </CuttingItem>
</CuttingItems>
</CuttingToolLifeCycle>
</CuttingTool>
</Assets>
</MTConnectAssets>
C.4 Drill with Individual Loci

Figure 37: Step Drill with Explicate Loci

Example 4: Example for Step Drill with Explicate Loci

```xml
<?xml version="1.0" encoding="UTF-8"?>
<MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:mtconnect="urn:mtconnect.org:MTConnectAssets:1.2"
xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2 http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd"
>  
<Header creationTime="2011-05-11T13:55:22" assetBufferSize="1024" sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
<Assets>
  <CuttingTool serialNumber="1" toolId="KSEM0781LD"
timestamp="2011-05-11T13:55:22" assetId="KSEM0781LD.1" manufacturers="KMT">  
    <CuttingToolLifeCycle>
      <CutterStatus><Status>NEW</Status></CutterStatus>
      <ConnectionCodeMachineSide>HSK63A</ConnectionCodeMachineSide>
      <Measurements>
        <BodyDiameterMax code="BDX">52.75</BodyDiameterMax>
        <OverallToolLength nominal="172.29"/>
      </Measurements>
    </CuttingToolLifeCycle>
  </CuttingTool>
</Assets>
</MTConnectAssets>
```
<Measurements>
  <CuttingItems count="3">
    <CuttingItem indices="1" itemId="KSEM0781LD" manufacturers="KMT">
      <Locus>FLUTE: 1, ROW: 1</Locus>
      <Measurements>
        <FunctionalLength code="LF1" nominal="154.42">154.42</FunctionalLength>
        <CuttingDiameter code="DC1" nominal="19.844">19.844</CuttingDiameter>
        <PointAngle code="SIG" nominal="140">140</PointAngle>
        <ToolCuttingEdgeAngle code="KAPR1" nominal="45">45</ToolCuttingEdgeAngle>
        <StepDiameterLength code="SLD1" nominal="39.8">39.8</StepDiameterLength>
      </Measurements>
    </CuttingItem>
  </CuttingItems>
</Measurements>
</CuttingTool>
</Assets>
C.5  Shell Mill with Different Inserts on First Row

Example 5: Shell Mill with Different Inserts on First Row

```xml
<MTConnectAssets xmlns:m="urn:mtconnect.org:MTConnectAssets:1.2"
xmlns="urn:mtconnect.org:MTConnectAssets:1.2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="urn:mtconnect.org:MTConnectAssets:1.2
http://mtconnect.org/schemas/MTConnectAssets\_1.2.xsd">
sender="localhost" assetCount="2" version="1.2" instanceId="1234"/>
  <Assets>
    <CuttingTool serialNumber="1" toolId="XXX" timestamp="2011-05-11T13:55:22"
assetId="XXX.1" manufacturers="KMT">
      <CuttingToolLifeCycle>
        <CutterStatus><Status>NEW</Status></CutterStatus>
        <Measurements>
          <DepthOfCutMax code="APMX" nominal="47.8">47.8</DepthOfCutMax>
          <CuttingDiameterMax code="DC">50.8</CuttingDiameterMax>
          <UsableLengthMax code="LUX">78.74</UsableLengthMax>
        </Measurements>
        <CuttingItems count="9">
          <CuttingItem indices="1-3" itemId="EDPT180564PDER-LD"
manufacturers="KMT">
            <Locus>FLUTE: 1-3, ROW: 1</Locus>
          </CuttingItem>
          <!-- Additional cutting items...
        </CuttingItems>
    </CuttingTool>
  </Assets>
</MTConnectAssets>
```

Figure 38: Shell Mill with Different Inserts on First Row
<Measurements>
  <CornerRadius code="RE" nominal="6.25">6.35</CornerRadius>
</Measurements>

<CuttingItem indices="4-9" itemId="EDPT180508PDER-LD" manufacturers="KMT">
  <Locus>FLANGE: 1-4, ROW: 2-3</Locus>
</CuttingItem>

</CuttingItems>
</CuttingToolLifeCycle>
</CuttingTool>
</Assets>
</MTConnectAssets>