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Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers —

Part 111: Tools for milling machines

Systèmes d'automatisation industrielle et intégration — Commande des dispositifs physiques — Modèle de données pour les contrôleurs numériques informatisés —

Partie 111: Outils pour fraiseuses

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14649-111 was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 1, *Physical device control*.

ISO 14649 consists of the following parts, under the general title *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers*:

— *Part 1: Overview and fundamental principles*

— *Part 10: General process data*

— *Part 11: Process data for milling*

— *Part 12: Process data for turning*

— *Part 111: Tools for milling machines*

— *Part 121: Tools for turning machines*

The following parts are under preparation:

— *Part 13: Process data for wire-EDM*

— *Part 14: Process data for sink-EDM*

Machine tool data model for general manufacturing processes is to form the subject of a future Part 110.

Gaps in the numbering were left to allow further additions. ISO 14649-10 is the ISO 10303 application reference model (ARM) for process-independent data. ISO 10303 ARMs for specific technologies are added after Part 10.

ISO 14649 is harmonized with ISO 10303 in the common field of product data over the whole life cycle. ISO 14649-1:2003, Figure 1, shows the different fields of standardization between ISO 14649, ISO 10303 and CNC manufacturers with respect to implementation and software development.

Introduction

Modern manufacturing enterprises are built from facilities spread around the globe, which contain equipment from hundreds of different manufacturers. Immense volumes of product information will be transferred between the various facilities and machines. Today's digital communications standards have solved the problem of reliably transferring information across global networks. For mechanical parts, the description of product data has been standardized by ISO 10303. This leads to the possibility of using standard data throughout the entire process chain in the manufacturing enterprise. Impediments to realizing this principle are the data formats used at the machine level. Most computer numerical control (CNC) machines are programmed in the ISO 6983 “G and M code” language. Programs are typically generated by computer-aided manufacturing (CAM) systems that use computer-aided design (CAD) information. However, ISO 6983 limits program portability for three reasons. First, the language focuses on programming the tool centre path with respect to machine axes, rather than the machining process with respect to the part. Second, ISO 6983 defines the syntax of program statements, but in most cases leaves the semantics ambiguous. Third, vendors usually supplement the language with extensions that are not covered in the limited scope of ISO 6983.

ISO 14649 is a new model of data transfer between CAD/CAM systems and CNC machines, which replaces ISO 6983. It remedies the shortcomings of ISO 6983 by specifying machining processes rather than machine tool motion, using the object-oriented concept of Workingsteps. Workingsteps correspond to high-level machining features and associated process parameters. CNCs are responsible for translating Workingsteps to axis motion and tool operation. A major benefit of ISO 14649 is its use of existing data models from ISO 10303. As ISO 14649 provides a comprehensive model of the manufacturing process, it can also be used as the basis for a bi- and multi-directional data exchange between all other information technology systems.

ISO 14649 represents an object-oriented, information- and context-preserving approach for NC (numerical control) programming that supersedes data reduction to simple switching instructions or linear and circular movements. As it is object- and feature-oriented and describes the machining operations executed on the workpiece, and not machine-dependent axis motions, it will be run on different machine tools or controllers. This compatibility will spare all data adaptations by postprocessors, if the new data model is correctly implemented on the NC controllers. If old NC programs in ISO 6983 are to be used on such controllers, it is necessary that the corresponding interpreters be able to process the different NC program types in parallel.

ISO TC 184/SC 1/WG 7 envisions a gradual evolution from ISO 6983 programming to portable feature-based programming. Early adopters of ISO 14649 will certainly support data input of legacy “G and M codes” manually or through programs, just as modern controllers support both command-line interfaces and graphical user interfaces. This will likely be made easier as open-architecture controllers become more prevalent. Therefore, ISO 14649 does not include legacy program statements, which would otherwise dilute the effectiveness of ISO 14649.

Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers —

Part 111: Tools for milling machines

1 Scope

This part of ISO 14649 specifies the data elements describing cutting tool data for milling machine tools and machining centres, which work together with the process data for milling machine tools and machining centres specified in ISO 14649-11. They can be used as criteria for selecting one of several operations; they do not describe complete information on a particular tool. Therefore, leaving out optional attributes gives the controller more freedom to select from a larger set of tools.

NOTE 1 The numerical control (NC) is assumed to have access to complete description of specific tools in a database. The milling_machine_tool_schema defined in this part of ISO 14649 serves as a basic tool schema, including the information required by the CNC to select a tool from the machine tool's tool magazine.

NOTE 2 In ISO 6983, the tool is defined by its identifier (e.g. "T8"). No further information concerning the tool type or geometry is given. This information is part of the tool set-up sheet, which is supplied with the NC program to the machine. The tool set-up sheet gives the relationship between the tool location (e.g. "slot 8 of the tool magazine") and the type of tool (e.g. "drill 4 mm").

This part of ISO 14649 also specifies the information to be provided in the tool set-up sheet:

— tool identifier;

— tool type;

— tool geometry;

— application-dependent expected tool life.

The milling_machine_tool_schema does not include information which is part of the tool database. The tool database is related to the machine tool and the tool itself, but is independent of the NC program. The following data types are outside the scope of this part of ISO 14649:

— normative tool life;

— tool location in the tool changer;

— adaptive items also know as tool holders or tool clamping devices;

— tools for other technologies, such as turning, grinding and electrical discharge machining (EDM)[1].

1) These technologies are described in other parts of ISO 14649.

NOTE 3 It is important to understand that all length measure types used in this part of ISO 14649 are not toleranced length measure types because they are used to describe the tools required for the manufacturing of a workpiece, not the actual dimensions of the tools available at the machine. A real tool will be selected by the tool management based on the actual tool dimensions and the tolerances of features.

This part of ISO 14649 uses the EXPRESS language as specified in ISO 10303-11.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3002-1, *Basic quantities in cutting and grinding — Part 1: Geometry of the active part of cutting tools — General terms, reference systems, tool and working angles, chip breakers*

ISO 10303-41, *Industrial automation systems and integration — Product data representation and exchange — Part 41: Integrated generic resource: Fundamentals of product description and support*

ISO 10303-42, *Industrial automation systems and integration — Product data representation and exchange — Part 42: Integrated generic resource: Geometric and topological representation*

ISO 14649-10, *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers — Part 10: General process data*

ISO 14649-11, *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers — Part 11: Process data for milling*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14649-10, ISO 14649-11 and the following apply.

3.1
overall assembly length
protruding length
dimension from the gauge plane to the frontmost point of the cutting tool, measured along the cutting tool axis

3.2
tool offset length
distance from the gauge plane to the specified point determined by the main function of the cutting component

4 Cutting tools for milling machine tools and machining centres

4.1 Header and references

The following listing gives the header and the list of entities referenced within this schema.

```
SCHEMA milling_machine_tool_schema;
(* Version 14.1 of April 30, 2004
   Author: ISO TC184/SC1/WG7 *)

REFERENCE FROM measure_schema (*ISO10303-41e2*)
    (plane_angle_measure,
     length_measure);
```

```
REFERENCE FROM geometry_schema (*ISO10303-42e3*)
    (direction);

REFERENCE FROM machining_schema (*ISO14649-10*)
    (machining_tool,
     technology);
```

4.2 Syntax of milling machine cutting tools

4.2.1 Milling machine cutting tools

Entity describing the technology specific information needed for description of a cutting tool for milling machine tools (e.g. milling cutter, reamer, drill, tap, rotating boring tools): it is a subtype of entity machining_tool, as defined in ISO 14649-10.

```
ENTITY milling_machine_cutting_tool
  ABSTRACT SUPERTYPE OF ( ONEOF(milling_cutting_tool, drilling_cutting_tool,
  tapping_cutting_tool, rotating_boring_cutting_tool, reaming_cutting_tool))
  SUBTYPE OF (machining_tool);
  its_cutting_edges:             SET [1:?] OF cutting_component;
  overall_assembly_length:       length_measure;
  effective_cutting_diameter:    length_measure;
  maximum_depth_of_cut:          length_measure;
  hand_of_cut:                   OPTIONAL hand_of_cut_type;
  coolant_through_tool:          OPTIONAL BOOLEAN;
END_ENTITY;
```


`its_cutting_edges:` information describing the cutting edge(s) of the cutting tool.

`overall_assembly_length:` entire length of the assembled tooling measured from the gauge plane to the tool's end along the tooling axis; used for tool collision check.

`effective_cutting_diameter:` largest or greatest cutting outer diameter of the cutting tool.

`maximum_depth_of_cut:` length of the maximum penetration of the tool capable of removing chips in one cut.

`hand_of_cut:` direction of cutter rotation as defined by type hand of cut.

`coolant_through_tool:` Boolean value which indicates whether the tool body has through-the-tool coolant capabilities or not; the default value is False.

4.2.2 Cutting component

Entity describing the name of the material composing the cutting edge of a solid tool or the insert and its technological data.

```
ENTITY cutting_component;
  tool_functional_length:        length_measure;
  its_material:                  OPTIONAL material;
  expected_tool_life:            OPTIONAL time_measure;
  its_technology:                OPTIONAL technology;
END_ENTITY;
```

`tool_functional_length:` measured maximum distance from the gauge plane to the cutting tip of the cutting component.

`its_material:` identification of the material composing the cutting edge of a solid tool or the insert.

EXAMPLE The attribute material_identifier of the entity material can be high speed steel (HSS), carbide or polycrystalline diamond (PCD).

`expected_tool_life:` expected number of hours that a given cutting tool can be used before tool wear significantly impacts the performance parameters. This value will also be dependent on a number of external factors, including workpiece material, desired part tolerances, and selected cutting parameters.

`its_technology:` defines the technological parameters to be used for machining (e.g. the spindle speed and feed of the tool which guarantee expected_tool_life).

4.2.3 Hand of cut type

Direction of cutter rotation (also called *cutting direction*). For rotating tools, the hand of cut may be determined by observing the drive end of the tool body when mounted so as to make a cut, as defined in ISO 3002-1:1982, 8.2. If the rotary motion of the tool body is clockwise, the hand of cut is right-hand; if the rotary motion of the tool body is anticlockwise (counterclockwise), the hand of cut is left-hand.


```
TYPE hand_of_cut_type = ENUMERATION OF(left, neutral, right);
END_TYPE;
```


4.3 Catalogue of milling machine cutting tools

4.3.1 Drilling cutting tool

Entity describing a tool used for drilling. During machining, the tool is moved in the direction of its axis.

```
ENTITY drilling_cutting_tool
  SUPERTYPE OF (ONEOF(counterbore, countersink, spade_drill, spotdrill,
  step_drill, twist_drill))
  SUBTYPE OF (milling_machine_cutting_tool);
  point_angle:                    plane_angle_measure;
END_ENTITY;
```

`point_angle:` angle defining the tip angle; it is measured between the cutting edge and the same cutting edge rotated by 180° about its tool axis.

4.3.2 NC spot drill (centredrill)

Entity describing the tool body of the spot drill, a drill used to preset a centre of a hole prior to drilling operations.

```
ENTITY spotdrill
  SUBTYPE OF (drilling_cutting_tool);
END_ENTITY;
```

4.3.3 Counterbore

Entity describing the tool body of the counterbore, a tool capable of enlarging the diameter of a previously formed hole.

```
ENTITY counterbore
   SUBTYPE OF (drilling_cutting_tool);
END_ENTITY;
```

4.3.4 Countersink

Entity describing the tool body of the countersink, a tool used for cutting a tapered enlargement at the opening of a hole.

```
ENTITY countersink
   SUBTYPE OF (drilling_cutting_tool);
   effective_cutting_diameter:    OPTIONAL length_measure;
   maximum_usable_length:         length_measure;
END_ENTITY;
```

`effective_cutting_diameter:` minimum cutting diameter of the sinking region. If not given, zero is assumed.

`maximum_usable_length:` maximum length of a cutting tool that can be used in a particular cutting operation without interference between the workpiece and the cutting tool. The length is measured in parallel to the tool's axis.

4.3.5 Twist drill

Entity describing the tool body of the twist drill, a drill having two or more cutting edges and two or more flutes for the passage of chips.

```
ENTITY twist_drill
   SUPERTYPE OF (tapered_drill)
   SUBTYPE OF (drilling_cutting_tool);
END_ENTITY;
```

4.3.6 Tapered drill

Entity describing the tool body of the tapered drill.

```
ENTITY tapered_drill
   SUBTYPE OF (twist_drill);
   taper_angle:                  plane_angle_measure;
END_ENTITY;
```

`taper_angle:` angle formed between the opposite cutting edges.

4.3.7 Spade drill

Entity describing the tool body of the spade drill, a tool capable of producing large, deep holes with a variety of bottom profiles. A spade drill typically consists of a replaceable blade or insert clamped in a holder on the drill shank.

```
ENTITY spade_drill
  SUBTYPE OF (drilling_cutting_tool);
END_ENTITY;
```

4.3.8 Step drill

Entity describing the tool body of the step drill, a type of drill with more than one cutting diameter. The diameter of the steps increases from the tip of the tool to the gauge plane.

```
ENTITY step_drill
  SUBTYPE OF  (drilling_cutting_tool);
  diameters:                  LIST [1:?] of length_measure;
  step_length:                LIST [1:?] of length_measure;
END_ENTITY;
```

`diameters:` list of outer diameters of the drill.

`step length:` length of the individual step. The sequence of the list is equal to the sequence of the steps in the list of diameters.

4.3.9 Milling cutting tool

This is the abstract base class for milling cutters. A milling cutter is a rotary cutting tool, usually with straight or helical flutes, capable of producing a variety of forms, contours or profiles such as slots, pockets and peripheral surfaces.


```
ENTITY milling_cutting_tool
  ABSTRACT SUPERTYPE OF (ONEOF(dovetail_mill, endmill, facemill, shouldermill,
  side_mill, t_slot_mill, thread_mill))
  SUBTYPE OF (milling_machine_cutting_tool);
  number_of_effective_teeth:    OPTIONAL INTEGER;
  edge_radius:                  OPTIONAL length_measure;
END_ENTITY;
```

`number_of_effective_teeth:` number of effective teeth possessed by the tool (see ISO 3002-1).

`edge_radius:` edge radius, r, of the tool. If not specified, zero is assumed.

NOTE As there are also customized shapes edges (chamfer, etc.) not used by the CNC, the attribute edge_radius is optional.