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

Part 12: Process data for turning

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

Partie 12: Données de procédé pour le tournage

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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 14649-12 was prepared by Technical Committee ISO/TC 184, *Industrial 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*

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.

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 must 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 center path with respect to machine axes, rather than the machining process with respect to the part. Second, the standard 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-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 running 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, the corresponding interpreters shall 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 the standard.

Figure 1 of ISO 14649-1 shows the different fields of standardization between ISO 14649, ISO 10303 and CNC manufacturers with respect to implementation and software development.

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

Part 12:
Process data for turning

1 Scope

This part of ISO 14649 specifies the technology specific data elements needed as process data for turning. Together with the general process data described in ISO 14649-10, it describes the interface between a computerized numerical controller and the programming system (i.e. CAM system or shop floor programming system) for turning. It can be used for turning operations on all types of machines including turning machine or lathe, or turning centers. In this version, feature and operation data models for conventional turning, involving only x and z movements, are covered. Features and operations for the composite machining including c-axis operation will be covered in the later version of this document or in a separate document. Also, the scope of this part of ISO 14649 does not include any other technologies, like milling, grinding, contour cutting, or EDM. These technologies will be described in other parts of the ISO 14649 series.

The subject of the turning schema, which is described in this document, is the definition of technology specific data types representing machining features and processes for turning operation on lathes. Not included in this schema are representations, executable objects, and base classes which are common for all technologies. They are referenced from ISO 10303's generic resources and ISO 14649-10. The description of process data is done using the EXPRESS language as defined in ISO 10303-11. The encoding of the data is done using ISO 10303-21.

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 10303-11:2004, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual*

ISO 10303-21:2002, *Industrial automation systems and integration — Product data representation and exchange — Part 21: Implementation methods: Clear text encoding of the exchange structure*

ISO 10303-224: 2001, *Industrial automation systems and integration — Product data representation and exchange — Part 224: Application protocol: Mechanical product definition for process planning using machining features*

ISO 14649-1:2003, *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers — Part 1: Overview and fundamental principles*

ISO 14649-10:2003, *Industrial automation systems and integration — Physical device control — Data model for computerized numerical controllers — Part 10: General process data*

ISO 14649-11:2004, *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 and the following apply.

3.1
Roughing
machining operation used to cut a part

NOTE While the aim of roughing is to remove large quantities of material in a short time, the surface quality is usually not important. The roughing operation is usually followed by a finishing operation, cf. finishing.

3.2
Finishing
machining operation used to cut a par

NOTE The finishing operation usually follows a roughing operation. The goal of finishing is to reach the surface quality required, cf. roughing.

4 Process data for turning

4.1 Header and references

The following listing gives the header for the turning schema and the list of types and entities, which are referenced within this schema.


```
SCHEMA turning_schema;

(*
   Version : 15
   Date    : 05.01.2005
   Author  : ISO TC184/SC1/WG7
   Contact : Suk-Hwan Suh <shs@postech.ac.kr>
             Stefan Heusinger <stefan.heusinger@isw.uni-stuttgart.de>
*)


(* ********************************************************************** *)
(* Types from machining_schema                  ISO 14649-10              *)
(* ********************************************************************** *)

REFERENCE FROM machining_schema(
   axis2_placement_3d,
   bounded_curve,
   cartesian_point,
   direction,
   general_profile,
   identifier
   in_process_geometry,
   label,
   length_measure,
   linear_profile,
   machine_functions,
   machining_operation,
   manufacturing_feature,
   material,
   open_profile,
   partial_area_definition,
```

```
   partial_circular_profile,
   plane_angle_measure,
   positive_length_measure,
   positive_ratio_measure,
   pressure_measure,
   property_parameter,
   rot_speed_measure,
   round_hole,
   speed_measure,
   taper_select,
   technology,
   thread,
   time_measure,
   toleranced_length_measure,
   two5D_manufacturing_feature,
   vee_profile,
   workingstep);

(* ************************************************************************ *)
(* Types from milling_ schema                ISO 14649-11                   *)
(* ************************************************************************ *)

REFERENCE FROM milling_schema(
   adaptive_control,
   approach_retract_strategy,
   process_model_list);
```


4.2 Manufacturing features for turning

4.2.1 General

The base class of all features used for turning is the *turning_feature*. The *turning_feature* is a subclass of the *two5D_manufacturing_feature* described in ISO 14649-10. The turning features described in this clause are fully harmonized with ISO 10303 AP224. Features that can be obtained by turning operation, as well as milling operation, such as *round_hole* and *thread*, are not described in this part of ISO 14649; but users can use these features by referencing ISO 14649-10. Also, *toolpath_feature* which is defined in ISO 14649-10 can be used for the toolpath type features in turning.

4.2.2 Turning feature

The entity *turning_feature* is the abstract base class for all features used for turning. The defined turning features are classified geometric shapes that can be obtained by turning the cylindrical workpiece with 2-axis (x and z) operation or 3-axis (x, z, and c) operation (Figure 1). In this version, features that can be obtained by 3-axis operation are not included as stated in Clause 1.

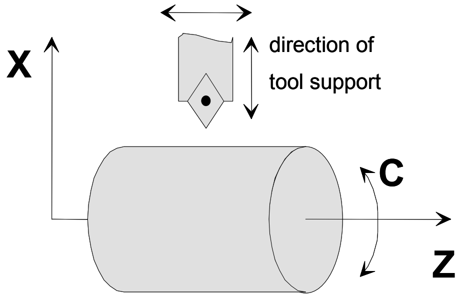

Figure 1: Axis and motion nomenclature of turning operation

Currently, the following features are included: *outer_round* (*outer_diameter*, *outer_diameter_to_shoulder*), *revolved_feature* (*revolved_flat*, *revolved_round*, *groove*, *general_revolution*), *knurl* (*straight_knurl*, *diagonal_knurl*, *diamond_knurl*, *tool_knurl*).

NOTE: Turning specific features; i.e., features which are not defined in AP224, but frequently used in common practice, such as *cut_in, circular_face* (including *end_face* and *step_face*) are described in Annex C of this document.

```
ENTITY turning_feature
   ABSTRACT SUPERTYPE OF (ONEOF(outer_round, revolved_feature, knurl))
   SUBTYPE OF (two5D_manufacturing_feature);
END_ENTITY;
```


4.2.3 Outer round

4.2.3.1 General

An *outer_round* is a type of *turning_feature* that is an outline or significant shape that is swept through a complete revolution about an axis. Each *outer_round* is either an *outer_diameter* or an *outer_diameter_to_shoulder*. The axis of revolution shall be the same as the z-axis of the feature.

```
ENTITY outer_round
   ABSTRACT SUPERTYPE OF (ONEOF (outer_diameter, outer_diameter_to_shoulder))
   SUBTYPE OF (turning_feature);
END_ENTITY;
```

4.2.3.2 Outer diameter

The *outer_diameter* is a subtype of *outer_round* that is a sweeping of an outline specified by a line segment one complete revolution about an axis. The line is finite in length and coplanar with the axis. The *outer_diameter* (Figure 2) may have a constant diameter around the axis of rotation (cylinder; left figure), or it may be tapered (cone; right figure). In case of the definition of a cylinder the *diameter_at_placement* and the *feature_length* are sufficient. A cone describes a continual transition from one diameter to another diameter across a certain *feature_length*. For its definition the additional attribute *reduced_size* is used. In other words, cone and cylinder, which are commonly used on the shop floor, can be respectively represented by *outer_diameter* or *outer_diameter* with taper as shown in Figure 2.

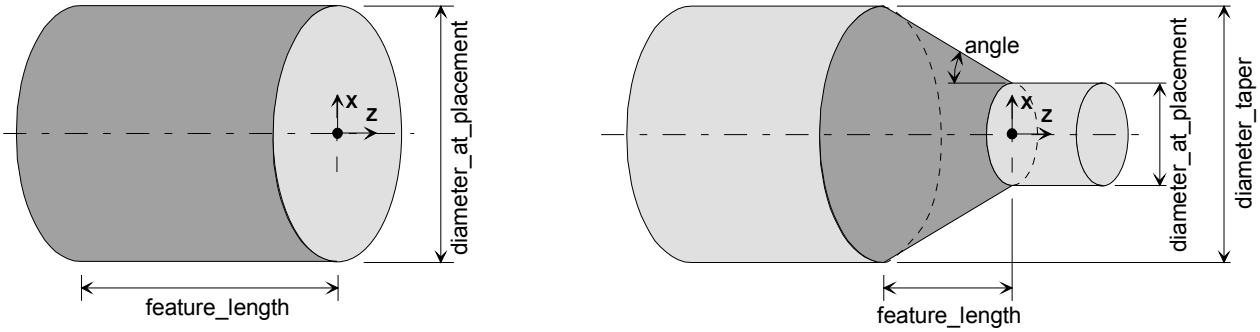

Figure 2: Outer_diameter (left) and outer_diameter with taper (right)

```
ENTITY outer_diameter
   SUBTYPE OF (outer_round);
   diameter_at_placement : toleranced_length_measure;
   feature_length        : toleranced_length_measure;
   reduced_size          : OPTIONAL taper_select;
END_ENTITY;
```

diameter_at_placement : This attribute describes the diameter at the side of the feature, where the origin of the co-ordinate system of the feature's placement is defined.

feature_length : The length of the feature. Its length is measured along its rotation axis from z = 0 of the feature's co-ordinate system to the leftmost point (negative value of z) of the feature.

reduced_size : The optional attribute *reduced_size* makes it possible to distinguish between the definition of cylinder and cone. If omitted, the feature *outer_diameter* describes a cylinder. A cone can be described by one of the methods defined in taper_select, which is defined in ISO 14649-10. For defining a cone, it can be selected between two possibilities. If a *diameter_taper* is used, this is the diameter of the opposite side of the feature's placement co-ordinate system. If an *angle_taper* is chosen for describing the cone, this angle is the angle between the negative z-axis and the line on the positive x-side of the z-axis defined by the intersection of the cone with the xz-plane of the feature, extended to meet the z-axis. An angle greater than 0 degrees and less than 90 degrees indicates a cone with increasing diameter for decreasing z-values, an angle between 0 degrees and –90 degrees indicates a cone with decreasing diameter for decreasing z-values.

4.2.3.3 Outer diameter to shoulder

An *outer_diameter_to_shoulder* is a type of *outer_round* that is a sweeping of a shape one complete revolution about an axis. The shape shall be specified by two lines that connect at a point and extend infinitely. The enclosed angle shall be smaller than 180°.

NOTE: A turning specific feature which is frequently used on the shop floor, the *step_face* can be represented by *outer_diameter_to_shoulder*. Details for *step_face* are described in Annex C.2.

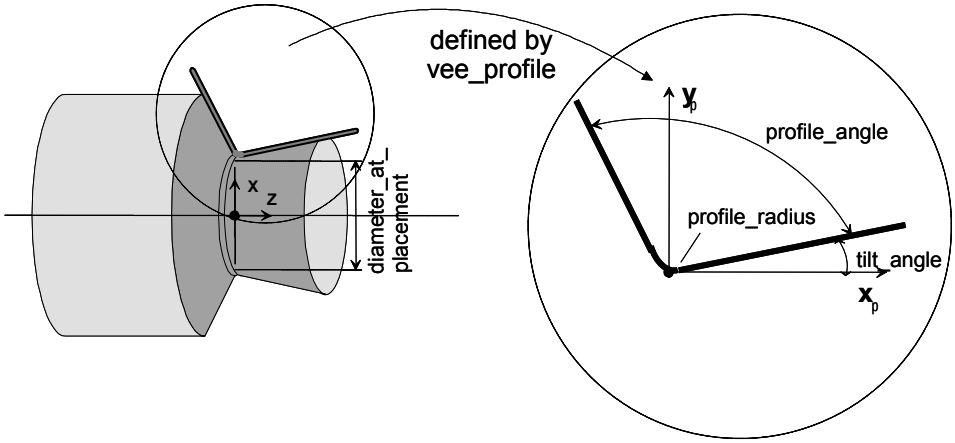

Figure 3: Outer_diameter_to_shoulder

```
ENTITY outer_diameter_to_shoulder
   SUBTYPE OF (outer_round);
   diameter_at_placement : toleranced_length_measure;
   v_shape_boundary      : vee_profile;
END_ENTITY;
```


diameter_at_placement : This attribute describes the diameter at the feature's placement (co-ordinate system). The z co-ordinate is the position where the two sides of the *vee_profile* come together.

v_shape_boundary: An outline or shape that shall be revolved about an axis. The *vee_profile* specifies the revolved shape required by an *outer_diameter_to_shoulder*. The placement of the profile shall be along the x-axis of the *outer_diameter_to_shoulder* at a specified distance away from the origin. The orientation of the y-axis of the *vee_profile* shall be the same as the x-axis of the *outer_diameter_to_shoulder* and the x-axis of the *vee_profile* shall be the same as the z-axis of the *outer_diameter_to_shoulder*.

4.2.4 Revolved feature

4.2.4.1 General

A *revolved_feature* is a subtype of *turning_feature* that is a sweeping of a planar profile on complete revolution about the z-axis. The planar profile shall be finite in length, coplanar with the axis of revolution, and shall not intersect the axis of revolution. The *revolved_feature* may be either an outer shape of a part or a volume removal, depending on the material side. Each *revolved_feature* is one of the following: *general_revolution*, *groove*, *revolved_flat*, or *revolved_round*.

```
ENTITY revolved_feature
   ABSTRACT SUPERTYPE OF (ONEOF (revolved_round, revolved_flat, groove,
  general_revolution))
   SUBTYPE OF (turning_feature);
   material_side : OPTIONAL direction;
   radius        : length_measure;
END_ENTITY;
```

material_side: The *material_side* specifies the material removal direction; i.e., the direction towards which the material moves as it is removed from the part. The *material_side* direction is defined in the feature co-ordinate system.

radius: The distance from the axis of rotation to define placement of the profile that will be swept about the axis. The value of this *length_measure* shall be greater or equal to 0.

4.2.4.2 Revolved flat

The *revolved_flat* is a type of *revolved_feature* that is the sweeping of a straight line about an axis.

NOTE: A turning specific feature which is frequently used on the shop floor, the *circular_face* can be represented by *revolved_flat*. Details for this feature are described in Annex C.2.

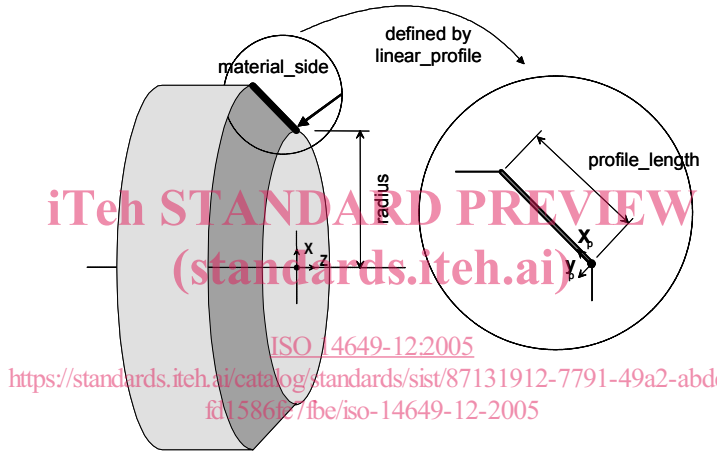

Figure 4: Revolved flat

```
ENTITY revolved_flat
   SUBTYPE OF (revolved_feature);
   flat_edge_shape : linear_profile;
END_ENTITY;
```

flat_edge_shape: A linear profile that when revolved about an axis defines the shape of an area of the part. The placement of the profile shall be along the x-axis of the *revolved_flat* at a distance specified by the inherited attribute *radius* away from the origin. The z-axis orientation of the *linear_profile* shall be the same as the y-axis of the *revolved_flat*, the x-axis and z-axis are independent of the orientation of the *revolved_flat* feature.

4.2.4.3 Revolved round

The *revolved_round* is a subtype of *revolved_feature* that is the sweeping of an arc about an axis.