

**Industrial automation systems and integration —
Product data representation and exchange —
Part 238:
Application protocol: Application interpreted model for
computerized numerical controllers**

CHANGES FOR EDITION TWO

This document describes specific changes for the second edition of ISO 10303-238 based on experience accumulated from deployment of the standard in the period 2007-2016.

Introduction

This Technical Corrigendum corrects ISO 10303-238:2007, Industrial automation systems and integration — Product data representation and exchange — Part 238: Application protocol: Application interpreted model for computerized numerical controllers.

The purpose of the modifications to the text of ISO 10303-238:2007 is to allow via point representations for toolpaths to better support high-speed milling operations, permit more detailed representation of tool contact area to better support speed and feed optimization for machining operations, clarify the placement of tool product models for simulation and collision checking, simplify the handling of in-process geometry, correct typographical errors and clarify descriptions in the document, and to replace the object identifier for the document and the applicable schema.

Modifications to the text of ISO 10303-238:2007

Page 15, 4.1.5

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete the following line from the list of application objects, and the following list of application objects with additional information requirements on page 17.

— In_process_geometry;

Page 63, 4.2.94

The purpose of this change is to extend the definition for Cutter_contact_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. This is analogous to the way in which ISO 10303 geometry placements are described using an axis direction as well as a reference direction. Replace clause 4.2.94 with the following:

4.2.94 Cutter_contact_trajectory

The Cutter_contact_trajectory application object is defined by clause 4.8 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

The data associated with a Cutter_contact_trajectory are the following:

- all of the data defined by ISO 14649-10, as modified below for the its_toolaxis attributes;
- its_toolref_direction;
- path_maximum_deviation;
- tool_axis_maximum_deviation.

See for additional discussion on the curve parameterization requirements defined by ISO 14649 on the basiccurve, its_toolaxis, and its_toolref_direction data associated with a Cutter_contact_trajectory.

NOTE The ISO 14649 EXPRESS description for Cutter_contact_trajectory, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY cutter_contact_trajectory
  SUBTYPE OF (trajectory);
  basiccurve:                curve_with_surface_normal;
  its_toolaxis:               OPTIONAL bounded_curve;
  its_toolref_direction:     OPTIONAL bounded_curve;      -- ADDED BY 10303-238
  its_contact_type:          OPTIONAL contact_type;
```

```

    path_maximum_deviation:    OPTIONAL length_measure;    -- ADDED BY 10303-238
    tool_axis_maximum_deviation: OPTIONAL plane_angle_measure;-- ADDED BY 10303-238
END_ENTITY;

TYPE curve_with_surface_normal = SELECT (bounded_pcurve, curve_with_normal_vector);
END_TYPE;

TYPE contact_type = ENUMERATION OF (side, front);
END_TYPE;

```

Page 65, 4.2.94

The purpose of this change is to extend the definition for Cutter_contact_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. Insert the following after clause 4.2.94.1 and renumber the following clauses:

4.2.94.2 its_toolref_direction

The its_toolref_direction specifies the orientation of an asymmetric tool measured in the plane defined by the its_toolaxis data. This is specified as a three-dimensional curve specifying IJK direction components at each point along the Cutter_contact_trajectory. The curve shall obey the same parameterization constraints as the “its_toolaxis” data. The its_toolref_direction need not be specified for a particular Cutter_contact_trajectory.

Page 65, 4.2.95

The purpose of this change is to extend the definition for Cutter_location_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. This is analogous to the way in which ISO 10303 geometry placements are described using an axis direction as well as a reference direction. Replace clause 4.2.94 with the following:

4.2.95 Cutter_location_trajectory

The Cutter_location_trajectory application object is defined by clause 4.8 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

The data associated with a Cutter_location_trajectory are the following:

- all of the data defined by ISO 14649-10, as modified below for the surface_normal attribute;
- its_toolref_direction;
- path_maximum_deviation;
- tool_axis_maximum_deviation.

See for additional discussion on the curve parameterization requirements defined by ISO 14649 on the basiccurve, its_toolaxis, and surface_normal data associated with a Cutter_location_trajectory.

NOTE The ISO 14649 EXPRESS description for Cutter_location_trajectory, as adapted by this part

of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY cutter_location_trajectory
  SUBTYPE OF (trajectory);
  basiccurve: bounded_curve;
  its_toolaxis: OPTIONAL bounded_curve;
  its_toolref_direction: OPTIONAL bounded_curve; -- ADDED BY 10303-238
  surface_normal: OPTIONAL bounded_curve;
  path_maximum_deviation: OPTIONAL length_measure; -- ADDED BY 10303-238
  tool_axis_maximum_deviation: OPTIONAL plane_angle_measure; -- ADDED BY 10303-238
END_ENTITY;
```

Page 66, 4.2.95

The purpose of this change is to extend the definition for Cutter_location_trajectory to permit the orientation of asymmetric tools to be described by augmenting the tool axis curve with a reference direction curve. Insert the following as clause 4.2.94.1 and renumber the following clauses:

4.2.95.1 its_toolref_direction

The its_toolref_direction specifies the orientation of an asymmetric tool measured in the plane defined by the its_toolaxis data. This is specified as a three-dimensional curve specifying IJK direction components at each point along the Cutter_location_trajectory. The curve shall obey the same parameterization constraints as the “its_toolaxis” data. The its_toolref_direction need not be specified for a particular Cutter_location_trajectory.

Page 67, 4.2.100

The purpose of this change is to modify the definition for Datum to clarify the relationship between a Datum and the Workpiece on which the Datum appears, in a manner analogous to the its_workpiece data that relates a Manufacturing_feature to the Workpiece on which the Manufacturing_feature appears. Add the following at the end of clause 4.2.100.

The data associated with a Datum are the following:

— its_workpiece.

4.2.100.1 its_workpiece

The its_workpiece specifies the Workpiece on which the Datum is defined.

Page 70, 4.2.105

The purpose of this change is to modify the definition for Datum_target to clarify the relationship between a Datum_target and the Workpiece on which the Datum_target appears, in a manner analogous to the its_workpiece data that relates a Manufacturing_feature to the Workpiece on which the Manufacturing_feature appears. Replace the list at the end of clause 4.2.105 with the following:

The data associated with a Datum_target are the following:

- identifier;
- its_workpiece.

Page 70, 4.2.105

The purpose of this change is to modify the definition for Datum_target to clarify the relationship between a Datum_target and the Workpiece on which the Datum_target appears, as described above. Insert the following after clause 4.2.105.1:

4.2.105.2 its_workpiece

The its_workpiece specifies the Workpiece on which the Datum_target is defined.

Page 76, 4.2.123

The purpose of this change is to extend the in-process description of the manufactured product information to any executable, and to extend the description to permit the full range of product properties, such as features and tolerances, to be specified, in addition to the geometry and topology. This replaces the In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan. This change also extends the definition of Executable to permit objects to be marked as enabled or disabled. Replace clause 4.2.168 with the following:

4.2.123 Executable

The Executable application object is defined by clause 4.6 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

NOTE 1 The modifications below extend the ISO 14649 In_process_geometry concept to allow the specification of in-process shape, features, and other product properties for any Executable. The shape_representation is specified using the workpiece.its_geometry. In particular, the integrated representation allows the use of shapes described by AIC 501 (edge-based wireframe), AIC 502 (shell-based wireframe), AIC 507 (geometrically-bounded surfaces), AIC 508 (non-manifold surfaces), AIC 509 (manifold surfaces), AIC 510 (geometrically-bounded wireframe), and AIC 512 (faceted brep), as well as the AIC 514 (advanced brep) descriptions originally supported by ISO 14649.

The data associated with an Executable are the following:

- all of the data defined by ISO 14649-10;
- as_is;
- enabled;
- fixture;
- removal;

— to_be.

NOTE 2 The ISO 14649 EXPRESS description for Executable, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the complete definition and explanation of usage.

```
ENTITY executable
  ABSTRACT SUPERTYPE OF (ONEOF( workingstep, nc_function, program_structure));
  its_id: identifier;
  as_is: OPTIONAL workpiece; -- ADDED BY 10303-238
  enabled: OPTIONAL BOOLEAN; -- ADDED BY 10303-238
  fixture: OPTIONAL workpiece; -- ADDED BY 10303-238
  removal: OPTIONAL workpiece; -- ADDED BY 10303-238
  to_be: OPTIONAL workpiece; -- ADDED BY 10303-238
END_ENTITY;
```

4.2.123.1 as_is

The as_is specifies a Workpiece which describes the shape and other properties of the manufactured product before the Executable is executed. The as_is need not be specified for a particular Executable. See 4.3.16 for the application assertion.

4.2.123.2 enabled

The enabled specifies whether the Executable is executed or ignored when processing the elements of a machining project. The Executable is executed if enabled is true or not specified, and ignored if enabled is false. The enabled need not be specified for a particular Executable.

4.2.123.3 fixture

The fixture specifies a Workpiece which describes the shape and other properties of the fixture that assists in the holding or positioning of the manufactured product for the Executable. The fixture need not be specified for a particular Executable. See 4.3.17 for the application assertion.

4.2.123.4 removal

The removal specifies a Workpiece which describes the shape and other properties of the material removed from the manufactured product by the Executable. The removal need not be specified for a particular Executable. See 4.3.18 for the application assertion.

4.2.123.5 to_be

The to_be specifies a Workpiece which describes the predicted shape and other properties of the manufactured product after the Executable is executed. The to_be need not be specified for a particular Executable. See 4.3.19 for the application assertion.

Page 93, 4.2.168

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete clause 4.2.168.

Page 98, 4.2.180.1

The purpose of this change is to correct grammar and misspelled words. In both list items, replace “vaue” with “value”. In the last list item, replace “the the” with “the” and replace “;” with “.” at the end of the list item.

Page 107, 4.2.194.1

The purpose of this change is to correct grammar. In the first sentence of the NOTE, replace “the the” with “the”.

Page 108, 4.2.197

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace 4.2.197 with the following. Retain 4.2.197.1 and 4.2.197.2 with no changes.

4.2.197 Machining_workingstep

The Machining_workingstep application object is defined by clause 4.6 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

NOTE 1 The In_process_geometry concept referenced by Machining_workingstep.its_effect in ISO 14649 is replaced by as-is, to-be, and removal properties associated with the Executable application object.

The data associated with a Machining_workingstep are the following:

- all of the data defined by ISO 14649-10, except for its_effect;
- final_features;
- toolpath_placement.

NOTE 2 The ISO 14649 EXPRESS description for Machining_workingstep, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY machining_workingstep
  SUBTYPE OF (workingstep);
  its_feature:      manufacturing_feature;
  its_operation:    machining_operation;
  -- its_effect:    OPTIONAL in_process_geometry;          -- REPLACED BY 10303-238
  final_features:   OPTIONAL SET [0:?] OF Manufacturing_feature; -- ADDED BY 10303-238
  toolpath_orientation: OPTIONAL axis2_placement_3d;      -- ADDED BY 10303-238
END_ENTITY;
```

Page 129, 4.2.255.1

The purpose of this change is to correct grammar. In the second sentence of the first paragraph, replace “the the” with “the”.

Page 143, 4.2.295.1

The purpose of this change is to correct grammar. In the second sentence of the first paragraph,

replace “the the” with “the”.

Page 169, 4.2.370

The purpose of this change is to modify the definition for Tool_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models for simulation and interference checking. Add the following at the end of clause 4.2.370.

- gage_placement;
- tool_end_placement.

Page 170, 4.2.370

The purpose of this change is to modify the definition for Tool_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models for simulation and interference checking. Add the following after clause 4.2.370.5.

4.2.370.6 gage_placement

The gage_placement specifies the location on the its_product tool model where the tool is mounted on a machine. The gage_placement need not be specified for a particular Tool_usage. If the gage_placement is not specified, the location shall be on the tool axis given by the tool_end_placement at the distance from the origin given by the overall assembly length of the referencing Machining_tool.

4.2.370.6 tool_end_placement

The tool_end_placement specifies the location on the its_product tool model of the tool end point. The axis parameter of the tool_end_placement indicates the tool axis. The tool_end_placement need not be specified for a particular Tool_usage. If the tool_end_placement is not specified, the location shall be the origin of the its_product tool model.

Page 173, 4.2.377

The purpose of this change is to modify the definition for touch_probe so that it becomes a type of machining_tool, to support a description of the probe usage, associated geometric shape, and other product information available for other types of tool. Replace clause 4.2.377 with the following.

4.2.377 Touch_probe

A Touch_probe is a type of Machining_tool (see 4.2.196) which identifies a inspection tool used to measure a workpiece.

NOTE This part of ISO 10303 modifies the definition of Touch_probe in clause 4.6 of ISO 14649-10 to be a type of Machining_tool so that Tool_usage information can be associated with it. The EXPRESS description for Touch_probe, as adapted by this part of ISO 10303, is shown below.

```
ENTITY touch_probe
  SUBTYPE OF (machining_tool);    -- ADDED BY 10303-238
  -- its_id: identifier;    -- now inherited from machining_tool
END_ENTITY;
```


Page 173, 4.2.379

The purpose of this change is to add cross_section_area_parameters to permit a more detailed representation of tool contact area than the depth and overcut parameters can provide to better support speed and feed optimization for machining operations. Replace clause 4.2.379 with the following. Add Figure 34 to List of figures and renumber subsequent figures.

4.2.379 Trajectory

The Trajectory application object is defined by clause 4.8 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

The data associated with a Trajectory are the following:

- all of the data defined by ISO 14649-10;
- its_material_removal_depth;
- its_material_removal_overcut;
- its_material_removal_total_volume;
- cross_section_area_parameters.

NOTE The ISO 14649 EXPRESS description for Trajectory, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the complete definition and explanation of usage.

```
ENTITY trajectory
  ABSTRACT SUPERTYPE OF (ONEOF(cutter_location_trajectory, cutter_contact_trajectory,
    axis_trajectory))
  SUBTYPE OF (toolpath);
  its_direction: OPTIONAL BOOLEAN;
  its_material_removal_depth: OPTIONAL material_removal_measure; -- ADDED BY 10303-238
  its_material_removal_overcut: OPTIONAL material_removal_measure; -- ADDED BY 10303-238
  its_material_removal_total_volume: OPTIONAL volume_measure; -- ADDED BY 10303-238
  cross_section_area_parameters: OPTIONAL bounded_curve; -- ADDED BY TC1
END_ENTITY;

TYPE material_removal_curve = bounded_curve; END_TYPE;
TYPE material_removal_measure = SELECT (
  length_measure,
  material_removal_curve
);
END_TYPE;
```

Page 174, 4.2.379

The purpose of this change is to add cross_section_area_parameters to permit a more detailed representation of tool contact area than the depth and overcut parameters can provide to better support speed and feed optimization for machining operations. Insert clause 4.2.379.4 after 4.2.379.3. Add Figure 34 and Figure 35 to List of figures and renumber subsequent figures.

4.2.379.4 cross_section_area_parameters

The `cross_section_area_parameters` specifies the area of material removed at each point of the Trajectory as measured perpendicular to the axis of the cutting tool. This is specified as a seven-dimensional curve specifying the cross section at each point along the toolpath. The curve shall obey the same parameterization constraints as the “its_speed” data associated with a **Error! Reference source not found.** (See). The `cross_section_area_parameters` need not be specified for a particular Trajectory.

Each point in the seven-dimensional curve shall describe the cross-section area parameters illustrated in Figure 34 and Figure 35. These parameters are as follows:

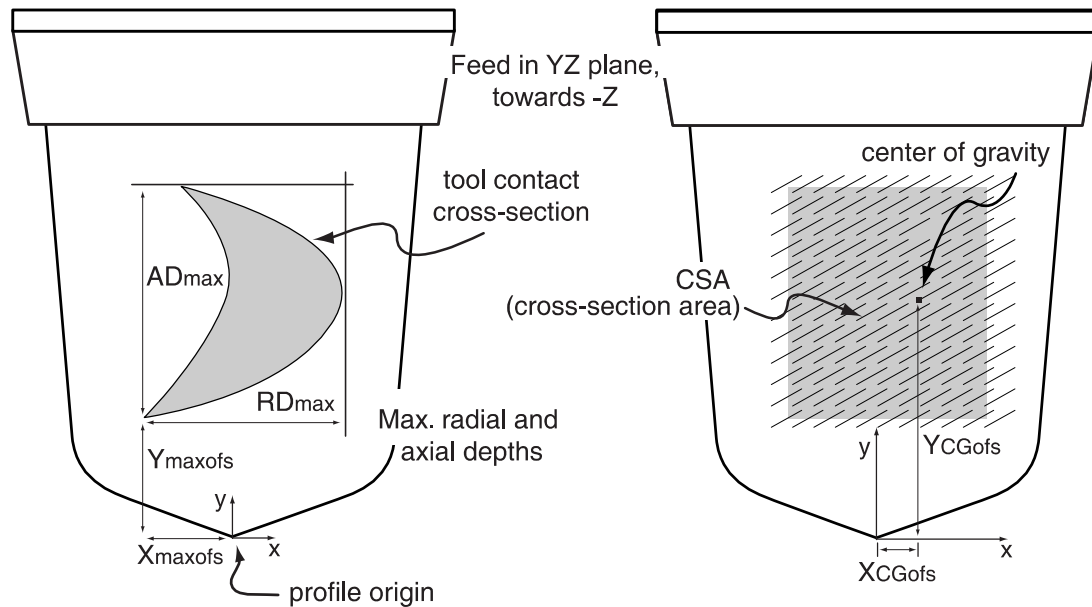


Figure 34 - Cross-section parameters for milling

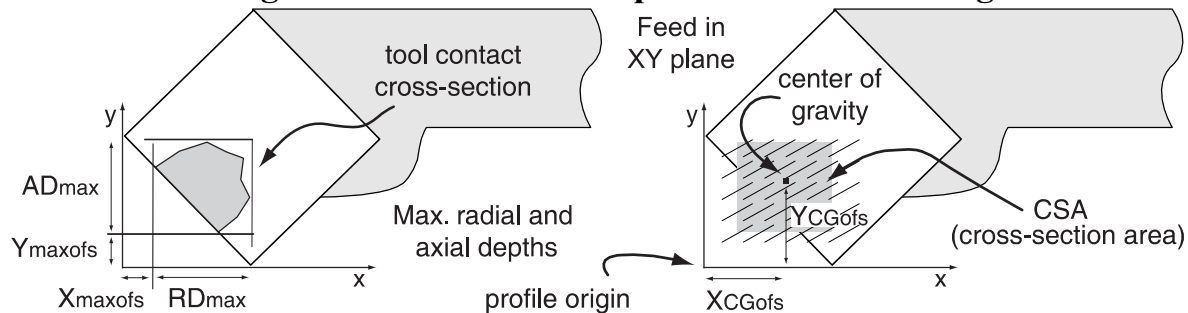


Figure 35 - Cross-section parameters for turning

- dimension 0 shall describe the maximum axial depth of the tool contact cross section, shown by AD_{max} in Figure 34 and Figure 35. The maximum axial depth for milling shall be measured parallel to the tool axis, regardless of whether the direction of feed is perpendicular to the tool axis. The maximum axial depth for turning shall be measured parallel to the spindle axis;
- dimension 1 shall describe the maximum radial depth of the tool contact cross section, shown by RD_{max} in Figure 34 and Figure 35. The maximum radial depth shall be measured perpendicular to both the tool axis and the feed direction;

- dimension 2 shall describe the location along the X axis where the maximum radial depth measure is located, shown by Xmaxofs in Figure 34 and Figure 35;
- dimension 3 shall describe the location along the Y axis where the maximum axial depth measure is located, shown by Ymaxofs in Figure 34 and Figure 35;
- dimension 4 shall describe the total area of the tool contact cross section in the X-Y plane, shown by CSA in Figure 34 and Figure 35;
- dimension 5 shall describe the location along the X axis of the centre of gravity of the tool contact cross section, shown by XCGofs in Figure 34 and Figure 35;
- dimension 6 shall describe the location along the Y axis of the centre of gravity of the tool contact cross section, shown by YCGofs in Figure 34 and Figure 35.

Page 178, 4.2.389

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace 4.2.389 with the following.

4.2.389 Turning_workingstep

The Turning_workingstep application object is defined by clause 4.3 of ISO 14649-12:2005. This part of ISO 10303 adds the following information requirements.

NOTE 1 The In_process_geometry concept referenced by Turning_workingstep.its_effect in ISO 14649 is replaced by as-is, to-be, and removal properties associated with the Executable application object.

The data associated with a Turning_workingstep are the following:

- all of the data defined by ISO 14649-12, except for its_effect;

NOTE 2 The ISO 14649 EXPRESS description for Turning_workingstep, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-12 for the original definition and explanation of usage.

```

ENTITY turning_workingstep
  SUBTYPE OF (workingstep);
  its_features:      LIST [2:?] OF manufacturing_feature;
  its_operation:     turning_machining_operation;
  -- its_effect:     OPTIONAL in_process_geometry;           -- REPLACED BY 10303-238
END_ENTITY;
```

Page 182, 4.2.399.5

The purpose of this change is to correct grammar. In the first sentence of the NOTE, replace “the the” with “the”.

Page 194, 4.2.417

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Replace 4.2.417 with the following.

able to as-is, to-be, and removal Workpiece objects. This change also adds the `toolpath_orientation` to allow reuse of nested workplans or workingsteps in different locations. Replace 4.2.417 with the following. Retain 4.2.417.1 with no changes.

4.2.417 Workplan

The Workplan application object is defined by clause 4.6 of ISO 14649-10:2004. This part of ISO 10303 adds the following information requirements.

NOTE 1 The `In_process_geometry` concept referenced by `Workplan.its_effect` in ISO 14649 is replaced by as-is, to-be, and removal properties associated with the Executable application object.

The data associated with a Workplan are the following:

- all of the data defined by ISO 14649-10, except for `its_effect`;
- `its_minimum_machine_params`;
- `toolpath_orientation`.

NOTE 2 The ISO 14649 EXPRESS description for Workplan, as adapted by this part of ISO 10303, is shown below. Refer to ISO 14649-10 for the original definition and explanation of usage.

```
ENTITY workplan
  SUBTYPE OF (program_structure);
  its_elements:      LIST[0:?] OF executable;
  its_channel:       OPTIONAL channel;
  its_setup:         OPTIONAL setup;
  -- its_effect:     OPTIONAL in_process_geometry;           -- REPLACED BY 10303-238
  its_minimum_machine_params:  OPTIONAL machine_parameters; -- ADDED BY 10303-238
  toolpath_orientation:  OPTIONAL axis2_placement_3d; -- ADDED BY 10303-238
WHERE
  WR1: SIZEOF(QUERY(it <* its_elements | it = SELF)) = 0;
END_ENTITY;
```

Page 194, 4.2.417

The purpose of this change is to add the `toolpath_orientation` to Workplan allow reuse of nested workplans or workingsteps in different locations. Add the following after 4.2.417.1.

4.2.417.2 toolpath_orientation

The `toolpath_orientation` specifies the placement of the set of toolpaths associated with the Executables given by the `its_elements` parameter. The `toolpath_orientation` need not be specified for a particular Workplan. The placement shall be applied cumulatively in addition to `toolpath_orientations` specified by nested Workplan or Machining_workinstep executables. If the `toolpath_orientation` is not specified, the toolpaths shall assume an origin of (0,0,0) and axis directions $X=(1,0,0)$ $Y=(0,1,0)$ and $Z=(0,0,1)$.

Page 196, 4.3

The purpose of this change is to add application assertions for the relationship between Datum and

Workpiece. Insert the following new subclauses after 4.3.12.

4.3.13 Datum to Workpiece

Each Datum references exactly one Workpiece object as its_workpiece. Each Workpiece acts as its_workpiece for zero or more Datum objects.

Page 196, 4.3

The purpose of this change is to add application assertions for the relationship between Datum_target and Workpiece, and to add application assertions for the as-is, fixture, removal, and to-be relationships between Executable and Workpiece. Insert the following new subclauses after 4.3.13 (which is renumbered as 4.3.14 by the insertion described above)

4.3.15 Datum_target to Workpiece

Each Datum_target references exactly one Workpiece object as its_workpiece. Each Workpiece acts as its_workpiece for zero or more Datum_target objects.

4.3.16 Executable to Workpiece (as as_is)

Each Executable references at most one Workpiece object as as_is. Each Workpiece acts as as_is for zero or more Executable objects.

4.3.17 Executable to Workpiece (as fixture)

Each Executable references at most one Workpiece object as fixture. Each Workpiece acts as removal for zero or more Executable objects.

4.3.18 Executable to Workpiece (as removal)

Each Executable references at most one Workpiece object as removal. Each Workpiece acts as removal for zero or more Executable objects.

4.3.19 Executable to Workpiece (as to_be)

Each Executable references at most one Workpiece object as to_be. Each Workpiece acts as to_be for zero or more Executable objects.

Page 424, Table 5

The purpose of this change is to replace In_process_geometry application object with references from Executable to as-is, to-be, fixture, and removal Workpiece objects. Insert the following entry to Table 5 after EXECUTABLE its_id.

executable to workpiece	PATH			machining_process_executable <= action_method <-
----------------------------	------	--	--	---

(as as_is)				<pre> action.chosen_method { action.name = 'as-is shape' } action => product_definition_process <- process_product_association.process process_product_association process_product_association.defined_product -> characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
<p>enabled</p> <p>#1: if value is true (mapping may also be omitted if value is true)</p> <p>#2: if value is false</p>	<p>descriptive_ - representation_ - item</p>	10303-45		<pre> machining_process_executable <= action_method characterized_action_definition = action_method characterized_action_definition <- action_property.definition { action_property.name = 'enabled' } action_property <- action_property_representation.property action_property_representation action_property_representation.representation -> representation representation.items[i] -> representation_item => descriptive_representation_item descriptive_representation_item.description {#1: (descriptive_representation_item.description = 'enabled') #2: (descriptive_representation_item.description = 'disabled')} </pre>
<p>executable to workpiece (as fixture)</p>	PATH			<pre> machining_process_executable <= action_method <- action.chosen_method { action.name = 'fixture shape' } action => product_definition_process <- process_product_association.process process_product_association process_product_association.defined_product -> characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
<p>executable to workpiece (as removal)</p>	PATH			<pre> machining_process_executable <= action_method <- action.chosen_method { action.name = 'removal shape' } action => product_definition_process <- process_product_association.process </pre>

				<pre> process_product_association process_product_association.defined_product -> characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
executable to workpiece (as to_be)	PATH			<pre> machining_process_executable <= action_method <- action.chosen_method { action.name = 'to-be shape' } action => product_definition_process <- process_product_association.process process_product_association process_product_association.defined_product -> characterized_product_definition characterized_product_definition = product_definition product_definition </pre>

Page 427, Table 5

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete the table entry for IN_PROCESS_GEOMETRY and subsequent table entries for as_is, to_be, and removal.

Page 443, Table 5

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete table entry “machining_workingstep to in_process_geometry (as its_effect)”

Page 456, Table 5

The purpose of this change is to modify the definition for Tool_usage to clarify how the tool product model is oriented with respect to toolpaths and machine models for simulation and interference checking. Insert the following after the TOOL_USAGE its_product table entry in Table 5.

gage_placement	axis2 - placement_3d	10303-42		<pre> machining_tool_usage <= action_method characterized_action_definition = action_method characterized_action_definition <- action_property.definition { action_property.name = 'gage placement' } action_property <- action_property_representation.property </pre>
----------------	-------------------------	----------	--	--

				<pre> action_property_representation action_property_representation.representation -> representation representation.items[i] -> representation_item => geometric_representation_item => placement => axis2_placement_3d </pre>
tool_end_placement	axis2_placement_3d	10303-42		<pre> machining_tool_usage <= action_method characterized_action_definition = action_method characterized_action_definition <- action_property.definition { action_property.name = 'tool end placement' } action_property <- action_property_representation.property action_property_representation action_property_representation.representation -> representation representation.items[i] -> representation_item => geometric_representation_item => placement => axis2_placement_3d </pre>

Page 456, Table 5

The purpose of this change is to modify the definition for touch_probe so that it becomes a type of machining_tool, to support a description of the probe usage, associated geometric shape, and other product information available for other types of tool. Replace the TOUCH_PROBE and subsequent its_id table entries in Table 5 with the following.

TOUCH_-PROBE	machining_tool	10303-238		<pre> machining_tool <= action_resource { action_resource.description = 'touch probe' } </pre>
--------------	----------------	-----------	--	---

Page 465, Table 5

The purpose of this change is to modify the mapping path relating touch_probe to workpiece_complete_probing so that is correct with respect to the updated mapping for touch_probe. Replace the workpiece_complete_probing to touch_probe (as its_probe) table entry in Table 5 with the following.

workpiece_complete -	PATH			<pre> machining_touch_probing <= [machining_operation <=] </pre>
----------------------	------	--	--	--

probing to touch_probe (as its_probe)				<pre>[machining_process_executable <=] action_method supported_item = action_method supported_item <- action_resource.usage[i] action_resource => machining_tool</pre>
---	--	--	--	---

Page 462, Table 5

The purpose of this change is to modify the mapping path relating touch_probe to workpiece probing so that is correct with respect to the updated mapping for touch_probe. Replace the workpiece_probing to touch_probe (as its_probe) table entry in Table 5 with the following.

workpiece - probing to touch_probe (as its_probe)	PATH			<pre>machining_touch_probing <= [machining_operation <=] [machining_process_executable <=] action_method supported_item = action_method supported_item <- action_resource.usage[i] action_resource => machining_tool</pre>
--	------	--	--	---

Page 471, Table 5

The purpose of this change is to replace In_process_geometry application object and separate references on Machining_workingstep, Turning_workingstep, and Workplan with references from Executable to as-is, to-be, and removal Workpiece objects. Delete table entry “workplan to in_process_geometry (as its_effect)”

Page 489, Table 7

The purpose of this change is to add the mapping specification for the its_toolref_direction data associated with the Cutter_contact_trajectory application object. Insert the following entry to Table 7 after CUTTER_CONTACT_TRAJECTORY its_toolaxis.

its_toolref_direction	bounded_curve	10303-42		<pre>machining_toolpath <= action_method characterized_action_definition = action_method characterized_action_definition <- action_property.definition { action_property.name = ‘tool reference direction’ } action_property <- action_property_representation.property</pre>
-----------------------	---------------	----------	--	--

				<pre> action_property_representation action_property_representation.representation -> representation representation.items[i] -> representation_item => geometric_representation_item => curve => bounded_curve </pre>
--	--	--	--	--

Page 492, Table 7

The purpose of this change is to add the mapping specification for the *its_toolref_direction* data associated with the *Cutter_location_trajectory* application object. Insert the following entry to Table 7 after *CUTTER_LOCATION_TRAJECTORY its_toolaxis*.

<i>its_toolref_direction</i>	<i>bounded_curve</i>	10303-42		<pre> machining_toolpath <= action_method characterized_action_definition = action_method characterized_action_definition <- action_property.definition { action_property.name = 'tool reference direction' } action_property <- action_property_representation.property action_property_representation action_property_representation.representation -> representation representation.items[i] -> representation_item => geometric_representation_item => curve => bounded_curve </pre>
------------------------------	----------------------	----------	--	--

Page 502, Table 7

The purpose of this change is to add the mapping specification for the *cross_section_area_parameters* data associated with the *Trajectory* application object. Insert the following entry to Table 7 after *TRAJECTORY its_material_removal_total_volume*.

<i>cross_section_area_parameters</i>	<i>bounded_curve</i>	10303-42		<pre> machining_toolpath <= action_method characterized_action_definition = action_method characterized_action_definition <- action_property.definition { action_property.name = 'cross section area parameters' } </pre>
--------------------------------------	----------------------	----------	--	---

				<pre> action_property <- action_property_representation.property action_property_representation action_property_representation.representation -> representation representation.items[i] -> representation_item => geometric_representation_item => curve => bounded_curve </pre>
--	--	--	--	--

Page 684, Table 11

The purpose of this change is to replace *In_process_geometry* application object and separate references on *Machining_workingstep*, *Turning_workingstep*, and *Workplan* with references from *Executable* to *as-is*, *to-be*, and *removal Workpiece* objects. Delete table entry “*turning_workingstep* to *in_process_geometry* (as *its_effect*)”

Page 721, Table 13

The purpose of this change is to add the mapping specification for the *its_workpiece* data associated with the *Datum* application object. Insert the following entry to Table 13 after *DATUM*.

datum to workpiece (as <i>its_workpiece</i>)	PATH			<pre> datum => shape_aspect shape_aspect.of_shape -> product_definition_shape <= property_definition property_definition.definition -> characterized_definition characterized_definition = characterized_product_definition characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
---	------	--	--	--

Page 723, Table 13

The purpose of this change is to add the mapping specification for the *its_workpiece* data associated with the *Datum_target* application object. Insert the following to Table 13 after *DATUM_TARGET id*.

datum_target to workpiece (as <i>its_workpiece</i>)	PATH			<pre> datum_target => shape_aspect shape_aspect.of_shape -> product_definition_shape <= property_definition </pre>
--	------	--	--	---

				<pre> property_definition.definition -> characterized_definition characterized_definition = characterized_product_definition characterized_product_definition characterized_product_definition = product_definition product_definition </pre>
--	--	--	--	--

Page 764, 5.1

The purpose of this change is to correct grammar. In the last sentence of note 6, replace “the the” with “the”.

Page 778, 5.2.1.2.2

The purpose of this change is to correct a grammar error. In the second sentence of the second paragraph, insert “to” before “support” in the phrase “has been added to Manufacturing_feature (See 4.2.198) support”.

Page 782, 5.2.1.3.1

The purpose of this change is to simplify awkward text. In the second sentence of the second paragraph, replace “that the profile is swept sweeps” with “that the swept profile sweeps”.

Page 782, 5.2.1.3.2

The purpose of this change is to correct a grammar error. In the second sentence of the fifth paragraph, replace “For a placement is at the top” with “For a placement at the top”. In the third sentence, replace “For a placement is at the bottom” with “For a placement at the bottom”.

Page 782, 5.2.1.3.2

The purpose of this change is to correct the description of the placement. In the second sentence of the fifth paragraph, replace the phrase “Z => Y and Y => -Z” with “Z => -Z and Y => -Y”.

Page 784, 5.2.1.3.3

The purpose of this change is to correct a grammar error. In the second sentence of the fifth paragraph, replace “For a placement is at the top” with “For a placement at the top”. In the third sentence, replace “For a placement is at the bottom” with “For a placement at the bottom”.

Page 784, 5.2.1.3.3

The purpose of this change is to correct the description of the placement. In the second sentence of the fifth paragraph, replace the phrase “Z => Y and Y => -Z” with “Z => -Z and Y => -Y”.

Page 786, 5.2.1.3.4

The purpose of this change is to correct a grammar error. In the second sentence of the seventh paragraph, replace “For a placement is at the top” with “For a placement at the top”. In the third sentence, replace “For a placement is at the bottom” with “For a placement at the bottom”.

Page 786, 5.2.1.3.4

The purpose of this change is to correct the description of the placement. In the second sentence of the fifth paragraph, replace the phrase “Z => Y and Y => -Z” with “Z => -Z and Y => -Y”.

Page 789, 5.2.1.4.1

The purpose of this change is to correct the references to exchange structure elements in the second example. In the text of EXAMPLE 2, replace “#10” with “#40” and replace “#20” with “#50”.

Page 791, 5.2.1.4.2

The purpose of this change is to correct a grammar error. In the second sentence of NOTE, replace “is appears” with “appears”.

Page 792, 5.2.1.4.5

The purpose of this change is to correct a grammar error. In the first sentence of NOTE, replace “the use of these are deprecated” with “the use of these is deprecated”.

Page 793, 5.2.1.4.6

The purpose of this change is to clarify the example. Replace the first paragraph of the example with the following.

EXAMPLE In the exchange file fragment below, #10 describes a count of 5 encoded as a measure_with_unit. The count unit is encoded by #20. Example 1 in 5.2.1.4.1 describes a count measurement encoded using measure_representation_item.

Page 793, 5.2.1.4.8

The purpose of this change is to correct the exchange file fragment in the example. Replace the usage of TIME_MEASURE with LENGTH_MEASURE in the first exchange file fragment. The fourth line of the first exchange file fragment should be as follows.

```
MEASURE_WITH_UNIT(LENGTH_MEASURE(12.),#30)
```

Page 794, 5.2.1.4.9

The purpose of this change is to correct the exchange file fragment in the example. Replace the usage of PLANE_ANGLE_MEASURE with MASS_MEASURE in the exchange file fragment. The fourth line of the exchange file fragment should be as follows.

```
MEASURE_WITH_UNIT(MASS_MEASURE(2.),#20)
```

Page 799, 5.2.1.4.18

The purpose of this change is to correct a grammar error. In the first sentence of NOTE, replace “the use of these are deprecated” with “the use of these is deprecated”. In the second sentence of NOTE, replace “an volume measure” with “a volume measure”.

Page 800, 5.2.1.4.19

The purpose of this change is to correct a grammar error. In the first sentence of the last paragraph, replace “These representation subtypes identifies” with “These representation subtypes

identify”.

Page 804, 5.2.1.5.2

The purpose of this change is to correct awkward text. In the first sentence of the second paragraph, replace “engineering discipline’s” with “the engineering discipline from whose”. In the first sentence of the third paragraph, replace “the the” with “the”. Replace the entire second sentence of the EXAMPLE, with the following.

The product_context (#40) identifies a design discipline, the product_definition_context (#70) identifies a life cycle stage, and instances #50 and #60 identifies this part of ISO 10303.

Page 806, 5.2.1.6.3

The purpose of this change is to correct reversed X and Y coordinates in the NOTE. In the first sentence of the second paragraph, replace the parenthetical expression with “(from +X,0 to 0,+Y to -X,0 to 0,-Y)”.

Page 806, 5.2.1.6.3

The purpose of this change is to permit a more concise representation of arc toolpaths to better support high-speed milling operations. Insert the following paragraph at the end of 5.2.1.6.3.

A toolpath containing a circular arc may also be described using a polyline with an instance of the via_arc_point subtype of cartesian_point (See 5.2.3.1.94).

Page 806, 5.2.1.6.4

The purpose of this change is to permit a more concise representation of arc toolpaths to better support high-speed milling operations. Insert the following paragraph at the end of 5.2.1.6.4.

A toolpath containing a complete circle may also be described using a polyline with two instances of the via_arc_point subtype of cartesian_point (See 5.2.3.1.94).

Page 810, 5.2.2.1.10

The purpose of this change is to add assembly_component_usage to the AIM security_classification_-item definition to better support workpiece product models brought in from AP203 data. Insert “assembly_component_usage,” before “machining_operation” in both the first sentence and in the EXPRESS specification.

Page 861, 5.2.3.1.58

The purpose of this change is to add EXPRESS constraints to the AIM machining_process_executable definition for the as_is, enabled, fixture, removal, and to_be data. Insert the following text for WR9 at the end of the EXPRESS definition for machining_process_executable.

```
WR9: (verify_optional_action_property (SELF, 'enabled')) AND
      (verify_enumeration_action_property (SELF, 'enabled',
      ['enabled', 'disabled'])) AND

(1 >= SIZEOF (QUERY (act <*
      USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
```

```

    (act.name = 'as-is shape')))) AND
(0 = SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'as-is shape') AND NOT
    ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) AND

(1 >= SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'fixture shape')))) AND
(0 = SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'fixture shape') AND NOT
    ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) AND

(1 >= SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'removal shape')))) AND
(0 = SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'removal shape') AND NOT
    ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) AND

(1 >= SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'to-be shape')))) AND
(0 = SIZEOF (QUERY (act <*
    USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
    (act.name = 'to-be shape') AND NOT
    ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS'
    IN TYPEOF (act))))) ;

```

Page 862, 5.2.3.1.58

The purpose of this change is to describe EXPRESS constraints to the AIM machining_process_executable definition for the as_is, enabled, fixture, removal, and to_be data. Insert the following text as the last item in the list describing formal propositions.

WR9: The **machining_process_executable** shall satisfy the following conditions:

- the **machining_process_executable** shall be the **definition** of at most one **action_property** with a **name** of 'enabled', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **descriptive_representation_item** with a **description** of 'enabled' or 'disabled';
- the **machining_process_executable** shall be the **chosen_method** of at most one **product_definition_process** with a **name** of 'as-is shape';
- the **machining_process_executable** shall be the **chosen_method** of at most one **product_definition_process** with a **name** of 'fixture shape';

- the **machining_process_executable** shall be the **chosen_method** of at most one **product_definition_process** with a **name** of 'removal shape';
- the **machining_process_executable** shall be the **chosen_method** of at most one **product_definition_process** with a **name** of 'to-be shape'.

Page 889, 5.2.3.1.75

The purpose of this change is to add EXPRESS constraints to the AIM machining_tool_usage definition for the Tool_usage gage_placement and tool_end_placement application object data. Insert the following text for WR4 and WR5 at the end of the EXPRESS definition for machining_tool_usage.

```
WR4: ((verify_optional_action_property (SELF, 'gage placement')) AND
      (verify_rep_item_for_action_property (SELF, 'gage placement',
      [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ]))) ;

WR5: ((verify_optional_action_property (SELF, 'tool end placement')) AND
      (verify_rep_item_for_action_property (SELF, 'tool end placement',
      [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ]))) ;
```

Page 890, 5.2.3.1.75

The purpose of this change is to add EXPRESS constraints to the AIM machining_tool_usage definition for the Tool_usage gage_placement and tool_end_placement application object data. Insert the following text at the end of the list of formal propositions.

WR4: The **machining_tool_usage** shall be the **definition** of at most one **action_property** with a **name** of 'gage placement', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **axis2_placement_3d**.

WR5: The **machining_tool_usage** shall be the **definition** of at most one **action_property** with a **name** of 'tool end placement', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **axis2_placement_3d**.

Page 892, 5.2.3.1.76

The purpose of this change is to add EXPRESS constraints to the AIM machining_toolpath definition for the its_toolref_direction data associated with the Cutter_location_trajectory and Cutter_contact_trajectory application objects. Replace WR14 and WR15 in the EXPRESS definition for machining_toolpath with the following text.

```
WR14: NOT (SELF.description = 'cutter location trajectory') OR
      ((verify_required_action_property (SELF, 'basic curve')) AND
      (verify_rep_item_for_action_property (SELF, 'basic curve',
      [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))) AND

      (verify_optional_action_property (SELF, 'surface normal')) AND
      (verify_rep_item_for_action_property (SELF, 'surface normal',
      [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))) AND

      (verify_optional_action_property (SELF, 'tool axis')) AND
      (verify_rep_item_for_action_property (SELF, 'tool axis',
      [ 'INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE' ]))) AND
```



```

(verify_optional_action_property
  (SELF, 'tool reference direction')) AND
(verify_rep_item_for_action_property
  (SELF, 'tool reference direction',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

(verify_optional_action_property
  (SELF, 'path maximum deviation')) AND
(verify_length_measure_action_property
  (SELF, 'path maximum deviation')) AND

(verify_optional_action_property
  (SELF, 'tool axis maximum deviation')) AND
(verify_angle_measure_action_property
  (SELF, 'tool axis maximum deviation'))
);

```

```

WR15: NOT (SELF.description = 'cutter contact trajectory') OR
(((verify_required_action_property      (SELF, 'basic curve')) AND
 (verify_rep_item_for_action_property (SELF, 'basic curve',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_PCURVE'])) )

```

OR

```

((verify_required_action_property      (SELF, 'basic curve')) AND
 (verify_rep_item_for_action_property (SELF, 'basic curve',
   ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

```

AND

```

(verify_required_action_property      (SELF, 'surface normal'))

(verify_rep_item_for_action_property (SELF, 'surface normal',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) )
) AND

```

```

(verify_optional_action_property      (SELF, 'tool axis')) AND
(verify_rep_item_for_action_property (SELF, 'tool axis',
  ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

```

```

(verify_optional_action_property
  (SELF, 'tool reference direction')) AND
(verify_rep_item_for_action_property
  (SELF, 'tool reference direction',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

```

```

(verify_optional_action_property      (SELF, 'contact type')) AND
(verify_enumeration_action_property  (SELF, 'contact type',
  ['side', 'front'])) AND

```

```

(verify_optional_action_property
  (SELF, 'path maximum deviation')) AND
(verify_length_measure_action_property
  (SELF, 'path maximum deviation')) AND

```

```

(verify_optional_action_property
  (SELF, 'tool axis maximum deviation')) AND
(verify_angle_measure_action_property

```

```
        (SELF, 'tool axis maximum deviation'))
    );
```

Page 893, 5.2.3.1.76

The purpose of this change is to add EXPRESS constraints to the AIM machining_toolpath definition for the cross_section_area_parameters data associated with the Trajectory application object. Replace WR16 in the EXPRESS definition for machining_toolpath with the following text.

```
WR16: NOT (SELF.description IN ['axis trajectory',
    'cutter location trajectory',
    'cutter contact trajectory']) OR
((verify_optional_action_property
    (SELF, 'material removal depth')) AND
((verify_length_measure_action_property
    (SELF, 'material removal depth')) OR
(verify_rep_item_for_action_property
    (SELF, 'material removal depth',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

(verify_optional_action_property
    (SELF, 'material removal overcut')) AND
((verify_length_measure_action_property
    (SELF, 'material removal overcut')) OR
(verify_rep_item_for_action_property
    (SELF, 'material removal overcut',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

(verify_optional_action_property
    (SELF, 'material removal total volume')) AND
(verify_rep_item_for_action_property
    (SELF, 'material removal total volume',
    ['INTEGRATED_CNC_SCHEMA.MEASURE_REPRESENTATION_ITEM'])) AND

(verify_optional_action_property
    (SELF, 'cross section area parameters')) AND
(verify_rep_item_for_action_property
    (SELF, 'cross section area parameters',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))
);
```

Page 895, 5.2.3.1.76

The purpose of this change is to describe EXPRESS constraints added to the AIM machining_toolpath definition for the its_toolref_direction data associated with the Cutter_location_trajectory application object. Insert the following text as the third item in the list describing formal propositions for WR14.

— the **machining_toolpath** shall be the **definition** of at most one **action_property** with a **name** of 'tool reference direction', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **bounded_curve**;

Page 896, 5.2.3.1.76

The purpose of this change is to describe EXPRESS constraints added to the AIM machining_toolpath definition for the its_toolref_direction data associated with the Cutter_contact_trajectory application

object. Insert the following text as the third item in the list describing formal propositions for WR15.

- the **machining_toolpath** shall be the **definition** of at most one **action_property** with a **name** of 'tool reference direction', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **bounded_curve**;

Page 897, 5.2.3.1.76

The purpose of this change is to describe EXPRESS constraints added to the AIM machining_toolpath definition for the cross_section_area_parameters data associated with the Trajectory application object. Insert the following text at the end of the list describing formal propositions for WR16.

- the **machining_toolpath** shall be the **definition** of at most one **action_property** with a **name** of 'cross section area parameters', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **bounded_curve**.

Page 898, 5.2.3.1.79

The purpose of this change is to update the EXPRESS constraints on the AIM machining_touch_probing definition so that they are correct with the updated mappings related to the Touch_probe application object. In WR4 of the EXPRESS definition for machining_touch_probing, replace the line:

```
(verify_required_action_property      (SELF, 'probe'))
```

with the following text:

```
(1 = SIZEOF (QUERY (mt <*  
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION_RESOURCE.USAGE') |  
  ('INTEGRATED_CNC_SCHEMA.MACHINING_TOOL' in TYPEOF(mt))))))
```

Page 899, 5.2.3.1.79

The purpose of this change is to update the EXPRESS constraints on the AIM machining_touch_probing definition so that they are correct with the updated mappings related to the Touch_probe application object. In WR5 of the EXPRESS definition for machining_touch_probing, replace the line:

```
(verify_required_action_property      (SELF, 'probe')) AND
```

with the following text:

```
(1 = SIZEOF (QUERY (mt <*  
  USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION_RESOURCE.USAGE') |  
  ('INTEGRATED_CNC_SCHEMA.MACHINING_TOOL' in TYPEOF(mt)))))) AND
```

Page 900, 5.2.3.1.79

The purpose of this change is to update the EXPRESS constraints on the AIM machining_touch_probing definition so that they are correct with the updated mappings related to the Touch_probe application object. Replace the last item in the list describing formal propositions for WR4 with the following:

— the **machining_touch_probing** shall appear in the **usage** set of exactly one **machining_tool**.

Page 900, 5.2.3.1.79

The purpose of this change is to update the EXPRESS constraints on the AIM machining_touch_probe definition so that they are correct with the updated mappings related to the Touch_probe application object. Replace the third item in the list describing formal propositions for WR5 with the following:

— the **machining_touch_probing** shall appear in the **usage** set of exactly one **machining_tool**.

Page 902, 5.2.3.1.80

The purpose of this change is to update the EXPRESS constraints on the AIM machining_workingstep definition so that they are correct with the removal of references to the In_process_geometry application object from Machining_workingstep, Turning_workingstep, and Workplan. Delete WR4 from the EXPRESS specification and renumber WR5 to WR4. Delete the description of WR4 from the Formal propositions and renumber the description of WR5 to WR4.

Page 903, 5.2.3.1.81

The purpose of this change is to update the EXPRESS constraints on the AIM machining_workplan definition to remove references to the In_process_geometry application object and add a constraint for the Workplan toolpath_orientation. Replace WR4 in the EXPRESS definition with the following:

```
WR4: ((verify_optional_action_property (SELF, 'toolpath orientation')) AND
      (verify_rep_item_for_action_property (SELF, 'toolpath orientation',
      [ 'INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D' ])));
```

Page 904, 5.2.3.1.81

The purpose of this change is to update the EXPRESS constraints on the AIM machining_workplan definition to remove references to the In_process_geometry application object and add a constraint for the Workplan toolpath_orientation. Replace WR4 in the Formal propositions with the following:

WR4: The **machining_workplan** shall be the **definition** of at most one **action_property** with a **name** of 'toolpath orientation', and the **representation** used to describe the **action_property** shall contain a **representation_item** of type **axis2_placement_3d**.

Page 924, 5.2.3.1

The purpose of this change is to permit a more concise representation of arc and helix toolpaths to better support high-speed milling operations. Insert the following new subclauses after 5.2.3.1.93. Add via_arc_point and via_helix_point to Index. Add Figure 53 to List of figures.

5.2.3.1.94 via_arc_point

A **via_arc_point** is a **cartesian_point**. When appearing in the **points** list of a **polyline**, the **via_arc_point** defines an arc starting at the previous point in the **polyline**, passing through the **via_arc_point**, and ending at the next point in the **polyline**. The arc defined by the **via_arc_point** shall be less than .

If two via points are considered coincident if any two consecutive points in the via are considered coincident, they shall be considered to define a straight line segment rather than an arc. context of enclosing representation. Extra via points between two non via points must define arcs of the same radius.

NOTE 1 Since the arc defined by a via is less than π , a full circle is described using more than one via point. The use of a via point to describe an arc is also found in the circular_path entity in ISO 10303-105[3].

If a via point and the preceding or following point in a polyline are considered coincident, the via point shall be considered to define straight line segments rather than an arc.

NOTE 2 Two points are considered coincident if they lie within the uncertainty distance given by the global_uncertainty_assigned_context of the enclosing representation.

EXAMPLE In the exchange file fragment below, #10 describes a 270 degree arc on the XY plane, starting at point #20, passing through point #30 and ending at point #40. Instance #50 describes a complete circle on the XY plane, starting and ending at point #60, passing through point #70 and point #80.

```
/* 270 degree arc, centered at (0,0,0) */
#10=POLYLINE('',(#20,#30,#40));
#20=CARTESIAN_POINT('start',(0,1.,0));
#30=VIA_ARC_POINT('via',(1.,0,0));
#40=CARTESIAN_POINT('end',(-1.,0,0));

/* complete circle, centered at (0,0,0) */
#50=POLYLINE('',(#60,#30,#40,#60));
#60=CARTESIAN_POINT('start and end',(0,1.,0));
#40=VIA_ARC_POINT('via #1',(-1.,0,0));
#30=VIA_ARC_POINT('via #2',(1.,0,0));
```

Figure 53 illustrates the arc and a complete circle described by the exchange file fragment.

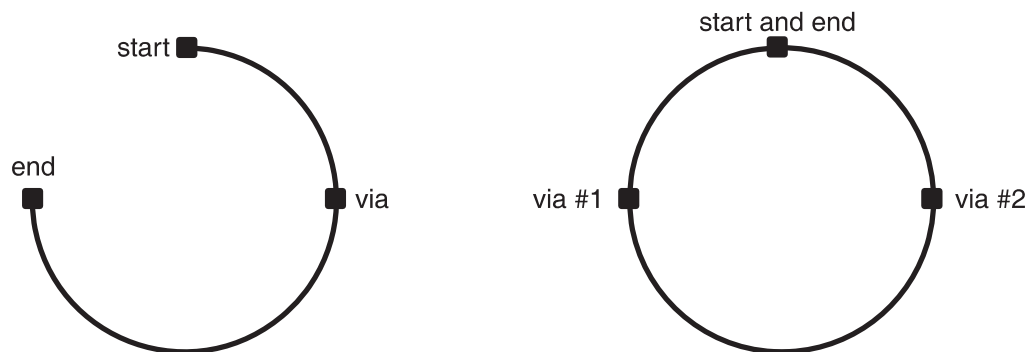


Figure 53 - Arcs with via points

EXPRESS specification:

```
*)
ENTITY via_arc_point
  SUBTYPE OF (cartesian_point);
  WHERE
  WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
  WR2: (0 = SIZEOF (QUERY (pl < *
    USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
    ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
  )));
END_ENTITY;
(*
```

Formal propositions:

WR1: The **via_arc_point** shall appear in the **points** list of at least one **polyline**.

WR2: The **via_arc_point** shall not appear as either the first or last element in the **points** list of any **polyline**.

5.2.3.1.95 via_helix_point

A **via_helix_point** is a **cartesian_point**. When appearing in the **points** list of a **polyline**, the **via_helix_point** defines an helix starting at the previous point in the **polyline**, passing through the **via_helix_point**, and ending at the next point in the **polyline**. As with **via_arc_point**, when projected to the plane, the arc defined by the **via_helix_point** shall be less than .

If a via point and the preceeding or following point in a polyline are considered coincident, the via point shall be considered to define straight line segments rather than a helix.

NOTE Two points are considered coincident if they lie within the uncertainty distance given by the **global_uncertainty_assigned_context** of the enclosing representation.

EXPRESS specification:

```
*)
ENTITY via_helix_point
  SUBTYPE OF (cartesian_point);
  WHERE
  WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
  WR2: (0 = SIZEOF (QUERY (pl < *
    USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
    ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
  )));
END_ENTITY;
(*
```

Formal propositions:

WR1: The **via_helix_point** shall appear in the **points** list of at least one **polyline**.

WR2: The **via_helix_point** shall not appear as either the first or last element in the **points** list of any **polyline**.

Page 956, 5.2.5.28

The purpose of this change is to eliminate the AIM `verify_optional_in_process_geometry` function which is no longer used with the removal of references to the `In_process_geometry` application object from `Machining_workingstep`, `Turning_workingstep`, and `Workplan`. Delete 5.3.5.28 and renumber the remaining clauses.

Page 976, 6.1

The purpose of this change is to replace `In_process_geometry` application object and separate references on `Machining_workingstep`, `Turning_workingstep`, and `Workplan` with references from `Executable` to `as-is`, `to-be`, and `removal` `Workpiece` objects. Replace the last list item in 6.1 with the following.

- no geometric shape information shall be specified for `Manufacturing_feature` `explicit_representation`, `Workpiece` `its_geometry` or `its_bounding_geometry`, or `Workpiece_setup` `its_restricted_area`.

Page 977, 6.2

The purpose of this change is to replace `In_process_geometry` application object and separate references on `Machining_workingstep`, `Turning_workingstep`, and `Workplan` with references from `Executable` to `as-is`, `to-be`, and `removal` `Workpiece` objects. Replace the last list item in 6.2 with the following.

- geometric shape information may be specified for `Workpiece` `its_geometry` or `its_bounding_geometry`, or `Workpiece_setup` `its_restricted_area`.

Page 1003, Annex A

The purpose of this change is to add `assembly_component_usage` to the AIM `security_classification_item` definition to better support workpiece product models brought in from AP203 data. Insert “`assembly_component_usage`,” before “`machining_operation`” in the EXPRESS `SELECT` type list for `security_classification_item`.

Page 1103, Annex A

The purpose of this change is to correct the expanded EXPRESS listing for `machining_tool_usage` to match the EXPRESS in 5.2.3.1.75. Replace the EXPRESS definition for `machining_tool_usage` with the following text.

```
ENTITY machining_tool_usage
  SUBTYPE OF (action_method);
  WHERE
  WR1: ((verify_optional_action_property (SELF, 'tool position')) AND
        (verify_descriptive_action_property (SELF, 'tool position')));

  WR2: ((verify_optional_action_property (SELF, 'tool carousel')) AND
        (verify_descriptive_action_property (SELF, 'tool carousel')));
```

```

WR3:  (1 >= SIZEOF (QUERY (act <*
      USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
      (act.name = 'tool usage')))) AND
      (0 = SIZEOF (QUERY (act <*
      USEDIN (SELF, 'INTEGRATED_CNC_SCHEMA.ACTION.CHOSEN_METHOD') |
      (act.name = 'tool usage') AND NOT
      ('INTEGRATED_CNC_SCHEMA.PRODUCT_DEFINITION_PROCESS' IN TYPEOF
(act))
      ))));

WR4:  ((verify_optional_action_property (SELF, 'gage placement')) AND
      (verify_rep_item_for_action_property (SELF, 'gage placement',
      ['INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D'])));

WR5:  ((verify_optional_action_property (SELF, 'tool end placement')) AND
      (verify_rep_item_for_action_property (SELF, 'tool end placement',
      ['INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D'])));
END_ENTITY;

```

Page 1105, Annex A

The purpose of this change is to add EXPRESS constraints to the expanded EXPRESS listing for machining_toolpath definition to match the EXPRESS in 5.2.3.1.76. Replace WR14, WR15, and WR16 in the EXPRESS definition for machining_toolpath with the following text.

```

WR14: NOT (SELF.description = 'cutter location trajectory') OR
      ((verify_required_action_property      (SELF, 'basic curve')) AND
      (verify_rep_item_for_action_property (SELF, 'basic curve',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

      (verify_optional_action_property      (SELF, 'surface normal')) AND
      (verify_rep_item_for_action_property (SELF, 'surface normal',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

      (verify_optional_action_property      (SELF, 'tool axis')) AND
      (verify_rep_item_for_action_property (SELF, 'tool axis',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

      (verify_optional_action_property
      (SELF, 'tool reference direction')) AND
      (verify_rep_item_for_action_property
      (SELF, 'tool reference direction',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])) AND

      (verify_optional_action_property
      (SELF, 'path maximum deviation')) AND
      (verify_length_measure_action_property
      (SELF, 'path maximum deviation')) AND

      (verify_optional_action_property
      (SELF, 'tool axis maximum deviation')) AND
      (verify_angle_measure_action_property
      (SELF, 'tool axis maximum deviation'))
      );

```



```

WR15: NOT (SELF.description = 'cutter contact trajectory') OR
  (((verify_required_action_property (SELF, 'basic curve')) AND
    (verify_rep_item_for_action_property (SELF, 'basic curve',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_PCURVE']))) )

  OR

  ((verify_required_action_property (SELF, 'basic curve')) AND
    (verify_rep_item_for_action_property (SELF, 'basic curve',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

  (verify_required_action_property (SELF, 'surface normal'))

AND

  (verify_rep_item_for_action_property (SELF, 'surface normal',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) )
) AND

  (verify_optional_action_property (SELF, 'tool axis')) AND
  (verify_rep_item_for_action_property (SELF, 'tool axis',
    ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

  (verify_optional_action_property
    (SELF, 'tool reference direction')) AND
  (verify_rep_item_for_action_property
    (SELF, 'tool reference direction',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

  (verify_optional_action_property (SELF, 'contact type')) AND
  (verify_enumeration_action_property (SELF, 'contact type',
    ['side', 'front']))) AND

  (verify_optional_action_property
    (SELF, 'path maximum deviation')) AND
  (verify_length_measure_action_property
    (SELF, 'path maximum deviation')) AND

  (verify_optional_action_property
    (SELF, 'tool axis maximum deviation')) AND
  (verify_angle_measure_action_property
    (SELF, 'tool axis maximum deviation'))
);

WR16: NOT (SELF.description IN ['axis trajectory',
  'cutter location trajectory',
  'cutter contact trajectory']) OR
  ((verify_optional_action_property
    (SELF, 'material removal depth')) AND
  ((verify_length_measure_action_property
    (SELF, 'material removal depth')) OR
  (verify_rep_item_for_action_property
    (SELF, 'material removal depth',
      ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])))) AND

  (verify_optional_action_property
    (SELF, 'material removal overcut')) AND
  ((verify_length_measure_action_property
    (SELF, 'material removal overcut')) OR

```

```

    (verify_rep_item_for_action_property
      (SELF, 'material removal overcut',
        ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE']))) AND

    (verify_optional_action_property
      (SELF, 'material removal total volume')) AND
    (verify_rep_item_for_action_property
      (SELF, 'material removal total volume',
        ['INTEGRATED_CNC_SCHEMA.MEASURE_REPRESENTATION_ITEM']))) AND

    (verify_optional_action_property
      (SELF, 'cross section area parameters')) AND
    (verify_rep_item_for_action_property
      (SELF, 'cross section area parameters',
        ['INTEGRATED_CNC_SCHEMA.BOUNDED_CURVE'])))
);

```

Page 1109, Annex A

The purpose of this change is to update the EXPRESS constraints on the AIM machining_workingstep definition so that they are correct with the removal of references to the In_process_geometry application object from Machining_workingstep, Turning_workingstep, and Workplan. Delete WR4 and renumber WR5 to WR4 in the EXPRESS definition for machining_workingstep.

Page 1110, Annex A

The purpose of this change is to update the EXPRESS constraints on the AIM machining_workplan definition to remove references to the In_process_geometry application object and add a constraint for the Workplan toolpath_orientation. Replace WR4 in the EXPRESS definition for machining_workplan with the following:

```

WR4: ((verify_optional_action_property (SELF, 'toolpath orientation')) AND
      (verify_rep_item_for_action_property (SELF, 'toolpath orientation',
        ['INTEGRATED_CNC_SCHEMA.AXIS2_PLACEMENT_3D']))) ;

```

Page 1213, Annex A

The purpose of this change is add the EXPRESS definitions for via_arc_point and via_helix_point to the expanded EXPRESS listing to match the EXPRESS in 5.2.3.1.94 and 5.2.3.1.95. Insert the following text after the EXPRESS definition for vertex_shell. Add via_arc_point and via_helix_point to Index.

```

ENTITY via_arc_point
  SUBTYPE OF (cartesian_point);
  WHERE
  WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
  WR2: (0 = SIZEOF (QUERY (pl <*
    USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
    ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
  ))) ;
END_ENTITY; -- 10303-238: integrated_cnc_schema

```

```

ENTITY via_helix_point
  SUBTYPE OF (cartesian_point);
  WHERE

```

```

WR1: SIZEOF(USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS')) > 0;
WR2: (0 = SIZEOF (QUERY (pl <*
    USEDIN(SELF, 'INTEGRATED_CNC_SCHEMA.POLYLINE.POINTS') |
    ((pl.points[1] = SELF) OR (pl.points[HiIndex(pl.points)] = SELF))
    )));
END_ENTITY; -- 10303-238: integrated_cnc_schema

```

Page 1262, Annex A

The purpose of this change is to eliminate the AIM verify_optional_in_process_geometry function which is no longer used with the removal of references to the In_process_geometry application object from Machining_workingstep, Turning_workingstep, and Workplan. Delete the EXPRESS definition for verify_optional_in_process_geometry.

Page 1287, Table B.1

The purpose of this change is add the short names for via_arc_point and via_helix_point to match the EXPRESS in 5.2.3.1.94 and 5.2.3.1.95. Insert the following into Table B.1 after vertex_shell.

VIA_ARC_POINT	VARPN
VIA_HELIX_POINT	VHLPN

Page 1289, C.2

The purpose of this change is to update the object identifier used by ISO 10303-28 implementations to identify the namespace for the EXPRESS schema. Replace subclause C.2 with the following text.

C.2 Requirements specific to ISO 10303-28

If the implementation method is ISO 10303-28, the file format shall be encoded according to the syntax and EXPRESS language mapping defined in ISO 10303-28 and in the AIM defined in Annex A of this part of ISO 10303. The ISO 10303-28 configuration shown below shall be used.

```

<?xml version="1.0"?>
<configuration
  xmlns="urn:oid:1.0.10303.28.2.1.2"
  xmlns:xs="http://www.w3.org/2001/XMLSchema">

  <schema targetNamespace="urn:oid:1.0.10303.238.2.0.1" />
  <option exp-attribute="attribute-content" tagless="true" />
  <uosElement name="iso_10303_28_terse" >
    <add_attribute name="schema" type="xs:NMTOKEN" usage="required" />

```

```
</uosElement>
</configuration>
```

The iso_10303_28_terse element shall identify the use of this part of ISO 10303 by the namespace ‘urn:oid:1.0.10303.238.2.0.1’ and the ‘schema’ attribute value of ‘integrated_cnc_schema’.

EXAMPLE The ISO 10303-28 configuration results in instance data written using the “attribute-content” encoding enclosed in the iso_10303_28_terse UOS element, as shown in the fragment below.

```
<?xml version="1.0"?>
<iso_10303_28_terse
  xmlns="urn:oid:1.0.10303.238.2.0.1"
  xmlns:exp="urn:oid:1.0.10303.28.2.1.1"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  schema="integrated_cnc_schema">

  <exp:header>
    <exp:name>dataset</exp:name>
    <exp:preprocessor_version>stepnc writer</exp:preprocessor_version>
  </exp:header>

  <!-- instance data -->
  <Axis2_placement_3d id="id1" Name="" Location="id2" Axis="id3" Ref_direction="id4"/>
  <Cartesian_point id="id2" Name="loc" Coordinates="3.5 -3.5 -4.16875"/>
  <Direction id="id3" Name="Z direction" Direction_ratios="0 0 1"/>
  <Direction id="id4" Name="X direction" Direction_ratios="1 0 0"/>
</iso_10303_28_terse>
```

Page 1294, E.1

The purpose of this change is to update the object identifier for the document. Replace the object identifier with the following text.

```
{ iso standard 10303 part(238) version(2) }
```

Page 1294, E.2

The purpose of this change is to update the object identifier for the schema. Replace the object identifier with the following text.

```
{ iso standard 10303 part(238) version(2) schema(1) integrated-cnc-schema(1) }
```

Page 1297, Figure G.1

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Workplan application object. Replace Figure G.1 with the following.

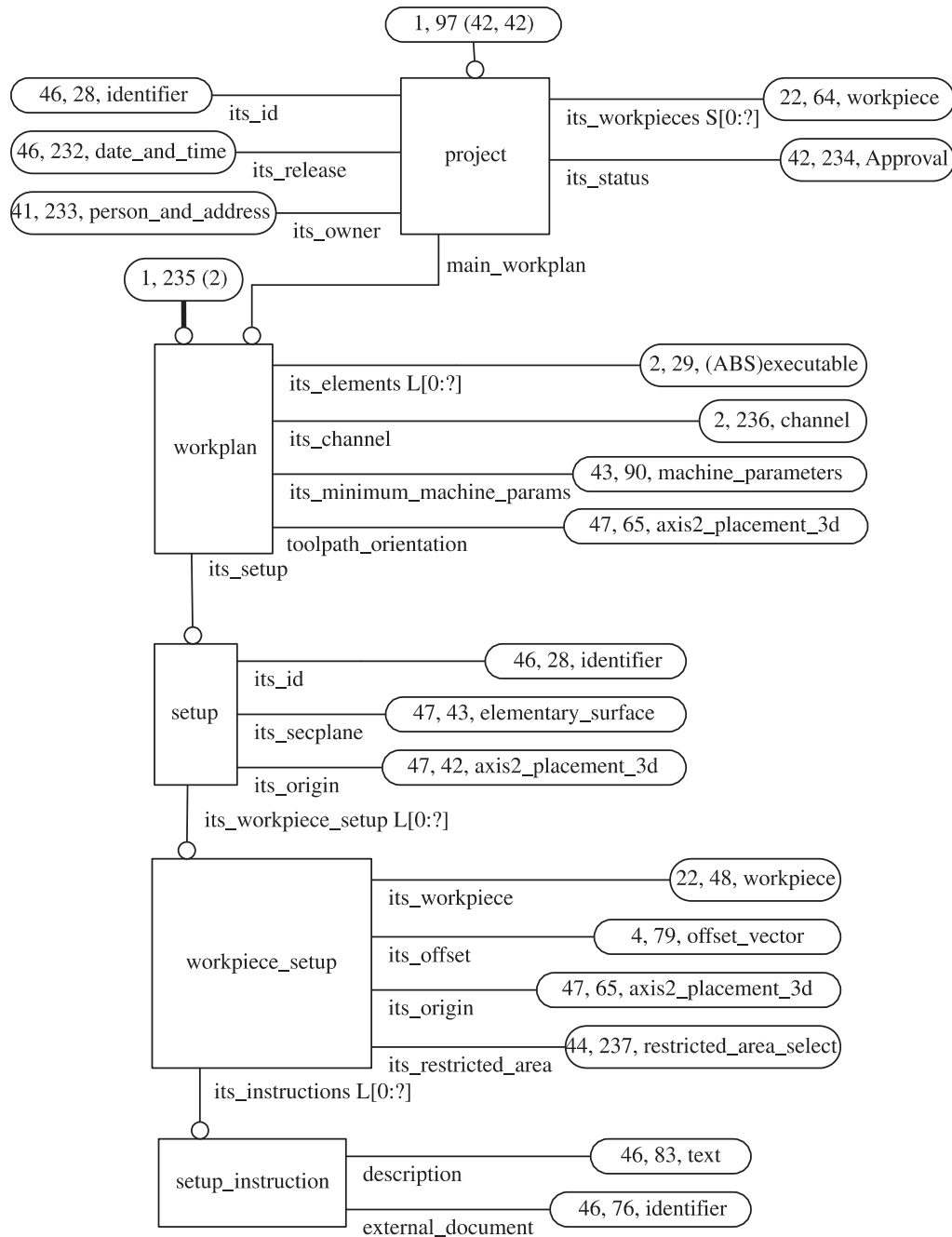


Figure G.1 - ARM diagram (1 of 48)

Page 1298, Figure G.2

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Executable application object. Replace Figure G.2 with the following.

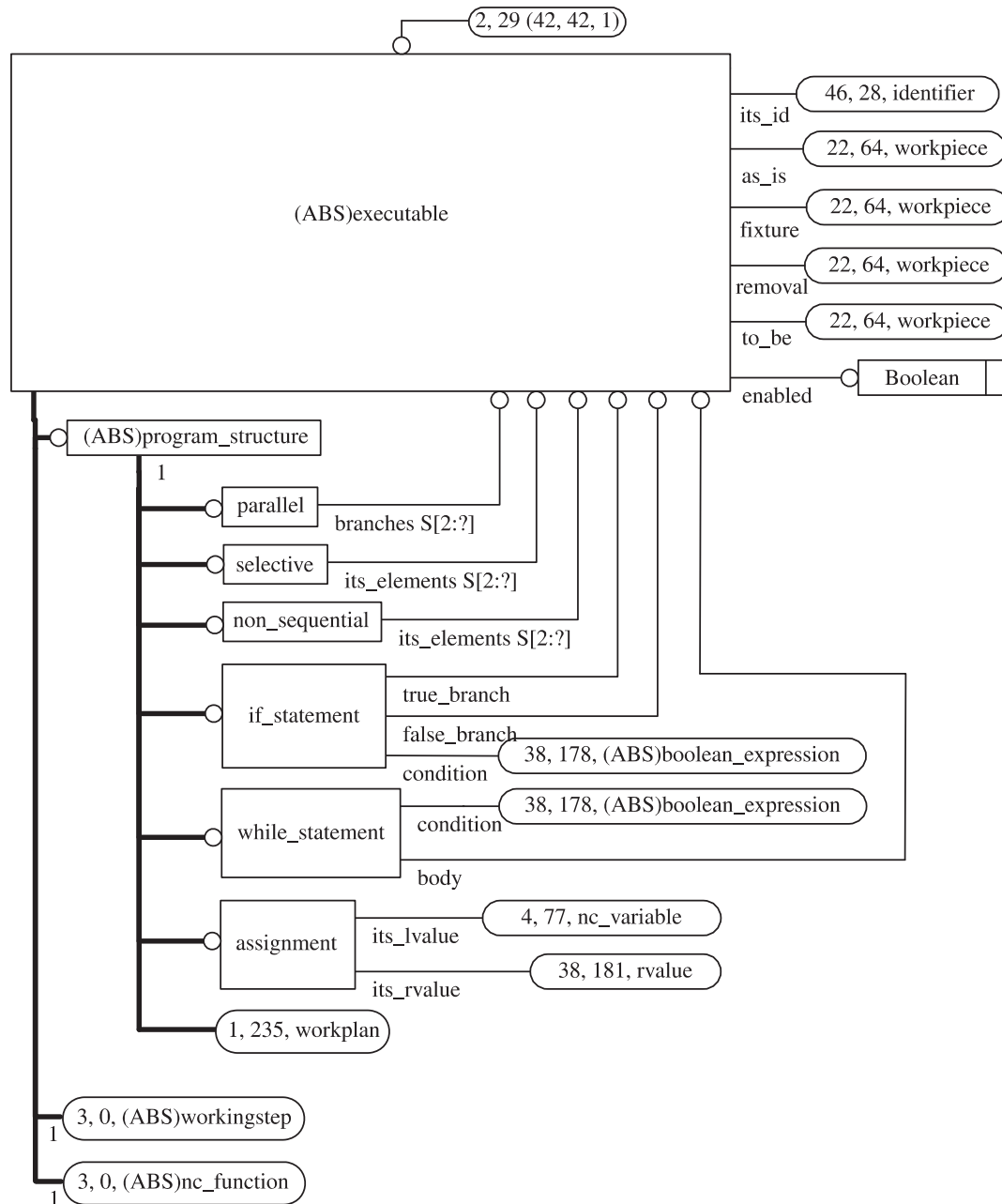


Figure G.2 - ARM diagram (2 of 48)

Page 1299, Figure G.3

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Machining and Turning_workingstep application objects. Replace Figure G.3 with the following.

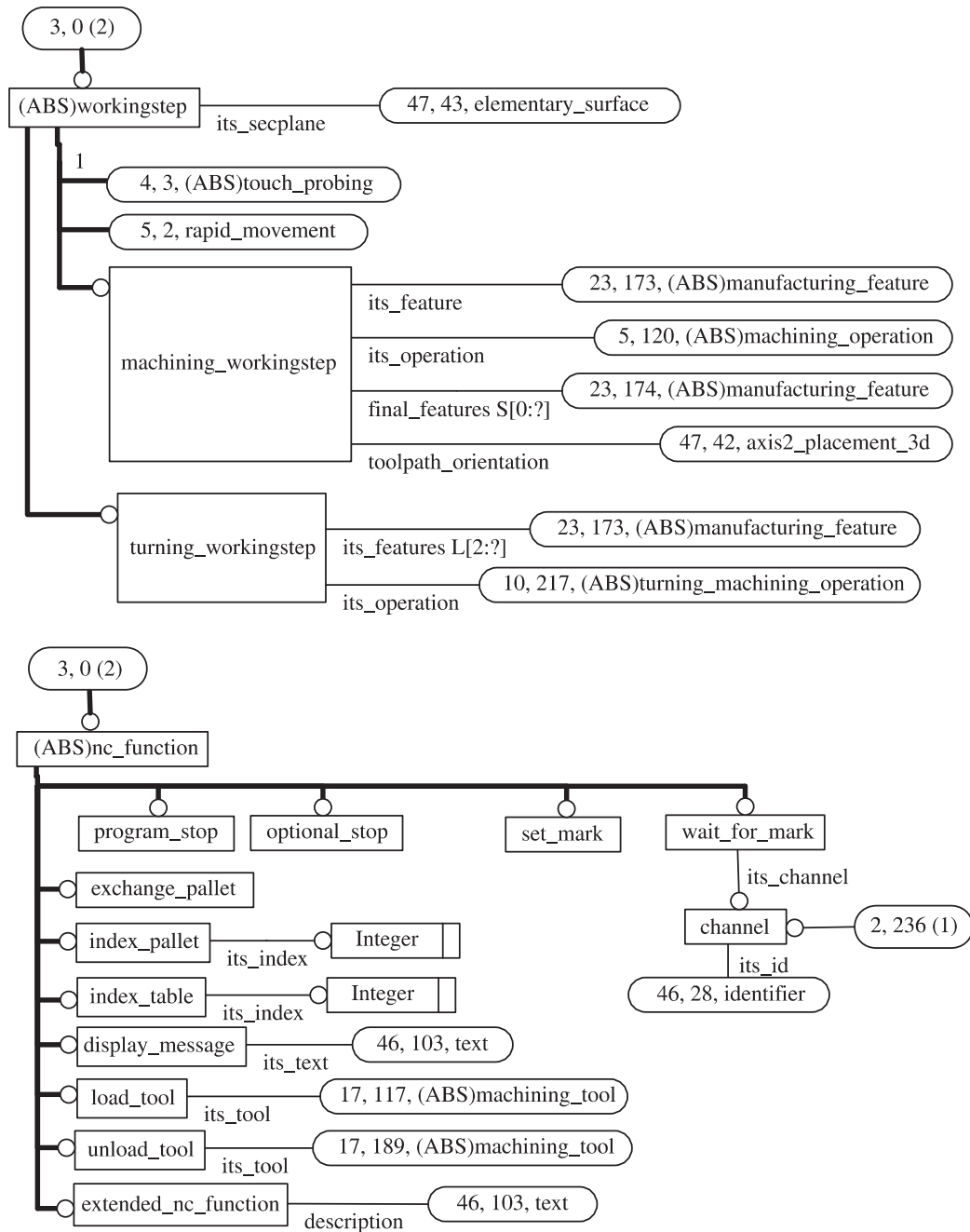


Figure G.3 - ARM diagram (3 of 48)

Page 1300, Figure G.4

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Touch_probe application object. Replace Figure G.4 with the following.

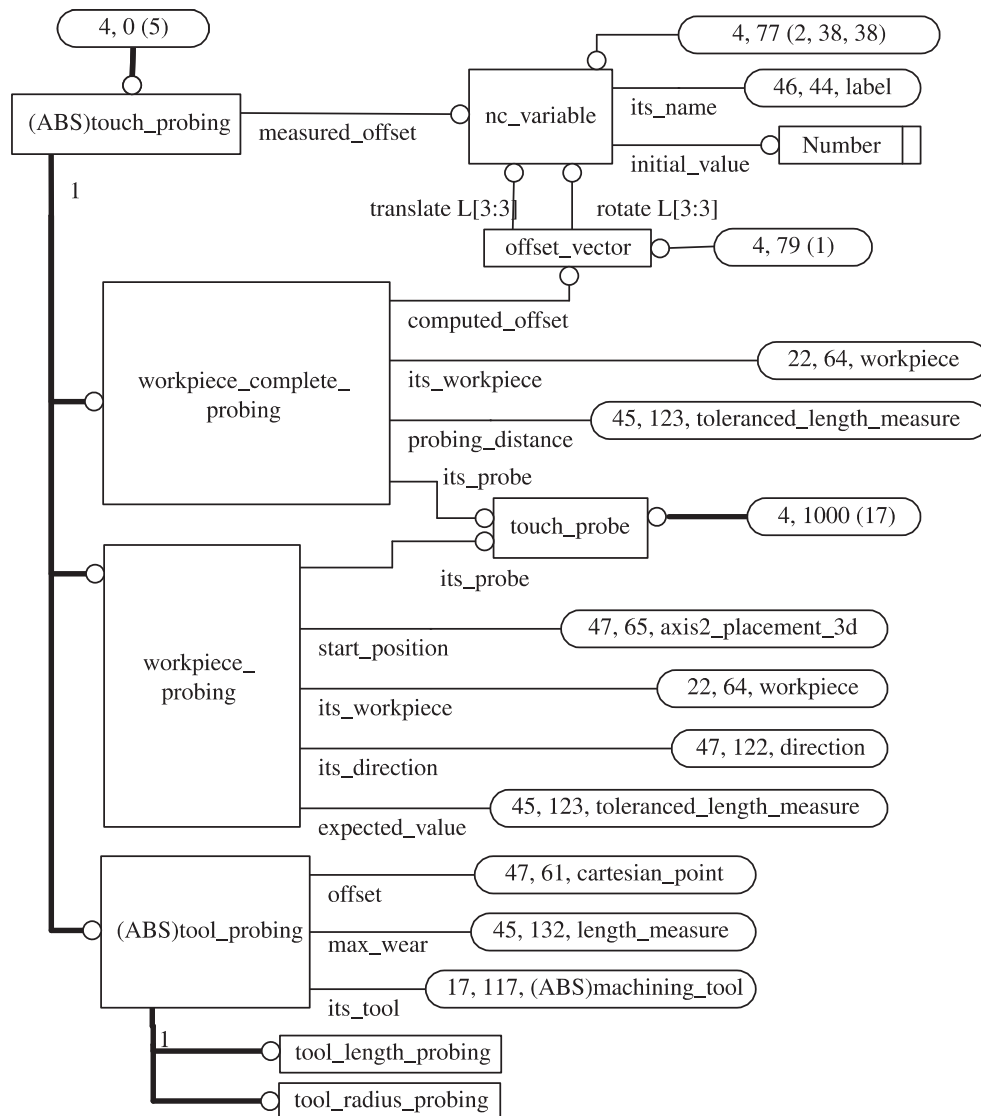


Figure G.4 - ARM diagram (4 of 48)

Page 1303, Figure G.7

The purpose of this change is to extend the ARM EXPRESS-G with the cross_section_area_parameters data associated with the Trajectory application object. Replace Figure G.7 with the following.

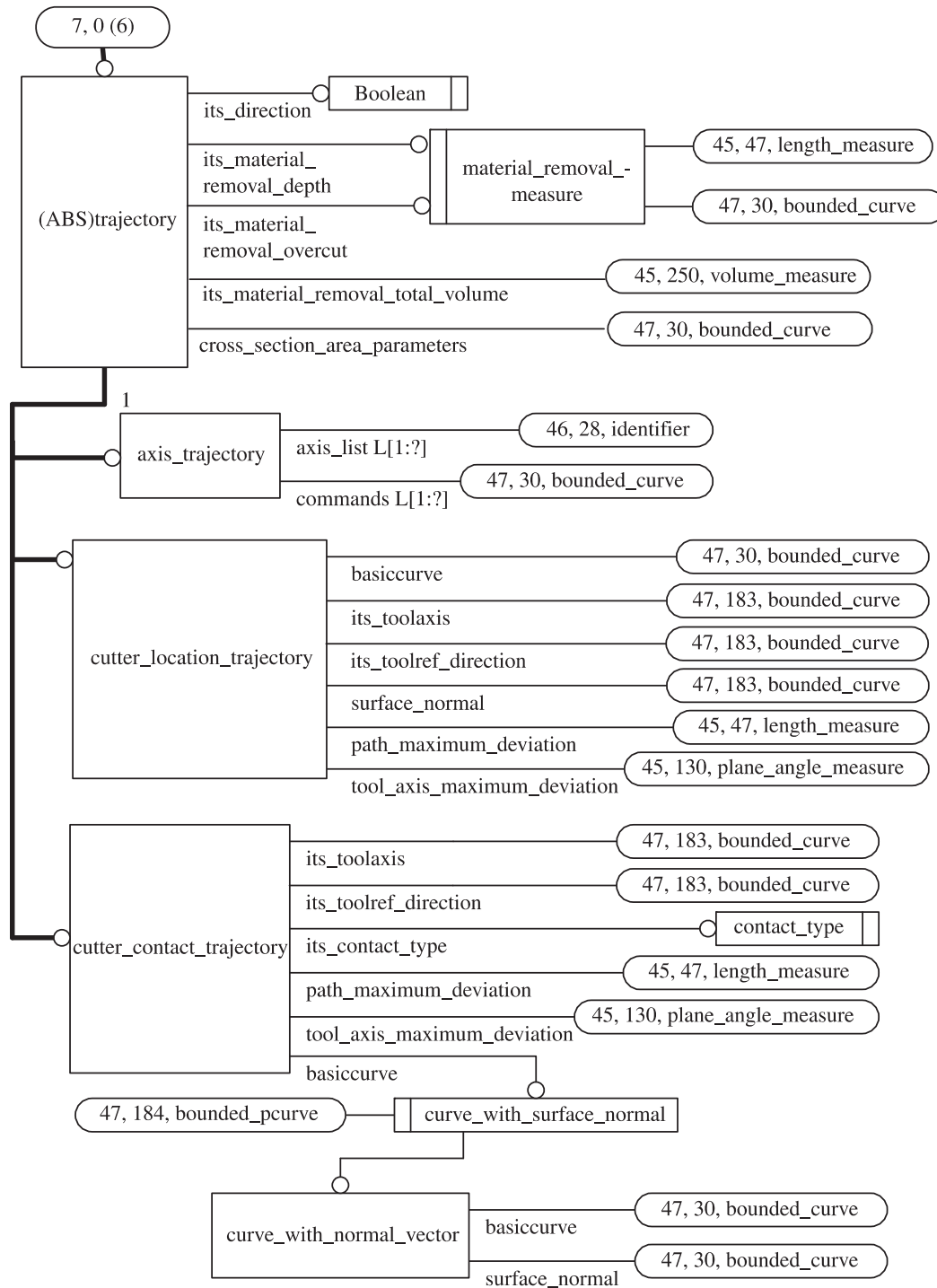


Figure G.7 - ARM diagram (7 of 48)

Page 1313, Figure G.17

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Touch_probe application object. Replace Figure G.17 with the following.

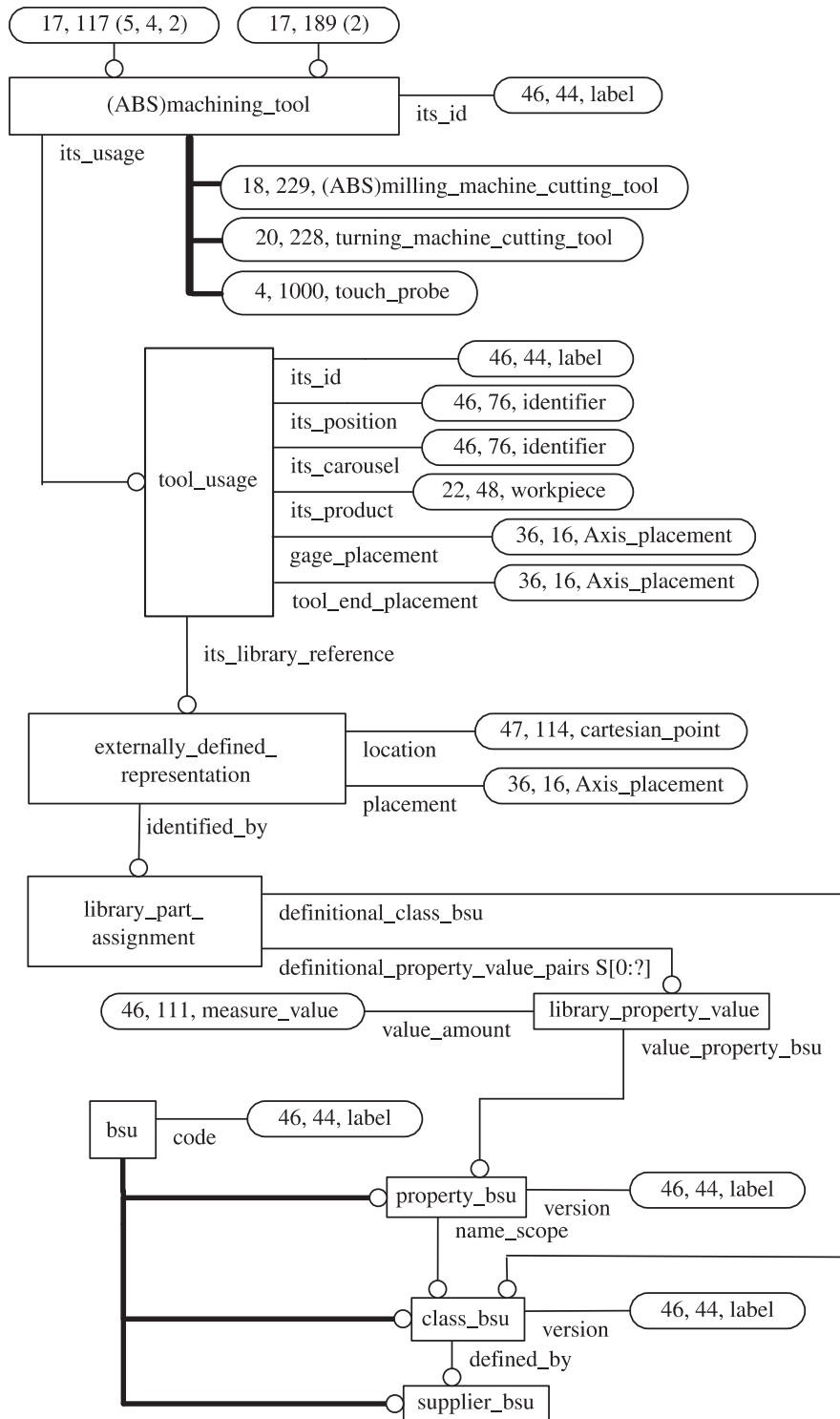


Figure G.17 - ARM diagram (17 of 48)

Page 1332, Figure G.36

The purpose of this change is to update the ARM EXPRESS-G with the modifications to the Datum and Datum_target application objects. Replace Figure G.36 with the following.

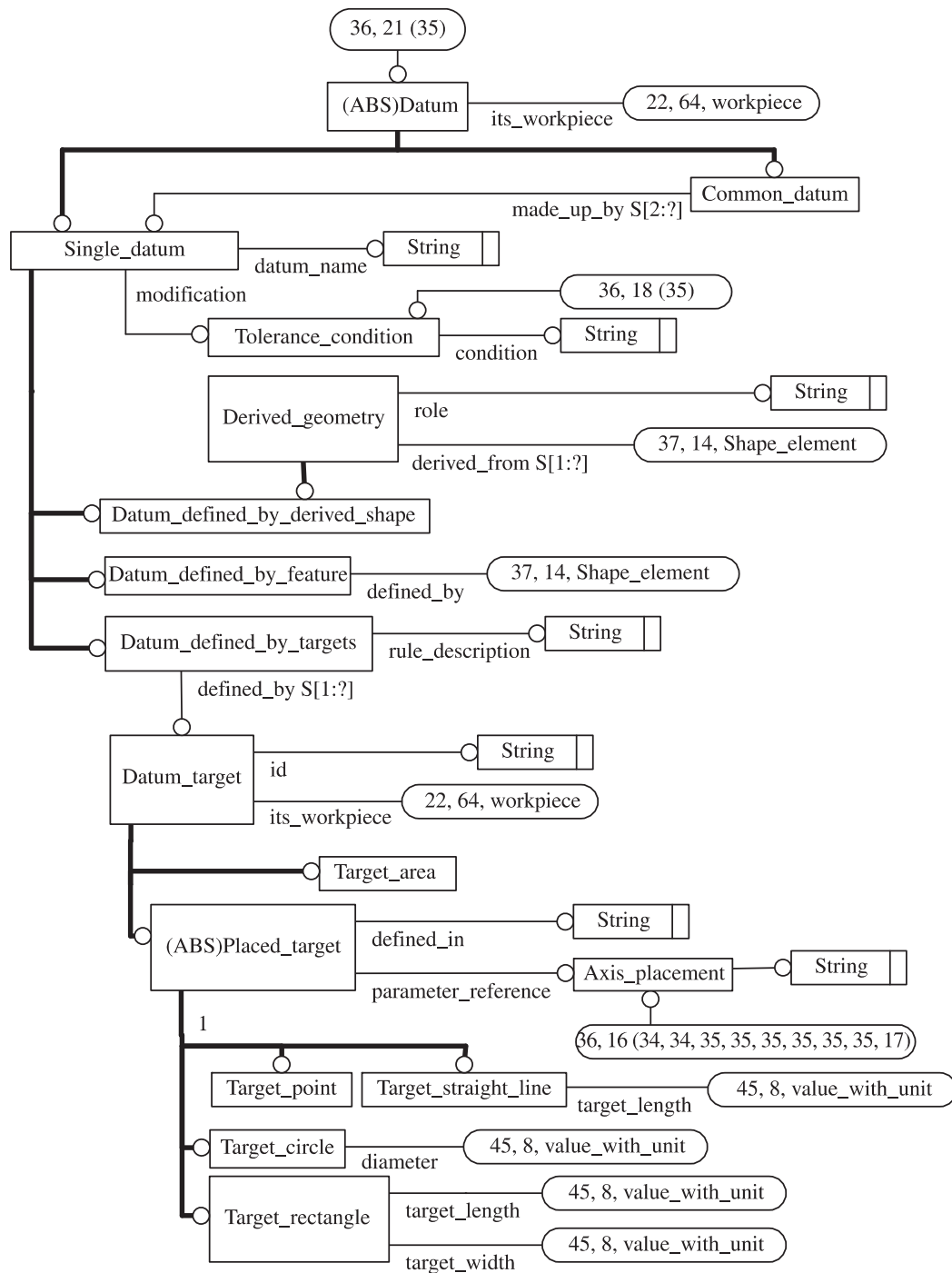


Figure G.36 - ARM diagram (36 of 48)

Page 1359, Figure H.13

The purpose of this change is to add *assembly_component_usage* to the *AIM security_classification_item* definition to better support workpiece product models brought in from AP203 data. Replace Figure H.13 with the following.

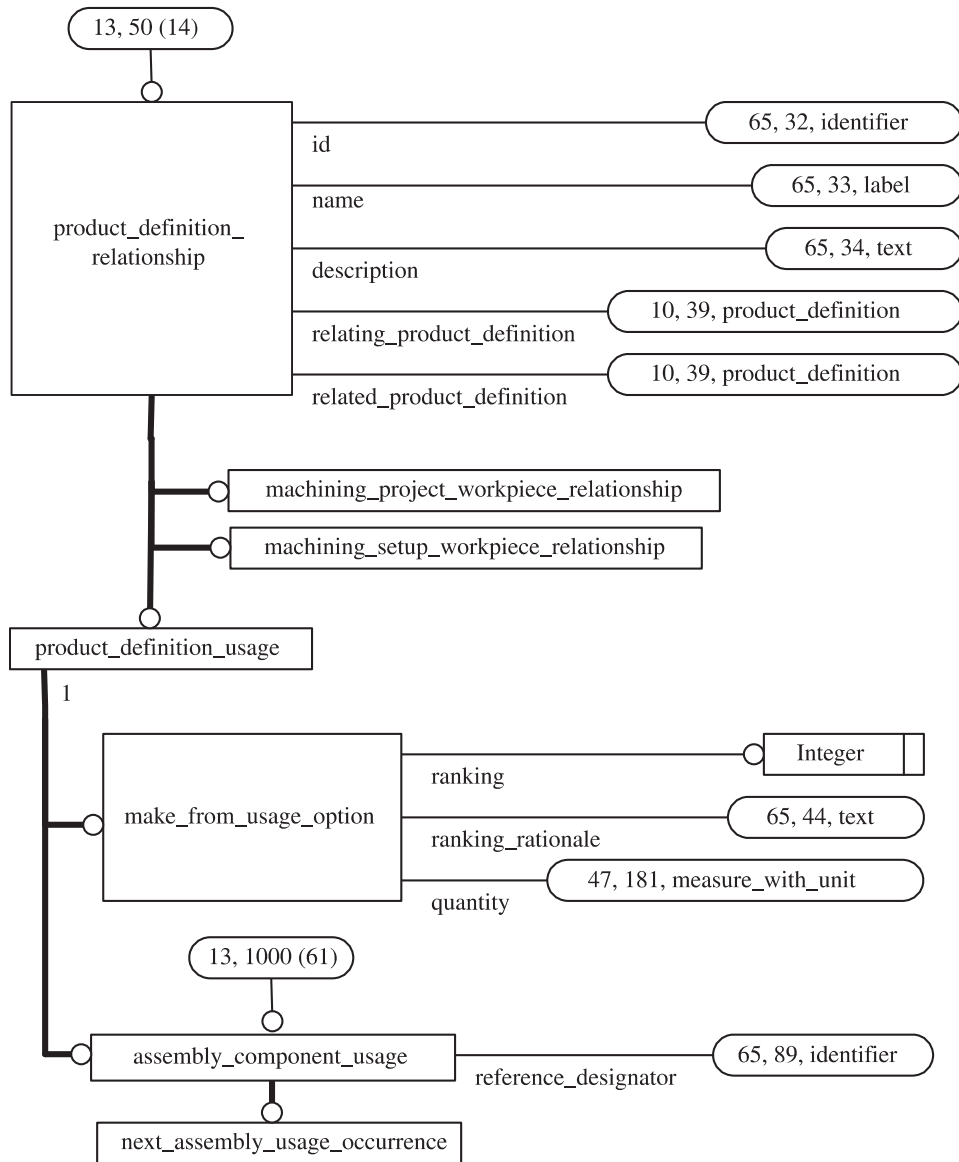


Figure H.13 - AIM EXPRESS-G diagram product definition relationship
Page 1371, Figure H.25

The purpose of this change is to add *via_arc_point* and *via_helix_point* to the AIM EXPRESS-G diagrams. Replace Figure H.25 with the following. Add *via_arc_point* and *via_helix_point* to Index.

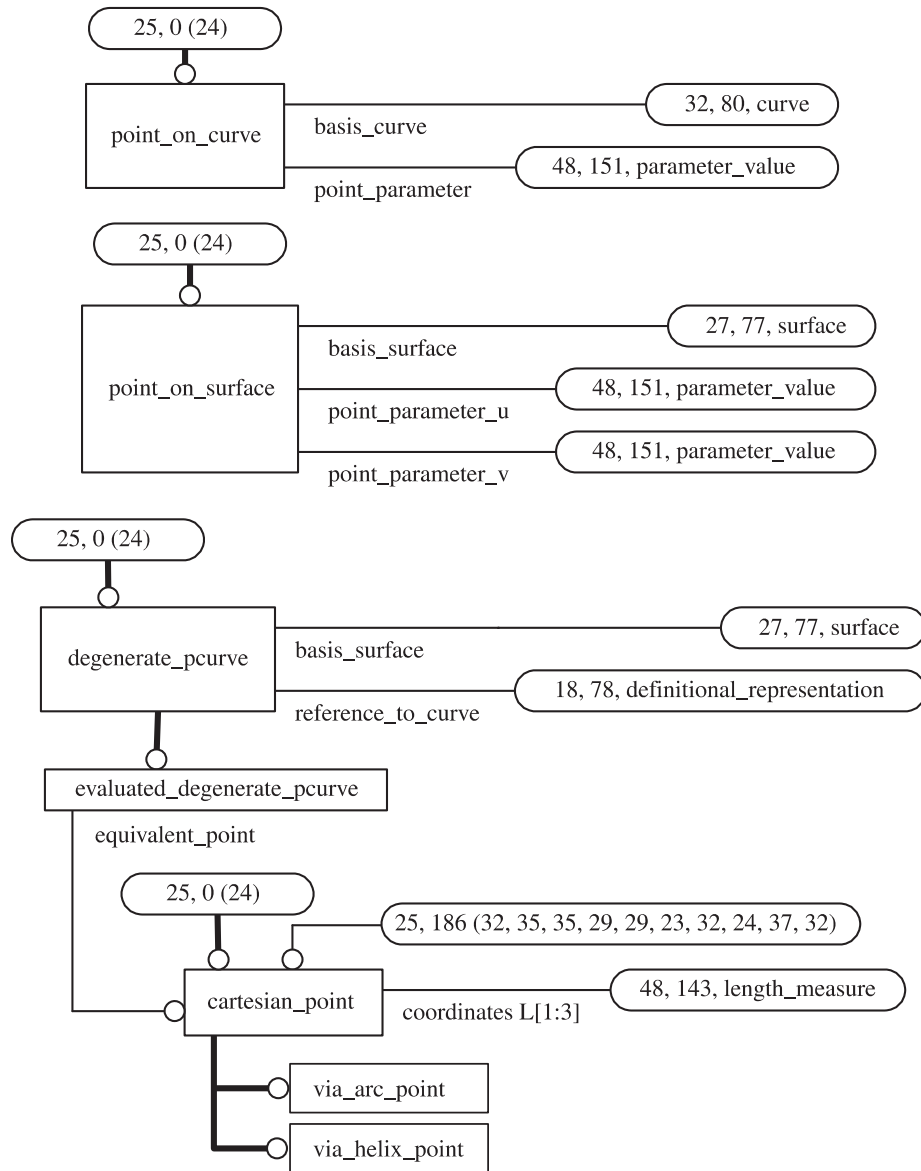


Figure H.25 - AIM EXPRESS-G diagram points

Page 1407, Figure H.61

The purpose of this change is to add `assembly_component_usage` to the `AIM security_classification_item` definition to better support workpiece product models brought in from AP203 data. Replace Figure H.61 with the following.

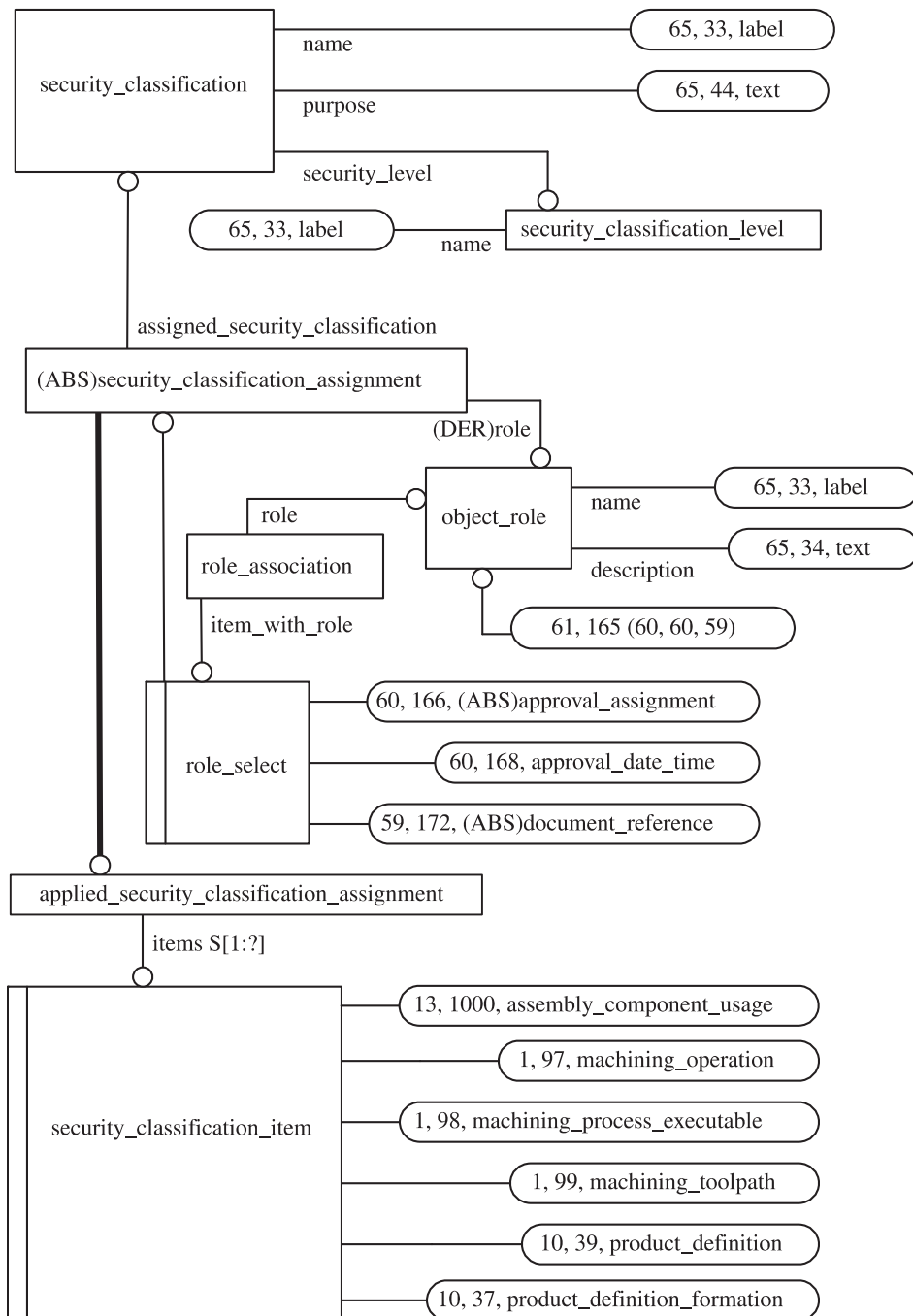


Figure H.61 - AIM EXPRESS-G diagram security classification

Page 1518, Bibliography

Insert the reference below and renumber all following references.

- [3] ISO 10303-105, *Industrial automation systems and integration -- Product data representation and exchange -- Part 105: Integrated application resource: Kinematics*

Change History (delete before publication)

Version 1.8 (in progress)

Clarified how the geometric accuracy impacts a via arc so that if a via point is within the geometric uncertainty of another point, then the arc degenerates to a line between them. Added `assembly_component_usage` to the security classification item select type to better support workpieces brought in from AP203 data.

Fine-tuned the mappings for touch probe to workpiece probing.

Version 1.7 (2009-02-27)

Fixed the wording of some of the “Purpose of” statements. Added mapping for fixture to the mappings for as-is, to-be, and removal workpieces on executable and updated all EXPRESS-G diagrams. Added `enabled` parameter to Executable. Fixed the EXPRESS definition in Annex A for `machining_tool_usage` so that it matches Clause 5. Added `its_toolref_direction` to both `Cutter_contact_trajectory` and `Cutter_location_trajectory`. Added `gage_placement` and `tool_end_placement` to `Tool_usage` to clarify how the tool product model is oriented with respect to toolpaths and machine models. Added `toolpath_orientation` to `Workplan`.

Version 1.6 (2008-08-26)

Added `its_workpiece` links to both `Datum` and `Datum_target` to clarify usage of `shape_aspect_of_shape` in the AIM. The definition and mapping are the same as the `Manufacturing_feature_its_workpiece`.

Replaced `In_process_geometry` application object and separate references on `Machining_workingstep`, `Turning_workingstep`, and `Workplan` with references from Executable to as-is, to-be, and removal Workpiece objects. This extends the in-process description of the manufactured product information to any executable, and extends the description to permit the full range of product properties, such as features and tolerances, to be specified, in addition to the geometry and topology.

Version 1.5 (2008-06-02)

Clarified description and diagram for cross-section parameters.

Version 1.4 (2008-05-30)

Replaced the `RDavg` and `XRDavg` parameters with cross-section area and XY offset of the center of gravity. Updated description and figures.

Version 1.3 (2008-05-16)

Enhanced descriptions of the `RDavg` and `XRDavg` parameters. Modified the definition and all

associated mappings and EXPRESS-G diagrams for the Touch_probe application object so that it is now a type of Machining_tool. This lets us associate product, geometric shape and other tool usage information with probes, which was previously not possible because they were a unique concept, not related to any other tools. Reordered a few changes so that everything is now listed in page order.

Version 1.2 (2008-05-14)

Added note on feed direction to turning cross-section diagram. Enhanced description of maximum axial depth parameter.

Version 1.1 (2008-05-12)

Updated the via_arc_point example to use 3D points rather than 2D. Updated the cross section parameter diagram to have the origin at the center and to use the APT general tool profile. Also added text in the definition of ADmax to say that it is always measured perpendicular to the tool axis, regardless of the feed direction.

Version 1.0 (2008-04-22)

Initial version circulated to STEP Manufacturing for discussion.