INTERNATIONAL STANDARD

**ISO 10303-523**

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# Industrial automation systems and integration — Product data representation and exchange —

## Part 523: Application interpreted construct: Curve swept solid

*Systèmes d'automatisation industrielle et intégration — Représentation et échange de données de produits —*

*Partie 523: Construction interprétée d'application: Solide balayé par une courbe*

Reference number
ISO 10303-523:2004(E)

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**Tables**



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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 part of ISO 10303 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 10303-523 was prepared by Technical Committee ISO TC184/SC4. *Industrial automation systems and integration,* Subcommittee SC4, *Industrial data.*

ISO 10303 is organized as a series of parts, each published separately. The structure of ISO 10303 is decribed in ISO 10303-1.

Each part of ISO 10303 is a member of one of the following series: decription methods, implementation methods, conformance testing methodology and framework, integrated generic resources, integrated application resources, application protocols abstract test suites, application interpred constructs, and application modules. This part is a member of the application interpreted construct series.

A complete list of parts of ISO 10303 is available from the Internet:

<http://www.tc184-sc4.org/titles/STEP_titles.htm>

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# Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing products throughout their life cycle. This mechanism is suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and as a basis for archiving.

This part of ISO 10303 is a member of the application interpreted construct series. An application interpreted construct (AIC) provides a logical grouping of interpreted constructs that supports a specific functionality for the usage of product data across multiple application contexts. An interpreted construct is a common interpretation of the integrated resources that supports shared information requirements among application protocols.

This document specifies the application interpreted construct for curve swept solid. This provides the definition of a shape representation containing swept solids, each of which is either a **swept_area_solid** or a **swept_disk_solid**. A new subtype of **surface_curve_swept_area_solid** is included to enable more precise control of the orientation of a planar area as it is swept along a directrix to create a solid.

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# Industrial automation systems and integration — Product data representation and exchange — Part 523: Application interpreted construct: Curve swept solid

## 1 Scope

This part of ISO 10303 specifies the interpretation of the integrated resources to satisfy the requirement for the definition of a shape representation containing implicitly defined solids created by sweeping operations. The solids defined by sweeping a planar area along a directrix curve. For the **surface_curve_swept_area_solid** both the area and directrix are explicitly defined. For other types of swept_area_solid the directrix is implicitly defined, as a line or a circle. In the case of the swept_disk_solid the bounds of the area are implicitly defined circles.

The following are within the scope of this part of ISO 10303:

— 3D geometry;

— directrix curves;

— swept area solids;

— swept disk solids;

— surface curve swept area solids;

— use of B-spline surfaces to define a ruled surface for the purpose of defining a swept solid;

— planar areas with explicit geometric bounnds;

The following are outside the scope of this part of ISO 10303:

— 2D geometry other than for the definition of a pcurve in the parameter space of a surface;

— boundary representation solid models;

— curves and surfaces not used as part of the definition of a swept solid;

— non-manifold geometry;

— offset curves and surfaces;

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— use of topology to bound geometric entities.

## 2 Normative references

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

ISO/IEC 8824-1:1995, *Information technology — Abstract syntax notation one (ASN.1): Specification of basic notation.*

ISO 10303-1: 1994, *Industrial automation systems and integration — Product data representation and exchange — Part 1 : Overview and fundamental principles.*

ISO 10303-11: 1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11 : Description methods: The EXPRESS language reference manual.*

ISO 10303-41: 2000, *Industrial automation systems and integration — Product data representation and exchange — Part 41 : Integrated generic resource: Fundamentals of product description and support.*

ISO 10303-42: 2000, *Industrial automation systems and integration — Product data representation and exchange — Part 42 : Integrated generic resource: Geometric and topological representation.*

ISO 10303-43: 2000, *Industrial automation systems and integration — Product data representation and exchange — Part 43 : Integrated generic resource: Representation structures.*

ISO 10303-202: 1996, *Industrial automation systems and integration — Product data representation and exchange — Part 202: Application protocol: Associative draughting*

## 3 Terms, definitions and abbreviations

### 3.1 Terms defined in ISO 10303-1

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-1 apply.

— application;

— application context;

— application protocol;

— implementation method;

— integrated resource;

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— interpretation;

— product data.

## 3.2 Terms defined in ISO 10303-42

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-42 apply.

— arcwise connected;

— axi-symmetric;

— bounds;

— coordinate space;

— curve;

— surface.

## 3.3 Terms defined in ISO 10303-202

For the purposes of this part of ISO 10303, the following term defined in ISO 10303-202 applies.

— application interpreted construct.

## 3.4 Terms defined in ISO 10303-511

For the purposes of this part of ISO 10303, the following term defined in ISO 10303-511 applies.

— advanced face.

## 3.5 Other definitions

**3.5.1**
**curve swept solid shape representation**
shape representation containing solids defined by sweeping a planar area along a directrix curve.

NOTE In the cases of an **extruded_area_solid** and a **revolved_area_solid** the dirctrix is not explicitly defined.

**3.5.2**
**ruled surface**
surface generated by a family of straight lines joining points with corresponding parameter values on two edge curves



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NOTE In this part of ISO 10303 a ruled surface is a B-spline surface of degree 1 in u, the edge curves are defined by the control points of the surface.has a domain which is part of

**3.5.3**
**ruled surface swept area solid**
solid created by sweeping a planar area along a directrix curve drawn on a ruled surface

## 3.6 Abbreviations

For the purposes of this part of ISO 10303, the following abbreviations apply.

AIC Application Interpreted Construct
AP Application Protocol

# 4 EXPRESS short listing

This clause specifies the EXPRESS schema that uses elements from the integrated resources and contains the types, entity specializations, and functions that are specific to this part of ISO 10303.

NOTE 1 There may be subtypes and items of select lists that appear in the integrated resources that are not imported into the AIC. Constructs are eliminated from the subtype tree or select list through the use of the implicit interface rules of ISO 10303-11. References to eliminated constructs are outside the scope of the AIC. In some cases, all items of the select list are eliminated. Because AICs are intended to be implemented in the context of an application protocol, the items of the select list will be defined by the scope of the application protocol.

This application interpreted construct provides a consistent set of geometric entities for the definition of a curve swept solid shape representation. Each solid in the representation is required to be a **surface_curve_swept_area_solid**, an **extruded_area_solid**, a **revolved_area_solid** or a **swept_disk_solid**. An instance of **surface_curve_swept_area_solid** may be specialised as a **ruled_surface_swept_area_solid**. The highest level entity in this AIC is **curve_swept_soild_shape_representation** which is a specialised type of **shape_representation** (see ISO 10303-41). The rules on this entity ensure that the shapes included are swept solids or mapped copies of swept solids.

EXPRESS specification:

```
*)
SCHEMA aic_curve_swept_solid;

 USE FROM geometry_schema  -- ISO 10303-42
                          (axis2_placement_2d,
                           axis2_placement_3d,
                           bezier_curve,
                           bezier_surface,
                           b_spline_curve,
```

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```
                                b_spline_curve_with_knots,
                                b_spline_surface,
                                b_spline_surface_with_knots,
                                cartesian_point,
                                circle,
                                composite_curve_on_surface,
                                conical_surface,
                                cylindrical_surface,
                                degenerate_toroidal_surface,
                                direction,
                                ellipse,
                                geometric_representation_context,
                                hyperbola,
                                line,
                                parabola,
                                pcurve,
                                plane,
                                polyline,
                                quasi_uniform_curve,
                                quasi_uniform_surface,
                                rational_b_spline_curve,
                                rational_b_spline_surface,
                                spherical_surface,
                                surface_curve,
                                surface_of_linear_extrusion,
                                surface_of_revolution,
                                swept_surface,
                                toroidal_surface,
                                trimmed_curve,
                                uniform_curve,
                                uniform_surface,
                                vector);

  USE FROM geometric_model_schema  -- ISO  10303-42
      (extruded_area_solid,
       revolved_area_solid,
       surface_curve_swept_area_solid,
       swept_disk_solid);

  USE FROM representation_schema(mapped_item);   -- ISO  10303-43

  USE FROM product_property_representation_schema   -- ISO  10303-41
      (shape_representation);
(*
```

NOTE 1 The **b_spline_curve** and **b_spline_surface** entities are explicitly interfaced (i.e. included in the USE FROM lists) to allow rules in the **ruled_surface_swept_area_solid** entity to access attributes of these entities. For the use of this AIC these entities shall only be instantiated as one, or more, of their subtypes.

NOTE 2 The schemas referenced above can be found in the following parts of ISO 10303:

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| | |
|---|---|
| geometry_schema | ISO 10303-42: 2000, as modified by amendment 1 |
| geometric_model_schema | ISO 10303-42: 2000, as modified by amendment 1 |
| representation_schema | ISO 10303-43 |
| product_property_representation_schema | ISO 10303-41 |

## 4.1 Fundamental concepts and assumptions

An application protocol that uses this AIC shall ensure that the **shape_representation** entity is instantiated as an **curve_swept_solid_shape_representation**.

All geometry imported into this AIC is used for the purpose of defining swept solids.

## 4.2 aic_curve_swept_solid schema entity definitions

### 4.2.1 curve_swept_solid_shape_representation

The **curve_swept_solid_shape_representation** is a type of **shape_representation** in which the shape of a product is represented by specialisations of **swept_area_solid** or **swept_disk_solid** entities.

Each **solid_model** in the **representation** is required to be a **swept_area_solid** or a **swept_disk_solid**.

Particular types of **swept_area_solid** that may be included are **extruded_area_solid**, **revolved_area_solid**, and **surface_curve_swept_area_solid**, including the **ruled_surface_swept_area_solid**.

EXPRESS specification:

```
*)
 ENTITY curve_swept_solid_shape_representation
 SUBTYPE OF (shape_representation);
 WHERE
  WR1: SIZEOF (QUERY (it <* SELF.items |
          NOT (SIZEOF (['AIC_CURVE_SWEPT_SOLID.SWEPT_AREA_SOLID',
                'AIC_CURVE_SWEPT_SOLID.SWEPT_DISK_SOLID',
                'AIC_CURVE_SWEPT_SOLID.MAPPED_ITEM',
                'AIC_CURVE_SWEPT_SOLID.AXIS2_PLACEMENT_3D'] *
                   TYPEOF(it)) = 1))) = 0;
   WR2: SIZEOF (QUERY (it <* SELF.items |
         SIZEOF(['AIC_CURVE_SWEPT_SOLID.SWEPT_AREA_SOLID',
                'AIC_CURVE_SWEPT_SOLID.SWEPT_DISK_SOLID',
          'AIC_CURVE_SWEPT_SOLID.MAPPED_ITEM'] * TYPEOF(it)) =1 )) > 0;
   WR3: SIZEOF (QUERY (mi <*  QUERY (it <* items |
                 'AIC_CURVE_SWEPT_SOLID.MAPPED_ITEM' IN TYPEOF(it)) |
   NOT ('AIC_CURVE_SWEPT_SOLID.CURVE_SWEPT_SOLID_SHAPE_REPRESENTATION' IN
             TYPEOF(mi\mapped_item.mapping_source.
                          mapped_representation)))) = 0;
   WR4: SIZEOF (QUERY (scsas <* QUERY (it <* SELF.items |
        'AIC_CURVE_SWEPT_SOLID.SURFACE_CURVE_SWEPT_AREA_SOLID' IN
```

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```
            TYPEOF(it)) |
          NOT(('AIC_CURVE_SWEPT_SOLID.SURFACE_CURVE' IN
                TYPEOF(scsas.directrix)) OR
                ('AIC_CURVE_SWEPT_SOLID.PCURVE' IN
                TYPEOF(scsas.directrix))))) = 0;
 END_ENTITY;
(*
```

Formal propositions:

**WR1:** The **items** in a **curve_swept_solid_shape_representation** shall be **swept_area_solid**s, **swept_disk_solid**s, **mapped_item**s, or **axis2_placement_3d**s.

**WR2:** At least one of the **items** shall be either a **swept_area_solid**, a **swept_disk_solid** or a **mapped_item**.

**WR3:** For any **mapped_item**, the **mapped_representation** of its **mapping_source** shall be a **curve_swept_solid_shape_representation**.

**WR4:** If there is a **surface_curve_swept_area_solid** in a **curve_swept_solid_shape_representation** the **directrix** shall be either a **pcurve** or a **surface_curve**.

## 4.2.2 Ruled_surface_swept_area_solid

A **ruled_surface_swept_area_solid** is a type of **surface_curve_swept_area_solid** in which the surface used to control the orientation of the **swept_area** as it is swept along the **directrix** is a ruled surface. The ruled surface is required to be defined as a **b_spline_surface** of degree 1 in the first parameter direction.

NOTE At all times during the sweeping operation the **swept_area** is maintained in the plane normal to the **directrix** and is oriented by keeping the x axis of the plane (z = 0) of the **swept_area** in the direction of the normal to the ruled surface at the current point on the **directrix**. This implies that the negative y axis of the **swept_are** plane lies in the direction of the projection of the ruling direction onto the plane normal to the **directrix**.

EXPRESS specification:

```
*)
ENTITY ruled_surface_swept_area_solid
  SUBTYPE OF(surface_curve_swept_area_solid);
  WHERE
  WR1: ('GEOMETRY_SCHEMA.B_SPLINE_SURFACE' IN TYPEOF(SELF.reference_surface))
         AND (SELF.reference_surface\b_spline_surface.u_degree = 1);
  WR2: ('GEOMETRY_SCHEMA.PCURVE' IN TYPEOF(SELF.directrix)) OR
        (('GEOMETRY_SCHEMA.B_SPLINE_CURVE' IN
           TYPEOF(SELF.directrix\surface_curve.curve_3d))
         AND
         (SELF.directrix\surface_curve.curve_3d\b_spline_curve.degree =
```



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```
         SELF.reference_surface\b_spline_surface.v_degree));
END_ENTITY;
(*
```

Formal propositions:

**WR1:** The **reference_surface** of a **ruled_surface_swept_area_solid** shall be a **b_spline_surface** of **u_degree** 1.

NOTE 2 This ensures that the reference surface has the form of a ruled surface bounded by two **b_spline_curves**. These curves have degree **v_degree** and are defined by the two sub-lists of the **control_points_list** of the **reference_surface**.

**WR2:** The directrix shall be either a **pcurve** or a **surface_curve**. If the **directrix** is a **surface_curve** the **curve_3d** shall be a **b_spline_curve** of the same degree as the boundary curves of the ruled surface that is the **reference_surface**.

EXPRESS specification:

```
*)
  END_SCHEMA; -- end AIC_CURVE_SWEPT_SOLID SCHEMA
(*
```

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# Annex A
(normative)

# Short names of entities

Table A.1 provides the short names of entities specified in the EXPRESS listing of this part of ISO 10303. Requirements on the use of the short names are found in the implementation methods included in ISO 10303.

## Table A.1 – Short names of entities

| Entity name | Short name |
|---|---|
| CURVE_SWEPT_SOLID_SHAPE_REPRESENTATION | CSSSR |
| RULED_SURFACE_SWEPT_AREA_SOLID | RSSAS |

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# Annex B
(normative)

# Information object registration

## B.1 Document identification

To provide for unambiguous identification of an information object in an open system, the object identifier

{ iso standard 10303 part(523) version(1) }

is assigned to this part of ISO 10303. The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.

## B.2 Schema identification

To provide for unambiguous identification of the aic_curve_swept_solid in an open information system, the object identifier

{ iso standard 10303 part(523) version(1) schema(1) aic-curve-swept-solid(1) }

is assigned to the aic_curve_swept_solid schema (see 4). The meaning of this value is defined in ISO/IEC 8824-1, and is described in ISO 10303-1.


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# Annex C
(informative)

# Computer-interpretable listings

This annex provides a listing of the EXPRESS entity names and corresponding short names as specified in this Part of ISO 10303 without comments or other explanatory text. This annex is available in computer-interpretable form and can be found at the following URLs:

```
Short names: <http://www.tc184-sc4.org/Short_Names/>

EXPRESS:  <http://www.tc184-sc4.org/EXPRESS/>
```

If there is difficulty accessing these sites contact ISO Central Secretariat or contact the ISO TC 184/SC4 Secretariat directly at: sc4sec@tc184-sc4.org.

NOTE – The information provided in computer-interpretable form at the above URLs is informative. The information that is contained in the body of this part of ISO 10303 is normative.

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# Annex D
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# EXPRESS-G diagrams

Figures D.1 through D.9 correspond to the EXPRESS generated from the short listing given in clause 4 using the interface specifications of ISO 10303-11. The diagrams use the EXPRESS-G graphical notation for the EXPRESS language. EXPRESS-G is defined in annex D of ISO 10303-11.

NOTE 1 The following select types are interfaced into the AIC expanded listing according to the implicit interface rules of ISO 10303-11. These select types are not used by other entities in this part of ISO 10303.

— geometric_set_select;

— boolean_operand.

NOTE 2 The rules on **curve_swept_solid_shape_representation** exclude the instantiation of some entities which are implicitly interfaced and, therefore, shown in the diagrams. These entities are marked with a * in the diagrams.

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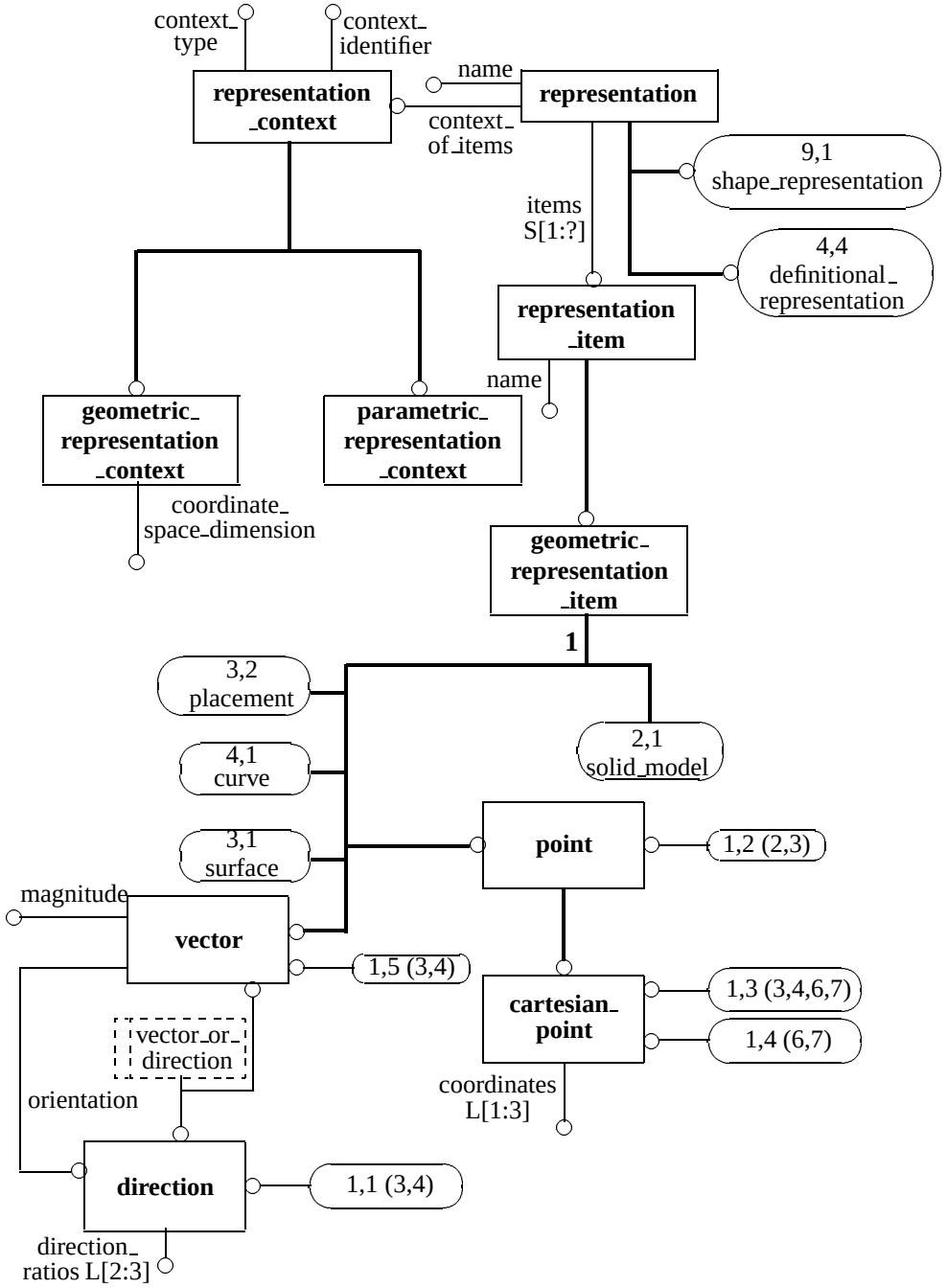


**Figure D.1 – aic_curve_swept_solid EXPRESS-G diagram page 1 of 9**



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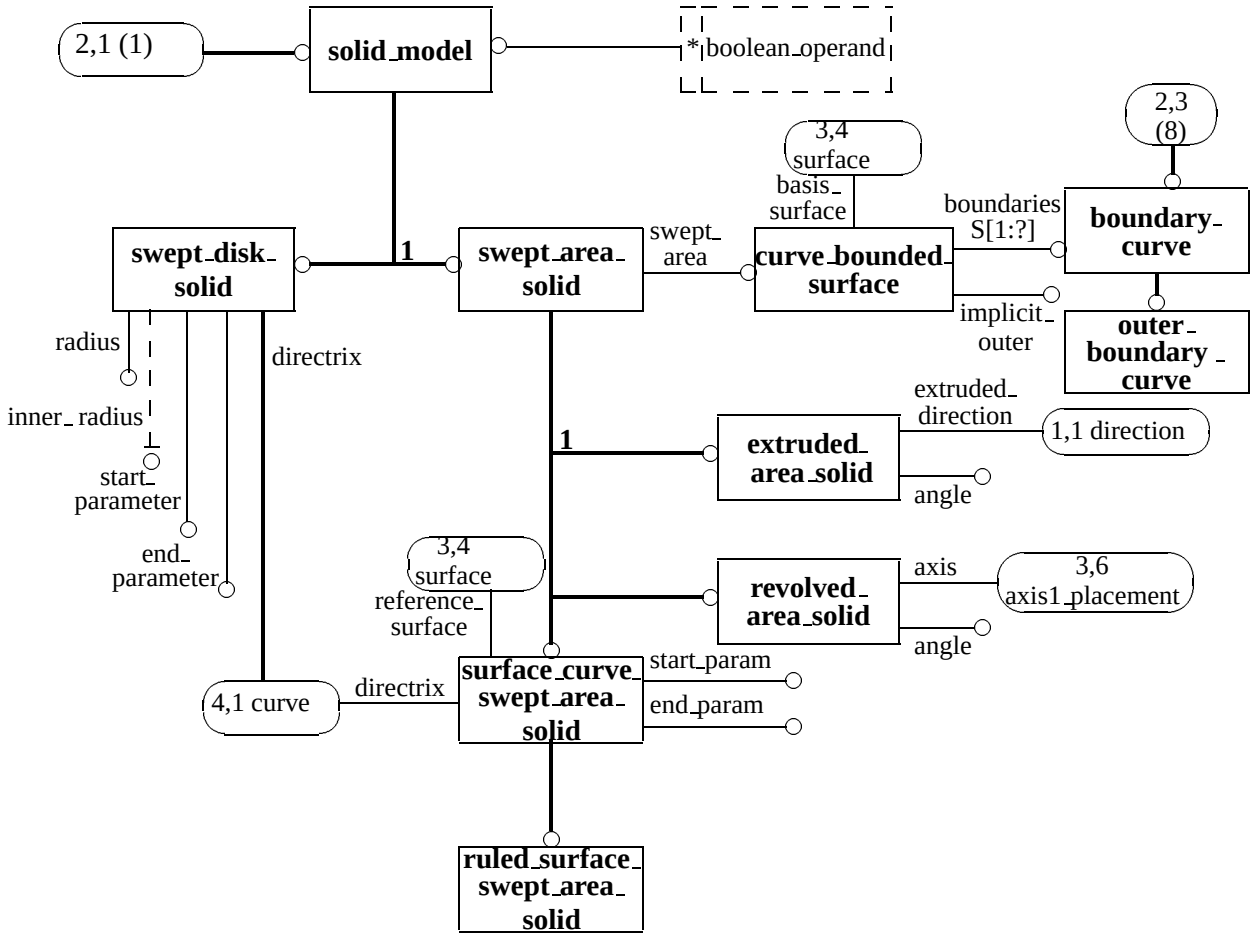


**Figure D.2 – aic_curve_swept_solid EXPRESS-G diagram page 2 of 9**


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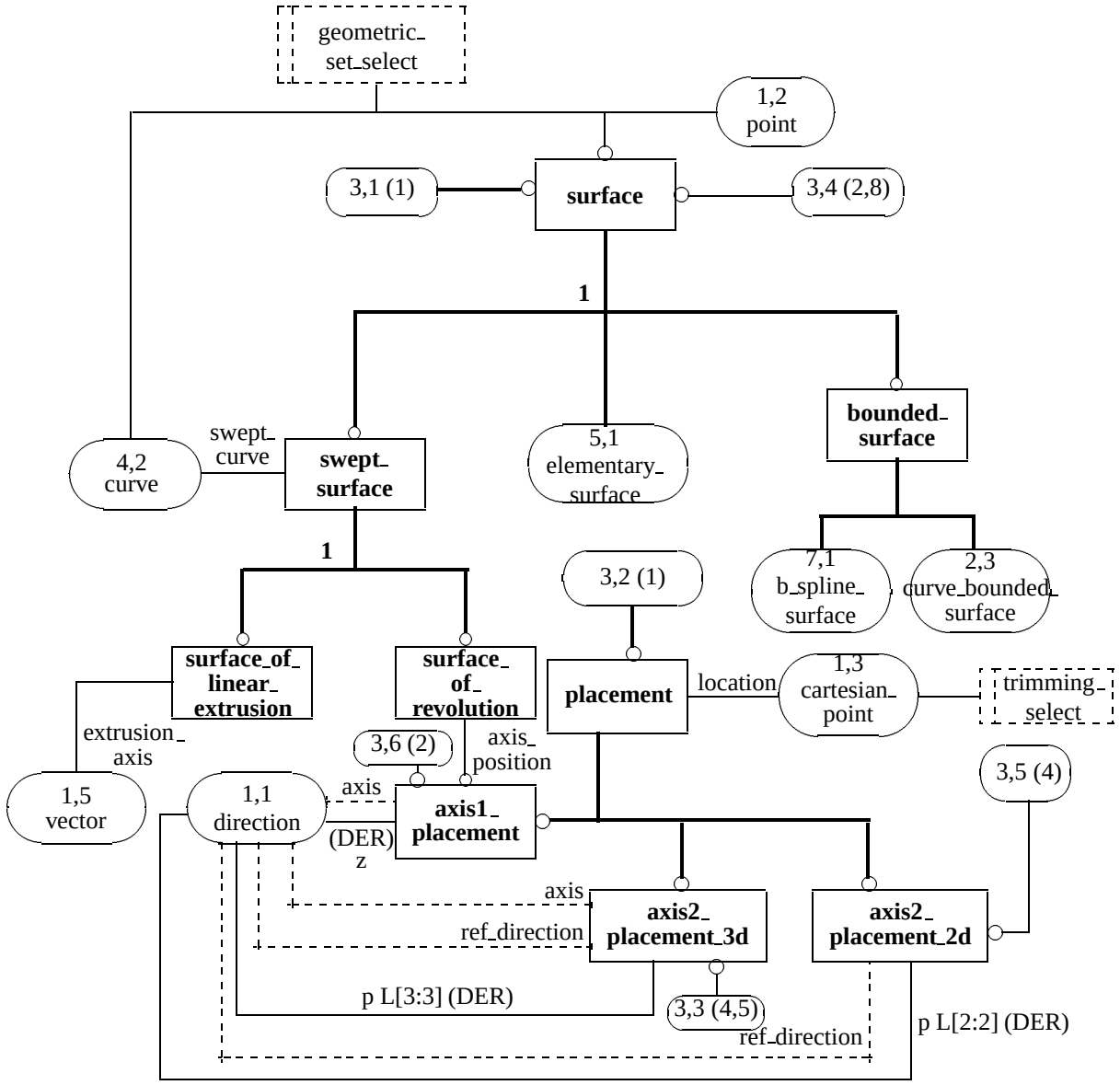


**Figure D.3 – aic_curve_swept_solid EXPRESS-G diagram page 3 of 9**



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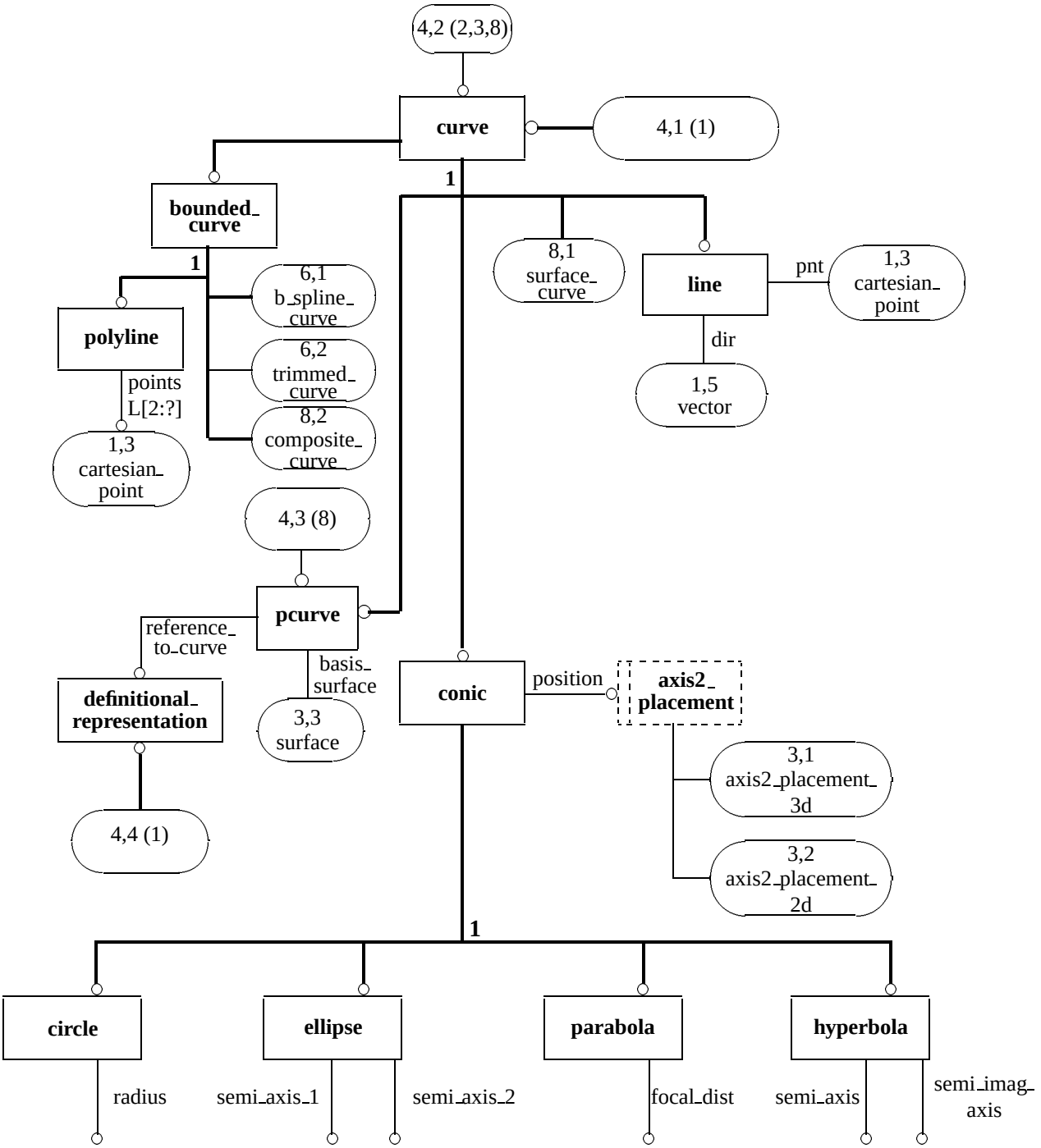


**Figure D.4 – aic_curve_swept_solid EXPRESS-G diagram page 4 of 9**

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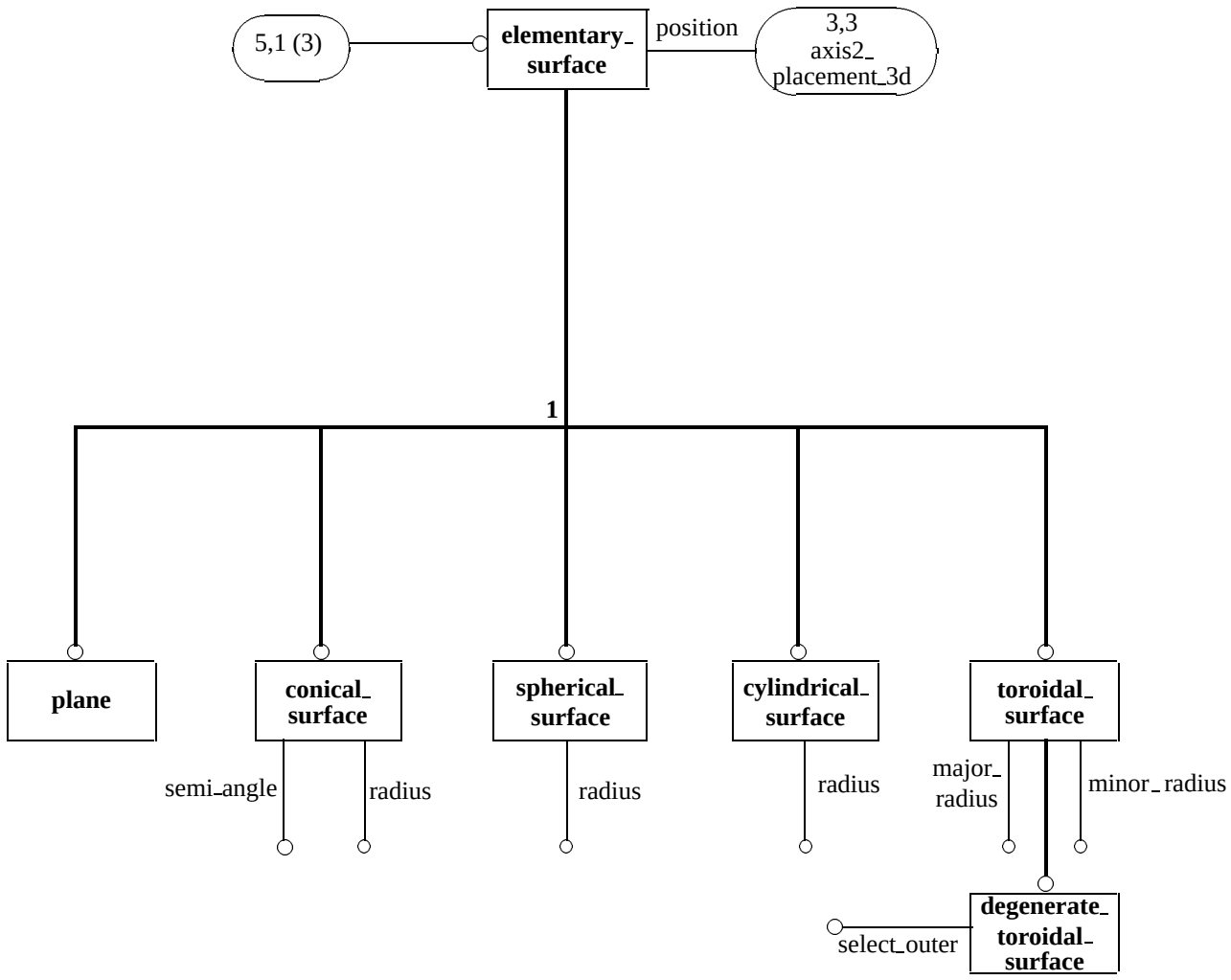


**Figure D.5 – aic_curve_swept_solid EXPRESS-G diagram page 5 of 9**



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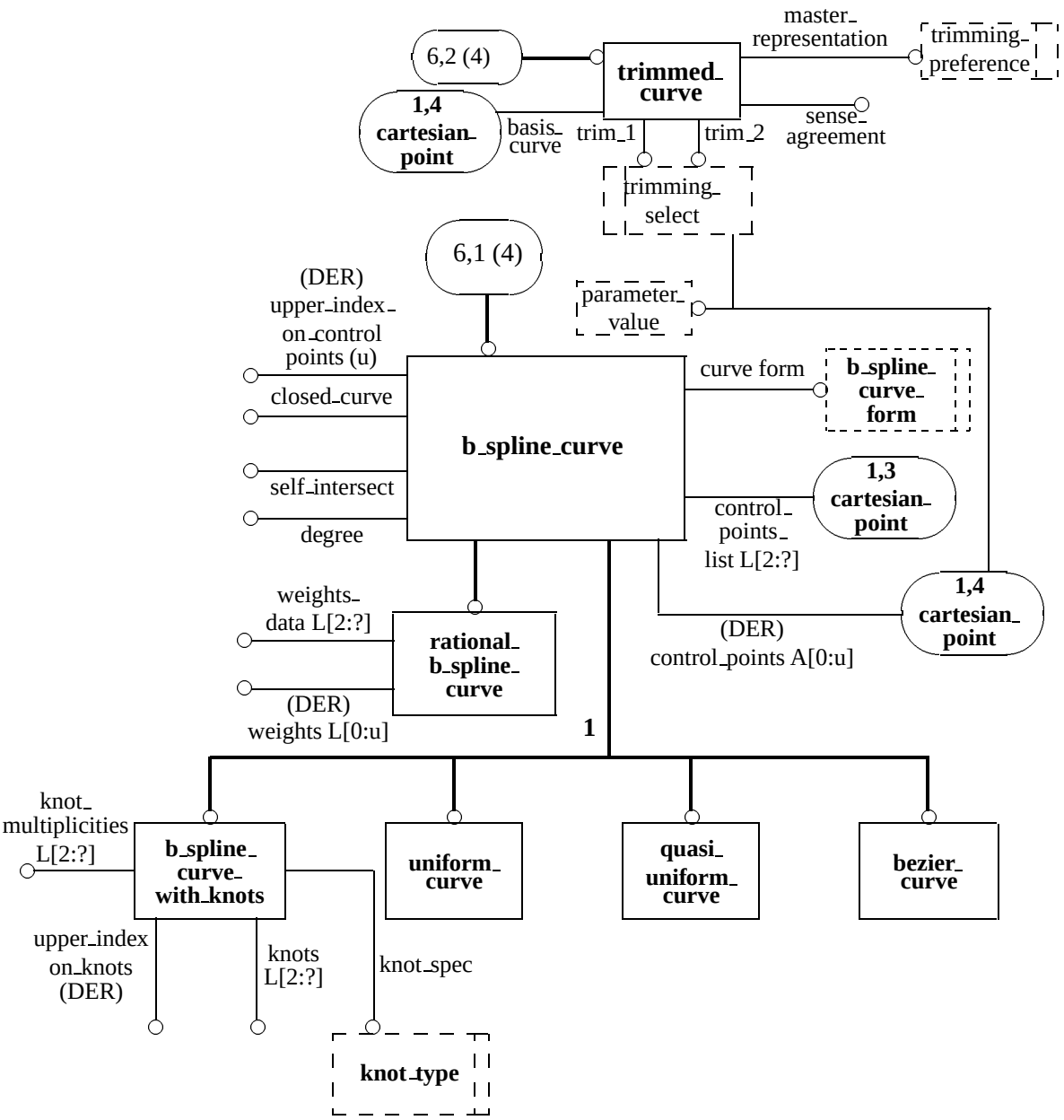


**Figure D.6 – aic_curve_swept_solid EXPRESS-G diagram page 6 of 9**


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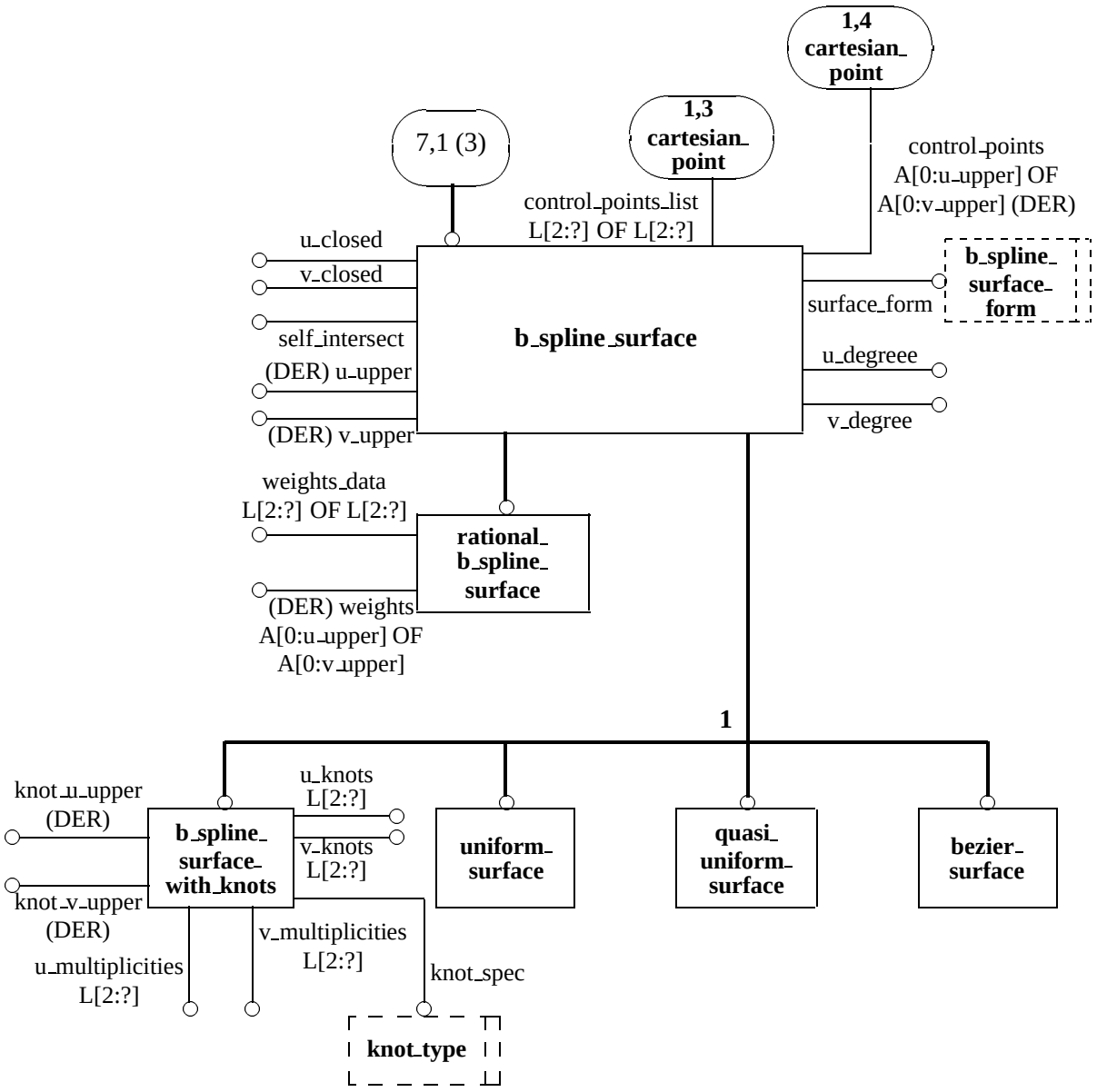


**Figure D.7 – aic_curve_swept_solid EXPRESS-G diagram page 7 of 9**



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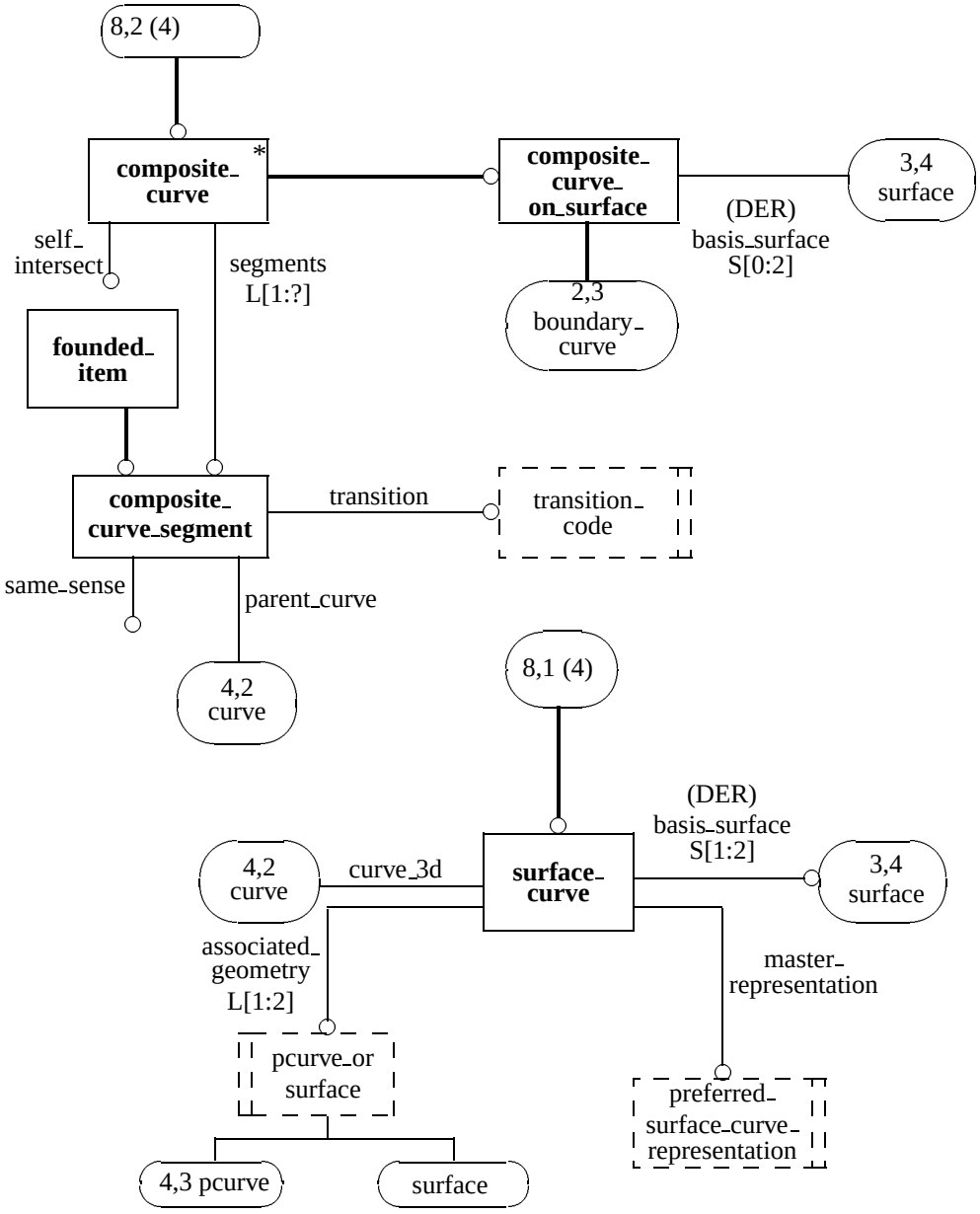


**Figure D.8 – aic_curve_swept_solid EXPRESS-G diagram page 8 of 9**


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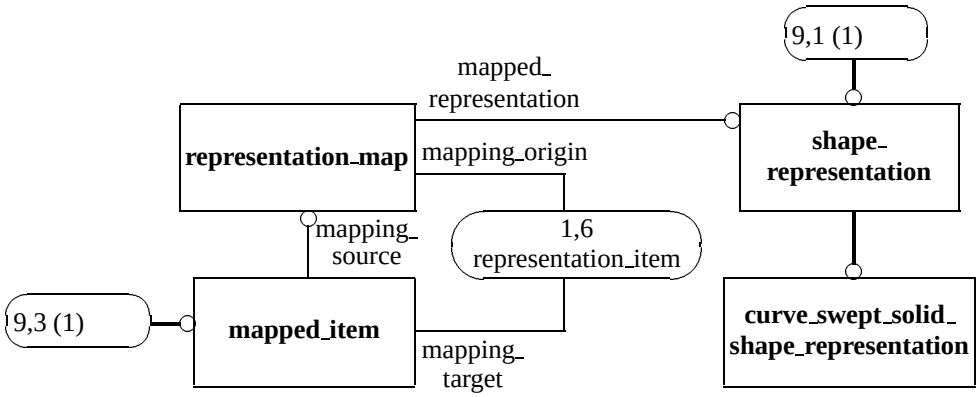


**Figure D.9 – aic_curve_swept_solid EXPRESS-G diagram page 9 of 9**

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# Annex E
(informative)

# AIC usage example

The part 21 file example below illustrates how this AIC may be used to define the shape of a complex swept solid with full control of the orientation during the sweeping process. This is a section of a part 21 file showing all the relevant geometry and geometric model definitions.

EXAMPLE 1
```
/* Part 523 geometry example, sweeping curve is a single segment
Bezier curve */
/* Geometry Definition of area to be swept defined on plane z=0
in shape of 2 semi-circles radii 10 and 5 joined by line segments
inner boundary is circle of radius 3 */
#1040 =(LENGTH_UNIT()NAMED_UNIT(*)SI_UNIT(.MILLI.,.METRE.));
#1041 =(NAMED_UNIT(*)PLANE_ANGLE_UNIT()SI_UNIT($,.RADIAN.));
#1100 = CARTESIAN_POINT('origin',(0.0,0.0,0.0));
#1101 = DIRECTION('Dir1',(1.0,0.0,0.0));
#1103 = DIRECTION('Dir3',(0.0,0.0,1.0));
#1104 = DIRECTION('slope1',(1.0,4.0,0.0));
#1105 = DIRECTION('slope2', (-1.0,4.0,0.0));
/* Points for second arc centre and trimming points */
#1106 = CARTESIAN_POINT('PtC2',(0.0,-20.0, 0.0));
#1107 = CARTESIAN_POINT('PtA',(10.0, 0.0, 0.0));
#1108 = CARTESIAN_POINT('PtB',(-10.0, 0.0, 0.0));
#1109 = CARTESIAN_POINT('PtE',(-5.0, -20.0 ,0.0));
#1110 = CARTESIAN_POINT('PtF',(5.0, -20.0 ,0.0));
#1111 = CARTESIAN_POINT('PtG',(3.0, 0.0 ,0.0));
/* Surface (plane) and curves */
#1120 = AXIS2_PLACEMENT_3D('Ax2P3DAxes',#1100,#1103,#1101);
#1121 = PLANE('Baseplane', #1120);
#1122 = AXIS2_PLACEMENT_3D('Ax2P3DCirc2',#1106,#1103,#1101);
#1124 = CIRCLE('Circ1',#1120, 10.0);
#1125 = CIRCLE('InnerC',#1120, 3.0);
#1126 = CIRCLE('Circ2',#1122, 5.0);
#1127 = VECTOR('Vec1',#1104, 10.0);
#1128 = VECTOR('Vec2',#1105, 10.0);
#1129 = LINE('LineFA',#1110, #1127);
#1130 = LINE('LineEB',#1109, #1128);
/* trimmed_curves and surface_curves */
#1140 = TRIMMED_CURVE('ArcAB',#1124,(#1107), (#1108),.T.,.CARTESIAN.);
#1141 = TRIMMED_CURVE('LinBE',#1130,(#1108), (#1109),.F.,.CARTESIAN.);
#1142 = TRIMMED_CURVE('ArcEF',#1126,(#1109), (#1110),.T.,.CARTESIAN.);
#1143 = TRIMMED_CURVE('LinFA',#1129,(#1110), (#1107),.T.,.CARTESIAN.);
#1144 = TRIMMED_CURVE('InC',#1125,(#1111), (#1111),.F.,.CARTESIAN.);
#1145 = BOUNDED_SURFACE_CURVE('scAB',#1140, (#1121), .CURVE_3D.);
#1146 = BOUNDED_SURFACE_CURVE('scBE',#1141, (#1121), .CURVE_3D.);
#1147 = BOUNDED_SURFACE_CURVE('scEF',#1142, (#1121), .CURVE_3D.);
#1148 = BOUNDED_SURFACE_CURVE('scFA',#1143, (#1121), .CURVE_3D.);
#1149 = BOUNDED_SURFACE_CURVE('scInner',#1144, (#1121), .CURVE_3D.);
```

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```
/* segments and composite curves (as boundary_curves) */
/* segAB */
#1155 = COMPOSITE_CURVE_SEGMENT(.CONTINUOUS., .T., #1145);
/* segBE */
#1156 = COMPOSITE_CURVE_SEGMENT(.CONTINUOUS., .T., #1146);
/* segEF */
#1157 = COMPOSITE_CURVE_SEGMENT(.CONTINUOUS., .T., #1147);
/* segFA */
#1158 = COMPOSITE_CURVE_SEGMENT(.CONTINUOUS., .T., #1148);
/* segInner */
#1159 = COMPOSITE_CURVE_SEGMENT(.CONT_SAME_GRADIENT., .T., #1149);
#1160 = OUTER_BOUNDARY_CURVE('Outer',(#1155, #1156, #1157, #1158), .F.);
#1161 = BOUNDARY_CURVE('InnerB',(#1159), .F.);
/* Area is defined as curve_bounded_surface */
#1170 = CURVE_BOUNDED_SURFACE('Area',#1121, (#1160, #1161), .F.);
/* Define points for ruled (Bezier) surface and directrix */
#1181 = CARTESIAN_POINT('PtP1',(0.0, 0.0, 10.0));
#1182 = CARTESIAN_POINT('PtP2',(60.0, 40.0, 10.0));
#1183 = CARTESIAN_POINT('PtP3',(140.0, 60.0, 10.0));
#1184 = CARTESIAN_POINT('PtP4',(200.0, 0.0 ,10.0));
/*Points Qn for second side of surface are offset by 100 initially in Y
 direction and progressively rotated, final offset in Z direction */
#1191 = CARTESIAN_POINT('PtQ1',(0.0, 100.0, 10.0));
#1192 = CARTESIAN_POINT('PtQ2',(60.0, 126.0, 60.0));
#1193 = CARTESIAN_POINT('PtQ3',(140.0, 110.0, 96.0));
#1194 = CARTESIAN_POINT('PtQ4',(200.0, 0.0 ,110.0));
/* Bezier curve and ruled Bezier surface */
#1201 = BEZIER_SURFACE('RuledSrf',1 , 3,
        ((#1181, #1182, #1183, #1184),
        (#1191, #1192, #1193, #1194)),
        .UNSPECIFIED., .F., .F., .F.);
#1202 = BEZIER_CURVE('Directrix', 3,
        (#1181, #1182, #1183, #1184), .UNSPECIFIED., .F., .F.);
/* Surface curve and ruled_surface_swept_area_solid */
#1203 = SURFACE_CURVE('ScDirect',#1202, (#1201), .CURVE_3D.);
/* swept area is shorter than Bezier curve  */
#1204 = RULED_SURFACE_SWEPT_AREA_SOLID('sweptsol', #1170, #1203,
                            0.05, 0.95, #1201);
/* Define swept_disk_solid to fit void of swept area and extend outside */
#1205 = SWEPT_DISK_SOLID('Core', #1202, 3.0, $, 0.0, 1.0);
/* Final representation contains swept area and swept disk */
#1290 = (GEOMETRIC_REPRESENTATION_CONTEXT(3)
        GLOBAL_UNIT_ASSIGNED_CONTEXT((#1040,#1041))
        REPRESENTATION_CONTEXT('Context for Swept solids',
        'This is a 3D context using millimetres'));
#1300 = CURVE_SWEPT_SOLID_SHAPE_REPRESENTATION('SweptRep',
            (#1204, #1205), #1290);
```

NOTE 1 #1204 is a solid formed by sweeping a planar area with a circular hole. The sweeping is along the directrix that is a B-spline curve instanced as a Bezier curve of degree 3 (#1202) this is referenced by surface_-



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curve #1203. The extent of the swept solid is slightly less (0.05 to 0.95) than the parametric extent of the directrix (0.0 to 1.0).

NOTE 2 #1201 defines a ruled surface as a Bezier surface of degree $1 \times 3$, note that the first sub-list of control points is identical to the control points of curve #1202 which forms one edge of the ruled surface. The directrix could, alternatively, have been defined as the pcurve $u = 0$. The second sub-list of the control points effectively defines the other edge curve of the ruled surface, in this example they were obtained by translating and progressively rotating the points from the first sub-list to give a final rotation of 90 degrees. The effect is to rotate the area as it is swept along the directrix. The ruled surface, directrix and control points are illustrated in figure E.2.

NOTE 3 The area to be swept is defined by the curve_bounded_surface instance #1170, this lies on the plane $z = 0$ (#1120) and has an outer boundary (#1160) composed of 2 semi circles of radii 10mm and 5mm joined by straight lines. It also has a circular hole defined by an inner boundary (#1160) which traverses a circle of radius 3mm, centred at the origin, in the negative sense (see #1149, #1144 and #1125). This area is illustrated in figure E.1

NOTE 4 #1205 is a swept_disk_solid that uses the same directrix as #1204 to sweep a circular disk of radius 3mm (with no inner hole). The parametric extent of the swept disk soild is (0.0 to 1.0) so that it extends beyond the ends of the hole in #1201.

NOTE 5 #1500 is an instance of **curve_swept_solid_shape_representation** containing the swept solids #1201 and #1205. It is defined in a 3 dimensional **geometric_representation_context** using millimetres and radians as units. This provides the context for all 3D geometry in the file. The final shape can be interpreted as an insulated cable of complex shape with a twist. #1205 defines a circular wire that exactly fits inside the insulation as defined by #1201. The wire projects slightly at each end. The complete solid is shown in figure E.3.

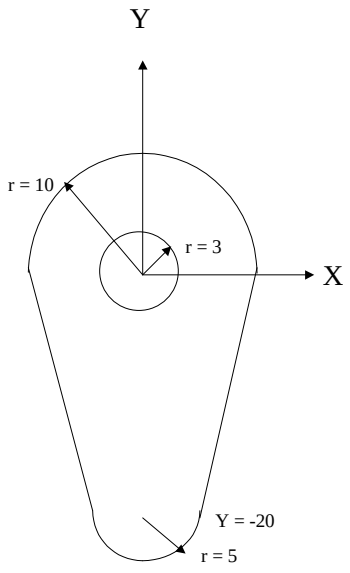


**Figure E.1 – Cross-section used to define swept solid**

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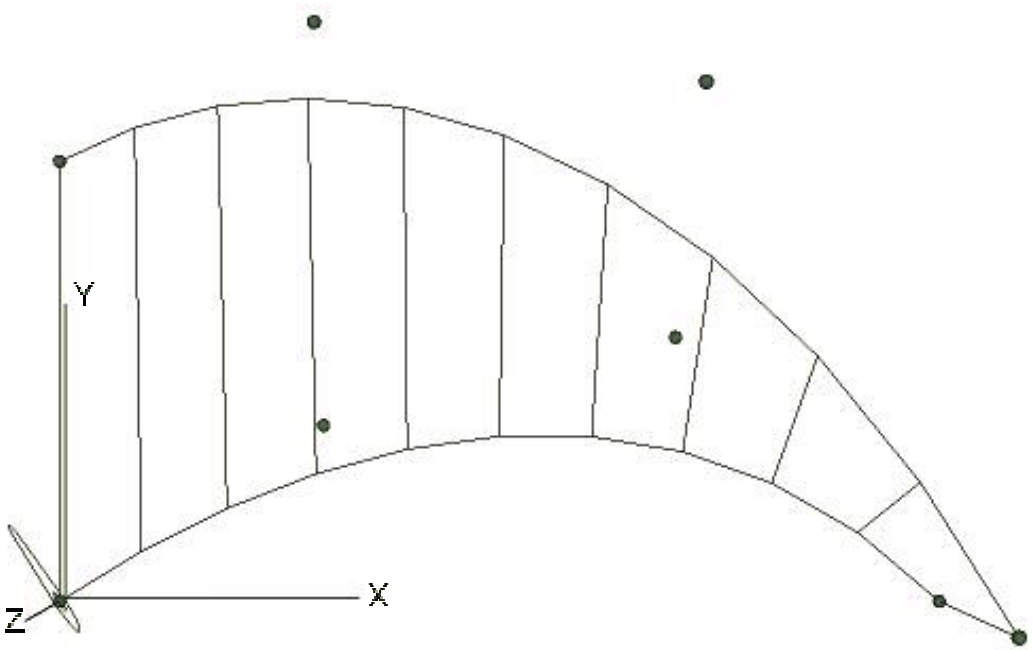


**Figure E.2 – Ruled surface and directrix curve**

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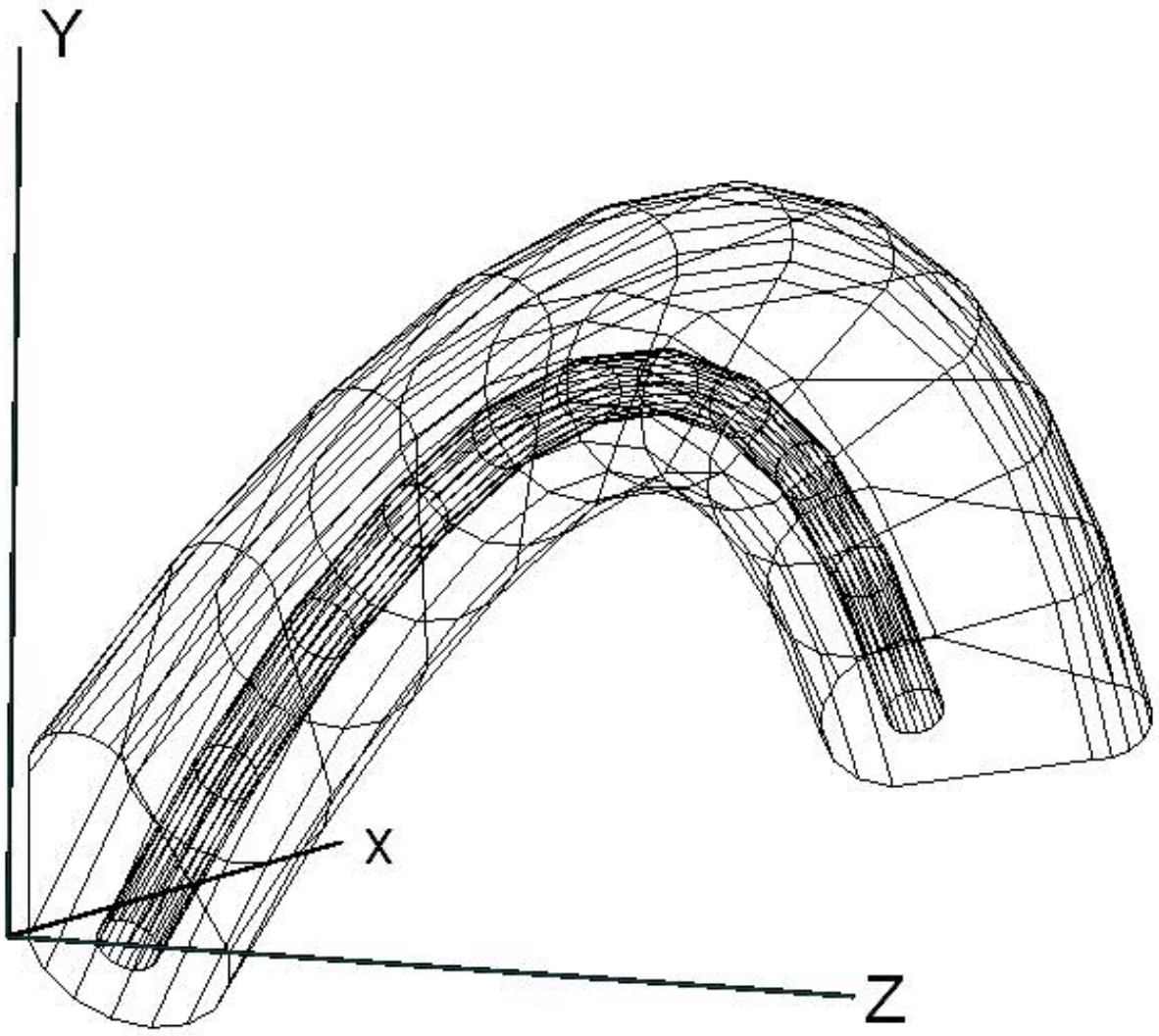


**Figure E.3 – Curve_swept_solid_shape_representation**

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