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

Part 513: Application interpreted construct: Elementary boundary representation

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

Partie 513: Construction interprétée d'application: Représentation des limites élémentaires

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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 3.

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 10303-513 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC 4, *Industrial data*.

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

`<http://www.nist.gov/sc4/editing/step/titles/>`

This part of ISO 10303 is a member of the application interpreted constructs series.

Annexes A and B form a normative part of this part of ISO 10303. Annexes C, D and E are for information only.

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 product data throughout the life cycle of a product independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

This International Standard is organized as a series of parts, each published separately. The parts of ISO 10303 fall into one of the following series: description methods, integrated resources, application interpreted constructs, application protocols, abstract test suites, implementation methods, and conformance testing. The series are described in ISO 10303-1. 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 the definition of a boundary representation solid with elementary geometry and explicit topology.

Industrial automation systems and integration — Product data representation and exchange — Part 513 : Application interpreted construct: Elementary boundary representation

1 Scope

This part of ISO 10303 specifies the interpretation of the generic resources for the definition of an elementary boundary representation model.
The following are within the scope of this part of ISO 10303:

— the definition of an **elementary_brep_shape_representation**, this is a representation composed of one or more **manifold_solid_brep**s each of which is defined with elementary geometry and complete explicit topology;

— the definition of the unbounded geometry of curves and surfaces used in the definition of the faces of such a B-rep model;

— the definition of the topological structure of a B-rep model;

— 3D geometry;

— B-reps;

— elementary curves, these are **line**s or **conic**s;

— **elementary_surface**s;

— geometric transformations;

— **polyline**s;

— unbounded geometry;

— use of topology to bound geometric entities.

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

— 2D geometry;

— bounded curves other than **polyline**s;

— bounded surfaces;

— offset curves and surfaces.

This AIC is independent of any industrial application domain.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10303. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10303 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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/TR 10303-12: 1997, *Industrial automation systems and integration - Product data representation and exchange - Part 12 : Description methods: The EXPRESS-I language reference manual.*

ISO 10303-41: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 41 : Integrated generic resources: Fundamentals of product description and support.*

ISO 10303-42: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 42 : Integrated generic resources: Geometric and topological representation.*

ISO 10303-43: 1994, *Industrial automation systems and integration - Product data representation and exchange - Part 43 : Integrated generic resources: Representation structures.*

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

ISO 10303-514: 1999, *Industrial automation systems and integration - Product data representation and exchange - Part 514: Application interpreted construct: Advanced boundary representation.*

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;

— 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;

— boundary;

— bounds;

— coordinate space;

— curve;

— open curve;

— orientable;

— surface;

— topological sense.

3.3 Terms defined in ISO 10303-202

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-202 apply.

— AIC.

3.4 Terms defined in ISO 10303-514

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-514 apply.

— manifold solid.

3.5 Other definitions

For the purposes of this part of ISO 10303 the following definitions apply:

3.5.1
elementary B-rep shape representation
a shape representation made up of one or more manifold solid B-reps. Each constituent B-rep is required to have its faces and edges defined by elementary geometry.

3.5.2
elementary geometry
geometry composed of **line**s, **polyline**s, **conic**s and **elementary_surface**s.

3.6 Abbreviations

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

AIC	application interpreted construct
AP	application protocol
B-rep	boundary representation solid model

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 and topological entities for the definition of manifold solid models with faces having elementary geometry and explicitly defined edges and vertices. The faces of the B-rep models are bounded by polylines, lines or conics.

The highest level entity in this AIC is the **elementary_brep_shape_representation.** This is a **shape_-representation** (see: ISO 10303-41) consisting of **manifold_solid_brep**s and **mapped_item**s defined as translated or transformed copies of **manifold_solid_brep**s having elementary geometry.

EXPRESS specification:

```
*)
SCHEMA aic_elementary_brep;
 USE FROM geometry_schema(axis2_placement_3d,
                          cartesian_point,
                          cartesian_transformation_operator_3d,
                          circle,
                          conical_surface,
                          cylindrical_surface,
                          degenerate_toroidal_surface,
                          direction,
                          ellipse,
                          hyperbola,
                          line,
                          parabola,
                          plane,
                          polyline,
                          spherical_surface,
                          toroidal_surface,
                          vector);
 USE FROM geometric_model_schema(manifold_solid_brep,
                                 brep_with_voids);

REFERENCE FROM geometric_model_schema(msb_shells);

USE FROM topology_schema(closed_shell,
                          connected_face_set,
                          edge_curve,
                          edge_loop,
                          face_bound,
                          face_outer_bound,
                          face_surface,
                          oriented_closed_shell,
                          vertex_loop,
                          vertex_point);


 USE FROM representation_schema(mapped_item);

 USE FROM product_property_representation_schema(shape_representation);

(*
```


NOTE 2 The **connected_face_set** entity is explicitly interfaced (i.e. included in the USE FROM lists) to allow rules in the **elementary_brep_shape_representation** entity to access attributes of this entity. For the use of this AIC this entity shall only be instantiated as one of its subtypes.

NOTE 3 The schemas referenced above can be found in the following parts of ISO 10303:

`geometry_schema`	ISO 10303-42
`geometric_model_schema`	ISO 10303-42
`topology_schema`	ISO 10303-42
`representation_schema`	ISO 10303-43
`product_property_representation_schema`	ISO 10303-41

4.1 Fundamental concepts and assumptions

The following entities are intended to be independently instantiated in the application protocol schemas that use this AIC:

— axis2_placement_3d;

— brep_with_voids;

— cartesian_point;

— cartesian_transformation_operator_3d;

— circle;

— closed_shell;

— conical_surface;

— cylindrical_surface;

— degenerate_toroidal_surface;

— direction;

— edge_curve;

— edge_loop;

— elementary_face;

— ellipse;

— face_bound;

— face_outer_bound;

— face_surface;

— hyperbola;

— line;

— manifold_solid_brep;

— mapped_item;

— oriented_closed_shell;

— parabola;

— plane;

— polyline;

— representation_map;

— spherical_surface;

— toroidal_surface;

— vector;

— vertex_loop;

— vertex_point.

An application protocol that uses this AIC shall require that all the above entities are supported.

An application protocol that uses this AIC shall permit the **shape_representation** entity to be instantiated as an **elementary_brep_shape_representation**.

4.2 aic_elementary_brep schema entity definition: elementary_brep_shape_representation

The **elementary_brep_shape_representation** is a type of **shape_representation** in which the representation items are specialisations of **manifold_solid_brep** entities. These differ from the more general B-rep in having only explicit geometric forms for their faces and edges. The face geometry is restricted to **elementary_surface**s, and the edge curves to **line**s, **polyline**s or **conic**s.

EXPRESS specification:

```
*)
ENTITY elementary_brep_shape_representation
SUBTYPE OF (shape_representation);
WHERE
  WR1 : SIZEOF (QUERY (it <* SELF.items |
         NOT (SIZEOF (['AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP',
               'AIC_ELEMENTARY_BREP.FACETED_BREP',
               'AIC_ELEMENTARY_BREP.MAPPED_ITEM',
               'AIC_ELEMENTARY_BREP.AXIS2_PLACEMENT_3D'] *
                  TYPEOF(it)) = 1))) = 0;
  WR2 : SIZEOF (QUERY (it <* SELF.items |
        SIZEOF(['AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP',
        'AIC_ELEMENTARY_BREP.MAPPED_ITEM'] * TYPEOF(it)) =1 )) > 0;
  WR3 : SIZEOF (QUERY (msb <* QUERY (it <* SELF.items |
          'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
          NOT (SIZEOF (QUERY (csh <* msb_shells(msb) |
           NOT (SIZEOF (QUERY(fcs <* csh.cfs_faces |
             NOT('AIC_ELEMENTARY_BREP.FACE_SURFACE' IN TYPEOF(fcs)))) = 0
               ))) = 0
                  ))) = 0;
  WR4 : SIZEOF (QUERY (msb <* QUERY (it <* SELF.items |
          'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
          NOT (SIZEOF (QUERY (csh <* msb_shells(msb) |
           NOT (SIZEOF (QUERY(fcs <* csh\connected_face_set.cfs_faces |
             NOT(('AIC_ELEMENTARY_BREP.ELEMENTARY_SURFACE' IN
                  TYPEOF(fcs\face_surface.face_geometry))
              ))) = 0
                  ))) = 0
                    ))) = 0;
  WR5 : SIZEOF (QUERY (msb <* QUERY (it <* SELF.items |
          'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
          NOT (SIZEOF (QUERY (csh <* msb_shells(msb) |
            NOT (SIZEOF (QUERY(fcs <* csh\connected_face_set.cfs_faces |
              NOT (SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* fcs.bounds |
        'AIC_ELEMENTARY_BREP.EDGE_LOOP' IN TYPEOF(bnds.bound)) |
               NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
                 NOT('AIC_ELEMENTARY_BREP.EDGE_CURVE' IN
           TYPEOF(oe.edge_element)))) = 0
                  ))) = 0
                ))) = 0
              ))) = 0
            ))) = 0;
  WR6 : SIZEOF (QUERY (msb <* QUERY (it <* SELF.items |
          'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
          NOT (SIZEOF (QUERY (csh <* msb_shells(msb) |
            NOT (SIZEOF (QUERY(fcs <* csh\connected_face_set.cfs_faces |
              NOT (SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* fcs.bounds |
        'AIC_ELEMENTARY_BREP.EDGE_LOOP' IN TYPEOF(bnds.bound)) |
               NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
```



```
                NOT (SIZEOF (['AIC_ELEMENTARY_BREP.LINE',
                      'AIC_ELEMENTARY_BREP.CONIC',
                      'AIC_ELEMENTARY_BREP.POLYLINE'] *
          TYPEOF(oe.edge_element\edge_curve.edge_geometry)) = 1 )
             )) = 0
             ))) = 0
               ))) = 0
                 ))) = 0
                  ))) = 0;
  WR7 : SIZEOF (QUERY (msb <* QUERY (it <* SELF.items |
          'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
          NOT (SIZEOF (QUERY (csh <* msb_shells(msb) |
            NOT (SIZEOF (QUERY(fcs <* csh\connected_face_set.cfs_faces |
              NOT (SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* fcs.bounds |
        'AIC_ELEMENTARY_BREP.EDGE_LOOP' IN TYPEOF(bnds.bound)) |
                NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
           NOT(('AIC_ELEMENTARY_BREP.VERTEX_POINT' IN TYPEOF(oe.edge_start))
               AND ('AIC_ELEMENTARY_BREP.VERTEX_POINT' IN
                TYPEOF(oe.edge_end))
           ))) = 0
             ))) = 0
              ))) = 0
                ))) = 0
                  ))) = 0;
  WR8 : SIZEOF (QUERY (msb <* QUERY (it <* SELF.items |
          'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
          NOT (SIZEOF (QUERY (csh <* msb_shells(msb) |
            NOT (SIZEOF (QUERY(fcs <* csh\connected_face_set.cfs_faces |
              NOT (SIZEOF(QUERY (elp_fbnds <* QUERY (bnds <* fcs.bounds |
        'AIC_ELEMENTARY_BREP.EDGE_LOOP' IN TYPEOF(bnds.bound)) |
                NOT (SIZEOF (QUERY (oe <* elp_fbnds.bound\path.edge_list |
                   ('AIC_ELEMENTARY_BREP.POLYLINE' IN
           TYPEOF(oe.edge_element\edge_curve.edge_geometry)) AND
           (NOT (SIZEOF (oe\oriented_edge.edge_element\
                 edge_curve.edge_geometry\polyline.points) >= 3))
             )) = 0
             ))) = 0
               ))) = 0
                 ))) = 0
                  ))) = 0;
  WR9 : SIZEOF (QUERY (msb <* QUERY (it <* items |
         'AIC_ELEMENTARY_BREP.MANIFOLD_SOLID_BREP' IN TYPEOF(it)) |
         'AIC_ELEMENTARY_BREP.ORIENTED_CLOSED_SHELL' IN TYPEOF
             (msb\manifold_solid_brep.outer)))
           = 0;
  WR10 : SIZEOF (QUERY (brv <* QUERY (it <* items |
         'AIC_ELEMENTARY_BREP.BREP_WITH_VOIDS' IN TYPEOF(it)) |
         NOT (SIZEOF (QUERY (csh <* brv\brep_with_voids.voids |
          csh\oriented_closed_shell.orientation)) = 0))) = 0;
  WR11 : SIZEOF (QUERY (mi <*  QUERY (it <* items |
                'AIC_ELEMENTARY_BREP.MAPPED_ITEM' IN TYPEOF(it)) |
         NOT ('AIC_ELEMENTARY_BREP.ELEMENTARY_BREP_SHAPE_REPRESENTATION' IN
```


