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

Part 515: Application interpreted construct: Constructive solid geometry

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

Partie 515: Construction interprétée d'application: Représentation géométrique constructive des solides

Reference number
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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.

Draft International Standards adopted by 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.

International Standard ISO 10303-515 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

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 protocols, abstract test suites, implementation methods, and conformance testing. The series are described in ISO 10303-1.

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

http://www.nist.gov/sc4/editing/step/titles/

Annexes A and B form a normative part of this part of ISO 10303. Annexes C and D 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 constructs 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 a consistent set of geometric and structural entities for the definition of Constructive Solid Geometry (CSG). The geometric information is conveyed by solid models, and the structural information is communicated through acyclic graphs.

Industrial automation systems and integration — Product data representation and exchange — Part 515: Application interpreted construct: Constructive solid geometry

1 Scope

This part of ISO 10303 specifies the interpretation of the integrated resources to satisfy requirements for representation of product shape using constructive solid geometry.

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

— solid primitives;

EXAMPLE 1 - sphere, right circular cone, right circular cylinder, and torus are types of solid primitives.

— regularised boolean operations of union, intersection, and difference on solid primitives, manifold brep and other solids;

EXAMPLE 2 - manifold solid breps, extruded face solids, revolved face solids, solid replicas, and half-space solids are other types of solids.

— extruded_face_solids and swept_face_solids to define new primitive shapes;

— boolean results generated by applying operators to solids.

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

— 2D geometric entities;

— self-intersecting geometry;

— evaluation of constructive solid geometry models to generate B-rep models.

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 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 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 10303-511: 1999, *Industrial automation systems and integration — Product data representation and exchange — Part 511: Application interpreted construct: Topologically bounded surface.*

ISO 10303-512: 1999, *Industrial automation systems and integration — Product data representation and exchange — Part 512: Application interpreted construct: Faceted boundary representation.*

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 purpose of this part of ISO 10303, the following terms defined in ISO 10303-1 apply:

— application;

— application context;

— application protocol (AP);

— implementation method;

— integrated resource;

— interpretation;

— product;

— product data.

3.2 Terms defined in ISO 10303-202

3.2.1
application interpreted construct (AIC)
a logical grouping of interpreted constructs that supports a specific function for the usage of product data across multiple application contexts

[ISO 10303-202:1996 definition 3.7.1]

3.3 Abbreviations

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

AIC	application interpreted construct
AP	application protocol
CSG	constructive solid geometry

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.

EXPRESS Specification:

```
*)
SCHEMA aic_csg;

USE FROM aic_advanced_brep;                                    -- ISO 10303-514

USE FROM aic_faceted_brep;                                     -- ISO 10303-512

USE FROM geometric_model_schema                                -- ISO 10303-42
     (block,
      boolean_operand,
      boolean_operator,
      boolean_result,
      box_domain,
      boxed_half_space,
      csg_primitive,
      csg_select,
      csg_solid,
      extruded_face_solid,
      half_space_solid,
      revolved_face_solid,
      right_angular_wedge,
      right_circular_cone,
      right_circular_cylinder,
      solid_replica,
      sphere,
      torus);

(*
```

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

aic_advanced_brep	ISO 10303-514
aic_faceted_brep	ISO 10303-512
geometric_model_schema	ISO 10303-42

4.1 Fundamental concepts and assumptions

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

— aic_csg

4.2 aic_csg entity definition: csg_shape_representation

A **csg_shape_representation** is a three-dimensional **shape_representation** that represents the shape of a **product** using constructive solid geometry operations and techniques. The solid objects may be either solid primitives, swept face solids, half-space solids, faceted B-rep solids (consistent with ISO 10303-512), or advanced B-rep solids (consistent with ISO 10303-514).

NOTE - An application protocol that uses this AIC may ensure that the **shape_representation** entity is instantiated as a **csg_shape_representation**.

EXPRESS Specification:

```
*)
ENTITY csg_shape_representation
  SUBTYPE OF (shape_representation);
WHERE
  WR1: SELF.context_of_items\
       geometric_representation_context.coordinate_space_dimension = 3;

  WR2: SIZEOF(QUERY (it <* SELF.items |
         SIZEOF(['AIC_CSG.CSG_SOLID',
                 'AIC_CSG.MAPPED_ITEM', 'AIC_CSG.AXIS2_PLACEMENT_3D',
                 'AIC_CSG.SOLID_REPLICA', 'AIC_CSG.REVOLVED_FACE_SOLID',
                 'AIC_CSG.EXTRUDED_FACE_SOLID'] * TYPEOF(it)) <> 1)) = 0;

  WR3: SIZEOF(QUERY (mi <* QUERY (it <* SELF.items |
               'AIC_CSG.MAPPED_ITEM' IN TYPEOF(it)) |
                NOT('AIC_CSG.CSG_SHAPE_REPRESENTATION' IN
       TYPEOF(mi\mapped_item.mapping_source.mapped_representation)))) = 0;

  WR4: SIZEOF(QUERY (sr <* QUERY (it <* SELF.items |
                'AIC_CSG.SOLID_REPLICA' IN TYPEOF(it)) |
                SIZEOF(['AIC_CSG.CSG_SOLID', 'AIC_CSG.REVOLVED_FACE_SOLID',
                        'AIC_CSG.EXTRUDED_FACE_SOLID'] *
                       TYPEOF(sr\solid_replica.parent_solid)) = 0)) = 0;

  WR5: SIZEOF(QUERY(it <* SELF.items |
                    NOT('AIC_CSG.AXIS2_PLACEMENT_3D' IN TYPEOF(it)))) > 0;

END_ENTITY;

END_SCHEMA; -- aic_csg
(*
```

WR1: The **geometric_representation_context** of the **csg_shape_representation** shall have a **coordinate_ space_dimension** equal to three.

WR2: The **items** in a **csg_shape_representation** shall be either of type **csg_solid**, **solid_replica**, **mapped_item**, **revolved_face_solid**, **extruded_face_solid** or **axis2_placement_3d**.

WR3: The **mapping_source** of any **mapped_item** in the **items** set of a **csg_shape_representation** shall be of type **csg_shape_representation**.

WR4: The **parent_solid** of any **solid_replica** in the **items** set of a **csg_shape_representation** shall be either of type **csg_solid**, **revolved_face_solid** or **extruded_face_solid**.

WR5: There shall be at least one element in the **items** set of a **csg_shape_representation**, which is not of type **axis2_placement_3d**.

Informal Propositions:

IP1: Any instance of **solid_model** used directly, or indirectly, as **first_operand** or **second_operand** of a **boolean_result** to define **csg_solid** in the **items** set of a **csg_shape_representation** shall be either of type **extruded_face_solid**, **revolved_face_solid**, **manifold_solid_brep**, or **solid_replica**. If it is of type **solid_replica**, its **parent_solid** shall be of type **csg_solid**, **extruded_face_solid**, **revolved_face_solid** or **manifold_solid_brep**.

IP2: Any instance of **manifold_solid_brep** used directly, or indirectly, as **first_operand** or **second_operand** of a **boolean_result** to define a **csg_solid** occurring in a **csg_shape_representation** shall be compatible with either the rules defined for its use in an **advanced_brep_shape_representation** or, the rules defined for its use in a **faceted_brep_shape_representation**. In particular each face shall either be of type **advanced_face** or, in the case of a **faceted_brep**, shall be a **face_surface** bounded by **poly_loops** and with a **plane** as **face_geometry**.

Annex A
(normative)

Short names of entities

Table A.1 provides the short names of entities specified in 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 names	Short names
CSG_SHAPE_REPRESENTATION	CSSHRP

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(515) 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_csg schema in an open system, the object identifier

{ iso standard 10303 part(515) version(1) object(1) aic-csg(1) }

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

Annex C
(informative)

EXPRESS-G diagrams

Figure C.1 through Figure C.15 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 - The following select types: curve_on_surface, founded_item_select, geometric_set_select, measure_value, reversible_topology, reversible_topology_item, transformation, trimming_select, vector_or_direction are interfaced into the AIC expanded listing according to the implicit interface rules of ISO 10303-11. These select types are not referenced by other entities of this part of ISO 10303.

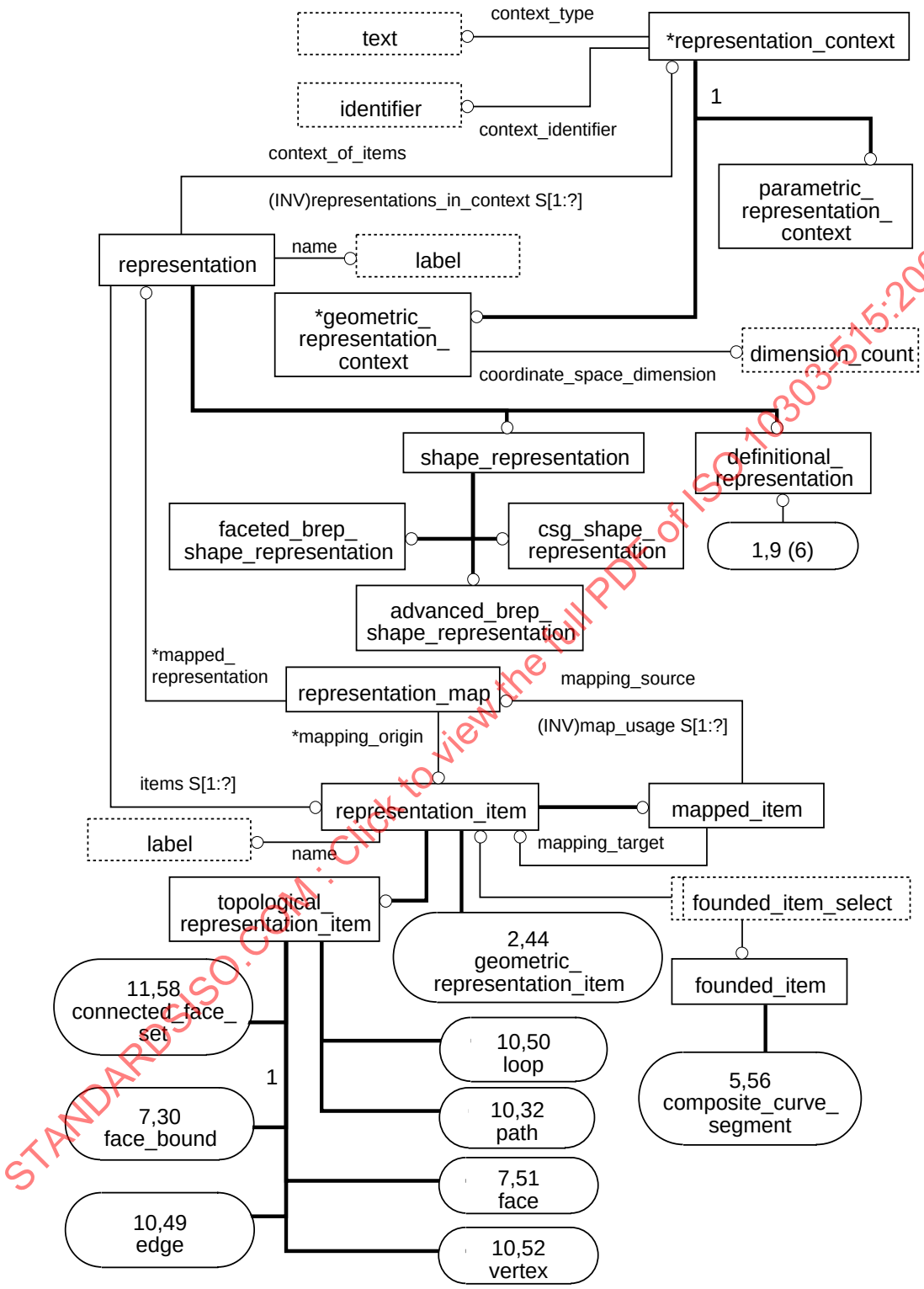

Figure C.1 – AIC expanded listing diagram in EXPRESS-G: 1 of 15

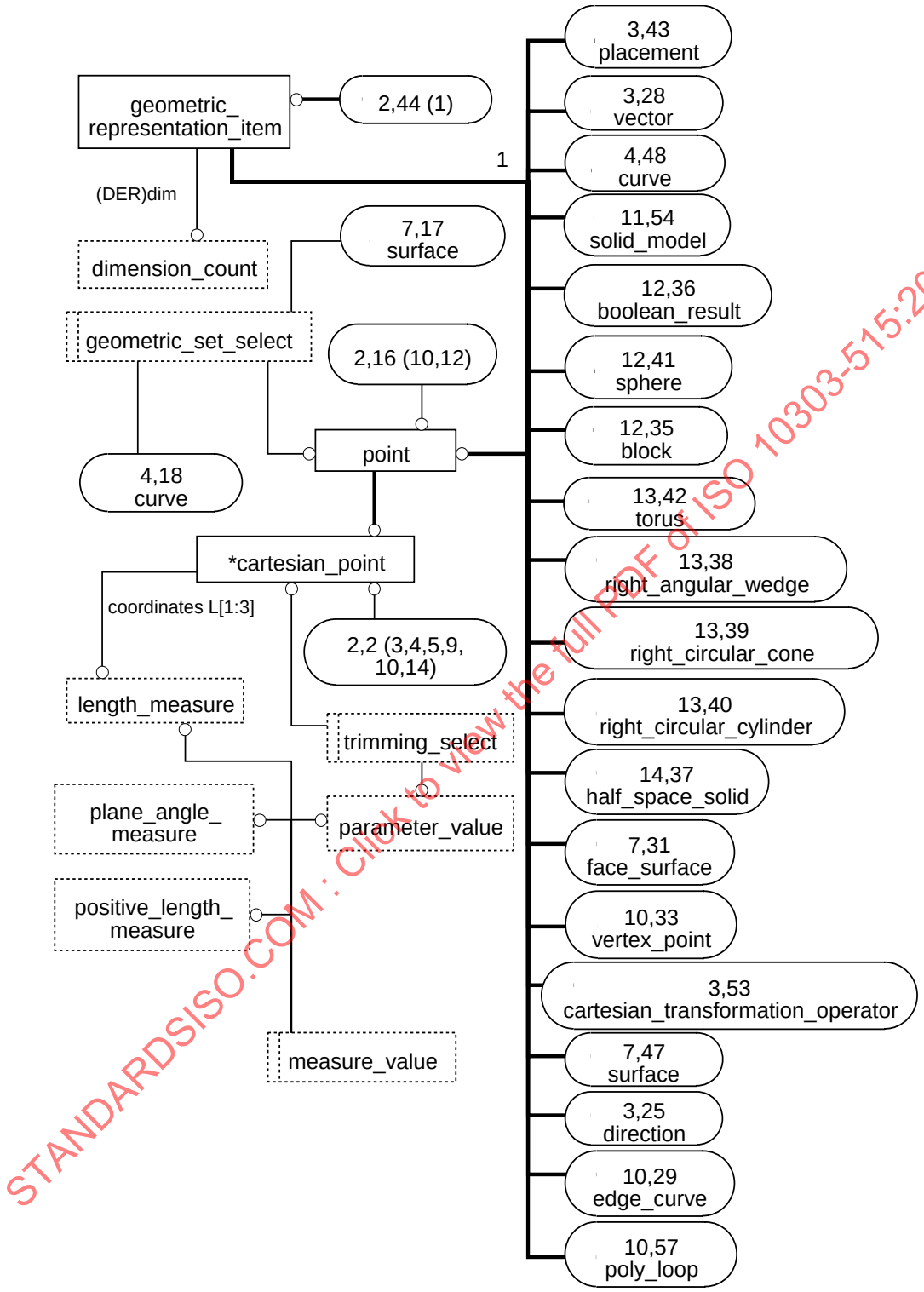

Figure C.2 – AIC expanded listing diagram in EXPRESS-G: 2 of 15

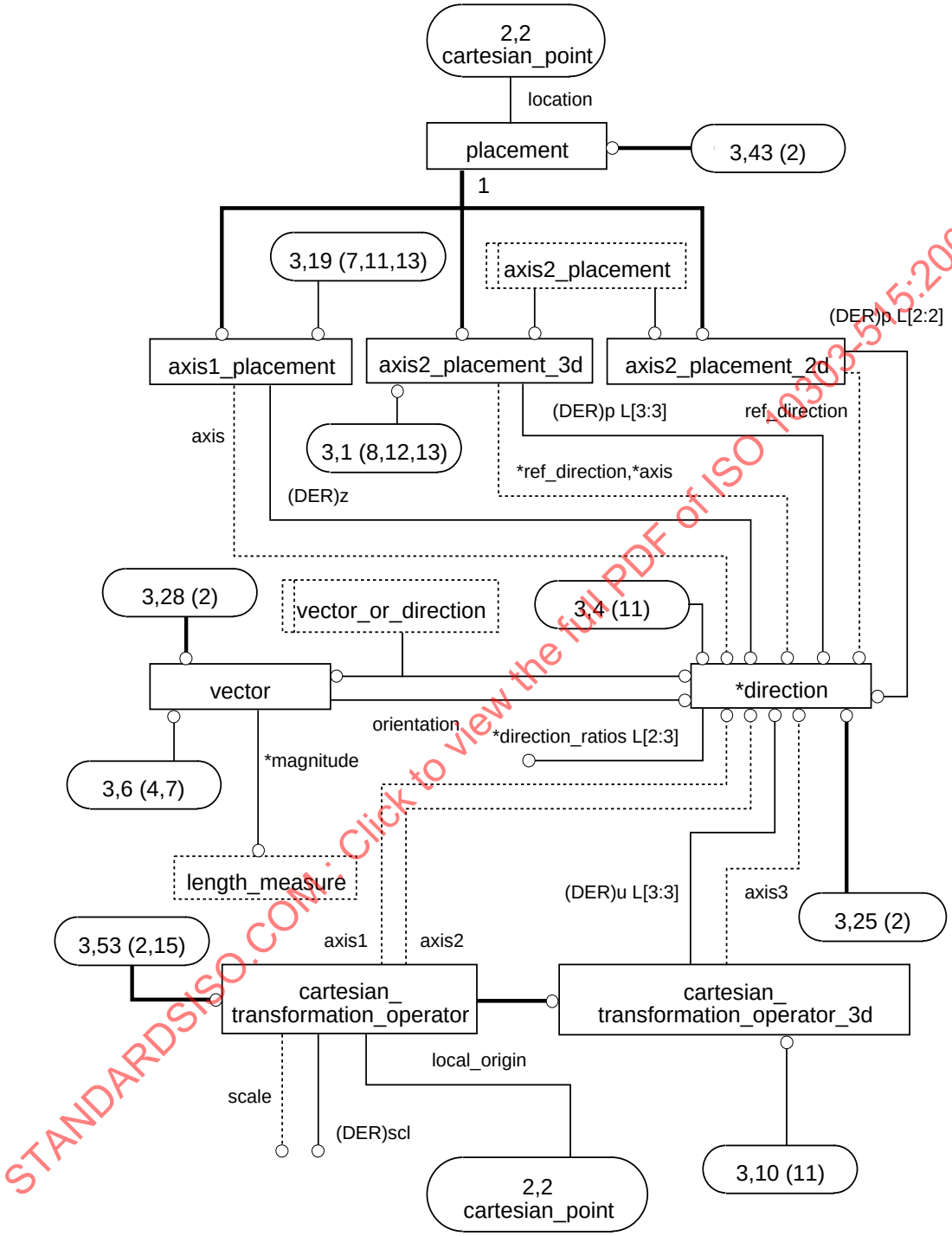

Figure C.3 – AIC expanded listing diagram in EXPRESS-G: 3 of 15

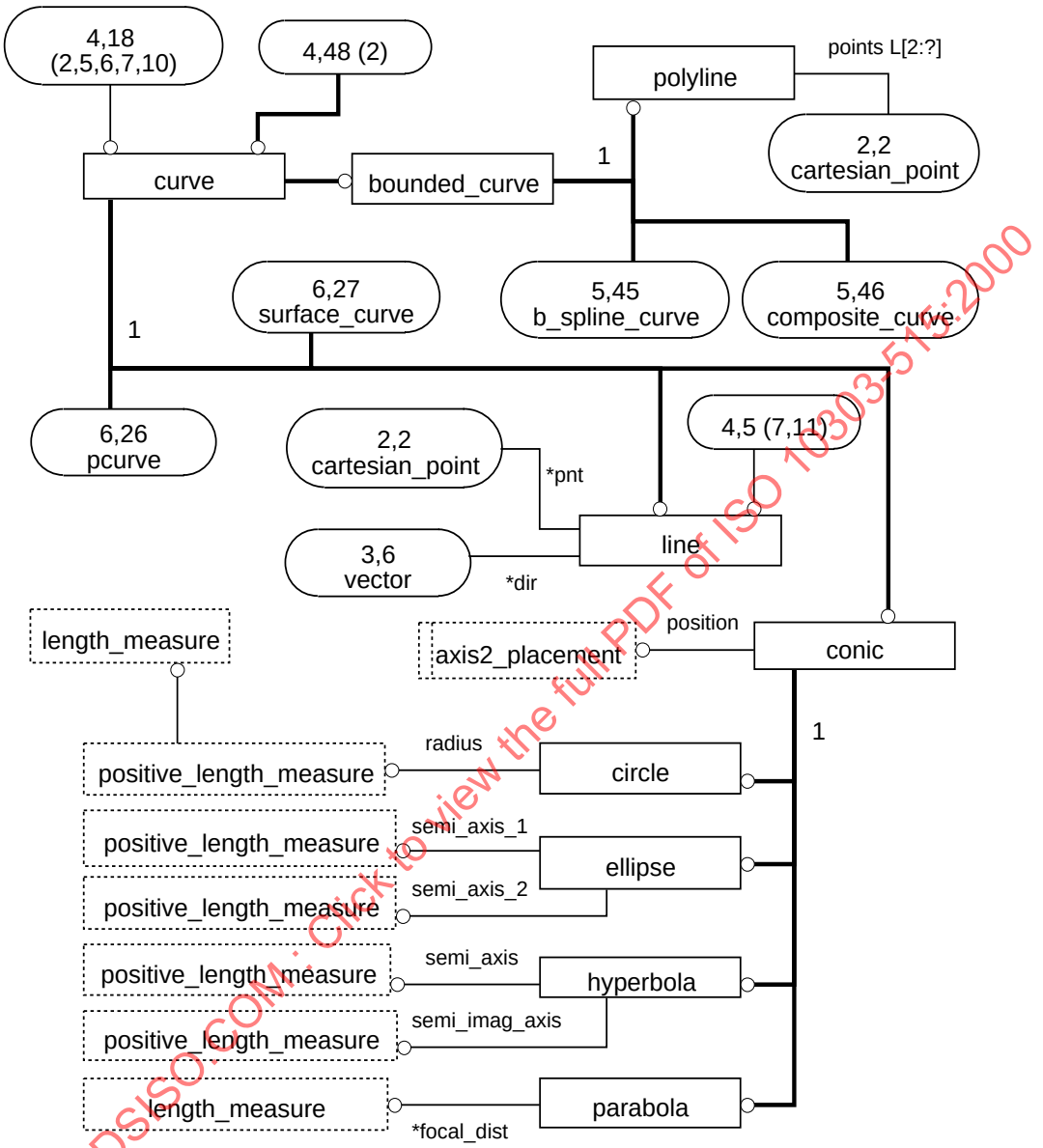

Figure C.4 – AIC expanded listing diagram in EXPRESS-G: 4 of 15

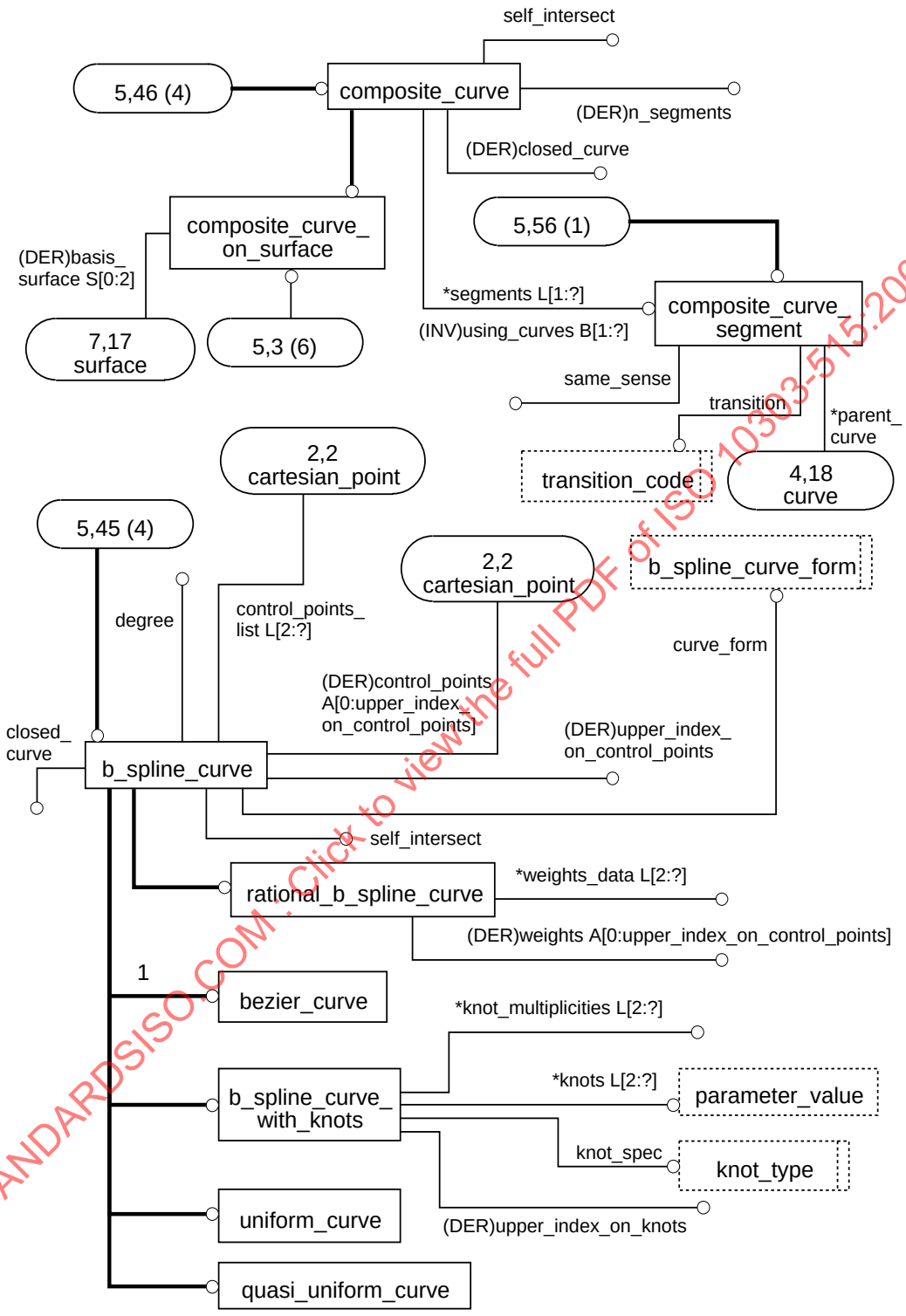

Figure C.5 – AIC expanded listing diagram in EXPRESS-G: 5 of 15

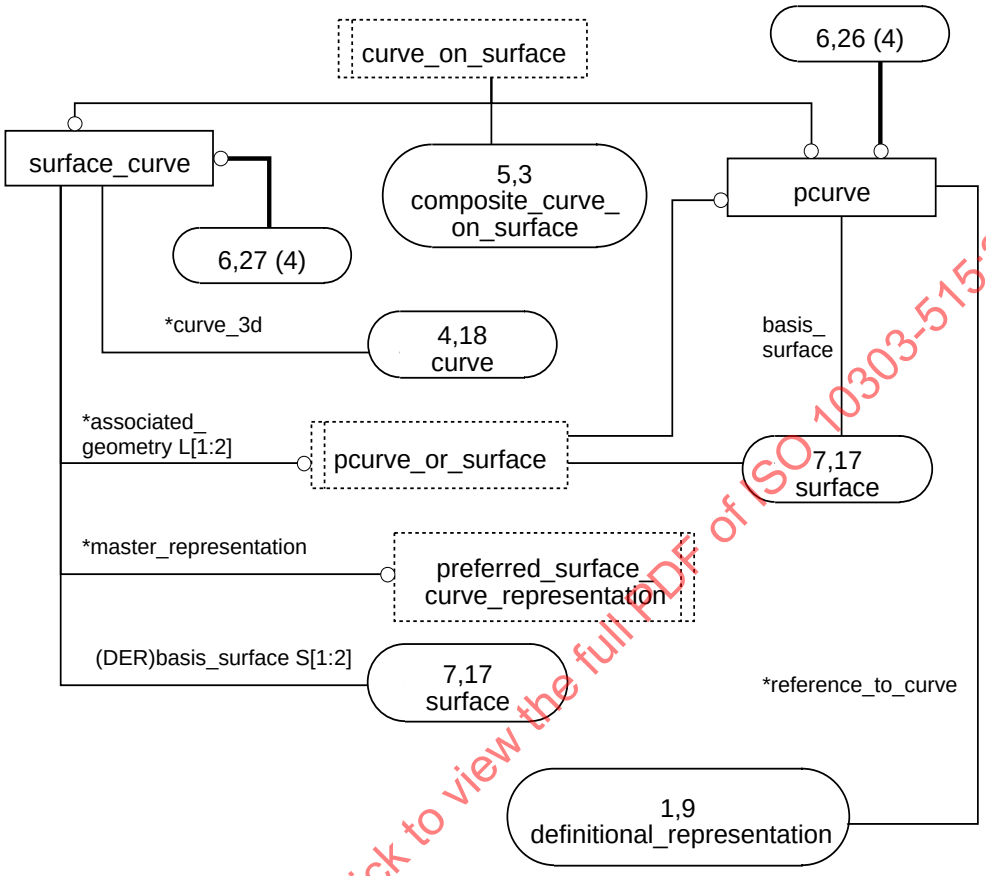

Figure C.6 – AIC expanded listing diagram in EXPRESS-G: 6 of 15

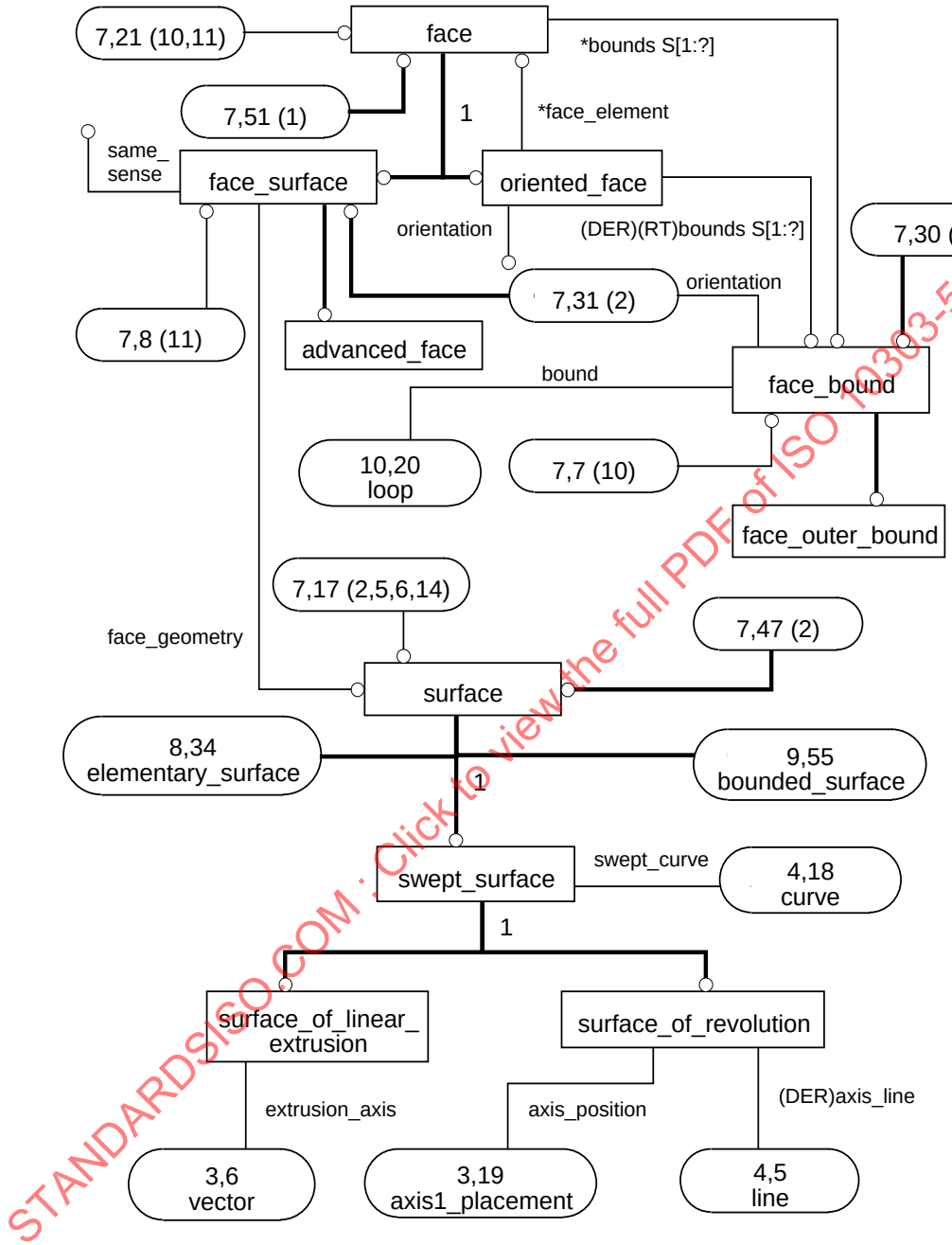

Figure C.7 – AIC expanded listing diagram in EXPRESS-G: 7 of 15

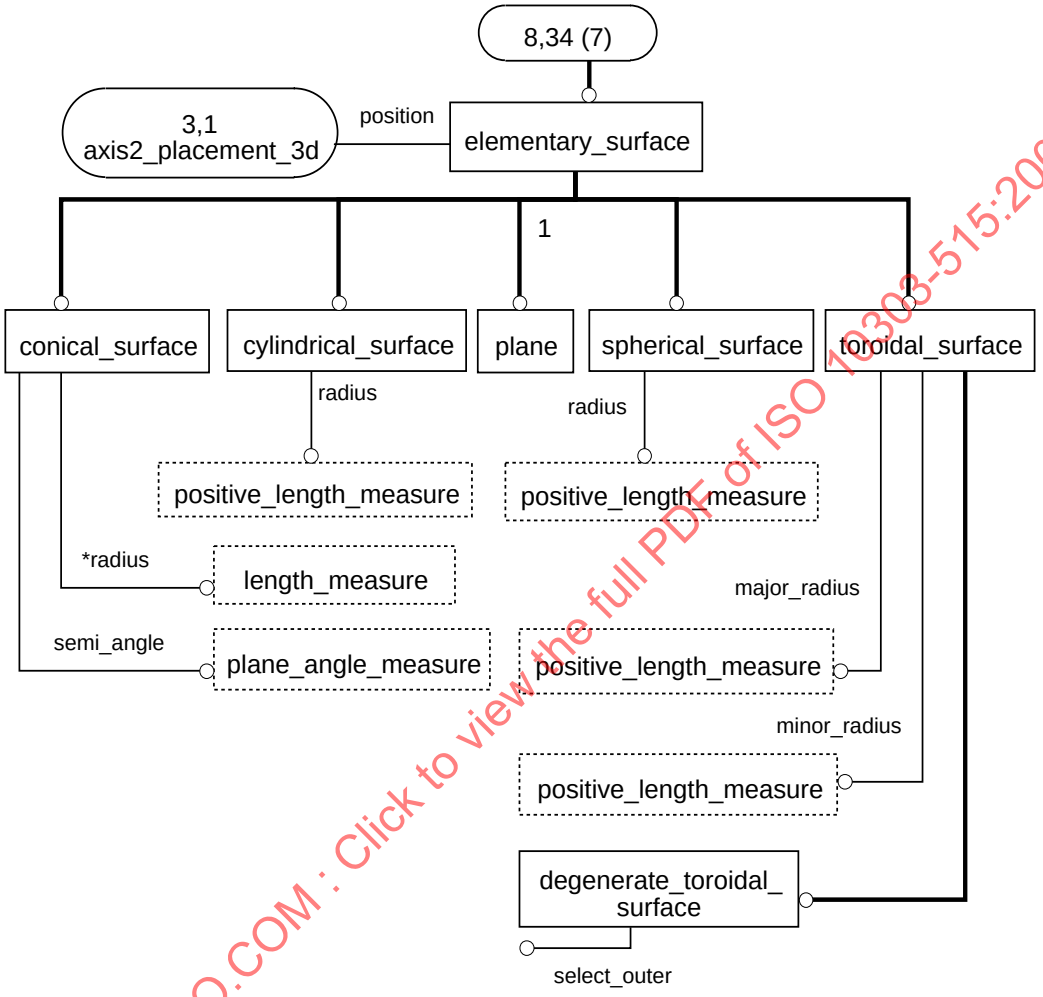

Figure C.8 – AIC expanded listing diagram in EXPRESS-G: 8 of 15

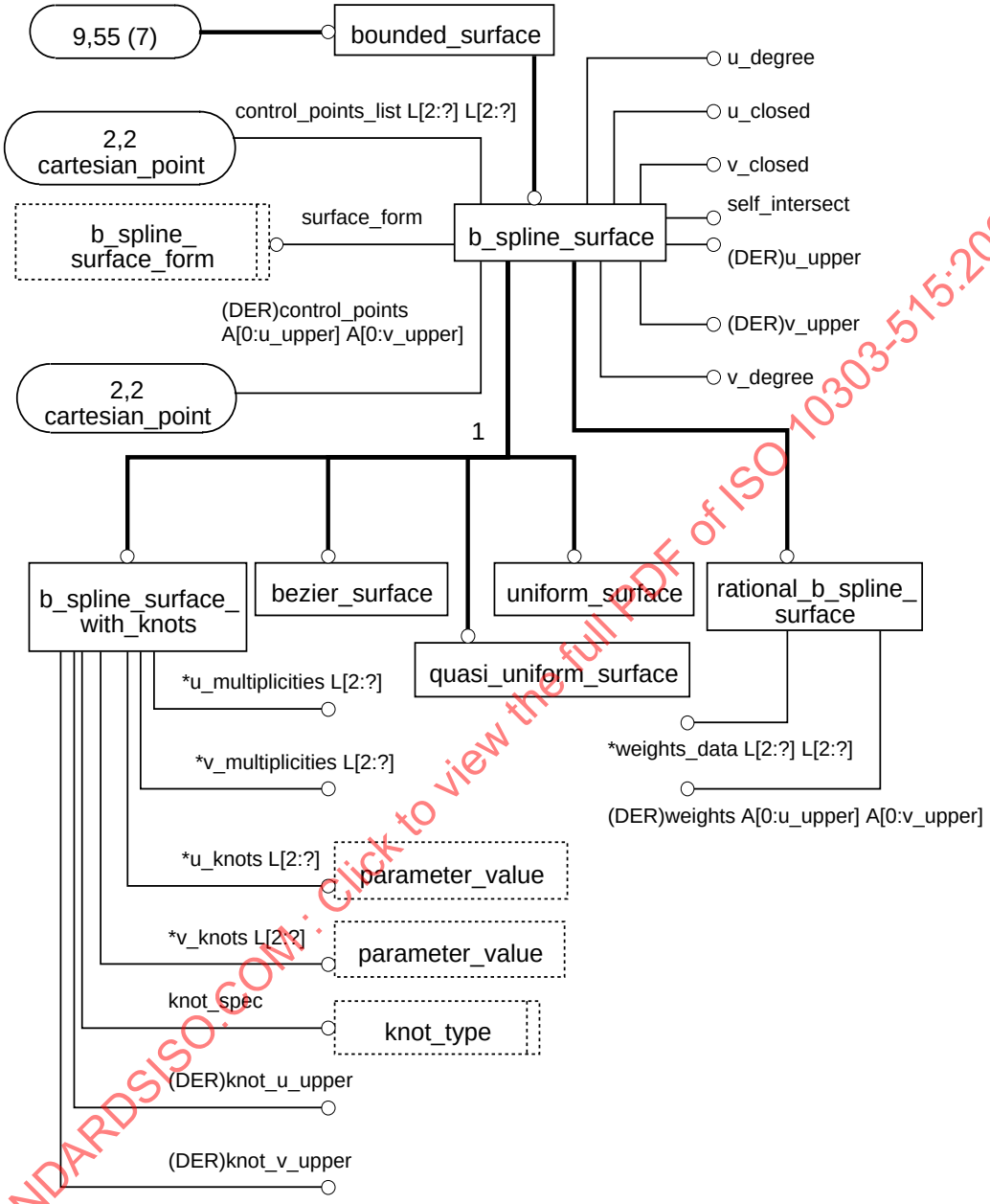

Figure C.9 – AIC expanded listing diagram in EXPRESS-G: 9 of 15

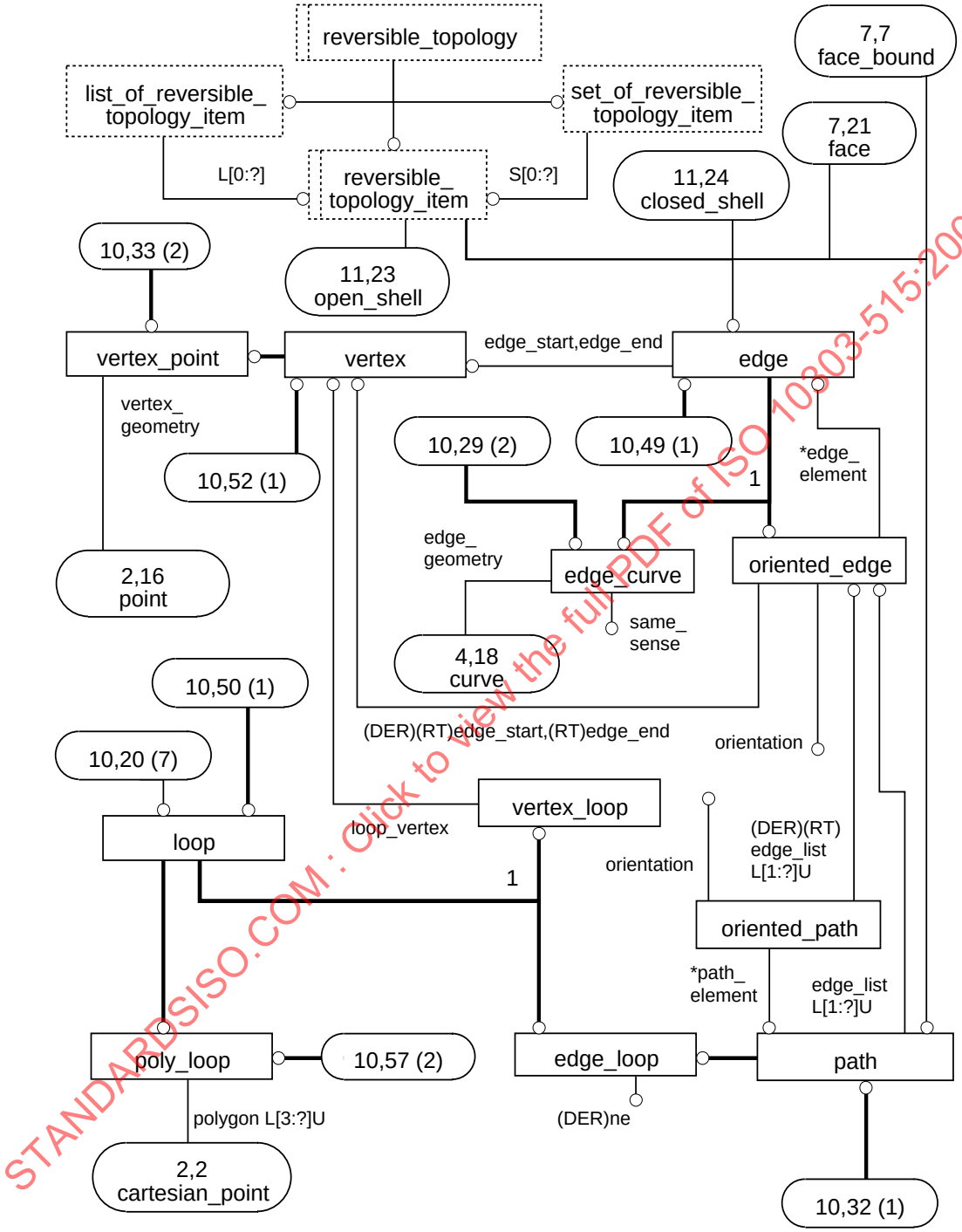

Figure C.10 – AIC expanded listing diagram in EXPRESS-G: 10 of 15

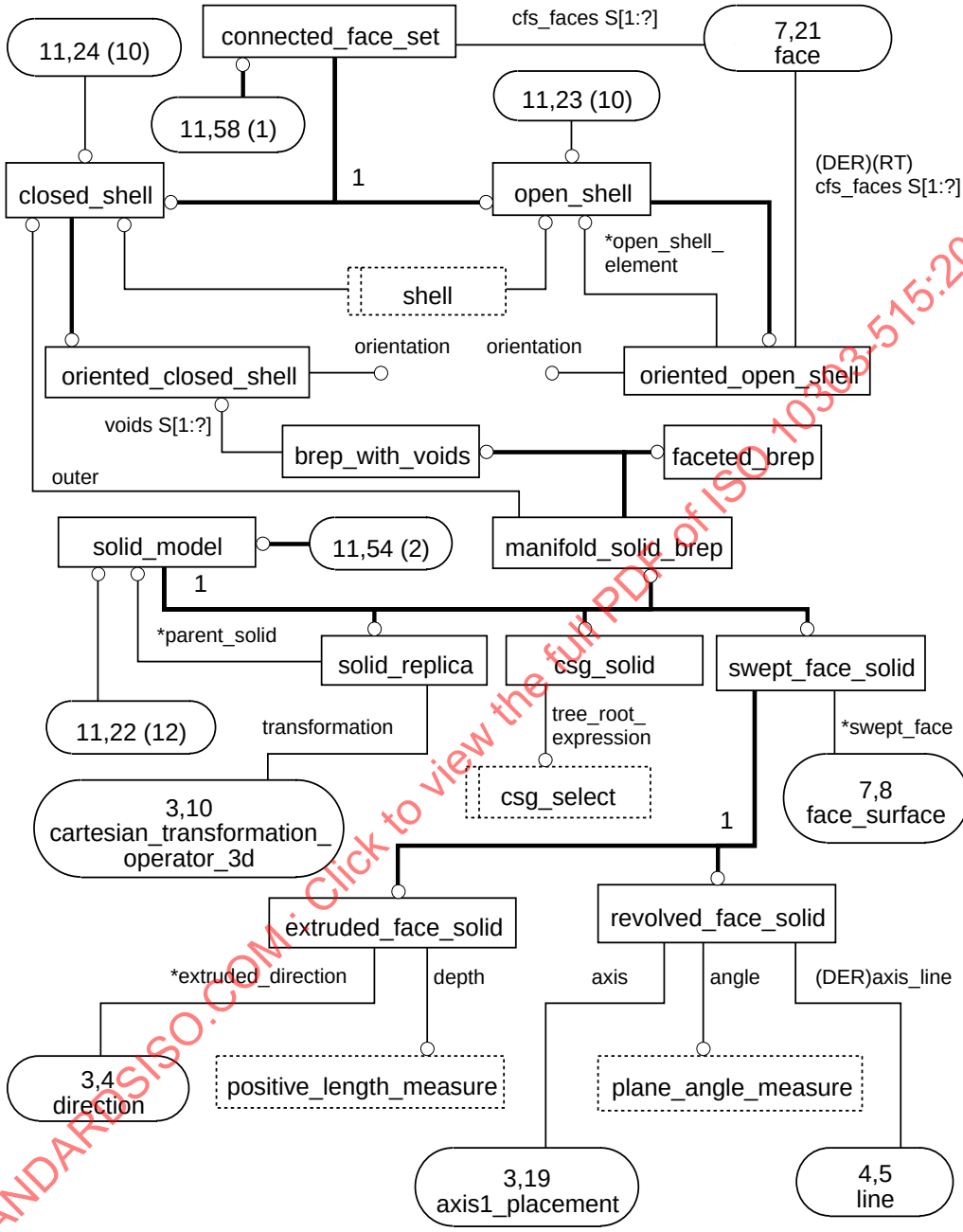

Figure C.11 – AIC expanded listing diagram in EXPRESS-G: 11 of 15

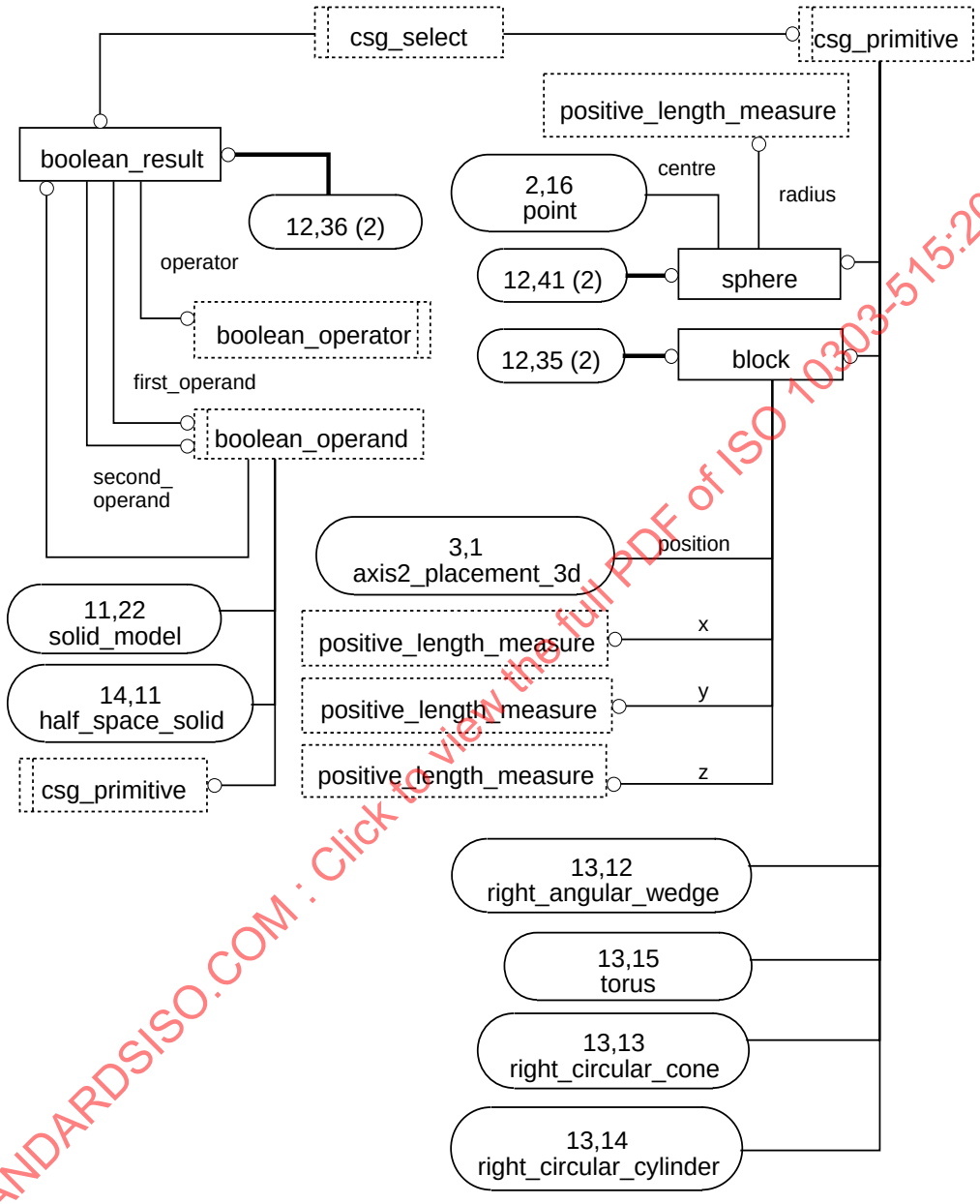

Figure C.12 – AIC expanded listing diagram in EXPRESS-G: 12 of 15

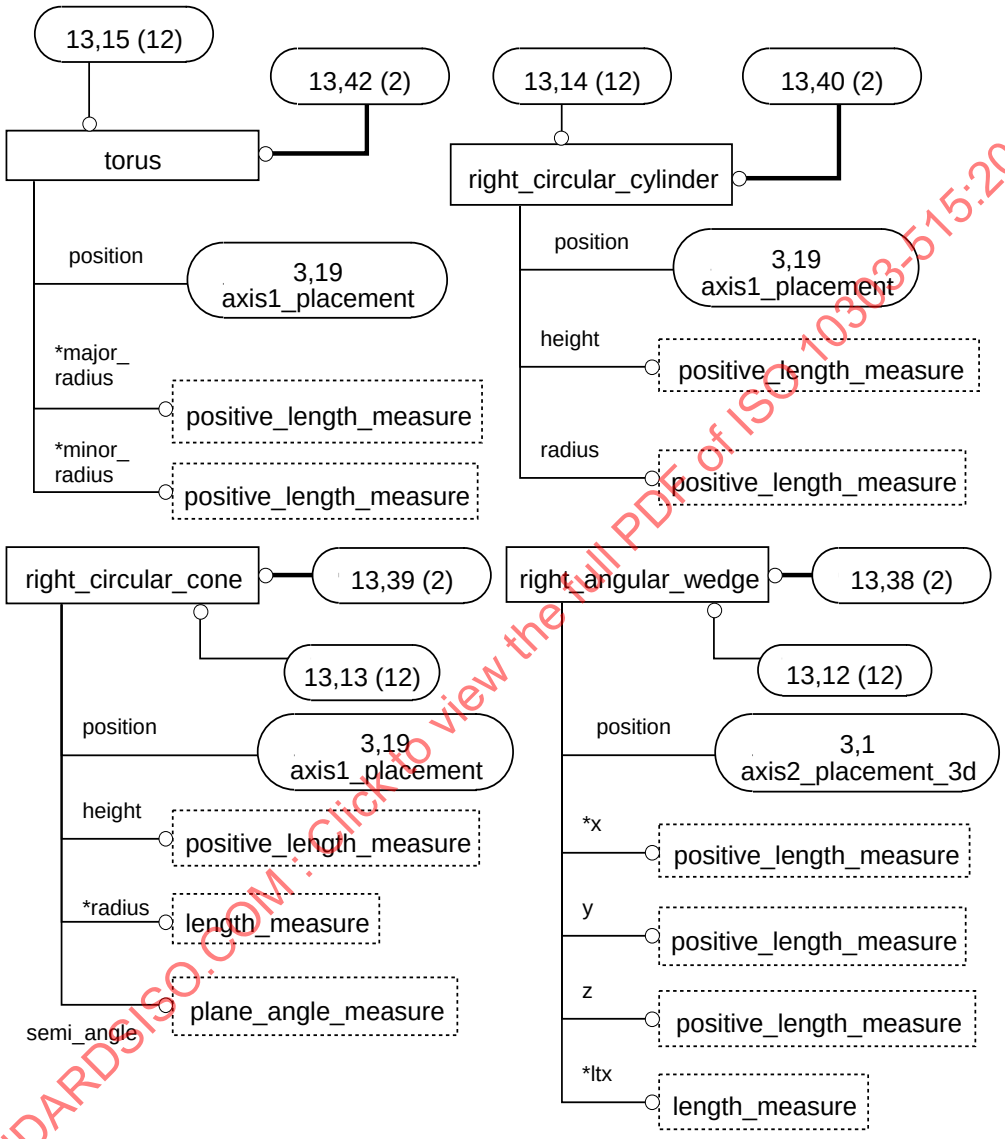

Figure C.13 – AIC expanded listing diagram in EXPRESS-G: 13 of 15

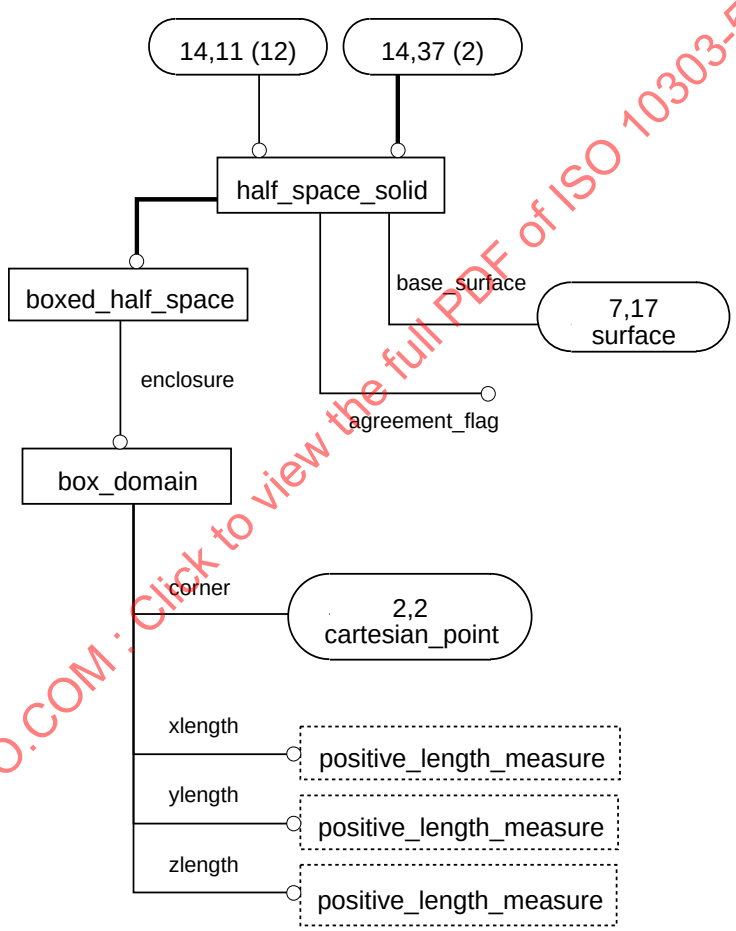

Figure C.14 – AIC expanded listing diagram in EXPRESS-G: 14 of 15

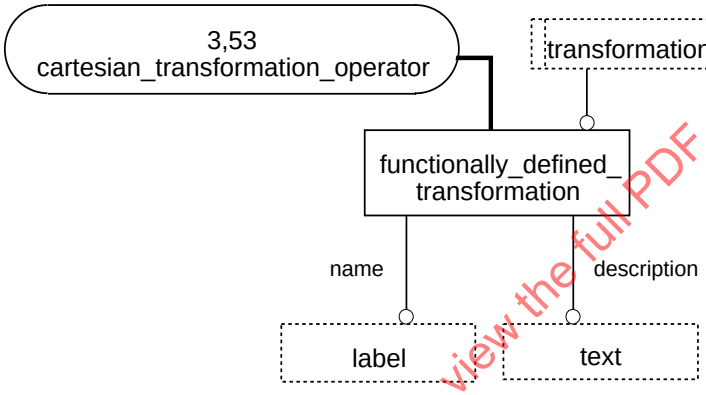

Figure C.15 – AIC expanded listing diagram in EXPRESS-G: 15 of 15