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

**Part 204:
Application protocol: Mechanical design
using boundary representation**

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

*Partie 204: Protocole d'application: Conception mécanique utilisant une
représentation délimitée*



Reference number
ISO 10303-204:2002(E)

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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.

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 10303-204 was prepared by Technical Committee ISO TC184/SC4, *Industrial automation systems and integration*, Subcommittee SC4 *Industrial data*.

This International Standard is organised as a series of parts, each published separately. The structure of this International Standard is described in ISO 10303-1.

Each part of this International Standard is a member of one of the following series: description methods, implementation methods, conformance testing methodology and framework, integrated generic resources, integrated application resources, application protocols, abstract test suites, application interpreted constructs, and application modules. This part is a member of the application protocol series.

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

[<http://www.tc184-sc4.org/titles/STEP_titles.rtf>](http://www.tc184-sc4.org/titles/STEP_titles.rtf)

Annexes A, B, C, D and E form an integral part of this part of ISO 10303. Annexes F, G, H, J and K 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 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 protocol series.

This Part of ISO 10303 specifies an application protocol (AP) for mechanical design using boundary representation solid models. A boundary representation solid model provides a complete description of the shape of a solid object by describing precisely the geometry and topology of all its internal and external boundaries.

This application protocol defines the context, scope, and information requirements for mechanical design using boundary representation models and specifies the integrated resources necessary to satisfy these requirements.

Application protocols provide the basis for developing implementations of ISO 10303. Application protocols provide the basis for developing abstract test suites for the conformance testing of AP implementations.

Clause 1 defines the scope of the application protocol and summarizes the functionality and data covered by the AP. An application activity model that is the basis for the definition of the scope is provided in annex F. The information requirements of the application are specified in clause 4 using terminology appropriate to the application. A graphical representation of the information requirements, referred to as the application reference model, is given in annex G.

Resource constructs are interpreted to meet the information requirements. This interpretation produces the application interpreted model (AIM). This interpretation, given in 5.1, shows the correspondence between the information requirements and the AIM. The short listing of the AIM specifies the interface to the integrated resources and is given in 5.2. Note that definitions and the EXPRESS provided in the integrated resources for constructs used in the AIM may include select list items and subtypes not imported into the AIM. The expanded listing given in Annex A contains the complete EXPRESS of the AIM without annotation. A graphical representation of the AIM is given in annex H. Additional requirements for specific implementation methods are given in annex C.

This Part of ISO 10303 contains the definition of conforming boundary representation solid models and the mechanisms to transfer them via an exchange structure as defined in Part ISO 10303-21. The exchange of such models, with associated visual presentation information is required during the initial design of a mechanical product and when detailed designs of components are communicated to suppliers and sub-contractors. In this Part B-reps are characterised by the fact that they can represent models with only planar surfaces (faceted B-rep), models with only analytical surfaces (elementary B-rep) and models with sculptured surfaces and curves (advanced B-rep). The application reference environment in which these B-rep models are used is the generation and exchange of volume-based data in the Computer-aided Mechanical design process. This application places fundamental requirements on the model exchange

and the neutral representation of models. The transfer and archiving of B-rep models at different stages of the design and engineering process requires the following to be maintained:

- the completeness of the models when mapped between application systems;
- the correctness of semantics of the representation;
- the accuracy of the geometric relationships between entity instances which form part of a B-rep model; in particular all vertices shall lie on the edges using them and all edge_curves shall lie on each face using this edge as part of the boundary.

Three different classes of implementation are specified in clause 6.

This application protocol was developed as one component of a series of Mechanical Design application protocols and is complemented by ISO 10303-205 Mechanical design using surface models, see (1). These Parts share a common application environment and have a similar scope for the representation of mechanical parts. The significant differences among these Parts of ISO 10303 is in the manner in which the shape of a mechanical part is represented. In this Part the representation is as a manifold solid boundary representation model. In ISO 10303-205 the shape of the part is represented by a surface model in which all surfaces and bounding curves are fully represented. Figure 1 gives a pictorial representation of the scope of this AP.

NOTE 1 In figure 1 the term scope refers to the intended scope of the information models in this Part of ISO 10303. These information models may be useful as part of an information model for applications shown as 'out of scope' in this diagram.

Figure 2 contains the data planning model that gives a high level description of the requirements for this application protocol, as well as the relationships between the basic data objects.

NOTE 2 A dashed line in figure 2 is used to denote an optional association.

The planning model illustrates that a product may be either a part or an assembly. The shape of a part or assembly is represented by a shape model which takes the form of one, or more, B-reps. Each B-rep is either a faceted B-rep, an elementary B-rep, or an advanced B-rep. Names can be associated with products, parts or shape models. Visual properties may optionally be attached to B-rep models.

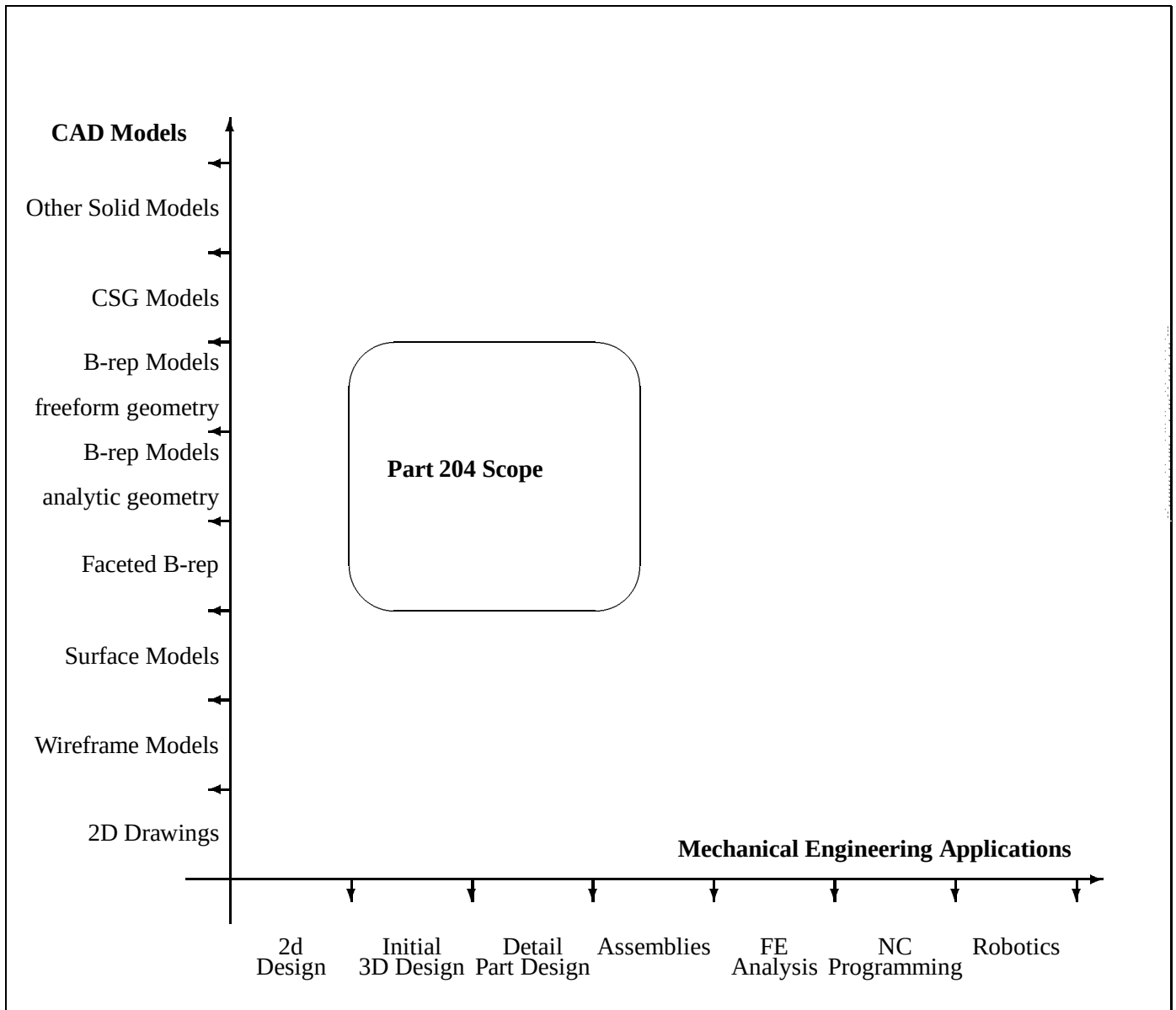


Figure 1 – The scope of this part of ISO 10303 in the contexts of CAD models and mechanical engineering applications

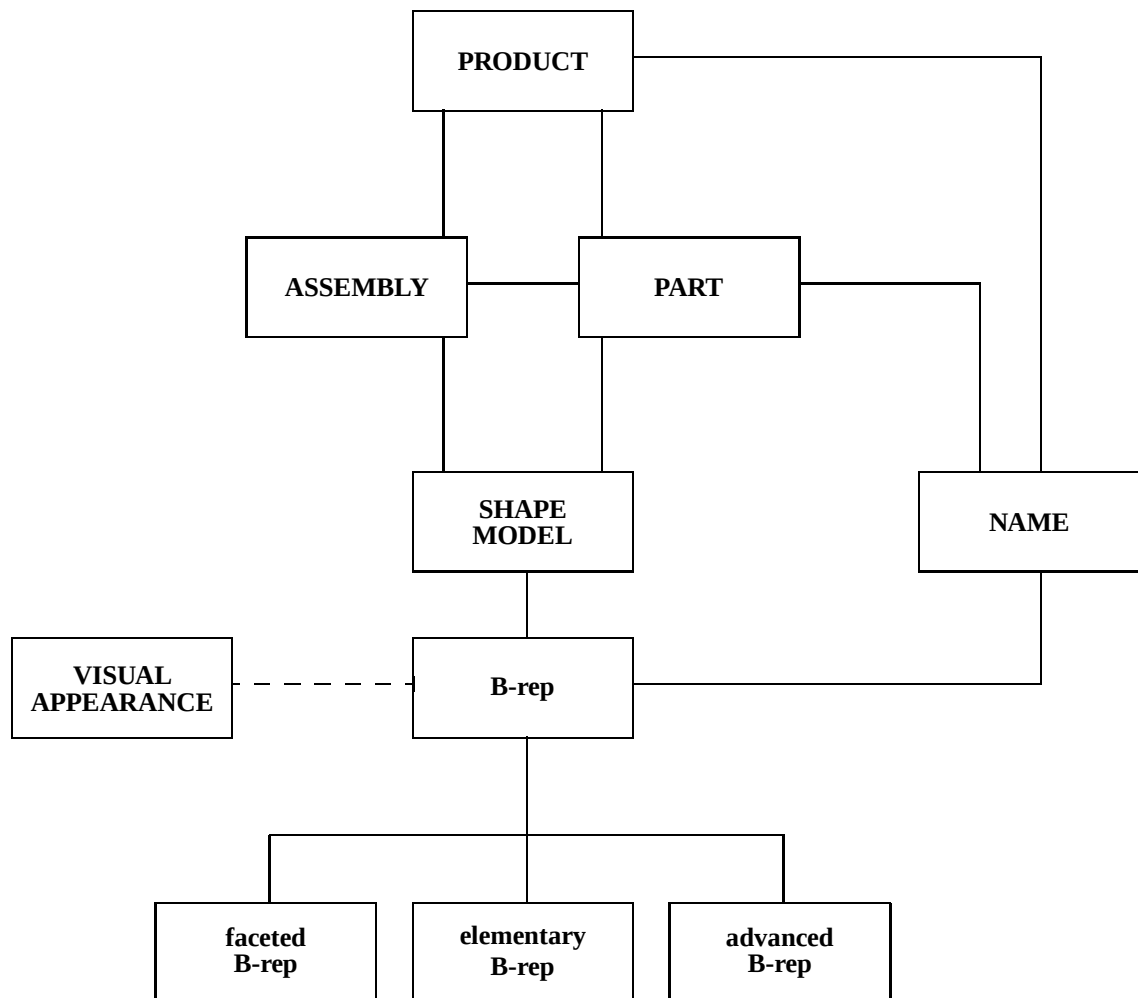


Figure 2 – Data planning model

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Part 204:

Application protocol: Mechanical design using boundary representation

1 Scope

This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for the use and exchange of boundary representation solid models in the mechanical engineering design context.

NOTE The application activity model in annex F provides a graphical representation of the processes and information flows that are the basis for the definition of the scope of this part of ISO 10303.

This document describes an application reference environment for the generation and exchange of volume-based design data in the computer-aided mechanical design process, together with appropriate data models and a physical file implementation form. The information model supports all geometric and topological aspects of a complete description of the shape and size of an object. It was originally developed for applications in mechanical engineering design using the CAD modelling technique boundary representation (B-rep) solid modelling and may be appropriate for other application areas using this technique.

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

- Three types of B-rep model that are used to represent shape:
 - a) faceted B-rep model;
 - b) B-rep model with elementary surfaces;
 - c) B-rep model with sculptured surfaces;
- curve and surface geometry;
- curves defined in parameter space (pcurves);
- manifold topology;
- product identification information;
- the association of simple presentation attributes such as line-style, line-width, colour with an entire B-rep model, or, with geometric or topological elements of a B-rep model;

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- preservation of user-defined names of objects;
- units and measures associated with geometric elements;
- assemblies of parts and sub-assemblies.

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

- Other types of shape representation:
 - a) wireframe models;
 - b) surface models;
 - c) geometrically trimmed curves and surfaces;
 - d) constructive solid geometry models;
 - e) compound B-rep models.
- Geometric and topological data:
 - a) 2D geometry, other than for the definition of pcurves;
 - b) self-intersecting geometry;
 - c) non-manifold topology.
- Dimensioning;
- Tolerances;
- Manufacturing information;
- Advanced presentation features such as multiple views, character fonts and symbols.

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 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 10303-21:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 21: Implementation methods: Clear text encoding of the exchange structure*

ISO 10303-22:1998, *Industrial automation systems and integration — Product data representation and exchange — Part 22: Implementation methods: Standard data access interface*

ISO 10303-31:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 31: Conformance testing methodology and framework: General concepts*

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 10303-44:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 44: Integrated generic resources: Product structure configuration*

ISO 10303-46:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 46: Integrated generic resources: Visual presentation.*

ISO 10303-511:2001, *Industrial automation systems and integration — Product data representation and exchange — Part 511: Application interpreted construct: Topology 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 10303-513:2000, *Industrial automation systems and integration — Product data representation and exchange — Part 513: Application interpreted construct: Elementary boundary representation*

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

ISO 10303-517:2000, *Industrial automation systems and integration — Product data representation and exchange — Part 517: Application interpreted construct: Mechanical design geometric presentation*

ISO 10303-518¹⁾, *Industrial automation systems and integration — Product data representation and exchange — Part 518: Application interpreted construct: Mechanical design shaded presentation*

ISO/IEC 8824-1:1998, *Information technology — Abstract Syntax Notation One (ASN.1): Specification of basic notation*

¹⁾To be published.

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.

- abstract test suite;
- application;
- application activity model (AAM);
- application context;
- application interpreted model (AIM);
- application object;
- application protocol (AP);
- application reference model (ARM);
- assembly;
- component;
- conformance class;
- conformance requirement;
- conformance testing;
- context;
- data;
- data exchange;
- implementation method;
- interpretation;
- integrated resource;
- model;
- PICS proforma;

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- presentation;
- product;
- product data;
- resource construct;
- structure;
- unit of functionality (UoF);

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;
- boundary representation solid model;
- bounds;
- curve;
- euler equations;
- inside;
- interior;
- parameter space;
- surface;
- topological sense.

3.3 Terms defined in ISO 10303-44

For the purposes of this part of ISO 10303, the following terms defined in ISO 10303-44 apply.

- bill_of_material structure;
- component;

- constituent;
- form, fit and function.

3.4 Other definitions

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

3.4.1

advanced B-rep

general boundary representation model which may have any geometric form for the faces and edges. In particular B-splines may be used to define the face and edge geometry.

3.4.2

computer-aided design

way of designing mechanical and other products utilizing computerized tools.

3.4.3

elementary B-rep

boundary representation model in which all surfaces are planar, cylindrical, conical, spherical or toroidal.

3.4.4

elementary geometry

geometry composed of lines, polylines, conics and elementary_surfaces.

3.4.5

faceted B-rep

simplified boundary representation model with planar faces and implicitly defined edges and vertices.

3.4.6

functional level

indicator used to distinguish geometric complexity of a B-rep model or other representation.

3.4.7

genus

topological property used to classify solids. The genus of a solid is an abstraction for the number of through holes in the solid.

3.4.8

manifold solid

arcwise connected solid such that, the interior of any infinitesimally small sphere, centred at any point on the boundary of the solid, is divided into precisely 2 regions, inside and outside the solid respectively.

3.4.9

normal direction

unit vector perpendicular to a surface and pointing away from the material.

3.4.10

orientation

mathematical sense of curves, loops or edges.

3.4.11

product version

identifier for a variant of a product.

3.5 Abbreviations

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

B-rep	Boundary representation solid
CAE	Computer Aided Engineering
CIM	Computer Integrated Manufacturing
CSG	Constructive Solid Geometry
FEA	Finite Element Analysis
ID	Identification
IDEF0	ICAM definition language 0
NIAM	Nijssen's Information Analysis Method
NC	Numerical Control

4 Information requirements

This clause specifies the information required for mechanical design using boundary representation.

The information requirements are specified as a set of units of functionality, application objects, and application assertions. These assertions pertain to individual application objects and to relationships between application objects. The information requirements are defined using the terminology of the subject area of this application protocol.

NOTE 1 A graphical representation of the information requirements is given in annex G.

NOTE 2 The information requirements correspond to those of the activities identified as being within the scope of this application protocol in annex F.

NOTE 3 The mapping table specified in 5.1 shows how the integrated resources and application interpreted constructs are used to meet the information requirements of this application protocol.

These requirements apply to system developers developing conforming implementations and to users of this application protocol to exchange physical files containing B-rep model data. An implementation claiming to conform to this application protocol shall ensure that the structure and constraints defined by these information requirements are satisfied when physical files are exchanged.

Functional Levels

The information requirements for mechanical design using boundary representation models are presented in terms of three distinct levels of functionality. The goal is to classify different implementations into levels distinguished by the complexity of the shape being represented.

The shape of each part described in this AP is composed of geometry and topology. The topology structure provides the connectivity and trimming information for the unbounded geometry of the part. In this Application Protocol the use of a topological entity requires that all associated geometry be defined. In order to classify different levels of design-shape complexity the criterion used is complexity of surface geometry. Level 1 has simple surface geometry for each face of the model, and much of the topological information is implicit. Both level 2 and level 3 provide for a complete explicit representation of the topology of the part in which all vertices, edges, loops and faces are included. The only distinction between level 2, and level 3 is in the complexity of the geometric curves and surfaces which are associated with the topological data. There is no distinction in topology structures between level 3 and level 2.

In this part of ISO 10303 three levels of complexity are defined.

B-rep level 1: Level 1 geometric complexity is for faceted B-rep models with planar surfaces as the bounding surfaces. Only points and planar polygons which can be implicitly represented by their vertex points are necessary for this representation.

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At level 1 much of the topological information is implicit. Edge and vertex information is not given and the shells consist of faces bounded by polygons. The face geometry is implicitly planar. The complete part shape is represented by the polyhedron.

EXAMPLE 1 box shapes;

EXAMPLE 2 faceted shape approximating a model of more complex shape.

Level 1 models can either be an exact model of a simple part or a simplified model of a more complex part which is suitable for a selected range of applications such as stereolithography, or finite element analysis.

Level 1 models can be represented in a more compact form than models from level 2 or level 3: edges and curves are not required to be explicitly defined, since these are always straight lines; the connecting points are sufficient for their definition.

EXAMPLE 3 Applications of these models:

- a) in rapid prototype manufacturing;
- b) for visualization purposes;
- c) for collision checks of parts;
- d) for kinematic studies;
- e) for robot programming and simulations.

B-rep level 2: Level 2 of geometric complexity is for models with elementary surfaces. In this level the geometry needed to represent the curves and surfaces of objects is elementary analytic geometry. The surfaces included at this level are the plane, sphere, cylinder, cone, and torus. The curves are lines and conics. Both curves and surfaces are unbounded, and the bounding information is contained in the topology data. At this level the complete part shape is represented by an elementary B-rep model.

EXAMPLE 4 Application examples:

- milled parts suitable for $2\frac{1}{2}$ D manufacturing;
- turned parts.

EXAMPLE 5 Part examples:

- bolts and screws (excluding the thread detail);
- piston of a simple piston-engine;
- motor housings.

NOTE 4 For the same part there can exist different model representations, which correspond to different application requirements.

NOTE 5 For a part there might exist a representation of level 1 and of level 2.

B-rep level 3: Level 3 of geometric complexity is for B-rep models with advanced surface descriptions.

This level will be used for modelling of parts whose geometric shape is representable with elementary , or sculptured surfaces, or swept surfaces with linear or rotational extrusions, or any combination of these. The generator curves for the extrusion can be analytic or free-form curves. The sculptured surfaces or free-form curves will be B-spline based. Level 3 includes more general forms of twisted curve and sculptured surface in addition to all those included in level 2.

EXAMPLE 6 Application examples:

- parts which require 3 to 5 axis NC machining for their manufacturing;
- dies for moulding;
- dies for forming;
- ergonomically formed consumer products.

EXAMPLE 7 Part examples:

- plastic housing of a telephone;
- car surface parts like fenders;
- housing block of a combustion engine.

NOTE 6 Level 3 is a superset of level 2 in the sense that all entities supported at level 2 are also supported at level 3.

NOTE 7 Level 3 models contain surfaces that may have any shape.

4.1 Units of functionality

This clause specifies the units of functionality for the mechanical design using boundary representation application protocol. This part of ISO 10303 specifies the following units of functionality:

- faceted_B-rep;
- elementary_B-rep;
- advanced_B-rep;
- name_preservation;

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- product_structure;
- visual_presentation_for_B-rep.

The units of functionality and a description of the functions that each UoF supports are given below. The application objects included in the UoFs are defined in 4.2.

4.1.1 faceted_B-rep

The faceted B-rep UoF provides the ability to define a boundary representation model all of whose faces are planar.

The following application objects are used by the faceted_B-rep UoF.

- B-rep;
- Direction;
- Face;
- Faceted_B-rep;
- Geometric_element;
- Global_unit;
- Location;
- Loop;
- Plane;
- Point;
- Poly_loop;
- Shell;
- Surface;
- Topological_element;
- Void.

4.1.2 elementary_B-rep

The elementary_B-rep UoF provides for the definition of a boundary representation model composed of shells having topologically bounded elementary surfaces as faces.

The following application objects are used by the elementary_B-rep UoF.

- B-rep;
- Bounded_curve;
- Circle;
- Conic;
- Conical_surface;
- Curve;
- Cylindrical_surface;
- Direction;
- Edge;
- Elementary_B-rep;
- Elementary_surface;
- Ellipse;
- Face;
- Geometric_element;
- Global_unit;
- Hyperbola;
- Line;
- Location;
- Loop;
- Parabola;

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- Plane;
- Point;
- Polyline;
- Shell;
- Spherical_surface;
- Surface;
- Topological_element;
- Toroidal_surface;
- Unbounded_curve;
- Vertex;
- Void.

4.1.3 advanced_B-rep

The advanced_B-rep UoF provides the ability to define a boundary representation model with topologically bounded surfaces as faces and sculptured geometry.

The following application objects are used by the advanced_B-rep UoF.

- Advanced_B-rep;
- B-rep;
- Bounded_curve;
- Circle;
- Conic;
- Conical_surface;
- Curve;
- Cylindrical_surface;
- Degenerate_toroidal_surface;

- Direction;
- Edge;
- Elementary_surface;
- Ellipse;
- Face;
- Geometric_element;
- Global_unit;
- Hyperbola;
- Line;
- Location;
- Loop;
- Parabola;
- Pcurve
- Plane;
- Point;
- Polyline;
- Sculptured_surface;
- Shell;
- Spherical_surface;
- Surface;
- Surface_curve;
- Surface_of_extrusion;
- Surface_of_revolution;
- Swept_surface;

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- Topological_element;
- Toroidal_surface;
- Twisted_curve;
- Unbounded_curve;
- Vertex;
- Void.

4.1.4 name_preservation

The name_preservation UoF provides the ability to associate and preserve user defined names with models or model components. This allows for the preservation of entity names that were defined by a user by means of a computer-aided application. The user-defined

name of an item is used as an alias to any implementation-dependent identifiers.

The following application objects are used by the name_preservation UoF.

- Name.

4.1.5 product_structure

The product_structure UoF provides the ability to define a product as an assembly of parts or of sub-assemblies. In this AP each part is defined as a B-rep model. Products are composed of individual parts and of collections of parts which form so called assemblies. Assemblies may consist of sub-assemblies and of individual parts. Individual parts are represented by specific geometric shape descriptions as B-rep models. Assemblies have specific geometric relationships with one another and to individual parts. This UoF includes the structures for the identification of mechanical parts assemblies and the structure that links the shape of the parts and assemblies to their identification.

These relationships are given by the following properties:

- a reference from an assembly to another assembly or to a part;
- a geometric relationship, which may be described with a transformation matrix, which allows translation, rotation, and, if required, mirroring and scaling;
- the assemblies and parts have names which a user may require to be unique within one product assembly.

The following detailed requirements are met by this UoF:

- the structural description of assemblies and parts with references to shapes;
- the assembly structure which is independent of the referenced shape of the product;
- the versioning of parts;
- the identification of multiple definitions of parts;
- the specification of the relationship between parts which comprise an assembly;
- the specification of the relationship between a part and its shape representation;
- the specification of the relationship of a part shape to the shape representation of an assembly.

The following application objects are used by the product_structure UoF.

- Assembly;
- Part;
- Product;
- Shape_representation;
- Transformation.

4.1.6 visual_presentation_for_B-rep

The visual_presentation_for_B-rep UoF consists of application objects for the association of elementary viewing information with geometric or topological components of B-rep models. This enables the user to specify the visual appearance of points, curves, and surfaces and to assign pre-defined colour, line-style (dashed, dotted and similar) and line-width to any geometric or topological entity.

The following application objects are used by the visual_presentation_for_B-rep UoF.

- 3D_projection;
- Curve_appearance;
- Light_source;
- Point_appearance;
- Presentation_appearance;
- Screen_image;

— Surface_appearance.

4.1.7 Relationship of units of functionality to functional levels

NOTE Table 1 shows the relationship between the units of functionality in this AP and the functional levels used in the definition of conformance classes.

B-rep level 1	B-rep level 2	B-rep level 3
name preservation		
product structure		
visual presentation for B-rep		
faceted B-rep	elementary B-rep	advanced B-rep

Table 1 – Use of units of functionality within functional levels

4.2 Application objects

This clause specifies the application objects for the mechanical design using boundary representation application protocol. Each application object is an atomic element which embodies a unique application concept and contains attributes specifying the data elements of the object. The application objects and their definitions are given below.

4.2.1 3D_projection

A 3D_projection is a type of Presentation_appearance (see 4.2.36) that is a 2-dimensional picture of a 3-dimensional shape. The picture is the image of a mapping defined by a camera model.

4.2.2 Advanced_B-rep

An Advanced_B-rep is a type of B-rep (see 4.2.4) which may include elementary geometry, sculptured geometry, and swept geometry.

4.2.3 Assembly

An Assembly is a collection of assemblies or parts which are connected together. It has a name assigned, which may describe the functionality, and uses transformations to position its sub-assemblies or components in space.

The data associated with an Assembly are the following:

- components;
- coordinate_system;
- user_defined_name.

4.2.3.1 components

The components specifies the constituents of the assembly; these may be individual parts or other assemblies.

4.2.3.2 coordinate_system

The coordinate_system specifies the Cartesian coordinate system used to define the geometry of the Assembly. This is the underlying global rectangular Cartesian coordinate system to which all geometry refers. A coordinate_system is identified with the context of the shape representation for an Assembly.

4.2.3.3 user_defined_name

The user_defined_name specifies a user-defined identifier for the Assembly. It consists of one or more words and may describe the functionality of the Assembly.

4.2.4 B-rep

A B-rep is a manifold boundary representation which defines a volume in terms of topology and geometry. The geometry is used to describe the shape of the object in terms of surfaces and edge-curves. The topology bounds the geometry to a finite extent and combines all bounded elements to define a manifold solid. The material side of the solid is defined by normal vectors to the faces; this normal shall point away from the material. Each B-rep is either an Advanced_B-rep (see 4.2.2), an Elementary_B-rep (see 4.2.15), or a Faceted_B-rep (see 4.2.19).

The data associated with a B-rep are the following:

- boundary;
- voids.

4.2.4.1 boundary

The boundary specifies the closed Shell (see 4.2.41) that is the outer boundary of the B-rep.

4.2.4.2 voids

The voids specifies a list of Voids (see 4.2.55) inside the B-rep. The voids need not be specified for a particular B-rep if it has a completely solid interior.

4.2.5 Bounded_curve

A Bounded_curve is a type of Curve (see 4.2.9) with finite extent and identifiable end points. Each Bounded_curve is either a Polyline (see 4.2.34) or a Twisted_curve (see 4.2.52).

4.2.6 Circle

A Circle is a type of Conic (see 4.2.7) generated by intersecting a conical surface with a plane perpendicular to the axis of the conical surface.

The data associated with a Circle are the following:

- radius;
- location.

4.2.6.1 radius

The radius specifies the distance of all points on the Circle from the centre.

4.2.6.2 location

The location specifies the centre point of a Circle and the normal direction to the plane of the Circle.

4.2.7 Conic

A Conic is a type of Unbounded_curve (see 4.2.53), it is a planar curve which may be produced as the intersection of a plane and a conical surface, where the axis of the Conic does not lie in the plane. Each Conic is either a Circle (see 4.2.6), an Ellipse (see 4.2.17), an Hyperbola (see 4.2.22), or a Parabola (see 4.2.28).

4.2.8 Conical_surface

A Conical_surface is a type of Elementary_surface (see 4.2.16) constructed by moving a line, which is fixed in one point, the vertex point, along a closed circle.

4.2.9 Curve

A Curve is a type of Geometric_element (see 4.2.20), it is a one-dimensional manifold in a space of dimension 2 or 3. Informally, a Curve can be envisioned as the path of a point moving in its coordinate space. Each Curve is either a Bounded_curve (see 4.2.5), a Pcurve (see 4.2.30), a Surface_curve (see 4.2.45), or an Unbounded_curve (see 4.2.53).

NOTE see figure G.9 in the NIAM diagrams.

4.2.10 Curve_appearance

Curve_appearance is a type of Presentation_appearance (see 4.2.36) that specifies the required appearance of a Curve (see 4.2.9) when it is visualised.

The data associated with a Curve_appearance are the following:

- colour;
- curve_font;
- curve_width.

4.2.10.1 colour

The colour defines the colour of the Curve when viewed with a colour display. It is specified by intensity values for red, green and blue. The colour need not be specified for a particular Curve, in which case the default option is black.

4.2.10.2 curve_font

The curve_font describes the lengths of the visible and invisible segments of a curve when visualised. The curve_font need not be specified for a particular Curve, in which case the default option is fully_visible.

4.2.10.3 curve_width

The curve_width specifies the apparent width of the curve when visualised. The curve_width need not be specified for a particular Curve, in which case the default option is that of the graphics system.

4.2.11 Cylindrical_surface

A Cylindrical_surface is a type of Elementary_surface (see 4.2.16) constructed by the parallel movement of a line along a closed circle, where the line is perpendicular to the plane of the circle.

The data associated with a Cylindrical_surface are the following:

- radius;
- axis.

4.2.11.1 radius

The radius defines the distance of points on the cylindrical_surface from the axis.

4.2.11.2 axis

The axis is the central axis of the cylindrical_surface, it is defined by the axis direction, and a point on the axis.

4.2.12 Degenerate_toroidal_surface

A Degenerate_toroidal_surface is a type of Toroidal_surface (see 4.2.50) in which the minor_radius is greater than the major_radius. The resulting surface is degenerate and self-intersecting. The attribute select_outer specifies which portion of this surface is selected to produce a well defined surface.

The data associated with a Degenerate_toroidal_surface are the following:

— select_outer.

4.2.12.1 select_outer

The select_outer specifies whether or not the outer portion of the degenerate surface is selected. When select_outer is true an apple shaped surface is defined; if false the Degenerate_toroidal_surface is lemon shaped.

4.2.13 Direction

A Direction is a type of Geometric_element (see 4.2.20), it is a unit vector in 3 dimensional space.

4.2.14 Edge

An Edge is a type of Topological_element (see 4.2.49) that is the bounded intersection curve of two surfaces. It is defined by the curve geometry and two vertices.

4.2.15 Elementary_B-rep

The Elementary_B-rep is a type of B-rep (see 4.2.4) which consists of only elementary geometric elements, all Faces (see 4.2.18) and Edges (see 4.2.14) being associated with elementary geometry.

4.2.16 Elementary_surface

An Elementary_surface is a type of Surface (see 4.2.43) which can be described by simple analytic equations. Each Elementary_surface is either a Conical_surface (see 4.2.8), a Cylindrical_surface (see 4.2.11), a Plane (see 4.2.31), a Spherical_surface (see 4.2.42), or a Toroidal_surface (see 4.2.50).

NOTE see figure G.8 in the NIAM diagrams

4.2.17 Ellipse

An Ellipse is a type of Conic (see 4.2.7) generated by intersecting a conical surface with a plane whose normal is at a small angle to the axis of the conical surface.

The data associated with an Ellipse are the following:

- location;
- major_radius;
- minor_radius.

4.2.17.1 location

The location specifies the position and orientation of the Ellipse. It is defined by the centre point, the normal direction to its plane, and the direction of one of the principal axes of the Ellipse.

4.2.17.2 major_radius

The major_radius specifies the half length of the longer principal axis of the Ellipse. It is equal to the maximum distance of any point on the ellipse from the centre.

4.2.17.3 minor_radius

The minor_radius specifies the half length of the shorter principal axis of the Ellipse. It is equal to the minimum distance of any point on the Ellipse from the centre.

4.2.18 Face

A Face is a type of Topological_element (see 4.2.49) that is a bounded portion of a Surface (see 4.2.43). It consists of the surface geometry, at least one surrounding loop, and possible inner loops, which can be regarded as holes in the surface. If the Face is used in a Faceted_B-rep (see 4.2.19), the loops are simplified and defined as Poly_loops (see 4.2.35).

The data associated with a Face are the following:

- face_geometry;
- bounds.

4.2.18.1 face_geometry

The face_geometry specifies the Surface (see 4.2.43) of which the Face is a bounded portion.

4.2.18.2 bounds

The bounds are the loops which define the boundaries of the Face. At most one of these may be an outer bound.

4.2.19 Faceted_B-rep

A Faceted_B-rep is a type of B-rep (see 4.2.4) with only planar surfaces and straight lines as geometric elements. The topology is simplified by using Poly_loops (see 4.2.35) which list all points defining the corners of the faces of the solid.

4.2.20 Geometric_element

A Geometric_element is part of the geometric description of a B-rep. Each Geometric_element is either a Point (see 4.2.32), a Curve (see 4.2.9), a Direction (see 4.2.13), a Location (see 4.2.25), or a Surface (see 4.2.43).

4.2.21 Global_unit

A Global_unit is a unit that is valid for all length measures or for all angle measures within the context of a shape model.

EXAMPLE 1 millimetre could be a global unit for length measures.

4.2.22 Hyperbola

An Hyperbola is a type of Conic (see 4.2.7) that is an open conic section defined by its radius, imaginary radius, the centre point, and the normal direction to its plane.

NOTE An Hyperbola may be generated by intersecting a conical surface with a plane whose normal is at a large angle to the axis of the conical surface.

4.2.23 Light_source

A Light_source is a type of Presentation_appearance (see 4.2.36) that specifies the way in which the components of a B-rep model are illuminated for viewing. There may be more than one Light_source associated with a particular view. The data associated with a Light_source are the following:

- colour;
- position;
- direction.

4.2.23.1 colour

The colour specifies the red, green and blue intensity values of the Light_source.

4.2.23.2 position

The position specifies the location of the Light_source. The position need not be specified for some types of Light_source.

4.2.23.3 direction

The direction specifies the directional properties of the Light_source. The direction need not be specified for some types of Light_source.

4.2.24 Line

A Line is a type of Unbounded_curve (see 4.2.53) which is defined by a point and a direction. The positive direction of the Line is that of the direction vector.

4.2.25 Location

A Location is a type of Geometric_element (see 4.2.20), it is the placement, or position and orientation, of a geometric element in the coordinate space. It is defined by a Point and 2 Directions (see 4.2.32 and 4.2.13).

4.2.26 Loop

A Loop is a type of Topological_element (see 4.2.49) that defines the boundary of a surface. The Loop has to be closed, and self-intersection is not allowed. A Loop consists of an ordered collection of at least one Edge (see 4.2.14) (in the case of edge_loop), or of a single Vertex (see 4.2.54) (in the case of vertex_loop), or of an ordered collection of points (in the case of a Poly_loop) (see 4.2.35).

4.2.27 Name

A Name is a user-defined identifier for an object. Any entity of this part of ISO 10303 that may be part of a B-rep model can be assigned a Name. Presentation_appearance (see 4.2.36) entities shall not have Names.

4.2.28 Parabola

A Parabola is a type of Conic (see 4.2.7) generated by intersecting a conical surface with a plane whose normal is parallel to a generating line of the conical surface. A parabola is defined by its focal length, (i.e., the distance between focal point and vertex point), vertex point, and the direction of the normal to its plane.

4.2.29 Part

A Part is a mechanical component which can be represented by a B-rep solid model.

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The data associated with a Part are the following:

- user_defined_name.

The user_defined_name specifies one or more words chosen by the user to identify and describe the functionality of the Part.

4.2.30 Pcurve

A Pcurve is a type of Curve (see 4.2.9), and is a 3D curve which is defined in the 2D parametric space of a Surface. The data associated with a Pcurve are:

- basis_surface;
- curve_2d.

4.2.30.1 basis_surface

The basis_surface specifies the Surface (see 4.2.43) which provides the parameter space for the definition of the curve_2d. The Pcurve itself lies on this Surface.

4.2.30.2 curve_2d

The curve_2d specifies the geometry of the Pcurve as a 2D curve definition which uses the parameter space of the basis_surface as its coordinate system.

4.2.31 Plane

A Plane is a type of Elementary_surface (see 4.2.16) which is unbounded and has a constant normal.

The data associated with a Plane are the following:

- location.

4.2.31.1 location

The location specifies the position and orientation of the Plane, it is defined by a point on the surface and the direction of the normal to the Plane.

4.2.32 Point

A Point is a type of Geometric_element (see 4.2.20), it is a precise location in real space. A Point is defined by its Cartesian coordinates in 3-dimensional space.

4.2.33 Point_appearance

A Point_appearance is a type of Presentation_appearance (see 4.2.36) that specifies the visual appearance of a Point (see 4.2.32). The data associated with a Point_appearance are the following:

- colour;
- marker;
- marker_size.

4.2.33.1 colour

The colour specifies the colour of the Point when viewed with a colour display. It is specified by intensity values for red, green, and blue. The colour need not be specified for a particular Point, in which case the default option is black.

4.2.33.2 marker

The marker specifies the form of the symbol used to display a Point. The marker need not be specified for a particular Point, in which case the default option is an addition sign (+).

4.2.33.3 marker_size

The marker_size specifies the size of the selected marker type. The marker_size need not be specified for a particular Point, in which case the default value for this size is 1 mm.

4.2.34 Polyline

A Polyline is a type of Bounded_curve (see 4.2.5) which consists of $n-1$ linear segments. It is defined by a list of n points.

4.2.35 Poly_loop

A Poly_loop is a type of Loop (see 4.2.26) used in the Faceted_B-rep (see 4.2.19). It is represented by an ordered coplanar collection of points forming the vertices of the loop. The loop is composed of straight line segments each joining a point in the collection to the succeeding point in the collection. The closing segment is from the last to the first point in the collection. The direction of the loop is in the direction of the line segments.

4.2.36 Presentation_appearance

A Presentation_appearance is a specification of the visual appearance which is relevant for the visualization of geometric models. The visual properties which may be specified include curve-style and

curve-width for curves; colour for B-rep models, surfaces, curves, points. `Presentation_appearance` is an abstract concept which is not itself instantiated but may be assigned to geometric elements, or to topological elements. Each `Presentation_appearance` is either a `3D_projection` (see 4.2.1), a `Curve_appearance` (see 4.2.10), a `Light_source` (see 4.2.23), a `Point_appearance` (see 4.2.33), or a `Surface_appearance` (see 4.2.44).

4.2.37 Product

A Product is a physical manufactured object. In the context of this part of ISO 10303 the shape of a Product is represented by one or more B-rep models (see 4.2.4) corresponding to the constituent parts of the Product. These may be collected together as an Assembly (see 4.2.3).

The data associated with a Product are the following:

- `coordinate_system`;
- `user_defined_name`;
- `version_and_id`.

4.2.37.1 `coordinate_system`

The `coordinate_system` specifies the Cartesian coordinate system used to define the precise geometry of the Product.

4.2.37.2 `user_defined_name`

The `user_defined_name` specifies the name selected by the user for reference purposes. It consists of one or more words and may describe the product functionality.

4.2.37.3 `version_and_id`

The `version_and_id` specifies terms including version number and identifier which uniquely identify an instance of a Product.

4.2.38 Sculptured_surface

A `Sculptured_surface` is a type of `Surface` (see 4.2.43) which is a general bi-parametric surface of polynomial or rational form.

4.2.39 Screen_image

A `Screen_image` is a collection of 2-dimensional images defined by `Presentation_appearance` instances which is intended to be displayed simultaneously. There is a maximum of one `Screen_image` present in any instance of a model which conforms to this part of ISO 10303.

4.2.40 Shape_representation

A Shape_representation is a representation of the precise size and shape of a mechanical product or component. A Shape_representation is made up of one or more B-rep models (see 4.2.4).

4.2.41 Shell

A Shell is a type of Topological_element (see 4.2.49). In the context of this part of ISO 10303 a Shell is always closed. A Shell is a collection of one or more Faces (see 4.2.18) which bounds a region in the 3-dimensional space. The topological normal of the Shell is defined as being directed from the finite to the infinite region. A Void (see 4.2.55) in a B-rep is represented by an interior shell which builds a “hole” inside an outer shell. For an interior shell the topological normal will point into the solid material.

NOTE see figure G.6 in the NIAM diagrams.

4.2.42 Spherical_surface

A Spherical_surface is a type of Elementary_surface (see 4.2.16) that is ball-shaped. It is defined by its radius and its centre point.

The data associated with a Spherical_surface are:

- radius;
- centre.

4.2.42.1 radius

The radius specifies the distance from any point on the Spherical_surface to the centre of the sphere.

4.2.42.2 centre

The centre specifies the fixed point which is equidistant from all points on the Spherical_surface.

4.2.43 Surface

A Surface is a type of Geometric_element (see 4.2.20). A Surface can be regarded as being generated by a continuously changing curve moving in space. Each Surface is either an Elementary_surface (see 4.2.16), a Swept_surface (see 4.2.48), or a Sculptured_surface (see 4.2.38). The extent of a Surface may be infinite.

NOTE see figure G.7 in the NIAM diagrams.

4.2.44 Surface_appearance

A Surface_appearance is a type of Presentation_appearance (see 4.2.36) that provides the specification of the visual appearance of a Surface (see 4.2.43) when displayed. The data associated with a Surface_appearance are the following:

- colour;
- grid_indicator;
- shading_method.

4.2.44.1 colour

The colour specifies the colour of the Surface when viewed with a colour display. It is specified by intensity values for red, green, and blue. The colour need not be specified for a particular Surface, in which case the default option is black.

4.2.44.2 grid_indicator

The grid_indicator specifies the way in which a surface is to be displayed. This includes the selection of the curves which are used to display the Surface. The value of the grid_indicator may be one or more of the following options:

- boundary curves;
- silhouette curves;
- segmentation curves;
- control grid;
- parameter lines;
- shading.

The grid_indicator need not be specified for a particular Surface, in which case the default option is silhouette curves.

4.2.44.3 shading_method

The shading_method specifies the algorithm used for the shading of a surface. The shading_method need not be specified for a particular Surface, in which case the default option is normal shading. Normal shading is based upon interpolated values of the surface normals.

4.2.45 Surface_curve

A Surface_curve is a type of Curve (see 4.2.9) which lies on a surface. It is defined in three dimensional space and in the parametric space of the surface. The data associated with a Surface_curve are the following:

- curve_3d;
- associated_geometry.

4.2.45.1 curve_3d

The curve_3d specifies a representation of the Surface_curve as a curve in the same three dimensional coordinate system as the surface.

4.2.45.2 associated_geometry

The associated_geometry specifies a set of one or two pcurves which provide two dimensional representations of the surface_curve in the parameter space of the surface, or surfaces, on which it lies. The surfaces are derived from this associated_geometry.

4.2.46 Surface_of_extrusion

A Surface_of_extrusion is a type of Swept_surface (see 4.2.48) constructed by sweeping a Curve (see 4.2.9) in a given fixed direction.

The data associated with a Surface_of_extrusion are the following:

- swept_curve;
- extrusion_direction.

4.2.46.1 swept_curve

The swept_curve specifies the curve which is swept in order to generate the Surface_of_extrusion. Any cross section of the surface perpendicular to the extrusion_direction has geometry identical to this curve.

4.2.46.2 extrusion_direction

The extruded_direction specifies the direction in which the swept_curve is extruded to generate the surface.

4.2.47 Surface_of_revolution

A Surface_of_revolution is a type of Swept_surface (see 4.2.48) constructed by rotating a Curve (see 4.2.9) a complete revolution about an axis.

The data associated with a Surface_of_revolution are the following:

- revolved_curve;
- axis.

4.2.47.1 revolved_curve

The revolved_curve specifies the curve which is rotated about the axis in order to generate the Surface_of_revolution.

4.2.47.2 axis

The axis specifies the axis about which the revolved_curve is revolved to generate the surface. It is the central axis of the surface which is generated.

4.2.48 Swept_surface

A Swept_surface is a type of Surface (see 4.2.43) constructed by sweeping a curve along another curve. Each Swept_surface is either a Surface_of_extrusion (see 4.2.46) or a Surface_of_revolution (see 4.2.47).

4.2.49 Topological_element

A Topological_element is part of the topological definition of a B-rep (see 4.2.4). Each Topological_element is either an Edge (see 4.2.14), a Face (see 4.2.18), a Loop (see 4.2.26), a Shell (see 4.2.41) or a Vertex (see 4.2.54).

4.2.50 Toroidal_surface

A Toroidal_surface is a type of Elementary_surface (see 4.2.16) constructed by rotating a circle around an axis lying outside the circle (or inside in the special case of a Degenerate_toroidal_surface), and in the plane of the circle. It is defined by a centre point, an axis, and two radii.

Each Toroidal_surface may be a Degenerate_toroidal_surface. (see 4.2.12)

The data associated with a Toroidal_surface are the following:

- centre_point;

- axis;
- major_radius;
- minor_radius.

4.2.50.1 centre_point

The centre_point specifies the point at the centre of the Toroidal_surface.

4.2.50.2 axis

The axis specifies the direction in which the swept_curve is extruded to generate the surface.

4.2.50.3 major_radius

The major_radius specifies the distance from the centre of the generating circle of the Toroidal_surface to the axis.

4.2.50.4 minor_radius

The minor_radius specifies the radius of the circle which is rotated about the axis to generate the Toroidal_surface.

Except for the special Degenerate_toroidal_surface type the minor_radius shall be less than the major_radius.

4.2.51 Transformation

A Transformation is a geometric operation composed of translation, rotation, mirroring, and uniform scaling. Transformations may be used to locate the components of an assembly.

4.2.52 Twisted_curve

A Twisted_curve is a type of Bounded_curve (see 4.2.5), in the context of this part of ISO 10303, is a general parametric 3-dimensional curve which is represented by a B-spline curve.

4.2.53 Unbounded_curve

An Unbounded_curve is a type of Curve (see 4.2.9) with infinite extent. An Unbounded_curve has a simple analytic equation to describe it. Each Unbounded_curve is either a Line (see 4.2.24) or a Conic (see 4.2.7).

4.2.54 Vertex

A **Vertex** is a type of **Topological_element** (see 4.2.49) that is a topological point which forms part of the boundary of an **Edge** (see 4.2.14), or of a **Face** (see 4.2.18).

4.2.55 Void

A **Void** is a hollow region inside a solid model. A void is represented by a **Shell** with a normal pointing into the empty space inside. This normal opposes the sense of the topological normal to the defining shell.

4.3 Application assertions

This clause specifies the application assertions for the mechanical design using boundary representation application protocol. The application assertions define the required relationships between the application objects defined in the previous clause, the cardinality of the relationships and any integrity rules required.

4.3.1 3D_projection to Screen_image

A **3D_projection** is in one **Screen_image**. A **Screen_image** contains one or more **3D_projections**.

4.3.2 3D_projection to B-rep

A **3D_projection** presents zero, one or more **B-rep** models. A **B-rep** model is associated with zero, one, or more **3D_projections**.

4.3.3 Assembly to Assembly

An **Assembly** contains zero, one or more **Assemblies**, in the role of sub-assemblies with associated transformation. An **Assembly** is part of zero, one or many **Assemblies**.

4.3.4 Assembly to Product

An **Assembly** is part of one or more **Products**. A **Product** contains zero, one, or more **Assemblies**.

4.3.5 B-rep to Shell

A **B-rep** consists of one or more **Shells**. Where two or more closed **Shells** are used to define a **B-rep** one of these shall be the outer shell and contain all the others. Each **Shell** is used to define one **B-rep**.

4.3.6 Curve to Edge

Each **Curve** in the exchange structure is used to define the geometry of zero, one, or more **Edges**. Each **Edge** has its geometry defined by one **Curve**.

4.3.7 Curve_appearance to Curve

A curve_appearance is associated with zero, one, or many Curves. A Curve is represented as zero or one Curve_appearances.

4.3.8 Curve_appearance to Edge

A curve_appearance is associated with zero, one, or many Edges. An Edge is represented as zero or one curve_appearances.

4.3.9 Edge to B-rep

Each Edge referenced by a B-rep model is used precisely twice with opposing orientations in the definition of that B-rep model. A B-rep has zero, one or many explicit Edges.

4.3.10 Edge to Edge

An Edge shall not intersect any other Edge except at a shared Vertex.

4.3.11 Edge to Vertex

An Edge is bounded by precisely two Vertices. A Vertex is used to bound one or more Edges.

4.3.12 Face to Face

A Face shall not intersect any other Face except along a common edge.

4.3.13 Face to Loop

A Face is bounded by one or more Loops. A Loop bounds one or more Faces.

4.3.14 Face to Surface

A Face shall have its geometry defined by precisely one Surface. In a faceted B-rep model the geometry of each Face shall be defined by precisely one Plane. Each Surface in the exchange structure shall be used to define the geometry of one or more Faces.

4.3.15 Loop to Edge

A Loop of type edge_loop shall be defined by one or more Edges. Each Edge shall be used in the definition of one or two Loops in a B-rep model.

4.3.16 Name to Geometric_element

A Geometric_element has zero or one user defined Name. A Name is associated with zero or one Geometric_elements.

4.3.17 Name to Topological_element

A Topological_element has zero or one user defined Name. A Name is associated with zero or one Topological_elements.

4.3.18 Part to Assembly

A Part may belong to one or more Assemblies. An Assembly contains one or more Parts. Each Part in the Assembly is located by one Transformation. An Assembly may not exist without a Part.

4.3.19 Part to Product

A Part is a direct component of zero, one or many Products; it may, also, be indirectly included in a product as part of an assembly. A Product consists of zero, one, or many Parts.

4.3.20 Part to Shape_representation

A Part shall have its shape defined by one or more B-rep models in a Shape_representation.

4.3.21 Point_appearance to Point

A Point_appearance may be associated with zero, one, or many Points. A Point is represented as zero or one Point_appearances.

4.3.22 Presentation_appearance to B-rep

A Presentation_appearance presents zero, one, or many B-reps. A B-rep model is presented by zero, one or many Presentation_appearances.

4.3.23 Presentation_appearance to Shell

A Presentation_appearance presents zero, one, or many Shells. A Shell is presented by zero, one or many Presentation_appearances.

4.3.24 Shape_representation to B-rep

Each B-rep model in the exchange structure shall be part of precisely one Shape_representation corresponding to one of the three levels of functionality defined in this document. The simplest possible form of representation compatible with the information requirements shall be used.

4.3.25 Shell to Face

A Shell is defined by one or more Faces. A Face is used to define one or more Shells. Within a given B-rep model a Face is associated with precisely one Shell.

4.3.26 Surface_appearance to Face

A Surface_appearance presents zero, one, or many Faces. A Face is presented by zero or one Surface_appearances.

4.3.27 Surface_appearance to Surface

A Surface_appearance presents zero, one, or many Surfaces. A Surface is presented by zero or one Surface_appearances.

4.3.28 Topological_element to Presentation_appearance

A Topological_element is associated with zero, one, or more, presentation_appearances to define its display properties. A Presentation_appearance presents zero, one or more Topological_elements.

4.3.29 Transformation to Assembly

A Transformation is used to locate zero or one Assembly, as a sub-assembly, in an Assembly. When an assembly has the role of a sub-assembly it shall be located by a Transformation. An Assembly may be located by zero or one transformations.

4.3.30 Transformation to Part

A Transformation may be used to locate zero or one Parts in an Assembly. Each Part in an Assembly is located by one Transformation.

4.3.31 Vertex to Point

Each Vertex has its geometry defined by precisely one Point. A Point is used to define the geometry of zero or one Vertex.

5 Application interpreted model

5.1 Mapping table

This clause contains the mapping table that shows how each UoF and application object of this part of ISO 10303 (see clause 4) maps to one or more AIM constructs (see annex A).

The mapping table is organized in five columns. The contents of these five columns are:

- Column 1) Application element: Name of an application element as it appears in the application object definition in 4.2. Application object names are written in uppercase. Attribute names and assertions are listed after the application object to which they belong and are written in lower case.
- Column 2) AIM element: Name of an AIM element as it appears in the AIM (see annex A), the term ‘IDENTICAL MAPPING’, or the term ‘PATH’. AIM entities are written in lower case. Attribute names of AIM entities are referred to as <entity name> . <attribute name>. The mapping of an application element may result in several related AIM elements. Each of these AIM elements requires a line of its own in the table. The term ‘IDENTICAL MAPPING’ indicates that both application objects of an application assertion map to the same AIM element. The term ‘PATH’ indicates that the application assertion maps to the entire reference path.
- Column 3) Source: For those AIM elements that are interpreted from the integrated resources, this is the number of the corresponding part of ISO 10303. For those AIM elements that are created for the purpose of this part of ISO 10303, this is the number of this part. For those AIM elements that are directly incorporated from an application interpreted construct (AIC) this is the AIC reference.
- Column 4) Rules: One or more numbers may be given that refer to rules that apply to the current AIM element or reference path. For rules that are derived from relationships between application objects, the same rule is referred to by the mapping entries of all the involved AIM elements. The expanded names of the rules are listed after the table.
- Column 5) Reference path: To describe fully the mapping of an ARM element, it may be necessary to specify a reference path through several related AIM elements. The reference path column documents the role of an AIM element relative to the AIM element in the row succeeding it. Two or more such related AIM elements define the interpretation of the integrated resources that satisfies the requirement specified by the application object. For each AIM element that has been created for use within this part of ISO 10303, a reference path up to its supertype from an integrated resource is specified.

For the expression of reference paths the following notational conventions apply:

- a) [] : multiple AIM elements or sections of the reference path are required to satisfy an information requirement;
- b) () : multiple AIM elements or sections of the reference path are identified as alternatives within the mapping to satisfy an information requirement;

- c) $\{ \}$: enclosed section constrains the reference path to satisfy an information requirement;
- d) $\rightarrow$: attribute references the entity or select type given in the following row;
- e) $\leftarrow$: entity or select type is referenced by the attribute in the following row;
- f) $[1]$: attribute is an aggregation of which a single member is given in the following row;
- g) $[n]$: attribute is an aggregation of which member n is given in the following row;
- h) $\Rightarrow$: entity is a supertype of the entity given in the following row;
- i) $\Leftarrow$: entity is a subtype of the entity given in the following row;
- j) $=$: the string, select, or enumeration type is constrained to a choice or value.
- k) $/$: the line continuations for strings that wrap.

This Part of ISO 10303 makes use of the following application interpreted constructs (AIC):

- part 511 = aic_topologically_bounded_surface : topologically bounded surface AIC;
- part 512 = aic_faceted_brep : faceted B-rep AIC;
- part 513 = aic_elementary_brep : elementary B-rep AIC;
- part 514 = aic_advanced_brep : advanced B-rep AIC (uses AIC1);
- part 517 = aic_mechanical_design_geometric_presentation: AIC for simple visual presentation of geometric models used in mechanical design;
- part 518 = aic_mechanical_design_shaded_representation : mechanical design shaded presentation AIC.

NOTE 1 The geometric AIC parts 511 and 514 are interdependent and their relationships via 'USE FROM' statements are illustrated in figure 3.

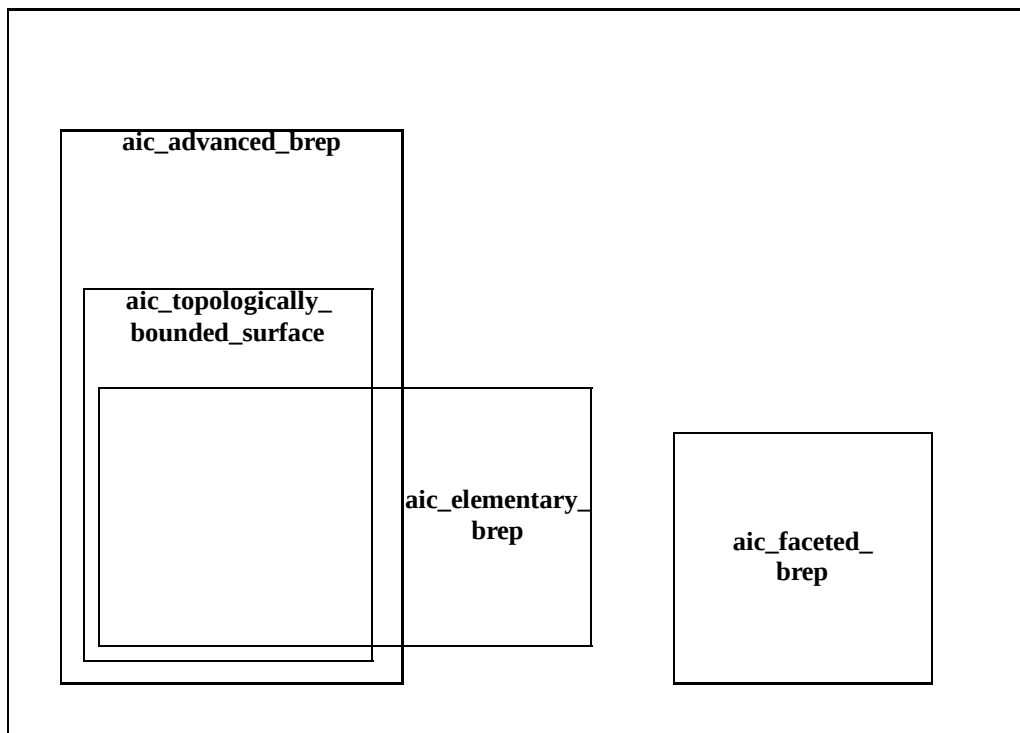


Figure 3 – Relationships between geometric AICs