INTERNATIONAL STANDARD

ISO 10303-109

First edition
2004-12-01

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

Part 109: Integrated application resource: Kinematic and geometric constraints for assembly models

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

Partie 109: Ressources d'application intégrées: Contraintes cinématiques et géométriques pour les modèles d'assemblage

Reference number
ISO 10303-109:2004(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Figures

Tables

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 10303 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10303-109 was prepared by Technical Committee ISO/TC184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

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

Each part of ISO 10303 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 the of integrated application resources series. The integrated generic resources and the integrated application resources specify a single conceptual product data model.

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

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

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation of product information and for the 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 integrated application resources series. Major subdivisions of this part of ISO 10303 are:

— Assembly feature relationship schema;

— Assembly constraint schema.

This part of ISO 10303 provides general representations for geometric relationships between component parts within an assembly model. The distinction of assembly, subassembly and component part is context dependent. An assembly in some engineering context could be a component part in another engineering context. In order to cope with this variety, this part of ISO 10303 uses the term ‘constituent’ to represent a generic concept that implies assembly or subassembly or component part in case these distinctions are not necessary.

EXAMPLE 1 For some applications, an electric motor is regarded as a single component part of a washing machine rather than as an assembly in its own right.

Detailed geometric relationships between constituents of an assembly are required in applications such as parametric representation of geometric constraints between constituents, motion animation of an assembly product, assembly/disassembly process planning, kinematics analysis and tolerance analysis.

Existing STEP resource parts support limited assembly model representations. They capture hierarchical relationship, alternative constituent and mutual position and orientation between two constituents. This part of ISO 10303 is intended to fill in missing information to enable the above mentioned applications.

An important concept newly introduced in this part of ISO 10303 is ‘assembly feature’. An assembly feature is a portion of a constituent meaningful for representing the connecting relation between constituents. The detailed geometric relationship between two constituents can be represented via the necessary number of pairs of assembly features one belonging to one constituent and the other belonging to the other constituent. The **assembly_feature_relationship_schema** has been created to capture feature level correspondence between constituents.

In most assembly related applications, not only correspondence of assembly features but also more detailed geometric constraint information such as parallelism, coincidence, tangency, and co-axial relationships are required at the geometric entity level.

EXAMPLE 2 Two plates belonging to different constituents are constrained to be parallel with distance-L.

These geometric constraint specifications applied between two constituents are summarised in the **assembly_constraint_schema**. In assembly related applications, the position and orientation of at least one constituent within an assembly model should be fixed to prevent infinite number of solutions. This constituent plays the role of an anchor. The necessary constraint is also included in the **assembly-_constraint_schema**.

This part of ISO 10303 is a member of a set of standards newly introduced for representing detailed geometric relationships among constituents of an assembly model of a product.
They are:

— ISO 10303-109: Integrated application resources: Kinematic and geometric constraints for assembly models
— ISO 10303-1101: Application Module: Product property feature definition module
— ISO 10303-1102: Application Module: Assembly feature definition module

The relationships between schemas in this part of ISO 10303 and existing integrated resource schemas of ISO 10303 are illustrated in Figure 1. The schemas occurring in Figure 1 are components of ISO 10303 integrated resources, and they are specified in the following resource parts:

`explicit_constraint_schema`	ISO 10303-108
`explicit_geometric_constraint_schema`	ISO 10303-108
`geometric_model_schema`	ISO 10303-42
`geometry_schema`	ISO 10303-42
`kinematic_motion_representation_schema`	ISO 10303-105
`kinematic_structure_schema`	ISO 10303-105
`parameterization_schema`	ISO 10303-108
`product_definition_schema`	ISO 10303-41
`product_property_definition_schema`	ISO 10303-41
`product_property_representation_schema`	ISO 10303-41
`product_structure_schema`	ISO 10303-44
`representation_schema`	ISO 10303-43

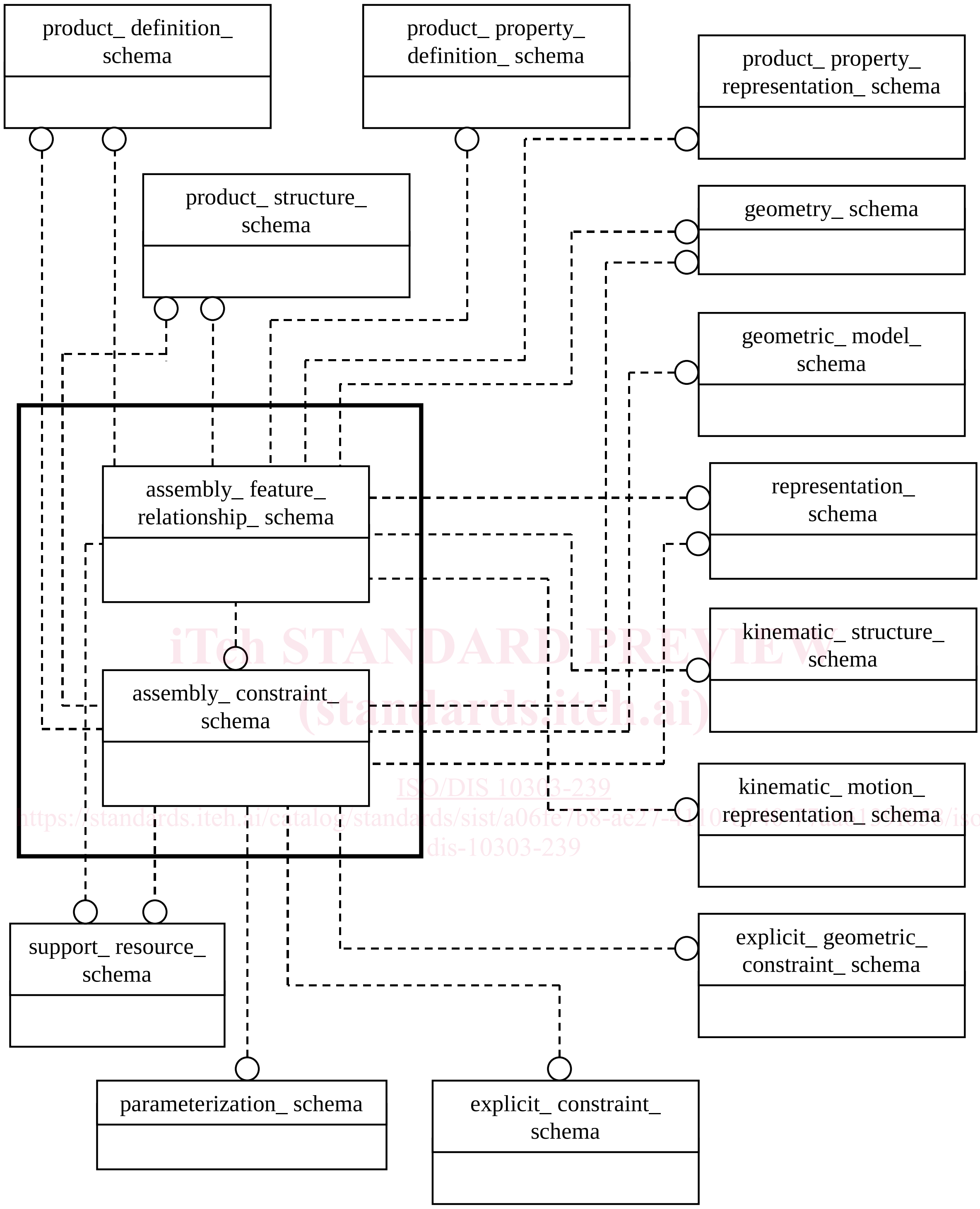

Figure 1 – Schema level diagram of relationships between ISO 10303-109 schemas (inside the box) and other resource schemas

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

Part 109:

Integrated application resource: Kinematic and geometric constraints for assembly models

1 Scope

This part of ISO 10303 specifies the resource constructs for the representation of detailed geometric relationships between constituents of an assembly model including geometric constraints between constituents.

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

— The association of shape aspect relationship with its representation;

— The association of instanced assembly feature relationship with its representation;

— The representation of detailed geometric information of instanced assembly feature relationship at the **geometric_representation_item** level in terms of elements such as assembly geometric constraints, kinematics pair and kinematics path;

— The representation of the fixed constituent which plays the anchor role in the assembly model.

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

— Product structure configurations of assemblies and their constituents.

— Tolerance information. See clause 5.2 of this part of ISO 10303.

2 Normative references

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

ISO/IEC 8824-1, *Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation*.
ISO 10303-1, *Industrial automation systems and integration – Product data representation and exchange – Part 1: Overview and fundamental principles*.
ISO 10303-11, *Industrial automation systems and integration – Product data representation and exchange – Part 11: Description methods: The EXPRESS language reference manual*.
ISO 10303-41, *Industrial automation systems and integration – Product data representation and exchange – Part 41: Integrated generic resource: Fundamentals of product description and support*.
ISO 10303-42, *Industrial automation systems and integration – Product data representation and exchange – Part 42: Integrated generic resource: Geometric and topological representation*.
ISO 10303-43, *Industrial automation systems and integration – Product data representation and exchange – Part 43: Integrated generic resource: Representation structures*.
ISO 10303-44, *Industrial automation systems and integration – Product data representation and exchange – Part 44: Integrated generic resource: Product structure configuration*.
ISO 10303-105, *Industrial automation systems and integration – Product data representation and exchange – Part 105: Integrated application resource: Kinematics*.
ISO 10303-108:2004, *Industrial automation systems and integration – Product data representation and exchange – Part 108: Integrated application resource: Parameterization and constraints for explicit geometric product models*.

3 Terms, definitions, and abbreviations

3.1 Terms defined in ISO 10303-1

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

— assembly;

— component.

3.2 Terms defined in ISO 10303-11

For the purposes of this document, the following terms defined in ISO 10303-11 apply.

— entity;

— entity data type;

— instance.

3.3 Terms defined in ISO 10303-41

For the purposes of this document, the following term defined in ISO 10303-41 applies.

— shape aspect.

3.4 Terms defined in ISO 10303-42

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

— boundary representation solid model (B-rep);

— constructive solid geometry (CSG);

— geometric representation item.

3.5 Terms defined in ISO 10303-43

For the purposes of this document, the following terms defined in ISO 10303-43 apply.

— representation;

— representation context.

3.6 Terms defined in ISO 10303-44

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

— constituent;

— sub-assembly.

3.7 Terms defined in ISO 10303-108

For the purposes of this document, the following terms defined in ISO 10303-108 apply.

— constrained element;

— constraint;

— constraint solver;

— defined constraint;

— dimensional constraint;

— directed constraint;

— explicit geometric constraint;

— logical constraint;

— reference element;

— sketch;

— undirected constraint.

3.8 Abbreviations

AP application protocol (of ISO 10303)

B-rep boundary representation

4 Assembly feature relationship

4.1 Introduction

The following EXPRESS declaration begins the **assembly_feature_relationship_schema** and identifies the necessary references.

EXPRESS specification:

```
*)
SCHEMA assembly_feature_relationship_schema;

  REFERENCE FROM assembly_constraint_schema; -- 10303-109
  REFERENCE FROM geometry_schema; -- 10303-42
  REFERENCE FROM kinematic_motion_representation_schema; -- 10303-105
  REFERENCE FROM kinematic_structure_schema; -- 10303-105
  REFERENCE FROM product_definition_schema; -- 10303-41
  REFERENCE FROM product_property_definition_schema; -- 10303-41
  REFERENCE FROM product_property_representation_schema; -- 10303-41
  REFERENCE FROM product_structure_schema; -- 10303-44
  REFERENCE FROM representation_schema; -- 10303-43
  REFERENCE FROM support_resource_schema; -- 10303-41
(*
```


NOTE 1 The schemas referenced above can be found in the following parts of ISO 10303:

assembly_constraint_schema	ISO 10303-109
geometry_schema	ISO 10303-42
kinematic_motion_representation_schema	ISO 10303-105
kinematic_structure_schema	ISO 10303-105
product_definition_schema	ISO 10303-41
product_property_definition_schema	ISO 10303-41
product_property_representation_schema	ISO 10303-41
product_structure_schema	ISO 10303-44
representation_schema	ISO 10303-43
support_resource_schema	ISO 10303-41

NOTE 2 See annex D, Figure D.1, for a graphical presentation of this schema.

4.2 Fundamental concepts and assumptions

An important concept in this part of ISO 10303 is **assembly_feature**. It is a portion of a constituent used for defining a connectivity relationship between constituents of an assembly model. It is actually defined in ISO 10303-1102: Assembly feature definition module as an entity named **instanced_assembly_feature** that is a subtype of **product_property_instanced_feature** defined in ISO 10303-1101: Product property feature definition module. As described in the introduction paragraph of this part of ISO 10303, these two modules in combination with this part of ISO 10303 support the concept of **assembly_feature**. See annex E, Figure E.1 for a graphical presentation of these relationships.

The **product_property_instanced_feature** itself is a subtype of **shape_aspect** defined in ISO 10303-41 as shown in annex E. The necessary number of pairs of **assembly_feature** instances one belonging to one constituent and the other belonging to the other constituent can represent the detailed geometric relationship between two constituents within an assembly model.

This schema provides resource constructs for linking **shape_aspect_relationship** with its corresponding **representation_relationship** and for detailing geometric information of the **representation_relationship**.

The entity **shape_aspect** defined in ISO 10303-41 is an identifiable element of the shape of a product, and is used to specify a portion of a product shape. The entity **shape_aspect_relationship** also defined in ISO 10303-41 relates two instances of **shape_aspect**.

EXAMPLE 1 If a product named “gear box” has a set of bearing holes for supporting a set of journals of a product named “shaft”, the bearing holes and the journals are **shape_aspect** instances. The instances of **shape_aspect** representing bearing holes may have some relationships with the instances of the **shape_aspect** representing journals. These relationships can be described by the use of **shape_aspect_relationship**.

The geometric shape of an instance of **shape_aspect** is represented by using an instance of **shape_representation** defined in ISO 10303-41. If a pair of **shape_aspect** instances are related with each other, the **shape_representation** instance of one **shape_aspect** instance may be specified in the context of the **shape_representation** instance of the other **shape_aspect** instance. An entity data type **shape_aspect_relationship_representation_association** is introduced to relate an instance of **shape_aspect_relationship** with an instance of **representation_relationship** representing the geometric relationship between two **shape_aspect** instances.

EXAMPLE 2 In the above example consisting of a gear box and a shaft, **shape_aspect_relationship_representation_association** is used to identify the **representation_relationship** representing the relative position and orientation between a bearing hole and a journal.

As for the representation of detailed geometric information of **instanced_assembly_feature_relationship**, this schema enables the selection from among **binary_assembly_constraint**, **constrained_kinematic_motion_representation** and **free_kinematic_motion_representation**.

4.3 Assembly feature relationship type definitions

4.3.1 Representing relationship

The **representing_relationship** type is used to distinguish those major subtypes of **instanced_-assembly_feature_relationship_representation_association** which are **binary_assembly_-constraint, constrained_kinematic_motion_representation**, and **free_kinematic_motion_-representation**.

EXPRESS specification:

```
*)
TYPE representing_relationship = SELECT
(binary_assembly_constraint,
constrained_kinematic_motion_representation,
free_kinematic_motion_representation);
END_TYPE;-- representing_relationship
(*
```


4.4 Assembly feature relationship entity definitions

4.4.1 Shape aspect relationship representation association

A **shape_aspect_relationship_representation_association** identifies an instance of **representation_-relationship** representing the geometric information of an instance of **shape_aspect_relationship**. This entity is used to describe the relative position and orientation between a pair of **shape_aspect** instances.

EXPRESS specification:

```
*)
ENTITY shape_aspect_relationship_representation_association;
  represented_shape_aspect_relationship: shape_aspect_relationship;
  representing_representation_relationship : representation_relationship;
WHERE
WR1: ('REPRESENTATIVE_SHAPE_REPRESENTATION' IN
       TYPEOF(representing_representation_relationship\
       representation_relationship.rep_1)) AND
      ('REPRESENTATIVE_SHAPE_REPRESENTATION' IN
       TYPEOF(representing_representation_relationship\
       representation_relationship.rep_2));
```

