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

Part 110: Integrated application resource: Mesh-based computational fluid dynamics

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

Partie 110: Ressources d'application intégrées: Dynamique des fluides computationnelle fondée sur la maille

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Foreword

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

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

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

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

ISO 10303-110 was prepared by Technical Committee ISO TC184 *Automation systems and integration,* Subcommittee SC4 *Industrial data.*

ISO 10303 is organised 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 of the 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 Internet:

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

Should further parts of ISO 10303 be published, they will follow the same numbering pattern.

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 integrated resources series. Major subdivisions of this part of ISO 10303 are:

— **basis_schema**;

— **hierarchy_schema**;

— **domain_schema**;

— **conditions_schema**;

— **equations_schema**;

— **results_schema**.

The relationships of the schemas in this part of ISO 10303 to other schemas that define the integrated resources of this International Standard are illustrated in Figure 1 using the EXPRESS-G notation. EXPRESS-G is defined in ISO 10303-11. The schemas identified in the bold boxes are specified in this part of ISO 10303. The **external_reference_schema**, **product_property_definition_schema**, **product_property_representation_schema**, and the **support_resource_schema** schemas are specified in ISO 10303-41. The **representation_schema** schema is specified in ISO 10303-43. The **mathematical_context_schema** and the **mathematical_description_of_distribution_schema** schemas are specified in ISO 10303-51. The **mesh_connectivity_schema** and the **mesh_topology_schema** schemas are specified in ISO 10303-52. The **analysis_schema** schema is specified in ISO 10303-53. The schemas illustrated in Figure 1 are components of the integrated resources.

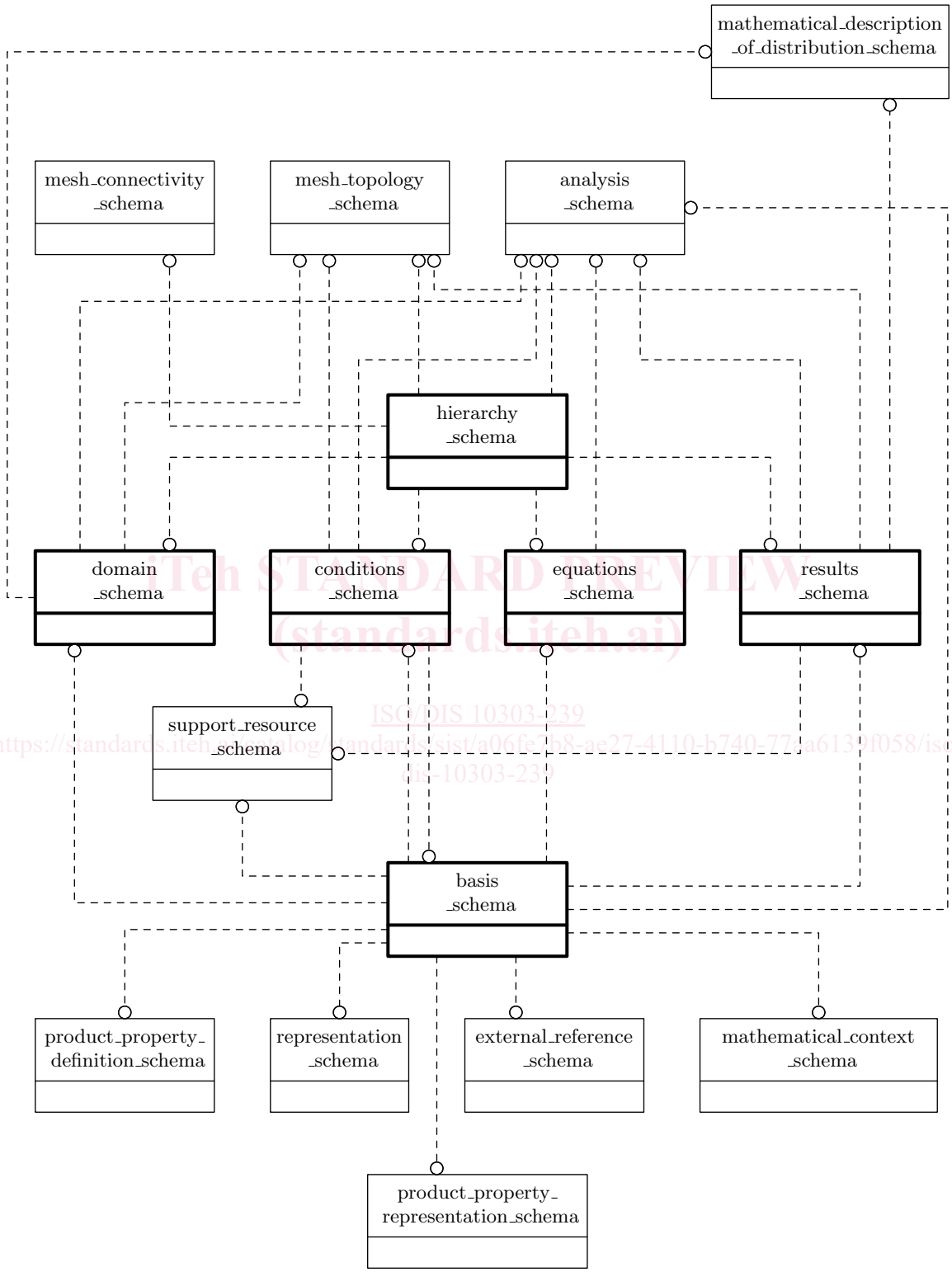

Figure 1 – Schema relationships

Industrial automation systems and integration — Product data representation and exchange — Part 110 : Integrated application resource: Mesh-based computational fluid dynamics

1 Scope

This part of ISO 10303 provides a general application independent means of representing computational fluid dynamics numerical analyses on structured and unstructured meshes. The schemas in ISO 10303-110 are specified in the EXPRESS language; EXPRESS is defined in ISO 10303-11.

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

— digital data on structured and unstructured meshes describing steady or unsteady fluid dynamics flowfields;

— data describing the fluid dynamics model including mesh description, mesh inter-connectivity, boundary conditions, and modeling parameters;

— data from solutions of equation sets commonly used in fluid dynamics analysis: Navier-Stokes equations, Euler equations, linear and nonlinear potential flow equations, small-disturbance equations, boundary layer equations, and stream function equations;

— data at any point in the analysis activity;

— single-phase flow of a liquid or a gas;

— laminar flow, transitional flow, turbulent flow (direct representation of turbulence, or represented by Reynolds-averaged data);

— incompressible or compressible flow;

— unsteady flow;

— perfect gas, or variable chemical composition (equilibrium flow, frozen flow, or finite-rate chemical reactions);

— data regarding the exchange of energy by molecular transport including convection, conduction, and advectation;

— rotating flowfields (e.g., turbomachinery);

— inertial and rotating frames of reference;

— Newtonian transport laws;

— reference to product geometry;

— administrative information necessary to track the approval and configuration control of the analysis of a product;

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

— representations of geometry;

— gross flow in networks (e.g., piping and ducting);

— the use that application programs may make of the data;

— the means by which application programs modify the data;

— the form in which the data is stored internal to an application.

The validity, accuracy and completeness of the data for a particular purpose are determined entirely by the applications' software.

NOTE The following are outside the scope of this edition of this part of ISO 10303 but are expected to be inside the scopes of later editions of this part:

— two- and three-phase flow;

— free surface flow;

— non-continuum flow (e.g., direct simulation of Monte Carlo data);

— data from non-analytical sources (e.g., experimental simulation such as wind tunnel or water tank testing, and product test such as flight test or sea trials);

— data regarding the exchange of energy by radiation;

— non-Newtonian transport laws;

— electro-magnetic interactions with a fluid;

— plasmas.

2 Normative references

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

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

ISO 10303-51, *Industrial automation systems and integration — Product data representation and exchange — Part 51: Integrated generic resource: Mathematical representation.*

ISO 10303-52, *Industrial automation systems and integration — Product data representation and exchange — Part 52: Integrated generic resource: Mesh-based topology.*

ISO 10303-53, *Industrial automation systems and integration — Product data representation and exchange — Part 53: Integrated generic resource: Numerical analysis.*

3 Terms, definitions, abbreviated terms, and symbols

3.1 Terms defined in ISO 10303-1

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

— application protocol (AP)

— integrated resource (IR)

3.2 Other terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.2.1
BC patch
subrange of a face of a zone where a given boundary-condition is applied

3.2.2
computational fluid dynamics
set of knowledge and tools used to generate exact or approximate solutions to the mathematical equations governing the motion of a fluid (gas or liquid)

NOTE The underlying knowledge is implemented in computing codes or application programs.

3.2.3
global BC patch data
boundary-condition data applied globally to a BC patch

EXAMPLE Specifying a uniform total pressure.

3.2.4
local BC patch data
boundary-condition data applied at each mesh point of a BC patch

EXAMPLE Varying total pressure specified at each vertex of a BC patch.

3.2.5
rind
one or more layers of cells on the boundary of a mesh

NOTE 1 Each cell in a rind has a thickness much less than a typical dimension within the mesh. The topology of the cells in a rind is defined by the topology of the boundary edges or faces of the mesh and by the layers of the rind. The geometry of the cells in a rind is defined by the positions of the vertices on the boundary and by cell properties.

NOTE 2 A rind is associated with external flow solution data in a fluid dynamics calculation.

3.3 Abbreviated terms

BC	boundary-condition
CFD	computational fluid dynamics
fd	fluid dynanics
mbna	mesh based numerical analysis

3.4 Symbols

Symbols for dimensions are given in Table 1.

Symbols for coordinate systems are given in Table 2.

Associated with the coordinate systems are unit vectors, the symbols for which are given in Table 3.

Symbols for physical properties are given in Table 4.

Symbols for nondimensional parameters are given in Table 5

Table 1 – Symbols for dimensions

Symbol	Description
M	mass dimension
L	length dimension
T	time dimesion
Θ	temperature
α	angle dimesin

EXAMPLE A length has dimension L, an area has dimension L^2, and a velocity has dimension L/T (alternatively written as LT^{-1}).

Table 2 – Symbols for coordinate systems

Symbol	Description
x, y, z	coordinates in a Cartesian system
r, θ, z	coordinates in a Cylindrical system
r, θ, ϕ	coordinates in a Spherical system
ξ, η, ζ	coordinates in an auxiliary system

Table 3 – Symbols for unit vectors

Symbol	Direction	Symbol	Direction	Symbol	Direction
$\hat{e}_x$	x-direction	$\hat{e}_r$	r-direction	$\hat{e}_\xi$	ξ-direction
$\hat{e}_y$	y-direction	$\hat{e}_\theta$	θ-direction	$\hat{e}_\eta$	η-direction
$\hat{e}_z$	z-direction	$\hat{e}_\phi$	ϕ-direction	$\hat{e}_\zeta$	ζ-direction