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Data structures for electronic product catalogues for building services —

Part 2: Geometry

Structures de données pour catalogues électroniques de produits pour les services du bâtiment —
Partie 2: Géométrie

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 59, *Buildings and civil engineering works*, Subcommittee SC 13, *Organization of information about construction works*.

A list of all the parts in the ISO 16757 series can be found on the ISO website.

Introduction

There is a growing need for electronic, machine-readable, digital information about building services. The designers in building services have to execute detailed calculations and simulations to ensure saving of energy and to satisfy hygienic and comfort criteria in heating, ventilation, air conditioning, and sanitary plants. Designers must have access to more complete and more accurate documentation to address these needs. The resulting designs have to describe the complete building services system without internal interference to avoid collision with other systems and components and the building structure.

These requirements can only be achieved with modern building services applications such as computer-aided design (CAD) and computer-aided engineering (CAE) systems, calculation programmes, BIM tools, and management software. The software systems need exact data of the used plant components because each component contributes to the performance of the whole building.

Thus, an international standard is required to provide the models and definitions for product catalogue data exchange.

Such a standard eliminates the need to manage different data formats or to use different manufacturer-specific software systems to deal with products of different manufacturers. The standard will lead to a significant reduction of costs for manufacturers and users. Integrating this data into building information modelling (BIM) systems allows data interchange between information technology (IT) systems. In addition to the benefits of planning, there will be further advantages for other software solutions, such as facility management and life-cycle management.

This part of ISO 16757 offers for the first time an interface which allows the uniform handling of data about technical, maintenance and service, as well as geometry, images, video and text information.

The objectives of this part of ISO 16757 are to facilitate

— automatic integration of catalogue data of all manufacturers in engineering applications such as CAD, CAE, dimensioning and calculation systems,

— uniform product selection across manufacturers,

— dimensioning of products using manufacturers' algorithms,

— possibility to recalculate and re-simulate the whole system with data of all building services components as often as required, and

— standardized representation of technical data for data exchange and life-cycle management.

This part of ISO 16757 specifically provides definitions and specifications for modelling and exchanging geometric information of building services components.

ISO 16757-1 gives the overview about the standard and the rationale for its elements and organization. This document defines the geometric elements which are used to represent the products in ISO 16757 catalogues. ISO 16757-3 defines the script language used in ISO 16757 (all parts) for various purposes. ISO 16757-4 contains IDM descriptions for ISO 16757 (all parts), including process descriptions for those processes which are to be supported by the standard and it comprises the rules for mapping of product and the property descriptions to IFC and for defining properties semantically with IFD. ISO 16757-5 defines an exchange format in XML by which electronic catalogues can be exchanged according to the definitions of ISO 16757 (all parts). The exchange format will be specified as an XML Schema Definition (XSD). The content parts of ISO 16757 will define standardized properties for the product groups and the composition of the technical data model. Furthermore, the content parts of ISO 16757 determine the specific programming function-interfaces to layout, calculate and simulate the products.

Data structures for electronic product catalogues for building services —

Part 2: Geometry

1 Scope

This part of ISO 16757 describes the modelling of building services product geometry. The description is optimized for the interchange of product catalogue data and includes

— shapes for representing the product itself,

— symbolic shapes for the visualization of the product's function in schematic diagrams,

— spaces for functional requirements,

— surfaces for visualization, and

— ports to represent connectivity between different objects.

The shape and space geometry is expressed as Constructive Solid Geometry (CSG) based on geometric primitives concatenated to boundary representations by Boolean operations. This part of ISO 16757 uses the applicable primitives from ISO 10303-42 and from ISO 16739 and adds primitives which are required for the special geometry of building services products. For symbolic shapes, line elements are also used.

This part of ISO 16757 neither describes the inner structure and internal functionality of the product nor the manufacturing information because this is typically not published within a product catalogue.

Building services products can have millions of variant dimensions. To avoid the exchange of millions of geometries, a parametric model is introduced which allows the derivation of variant-specific geometries from the generic model. This is necessary to reduce the data to be exchanged in a catalogue to a manageable size. The parametric model will result in smaller data files, which can be easier transmitted during data exchanges.

The geometry model used does not contain any drawing information such as views, line styles or hatching.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 16757-1, *Data structures for electronic product catalogues for building services — Part 1: Concepts, architecture and model*

ISO 6707-1,*Buildings and civil engineering works — Vocabulary — Part 1: General Terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16757-1 and ISO 6707-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
product shape
geometric representation of the space defined by the product's external boundaries

3.2
product surface
coloured and textured outer boundary of the product's shape whose rendered appearance responds to relative lighting and viewing angles

3.3
port
located, oriented and directed feature of the product's geometry model (1) for connecting the product with other ports to transfer media or (2) to fasten the product to other products, accessories, walls, ceilings, floors, etc. or (3) for executing control

3.4
solid model
complete representation of the nominal shape of a product such that all points in the interior are connected and that any point can be classified as being inside, outside or on the boundary of a solid.

[SOURCE: ISO 10303-42:2014, 6.4.1]

3.5
parametrizable primitive solid
model of a defined primitive solid, e.g. a block, cylinder, sphere or cone whose dimensions are represented by parameters to generate variants

3.6
constructive solid geometry
CSG
type of geometric modelling in which a solid is defined as the result of a sequence of regularised Boolean operations operating on solid models

[SOURCE: ISO 10303-42]

3.7
clipping
operation applied to a geometric model to remove parts of the model beyond a defined boundary

4 Catalogue structure and catalogue information

All kinds of product data in the scope of ISO 16757 can be transmitted in a product catalogue data file.

The catalogue structure which is explained in more depth in ISO 16757-1 is depicted in Figure 1.

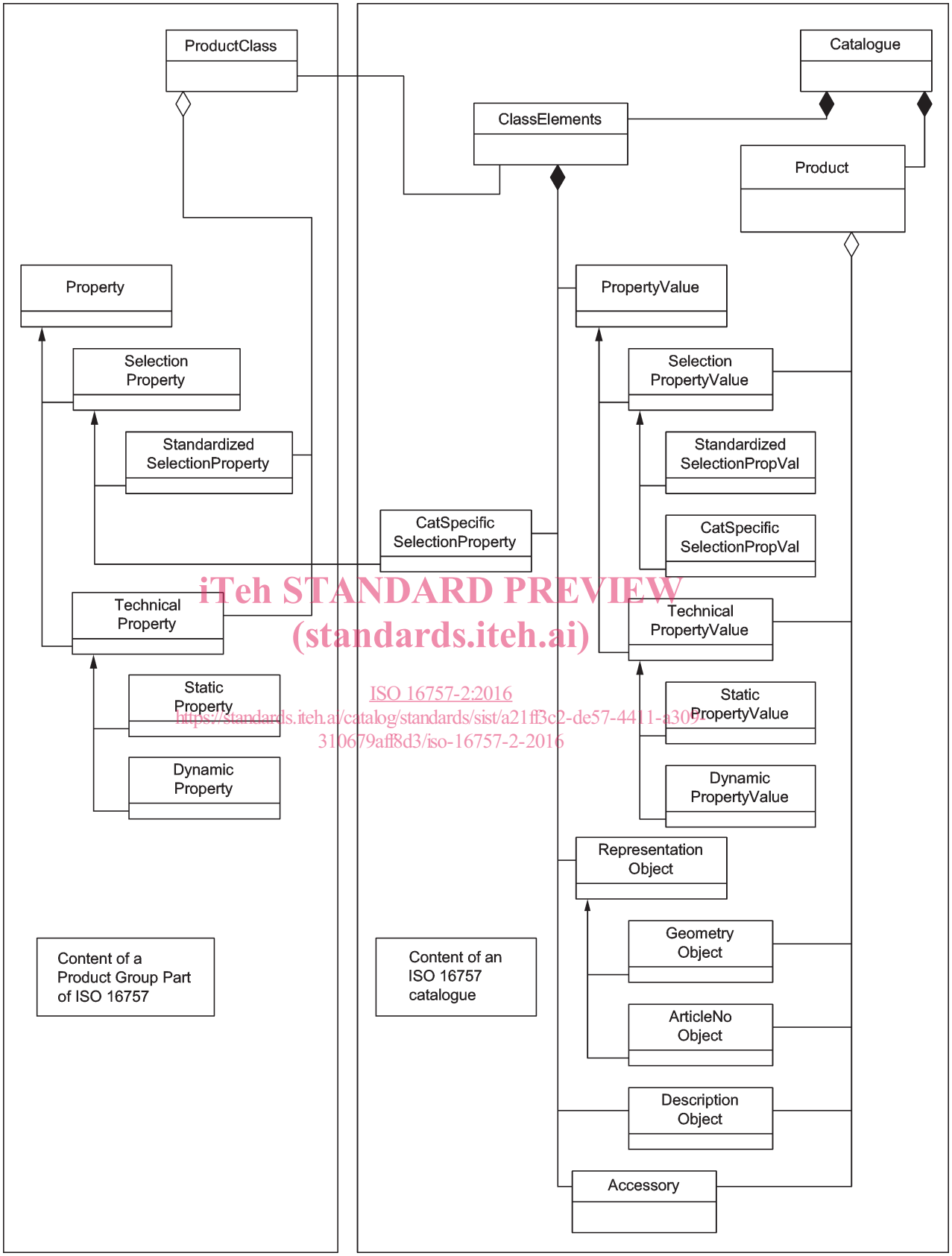

Figure 1 — Overview of the elements of a catalogue and the kinds of properties

5 Geometry

Geometry objects are representation objects in a catalogue. They can represent a product, an accessory or a part of one of them (see Figure 2).

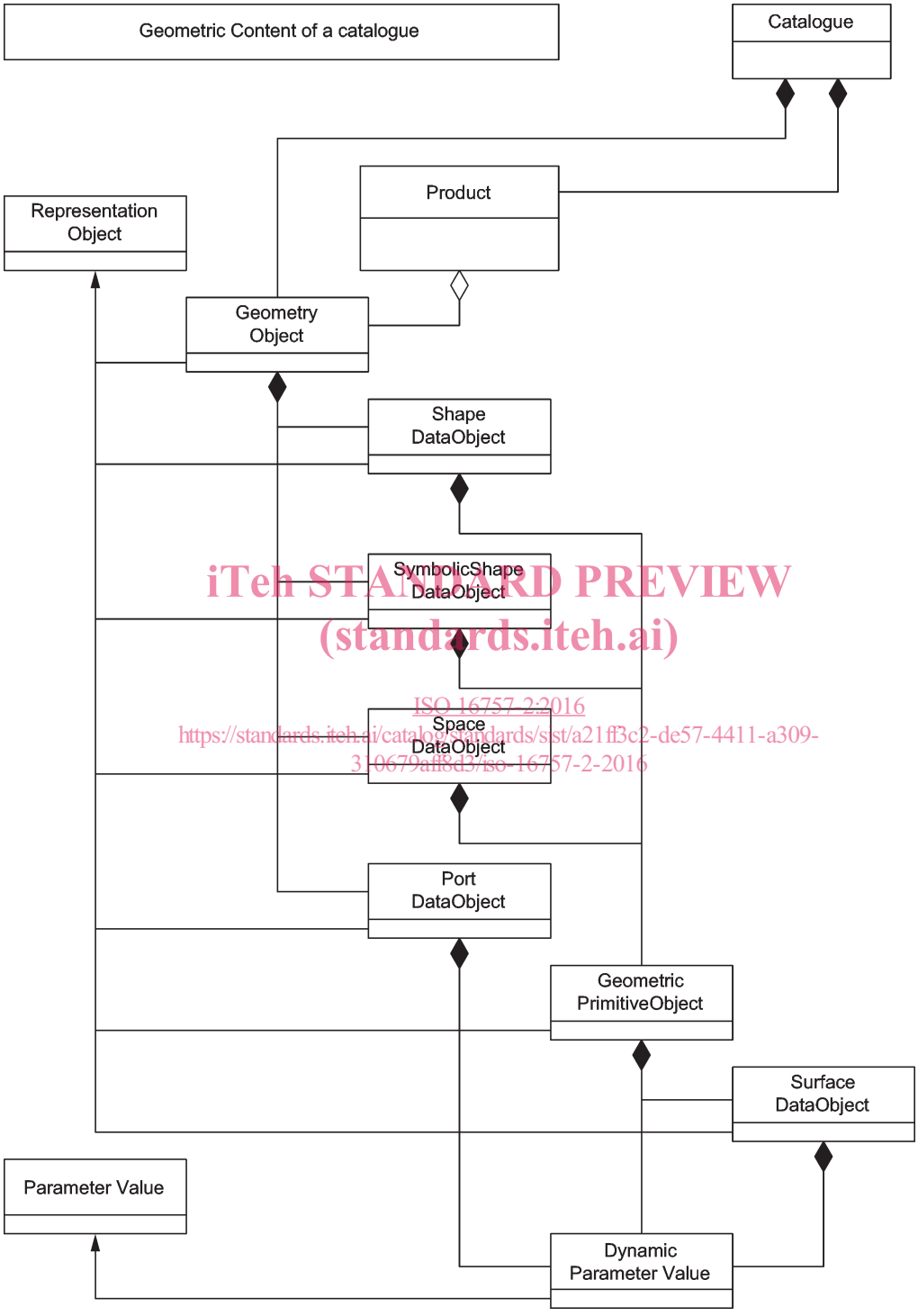

Figure 2 — Overview of the geometric elements of a catalogue and the kind of data objects

Geometry contains different kinds of geometric data:

— shapes;

— symbolic shapes;

— spaces;

— surfaces;

— ports.

The shapes, symbolic shapes and spaces are built by CSG trees. The leaves are geometric primitives (see Clause 7). For each primitive, a number of attributes have been defined which have to be supplied with concrete values to build the respective shapes. The inner nodes are CSG operators which also may have attributes that need to be fed by values. In the same way, attributes are specified for ports, and by filling in specific values for the attributes, specific ports are described.

To support the representation of a number of variants, each geometric representation is abstract, i.e. the attributes are not filled by fixed values for each product. Rather, the attribute values are described by formulas which use geometric properties as their parameters. These geometric properties are defined by the manufacturer, i.e. they are specific for the catalogue and may be different from catalogue to catalogue.

The geometric properties provide specific values for each product. They have to be computed for each product on the basis of the technical property values of that specific product variant. Thus, they are derived properties, and they are provided with a function which computes the actual value of the property for a given product variant (see ISO 16757-1). Some geometric properties may also be dynamic, i.e. they depend not only on the product properties, but also on conditions in the environment of the installed product.

A single product can consist of one or more components (see Figure 3). Each component of such a product shall be described as a separate geometric entity.

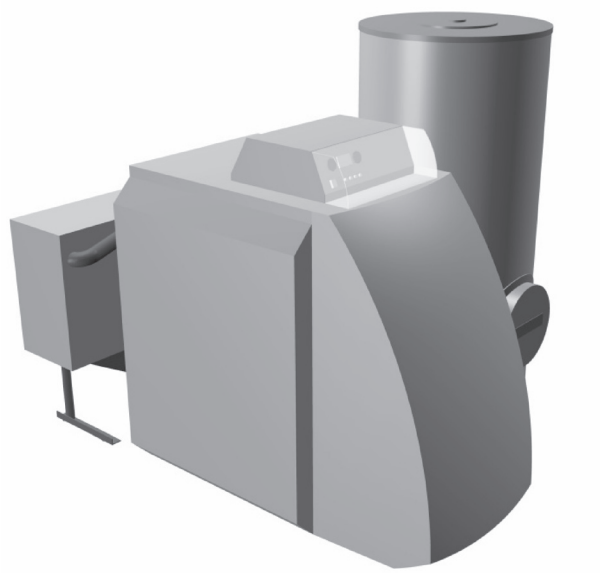

Figure 3 — Single product (heater with heat exchanger and water storage) as an assembly of components

5.1 Shapes

Shapes support the visualization of the product as a 3D geometry model (see Figure 4). In addition, they are required for interference checking with other shapes and spaces in the building model or the building services system model surrounding the building services product.

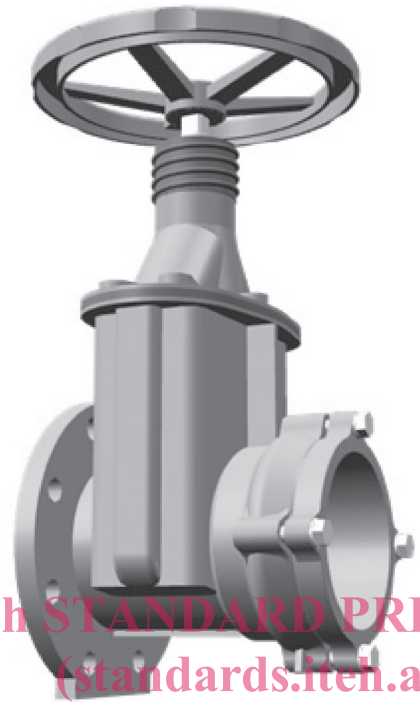

Figure 4 — Shape of a valve

5.2 Symbolic shapes

In addition to shapes, symbolic shapes are useful for the understanding of the model in visualizations and drawings. To illustrate, a 3D representation of a valve's shape cannot give information provided by a symbolic shape, e.g. a valve symbol will give additional information about the type of the valve, its function and form of activation.

The symbolic shape object also contains information about whether it is 2D or 3D.

The method for describing symbolic shapes is the same as that for shape data.

5.3 Space data

The description of the product's shape alone is not sufficient to check whether a product is correctly installed into the building services system. Many pieces of equipment need an operation space in front of their control or display panel, and additional space for installation and/or assembly (see Figure 5).

Spaces are categorized as follows.

5.3.1 Overall space

The space required for preliminary automatic interference checks by CAD systems, including all other spaces: the minimum operation space, the access space, the placement and transportation space and the installation space of the product.

5.3.2 Minimum operation space

The space needed by the product to function correctly, including spaces of opening doors, hatches, etc.

5.3.3 Access space

The space required by operators when maintaining and operating the product.

5.3.4 Placement and transportation space

The space needed by the largest single subassembly into which the product can be broken down to allow it to be moved in or out of the building to or from its place of installation.

5.3.5 Installation space

The space necessary for the onsite assembly and installation or de-installation of the product.

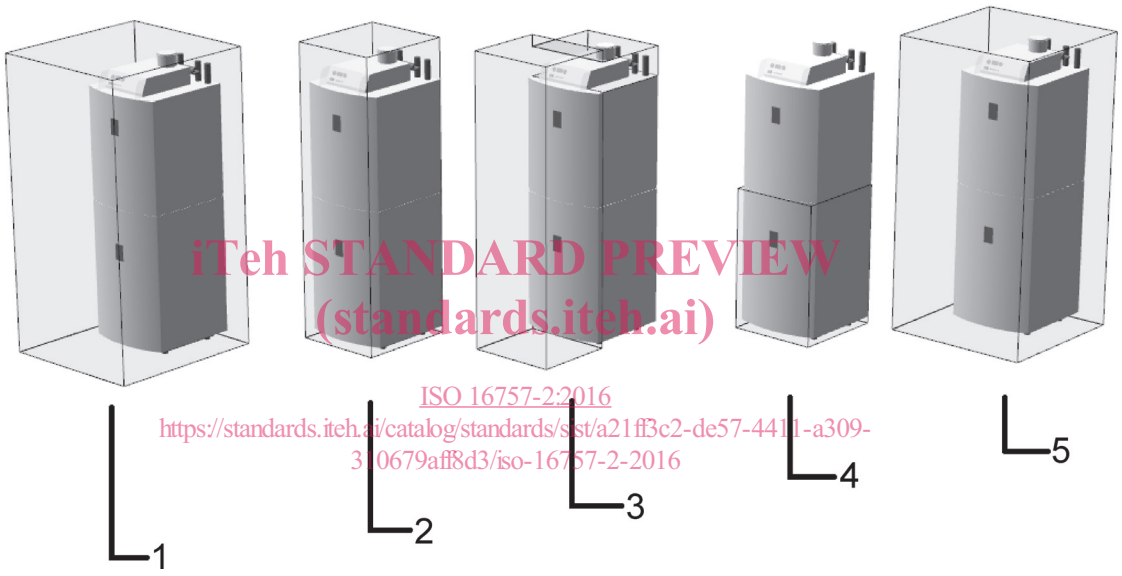

Figure 5 — Spaces of a product

The overall space is described by one single CSG primitive that represents an amalgamation of the product shape and all other spaces noted.

The other spaces can be assembled using one or more geometric primitives. They are configured in the same way as the shape itself.

5.4 Surfaces

Surfaces describe the colour and the texture of the product surface. Each different combination of colour and texture is listed once in the exchange data file and is referenced by geometric data.

5.5 Ports

Ports have to provide all the data which are necessary to identify product ports within a building services system model and to determine whether pairs of ports fit, or not.

Sufficiently described ports allow the automated installation of building services components in a system (e.g. automatic alignment) and for geometric checks to determine whether proper installation into a system is feasible.

The ports of a product can be categorized as

— media-carrying ports (carrying media (e.g. gas or liquid) to pipes, ducts, valves, fittings, etc.);

— fastening ports (means to fasten product to accessories, walls, ceilings, floors, etc.);

— control and monitoring signal ports.

If the software application analyses port information, it can automatically position the product relative to other system components, or offer alternative positions, e.g. placing a water heater on top, beside or behind a boiler. The same principle holds for fans and mounting frames, pumps and base frames, etc.

For this purpose, the ports have to be checked for functional and geometrical fitting.

6 Methodology of geometric description

6.1 Principle of geometric representation

The geometric representation of products in product catalogues comprises four main parts.

a) A combination of 3D solid primitives and the order to combine them by Boolean operations. This can be used to represent the product's shape, its symbolic geometry or the product's spaces.

   The positions and dimensions of the primitives can be constants, variables or mathematical rules using constants and variables. One combination of 3D solid primitives can be used for the geometric representation of a large range of product variants in a product series.

b) A definition of the product's surfaces to describe their visual appearance by allocation of a material definition.

c) A description of the product's ports to the building services system or other products, including their positions, directions and dimensions.

d) A function ('get_geometry_values') or a set of functions which retrieve the property values of a product required for the calculation of its geometry. Together with the 3D-solid primitives, the surface values and the coordinate systems, these property values form the geometric representation of a single, identifiable product (see 6.5).

6.2 Level of detail

It is not unusual for a building to contain thousands of building services products. If they are all represented in great detail in a geometric building model, the data volume will increase dramatically.

Designers who use, for instance, thousands of radiators and radiator valves in one building model are not interested in a detailed view of the product. In drawings with large scales, a symbolic reference or less detailed visualization can be more informative than a detailed one.

A detailed visual impression of the product is often only required in certain instances. For example, when selecting a product, designers are usually very interested in its detailed geometry.

Levels of detail will be used in different documentations.

a) Schema drawing:

   1) Horizontal schema (e.g. for air condition flow plans):

      i) Pipes and ducts are represented by two parallel guided lines in 2D;

ii) Devices are represented by 2D symbols;

2) Vertical schema (e.g. for potable water plans, sewage plans and heating plans):

i) Pipes and ducts are represented by one guided line in 2D;

ii) Devices are represented by generic 2D symbols;

3) Isometric schema (e.g. for piping plans):

i) Pipes and ducts are represented by one guided line in 3D;

ii) Devices are represented by generic 3D symbols.

b) Spatial representation:

The spatial representation is very much dependent on the usage and the user.

EXAMPLE:

1) Building services system product manufacturers are interested in a nearly photo-realistic geometric representation which gives maximum information about the product.

2) Building services system designers are interested in a geometric representation which gives minimum information about the kind of the products for sizing, selecting, installing and operating.

3) Architects are interested in

— a generic representation of pipes and devices to realize room management, and

— a detailed representation of pipes and devices to get a visual impression of the visible parts of the building services systems (e.g. air outlets, radiators, visible pipes, visible ducts and other visible technical devices).

4) Owners, supervisors and general contractors are interested in a dynamic floating representation of pipes and devices, less detailed in an overview and more detailed while zoomed, for to check interoperability.

5) Users of receiving or interpreting applications are interested in a good performance of their software system.

To fulfil all these requirements, ISO 16757 provides for each building services product the following parallel levels of geometric details to design building services systems.

Level 1:

Less detailed symbolic shape geometry to design schemas as overview of building services systems. The symbol stands for the main function of the product. The symbol distinguishes, for example, a fire damper from a duct, a radiator from a heater, a bath tub from a sink and a valve from a pressure gauge. The geometry can contain four symbolic shapes to be used as a 2D top view, a 2D front view, a 2D side view or as 3D model.

Level 2:

High-detailed symbolic shape geometry to design schemas as overview of building services systems. This symbol stands for the explicit main function and sub functions of the product. The geometry can contain four symbolic shapes to be used as 2D top view, 2D front view, 2D side view or as 3D model.

Level 3: