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Data structures for electronic product catalogues for building services

Part 1: Concepts, architecture and model

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National foreword

This British Standard is the UK implementation of ISO 16757-1:2015.

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A list of organizations represented on this committee can be obtained on request to its secretary.

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INTERNATIONAL STANDARD

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Data structures for electronic product catalogues for building services —

Part 1: Concepts, architecture and model

Structures de données pour catalogues électroniques de produits pour les services du bâtiment —

Partie 1: Concepts, architecture et modèle

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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.

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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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

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

ISO 16757 consists of the following parts, under the general title *Data structures for electronic building services product catalogues*:

— *Part 1: Concepts, architecture and model*

— *Part 2: Geometry*

The following parts are planned:

— *Part 3: Script language and functions*

— *Part 4: Cooperation with building information modelling standards*

— *Part 5: Product catalogue exchange format*

Introduction

These Content Parts of this International Standard will define standardised properties for the product groups and the composition of the technical data model. Furthermore, they determine the specific programming function-interfaces to layout, calculate, and simulate the products.

There is a growing need for information about building services systems during the planning and design of buildings. 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. They have to provide better and better documentation to verify the compliance with these requirements. The resulting designs have to describe the complete plants without internal interference or intersection with the building.

These requirements can only be achieved with modern engineering applications like CAD- and CAE-systems, calculation programs, BIM tools, and management software. The software systems need exact data of the used plant components. Each component contributes to the performance data of the whole building.

There are many manufacturers, who provide products to certain sectors of building services (such as heating, ventilation, air conditioning, sanitary). Others provide only certain product groups (radiators, heaters, air condition equipment, air pipes, valves, devices).

Classical catalogues provide product data in tables and show the design algorithms in diagrams and design rules. In addition to the technical properties required for functional design and calculation (e.g. in the form of curve diagrams), such catalogues also contain the geometry data needed for dimensional design and construction (e.g. in the form of dimensional drawings with port details) and the descriptive objects serving for visualization (such as photos, video sequences, or acoustical sequences).

Additionally, nearly all big manufacturers provide their own software (mostly for free) as electronic catalogues to select, to design, and to calculate their products.

Unfortunately, none of these software solutions meets all the requirements of the planner. Needless to say, that each program contains only the product range of its manufacturer. So it is not possible to perform a continuous planning of the plant with products of different manufacturers.

Thus, it is desirable to provide engineering applications which are independent from the manufacturers. The next problem is that data files from different manufacturers — if available at all — are organized in different data formats, structures, and terminologies.

Independent CAD-systems and calculation software need to get data and algorithms in a uniform way. Only if product data and algorithms are automatically available, the calculation and simulation of a complete HVAC plant is possible.

Software providers cannot afford to provide all data from all product manufacturers in the format required by their system. Also, product manufacturers cannot provide current information about their products in the formats of all potential software systems. Thus, we have a typical situation where standardization is required to improve the exchange of information between business partners.

Within single product groups (e.g. radiators), national initiatives to standardize exchange formats have already been conducted. But there is a lack of unification of existing formats across all product groups.

Required is a uniform, internationally standardised definition for product catalogue data interchange.

Such a definition eliminates the need to manage different data formats and to use different software systems to deal with products of different manufacturers, and this leads to a significant reduction of costs for manufacturers and users. Integrating this data into BIM-systems (Building Information Modelling) allows data interchange between IT systems. In addition, to the benefit for planning, there will be an amount of advantages for other software solutions, e.g. facility management and life cycle management.

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

ISO 16757 is a multi-part standard. Future parts will include:

— an overview of ISO 16757 and the rationale for its elements and organization;

— geometric elements which are used to represent the products in the catalogues of ISO 16757;

— definition of the script language used in ISO 16757 for various purposes;

— IDM descriptions for ISO 16757, 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;

— definition of an exchange format in XML by which electronic catalogues can be exchanged according to the definitions of ISO 16757. The exchange format will be specified as an XML Schema Definition (XSD).

Data structures for electronic product catalogues for building services —

Part 1: Concepts, architecture and model

1 Scope

The primary purpose of this International Standard is the provision of data structures for electronic product catalogues to transmit building services product data automatically into models of building services software applications. This includes a meta model for the specification of product classes and their properties and a meta model for the product data which is exchanged in product catalogues. Product data has to follow the specifications for their product groups.

The standard series is split into two areas:

— Basic concepts like conceptual models, languages, geometry representations, and XML schemas for data exchange are provided in the Conceptual Parts of the standard series (Parts with a one digit number).

— Using these resources, the Content Parts of this International Standard define for various product groups of building services concrete models for the description and the exchange of products.

The basic concepts which are provided by the standard series include the following:

— resources for the specification of selection properties and a selection property tree guiding the selection process to identify the appropriate product variant from a parametric electronic catalogue;

— resources for the specification of dependent properties and their computational functions to compute their values in dependency from installation parameters;

— resources for the specification of composition relationships between products which can be used to model structures like bill of materials or accessory relationships;

— resources for a parametric constructed solid geometry (CSG) based geometry representation containing specific CSG elements geometrical elements which are typical for building services products.

This part of ISO 16757 specifies

— the underlying concepts,

— a generic model specifying the available modelling elements and their relationships, and

— a framework for the specification of the Content Parts by describing the elements which are to be provided by these Parts.

Not in scope of this part of ISO 16757 are the following:

— a detailed description of the used geometrical primitives;

NOTE Geometry is described in ISO 16757-2.

— a specification of the script language used to exchange algorithms for computing the values of dependent and computable properties;

NOTE The script language is described in ISO 16757-3.

— a specification of the XML Schema specifying the data structures for the catalogue exchange;

NOTE The XML schema is described in ISO 16757-5.

— a description of the relationships to standards of the area of buildingSMART;

NOTE The relationships to standards of the area of buildingSMART is described in ISO 16757-4.

— definition of models for specific product groups.

NOTE 1 Definitions of models for specific product areas are described in ISO 16757-10 et. seq., the Content Parts of ISO 16757.

NOTE 2 All parts are still under development.

2 Terms and definitions

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

2.1
accessory
product of the same or of different product groups, which can be attached to a product

Note 1 to entry: An accessory is not a different type of product, it plays an ancillary role to another product.

2.2
accessory hierarchy
representation of the dependencies between products and accessories

2.3
article number
manufacturer's reference number, GTIN, or other identifier identifying the product or constituents of a product

2.4
building information modelling
BIM
construction of a model that contains the information about a building for all phases of the building life cycle

Note 1 to entry: In many cases, the abbreviation BIM is also used for the result of the building information modelling, namely the building information model.

2.5
building services
utilities and installations supplied and distributed within a building such as electricity, gas, heating, water, and communications

[SOURCE: ISO 16484-2]

2.6
building services system
BSS
technical system that provides building services in a building

[SOURCE: ISO 16484-2]

2.7
BSS property
technical property that describes an aspect of the current state of a BSS

Note 1 to entry: A BSS property cannot get a value in a catalogue because the states of the building services system are not known and will vary according to the specific system and its various system states.

EXAMPLE In the example given in 2.10, 'media volume flow' and 'media density' are BSS properties.

2.8
catalogue metadata
data in the catalogue which contains data about the catalogue itself

EXAMPLE Catalogue metadata include standard numbers, data for version management, the manufacturer's name, and global location number, as well as file check details.

2.9
descriptive object
object giving descriptive and/or visual information about the product

EXAMPLE Descriptive objects are pictures, descriptions, videos, etc.

2.10
dynamic property
technical property, that reflects the product's behaviour under the operating conditions of the building services system in which the product is installed

EXAMPLE The dynamic property 'pressure loss of a pipe elbow' is dependent of the 'media volume flow' and the 'media density'. In a catalogue, the manufacturer of a pipe elbow has to provide a means to allow the determination of the actual 'pressure loss' for various values of 'media volume flow' and 'media density'

Note 1 to entry: A dynamic property does not get a value from a product catalogue because the value of a dynamic property is dependent on the state of the building services system into which the product will be integrated. Therefore, the value may vary according to the state. The catalogue normally contains some means which allow the product user to determine the value of that property in a given state of the building services system.

2.11
facility management
FM
all the services before, during, and after utilisation of real estate properties and infrastructure based on a holistic (integral) strategy

[SOURCE: ISO 16484-2:2004]

2.12
function
formula
algorithms and formulas for the calculation of computable product properties

Note 1 to entry: The representation of functions and formulae follows a simple program script syntax.

2.13
Global Trade Item Number
GTIN
identifier for trade items used to look up product information in a database GS1

2.14
product
orderable, technical entity

2.15
product catalogue
compilation of information about products

Note 1 to entry: A product catalogue can be related by its article numbers to price lists.

2.16
product group
set of products described by common properties

2.17
product index
compilation of references to all property values of a defined product, the product description, the product geometry, and the product article numbers

2.18
product series
types of products, defined by the manufacturer, which are commonly constructed and manufactured

2.19
property
defined parameter suitable for the description and differentiation of products

[SOURCE: ISO/TS 13399-5:2014]

Note 1 to entry: The description of a product is the description of its properties.

2.20
representation object
object that represents a product or a part of it as a whole

EXAMPLE Article numbers and geometry are representation objects.

2.21
static property
technical property that is independent of the operating conditions of the building services system in which the product is installed and which gets its fixed value from the catalogue

2.22
selection property
property which is used for the selection of a certain product from the product variants of the catalogue

2.23
technical property
property which is used to represent technical data and functions for designing, calculating, and simulating the product

Note 1 to entry: Technical properties comprise static and dynamic technical properties.

3 Requirements and fundamentals

The strategic interest of this International Standard is the provision of product data for design, calculation, and simulation of Building Services systems within engineering application models. This means it is necessary to exchange machine-readable product data from manufacturers to engineering applications and to building information models in an automatic way.

Basically, the products are described by three elements (see Figure 1):

— property values;

— representation objects (like geometry);

— descriptive objects (like text documents, pictures, etc.).

In addition, products can be supplemented by a number of accessories which can be optionally selected in addition to the product itself. Which and how many accessories belong to a product is described by specific rules.

The properties which are used to describe a product have to be defined in a standard (one exception are the catalogue-specific selection properties; see below). The purpose of the Content Parts of this International Standard is exactly the definition of these properties. In Figure 1, which gives a high-level overview about the modelling levels of this International Standard, the meta model on the left side specifies which kinds of properties can be defined for a product group. A Content Part of this International Standard for a product group has to specify which properties are required for the representation of products of this product group. Thus, it will define properties of the various kinds shown in Figure 1; technically speaking, it will provide an instance of the meta model. The various kinds of properties are described below.

On the right side of Figure 1, the elements are shown which make up an ISO 16757 product catalogue. All elements which belong to a product class are grouped under a ClassElements object which is related to the respective ProductClass (see Figure 1). The property values in the catalogue belong to a property which has been defined in the respective Content Part for the product group the product belongs to (not explicitly shown in Figure 1). Some (selection) properties are catalogue specific; their definition will be provided in the catalogue and they are only applicable for that catalogue.

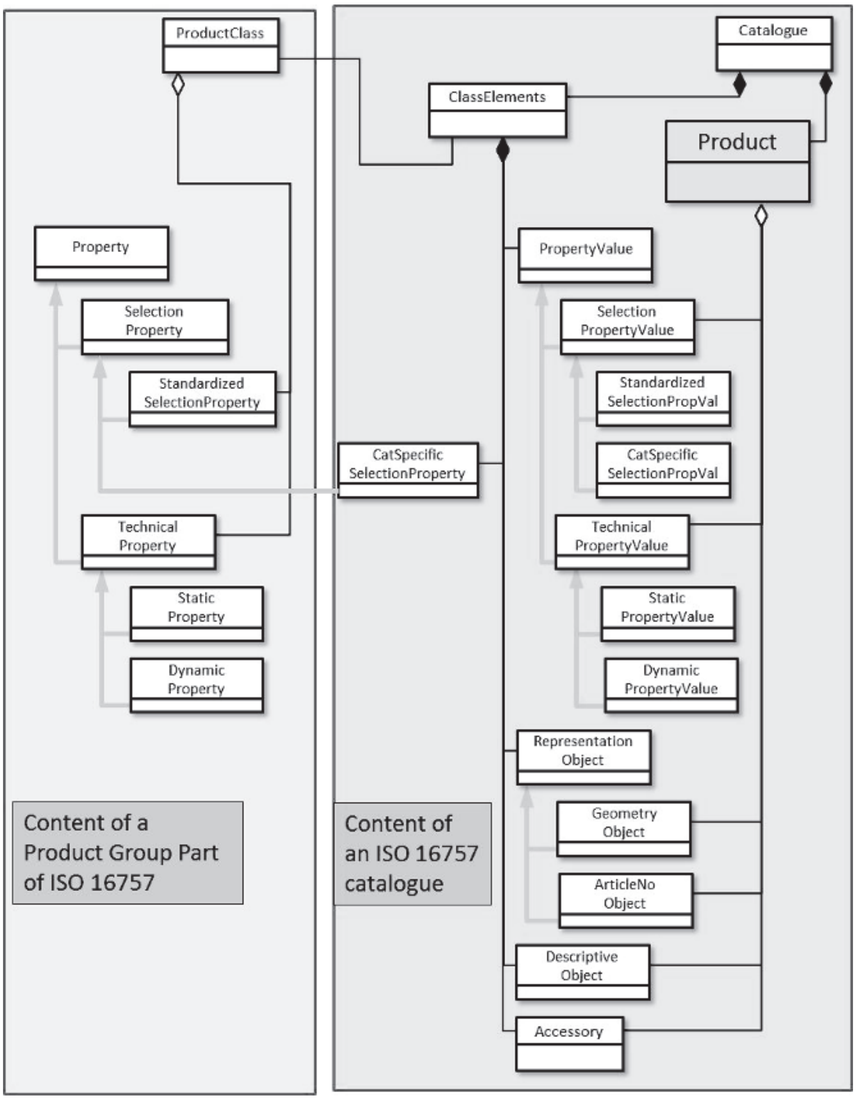


Figure 1 — Overview about the elements of a catalogue and the kinds of properties

The diagram in Figure 1, as well as the diagrams in a number of further figures, is drawn by use of the Unified Modelling Language (UML) class diagrams (see ISO/IEC 19505-1). The following semantics is assumed for the relationships:

Subclass relationship (is-a)

 Composition relationship (sub-object belongs physically to the upper object)

 Aggregation relationship (sub-object belongs logically to the upper object)

Properties of different kinds have different roles:

— Technical properties describe those values which are used as basic parameters in the simulation and the design of building services systems. Technical properties can be **static** or **dynamic**, i.e. dependent of parameters of the building service system in which the product is being installed. Dynamic properties provide a function specification giving the parameters from which the actual value of the property depends.

— Selection properties are used to select a single product from a catalogue which often contains more than a million products of similar kind. By specifying all applicable selection properties, a product has been identified. Selection properties might be catalogue specific.

— Information about the catalogue itself and its administration is transmitted by values of **catalogue metadata** (not shown in Figure 1).

These different kinds of properties and the related objects will be described in more detail in the following clauses. In this clause, the decisions taken for the definition of these properties and objects will be motivated.

3.1 Content of a catalogue

An ISO 16757 catalogue (in the following just called a catalogue) is an electronic catalogue containing at least one product, but normally many products. The product groups which can be transmitted in ISO 16757 catalogues will be defined in ISO 16757-10 et seq., the Content Parts.

Accessories normally belong to a different product group as the main product. They can be described in separate product catalogues. Products outside the catalogue can be referenced from inside the catalogue. Therefore, the identification and the name of the data entity (e.g. the data file) of the external catalogue has to be included into the reference. It is always assumed that the name is unique in the current context of the catalogue. More information will be given in ISO 16757-5 where the concrete exchange of product catalogues is described.

A product may consist of several articles which build the product. The division of products into different articles with several article numbers is depending on manufacturers' conventions and has no technical influence.

EXAMPLE Fire dampers have to be checked in certain time intervals. They can be activated manually or by a separate control device. For one manufacturer, the combination of the fire damper together with its control device is a single article with a single article number. Other manufacturers provide them as a product, consisting of two articles with two different article numbers.

3.2 Manufacture vs. user view of a catalogue

Catalogue providers and catalogue users can have different interests and they use catalogues with different intentions.

NOTE 1 The user's goal is to get information in a way which makes the products of different manufactures comparable based on standardised terminology and definitions. This would help users to find the best fitting products at lowest prices.

NOTE 2 This International Standard does not standardize the exchange of price information or any other commercial information. This information may supplement an ISO 16757 compliant catalogue, but its format is not in the scope of this International Standard.

NOTE 3 Many manufacturers are not willing to produce product catalogues which make them easily comparable with other manufacturers. They argue, when all products were comparable, the specific product differences became invisible. In addition, new developments and inventions would not have a chance to be communicated unless the new concepts are incorporated into the standardised terminology. In fact, manufacturers have the motivation to present their products as positive as possible. Besides, they are responsible for their data. Ownership and copyright of catalogues is with the manufacturers. Therefore, the product catalogues are manufacturer-related and they are produced by the manufacturers themselves.

To support both views, this International Standard follows two principles:

a) ISO 16757 provides technical properties which are needed for calculation, representation, ordering, and simulation in different application cases in a standardised form. These properties will be imported into application systems on the user's site like engineering applications, simulation tools, etc. These properties shall be standardised in the Content Parts of this International Standard for the relevant product classes.

b) ISO 16757 allows manufacturers to use their internal terms for the description of products. This can be done by providing standard properties without determining the allowed set of values (e.g. for colours, so that manufacturers can use their own colour coding) or by allowing manufacturers to define catalogue-specific properties which have a specific place in the selection process (and are thus still useable in a computer-supported variant selection process).

One of the main use cases for many properties is the selection of a specific variant among its many similar variants. This will be explained below in more detail. The properties which are supposed to be used in this process are called **selection properties** in this International Standard.

Normally, selection properties are standardised in the Content Parts of ISO 16757 to enable consistent product selection as far as possible. In addition, ISO 16757 allows manufacturers to specify catalogue-specific selection properties. The definition of these properties shall be provided in the catalogue.

As a conclusion, the following main kinds of properties are provided by this International Standard:

— standardised selection properties;

— catalogue specific selection properties;

— technical properties for technical calculation and design.

It is possible that sometimes the content of selection properties and the content of technical properties seem to be redundant. But in fact, in most cases for selection and for calculation, different views on a property are necessary. A very obvious example is the car battery: it has a nominal voltage of 12 V, but the real value of a fully charged battery is around 13 V. Whereas for the selection, a nominal value is most important, for the calculation, the real value is necessary which can deviate from the nominal value. Thus, sometimes the same property name can be used, but they convey different semantics (which in some other approaches is distinguished by different qualifiers for property values). In this International Standard, these different properties shall be identified by different identifiers.

3.3 Parametric representation of catalogue data

Based upon the process in which the provision, exchange, and use of standardised product data are performed, a product catalogue may contain a single product or a number of products. To deal with a big number of products, one essential part of the catalogue structure of this International Standard are mechanisms to represent similar products in a compact way. That means, the products are not described separately in the structure but each potential property value and each technical property element is available only once in the structure. To isolate a single product, a configuration mechanism allows the selection of values and elements which describe exactly this product.

Product representation objects like geometry are also organized in a parameterized way. Most product series define shapes, which are geometrically the same for all variants of that product series. They only differ in their dimensions. In the same way as the data management uses the same property data for different products, the same basic geometry can be used to describe similar shapes. Dimensions are described as parametric terms containing properties as parameters, which are filled with actual values of the selected variant.

If one of the variants of a product is selected, it can be taken into the target (e.g. the building information model) in two ways: Either as a fixed product where all selection parameters are filled with actual values or as a parametric product where the variations still exist and the actual values of the parameters are given as well. The scope of this International Standard is only the representation of parametric structures in the exchange file.

3.4 Dynamic technical properties describing the behaviour of a product

The interest of application software is to get information about the product's behaviour in different load cases. This data are provided in paper catalogues by data tables, formulas, and diagrams. They determine the values of specific properties in different load cases.

In this International Standard, the behaviour of a product is defined by dynamic properties. Dynamic properties are properties whose values are dependent on values of other properties which describe the installation situation of the product in a given building services system. If the state of the surrounding system changes, i.e. if the values of the BSS properties are changed, then the values of the dynamic properties might change as well.

Thus, the values of dynamic properties cannot be transferred as single values in the catalogue because there is no single value for all situations. Rather, the manufacturer has to provide some means which allows the user to determine the correct property value in a given system situation.

NOTE In conventional product data sheets, this is normally done by tables, formulas, or diagrams where the reader can relate some situation specific parameters of the system with the actual behaviour of the product, i.e. with the values of the dynamic technical properties. Thus, this International Standard does not require manufacturers to provide more information as they are used to provide in their print media. But this International Standard provides a method to transfer this information in a way which can be understood by a computer.

Thus, the definition of a dynamic property comprises two elements:

a) the definition of the property itself (describing name, data type, allowed values, etc.);

b) the definition of the properties on which the value of the dynamic property depends (these properties describe the current state of the building services system into which the product is integrated).

BSS properties are defined in Content Parts of this International Standard. A catalogue cannot provide values for these properties — they describe the system context into which the product will be installed. Only with the description of the actual system context the values of dynamic properties can be determined giving the specific behaviour of the product under these conditions. Thus, the standard defines that the computable property is a function of some other BSS properties. The implementation of the function itself is product and manufacture specific, it may differ from product to product. Only the manufacturer can specify how the product behaves under these conditions – he has to provide the means to compute this dependency in his catalogue.

Dynamic parameters can be described generally by the function:

DynParam = f (BSS properties technical product properties)

The Content Parts of this International Standard shall provide such a function specification for any dynamic property.

The purpose of defining dynamic properties is to enable software systems which process the received catalogue data to determine the value of the dependent properties for specific situations. Thus, one requirement for ISO 16757 catalogues is to transfer the manufacturer specific method for determining a dependent value for a specific product into the software systems of the users.

There are different ways how that can be done: One way is to produce a table of values which specifies the resulting values of the dependent property for some given combinations of parameters of the function. Another way is to provide a function as a mathematical term, and the third way is to describe the calculation of the value of the dependent property by means of an algorithm in some algorithmic language. In different situations, different methods are best suited for transferring this information.

All these methods for describing the dependency of the property values from the actual parameter values can be used by the catalogue provider. For this purpose, this International Standard is providing an algorithmic language by which the calculation rules for the dynamic properties can be specified and transmitted within the catalogue. In addition or alternatively to the transfer of this information in a catalogue, it can also be exchanged by other means outside of the catalogue. For instance, the manufacturer can provide web services which can be called by software systems to get the specific value of a dynamic property in a given load case of a system

With this approach, this International Standard enables software vendors to make use of the information about the behaviour of products. This would not be possible if this information is only provided in form of diagrams. To make use of the data, software systems have to interpret the ISO 16757 algorithmic language. Then the manufacturer specific algorithms can be executed in the software system. Due to the standardization of the functional interfaces, any engineering software can use the same interface for products of different manufacturers.

EXAMPLE Calculation of the computable property pressure loss of an air diffuser

In the final analysis, the pressure loss is dependent on these properties:

— Pressure drop coefficient 'ζ' of the air diffuser (technical product property)

— Effective cross section of the air diffuser (technical product property)

— Duct roughness of the air diffuser (technical product property)

— Hydraulic diameters of the air diffuser (technical product property)

— Adjustment of the air diffuser's throttle element (BSS property)

— Volume flow from the connected BSS (BSS property)

— Air pressure from the connected BSS (BSS property)

— Air temperature from the connected BSS (BSS property)

— Air humidity from the connected BSS (BSS property)

— Air pollution from the connected BSS (BSS property)

— Kinematic air viscosity from the connected BSS (BSS property)

The pressure drop coefficient 'ζ' is an individual product value, measured on a test bed. It cannot be derived from other product properties. At one certain position of the throttle element, it is nearly constant. For an exact calculation, however, it is necessary to regard that it is also dependent on the BSS properties.

In our example, the content standard describing air diffusers defines the interface of a pressure-loss function:

```
DP = Get_Pressure_Loss (ThrottleAdjustment,VolumeFlow,AirPressure,
AirTemperature,AirHumidity,AirPollution, AirViscosity)
```

The parameters `ThrottleAdjustment`, `VolumeFlow`, `AirPressure`, `AirTemperature`, `AirHumidity`, `AirPollution`, and `AirViscosity` are all input parameters, whose values are defined in the BSS model — they have to be imported by the engineering system from its internal model. The function itself may read technical properties of the product from the ISO 16757 catalogue data. The function delivers as its result the value DP which is the pressure loss of the air diffuser in the defined system situation. Thus, the pressure loss DP is a dynamic property of the diffuser.

3.5 Descriptive objects and representation objects

Wherever the user has to do a selection to find his desired product, it might be necessary to support the selection by providing descriptive objects like pictures, videos, drawings, or audio data.

Descriptive objects normally reside in autonomous data files (PDF, AVI, MP3...) which are linked by external references to the product. So they are not included in the main exchange data structure.

Building services products can have millions of variant dimensions. But instead of transmitting also millions of geometries in a catalogue, it is required that the geometry of a specific variant can be generated from template geometries of the product. Thus, the geometry model has to support the adaptation of a geometric representation by modifying some dimensional parameters.

It is difficult to change the dimensions of a shape in a boundary representation due to the big number of rules which need to be defined for the adaptation of the geometry to modified dimensions. On the other hand, this is quite simple with the CSG representation, the constructive solid geometry which allows to build complex geometric objects by combining primitive solids with Boolean operations. In particular, it supports the parameterization of these elements in an easy way. Therefore, this International Standard uses CSG models, and ISO 16757-2 gives more details on CSG modelling.

The geometry of building services components has some specific requirements with respect to shape representation. Normal CSG-primitives like cubes, cylinders, sweep-bodies, etc. have to be supplemented by special sheet-metal primitives, like rectangle-round transitions, oval channels, tee-branches, and Y-pieces. This is explained in more detail in ISO 16757-2, where the geometric primitives from STEP and IFC are examined and used wherever possible. For those requirements which cannot be fulfilled by these primitives, specific ISO 16757 primitives have been defined.

Manufacturers will seek to show their products in a realistic detailed form. In contrast, engineering application users designing a building services system have three main interests in geometry:

a) function, position, and shape of the product itself;

b) function, position, direction, form and dimension of ports;

c) position and dimensions of interference spaces.

The receiving software systems which make use of the product data in the catalogue do not require the complete geometry of the product. It is not their goal to manufacture the product. They only use the product data to incorporate the product as a component into a building services system. Shape data itself is often only of limited relevance for building services system design. If thousands of components are represented by detailed geometry, the response time of software systems would slow down and the drawings would be overloaded. Therefore, the users need to get as much geometric information about the product as their engineering application requires, but not more.

As a consequence, the standard has to provide geometry representations in different levels of detail. Again, more information is given in ISO 16757-2.

3.6 Purpose of Content Parts

Whereas this part of ISO 16757-2 to ISO 16757-9 describe the generic mechanisms which are needed to specify properties and to produce and use product catalogues, the Content Parts with numbers greater than nine specify the properties and the selection hierarchy for specific product groups.

Thus, a Content Part contains the following elements:

— a set of selection properties and the respective selection hierarchy which allows the selection of products of that product class in a given catalogue;

— a set of technical properties specifying the static characteristics of the products;

— a set of BSS-properties which describe the characteristics of a building services system (the BSS properties are used as parameters for the functions describing the dynamic properties);

— a set of function declarations using the BSS-properties and technical properties as parameters returning a value for a dynamic property.

In order to feed this information into engineering systems, this information shall be provided also in form of an XML file. The elements to build such a file and the schema which this file has to instantiate are described in ISO 16757-5.

3.7 Relationship to dictionary standards (ISO 13584, ISO 12006-3)

Basically, PLIB ISO 15384 is a standard which describes a model for the definition of a product ontology or dictionary and provides means for the definition of (product-) classes and properties (for characterization classes which are to be distinguished from pure classification classes without properties). It allows also describing relationships between classes (by properties of class reference type) which is in most cases interpreted as a composition relationship. This model is defined in ISO 13584-42 and ISO 13584-25. The goal of such a dictionary is the provision of a reference structure which can be used to describe the meaning of elements in exchange files and databases. By referencing a property or class in the reference dictionary, the meaning of the element is described. In the building area, the same goal has been pursued with the definition of the IFD data model in ISO 12006-3.

NOTE ISO 12006-3 is used as the basis of the buildingSMART Data Dictionary (bSDD).

This International Standard builds on these International Standards. It provides structures for the definition of properties and product classes and assumes that these properties and classes are defined according to PLIB and/or ISO 12006-3. In addition, it adds to these standards by defining

— additional structures for the properties (e.g., the selection property hierarchy),

— specifications of property roles (catalogue properties, product properties, BSS properties), and

— specific specializations and extensions to PLIB concepts like dynamic properties as a specialization of dependent properties in PLIB.

4 Product configuration and selection

Product catalogues provide a wide range of product variants. For instance, a series of products, available in 100 length-dimensions, 100 width-dimensions, 100 height-dimensions, and in 50 colours makes a sum of 100 × 100 × 100 × 50 = 50 Mio. variants.

Manufacturers of silencers, for instance, sometimes deliver billions of product variants. In such a case, it is impossible to describe every variant separately in the catalogue.

Thus, a mechanism is needed to generate all the product variants from a compact representation of the product data in the catalogue.

4.1 Configuration by referencing properties

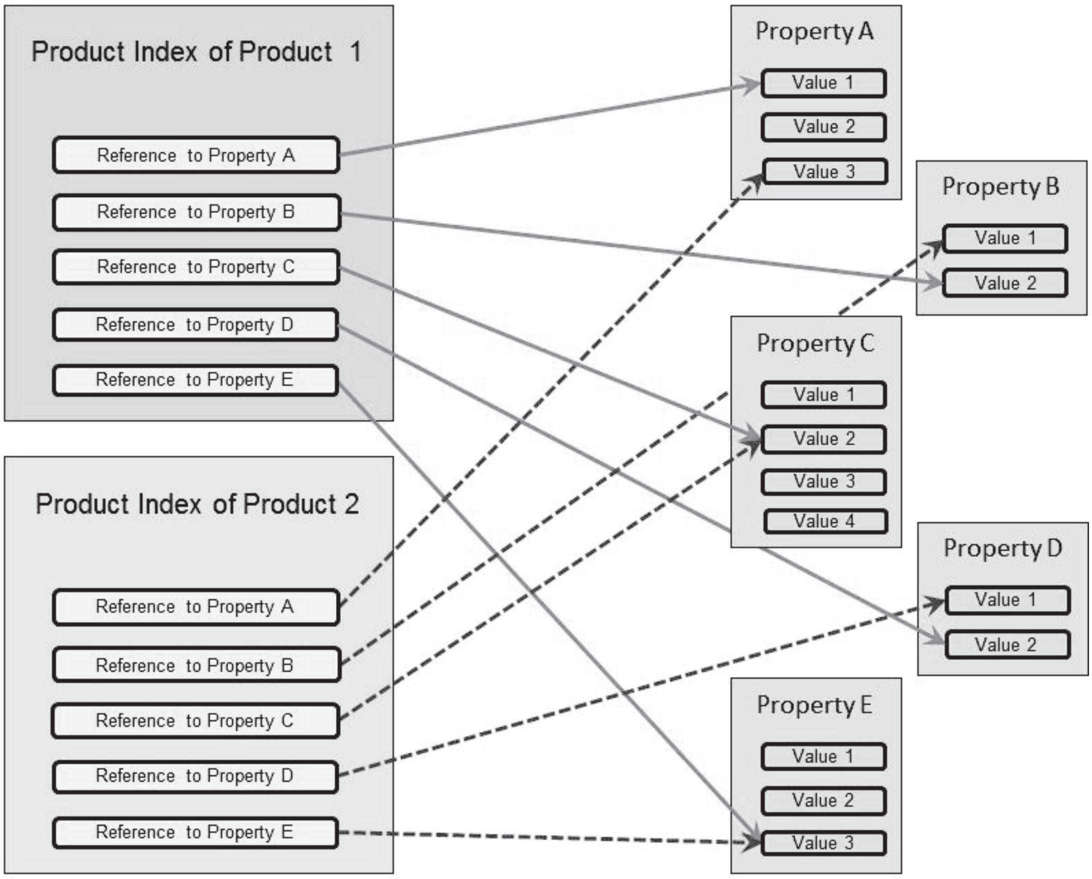
The single products in a product series normally differ in a few properties like range of use, shape, dimensions, colour, etc.

All deliverable, single products can be described as combinations of the values of these selection properties. Each value of a property is listed only once in the data exchange file. The billions of product variants then can be described by combinations of references to the appropriate property values (see Figure 2).

Any combination of property values defines potentially a single product. But not all of these combinations form a valid product. Two mechanisms are provided by this International Standard to identify the valid products:

Product index:

A product index is an object that contains references to the values of selection properties which represent a single product. At least one manufacturer article number is related to a product index. But with accessories and combined products, a list of article numbers can be related to one product element.



Product Index of Product 1: A=1, B=2, C=2, D=2, E=3
Product Index of Product 2: A=3, B=1, C=2, D=1, E=3

Figure 2 — Product indexes referencing property values

Rule based definition of valid property combinations:

With the product indexes, the number of data elements in the exchange file can be minimized. However, the numbers of combinations themselves (in practice more than 10^{16} are possible) can lead to data files which are too big to be manageable any more.

In these cases, the catalogue provider should introduce rules for specifying valid combinations of property values. For instance, a product can be deliverable in red combined with yellow, in green combined with blue, in brown with any other colour, but not in brown combined with violet.

Such rules are implemented in ISO 16757 catalogues as a function which is provided by the manufacturer. This function takes as input an incomplete product index in which some of the references to properties are not filled with a value. The result of the function is either a complete product index or an empty value. An empty value means that the incomplete product index is not valid, i.e. that for the given product value combination no products exist.

Product indexes shall be able to co-exist with the rule based definition of valid products.

EXAMPLE 1 One product series consists of a big amount of products, whose configuration can be generated. A different product series has only a few products. Because their configurations differ at least in the reference to the different product series, both product series are configured independently.

EXAMPLE 2 Most of the product configurations of one product series can be generated by the generation function. A few products are special and cannot simply be described by a generation function. Thus, it is easier to list them as product configuration elements.

4.2 Selection of specific products

The selection process is based on an information retrieval strategy, and the selection properties are organized in a tree guiding the search process. Starting at the root of the selection tree, properties are selected step by step and their value is fixed. If a property P_1 is selected in step n, then it is a sub-property of property P_2 which has already been selected in one of the previous steps (1, .. n-1). Thus, the selection process works as follows:

— In the first step, the user selects the root property and assigns a value. Implicitly, the user reduces the number of possibly valid product indexes, only those which reference the selected value for the root property are still valid. All product indexes referencing a different property value for the root property are excluded from the potential result set.

— In the following steps, the user selects a sub-property of one of the already selected properties and assigns a value to it. If there exists more than a single choice, the user is free in choosing one possibility. By this process, the number of still valid product indexes is reduced step by step. This process is continued until only one single product remains.

EXAMPLE Selection of a fire damper:

The first selection is the selection of the product category Fire Dampers. Afterwards, the next selection can be based on the form, choosing between round and rectangle fire dampers. The following selection may regard the kind of control device. By such a selection sequence, the user sets more importance in the fire damper's shape than in its handling.

Perhaps a certain control device is not deliverable with the selected round fire damper. In that case, the user has to choose a different control device which fits to the selected form. If the user sets highest importance in the exact kind of control device, he can start the selection with this property. For his selection, possibly only fire dampers with rectangle ports are valid and will be presented for the next selection step by the selection system.

It is assumed in this example that the properties *shape* and *control device* are both sub-properties of the root property *product category*.

Not all selection properties are applicable for any product. For a given product, only some of the selection properties apply. This is reflected in the search tree by different kinds of connections between the property and its sub-properties. In one case, only one subsequent branch can be selected, i.e. all the other branches and the respective properties are excluded from the further search and are not applicable to the product. In the other case, all subsequent branches can be selected step by step and they are all applicable to the product. More details can be found in the information model in Clause 8.

The content Parts of ISO 16757 will contain

— a definition of the selection properties (name, object type, definition) along the rules of IFD for the respective product class, and

— a definition of the selection tree specifying the proposed selection process and the dependency of properties in the selection process.

In the following, an example of a selection tree for the area of heat pumps is illustrated. In that example also, the allowed values for each property are shown.

EXAMPLE Heat Pumps:

- Property ‘Area of Application’
  - Heating
  - Water heating
  - Heating and Water heating
  - Property ‘Type’ (Level 2)
    - Brine-to-Water
    - Water-to-Water
    - Air-to-Water
    - Air-to-Air
    - Direct Evaporation
    - Property ‘Heat Source’ (Level 3)
      - Outside Air
      - Ambient Air
      - Natural Heat of the Earth
      - Groundwater
      - Surface Water
      - Sewage
      - Absorber
    - Property ‘Method of Operation’ (Level 2)
      - Monovalent
      - Monoenergetic
      - Bivalent alternative
      - Bivalent parallel
      - Property ‘Additional heat’ (Level 3)
      - With
      - Without
    - Property ‘Model’ (Level 2)
      - Compact
      - Split
      - Property ‘Installation side’ (Level 3)
      - Inside

        — Outside
        — Both
      — Property ‘Drive power’ (Level 2)
        — Electricity
        — Gas
        — Property ‘Functional principle’ (Level 3)
        — Compression
        — Absorption
        — Adsorption

The user’s selection of one single product may lead to a product index which references the following values:

- Property ‘Area of Application’
  - Heating and Water heating
  - Property ‘Type’
    - Air-to-Water
    - Property ‘Heat Source’
      - Outside Air
    - Property ‘Method of Operation’
      - Monovalent
      - Property ‘Additional heat’
      - With
    - Property ‘Model’
      - Split
      - Property ‘Installation side’
      - Both
    - Property ‘Drive power’
      - Electricity
      - Property ‘Functional principle’
      - Compression

4.3 Standardised and catalogue-specific properties

Whenever possible, the content standards of this International Standard define standardised selection properties. They can be defined most easily, if they are related to physical principles (burner — heat pump) or to separate use cases (floor heating, radiant heater). In the content standards, properties may be further specified by a dedicated and closed value list. The values in such a list get an identifying code which allows to easily reference the values, e.g. from the product index.

Manufacturers get some flexibility with respect to selection properties:

a) If the standard defines a property without a value list, manufacturers can use their own values. For instance, if the values for colour are not standardised, manufacturers can transmit their company-specific colour designations;

b) Manufacturers may add additional selection properties which are not defined in the standard. Thus, they can add further selection criteria to support the identification of products specifically for a catalogue. In that case, they shall provide the definition of these properties within the catalogue.

5 Technical properties

A single product which has been identified by its selection properties has a defined set of technical properties. The technical properties are specified in the Content Part describing the respective product class.

Two kinds of technical properties are part of the exchange file:

a) static properties, giving some static characteristics of the selected product;

b) dynamic properties with values which depend on the specific application case, i.e. the installation situation.

The values of static properties describe static characteristics of the products which do not change. Thus, they are transmitted as part of the catalogue. The values of dynamic properties, however, describe dynamic characteristics of products which can only be determined with respect to the state of the whole system in which the product has to work. Thus, for dynamic properties, no value can be transmitted in the catalogue. Rather, the catalogue transmits the algorithm to compute the value.

In the Content Parts of this International Standard, the following properties are defined for each product class:

— static properties for which values can be exchanged in the catalogue;

— dynamic properties for which a function implementation can be transmitted in the catalogue which defines how the value can be calculated;

— BSS properties which are used as parameters of the calculation function and for which no values can be transmitted in the catalogue.

The BSS properties do not describe the product itself, but they describe characteristics of the environment into which the product is installed in a concrete application case. For these parameters, no values are exchanged in the catalogue because they have to be provided by the designer or the engineering system.

In many cases, the technical properties are fixed after the selection process on the basis of the selection properties. But it is also possible that one or several dynamic properties are relevant for the selection of a product, e.g. when for a specific system at a specific installation location specific performance requirements have to be fulfilled. In that case, some of the selection properties might be irrelevant for the selection, but the behaviour of the product in this specific situation is important. Thus, the first selection phase based on the selection properties will stop with some unspecified property values for selection properties and result in a set of products. Afterwards, the behaviour of these products in the given situation is checked by the engineering system: It will compute the dynamic property values for this situation and allow a comparison of the products' behaviours to identify the best fitting product.

For instance, a valve adjustment can be calculated for a defined single valve. But when selecting a radiator, its height and width can be selected first, leaving the length unspecified. Then for all radiators with the given width and height it can be checked, whether they fulfil the technical design requirements. In the end the radiator fulfilling best these requirements will be selected and it has a defined length.

5.1 Static properties

Static properties carry static technical information about a product, like length, width, and height of a radiator or its water content and its minimal mass flow. As a technical specification, most of the properties are of numeric or integer type, and they usually contain a unit.

The properties are organized in a hierarchical structure of blocks which contain properties which are closely related to each other. An example for radiators:

- Technical properties: width, height
  - Technical sub property I: length
  - Technical sub property II: standardised heat output, radiator exponent
  - Technical sub property III: Pressure loss data (ζ)
  - Technical sub property IV: Reduced heat output

The result is a tree structure of properties, and a product in a catalogue is described by at least one instance of each block. As soon as the product has been selected by the selection properties, the related blocks can be identified via the product index representing the product.

The modification of a static property value really modifies the physical or technical characteristic of a product. As such, in many cases, the selection process might also include some of these static properties. this International Standard requires in this case that the respective static property is replicated as a selection property. This provides a clear text description of the static property supporting the independence of the selection process and avoiding a mixture of the dependency relationship of the selection properties and the block structure of the static properties. This is also supported by the observation that often different values are presented for selection and for design: A nominal value is provided for the selection of a product, but the real value may deviate from this nominal value, so that in the calculation, a different value has to be used.

5.2 Dynamic properties

Dynamic properties describe the dynamic behaviour of a product in its installation location. Thus, in a catalogue, they do not carry fixed values, but they carry the implementation of a function which computes the dynamic value of the property. This function has parameters which describe the relevant installation situations.

The Content Parts of this International Standard associate to each dynamic property a function specification. The parameters of these functions refer to a specific type of properties, the BSS properties. BSS properties do not describe the product. Therefore, their values cannot be transmitted in a product catalogue. Rather, their values originate from the environment into which the product will be installed, the building services system. The function computes values of the dynamic property for the specific case described by the BSS properties. For example, the velocity of water inside a valve and its pressure loss are properties of the product, but they depend on the volume flow and throttle adjustment of the system in which the valve is installed.

The function interfaces are specified in the respective Content Parts of the product class, stating the name, type, and range of the functions and their parameters. Within the implementation, the function can access all static properties of the product. The language will be defined in ISO 16757-3.

EXAMPLE For air ducts, the following properties can be defined in a respective Content Part of this International Standard describing the product class air_ducts:

1) Static properties (to be delivered in the catalogue):

```
Height of an air duct, in m
Width of an air duct, in m
```

2) BSS property (value not to be delivered in a catalogue, but to be provided by the system model into which the product will be installed):

```
Volume flow, in m³/h
```

3) Dynamic property (value not to be delivered in a catalogue, but the implementation of the function computing the value):

```
Air Velocity, in m/s
```

The standardised description of the air_duct class will only define the function interface with parameters, parameter types, and parameter ranges. The implementation of the function will be delivered by the catalogue provider.

The function declaration in the standard can be noted as follows in a pseudo language:

```
real function Velocity (REAL VolumeFlow IN);
```

The function implementation in the catalogue might be as follows:

```
real function Velocity (REAL v IN);      // Function start
real w,h;     // Declaration of variables as float
w= GET_REAL_VALUE (‘ProductTechnicalProperty’,‘width’)
       // Fetching width from technical data
h= GET_REAL_VALUE (‘ProductTechnicalProperty’,‘height’)
       // Fetching height from technical data
Velocity = v/(w*h)/3600.;  // Calculating velocity with formula
end function Velocity;     // Function end
```

6 Accessories and composed products

In most cases, for a product, a number of accessories is required, e.g. installation material or manuals. Thus, to each product, a number of accessories may belong, and the user can select the relevant accessories. The selection is supported by a hierarchy of accessory groups which can have an unlimited number of levels.

The accessory selection is different from the product selection. During product selection, property values are specified to identify a single product from the set of products in the catalogue. The accessory selection starts after the product has been selected, and from all available accessories for that product, it selects those which are required in the concrete situation.

Each selectable accessory is described as a single product. This product can be part of the same catalogue, but it can also reside in an external product catalogue. In both cases, the accessory is represented by a product index in the respective catalogue which is referenced from the accessory selection tree. There can be also accessory products which are not described in an ISO 16757 compliant catalogue. In that case, a descriptive object is often used to describe these accessory products.

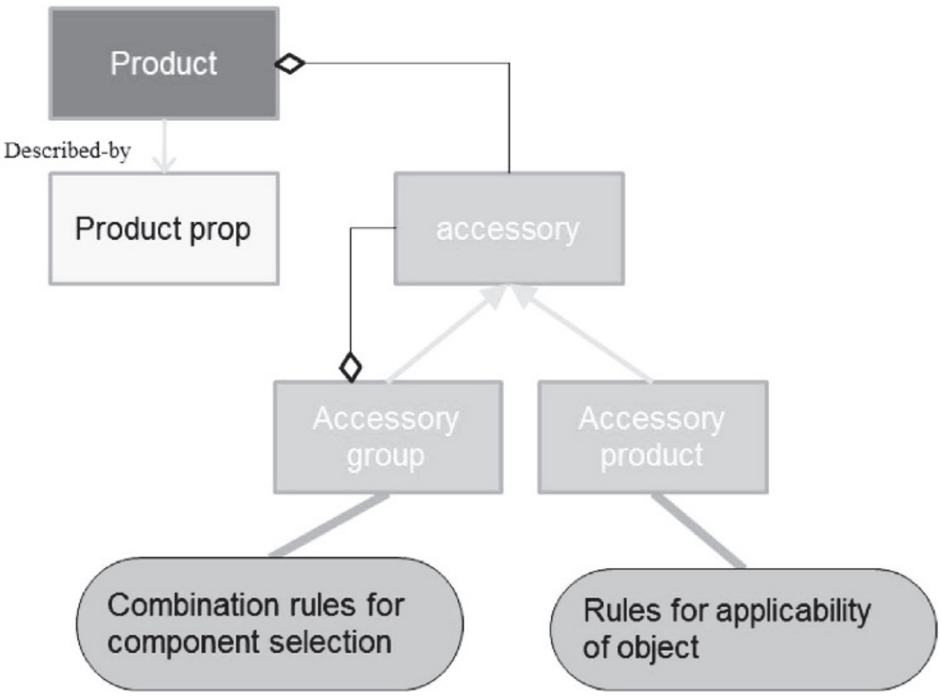


Figure 3 — Accessory tree

The accessory hierarchy basically consists of two types of nodes (see Figure 3):

— Accessory Group

An accessory group represents a set of accessory groups or a set of accessory products. It is identified by a free description or a name, and it determines the minimum and maximum number of elements which have to be selected from the next level. Thus, the group defines whether all of its constituents need to be selected or only one or exactly one, etc.

— Accessory Product

An accessory product represents a single accessory. Accessory products build the leaves of the accessory hierarchy. They determine the number of products which are necessarily bundled (by an attribute called multiplier). Accessory products have further attributes:

— Accessory Description

The accessory description contains the manufacturer's name for the accessory product, article numbers, shipping units, etc. and, if available, an external reference to its product index in the manufacturer's catalogue.

— Accessory Conditions

For an accessory product, a number of accessory conditions may exist. An accessory condition determines under which conditions (values of product properties, application properties, and computable properties) the accessory can be used. Basically, it gives a restriction for which products this accessory product is valid.

— Accessory Geometry Position

Accessory geometry can be taken from an external data file or can be set in the product's data file itself. The 'Accessory Geometry Position' defines the position of the accessory geometry relative to the product geometry.

This results in the following structure of the accessory hierarchy:

Each product index representing a single product can refer to an 'Accessory Group' which builds the root of the accessory selection hierarchy for this product.

An 'Accessory Group' with dependent accessory groups has, as attribute, the minimum and maximum number of dependent 'Accessory Groups' which can be selected.

An 'Accessory Group' can reference 'Accessory Products'. A multiplier allows defining required bundles of accessories by specifying the quantity of such a bundle. The 'Accessory Products' form the leaves of the selection tree. They might refer to another selection tree for dependent accessories.

No loops are allowed in the hierarchy.

Given the possibility that an accessory can be used in several ranges of values (e.g. straight and angular design or two different temperature ranges) or that several ranges of values shall be fulfilled at the same time (e.g. straight design and wall installation or a specific pressure and a specific temperature), the data contain a validity identifier:

— the conditions of data with the same validity identifier apply jointly (AND operation);

— the conditions of data with different validity identifiers apply alternatively (OR operation).

Hence, all conditions of data with the same identifier shall be fulfilled. On the other hand, it suffices if the conditions of data with a single identifier are fulfilled for the accessory product to be selectable.

EXAMPLE The structure of the accessory data tree could be as follows:

```
Acc. group:                   Accessories Selectable: 0 up to 3
Acc. group:                   Installation Accessory Selectable: 0 up to 2
Acc. group:                   |   Wall installation Selectable: 0 up to 2
Acc. group:                   |   | Wall brackets
Acc. product:                 |   | | Multiplier: 1
Acc. product description:     |   | | 4 mounting brackets No. 3210 in package
Acc. condition:               |   | | up to 150 kg load
Acc. group:                   |   | Radiation shield  Selectable: 1 up to 1
Acc. product:                 |   |    Multiplier: 1
Acc. product description:     |   |    Radiation shield No. 43
Acc. group:                   |   |    Fixing clips
Acc. product:                 |   |    |   Multiplier: 16
Acc. product description:     |   |    |   Clips No. 5432
Acc. condition:               |   |    |   dry wall element installation
Acc. group:                   |   |    Fixing bolts
Acc. product:                 |   |       Multiplier: 24
Acc. product description:     |   |       Screws No. 654
Acc. condition:               |   |       concrete wall installation
Acc. group:                   |   Floor installation Selectable: 1 up to 1
Acc. group:                   |     Floor rack
Acc. product:                 |        Multiplier: 2
Acc. product description:     |        Floor rack, green
Acc. condition:               |        up to 2 000 mm length
Acc. group:                   Tools Selectable: 0 up to 2
Acc. group:                   |   Mounting tool set
Acc. product:                 |   |   Multiplier: free
Acc. product description:     |   |   Mounting tool No. 76 for quick installation
Acc. condition:               |   |   …
Acc. group:                   |   Colour aerosol spray cans
Acc. product:                 |   Multiplier: free
Acc. product description:     |   Colour cans No. 8765 to refresh surface
Acc. group:                   Manuals Selectable: 0 up to 3
Acc. group:                     Pipe port advices
Acc. product:                   |   Multiplier: free
Acc. product description:       |   Pipe port advice manual No. 98
Acc. group:                     Electrical Ports
Acc. product:                   |   Multiplier: free
Acc. product description:       |   Electrical Port manual No. 99
Acc. group:                     Shipping instructions
Acc. product:                      Multiplier: free
Acc. product description:          Shipping instructions manual No. 100
```


The selection of accessory could run as follows:

First selection:

```
Accessories
Installation Accessory
Tools
Manuals
```

Selecting ‘Installation Accessory’ leads to:

```
Installation Accessory
Wall installation
Floor Installation
```

Selecting ‘Wall installation’ leads to:

```
Wall installation
Wall brackets
Radiation shield
```

Selecting ‘Radiation shield’ leads to:

```
Radiation installation
Fixing clips — dry wall element installation
Fixing bolts — concrete wall installation
```

Selecting ‘Floor installation’ leads to:

```
Floor installation
Floor rack — up to 2 000 mm length
```

Selecting ‘Tools’ leads to:

```
Tools
Mounting tool set
Colour aerosol spray cans
```

Selecting ‘Manuals’ leads to:

```
Manuals
Pipe port advices
Electrical ports
Shipping instructions
```

7 Representation objects and descriptive objects

7.1 Article numbers

The product article numbers are related to the product index. One product can consist of one or more articles. Each of the articles has the following:

— Manufacturer article number;

— GTIN (global trade item number);

— etc.

7.2 Geometry data

Geometry data are divided into the following:

— shape data;

— symbolic shape data;

— space data;

— surface data;

— port data.

The single product consists of one or more components (see Figure 4). Each part of this assembly is described separately.

Figure 4 — Single Product (heater with heat exchanger and water storage) as assembly of components

Basis for the geometrical objects are CSG-primitives like cubes, cylinders, sweep-bodies, etc. which have been taken from STEP (ISO 10303-42) and IFC (ISO 16739). But to model the geometry of building services products, additional primitives are necessary, in particular, special sheet-metal primitives, like rectangle-round transitions, oval channels, tee-branches, and Y-pieces. These primitives are described in detail in ISO 16757-2.

The primitives can be concatenated to more complex geometrical objects by regularized Boolean operations resulting in an operator tree. Operators are union, difference, or intersection of shapes.

ISO 16757 geometries are defined as parametric 3D-models. This means that similar geometrical objects are defined once in a generic way together with a function which can compute a concrete geometry based on dimensional parameters. For a given product, these parameters can be read from the product property values, and the actual geometric values for the product can be computed.

This calculation has to be done in the engineering system which produces the geometrical representation. To feed this system with the relevant property values, a specific function is defined in ISO 16757 which shall be implemented by the engineering system and provides access to the property values in the catalogue. This function is described in ISO 16757-3.

7.3 Product description

The product description contains describing text and delivery terms for the product. It is referenced by the product index in the same way as properties are. So, the same description can be used for ranges of products with different article numbers.

7.4 Descriptive objects

Descriptive objects can be pictures, drawings, videos, audios, etc. They are represented in separate, accompanying data files, called from the product catalogue data file by external references.

All product properties which define the selected product can be accompanied by descriptive objects. Descriptive objects are selected together with the product.

Pictures can explain the properties to the user, videos can show how the product is implemented, and drawings can give advice for installation and service. Every data with product properties can have an external reference to descriptive objects.

8 Requirements to implement ISO 16757 in engineering systems

This International Standard defines metadata for a catalogue and the catalogue data itself. The particular aspect of this International Standard is its possibility to describe dynamic properties and parametric geometries by means of functions. Thus, an engineering system which takes the information from the catalogue in its entirety has to be capable of executing these functions. To do this, the engineering system has to provide the following features:

a) The engineering system shall be able to parse the ISO 16757 catalogue and to provide the hierarchical search to allow the selection of products from the catalogue.

b) The engineering system shall implement the language defined in ISO 16757-3.

   NOTE This can be done in several ways, e.g. by translating the language constructs into elements of the system's internal script language or by providing a language interpreter.

c) In the function bodies which are part of the product catalogue, it is necessary to access product data in the catalogue, mainly technical properties. To support this data access, in ISO 16757-3, a number of abstract access functions are defined. The engineering system shall implement these access functions to enable the access to property values and other catalogue data when executing the functions.

   Manufacturers can provide an alternative to the exchange of function implementations: They can provide services which compute the dynamic property values or the dimension specific geometries. In that case, the software has to support calls to these external functions.

d) Many parameters of the functions of dynamic properties are BSS properties describing a specific state of the overall system. When the function is executed, then the engineering system has to feed the relevant property values as parameters into the function. This requires a mapping of internal properties used by the engineering system to BSS properties which are defined in the Part for the respective product class.

9 Data model

The previous chapters have described how the exchange of product information in electronic catalogues has to be performed in the case of highly configurable products having complex and dynamic technical properties. In this chapter, a model will be developed which forms the basis for ISO 16757-2, ISO 16757-3, and ISO 16757-5 which contain the concrete specifications for the representation of geometry, functions, and exchange format.

This International Standard allows for the representation of information on two levels:

a) definition of product groups and the resources which exist to describe them in Content Parts (ISO 16757-10 et seq.), and

b) electronic catalogues in accordance to the definition of the product groups.

Based on these resources, the content parts of this International Standard can be defined and the catalogues can be generated by manufacturers and interpreted by users according to the content parts.

This chapter summarizes and formalizes the meta model elements which have already been discussed in the previous chapters and which build a meta model for the definition of product groups.

This model will be extended in other parts of this International Standard: In ISO 16757-5, a model of property values and their relationships is defined as a basis for the XML exchange format for e-catalogues. In ISO 16757-3, basic operations and functions are defined which build a programming interface to access elements of catalogues. In addition, ISO 16757-3 also defines the script language which is used for formulating the functions of dynamic properties.

9.1 Properties

Properties are the central elements for describing products of a product class in electronic catalogues. The properties which are used in this International Standard are comparable to properties defined in other standards like IFD (ISO 12006-3) or PLIB (ISO 13584-42). But this International Standard defines structures on top of these properties which allow relating them for selection purposes and for describing dynamic characteristics.

Properties are always related to a product class and they can be interpreted correctly only in the scope of this product class. It is required that any property defined for this International Standard is specified in a property dictionary, either in a dictionary provided by ISO or IEC (e.g., the IEC component database, IEC 61360) or in a publicly available dictionary of an industry consortium which can be uniquely referenced (e.g., the bSDD). Any property shall be identified by a world-wide unique identifier, possibly by more than a single one. This can be done by a globally unique identifier (GUID) as in bSDD or by an identifier according to ISO 29002-5.

In the following subsections, the various perspectives under which properties can be described and the various relationships between properties are introduced in detail.

9.1.1 Technical perspective of properties

In this subsection, different kinds of properties are introduced. Depending on the kind, a property defines different structures for conveying information about products in the property values.

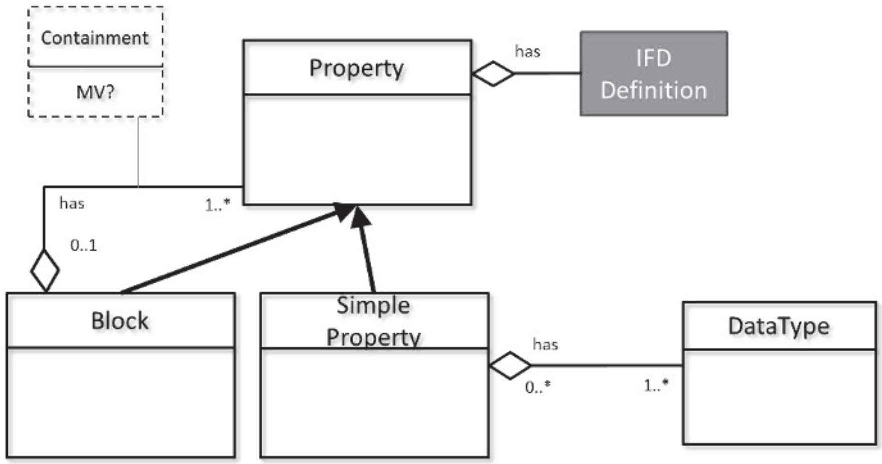


Figure 5 — Simple properties and blocks

Properties can be simple or complex (see Figure 5). Complex properties (called blocks) comprise a number of other properties. Properties which are part of a block can be characterized as multi-valued, i.e. in a catalogue. These properties can have more than a single value within an instance of the block.

Each simple property has a data type. Basically, three data types are distinguished:

— Numeric

— String

— Function

Numeric properties specify numeric property values of any kind (integer, float, etc.).

String properties specify character strings of any length.

Functional properties are numeric or string properties and contain a function specification (basically the parameters which go into the function) which can be used to compute the actual value of the property. More details will be given in the following sections.

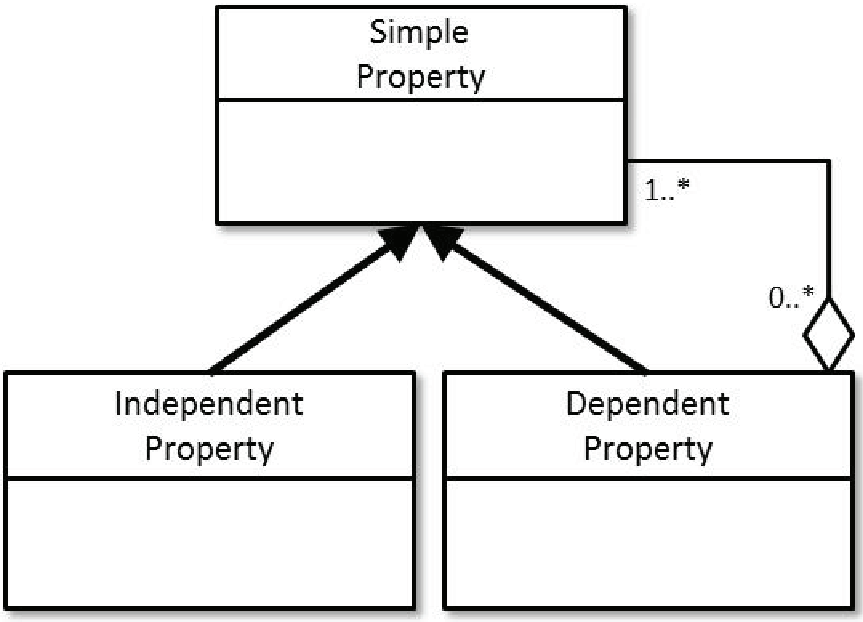


Figure 6 — Dependent properties

Properties may have values which are dependent on the values of other properties. For example, a physical value like the length of a piece of metal is dependent on its temperature, time is dependent on speed, etc. This is modelled according to PLIB (ISO 13584-42), as shown in Figure 6.

Properties can be independent, i.e. they are not dependent on other properties. Actually, this will often mean that the dependency is not relevant and therefore not captured in the product model. A dependency is specified by a dependent property which is linked to one or several (condition) properties from which its value is dependent.

A dependent property can have different values for different conditions. For instance, the length of a product might vary depending on its temperature. In this International Standard, the values can be calculated by a function (see below). Thus, dependent properties are always functional properties.

9.1.2 Content perspective of properties

Another perspective from which properties can be examined is their use in different areas of the standard, i.e. the role of the property.

This International Standard distinguishes three roles (see Figure 7):

a) Catalogue Property: The property describes the catalogue, i.e. it is not part of the product description, but describes aspects of the exchange of product data, as for instance, the creation time of the catalogue, etc.

b) Product Property: The property describes the product itself, i.e. it is a property which can be used, e.g. for product selection, product visualisation, or product simulation.

c) Building Services System Property (BSS Property): The property describes the installation environment of a product, as for instance, the temperature or mass flow of the inflowing water of a heating device. In this case, the property will be used as a parameter for calculation functions which compute dynamic characteristics of a product under specific conditions.

The product properties can be further split:

a) Selection properties allow the selection of a product from a series of products. If all selection properties are specified, a single product is identified.

b) Technical properties describe the technical characteristics of a product which are used to design or simulate a building services system. Technical properties can be further split into Static Properties which carry the static characteristics of a device like dimensions, materials, etc. and Dynamic Properties which specify the dynamic behaviour of a device under different circumstances.

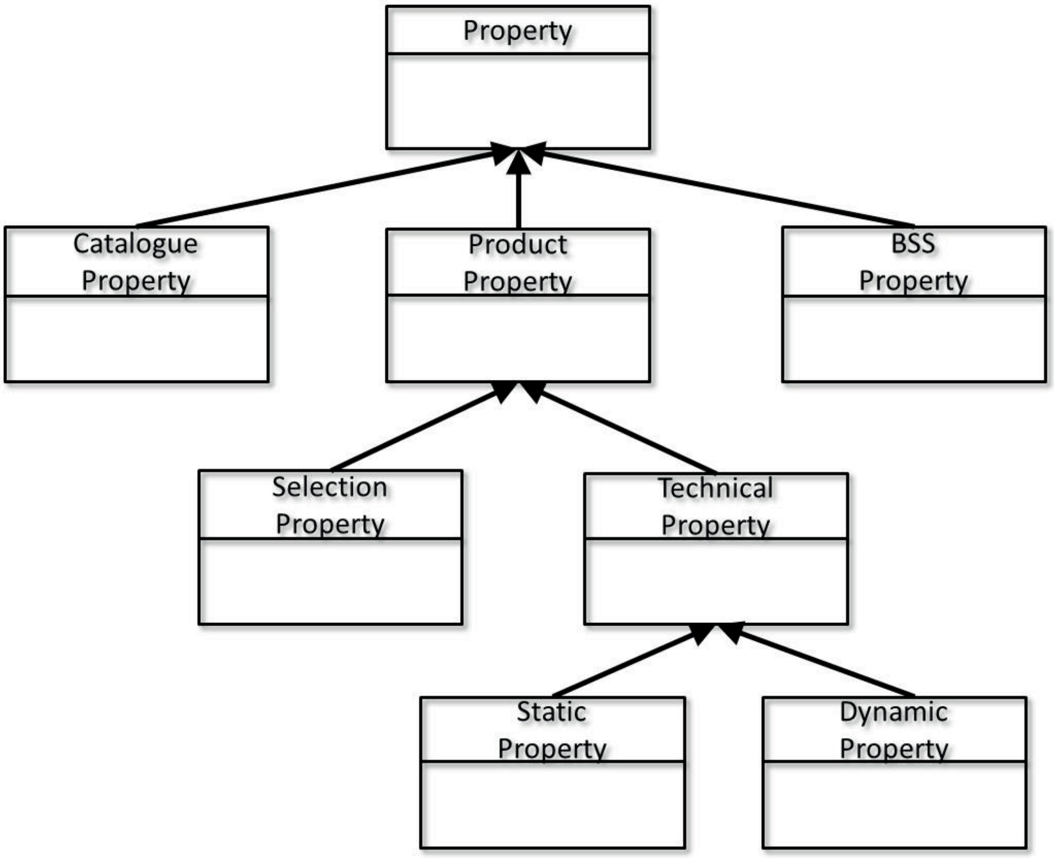


Figure 7 — Roles of properties

The relationship between the content perspective and the technical perspective of properties is as follows:

— Catalogue properties and selection properties are always independent properties. They are not dependent on a condition property.

— BSS properties are used as condition properties. They specify external conditions which influence the behaviour of a product which is represented by one or several dependent technical properties.

— Technical properties comprise any kind of property:

  — static properties are independent properties, which describe static characteristics of a product like length or height (in which case the dependency to temperature is neglected because it is not relevant);

  — properties, which influence the behaviour of the product like the status of control elements;

  — dynamic properties, which describe the behaviour of the product in dependence of external conditions (BSS properties) or the product status.

9.2 Selection properties and the selection property hierarchy

Selection properties are used for selecting a single product from the set of products in a catalogue. They are separated from the technical properties because they are used in the selection process rather than in the design and simulation of the building services system. They are supposed to be displayed to humans for selecting products. As soon as a value has been chosen for all selection properties, the product is identified.

To fulfil this purpose, selection properties are restricted to be

— simple properties, i.e. a selection property cannot be a block,

— independent properties, i.e. there does not exist a value dependency to other properties, and

— string properties.

A further characteristic of selection properties in this International Standard is their incorporation in selection hierarchies which guide the selection of products from the catalogue. In the model, the position of a property in the hierarchy is imposed by proxy objects, so that the properties are not directly related to each other. A proxy object (or proxy for short) represents a property in the hierarchy. A property can be represented by more than one proxy, i.e. the property may appear at several positions in the hierarchy. The proxy can be related to a number of sub-proxies representing the properties of the next lower level in the hierarchy. Often, the proxies are unified with the properties they represent and are called sub- and super-properties of another property.

The selection hierarchy specifies the selection process in which a product is selected from the set of products of a catalogue. Positioning properties B and C below a property A can have one of the following two reasons:

— Specialization of the type of the product: If properties B and C are sub-properties of property A, then there can be an existence dependency of B and C from the values of A. For instance, the property A may have a controlled list of values defining the potential types of heating devices. When a specific value for A has been chosen, then only one of the sub-properties is meaningful for the selected product type. Thus, the value of A specifies the type of the actual product, and depending on the type, either property A or property B can be used to describe the product.

EXAMPLE (Taken from VDI 3805-29): The property A may have two possible values: 'fitting' and 'pipe'. If the value is fitting, then only fitting-related properties can be used; if the value is 'pipe' then only pipe related properties can be used. Thus, the two branches of the hierarchy below property A are exclusive; only one can be used for describing a product.

— Defining the search sequence: The product selection process follows the selection hierarchy: In the first step, the value of the higher level property is determined, and afterwards, the values of properties of the next level are selected. The search process does not impose any order on parallel branches, but it enforces the search order from the root of the hierarchy down to the leaves.

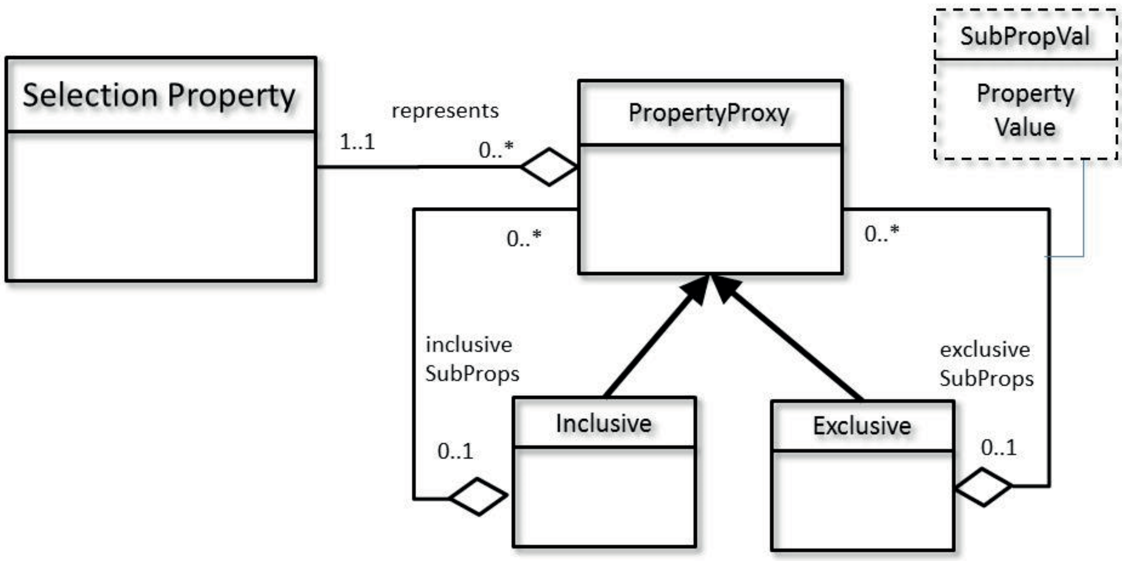


Figure 8 — Selection hierarchies of selection properties

According to these different kinds of relationships, there are two types of proxy objects (see Figure 8):

a) An inclusive proxy allows the use all properties of the next level for the description of a product. Thus, if a property A is represented by an inclusive proxy and has sub-properties B and C, then a product can be described in addition to values of A also by values of B and C. During the product selection process, B and C values can be selected in any order after the A value has been selected.

b) An exclusive proxy enforces the selection of exactly one of the sub-properties. Within a single product, only one of the sub-properties shall be used. Thus, if a property A is represented by an exclusive proxy and has sub-properties B and C, then a product can be described either by properties A and B or by properties A and C, but B and C shall not be used within a single product. The selection of the sub-property is determined by the value of the property, i.e. in the example, the value of A determines which of the sub-properties becomes meaningful for the product. In other words, the value of property A determines the type of the product, and depending on the type, only specific further properties are meaningful for the product.

In the model, the value which determines the sub-property is linked to the exclusiveSubProps relationship as an attribute.

EXAMPLE In Figure 9, property A is an exclusive node in the hierarchy (illustrated by the white box), whereas B, C, D, E, F are inclusive nodes (illustrated by the dark boxes). The white boxes on top of the sub-properties of A contain the property values of A which determine the usage of this property. There can be several values which determine the same sub-property.

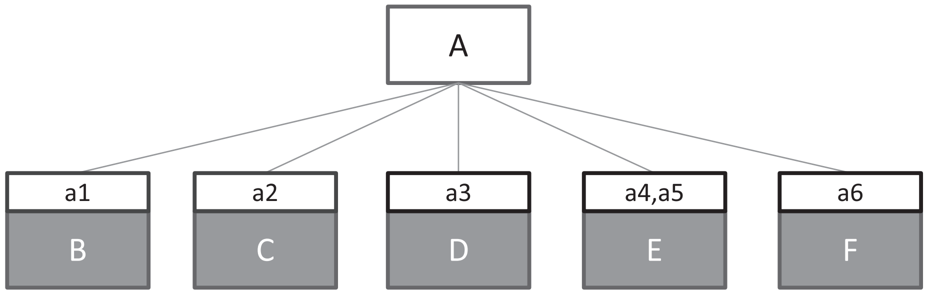


Figure 9 — Selection hierarchy with exclusive property proxies

EXAMPLE Figure 10 shows an example (taken from VDI 3805-5) which describes the product class of air ducts. It shows that different proxies may represent the same property. This is indicated by proxies with the same hatching.

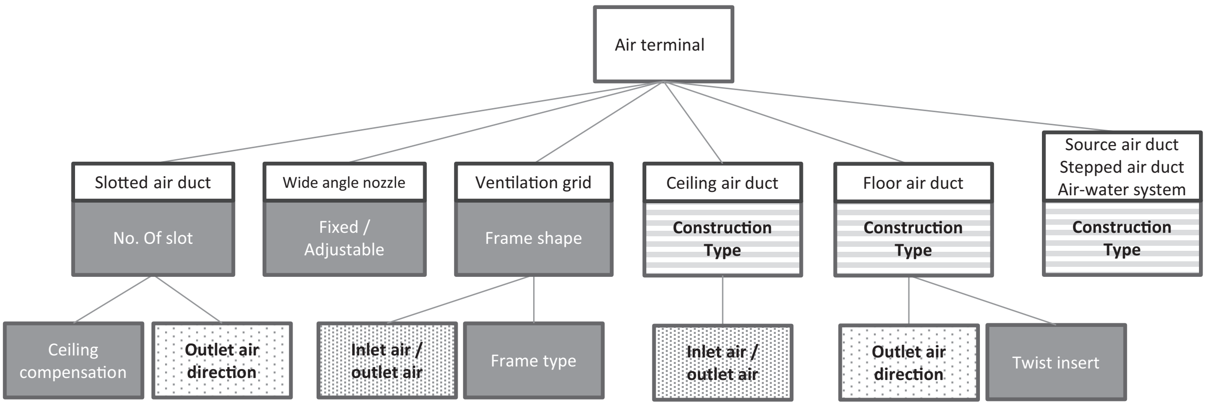


Figure 10 — Selection hierarchy according to VDI 3805-5

9.3 Technical properties

Technical properties allow the description of static and dynamic technical aspects of products. Static aspects (which are fixed for the product) are represented by independent properties, dynamic aspects (which vary according to various conditions) are represented by the dependency between dependent properties and their condition properties.

Technical properties can be

— simple properties or blocks,

— of any data type, and

— dependent, independent, or condition properties, and the dependent properties are represented by functional properties.

Technical properties are often structured in a hierarchy of blocks. This provides the possibility to structure the design properties and to deal with multiple instances of properties (which is possible by means of the multi-valued flag; see Figure 5). Multiple instances of a property appear if multiple substructures of similar kinds have to be attached to a product or a part of the product. For instance, a pipe can have different separated layers which allow the transport of outgoing air and of fresh air within the same pipe. To describe such a pipe, these two layers and the boundaries between them have to be described. If a block B is defined which contains the properties to describe such a layer, then in a catalogue, this will lead to two (or in other cases more) instances of B which belong to the same upper block representing this pipe.

A dynamic property does not have a value which can be transmitted in a catalogue. Instead, the property value has to be computed for a given situation. Rather than providing a value for such a property, a catalogue has to provide a rule or an algorithm defining how this value can be calculated under the condition which the product has to face in a specific system.

Therefore, a dynamic property is a functional property and carries a function to calculate the actual value. This encompasses two elements (see Figure 11):

a) The property definition (e.g. in one of the content Parts of this International Standard) contains a function specification comprising a definition of the function header (name, parameters) and a definition of its purpose. The parameters of the function include at least one BSS property, and the values for the BSS properties are given in the calculation process by the application system which is used to design the system.

b) The property value contains an implementation of the function. Thus, the manufacturer can put his knowledge about the behaviour of the product in the implementation of this function. As a result, the description of the behaviour of a product follows a standardised template (functional property with a function specification) but contains the knowledge of the manufacturer about the exact behaviour of his products (manufacturer specific implementation).

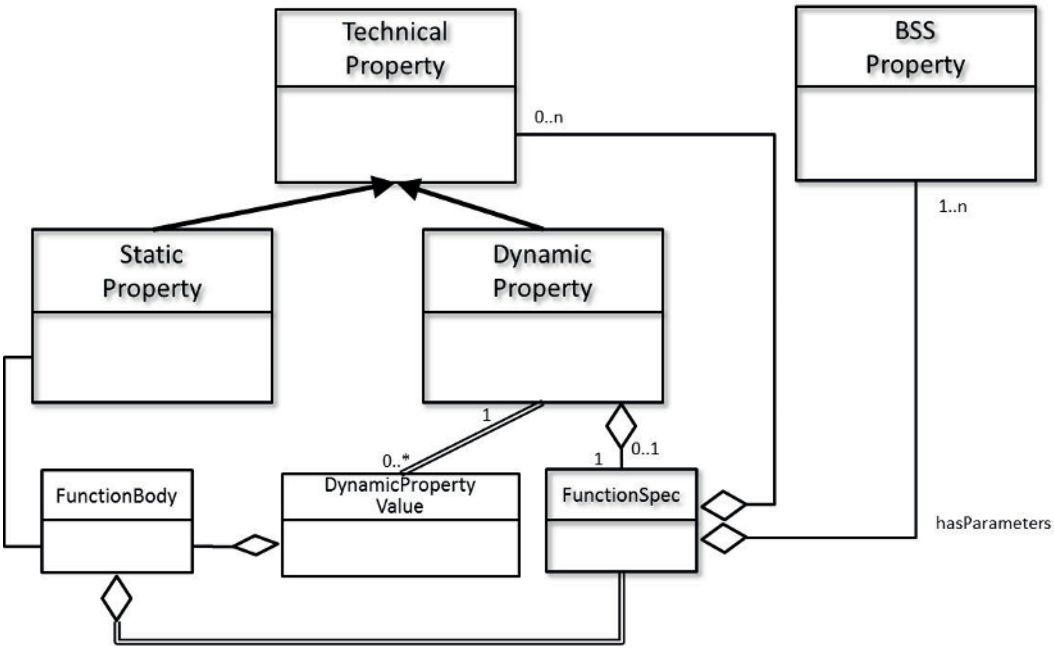


Figure 11 — Dynamic properties

The definition and implementation of the functions is formulated by the ISO 16757 script language (see ISO 16757-3). Another possibility is that the manufacturer gives a reference, for instance, to a Web Service, which can be called by an application system to get the value of the dynamic property for a specific system state.

10 Embedding of product data of selected products into the building information model

A building information model describes a specific building object over its whole life cycle, including the phases of

— Design,

— Construction,

— Operation and maintenance, and

— Deconstruction.

So it accompanies the building during its whole life. Product data of the building services products constitute a very important part of the building information model.

Together with the Building Services data, the constructors data, and the FM data, the product data coming from this International Standard will be incorporated and embedded into the building information model (see Figure 12).

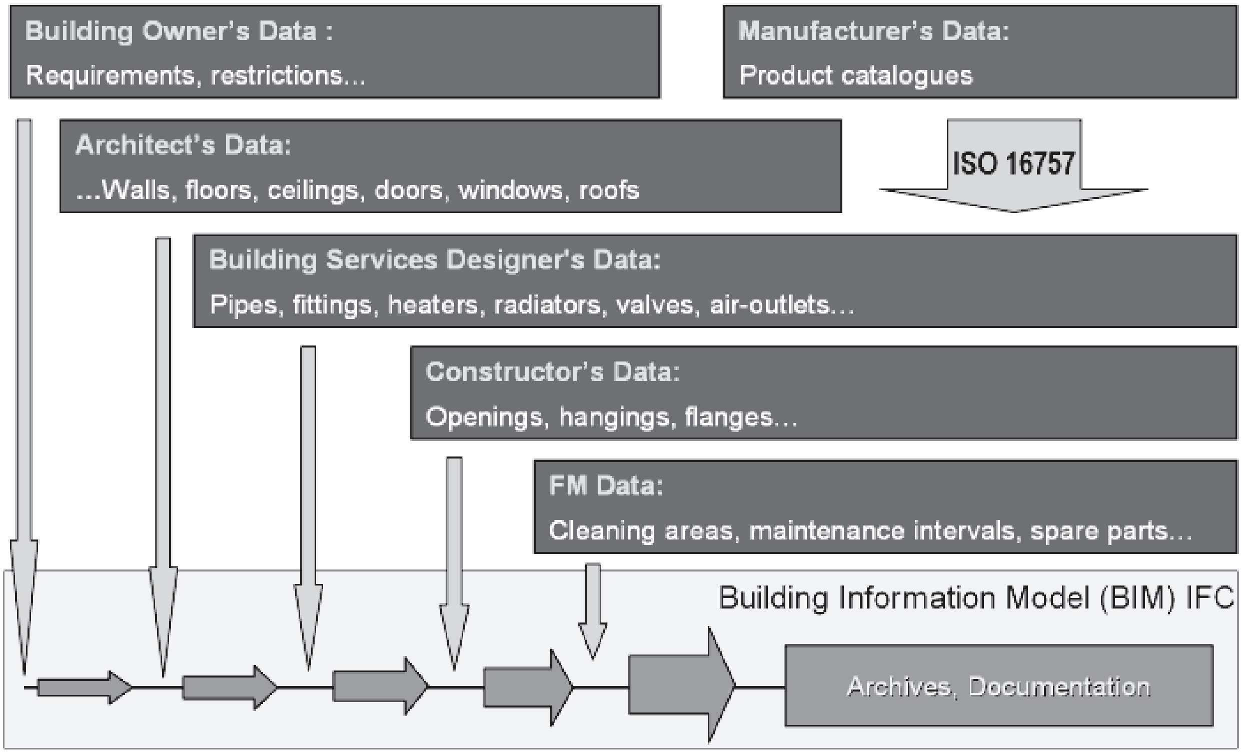


Figure 12 — Integration of ISO 16757 into BIM

All the selection properties of the selected single product will be mapped to IFC properties.

Design data for building services components is a new kind of data which is, to a large extent, not yet available in IFC. Therefore, these properties have to be taken over into the building information model in the form defined by this International Standard. The same applies for the functions.

If all these data can be transmitted into the building information model, then it is possible to redesign the Building Services system models from the building information model. Thus, the building information model of a building can be used to recalculate and simulate the building for various changes like incorporation of new building services products, redesign for an extension of the building, etc.

More details on the relationship between this International Standard and building information model standards can be found in ISO 16757-4.

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