TECHNICAL REPORT

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Symbol libraries for construction and facilities management

Librairie de symboles pour la gestion de la construction et des aménagements

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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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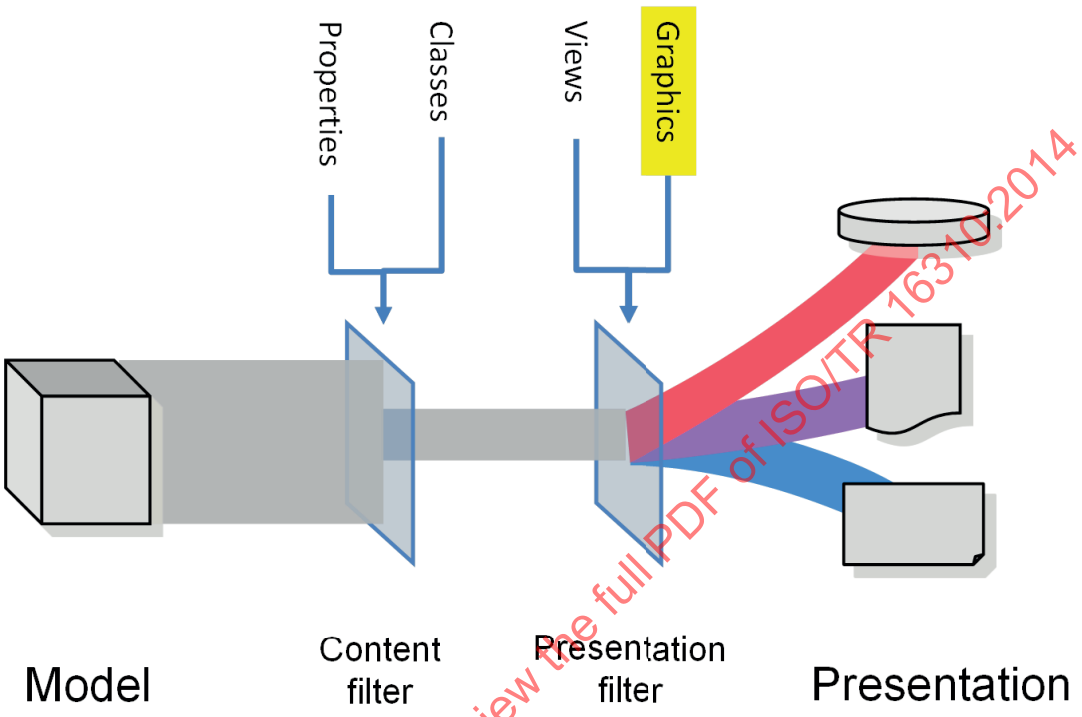
For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 10, *Technical product documentation*, Subcommittee SC 8, *Construction documentation*.

Introduction

Drawings, documents, and other presentations are increasingly being derived from models instead of being produced independently. The content, text, and graphics of the presentation are defined by applying rules, filters, to the model.



a) **Content** is selected from the model by using classification or other properties of the objects therein.

b) **Appearance,** using the presentation filter, is defined by selecting views, including formatting of content, and applying graphics. The graphics can be taken directly from the model but is often simplified and/or made more distinct by using **symbols** or simplified representation.

c) **Presentations** in the form of text, drawings, images, or other forms are the result, to be viewed on screen or printed.

Technical documentation relies heavily on graphics, whether it is presented on paper as drawings, or displayed on a computer screen. Also, much of the graphics is usually in the form of symbols or simplified representation. A symbol is a shape or a sign which represents something else, like the "flag" that symbolizes a light switch, while simplified representation resembles the object, and has physical dimensions equal to the object.

Standardized symbols play the role of a uniform (non-lexical) language that is understood in the same way by different readers. The potential benefits of using standardized symbols include savings in producing models and documentation, but above all, they serve to facilitate the efficient use of the documentation, and not least to avoid costly mistakes caused by misinterpretation.

This Technical Report investigates the needs and requirements within the construction and facilities management sector for symbol libraries, in digital form as well as the conventional printed form. Which libraries are needed? And how should they be defined, distributed, and maintained? The conclusions will be used to make decisions on future standardization.

Present standards for construction-related symbols have been created mainly to support uniform appearance on paper drawings produced by different authors.

The need for libraries of agreed symbols has not diminished over the years, but new issues related to the use of symbols have surfaced as practice has shifted from manual drafting to the use of computers

for producing drawings and CAD/BIM models. Also, the roles of national and international standards have changed over the past few years. Overlapping parts of national and international standards have required the withdrawal of national standards without them being fully replaced by international standards. In particular, this applies to Europe, where published EN standards must not in any part be conflicting with national standards. Altogether, there is a need for a new approach to symbol standards.

This Technical Report is the outcome of a proposal for a joint effort of the committees ISO TC 10/SC 8, *Construction Documentation*, and ISO TC 59/SC 13, *Organization of information about construction work*.

In the final section of this Technical Report are recommendations for future standardization work, for sharing and discussion within the standardization community, in particular ISO TC 10/SC 8 and ISO TC 59/SC 13. Also, the work should be coordinated with standards and activities of buildingSmart International. The intended goal is to arrive at a common roadmap. Out of this, concrete standardization efforts can be initiated and carried out.

Symbol libraries for construction and facilities management

1 Scope

This Technical Report intends to specify the requirements and needs for supplying and managing standardized symbolic descriptions of objects that need to be specified in the construction process. Within this context, the term "symbol" is interpreted to cover pure symbolic presentation as well as simplified representation of geometrical shapes of objects.

2 Existing standards

The present situation is that standards are available only for some arbitrary categories of symbols, not covering the everyday needs of those producing and using documentation for buildings and civil works. The following table shows a brief review of ISO and EN standards as well as national standards for some countries. It is not a complete list but rather examples of the present situation.

Standard number	Title
ISO	
ISO 3766	Construction drawings — Simplified representation of concrete reinforcement
ISO 7518	Technical drawings — Construction drawings — Simplified representation of demolition and rebuilding
ISO 5261	Technical drawings — Simplified representation of bars and profile sections
ISO 5845 (all parts)	Technical drawings — Simplified representation of the assembly of parts with fasteners
ISO 6411	Technical drawings — Simplified representation of centre holes
ISO 6410 (all parts)	Technical drawings — Screw threads and threaded parts
ISO 4067-2	Building and civil engineering drawings — Installations — Part 2: Simplified representation of sanitary appliances
ISO 14617 (all parts)	Graphical symbols for diagrams
ISO 1219-1	Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphical symbols for conventional use and data-processing applications
ISO 11091	Construction drawings — Landscape drawing practice
ISO 7519	Technical drawings — Construction drawings — General principles of presentation for general arrangement and assembly drawings
ISO 7437	Construction drawings — General rules for execution of production drawings for prefabricated structural components

Standard number	Title
ISO 2553	Welded, brazed and soldered joints — Symbolic representation on drawings
ISO 6790	Equipment for fire protection and firefighting — Graphical symbols for fire protection plans — Specification
ISO 128-50	Technical drawings — General principles of presentation — Part 50: Basic conventions for representing areas on cuts and sections
EN	
EN 1861	Refrigerating systems and heat pumps — System flow diagrams and piping and instrument diagrams — Layout and symbols
SS - Swedish Standard	
SS 32269:2008	Construction drawings — Representation of fasteners
SS 32268:2008	Construction drawings — Representation— Beams and columns of steel
SS 32267:1994	Construction drawings— Representation — Excavation drawings
SS 32270:1994	Construction drawings — Symbols and designations for fittings
SS 32264:1993	Construction drawings — Representation on drawings for drainage, water services, heating and mechanical ventilation
SS 32260:1986	Construction drawings — Installations — Symbols and designation for heating, ventilation and sanitary installation and for automatic control
SS 32231:1974	Symbols and designations for refrigerating plants
NS - Norwegian Standard	
Not updated:	
NS 2410:1984	Technical drawings — Building drawings — Drawings for structural metal work
NS 3037:1975	Building drawing — Drawings for concrete components
NS 8313:1983	Building and civil engineering drawings — Simplified representation of fittings
NS 8330:1982	Building and civil engineering drawings — Drawings for construction of reinforced concrete
NS 8331:1982	Building and civil engineering drawings — Symbols for concrete reinforcement
NS 8340:1987	Construction drawings — Installations — Graphical symbols for plumbing, heating, ducting and ventilation
NS 8341:1987	Construction drawings — Installations — Simplified representation of sanitary appliances
NS 8342:1987	Construction drawings — Installations — Graphical symbols for automatic control

Standard number	Title
NS 8343:1987	Construction drawings — Installations — Graphical symbols for refrigerating plants
NS-ISO 6790:1986	Equipment for fire protection and fire protection plans — Specifications
BS - British Standard	
BS 8541-1	Library objects for architecture, engineering and construction — Identification and classification — Code of practice
BS 8541-2	Library objects for architecture, engineering and construction — Recommended 2D symbols of building elements for use in building information modelling
BS 8541-3	Library objects for architecture, engineering and construction — Shape and measurement — Code of practice
BS 8541-4	Library objects for architecture, engineering and construction — Attributes for specification and assessment — Code of practice

In the process of producing symbol libraries, each standardization project should include further research about existing standards within its scope.

3 Ongoing standardization related to symbols

3.1 BIM

3.1.1 Current standardization revolves to a great extent around building information modelling (BIM). Coordination with product modelling efforts such as Standard for the Exchange of Product data (STEP) and buildingSmart is naturally of the essence, and should contribute to the presentation facilities of product models.

3.1.2 IFC, Industry Foundation Classes, is a buildingSmart specification for the structure and format for the exchange of building information models and their objects. The current IFC version, IFC 4, has been approved as an International Standard, ISO 16739.

3.1.3 buildingSmart data dictionary (previously IFD), also a buildingSmart initiative, is a publicly accessible database to hold the terminology to use for properties connected to different classes of objects in an object library. The properties are identified in a language-independent way, making it possible to exchange objects across system borders and languages. IFD is work in progress, and so far suggestions for properties within a limited number of object classes exist.

3.1.4 IDM, Information Delivery Manual, specifies a method for defining information sets to be exchanged between systems. The method takes its starting point in a process map for the process to be supported, then further specified into exchange requirements, and finally detailed to describe the functional parts, i.e. the units of information to be exchanged. The general description has been approved as a part of an International Standard, ISO 29481-1, and one more part of the International Standard is being produced, for management communication.

3.1.5 MVD, model view definitions, specifies a subset of IFC standard objects to be used in specific information exchanges, as a technical implementation of the IDM. A number of MVD's are being defined by buildingSmart International, but are not yet broadly adopted in the market.

3.1.6 BIM guidance, ISO/TS 12911, suggests a framework for BIM manuals on the generic level. The framework is intended as a basis for further detailing appropriate on different levels such as the national level, the company level, or the construction project level. Possible connections to symbols are the prescription of symbols and symbol libraries to be used as well as the process of retrieving, exchanging, and storing them.

3.1.7 Product data for building services systems models, an ISO TC 59/SC 13 work item, is to offer a common interface which allows the uniform handling of data relating to building service sectors about technical, commercial, maintenance, service, as well as geometric data, images, video, and text information. The general description has been under development as an International Standard, ISO 16757-1:—. The proposed part 2 and part 5 of ISO 16757 are to, respectively, deal with geometry and product catalogue, to which the symbol library issue will be closely related. An important aspect of the International Standard is that it deals with parametric representation of objects.

3.2 Distribution

3.2.1 Within IEC, the use of databases for symbols and other libraries is a reality for a number of years already. Maintenance teams are responsible for adjusting and developing the libraries in a smoother way than the revision procedure for an International Standard requires. The experience from this should be further investigated.

3.2.2 ISO OBP (Open Browsing Platform) contains a collection of concepts, terms, and symbols. It is fully operational but there are suggestions for developing it. In particular, there is a demand for establishing a structure that allows symbols and terms to carry the requirements of the International Standard. Essentially, the entire International Standard should then be available in the database, not just the representation of separate symbols. Also, the format for symbols needs to be revised to allow for use in CAD/BIM application software.

3.3 Other disciplines

Within ISO TC 10/SC 10, symbols for the process industry are being developed, in particular for use with process diagrams. These International Standards have several objects in common with building services systems, such as pumps, valves, and fans. Main products are ISO 14617 (all parts), ISO 10628 (all parts), ISO 14084-1:— and ISO 14084-2:—, and ISO 15519-1 and ISO 15519-2:—.

4 Objects and symbols

4.1 Representation and presentation

4.1.1 Overview

Any **representation** of a real-world (physical) object consists of a set of data corresponding to it. The same applies to any other (intangible) phenomenon which needs to be represented in a model-based construction process. The data for the object are always a subset of the potential complete description of the object, containing a number of properties that are perceived. In most cases, the properties are a subset adapted to the intended use of the data.

For example, the representation of a tree, in a literary text, can consist of a description of the way it looks, how it moves in the wind, and how the bark feels to the hand. A representation of the same tree, for the use of a landscape architect, can instead contain the name of the species (identifier) as well as some properties that are useful for purchase, planting, and maintenance. Thus, the same phenomenon can be represented by a number of “aspect” objects, such as a floor slab as seen by the architect vs. the structural engineer.

The **presentation** is a view of the object data, intended for a specific purpose. A symbol is a graphical presentation of the object, suited for use on a drawing or a diagram, etc. In addition to line graphics, selected

properties can also be displayed as annotation. Symbolic presentation aims at improving readability of the document for the intended use, by being easily recognizable as opposed to the geometry of the physical object (which can be similar for widely different functions) and by sorting out irrelevant information.

Type and **instance** are two states of the representation. A type object defines the properties but does not contain the actual data for each property. When a type object is instantiated, the object will be populated with individual property data, such as its location, individual identity, and perhaps also colour, size, connections to other objects, etc. The graphics presented as a symbol are specified by the type, but the definitive appearance may be modified when the object is instantiated, by setting properties that affect the graphics.

In conclusion, symbol libraries should contain graphics for presentation, but the presented symbols are also connected to an underlying representation of objects. The symbol illustrates one or more of the properties of a represented object. The presentation is also often adjusted to the individual situation, with respect to the instantiation of a type as well as to the intended use of the document where the symbol appears. In the following subclauses, the types of variations are investigated more in detail.

4.1.2 Presentation views

The presentation of an object is strongly connected with the intentional specification on how to visualize a specific aspect of the object model representing the object. A presentation view will need to be this kind of an intentional way of recognition.

A symbol is a specialized visual model of a product with an intentional view how to communicate the desired aspects of the object to relevant parties. A symbol of an object has a so-called mapping relationship with the original object, which may be a 3D, 2D, or non-dimensional (no geometry) existence. The symbol is considered in itself to be a displayable object for communication and can both be 3-dimensional and 2-dimensional in existence, although 2D symbols are by far the most common.

EXAMPLE 1 North point: 2D symbol for a non-dimensional object.

EXAMPLE 2 3D House or cube: 3D symbol for viewing projection.

EXAMPLE 3 Door: 2D symbols for 3D object.

Symbols must have several essential factors to be identified and inter-operatively communicated in order to cope with these technical requirements. Major factors are

— presentation contents/detail,

— dimension,

— projection method,

— scale, and

— presentation style.

Symbol libraries should cope with these factors from the point of presentation view.

Presentation contents are those which should be delivered to receivers and need to be identified in advance with common understanding between related parties, that is, senders/providers and receivers. There are currently some specifications, e.g. in the U.S.A and Denmark, that define predefined levels of detail or levels of development (LoD) that should be considered in order to specify the relevance of the supplied information with respect to its purpose within a specific period of its lifecycle. How to determine the detail level of presentation is just the same task with this consideration. IDM-like specification rules are quite effective to determine which items will be delivered. IDM, Information delivery manual, has been developed by ISO TC 59/SC 13 and can identify delivering contents through individual processes in a formal and standardized way.

Dimension of the presentation is also a main factor of the presentation view. 2D symbols have long been used in conventional presentation using paper drawings, but the advancing use of ICT makes it quite

useful to present information in 3D visualization way on screens or electric monitors. Symbols can be 3D objects and displayed as such with flexibility of viewing control methods. VR (virtual reality) and AR (augmented reality) have a wide possibility to utilize this kind of presentation. Symbol libraries have to be implemented to bring in both 2D and 3D symbolic objects.

Projection methods have been key factors for graphical presentation and ISO 5456 has been published with a title, projection methods, including fundamental theories and various kinds of individual projection methods. 2D symbol objects need to be referred by a specific projection method for practical use in paper-oriented drawing sheets or monitors. A drawing sheet may have several presentation view ports with different projection methods or scales and so on. There is a possibility to handle it in sophisticated way, but how to manage this issue depends on individual ICT applications and is out of scope of this Technical Report.

3D symbol objects may be dealt with in two different ways. One way is similar to 2D symbols; conventional projections of the original 3D symbol model are derived by calculation and used as such. The other way is without intrinsic projection method; the object is displayed dynamically on screen with altering presentation view using a view controlling systems.

Scale as a property affects how objects should be presented when printed or displayed. How scale is dealt with depends on whether symbol objects stored in libraries are parametric or non-parametric. For non-parametric objects, it must be decided in advance of usage which values should be allocated. The size of displayed symbols is determined by the original size of stored symbols and required presentation of scale. Coordinate systems are also transformed through source coordinate systems, view-port coordinate systems, and drawing sheet coordinate systems. Presentation contents have to be determined to be optimized in scale, and may be changeable according to various scales used for presentations. At a small scale the symbol graphics may be considerably reduced compared to a large scale presentation. Too complex contents could reduce the recognition of symbols. There is an increasing demand for dynamic scaling of symbols, where the symbol size and content adapts to the view and the type of device used.

Presentation style is the function to individually deal with presentation of objects and their appearance. Presentation styles normally consist of line type, line width, colour and hatching type, etc. The style may be adjusted to suit the purpose of the presentation, e.g. a symbol of the same object may be differently presented by the architect and the HVAC designer, or depending on whether the object is to be added or removed/demolished. The style can be predefined and conform to standardized conventions.

4.2 Classification

4.2.1 General

Classification is a key property for objects, grouping them according to some subdivision that is useful for a certain purpose of their use. Symbols are classified by their reference to objects.

4.2.2 Schemas

Classification schemas specify the structure of the classification and define the individual classes. Schemas are mostly hierarchical, meaning that there are some general classes divided into subclasses, on two or, usually, more levels. When a hierarchical schema is used, this means that the object is positioned in the hierarchical context and can be grouped or sorted on the suitable level. Classification can also be faceted, combining multiple concepts into one schema.

4.2.3 Classification and identification

While classifying groups of objects into classes, there is also a need to identify each occurrence of an object. There are systematic approaches for identification, aiming at securing that each object is uniquely identifiable. Relevant International Standards for identification and reference designations of symbol instances are ISO 4157 and ISO/IEC 81346, respectively.

4.2.4 Multiple classifications

Because objects are used for different purposes along the construction and facility management process, there is a need for classifying an object in more than one way. The multiple classifications will serve the purposes of

— search and retrieval of a symbol in a repository, and

— filtering symbols for presentation.

The concept of multiple classifications means that an object can belong to more than one class within a specific classification table, but also that it can be classified by more than one classification table.

EXAMPLE 1 A component that combines a pump and a valve belongs to both these classes and can be retrieved by searching for either of them or a combination of both (search for all pumps, all valves or all pump-and-valve combinations).

EXAMPLE 2 In a project, national tables for two countries are used, in order to integrate with other systems in each country. For example, the client from one country and the main contractor from another country both need to use their own systems for procuring services and material.

EXAMPLE 3 A part of the building is classified according to the building element table for design and for management purposes, and according to the production result table for construction purposes.

As for implementation of an internationally standardized construction-related classification, the buildingSmart data dictionary (bSdd) is expected to play a central role to strengthen interoperability of exchanged product data for BIM. So far, however, it is still under development and has not been able to handle object library data in a very practical and convenient way. The way of handling symbol library data is not yet specified. bSdd development is based on ISO 12006-3, object-oriented framework for classification, and considered to be well-modified to cope with ISO 12006-2, table-oriented classification schema which is under renewal. This situation suggests the possibility to develop a harmonized classification rule to put symbol library data efficiently in BIM practices.

4.2.5 Mapping between classification systems

As classification systems in construction commonly are defined nationally, there sometimes (and with an increasing frequency) occurs a need to transform the classification made using one system to classification according to another system. The concepts of ISO 12006-2 are designed to facilitate this mapping between classification systems; as long as the conceptual type of the table is the same there is a possibility to do the mapping. If the exact mapping for a subclass cannot be identified, the alternative is to map to a higher class in the hierarchy. This means that information is lost in the mapping process. Therefore, multiple classifications are preferred from a precision viewpoint.

4.2.6 Conclusion

As most symbols present physical parts of a product, such as a building, classification of building elements is a suitable basis for structuring of symbols and symbol libraries. ISO 12006-2 offers a framework for classification, but as the contents of the classification tables are not agreed internationally, national classification will be applied. Mapping between the systems can hopefully be supported by the concepts database of the buildingSmart data dictionary.

5 Industry cooperation

The implementation for use of symbol libraries requires the cooperation of several parties involved in the construction and facility management processes.

5.1 Key roles

Some key roles with specific tasks in the implementation process can be identified.

— Standards bodies at international level give formats and generic content that need not vary on the national level.

— Standards bodies nationally coordinate local specializations and offer quality assurance.

— Trade associations coordinate product type input (for example ANSI standards predominate over international electrical standards in the USA).

— Manufacturers and software suppliers may aim for local and/or international compliance to templates. They hold their own data sets and distribute it how they choose.

— The users of drawings/presentation will welcome consistent appearance.

All these roles need to be involved in order for the implementation of standards to be successful.

6 Suggestions for further standardization

6.1 General

There needs to be several activities in order to successfully create, implement, and disseminate International Standards for symbols and symbol libraries. Practical use of the libraries will require not only traditional paper standards but also libraries in digital format for direct use with BIM software.

6.2 Concepts and principles

A general standard should be created to serve as the basis for building symbol libraries in a consistent and sustainable form, by ISO and other parties. By conforming to this standard it will be possible to ensure symbols for use across technological borders as well as different activities and disciplines in the construction and facility management processes. Among the things to be specified are

— the relationship between objects and symbols,

— types of symbols,

— the context for use of symbols, including the aspects discussed in this Technical Report, and

— metadata for symbols.

6.3 Overall library

When general principles and concepts are agreed it will be feasible to collect symbols into libraries and standardize them.

A strategic approach is to begin with the primary aspects, and then add more detailed specifications for variants. Existing standards will be the starting point for collecting graphical symbols that have already been agreed on the international or national levels.

Standard series can be subdivided into standard parts by application area. A simple suggestion based on functional building elements follows, to serve as an outline for subsequent work.

— Foundations

— Structural

— Landscaping

— Exterior building components

— Interior components

— HVAC and sanitary

— Electrical

— Control and monitoring

— Transportation systems

Some application-independent symbols, e.g. annotation, should be collected into a separate part (separate parts) of the standard series.

6.4 Access to symbols

Symbol libraries should be available in electronic format from a searchable database through the Internet. For the libraries and the individual symbols there should be appropriate classification(s) and metadata as well as textual description.

Symbols should be in a neutral vector-based format, but also object-based formats like IFC file format should be considered, allowing the symbols to be exchanged with full functionality by CAD/BIM systems and other software tools. In order to facilitate software integration, IFC object types should be considered for classification, as well as global identifiers for identifying the symbols and properties.

6.5 Development of libraries

Symbol libraries have to be able to be built by individual organizations, in the construction industry and software providers, as well as the library of basic symbols provided by ISO. ISO needs to provide the specifications for the library structure and access method.

6.6 Organization

For the production of symbol libraries, the organizational form has to be considered. Traditional ISO projects run by working groups will probably not be the way best suited to complete the task. Rather, a targeted cooperation between standardization and implementers, e.g. the software industry, would lead to a more efficient standardization and implementation process.

As a start, an ISO working group for the general standard part(s) is recommended, consisting of experts from the domains of construction and FM. To coordinate further implementation on international and national levels, a separate implementation group is proposed.

6.7 Preparations and marketing for implementation

6.7.1 Software

The standards will have to be developed in cooperation with software and object library providers. Functionality for access to standard symbols should be developed, making it possible to exchange them between libraries and systems. The system vendors should ensure that symbols conforming to the standard are available.

6.7.2 Use

The users should be made aware of the standards by their software vendors as well as the standards organizations (including the maintenance organizations). The uptake and use of standard symbols will benefit from the awareness among clients demanding models/drawings as well as those parties

producing them. Paramount to successful implementation is also that the libraries are qualitative, that they cover the intended subject area and that they are easy to use.

6.8 Maintenance of symbol libraries managed by ISO

It has to be possible to continuously update the symbol libraries, changing the appearance and properties of individual symbols and adding and deleting symbols. A maintenance process needs to be established, defining the responsibility for keeping the libraries up to date and for developing the distribution forms to market needs. Revision management should be applied on the level of the individual symbol. This will differ from the normal procedure for updating standards, and requires ISO sanctioning.

Annex A
(informative)

Structuring of symbols

The top structure would consist of symbol libraries for the main areas or disciplines. Within each area, the intended usage and level of development sets the requirements for symbolic representation of objects. Figure A.1 summarizes the different aspects as described in Clause 5.

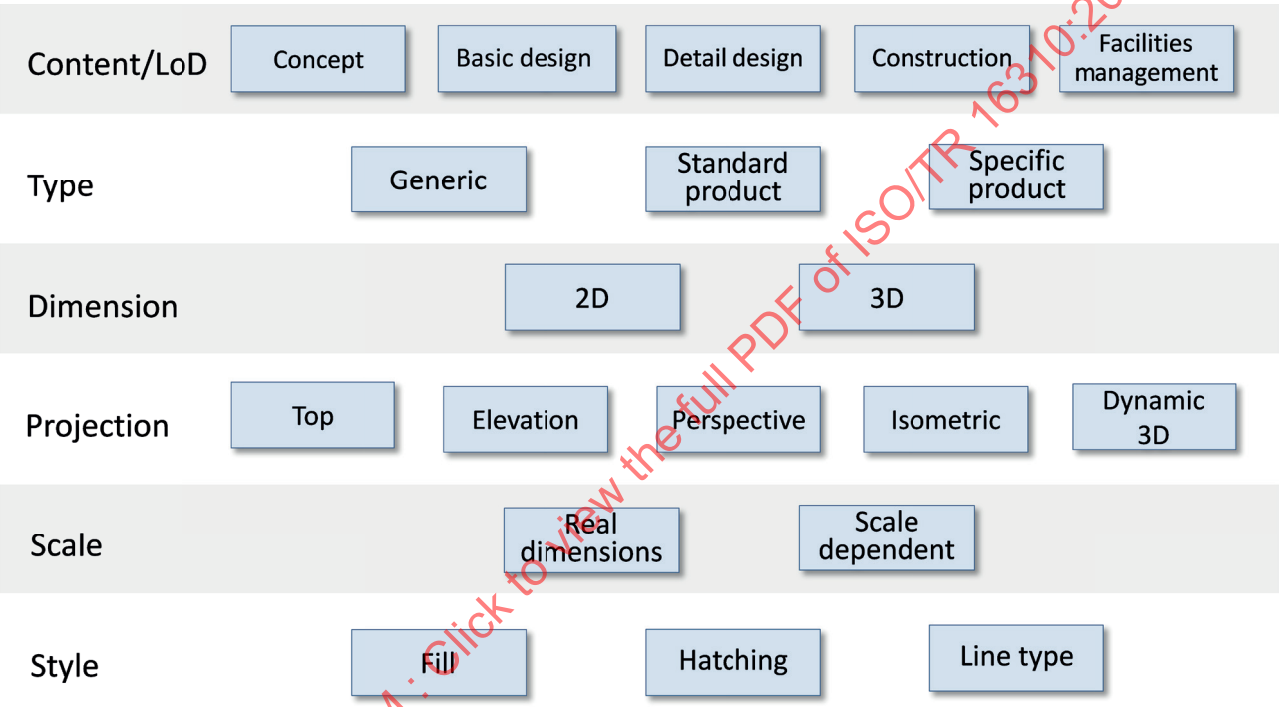


Figure A.1 — Aspects of symbolic representation

For a selected area and level of development, the usage will determine

— whether the symbol should depict a generic type, a selected standard product, or a specific product from a supplier,

— whether 2D or 3D symbols are required,

— what projections are needed,

— whether presentation is symbolic (scale dependent, or showing real dimensions), and

— whether symbol attributes like fill, crosshatching, or line types need to be applied.

EXAMPLE Air handling unit