GUIDE 77-3

Guide for specification of product properties and classes —

Part 3: **Experience gained**

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Foreword

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

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

Draft Guides adopted by the responsible Committee or Group are circulated to the member bodies for voting. Publication as a Guide requires approval by at least 75 % of the member bodies casting a vote.

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

ISO/IEC Guide 77-3 was prepared by the Joint Technical Advisory Group of the ISO Technical Management Board and the IEC Standardization Management Board on product properties and families.

ISO/IEC Guide 77 consists of the following parts, under the general title *Guide for specification of product properties and classes*:

— *Part 1: Fundamental benefits*

— *Part 2: Technical principles and guidance*

— *Part 3: Experience gained*

Introduction

This part of ISO/IEC Guide 77 contains a number of experience reports about the development of reference dictionaries. It contains examples from ISO/TC 29 (on cutting tools), ISO/TC 184/SC 4 (on instrumentation and fasteners), and IEC/SC 3D (on the IEC reference dictionary).

The **common ISO 13584/IEC 61360 dictionary model** (2.1) and the methodology as described in ISO/IEC Guide 77-1 and ISO/IEC Guide 77-2 have been used and are being used as the basis for the development of reference dictionaries. To support future developers of reference dictionaries, this part of ISO/IEC Guide 77 describes the experiences gained in some projects over the last few years. The experiences reported are based on work from different standardization committees. The aim of this part of ISO/IEC Guide 77 is to give practical information, such as the following:

a) Which kind of procedures have been adopted for the creation of the different reference dictionaries?

b) What basic decisions have been taken in the creation process?

c) How much effort has been spent on these projects?

d) How have the resources of the common ISO/IEC data model been used?

e) How will the reference dictionaries be maintained?

The following International Standards are used as examples:

— ISO 13399, a reference dictionary for cutting tools developed by ISO/TC 29/WG 34;

— IEC 61360, the reference dictionary of components within the electrotechnical domain developed by IEC/SC 3D;

— ISO 13584-501, an initial reference dictionary content of laboratory and environment measuring instruments to be registered into ISO 13584-501RA (Registration Authority), developed by ISO/TC 184/SC 4/WG 2;

— ISO 13584-511, a reference dictionary of fasteners developed by ISO/TC 184/SC 4/WG 2 with support from ISO/TC 2.

The examples provided contain a variety of different approaches, based on different starting points and goals. Due to these different approaches, the clauses in this part of ISO/IEC Guide 77 describing each of the individual projects are not structured in the same way. Rather than following a uniform structure, they emphasize those aspects which were important for their specific development process. To give an initial overview, key points and common and differentiating aspects have been summarized in Clause 3. Clauses 4 to 7 contain the detailed reports about the development projects.

NOTE In the context of this part of ISO/IEC Guide 77, the term “reference dictionary” is used to refer to the data dictionaries that have been built in the above-mentioned technical standardization committees on the basis of the data model defined in ISO 13584 and IEC 61360. In other communities (e.g. in the semantic Web world), such a reference dictionary would be seen as a special case of an ontology.

Guide for specification of product properties and classes —

Part 3: Experience gained

1 Scope

This part of ISO/IEC Guide 77 provides general advice and guidance for the description of products and their characteristics by the use of ISO 13584 and IEC 61360 for the creation of computer processable product libraries, catalogues and reference dictionaries. This description will provide the details of the products and their properties in an unambiguous manner, capable of computer communication in a form that is independent of any proprietary application software. The term “product” is taken to include devices, processes, systems, installations, etc. This part of ISO/IEC Guide 77 is intended to assist in the objective of enabling the flow of technical information between internal and external business partners in a cost effective and timely manner.

The guidance in this part of ISO/IEC Guide 77 is intended to assist the following groups:

— convenors and members of ISO technical committees;

— technical experts contributing their knowledge to the development of reference dictionaries, data bases and product libraries;

— information experts responsible for the generation of applications of ISO 13584, particularly related to standardized reference dictionaries;

— managers and technical experts in the manufacturing industry.

This part of ISO/IEC Guide 77 is intended to provide practical information of the experience gained in the creation of product reference dictionaries within ISO and IEC. This part of ISO/IEC Guide 77 is intended for information only, in areas such as education.

The following are within the scope of this part of ISO/IEC Guide 77:

— experience of developing a reference dictionary for cutting tools;

— experience of developing a reference dictionary for electronic components;

— experience of creating a system for the maintenance of a reference dictionary for measuring instruments;

— experience of developing a reference dictionary for fasteners.

The following are outside the scope of this part of ISO/IEC Guide 77:

— an overview for ISO technical committees and industrial managers for the development of computer-processable product libraries, reference dictionaries and catalogues;

NOTE 1 An overview of the development of computer-processable product libraries, reference dictionaries and catalogues is provided in ISO/IEC Guide 77-1.

— technical guidance for the creation of product libraries and dictionaries.

NOTE 2 Technical guidance for the creation of product libraries and dictionaries is provided in ISO/IEC Guide 77-2.

2 Terms and definitions

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

2.1
common ISO 13584/IEC 61360 dictionary model
data model for product ontology, using the information modelling language EXPRESS, resulting from a joint effort between ISO/TC 184/SC 4/WG 2 and IEC/SC 3D

[ISO/IEC Guide 77-2:—, 2.6]

2.2
is-a relationship
class inclusion relationship associated with inheritance

[ISO/IEC Guide 77-2:—, 2.9]

2.3
reference dictionary
product ontology compliant with the **common ISO 13584/IEC 61360 dictionary model** (2.1)

[ISO/IEC Guide 77-2:—, 2.21]

3 Overview

The initiators and drivers of the selected projects are quite different groups, as outlined below.

— ISO 13399 was developed by the leading manufacturers of cutting tools (AB Sandvik Coromant and Kennametal, Inc.).

— The IEC reference dictionary (IEC 61360) was initially based on the internal Philips model. Since 1989, the work has been handed over and further developed by the horizontal committee IEC/SC 3D in the IEC organization.

— ISO 13584-501 was developed in cooperation between an industrial association in Japan (JEMIMA, Japan Electric Measuring Instruments Manufacturers' Association) and a PLIB software provider (TOSHIBA Corporation).

— The fastener reference dictionary (ISO 13584-511) was developed by the Chinese National Institute of Standards with support of technical experts from China and from ISO/TC 2.

The reference dictionary of cutting tools supports an entity-relationship information model, which describes the assembly of the components of a modern cutting tool with defined cutting edges, whereas the other dictionaries are stand-alone reference dictionaries, which are not linked to an additional model.

The examples show different approaches to maintenance: ISO 13584-511 relies on the normal maintenance mechanisms defined for paper-based International Standards, whereas ISO 13399 and IEC 61360 have installed or will install a maintenance agency to maintain the **reference dictionary** (2.3) as a standard. The reference dictionary related to the maintenance procedure of ISO 13584-501 itself is not standardized. It is instead registered on behalf of ISO by a registration authority in accordance with maintenance procedures defined in ISO 13584-501. These procedures are similar to the procedures defined by IEC.

All projects were truly interdisciplinary efforts, in which experts of the modelling methodology were involved alongside the technical experts. In addition, software engineers have developed various tools to support the development process, and they also implemented prototype applications to ensure the usability of the reference dictionaries in actual applications. It was even suggested to involve marketing experts, in order to ensure that information about new products and new applications are considered in the reference dictionary.

All projects reported the importance of software tools to support the development process. This includes editors for capturing information, tools for checking the correctness of data, means for distributing information, etc. Three reference dictionaries are published in the STEP file format (ISO 10303-21). IEC has decided to make IEC 61360 available in this format as well in the near future.

For the reference dictionary of cutting tools, a specific convention for the creation of names and definitions was defined. Some of the standards use conventions for the generation of identifiers (e.g. to distinguish between identifiers for classes and properties.

Some interesting aspects concerning the use of the underlying data model are outlined below.

a) Reuse of properties across reference dictionaries: the use of the is-case-of mechanism for this purpose is illustrated in Clause 4 in the context of the reference dictionary for cutting tools which uses entries for some nuts and bolts from ISO 13584-511.

b) Visible and applicable properties: the reference dictionary of cutting tools and the IEC reference dictionary make all properties visible at the root class and apply them to different classes in their class hierarchies. This has the advantage that a property can be applied to multiple classes in the hierarchy in various branches. The properties defined in the IEC reference dictionary include in their definition the classes for which the property is defined – this concept was used already before the concept of visible properties was introduced into the PLIB data model. The reference dictionaries developed under ISO 13584 use the visible properties to define the property domain, i.e. the definition of the property is linked to the definition class for which it is visible. This makes it possible to tailor the property definition to its domain and to take special aspects of the domain into account.

c) The reference dictionary for fasteners clusters various properties in the form of features. Such a feature can be associated as a whole to a class (in the sense of a complex property). This allows for structuring the set of properties and for a special organization of the characterization class hierarchy.

An important aspect for quality assurance is the possibility to formally validate exchange files. In view of the use of reference dictionaries in computer-to-computer communication, e.g. as database schemas, it is of the utmost importance to ensure the correctness of data. Dictionary providers may be made liable for the correctness of their data.

Lastly, the reports show that the development of formal reference dictionaries requires a significant effort. Some of the projects took several years and involved a number of man years. It is important to plan such a project accordingly, i.e. to establish the necessary environment with respect to resources, liaisons and cooperation with relevant technical committees. In addition, the maintenance process should be considered from the start.

NOTE Annex C contains a Web site address providing links to organizations responsible for the maintenance of reference dictionaries. Another address points to a Web site with links to various tools that are useful for the development of reference dictionaries, including those tools that have been used by the projects described in this part of ISO/IEC Guide 77.

4 Developing a PLIB reference dictionary for ISO 13399

4.1 General

ISO 13399 provides a reference dictionary for cutting tools data representation and exchange. The development of ISO 13399 was carried out by cooperation between the world's largest manufacturers of machine cutting tools in a project that lasted for more than 5 years (see 4.12).

The reasons for the development of ISO 13399 were:

— cutting tools with defined cutting edges have become more complex with multiple replaceable inserts to perform the cutting operation;

— the use of cutting tools has become more adaptable following the changes in design of machine tools able to use the same tool for many different operations;

— the existing standard, ISO 3002, only defined cutting tools with brazed cutting items for single operations;

— the reference system in ISO 3002 was not adequate to define all the properties of all the components of a modern cutting tool (see Figure 1);

— customers increasingly require that cutting tool data should be supplied in computer processable form and the suppliers need to have one method for supplying this data to reduce their costs and complexity;

— the main method of supplying data for modern cutting tool components and assemblies is intended to be the information model of ISO 13399-1;

— the reference dictionary of classes and properties for cutting tools was therefore developed as a separate part of ISO 13399 to allow for the incorporation of new developments and new requirements without the need to change the information model. In this case, just an update of the reference dictionary would be required.

4.2 Determining the scope of the development project

The development project was to produce a new reference dictionary for ISO 13399. The main role of the reference dictionary is to support the entity relationship information model (the information model) specified in ISO 13399-1. The information model provides the resources to represent component parts of a modern cutting tool and the assembly of parts to form a complete tool. The information model also enables parts to be identified by using standardized labels from the reference dictionary, or to be referred to by their aliases using the labels used by particular companies.

The main activities in the development of the reference dictionary were therefore to develop the class hierarchy of items within the domain of machine cutting tools and to define the properties of these classes.

The scope of the domain is indicated in Figure 1. A modern cutting tool is an assembly of four main parts, as follows:

— cutting item: removes material from the work piece by a shearing action at defined cutting edges;

— tool item: supports the cutting item or items in the cutting operation;

— adaptive item: provides the connection between the tool item and the machine tool;

— assembly item: provides the forces to hold the cutting item on the tool item.

These four parts were the starting basis for the class hierarchy. The cutting item may be a detachable insert capable of being repositioned to bring different cutting edges into use, or permanently attached by means of a brazed joint, or part of a solid tool.

The convention adapted for the scope was that the classes and their properties applied to the “tool in the hand”. The alternative convention is for the “tool in use”. The “tool in use” convention will require additional classes and properties which will be the subject of a subsequent project.

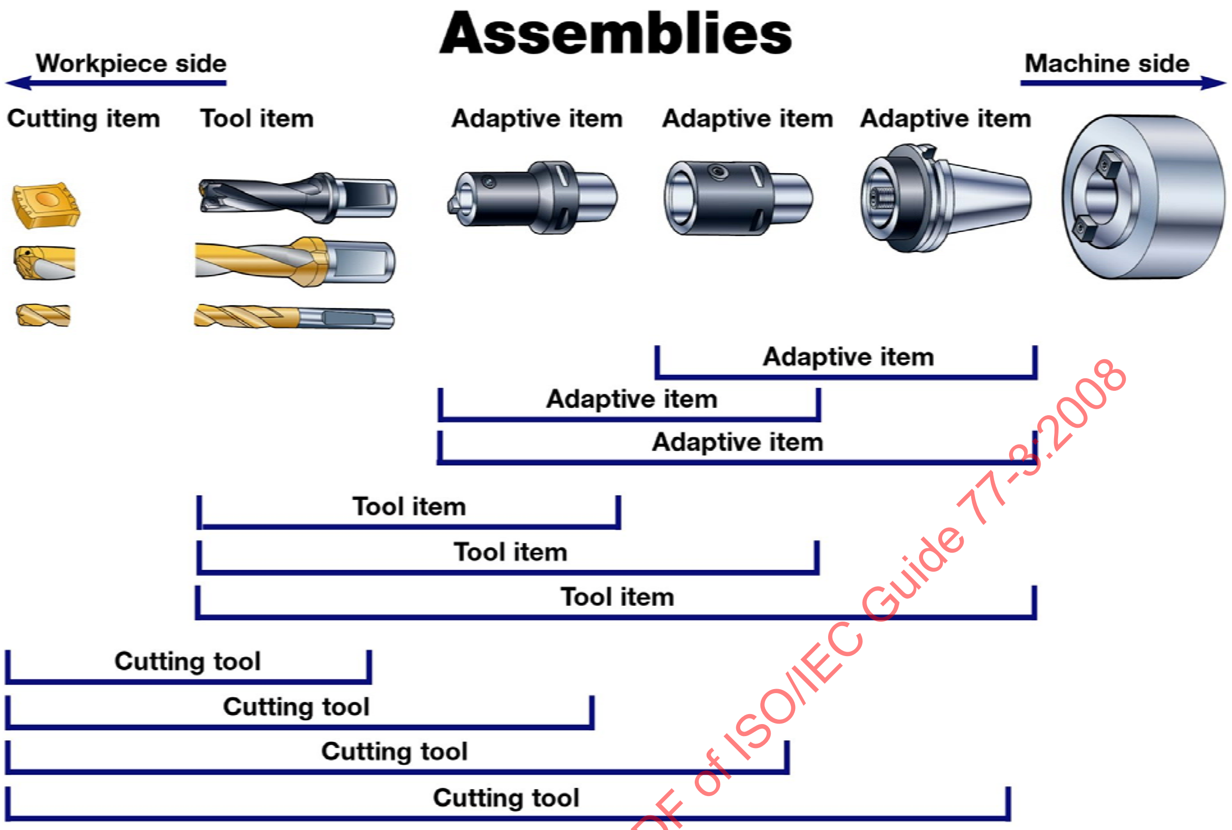


Figure 1 — Scope of the domain of cutting tools

4.3 Selection of the project team

The selection of the project team is an important component of the development and depends on the scope of the project. It should always include domain experts and information modellers. However, the ISO 13399 project did not include marketing experts or software developers. While these omissions could be justified in the earlier phases, once the development reached the point where the technical outcome was clear, the extension of the scope of the project team to include marketing and software experts would have been valuable.

The role of the domain experts was to input their knowledge from their companies' products, as well as to generalize them to a neutral representation that could be applicable to all products in the cutting tool industry. The domain experts were also familiar with both the existing standard (ISO 3002) in this domain and what was now needed as a result of new developments in the technology of cutting tools.

The role of the information modellers was to interpret the ISO 13584 standard model and ensure that the requirements of the domain experts could be met by the provisions of the standard. It is important that the information modellers are conversant with the development of ISO 13584 and aware of any changes that have occurred or are planned. This requires an active liaison between the project and the WG 2 of ISO/TC 184/SC 4.

If software developers are included in the project team, then their role would be to anticipate what the implementation issues could be and to input new ideas in the functionality of software that would use ISO 13399.

The role of marketing experts would be to provide a bridge between the needs of customers and the developers of ISO 13399, and to input information on new product types and new applications to extend its scope.

4.4 Supporting software

The development of a reference dictionary requires software to support the activities. The software needed to support the development of the reference dictionary for ISO 13399 was:

- an editor for the compilation of the reference dictionary;
- ISO STD2 Template for the production of the standard documents;
- software to convert the reference dictionary file to a printable version;
- CAD software to create the diagrams to support the definitions of properties;
- a database to provide a searchable record of the content and provide checks against duplication of names, etc.;
- spreadsheet software to provide complete lists of classes and properties.

It was necessary to train the members of the project team in the use of the software that was appropriate to their roles.

4.5 PLIB information model

The PLIB information model used for this project was ISO 13584-25. This model was further constrained to limit the meaning of the data types used in the reference dictionary:

- the classes used were item classes and feature classes only;

NOTE In ISO 13584-42, only these kinds of classes exist.

- some of the data types were constrained to use only a limited number of data formats.

The scope and constraints on the model were described in ISO/TS 13399-100 by adopting the diagrammatic presentation methods used in IEC 61360-2.

The domain experts were provided with some training in the use of ISO 13584 by using the editor software. It was not necessary to refer directly to the information model for the reference dictionary. The domain experts soon understood the principles of the development and were very comfortable with compiling the reference dictionary by using the editor software.

4.6 Establishment of liaisons

ISO/TC 29 was the technical committee responsible for ISO 13399 and an official liaison was established between ISO/TC 29 and ISO/TC 184/SC 4. This relationship was essential to provide access to the latest development in the technology and standards for product data representation.

4.7 Development of the classification

4.7.1 Main classes

The main sections of the class hierarchy were initially identified as:

a) cutting items: the portion of the cutting tool in contact with the workpiece;

b) tool items: the assembly that is the support for the cutting item;

c) adaptive items: the components that connect the tool item to the machine tool;

d) accessory items: items that hold the cutting item to the tool item and items that are used to create the assembly.

The root class was an item class and the main classes were either item classes or feature classes, where a feature was an aspect of an item class that could not exist in isolation.

As the development of the reference dictionary proceeded, changes to this initial division needed to be made:

— accessory items were restricted to assembly items to hold the cutting item in place on the tool item;

— further main classes were identified as:

  — reference systems to provide a coordinate axis system for the definition of angles and lengths;

  — classes that were common to several of the original sections;

  — classes of connection systems.

The classes were either item classes or feature classes. Every effort was made to keep the class hierarchy with as few subsidiary levels as possible and to avoid information modelling in the class hierarchy.

4.7.2 References to other dictionaries

As the reference dictionary neared to completion, it was realized that two of the classes in ISO 13399 were the same concepts as classes in ISO 13584-511:

— threaded fasteners as a subclass in the assembly item class;

— thread as a common feature of several classes.

The class of externally threaded item was copied from ISO 13584-511 and was defined as an item_class_case_of in ISO 13399. Then a reference was made from ISO 13399 to the class with the same name in ISO 13584-511. The properties for this class in ISO 13399 were imported from ISO 13584-511 (by use of the "Add dictionary" function in the dictionary editor). By this means, the contents of the externally threaded item class from ISO 13584-511 are known to the reference dictionary in ISO 13399. There are some special threaded fasteners particular to the assembly of cutting tools that are not standardized in the sources from which ISO 13584-511 is derived. These special items were created in ISO 13399 as subclasses of externally threaded item. The illustration of the reference to externally threaded item is shown in Figure 4.

Thread, as a feature of an object, is a common feature of several items in the domain of ISO 13399 and so it was made a feature class with no superclass, other the root class. Care was taken to ensure that the properties of thread did not include any properties related to the cutting of the thread, which are properties of some types of cutting item. The feature class of thread in ISO 13584-511 did not include all the types of thread and all the properties of a thread that were thought to be necessary for ISO 13399. Cooperation with the developers of ISO 13584-511 was therefore established to extend ISO 13584-511 to meet the requirements of ISO 13399 and when this is completed the reference can be made from ISO 13399 to ISO 13584-511 in the same manner as for the externally threaded item.

4.7.3 Feature classes

ISO 13584 makes it possible to organize features into a class hierarchy, where a feature is defined as a class of objects that cannot exist in isolation, e.g. a cutting edge is a feature of a cutting item. This aspect of the class hierarchy is needed to avoid repetition, e.g. to avoid having to define a subclass of cutting edge for every class of cutting item. It is also necessary to be able to assign properties to a feature as a class.

In ISO 13399, the association between an object and a feature was made by assigning a property to the item class that indicates by its value whether the object possesses the feature. The data type for this kind of property was Boolean, e.g. a cutting item may or may not have a chip breaker as part of its design. The Boolean property "chip breaker property" was made applicable to the cutting item class and the value of the property will indicate whether or not an instance of a cutting item has a chip breaker. The properties of the chip breaker itself are then made applicable to the chip breaker feature class.

However, ISO 13584 does not provide the means to identify the item class of which the feature class is a part: Only the forward association can be identified by the method described above. The correct association between a feature and the object of which it is a part would have to be achieved in a software implementation of the reference dictionary.

4.7.4 Assigning class names

Class names were devised by the domain experts based on common industrial practice, where possible. Differences between the class names used for the same concept in the companies that participated in the project team were resolved by choosing either one of the alternatives, or by devising independent names for use in ISO 13399. The convention adopted for long names was to use only lower case letters with no joining character between multiple words. Where groups of classes were associated with an aspect of a cutting tool, the names were devised with common elements to identify the association.

The convention adopted for short names was to use lower case letters in a truncated form of the long name. The compilation of the classes in a data base was used to verify that there was no repetition of names or short names.

4.7.5 Assigning definitions

Definitions were derived from other International Standards, wherever possible, and in these cases the source was identified. However, much of the content of the reference dictionary was new material that needed original definitions. Whenever it was possible, a diagram was produced to support the definition.

4.7.6 Assigning identification codes

The assignation of an identification code to a class is a fundamental feature of the PLIB method. For ISO 13399, each identification code was a random number that was generated by the editor software. The benefit was to assign no meaning to the code so that the position of a class could be changed if it was necessary to change the class hierarchy as the reference dictionary developed.

4.7.7 Assigning applicable properties

Properties were selected from the list of visible properties (see 4.8) to be applicable to the appropriate level of the class hierarchy. This was the important contribution from the domain experts and also resulted in changes to the class hierarchy to reflect the grouping of classes and their properties.

4.7.8 Examples of the classification

A high level view of the class hierarchy in ISO 13399 is shown in Figure 2. Note that there is an additional library from ISO 13584-511.

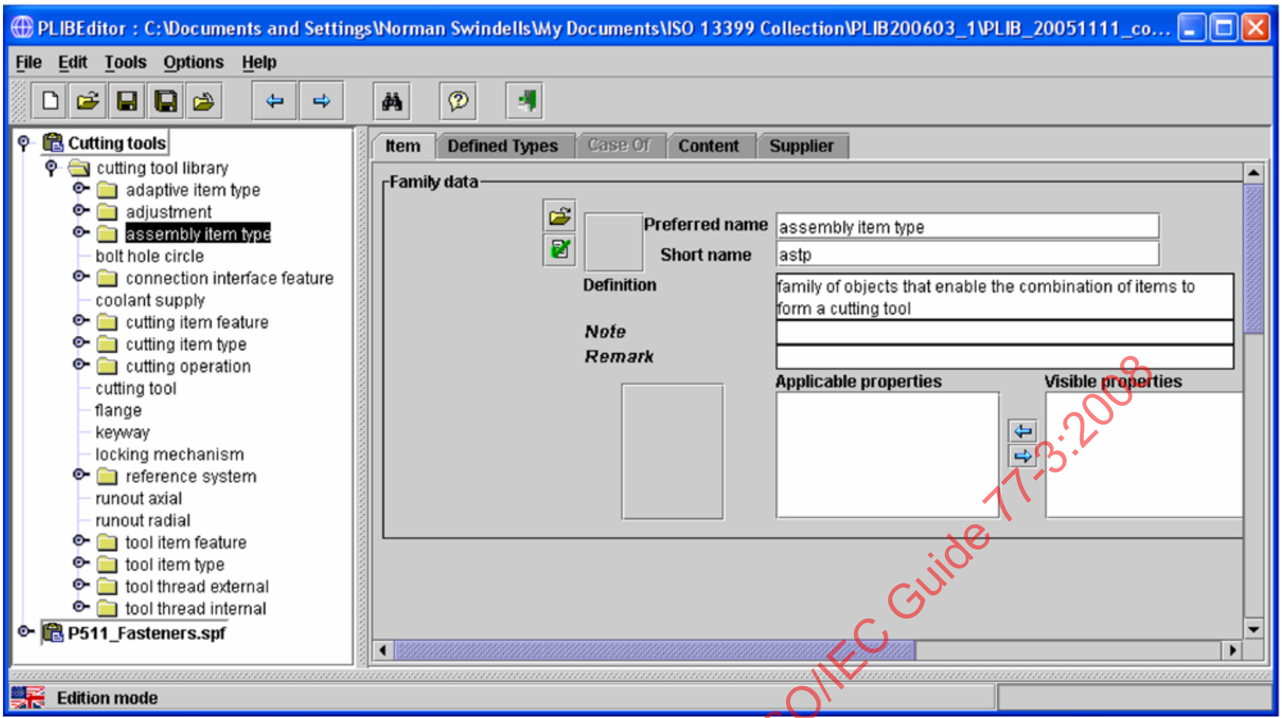


Figure 2 — The main classes in the ISO 13399 reference dictionary

An expanded section of the classification that defines the cutting item feature class is shown in Figure 3, together with the definition of cutting edge major and its applicable properties.

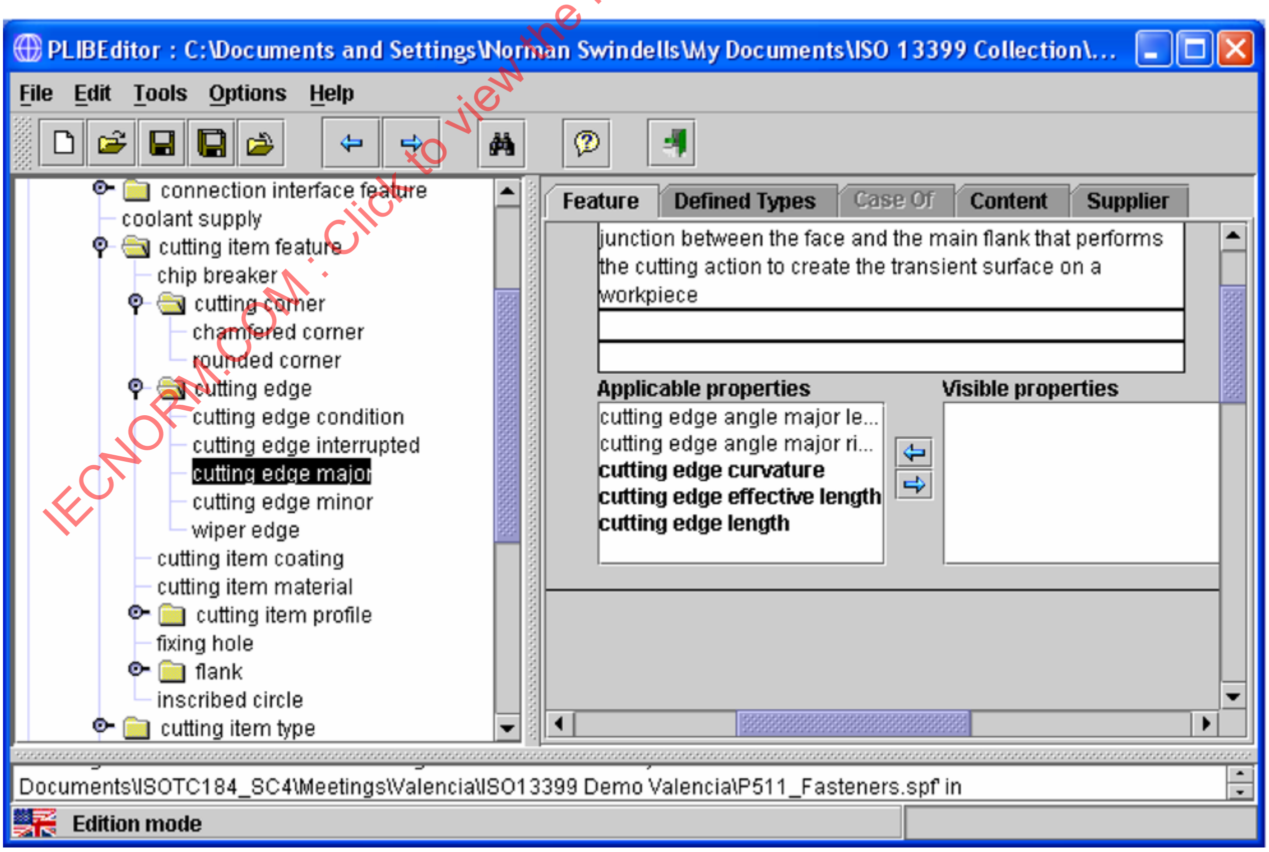


Figure 3 — Part of the classification of cutting item features

An example of the use of another reference dictionary as a reference is provided in Figure 4. This example shows the properties from ISO 13584-511 applied to the externally threaded fastener component in ISO 13399. Note that the identification of the class is “Item case of”, signifying that it is defined in another dictionary.

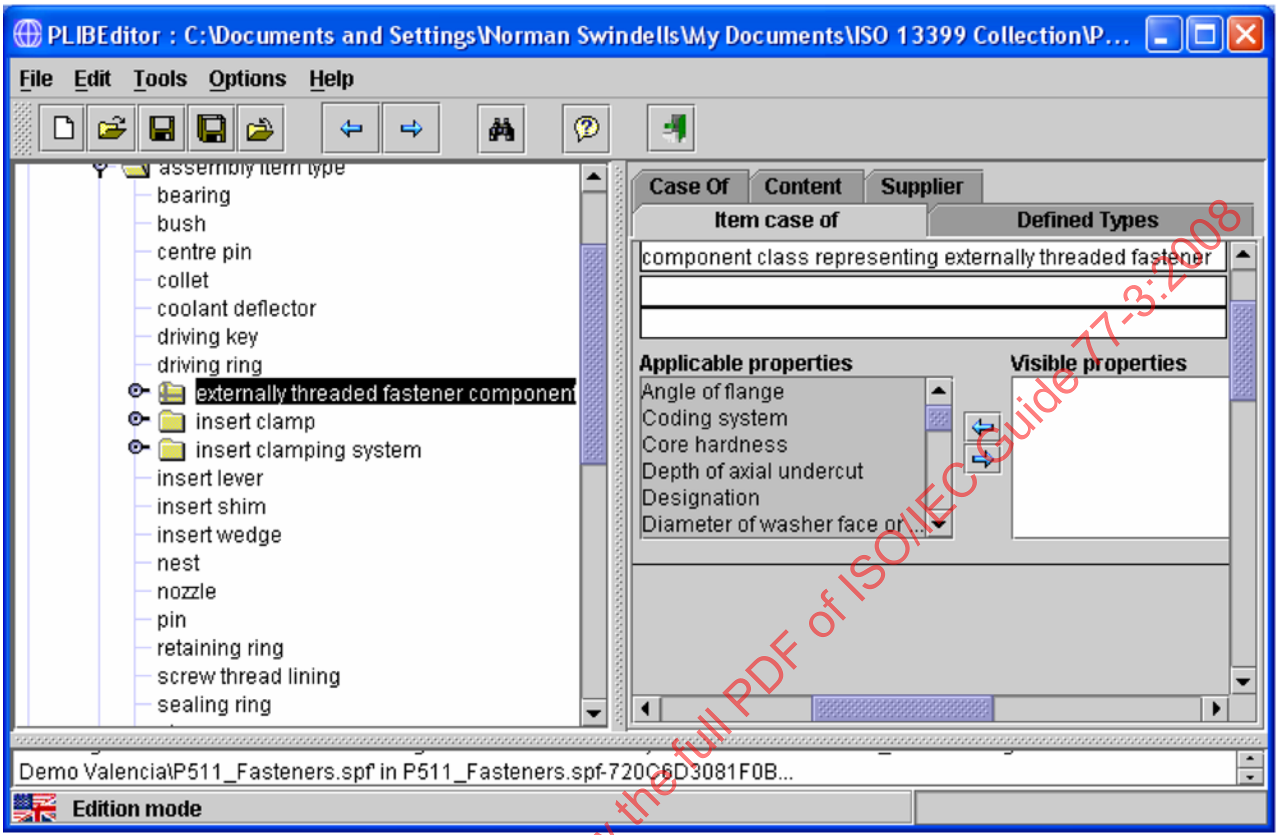


Figure 4 — Example of the references to ISO 13584-511 for the applicable properties of the externally threaded fastener component

4.8 Visible properties

4.8.1 Choice of visible properties

The development of the list of visible properties was the largest part of the development process. The companies in the development team provided lists of properties from their company data bases and a great effort was made either to harmonize the names or to create independent names and derive rigorous definitions. The concepts enshrined in the definitions were regarded as the most import aspects of the properties with the names acting as labels for the definitions. The properties chosen for representation in the reference dictionary were restricted to the properties that are commonly described in the tool company catalogues. There were no properties defined in the reference dictionary that related to the design or manufacture of the tools. This restriction was to protect the intellectual property of the manufacturers.

4.8.2 Name scope of identification codes

All the visible properties were created at the root level of the reference dictionary and used identification codes that were generated at random by the editor software. This had the advantage that the assignment of applicable properties could be made at any level in the class hierarchy.

4.8.3 Assignment of property names

The convention adopted for long names of properties was to use only lower case letters with no joining character between multiple words. Where groups of properties were associated with an aspect of a cutting tool, the names were devised with common elements to identify the association.

The usual convention adopted for short names was to use lower case letters in a truncated form of the long name. In some cases, the short name was derived from the common industry symbol for the property. A compilation of the properties names in a data base was used to verify that there was no repetition of short names.

4.8.4 Assignment of property symbols

Property symbols were copies, in upper case symbols, of the short name. The data base was used to ensure that there was no repetition of symbols.

4.8.5 Development of property definitions

The development of definitions was a joint effort between the domain experts and the information modellers. All the definitions were in British English, so it was helpful to have a native British English speaker as part of the development team. Definitions were derived from existing International Standards where they existed, but much of the content was new and original definitions needed to be derived in most cases. It was necessary to review and revise definitions several times in some cases where the concept described was particularly complex, or else it was necessary to relate definitions to other properties that came later in the development process.

4.8.6 Assignment of diagrams to the property definitions

Each definition of a geometric property in ISO 13399 was supported by a diagram. Each diagram could illustrate several properties. The diagrams were developed in industry standard CAD systems, and then converted to the JPEG format for inclusion in the reference dictionary.

4.8.7 Identifying data type, unit name and synonyms

For each property, a data type was identified and a unit string was assigned if the data type was a real value. In a few cases, synonyms were identified where industrial practice required them but the number of synonyms was kept to a low level.

4.9 Checking the records

Spread sheets were used to display the whole contents of the reference dictionary to check for any missing items in each record. The content of the reference dictionary was converted into a form that could be displayed in a spreadsheet by using the software for producing a printable version.

4.10 Prototype implementation

The purpose of the reference dictionary was to provide the terminology for use by the entity relationship model in ISO 13399-1. A prototype implementation of the information model in ISO 13399-1 was therefore created to demonstrate that the information model could make a correct reference to the section of the reference dictionary for cutting items, could use the aliasing capability and could demonstrate the assembly of a cutting tool from components defined in the reference dictionary.

4.11 Producing the standard documents

The reference dictionary was developed as single data file that contained all the classes and their properties. However, it was decided to publish the reference dictionary in sections in a series of documents to achieve a manageable compilation of the contents in a form that would be understandable by a tool engineer without the need for specialist software. The parts were conceived as Technical Specifications, with a shorter ballot process and with the capability for more frequent revision.

The standard documents of ISO 13399, *Cutting tool data representation and exchange*, are:

— Part 1: *Overview, fundamental principles and general information model;*

— Part 2: *Reference dictionary for the cutting items;*

— Part 3: *Reference dictionary for tool items;*

— Part 4: *Reference dictionary for adaptive items;*

— Part 5: *Reference dictionary for assembly items;*

— Part 50: *Reference dictionary for reference systems and common concepts;*

— Part 60: *Reference dictionary for connection systems;*

— Part 100: *Definitions, principles and methods for reference dictionaries*.

All these documents were produced by using the ISO Template STD2. The sections of the dictionary in each dictionary document were isolated from the complete file and the contents of a section were converted into a printable form. The classes and their applicable properties were published as one annex and the details of the properties and the classes to which they applied were published as another annex. Diagrams to illustrate the properties were published in a series of annexes and reference to the diagram that illustrated a property was made in the description of the relevant property.

ISO/TS 13399-100 was a specification of how ISO 13584 was constrained for the purpose of the reference dictionary. The method adopted for describing the implementation of ISO 13584 was based on the approach in IEC 61360-2, using simple diagrams to describe the information model and formal text to define the constraints.

There is a risk in publishing the parts in stages because later developments may have an impact on information already published. ISO/TS 13399-2 was regarded as complete and ISO/TS 13399-100 was independent of the others and so both these parts were published first. There was a strong interaction between ISO/TS 13399-3, ISO/TS 13399-4, ISO/TS 13399-50 and ISO/TS 13399-60 and so these parts were developed and published together. ISO/TS 13399-5 was less dependent on the other parts and so was published last. A second edition of ISO/TS 13399-100 was created at the end of the project to support the establishment of an agency for managing the updating of the dictionary.

4.12 Expenditure of effort

The production of the reference dictionary for ISO 13399 was a major effort. The project involved the two largest manufacturers of cutting tools and took approximately five years. In that time there were approximately four meetings per year of the full project team of usually six people, each lasting for two weeks. In addition, there were several man months of individual efforts between the meetings in order to produce the standard documents and the drawings to illustrate the property definitions. The effort in the regular meetings amounted to approximately five man years and the associated individual efforts approximately doubled that to achieve a total of approximately ten man years of effort.

4.13 Conclusions

The production of the reference dictionary in ISO 13399 was more a research project than a development project. There was almost no information available at the start of the project about how to proceed with this task. There was also no knowledge of the information technology by the domain engineers and there was only one other reference dictionary that could be used as a partial guide. The progress was therefore one of experimentation in the early stages until confidence could be gained and the process could become quicker. The result is, however, unique both in the domain of machine cutting tools and within the field of product data technology.

The main features of the reference dictionary are suggested to be the following:

- the single coordinate reference system that applies to all components of the cutting tool from the workpiece to the machine tool;
- the capability to define with respect to this coordinate system all the components of a modern cutting tool and all the properties that are commonly available in tool catalogues;
- the capability to support the entity relationship model of ISO 13399-1 with terms and their definitions;
- the association of the visible properties with the root class of the reference dictionary;
- the use of random number strings as the identification codes for classes and properties;
- the use of item classes and feature classes to simplify the class hierarchy;
- the use of references to another reference dictionary to access the concepts that are held in common between the two reference dictionaries.

5 Development of the IEC 61360 reference dictionary

5.1 Introduction

The IEC 61360 reference dictionary has been developed over many years as part of the IEC 61360 series of standards. The IEC committee SC 3D, which is responsible for IEC 61360, was established in 1989. Prior to the establishment of IEC/SC 3D, a major part of the content as it is today had already been developed as part of a project that was carried out within the Philips electronics company. For approximately five years, 20 people across the product divisions worked on the establishment of the Philips Corporate Component Database (CCD). In 1989, the work was handed over to IEC and SC 3D was established to maintain and further develop the reference dictionary.

By that time, a large part of the principles for describing properties and classes still valid and used today had been defined in documents and entity relationship models. The attributes and structure of the reference dictionary that was set up were intended to comply with ISO/IEC 11179-3 as an umbrella standard that should cover all dictionaries. The ISO/IEC information model formally described in EXPRESS language was not developed until many years later, in cooperation between IEC/SC 3D and ISO/TC 184/SC 4/WG 2.

The IEC 61360 component reference dictionary in database format (http://std.iec.ch/iec61360) has been on-line since 2003, and it officially replaced the paper standard in 2005. The total effort for developing the original reference dictionary content, new additions, the EXPRESS model and the standardization work in general is substantial, and can be estimated at about 150 man years.

5.2 Scope and objectives

To define the scope of a reference dictionary, it is necessary to look at the context in which the work on the reference dictionary takes place, and to define objectives. As the work on IEC 61360 takes place within the context of the IEC organization, its scope is primarily defined by the scope of work of the IEC. The IEC 61360 reference dictionary is open to all the committees within IEC to make proposals for extending or changing its content.

The IEC 61360 reference dictionary was originally conceived in the context of providing a basis for the exchange of information on electric/electronic components, although the principles and methods of IEC 61360 may also be used in areas outside the original conception, such as assemblies of components and electrotechnical systems and subsystems.

The IEC 61360 reference dictionary and database follow the methodology of IEC 61360-1 and the information model of IEC 61360-2 and IEC 61360-5, and include the following:

a) a class hierarchy of components;

b) a set of characteristic properties associated with each class that fully describe components belonging to a class: within the class hierarchy, subclasses inherit properties from those classes above them in the tree;

NOTE In IEC 61360, the term “data element type” or “DET” is used in the sense of “property”, as used throughout this part of ISO/IEC Guide 77.

c) where relevant, conditions for which the property values are valid.

Use of IEC 61360 facilitates the exchange of data describing electrotechnical systems through a defined structure for the information to be exchanged in a computer-sensible form. Each property to be exchanged will have an unambiguously defined meaning and consistent naming, and, where relevant, a defined value list, a prescribed format and defined units of measure for all quantitative values. There is also provision for:

— control of changes to definitions of the properties through version and revision numbers;

— inclusion of notes and remarks to clarify and help in the application of the definitions;

— indication of the sources of definitions and value lists;

— associated figures and formulae.

5.3 Organizing the work

The work on the IEC 61360 series of standards is the responsibility of the IEC Subcommittee 3D (SC 3D) which is established under Technical Committee 3 (TC 3). Under SC 3D there is one active working group, SC 3D/WG 2, which acts as the maintenance team of IEC 61360. Within a regular year, one subcommittee meeting and three working group meetings take place. Within IEC, the work of SC 3D is regarded as horizontal, i.e. it is generally applicable across the work of the technical committees and subcommittees.

In order to develop content for the IEC 61360 reference dictionary, it is desirable that these originate from proposals prepared by IEC committees that are responsible and setting standards in a particular technical area. In this way, SC 3D takes the role of managing the reference dictionary and the IEC 61360 standard where the IEC Committees take the role of technical experts in preparing proposals and validating the semantics of the proposed reference dictionary content, such as names and definitions.

To formalize and support a working relation with a committee, a liaison can be established. There are the existing liaisons to IEC/SC 47D and IEC/TC 65. Outside the IEC, liaisons are established to ISO/TC 184/SC 4, JTC 1/SC 32, ECALS/JEITA, SI 2/ECIX.

5.4 ISO/IEC information model

IEC 61360-2 contains the information model, using the EXPRESS modelling language as defined in ISO 10303-11. In this model, the definition and structure of IEC 61360-1 is formalized and presented in a computer sensible form. Use of this information model makes it possible for dictionary information to be exchanged between different systems using the STEP physical file format as defined in ISO 10303-21.

This information model has also been accepted as the common information model with ISO/TC 184/SC 4 and is reproduced as ISO 13584-42. This basic model has been completed in ISO 13584-25 which correlates to IEC 61360-5. Use may be made of other parts of ISO 13584 for extension of the concepts defined in IEC 61360. In particular, ISO 13584-24 contains provisions which allow:

— extensions of the class structure to include feature and functional model classes;

— tabulation of properties;

- functional relationships among properties;
- references to graphical information;
- structuring of parts libraries.

5.5 Constraining and explaining the IEC use of the ISO/IEC information model

The ISO/IEC information model offers many constructs that can be of service when implementing a solution based on this model. When building a reference dictionary, certain optional aspects of the model might be outside the scope or less important, so that a decision needs to be made as to what extent the information model will be implemented.

For the parts of the model that are mandatory and those that are optional while being within scope, a decision needs to be made as to how to implement generic mechanisms and add constraints to, for example, allowed cardinality between objects, use of characters and configuration rules. For IEC 61360 these are defined in IEC 61360-1.

IEC 61360-1 has proven to be a useful document in the experience of the standardization work within IEC SC3D, as well as in other standardization communities. There is evidence of at least one multinational company implementing IEC 61360 that has written its own version of IEC 61360-1.

The experience shows that it is useful to have such a document for two reasons:

a) To have a document showing the implemented parts of the formal ISO/IEC information model that is geared towards the human reader. The formal definition of the ISO/IEC information model in EXPRESS language (as defined in IEC 61360-2 and IEC 61360-5), have the goal of being mathematically correct but is less suitable as a human readable document.

b) To define in a structured way the parts of the ISO/IEC information model that are used and additional constraints as a specification for the particular usage.

5.6 Property specification attributes

5.6.1 Organization of properties

For guiding purposes, the attributes of the properties are organized based on the principles as described in ISO/IEC 11179-3, and are divided into the following four main groups:

- identifying related attributes;
- semantic related attributes;
- value related attributes;
- relationship attributes of a property related to relations among entities.

In IEC 61360-1 the various attributes of properties as encountered in the specifications are explained. The following aspects are addressed as shown in the example for the attribute code.

Attribute name:	code
Attribute definition:	unique six-character code of a property
Comments:	the first three characters should be alphabetic, the last three numeric (format AAANNN). The character “X” should not be used as first character. The codes are issued sequentially and should not have any relationship with the meaning of the properties. In the case of at least one attribute of the property affecting or changing the meaning and/or communication of the property, a new (other) property, having a new code, should be defined. Such attributes are: — definition; — unit of measure; — condition; — value format; — value code; — data type.
Obligation:	mandatory
Character type of values:	upper-case Latin letters A to Z (to avoid misunderstanding, the upper-case Latin letters O and I should not be used) digits 0 to 9.

The other attributes are defined in a similar manner.

5.6.2 Administrative attributes

Administrative attributes have not been addressed in IEC 61360-1 up until now. The relevant attributes in this area have been identified as part of the database implementation, as shown in the overview in Table 1.

Table 1 — Administrative attributes

Name	**Definition**	**Example**
Status level	name of phase related to the life cycle of the item NOTE 1 Values in accordance with document 3/663/INF.	Standard
Published in	list of identity numbers of publicly available documents in which the item is also published NOTE 2 Edition number and or year to be included as appropriate.	IEC 61360-4
Published by	organization responsible for the publication	IEC
Proposed on	date when the item was proposed	1997-04-01
Released on	date when the item was made available as a standardized item	1997-08-03
Version initiated on	date when the change leading to a new version was initiated	2004-02-05
Version released on	date when the new version was released	2004-05-03
Obsolete from	date when the item was considered obsolete (for whatever reason, including replacement)	2005-06-28

5.7 Classification of components

5.7.1 Classification principles

The goal of defining characterization classes and organizing them in a class hierarchy is to arrange the properties in an unambiguous and structured way. Each property is defined as visible at the level of the root class. This implies that the property may be defined as applicable at any class in the component class tree.

The class or classes in which the property is defined as applicable provide semantic context for the property definition. Without the context of the class the property has insufficient meaning. A property, which is defined as applicable to a particular class, should also be applicable to all subclasses of that class. Properties that are only applicable for a limited number of subclasses should be repeated in each relevant subclass.

The experience shows that the class hierarchy helps in providing an unambiguous context for the property definitions and consistency among the collection of classes. This is important for the definition and maintenance aspects of the dictionary. Other views might be developed that support usage of the dictionary content.

When re-use of groups of properties are required in several contexts, the use of feature classes can be considered. A feature class and its properties are defined in a specific branch of the class hierarchy but can be referred (called) from any class in the class hierarchy and made applicable as such. This is, for instance, the preferred approach for definition of properties in the measurement instruments domain of IEC/TC 65. The class from which a feature class is called provides the semantic context.

A more detailed description of the principles for organizing the characterization classes defined for IEC 61360 can be found in IEC 61360-1:2004, Clause 5.

Figure 5 gives an example of the classification and a class definition in the IEC 61360 reference dictionary.

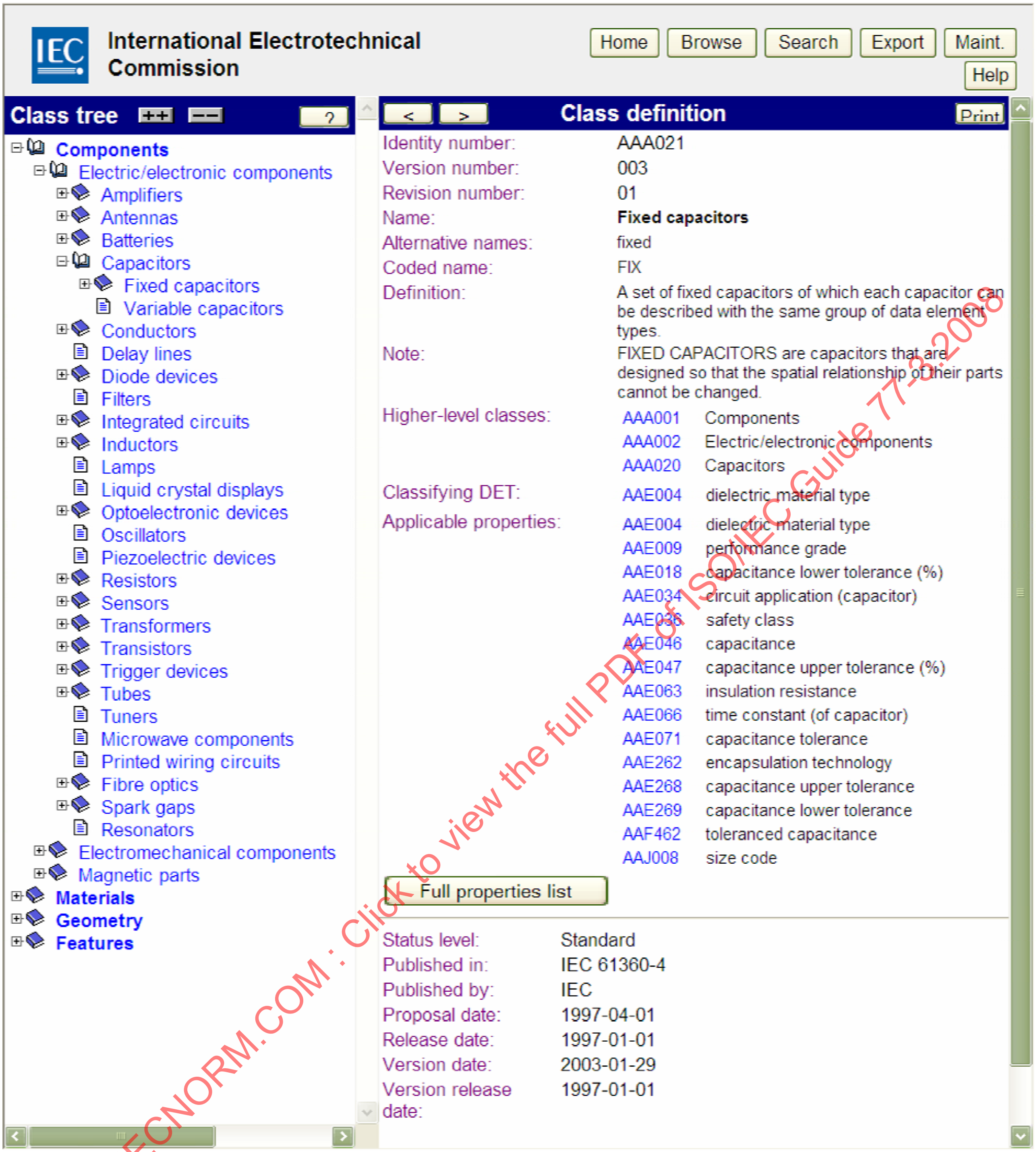


Figure 5 — Example of the classification and a class definition in the IEC 61360 reference dictionary

5.7.2 Classifying property

A classifying property is a property with a data type “non-quantitative code” which therefore has a value domain consisting of a value list containing at least two items. Its principal function, when associated with a class, is to provide a list of the sub-classes to that class. Thus, in the IEC reference dictionary, all classes except for the leaves have an associated classifying property. As with all properties, it is inherited to the subclasses. In the subclass, the value of this property is set to the value of the coded name of the subclass. Thus, each class contains a property that has a predefined value specifying the class name.

An example is shown in Figure 6, where the property dielectric material type is shown on the right side, which belongs to the class fixed capacitors. The value list of this property contains four values, which correspond to the four subclass of the class fixed capacitors. In a subclass, these values are automatically set for this property.

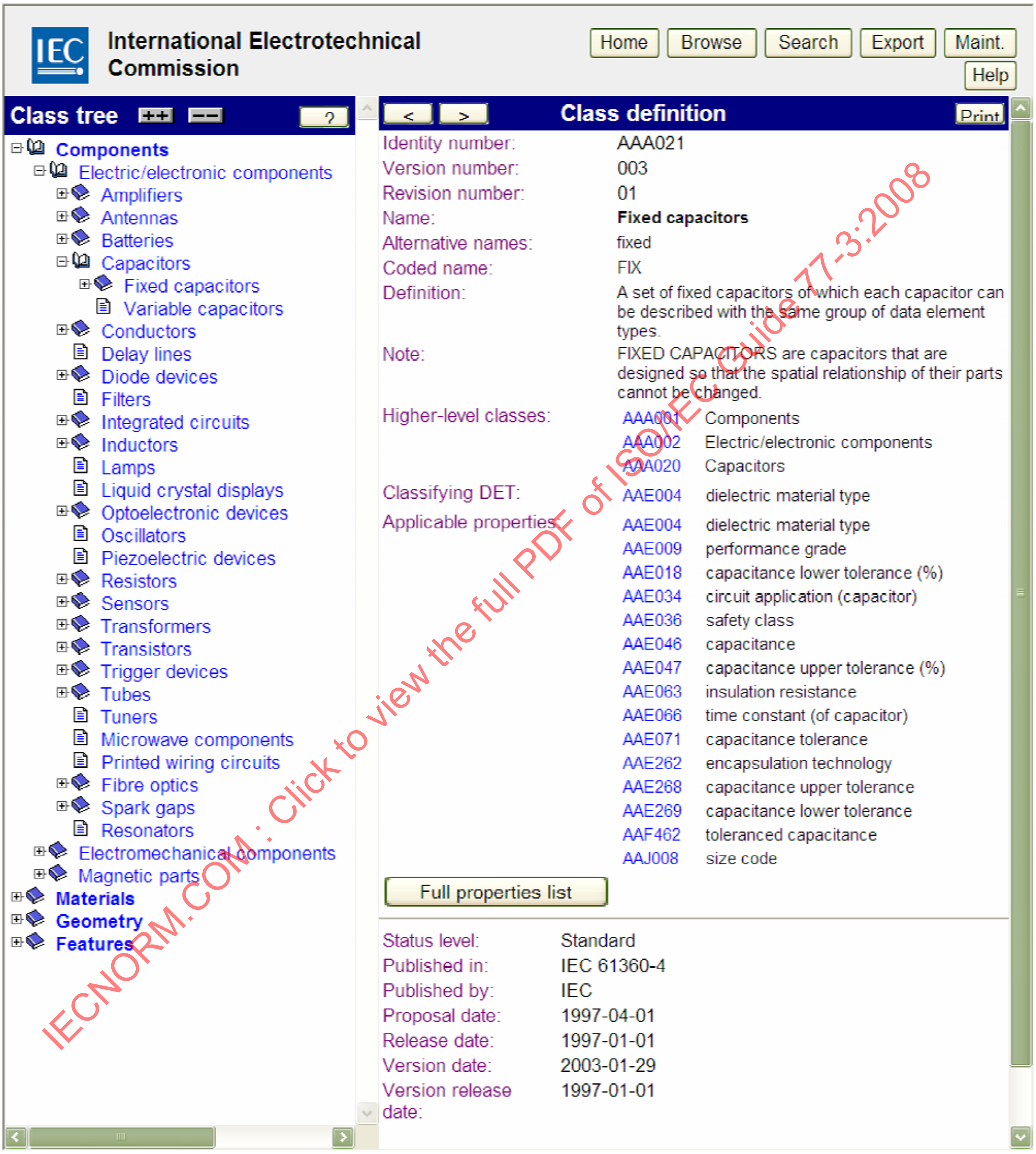


Figure 6 — Example of a classifying DET definition

5.7.3 Class specification attributes

In IEC 61360-1 the various attributes of classes as encountered in the specifications are explained.

5.8 Maintenance procedure

5.8.1 Overview

Defining a maintenance procedure is an important part of dictionary development. The purpose of the maintenance procedure is to ensure that the available released dictionary content is relevant, validated and approved, and that change requests are managed in a predefined and agreed upon manner within a particular time frame.

Initially, the IEC 61360 reference dictionary was published as a paper standard, as IEC 61360-4. The development of this paper standard followed the classic IEC procedures, as described in the ISO/IEC Directives, Part 1. Since 2003, the reference dictionary has also been available in an on-line database (IEC 61360-4-DB) via the IEC Web site, and replaced the paper standard in 2005. In order to maintain the reference dictionary in a database, a consolidated procedure has been developed which is applicable to all IEC standards in database format. Below, a short description of these procedures is given which is extracted from the proposed consolidated procedures document.

The procedures are based on the use of a Web-accessible database and electronic communication. The prescribed throughput time for maintenance/validation can only be achieved by means of electronic communication. The procedures are in three parts:

— first, the preliminaries,

— followed by either the normal database procedure, or

— the extended database procedure.

Figure 7 provides an overview of the procedures.

5.8.2 Preliminaries

This is the initial part of the maintenance procedures that should be completed for every change request (CR), consisting of the stages listed below.

— **Initiation of change request:** entering of a CR with the required information in a Web-accessible database by an authorized person or body also referred to as proposer.

— **Preparation for evaluation:** preparation by the secretary of the technical committee (TC) or subcommittee (SC) to ensure that all mandatory entries of the CR are appropriately filled-in.

— **Evaluation of the CR:** action by the validation team (VT) to determine whether the CR is within the scope of the database and valid for further work, or should be rejected.

— **Resolution:** conclusion as to whether the CR should be:

  — continued with the normal database procedure,

  — continued with the extended database procedure,

  — improved and re-evaluated, or

  — rejected altogether.

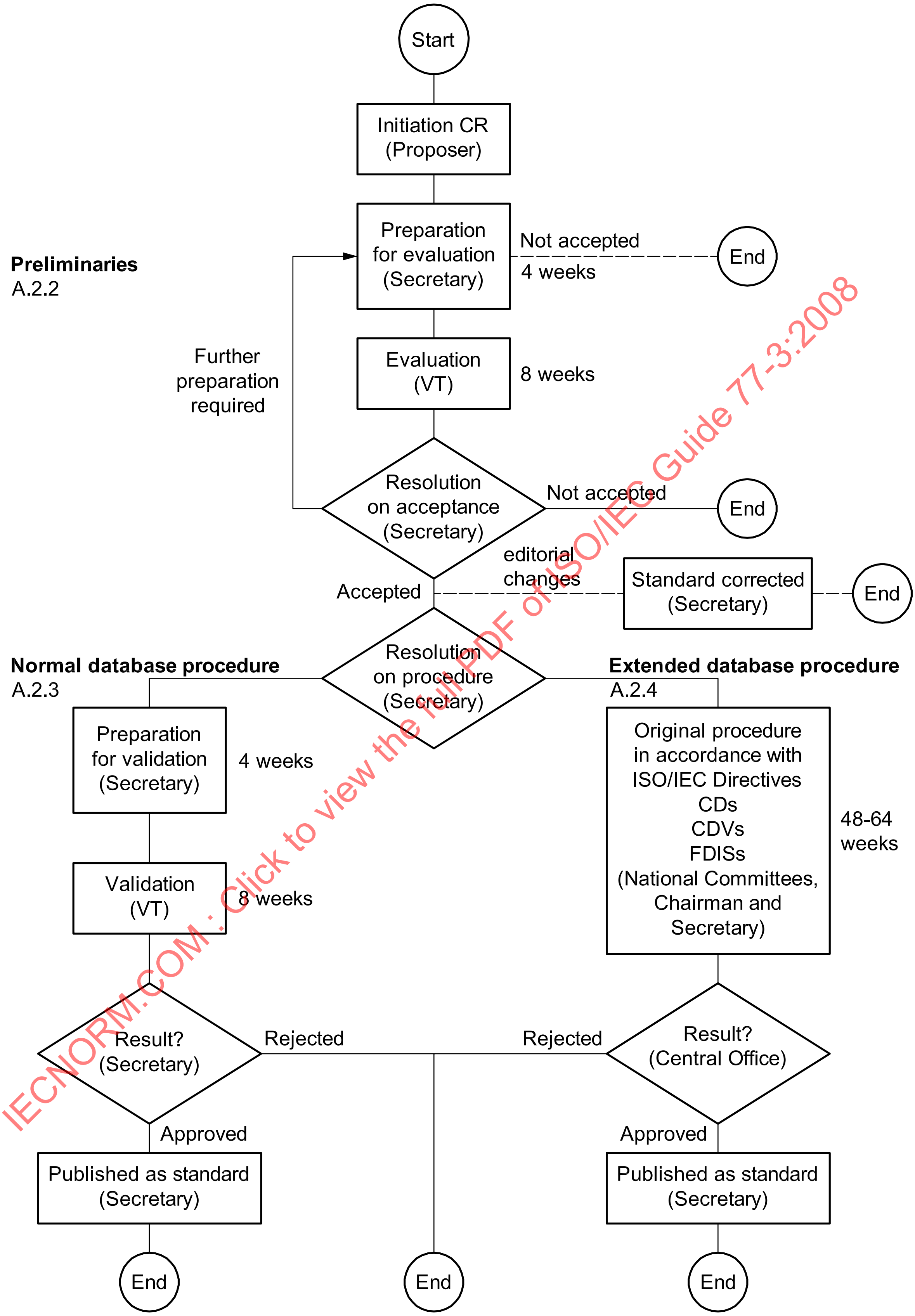


Figure 7 — Overview of the maintenance procedures

5.8.3 The normal database procedure

5.8.3.1 The normal database procedure is faster than the extended procedure and relies on the use of the validation team (VT) acting on behalf of the national committees for the final voting on proposals. The normal database procedure is typically applicable for changes to existing items and for new items within the boundaries of the existing domain of the database, or in cases where there is an urgent need for standardization.

NOTE More detailed rules applicable to a specific standard can be provided by the technical committee or subcommittee responsible.

Figure 8 shows a process map of this procedure.

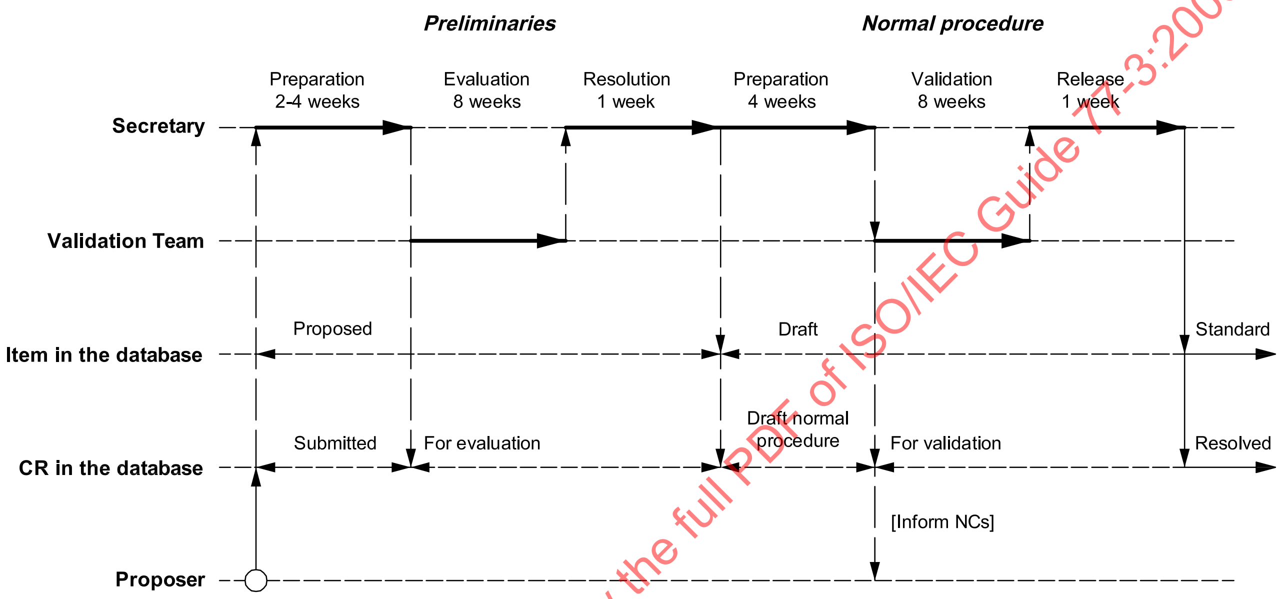


Figure 8 — Process map of the normal database procedure including preliminaries

5.8.3.2 **Preparation for validation**: the TC/SC secretary revises the proposal in line with the comments received during the evaluation stage and checks that the item(s) associated with the CR are, after possible changes still sufficiently and properly described, within the scope of the database and consistent with items already existing in the database. If required, corrections are made. For this, the secretary might seek assistance from the maintenance team (MT) or from other internal or external experts. This preparation should be carried out within four weeks.

5.8.3.3 **Validation**: when the quality of the information is satisfactory, the status level of the change request is changed to for validation, and the validation team (VT) called to vote by the secretary. Voting should be completed within eight weeks. If the proposed item(s) are accepted, the status level of the item(s) is changed to standard. If they are not accepted, then the reason(s) are noted in the remark and the status level of the item(s) is set to rejected.

5.8.3.4 After setting the final status levels for the items and noting the reasons, the status level of the change request is set to resolved, and the procedure is finished (maximum two weeks). With the normal database procedure, it is possible for proposals to be approved within approximately 24 weeks.

5.8.4 Adding new content

The placement of new content at the appropriate place in the class tree will need to be reviewed on a case-by-case basis. When new content is considered to be within the valid scope of the IEC 61360 reference dictionary but falls outside the scope of the existing classes, an option is to place this under a new branch of the root class.

5.8.5 Involvement of IEC domain experts

For the semantic quality and consistency across IEC standards developed within a particular domain, the involvement of the relevant IEC experts in the preparation of proposals is highly recommended. On the basis of incoming proposals, the related TC or SC can be contacted and a group of experts assigned, which are then organized into a domain-specific validation group. This VG can then be reactivated when required. First experiences are currently gained with this approach.

5.9 Tools and publication

In the development of the IEC 61360 reference dictionary, a number of software tools have been used and are used for maintenance and publication. In the course of developing the reference dictionary, an editor tool has been developed which performs syntactical checks in accordance with the ISO/IEC information model and added constraints as described in IEC 61360-1. The tool also guides the user in filling the appropriate attributes. Several import and export mechanisms have been added to support the maintenance and publication of IEC 61360.

For support of the reference dictionary in database format, an import template has been developed to facilitate requests for change or new content. The template makes checks and delivers the proposed content in the appropriate format for direct uploading into the IEC 61360 database.

The IEC database containing the IEC reference dictionary is managed by the IEC central office in Geneva. This database offers a limited number of checks which might be further improved with the planned change to a relational database.

The export from the IEC database is in structured HTML, which can be read and imported for further processing by a wide variety of applications, such as Microsoft Excel. All required information is included in eight separate files. The dictionary content cannot be checked against the ISO/IEC model on all aspects. To ensure that the dictionary content is fully compliant with the standard, a conversion to a STEP physical file (ISO 10303-21 format) is required. When converted to this format, several parsers exist that are able to perform rigorous checks against the model. For converting the structured HTML to STEP physical file, software has been developed that will be made available through the IEC Web site.

A recent development has been the definition of an XML-schema for the ISO/IEC model. When the XML-schema is stable, an export in this format will also be made possible through conversion software.

5.10 Global unique identification

5.10.1 General mechanism

To make an identifier in the reference dictionary globally unique, a registration authority identification needs to be defined and added to the identifier. The registration authority identification concept is explained and defined in ISO/IEC 6523-1. First, an organization identification scheme is selected from the schemes registered as part of the standard using the international code designator (ICD). Then, within this scheme, a particular organization is identified with the organization identifier (OI).

Table 2 — Global unique identification

Data element name	Description	Obligation	Data type	Maximum length
International Code Designator (ICD)	Identification of an organization identification scheme	Mandatory	Integer	4
Organization Identifier (OI)	Identification of an organization within an identification scheme	Mandatory	String	35

For the IEC reference dictionary, the ICD code 0112 is used, which stands for: “Registration of Standardization Organization”. For the organization identifier (OI), number 2 is used, which stands for: “IEC”.

Altogether, the source identification for the IEC 61360 reference dictionary is: “0112/2///61360_4_1”

The added 61360_4_1 at the end is the standards identifier (SI), which is described in ISO 13584-26 as an extension to ISO/IEC 6523-1. An example of the full globally unique identification of a particular property is: 0112/2///61360_4_1.AA000-001.AAF307-005.

Here, AAA000-001 is the identification of the class in which property AAF307-005 is defined (made visible) in the IEC reference dictionary.

5.10.2 Class and property codes

The identification of a class and property consist of combination of the code attribute and its version.

The code has the structure of three letters followed by three numbers as can be seen in the example given in 5.6.1. No apparent meaning is given to the codes although for practical reasons, ranges have been allocated in the past to separate classes from properties and ranges have been given for the development of new properties to groups.

The specific code structure of three letters and three numbers has been inherited from the dictionary content that was originally developed by Philips. It is not exactly clear what the reasons were for choosing this structure. However, it has been useful and adequate as a basis for the unique identification in the IEC dictionary and as a useable reference code in human-to-human communication thus far.

5.11 Conclusions

5.11.1 Effort

The IEC dictionary inherited its original content in 1989 from the Philips Corporate Component Database (CCD). This content was developed over a period of five years with a considerable amount of effort. The total effort for developing the original dictionary content, new additions, the EXPRESS model and the standardization work in general is substantial and can be estimated at about 150 man-years.

5.11.2 Documentation

It is recommended to create a document that is geared to the human reader and that specifies which parts of the ISO/IEC information model are used, as well as additional constraints and conventions, as is done in IEC 61360-1.

5.11.3 Organizing dictionary content

The IEC dictionary uses a class hierarchy to organize and define the classes and properties. The experience shows that the class hierarchy helps in providing an unambiguous context for the property definitions and consistency among the collection of classes. This is important for the definition and maintenance aspects of the dictionary. Other views might be developed that support usage of the dictionary content.

5.11.4 Maintenance process

The paper-based procedure for creating standards has been replaced for the maintenance of the IEC dictionary with a database-oriented procedure. This procedure is more geared to change management on parts of the dictionary down to item level, where the throughput time is shortened by the use of a validation team that represents the national committees in the voting procedure.

Within IEC SC3D, it is the recommended approach to organize domain expertise from IEC technical committees and subcommittees in validation groups, which contribute to the preparation of new proposals towards checking the relevance and semantics. An important aspect that results from the use of a VG is the coordination of IEC standardization work in the related domain(s).

5.11.5 Publication

The IEC dictionary is available under the IEC Web page (http://std.iec.ch/iec61360). The possibility to reference by use of an URL to individual items has proven to be useful. In the maintenance process, new proposed items are first created in a separate database that can be viewed by member of the validation team. To have proposed items available in the format of the database and its user interface has proven to be useful so far.

The current export support for making the IEC dictionary content available is in structured HTML and contains all the information required to convert to a ISO 10303-21 file, which can check compliance against the ISO/IEC information model. Additional publication formats or conversion services, e.g. to XML-schema and standardized Excel formats, are recommendations awaiting implementation.

6 Development of the ISO 13584-501 reference dictionary

6.1 General

This clause gives an outline of the activities deployed for the development of the initial reference dictionary content for the ISO 13584-501 registration authority, which covers environment and laboratory measuring instruments. The work flow of the activities is analysed and illustrated in Annex A using IDEF0 diagrams (see Figures A.1 to A.5), with the aim of showing how a typical reference dictionary development project may be organized and managed by a technical committee or subcommittee of ISO and/or IEC. It was learned later that many of the activities in the Figures A.1 to A.4 are common or very similar in other standard reference dictionary development projects. In order to understand the notation in IDEF0 diagrams, some prior knowledge may be needed. As shown in Figure 9, a box signifies a step of activity, and an arrow shows a direction of information flow. A box consists of input, control, output and mechanism sides of an activity (often abbreviated as ICOM). For example, a sample of product catalogue is an input for reference dictionary standardization, a normalized reference dictionary is an output of the activity, while laws and regulations are part of control or constraints on it and tools are regarded as part of mechanism to facilitate it.

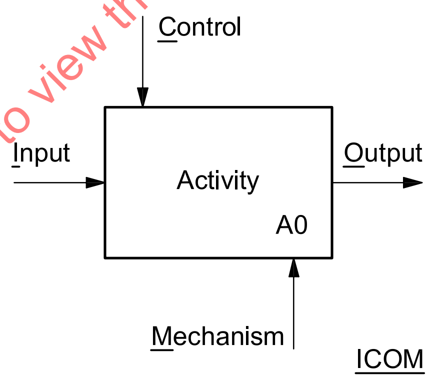


Figure 9 — Description of an activity in IDEF0 diagram

6.2 Starting and conducting a dictionary project

6.2.1 Selection of a project team

The project team consisted of three groups in general. One was a group of people who managed the progress of the reference dictionary standardization and tried to run the project keeping the time frame. They were the steering board of the project. Another was a group of domain experts who had professional knowledge about the products and were well versed in semantic description of the products and their properties possibly covered by the reference dictionary. The third group consisted of PLIB data modelling experts who were knowledgeable about the ISO 13584/IEC 61360 data model and were competent to generate a dictionary file conformant to the ISO 13584/IEC 61360 data model. The steering group included the representatives of two other groups. Otherwise, keeping the time frame of the dictionary development might have been extremely difficult as the project went on. For the ideal representation of domain experts, it is desirable that all the principal product domains under consideration be represented by at least one domain expert on the steering board, in order to synchronize various tasks for the reference dictionary development. Likewise, if no PLIB data modelling expert were on the steering board, the resulting reference dictionary would have been derived into non-conformance with the data model all too quickly, for want of understanding about the data model among the domain experts.

6.2.2 Liaison with organizations

It is also desirable that technical experts of related technical committees and subcommittees be involved from the beginning in the peer group for technical advice. Such involvement may be helpful to avoid political disputes at a later stage of standardization. In the case of ISO 13584-501, liaison within the Japanese mirrors went smoothly since many participants were from an industrial association, the Japan Electric Measuring Instruments Manufactures' Association (JEMIMA), which holds the secretariat of the Japanese mirror of IEC SC65B and hosted the ISO 13584-501 dictionary standardization. In addition, the liaison with IEC SC65B was established in the course of the dictionary development.

6.3 Development of the reference dictionary

6.3.1 Specification of the scope of the reference dictionary

The scope of a text standard is nominally fixed with the onset of a new work item (NWI) proposal. However, without a clear definition of terms, describing clearly what is actually meant by the scope statement of a standard, the scope remains subject to wide interpretation. When a reference dictionary is developed based on an existing standard, the range of products and their properties covered by the reference dictionary might be quite clearly understood by people. However, when a reference dictionary as standard is newly developed or as part of a new standard, it is not easy to determine the range of products and their properties to be treated within the reference dictionary. In particular, if the dictionary development has no finite set of predefined standards to be based upon, then the linguistic interpretation of the scope of the reference dictionary might be subject to wide consultation among the project members. Confusion could be avoided if the abstract concepts of the products, available as classes in the upper hierarchy of the reference dictionary, were rigorously defined with no delay in clear language referencing definitions available from well-established standards or jurisdictions.

In the case of ISO 13584-501, the International Classification for Standards (ICS) was referenced to find the standards to be covered. In addition, various European Union (EU) Council Directives were reviewed as primary source materials to be considered for the practical definitions of the range of products within a given domain reference dictionary. This is because many laws and regulations in EU member states are derived from the directives, and even in the countries outside the EU, they are respected among manufactures of products for exportation reasons. More domain specific technical definitions were found among various terminology standards of both ISO and IEC. Above all, International Electrotechnical Vocabulary (IEV) gave a panoply of useful information about standardized terminology and definitions in the electrotechnical domain. Meanwhile, reputable language dictionaries such as the Oxford English Dictionary (OED), in particular on CD-ROMs, were another useful source of materials to rely on. They illustrate how a word or term would be perceived or understood by intelligent native speakers in different contexts. They also show how a meaning of a term has been differentiated over decades. We tried to avoid unnecessary overloading or euphemism when we employed a technical term in the domain reference dictionary since we intended to address a wide range of readers. Once the linguistic description of the scope was fixed, we tried to find what physical products on the market fell exactly within this scope. From their specifications, we extracted applicable properties. The task of finding the ostensive definitions of the scope was delegated to domain experts on the steering board.

6.3.2 Identification of properties of products

6.3.2.1 Schematic view

Figure A.3 of the IDEF0 decomposition gives the breakdown of the activity A2 of identifying the properties in the course of the ISO 13584-501 dictionary development. This may apply, however, to many other dictionary development projects, as well for most part of the work.

6.3.2.2 Identification of applicable properties

Once the products in the scope were discovered, one could extract properties of each product from the datasheet, catalogues, and manuals of the products. They were the immediate candidates for the applicable properties of a product. In addition, the standards and regulations about the products often gave a good summary about the properties of a group of products. When collecting properties, also the units of measurement, conditions for measurement, underlying data types, and possibly short names and letter symbols, if available, were extracted from the information. Some of the properties appeared with different names in different products. It was useful to group together such possibly identical or related properties for later refinement. As a result of the activities at this stage, we obtained a tentative list of applicable properties for each product on the market in the scope.

6.3.2.3 Identification of properties to import

Some of the properties we listed in the tentative list of applicable properties had been defined already in some other reference dictionaries. In such cases, it is better to import the properties than to define them again. Importing the properties saves cost of development, but more importantly, it ensures interoperability among different reference dictionaries. For this purpose, the ISO 13584/IEC 61360 data model provides the case_of mechanism. Unfortunately, there are cases where properties exist which belong to other areas, but a reference dictionary has not yet been defined. In these cases, all the properties were defined for the ISO 13584-501 reference dictionary. However, in such a case, it is recommended to mark the properties as "should have been imported from other germane technical reference dictionary" for future replacement or deprecation if such a reference dictionary is later defined for that domain. Current practice in ISO 13584-501 is to mark those properties with a character "F" (foreign) in their BSU codes for purely administrative purposes.

6.3.2.4 Definition of visible properties

At this stage, domain experts defined the attributes of properties, such as preferred name, definition, data type, unit of measurement with the help of modelling experts. Another indispensable task at this stage was to clearly set the definition of properties. For this purpose, existing standards in the domain about product properties are most useful. In addition, regulations on the products provide workable definitions for the products. By using a tentative class hierarchy, the definition class of each property can be determined. If the exact definition class is not yet available, it may be provisionally set to the uppermost class in the reference dictionary.

6.3.2.5 Unification or differentiation of properties

Unification or differentiation of properties required close collaboration between domain experts and data modelling experts. Sometimes the same properties were referenced by different names in products and by manufacturers. Sometimes, different concepts were referenced by the same name particularly when the abstraction of the concepts contained some degree of commonality. One of the useful litmus tests for determining the identity or difference of properties was to see if we could assign physically the values of one property to another, e.g. we quickly see that a DC input voltage of some equipment cannot be assigned to an AC input of another, even though they may be linked by the same property name input voltage and have the same unit of measurement (i.e. "V").

However, we had to be mindful that before this stage, essentially equal concepts might be expressed with different property names and units. We also had to take note that sometimes a property might be modelled using a wrong data type, when they were drafted by domain experts who investigated existing catalogues and standards. Some of the typical examples of errors were the misuse of string data type for all numerical properties, misuse of real and integer data types for integer measure and real measure data types. Such errors needed to be corrected by data modelling experts.

6.3.2.6 Refinement of name scope

The definition class of a property denotes the domain of discourse in which the set of values of this property is meaningful. For example, the definition of the mass of a car may be significantly different from that of a screw, since the former needs a clear definition about the state of the car and the laws and regulations, according to which the mass should be measured, while the latter may be determined by a relatively simple physical measurement. Thus, even if the names, units of measurement, and the data types of the two properties are identical, they are still different properties, i.e. they only share common linguistic origin or connotation. A human being may discern the difference by an appropriate textual explanation, while a computer may only sense this by the detection of differences in values or in the data structure. Setting the definition class of a property correctly is important for describing the domain of discourse of the property. It should not be confused with associating appropriate properties to a class for defining or characterizing a class with predefined properties. There is a tendency to believe that the more the product becomes complex and special, properties need to be defined more specific with respect to their definition class for clarifying their conditions of measurement or applications. Examples of such properties are technical properties (e.g. mass, weight, height, width, depth, length, capacity, input voltage, output voltage, etc.) which commonly appear in many products, including the measuring instruments.

6.3.3 Development of product classification

There may be hundreds of ways of classifying a given set of products if there are no explicit rules or criteria. The creation of an unnecessary class should be avoided unless the concept of the class is commonly used and applied in many phases of industrial design and processes. It needs to be seen whether the concept of the class is used in a particular design phase of a product, or of a system which uses the product as a component, or it is indispensable for maintenance, operation, and/or transaction of the product on universal scale. For example, the concept of exhaust gas measuring equipment is used in an industrial regulation, while the concept of commodity lacks common definition. It needs to be seen whether the class has any explicit and outstanding property that differentiates it from others.

6.3.4 Generation of the dictionary file

A set of specialized tools were used to generate a dictionary file. First, a dictionary template that is composed of seven customized pages of a well-known spreadsheet software was delivered from the modelling experts to the chairs of domain experts to be filled by them. There this template was used to gather corrections and additions to the current dictionary definitions, and to consolidate change requests. It was then returned to the group of modelling experts, where all the dictionary data elements were converted into a reference dictionary in STEP physical file format (ISO 10303-21), whose entity syntax was compliant to the ISO 13584-25 conformance class 4 (CC4). For the conversion, a commercial PLIB-LMS (Library Management System) named OmniPhase™ developed and marketed by Toshiba corporation was rendered for service. In order to check conformity with ISO 13584, two other different commercial EXPRESS-compilers, i.e. ECCO™ of PDTec GmbH, and JSDAI™ of LKSoft GmbH, were used in parallel.[1)]

6.3.5 Review of the reference dictionary

Reviews were conducted over the Internet, several times a year during the ISO 13584-501 development project, actually by installing the reference dictionary into PLIB-server systems equipped with STEP physical file read/write capability. Sometimes, sample libraries were created for review purpose with actual product data in order to ensure the usability of the reference dictionary.

Putting the reference dictionary into STEP physical file format bears special importance to ensure data quality. Since both ISO 13584 and IEC 61360 standards define in some of their parts the data model, users of the standards expect that all major and mandatory data requirements specified in the standards are met by any formal release of the reference dictionary. Since both standards declare that the reference dictionaries conformant to the data model are computer sensible or interpretable and define the mechanism of product identification and property specification, users may naturally use the dictionary file in an automated process to define the manufacturing design process or the procurement database within a company. If a fatal accident occurs because of the clear and explicit discrepancy of the reference dictionary against the data model, which could have been easily detected by a data model conformance check with an EXPRESS compiler, then in the worst case, the person or organization that issued the reference dictionary as manufacturer may be liable for this accident. In the general understanding of the terms of the EU Council Directive 85/374/EEC, concerning

1) OmniPhaseTM, ECCOTM and JSDAITM are examples of a suitable products available commercially. This information is given for the convenience of users of this part of ISO/IEC Guide 77 and does not constitute an endorsement by ISO and IEC of these products.

liability for defective products including incorporeal objects such as electricity, this may be attributed to those who own the logo on the product (or maybe the copyright in the case of incorporeal objects). Thus, in the case of ISO 13584/IEC 61360 compliant dictionary standards, the data model is essential. Therefore, a particular step of validation against the data model should be mandatory and inevitable in the review process of the dictionary maintenance and registration procedures, in addition to the normal semantic review process applied to other non data model setting standards.

6.4 Publishing the standard

The body of a standard document itself needs to be developed by the use of human hands and brains. However, in order to generate a list of definitions for classes and properties that should be put into normal or informal annexes, a set of tools may be used to extract relevant information from the dictionary file or database. In the case of ISO 13584-501, all the class and property definitions were automatically generated and formatted into standardized forms. This was done using a publicly available technology known as XSL-FO embedded in OmniPhase.

6.5 Applying dictionary standards

The reference dictionary developed in this way will be used in industry as a basis for corporate or departmental product/part databases used for selecting products/parts based on their specification for procurement or engineering purposes. Special attention should be drawn to the fact that such an electronic reference dictionary, regardless of whether it is in the standard exchange file format or not, can be directly read into ISO 13584/IEC 61360 based engineering/commerce systems and that it forms a particular database for a technical/business domain. This is because an ISO 13584/IEC 61360 reference dictionary is computer-sensible, and may create a user database system for a specific domain without any programming by human beings. This is in all likelihood a totally new situation in the history of the use of International Standards, which have traditionally been provided only in paper form. Even if the reference dictionary is not designed directly for such use, some of the data elements of the reference dictionary may be referenced by other reference dictionaries by means of an automated referencing mechanism, called case_of in the ISO 13584/IEC 61360 data model. Thus, errors such as duplication of BSUs and/or names might incur tremendous product liability risks, and the compliance of the reference dictionary with the data model and its maintenance status should be strictly checked before it is released.

6.6 Provision of tools, experts, and financial resources

During the development project, two commercial and one free PLIB tools were used to support the work of the experts. One commercial tool provided a PLIB database and made it possible to review the reference dictionary over the Internet. The other tools were used for experimentation purposes and for checking interoperability across different tools.

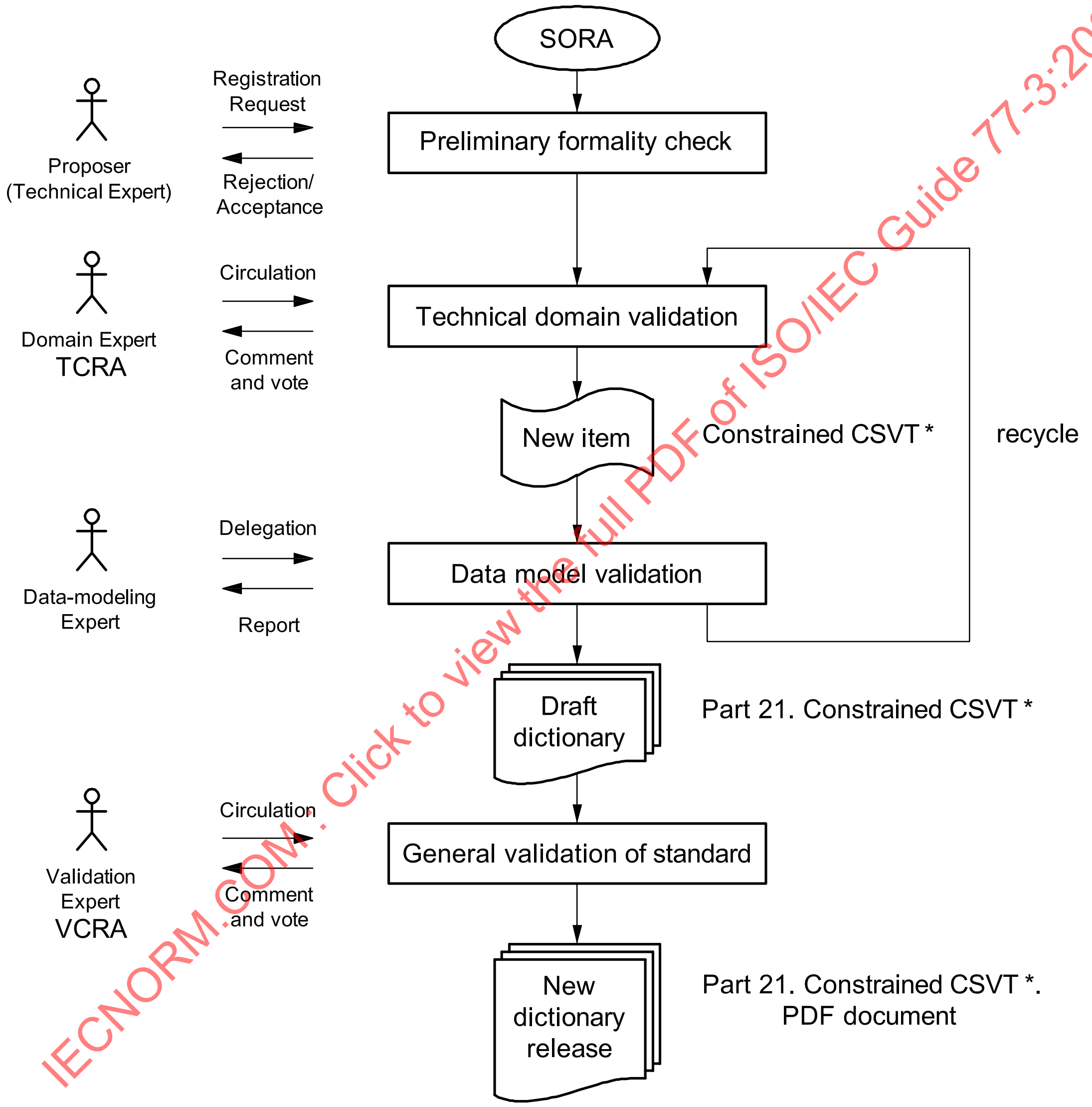
The standardization project was largely financed by JEMIMA, which has been one of the co-proponents of ISO 13584-501, and most of the human cost of domain experts was shouldered by the industrial association with approximately 100 member companies. A precursor project before this standardization project had been subsidized by a governmental research fund. Meanwhile, the cost of human labour of modelling experts was financed by the companies to which they belong.

6.7 PLIB information model

ISO 13584-25 conformance class 4 was used to describe the content of the initial ISO 13584-501 reference dictionary.

6.8 Planned maintenance for the reference dictionary

ISO 13584-501 is planned to use the registration authority (RA) model for the maintenance of RA-registered reference dictionary. The idea is that the dictionary elements gathered and registered by an RA are not themselves part of the standard, but the registration process of the dictionary elements, and the requirement on the elements are. Figure 10 gives an abridged view of the ISO 13584-501 registration procedure, demonstrating that one of the distinct characteristics of the ISO 13584-501RA procedure is that there is an explicit stage of data model compliance check of the registered data elements against the ISO 13584/IEC61360 dictionary model. Through this process, a new reference dictionary can be syntactically and semantically validated after the integration of existing and newly registered data elements. For the semantic review of the content, a committee consisting of technical domain experts will be formed. For overall review, another international committee will be formed consisting of members who are appointed by interested national bodies. Since ISO 13584-501 reached IS stage and the ISO Technical Management Board passed the resolution on establishing the RA, the RA was expected to start its operation within the year 2005. The reference dictionary collected by the RA will be updated and maintained by an automated means. An early version of the RA dictionary maintenance system is already in place and under the field test at the official ISO 13584-501RA site (http://www.iso13584-501ra.org/rabyt/index.html) for registered technical experts of the RA. Some of the internal view of the automated system is shown in Figure 11.



Key

SORA	Secretary of RA
TCRA	Technical Committee of RA
VCRA	Validation Committee of RA
RA	Registration Authority
CSV	comma separated values

Figure 10 — Abridged view of ISO 13584-501 registration procedure

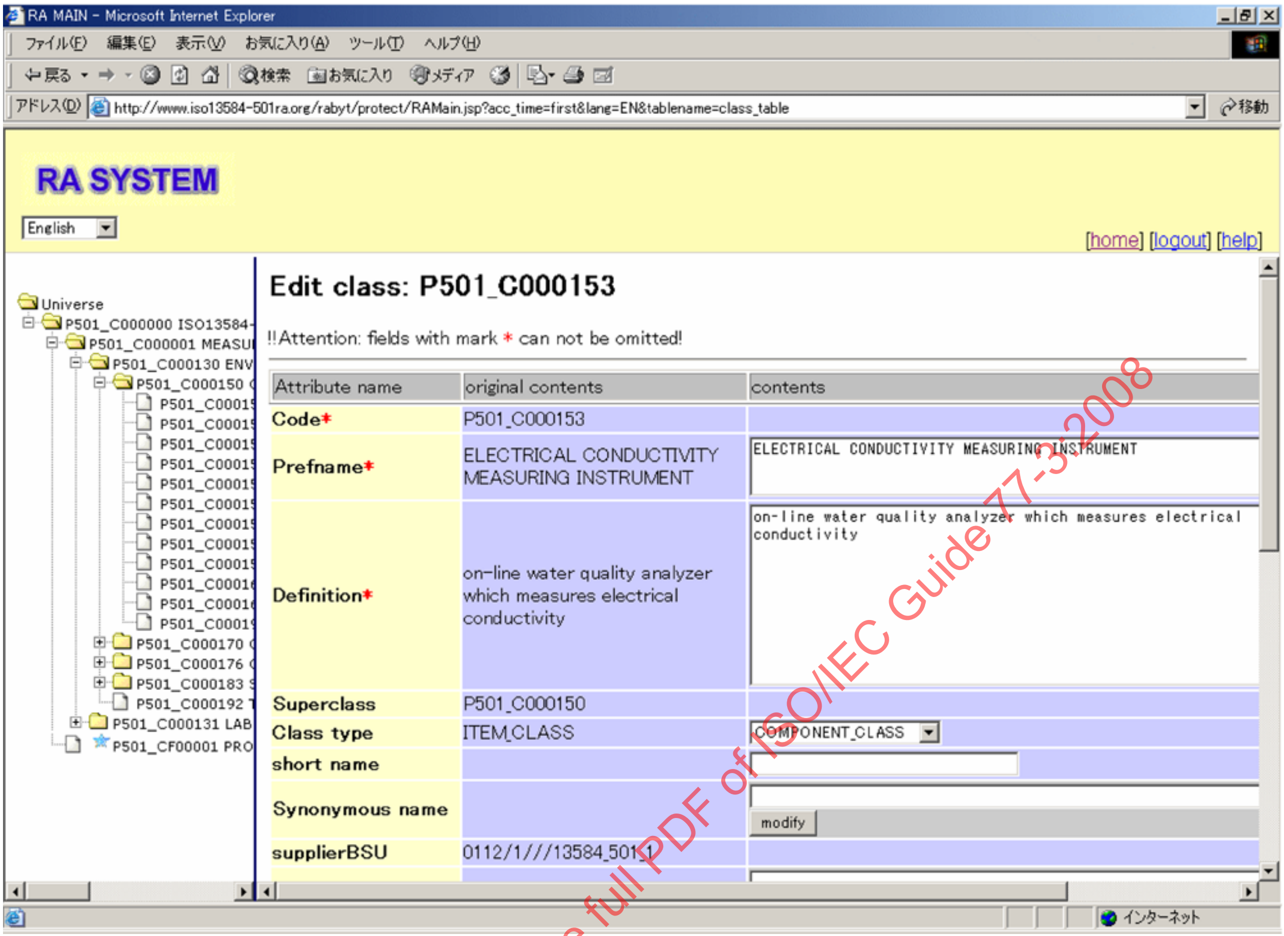


Figure 11 — A view of automated ISO 13584-501RA over Internet

6.9 Expenditure of effort

The meetings of domain experts took place every month, and usually 12 to 15 people were present each time. Each of the participants was supposed to spend approximately 10 % of their work time for the dictionary development. For the steering group meetings, which took place every two weeks, four to six people were regularly present. Two of them from the industrial association spent two to three days per week for the dictionary development. Data modelling and documentation were done by two PLIB data modelling experts who spent one week per month for the project. The total efforts which include the time spent for developing the document would amount to little more than 20 man months per year.

6.10 Conclusion

The appropriateness of a reference dictionary can be only proven through its use in business. In this regard, we can hardly claim that we have completed a full cycle of the dictionary development whilst most of its properties remain unused or the reference dictionary remains on a bookshelf of a library, being referenced only by standards writers. The final aptitude of dictionary definitions may be judged only when they are instantiated and deployed in a phase of product life-cycle. Actually, in our process of ISO 13584-501 dictionary build-up, many properties once defined will need to be refined when they are put to practice even in an experimental environment. For this, it may be a daring adventure to develop a complete reference dictionary with ISO status, within a time frame of two to three years allowed for an International Standard. We believe more field tests are needed before arriving at a reference dictionary with stable and reliable definitions, while the improvement is only possible by putting the reference dictionary into practice. On this account, we hope the RA to be installed by ISO 13584-501 will play a leading role in dynamically progressing toward the end.

7 Development of the ISO 13584-511 reference dictionary

7.1 Identifying the scope

Fasteners constitute a mature technical area, and the product standards in ISO/TC 2 cover most of the fasteners in general use in the market. The data in those standards is vast and relatively stable. Therefore, a project was initiated by the China National Institute of Standardization to develop a reference dictionary to formalize the content of these standards. This project was performed in ISO/TC184/SC4/WG2, and the result was ISO 13584-511. Non-standardized fasteners have been explicitly excluded from the scope, as specified in the Scope statement: "This part of ISO 13584 specifies a reference dictionary for all the parts described in the various ISO mechanical fastener standards, together with their descriptive properties and domains of values."

Later, certain requirements were added to describe non-standardized fasteners as well, e.g. by ISO/TC 29, the committee developing ISO 13399. This will be addressed later on the basis of a formal liaison among ISO/TC2, ISO/TC29, and ISO/TC184/SC4.

7.2 ISO 13584-511 team and cooperation with TC 2

A reference dictionary as ISO 13584-511 should meet at least two requirements:

— those for mechanical engineering, and

— those for PLIB dictionary modelling methodology.

This means that the development should be done by both fastener domain experts and data modelling experts. Hence, people with different backgrounds (mechanical background and data modelling background) were chosen when the team was first set up.

The team worked in very close cooperation with ISO/TC 2, whose former chairman attended most of the ISO/TC 184/SC 4/WG 2 meetings for the development of ISO 13584-511 and was deeply involved in the project.

7.3 Classification

7.3.1 Higher level of ISO 13584-511 hierarchy

At the upper level of the hierarchy of ISO 13584-511, the compatibility to the International Classification for Standards (ICS) was considered. Therefore, the classes of ISO 13584-511 are related to high level classes in the ICS.

The class thread has not been put under the fastener class but at the same level under the superclass mechanical component for general use. This was done to emphasize that the properties of thread are supposed to be referenced from other classes, also in different reference dictionaries, beside the fastener class.

The term of bolts, screws, studs in ICS has been changed to externally threaded fasteners in the ISO 13584-511 reference dictionary, because the difference between bolts and screws is not obvious. This was a result of the discussions with TC 2.

Some of the subclasses of fasteners in the ICS (e.g. rings, bushes, clamps, staples) have not been included into the ISO 13584-511 reference dictionary because there do not exist related fastener standards amongst ISO standards.

7.3.2 Lower level of ISO 13584-511 hierarchy

Basically, a fastener consists of a number of features: a head, a shank, a thread, an end, etc. For all these parts, a number of properties can be defined. If the class hierarchy is now organized in accordance with these different parts, we get a very complex class hierarchy which is built from the possible combination of these different parts (see Figure 12). If we use the head type as the discriminator at the highest level, each head type needs to be combined with (at the next level) each shank type, and at the next level, each of these combinations is combined with each end type, etc. On the one hand, it is quite arbitrary which of these categories is used at which level, and on the other hand, we get a huge hierarchy which is difficult to handle. Thus, this approach is too complex, the hierarchy is very deep, it is inconvenient to search, and the structure seems too be difficult to expand.

An alternative approach models the various parts of fasteners explicitly. The composition of a fastener is modelled, and the properties are associated with the parts. Thus, in this approach feature classes are introduced as head feature, shank feature, end feature and internal driving feature, and each fastener (e.g. a bolt or a screw) is composed of these four features. For each special type of fastener, it is then specified which kind of features are used for its composition. This results in a very simple and clear class hierarchy, reduces the number of levels and is easy to expand. Therefore, it was decided to follow the second approach.

Figures 12 and 13 show the two approaches using only two sub-hierarchies of metric threaded bolt/screw.

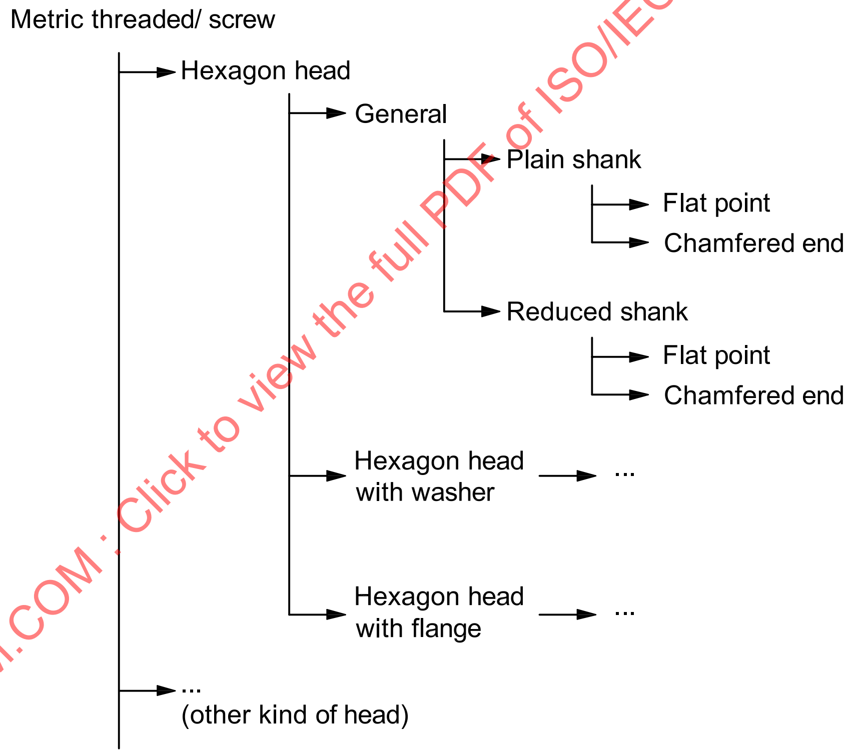


Figure 12 — Approach 1, no features (here the hierarchy may become very complex)

Metric threaded bolt/ screw

- → Hexagon head bolt
- → Hexagon head bolt with flange with fine pitch thread, full shank
- → Hexagon head bolt with flange with fine pitch thread, reduced shank
- → Hexagon head bolt with flange, full shank
- → Hexagon head bolt with flange, reduced shank
- → Hexagon head bolt with metric fine pitch thread
- → Hexagon head screw
- → Hexagon head screw with metric fine pitch thread
- → ...

Figure 13 — Approach 2, using features (simple hierarchy of classes)

To implement this idea into the fastener reference dictionary, the sub-tree under externally threaded fastener class has two branches (see Figure 14):

— the externally threaded fastener component branch, and

— the externally threaded fastener feature branch.

Four geometry features are used in the feature branch: head, shank, end and internal driving.

NOTE External driving features are included in the head features.

Any bolt or screw in the component branch is related to up to four features in the feature branch which are leaf classes beneath the four geometry features classes head, shank, end and internal drive.

The terms component class and feature class have only been used to distinguish real fastener component classes and geometry feature classes in the ISO 13584-511 reference dictionary. This is not affected by the planned changes in the second edition of the underlying PLIB standard (ISO 13584-42) where the concept feature class as a separate class entity for modelling a feature, or a composite property, will be no longer available in the future version of ISO 13584-42, but it would remain in essence the same, as a specialization of item class by flagging that it is a feature. The conceptual distinction of the two kinds of classes is important in the context of this reference dictionary.

7.4 Example hierarchy of externally threaded fastener and the reference mechanism

7.4.1 Externally threaded fastener hierarchy introduction

Figure 14 shows the hierarchy of externally threaded fastener. Only the externally threaded fastener class uses this kind of composition mechanism with references to feature classes, because some of the other components do not have so obvious feature categories, or they have features which are very simple so that it does not make sense to introduce special classes for them. In these cases, the properties are directly defined for the respective component class.

The arrow (Figure 14) from externally threaded fastener component class to externally threaded fastener feature class illustrates the reference mechanism for the purpose of referencing the feature classes and their properties by any externally threaded fastener component.

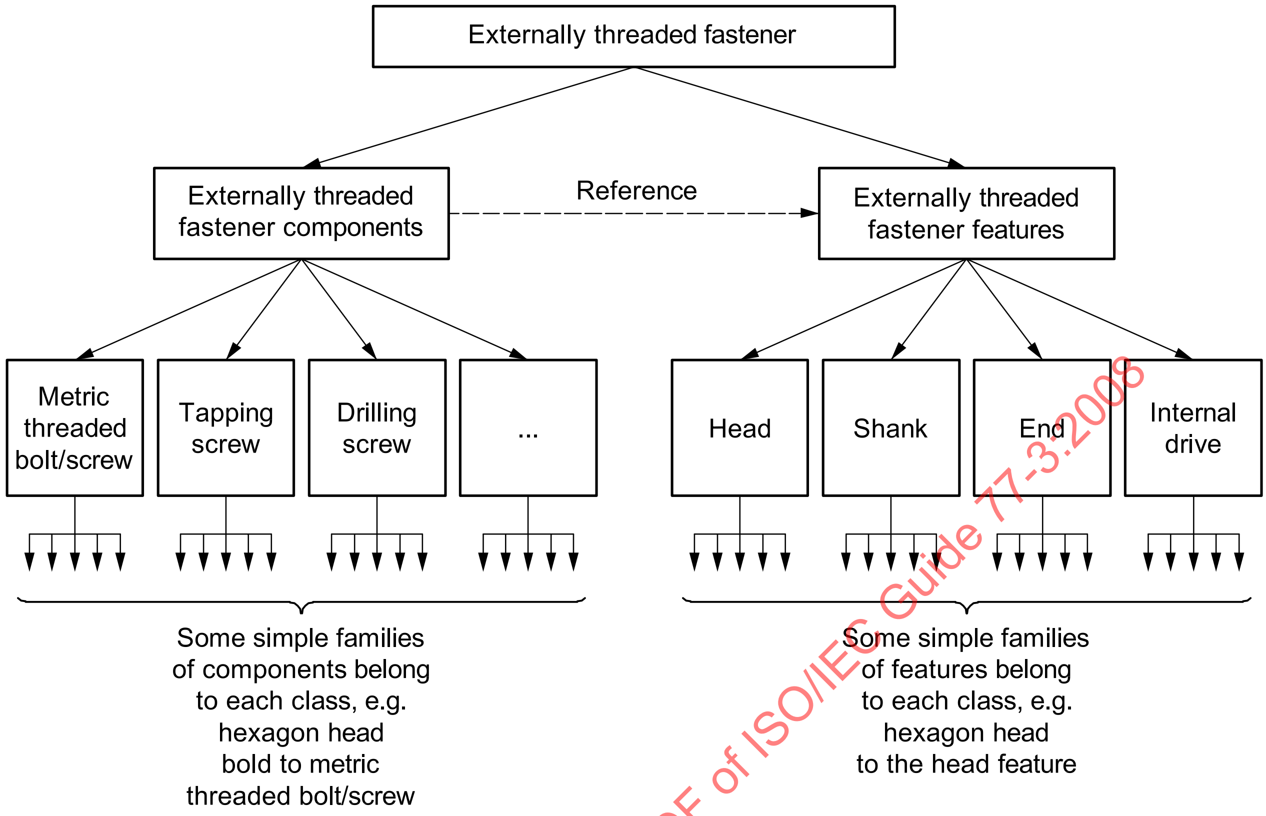


Figure 14 — Main hierarchy of externally threaded fastener

7.4.2 Reference properties and reference mechanism

In the ISO 13584 modelling methodology, the reference mechanism is realized by using two kinds of properties — the class_instance_type property and the sub-class selection property.

A class_instance_type property references the respective feature class from the component class by its BSU. In the model of ISO 13584-511, there are five class instance type properties defined:

a) head properties, indicating head class;

b) shank properties, indicating shank class;

c) end properties, indicating end class;

d) internal drive properties, indicating internal drive class;

e) thread properties, indicating thread class.

Each of these classes is specialized into some leaf classes (see the example in Figure 15), and each leaf class is identified by a code value. It is necessary to go to a specialized class when a specific fastener is modelled. This is done by a sub-class selection property. There are five subclass selection properties, which all provide a list of possible values or code list:

— type of head;

— type of shank;

— type of end;

— type of internal drive;

— type of thread.

EXAMPLE 1 The right column in Figure 15 shows some of the values (codes) of type of head and the left column shows their corresponding head features.

EXAMPLE 2 Hexagon head bolt (Figure 16) is composed of four features: hexagon head with washer, plain shank, flat point, and metric external thread. In this case, the values of these subclass selection properties contain the following code: type of head = HEXW, type of shank = PLA, type of end = FLA, type of thread = MET.

Some values of type of head

Head properties

12 point flange head	12PFL
Button head	BUT
Cup head	CHD
Cheese head	CHS
Cylindrical head	CLD
Countersunk head	COT
Cheese raised head	CRAI
Eyelet shape head	ELS
Eye shape head	EYS
Hexagon head with flange	HEWF
Hexagon head	HEX
Hexagon head with collar	HEXO
Hexagon head with washer face	HEXW
...	

Figure 15 — Some values of type of head and corresponding head features

Figure 16 shows how the subclass selection properties are used for the selection of the correct leaf feature class. The subclass selection properties are defined above the split of the component hierarchy and the feature hierarchy, i.e. they are visible in both branches. They are made applicable (i.e. usable) at the level of the general fastener types and at the level of the general feature types, i.e. the concrete types of fasteners and features are sitting below this level.

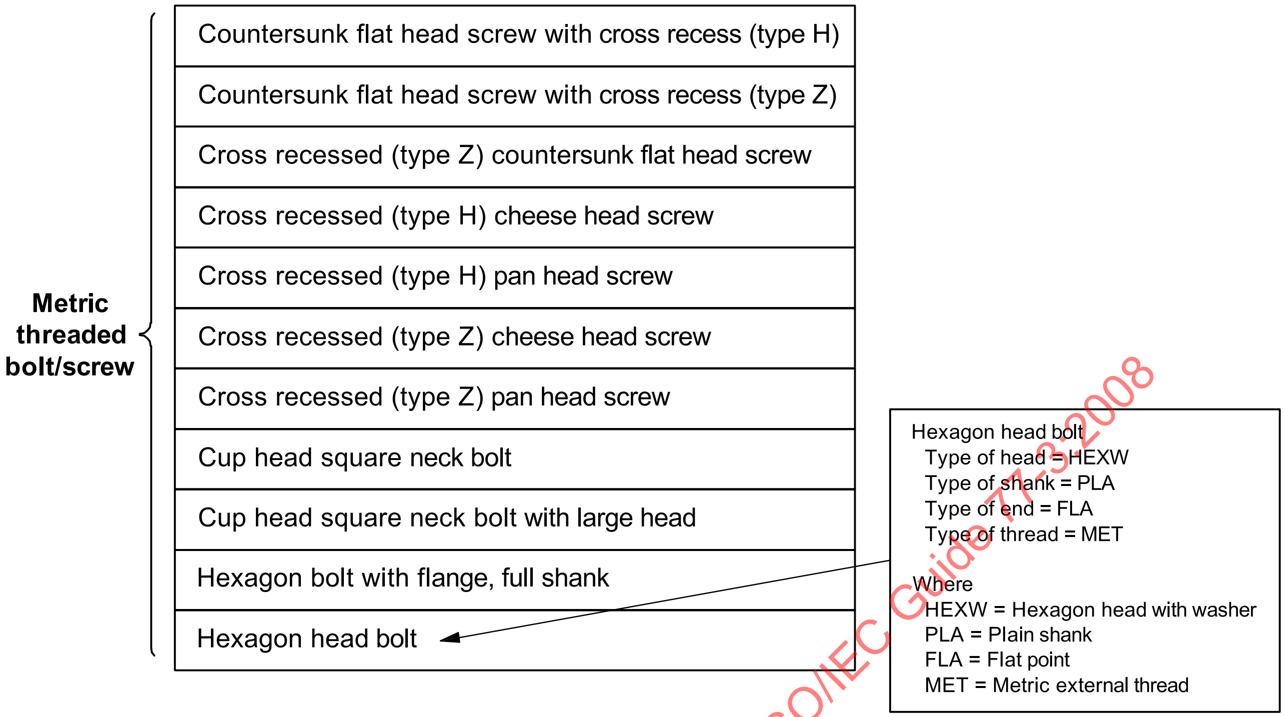


Figure 16 —Sub-class selection property assignment of hexagon head bolt

A sub-class selection property has a specific characteristic (in this sense, it is a special kind of property): if it is made applicable for a class A, then this property may be given a value in one of the subclasses of A, and this value is assigned at the subclass level. Each instance of the class (e.g. each fastener) has the same value for this property. We first assign values to these properties for the features at the leaf level, e.g. in the feature branch, the feature hexagon head with washer is given the code HEXW. Then we can use this code in the component branch to select the respective feature, e.g. for the class hexagon head bolt, the property type of head is given the value HEXW. Thus, the selection of the correct feature class (see Figure 17) is done by the match of the corresponding subclass selection properties.

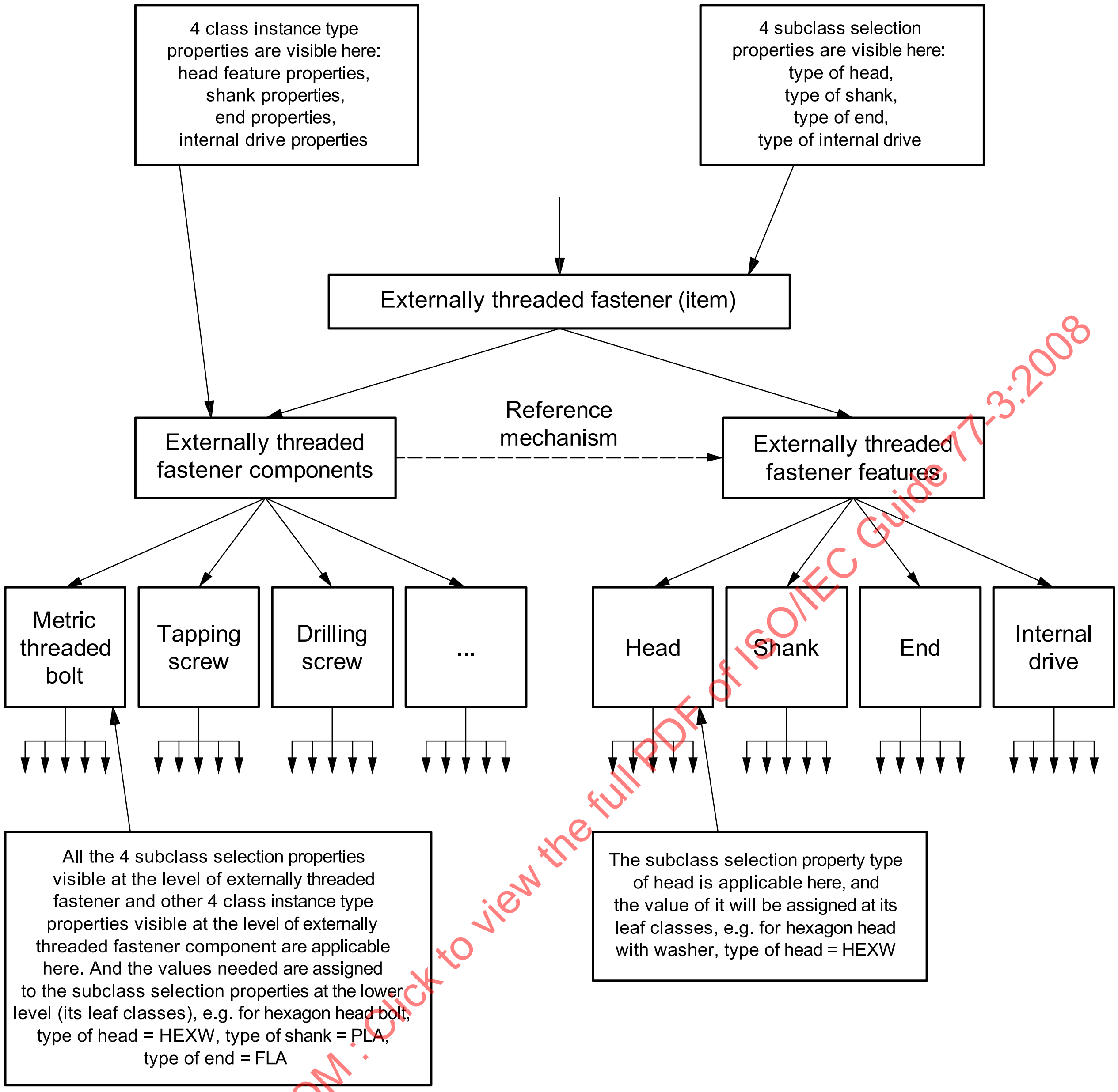


Figure 17 — Feature reference mechanism

7.5 Properties

7.5.1 Global property and local property

During the development of ISO 13584-511, we found that some of the properties (e.g. material, mass, manufacture date, etc.) can be used not only in this reference dictionary but also in other ones. On the other hand, as the basic principle that duplication should be avoided in international standardization, we realized that we should distinguish such properties from the properties that can be used only in a single reference dictionary. We also checked IEC 61360-4-DB, and referenced four properties from it:

— AAE012 International standard;

— AE687 Quality authentication;

— AAE752 Mass;

— AAF043 National standard.

Global properties are properties that are specified for use in several reference dictionaries.

Local properties are properties that are specified for use in a single reference dictionary.

EXAMPLE 1 P511BAA008 Designation is a local property only for fastener reference dictionary.

EXAMPLE 2 P511BAA011 EAN/UCC code is a global property which can be used for the reference dictionaries of Mechanical component for general use.

7.5.2 Geometry and non-geometry property

In the past, it was mainly those people involved in product design and engineering who were interested in part libraries. They mainly focused on the geometries of products and, as a result, most product properties in real part libraries (or standard part libraries) provided in the market by CAD/CAx system vendors were geometry properties rather than non-geometry properties. In recent years, along with the further usage of IT applications in industry, many logistic and warehouse people have paid attention to e-catalogues which include more non-geometry properties (e.g. management properties) and, of course, also a few geometry properties (e.g. main dimensions about product shape). Now people have realized that the non-geometry properties are similar important as geometry properties in part library.

Geometry properties are properties specified for geometry characteristics of components.

Non-geometry properties are properties specified for non-geometry characteristics of components, including properties like material, mass, hardness, manufacture date, etc. If a property is not a geometry property, it is a non-geometry property.

EXAMPLE 1 The property nominal length P511BAA257 is a geometry property specified at fastener class.

EXAMPLE 2 The property fastener hardness class P511BAA344 is a non-geometry property which is specified at fastener class.

NOTE Fastener hardness class is not a class in the sense of ISO 13584-42: it is the name of a property.

7.5.3 Reference mechanism property and general property

As discussed in 7.4.2, reference mechanism properties are such properties which have the function to establish a relationship between classes. This allows the clustering of properties in feature classes. The reference mechanism is implemented by two kind of properties – class instance type properties and subclass selection properties. These properties do not describe product characteristics, they are used for establishing the relationship from a class to its features.

Class instance type properties are used as pointers which reference another class by means of the BSU of the other class. The data type is class instance type.

A class_instance_type property in ISO 13584-511 normally references a feature which stands for a category of features rather than a feature class itself. Thus, there exist a number of subclasses of the referenced feature class. To select one of these subclasses, subclass selection properties are used: A sub-class selection property has the same value for the whole class and specifies the subclass which is referenced by the class_instance_type property.

The detailed description of the reference mechanism can be found in 7.4.2.

All the other properties are called general properties and describe real characteristics of the modelled product in the reference dictionary.

7.6 Hardness and thread

7.6.1 Hardness

Hardness is an important mechanical characteristic of mechanical components in general use. Four properties are defined in the reference dictionary for hardness:

— core hardness;

— surface hardness;

— fastener hardness class; and

— hardness test method ID.

During Committee Draft (CD) ballot, hardness was defined as a PLIB-class with only two properties: code of hardness rating scale and value of hardness rating. However, during DIS ballot, the class was deleted and the relevant properties were directly used in the relevant classes. Reasons for this decision:

a) hardness has no subclasses;

b) there are only a few properties;

c) these properties are mostly used in the fastener reference dictionary and not important for other reference dictionaries.

7.6.2 Thread

In contrast with hardness, thread was only specified by some properties rather than a class during CD ballot. However, a thread class was introduced during DIS ballot.

As already mentioned, thread is defined as a subclass of mechanical component for general use beside fastener, rather than in the geometry feature branch of externally threaded fastener feature, even if it is a real geometry feature class similar to head, shank, end, and internal drive of fastener. However, it was decided to define it at a higher level outside fastener to support references from other components of mechanical components for general use besides fasteners.

There are five subclasses under thread class: metric external thread, metric internal thread, tapping screw thread, thread forming screw thread, wood screw thread.

7.7 Tools

The most important tool which has been developed is the CNISPLBrowser by which we can browse the reference dictionary, check constrains and errors, and generate most annexes of ISO 13584-511. Thus, this software tool covers most work of the standard documentation.

7.8 Conclusion

The reference dictionary of ISO 13584-511 only includes the parts described in the various ISO mechanical fastener standards. It is necessary to add a large number of particular fasteners for using reference dictionary in business. Actually, when building up the ISO 13584-511 reference dictionary, it is very important and difficult to give out the unambiguous definitions of many properties and classes because those definitions are represented by the figures, and not by the language in ISO mechanical fastener standards. Hence, the members of the team should include an expert on fasteners. In addition, the important aspects for us in the future may be how to use it in business and how it may be extended.

8 Lessons learned

8.1 General

In order to sum up the experience gained from the various projects, feedback was requested on the basis of a small questionnaire containing the questions below.

a) If you had to do the same or a similar project, what would you do as you did, what would you do differently?

b) What do you consider as your biggest mistake? What do you consider as your best decision during the development process?

c) What do you think other groups can learn from your experience? What advice can you give them?

The responses provided are given in 8.2 to 8.4.

8.2 ISO/TC 37 (reference dictionary for cutting tool)

Q: If you had to do the same or a similar project, what would you do as you did, what would you do differently?

A: We would do the same as we did.

Q: What do you consider as your biggest mistake?

A: We cannot identify a “biggest mistake”. We had to learn from small mistakes, in the absence of any guidance, and the initial learning process was longer than we had expected.

Q: What do you consider as your best decision during the development process?

A: To involve domain experts from more than one company.

Q: What do you think other groups can learn from your experience?

A: The benefit of using a PLIB editor for capturing domain knowledge.

Q: What advice can you give them?

A: Make sure that the domain experts understand enough of the information modelling approach to contribute their expertise efficiently at an early stage.

8.3 IEC/TC 3/SC 3D (reference dictionary of electrotechnical components)

Q: If you had to do the same or a similar project, what would you do as you did, what would you do differently?

A: Nowadays, under influence of technological developments on databases and user experience the following would have been done differently:

— make requirements and configuration rules on data format less strict (allow version changes that do not affect the data type);

— create optionality to instantiate the levels of specified level types (when min, typ, max is specified, allow e.g. to only instantiate typ);

— extend the condition mechanism to allow the definition of optional conditions.

Q: *What do you consider as your biggest mistake?*

A: The transition of the dictionary content from paper-based to database format should have been done sooner. The failure to clarify the copyright rules properly has caused different interpretations on the allowed usage.

Q: *What do you consider as your best decision during the development process?*

A: Organizing the dictionary content in a classification hierarchy with single inheritance.

Q: *What do you think other groups can learn from your experience?*

A: Create well-defined conventions and requirements on the dictionary content as well as configuration management rules by creating a document similar to IEC 61360-1 relevant to the domain.

Q: *What advice can you give them?*

A: Consult the user community both before and after the publication of dictionary content. Publish dictionary content as soon as possible even if it is a limited domain so that a wide user community can be reached and can give feedback on the content as well as the way the information is structured.

8.4 ISO/TC 184/SC 4/WG 2, ISO 13584-501 project team (reference dictionaries for measuring instruments)

Q: *If you had to do the same or a similar project, what would you do as you did, what would you do differently?*

A: When we started the project, we had only primitive tools and a simple PLIB server for capturing the product concepts for building a PLIB dictionary.

Now we have more sophisticated tools, which may convert definitions in spreadsheets into a PLIB dictionary and vice versa, so we may gather information more directly from the domain experts. (For domain engineers, PLIB tools or OOP concepts in general are too difficult to handle.)

Thus, if we had to redo the project, we would use the online software tools more intensively.

ISO 13584-501 was one of the pioneers of the reference dictionaries. There are many things we have learned or found on the way. So in this sense all the problems we had might not have been avoidable.

Nevertheless, one of the most difficult things was to explain basic PLIB concepts to domain engineers, and on this account the present ISO 13584-42 document was not very helpful. In this light, this problem still persists, and as long as it does so, it would not be a good idea to start a PLIB dictionary development involving too many domain engineers. We should have selected a small team of willing few experts from companies that could provide just resources for the objective.

Q: *What do you consider as your biggest mistake?*

A: Letting the domain engineers develop the first draft of the document. We learned that it requires a special talent and expertise to develop an International Standard. We should have clearly separated the supply of domain knowledge and the development of an International Standard, such as for ISO.

Another important aspect is that the industrial organizations standing behind the development should have all required international contacts to clarify political problems early. It would be advantageous, if the reference dictionary were in real use by industry before standardization starts.

Q: *What do you consider as your best decision during the development process?*

A: Having adopted a database-oriented approach from the onset of dictionary development.

Q: *What do you think other groups can learn from your experience? What advice can you give them?*

A: The development cost, time, and human resources necessary for the development of a reference dictionary should not be underestimated. It is important to have a clear vision of the target users of the reference dictionary and how they will use the reference dictionary in their business.

Otherwise, the danger is that the reference dictionary will soon lose interest and support in industry.

9 Conclusions

9.1 General

This clause contains a summary of the important statements, as well as some conclusions drawn from the experience of the various projects.

9.2 Efforts

All projects give the advice to not underestimate the efforts which are involved in the development of a reference dictionary. It became obvious that the development of a reference dictionary is more than just transferring existing standards into a different representation: the elements which are required for a reference dictionary are not always available in the current standards (e.g. definitions, clear relationships between defined elements, possible values of properties, etc.). This requires inventing new elements or to sharpen existing definitions. Thus, it is important to have both domain experts and modelling experts in the team, and it is necessary to have tools available that support the experts in creating their specifications and reviews, check the data for syntactic correctness and automate part of the work.

The projects felt to be pioneers in the area of building reference dictionaries. This increased the necessary efforts because no examples existed on how to organize the development process. Each project had to develop their own strategies and spend time on organizing and evaluating the defined processes, sometimes in form of trial and error. Other projects spent efforts on developing software for visualizing and checking dictionary data. All this increased the overall efforts.

It is still true today that the effort for the development of a reference dictionary should not be underestimated. On the other hand, it is expected that with the experiences gained, with more tooling available, and with more experienced people, the required efforts for developing reference dictionaries will significantly be reduced for future projects.

9.3 Project setup

As already mentioned, all projects involved modelling engineers and technical engineers in the project teams, and they tried to involve people from different companies from the beginning to get different views into the team and ensure that the result is supported by a broad community.

Another issue for a good project setup is to identify from the beginning all potential political and legal problems. Examples are overlaps with other development groups or copyright issues. The projects tried to clearly identify the scope of the reference dictionary (e.g. by referring to the ICS) and to involve all potentially interested parties to avoid conflicts with respect to competence and responsibility. A clear specification of the conditions for use is a prerequisite that companies will use the dictionary in their daily business processes. Therefore, the copyright rules should be specified as early and as clear as possible.

9.4 Required knowledge and training of experts

In many reports, problems or achievements with respect to the training of experts were mentioned. It is clear that the domain experts need to have some understanding of the formalization of knowledge in a reference dictionary. In some reports the lack of this understanding was regarded as a main problem slowing down the process. On the other hand, in ISO/TC 29 this was not seen as a big problem: experts did not need to