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PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

Requirements concerning the interoperability between electromechanical and electrical applications in CAx-systems

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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REQUIREMENTS CONCERNING THE INTEROPERABILITY BETWEEN ELECTROMECHANICAL AND ELECTRICAL APPLICATIONS IN CAx-SYSTEMS

FOREWORD

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IEC-PAS 62515 has been processed by technical committee 3: Information structures, documentation and graphical symbols.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
3/837/NP	3/855/RVN

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned will transform it into an International Standard.

This PAS shall remain valid for an initial maximum period of three years starting from 2007-09. The validity may be extended for a single three-year period, following which it shall be revised to become another type of normative document or shall be withdrawn.

INTRODUCTION

During the preparation of several international IEC standards, especially ISO/IEC 10303-212, the question arose as to how to deal with the requirements concerning the physical layout of cubicles, panels, boards, in which devices of different size and of any product class are used, defining the requirements for their installation, service and operation.

The existing definitions on the national level as well as the definitions on the international level do not suffice to supply, process and exchange the data in a computer-sensible form with partners in a process chain. This includes, for example, the installation of devices using robots as well as the semi- or automatic wiring in cubicles.

At the same time, software suppliers requested the German Electrotechnical Commission within VDE (DKE) to define related specifications. For this purpose a task-force has been established, consisting of members of the following companies.

ABB Calor-Emag Schaltanalagen AG	Mannheim
Robert Bosch GmbH	Crailsheim and Stuttgart
Klöckner-Moeller GmbH	Bonn
L. Schuler GmbH	Goeppingen
Siemens AG	Erlangen

During the specification period members of the task force established the request to specify a list of minimum requirements for a software system concerning the needs within electrotechnical applications.

The results of the task force concerning data element types are already widely included within IEC 61360-4.

REQUIREMENTS CONCERNING THE INTEROPERABILITY BETWEEN ELECTROMECHANICAL AND ELECTRICAL APPLICATIONS IN CAx-SYSTEMS

1 Scope

This PAS is intended to serve as a checklist and guideline for the evaluation of CAx-software for applications within the electromechanical field by users in industry.

This PAS provides a set of data element types required in the context of electromechanical applications, especially in the context of electrical applications and their mechanical representations in the real or virtual three-dimensional world.

Where possible, existing internationally standardized data element types have been taken from the existing data element repository as listed in the data base of IEC 61360 available under the URL http://std.iec.ch/iec61360

Available data element types are indicated by their identity number, followed by its name and the definition as given in the data base at the time of publication of this document.

The application of standardized data element types supports the automatization of design processes during the development of products, systems and plants.

2 Normative references

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

IEC 60027 (all parts), *Letter symbols to be used in electrical technology*

IEC 60715:1981, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of electrical devices in switchgear and controlgear installations*

IEC 61346-1:1996, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

IEC 61360-4:DB, *Standard data element types with associated classification scheme for electric components – Part 4: IEC reference collection of standard data element types and component classes*

IEC 61666:1997, *Industrial systems – Installations and equipment and industrial products – Identification of terminals within a system*

IEC 81714-3:2004, *Design of graphical symbols for use in the technical documentation of products – Part 3: Classification of connect nodes, networks and their encoding*

ISO 31 (all parts), *Quantities and units*

ISO 128 (all parts), *Technical drawings – General principles of presentation*

ISO 129, *Technical drawings – Indication of dimensions and tolerances*

ISO 406:1987, *Technical drawings – Tolerancing of linear and angular dimensions*

ISO 3098 (all parts), *Technical product documentation – Lettering*

ISO 5455:1979, *Technical drawings – Scales*

ISO 5457:1999, *Technical product documentation – Sizes and layout of drawing sheets*

ISO 6428:1982, *Technical drawings – Requirements for microcopying*

ISO 7200:2004, *Technical product documentation – Data fields in title blocks and document headers*

ISO 10303-42:2003, *Industrial automation systems and integration – Product data representation and exchange – Part 42: Integrated generic resource: Geometric and topological representation*

ISO 10303-212:2001, *Industrial automation systems and integration – Product data representation and exchange – Part 212: Application protocol: Electrotechnical design and installation*

ISO 10303-214:2003, *Industrial automation systems and integration – Product data representation and exchange – Part 214: Application protocol: Core data for automotive mechanical design processes*

3 Terms and definitions

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

3.1
object
entity treated in the process of design, engineering, realization, operation, maintenance and demolition

NOTE 1 The entity may refer to an abstract or physical object or to a set of information associated with it.

NOTE 2 Depending on its purpose, an object may be viewed in different ways, called “aspects”.

[IEC 61346-1, 3.1]

3.2
system
set of interrelated objects

NOTE 1 Examples of a system: a drive system, a water supply system, a stereo system, a computer.

NOTE 2 When a system is a part of another system, it may be considered as an object.

[IEC 61346-1, 3.2]

3.3
aspect
specific way of selecting information on or describing a system or an aspect of a system

NOTE Such ways may be:

– what the system is doing (function viewpoint);
– how the system or object is constructed (product viewpoint);
– where the system is located (location viewpoint).

[IEC 61346-1, 3.2]

3.4
function
purpose related to an object

[IEC 61346-1, 3.4]

3.5
product
intended or accomplished result of labour or of a natural or artificial process

NOTE 1 A product usually has a part number, order number, type number, and/or a name.

NOTE 2 A technical system or plant can be considered as a product.

[IEC 61346-1, 3.5]

3.6
structure
organization of relations among objects of a system describing constituency relationships (”consist of”/”is a part of”)

[IEC 61346-1, 3.6]

3.7

reference designation
identifier of a specific object with respect to the system of which it is a constituent, based on one or more aspects of that system

[IEC 61360-1, 3.7]

3.8
terminal
point of access to an object intended for connection

NOTE The connection may refer to
a) a physical interface between conductors and/ or contacts to provide a signal or energy path;
b) an association of functional nature established between logical elements, software modules, etc. for conveying information.

3.9
terminal designation
identifier of a terminal with respect to the object to which it belongs, related to one aspect of the object

[IEC 61666, 3.8]

3.10
terminal function designation
identifier of a terminal with respect to the function of the object to which it belongs, related to one aspect of the object

3.11
terminal product designation
identifier of a terminal with respect to the product of the object to which it belongs, related to one aspect of the object

3.12
terminal location designation
identifier of a terminal with respect to the location of the object to which it belongs, related to one aspect of the object

3.13
terminal strip
assembly of different terminals with a common identification

3.14
connect node
node designed for connection to a specific kind of net, for example, electrical

[IEC 81714-2, DB]

3.15
2D Cartesian coordinate space
type of Cartesian coordinate space that is defined by two mutually perpendicular axis

[ISO 10303-201]

3.16
3D Cartesian coordinate space
type of Cartesian coordinate space that is defined by three mutually perpendicular axis

[ISO 10303-201]

4 Identification and classification of objects

The following requirements concerning the identification of objects within a plant or system are based on IEC 61346-1.

4.1 Identification of objects

Each object within a context may be identified according to the aspects regarding

– its function-oriented structure; and/or
– its location-oriented structure; and/or
– its product-oriented structure.

At least one of these reference designations is required in order to identify an object unambiguously within its context. There may also be cases where all three reference designations are provided. Each of these reference designations may be unambiguous on its own or all together may uniquely identify the object.

As all reference aspects via their reference designations are related to the same object, these have been collected within the reference designation set.

As there is an increasing need for interoperability of data between mechanical and electrical CAx-systems, the common use of the reference designations is needed in order to identify

identical objects in both application environments as identical objects during data exchange or within a data base.

During the concurrent phases of development of a plant under participation of different disciplines several sets of designation and the knowledge of their origin is needed. At the latest if data are merged together in a single consistent data base the reference designations need to be unique.

A physical layout, for example, of a constructional unit including the components to be built into it, can be prepared without knowing the final physical or virtual wiring among the components based on a wiring list or a circuit diagram or knowledge of the final reference designations of which the constructional unit is a part.

In these cases, only the parts list exists with the indication of the quantity and identifying position numbers.

For these cases, the identifying position number could serve as a special kind of a reference designation (here the location reference designation), seen from the mechanical or process discipline views as it collects all items under the location aspect. This results in the request that an object, for specific periods of time, may be associated with more than one reference designation set; however, precisely one associated with a discipline dependent on the context.

For safety and economic reasons, however, at the latest for the phases of installation, commissioning and operation of a plant, only a SINGLE consistent reference designation set is recommended, which needs to be accorded among the participating disciplines.

The following data element types are required to an object.

reference designation set
set of reference designations of which at least one unambiguously identifies the object of interest [IEC 61346-1]

being composed of

– **product-oriented reference designation;**
– **function-oriented reference designation;**
– **location-oriented reference designation.**

NOTE Other members of the set need not necessarily identify the object of interest but other objects of which it is a constituent.

4.2 Identification of connect nodes of objects

Each object may be associated with zero; one or many connect nodes, i.e. terminals (term used in electrotechnology), or connections (term used in the non-electrical area), like piping, etc. which connect it with its surrounding context.

This PAS deals with those classes of connect nodes which connect an object via nets of electrical, optical or any other type to other objects; see IEC 81714-3. A connect node of an object does not need to be associated with a graphical representation.

Each connect node may, as the object itself, be identified according to the aspects regarding

– its function-oriented structure; and/or
– its location-oriented structure; and/or
– its product-oriented structure.

At least one of these reference designations is required in order to identify an object unambiguously within its context. There may also be cases where all three reference designations are provided. Each of these reference designations may be unambiguous on its own or all together may uniquely identify the object.

As all reference aspects via their reference designations may occur related to the same object, these have been collected within the terminal designation set.

As interoperability of data between mechanical and electrical CAx-systems is required, the common use of the terminal designations is needed in order to identify identical objects in both application environments as identical objects during data exchange or within a data base.

The following data element types are required to each connect node.

terminal designation set
set of terminal designations each identifying the same terminal from different aspect of the object [IEC 61666]

being composed of

– **product terminal designation**

  alphanumerical characters used to identify uniquely a specific terminal to a net of a product assembly [IEC 61666]

– **function terminal designation**

  alphanumerical characters used to identify uniquely a specific function to a net of a function assembly [IEC 61666]

– **location terminal designation**

  alphanumerical characters used to identify uniquely a specific location to a net of a location assembly [IEC 61666]

4.3 Classification of connect nodes of objects

As in the majority of cases available products have more than only electrical connect nodes, and also connect nodes of other classes, it is required that a connect node be associated with a classification of its type. This is covered by the data element type *AAF391 connect node code*.

It is possible to connect only connect nodes of the same class.

The following data element types are applicable.

AAF391
connect-node code
code of the type of connect node of a component

NOTE For full information, see IEC 81714-3.

4.4 Classification of nets

The net connecting the participating connect nodes needs to be the appropriate one and shall correspond to the same class as that to which the connect nodes belong.

The classification of connect nodes and nets allows the integral management of all connect nodes of components and of nets. This is of high importance for the interoperability between mechanical and electrotechnical CAx-systems.

The following data element types are applicable.

coded net class
code of the type of a network

NOTE For full information, see IEC 81714-3.

5 CAx-applications

This clause specifies general issues which need to be taken into account.

5.1 Use of units in software applications

With respect to the data element types listed here, respectively referring the IEC data dictionary IEC 61360-4, all quantitative data elements are shown with its basic SI-units (for example, m, kg, s) according to ISO 31 or IEC 60027, without any decimal prefix sign.

In a software tool, a variety of decimal prefix signs may be needed according to the habits of the user or the industrial environment. Therefore, it is advised that the software allows the user to adapt the presentation of a quantitative data element type with any of those prefix signs as listed in ISO 31 or IEC 27 respectively according to his needs, although the system is storing the value in the basic SI-unit.

5.2 General

The application of the following International Standards is considered as a prerequisite: ISO 128, ISO 129, ISO 406, ISO 3098, ISO 5455, ISO 5457, ISO 6428, and ISO 7200.

5.3 Coordinate system

Pictorial presentations for layout purposes are laid down in the normal projection method within a 2D Cartesian coordinate space.

When presenting a 2D pictorial presentation on a drawing page, the local reference point overwrites those data of the local coordinate system. of the pictorial presentation.

As the origin of the coordinate system of a drawing (landscape, portrait), the left lower corner of the cut sheet is defined (see ISO 5457).

5.4 Reference point of 2D/3D pictorial presentations

The origin of the 2D Cartesian model space is defined as the reference point for a pictorial presentation for layout purposes in a 2D space (see Figure 1). This reference point remains unchanged for all projection views of an object.

The same reference point is applied also within the 3D Cartesian model space.

5.5 2D/3D routing

In order to allow a computer-supported routing of connections within a CAx-system, each connect node needs to be associated to the appropriate class.

As a consequence, for example within a 2D/3D geometry modeller, it is required that the position of a connect node be associated with specific data, for example, connect node class and connecting direction. When the logical data from a net list, produced by an electric CAx-system, are combined with the data of the geometry modeller, a routing process of the net may start. This applies for each type of net.

The connecting directions assigned to a connect node are either defined as sectors within the 2D-space or by a vector within a 3D-space.

The connection information – which connect node is connected to others – is defined when specifying the connectivity, for example, within a circuit diagram. When assigning a component to this functional connection during the routing process, the connection may carry the cross-section, colour and bending radius, etc. of the specified component type.This information can be used when defining the layout of components installed for example within a constructional unit.

The routing result is either an open polyline in the 2D or in the 3D space, defining the geometrical route of each connection between two connect nodes as a sequence of 2D points (or 3D points) within a 2D space (or 3D space). During the routing process, the relevant data element types such as *AAF352 terminal to contact angle* specifying the direction how a conductor may access the connect node, *criticality* providing a weighting factor for routing, *AAF470 bending radius*, *AAE022 outside diameter* of the cable etc. need to be taken into account.

The data element type *AAF391 connect node code* is required for those cases when different product classes have been assigned or will be assigned to a product, for example, an electric driven pneumatic valve having electrical and pneumatic connect nodes, or a hydraulic brake controller in a car with electrical and hydraulic connect nodes. If no value has been assigned to the data element *connect node code*, the value E is assumed representing an electrical connect node.

The classification supports an overall look at the occurring connect node classes for the installation within a constructional unit. The information of the connect node class allows also a selective presentation and management of different classes of nets in analogy with the connect node classes at components.

NOTE The routing of connections within this context may be different from the routing on printed circuit boards.

6 Arrangement drawings

In order to prepare arrangement drawings, the possibilities applied in industry for dimensioning, such as, for example, chain dimensioning, based on the scale associated with the presentation of the object, need to be available in the CAx system (see ISO 5455).

6.1 2D projection views

This clause establishes the data requirements for the presentation of components in a 2D space in constructional units, for example, in a cubicle.

Within a lot of industrial electrotechnical applications the presentation in a 2D space is sufficient. In other cases, where, for example, for quality reasons, collision or other installation investigations are needed, it is recommended that a model in a 3D-space be applied.

In this context the views in the 2D space correspond to the projection views established in accordance with ISO 128. See Figure 1.

The reference point is defined as the three-dimensional point to which the geometric figures of a component/device are related.

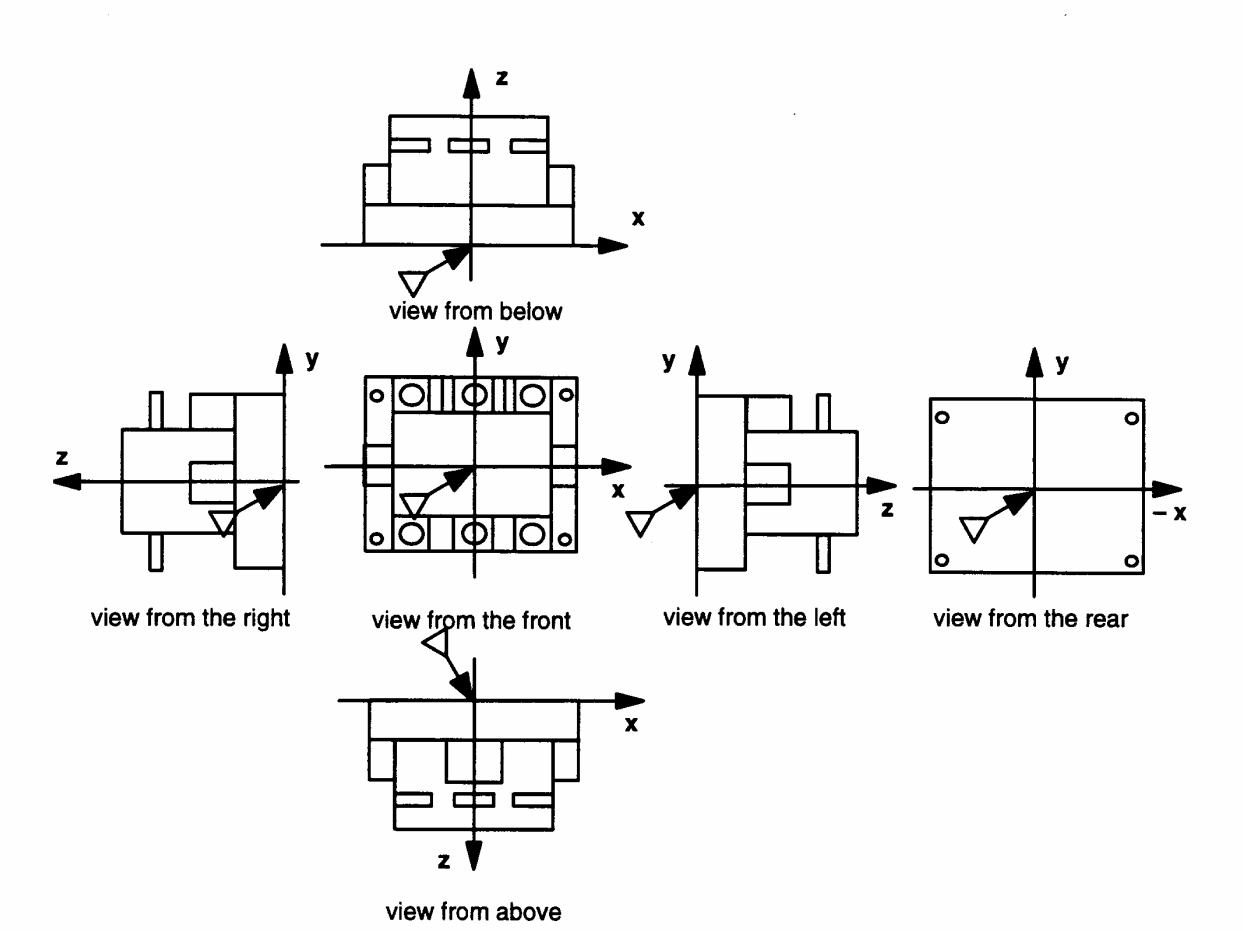

Figure 1 – Definition of projection views based on ISO 128 with indication of reference point

It is a convention that the view from the front of a body always be established as the x/y-space of a 3D space.

As each projection view is associated with a given product, or product class, respectively, it reflects within a 2D space (eventually calculated by a scale factor) the real dimensions of the considered body.

All projection views including details may be associated with several product types. This leads to a reduction of storage capacity within a library.

The following data element types are applicable.

AAF392
project view code
coded abbreviation of the two-dimensional projection view of an item

AAF396
scale
the value of the denominator of the real things magnitude of the magnitude of the model

6.2 Net and gross dimensions

For each projection view of a component there is a need to differentiate among different levels of presentation; those pictorial presentations serving for the presentation of the net dimensions and those of the gross dimensions.

Pictorial presentations based on the net values represent the real dimensions of the physical body, reduced or enlarged by a scale factor.

Pictorial presentations based on the gross values represent the dimensions covering the additional space required for

– the wiring/connection of the terminals;
– the blasting space for switching devices;
– the space required for the installation, operation, service and decommissioning of the device;
– the minimum distances to neighbouring objects caused by heating dissipation of the object.

The simplified presentation level for the gross (net) dimensions of a device corresponds to the common enclosing envelope of all gross (net) dimensions.

This is applicable also to presentations in a 3D space.

The following data element types are applicable.

AAF397
net area
value of the area (in m^2) of a two-dimensional plane defining the effective physical contour of a geometrical object

AAF398
gross area
value of the area (in m^2) of a two-dimensional plane associated with a geometrical object due to installation, protection, operation, service and maintenance reasons

AAF399
net space
value of the volume (in m^3) of a three-dimensional space defining the effective physical contours of a geometrical object

AAF400
gross space
value of the volume (in m^3) of a three-dimensional space associated with a geometrical object due to installation, protection, operation, service and maintenance reasons

REMARKS
1 The gross space encloses completely the net space of the geometrical object.

2 The gross space is normally not possible to be occupied by other geometrical objects.

6.3 Level of presentation

In order to keep investments low for the preparation of the geometry model, reduce storage capacity and shorten reaction time of a system, each projection view may be presented either in a simplified or detailed level of presentation. The simplified presentation is limited generally to the presentation of a graphical primitive, such as rectangle, circle, whereas the detailed level of presentation depicts the complete body contours in the projection view. See Figure 2.

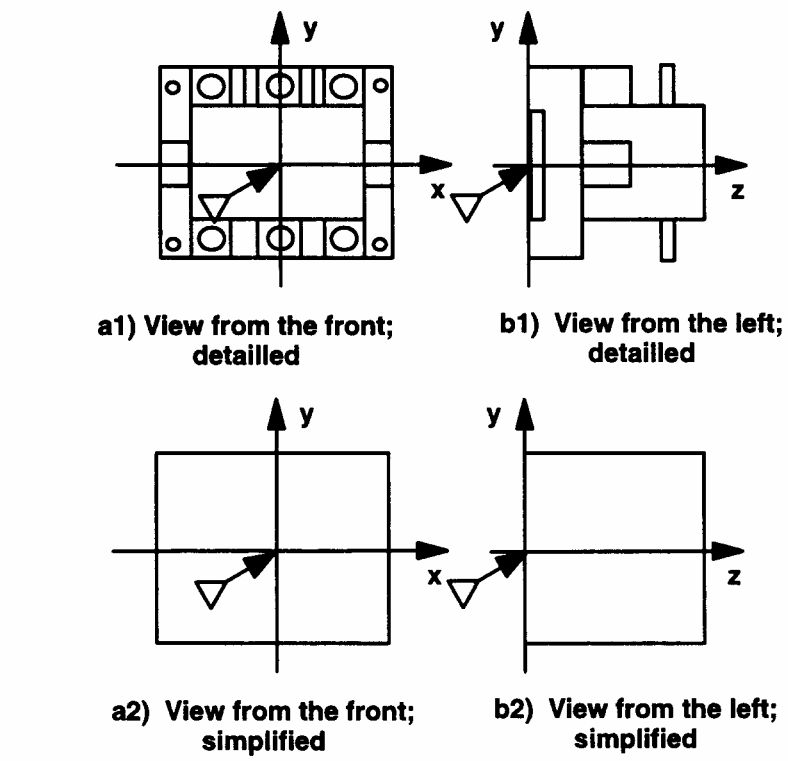

Figure 2 – Levels of presentation

When applying the simplified level of presentation, the data element types of the relevant solid model need to be supplied together with the data element type *AAF396 scale* along with the front view.

With these data, the receiving system may generate the missing projection views automatically or generate a simple 3D geometry model reduced or enlarged by the associated scale value.

6.4 Detail drawings

A projection view (see data element type *AAF392, project view code*), independent of its level of presentation may be associated with a list of zero, one or many detail drawings, each of which may be associated with a separate scale value. It is recommended, however, always to apply the same scale value for these drawings.

6.5 Foot prints

Foot prints serve for the presentation of installation requirements of devices or component types. By positioning of a constructional unit at a defined physical location, the fixing points and the mounting features are known, for example, via screws, rivets, C-profiles, and may therefore be transferred to an NC system for the manufacturing of the supporting metal sheet.

Information about predefined foot prints with associated patterns can be found in the IEC components data base under the class tree: geometry/package outline

In the case of the arrangement of a cubicle on a wall or floor or any other constructional item in a building, the mounting figures show in graphical form data for through-holes or excavations on the floor level. These requirements may, therefore, be referenced by a civil engineer for use in a CAx system for structural engineering and underground and surface level construction.

mounting figure; foot print

Depending on the mounting feature, a device may be associated with one or more figures indicating the mounting requirements designed to fasten a device to its seating plane.

Example 1

Figure showing the drilling holes needed, its dimensions and further information concerning, for example, the use of NC-tools for the manufacturing of the base plane the device is planned to be mounted upon.

Example 2

Figure showing the cut-out of a front plane of a control panel needed for the mounting of a metering instrument.

Example 3:

Figure showing the cut-outs in the basement intended for the cabling from and to a cubicle.

The requirements with respect to the data transfer for example for the NC manufacturing of mounting plates, supporting metal sheet, or the transfer of data to structural engineering and underground and surface level construction are not part of this report.

6.6 Further required data element types

As the data base of IEC 61360-4 is a resource of data element types associated with products, not all data element types listed here will be made available in the data base.

AAG001
distance of seating plane
distance between the surface plane (in m) on which the component/device is mounted in relation to the reference plane of the constructional unit it is built in or on

keep-out-area
two-dimensional closed plane intended for future installation of components/devices

keep-out-space
three-dimensional closed space intended for future installation of components/devices

routing area
two-dimensional area exclusively reserved for the physical routing of cables and wires

NOTE This virtual area is defined independently of the physical existence of, for example, cable trays. Such items may be placed within such areas but not exceed them. However, an item, for example, a cable duct, or tray may also be defined as a routing area.

routing space
three-dimensional space exclusively reserved for the physical routing of cables and wires

NOTE This virtual space is defined independently of the physical existence of, for example, cable trays. Such items may be placed within such spaces but not exceed them. However, an item, for example, a cable duct, or tray may also be defined as a routing space.

6.7 Presentation levels of (electric) terminal strips within a 2D space

For economic reasons, two presentation levels have been defined.

– detailed

  Each terminal type being a constituent of the terminal strip is associated with a separate geometry.

– simplified

  The simplified presentation in the 2D-space is done by a simple rectangular or as a right angular block in the 3D-space.

Based on the view from the front, the total net length (along the x-axis) of the terminal strip is calculated from the widths of each of the terminal types composing the terminal strip. The total height (along the y-axis) of the terminal strip is taken as the maximum height of all terminal types composing the strip. The maximum depth (along the z-axis) of the terminal strip is taken as the maximum depth of all terminal types composing the strip.

These data may be generated by the CAx-system.

In any case the terminal strip is being considered as an assembly of components, of which the single terminals follow each other in a specified sequence (list of).

NOTE If there is the need to allocate separate terminal strips for example on a single C-bar, and it is desired that all terminal strips on that bar be handled as a unit, then it is recommended that a separate reference designation be assigned to each terminal strip. This allows the establishment of a hierarchical assembly structure providing the possibility to identify the assembly, each of the terminal strips within the assembly and each terminal within each terminal strip: for example -X1X2X30A, where -X1 is the assembly of terminal strips on the C-bar, -X2 one of the many terminal strips within -X1, -X30 a terminal within -X2, and A one of the physically available connect nodes of the terminal -X2. This example assumes that a terminal has at least two connect nodes.

A terminal respective terminal strip may be provided by the supplier with several fixing possibilities, see *AAE006 mounting features*; however, only one possibility can be applied.

7 Modelling of devices/equipment within the 3D space

This clause defines the requirements for the installation of devices within a 3D space for the installation in constructional units, for example, a cubicle.

7.1 Product data for (plug) connectors

For economic reasons a differentiation is made between

– single connect node type; and
– global connect node type.

Single connect nodes are geometrically explicitly modelled due to their size and the consequences for the connection, for example, bar connections or plug-in units of bigger size. In this case, the single connect node is defined in the 3D space as a geometric model including a directed space vector; the latter defining the connection direction, required by its counterpart for a correct connection.

Global connect node types are defined as multi-pole terminals, which, due to their quantity or physically small size, need not be geometrically explicitly modelled within the 3D space. The global connect node is a point in a 3D space including a directed space vector; the latter defining the connection direction, required by its counterpart for a correct connection.

When having adequate functionality within a CAx-system, these features avoid canting or twisting of the parts to be interconnected.

In the case of plug-in connectors information about the contact sex need to be associated to the connect node, avoiding that connections are planned having the same contact sexes. See data-element type *AAE353 contact sex*.

7.2 Net and gross dimensions

The following net and gross dimensions apply.

AAF362
centre of gravity (x-axis); x-axis displacement of centre of gravity
nominal value of the x-displacement (in m) of the centre of gravity of a component related to the reference point of that component

AAF363
centre of gravity (y-axis); y-axis displacement of centre of gravity
nominal value of the y-displacement (in m) of the centre of gravity of a component related to the reference point of that component

AAF472
centre of gravity (z-axis); z-axis displacement of centre of gravity
nominal value of the displacement of the centre of gravity of a component in z-axis direction with respect to the reference point of the component

The centre of gravity is a point inside, or sometimes outside, a body at which the gravitational potential energy of the body is equal to that of a single particle of the same mass located at that point and through which it may be regarded that the resultant force of the gravitational forces on the constituent particles of the body acts.

NOTE The centre of gravity may be calculated if using a solid modeller.

AAF399
net space
value of the volume (in m^3) of a three-dimensional space defining the effective physical contours of a geometrical object

NOTE The net space needs to be described as a volume model, i.e. either as boundary representation (brep) or approximated as faceted boundary representation (faceted brep), since when using other kinds of presentation methods, for example wire-frame, the body is not unambiguously defined and no collision investigations can be executed.

AAF400
gross space
value of the volume (in m^3) of a three-dimensional space associated with a geometrical object due to installation, protection, operation, service ands maintenance reasons

REMARKS

1 The gross space completely encloses the net space of the geometrical object.

2 The gross space is defined as a space normally not possible to be occupied by other geometrical objects.

NOTE For reasons of collision investigations, the gross space needs to be described as a volume model. In order to make both body presentations distinguishable on the screen, the gross body could be shown as a wire-frame presentation. The presentation of the wire-frame body could be made using a different colour or a different line-type.

7.3 Mounting positions

A device is associated with information about its preferred mounting position and possible deviations. Today, this is mostly done by presenting graphical symbols in catalogues, which are not computer-interpretable. For this reason this report establishes data element types, which may be applied in CAx-systems checking the correctness of the installation of a device within the defined limits (see Figure 1).

AAF401
x-coor preferred mounting position
value of the distance (in m) on the x-axis of the direction of the preferred mounting position of a component

AAF402
y-coor preferred mounting position
value of the distance (in m) on the y-axis of the direction of the preferred mounting position of a component

AAF403
z-coor preferred mounting position
value of the distance (in m) on the z-axis of the direction of the preferred mounting position of a component

NOTE If no value is specified, the preferred mounting position corresponds to the direction of the y-axis the device is being specified in.

AAF404
mounting deviation y/z
absolute value of the angle (in °), indicating the maximum rotation deviation from the y-axis within the y/z-plane of the three-dimensional coordinate system, under which the device fulfils its terms of operation

NOTE In the case where the value of this data element type is not provided, it is assumed that no deviation from the preferred mounting position is possible.

AAF405
mounting deviation y/x
absolute value of the angle (in °), indicating the maximum rotation deviation from the y-axis within the y/x plane of the three-dimensional coordinate system, under which the device fulfils its terms of operation

NOTE In the case that the value of this data element type is not provided, it is assumed that no deviation from the preferred mounting position is possible.

7.5 Further definitions

keep-out space
three-dimensional space intended for future installation of components/devices

routing space
three-dimensional space exclusively reserved for the routing of cables and wires

NOTE This area is defined independently of the physical existence of e.g. cable trays. Such items may be placed within such areas but not exceeding them. However, an item, for example, a cable duct, or tray may be defined as a routing space.

7.6 Parametric descriptions of devices within a 3D space

E-CAx-systems are normally not provided with the capability of generating solid bodies within a 3D space. In order to generate a simple body geometry within a 3D modeller, often a parametric description of such bodies suffices. If the single parameters of the different body types are known, a 3D modeller can generate the bodies and they could be interactively placed within an arrangement. Such generation does not, however, support any connectivity among related connect nodes as the connect nodes are not explicitly associated with such bodies.

This clause defines requirements for geometric elements independently of whether they will be applied within the context of a wire-frame, surface, CSG or solid-modeller. The geometric elements with their parameters are intended to be used within an application area using a 3D modeller; the parameters might be defined within the context of a two-dimensional geometric application and will allow specifying the body.

The parameters associated with the different geometric elements describe each of the basic geometrical elements in a simplified form which is, however, often sufficient for collision inquiries etc.

It is agreed that the simplified geometric elements are not sufficient for such requirements, including the presentation of the interconnectivity between these geometric representations by means of conductors, cables, pipes, etc. In these cases, the relevant bodies need to have the information of the terminals or the connectors, i.e. the geometric position, its direction and identification of each terminal or connector belonging to the object of interest.

In the case of a limited amount of and of repeated use of components dealt with in a layout, it may also be economic for a user to define the geometry in a solid modeller by himself, according to the data supplied by the manufacturer.

It is acknowledged that the amount of work to be invested in the creation of a geometric representation by solid modelling is economic only in those cases where the manufacturer of such a product supplies his clients with such geometric representations and provides also the update of such data.

7.7 Parametric description of solid primitives according to IEC 61360-4/ISO 10303-42

For the parametric description of bodies, the following data element types are supplied.

7.7.1 Position and direction

The following data elements define the local position location and the direction of the axis of a solid within a 3D-space.

AAF406
x-coordinate position location
value as specified by the level (miNoMax) of the length (in m) of the x-coordinate of the location of a point on the symmetry axis of a constructive solid geometry primitive

AAF407
y-coordinate position location
value as specified by the level (miNoMax) of the length (in m) of the y-coordinate of the location of a point on the symmetry axis of a constructive solid geometry primitive

AAF408
z-coordinate position location
value as specified by the level (miNoMax) of the length (in m) of the z-coordinate of the location of a point on the symmetry axis of a constructive solid geometry primitive

AAF411
angle axis to x-axis
value of the angle (in °) between the orientation of the axis of a constructive solid geometry primitive and the X-axis of the placement coordinate system

AAF412
angle axis to y-axis
value of the angle (in °) between the orientation of the axis of a constructive solid geometry primitive and the Y-axis of the placement coordinate system

AAF413
angle axis to z-axis
value of the angle (in °) between the orientation of the axis of a constructive solid geometry primitive and the Z-axis of the placement coordinate system

7.7.2 Right angular block

In order to describe a right angular block, the following data element types are applicable

AAE019
body length
value as specified by the level (miNoMax) of the length (in m) of the body of a component in the x-direction

AAE020
body height
value as specified by the level (miNoMax) of the height (in m) of the body of a component in the z-direction

AAE021
body breadth
value as specified by the level (miNoMax) of the breadth (in m) of the body of a component in the y-direction

7.7.3 Right circular cylinder

In order to describe a right circular cylinder, the following data element types are applicable.

AAF409
cylinder radius
value as specified by the level (miNoMax) of the radius (in m) of a cylinder

AAF409
cylinder height
value as specified by th level (miNoMax) of the distance (in m) between the two planar circular faces of a cylinder

7.7.4 Right circular tube

In order to describe a right circular tube, the following data element types are applicable.

AAE753
inside diameter
value as specified by the level (miNoMax) of the inside diameter (in m) of a component with a body of circular cross-section

AAE022
outside diameter
value as specified by the level (miNoMax) of the outside diameter (in m) of a component with a body of circular cross-section

AAF409
cylinder height
value as specified by the level (miNoMax) of the distance (in m) between the two planar circular faces of a cylinder

7.7.5 Right circular truncated cone

The right circular cone is described by the following data element types.

AAF414
cone radius
value of the radius (in m) of the cone on the axis at the top of a right circular cone

NOTE If the radius is zero, the cone has an apex at this point. If the radius is greater than zero, the cone is truncated.

AAF415
cone height
value as specified by the level (miNoMax) of the distance (in m) between the two planar circular faces of a right circular cone, if the radius is greater than zero; or from the base to the apex if the radius equals zero

AAF416
semi angle
value of the angle (in °) between the axis of the cone and the generator of the conical surface of a right circular cone

7.7.6 Right circular cone

The right circular cone is a solid with a circular plane and sloping sides meeting centrally at an apex.

It is defined by the same data element types used to describe a right circular truncated cone. If the value of the data element type *cone radius* is defined as zero, the geometry corresponds to a right circular cone. In this case the data element *cone height* is the distance between the circular basic plane and the apex of the cone.

7.7.7 Sphere

The sphere is described by the following data element types.

AAF417
sphere radius
value of the length of the radius (in m) of a sphere

AAF418
x-coordinate of centre
value as specified by level (miNoMax) of the distance (in m) on the x-axis of the centre of a sphere

AAF419
y-coordinate of centre
value as specified by level (miNoMax) of the distance (in m) on the y-axis of the centre of a sphere

AAF420
z-coordinate of centre
value as specified by level (miNoMax) of the distance (in m) on the z-axis of the centre of a sphere

7.7.8 Torus

The torus is described by the following data element types.

The position describes the location of the central point on the axis and the direction of the axis. This defines the centre and plane of the directrix.

AAF421
mayor radius of torus
value as specified by the level (miNoMax) of the radius of the directrix of a torus

AAF422
minor radius of torus
value as specified by the level (miNoMax) of the radius of the generatrix of a torus

7.7.9 Right angular wedge

The right angular wedge is described by the following data element types.

AAF423
wedge x-size
value as specified by the level (miNoMax) of the length (in m) of the right angular wedge along the placement X-axis

AAF424
wedge y-size
value as specified by the level (miNoMax) of the length (in m) of the right angular wedge along the placement Y-axis

AAF425
wedge z-size
value as specified by the level (miNoMax) of the length (in m) of the right angular wedge along the placement Z-axis

AAFxxx
ltx
length in the positive x-direction of the smaller surface of the wedge (ISO 10303-42, 6.4.5.6)

7.7.10 Right angular truncated pyramid

The right angular truncated pyramid is described by the following data element types.

AAF426
mayor edge
value as specified by the level (miNoMax) of the length (in m) of the edge of the square basic plane of a right angular truncated pyramid

AAF427
minor edge
value as specified by the level (miNoMax) of the length (in m) of the edge of the square top plane of a right angular truncated pyramid

AAF428
primitive height
value as specified by the level (miNoMax) of the distance (in m) between the apex and the base plane or between the two parallel planes of a right constructive solid geometry primitive

7.7.11 Right angular pyramid

The right angular pyramid is a solid with a square plane and sloping sides meeting centrally at an apex.

This solid is defined by the same data element types used to describe a right angular truncated pyramid. If the data element type *minor edge* is defined as zero, the geometry corresponds to a right angular pyramid. In this case, the *primitive height* is the distance between the square basic plane and the apex of the pyramid.

7.7.12 N-edged regular column

The n-edged regular column is described by the following data element types.

AAF429
edge length
value as specified by the level (miNoMax) of the length of the edge of an N-edged regular column

AAF428
primitive height
value as specified by the level (miNoMax) of the distance (in m) between the apex and the base plane or between the two parallel planes of a right constructive solid geometry primitive

AAF437
column type
value indicating the number of corners defining the column type

7.7.13 Half-sphere

The half-sphere is a specialization of a sphere and described by the following data element types.

AAF417
sphere radius
value of the length of the radius (in m) of a sphere

AAF418
x-coordinate of centre
value as specified by the level (miNoMax) of the distance (in m) on the x-axis of the centre of a sphere

AAF419
y-coordinate of centre
value as specified by the level (miNoMax) of the distance (in m) on the y-axis of the centre of a sphere

AAF420
z-coordinate of centre
value as specified by the level (miNoMax) of the distance (in m) on the z-axis of the centre of a sphere

AAFxxx
sphere angle
value of the angle (in °) between the axis of the sphere and the generator of the circular surface of a sphere

NOTE In the case of a half-sphere the angle is 90°.

7.7.13 Spherical segment

The spherical segment is described by the following data element types.

AAF418
x-coordinate of centre
value as specified by the level (miNoMax) of the distance (in m) on the x-axis of the centre of a sphere

AAF419
y-coordinate of centre
value as specified by the level (miNoMax) of the distance (in m) on the y-axis of the centre of a sphere

AAF420
z-coordinate of centre
value as specified by the level (miNoMax) of the distance (in m) on the z-axis of the centre of a sphere

AAF417
sphere radius
value of the length of the radius (in m) of a sphere

AAF432
minor radius
value as specified by the level (miNoMax) of the length (in m) of the radius of the circular plane of a spherical segment

AAFxxx
segment height
value as specified by the level (miNoMax) of the length (in m) of the distance between the planar circular plane and the surface of the spherical segment

8 General product data

The following data element types are required.

AAE834
component description
description of a component according to the manufacturer

REMARK Additional to the structured data in other data elements, free text description.

AAH547
type number
type number as given to a component by the manufacturer

REMARK This type number is the one that normally identifies the part uniquely. If the component is large enough, it will be the product code marked on the component and referenced in data sheets

AAH549
ordering code
code as required by a component manufacturer or supplier to identify the component when placing an order

REMARK The ordering code may or may not be identical to the type number. In some cases, it may consist of the type number supplemented by additional information such as value, rating, speed, etc.

AAE006
mounting features
code(s) of the mounting features which are designed to fasten a component to its counterpart

Value list:

through its terminals:

NS = inserted

SMD = surface mounted with threaded parts

with threaded parts:

TAP = tapped hole

STD = stud

HOL = through hole

clamped:

BRC = with bracket

C-profile according to IEC 60715:

C20 = width 20 mm

C30 = width 30 mm

C40 = width 40 mm

C50 = width 50 mm

top hat rail for snap on:

35 × 7,5 = width 35 mm; height 7,5 mm according to IEC 60715

35 × 15 = width 35 mm; height 15 mm according to IEC 60715

75 × 25 = width 35 mm; height 25 mm according to IEC 60715

NOTE A product may be supplied with one or more mounting possibilities; within the application, however, only a single mounting feature can be used.

AAE752
mass
nominal mass (in kg) of a component

AAE433
installation instruction
text giving additional information with respect to the installation of a component

8.1 Additional data

AAE027
mounted height
value as specified by level (miNoMax) of the mounted height of a component (in m), referred to as the seating plane

REMARKS
BSI: mounted height (seated height)
The distance of the farthest part of the component above the reference plane measured in a direction perpendicular to this plane
BSI: seating plane (reference plane)
The surface plane of the circuit on which the component is mounted

8.2 General data for conductors and cables

This clause describes the data element types, which are applicable in the context of a geometric and topological layout of a constructional unit, for example, a cubicle. These data need to

be supplied either by the supplier of the relevant product respectively will be specified during the design process from the user.

The actual data element types are limited to electrical conductors.

AAF470
bending radius
minimum and typical value of the allowed radius measured to the centre-line of the conductor when bending it into a planar curve

NOTE Applying a smaller bending radius than the minimum value may result in damaging the conductor, affecting its function or shortening its lifetime.

The minimum value applies to a single bending of a conductor and the typical value to the multiple bending of a conductor. The minimum bending radius is often implemented using a template.

AAF471
bending radius factor
minimum and typical ratio of the bending radius expressed as a multiple of the nominal outside diameter.

The radius allowed is defined as DET AAF470 and the outside diameter is defined as DET AAE022.

AAF242
conductor shape
code of the shape of the conductive part of a conductor

AAF246
conductor diameter
value as specified by the level (miNoMax) of the diameter (in m) of a conductive part of a round conductor

AAE022
outside diameter
value as specified by the level (miNoMax) of the outside diameter (in m) of a component with a body of circular cross-section

calculated length
length of a cable or conductor (in m) derived from its physical positions in a virtual 3D space by calculation

absolute length allowance
length defined as absolute value (in m), added to the calculated length of a cable or conductor

relative length allowance
length, defined as a relative value (in %), added to the calculated length of a cable or conductor

cut length
absolute length of a conductor or cable (in m), cut for example from a cable reel

stripping length
length of the stripped insulation (in m) at an end of a cable

criticality; weighting factor
number indicating the level of priority associated to a net for optimization of the physical wiring within a given constructional unit or among different locations, for example, on a printed circuit board, within a row of a cubicle

1 = highest priority

256 = lowest priority

8.3 General data per connect node

The following data elements types are required.

AAAxxx
product terminal designation
alphanumerical characters used to identify uniquely a specific function to a net of a product assembly (IEC 61666)

AAAxxx
function terminal designation
alphanumerical characters used to identify uniquely a specific function to a net of a function assembly (IEC 61666)

AAAxxx
location terminal designation
alphanumerical characters used to identify uniquely a specific location to a net of a location assembly (IEC 61666)

NOTE The product, function, and location terminal designation is to be considered as a terminal designation set, where all its components need to be existent.

AAF359
permutability indicator
mark that indicates whether the terminals of one function or one component may be exchanged

NOTE 1 For detailed information, see IEC 81714-2.

AAF358
swapability indicator
mark that indicates whether the terminal pairs or terminal groups of one function or one component may be exchanged

NOTE For detailed informationm, see IEC 81714-2.

AAE353
contact sex
IEC code of the type of the contact of a connector

AAE352
terminal-to-contact angle
code of the angle between terminal and contact of a connector

AAE007
terminal shape
code of the shape of the terminals of an electric, electronic or electromechanical component

AAF435
terminal connection type
code of the type of connection for which a terminal or connector is being designed

Code(s) of the connection types for which a terminal is being designed.

non-releasable connections:

01	=	solded
02	=	welded

releasable connections:

05	=	screwed
06	=	wire-wrap
07	=	termi-point 2,4 x 0,8 mm
08	=	insulation displacement connection

releasable flat connections according to IEC 760:

10	=	flat 2,8 x 0,5 mm
11	=	flat 2,8 x 0,8 mm
12	=	flat 4,8 x 0,5 mm
13	=	flat 4,8 x 0,8 mm
14	=	flat 6,3 x 0,8 mm
15	=	flat 9,5 x 1,2 mm

8.4 Thermal data

AAE257
power dissipation
maximum power (in W) of an electric/electronic or electromechanical component which may be dissipated continuously at specified temperature of a temperature type

AAE685	=	temperature
AAE683	=	temperature type

AAF436
simultaneity factor
value of the ratio of 1) the effective time of handling and 2) the maximum available time of the handling of a component

8.5 Environmental data

This subclause refers to a mandatory resource of environmental data element types which effect the selection of products and their operation. Any applicable environmental related data element type shall be selected from that resource only.

For full information of relevant classes with associated data element types, IEC 61360 DB (http://std.iec.ch/iec61360) should be consulted under the class *AAA233 Feature class*, with the subclass *AAAXXX Environmental conditions.*

9 Requested functionality of an E-CAD layout system

This clause specifies the essential requirements a user expects to be fulfilled from a software tool designed for the arrangement of devices and equipment for installation in constructional units.

9.1 General

- Managed objects need to be selectable according to different aspects (for example, product, function and location aspects).

- Possibilities of logical operations applying several selection criteria combined by AND and OR.
- Additional selection within a selection list of objects, considering the left selection criteria, i.e. irrelevant criteria will not be offered for further selection at this stage of selection but may be shown.
- Selected objects are offered in a separate window. It may be chosen whether an automatic or interactive placement shall apply. A flag is needed in order to differentiate whether a device has been manually or automatically placed. By placing the objects, hierarchic structure relations are built up between the objects, for example, among a supporting sheet metal and all devices being mounted on that sheet metal.
- Interactive (manual) placing should be carried out by pick and paste. Objects which are already placed disappear from the selection list.
- Automatic placing of selected objects, sorting in ascending/descending sequence, and placing on the defined object, for example, a supporting sheet metal according to a single criterion, for example, weight, or by several criteria which may be logically combined by AND and OR.
- Possibility of cross-referencing (after placing of a device) for back annotation in a drawing, for example, a circuit diagram. This would offer the possibility of allowing a cross-reference between the functional presentation in the circuit diagram and the physical presentation in an arrangement drawing.
- Verification of whether all objects represented in the circuit diagram are also placed in the arrangement drawings with the possibility of generating a difference list.
- Supporting hierarchical design of objects to create bigger assemblies forming structure trees; for example, the object ”cubicle” contains ...; the object ”PLC 1” contains ... .
- Deleting and copying of tree structures.
- Each object is to be associated with at least identifying, classifying and describing data element types.
- Placing of pictorial presentations may be done on different pages of a drawing. For example, a device, which is defined as one graphical symbol within a sheet of a circuit diagram, may need to be mounted on different supporting metal sheets, each of which presented on different arrangement drawings.
- Availability of general geometric construction routines of a mechanical 2D-CAD system, for example,
  - automatic dimensioning of objects with possibility to associate different scales when presented in a drawings;
  - possibilities of manipulation on graphical objects (for example, trimming of lines, corners, edges);
  - possibilities of presentation (for example, line width, hatching, leader lines);
  - selection of different dimensioning possibilities, for example, parallel, ascending, coordinate dimensioning.
- Distinctive catching points on each element (corner, centre,etc.) for processing of the element.
- Aligning of graphical objects along free selectable drawing elements (for example, along auxiliary lines).
- Views from the right, from the left, from below, and from above may be generated by having the view from the front and the parameter depth(z-axis).
- Generation of parallel section planes at free defined positions at different heights, for example, of a cubicle, in order to check visually a possible collision.

- Availability of the layer method or an equivalent mechanism for the different presentation of different classes of objects; this includes the possibility to associate objects to one or many classes.
- Global changes at selected objects, with back annotation, for example, in the circuit diagram in case of a change of the reference designations of one or many objects.
- All objects, i.e. devices, may be placed. If the data base does not yet count with the related pictorial representation for the device, for example, the view from the front, it should be possible to define it in the application view without having the need to define this object previously in the general library view. This will allow the association of only a single object instance with some specifics which otherwise would be made available also for others if in the general library.
- Working with predefined assembly structures and documents or with existing assembly structures or documents from as-built projects; superfluous objects need to be deleted, others to be supplemented. After finalizing the arrangement documents, the related cross-references will be generated among the circuit diagrams and the arrangement drawings.

9.2 General 3D requirements

The application of the requirements set up in this clause seem to be economically justified only if a limited range of products or product classes is applied. In the case where the product range is not limited, the applications using a 3D space model fully associated with connect nodes, etc. seem to be economic only if the required information is made available bythe manufacturer or supplier of the product in a computer interpretable format.

It is recommended that the STEP standards ISO 10303-212 and ISO 10303-214, which are in this case applicable, be applied.

Prerequisites for any additional functionality in systems and raising productivity and quality during the engineering design and manufacturing process, is the three-dimensional capturing of devices with related identification, description and classification of its connect nodes according to the requirements established within this PAS.

Only then the user can count with such functionality as, for example,

- auto-routing of nets within a 3D space derived from the net list;
- calculation of lengths of conductors and cables;
- semi-automatic or automatic lettering for cable/conductor ends;
- application of predefined conductors and cables as an assembly of products;
- investigation of critical areas/spaces with respect to the space filled within the routing space;
- investigations of heat concentration (hot spots), heat flow and related feed-back actions;
- automatic calculation of thermal losses of components within a cubicle;
- investigations of electromagnetic reliability and related feed-back actions;
- use of robots for the installation of devices;
- use of robots for semi-automatic wiring;
- use of NC-systems for punching of sheet metal.

Bibliography

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