



BSI Standards Publication

Representation of process control engineering — Requests in P&I diagrams and data exchange between P&ID tools and PCE-CAE tools

National foreword

This British Standard is the UK implementation of EN 62424:2016. It is identical to IEC 62424:2016. It supersedes BS EN 62424:2009, which will be withdrawn on 19 August 2019.

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Representation of process control engineering - Requests in P&I diagrams and data exchange between P&ID tools and PCE-CAE tools (IEC 62424:2016)

Représentation de l'ingénierie de commande de processus -
Demandes sous forme de diagrammes P&I et échange de
données entre outils P&ID et outils PCE-CAE
(IEC 62424:2016)

Darstellung von Aufgaben der Prozessleittechnik -
Fließbilder und Datenaustausch zwischen EDV-Werkzeugen
zur Fließbilderstellung und CAE-Systemen
(IEC 62424:2016)

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European foreword

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- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2017-05-19
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2019-08-19

This document supersedes EN 62424:2009.

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The text of the International Standard IEC 62424:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60848	NOTE	Harmonized as EN 60848.
IEC 61512-1	NOTE	Harmonized as EN 61512-1.
IEC 61987-1	NOTE	Harmonized as EN 61987-1.
ISO 10628-1	NOTE	Harmonized as EN ISO 10628-1.
ISO 10628-2	NOTE	Harmonized as EN ISO 10628-2.
ISO 13628-6	NOTE	Harmonized as EN ISO 13628-6.
ISO 13703	NOTE	Harmonized as EN ISO 13703.

Annex ZA

(normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61511-1	-	Functional safety - Safety instrumented systems for the process industry sector - Part 1: Framework, definitions, system, hardware and application programming requirements	EN 61511-1	-
IEC 81346-1	2009	Industrial systems, installations and equipment and industrial products - Structuring principles and reference designations - Part 1: Basic rules	EN 81346-1	2009
ISO 13849-1	-	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design	EN ISO 13849-1	-
W3C XML 1.0	2004	Extensible Markup Language (XML) 1.0	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**REPRESENTATION OF PROCESS CONTROL ENGINEERING –
REQUESTS IN P&I DIAGRAMS AND DATA EXCHANGE
BETWEEN P&ID TOOLS AND PCE-CAE TOOLS**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 62424 has been prepared by IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 2008. This edition constitutes a technical revision.

This second edition is a compatible extension of the first edition. The main changes and extensions are detailed in Annex E and are summarized below:

- a) updated definitions and new definitions;
- b) identification replaced with reference designation;
- c) updated PCE categories and process functions;
- d) CAEX version 3.0, introduction of:
 - native multiple role support;

- nested interfaces;
 - life cycle meta information;
 - a separate Attribute library;
 - updated examples;
- e) updated electronic data model of the PCE request:
- new normative attribute library for basic PCE request attributes;
 - new informative extended attribute library for further PCE request attributes;
 - new informative electronic data model for the PCE request.

The text of this standard is based on the following documents:

CDV	Report on voting
65/544/CDV	65/560B/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Efficient process engineering requires highly sophisticated tools for the different needs of the involved work processes and departments. These engineering tools are normally specialized in Process Design (PD), in Process Control Engineering (PCE), etc. Therefore, a working interoperability is essential to optimize the engineering process in total. Thus, the definition of a harmonized interface and data management is a core task to ensure a smooth workflow during the whole project and to guarantee data consistency in the different tools.

This standard defines procedures and specifications for the exchange of PCE relevant data provided by the Piping and Instrumentation Diagram (P&ID) tool. The basic requirements for a change management procedure are described. A generally accepted technology for machine information exchange, the Extensible Markup Language (XML) is used. Hereby, a common basis is given for information integration.

However, a definition for uniform semantics is still necessary. CAEX (Computer Aided Engineering eXchange) as it is defined in this document is an appropriate data format for this purpose. This concept of data exchange is open for different applications.

The main task of a data exchange is transporting/synchronizing information from the P&ID database to the PCE databases and vice versa. The owner's reference designation system and a unique description of the processing requirement is the key for a unique identification. For detailed information about representation of PCE loops in P&IDs see Clause 6.

The data exchange system may be a stand-alone, vendor independent application or a module in an engineering environment. The data between a P&ID tool and a PCE tool and vice versa is exchanged via CAEX.

After the data exchange, there are three places where information about the plant is stored. Both the proprietary databases of the considered tools include private and common information. Both are stored at different places and in different divisions that are working on them. Hereby, the intermediate database CAEX only stores common information. In a wider approach, the intermediate database should store both common and private information. This becomes important if a third application is connected to the neutral database. If the intermediate database is used as a temporary data stream only (without storing the information in a file), the information will be lost after processing the data conciliation.

Figure 1 illustrates the information flow for the P&ID and the PCE database reconciliation. The data exchange is done via a neutral intermediate CAEX database, not directly from database to database. The intermediate CAEX database should be a file (for file based data exchange) or a stream (for network based data exchange). The term "CAEX database" within this standard has to be understood in this way, it does not denominate a database product as for example SQL.

Annex C of this standard contains the full XML schema of the CAEX Model. It is attached to this publication in XSD format.

NOTE Buyers of this publication can copy it for their own purposes only in the required amount.

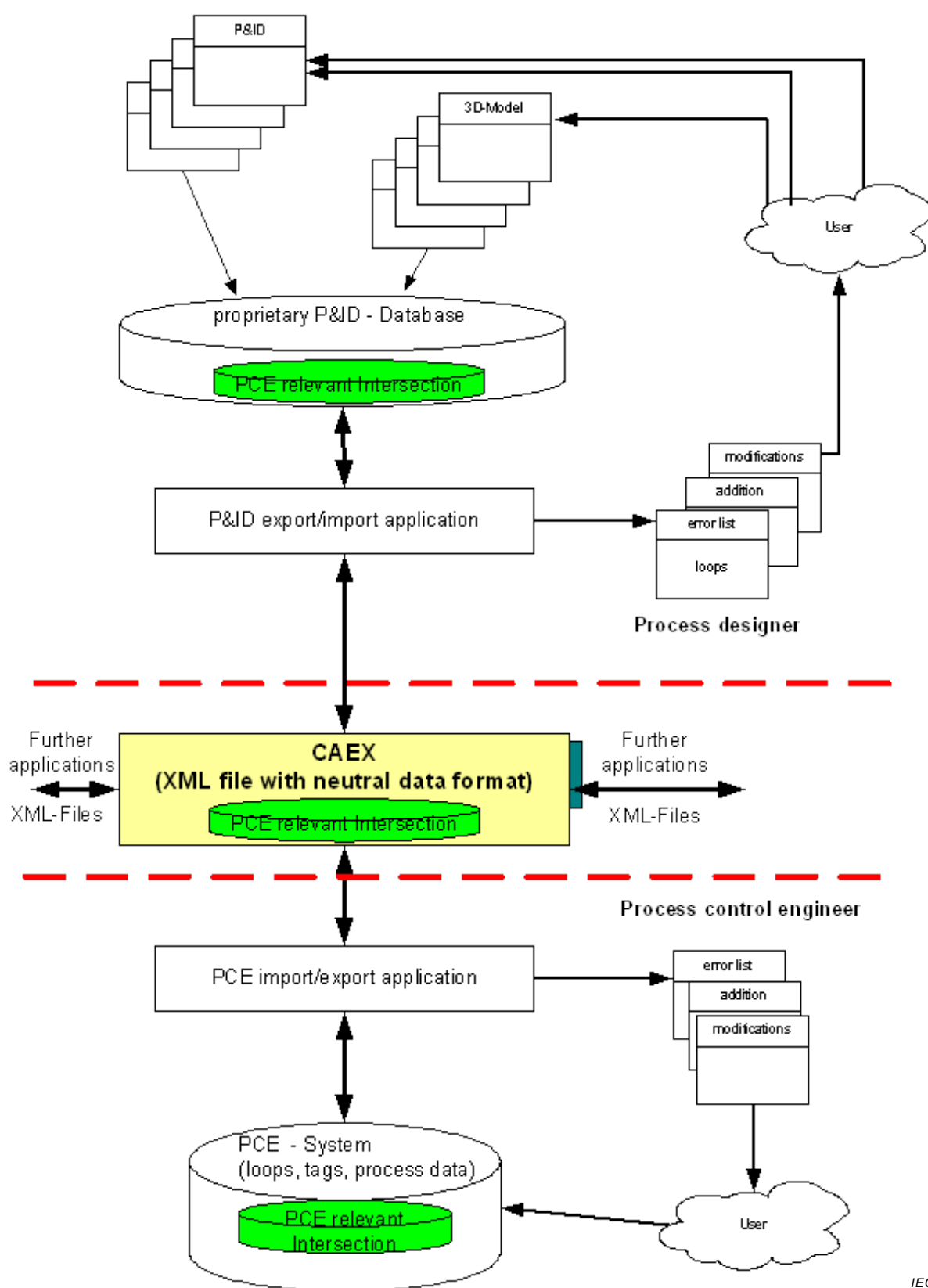


Figure 1 – Information flow between P&ID and PCE tool

REPRESENTATION OF PROCESS CONTROL ENGINEERING – REQUESTS IN P&ID DIAGRAMS AND DATA EXCHANGE BETWEEN P&ID TOOLS AND PCE-CAE TOOLS

1 Scope

This International Standard specifies how process control engineering requests are represented in a P&ID for automatic transferring data between P&ID and PCE tool and to avoid misinterpretation of graphical P&ID symbols for PCE.

It also defines the exchange of process control engineering request relevant data between a process control engineering tool and a P&ID tool by means of a data transfer language (called CAEX). These provisions apply to the export/import applications of such tools.

The representation of the PCE functionality in P&IDs will be defined by a minimum number of rules to clearly indicate their category and processing function, independent from the technique of realization (see Clause 6). The definition of graphical symbols for process equipment (e.g. vessels, valves, columns, etc.), their implementation and rules for the reference designation system are not in the scope of this standard. These rules are independent from this standard.

Clause 7 specifies the data flow between the different tools and the data model CAEX.

2 Normative references

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

IEC 61511-1, *Functional safety – Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and application programming requirements*

IEC 81346-1:2009, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

ISO 13849-1, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

Extensible Markup Language (XML) 1.0 (Third Edition), W3C Recommendation 04 February 2004, available at <http://www.w3.org/TR/2004/REC-xml-20040204/>

3 Terms and definitions

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

3.1

actuator

functional unit that generates the manipulated variable, required to drive the final controlling element, from the output variable of the controlling element

EXAMPLE A practical example of an actuator acting directly on the final controlling element is a pneumatic control valve.

Note 1 to entry: If the final controlling element is mechanically actuated, it is controlled via an actuating drive. The actuator drives the actuating drive in this case.

[SOURCE: IEC 60050-351:2013, 351-49-07]

3.2

actuating drive

physical unit used for driving mechanically actuated final controlling elements

Note 1 to entry: Examples of actuating drives are electric, hydraulic or pneumatic actuating drives, diaphragm systems or piston actuators.

Note 2 to entry: No actuating drive is required for a final controlling element if the manipulated variable at the controller output is capable of directly influencing the mass flow or energy flow, i.e. without any mechanical intermediate variable (quantity).

[SOURCE: IEC 60050-351:2013, 351-56-16]

3.3

adjusted nominal pipe size

size of the related pipe for the process connection of the PCE request in case of pipe diameters size reduction based on process requirements

3.4

bubble

oval symbol used to denote the PCE category and processing function of a PCE request and to uniquely identify a PCE request

Note 1 to entry: On the basis of ISA 5.1:2009, Clause 3.

3.5

closed-loop control

process whereby one variable quantity, namely the controlled variable is continuously or sequentially measured, compared with another variable quantity, namely the reference variable, and influenced in such a manner as to adjust to the reference variable

Note 1 to entry: Characteristic for closed-loop control is the closed action in which the controlled variable continuously influences itself in the action path of the closed loop.

[SOURCE: IEC 60500-351:2013, 351-47-01]

3.6

control narrative

verbal description of a functional control scheme

3.7

design pressure

maximum pressure for which the system or component was designed for continuous usage

[SOURCE: ISO 13628-6:2006, 3.4]

3.8

design temperature

maximum temperature for which the system or component was designed for continuous usage

3.9

equipment ID

unique identifier of equipment

3.10**equipment/pipe flag**

unique identifier of equipment/pipe type

3.11**final controlling element**

functional unit forming part of the controlled system and arranged at its input, driven by the manipulated variable and manipulating the mass flow or energy flow

Note 1 to entry: If the final controlling element is mechanically actuated, an additional actuator (positioner) is used in some cases.

Note 2 to entry: The output variable of the final controlling equipment is usually not free from feedback. The interface between the actuator and the final controlling element should therefore be selected in such a way that the manipulated variable is not affected by feedback from the final controlling element.

[SOURCE: IEC 60050-351:2013, 351-49-08, modified – The figures are deleted.]

3.12**final controlling equipment**

functional unit that consists of an actuator and a final controlling element

[SOURCE: IEC 60050-351:2013, 351-49-09, modified – The figure is deleted.]

3.13**function chart**

graphic description tool with symbolic representation of sequential control systems

Note 1 to entry: The symbolic representation of steps, commands, transitions and directed links is based on input and output Boolean variables and also on internal state variables and binary delay elements.

Note 2 to entry: The elements, rules and basic structures for function charts are given in IEC 60848.

[SOURCE: IEC 60050-351:2013, 351-53-08, modified – The word "tool" has been added in the definition and Note 2 has been slightly shortened.]

3.14**heat tracing**

heating system for pipe to prevent freezing of process requirements or to keep process conditions

3.15**heat tracing type**

type of heating system for pipe

EXAMPLE Steam or electrical heating system.

3.16**heat tracing temperature set point**

set point for the controller of a heat tracing

3.17**insulation type**

description of the insulation type used

EXAMPLE Sound insulation.

3.18**insulation thickness**

thickness of insulation added to the outer diameter of the pipe size

3.19**intermediate database**

intermediate data storage system between source and target tool

3.20**material balance point**

balance point of the process calculation

3.21**medium code**

abbreviation and identifier for the fluid running through a process pipe

3.22**medium code description**

description of the fluid running through a process pipe

3.23**neutral database**

vendor independent data storage system

3.24**open-loop control**

process whereby one or more variable quantities as input variables influence other variable quantities as output variables in accordance with the proper laws of the system

Note 1 to entry: Characteristic for open-loop control is the open action path or in case of a closed action path the fact that the output variables being influenced by the input variables are not continuously or sequentially influencing themselves and not by the same input variables.

[SOURCE: IEC 60050-351:2013, 351-47-02]

3.25**PCE category**

letter that designates the kind of process control engineering request

Note 1 to entry: Unlike other standards, this standard uses the term "PCE category" instead of "measured variable" (e.g. temperature measurement) for the first digit of the PCE request. The PCE category as defined in this standard allows to unambiguously identify the kind of PCE request, without the need to specify a second letter as modifier for final controlling equipments. Based on this, only one letter for sensing element and final controlling equipment identification of PCE request is necessary.

3.26**PCE control function**

function in a PCE control

Note 1 to entry: According to 4.2.7 of IEC 61512-1:1997.

3.27**PCE loop**

collection of PCE requests and PCE control functions depicting their functional coherence

3.28**PCE request**

requirement for process control equipment

Note 1 to entry: Each PCE request is graphically represented by a bubble which collects all information on the functional requirements.

3.29**pipe diameter size**

nominal size of the related pipe for the process connection of the PCE request

3.30**pipe ID**

unique identifier of pipe

EXAMPLE Isometrics number.

3.31**pipe specification**

abbreviation and identifier for the specification of piping equipment

Note 1 to entry: Defines the size, material, design, pressure and temperature for all elements of a pipe.

3.32**process control equipment**

entirety of devices and programs and, in a broader sense, all instructions and programs used for the task of controlling equipment having a process control function

Note 1 to entry: Control equipment also comprises the process control station and instructions include operating manuals.

Note 2 to entry: Providing a process with control equipment is denoted as process automation.

[SOURCE: IEC 60050-351:2013, 351-56-24, modified.]

3.33**process control function**

function to work on process variable quantities, which is composed of basic functions of process control, specific to particular functional units of the plant

Note 1 to entry: In addition to process control functions associated with specific control levels, there can also be process control functions that link input and output variables across several control levels. For instance, a process control function in the feedback path with the controlled variable as input variable and the manipulated variable as output variable, describes the action path from the sensing element via the controller to the final controlling element. Another process control function connects the operator with the indicators for the process variables. In view of the diversity of definitions of process control functions, standardization is not appropriate at this time.

[SOURCE: IEC 60050-351:2013, 351-55-16]

3.34**processing function**

function in a process

Note 1 to entry: A processing function serves a control module according to 3.10 and 5.2.2.4 of IEC 61512-1:1997.

3.35**proprietary database**

vendor specific data storage system, with syntax and/or semantic not complying to any standard

3.36**PU-vendor****Package Unit vendor**

supplier of a process unit in a plant

3.37**reference designation**

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

Note 1 to entry: Terms "object", "aspect" and "system" are also defined in IEC 81346-1:2009, respectively at 3.1, 3.3 and 3.2.

[SOURCE: IEC 81346-1:2009, 3.11].

3.38

schema

XML based description of rules such that when an XML document conforms to those rules it is considered "valid" according to that schema

Note 1 to entry: On the basis of Extensible Mark-up Language (XML) 1.0 (Third Edition), W3C Recommendation, Clause 2.

3.39

sensing element

functional unit that senses the effect of a measured variable at its input and places a corresponding measurement signal at its output

EXAMPLE Thermocouple, foil strain gauge, pH electrode.

Note 1 to entry: The corresponding physical unit is named sensor or detecting device.

[SOURCE: IEC 351:2013, 351-56-26, modified.]

3.40

source database

data storage system of the source tool

3.41

target database

data storage system of the target tool

3.42

typical identification

abbreviation and identifier for a graphical diagram in a database, a group of signals or grouped PCE requests

4 Abbreviations

Table 1 shows abbreviations used in this standard.

Table 1 – Abbreviations

CAE	Computer Aided Engineering
CAEX	Computer Aided Engineering eXchange
CCR	Central Control Room
GMP	Good Manufacturing Practice
PCE	Process Control Engineering
PCS	Process Control System
P&ID	Piping and Instrumentation Diagram
PD	Process design
PL	Performance level according to ISO 13849-1
PU	Package Unit
SIL	Safety Integrity Level according to IEC 61511-1
SIS	Safety Instrumented System according to IEC 61511-1
XML	Extensible Markup Language

5 Conformity

To claim conformity to this standard with respect to the graphical representation of PCE requests in P&IDs, the requirements of Clause 6 shall be fulfilled.

To claim conformity to this standard with respect to the PCE relevant data exchange, the requirements of Clause 7 and the following requirements shall be fulfilled.

The data exchange shall be performed by a separate or integrated import/export application that provides for the data exchange between the related tool and CAEX.

The goal of the import/export application is to provide for data reconciliation for the intersection of the source and target databases. It is able to read the proprietary database of the considered tool and to reconcile the data with the neutral CAEX database.

The export/import application shall check, report and provide the intersection data of both databases. The neutral database shall be open for additional applications.

The data import function shall enforce a configurable checking step (e.g. rule based) during the import process; it shall not allow unguided automatic changes. The configurable checking step shall include functionality for automatic or manual acceptance of data changes, allowing single decisions up to bulk data management.

All changes in the proprietary database and all discovered data inconsistencies shall be reported by the import application. The generation of the report shall be configurable. The import/export application has to assure that the intersection of the different databases contains the same information, and that additional division specific data is handled in a consistent way. Data manipulation by a project division is an ongoing process during the whole project and beyond it. Thus the creation, changing and deletion of data shall be possible during the life-cycle of the plant.

CAEX databases have to be consistent. This requires a consistency check before exporting the data. This procedure has to be followed after a successful data manipulation in a P&ID tool or PCE tool in order to bring the new information into the neutral database or vice versa. Before any data changing action is carried out, the user shall be informed and asked for confirmation. The consistency check shall encompass at least the following steps and fulfill the following requirements:

Data export from source database to neutral database shall comprise the following activities.

- a) Check P&ID and PCE database for at least:
 - 1) duplicate PCE requests or loop designations;
 - 2) mandatory fields being filled in;
 - 3) correct use of numbering system of the PCE requests.

Inconsistent data shall not be exported.

- b) Generate PCE relevant information;
- c) Check for changed information in comparison with previously stored data in the neutral database;
- d) Renaming of PCE request shall be supported by the export functionality;
- e) Perform data export from proprietary into neutral database:
 - 1) For example, if the PCE request has been changed, the old PCE request within the neutral database has to be deleted and the new one shall be exported from the proprietary database into the neutral database. The old PCE request information shall be stored in a backup storage system;

2) Other changes shall be performed with the existing object.

f) Generate reports after each data exchange:

For example, new PCE requests list, missing PCE requests list, changed PCE requests list, deleted PCE requests list, problems and error list.

Data import from neutral database into the target database shall comprise the following activities.

g) Generate PCE relevant information from neutral database;

h) Check for changed information by comparing the neutral database with the target database;

i) Perform data import from the neutral into the proprietary database;

j) Renaming of PCE request shall be supported by the import functionality;

k) Generate reports after each data exchange:

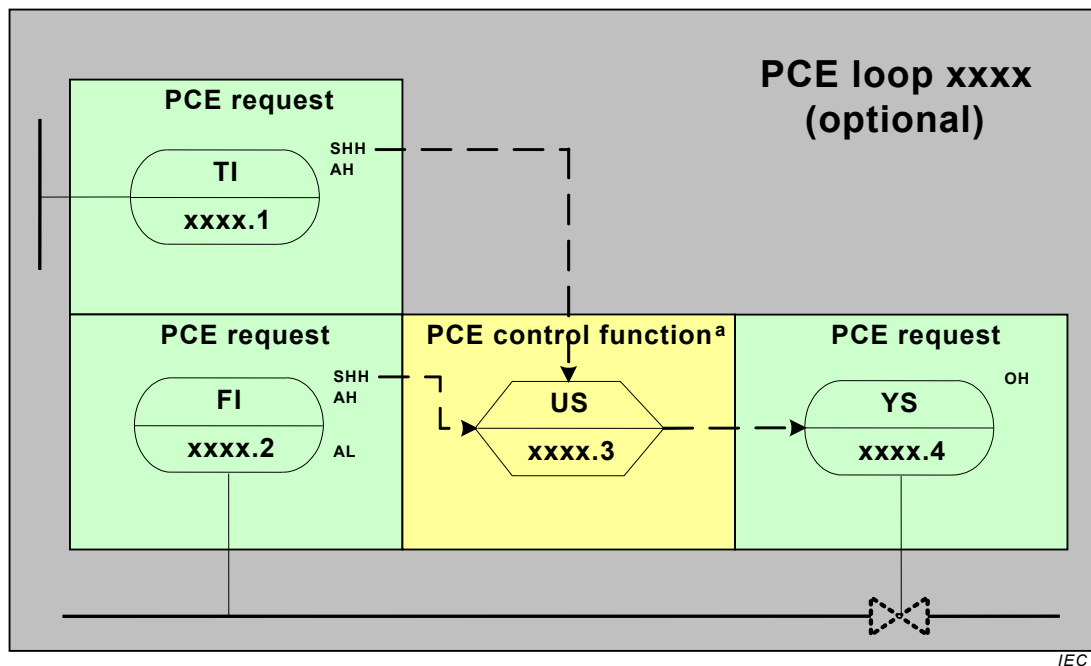
1) For example, error lists;

2) inconsistencies due to imported data shall be detected by the target application during the import process and are not considered within this standard.

6 Representation of PCE requests in a P&ID

6.1 PCE request and PCE loop

In a P&ID the functional design of a plant is determined. Details of technical equipment are given only if functions are correlated with the design of specific equipment. Consequentially, the P&ID describes requirements for the design of the process control equipment. Each PCE request shall be illustrated in the P&ID with an individual reference designation. In order to meet the requirements of data handling, the same reference designation shall not be used for different PCE requests. Functional coherence should be depicted by collecting the individual PCE requests in a PCE loop. A PCE loop does not have a graphical representation. Depending on the engineering strategy, a PCE loop thereby consists of at least one, but may also combine several PCE requests. If PCE loops are used, these shall be represented in the reference designation of all concerned PCE requests. An example of this concept is given in Figure 2.



^a The PCE control function used in Figure 2 is defined in 6.3.10.

Figure 2 – Organization of PCE requests

6.2 Objectives and principles

This 6.2 defines how to represent the process control engineering functionality in P&IDs. Technical details of the used equipment shall not be depicted in general. This is due to the goal to ensure a smooth engineering workflow by separating process and instrumentation design.

Therefore the following items are set out in the standard:

- the PCE categories and functions;
- the graphical representation of PCE requests in a P&ID;
- the type of functional connection between the PCE requests: the control functions;
- the graphical representation of signals in a P&ID.

In addition a reference designation system used for PCE requests in a P&ID shall be specified (see 6.3.5).

Detailed information on complex control functions shall not be part of the P&ID. Therefore, additional documentation (e.g. control narratives, function charts) has to be prepared to define the required functionality. A control function shall also be individually identified and shall be represented on the P&ID.

6.3 Requirements for the reference designation and representation of PCE requests

6.3.1 General

Each PCE request shall be graphically represented by a bubble, which collects all information about the functional requirements. Three data fields inside and ten data fields outside the bubble are defined to hold all the information of a PCE request (see Figure 3). For detailed information see 6.3.3 to 6.3.9.

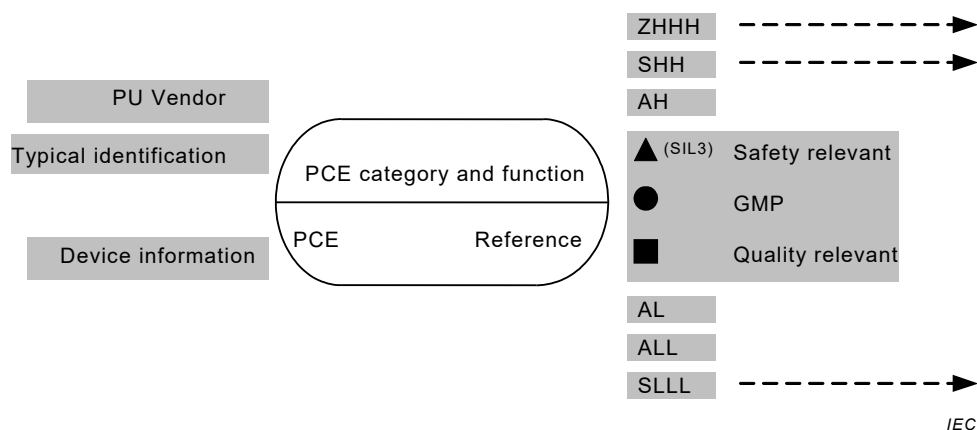


Figure 3 – General representation of a PCE-Request in a P&ID

As stated before, only the PCE functionality shall be depicted on the P&ID, not the PCE implementation. In exceptional cases however, there might be constellations where the presentation of detailed realization information is inevitable. For example, in the case of a multi-sensing element which means an instrument that produces measurements for different categories, every category shall be represented by its own bubble. The bubbles are stacked up, as shown in Figure 4.

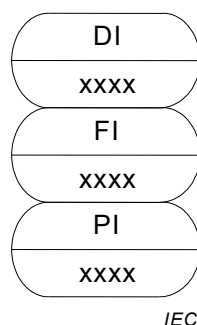


Figure 4 – Multi-sensing element

In all cases where the PCE request is connected to the equipment or pipe, this shall be shown by a full line, connecting the bubble with the equipment or pipe.

6.3.2 Types of lines

Signal lines are used to illustrate the functional relationship between PCE requests. A signal line shall be depicted as a dashed line with an arrow to indicate the information flow. Source of information flow shall be a bubble of a PCE control function or request or switching action consisting of the six fields on the right side of the bubble. The sink of information flow shall be a bubble of a PCE request or a control function.

Process connections shall be depicted by a solid line without a direction. Multi-sensing elements instruments with only one process connection shall have an extra bubble for each category and only one process connection.

6.3.3 Displaying the location of the operator interface

Each PCE request is graphically represented by a bubble. This standard distinguishes the location of the operator interface between a local interface, a local control panel and a central control room. The location does not reflect any realization in systems.

A local interface shall be represented as shown in Figure 5. It could be for example a pressure gauge.

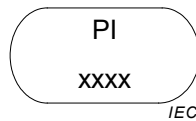


Figure 5 – Local interface

Operator action/information on a local control panel shall be represented as shown in Figure 6.

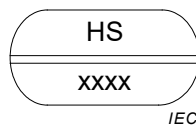


Figure 6 – Manually operated switch in local control panel

Remote requests operated in a central control room shall be represented as shown in Figure 7.

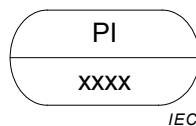


Figure 7 – Pressure indication in central control room by a central control system

It is recommended to simplify the presentation of PCE for combined local interface and indication in central control room by only one bubble as shown in Figure 7. For this case it is required to have a note in the definitions of a P&ID.

6.3.4 PCE categories and processing functions

6.3.4.1 Indication of PCE categories and processing functions

The upper part of the bubble shall show the information of the PCE category and its PCE processing function. Each bubble shall have one PCE category and should have one PCE processing function. For the definition of the processing function see 6.3.4.3.

6.3.4.2 PCE categories

The first letter represents the PCE category and shall be selected from Table 2 if the measuring or initiating variable is listed in that table. If this is not the case, a new category may be defined. A unique definition is recommended to provide for an automatic transfer to the specific equipment specification for the process control engineer. In case of amendments of categories of Table 2, a coding via letter X as described in table footnote ^b may be used.

Modifying letters for the PCE category shall not be used to avoid misinterpretation in the course of automatic transfer to the specific equipment specification for the process control engineer.

Table 2 – PCE categories

Letter	PCE category
A	Analysis
B	Optical measurement, e.g. flame detection
C	^a
D	Density
E	Voltage
F	Flow
G	Distance, length, position
H	Hand or manual and manually initiated operation
I	Current
J	Power
K	Time based function
L	Level
M	Moisture or humidity
N	Actuation setting electrical (all type of electrical consumer, e.g. motor, heater) ^c
O	^a
P	Pressure
Q	Quantity or counter
R	Radiation
S	Speed or frequency (including acceleration)
T	Temperature
U	Used for PCE control function (see 6.3.10)
V	Vibration, mechanical analysis, torque
W	Weight, mass, force
X	^b
Y	Actuation setting non electrical like hydraulic or pneumatic (switching, varying, restricting, e.g. valve-operated) ^c
Z	^a
^a The definition of this letter should be defined by users. ^b The unclassified letter X is intended to cover unlisted meanings that will be used only once or used to a limited extent. If used, the letter may have any number of meanings as a PCE category and any number of meanings as a PCE function. ^c The use of N for motor driven or heater final controlling equipments and Y for hydraulic or pneumatic valve driven final controlling equipments is based on different PCE activities and specific maintenance requirements for both types of final controlling equipments. Moreover, in the light of increased maintenance requirements in the plant, immediate identification for transferring of data and relevant attributes of the final controlling equipment to asset management systems is necessary.	

6.3.4.3 PCE processing functions

Starting with the second character, the successive letters in the upper part of the bubble shall represent the processing function of the PCE request. The letters given in Table 3 shall be used to indicate the processing function of a PCE request.

Table 3 – PCE processing function

Letter	Processing function
A	Alarm, message
B	Restriction
C	Control (all kind of control scheme, e.g. split-range, PID controller or ON-OFF controller – typically used for closed-loop control)
D	Difference
E	Shall not be used
F	Ratio
G	Shall not be used
H	High limit, on, opened
I	Indication of analogue values
J	Shall not be used
K	Time rate of change e.g. for acceleration or calculating a derivation
L	Low limit, off, closed
M	Shall not be used
N	Shall not be used
O	Local or PCS status indication of binary signals
P	Point (test) connection
Q	Integrating, quantity or counting
R	Recorded value
S	Binary control function or switching function (not safety relevant)
T	Shall not be used
U	Shall not be used
V	Shall not be used
W	Shall not be used
X	^b
Y	Computing function
Z	Binary control function or switching function (safety relevant) ^a
^a The <i>triangle</i> may also be used to indicate in a redundant way that the processing function is safety relevant (see Figure 3). ^b The unclassified letter X is intended to cover unlisted meanings that will be used only once or used to a limited extent. If used, the letter may have any number of meanings as a PCE category and any number of meanings as a PCE function.	

The letters B, Q, I and R apply to the preceding processing function and can be used several times in one processing function, e.g. FIQI means the indication of a flow and its counting.

The PCE processing functions A, H, L, O, S and Z shall only be used outside the bubble. In this case the PCE category may stand as a single value in the upper part of the bubble. In addition, a detailed definition for the signal information (see 6.3.2) to be transferred automatically to the control equipment specification for the process control engineer is given by this way.

In cases of a PCE request with PCE processing functions A, H, L, O, S and Z only a PCE request can be without a PCE processing functions, e.g. see Figure 22 for the PCE category H.

NOTE The letters O, A, S, and Z are used on a specific level, e.g. AH for High-Alarm or SHH for High-High-Switch point. On every level it is possible to combine the letters OASZ, e.g. OSL for binary status indication and switching at low level.

For the PCE categories N and Y the processing function S and Z remain inside the bubble due to the pure unique binary on/off function and no dedicated signal line deviated from the processing functions S and Z for a final controlling equipment (see Table 5).

The combination of processing functions shall be used in the sequence given in Table 4. The table hierarchy shall be from left to right and per column top down.

Table 4 – Sequence combinations

Category	Sequence	1	2	3	4
See Table 3	1	F	D	Y	C
	2	B	Q	X	--

6.3.4.4 PCE processing functions for final controlling equipments

The PCE processing functions shall be used for final controlling equipments in the same way as for sensing elements. Some examples are shown in Table 5.

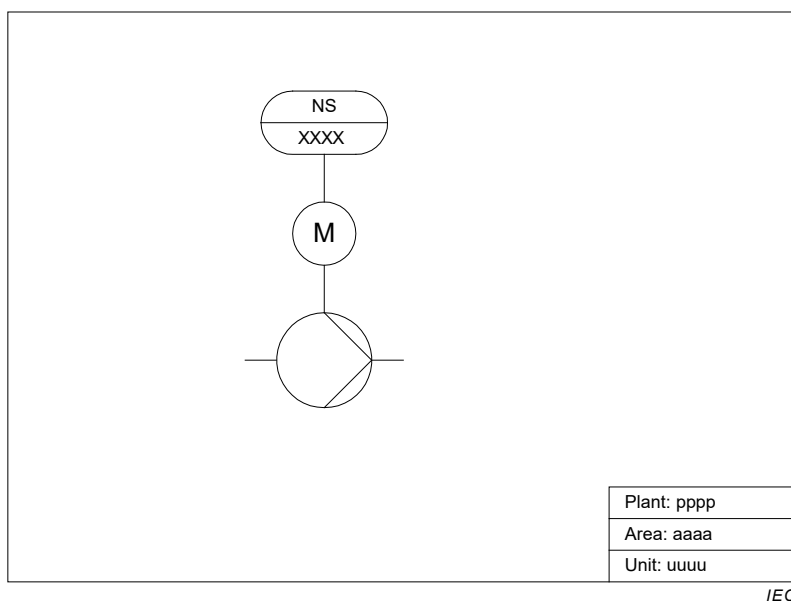
Table 5 – PCE processing functions for final controlling equipments

Letter	Processing function
YS	Non electrical actuating drive with open-loop-control function e.g. On/off valve
YC	Non electrical actuating drive with closed-loop-control function e.g. Control valve
YCS	Non electrical actuating drive with closed-loop-control function and open-loop-control (open/close) function e.g. Control valve with on/off function
YZ	Non electrical actuating drive with open-loop-control function (safety related e.g. On/off valve (safety relevant))
YIC	Non electrical actuating drive with closed-loop-control function and position indication e.g. Control valve with position indication
NS	Electrical actuating drive with open-loop-control function e.g. On/off motor
NC	Electrical actuating drive with closed-loop-control function e.g. Control motor

Graphical representation of the equipment valve including further functional details in the equipment symbols in accordance to ISO 10628-1 and ISO 10628-2 in the P&ID cannot be used in the CAEX model. Such details should be placed in the PID database.

6.3.5 PCE request reference designation system

A reference designation system (e.g. IEC 81346-1) shall be used in order to identify the PCE request unambiguously. This reference designation shall be independent of the PCE processing function of the PCE request and depicted in the lower part of the bubble. Preceding reference designation levels (e.g. site, plant, unit, area) may be omitted in the bubble if the request within the context of the P&ID is unique (see Figure 8). If PCE requests are combined in a PCE loop, their reference designation shall have separated levels for the loop and the request.



NOTE In the bubble of the depicted request only the last level of the reference designation system is shown. The plant, area and unit information can be taken from the lower right corner. Thus the complete reference designation of the request is: pppp-aaaa-uuuu-xxxx.

Figure 8 – Example of PCE request reference designation

6.3.6 PU-vendor and typical identification

If applicable, PU vendor information should be given above the horizontal line, but outside the bubble on its upper left side, as shown in Figure 9. If this field is not used for PU vendor information, it may be used to show other project specific information.

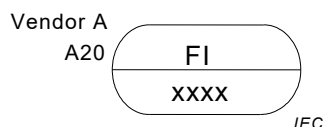


Figure 9 – Example of flow measurement with indication in the CCR delivered by vendor A specified by typical identification A20

To support automatic loop, request and tag generation with PCE-CAE tool, requests, especially motor requests should be indicated by a typical identification on the upper left side, outside the bubble. These typical identification are fixed by the project team and are used to determine the composition of the PCE request, e.g. how the motor drive should be switched (with start-stop only, with start-stop and running indication, with current measurement, etc.) or a combination of measuring systems.

6.3.7 Device information

If, because of the PCE category, additional device information is needed (e.g. orifice for flow measurement), this should be indicated in the lower zone outside the bubble on the left side (see Figure 10).

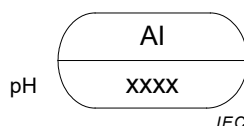


Figure 10 – Example of pH-measurement with indication in the CCR

6.3.8 Alarming, switching and indicating

The characters H and L as PCE processing functions, indicating the high or low limit, shall be used in combination with A, O, S or Z only if an automatic action (S or Z), an operator action (A) or an indication (O) is activated when the limits are reached. In each level (e.g. H, HH, HHH) it shall be possible to combine alarming and switching function, e.g. AS or AZ. These functions shall always be indicated outside the bubble, as shown in Figure 11. Up to three levels for high and also for low alarm/switching/indication shall be possible.



Figure 11 – Example of flow measurement with indication in the CCR and high and low alarm

The representation shall be: <processing function><alarm level>, whereas the order of the processing function shall be O, A, S, Z.

It shall be unambiguous and shall be connected to the controlling function or the final controlling equipment starting with the SH, SHH, SHHH, SL, SLL or SLLL symbols as shown in Figure 12.

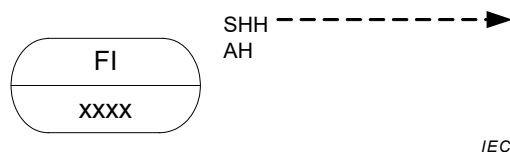


Figure 12 – Flow measurement with indication in the CCR and high alarm and a high-high switching function

The combination of Figure 11 and Figure 12 with additional safety relevant switches may be used as shown in Figure 13.

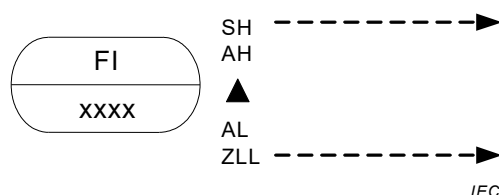


Figure 13 – Flow measurement with indication in the CCR and a high-high switch limit, a high alarm, a low alarm and a low-low switch limit for a safety function

To identify the level of an alarm or switching level the letters H, HH, HHH, L, LL and LLL should be used. The sequence from upper level to lower level is HHH – HH – H – L – LL – LLL.

6.3.9 Safety-relevant, GMP and quality-relevant PCE requests

Outside the bubble, a circle symbol should be used as an indication for GMP relevant sensing elements or final controlling equipments and a square for the indication of a quality relevant PCE request. A triangle should be used for a safety function (categorized by SIL or PL) (see Figure 14).

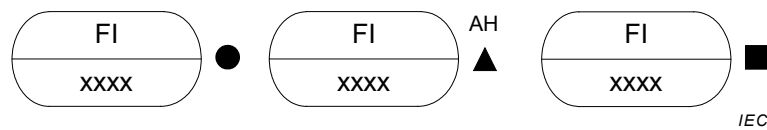


Figure 14 – GMP relevant, safety relevant and quality relevant flow measurement with indication in the CCR

These symbols shall be placed as closely as possible to the bubbles on the right side. Crossing of signal lines connected in the center is acceptable.

6.3.10 PCE control functions

PCE control functions essentially contain the functional relationship between sensing elements and final controlling equipments. These control functions are the “building stones”, the elements of the entire process functionality. Mostly they are technically achieved via control system configuration. Safety related control functions are usually implemented by SIS configurations (logic solver) according to IEC 61511-1.

In simple configurations, e.g. one sensing element and one final controlling equipment, where the relation is unambiguously represented in the P&ID, the PCE control function should be omitted.

The symbol for the PCE control function is the hexagon. This hexagon, see Figure 15, symbolizes the control functionality which has one or more sensing elements as inputs, and one or more final controlling equipments as outputs.

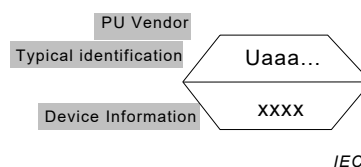


Figure 15 – Control function

The hexagon symbol shall be connected with signal lines (see 6.3.2.) to the various bubbles that represent the relevant PCE requests (see Annex B). The arrows indicate the direction of the information (sensing element to PCE control function and PCE control function to final controlling equipment).

If applicable, PU vendor information shall be given above the horizontal line, but outside the hexagon on its upper left side. If this field is not used for PU vendor information, it may be used to show other project specific information.

To support automatic loop, request and tag generation with PCE-CAE tool, especially functional logic design request, should be indicated especially functional logic design should be indicated by a typical identification on the upper left side, outside the hexagon.

In case of a safety relevant control function, UZ...., required SIL or PL shall be indicated in the lower zone outside the hexagon on the left side as shown in Figure 16. Other relevant information, e.g. 2oo3 configuration should be added as appropriate. For non-safety control functions this field should be used for additional relevant information.

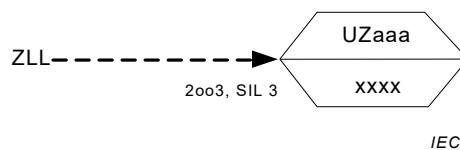


Figure 16 – Safety relevant control function

The PCE control functions shall be identified separately. The PCE control function shall be identified unambiguously within the reference designation system used. This reference designation shall be independent of the PCE processing function of the PCE control function and depicted in the lower part of the hexagon. Preceding reference designation levels (e.g. site, plant, unit, area) may be omitted in the hexagon if the control function within the context of the P&ID is unique (see 6.3.5). If control functions are integrated in a PCE loop, their reference designation shall have different levels for the loop and control function.

The detailed and complete function of the U shall be documented in a separate document, entitled with the U reference designation.

The upper part of the hexagon symbol shall contain *Uaaa*, where *a* is one or more of the PCE processing functions A, C, D, F, Q, S, Y or Z (see Table 3).

NOTE Compared to a PCE request, the processing functions are normally not unique in a PCE control function. Therefore the processing function A, S and Z remain in the hexagon as placeholder and higher level explanation of the complete function.

It is possible, for example, that a US has a partial UZ-character. In that case the U shall become the designation USZ. Every USZ shall have at least one sensing element and one final controlling equipment which is safety relevant, this means that at least one sensing element and one final controlling equipment connected to a USZ has the Z as a processing function.

7 Neutral data exchange of PCE relevant P&ID information

7.1 Objectives

P&IDs include a variety of information relevant for process control engineering purposes. Clause 6 defines how basic information concerning PCE requests and their process relevant functionality shall be represented in a P&ID. The given specification concerns primarily the graphical notation, but of course, this establishes structural and semantic fixings too. In this Clause 7, these structural and semantic fixings will be mapped to a semiformal form. To do this, the CAEX system description language (see Annex A) is used. For this language, an XML representation is given in Annex C, which allows an open exchange of the modeled data between the P&ID system and the PCE systems.

7.2 Meaning of P&ID elements

P&IDs show a plant (or a part of it) in its function as a physical framework. Aspects are the material flow through vessels and pipes, physical actuations (pumps, stirrers, electrical heating), the coupling between the physical and the control world (PCE requests), and the main dependencies between the control functions.

P&IDs, representing PCE requests in accordance with this standard show functional requirements (roles) and not the assembly of equipment. A shown pump symbolizes not the equipment "pump" but the requirement: At this place a "pumping functionality" is needed. Additional attribute requirements concerning this pumping functionality like "flow rate", "inlet pressure" and so on can be added.

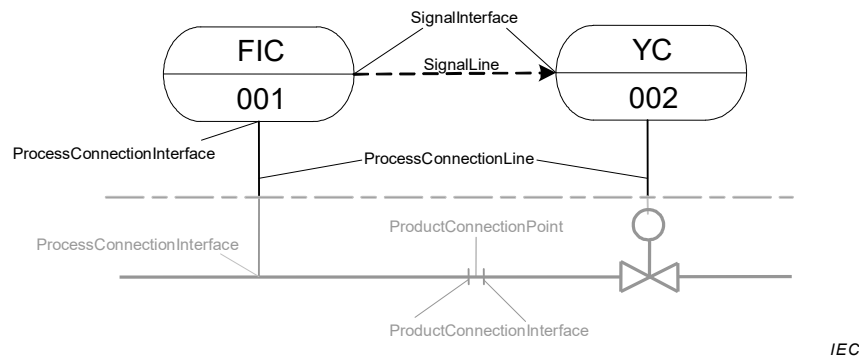


**Figure 17 – P&ID elements and associations
(PCE relevant items are shown in dark lines)**

P&IDs show graphically the functional relationship between the elements. In the example given in Figure 17 four main classes of relationships are shown.

Note that graphical representations of the equipment including further functional details in the equipment symbols in accordance with ISO 10628-1 and ISO 10628-2 used in the P&ID cannot be used in the CAEX model. Such details will be placed in a database.

a) Signal connections

Signal connections are notated as declared in Clause 6 by a dashed line, the so-called “SignalLine”. The SignalLine only symbolizes the functional influence between PCE requests and not electrical wiring.

b) Process connections

Process connections are notated as declared in Clause 6 by a plain line, the so-called “ProcessConnectionLine”. The ProcessConnectionLine symbolizes the information flow from the control world to the physical process or vice-versa. The ProcessConnectionLine only symbolizes the functional coupling between a PCE request and the material balance point but not the actual layout in the plant.

c) Product connections

Product connections symbolize the coupling of two pieces of equipment with the possibility of material transfer between them (such as pipe-pipe or pipe-vessel). The properties of this kind of association are not the subject of this standard.

d) Mechanical connections

Mechanical connections symbolize the mechanical coupling within actuation elements (drive-valve, motor-pump). The properties of this kind of connections are not the subject of this standard.

7.3 PCE relevant information of P&ID tools

Besides general structural and functional information, P&ID tools handle a variety of information which is of direct interest to the PCE.

a) Control relevant information

PCE requests, process connections, signal lines with all their attributes and interfaces as described in Clause 6 comprise the process-relevant information needed for the process control engineering.

b) Additional information

In many cases, the P&ID tools support additional process-relevant or technology-relevant functional requirements concerning the process connections. Examples are maximum pressure, pipe diameters, information concerning the medium and so on. That information

is usually important for the process control engineering tools too. Clause 8 gives a minimum list of relevant additional parameters.

7.4 Formal description of PCE relevant information of P&ID tools

7.4.1 General object model of a plant hierarchy

The P&ID is the most important interface between process engineering and process control engineering. It is of fundamental interest to standardize not only the graphical notation of the PCE relevant information but also a data exchange format which supports an open information flow from the P&ID tools to the PCE tools and vice versa.

Figure 18 shows a general data model of a plant hierarchy and highlights the PCE data model for PCE relevant information as described in Clause 6.

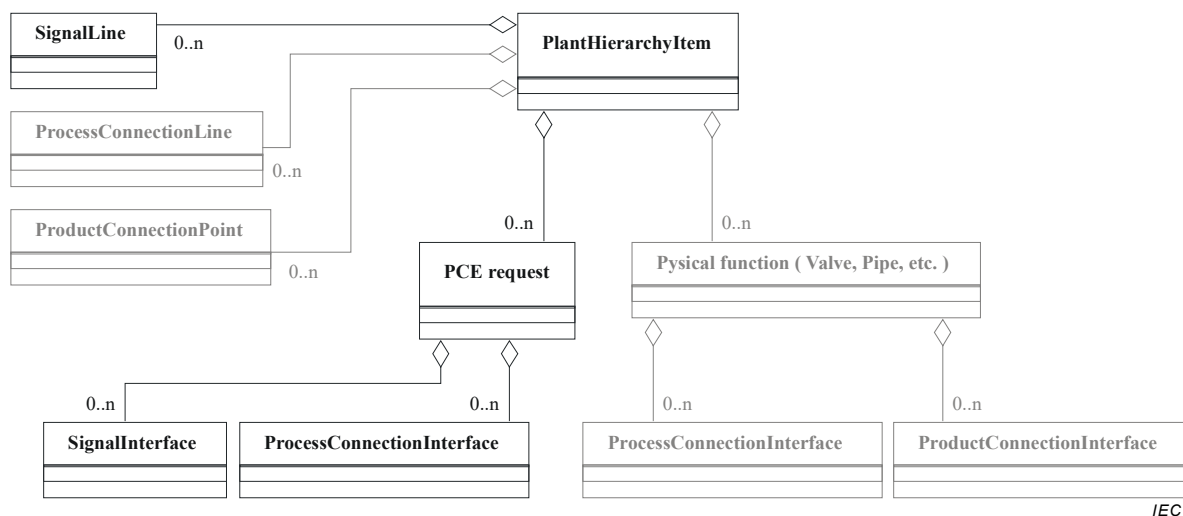


Figure 18 – Process data model (PCE relevant items are shown in dark lines)

The specifications in Clause 6 provide that

- a plant hierarchy item is a logical element collecting PCE request, SignalLines, Physical functions, ProcessConnectionLines and ProductConnectionPoints; the shaded objects shown in Figure 18 are not in the scope of this standard; plant hierarchy items may contain other nested plant hierarchy items (this allows creating a hierarchical breakdown structure of the plant);
- each PCE request contains 0...n ProcessConnectionInterfaces and 0...n SignalInterfaces;
- each plant hierarchy item, PCE request, SignalLine, ProcessConnectionInterface and SignalInterface shall have a set of attributes;
- each PCE request is part of one and only one plant hierarchy item; and
- control functions shall be handled in the same way as PCE requests but do not include ProcessConnectionInterfaces.

7.4.2 General object model of a PCE request

Figure 19 depicts the data model of a PCE request. A PCE request shall consist of 1...n interfaces and a set of attributes which may be extended by additional attributes and additional interfaces. Furthermore, common types of interfaces are presented.

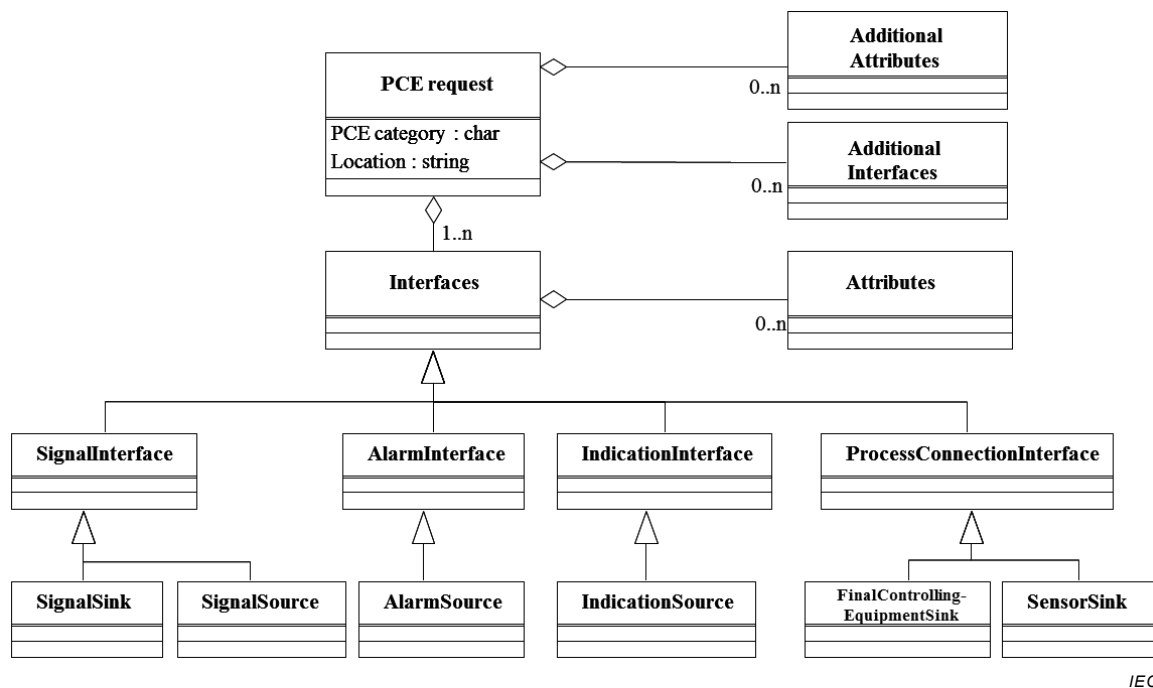


Figure 19 – PCE request data model

Each concrete PCE request possesses at least either a SignalInterface or a ProcessConnectionInterface with respect to the signal output of its processing function. A PCE request without any interface makes no sense.

Each PCE request shall have the following attributes (mandatory):

- PCE category (see Table 2);
- PCE reference designation;
- Location (local, local control panel, central control system).

Each PCE request should have one or more of the following attributes (optional):

- PU vendor (string);
- typical identification (string);
- device information (string);
- processing function (string) (see Table 3);
- GMP relevant (Boolean);
- safety relevant (Boolean);
- quality relevant (Boolean).

The CAEX data model of these attributes is defined in 7.5.3. Additional PCE relevant attributes are defined in Clauses 8 and D.1.

The graphical symbol for a PCE request – bubble or hexagon – carries no additional information and is not mapped to the CAEX model.

7.5 Modeling PCE relevant information using the CAEX system description language

7.5.1 Overview

The electronic data representation and exchange of plant information including PCE requests is supported by the data exchange format CAEX defined in this standard. The CAEX system

description language provides an XML schema that supports an exchange of CAE data by means of an XML file. The syntax of CAEX and the semantic definitions of this standard allow for the exchange of instance data (plant data), type data (class data) and complete libraries as well. Furthermore it comprises means to support the change management process.

The data format CAEX is generally able to model and to exchange arbitrary object model information with a standardized syntax, but it does not provide a general semantic standard. Instead, it is designed to model semantics. Hence, CAEX is conceptually able to model and to exchange e.g. a complete P&ID including graphics and proprietary semantics, but this standard focus on PCE relevant information only and standardizes the semantics of a PCE request and PCE relevant attributes for an electronic data exchange between P&ID tools and PCE-CAE tools.

The XML schema of CAEX and the concepts behind are specified and explained in Annex A. The schema file is given in Annex C. Examples are given in Annex D.

7.5.2 Basic CAEX mappings

The exchange of plant information by means of CAEX requires the modeling of the described engineering data in a CAEX data model. This comprises the modeling of templates as follows.

- a) A CAEX data model of PCE request related attribute types: Basis of a template modeling is a predefined attribute type library. A normative definition of a CAEX attribute type library is defined in 7.5.3. An informative definition of additional attributes is provided in Clause D.1. Examples about the application of both libraries are provided in Clause D.4.
- b) A CAEX data model of required signal classes: A template for common interfaces shall be predefined as CAEX InterfaceClasses, e.g. SignalSource, SignalSink, FinalControllingEquipmentSource, AlarmSource, SensorSink and IndicationSource. An informative example for a CAEX interface class library is given in Figure D.3.
- c) A CAEX data model of a PCE request role class: An example of a CAEX role class is provided in Clause D.3. A template for a PCE request and a SignalLine shall be predefined as each one CAEX RoleClass, e.g. PCERequest and SignalLine. These predefined role classes utilize the standard attributes from the attribute type library a) and interface classes b) required for the data exchange. An informative example for a CAEX role class PCERequest is given in Figure D.5.

In addition to the described templates, the exchange of plant information requires the modeling of concrete and individual object instances according to Figure 18. This comprises the following.

- d) A CAEX data model of a concrete plant hierarchy, which contains individual instances of physical functions or PCE requests with their interfaces and attributes and relations. The plant hierarchy shall be represented by a CAEX InstanceHierarchy.
- e) A CAEX description of concrete elements of the plant hierarchy. Those plant hierarchy items, e.g. the physical function of a pipe, shall be represented by a CAEX InternalElement with an optional association to a role class e.g. "Pipe". CAEX InternalElements may contain further InternalElements as nested objects. This allows for defining the desired breakdown structure. The detailed data model of the InternalElements may be user defined and is not in the scope of this standard.
- f) A CAEX description of concrete PCE requests: A PCE request shall be represented in CAEX as InternalElement within the plant hierarchy associating a PCE request role class. The CAEX tag "Name" of the InternalElement shall represent the name of the PCE request. The associated PCE request role class references standard CAEX attributes (a) defined in 7.5.3. The concrete requirements for the PCE request (attribute values and the required interfaces) shall be stored in the RoleRequirements of the InternalElement. If applicable, additional attributes and interfaces, which are not predefined in the role class, shall be added here too.

NOTE In a later engineering phase, the same InternalElement can additionally be assigned to a corresponding SystemUnitClass which describes the concrete technical implementation of the PCE request. This is not in the scope of this standard. See A.2.10 for related CAEX concept details.

g) A CAEX data model of concrete signal lines which is supported in two ways:

- Either a signal line between two PCE requests of the same plant hierarchy item is described with CAEX by means of an InternalLink of the belonging PCE request which directly links the corresponding interfaces of the two PCE requests. InternalLinks do not support properties, therefore they can only represent simple relations. An example for those signal lines is given in Clause D.4.
- Or the signal line is represented as an own CAEX object. If the SignalLine is considered as an object for itself with its own properties, this shall be represented as a CAEX InternalElement with an associated RoleClass “SignalLine”. A signal line implements two external interfaces which shall be named as “SideA” and “SideB”. The connection between two PCE requests is modeled by means of each, an InternalElement for both PCE requests and, and another InternalElement for the SignalLine. Furthermore, two InternalLinks have to be defined: One InternalLink connects the source PCE request interface with the “SideA” interface of the signal line, and a second InternalLink connects the signal line interface “SideB” with the sink interface of the second PCE request.

A signal line between two plant hierarchy items of the same level shall be described in CAEX in the same way as signal lines between two PCE requests, linking the corresponding interfaces of the two plant hierarchy items. An example for those signal lines is given in Figure 22.

h) A CAEX data model of concrete interfaces: PCE requests associated to the PCE request role class inherit the predefined interfaces of this role class. Additionally required interfaces shall be additionally implemented by means of the CAEX element ExternalInterface within the corresponding InternalElement.

- Each defined alarming function (AH, A, ALL..) implements an additional AlarmInterface within the PCE request.
- Each defined additional switching function (SH, SHH,...,SL,...,ZH,...) implements an additional SignalInterface within the PCE request.
- Each defined indication function (I, O, OH, ...) implements an additional IndicationInterface.

The function OSH creates an IndicationInterface and a SignalInterface as well.

i) CAEX description of concrete process connections

Process connections are outside the scope of PCE and are not mapped to the CAEX model within this standard. All additional information given by the P&ID tool with respect to a process connection shall be mapped to attributes of the corresponding ProcessConnectionInterface. Each end of a process connection at a PCE request implements an additional ProcessConnectionInterface within this PCE request.

7.5.3 Standard CAEX library of PCE request related attributes

This 7.5.3 defines a standard CAEX representation of PCE request related attributes according to 7.4.2 in form of a standard CAEX attribute type library. Figure 20 and Figure 21 show this library which is named as IEC62424AttributeLib. This standard attribute type library defines the CAEX data model of the attributes covering syntax and semantics. Regarding this library, the following provisions apply.

- Attributes of PCE requests shall reference corresponding attributes of the AttributeTypeLib “IEC62424AttributeLib”.

NOTE Examples for the application of this library are provided in Clause D.4.

AttributeTypeLib				
= Name		IEC62424AttributeLib		
Version		3.0.0		
AttributeType (10)				
	= Name	= AttributeDataType	Constraint	Description
1	PCECategory	xs:string		
2	PCEReferenceDesignation	xs:string		
3	Location	xs:string	Constraint = Name ValueRange NominalScaledType RequiredValue (3) Rbc Text 1 Local 2 Local Control Panel 3 Central Control System	
4	PU-Vendor	xs:string		
5	TypicalIdentification	xs:string		
6	DeviceInformation	xs:string		
7	ProcessingFunction	xs:string		
8	GMPrelevant	xs:boolean		false or true
9	SafetyRelevant	xs:boolean		false or true
10	QualityRelevant	xs:boolean		false or true

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Figure 20 – CAEX data model of major PCE request related attributes

```

<AttributeTypeLib Name="IEC62424AttributeLib">
  <Version>3.0.0</Version>
  <AttributeType Name="PCECategory" AttributeDataType="xs:string"/>
  <AttributeType Name="PCEReferenceDesignation" AttributeDataType="xs:string"/>
  <AttributeType Name="Location" AttributeDataType="xs:string">
    <Constraint Name="ValueRange">
      <NominalScaledType>
        <RequiredValue>Local</RequiredValue>
        <RequiredValue>Local Control Panel</RequiredValue>
        <RequiredValue>Central Control System</RequiredValue>
      </NominalScaledType>
    </Constraint>
  </AttributeType>
  <AttributeType Name="PU-Vendor" AttributeDataType="xs:string"/>
  <AttributeType Name="TypicalIdentification" AttributeDataType="xs:string"/>
  <AttributeType Name="DeviceInformation" AttributeDataType="xs:string"/>
  <AttributeType Name="ProcessingFunction" AttributeDataType="xs:string"/>
  <AttributeType Name="GMPrelevant" AttributeDataType="xs:boolean">
    <Description>false or true</Description>
  </AttributeType>
  <AttributeType Name="SafetyRelevant" AttributeDataType="xs:boolean">
    <Description>false or true</Description>
  </AttributeType>
  <AttributeType Name="QualityRelevant" AttributeDataType="xs:boolean">
    <Description>false or true</Description>
  </AttributeType>
</AttributeTypeLib>

```

IEC

Figure 21 – XML code of the attribute type library

7.5.4 Mapping of indirect links between PCE requests of different plant sections

This 7.5.4 defines how to model indirect links between PCE requests of different plant sections. If a signal interface of a PCE request represents an external interface of the corresponding plant section, the internal signal interfaces of the considered PCE request shall be mapped to the external interfaces of the corresponding plant section. The mapping between a PCE request interface and an external interface of the corresponding plant section is defined by means of an additional InternalLink stored in the corresponding plant section.

The described mapping and a corresponding use case is illustrated in Figure 22 which gives an example in which a SignalLine couples a PCE request of PlantSection A1 with a PCE request of PlantSection A2. In this case, the plant sections themselves get each external signal interfaces “In” and “Out” respectively.

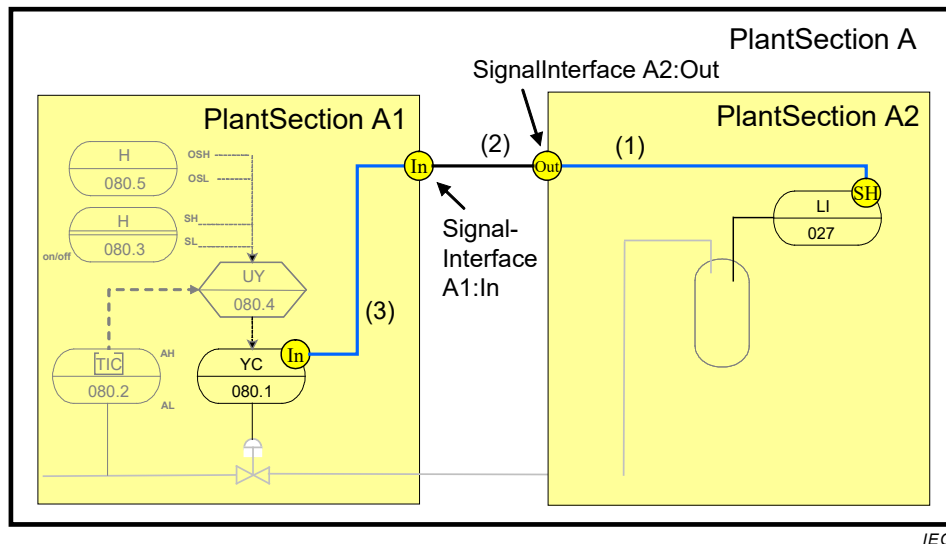


Figure 22 – Example of two plant sections and a signal connection via external interfaces

The SignalLine in this case is described in CAEX by means of three links:

- 1) link which is part of plant section A2, connecting A2/027/SH with A2/Out;
- 2) link which is part of the superior plant section A, connecting A2/Out with A1/In;
- 3) link which is part of plant section A1, connecting A1/In with A1/080.1/In.

A corresponding CAEX model is shown in Figure 23 which demonstrates how the signal line parts are defined separately in the InternalElements A, A1 and A2. Note that this simplified CAEX representation only models involved PCE requests.

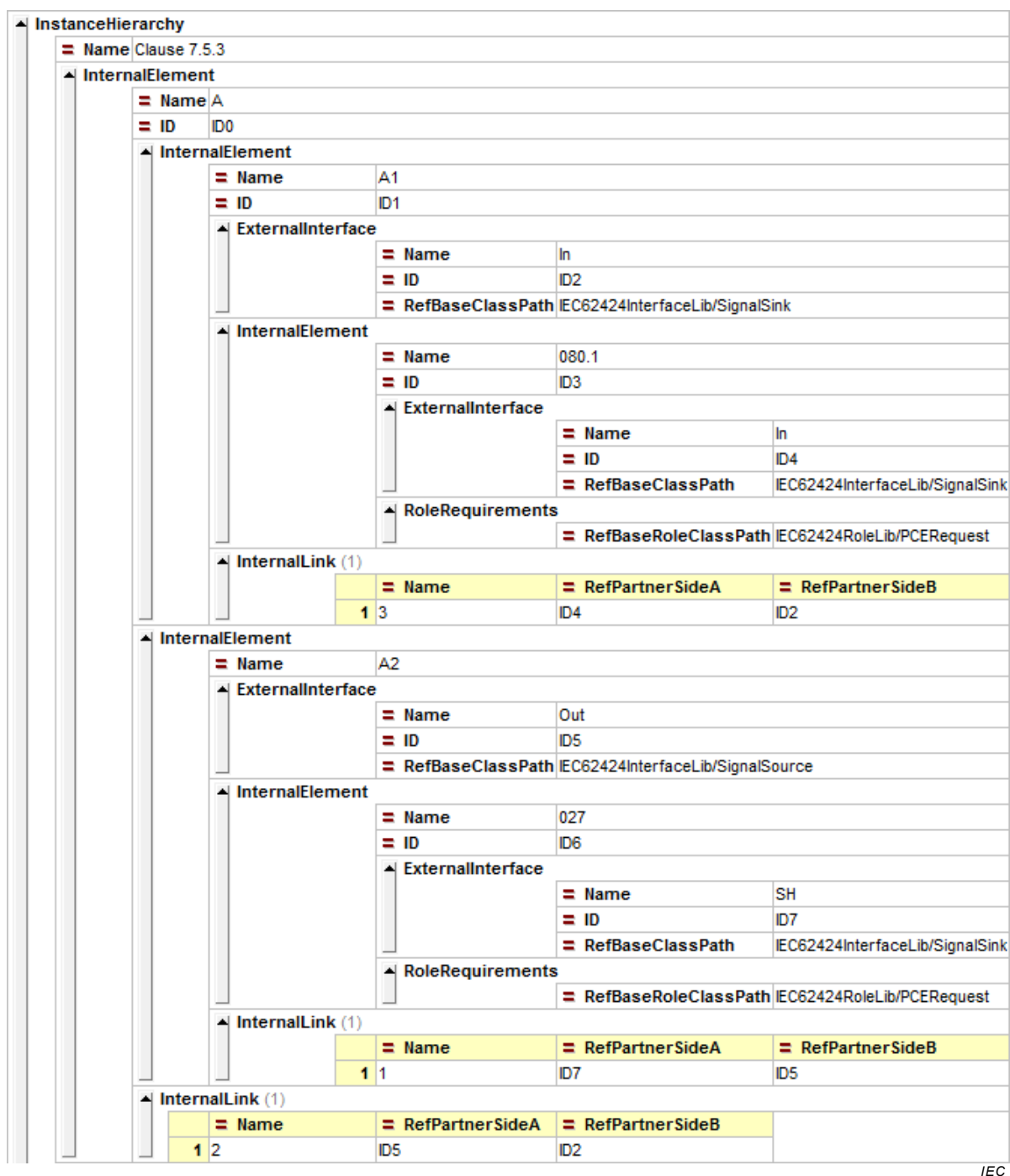


Figure 23 – Simplified CAEX model of indirect links between PCE requests across different plant hierarchy items

The full XML text for this example is shown in Figure 24. For better readability, mandatory attributes of the PCE request are not present.

```

<InstanceHierarchy Name="Clause 7.5.3">
  <InternalElement Name="A" ID="ID0">
    <InternalElement Name="A1" ID="ID1">
      <ExternalInterface Name="In" ID="ID2" RefBaseClassPath="IEC62424InterfaceLib/SignalSink"/>
      <InternalElement Name="080.1" ID="ID3">
        <ExternalInterface Name="In" ID="ID4" RefBaseClassPath="IEC62424InterfaceLib/SignalSink"/>
        <RoleRequirements RefBaseRoleClassPath="IEC62424RoleLib/PCERequest"/>
      </InternalElement>
      <InternalLink Name="3" RefPartnerSideA="ID4" RefPartnerSideB="ID2"/>
    </InternalElement>
    <InternalElement Name="A2">
      <ExternalInterface Name="Out" ID="ID5" RefBaseClassPath="IEC62424InterfaceLib/SignalSource"/>
      <InternalElement Name="027" ID="ID6">
        <ExternalInterface Name="SH" ID="ID7" RefBaseClassPath="IEC62424InterfaceLib/SignalSink"/>
        <RoleRequirements RefBaseRoleClassPath="IEC62424RoleLib/PCERequest"/>
      </InternalElement>
      <InternalLink Name="1" RefPartnerSideA="ID7" RefPartnerSideB="ID5"/>
    </InternalElement>
    <InternalLink Name="2" RefPartnerSideA="ID5" RefPartnerSideB="ID2"/>
  </InternalElement>
  <InternalElement Name="A" ID="ID1">
    <InternalElement Name="A1" ID="ID2">
      <InternalElement Name="080.1" ID="ID3">
        <ExternalInterface Name="In" ID="ID4"/>
      </InternalElement>
    </InternalElement>
    <InternalElement Name="A2" ID="ID5">
      <InternalElement Name="027" ID="ID6">
        <ExternalInterface Name="SH" ID="ID7"/>
      </InternalElement>
    </InternalElement>
    <InternalLink Name="1" RefPartnerSideA="ID7" RefPartnerSideB="ID4"/>
  </InternalElement>
</InstanceHierarchy>

```

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Figure 24 – Simplified CAEX model of indirect links between PCE requests across different plant hierarchy items

7.5.5 CAEX description of direct links between PCE requests of different plant sections

This 7.5.5 defines how to model direct links between PCE requests of different sections of a plant. If a signal interface of a PCE request is not represented by an external interface of the corresponding plant hierarchy item, a link to other PCE request interface of other plant hierarchy items shall be described in CAEX by a CAEX InternalLink that references both PCE request interfaces directly by means of their IDs (see Figure 25). The link is a part of a higher level plant hierarchy item.

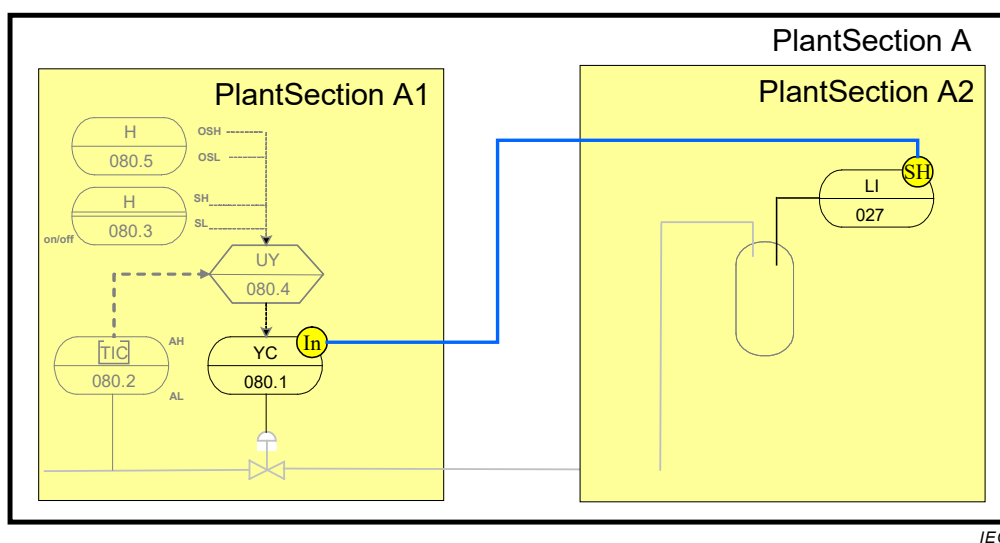


Figure 25 – Example of two plant sections and a direct connection

A corresponding CAEX model is shown in Figure 26 which demonstrates how the signal line is defined as part of the InternalElement A ("PlantSection A"). Note that this simplified CAEX representation only models involved PCE requests.

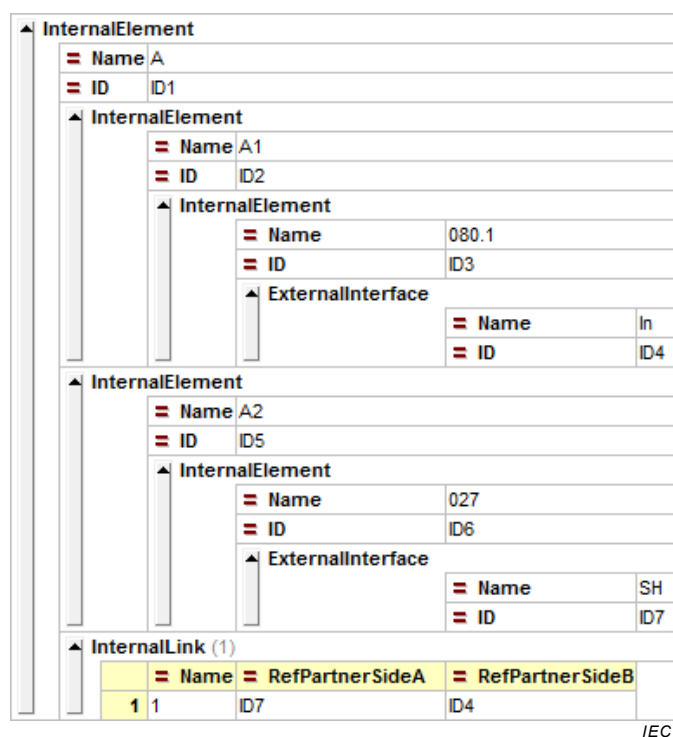


Figure 26 – Simplified CAEX model of direct links between PCE requests across different sections of a plant

The full XML text for this example is shown in Figure 27.

```
<InternalElement Name="A" ID="ID1">
  <InternalElement Name="A1" ID="ID2">
    <InternalElement Name="080.1" ID="ID3">
      <ExternalInterface Name="In" ID="ID4"/>
    </InternalElement>
  </InternalElement>
  <InternalElement Name="A2" ID="ID5">
    <InternalElement Name="027" ID="ID6">
      <ExternalInterface Name="SH" ID="ID7"/>
    </InternalElement>
  </InternalElement>
  <InternalLink Name="1" RefPartnerSideA="ID7" RefPartnerSideB="ID4"/>
</InternalElement>
```

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Figure 27 – XML code of the simplified CAEX model

7.5.6 PCE loops

PCE loops are identified by a reference designation system. PCE loops will not be mapped to CAEX structural elements. The target tool has to know the special meaning of the reference designation system to be able to identify PCE loops.

8 Additional PCE attributes

The objective of this Clause 8 is to give a minimum set of typical attributes which are usually stored in P&ID systems and are relevant in the PCE environments. If applicable, these attributes shall be exchanged using the syntax as shown in Table 6 via the CAEX data exchange format.

The attributes given in Table 6 describe information with respect to the special process connections. These attributes shall be mapped to additional attributes of corresponding process connection interfaces.

A CAEX based electronic data model of these attributes is provided in Clause D.1.

Table 6 – P&ID attributes relevant in PCE environment

Attributes	Syntax	CAEX mapping
Medium code	MediumCode	RoleClass/Attribute (see A.3.24 and D.1)
Medium code description	MediumCodeDescription	RoleClass/Attribute (see A.3.24 and D.1)
Material balance point	MaterialBalancePoint	RoleClass/Attribute (see A.3.24 and D.1)
Pressure rating	PressureRating	RoleClass/Attribute (see A.3.24 and D.1)
Design temperature	DesignTemperature	RoleClass/Attribute (see A.3.24 and D.1)
Design pressure	DesignPressure	RoleClass/Attribute (see A.3.24 and D.1)
Pipe specification	PipeSpecification	RoleClass/Attribute (see A.3.24 and D.1)
Pipe diameter size	PipeDiameterSize	RoleClass/Attribute (see A.3.24 and D.1)
Adjusted nominal pipe size	AdjustedNominalPipeSize	RoleClass/Attribute (see A.3.24 and D.1)
Heat tracing	HeatTracing	RoleClass/Attribute (see A.3.24 and D.1)
Heat tracing type	HeatTracingType	RoleClass/Attribute (see A.3.24 and D.1)
Heat tracing temperature set point	HeatTracingTemperatureSetPoint	RoleClass/Attribute (see A.3.24 and D.1)
Equipment/pipe flag	EquipmentPipeFlag	RoleClass/Attribute (see A.3.24 and D.1)
Equipment ID	EquipmentID	RoleClass/Attribute (see A.3.24 and D.1)
Pipe ID	PipeID	RoleClass/Attribute (see A.3.24 and D.1)
Insulation type	InsulationType	RoleClass/Attribute (see A.3.24 and D.1)
Insulation thickness	InsulationThickness	RoleClass/Attribute (see A.3.24 and D.1)

The attributes given in Table 7 concern information with respect to the internal object management. They shall be mapped to additional attributes of the corresponding object.

Table 7 – Data handling attributes

Attributes	Syntax	CAEX mapping
Internal unique ID	InternalUniqueID	RoleClass/Attribute (see A.3.24 and D.1)
Short description	ShortDescription	RoleClass/Attribute (see A.3.24 and D.1)

Annex A (normative)

CAEX – Data model for machine information exchange

A.1 CAEX and its diagram conventions

The neutral data format CAEX defines structures for the definition and storage of objects with their characteristics and their relationships. CAEX is the basis of a general exchange format for CAE planning data and is specified as XML schema.

The schema diagrams use the following conventions in order to illustrate the structure of the CAEX schema elements, the types of the elements, the attributes, the rules for optional elements and the repetitions (see Table A.1).

Table A.1 – XML notation conventions

Diagram element	Description	Example
Rectangle with solid border	Indicates a mandatory XML element	
Rectangle with dashed border	Indicates an optional XML element that may be implemented	
Datatype	Indicates the datatype of an element – after the keyword "type" in the second line of an element	
Namespace	Indicates the namespace of the used datatype. (Keyword "xs:") The described CAEX schema refers to the namespace of W3C (xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"). The targetNamespace of the CAEX types is http://www.dke.de/CAEX	
Sequence	Indicates that the following elements shall be in the defined order	
Range	Indicates the allowed number of occurrences. For example 1 to infinite	
Plus sign	Indicates that this XML-element contains other elements. The containing elements are hidden	
Minus sign	Indicates that all containing XML-elements are shown	
Greying background with dashed rectangle	Indicates that the shown elements are composed in a defined datatype. The name of the datatype is shown at the top of the dashed rectangle with dashed lines	

A.2 General CAEX concepts

A.2.1 General CAEX terms

This A.2.1 describes all CAEX terms (see Table A.2).

Table A.2 – CAEX data types and elements (1 of 3)

Data types and elements	Detailed description
AdditionalInformation	Optional auxiliary field that may contain any additional information about a CAEX object. It shall be used in the substructure of the header.
Alias	Describes the alias name of an external CAEX file to enable referencing elements of the external CAEX file.
Attribute	Characterizes properties of a SystemUnitClass, RoleClass, InterfaceClass, InternalElement or RoleRequirements.
AttributeDataType	Describes the data type of the attribute using XML notation.
AttributeFamilyType	Defines base structures for attribute type definitions.
AttributeNameMapping	Allows the definition of the mapping between attributes of a related role class or its interfaces and attributes of the hosting system unit.
AttributeType	Defines base structures for attribute definitions.
AttributeTypeLib	Container element for a hierarchy of Attribute type definitions. CAEX supports multiple attribute type libraries.
AttributeValueRequirementType	Defines base structures for definition of value requirements of an attribute.
CAEXBasicObject	CAEX basic object that comprises a basic set of attributes and header information which exist for all CAEX elements.
CAEXFile	Root element of the CAEX schema.
CAEXObject	CAEX basis object derived from CAEXBasicObject, augmented by Name (required) and ID (optional).
ChangeMode	Optionally describes the change state of a CAEX object. If used, the ChangeMode shall have the following value range: state, create, delete and change. This information should be used for further change management applications.
Constraint	Element to restrict the range of validity of a defined attribute.
Copyright	Organizational information about copyright.
DefaultValue	A predefined default value for an attribute.
Description	Textual description for CAEX objects.
ExternalInterface	Description of an external interface of a RoleClass, SystemUnitClass or InternalElement.
ExternalReference	Container element for the alias definition of external CAEX files.
FileName	Describes the name of the CAEX file.
Header	Defines a group of organizational information, like description, version, revision, copyright, etc.
ID	Optional attribute that describes a unique identifier of a CAEX object.
InstanceHierarchy	Root element for a system hierarchy of object instances.
InterfaceClass	Class definition for interfaces.

Table A.2 (2 of 3)

Data types and elements	Detailed description
InterfaceClassLib	Container element for a hierarchy of InterfaceClass definitions. It shall contain any interface class definitions. CAEX supports multiple interface libraries.
InterfaceClassType	Shall be used for InterfaceClass definition, provides base structures for an interface class definition.
InterfaceFamilyType	Defines base structures for a hierarchical InterfaceClass tree. The hierarchical structure of an interface library has organizational character only.
InterfaceIDMapping	Allows the definition of the mapping between interfaces of a related role class and interfaces of the hosting system unit.
InternalElement	Shall be used in order to define nested objects inside of a SystemUnitClass or another InternalElement. Allows description of the internal structure of a CAEX object.
InternalElementType	Type for the definition of nested objects inside of a SystemUnitClass.
InternalLink	Shall be used in order to define the relationships CAEX ExternalInterfaces.
LastWritingDateTime	Date and time of the creation of the CAEX document.
MappingObject	Host element for AttributeNameMapping and InterfaceIDMapping.
MappingType	Base element for the MappingObject.
Name	Describes the name of the CAEX object.
NominalScaledType	Element to define constraints of nominal scaled attribute values.
OrdinalScaledType	Element to define constraints of ordinal scaled attribute values.
OriginName	Name of the origin of the CAEX document, e.g. the source engineering tool or an exporter software.
OriginID	Unique identifier of the origin of the CAEX document, e.g. a unique identifier of a source engineering tool or an exporter software. The ID shall not change even if the origin gets renamed.
OriginVendor	The vendor of the data source of the CAEX document.
OriginVendorURL	The vendor's URL of the data source of the CAEX document.
OriginVersion	Version of the origin of the CAEX document, e.g. the version of the source engineering tool or the exporter software.
OriginRelease	Release information of the origin of the CAEX document, e.g. the version of the source engineering tool or the exporter software.
OriginProjectTitle	The title of the corresponding source project.
OriginProjectID	A unique identifier of the corresponding source project.
Path	Describes the path of the external CAEX file. Absolute and relative paths are allowed.
RefAttributeType	Refences an attribute type in the attribute library.
RefBaseClassPath	Stores the reference of a class to its base class. References contain the full path to the referred class object.
RefBaseSystemUnitPath	Stores the reference of an InternalElement to a class or instance definition. References contain the full path information.
RefSemantic	A reference to a definition of a defined attribute, e.g. to an attribute in a standardized library, this allows the semantic definition of the attribute.

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Data types and elements	Detailed description
RequiredMaxValue	Element to define a maximum value of an attribute.
RequiredMinValue	Element to define a minimum value of an attribute.
RequiredValue (NominalScaledType)	Element to define a required value of an attribute. It may be defined multiple times in order to define a discrete value range of the attribute.
RequiredValue (OrdinalScaledType)	Element to define a required value of an attribute.
Requirements	Defines informative requirements as a constraint for an attribute value.
Revision	Organizational information about the state of the revision.
RoleClass	Definition of a class of a role type.
RoleClassFamilyType	Defines base structures for a hierarchical RoleClass tree. The hierarchical structure of a role library has organizational character only.
RoleClassLib	Container element for a hierarchy of RoleClass definitions. It shall contain all RoleClass definitions. CAEX supports multiple role libraries.
RoleClassType	Shall be used for RoleClass definition, provides base structures for a role class definition.
RoleRequirements	Describes role requirements of an InternalElement. It allows the definition of a reference to a RoleClass and the specification of role requirements like required attributes and required interfaces.
SchemaVersion	Describes the version of the schema. Each CAEX document shall specify which CAEX version it requires. The version number of a CAEX document shall fit to the version number specified in the CAEX schema file.
SourceDocumentInformationType	Defines a structure to model information about the data source of the present CAEX document.
SourceObjID	Attribute representing the ID of the source object in the source data model.
SourceObjectInformation	Organizational information about the source of the corresponding CAEX object.
SuperiorStandardVersion	Describes the version of a superior standard. The version string is defined in the superior standard.
SupportedRoleClass	Allows the association of the corresponding SystemUnitClass to a RoleClass. This describes, which role the SystemUnitClass can play. A SystemUnitClass may reference multiple roles.
SystemUnitClass	Shall be used for SystemUnitClass definition, provides definition of a class of a SystemUnitClass type.
SystemUnitClassLib	Container element for a hierarchy of SystemUnitClass definitions. It shall contain all SystemunitClass definitions. CAEX supports multiple SystemUnitClass libraries.
SystemUnitClassType	Defines base structures for a SystemUnit class definition.
SystemUnitFamilyType	Defines base structures for a hierarchical SystemUnitClass tree. The hierarchical structure of a SystemUnit library has organizational character only.
Unit	Describes the unit of a variable.
UnknownType	Element to define constraints for attribute values of an unknown scale type.
Value	Element to describe the value of an attribute.
Version	Organizational information about the state of the version.

A.2.2 General CAEX concept description

A.2.2.1 CAEX basic concept

The general goal of CAEX is the vendor independent storage of hierarchical object information. Object-oriented concepts as encapsulation, classes, class libraries, instances, instance hierarchies, inheritance, relations, attributes, attribute types, attribute type libraries and interfaces are explicitly supported. XML provides means for modeling classes and instances.

A CAEX class or AttributeType represents a re-usable data model (template) of a real physical or logical item and is modeled either as a SystemUnitClass, a RoleClass, an Interface Class or an AttributeType.

- a) **SystemUnitClasses** describe physical or logical plant objects or units including their technical realization and internal architecture. They consist of attributes, interfaces, nested internal elements and relations between the internal elements. The internal elements may contain further nested elements – this allows for the description of predefined structures with multiple hierarchy levels. The concept of internal elements allows describing the internal architecture of a plant object.

SystemUnitClasses are collected in libraries of the type **SystemUnitClassLib**: This CAEX element allows collecting an arbitrary number of objects of the type SystemUnitClassType within a library. CAEX supports the definition of multiple SystemUnitClass libraries. SystemUnitClasses can be arranged within the library as a tree in order to depict the user's library breakdown structure. A SystemUnitClass can further be inherited from another SystemUnitClass by means of a reference. SystemUnitClassLibs can for example be used to store product catalogues.

- b) **RoleClasses** also describe physical or logical plant objects, but, compared to SystemUnitClasses, they are an abstraction of a concrete technical realization. RoleClasses contain attributes and interfaces, but do not describe the concrete internal implementation of the object. A RoleClass is used in order to define the meaning (semantics of) and the requirements for a plant object.

RoleClassLib: This CAEX element allows for collecting an arbitrary number of objects of the type RoleClassType within a library. CAEX supports the definition of multiple RoleClass libraries. RoleClasses can be arranged within the library as a tree in order to depict the user's library breakdown structure. A RoleClass can further be inherited from another RoleClass by means of a reference.

- c) **InterfaceClasses** describe types of interfaces. InterfaceClasses comprise a set of specific attributes and are used in order to specify interfaces for RoleClasses, SystemUnitClasses and InternalElements. Interfaces are required in order to define relations between objects.

InterfaceClassLib: This CAEX element allows collecting an arbitrary number of objects of the type InterfaceClassType within a library. CAEX supports definition of multiple InterfaceClass libraries. InterfaceClasses can be arranged within the library as a tree in order to depict the user's library breakdown structure. An InterfaceClass can further be inherited from another InterfaceClass by means of a reference.

- d) **AttributeTypes** describe types of attributes. Attributes are required in order to define properties of objects comprising their attribute names, values etc.

AttributeTypeLib: This CAEX element allows for collecting an arbitrary number of attribute types within a library. CAEX supports the definition of multiple AttributeType libraries. AttributeTypes can be arranged within the library as a tree in order to depict the user's breakdown structure. An AttributeType can further be inherited from another AttributeType by means of a reference.

SystemUnitClasses, RoleClasses, InterfaceClasses and AttributeTypes finally serve for predefining useful templates to be instantiated and re-used. The CAEX element **InstanceHierarchy** allows the storage of those object instances. A CAEX object instance is a concrete data object that corresponds to a certain real physical or logical item. A CAEX instance is modeled either as an InternalElement or an ExternalInterface. The term "instance" describes an individual object with individual properties. Each class can be instantiated