



International
Standard

ISO 20140-5

**Automation systems and
integration — Evaluating energy
efficiency and other factors of
manufacturing systems that
influence the environment —**

**Part 5:
Environmental performance
evaluation data**

*Systèmes d'automatisation et intégration — Évaluation de
l'efficacité énergétique et autres facteurs de fabrication des
systèmes qui influencent l'environnement —*

*Partie 5: Données d'évaluation de la performance
environnementale*

**Second edition
2024-09**



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Foreword

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

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*, in collaboration with the International Electrotechnical Commission (IEC), Technical Committee IEC/TC 65, *Industrial-process measurement, control and automation*.

This second edition cancels and replaces the first edition (ISO 20140-5:2017), which has been technically revised.

The main changes are as follows:

- a) renewal of [Clause 4](#) according to EPE data class definition;
- b) restructuring and updates of Clauses 5 to 8 into new [Clause 5](#) and [Clause 6](#) in terms of EPE data class definitions and their properties;
- c) replacement of Annexes with new [Annex A](#), [Annex B](#) and [Annex C](#).

A list of all parts in the ISO 20140 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The ISO 20140 series specifies a method for evaluating the energy efficiency and other factors of a manufacturing system that influence the environment, such as energy consumption, waste, and release.

The ISO 20140 series can be used for:

- benchmarking the environmental performance against a generic reference manufacturing system or comparing between different manufacturing systems;
- alternative studies for improving environmental performance;
- setting targets for improving environmental performance;
- visualizing the environmental performance of a manufacturing system under operation;
- managing carbon footprints of products (CFP) in a supply chain;
- evaluating the environmental performance of manufacturing systems.

Expected users of the ISO 20140 series are:

- a) managers who are responsible for the environmental conditions of a manufacturing system;
- b) engineers who design manufacturing processes for products;
- c) engineers who design a manufacturing system;
- d) engineers and supervisors who are responsible for manufacturing products.

This document classifies environmental performance evaluation (EPE) data. The classification intends to support the association of EPE data with context information and transferring them across various locations and disciplines in the manufacturing system.

This document provides EPE data classes which are used in the aggregation process specified in ISO 20140-3 to evaluate environmental performance of a manufacturing system. This document intends to allow mapping EPE data to various implementations based on different technologies by providing formal and technology-independent definitions of EPE data classes. The EPE data classes are intended to be stored in concept data dictionaries (e.g. IEC CDD).

This document is the second edition of ISO 20140-5, which replaces the first edition ISO 20140-5: 2017. The objective and the scope of both documents are the same. Both documents define the same set of EPE data classes. In order to improve the applicability of EPE data for evaluating various manufacturing processes, this document defines EPE data classes by a classification scheme differently from the first edition. The classification of the first edition is based on properties of manufacturing operations, i.e., source and time of EPE data generation. The classification of this document is based on a general concept of a manufacturing process, and detailed EPE data classes are defined systematically. The definitions of EPE data classes and types of properties are given respectively in [Clause 5](#) and [Clause 6](#) of this document. In order to retain the general use of the definitions, individual EPE data derived from EPE data classes and its properties are not described in this document. Detailed individual EPE data and properties specified in the first edition of ISO 20140-5 can be represented by using the class definitions given in this document.

Automation systems and integration — Evaluating energy efficiency and other factors of manufacturing systems that influence the environment —

Part 5: Environmental performance evaluation data

1 Scope

This document defines a set of environmental performance evaluation (EPE) data classes, including their properties.

It is applicable to entire manufacturing facilities or to parts of a manufacturing facility.

This document applies to manufacturing systems including discrete, batch and continuous control, which are defined in IEC 62264-1.

The following are outside the scope of this document:

- syntax of EPE data and data models;
- protocols to exchange EPE data;
- functions that can be enabled by the use of EPE data;
- product life cycle assessment;
- EPE data that are specific to a particular industry sector, manufacturer or machinery;
- acquisition of EPE data.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 10303 (all parts), *Industrial automation systems and integration — Product data representation and exchange*

ISO 11014, *Safety data sheet for chemical products — Content and order of sections*

ISO 13584-42, *Industrial automation systems and integration — Parts library — Part 42: Description methodology: Methodology for structuring parts families*

ISO 14224, *Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment*

ISO/TS 15926-4, *Industrial automation systems and integration — Integration of life-cycle data for process plants including oil and gas production facilities — Part 4: Initial reference data*

ISO 20140-1, *Automation systems and integration — Evaluating energy efficiency and other factors of manufacturing systems that influence the environment — Part 1: Overview and general principles*

IEC TS 62720, *Identification of units of measurement for computer-based processing*

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 61360-4, *IEC/SC 3D — Common Data Dictionary (CDD — V2.0015.0004)*

IEC 61987 (all parts), *Industrial-process measurement and control — Data structures and elements in process equipment catalogues*

IEC 62683-1, *Low-voltage switchgear and controlgear — Product data and properties for information exchange — Part 1: Catalogue data*

IEC/TR 63213, *Power measurement applications within electrical distribution networks and electrical installations*

3 Terms, definitions, abbreviated terms and conventions

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20140-1 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1.1

assembly

number of parts, subassemblies or combinations thereof joined together

[SOURCE: IEC 60194:2021, 3.1.72, modified — removed Note 1 to entry.]

3.1.2

attribute

data element for the computer-sensible description of a class definition or a property

[SOURCE: IEC 61360-1:2017, 3.1.2, modified — “a property, a relation or a class” was replaced with “a class definition or a property”.]

3.1.3

classifying property

property applicable for a particular class, having a value list whose values define the subclasses of the class

[SOURCE: IEC 61360-1:2017, 3.1.7]

3.1.4

consumable

any part or material that is necessary for continued use or maintenance of the product

[SOURCE: IEC/IEEE 82079-1:2019, 3.7]

3.1.5

environmental performance evaluation data

EPE data

data that are used to evaluate the environmental performance

[SOURCE: ISO 20140-3:2019, 3.7]

3.1.6

environmental performance evaluation data class

EPE data class

description of a set of EPE data that share common characteristics

Note 1 to entry: Adapted from IEC 62832-2:2020.

3.1.7

environmental performance evaluation data class definition

EPE data class definition

grouping of references to property or to another EPE data class definition, that defines the shared structure of a group of EPE data classes

3.1.8

environmental performance evaluation data value

EPE data value

number, text, or artefact encoding that expresses a quantity or quality held by EPE data

3.1.9

material

substance or mixture within a product or a part of a product

[SOURCE: IEC 62474:2012, 3.15]

3.1.10

part

material or functional element that is or can be a constituent of different products

[SOURCE: ISO 13584-1:2001, 3.1.16, modified – The phrase “intended to constitute a component” is replaced by “is or can be a constituent”.]

3.1.11

product

intended or accomplished result of labour, or of a natural or artificial process

[SOURCE: IEC 81346-1:2022, 3.6]

3.1.12

property

defined parameter suitable for the description and differentiation of objects

Note 1 to entry: A property describes one characteristic of a given object.

Note 2 to entry: A property can have attributes such as code, version, and revision.

Note 3 to entry: The specification of a property can include predefined choices of values.

[SOURCE: IEC 61360-1:2017, 3.1.24]

3.1.13

subclass definition

environmental performance evaluation (EPE) data class definition that is included in another EPE data class definition

3.1.14

tool

device for imparting a desired shape, form, or finish to a material

Note 1 to entry: The desired shape can be achieved by different means, e.g. by material removal, forming, shaping.

[SOURCE: ISO 14955-3:2020, 3.5]

3.1.15**value type**

stereotype of properties that is used to define types of values that are allowed to express information

3.2 Abbreviated terms

CAS	Chemical Abstracts Service
CFP	Carbon Footprint of Products
ECD	Environmental Characteristics Data
EPE	Environmental Performance Evaluation
GHG	Greenhouse Gas
ID	Identifier
IO	Input and Output
LCA	Life Cycle Assessment
NC	Numerical Control
UML	Unified Modelling Language

3.3 Conventions for defining class definitions and properties

Words connected with underscore (e.g. EPE_data) are used for representing class definitions and properties in [Clause 4](#), [Clause 5](#) and [Clause 6](#).

[Table 1](#) is the template used in this document for specifying an EPE data class definition.

Table 1 — Template for specifying EPE data class definitions

Attributes of the class definition	Value of the attribute	
ID of the class definition	<ID of the class definition >	
Preferred name	<preferred name of the class definition >	
Description of the class definition	<description of class definition >	
Source of the description	<source of the description>	
Preferred name of parent class definition	Subclause number defining the parent class definition	
<preferred name of parent class definition>	< Subclause number where the parent class definition is defined.>	
Property included in the class definition	Cardinality	Subclause defining the property
<preferred name of property #1>		<subclause number defining the property #1>
...		...
<preferred name of property #N>		<subclause number defining the property #M>
Class definitions included in this class definition	Cardinality	Subclause defining the class definition

Table 1 (*continued*)

<preferred name of class definition #1>		<subclause number defining the class definition #1>
...		...
<preferred name of class definition #N>		<subclause number defining the class definition #N>

The shaded cells indicate the meaning of associated unshaded cell.

The text in the angle bracket (i.e. "<" and ">") in each unshaded cell describes what the cell is used for.

The "Attributes of the class definition" part of the template provides identifying information for this EPE data class definition formatted as fields (unshaded cells) with respective values. The fields are designated ID of the class definition, Preferred name, and Description of the class definition.

The "Preferred name of parent class definition" part of the template provides references to another EPE data class definition (parent class definition). The EPE data class definition being specified inherits the properties of the parent class definition, which is referenced by preferred name.

The "Property included in the class definition" part of the template provides a list of properties for inclusion into this EPE data class definition by indicating the preferred names and the number of possible occurrences (cardinality). The first row for the "Property included in the class definition" part of the template is used for the classifying property of the class definition, if applicable. The preferred names of classifying properties are represented in bold text.

The "Class definitions included in the class" part of the template provides a list of other EPE class definitions for inclusion into this EPE data class. The EPE data class definition being defined inherits the properties of the included EPE data class definition that is referenced by indicating the preferred name and number of possible occurrences (cardinality).

NOTE For ease of understanding, reference subclause numbers in this document are added to the tables.

The field "Cardinality" contains a range which defines the number of constituent elements, which are properties or EPE class definitions. The range is expressed using the following convention:

[a..b]

where:

- a is the minimum number of constituent elements;
- b is the maximum number of constituent elements.

EXAMPLE The number of constituent elements can be expressed as follows:

- [0..1] indicates the EPE class definition has none or one constituent element;
- [0..n] indicates the EPE class definition has none or as many as n constituent elements;
- [1..1] indicates the EPE class definition has one constituent element;
- [1..n] indicates the EPE class definition has one or as many as n constituent elements.

[Table 2](#) specifies the template used to list subclass definitions which are EPE class definitions derived from the class definition that is defined by the template of [Table 1](#). It also indicates the value of the classifying property which characterizes each subclass definition.

Table 2 — Template for listing subclass definitions

Classifying property	Preferred name of subclass definition that is derived from the class definition	Subclause number in this document specifying the subclass definition
<value of classifying property #1>	<preferred name of subclass definition #1 that is derived from the class definition to be defined>	<subclause # for subclass definition #1>
....		
<value of classifying property #N>	<preferred name of subclass definition #N that is derived from the class definition to be defined>	<subclause # for subclass definition #N>

[Table 3](#) specifies the template to be used for defining a specific property.

Table 3 — Template for defining properties

Attribute of the property	Value of the attribute
ID of the property	<ID of the property >
Preferred name	<preferred name of the property >
Description of the property	<description of the property >
Source of the description	<source of the description>
Value type	< type of the property value which is defined in 3.4 >
Code of quantity	< Identifier of quantity defined by IEC TS 62720. This attribute applies properties whose value type is MeasureType.>
Coding system	<This attribute is used to specify the coding system(s) in case of properties whose value type is CodeType.>

The template provides the definition of a specific property of EPE data (identity and meaning) and the attributes for defining it. In some cases, additional rows are added.

Each shaded cell indicates the name of an attribute; the value is shown in the unshaded cell.

A specific property is defined by providing data in the relevant unshaded cells (i.e. the table is filled). An “N/A” in an unshaded cell indicates that the field is not applicable to the definition of the specific property.

The attribute of Code of quantity is used for specifying the quantity of the value specified by the property in the case where its value type is MeasureType.

NOTE Since multiple units of measure can be used for a property, identifiers of quantities defined by IEC TS 62720 is used for specifying the code of quantity, instead of unit of measures. Specifying the unit of measure for properties is out of the scope of this document. In an implementation of exchanging properties, a unit of measure corresponding to the code of quantity is specified separately.

The attribute of Coding system can be used in the following three different ways for properties whose value type is CodeType.

- In the case where a specific existing coding system is used, a reference to the coding system (e.g. designation of standard, URL, name of coding systems) is specified.
- In the case where only the coding system is defined by this document, the Table number of the Table defining it is indicated. In this case, the coding system is defined by using the template specified by [Table 4](#).
- In the case where multiple coding systems can be used, “SELECTABLE” is indicated. In this case, applicable coding systems are listed by using the template specified by [Table 5](#).

[Table 4](#) is the template for specifying the coding system by listing the possible values for properties defined with [Table 3](#), whose value type is CodeType or IndicatorType.

Table 4 — Template for listing possible values of a property

Possible value for the property	Description
<possible value #1 of the property to be defined>	<description of the possible value #1>
...	...
<possible value #N of the property to be defined>	<description of the possible value #N>

[Table 5](#) specifies the template for listing the applicable coding systems for properties defined with [Table 3](#) whose value type is CodeType.

Table 5 — Template for listing applicable coding systems

Designation of coding system	Name of coding system
<designation of coding system #1>	<name of coding system #1>
...	...
<designation of coding system #N>	<name of coding system #N>

3.4 Value types

[Table 6](#) lists value types used by definitions in this document. The pascal case (e.g. PascalCase) is used for reserved terms.

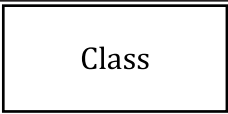
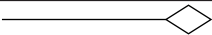
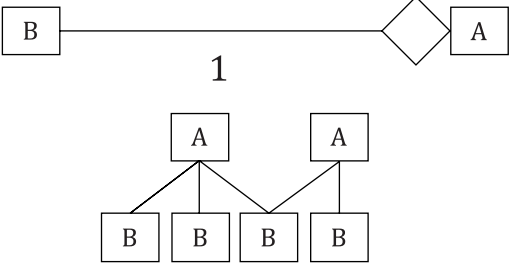
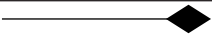
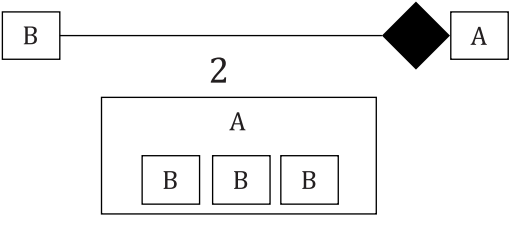
Table 6 — Definitions of value types

Value type designation	Value type description
AmountType	A number of monetary units specified in a currency where the unit of currency is explicit or implied.
BinaryObjectType	A data type representing graphic, picture, sound, video, or other forms of data that can be represented as a finite length sequence of binary octets.
CodeType	A character string that is used to represent an entry from a fixed set of enumerations.
DateTimeType	A particular point in time together with the relevant supplementary information to identify the time zone information. This is a specific instance on time using the ISO 8601 CE (Common Era) calendar extended format and abbreviated versions.
IdentifierType	A character string to identify and distinguish uniquely, one instance of an object in an identification scheme from all other objects in the same scheme.
IndicatorType	A list of two mutually exclusive Boolean values that express the only possible states of a Property. EXAMPLE 1 “True” or “False”.
MeasureType	A numeric value determined by measuring an object along with the specified unit of measure.
NumericType	A number that is assigned or is determined by calculation, counting, or sequencing. It does not require a unit of quantity or unit of measure.
QuantityType	A counted number of non-monetary units, possibly including fractions.
TextType	A character string generally in the form of words of a language. EXAMPLE 2 A finite set of characters.

3.5 UML notation

[Table 7](#) defines the UML notations used in this document.

Table 7 — UML notation used

Symbol	Definition
	Represents a UML class of objects, each with the same types of attributes. Each object is uniquely identifiable or enumerable. No operations or methods are listed for the classes.
 Association Name	An association between elements of a class and elements of another or the same class. Each association is identified. Can have the expected number or range of members of the subclass, when '*' indicates an indeterminate number. EXAMPLE 1 0..* means that zero or more members of the subclass can exist. The semantics of the association are defined in the object relationship table of each object participating in the relationship.
	Generalization (arrow points to the super class) shows that an element of the class is a specialized type of the super class.
	Aggregation shows an element of the class (whole element) is made up of elements of other classes (part elements). EXAMPLE 2  Key 1 Is an aggregation of The aggregation notation identifies that the lifetime of the part element is independent of the whole element. The part element is able to be a part of multiple parent elements. When a whole element is deleted, the part elements are not deleted. The parts' physical relationship is independent of its lifetime relationship. A part can be represented directly in the whole or referenced from the whole.
	A composition relationship represents a whole-part relationship and is a type of aggregation. A composition relationship specifies that the lifetime of the part classifier is dependent on the lifetime of the whole classifier. Composition shows a strong form of aggregation, which requires a) a part instance is included in only one composition at a time and b) the composition object has sole responsibility for disposition of its parts. EXAMPLE 3  Key 2 Is a composite of The composition notation identifies that the lifetime of the part elements is dependent on the whole element. When a whole element is deleted, the part elements are deleted. The parts' physical relationship is independent of its lifetime relationship as a part represented directly in the whole or referenced from the whole.

4 Outline of EPE data

4.1 Overview

[Clause 4](#) outlines the information necessary to specify class definitions for EPE data.

As an introduction to the set of EPE data class definitions which represent structures of EPE data, a simplified overview of class hierarchy and composition relationship of EPE data is shown in [Figure 1](#). Only the major elements are shown in [Figure 1](#). Precise definitions of the EPE data classes are described in [Clause 5](#).

NOTE 1 The relationships between EPE data, EPE data class and EPE data class definition are explained in [4.2](#).

NOTE 2 As a background of EPE data, [Annex A](#) explains a relationship to the other related international standards.

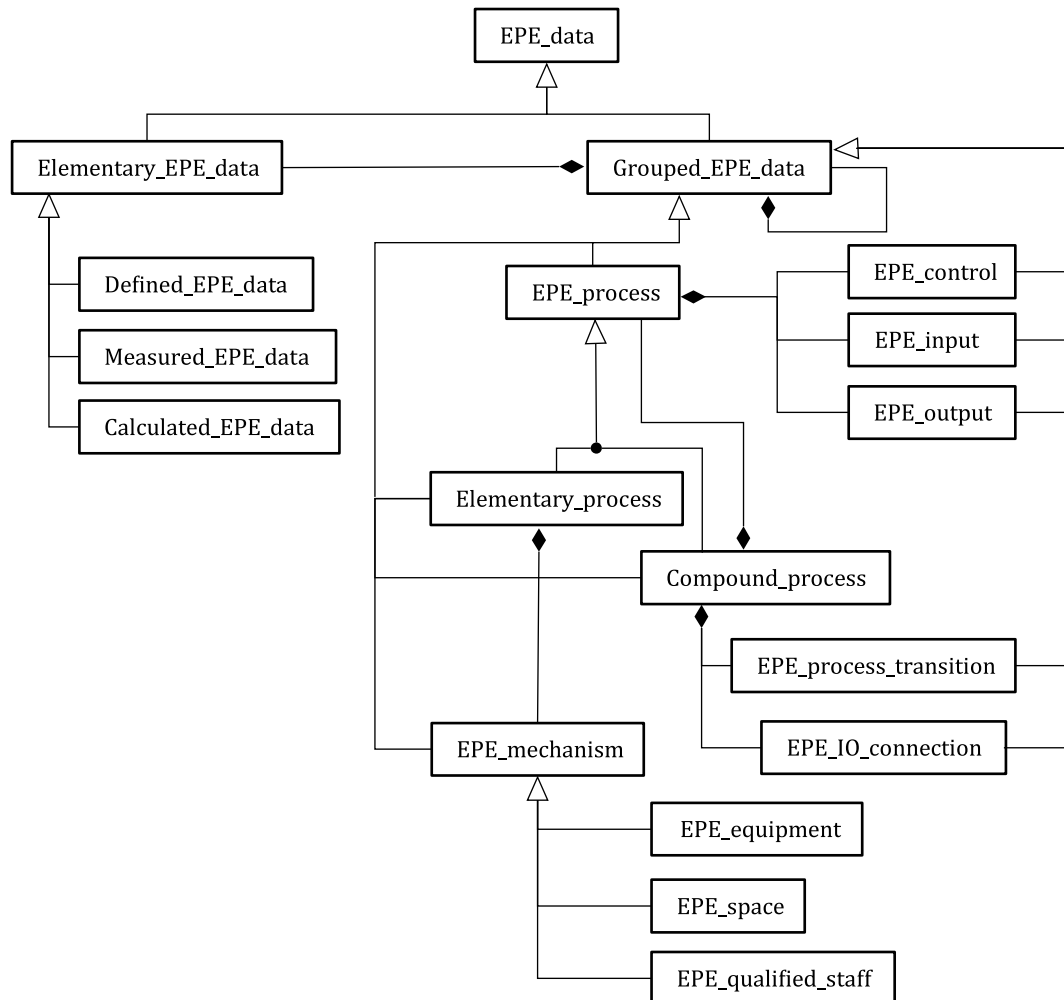


Figure 1 — Overview of classes of EPE data

4.2 EPE data, EPE data class and EPE data class definition

4.2.1 EPE_data

4.2.1.1 Overview

As depicted in [Figure 2](#), EPE_data (see [5.2](#)) can be either Elementary_EPE_data (see [5.3](#)) or Grouped_EPE_data (see [5.4](#)).

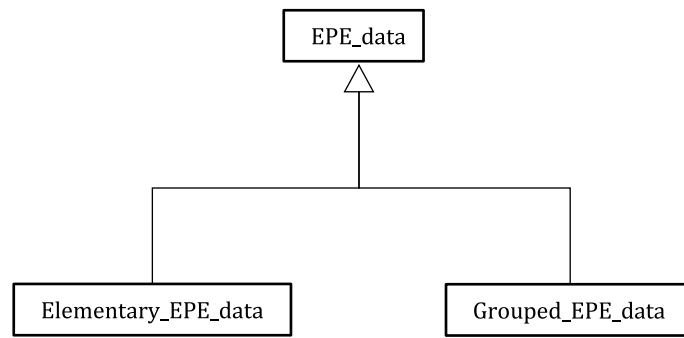


Figure 2 — Overview of classes of EPE_data

4.2.1.2 Elementary_EPE_data

An Elementary_EPE_data has two parts. One part is the EPE_data_value (see 5.3), and the other part is the EPE data description, which explains what the EPE_data_value means.

EXAMPLES Quantity of a particular lot of material, measured power consumption of an instance of a particular type of equipment at a given time, and dimensions of a particular type of equipment in its specification.

An EPE data description has one or more data elements, each of which is a pair of a property and a value corresponding to the property.

The property of a data element specifies what type of characteristic is represented by the data element.

A value of a data element defines a particular characteristic of the EPE data in terms of the type of characteristic given by the property.

[Figure 3](#) shows the structure of Elementary_EPE_data.

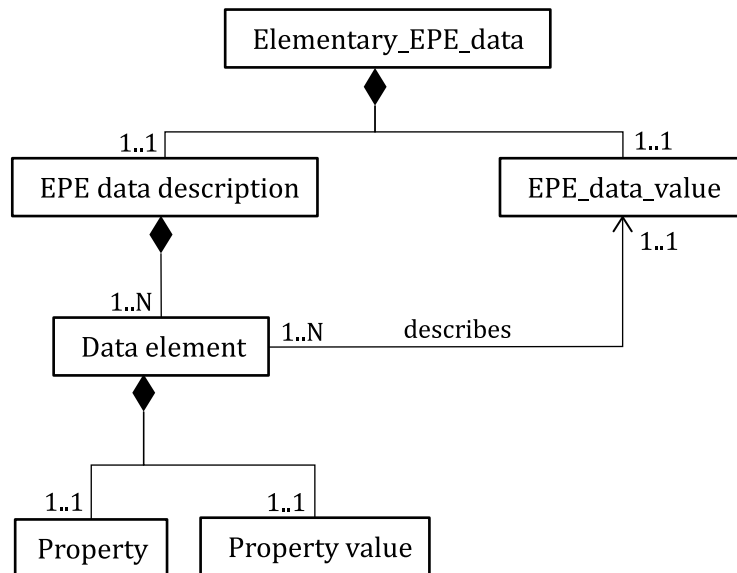


Figure 3 — Elementary_EPE_data

A property consists of multiple pairs, each of which is made of an attribute and the corresponding attribute value.

4.2.1.3 Grouped_EPE_data

A Grouped_EPE_data includes multiple Elementary_EPE_data and represents a tangible or intangible object.

EXAMPLE 1 A process (e.g. particular painting process in a given production line on a given day) and a piece of equipment (e.g. particular pieces of equipment identified by a serial-number in a given production line).

Each Elementary_EPE_data that contributes to the composition of a Grouped_EPE_data represents one characteristic of the object.

EXAMPLE 2 Time duration of a process, and power consumption of a piece of equipment.

Grouped_EPE_data can include other Grouped_EPE_data.

[Figure 4](#) shows the structure of Grouped_EPE_data.

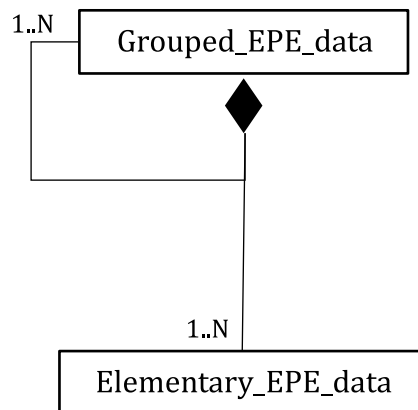


Figure 4 — Grouped_EPE_data

4.2.2 EPE data class

EPE data class is the description of a set of EPE data that share common characteristics.

For Elementary_EPE_data, common characteristics shared by EPE data in an EPE data class are a set of data elements.

EXAMPLE 1 The percentage of a composition of a given material (e.g. percentage of naphtha of a type of crude oil), measured power consumption of an individual of a given type of equipment (e.g. electric power consumption of a press machine), and dimensions of a given type of equipment (e.g. dimensions of conveyer).

For Grouped_EPE_data, common characteristics shared by EPE data in an EPE data class are a set of Elementary_EPE_data.

EXAMPLE 2 A type of process (e.g. painting process), and a type of equipment.

An EPE data class can be defined based on an EPE data class definition by inheriting all properties of the EPE data class definition and assigning values to some properties.

[Figure 5](#) shows the relationship between EPE data class and EPE data.

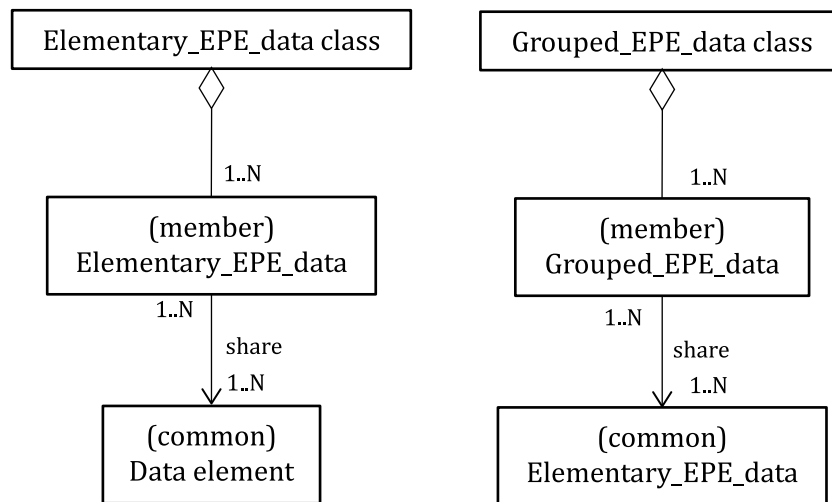


Figure 5 — Relationship between EPE data class and EPE data

Values of properties and EPE_data_values of EPE data classes can be left undefined.

Each EPE data can be deemed as an implementation of an EPE data class that represents a group of EPE data that shares common characteristics.

4.2.3 Descriptions of EPE data class definition

EPE data class definition is a collection of references to properties, that defines the structure of a group of EPE data classes that share the same structure.

EPE data class definition is used as a template for defining EPE data classes, but it includes neither value of a property nor EPE data value. An EPE data class definition defines only the common structure of EPE data classes by using references to properties and references to other EPE data class definitions.

A structure of EPE data class definition together with definitions of related properties provides the semantics of EPE data independent from real implementations of the manufacturing system.

Figure 6 shows the structure of EPE data class definition and its relationship with EPE data class and EPE data.

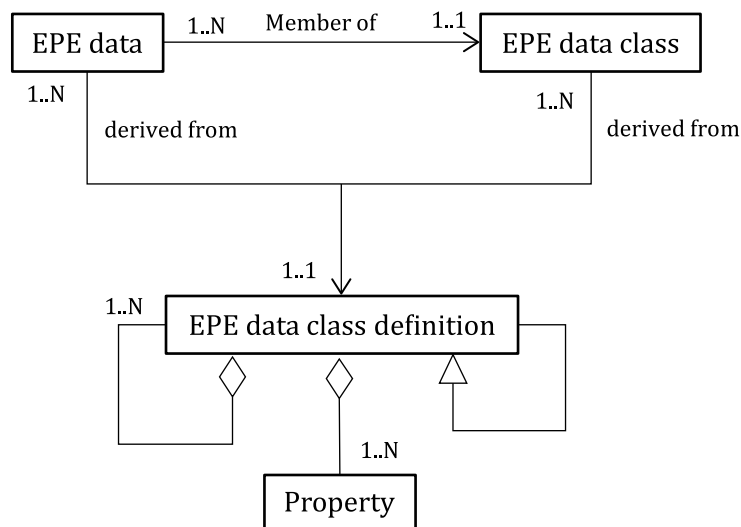


Figure 6 — Structure of EPE data class definition

NOTE This document defines a common set of EPE data class definitions so that EPE data classes can be defined and necessary EPE data can be used.

4.2.4 Hierarchy of EPE data class definitions

EPE data class definitions have two types of hierarchies. One is the inheritance hierarchy where the “is a” relationship associates two EPE data class definitions. The other is the structural hierarchy where the “has” relationship associates two EPE data class definitions (see [Figure 6](#)).

In an “is a” relationship, all properties of the parent EPE data class definition are inherited by the child EPE data class definition. As a result, properties of an EPE data class derived from the parent EPE data class definition are inherited to every child EPE data class derived from the child EPE data class definition.

In a “has” relationship, all properties of all given constituent EPE data class definitions are included in the EPE data class definition to be defined. It is allowed to specify multiple constituent EPE data class definitions in an EPE data class definition. As a result, an EPE data class derived from the EPE data class definition includes EPE data class derived from the constituent EPE data class definition included in the EPE data class definition. Furthermore, an EPE data that is derived from the EPE data class includes the constituent EPE data.

EXAMPLE EPE process has EPE input. An energy consuming process is a type of EPE process which has an EPE input. Therefore, the energy consuming process also has an EPE input, although EPE input is actually the energy input.

4.3 EPE_process

4.3.1 Overview

An EPE_process (see [5.4.2](#)), which is a type of Grouped_EPE_data, represents a manufacturing process.

An EPE_process can be a manufacturing process to be evaluated by EPE specified by ISO 20140-2 or a constituent activity which is a result of the decomposition sub-process specified by ISO 20140-3.

An EPE_process includes one or more EPE_inputs (see [5.4.3](#)), one or more EPE_outputs (see [5.4.4](#)) and an EPE_control (see [5.4.6](#)).

Each EPE_input or EPE_output is directly associated with a particular environmental influence.

There are two types of EPE_process. One type is the Elementary_process (see [5.4.2.2](#)) and the other is the Compound_process (see [5.4.2.9](#)).

[Figure 7](#) shows the structure of EPE_process.

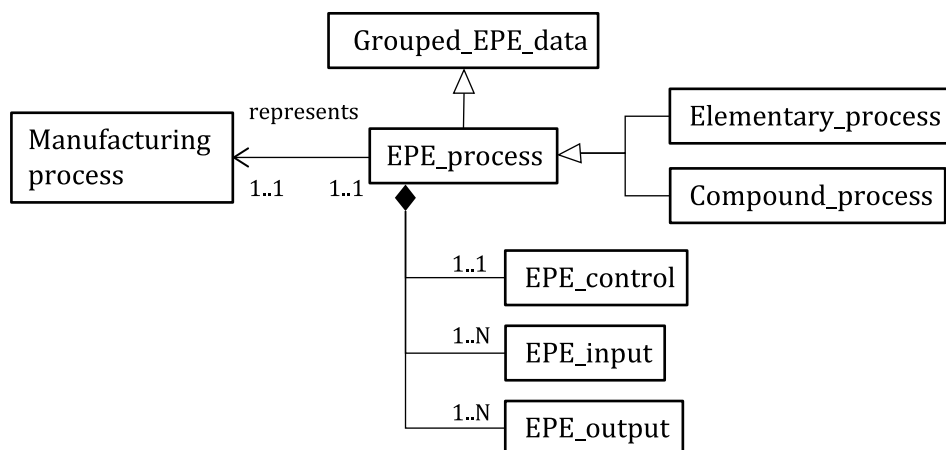


Figure 7 — Structure of EPE_process

4.3.2 Elementary_process

An `Elementary_process` is an `EPE_process` that has no `EPE_process` within. It has one or more `EPE_mechanism` (see [5.4.5](#)).

[Figure 8](#) shows the structure of `Elementary_process`.

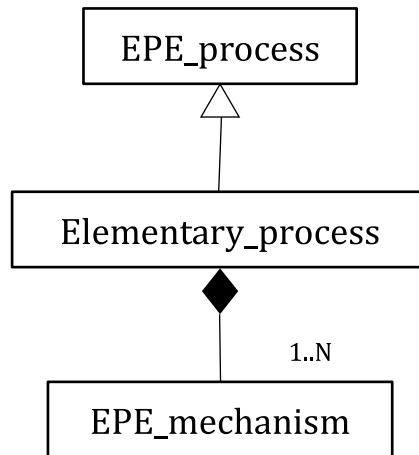


Figure 8 — Structure of `Elementary_process`

4.3.3 Compound_process

A `Compound_process` is an `EPE_process` that includes two or more `EPE_process` classes. `EPE_process` classes in a `Compound_process` can be associated by `EPE_process_transition` classes (see [5.4.7](#)). A `Compound_process` can have `EPE_IO_connection` classes (see [5.3.5](#)) which associate `EPE_input` classes and `EPE_output` classes of the `Compound_process` and of its constituent `EPE_process` classes.

A `Compound_process` has a structural hierarchy. Each `EPE_process` of a `Compound_process` is an `Elementary_process` or a `Compound_process`, i.e. a `Compound_process` can be broken down into multiple `Elementary_process` classes.

NOTE This break down process corresponds to the decomposition sub-process specified in ISO 20140-3.

All `EPE_mechanism` classes used by the `Compound_process` are included in the `Elementary_process` classes of the `Compound_process`, and a `Compound_process` does not directly have any `EPE_mechanism`.

[Figure 9](#) shows the structure of a `Compound_process`.

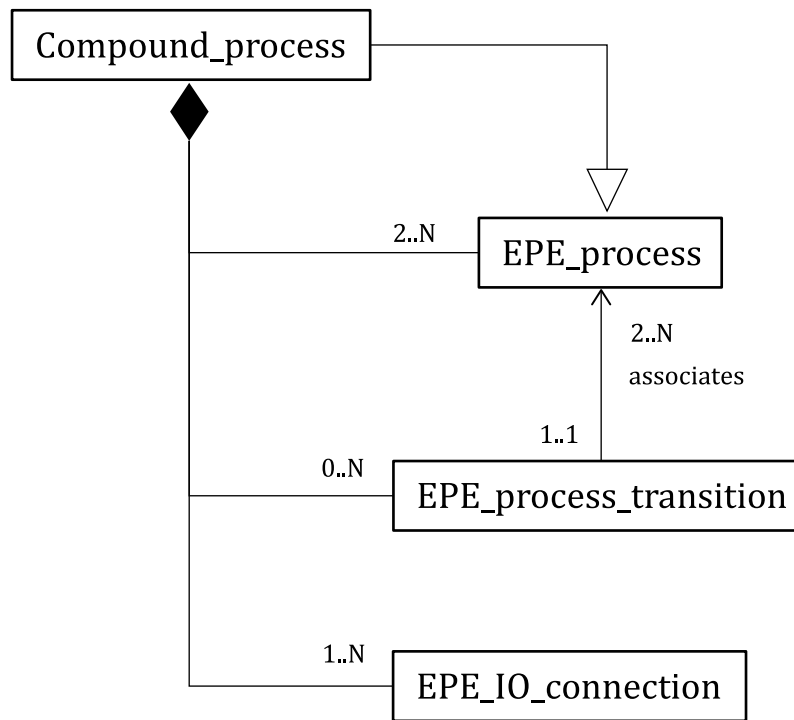


Figure 9 — Structure of Compound_process

[Figure 10](#) shows an example of a Compound_process. It depicts a Compound_process consisting of three Elementary_process classes and one Compound_process.

The Compound_process X starts with Elementary_process A. After completion of the Elementary_process A, Elementary_process B and Elementary_process C are triggered and executed in parallel. After both Elementary_process B and Elementary_process C completed, the Compound_process Y is triggered and executed. After the Compound_process Y is completed, the Compound_process X ends.

Input 1 and Input 2 of the Compound_process X are connected internally to an input of Elementary_process A and an input of Elementary_process C respectively.

The output of Elementary_process A is connected to an input of Elementary_process B, the output of Elementary_process B is connected to an input of Compound_process Y. The output of Compound_process Y is connected to the output of Compound_process X internally.

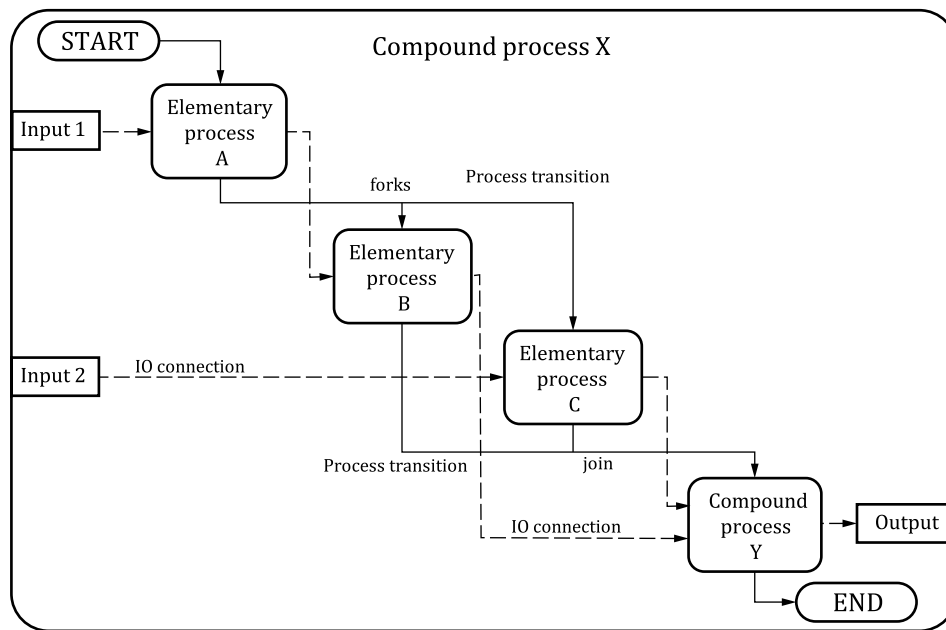


Figure 10 — Example of Compound_process

4.3.4 EPE_process_transition

An EPE_process_transition is a Grouped_EPE_data that associates one or more leading processes to one or more following processes in terms of sequence of execution.

An EPE_process_transition having only one leading process and multiple following processes is called “fork”, and An EPE_process_transition having only one following process and multiple leading processes is called “join”.

EPE_process_transition classes allow a Compound_process to represent its activities executed in parallel and its activities executed in serial.

Figure 11 shows the structure of an EPE_process_transition.

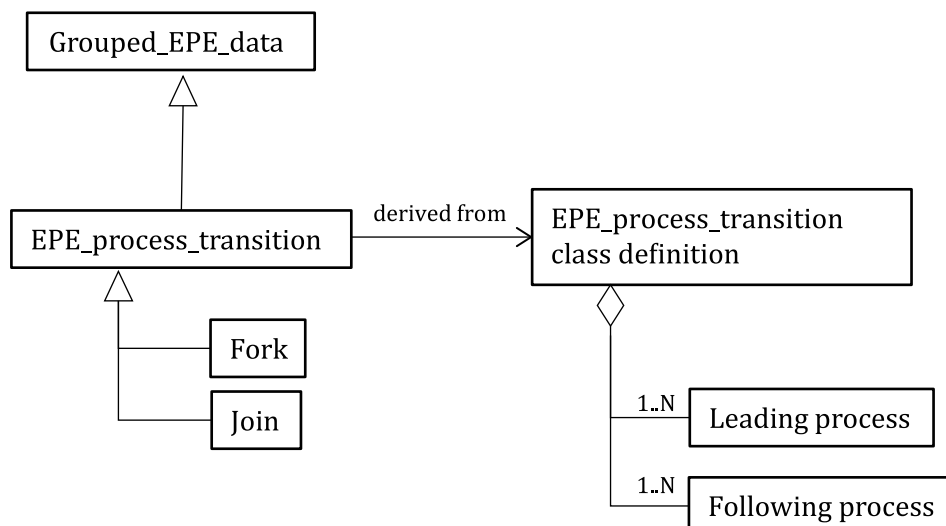


Figure 11 — Structure of EPE_process_transition

4.3.5 EPE_IO_connection

An EPE_IO_connection is a Grouped_EPE_data that associates

- an EPE_input of a Compound_process and an EPE_input of its constituent EPE_process,
- an EPE_output of a constituent EPE_process and an EPE_input of another constituent EPE_process, or
- an EPE_output of a constituent EPE_process and an EPE_output of the Compound_process.

A Compound_process can have EPE_input classes and EPE_output classes. The EPE_input classes are usually associated with EPE_input classes of its constituent EPE_process classes. Some of the EPE_input classes of constituent EPE_process classes are associated with EPE_output classes of other constituent EPE_process classes and do not appear as EPE_input classes of the Compound_process. Similarly, although the EPE_output classes are usually associated with EPE_output classes of its constituent EPE_process classes, some of the EPE_output classes of constituent EPE_process classes can be associated with EPE_input classes of other constituent EPE_process classes and do not appear as EPE_output classes of the Compound_process.

Figure 12 shows the structure of EPE_IO_connection.

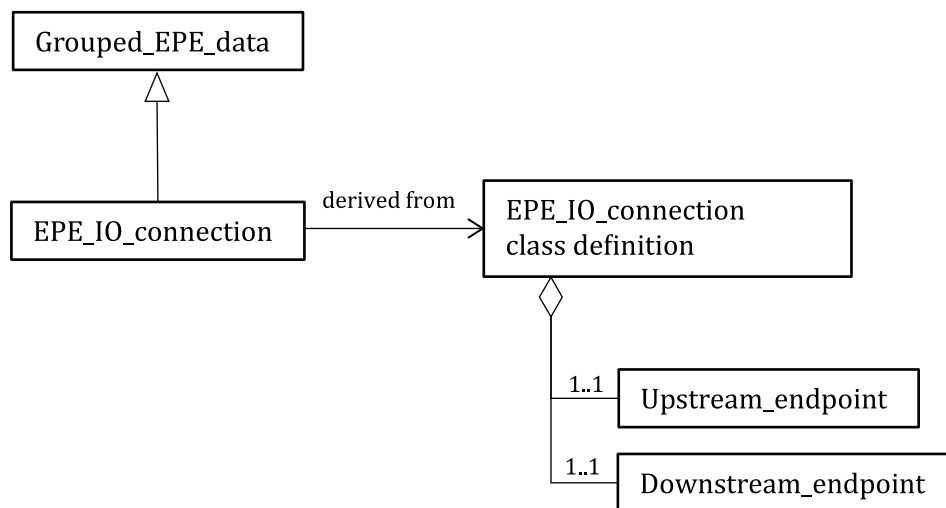


Figure 12 — Structure of EPE_IO_connection

4.3.6 Flow_control_process

A Flow_control_process (see 5.4.2.8) is an Elementary_process and has one or more EPE_input classes and one or more EPE_output classes, dedicated for branching and merging of flows between EPE_output classes and EPE_input classes of different EPE_process classes. It is also possible to buffer the flow.

In the case of branching, it has only one EPE_input and multiple EPE_output classes. It can store the input temporally with upper limit.

4.4 EPE_input

An EPE_input is a Grouped_EPE_data that represents a particular type of input to EPE_process classes together with its Upstream_data (see 5.4.3.9), which represents accumulated environmental influence caused before the input reaches the EPE_process.

NOTE The Upstream_data of EPE_input is used to evaluate environmental influence caused by EPE process that has the EPE_input and consumes it.

EXAMPLE 1 Energy, material, part, assembly, and consumable.

EXAMPLE 2 Information about quantity of GHG emission caused by producing input parts and information about energy used for transporting input material from the place it is produced.

The quantity of EPE_input is represented by an Elementary_EPE_data, although the way to indicate it depends on the type of EPE_input. Therefore, a corresponding type of Elementary_EPE_data is used depending on the type of EPE_input.

EXAMPLE 3 Number of pieces of a part, mass of material, volume of material in gas phase, quantity of energy in electricity.

Some types of EPE_input can be considered as environmental influence about a particular type of environmental aspect caused by the process.

EXAMPLE 4 Consuming energy, consuming material of limited earth resource.

The Upstream_data is a Grouped_EPE_data that represents accumulated environmental influence caused before the input is coming to the process or before the output is going out from the process.

Upstream_data can include information about consumed energy, consumed materials, emitted GHGs and emitted harmful substances.

Figure 13 shows the structure of EPE_input.

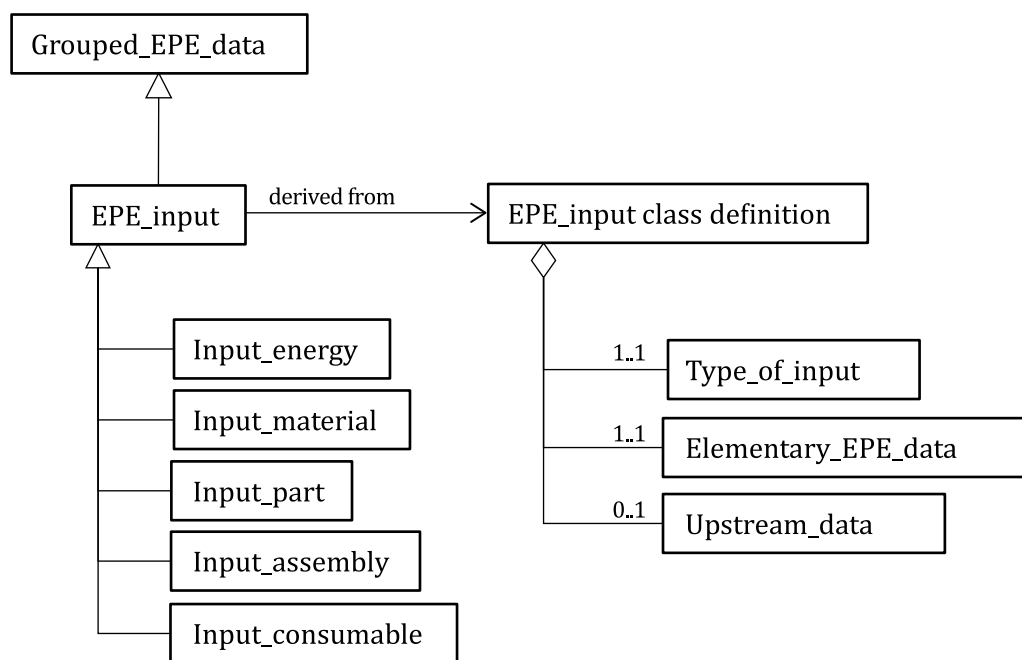


Figure 13 — Structure of EPE_input

Energy used by the manufacturing system can be obtained from various sources. For example, the electric energy can be generated by hydroelectric or fossil-fuel power plants or by renewable sources of energy such as wind and solar energy. The environmental impact of generating, transmitting, storing, and distributing energy depends on the energy resource and the technology used to convert and supply the energy to the manufacturing system.

4.5 EPE_output

An EPE_output is a Grouped_EPE_data that represents a particular type of output from EPE_process classes together with its Upstream_data, which represents accumulated environmental influence caused before the output is passed to the following EPE_process.

NOTE The Upstream_data of EPE_output is used by the EPE_process in the downstream.

EXAMPLE 1 Final product, by-product, energy, GHG, and harmful substance.

Some types of EPE_output can be considered as environmental influence about a particular type of environmental aspect caused by the EPE_process.

EXAMPLE 2 Emitting GHG, emitting harmful substance.

The quantity of EPE_output is represented by an Elementary_EPE_data, although the way to indicate it depends on the type of EPE_output. Therefore, a corresponding type of Elementary_EPE_data is used depending on the type of EPE_output.

Figure 14 shows the structure of EPE_output.

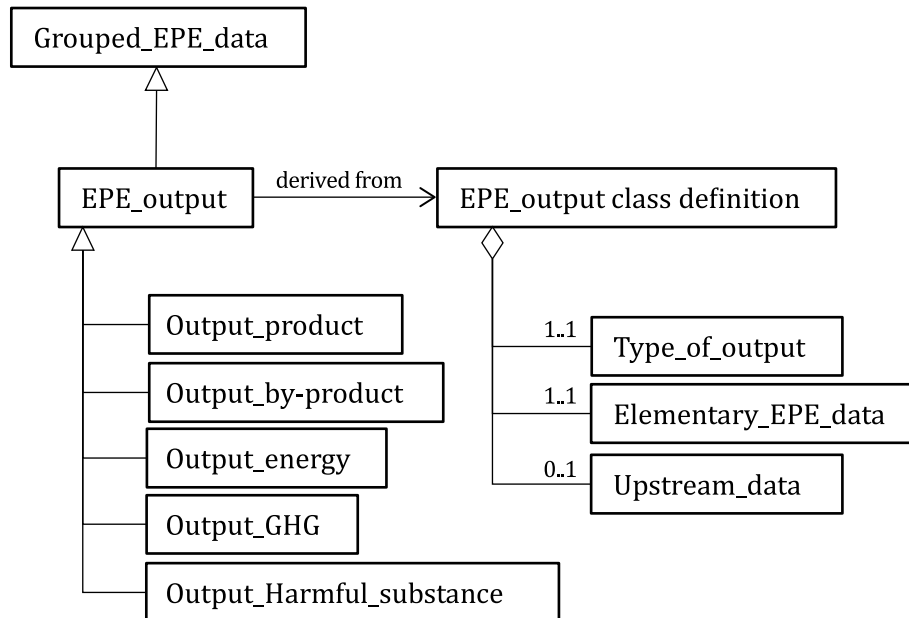


Figure 14 — Structure of EPE_output

4.6 EPE_mechanism

4.6.1 General

An EPE_mechanism is a Grouped_EPE_data that represents the means used to perform a function of Elementary_process classes.

EXAMPLE 1 Equipment, person, and space.

An EPE_mechanism can include multiple Elementary_EPE_data which represent characteristics of the EPE_mechanism and are used to calculate the quantity of EPE_input classes or the quantity of EPE_output classes, or both, of the EPE_process.

EXAMPLE 2 Rated power consumption of a type of equipment can be used for calculating input energy of an EPE_process.

EXAMPLE 3 Volume of space that requires air conditioning can be used for calculating input energy of an EPE_process.

EXAMPLE 4 The area of workspace that requires lighting can be used for calculating input energy of an EPE_process.

An EPE_mechanism can have structural hierarchy by having other EPE_mechanism classes as its constituents.

NOTE This feature can be used to represent complicated structured equipment.

Figure 15 shows the structure of an EPE_mechanism.

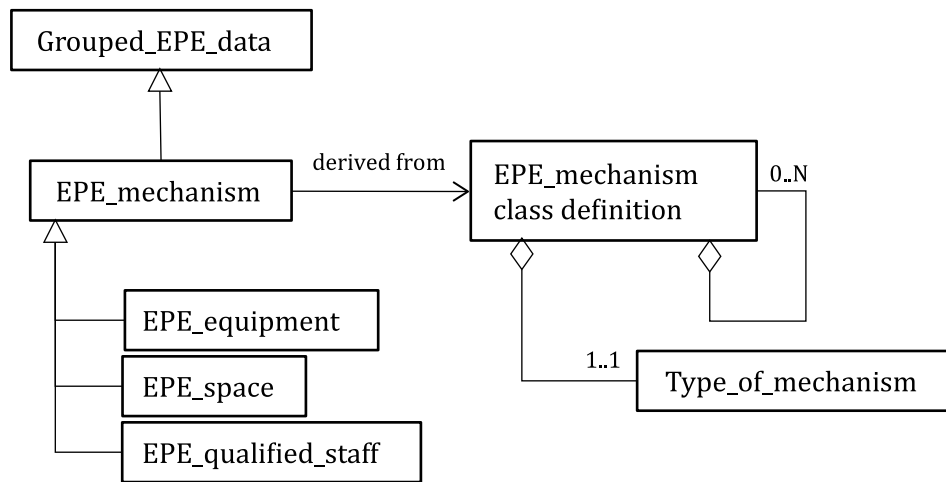


Figure 15 — Structure of EPE_mechanism

4.6.2 EPE_equipment

EPE_equipment (see [5.4.5.2](#)) is a type of EPE_mechanism that represents a piece of equipment used in the Elementary_process.

An EPE_equipment as an EPE data represents a particular piece of individual equipment that exists in real world or is virtually planned, for a particular application. It has one or more Elementary_EPE_data based on the corresponding EPE_equipment class definition defined by [5.4.5.2](#). EPE_data_value of each Elementary_EPE_data represents the characteristics of the equipment in terms of the Elementary_EPE_data.

EXAMPLE 1 An NC machine installed in a particular production line in the real world.

EXAMPLE 2 A planned production line designed including some NC machines for a particular factory site.

An EPE_equipment as an EPE data class represents a type of designed equipment. It has one or more Elementary_EPE_data based on the corresponding EPE_equipment class definition defined by [5.4.5.2](#). The EPE_data_value of each Elementary_EPE_data can be left undefined. If it is defined, the EPE_data_value of each Elementary_EPE_data represents the characteristics of the equipment type in terms of the Elementary_EPE_data.

EXAMPLE 3 A type of NC machine designed by a particular vendor.

An EPE_equipment as an EPE data class definition represents a generic common structure of similar types of EPE_equipment classes. It has reference to one or more Elementary_EPE_data, but it has no EPE_data_value.

EXAMPLE 4 A generic type of NC machine.

An EPE_equipment class definition represents a structure of EPE_equipment classes that share a common structure. An EPE_equipment class represents a type of designed equipment. The structure of an EPE_equipment class is derived from the corresponding EPE_equipment class definition. An EPE_equipment as an EPE data is a member of an EPE_equipment class and interpreted as an implementation of the EPE_equipment class.

Each EPE_equipment as an EPE data, or EPE_equipment class has some Elementary_EPE_data, which can be used for calculating an EPE_input or an EPE_output, which is considered as environmental influence, of the corresponding Elementary_process.

EXAMPLE 5 Rated power consumption, designed quantity of GHG emitted, and energy consumed for producing the equipment.

Each EPE_data_value of Elementary_EPE_data of an EPE_equipment as an EPE data can be derived from the EPE_equipment class or defined dedicated to the particular individual of EPE_equipment.

These EPE_data_value of an Elementary_EPE_data for EPE_equipment as an EPE data can differ depending on the mode of operation of the equipment. An EPE_equipment, as either an EPE data or an EPE data class, can include multiple operation modes.

Each operation mode is specified by Possible_EPE_operation_mode (see 5.4.5.5).

EXAMPLE 6 Energy consuming rate, material consuming rate, GHG emission rate.

Figure 16 shows the relationship between EPE_equipment as an EPE data, EPE_equipment class and EPE_equipment class definition.

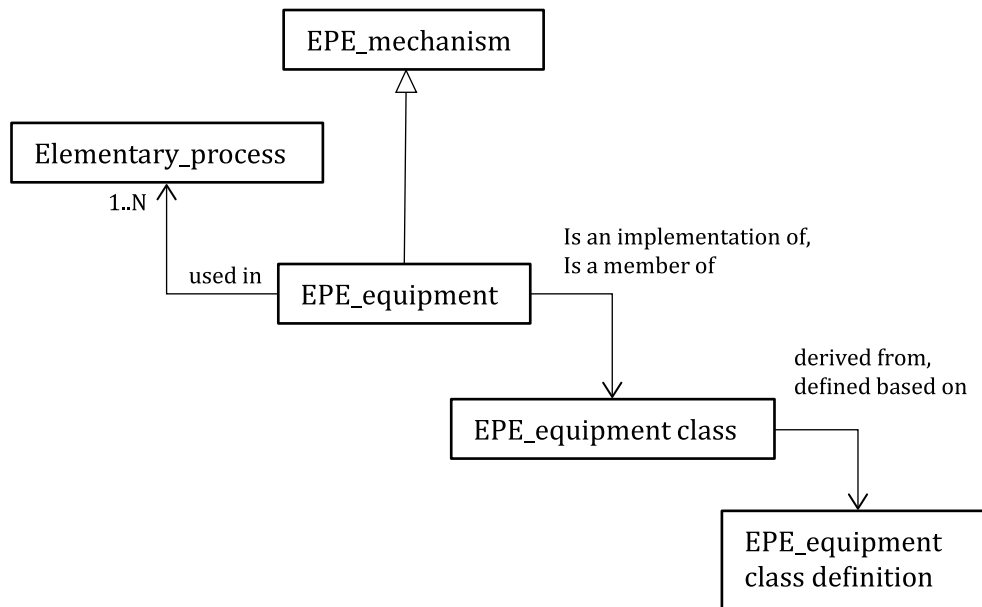


Figure 16 — Relationships between EPE_equipment, EPE_equipment class and EPE_equipment class definition

4.6.3 EPE_space

EPE_space (see 5.4.5.3) is a type of EPE_mechanism that represents physical space used for a process. It includes one or more environmental condition data, which indicate conditions surrounding an EPE_space. Each environmental condition data represents one of environmental conditions defined by the IEC 60721 series.

Environmental condition data includes states in the surrounding environment parameters that might not be controllable (e.g. weather) by the manufacturing system.

The differences in environmental condition data can affect the environmental performance of manufacturing processes.

NOTE 1 Environmental condition data such as the average ambient temperature are relevant when assessing the environmental benefits of using various sources of energy such as heat pumps or electrical heating and cooling.

NOTE 2 Real time measurement of environmental condition data can be critical when the manufacturing process includes thermal or chemical processes.

EXAMPLE 1 The air quality of the environment surrounding the manufacturing system (e.g. air-conditioned manufacturing facility) as well as weather parameters are ECD needed for the EPE of a manufacturing system. Weather can be considered as an environmental condition data, unless the manufacturing system boundaries are factored into a controlled environment, such as an air-conditioned manufacturing facility.

EXAMPLE 2 Demand response data exchanged with the smart grid are also a type of environmental condition data.

4.7 EPE_control

EPE_control is a Grouped_EPE_data that represents control, which is defined as “conditions required to produce correct output”, of a manufacturing process.

EPE_control provides conditions for the EPE_process to execute its process.

An EPE_control has multiple Elementary_EPE_data that specify the conditions. The Elementary_EPE_data include starting time, ending time, and time period required.

[Figure 17](#) shows the structure of EPE_control.

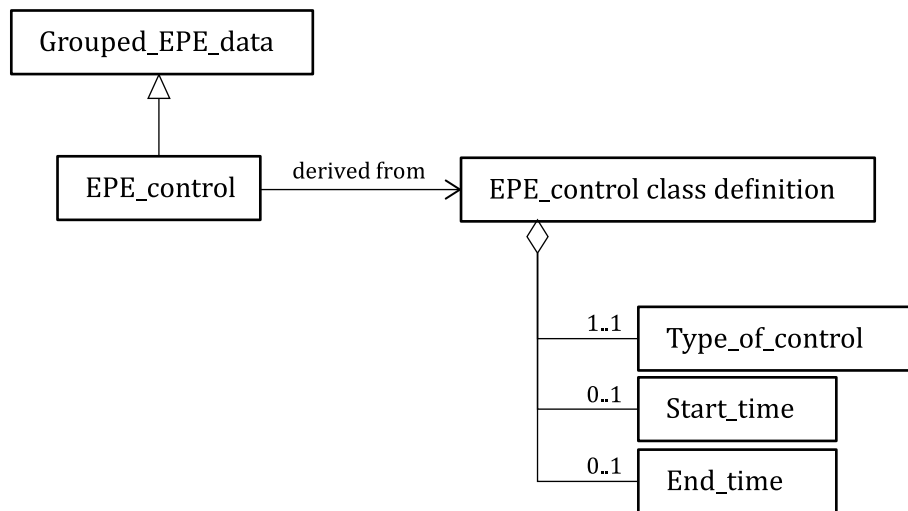


Figure 17 — Structure of EPE_control

5 EPE data class definitions

5.1 Overview

[Clause 5](#) defines class definitions for EPE data.

NOTE To avoid complexity, “class definition” is omitted from the name of each class definition (e.g. EPE_data class definition → EPE_data) in [5.2](#) to [5.4](#).

5.2 Class definition of EPE_data

[Table 8](#) shows the overview of EPE_data as a class definition.

Table 8 — Overview of EPE_data

Attributes of the class definition	Value of the attribute	
ID of the class definition		
Preferred name	EPE_data	
Description of the class definition	the top-level class definition of the semantic structure of EPE data defined by this document	
Preferred name of parent class definition	Subclause number defining the parent class definition	
<None>	<N/A>	
Property included in the class definition	Cardinality	Subclause defining the property
Structure_of_EPE_data	1..1	6.2.42
ID_of_EPE_data_class	1..1	6.2.14