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BSI Standards Publication

Industrial-process measurement, control and automation — Digital factory framework

Part 1: General principles

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National foreword

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Industrial-process measurement, control and automation – Digital factory framework –
Part 1: General principles

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION – DIGITAL FACTORY FRAMEWORK –

Part 1: General principles

FOREWORD

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- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 62832-1, which is a technical specification, has been prepared by IEC technical committee 65: Industrial-process measurement, control and automation.

This first edition cancels and replaces IEC TR 62794 published in 2012. This edition constitutes a technical revision.

This first edition includes the following significant changes with respect to IEC TR 62794:

- initial project was split into several parts to facilitate work progress;
- contents were completely reworked based on National Committee comments.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
65/629/DTS	65/649/RVC

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

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

A list of all parts in the IEC 62832 series, published under the general title, *Industrial-process measurement, control and automation – Digital factory framework* can be found on the IEC website.

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

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

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

0.1 Market demand and situation

High performance, flexible dynamic processes, and agile machines and production systems are essential to meet the demands for quality, delivery and cost of the products. This results in an increased complexity of the plant life cycle. In addition, all existing information of a product or a production system is described and modified through the whole life cycle of a product or production system, for example during the planning, development process, and operation. This situation spurs the enterprise to exchange product and production system data in electronic form.

However, each enterprise and each department inside the enterprise describes their products and production systems according to their own data management schemes, often using different terms, structures, and media.

EXAMPLE Examples for data management schemes are paper-based, databases, disks, e-catalogues, cloud.

Therefore, no seamless information exchange can be found between all the actors involved in the life cycles of both products and production systems.

Efficient exchange of data between and within enterprises can only be performed if syntax (format) and semantics (meaning) of the information has been defined in a unanimous and shared manner.

0.2 History of standardization in this area

Earlier work started with the initial objective to replace paper data sheets with an electronic description of electronic components used in products, and to use it in software tools for electronic wiring and assembly (for example, when designing electronic boards).

Additionally, concepts were developed for profiling of devices used in production systems, in order to describe parameters and behavioural aspects to facilitate integration and reduce engineering costs, providing guides for standards developers.

NOTE 1 See Device Profile Guideline (IEC TR 62390).

IEC 61987-10 made an important step toward this objective by defining fundamentals that aim at describing devices used in production systems by creating lists of properties (LOPs). The properties themselves are compiled into blocks that describe given features of a device. Further parts of IEC 61987 and other related standards (e.g. IEC 62683) define reference LOPs for electronic/electric components and materials used in electro-technical equipment and systems, such as equipment for measuring flows, pressures, temperatures, levels and densities.

NOTE 2 Although the title of IEC 62683 is “Low-voltage switchgear and controlgear – Product data and properties for information exchange”, the intent of IEC 62832 is to use the information exchange for interoperability in describing devices that are used in production systems.

IEC 61360-1, IEC 61360-2 and ISO 13584-42 specify the principles to be used for defining characterization classes of parts and their properties. As a result, a database was developed, also named IEC Common Data Dictionary (IEC CDD), which contains the reference collection of classes and associated properties. ISO 22745 specifies open technical dictionaries (OTDs) and their application to master data. ISO/IEC Guide 77 provides recommendations for the description of products and their properties for the creation of these classes, catalogues and reference dictionaries.

NOTE 3 ISO/IEC Guide 77 uses the term “product”. It is taken to include devices, processes, systems, installations, etc.

ISO 15704 specifies requirements of enterprise reference architectures and methodologies for supporting the applications in terms of the interoperability, the integration, and the architectures of the applications throughout the life cycle and supply chain aspects of the systems.

A number of efforts have addressed the development of business and manufacturing enterprise models to aid in understanding of different aspects of the enterprise to realize improvements in enterprise operations. Additionally, models for enterprise and control systems have been developed to support the production operations, but gaps remain in development of models to bridge from the manufacturing system design environments to the manufacturing operation environments, in terms of sharing information of the process, equipment, and devices.

NOTE 4 IEC 62264 defines models of functions in the manufacturing and control domains and information exchanged with the enterprise domain.

0.3 Purpose and benefits of IEC 62832

While the standards mentioned above provide a method for describing properties of a given device, IEC 62832 extends this method by defining a reference model for the representation of production systems, which include the devices.

In order to manage a production system effectively throughout its life cycle, it is very important to have its digital representation and to maintain the contents appropriately in response to its evolution in its life cycle. Activities related to the production system will access, update, and use the contents of digital representation in order to support the whole life cycle of the production system. This digital representation provides a consistent information interchange between all processes and partners involved and makes related information understandable, reusable and changeable through the entire production system life cycle.

Dictionaries and models can help to establish such digital representation by providing descriptions of elements, such as equipment and devices, of the production system. However, additional information is needed in order to achieve the intended digital representation of production systems, such as descriptions of relationship between the elements.

IEC 62832 provides a framework used for establishing and maintaining the digital representations of production systems, including the elements, relationships between these elements and the exchange of information about these elements.

The framework aims at reducing the interoperability barriers for exchange of information for the various activities related to production systems. The main advantages of this method are that all information related to a production system is described in a standardized manner, and it can be used and modified through its entire life cycle. The method defined in IEC 62832 is kept as generic as possible in order to enable its use in several industrial sectors.

NOTE Enterprise modelling concepts are described in standards referenced in the Bibliography (for example ISO 15704, ISO 11354-1).

0.4 Contents of the IEC 62832 series

The IEC 62832 series consists of multiple parts which provide:

- general introduction to the model and principles of the Digital Factory framework (DF framework);
- detailed data model for all the model elements of the DF framework;
- description of how the DF Framework is used to manage the life cycle of a production system;
- description of how data is migrated into the DF framework.

INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION – DIGITAL FACTORY FRAMEWORK –

Part 1: General principles

1 Scope

This part of IEC 62832, which is a Technical Specification, defines the general principles of the Digital Factory framework (DF framework), which is a set of model elements (DF reference model) and rules for modelling production systems.

This DF framework defines:

- a model of production system assets;
- a model of relationships between different production system assets;
- the flow of information about production system assets.

The DF framework does not cover representation of building construction, input resources (such as raw production material, assembly parts), consumables, work pieces in process, nor end products.

It applies to the three types of production processes (continuous control, batch control or discrete control) in any industrial sector (for example aeronautic industries, automotive, chemicals, wood).

NOTE 1 This document does not provide an application scenario for descriptions based on ISO 15926, because ISO 15926 uses a different methodology for describing production systems.

NOTE 2 In order to support oil and gas production systems, other methodologies for describing the assets can be used (for example based on ISO 22745 or ISO 13584-42).

The representation of a production system according to this document is managed throughout all phases of the production system life cycle (for example design, construction, operation or maintenance). The requirements and specification of software tools supporting the DF framework are out of scope of this document.

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/IEC 6523 (all parts), *Information technology – Structure for the identification of organizations and organization parts*

ISO/IEC 11179-6, *Information technology – Metadata registries (MDR) – Part 6: Registration*

ISO TS 29002-5:2009, *Industrial automation systems and integration – Exchange of characteristic data – Part 5: Identification scheme*

3 Terms, definitions, abbreviated terms and conventions

3.1 Terms and definitions

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

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

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

NOTE Relationships between definitions are shown in Annex A.

3.1.1
activity
group of tasks that are classified as having a common objective

EXAMPLE Electrical wiring design, PLC programming, mounting, wiring, drive configuration, modelling, simulation, monitoring.

[SOURCE: IEC 62264-1:2013, 3.1.1, modified – The example has been added.]

3.1.2
asset
physical or logical object owned by or under the custodial duties of an organization, having either a perceived or actual value to the organization

[SOURCE: IEC TS 62443-1-1:2009, 3.2.6, modified – The note has been deleted.]

3.1.3
collection of data elements
CDEL
identified set of data elements

3.1.4
concept dictionary
collection of concept dictionary entries that allows lookup by concept identifier

Note 1 to entry: There are standardized dictionaries (e.g. IEC CDD), consortium dictionaries (e.g. eOTD®[1] and eCl@ss®[2]), supplier dictionaries and DF dictionaries.

[SOURCE: ISO TS 29002-5:2009, 3.5, modified – The note has been added.]

3.1.5
concept dictionary entry
description of a concept containing, at a minimum, an unambiguous concept identifier, a term, and a definition

[SOURCE: ISO TS 29002-5:2009, 3.3, modified – The term "identifier" has been replaced with "concept identifier" and the note to entry has been deleted.]

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1 eOTD® is the registered trademark of a product supplied by ECCMA (Electronic Commerce Code Management Association). This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named.

2 eCl@ss® is the registered trademark of a product supplied by the eCl@ss e.V. association. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named.

3.1.6
data element
unit of data consisting at least of the reference to a data element type and a corresponding value

3.1.7
data element relationship
relationship between data elements

3.1.8
data element type
unit of data for which the identification, description and permissible values have been specified according to a data specification

Note 1 to entry: This definition was derived from both ISO 22745-2:2010, 15.2 and ISO 13584-42:2010, 3.28.

Note 2 to entry: The concept of data element type is represented in many publications by the term "property".

3.1.9
data specification
rules for describing items belonging to a particular class using entries from a concept dictionary and reference to a specific formal syntax

EXAMPLE An ISO TS 22745-30 compliant identification guide, ISO 13584-511 and ISO 8000-2 are data specifications.

[SOURCE: ISO TS 29002-4:2009, 3.5, modified – Example 1 has been modified, the reference to ISO 8000-102 has been updated and replaced by ISO 8000-2 and Example 2 has been removed.]

3.1.10
DF asset
digital representation of a production system asset

Note 1 to entry: A DF asset is uniquely identified either by a role identifier (for role-based equipment information) or a serial number (for physical asset information).

3.1.11
DF asset class
description of a set of DF assets that share common data element types

3.1.12
DF asset link
digital representation of a relationship between two or more PS assets

3.1.13
DF library
library owned by an enterprise for use in one or more Digital Factories

3.1.14
DF reference model
set of model elements for creating and managing a Digital Factory

3.1.15
Digital Factory
digital representation of a production system

Note 1 to entry: A Digital Factory can represent an existing or planned production system.

3.1.16
enterprise
one or more organizations sharing a definite mission, goals and objectives which provides an output such as a product or service

[SOURCE: IEC 62264-1:2013, 3.1.10]

3.1.17
library
identified set of DF asset classes, DF asset class associations, data element relationships and view elements

3.1.18
life cycle
evolution of a system, product, service, project or other human-made entity from conception through retirement

EXAMPLE Typical phases of a production system life cycle are conceptual development, planning, specification, design, engineering, construction, configuration, commissioning, operation, maintenance, decommissioning, and disposal.

[SOURCE: ISO/IEC/IEEE 15288:2015, 4.1.22, modified – The example has been added.]

3.1.19
master data
data held by an organization that describes the entities that are both independent and fundamental for that organization, and that it needs to reference in order to perform its transactions

[SOURCE: ISO 8000-2:2012, 11.1, modified – The three notes and the example have been removed.]

3.1.20
production system
system intended for production of goods

Note 1 to entry: The concept of production system includes spare parts.

Note 2 to entry: The concept of production system does not encompass the whole manufacturing facility. It excludes in particular the supporting infrastructure (such as building, power distribution, lighting, ventilation). It also excludes financial assets, human resources, raw process materials, energy, work pieces in process, end products.

Note 3 to entry: Production systems can support different types of production processes (continuous, batch, or discrete).

3.1.21
production system asset
PS asset
asset that is a constituent of a production system

Note 1 to entry: A PS asset can be a part, a device, a machine, software, a function, a control system or any collection of PS assets. It can have physical characteristics, for example mechanical, electrical, electronic, and/or role-based characteristics, for example function, information.

3.1.22
supplier library
library provided by a data supplier

EXAMPLE Data suppliers can be device manufacturers, machine manufacturers, vendors, distributors, system integrators.

3.1.23
technical discipline
area of technical expertise

EXAMPLE Electrical wiring, pipe layout, automation and mechanic.

3.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

CDEL	Collection of Data Elements
DER	Data Element Relationship
DF	Digital Factory (as qualifier)
ID	Identifier
IEC CDD	IEC Common Data Dictionary (see IEC 61360)
LOP	List of Properties (see IEC 61987-10)
PLC	Programmable Logic Controller
PS	Production System (as qualifier)
RAI	Registration Authority Identifier (see ISO/IEC 6523)
UML	Unified Modeling Language (see ISO/IEC 19505-1)
VFD	Variable Frequency Drive

NOTE The abbreviated term DF is only used as a qualifier for model elements specified in this document. It is not to be understood as a replacement for the Digital Factory concept defined in 3.1.15.

3.3 Conventions

The conventions for UML notation used in this document are defined in Annex C.

4 Overview of the DF framework

4.1 General

The DF framework specifies the DF reference model and rules for a Digital Factory. The DF reference model is a set of model elements. The rules govern the instantiation of DF assets and the establishment of links between DF assets.

The DF framework enables each enterprise to use and develop interoperable software tools and applications in order to support all activities within the life cycle of a production system. These activities access and update the information in the Digital Factory.

The DF framework relies upon referencing or integrating information (master data), from several sources, such as:

- standardized dictionaries;
- consortium dictionaries;
- supplier dictionaries;
- supplier libraries.

The DF framework also defines rules for construction of libraries based on these concept dictionaries.

A production system (in the real world) is composed of PS assets, and is represented by a Digital Factory (in the virtual world). The Digital Factory is composed of DF assets. DF assets are representations of the PS assets. Relationships between PS assets are represented as DF asset links.

The DF asset contains the role-based equipment information and/or the physical asset information.

NOTE IEC 62264-2 describes the concepts of a role-based equipment and a physical asset.

The DF framework is illustrated in Figure 1. The arrows in the figure represent the rules for construction of DF assets and information exchanges.

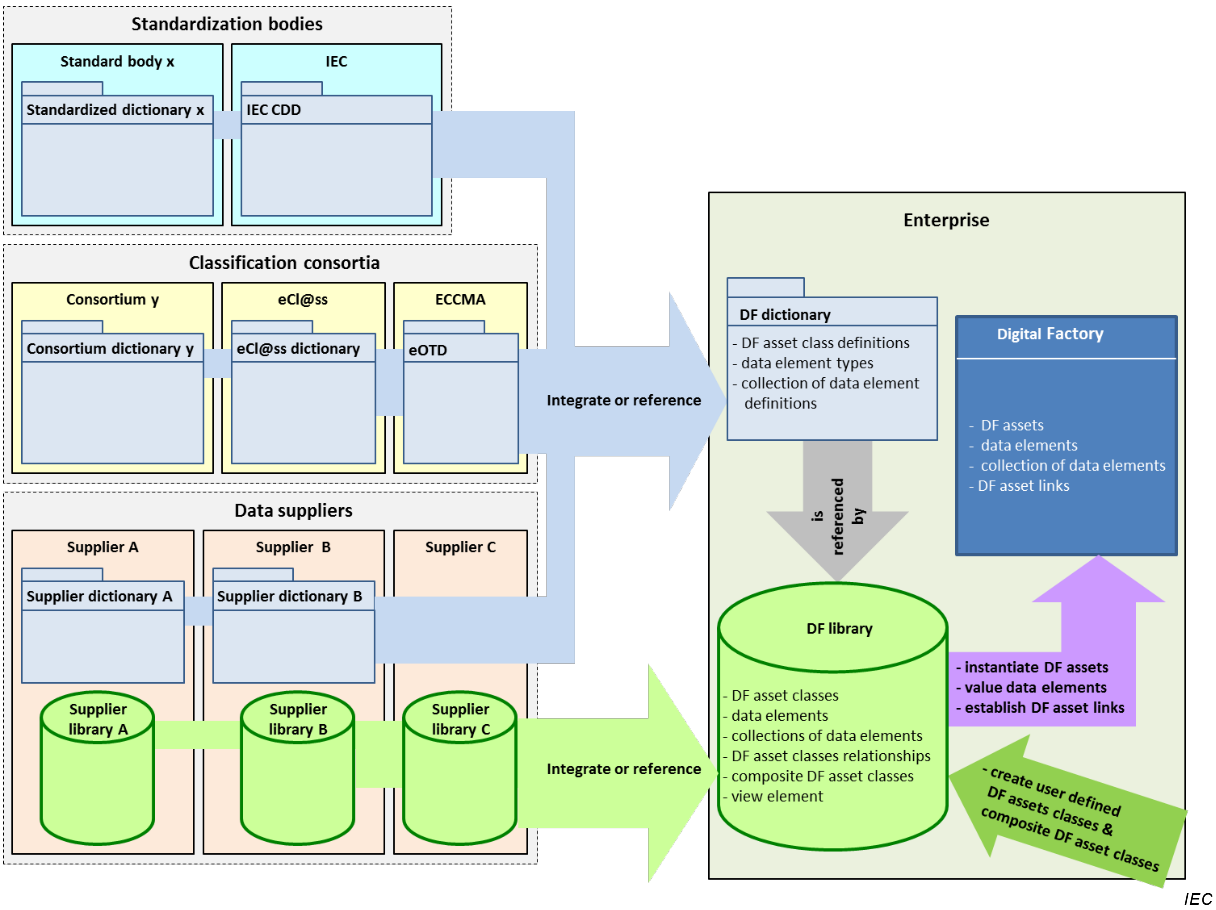


Figure 1 – DF framework overview

This document defines the concept of libraries of DF asset classes. The DF asset classes provide the data structures for the proper representation of a production system and its components. These DF asset classes are constructed with data elements defined in concept dictionaries.

4.2 DF reference model

The DF reference model includes the following model elements:

- concept identifier;
- concept dictionary entry
  - data element type;
  - CDEL definition;
  - DF asset class definition;
- concept dictionary

  - standardized dictionary;
  - consortium dictionary;
  - supplier dictionary;
  - DF dictionary;
- data element;
- collection of data elements;
- DF asset class
  - DF asset class header;
  - DF asset class body;
- view element;
- library
  - supplier library;
  - DF library
- DF asset
  - DF asset header;
  - DF asset body;
- relationship
  - DF asset link;
  - DF asset class association;
  - data element relationship;
- Digital Factory.

Model elements are either defined by this document or are derived from other standards.

NOTE The concept identifier is based on ISO TS 29002-5, the model elements for class, data element, concept dictionary and library are derived from ISO/IEC 11179, the model element for collections of data elements is derived from IEC 61360 and IEC 61987-10.

An overview of the different model elements is provided in Annex B.

4.3 Use of the Digital Factory

Throughout the life cycle of the production system, the information in the Digital Factory will be added, deleted or changed by the various activities during the life cycle phases. In this way, the Digital Factory will always contain up to date information of the production system (see Figure 2).

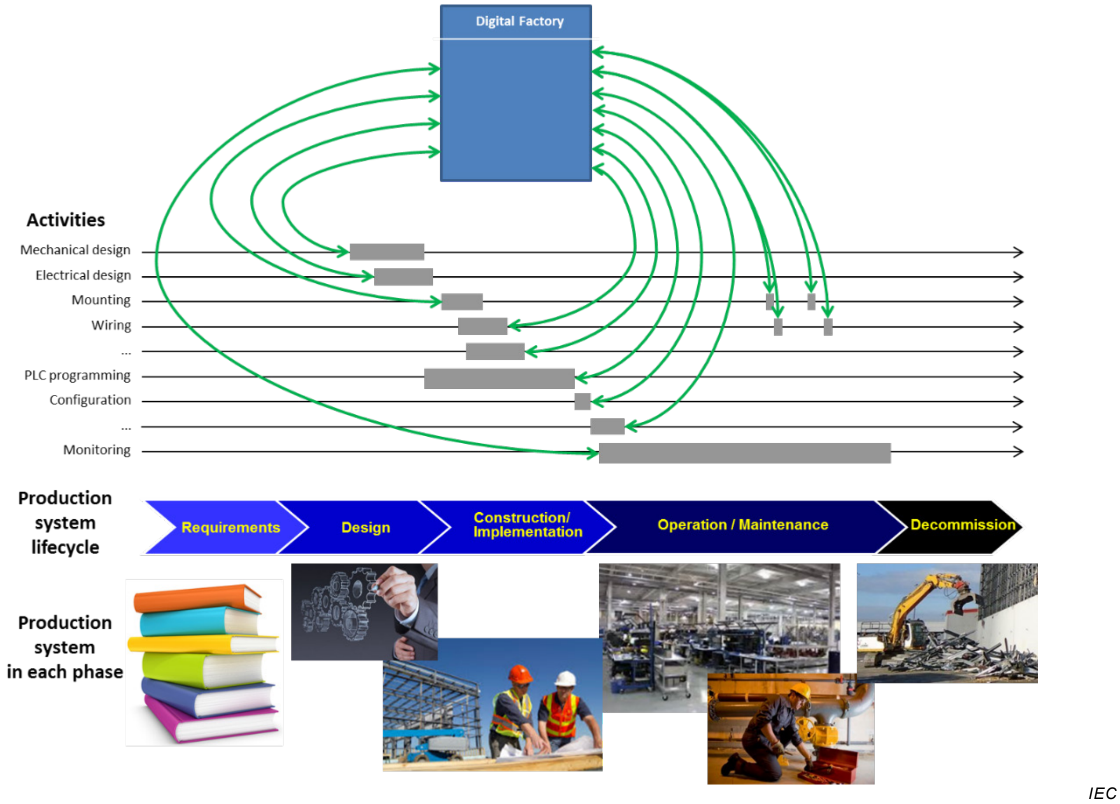
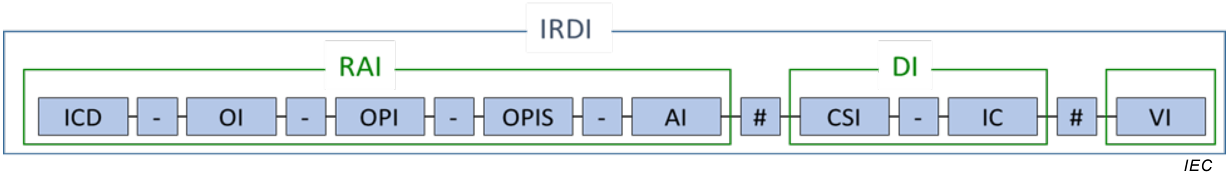


Figure 2 – Overview of the Digital Factory and example activities

5 DF reference model

5.1 Concept identifier

For communication purposes, concept identifiers according to ISO TS 29002-5 shall be used for identification of the following model elements (concepts) in the DF reference model: DF asset class definitions, data element types, and CDEL definitions. An overview of the ISO TS 29002-5 identifier and related other standards is shown in Figure 3.



Key

IRDI: international registration data identifier (ISO/IEC 11179-6):

Organization:

RAI: registration authority identifier (ISO/IEC 6523)

ICD: international code designator

OI: organization identifier

OPI: organization part identifier

OPIS: organization part identifier source indicator

AI: additional information

Data:

DI: data identifier

CSI: code space identifier

IC: item code

Version:

VI: version identifier

The fields "#" and "-" are separators.

Figure 3 – Identification standard

A concept identifier consists of several parts:

- the registration authority identifier (RAI) describes the origin of the identifier;
- the data identifier (DI) identifies the concept (for example class, data element) within the concept dictionary;
- the version identifier (VI) identifies the version of the concept description.

The DI is composed of an optional code space identifier (CSI) and a mandatory item code (IC).

NOTE 1 In ISO/IEC 11179, the term "international registration data identifier (IRDI)" is used for "concept identifier" in ISO TS 29002-5.

NOTE 2 Within some other standards, the term “code” is used instead of “concept identifier”.

NOTE 3 Examples in this part of IEC 62832 only show the value of the item code (IC) of the identifier.

NOTE 4 ISO 29002 is a common resource used by several standards. Standards using ISO 29002 as a reference restrict the syntax and add semantics elements to the syntax.

5.2 Concept dictionary entry

5.2.1 General

All concept dictionaries used in the DF reference model (standardized, registered and supplier concept dictionaries) may have different structural organization and contents, however all entries in these dictionaries shall conform to the definition of a concept dictionary entry. This requirement enables integration of the contents of these dictionaries into the DF dictionary.

A concept dictionary entry shall include at least a concept identifier, a name, and a definition.

Subclauses 5.2.2 to 5.2.4 specify the following types of concept dictionary entries: data element type, CDEL definition, and DF asset class definition.

5.2.2 Data element type

A data element type shall include a data type and may also include further information like symbol, physical unit, value range, or relationship to other data elements.

Data element types can be defined independently from other concepts.

The standard relevant to the concept dictionary specifies the rules for describing data element types.

5.2.3 CDEL definition

CDEL definitions shall include references to data element types in the form of concept identifiers. CDEL definitions are groupings of data element types which can be used to describe specific aspects of a PS asset (e.g. address information, faceplate of a device, a functional element of an asset or a collection of characteristics regarding different measurement principles).

5.2.4 DF asset class definition

DF asset class definitions shall include references to CDEL definitions and/or data element types in the form of concept identifiers. DF asset class definitions serve as a base for DF asset classes.

EXAMPLE 1 A DLOP (Device List of Properties) of IEC 61987 is an example for a DF asset class definition describing physical assets. In this case, the DF asset class definition provides a model for describing the information about structure and specifications of PS assets.

EXAMPLE 2 An OLOP (Operating List of Properties) of IEC 61987 is an example for a DF asset class definition describing role-based equipment. In this case, the DF asset class definition provides a model for describing the information about requirements for PS assets.

5.3 Concept dictionary

5.3.1 General

A concept dictionary can contain data element types, CDEL definitions and DF asset class definitions.

A concept dictionary can be:

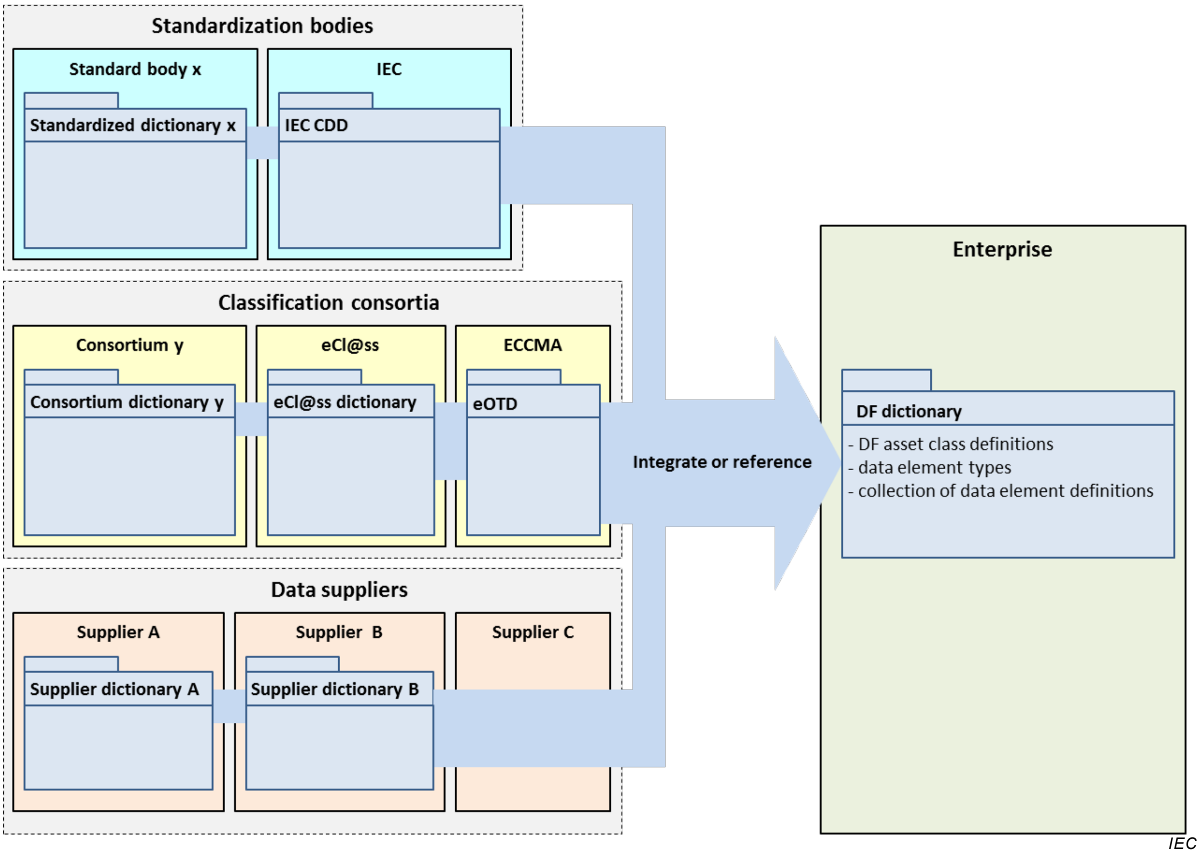
- a standardized dictionary managed by standardization bodies;
- a consortium dictionary managed by an independent organization or consortium;
- a supplier dictionary managed by a data supplier;
- a DF dictionary owned by an enterprise.

5.3.2 DF dictionary

The DF dictionary is used to construct the DF asset classes. The DF dictionary may contain concept dictionary entries belonging to one specific domain or to multiple domains.

EXAMPLE Examples of domains are electric/electronic components, low voltage switchgear, process automation, mechanical construction.

It may integrate or reference concept dictionary entries defined in concept dictionaries provided by several different organizational sources as shown in Figure 4, as long as the registration authority of each of these concept dictionaries is identified by a registration authority identifier (RAI).



NOTE Further details are provided in Clause A.1.

Figure 4 – Example of sourcing of a DF concept dictionary

5.4 Data element

A data element is used to represent a characteristic of a PS asset.

A data element consists of a reference to a data element type and a value compliant with the data element type. The value of a data element may be defined or undefined.

NOTE Depending on the implementation, “undefined” can correspond to a default value, an “empty” value or no value at all.

EXAMPLE The value of a data element can be “undefined” when defining DF asset classes or in early phases of the life cycle of the production system.

5.5 Collection of data elements

A collection of data elements (CDEL) contains data elements and/or CDELs, and is specified using a CDEL definition. A CDEL may contain at the same time data elements with defined values and data elements with undefined values.

Each data element of a CDEL shall be individually accessible.

A CDEL is used in a DF asset or DF asset class to describe a set of characteristics of a PS asset, belonging to a particular aspect or feature.

NOTE IEC 61987-10 defines a concept named block of properties which maps to CDEL.

5.6 DF asset class

5.6.1 General

A DF asset class describes a set of DF assets that share common data element types.

A DF asset class consists of a DF asset class header and a DF asset class body.

A DF asset class is derived from one or more DF asset class definitions.

5.6.2 DF asset class header

A DF asset class header is used to manage the corresponding DF asset class in a library.

Examples of information provided in a DF asset class header are:

- identification information, used to differentiate the DF asset class from others;
- references to one or more DF asset class definitions;
- optional information for filtering the information from the DF asset classes in a library or from the DF assets in the Digital Factory, which can be used to support specific application aspects or technical disciplines.

NOTE 1 The information for filtering is provided by the supplier (or owner) of the library.

The information in the header is provided in the form of a CDEL.

NOTE 2 The data structure of this CDEL will be specified in a subsequent part of IEC 62832.

5.6.3 DF asset class body

A DF asset class body describes the characteristics and structure of a set of PS assets or requirements for PS assets.

The contents of a DF asset class body is derived from the referenced DF asset class definition. Additional contents may be provided.

EXAMPLE 1 Within a DF asset class body, the part representing the physical asset can be derived from a DLOP of IEC 61987. In this case, the DF asset class body provides information about characteristics and structure of the PS asset (e.g. specification of a particular model of device provided by a particular manufacturer).

EXAMPLE 2 Within a DF asset class body, the part representing the role-based equipment can be derived from an OLOP of IEC 61987. In this case, the DF asset class body provides information about the requirements for a PS asset (e.g. “OLOP for pressure measuring equipment”).

For basic types of PS asset, the DF asset class body is composed of data elements and/or CDELs (see Figure 5).

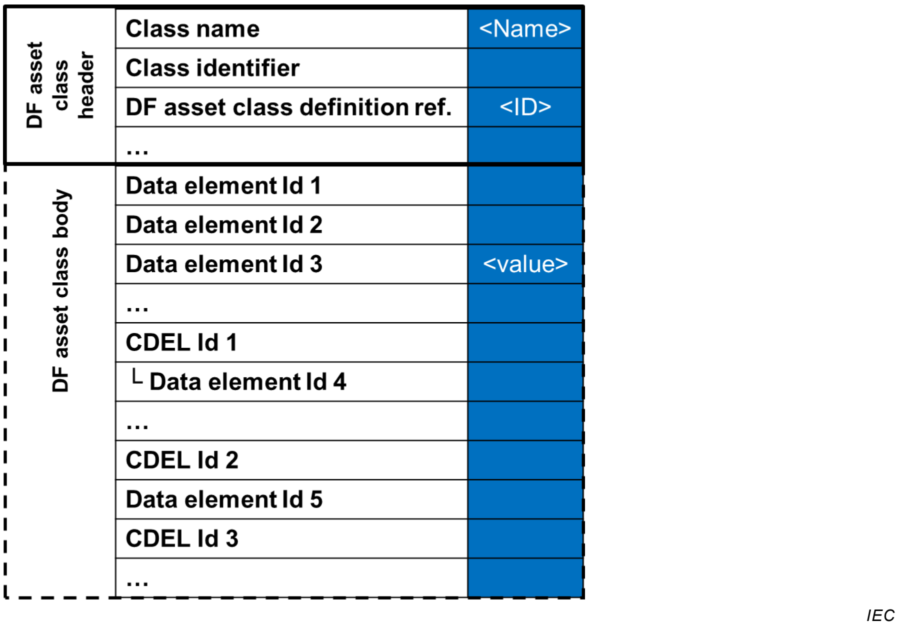


Figure 5 – Example of DF asset class

For composite types of PS asset, the DF asset class body is composed of data elements, CDELs and/or the structure description of the DF asset class. The structure description of the DF asset class is provided by DF assets and/or DF asset classes and their relationships. DF assets and DF asset classes represent the components of the PS asset. The respective relationships (DF asset links and/or DF asset class associations) represent the connections between the components (see Figure 6).

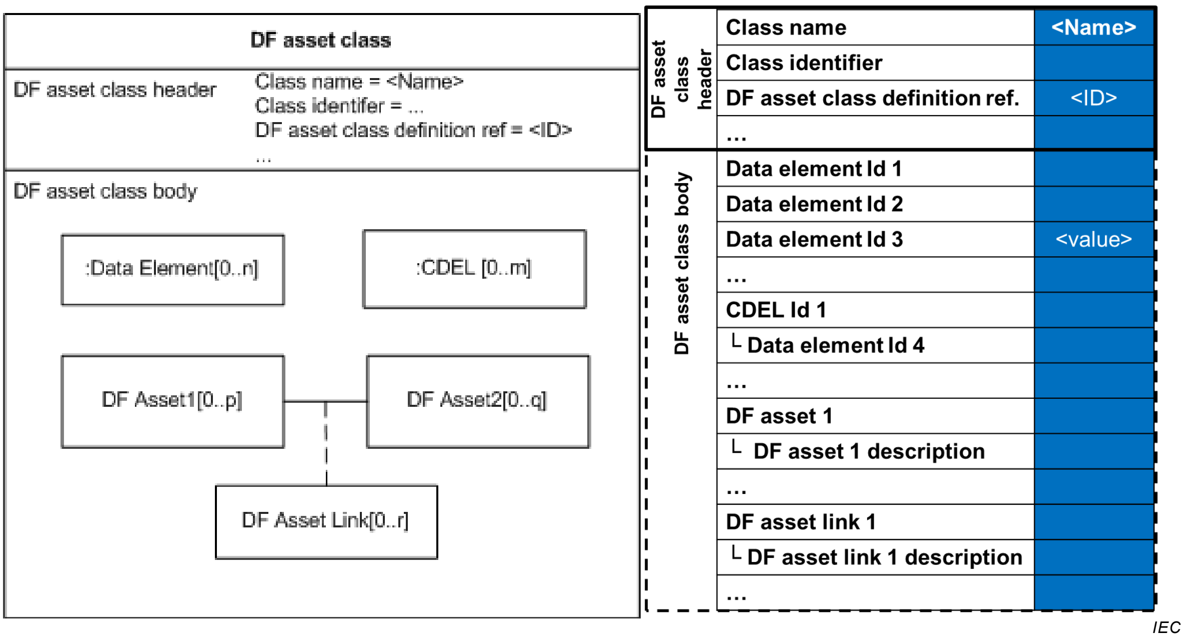


Figure 6 – Example of composite DF asset class

A DF asset contained in a composite DF asset class is not a particular physical asset but it is role-based equipment.

A constituent DF asset class can be replicated into multiple DF assets in a composite DF asset class depending on statements of multiplicity (e.g. [0..n]).

A constituent DF asset has a relative role. When the composite DF asset class is transformed to a DF asset, the relative role of its constituent DF assets will be replaced with a particular role related to the role of the composite DF asset.

The data elements and CDELs in the body reference their respective dictionary entries which may be contained in different concept dictionaries.

Most data elements have a defined value.

If the DF asset class body provides a structure description, the DF assets and the DF asset links are specified as described in 5.9 and 5.10.

5.7 View element

A view element is used for filtering information from a library (supplier library or DF library) or from the Digital Factory.

EXAMPLE 1 Examples of filtered information are DF assets, data elements or DF asset links.

EXAMPLE 2 Examples for the purpose of filtering are the use by a particular technical discipline or for a particular application aspect.

View elements may be defined by data suppliers of supplier libraries in order to support efficient access to the asset information, by tool providers in order to allow efficient integration of the tool with the Digital Factory, or by the enterprise in order to support user-specific use-cases.

The view element can include references to DF assets and references to data elements and identifications of the intended technical discipline.

View elements may be provided in a library (for example supplier library or DF library).

5.8 Library

5.8.1 General

The purpose of a library is:

- to facilitate reuse of design by providing standardized classes, which can be combinations of multiple associated classes;
- to assist in maintaining the quality level of design.

For a library to be integrated in the DF framework, the contents of the library should comply with the DF reference model specified by IEC 62832 (all parts).

The contents of a library are defined using concept dictionary entries of one or more concept dictionaries.

There are two types of libraries, supplier libraries and DF libraries.

The libraries may include:

- DF asset classes;
- DF asset class associations;
- data element relationships;
- view elements.

5.8.2 Supplier library

Supplier libraries are used to provide information about PS assets. If a supplier library does not comply with the DF reference model, additional work will be required to be able to integrate it in the DF framework.

5.8.3 DF library

A DF library is used for creating and maintaining one or more Digital Factories.

The contents of a DF library are created by integrating or referencing selected contents of supplier libraries. Contents may also be created by the enterprise.

5.9 DF asset

5.9.1 General

A DF asset is used for representing a specific PS asset. It is derived from a DF asset class, then values are defined for all relevant data elements.

The DF asset contains the role-based equipment information and/or the physical asset information.

NOTE IEC 62264-2 describes the concepts of a role-based equipment and a physical asset.

A DF asset consists of a DF asset header and a DF asset body (see example in Clause B.2).

5.9.2 DF asset header

A DF asset header is used to manage the corresponding DF asset in a Digital Factory.

Examples for information provided in a DF asset header are:

- identification information, which is used to differenciate the DF asset from others in the Digital Factory through its life cycle;

  EXAMPLE 1 DF asset identifier.

  EXAMPLE 2 Serial number for physical asset information.

  EXAMPLE 3 Role identifier for role-based equipment information.
- reference to the corresponding DF asset class;
- information on PS asset status;

  EXAMPLE 4 Planned, on the shelf, configured, installed, in operation, decommissioned.
- optional information for filtering the DF information in the DF asset body, which can be used to support specific application aspects or technical disciplines. The information for filtering can be inherited from the corresponding DF asset class or defined by the enterprise.

The information in the DF asset header is provided in the form of a CDEL.

NOTE The data structure of this CDEL will be specified in a subsequent part of IEC 62832.

5.9.3 DF asset body

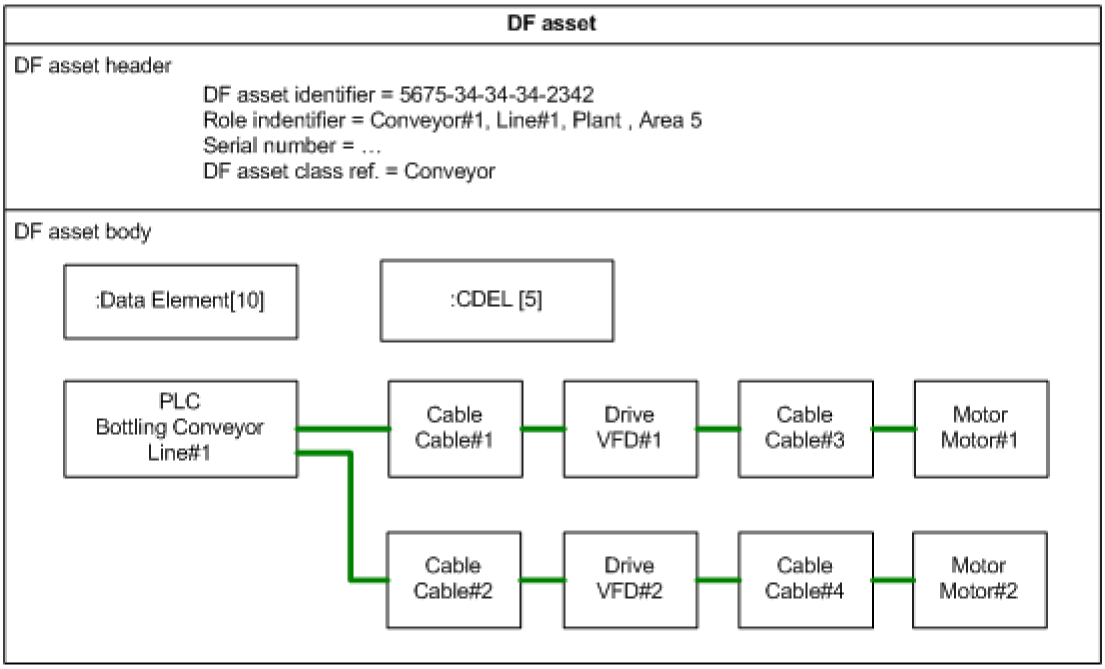
The information in the DF asset body is used to represent the characteristics of the PS asset.

The structure of the DF asset body is defined by the DF asset class body.

A DF asset body may include:

- data elements;
- CDELs;
- DF assets;
- DF asset links.

DF assets in the DF asset body shall be included together with their respective DF asset links (see Figure 7).



IEC

DF asset header	**DF asset identifier**	5675-34-34-34-2342
	Role identifier	Conveyor#1, Line#1, Plant Area 5
	Serial number	…
	DF asset class ref.	Conveyor
	…	
DF asset body	**Data element Id 1**	<value>
	Data element Id 2	<value>
	Data element Id 3	<value>
	…	
	CDEL Id 1	
	└ Data element Id 4	<value>
	…	
	DF asset 1	(PLC Bottling Conveyor Line#1)
	└ DF asset 1 description	…
	…	
	DF asset link 1	(Link between PLC and Cable#1)
	└ DF asset link 1 description	…
	…	

IEC

Figure 7 – Example of composite DF asset

Within Figure 7, the DF asset is identified by the information in the DF asset header, including the DF asset identifier, serial number of the PS Asset, role identifier and the reference to the respective DF asset class. The DF asset body provides the description of the features and capabilities of the PS asset. In this example, the PS asset is described by a set of data elements, some are provided as single data elements (ten single data elements) and some are collected in CDELs (five CDELs containing a number of data elements). The DF asset is composed of a number of constituent DF assets (e.g. a PLC, cables, drives), which are shown with their role identifiers. The DF asset links between these DF assets are shown with green lines.

5.10 DF asset link

A DF asset link describes an established relationship between two or more DF assets.

A DF asset link includes

- an identifier within a Digital Factory,
- an optional reference to a DF asset class association, and
- identification of two or more end points of the linked DF assets.

DF asset link may be used in DF asset class body and DF asset body.

5.11 DF asset class association

A DF asset class association describes the DF asset links which can be established between DF assets.

A DF asset class association may identify the characteristics and structure of the DF asset classes used to check compatibility between DF asset classes.

EXAMPLE Check for compatibility between two DF asset classes for information exchange, electrical connections, or physical interfaces.

A DF asset class association includes at least an identifier within a library and identification of two or more end points of the associated DF asset classes.

A DF asset class association may include or reference one or more data element relationship(s).

NOTE ISO 19440 describes a set of attributes for an enterprise reference model for such relationships.

5.12 Data element relationship

Data element relationships (DER) can be defined between two or more data elements of the end points of a DF asset class association.

A DER includes

- an identifier within a library,
- references to one or more data elements of each associated DF asset class, and
- a rule.

A data element relationship (DER) specifies a rule used to check compatibility between associated DF asset classes. The rule is expressed as a set of equations or a reference to an algorithm.

The rules can be provided by relevant international standards or by the data supplier of a library for a DF asset class which is involved in the DF asset class association.

If a data element relationship is included or referenced in a DF asset class association, the specified rule may be used to check the corresponding DF asset link.

NOTE Multiple data element relationships can be used to check compatibility for one DF asset link.

EXAMPLE When connecting a motor to a drive, data element relationships can be applied between the data elements corresponding to electrical characteristics of the motor and the drive.

Figure 8 shows examples of data element relationships.

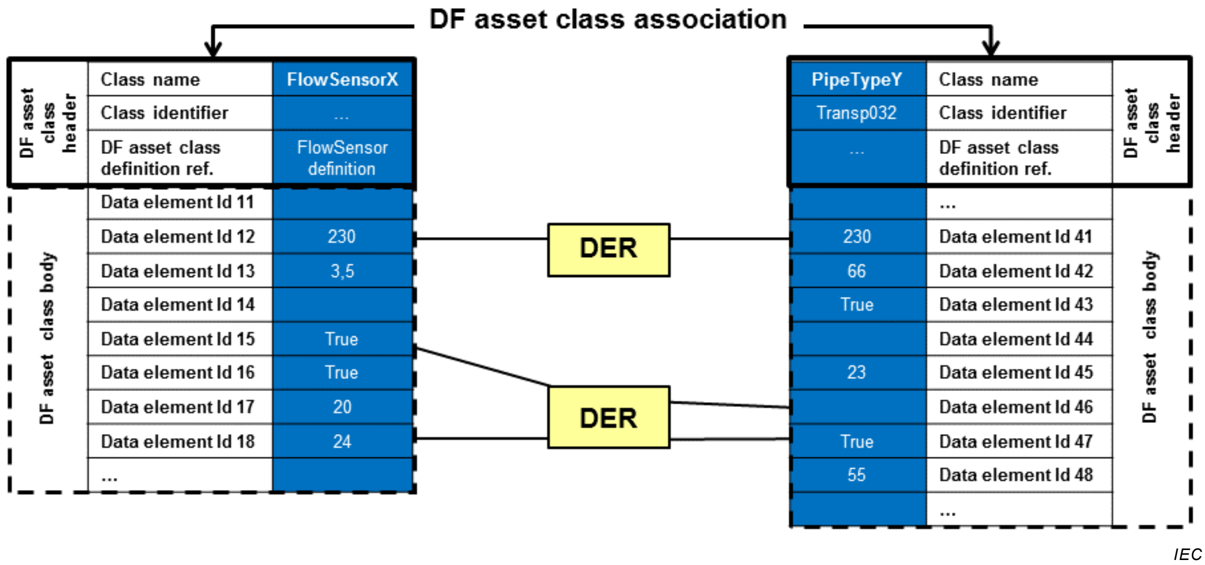


Figure 8 – Example of data element relationships

5.13 Digital Factory

A Digital Factory is used to represent a production system.

A Digital Factory is the DF asset that is positioned at the highest level of a DF asset hierarchy and with specific management information in the DF asset header for the Digital Factory.

The DF asset header for a Digital Factory identifies the design of the modelled production system including all PS assets and relationships.

Examples of information provided in the DF asset header for a Digital Factory are:

- purpose of the Digital Factory

EXAMPLE Revamping of brewery for 2020.

- life cycle phase of the production system;
- state of the Digital Factory;
- revision of the Digital Factory.

The body of a Digital Factory is a DF asset body which may include:

- data elements;
- CDELs;
- DF assets;
- DF asset links.

6 Rules of the DF framework

6.1 Example for representing a production system

This Subclause 6.1 provides an example for representing a production system using model elements of the DF framework.

In the DF asset described in Figure 7, the DF asset is a conveyor system comprised of other DF assets. The conveyor system is installed at a specific location with a specified role and identification.

The DF assets in the DF asset body for the conveyor system comply with DF asset class definitions for VFD (Variable Frequency Drive), PLC and motor in the DF dictionary.

The VFD class definition is an example of a DF asset class definition. The VFD class definition defines the data element types for the VFD asset class. The VFD class is a DF asset class in the DF library, with a specific value (manufacturer#1) for the data element "manufacturer name". Since a VFD device can be used in many applications, additional information is added for the location when the VFD device is configured and installed with a particular role in a particular application. Similar values are added for the PLC and motor in the application.

Figure 9 shows an example of how DF asset classes and DF assets are used.

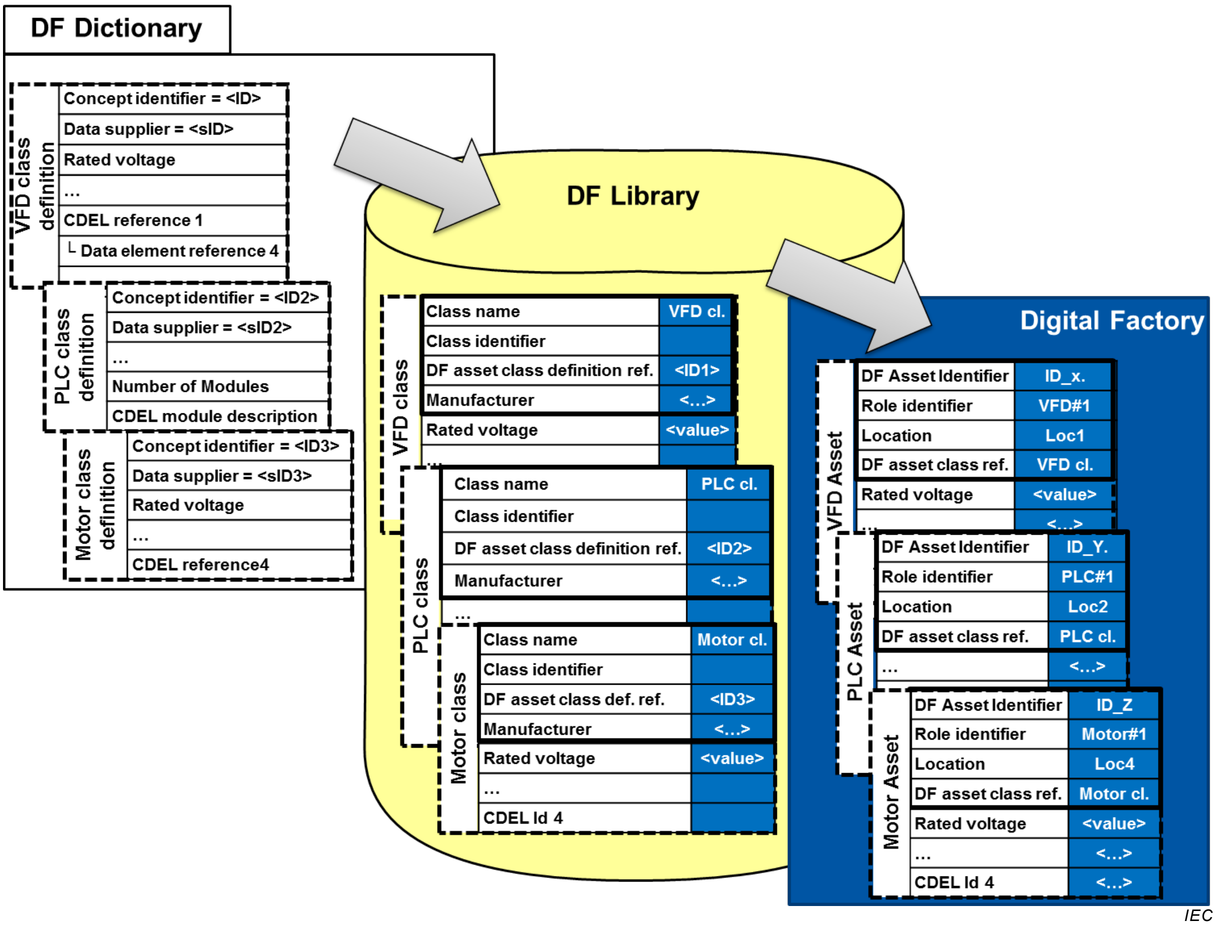


Figure 9 – Example of DF asset and DF asset class

6.2 Rules for integration in the DF library

The exchange of information for data elements, CDEL, and DF asset classes between data supplier and enterprise is based on the exchange of <identifier, value> pairs. The identifier determines the concept that describes the meaning of the value.

In order for the enterprise to define and construct new DF asset classes, the definitions from the DF dictionary shall be used.

When integrating the contents of supplier libraries into a DF library, the owner of the DF library needs to consider the references from the supplier library contents to the concept dictionary entries in the respective concept dictionaries (see Figure 10). One enterprise may have one or more DF libraries (for example for different projects).

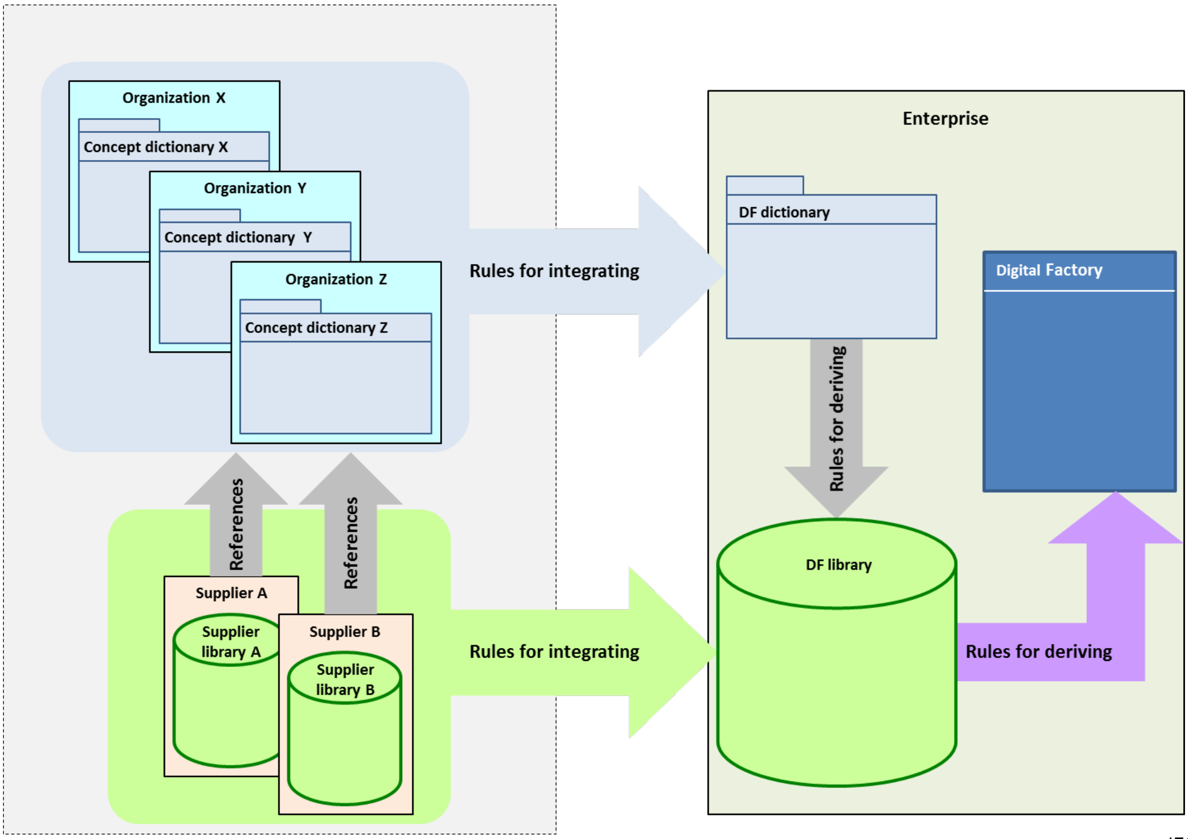


Figure 10 – Integration with the DF library

6.3 Rules for using DF assets in a Digital Factory

Rules are specified for defining the values for the DF assets, the DF asset links, and DERs to represent the composite PS assets, such as the sub-systems, equipment, and devices of the production system. DF asset links and DERs are used to represent the interfaces and connections between the PS asset.

In order to integrate a DF asset in the Digital Factory, the corresponding DF asset class shall be defined in the DF library. Depending on the purpose of modelling, the DF asset in the Digital Factory should appropriately represent the status of the PS asset.

EXAMPLE 1 A PS asset intended for use for a particular purpose in a future production system is described with a DF asset by assigning a value to the data element “role identifier” of the corresponding DF asset class.

EXAMPLE 2 A PS asset installed in an actual production system is described with a DF asset by assigning a value to the data elements “serial number” and “role identifier” of the corresponding DF asset class.

EXAMPLE 3 If a non-functioning PS asset is replaced by another one from the same type, the value of the data element “serial number” of the corresponding DF asset is updated accordingly.

6.4 Reuse of a Digital Factory structure

The structure of a Digital Factory may be copied for another similar production system. This allows the reuse of designs. In order to copy the structure of the Digital Factory, the identifiers of all physical asset information shall be replaced. The correct handling of all other identification information should be considered.

Annex A
(informative)

UML Model

A.1 Concept dictionary

The concept dictionary defines the concepts, classes, and terms that are used to construct the DF asset classes. Figure A.1 shows that a DF asset class definition may be composed from other model elements such as CDEL definition and Data element type. CDEL definitions may be composed from other CDEL definitions. All concepts defined in a concept dictionary are uniquely identified by the combination of RAI of the concept dictionary with the code of the concept.

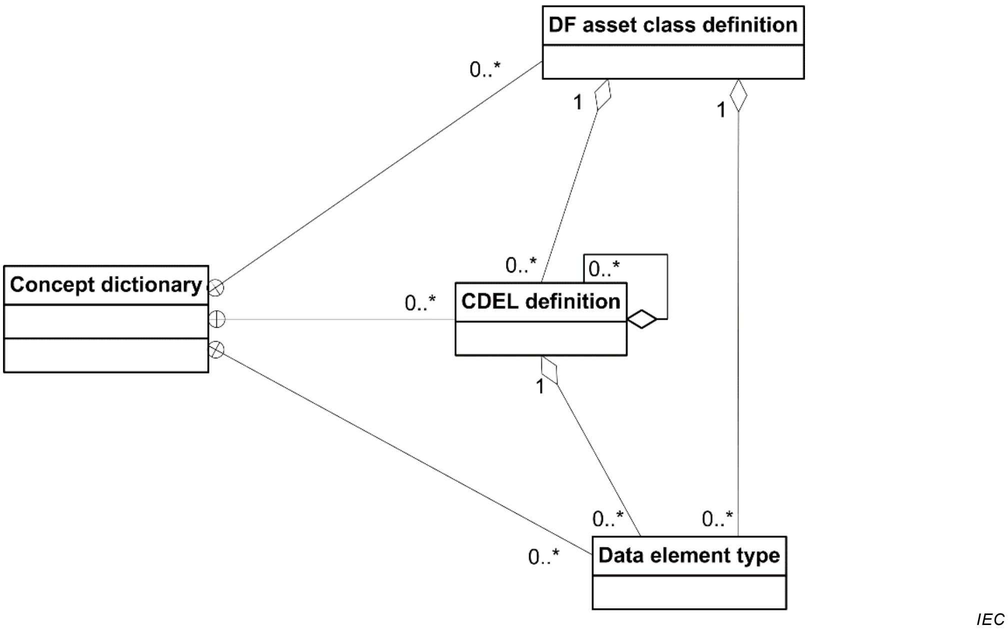


Figure A.1 – Concept dictionary and related class definitions and type

Figure A.2 shows that the DF reference model differentiates two relationships: DF asset class association and data element relationship. The main difference between these relationships is the type of end point of the respective relationship. The end points for a data element relationship are always data elements. The end points for a DF asset class association are always DF asset classes.

A DF asset class association is described by providing information about the profile of the relationship and a reference to the standard defining that relationship.

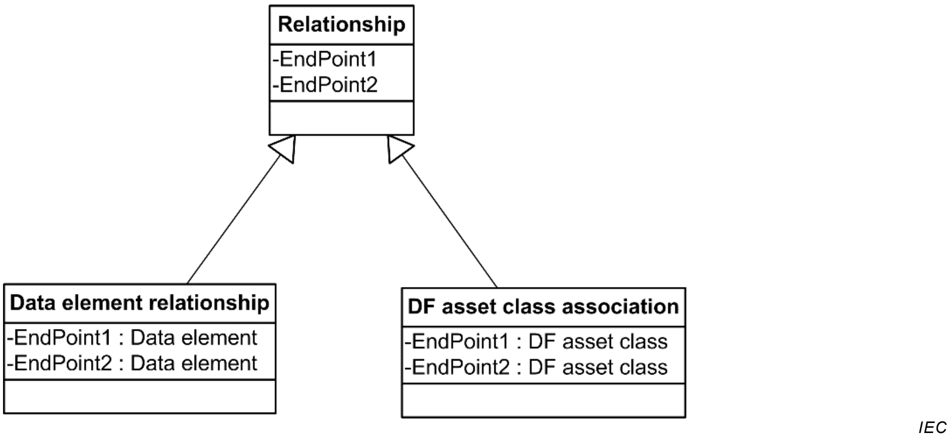


Figure A.2 – Types of relationship

A.2 Library

A library may contain a number of DF asset classes, of DF asset class associations, of data element relationships and of view elements (see Figure A.3).

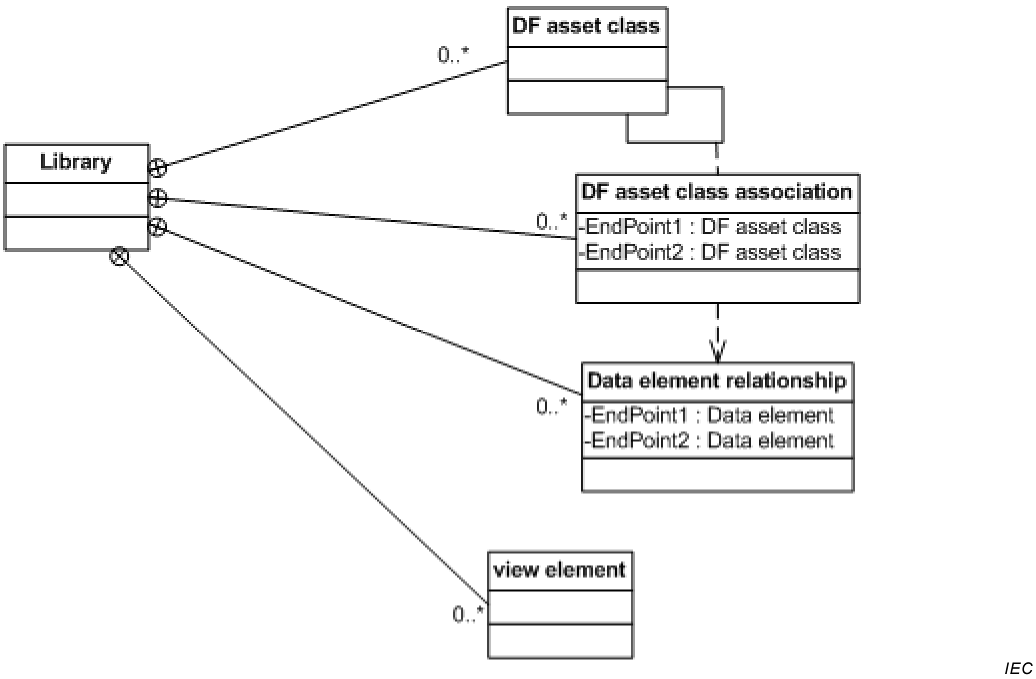


Figure A.3 – Library

The body of a DF asset class is derived from a DF asset class definition and is defined by means of CDEL and Data elements (see Figure A.4 and Figure A.5).

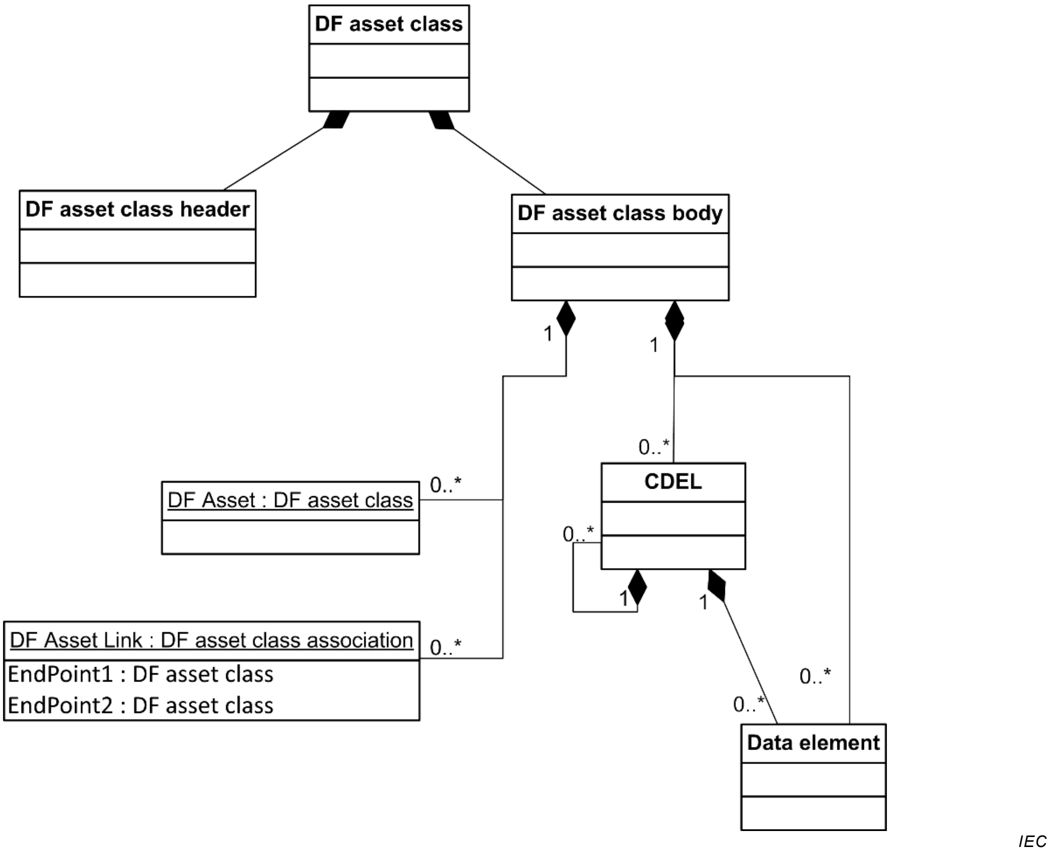


Figure A.4 – DF asset class

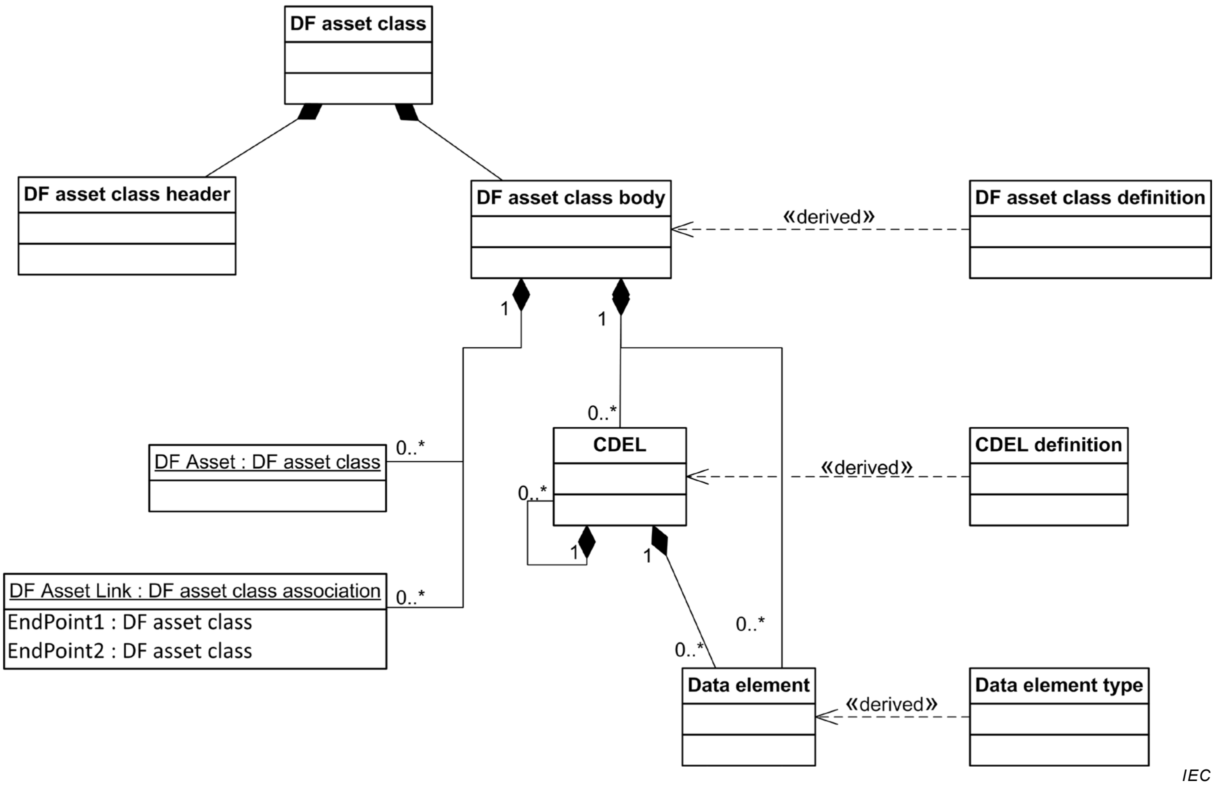


Figure A.5 – DF asset class showing origin of definitions

Also a DF asset class may be defined by composition of other DF assets (constituents) (see Figure A.6). In such a case, the DF asset links between the constituents are part of the definition of the composed DF asset class. As shown in the diagram, the composed DF asset class in most cases will be a different class than the constituent DF asset class. A constituent

DF asset class in turn may also be a composed DF asset class. This can result in a hierarchy of classes.

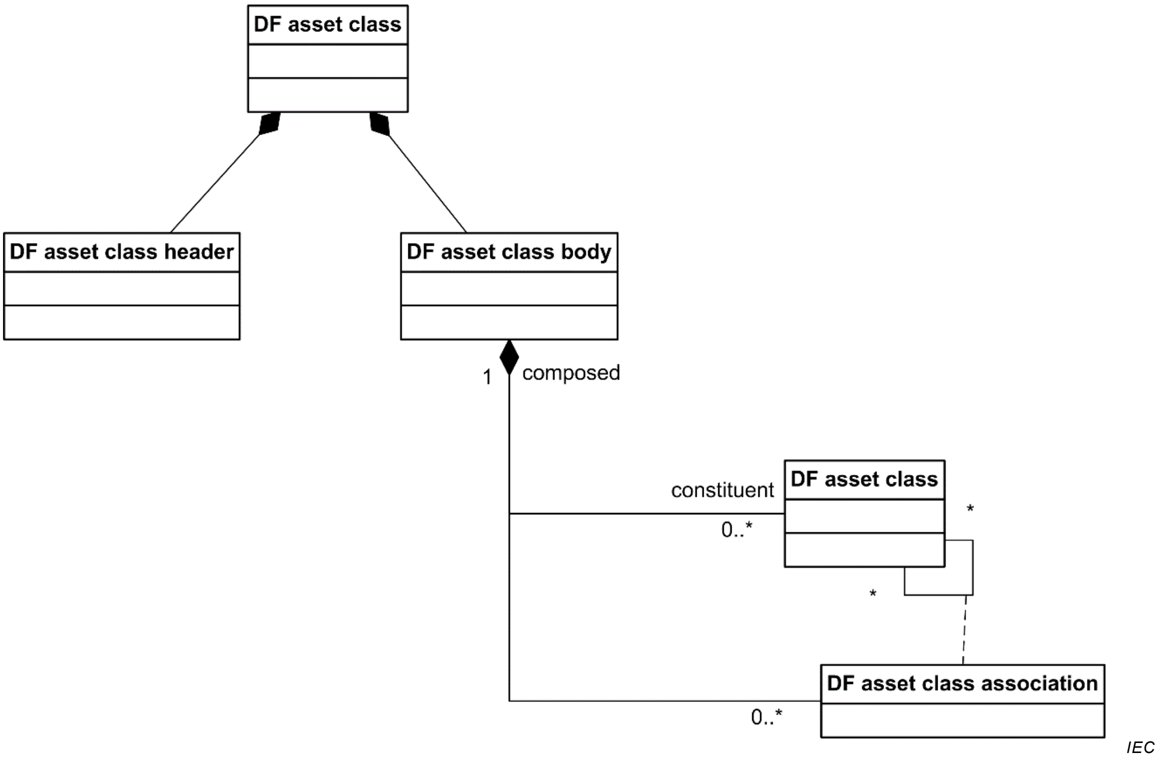


Figure A.6 – Composed DF asset class

A.3 Digital Factory

A Digital Factory has a DF asset header and a DF asset body. The DF asset body is composed of the respective DF assets and the DF asset links (see Figure A.7 and Figure A.8).

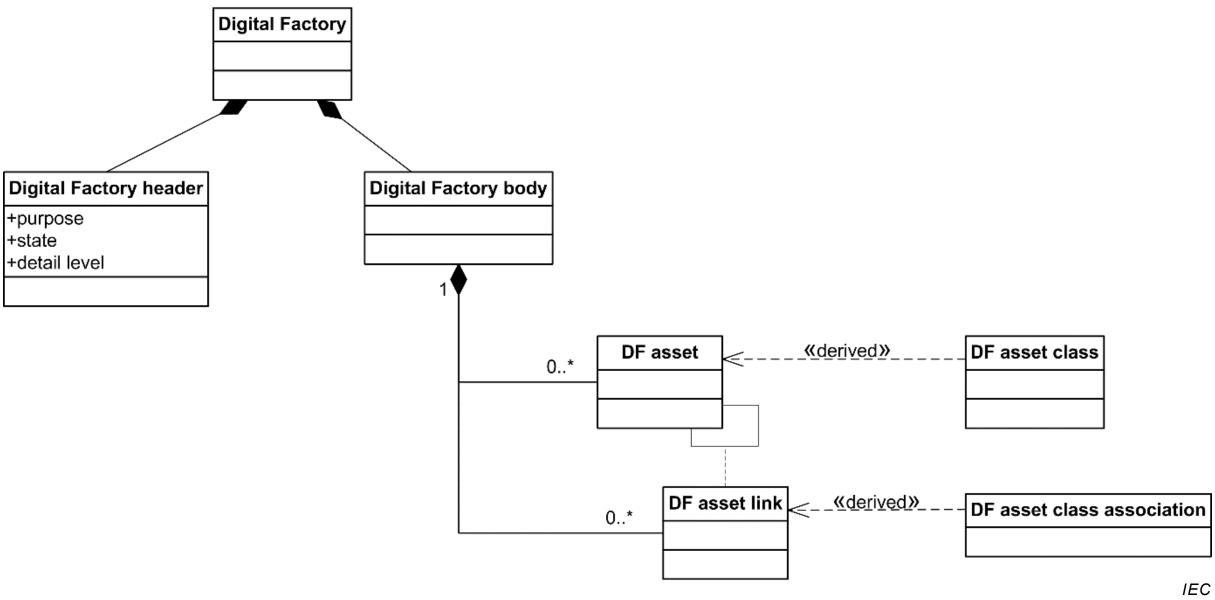


Figure A.7 – Digital Factory structure

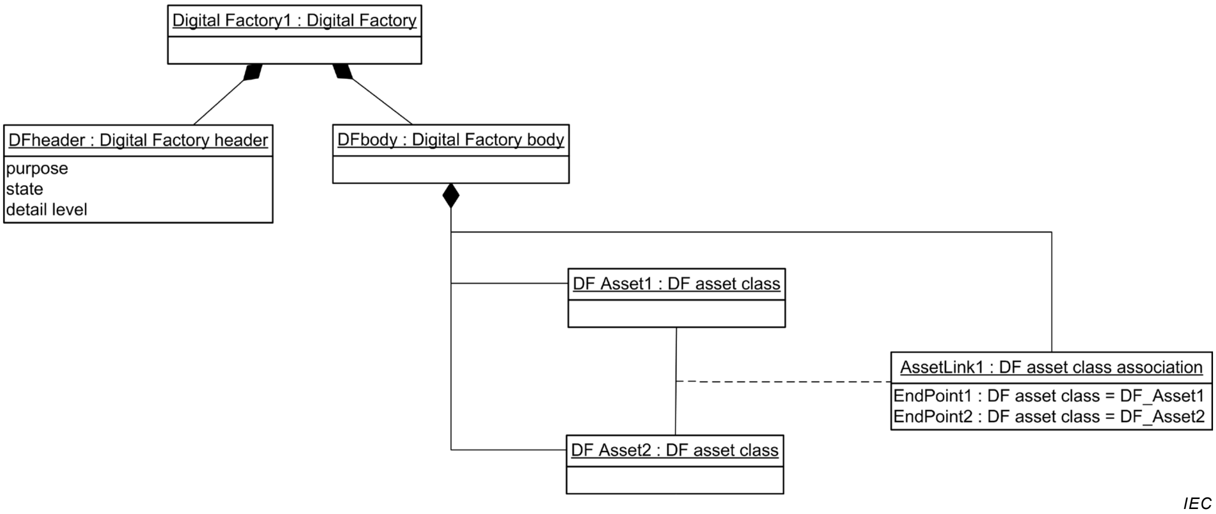


Figure A.8 – Digital Factory

The relevant relationships between the DF assets are represented by asset links, which are derived from DF asset class association (see Figure A.9).

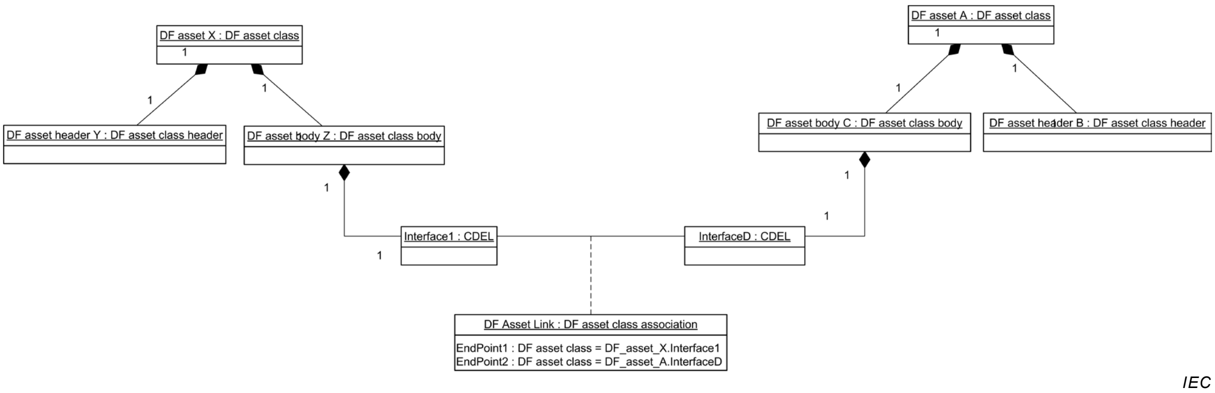


Figure A.9 – Relationship between DF assets

Figure A.10 shows how a composed DF asset can be represented within a Digital Factory. The composition may be defined by a respective DF asset class (as shown in Figure A.6).

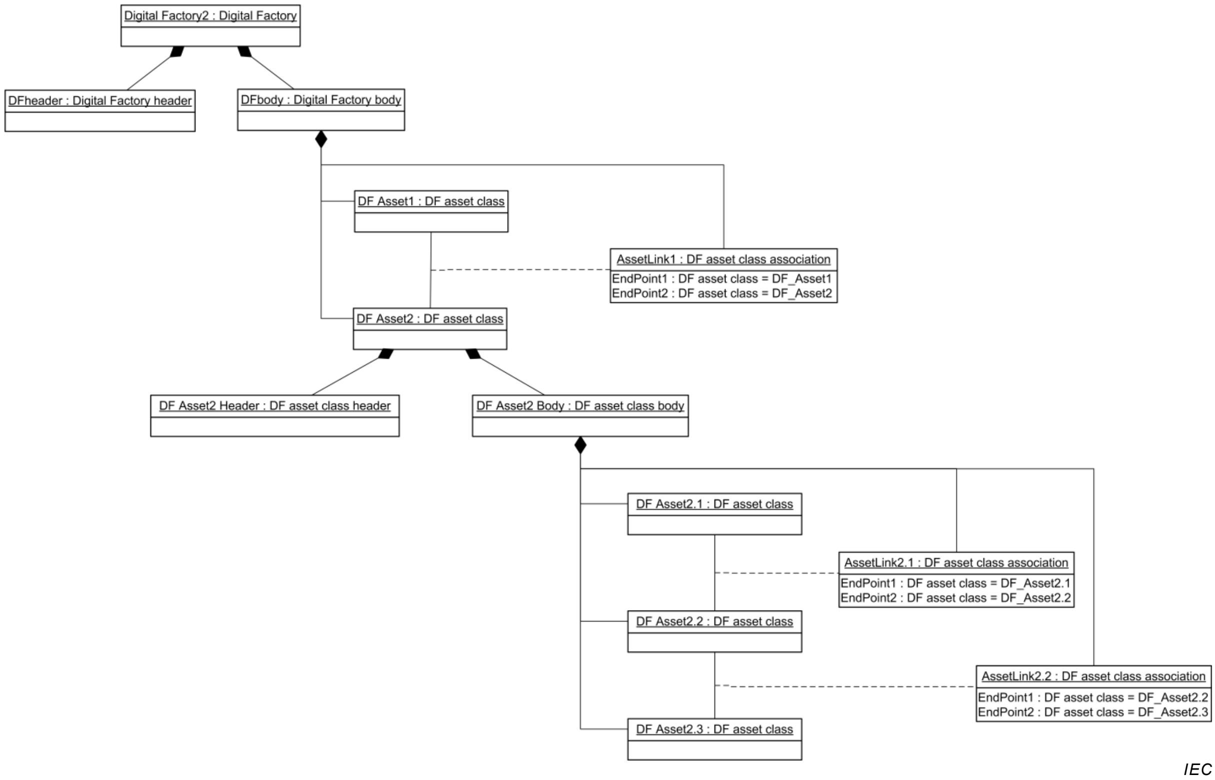


Figure A.10 – Digital Factory with composed DF asset

When a link between DF assets is established, the DERs referenced by the respective DF asset class association may be used to evaluate the validity of the link (see Figure A.11).

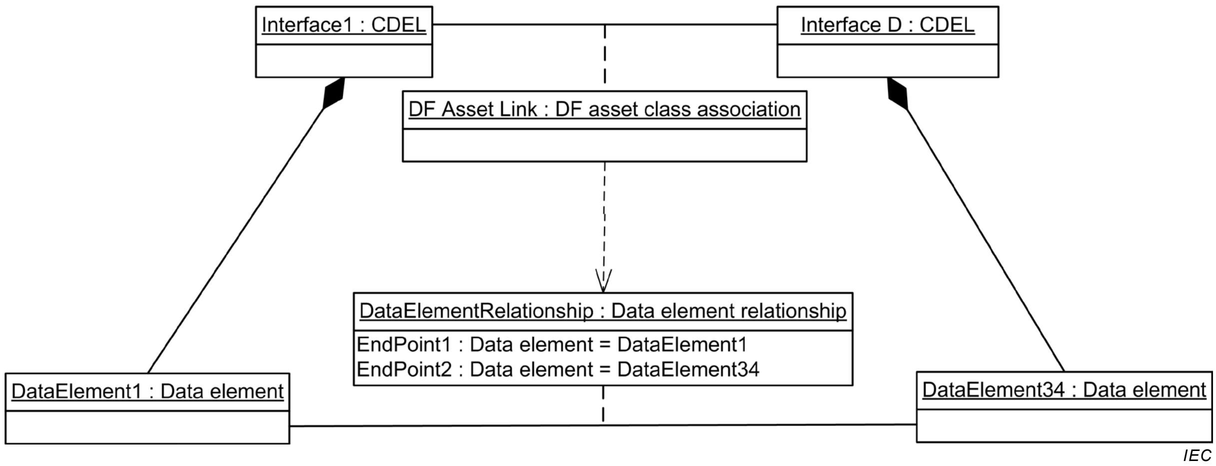


Figure A.11 – DF asset link and DER

Annex B
(informative)

Overview of model elements

B.1 Model elements

Table B.1, Table B.2 and Table B.3 provide an overview of models elements used respectively for the Digital Factory, libraries and dictionaries.

Table B.1 – Model elements of the Digital Factory

Model element	Definition	Owner	Description
Digital Factory	digital representation of a production system	Enterprise	Header (examples): – Purpose of the Digital Factory; – Life cycle phase of the production system; – State of the Digital Factory; – Revision of the Digital Factory. Body: – data elements; – CDELs; – DF assets; – DF assets links
DF asset	digital model of a production system asset	Enterprise	Header (examples): – identification information; – reference to the corresponding DF asset class; – information on PS asset status; – optional information for filtering the DF information in the DF asset body Body: – data elements; – CDELs; – DF assets; – DF asset links
data element	pair consisting of the identifier of a data element type and a value	Enterprise	– reference to a data element type – value
collection of data elements (CDEL)	identified set of data elements	Enterprise	– reference to a CDEL definition; – data elements.
DF asset link	digital representation of a relationship between two or more PS assets	Enterprise	– identifier within a Digital Factory – optional reference to a DF asset class association – identification of end points of the linked DF assets

Table B.2 – Model elements of libraries

Model element	Definition	Owner	Description
library	identified set of DF asset classes, DF asset class associations, data element relationships and view elements	Supplier Enterprise	– DF asset classes – DF asset classes associations – Data element relationships – View elements
supplier library	library provided by a data supplier	Supplier	see “library”
DF library	library owned by an enterprise for use in one or more Digital Factories	Enterprise	see “library”
DF asset class	description of a set of DF assets that share common data element types	Supplier Enterprise	Header: – identification information – references to one or more DF asset class definitions – optional information for filtering the information from the DF asset classes in a library or from the DF assets in the Digital Factory Body: – Data elements – CDELs for composite asset classes: – Data elements – CDELs – DF assets – DF asset classes – DF asset links – DF asset class associations
DF asset class association	relationship between two or several DF asset classes	Supplier Enterprise	– identifier within a library – identification of two or more end points of the associated DF asset classes – (optional) one or more data element relationship(s) (or references)
view element	used for filtering information from a library (supplier library or DF library) or from the Digital Factory	Supplier Enterprise	– references to DF assets – references to data elements – identification of technical discipline intended

Table B.3 – Model elements of dictionaries

Model element	Definition	Owner	Description
concept dictionary	collection of concept dictionaries entries which defines the concepts, classes, and terms that are used to construct the DF asset classes	<depends on dictionary variant, see the four options below>	– Data element types – CDEL definitions – DF asset class definitions
standardized dictionary		Standardization body	
consortium dictionary		Independent organization or consortium	
supplier dictionary		Supplier	
DF dictionary		Enterprise	
DF asset class definition	groupings of references to CDEL definitions and references to data element types	<depends on dictionary variant, see options for concept dictionary>	– Concept identifier – List of references to data element types – List of references to CDEL definitions
data element type	unit of data for which the identification, description and permissible values have been specified according to a data specification	<depends on dictionary variant, see options for concept dictionary>	– Concept identifier – Name – Definition Optional: – Symbol – Physical unit – Value range – Relationship to other data elements
CDEL definition	groupings of data element types which can be used to describe specific aspects of a PS asset	<depends on dictionary variant, see options for concept dictionary>	– Concept identifier – List of references to data element types

B.2 Example DF asset description

Figure B.1 provides an example structure of a DF asset describing both physical asset and equipment role.

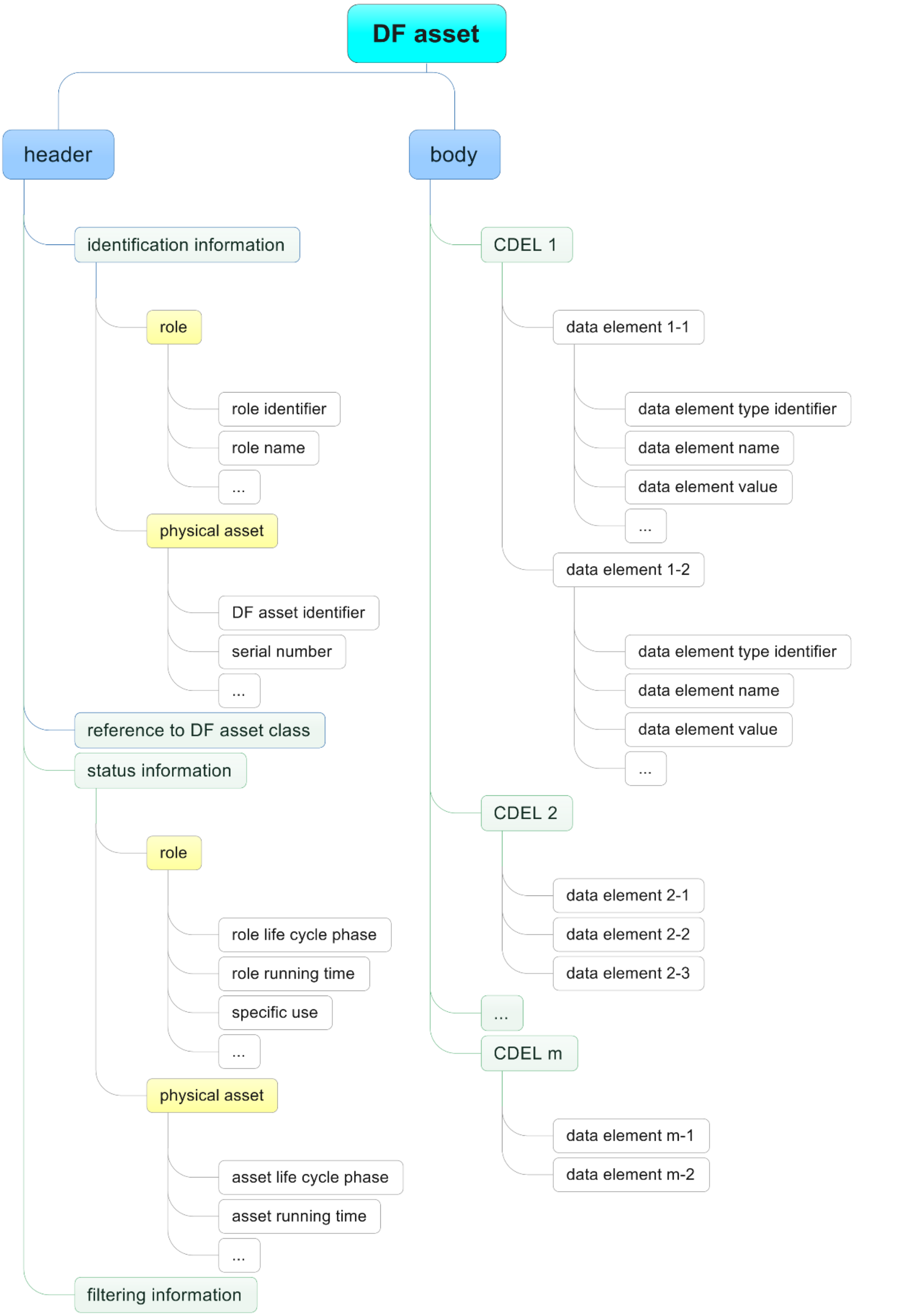


Figure B.1 – Example structure of a DF asset

Annex C
(informative)

UML notation

C.1 General

These general elements can be used in different UML diagrams.

qualified identifier
is an identifier, which shows an identifier together with the package name (namespace), in which the respective model element is defined. The identifier of the model element is separated from the package name by a double-colon ("::").

EXAMPLE <class name>::<package name>

note
contains information for people reading the UML diagram (or model). Notes provide additional context to help explain details that are not apparent in the diagram (see Figure C.1).

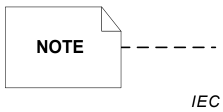


Figure C.1 – Note

C.2 Class diagram

The class diagram is one of the UML specification methods. The UML elements which are used in the class diagrams of IEC 62832 are explained in this Clause C.2.

class
is a description of a set of objects that share the same attributes, operations, methods, relationships, and semantics (see Figure C.2).

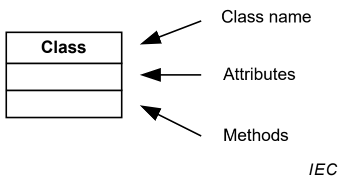


Figure C.2 – Class

abstract class
is a class that cannot be directly instantiated and is used only for specification purposes. A class is abstract if it has no instances. An abstract class is used only to inherit from. Abstract classes are represented by an italicized class name.

association
is the semantic relationship (between two or more classifiers) that specifies connections among their instances (see Figure C.3).

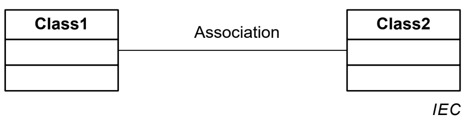


Figure C.3 – Association

composition
is a form of symmetric association that specifies a whole-part relationship between the composition (whole) class and a subordinate (part) class in which removing the whole also removes the parts (see Figure C.4).

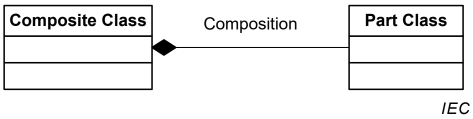


Figure C.4 – Composition

aggregation
is a form of asymmetric association that specifies a whole-part relationship between the aggregate (whole) class and a subordinate (part) class (see Figure C.5).

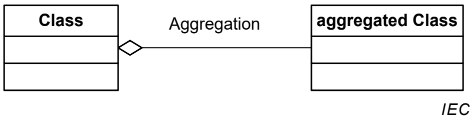


Figure C.5 – Aggregation

containment
represents the nesting of model elements in other model elements (for example the containment of classes in libraries).

Figure C.6 – Containment

NOTE The qualified name of the contained class in Figure C.6 is "Package1::ContainedClass".

dependency
is a form of association that specifies a dependency relationship between two classes. An arrowhead can be used to indicate an asymmetric dependency, where the dependent class (the client) is shown at the arrow head and the independent class (the supplier) is shown at the other end of the dependency (see Figure C.7, Class2 depends on Class1).

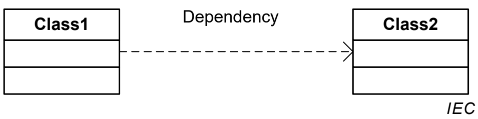


Figure C.7 – Dependency

generalization
is the taxonomic relationship between a more general element and a more specific element that is fully consistent with the first element and that adds additional information. It is used for classes, packages, use cases, and other elements. The construct is also used to describe Inheritance (see Figure C.8).

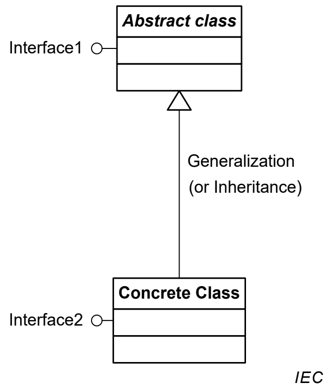


Figure C.8 – Abstract class, generalization and interface

interface
is a mechanism used to conveniently package and reuse a collection of methods (method signatures) and properties. An interface is an abstract class that only contains method signatures and can also contain properties. There is no underlying implementation for the methods. Essentially, an interface is a promise to implement a standard package of methods and properties. An interface can be inherited by an abstract class as well as by a concrete class. A concrete class may also provide an implementation for an interface. In Figure C.8, the concrete class implements Interface1 (inherited with abstract class) as well as Interface2.

multiplicity
multiplicity specification is shown as a text string comprising a comma-separated sequence of integer intervals (see Figure C.9), where an interval represents a (possibly infinite) range of integers, in the format: “lower-bound .. upper-bound” where lower-bound and upper-bound are literal integer values, specifying the closed (inclusive) range of integers from the lower bound to the upper bound. In addition, the star character (*) can be used for the upper bound, denoting an unlimited upper bound.

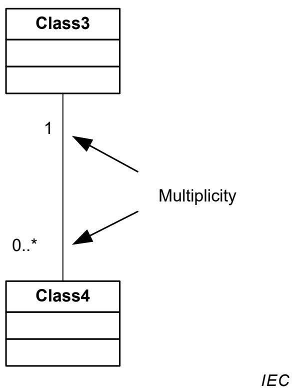


Figure C.9 – Multiplicity

association class
is a class providing more detailed information on an association between two or more classifiers. An association class is depicted by an association symbol with a class symbol connected with a dashed line (see Figure C.10).

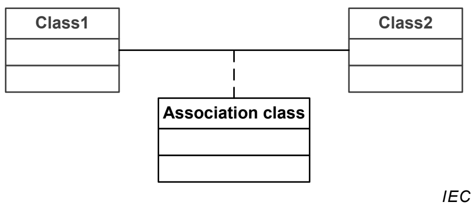


Figure C.10 – Association class

C.3 Object diagram

An object diagram show objects and their relationships at a point in time. It can be used to provide examples of implementations or examples of specific data. The following elements can be shown in object diagrams.

object
is a description of an object with specific attributes, relationships, and semantics (see Figure C.11). An object identifier may always be recognized by the underline. If an object is derived from a specific class, the class identifier is provided. Object identifier and class identifier are separated by a colon (<object identifier>:<class identifier>).

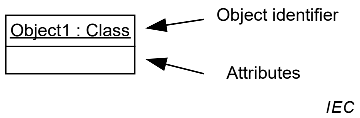


Figure C.11 – Class

link
is an instance of an association. Since links are instances of associations, the name of a link is also shown with underline (see Figure C.12). Showing the name of the association is optional.

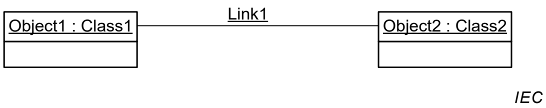


Figure C.12 – Link

According to ISO/IEC 19505-1:2012, instances should be represented with similar shapes like the respective classes. That is why links, which are instances of composition or aggregation are shown with respective adornments (see Figure C.13 and Figure C.14).

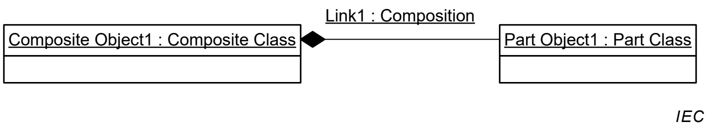


Figure C.13 – Link instantiated from composition

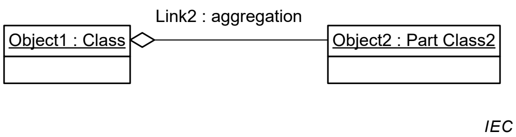


Figure C.14 – Link instantiated from aggregation

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