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ELECTRICAL/CABLEWAY
APPLICATION PROTOCOL

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<u>**Contractor/Contract Identification**</u>

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Foreword

This document has been prepared for the Navy/Industry Digital Data Exchange Standards Committee (NIDDESC).

The need for reliable mechanisms for the exchange of product model data describing ships between dissimilar systems has been recognized as an important capability for years by industry and government organizations. As a result of this interest, the NIDDESC was formed in 1987 to pursue the development of this capability. This effort has focused on achieving this capability through the ISO (the International Organization for Standards), a worldwide federation of national standards bodies.

This document is a user guide for using ISO/IEC 10303-212:2000, prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*. ISO 10303 is Standard for the Exchange of Product Model Data and Part 212 is the Application Protocol (AP) entitled *Electrotechnical design and installation*. ISO/IEC 10303-212:2000 (AP 212) provides the ship community with a useful mechanism for exchanging ship electrical and cableway information.

Annex A is for information only.

Background

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. Currently, there is an initiative underway within Technical Committee ISO TC184/SC4, *Industrial automation systems and integration*, Subcommittee SC4 *Industrial data* to create neutral product model data exchange standards. The standard is called the **ST**andard for the **E**xchange of **P**roduct model data (STEP) and is designated ISO 10303. The ship community is participating in this standard to ensure that ship product model data can be exchanged between Computer Aided Design (CAD) systems to support real business processes.

A companion standard for STEP is ISO 13584, **P**arts **LIB**rary (PLIB). The ship community is also participating in the development of STEP and will require part library exchanges in advance of most STEP ship exchanges.

The team working on product model data for ships is ISO TC184/SC4/WG3/T23, *Product modelling* T23 *Ships*.

The following product data standards are principally relevant to the ship community. These standards are being prepared by T23 except as otherwise noted.

— ISO/IEC 10303-212 (AP 212) **-** Electrotechnical design and installation

NOTE 1 AP 212 is being prepared by ISO TC184/SC4/JWG9, *Electrical and electronic applications*, a joint working group with IEC TC3.

— ISO 10303-215 (AP 215) – Ship moulded forms

— ISO 10303-216 (AP 216) – Ship arrangements

— ISO 10303-218 (AP 218) – Ship structure

— ISO 10303-226 (AP 226) – Ship mechanical systems

— ISO 10303-227 (AP 227) – Plant spatial configuration

NOTE 2 ISO 10303-227 is being used in accordance with NSRP 0424 [1] to represent ship piping and heating, ventilation and air conditioning (HVAC).

NOTE 3 AP 227 is being prepared by ISO TC184/SC4/WG3/T20, Process plant.

— ISO 10303-234 (AP 234) – Ship operational logs, records and messages

These standards are described in more detail below.

ISO 10303-215

ISO 10303-215 specifies an application protocol (AP) for the exchange of product data representing a ship's internal subdivision information between different organizations with a need for the data. Such organizations include ship owners, design agents, and fabricators. This AP has been developed to support the shipbuilding activities and computer applications associated with the Functional Design, Detail Design, and Production Engineering life cycle phases for commercial or military ships. The types of design activities and computer applications supported include naval architectural analyses (e.g., damaged stability, compartmentation and access, and floating positions), structural analysis, interference analysis, and weight analysis.

ISO 10303-216

ISO 10303-216 specifies an application protocol (AP) for ship moulded forms and related hydrostatic properties. The AP supports hull moulded forms and moulded forms for structures internal to the ship, and supports surface and underwater ships for commercial and military use.

In this context:

— a ship moulded form is the shape and set of dimensions of a ship (or any part of it) that does not include information on the thickness of the material from which it is constructed;

— hydrostatic properties are characteristic parameters used to assess the intact stability and flotation of the ship.

ISO 10303-218

ISO 10303-218 specifies the information requirements for exchange of ship structural systems data for ship predesign, design, production, and inspection/survey. Product definition data pertaining to the ship's structure includes: hull structure, superstructure, and all other internal structures of commercial and naval ships.

ISO 10303-226

ISO 10303-226 specifies the use of the integrated resources necessary for the exchange of ship mechanical systems information.

Distributed systems APs

ISO 10303 contains other product model data exchange standards that are not ship specific but that can be used by ship industries. ISO/IEC 10303-212 provides electrical design and installation information. ISO 10303-227 provides piping and HVAC data needed to support functional design, detail design, production engineering, fabrication, assembly, and testing.

ISO 13584

ISO 13854 (Parts Library) is a companion standard to STEP. Before a product model exchange can successfully take place, a successful part library exchange is necessary. A successful PLIB standard is critical to the ship APs.

Introduction

ISO 10303 is an International Standard for the computer-interpretable representation and exchange of product data. The objective is to provide a neutral mechanism capable of describing product data throughout the life cycle of a product, independent from any particular system. The nature of this description makes it suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving.

ISO 10303 is organised as a series of parts, each published separately. The parts of ISO 10303 fall into one of the following series: description methods, integrated resources, application interpreted constructs, application protocols, abstract test suites, implementation methods, and conformance testing.

This document provides guidance on the usage of ISO/IEC 10303-212:2000 for representing and exchanging product data about ship electrical systems.

ISO/IEC 10303-212 is an application protocol for the design and installation of electrotechnical systems such as plants, industrial systems, and vehicles. ISO/IEC 10303-212 alone provides a complete reference for electrotechnical design and installation, but the formal style of the standard leaves many reasonable questions unanswered. Discussion of what is not in the standard, why certain features are defined as they are, and how one might implement some particular feature have no place in a standard but are nevertheless of interest to most users. Such discussions, explanations, and examples are presented in this usage guide.

Because of ISO/IEC 10303-212's generic nature, the need for usage guidelines is especially acute. For example, connection is not confined to flow of current, but it includes flow of matter, information, and energy. Furthermore, ISO/IEC 10303-212 does not use terms that are familiar to ship community electrical engineers. Thus, it is difficult to pick the right entities for a data exchange scenario.

The explanations in this usage guide also help the reader appreciate the relationships among different parts of ISO/IEC 10303-212:2000. They also expose points and implications that are not captured in the standard itself. In addition, the detailed use cases make this usage guide more accessible than the formal standard.

ISO/IEC 10303-212 is not confined to shipboard electrical systems; rather, it covers a wide range of electrical systems. This usage guide also bridges the semantic gap between the ship application domain and genericity of ISO/IEC 10303-212:2000.

This document provides guidelines for using ISO/IEC 10303-212 for exchanging shipboard electrical system data. However, it does not provide a formal description of the model nor does it discuss electrical system design issues.

This guide is written primarily for the people implementing ISO/IEC 10303-212 within the ship community. It also would be useful to anyone who wants to learn more about ISO/IEC 10303-212.

Several of the U. S. Navy-Industry Digital Data Exchange Standards Committee (NIDDESC) specifications have served as input for the development of ISO 10303ship application protocols. Version 1.0 of this document was a specification for shipboard electrical systems that followed the structure of a STEP AP.

The original intent was to make it an ISO standard; however, that work was discontinued in September 1995 and instead T23 began working with JWG9 to enable the use of ISO/IEC 10303-212 for ship electrical systems data. The purpose of this document is to provide guidance on the use of ISO/IEC 10303-212 as a solution for the core requirements of exchanging data about shipboard electrical systems.

The approach taken to evaluate the suitability of ISO/IEC 10303-212 for ship community requirements was to collect a number of different use cases based on the core requirements and then to treat these use cases as the test cases for ISO/IEC 10303-212. These use cases were used to create instance diagrams shown in this usage guide. The instance diagrams illustrate the portions of the physical file that are crucial for understanding the mapping.

1 Scope

This document specifies the requirements for the exchange of ship electrical system data. It provides guidance on the use of ISO/IEC 10303-212:2000 for exchange ship data.

The following are within the scope of this document:

— representation of ship electrical information using ISO/IEC 10303-212:2000.

The following are outside the scope of this document:

— formal mappings between ship electrical models and ISO 10303-227:2000;

— requirements for ship electrical systems.

2 Normative references

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 10303-1:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 1: Overview and fundamental principles*.

ISO 10303-11:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual*.

ISO/IEC 10303-212:2000, *Industrial automation systems and integration — Product data representation and exchange — Part 212: Application protocol: Electrotechnical design and installation*.

3 Terms, definitions, and abbreviations

3.1 Terms defined in ISO/IEC 10303-212

For the purposes of this document, the terms and definitions given in ISO/IEC 10303-212:2000 apply.

3.2 Other terms and definitions

For the purposes of this document, the following definition applies:

3.2.1
fault current
short-circuit current

the current under a fault condition

3.3 Abbreviations

For the purposes of this standing document, the following abbreviations apply:

AC	alternating current
ACSR	aluminum conductor steel reinforced
ANSI	American National Standards Institute
AP	application protocol
ARM	application reference model
ATS	abstract test suite
AWG	American Wire Gauge
CBS	circuit breaker sizing
CD	committee draft
CFR	Code of Federal Regulations
CTC	Concurrent Technologies Corporation
DIS	Draft International Standard
DC	direct current
DOD	Department of Defense
D-U-N-S®	Data Universal Numbering System
(E)	English
EDT	entity data type
FCC	Federal Communications Commission
FDIS	Final Draft International Standard
GE	General Electric
GUID	globally unique identifier
ICD	international code designator
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
id	identifier
IR	integrated resource
IS	International Standard
ISO	International Organization for Standardization
NATO	North Atlantic Treaty Organization
NSRP	National Shipbuilding Research Program
OI	organization identifier
OSI	Open Systems Interconnect
PLC	programmable logic controller
PLIB	Parts Library standard (ISO 13584)
rms	root mean square
SC4	Subcommittee 4
SES	shipboard electrical system
SOLIS	SC4 On-line Information Service
STEP	Standard for the Exchange of Product Model Data
TC	Technical Committee
UNECE	United Nations Economic Commission for Europe
UoF	Unit of Functionality
WD	working draft

4 Conventions used in this document

Names of entity data types (EDTs) are capitalized and names of real-world concepts are lower case. For example, one could say: "The Device entity data type is used to represent a device." The first instance of "Device" refers to the entity data type and the second reference to the "device" refers to common English usage of the word "device."

Instances of EDTs are identified by #nnn where nnn is a number. For example, referring to Figure 1, #301 stands for the instance of the Single_device EDT that represents device Bus001.

Attributes have been appended with "attribute." For example, referring to Figure 1, one could say: "The assigned_document attribute of instance #2034 is an instance (#2030) of the document_component EDT."

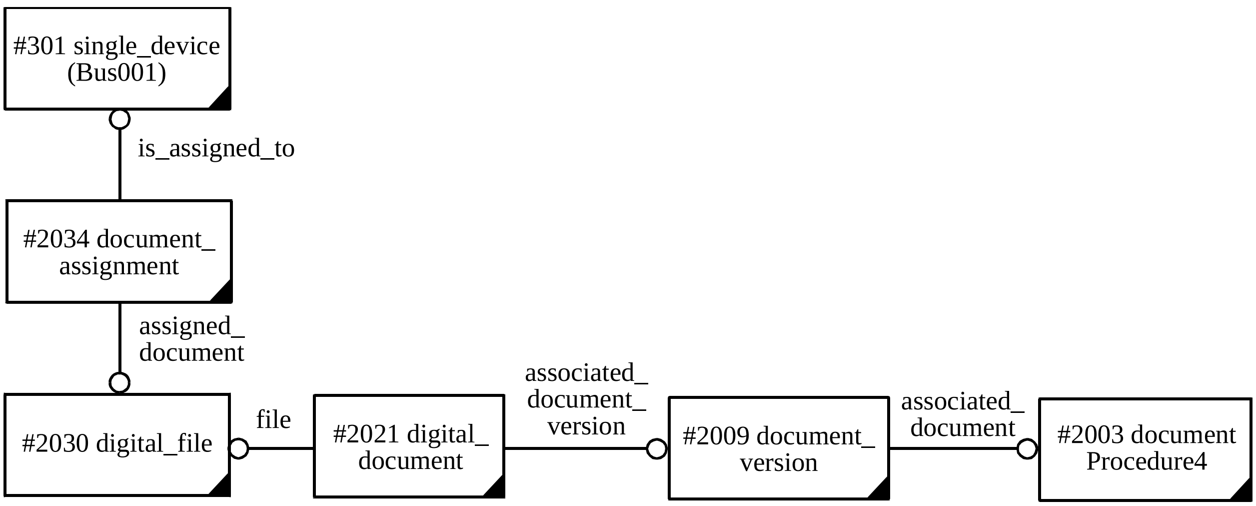

Figure 1 — Explanation of conventions used for instance identifier and subtype

5 Overview of the AP

5.1 Fundamental concepts

This clause explains some of the fundamental concepts and their representation in ISO/IEC 10303-212. The topics covered are:

— items and related entities;

— data elements;

— classification.

The idea of "item" is closely related to the idea of "product," however, close scrutiny reveals different aspects behind the concept of product. Data elements are primarily used to describe product and classification is used to organize the information into manageable units.

5.1.1 Item and related entities

This clause describes the concept behind the Item and related EDTs and explains the differences between the Item, Device, and Physical_instance EDTs.

To better understand items and their related entities, consider Figure 2, which shows a pilot lamp consisting of an assembly of a light source (L1), two variable resistors (R1, R2), and two wires (W1, W2). The resistors share the same specification.

Table 1 shows the specification of the items in the purchase order. Note the order quantity for resistor in the table. The order quantity is two because R1 and R2 have same specification. The specification of the resistor can be represented by an instance of the Item EDT. Thus, the same instance of the Item EDT is used to specify resistors R1 and R2; however, this is not the case with wires W1 and W2 because the specifications for these wires are not the same. The specification of W1 is represented by an instance of the Item EDT, and the specification of W2 is represented by another instance of the Item EDT.

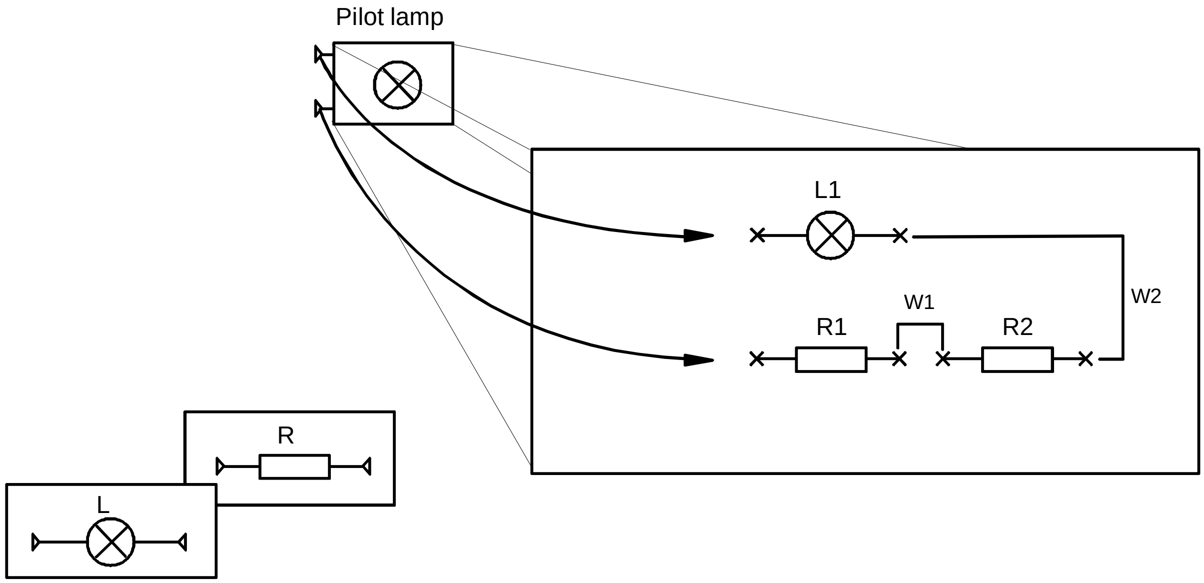

Figure 2 — Assembly of pilot lamp

Table 1 — Bill of material for pilot lamp

Item	Catalog id	Qty
Bulb	B123	1
Resistor	R234	2
Wire assembly	W123	1
Wire assembly	W124	1

Resistors R1 and R2 share the same specification; however, they are used differently in the design. Both of them are variable resistors; however, R1 is set at 2 ohms, and R2 is set 10 ohms. Thus, even though no distinction is made between R1 and R2 during the purchasing phase, a distinction is made in the design phase. Two design engineers will discuss the design in terms of R1 and R2. This design information is represented by an instance of the Device EDT. The Single_device EDT is a subtype of the Device EDT and has been used in most of the use cases. The Single_device EDT is used for discrete devices. This is in contrast with Quantified _device, which is used to represent devices that are not discrete, such as paint, oil, and glue. Unlike discrete devices, these cannot be counted; rather, a quantity is specified for these types of "devices," e.g., a gallon of paint or a liter of oil.

Resistor R1 is represented by an instance of the Single_device EDT, and its specification is given by an instance of the Item EDT. Resistor R2 is represented by a different instance of the Single_device EDT, but its specification is given by the same instance of the Item EDT.

Suppose that the pilot lamp is used in an automobile. The design of the car also includes the design of the pilot lamp. Information represented by the Single_device EDT is useful for discussing the design of the car, but it is not sufficient for the a state's motor vehicle registry, which must track each individual vehicle. Thus, instances of the Single_device EDT cannot represent the value of the car's vehicle identification number. ISO/IEC 10303-212 provides the Physical_instance EDT to represent such information. The Physical_instance EDT can refer to the same instance of the Single_device EDT, and many instances of the Single_device EDT can refer to the same instance of the Item EDT.

To understand the concept behind the Item EDT in ISO/IEC 10303-212, it is essential to distinguish between the specification of things and the things themselves. The specification of things is typically used in the purchase request for the things and the things that are actually sold and bought. The specification of a thing can also be called the product type; therefore, the product type specifies the nature of the product but does not specify the product itself. Both the product type and the actual product are things of significance. A product type is usually identified by a "model number" or its equivalent, and its other attributes describe characteristics of the model, regardless of the number of products conforming to the related product type.

Figure 3 shows the portion of the ISO/IEC 10303-212 ARM diagram that represents Item and related entities.

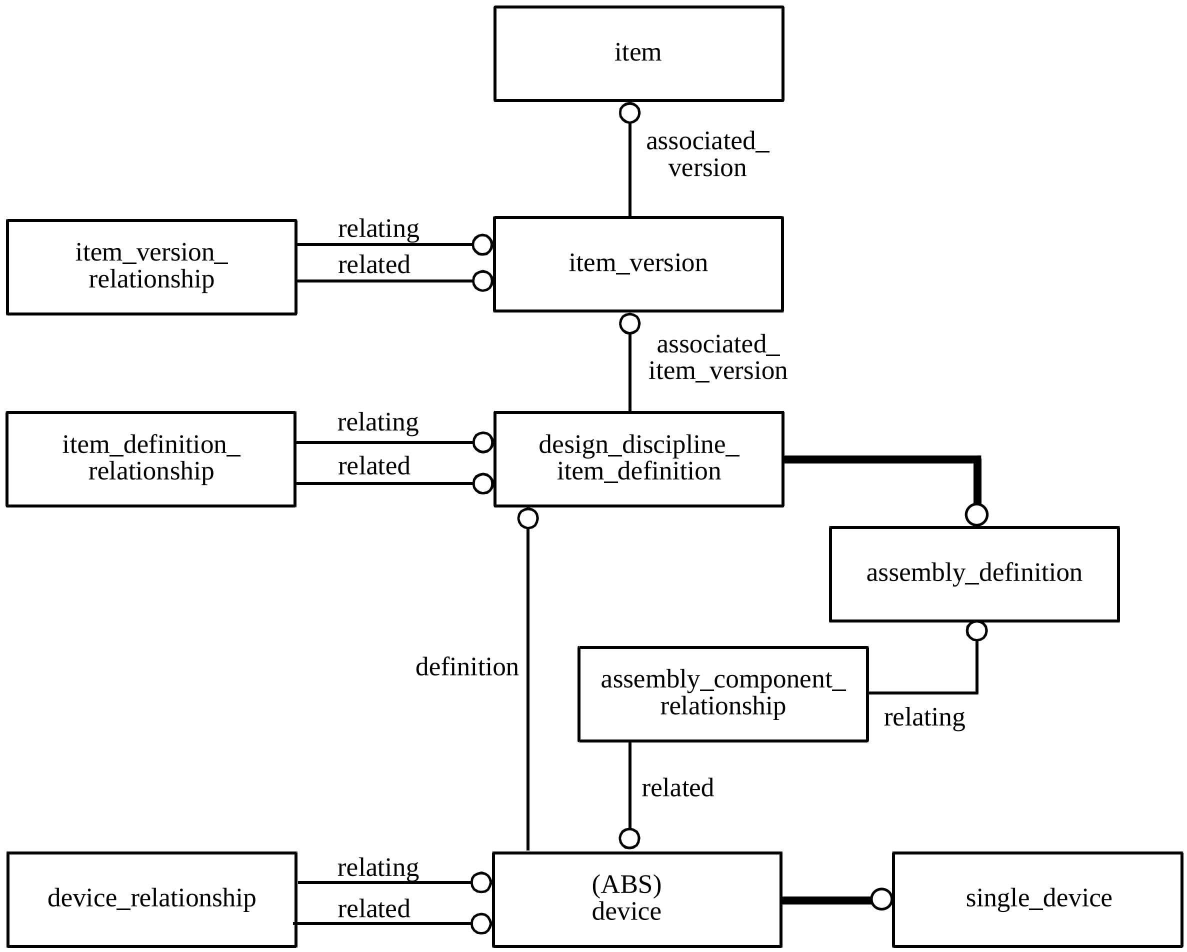

Figure 3 — Item and related entities

A product type is a "real-world" thing that describes a product, another real-world thing. Product type is metadata such as a description of a part in a parts catalog, a blueprint for a house, or an engineering drawing for a system.

Generally speaking, the Item EDT can be used to represent the things that are or could be described in a catalog. Attributes that may appear in the catalog entry specifying the thing provide the generic, or typical, nature of the product.

An Item is a thing produced or intended to be produced, set up, designed, and installed in an electrotechnical system. An item can either be a single component or an assembly of arbitrary complexity. Furthermore, an item can be anything that does not have its own EDT in ISO/IEC 10303-212. It can be anything from the electrotechnical equipment controlling a whole plant down to a tiny piece of wire. An Item is an accessory, part, or software, although the classification of an Item as a part, accessory, or software can depend on the viewpoint of the user.

An Item_definition_relationship is a relationship between two Design_discipline_item_definition objects; thus, it should logically be called a Design_discipline_item_definition_relationship. Possible types of the relationship are specified by the relation_type. Values for the attribute can include alternate, derivation, and substitution. An alternate relationship defines a relationship based on the possibility of substitution, and a substitution relationship is based on actual replacement. The list can be extended by an agreement between the sender and receiver.

An Item_version is a variant of an Item. The version may refer to a variant that has been refined or improved over time. The version may also refer to two parallel variants.

EXAMPLE 1 A motor has an explosion-proof version and a drip-proof version.

An Item_identification is a sequence of alphanumeric characters that label an Item. It can uniquely identify the equipment for repair or exchange; therefore, Item_identification allows the determination of the exact type of equipment. An Item_identification of an Item can be unique to each organization.

EXAMPLE 2 The order number can serve as an Item_identification.

The id attribute specifies an identifier consisting of alphanumeric characters that is unique within its scope. This is not the typical human-interpretable string as in most application objects. If an Item does not have any ordering information, the id attribute contains an empty string. The optional coding_type attribute specifies the syntax used for the id.

An item can be classified as a part, accessory, or software. Accessories are further differentiated from the normal product.

NOTE Accessories include insulators or fixing material such as cable ducts, bushings, and screws.

Software, such as operating systems and programmable logic controller (PLC) code that are required by the product to fulfill its functionality, can also be represented.

Many Design_discipline_item_definitions can exist for a given item_version.

EXAMPLE 3 One could say that there exists one equivalent circuit for normal operation, and another equivalent circuit for each fault condition. In this case, one can have multiple Design_discipline_item_definitions, each pointing to the same item_version.

A product can either be modeled as a noncomposite unit or as a composite unit. A noncomposite unit can have an inner structure, but it is not relevant for the application, e.g., when buying an assembly from the supplier where the internal structure of the assembly is irrelevant. Where the inner structure of the product is desired, ISO/IEC 10303-212 allows a description of hierarchic product structure. A key capability of this AP is the ability to pass electrical/cableway data describing various hierarchical structures of electrical/cableway model objects. This facility is used to model the decomposition of a high-level object, such as an engineering system, into lower-level engineering systems and their constituent engineering parts and distribution interconnections.

An Assembly_definition is a type of Design_discipline_item_definition that is characterized by a relevant assembly structure. It does not imply mechanical assembly, although mechanical assembly is not precluded. It can be used to define an assembled module, which is a temporary test rig that can be assembled to test a system. An Assembly can be assembled by connecting a signal generator to an item under testing using jumper cables/patch cords. An Assembly_definition can also be used to define a procurement package such as an electronic hobby kit containing a printed circuit board. The components of the kit can be represented by the Assembly_defintion, although these components are not soldered on the printed circuit board.

An Assembly_component_relationship is the relationship between an assembly and a constituent. The assembly is represented by the Assembly_definition EDT, and the constituent is represented by the

Device EDT. The relating attribute specifies the Assembly_definition that has subordinate constituents. The related attribute specifies the Device that acts as a component of the relating Assembly definition. The placement attribute specifies the geometrical transformation that is used to calculate the exact spatial position of the constituent within the assembly; however, this is an optional attribute to be used where spatial relationships are implied. An Assembly_component_relationship can either be a Next_higher_assembly or a Promissory_usage. The constituent can also be an assembly. An assembly can be considered as a package of things that belong together for some purpose. Following this idea, devices can belong to more than one such package; thus, the same instance of Device can be a constituent of more than one assembly. These assemblies are defined through the object Design_discipline_item_definition. This document does not constrain the Assembly_component_relationship between the packages. One can be a subset of another, they can be disjointed sets, or they can be partially overlapping sets.

EXAMPLE 4 The power supply cord of an overhead projector belongs to the sales package of the projector as well as to the package of power supply cords that are currently in stock.

5.1.2 Data elements

Data element is used to represent the characteristics of an item. Properties of the item are represented by the Data_element EDT, which comprises two subtypes—the Predefined_data_element and User_defined_data_element EDTs. Figure 4 shows the relevant part of ISO/IEC 10303-212 ARM diagram.

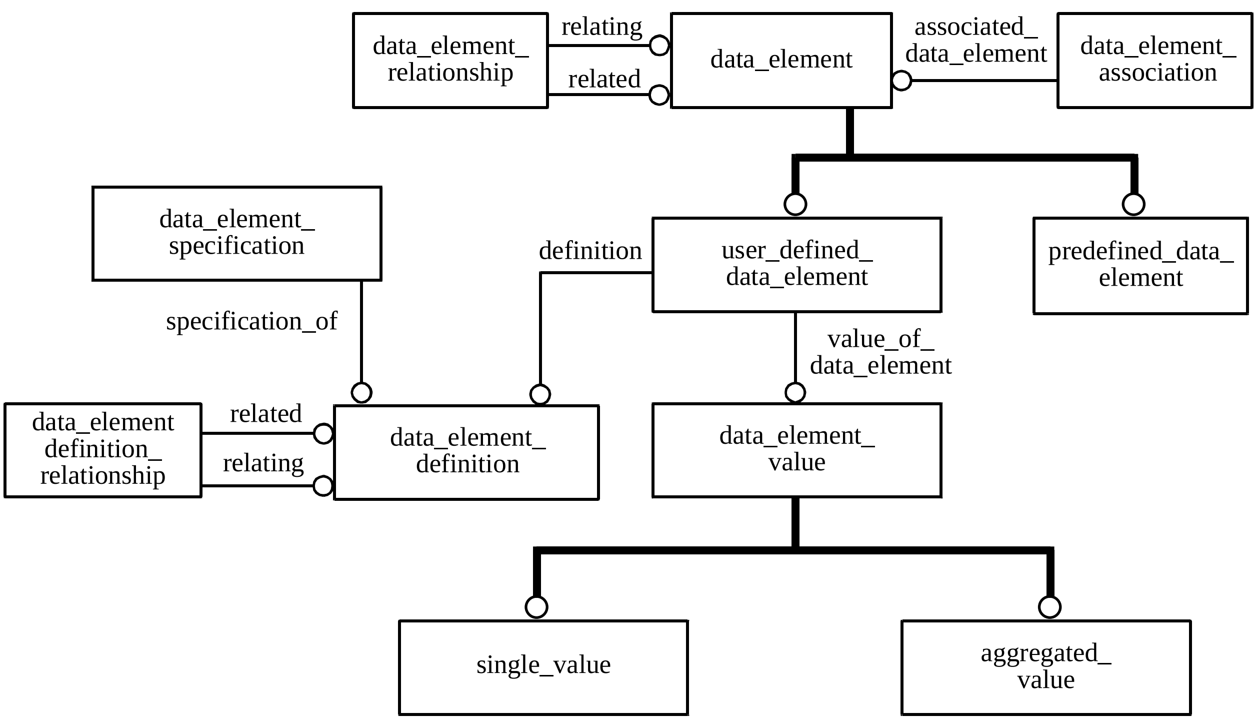

Figure 4 — Entities for specifying properties

The Data_element EDT represents a technical or administrative property that can be used to characterize an object. Instances of the Data_element EDT allow one to furnish the constructs of a model with technical or administrative data. The value_deterinemation attribute specifies the type of data given by Data_element. This is an optional attribute. Possible values for this attribute are:

— actual—a value that exists;

— assessment—an estimated quantity;

— calculated—a quantity computed using mathematical methods;

— measured—a quantity that is measured;

— setpoint—a quantity that is to be used as a specified value.

The above list can be extended by an agreement between the sender and receiver.

NOTE 1 An object can represent a thing or a relationship between things.

NOTE 2 The actual value of physical quantities is unknowable because of the uncertainty principle.

A Data_element_relationship associates two Data_element objects for dependency, grouping, substitution, tolerancing, and equivalence. The equivalence relationship is a relationship where both Data_element instances represent the same fact.

EXAMPLE 1 The assertion that two length values are to be considered the same, regardless of rounding differences.

This list of relationships can be extended by an agreement between the sender and receiver. Data_element objects that are related to each other in a sequential manner shall be captured as a one-dimensional array using Aggregated_value objects.

A Data_element_association associates an item with a Data_element through the associated_item and associated_data_element attributes. The definitional attribute specifies whether the associated_data_element acts as an identifying characteristic for the associated_item. The data_element_context specifies an environment for which the Data_element_association is valid. This is an optional attribute.

A Data_element_definition is the definition of Data_element. The admitted_level attribute specifies significant levels that the data element associated to the Data_element_definition can possess. The admitted_level attribute can be used to specify maximum and minimum values for a given property. Fault clearing time is an important property for a circuit breaker. Both maximum and minimum fault clearing times are important in coordinating two or more circuit breakers. For instance, maximum fault clearing time of the primary circuit breaker should be less than the minimum clearing time of the secondary circuit breaker to allow the primary circuit breaker to act first. The attribute admitted_level can also be used to specify nominal values. This can be used to specify the steady-state rating for a motor. This is in contrast to peak load rating for a motor, which specifies the peak load for short time. The admitted_level attribute can also be used for specifying values, rather than stating actual, measured, or estimated values. For instance, the power utility company may specify the required power factor on a consumer. Finally, the attribute admitted_level can also be used to specify typical values. For instance, amplification factor for given type of transistor is generally specified as typical value. Available options include maximum, minimum, nominal, specified, and typical. The optional source attribute specifies the query information for retrieving the Data_element_definition. The specification attribute specifies the definitional description for the Data_element_definition.

An instance of the Data_element_definition_relationship EDT associates an instance of the Data_element_definition EDT with another instance of the Data_element_definition EDT. The association can describe a decomposition and substitution relationship and restrict the domain of values.

EXAMPLE 2 The output range of a 4-bit, analog-to-digital converter is restricted to 16 discrete values, while the input voltage is restricted to a continuous range.

This list can be extended by agreement between the sender and receiver.

The Data_element_specification EDT is the human-interpretable description of a Data_element_definition. The definition attribute provides the human-interpretable definition. The remark attribute specifies human-interpretable text that gives further details about the Data_element_specification EDT. Using the language symbols defined in ISO 639, the language_code attribute specifies the language used to provide human-interpretable description. The language_code need not be specified for a particular Data_element_specification. The attribute note specifies a statement that provides more information about the definition. The note need not be specified for a particular Data_element_specification. The value of a Data_element is represented by Data_element_value. The value can be logical, numerical, or textual.

5.1.3 Classification

Since many thousands of electrical components exist, companies have long classified them and organized them into classification systems. Companies supplying and purchasing large power systems attach so much importance to component classification that agreement on such a system is a significant aspect of contract negotiations.

NOTE IEC 61360-4 [2], which is currently being developed and used by the electronics industry, contains a classification system at a high level of abstraction.

The technique of classification can be used to organize electrical components as well as more abstract concepts such as ship operating conditions.

EXAMPLE 1 The load on the electrical system of a ship varies according to the ship's operating conditions. These conditions, which typically include shore, cruise, and anchor, are organized into a classification hierarchy.

EXAMPLE 2 The electrical system of a ship can be operating under one of the following two conditions—fault condition or normal condition. These conditions are organized into a classification hierarchy.

Figure 5 shows the relevant part of the ISO/IEC 10303-212 ARM diagram.

An instance of the General_classification EDT represents each node in a classification hierarchy. A separate instance of the General_classification EDT represents each member of the classification hierarchy. A classification can then be applied to any instance of an EDT selected by the Classified_item_select.

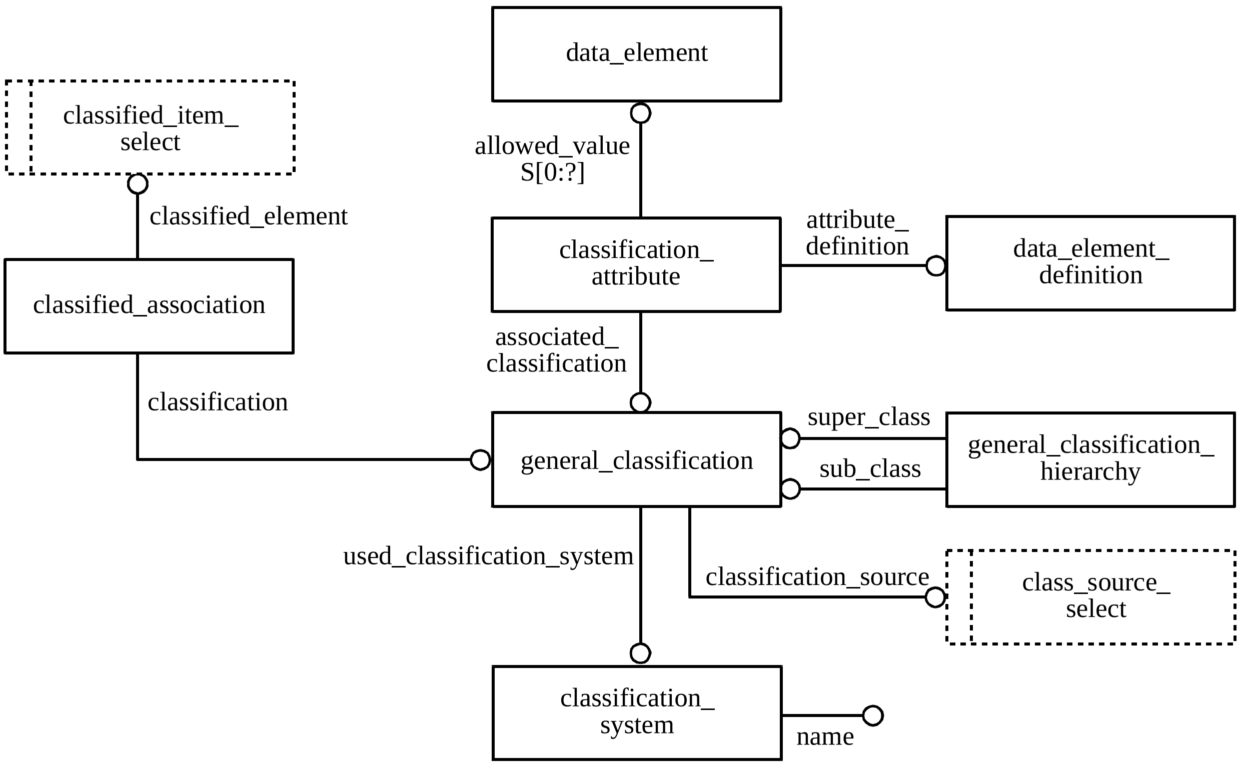

Figure 5 — Entities for classification

The General_classification EDT can be used as a criterion for selecting a specific type of equipment from a component database. The classification source attribute, an optional attribute, specifies the library reference that contains the specification of the General_classification EDT. The used classification system attribute specifies the Classification_system EDT that contains information on how to interpret the class value attribute of the General_classification EDT. The class value attribute identifies the Class_information EDT that is applied to a classified item in accordance with a given Classification_system EDT. The membership of an item in a category depends on the Classification_attribute EDT.

The Classification_association relates General_classification and the object that is to be categorized through the classification attribute and classified element attribute, respectively. The definitional attribute specifies whether the General_classification acts as an identifying characteristic of the object assigned by the associated classification attribute. If the value of the definitional attribute is true, the General_classification serves as an identification criterion for the associated item.

The purpose of an instance of the Classification_association EDT is specified by the value of the attribute role. Possible values include electromagnetic compatibility, environmental conditions, flow direction, generic, and protection class. This list can be extended through an agreement between the sender and receiver.

EXAMPLE 3 Environmental conditions are classified according to classification systems such as IEC 60079 [3] [4]. Using an instance of the Data_element EDT, one can specify nonclassified data, such as the actual value of temperature. The flow direction classification can give information as to whether the element acts as an input port, output port, or a bidirectional port. The flow is not confined to the flow of current, but it encompasses the flow of matter, energy, and information. Generic classification implies that no additional information is given. A classification based on the protection class classifies an item with respect to its ability to withstand environmental conditions. The protection class can be based on electrical shock, vibration, or humidity. This classification also provides the classification of items based on environmental hazards posed by the item. When the protection class that is requested in a specific environment needs to be specified, a requirement can be associated with the object of interest.

A General_classification_hierarchy associates sub_class General_classification with its super_class General_classification.

EXAMPLE 4 An instance of General_classification EDT can represent electric motors. The subclasses for electric motors can consist of linear motors and rotational motors, each of which can be represented by instances of the General_classification EDT. The rotational motors can further be classified as alternating current, direct current, or universal. These three classes can be represented by three different instances of the General_classification EDT.

The repetitive use of the General_classification_hierarchy EDT can create a network of linked General_classification, which is not confined to a tree-structured classification hierarchy. Refer to Annex D of IEC 61360-4 [2] for a classification table.

In summary, the General_classification EDT represents the class of an item within some classification system. The Classification_association EDT associates an item to General_classification EDT. The General_classification_hierarchy EDT links different General_classification EDT (classes) into a network of subclasses and superclasses. Finally, Classification_system EDT provides the criteria for classification.

EXAMPLE 5 A typical use of classification is in contract specifications. Communication components can be constrained to a certain Federal Communications Commission (FCC) class. Similarly, portable equipment may have to comply with certain vibration requirements. Classification unit of functionality (UoF) entities are useful for representing such a classification environment.

An instance of the General_classification EDT is associated with an instance of the Classification_association EDT, which, in turn, is associated with an instance of either the Item EDT or the Item_version EDT; thus, instances of the Item and Item_version EDTs are valid candidates for classification. The choice depends on the merits of an individual case.

EXAMPLE 6 It may be advisable to classify the various versions of a motor if different versions of this item are required for inclusion in the supplier's catalog.

ISO/IEC 10303-212 does not require that one include the complete classification system; rather, one can choose to include only those items that are actually in the design. It is not possible to represent the classification hierarchy if only some of the classes are included; therefore, the use of the General_classification_hierarchy EDT is optional. On the other hand, parties exchanging data may agree to include the complete classification system as part of the exchange file.

Furthermore, ISO/IEC 10303-212 does not specify whether the classification attributes are inherited. This issue needs to be addressed between the sender and receiver. One can also exclude the attributes from the ISO/IEC 10303-12 file and obtain them from an external dictionary that is referenced through the classification source attribute.

ISO/IEC 10303-212 also does not constrain the scope of the classification system. The classification system can be a company internal, North Atlantic Treaty Organization (NATO), ISO, or IEC standard, among other things. The id attribute of the Classification_system identifies the classification system. Many classification schemes can exist for a particular manufacturer.

EXAMPLE 7 A customer uses the NATO classification system, as well as a maintenance classification system. Another customer puts everything as data elements.

Normally, the classification elements are the decision elements. The classification schemes are represented by the entity Classification_system. The definition of the classification system can be in an external document, which is attached to the Classification_system through the Document_assignment EDT. The external document need not contain the classification scheme. The only constraint imposed by AP 212 is that it must be useful. It is important to reference the document so that one would easily be able to locate the document.

EXAMPLE 8 The classification scheme can be based on IEC 61346 [5]and IEC 60204 [6]. The NATO classification scheme is another example. Similarly, shipbuilding classification schemes can be used. There are also classification schemes based on environmental conditions, enclosures, being waterproof, and being explosion-proof. There are also safety rules, set up by either the government or a registration company. For ships, registration companies also have classifications.

NOTE The ISO/IEC 10303-212 development team felt that even if ISO/IEC 10303-212 mandated a specific classification system X, most contracting parties would ignore it, using another scheme Y. Furthermore, the development team noted that ISO 10303 attempts to accommodate multiple discipline views and to avoid arbitrarily restricting use of a data model; thus, the team felt that an ISO 10303 AP should not dictate a certain classification system. For example, the oil and gas group within the same ISO subcommittee that is developing ISO 10303 uses the POSC/CAESAR classification system for a specific application.

EXAMPLE9 IEC 61360-4 [2] can be used as a classification system, although this is its primary purpose. The primary purpose of IEC 61360 is to provide a repository of attribute and property definitions. However, to successfully do this, standard developers had to create a classification system. Most large companies have their own classification systems that are for internal use only; however, they may be given to a supplier in order to provide data in a convenient form.

5.2 Patterns

This clause introduces some important patterns that appear within the use cases.

5.2.1 Single_device to Item

This pattern is illustrated in Figure 6.

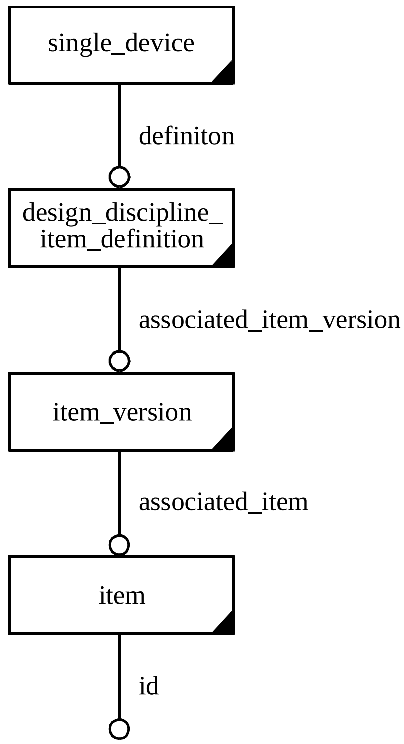

Figure 6 — Single_device to Item

A Single_device is defined by a Design_discipline_item_definition. A Design_discipline_item_definition is associated with an Item_version. An Item_version is a version of an Item.

There can be many instances of the Single_device defined by the same instance of Design_discipline_item_definition. There can be many instances of the Design_discipline_item_definition EDT associated with the same instance of Item_version. An item can have many versions, so there can be many instances of the Item_version EDT linked to the same instance of the Item EDT.

5.2.2 Associating a property value to a device

This pattern is illustrated in Figure 7.

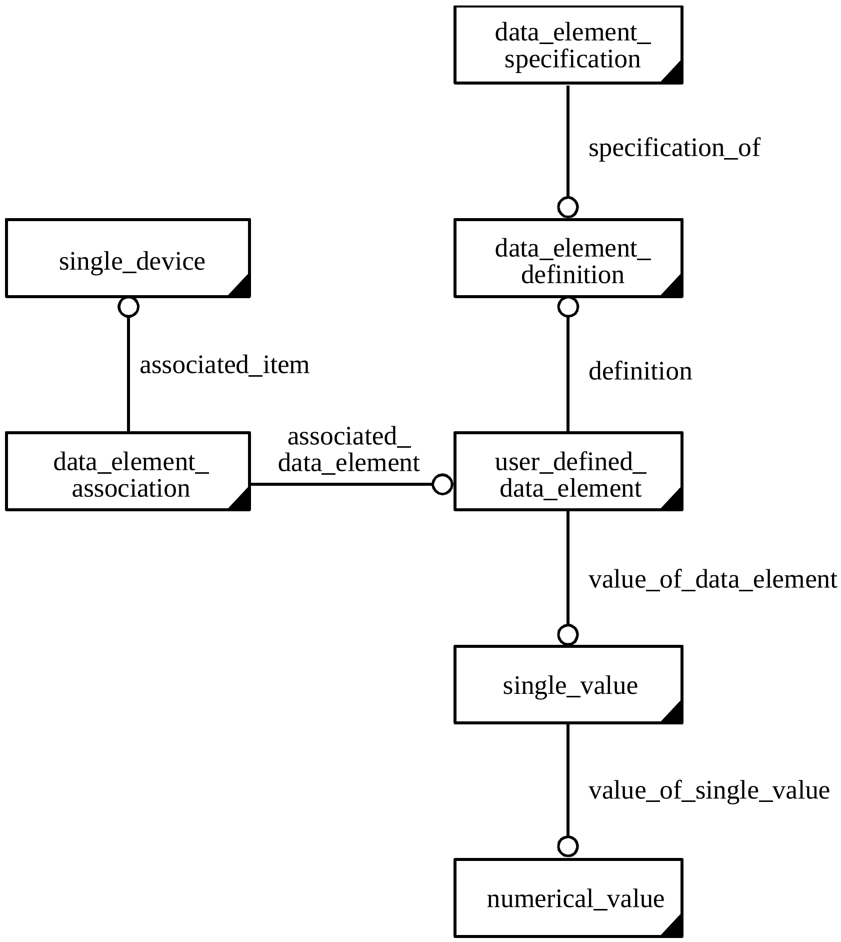

Figure 7 — Associating a property value to a device

Since ISO/IEC 10303-212 has few electrical or physical properties built into the ARM, the User_defined_data_element EDT is used frequently.

An instance of the Data_element_association EDT links an instance of the User_defined_data_element EDT with an instance of the Single_device EDT. The definition attribute of the User_defined_data_element EDT references the instance of the Data_element_definition EDT that defines the property. The value_of_data_element attribute references the instance of the Single_value EDT where the property value is stored.

EXAMPLE A single instance of the Data_element_definition EDT would be used to define the concept of inductance. It would be referenced by many instances of the User_defined_data_element EDT, each representing a different value of inductance.

5.2.3 Relating data elements

This pattern is illustrated in Figure 8.

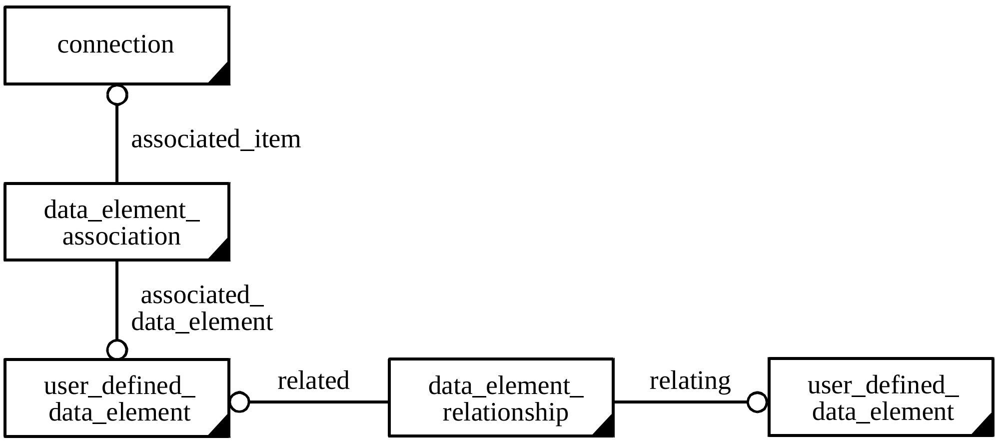

Figure 8 — Relating data elements

An instance of the Data_element_relationship EDT relates two instances of the User_defined_data_element EDT.

EXAMPLE The amount of current flowing through a connection between two devices is identified by an instance of the User_defined_data_element, attached to an instance of the Connection EDT. This is the current flowing through the connection when a particular operating point of the electrical system is in effect. The dependency between the current and the operating point is represented by an instance of the Data_element_relationship EDT that connects the instance of the User_defined_data_element EDT representing the current flow with the instance of the User_defined_data_element EDT representing the operating point.

5.2.4 Definition of device and terminal

This pattern is illustrated in Figure 9.

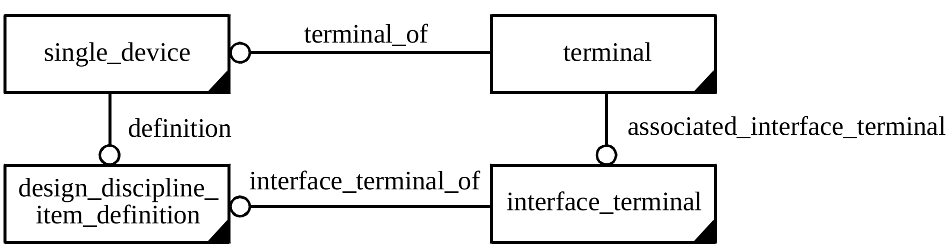

Figure 9 — Definition of device and terminal

A Single_device EDT is defined by a Design_discipline_item_definition. The Single_device may have one or more terminals defined by instances of the Terminal EDT. An instance of the Interface_terminal EDT defines each terminal. Each Design_discipline_item_definition has terminals defined one or more instances of the Interface_terminal EDT.

In mathematical terms, this diagram should "commute." That is, starting from an instance of the Terminal EDT, if one follows the terminal_of attribute then the definition attribute, one should arrive at the same instance of the Design_discipline_item_definition as if one follows the associated_interface_terminal attribute then the interface_terminal_of attribute.

5.2.5 Connecting devices

This pattern is illustrated in Figure 10.

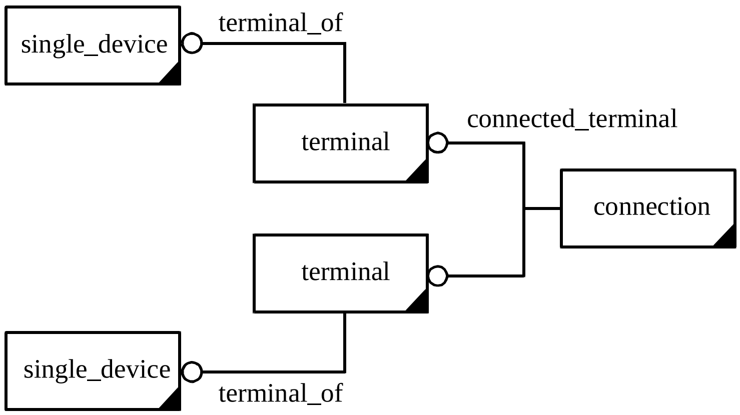

Figure 10 — Connecting devices

An instance of the Connection EDT connects two or more instances of the Terminal EDT. Each Terminal is a terminal of a Single_device.

5.2.6 Decomposing a device as an assembly

This pattern is illustrated in Figure 11.

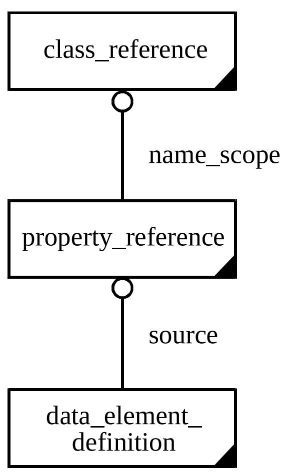

Figure 11 — Decomposing a device as an assembly

An instance of the Assembly_definition EDT may be the definition of an instance of the Single_device EDT. The assembly represents the fact that the device is actually an abstraction that is realized by several less abstract devices.

5.2.7 Attaching a file that contains additional information about a device

This pattern is illustrated in Figure 12.

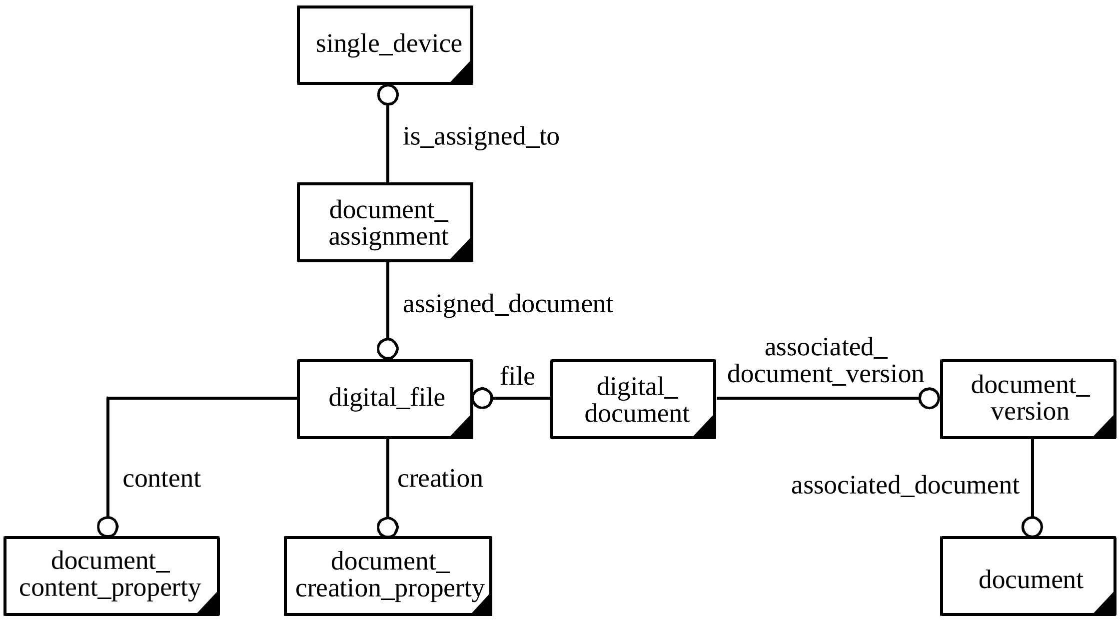

Figure 12 — Attaching a file that contains additional information about a device

An instance of the Document_assignment EDT links an instance of the Digital_file EDT to an instance of the Single_device EDT. The Digital_file gives information about a file located separately from the ISO/IEC 10303-212 physical file that contains additional information about the device not specified in the ISO/IEC 10303-212 physical file.

5.2.8 Defining a data element in an external library

This pattern is illustrated in Figure 13.

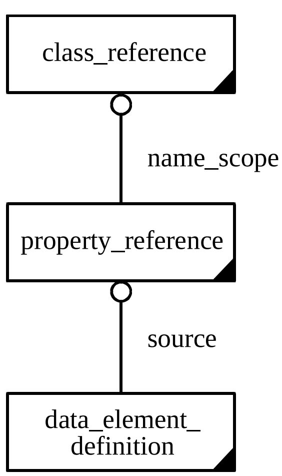

Figure 13 — Defining a data element in an external library

An instance of the Data_element_definition EDT may have its source given as a property defined in an external library.

5.2.9 Path

This pattern is illustrated in Figure 14.

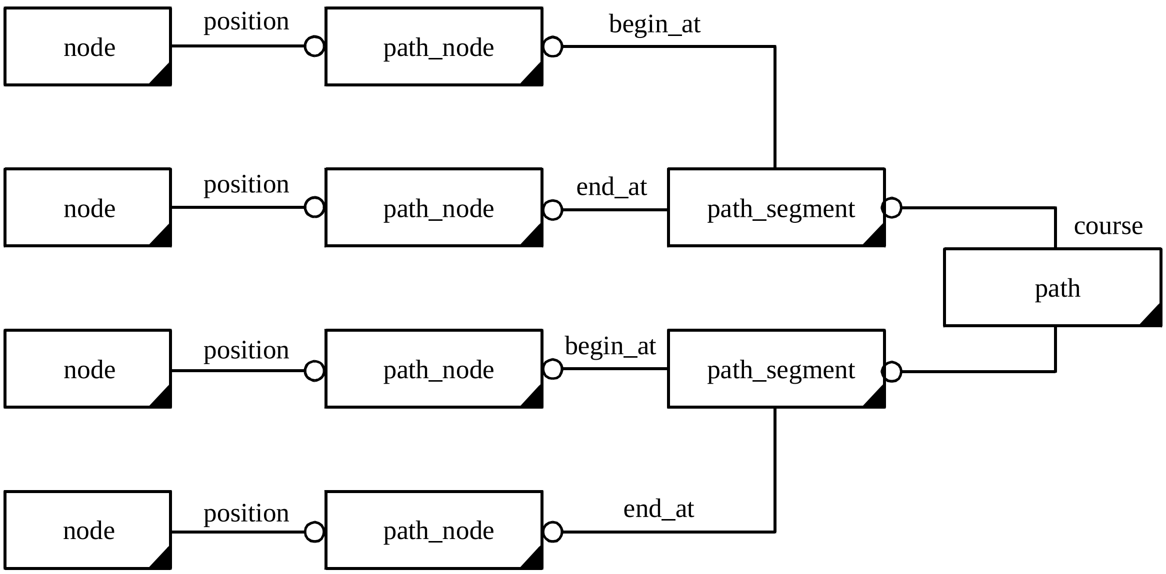

Figure 14 — Path

A path is made up of multiple segments. Each segment begins and ends at a node.

5.2.10 Routes

This pattern is illustrated in Figure 15.

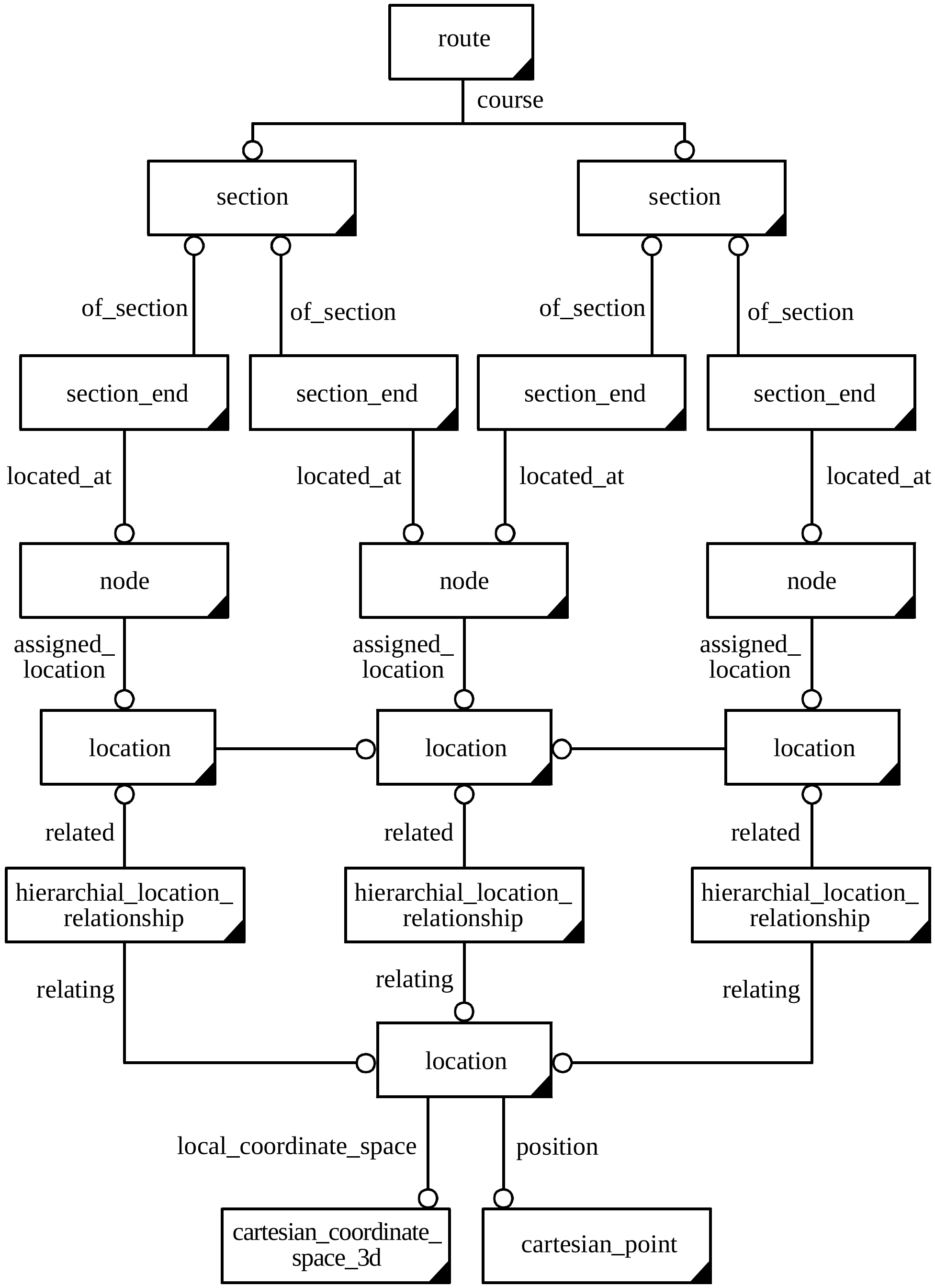

Figure 15 — Routes

A route for a cable is made up of several sections. The beginning and end of each section are represented by instances of the Section_end EDT. Normally, if segments S1 and S2 are adjacent in the route, then each will have a Section_end that is located at the same Node.

NOTE An exception to this might occur when a route penetrates a wall. Two adjacent sections of the route might terminate on either side of the wall.

Instances of the Node EDT represent positions within a ship. These positions can be specified very precisely or very loosely. Positions can be related in a hierarchy.

EXAMPLE In a loose specification, the position "engine room" may be decomposed into positions "left front of engine room," "right front of engine room," etc.

5.2.11 Attaching devices to routes

This pattern is illustrated in Figure 16.

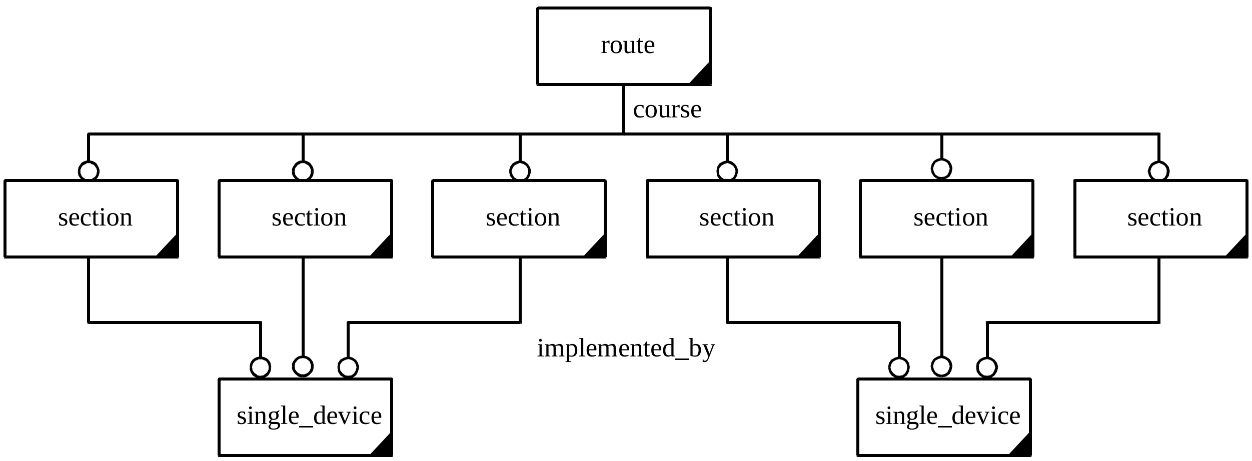

Figure 16 — Attaching devices to routes

A route represents a logical path through a ship. Specific devices may realize this path. The same device may realize several sections of a route.

6 Recommended practices

This clause contains the recommended practices for use of ISO 10303-212:2000 for representing ship product data.

RP 0424-1

Recommendation: Use the physical view to represent the input and output of fault current analysis.

Reason: The resistance and reactance parameters that are required for the fault current analysis are only available during physical design and would not normally be known during functional design.

RP 0424-2

Recommendation: Use a referencing mechanism to communicate the X (reactance) and R (resistance) values of standard components.

Reason: ISO/IEC 10303-212 provides the option of either representing a component internally or referencing it. For standard components, values may be taken from external sources. For example, the resistance and reactance data for all types of electrical components contained in the system are needed for the fault current analysis. Typical of the standard components used in fault current analysis are copper and aluminum cables, aluminum conductor steel reinforced (ACSR) overhead cables, busways, switches, circuit breakers, current and voltage transformers, non-time-delay fuses, and dual-element fuses. External sources can include ISO 13584-compliant parts libraries, as well as paper documents such as Bussmann's manual titled, "A Simple Approach to Short Circuit Current Calculations," the Federal Electric Pacific Catalog, and the GE Industrial Power Systems Data Book.

RP 0424-03

Recommendation: Provide explicit X and R values for non-standard components.

EXAMPLE In Figure A.17, the generator is a non-standard component.

Reason: They cannot be referenced from an external source.

RP 0424-04

Recommendation: Use an instance of the Item_version EDT, along with associated instances of Item for each product.

Reason: Item and Item_version can unambiguously specify a product. For example, the type of circuit breaker can be specified as GE AKRU-50; however, different views of the same product can be realized by the Design_discipline_item_definition EDT. Each view would have one instance of the Design_discipline_item_definition EDT. All of these instances of Design_discipline_item_definition will point to the same Item_version. Typical examples of a view include detailed design, fault current analysis, and breaker sizing.

RP 0424-05

Recommendatation: Apply internationally standardized data element types to support automatic data processing.

RP 0424-06

Recommendation: Identify each "definable object" with a GUID of the form:

0060/<duns-no>//.<local-id>

where <duns-no> is the company's D-U-N-S number, and <local-id> is a string that is unique within the company.

RP 0424-07

Recommendation: Use the host id of the computer concatenated with the date and time as the <local id>. Give the date and time in the "extended" format specified in clause 5.4.1 of ISO 8601:1988. This format is yyyy-mm-ddThh:mm:ss,ffff, where yyyy is the year, mm is the month, dd is the day of the month, hh is the hour, mm is the minute, ss is the second within the minute, and ffff is a decimal fraction of seconds.

RP 0424-08

Recommendation: Copy the parts referenced from a parts library into the ISO/IEC 10303-212 file.

Reason: It is not possible to ensure that the same version of a library is used thoughout the life of the product. For example, during the life span of a ship, there can be many different versions of the library and data exchanges would have to usethe same version of library. If this cannot be ensured, then it is advisable to to copy the information into the data file. Even if the library items require one megabyte of data, it is insignificant compared to the total space used by the design.

Annex A
(Informative)

Users guide

A.1 Technical discussion

This clause provides an overview of ship electrical system (SES) design.

It is useful to recognize five distinct phases of the life cycle of the shipboard electrical system (SES). They are:

— contract and functional design;

— detail design;

— production;

— operation and maintenance;

— disposal.

The contract and functional design phase is typically used to identify a preliminary purchasing bill of material in which purchase specification and long lead-time equipment and components are identified. The functional design data and contract specifications are the basis of acceptance testing, which is done after erection and commissioning. Although the contractual phase comes before the functional design phase, they have been combined for this document into a single phase.

The central concern of the detail design phase is a three-dimensional spatial plan that shows the arrangement of electrical equipment. This is also concerned with the cabling layout. Designers are concerned with the arrangement of equipment and cables in the three-dimensional space to ensure proper assembly and non-interference.

The central concern for the production engineering phase is to define the installation requirements for the equipment, components, cables, and accessories in the electrical systems. Cable information for this phase consists of cut lengths and equipment "hook-up" instructions and specifications. The production engineering function creates and uses the production bill of material view.

The electrical systems product view taken by users in support engineering is mainly that of the functional design, but from the standpoint of defining the support requirements of the product. Such requirements include spare parts complements, maintenance procedures and related documentation, and operational specifications and documentation.

In order to express all the subtleties of a complex system, such as a SES, we must use several different viewpoints (see Table 2). One such set of viewpoints is product-oriented, function-oriented, and location-oriented parts of ISO/IEC 10303-212. The following table provides the correspondence between traditional diagrams and the ISO/IEC 10303-212 classification.

Table 2 — Viewpoints

Viewpoint	Diagrams
Function-oriented diagrams	Function diagrams Circuit diagrams Net list
Location-oriented drawings	Installation drawings Layout drawings
Product-oriented drawings and lists	Bill of material Connection diagram Wiring list

Electrical systems are generally designed through a round-trip engineering process, in which electrical system design evolves gradually through an iterative process of different types of analyses. These analyses often include load analysis, fault current analysis, and voltage drop analysis. Together, these analyses ensure that the system can provide requisite voltage for the satisfactory operation of the load under various operating conditions and that this can be done without overloading the system. Operating conditions include those encountered during various kinds of faults. Later, a method of classifying the operating condition is given. The fault current analysis allows the designer to obtain the maximum and minimum potential fault current in each branch in an electric power distribution system.

For electrical systems in buildings, the primary design guideline in the United States is the National Electric Code (NEC) [7]. IEEE 141-1993 [8] is also applicable. For electrical systems on ships, IEEE 45-1998 [9] and DOD-STD- 2003-2 [10] are applicable.

A.2 Implementation agreements

Figure A.1 shows the table of contents of a typical implementation agreement.

Sample implementation agreements will be added as a separate annex in a future version of this document.

Figure A.1 — Table of contents of implementation agreement

A.3 Use cases

This clause contains a series of use cases for the representation of ship electrical system product model data using ISO/IEC 10303-212. Because the focus is on showing the features of ISO/IEC 10303-212, some of the presentations are incomplete. More details may be found in the accompanying physical files.

Each use case is structured in the following manner:

— The purpose clause provides an overview of the application scenario. This is intended to provide enough detail to determine if there is a need to go further.

— The background clause provides electrical engineering context to the application scenario. This broadly defines the types of concepts and issues that are relevant for the application scenario.

— The data exchange clause provides specific data items that are exchanged in the application scenario.

— The example clause provides a specific example. Every attempt has been made to take examples from the ship community.

— The instance diagram clause provides the instance diagrams for the application scenario as well as a textual description.

A.3.1 One-line diagram

A.3.1.1 Purpose

This clause provides guidance on the use of ISO/IEC 10303-212 for exchanging data used to represent a one-line diagram.

A.3.1.2 Background

The purpose of a one-line diagram is to provide the most important information about a system in a concise manner. In a one-line diagram of a circuit, a single line between two ends represents a transmission line. The circuit is often simplified further by omitting the completed circuit through the neutral return and indicating the components by standard symbols instead of their equivalent circuits.

It is seldom necessary to show all three phases of a circuit diagram when conveying the most detailed information about a three-phase system. In fact, a complete diagram is more likely to hide than to clarify the information one may be seeking from the viewpoint of the system. Because a balanced three-phase system in which each phase has the same load is always analyzed as a single-phase system circuit composed of one of the three lines and a neutral return, it is unnecessary to show more than one phase and the neutral return when drawing a circuit diagram. This argument is true for human interpretation, as well as for data exchange between computer applications. Limiting the transferred data to only one phase for the balanced system can contain thefile size or the amount ofdata.

The importance of the different features of a system varies with the problem under consideration; thus, the amount of information about the system included in the one-line diagram varies according to the problem. For example, the location of circuit breakers and relays is insignificant when performing a load study. Breakers and relays are not shown in a one-line diagram if the primary purpose of the diagram is to provide information for a load study. On the other hand, determination of the stability of a system under transient conditions resulting from a fault depends on the speed with which the relays and circuit breakers operate to isolate the faulted part of the system. Information about the circuit breakers, therefore, is extremely important. One-line diagrams may include information about existing and potential transformers that connect relays to the system or that are installed for metering. The amount of information about the system included in the one-line diagram also varies according to the practice of the particular company preparing it.

A.3.1.3 Data exchange

This clause will be supplied in a later version of this document.

A.3.1.4 Example

Figure A.2 shows a one-line diagram of a small portion of a ship electrical system. This system consists of nine components that connect the generator to the load through a network of cables, buses, and switches.

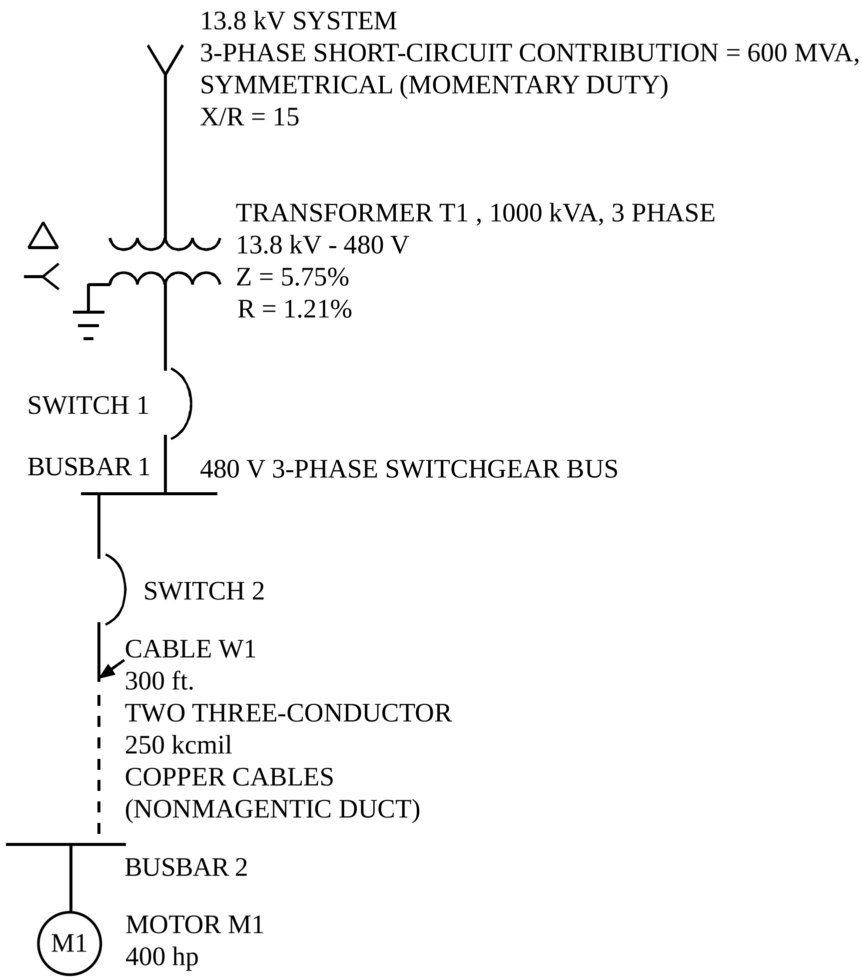

Figure A.2 — One-line diagram

A.3.1.5 Instance diagram

A.3.1.5.1 Specifying the system

An instance of the Item EDT is used to represent a thing that is produced or intended to be produced, set up, designed, and installed in an electrotechnical system.

NOTE See clause 5.1.1 for a discussion of entities related to Item.

Figure A.3 shows the instances that represent information about the system. The system and generator are both represented by instances (#10, #11) of the Item EDT, which references an instance (#40) of the Item_identification EDT. Different instances (#12, #13, #14, #15, #16, #17, #18, and #19) of the Item EDT are used to represent the transformer, busbar 1, switch 1, switch 2, cable, busbar 2, motor, and ground.

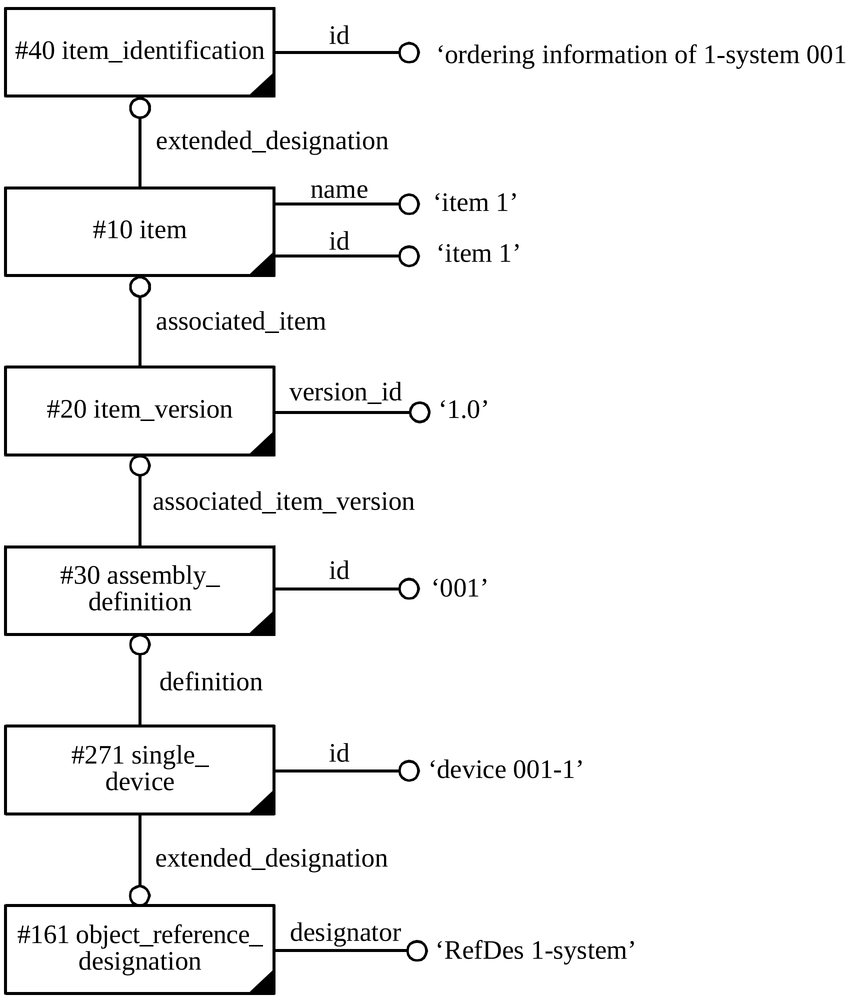

Figure A.3 — Specifying the system

Engineers generally do not consider a ground as a device. Nonetheless, in ISO/IEC 10303-212, a ground is represented by an instance of the Device EDT because it is part of the system. Representing a ground as a device allows ISO/IEC 10303-212 to use the same mechanisms for specifying connectivity of the ground as would be used to specify the connectivity between physical devices. The ground is represented by an instance (#361) of the Single_device EDT.

The system and all of its components, as well as the typical nature of all of the objects in the example, are represented by instances of the Item_version, Item, and Item_identification EDTs. Item_identification information can also be used for procurement and ordering**.**

NOTE See clause 5.1.1 for a discussion of entities related to Item.

The Item_identification EDT contains a string that identifies an Item EDT. In the example, the system and its components are all identified through the instances of the Item_identification EDT. The system is represented by an instance (#10) of the Item EDT, which references instance (#40) of the Item_identification EDT. The ordering information of the system is also contained in the same instance (#40) of the Item_identification EDT that identifies the other item. The system components are all identified through instances of the Item_identification EDT. The "id" attribute of the Item_identification EDT can also be used as the ordering information to purchase components. Different instances (#2, #3, #4, #5, #6, #7, #8, and #9) of the Item_identification EDT are used to represent the identification information about the transformer, busbar 1, switch 1, switch 2, cable, busbar 2, motor, and ground.

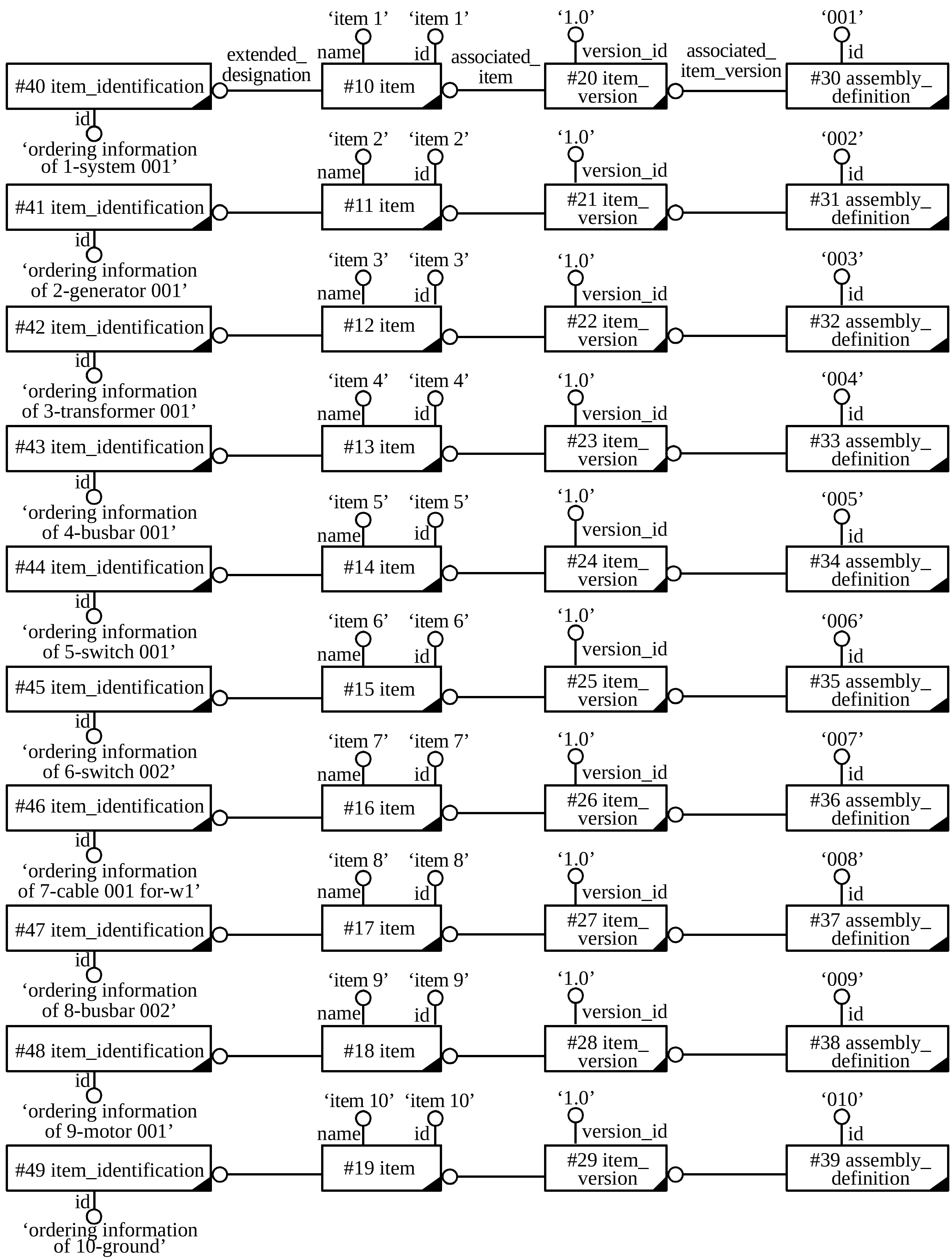

Figure A.4 — Specifying components and system

An Item_version is a variant of an associated Item. The version for the system is represented by an instance (#20) of the Item_version EDT, which references the instance (#10) of the Item EDT. Similarly, the generator is represented by an instance (#11) of the Item EDT (see Figure A.4). The version of the generator is represented by an instance (#21) of the Item_version EDT, which references the instance (#11) of the Item EDT. Different instances (#22 and #23) of the Item_version EDT are used to represent the transformer and busbar 1. Similarly, instances of the Item_version EDT exist for switch 1, switch 2, cable, busbar 2, motor, and ground.

The Assembly_definition EDT is used to define an Item_version in terms of subordinate Item_version objects. The system, generator, transformer, and busbar 1 are represented by instances (#30, #31, #32, and #33, respectively), of the Assembly_definition EDT. Similarly, instances of the Assembly_definition EDT exist for switch 1, switch 2, cable, busbar 2, motor, and ground.

The combination of the Item_version, Item, and Item_identification EDTs defines the typical characteristics of a component, and instances of the Single_device EDT correspond to the placement of components with these typical characteristics within a design. Each of the nine components has its corresponding instance of the Single_device EDT. The system, generator, transformer, and busbar 1 are represented by instances (#271, #281, #291, and #301, respectively) of the Single_device EDT. Similarly, instances of the Single_device EDT exist for switch 1, switch 2, cable, busbar 2, motor, and ground.

An instance of Item EDT is used to provide the typical nature of an item. The item is identified by an instance of the Item_identification EDT that is referenced by the instance of Item EDT, where the instance of Item EDT is the instance that represents the item. While the Item_identification EDT identifies the item, the Object_reference_designation EDT identifies the device.

The system and its components have their corresponding instances of the Object_reference_designation EDT. The system, generator, and transformer are represented by instances #161, #163, and #165, respectively, of the Object_reference_designation EDT. Similarly, instances of the Object_reference_designation EDT exist for busbar 1, switch 1, switch 2, cable, busbar 2, motor, and ground.

A.3.1.5.2 Specifying the structure of the system

Figure A.5 is the instance diagram showing how the system comprises these nine components. The Next_higher_assembly EDT is used to represent the relationship between the assembly and its constituent. The "related" attribute of the Next_higher_assembly EDT specifies a constituent of an assembly, and the "relating" attribute specifies the immediate parent assembly of the constituent. The example uses the Next_higher_assembly EDT to define the composition of the system.

The generator and transformer are defined as constituents of the system by instances (#779 and #780, respectively), of the Next_higher_assembly EDT. Similarly, different instances of the Next_higher_assembly EDT represent busbar 1, busbar 2, switch 1, switch 2, cable, motor, and ground. All of the instances of the Next_higher_assembly EDT corresponding to the components refer to the same instance (#30) of the Assembly_definition EDT.

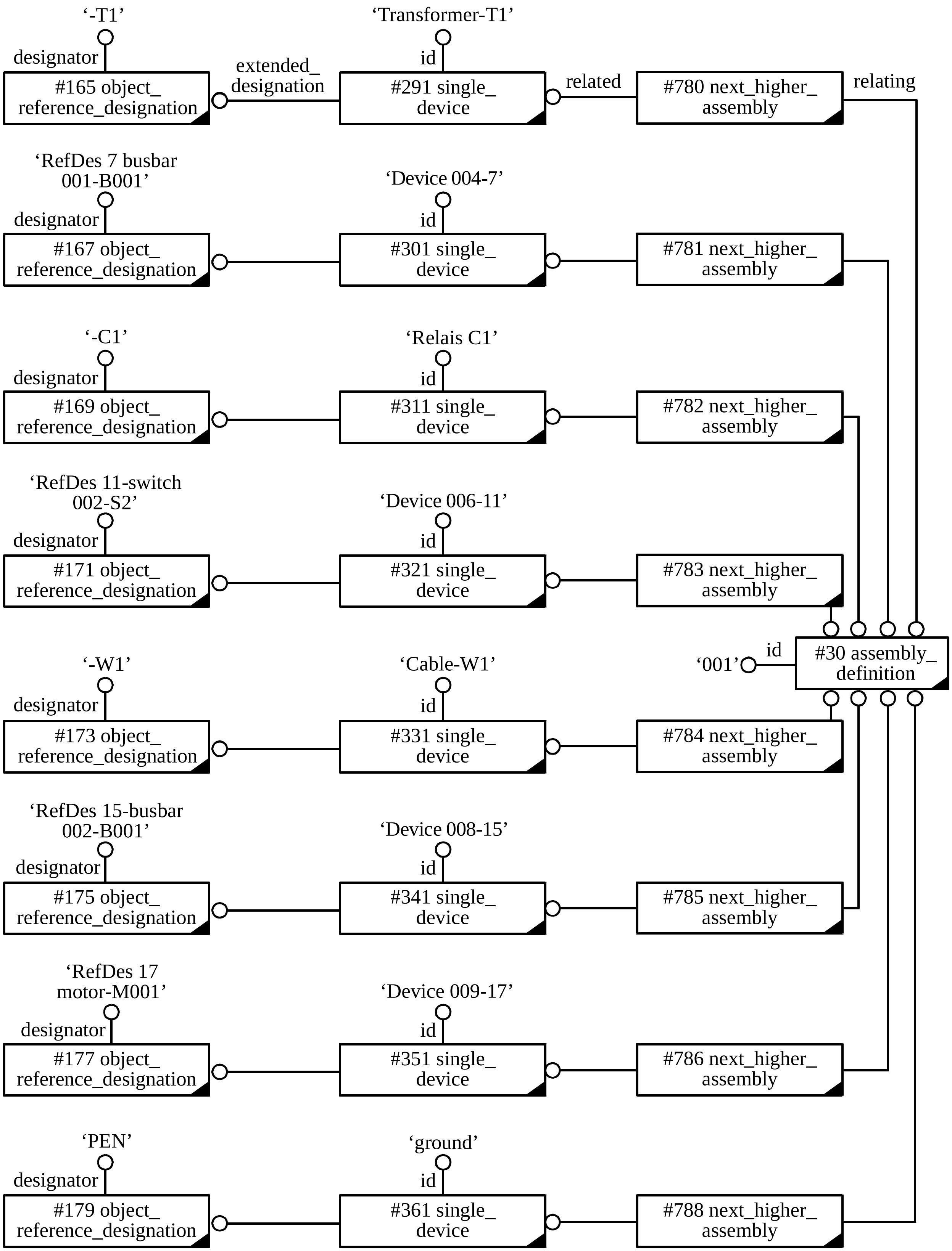

Figure A.5 — Specifying the structure of the system

A.3.1.5.3 Specifying the connectivity

Figure A.6 shows how ISO/IEC 10303-212 represents components that are connected to form a system. These components have associated terminals that are represented by the Interface_terminal EDT. The generator, motor, and ground have one terminal each.

NOTE The access points of the devices are represented by the instances of Terminal EDT. The connection between devices is represented by an instance of the Connection EDT. A Connection connects Terminals.

Labels are attached to the terminals for identification. These terminal designations are also incorporated into the model through the instances of the Terminal_designation EDT.

Terminals serve as access points for the devices. These devices are connected to form a system. The association between two or more instances of the Terminal EDT is represented by an instance of the Connection EDT. The system in the example has a connection between the generator and the transformer, which is represented by an instance (#363) of the Connection EDT. Another connection is made between the transformer and busbar 1, represented by another instance (#364) of the Connection EDT.

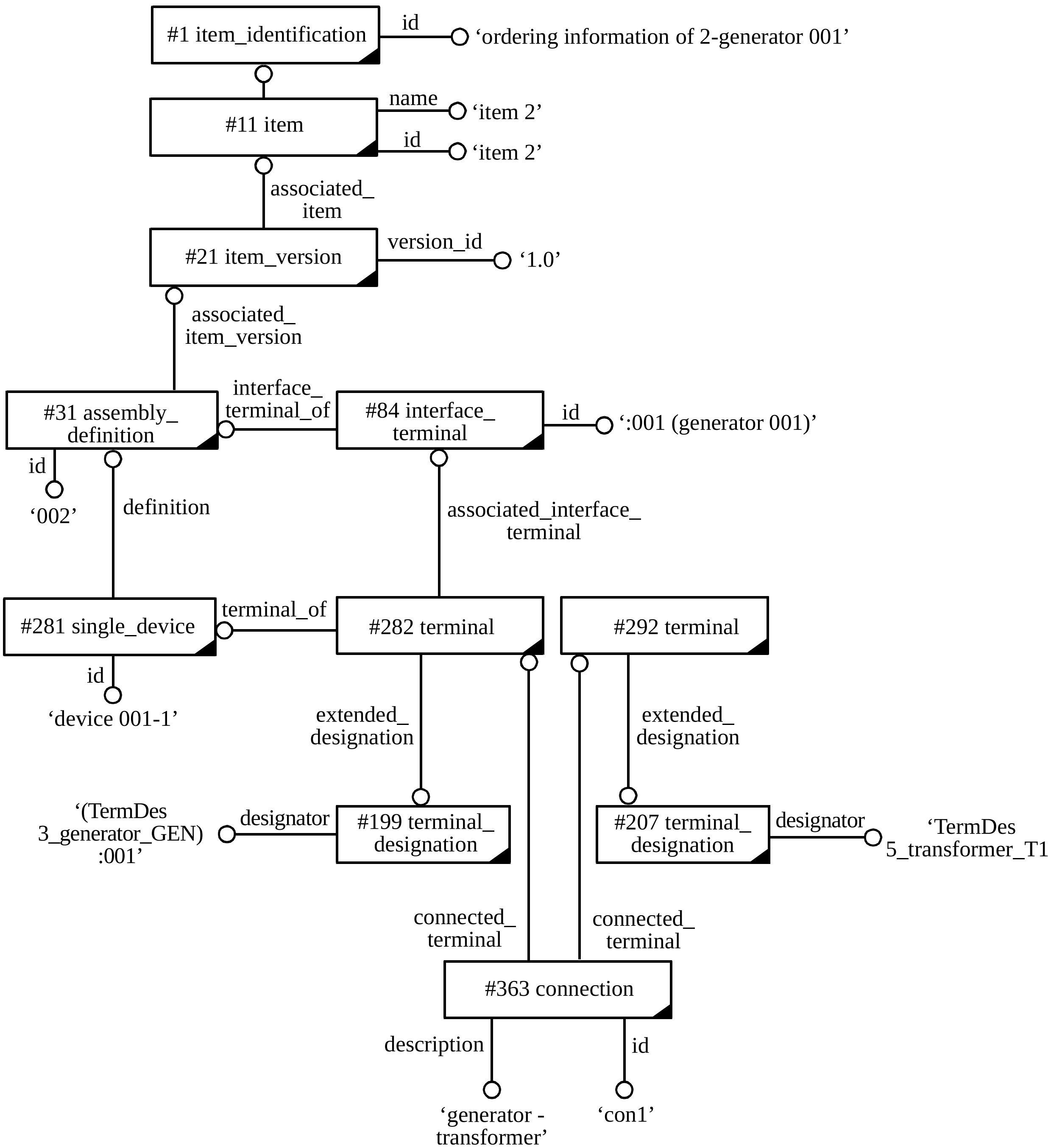

Figure A.6 — Specifying the connectivity

The terminal corresponding to instance #282 belongs to the generator, and the terminal corresponding to instance #292 belongs to the transformer. Fault F1 is represented by an instance (#371) of the Connection EDT, which provides the connection to the ground.

An instance (#363) of the Connection EDT establishes the connection between the generator and the transformer by connecting the terminal bundle corresponding to instance #282 with the terminal bundle corresponding to instance #292.

A.3.1.5.4 Classifying the connections

Figure A.21 shows the classification hierarchy of connections under normal and fault conditions. The instance diagram is shown in Figure A.7. The root of the connection classification hierarchy is represented by an instance (#379) of the General_classification EDT, and the root of the fault classification hierarchy is represented by an instance (#374) of the General_classification EDT. The type of fault F1 is represented by an instance (#375) of the General_classification EDT. The relationship of fault F1 to other types of faults is represented by an instance (#399) of the Classification_association EDT. Through this relationship entity, the classification information is assigned to the connection.

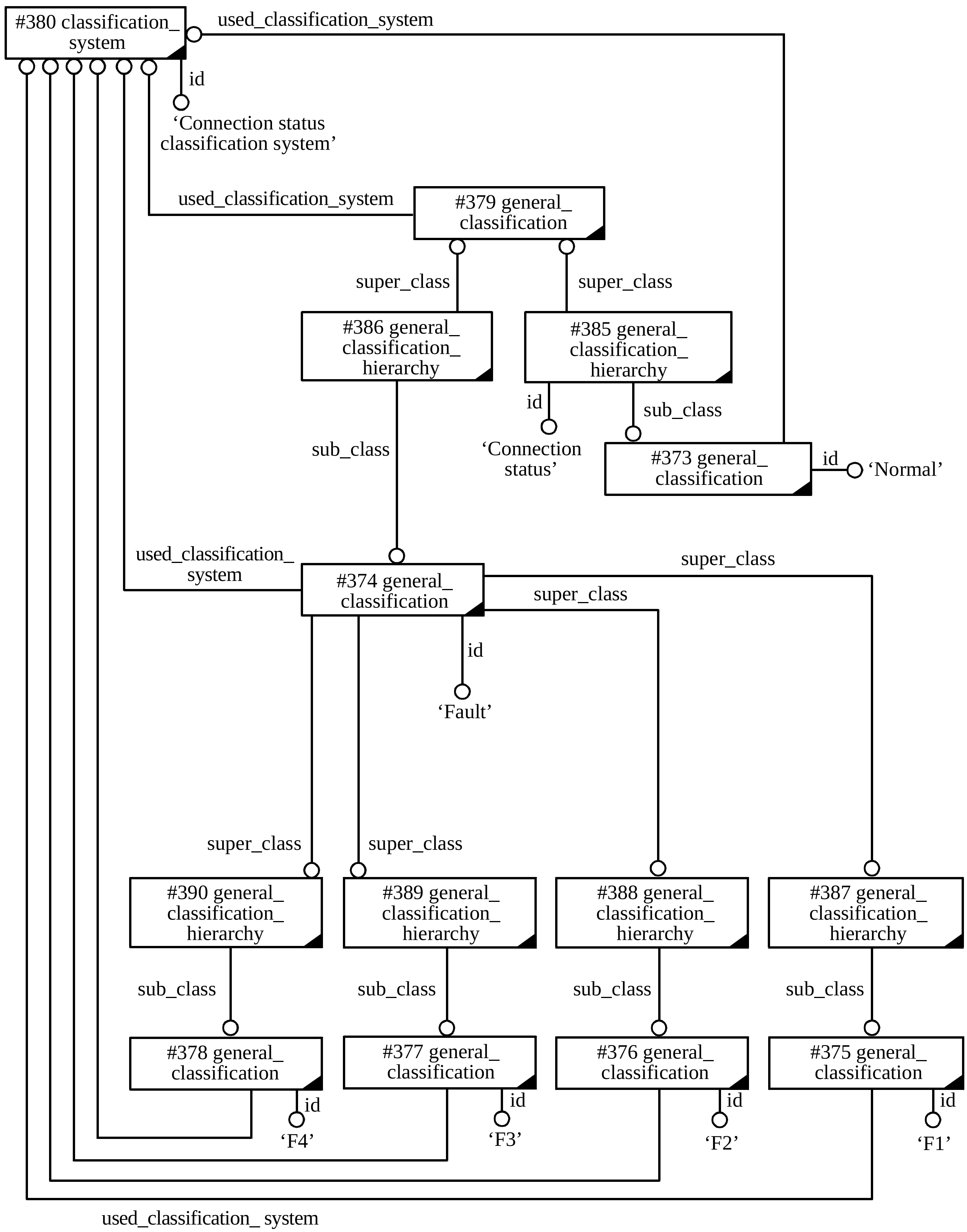

Figure A.7 — Classifying the connections

A.3.1.5.5 Specifying additional information in an external document

In some cases, additional information that ISO/IEC 10303-212 cannot represent needs to be specified. For example, the specification of algorithms and mathematical models cannot easily be represented in ISO/IEC 10303-212. Therefore, ISO/IEC 10303-212 has a mechanism for referencing an external document. This is also useful when including the complete information from an external source is inefficient. For example, an external source can be another standard. In this case, a reference to the external source would suffice rather than repeating the definition in ISO/IEC 10303-212 or an exchange file. ISO/IEC 10303-212 provides a mechanism to associate a document with an instance of the Single_device EDT. This document can be used to provide additional information about the device.

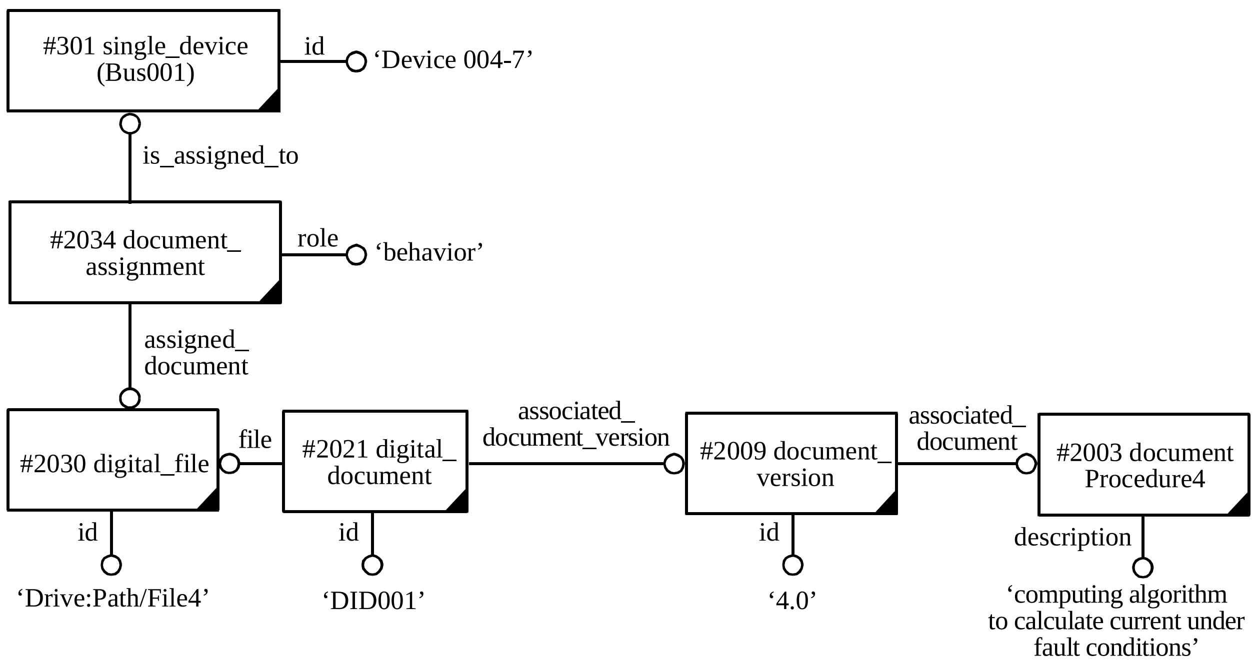

Figure A.8 — Specifying additional information in an external document

In the example, busbar 1 has an external source of information, a document containing additional information. The external document provides a behavioral model of the bus under different operating conditions. Typical operating conditions are normal operation and operation under fault. As shown in Figure A.8, Busbar 1 is represented by an instance (#301) of the Single_device EDT.

An electronic file is associated with instance (#301) that represents busbar 1. The electronic file is represented by an instance (#2030) of the Digital_file EDT. The relationship between the electronic file and busbar 1 is represented by an instance (#2034) of the Document_assignment EDT; thus, through instance (#2034), the electronic file is assigned to busbar 1. The Document_assignment EDT has an attribute that defines the role of an assigned document. In the example, the role is "behavior." The electronic file is considered to be a document in digital form; therefore, it is represented by an instance (#2021) of the Digital_document EDT. The version of the document is represented by an instance (#2009) of the Document_version EDT. The versioned document is represented by an instance (#2003) of the Document EDT. Through instances of the Document_component EDT (#2030), the Document_representation EDT (#2021), the Document_version EDT (#2009), and the Document EDT (#2003), the reference to the electronic file is completely specified.

A.3.2 Load analysis

A.3.2.1 Purpose

This clause specifies the use of ISO/IEC 10303-212 for representing load analysis data. The purpose of load analysis is to determine the aggregate power requirements of all electric power-consuming devices. This type of analysis is conducted using worst-case scenarios to determine maximum and minimum power requirements under various ship operating conditions. The maximum power summary is used to establish the generating plant capacity and power plant configuration, and the minimum power summary is used for loading diesel engine prime movers in order to avoid excessive maintenance required when diesel engines are operated at light loads for long periods of time.

A.3.2.2 Background

Load analysis determines the voltage, current, power, and power factor at various points in an electrical network under existing or contemplated conditions of normal operation. Load analysis is essential in planning the future development of the system because satisfactory operation of the system depends on knowledge about the effects of interconnections of various system components. Load analysis uses different service factors to account for the variability of the load. Service factors typically consist of a load component and a cycle component. The load component is the ratio of the actual load when energized under a particular operating condition. For example, a motor running at a lower speed or a pump operating below its rated delivery would be characterized by a service factor. The cycle component reflects the percentage of time a piece of equipment operates during the total timeframe of an operating condition. Often, a single service factor is used to represent both of these components. Equipment that is operated occasionally under abnormal conditions only is assumed to have a service factor of zero. In most cases, these service factors are selected from an empirical database. In other cases, however, the factors for major loads must be determined analytically based on specific operating scenarios.

A.3.2.3 Data exchange

This clause summarizes the ISO/IEC 10303-212 concepts and entities used to represent the input and output data for load analysis (see Table 3). The hierarchical decomposition of the system produces theinput data for the load analysis. At the lowest level are components with user-defined attributes for maximum and minimum power requirements at various operating conditions. The output data for the load analysis reflect the same hierarchy with the aggregate power requirements attributes attached to each nonleaf node above the lowest level in the hierarchy. The example shows the representation of the output and input data.

Table 3 — Concepts and entities used in load analysis

Concept	Entity
Item	Item Item_identification Item_version
Assembly	Assembly_definition Next_higher_assembly
Classification	General_classification Classification_association General_classification_hierarchy Classification_system
Data element	Data_element_association Data_element_definition Data_element_specification User_defined_data_element
Value	Single_value Numerical_value
Device	Single_device
Designation	Object_reference_designation

A.3.2.4 Example

The example consists of a simplified shipboard electrical system that is composed of two subsystems: a propulsion auxiliary subsystem and a ship service auxiliary subsystem. Two load groups correspond to these two subsystems. The load analysis data for the two load groups are given in Table 4.

Table 4 — Load analysis data

Load group	Shore	Anchor	Cruise
propulsion auxiliary	12.1 kW	736.6 kW	1492.3 kW
ship service auxiliary	73.1 kW	128.7 kW	107.2 kW
Totals	991.8 kW	2019.8 kW	2775.9 kW

The propulsion auxiliary load group contains three pump motors, which are designated as "nncnds pump port outbd," "nncnds pump port insd," and "nncnds pump port outbd." Table 5 provides a breakdown of the propulsion auxiliary load group only.

Table 5 — Breakdown of the propulsion auxiliary load group

Load Group	Amp	Power	Volt	Max total	Shore		Anchor		Cruise	
PROPULSION AUX	KW	HP	EFF	KW	Fac-tor	KW	Fac-tor	KW	Fac-tor	KW
nn cnds pump port outbd	0.0	125.00	0.95	98.2	0	0.0	90	88.3	90	88.3
nn cnds pump port insd	0.0	125.00	0.95	98.2	0	0.0	0	0.0	0	0.0
nn cnds pump stbd outbd	0.0	125.00	0.95	98.2	0	0.0	90	88.3	90	88.3

A.3.2.5 Instance diagram

A.3.2.5.1 Specifying the system

Figure A.9 shows how the specification of the system and its two subsystems is represented by an instance of the Item EDT, which provides the typical characteristics of the system. The typical nature of the propulsion system is provided by an instance (#12) of the Item EDT, and the identification of this system is represented an instance (#2) of the Item_identification EDT. The item can have many versions. The specific version that is used by the system under consideration is represented by an instance (#22) of the Item_version EDT. The Item EDT provides the typical nature of the object, and the Single_device EDT represents the object itself. The propulsion system is represented by an instance (#272) of the Single_device EDT. The Item_idenitification EDT provides the identity for the product type, and the Object_reference_designation EDT provides the identity for the product. The propulsion system is designated as "device 3." This is represented by an instance (#162) of the Object_reference_designation EDT. The remaining objects in the example have a similar representation.

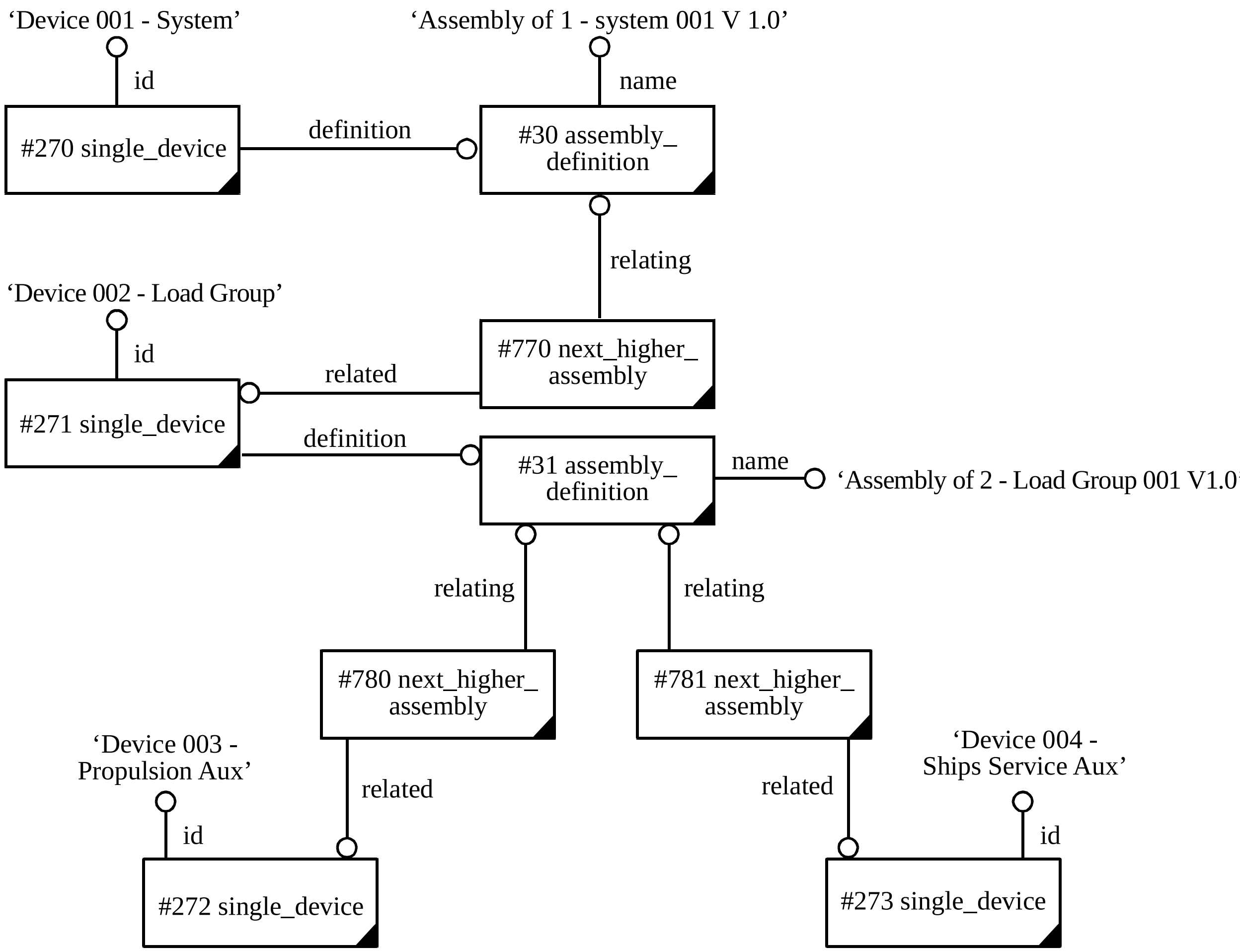

Figure A.9 — Specifying the system

The composition of the system is provided by the Assembly_definition and Next_higher_assembly EDTs. The Next_higher_assembly EDT represents the parent-child relationship in the composition hierarchy. The system is a parent object that has two children, the propulsion and auxiliary systems. Both of these subsystems are represented as constituents of the system by instances (#780, #781) of the Next_higher_assembly EDT.

A.3.2.5.2 Specifying the operating condition

Figure A.10 shows the representation of a classification system of the three ship operating conditions defined in Table 4. These conditions are designated as "shore," "anchor," and "cruise." The classification system, referred to as the "load analysis status classification system," is represented by an instance (#380) of the Classification_system EDT. The "id" attribute of the Classification_system EDT has the string value of "load analysis status classification system."

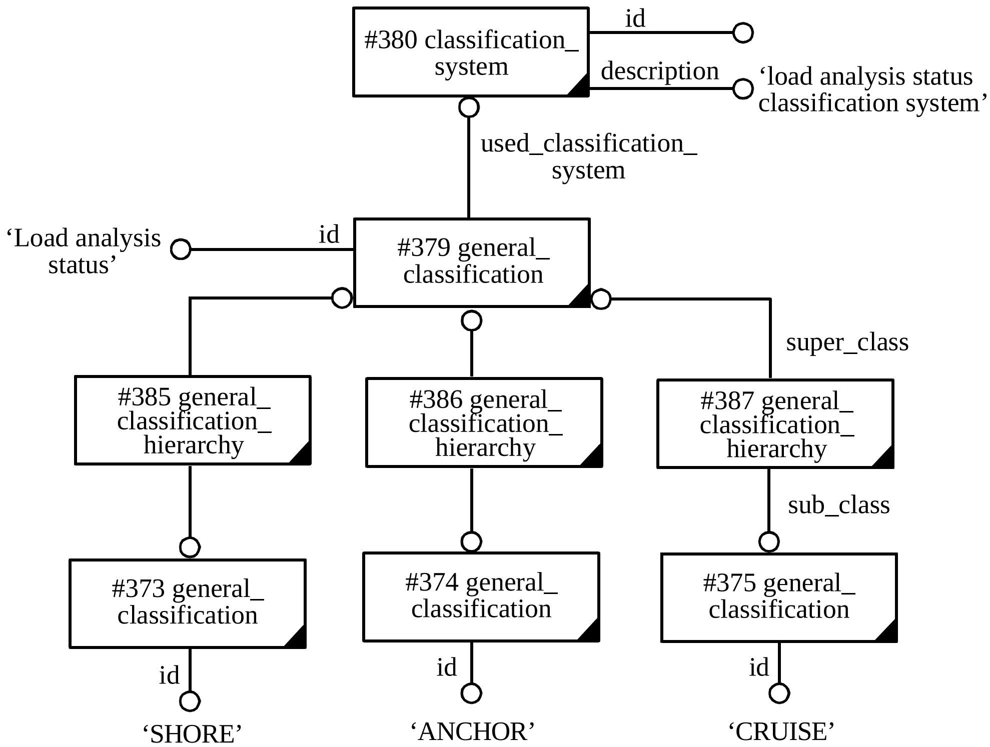

Figure A.10 — Specifying the operating condition

A classification contains classes that are represented by instances of the General_classification EDT. These classes are hierarchically related in a tree structure. The nodes of the tree structure are the classes, represented by the instances of the General_classification EDT, and the branches of the tree are built by the instances of the General_classification_hierarchy EDT. An instance of the General_classification_hierarchy EDT relates a higher-level class to a lower-level class; thus, an instance of the General_classification_hierarchy EDT creates a parent-child relationship between two instances of the General_classification EDT.

The "load analysis status classification system" is composed of four classes—one root class and three children. The root class, represented by an instance (#379) of the General_classification EDT, designates the root class for ship operating conditions. An instance (#385) of the General_classification_hierarchy EDT establishes the association between the parent class to the child class, as represented by instances #379 and #373, respectively.

An instance (#373) of the General_classification EDT represents the class for the "SHORE" operating condition. Another instance (#374) represents the class for the "ANCHOR" operating condition, and instance #375 represents the class for the "CRUISE" operating condition.

An instance (#385) of the General_classification_hierarchy EDT relates the instance (#373) of the General_classification EDT representing the class for the "ANCHOR" operating to the instance (#379) of the General_classification EDT representing the root class of ship operating conditions.

An instance (#386) of the General_classification_hierarchy EDT relates the instance (#374) of the General_classification EDT representing the class for the "ANCHOR" operating to the instance (#379) of the General_classification EDT representing the root class of ship operating conditions.

An instance (#387) of the General_classification hierarchy EDT relates the instance(#375) of the General_classification EDT representing the class for the "CRUISE" operating condition to the instance (#379) of the General_classification EDT representing the root class of ship operating conditions.

A.3.2.5.3 Specifying the propulsion auxiliary system

The propulsion auxiliary system consists of three pump motors, which are designated as “nncnds pump port outbd,” “nncnds pump port insd,” and “nncnds pump port outbd.” Figure A.11 shows how the load factors for the various operating conditions can be specified. Consider the representation of the maximum total kW of the motor labeled, “nn cnds pump port outbd.” ISO/IEC 10303-212 does not have an EDT to represent the maximum total kW of the motor; rather, an instance (#1034) of the User_defined_data_element EDT is used to define this data element. While at shore, total Kw needed by the motor is 0. The general_classification EDT enables classification based on operating condition of the ship namely “Shore, Anchor, or Cruise.” This classification is associated to the load factor of the motors at the operating condition mentioned above via classification association EDT. The load factor is represented by user-defined_data_element EDT. The value of maximum total kW, 0kW, is represented by an instance (#1032) of the Numerical_value EDT. Measured in kilowatts, the numerical value for this parameter is 0. An instance (#1032) of the Numerical_value EDT is referenced by instance (#1033) of the Single_value EDT. This instance of Single_value is, in turn, referenced by an instance (#1034) of the User_defined_data_element EDT. Similarly, the operating condition of Anchor and Cruise is also represented in Figure A.11.

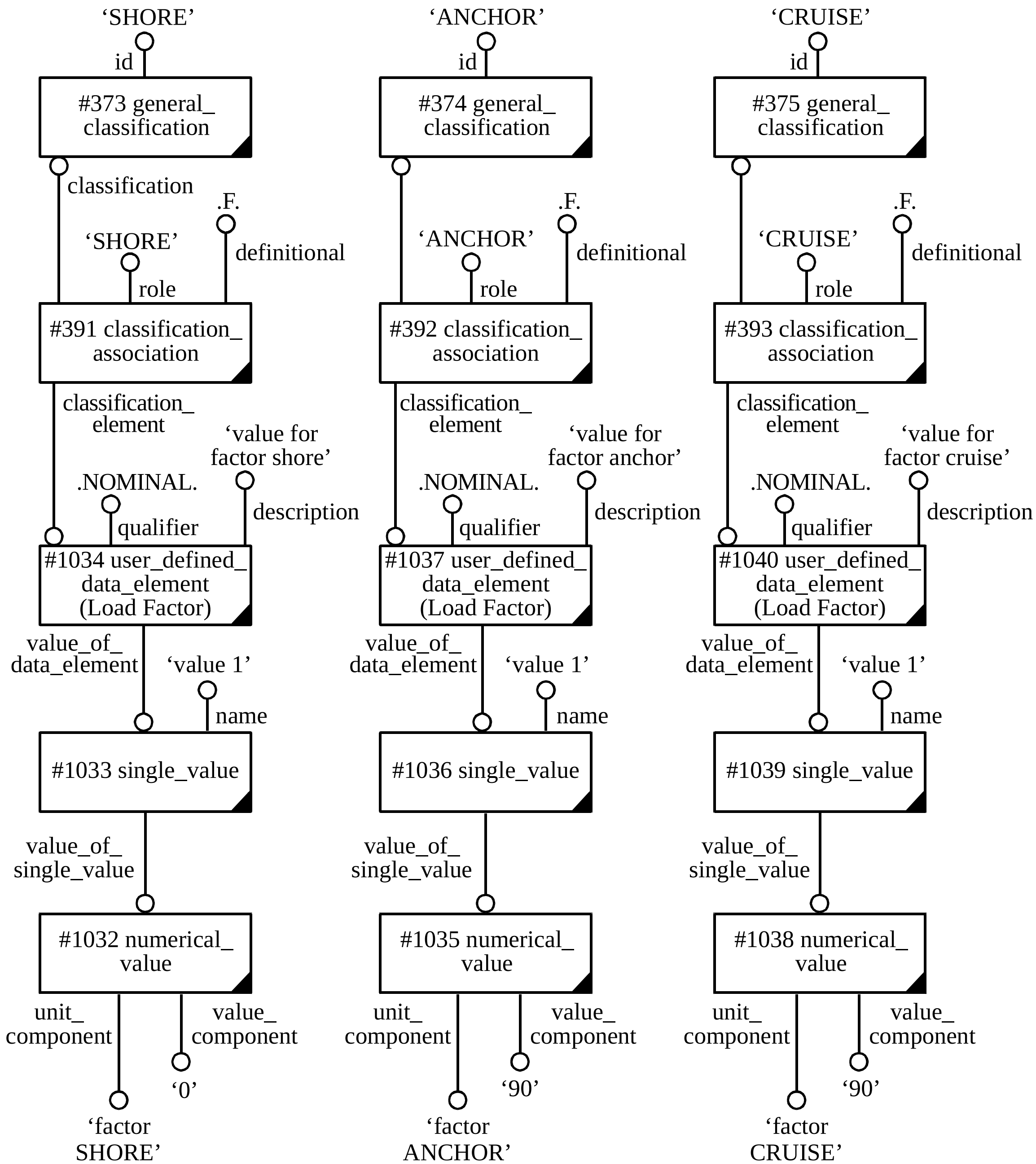

Figure A.11 — Associating load factor with classification system

Thus far, the representation of the maximum total parameter for the "nn cnds pump port outbd" motor has been considered. As shown in Figure A.12, the power of the motor is represented by an instance (#1023) of the Numerical_value EDT, which, in turn, is referenced by an instance (#1024) of the Single_value EDT. This instance of Single_value is further referenced by an instance (#1025) of the User_defined_data_element EDT. The definition of the user-defined data element is provided by an instance (#1001) of the Data_element_definition EDT. Finally, the specification of the user-defined data element is provided by an instance (#1011) of the Data_element_specification EDT. The user-defined data element is associated with the “nn cnds pump port outbd” motor through instance #1063 of the Data_element_-association EDT.

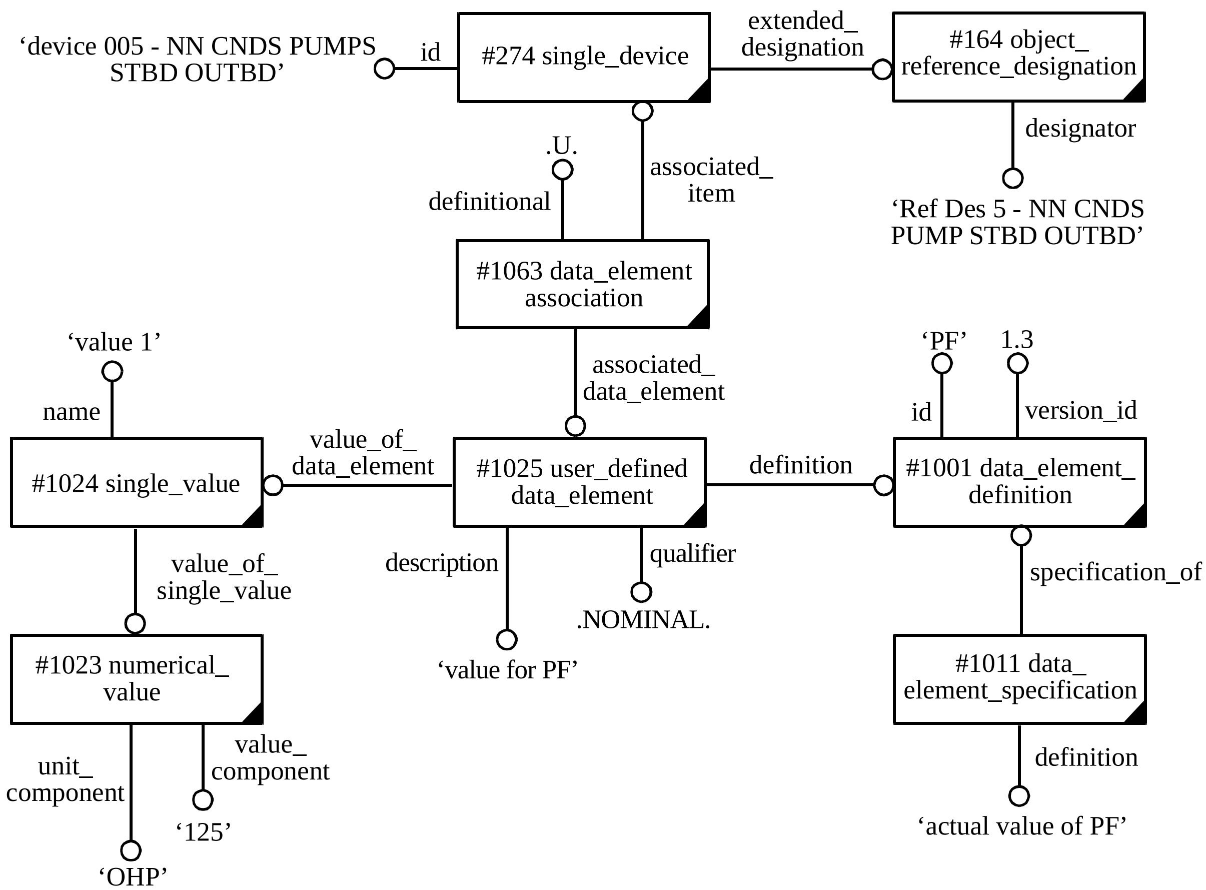

Figure A.12 — Associating data element with device

Corresponding explanations are applicable for amps, power, max total, factor shore, factor anchor, and factor cruise. Similar instances can also be used to specify the parameters for the "nn cnds pump port insd" and "nn cnds pump stbd outbd" motors.

A.3.3 Voltage drop analysis

A.3.3.1 Purpose

This clause specifies the use of ISO/IEC 10303-212 to represent information about voltage drop analysis of an electrical power distribution system. Voltage drop analysis is conducted to ensure that all system components are supplied with satisfactory voltage under operating conditions.

A.3.3.2 Background

Voltage drop analysis allows a designer to obtain the voltage drop at each node (bus) in an electrical power distribution system. This type of analysis generally uses the percent method of voltage drop calculation as described in [11]. Voltage drop values are calculated on a "per-segment" and "cumulative" basis and then expressed as a percentage of the source voltage and as an absolute voltage drop in volts. The nominal and actual voltages occurring at each point in the network are also given. Through voltage drop analysis, one can easily account for voltage transformers, single- and three-phase systems, and frequencies of 50 or 60 Hz.

Voltage drop calculation across cables makes use of voltage drop factors. For example, the voltage drop factor is 0.28 for copper conductors in a magnetic conduit when the lagging load power factor is 1.00 and the wire size is 1000 AWG. This factor is valid for a three-phase, line-to-line voltage drop for a 600 V single-conductor cable per 10,000 amperes-feet, at 60 degrees centigrade, and 60 Hz.

A.3.3.3 Data exchange

Table 6 shows the main concepts and ISO/IEC 10303-212 ARM-level entities that are used in the example. Two important concepts of data exchange in this example include the data element (see clause 7.2) and voltage drop parameters. The User_defined_data_element, Data_element_definition, Data_element_specification, and Data_element_relationship EDTs facilitate the exchange of voltage drop parameters.

Table 6 — Concepts and entities used

Concepts	Entities
Item	Item Item_identification Item_version
Assembly	Assembly_definition Next_higher_assembly
Device	Single_device Object_reference_designation
Data_element	Data_element_association Data_element_definition Data_element_specification User_defined_data_element
Value	Numerical_value Single_value
Connection	Interface_terminal Terminal_designation Terminal Connection

A.3.3.4 Example

Figure A.13 shows a simple electrical system consisting of five motors that are connected by cables. This example considers the cable voltage drops; it does not cover the dynamic voltage drops that may arise, for example, from the switching of motors. The voltage drops across the cables can be calculated if the voltage at both terminals is known. The example specifies the voltage at the terminal. The factor, as shown in Figure A.13, provides the voltage drop factor of the cable that is used to calculate the voltage drop.

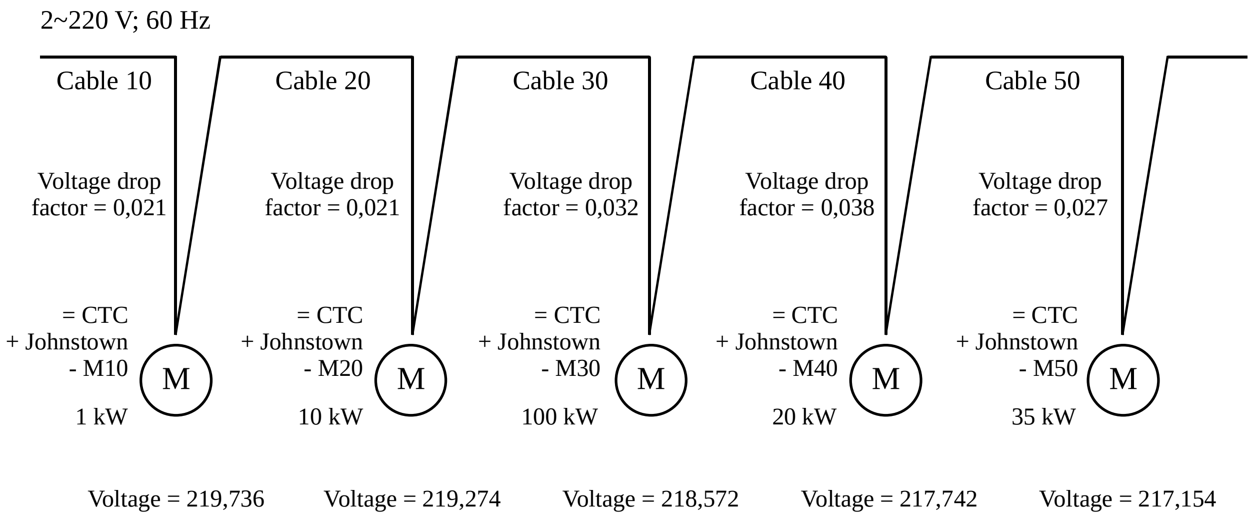

Figure A.13 — Simple electrical system

A.3.3.5 Instance diagram

A.3.3.5.1 Specifying the system

The instance diagram for the system specification (Figure A.14) is similar to that of the one-line diagram (see clause A.3.1.5). The system and its components are represented by instances of the Single_device EDT, the devices are identified by instances of the Object_reference_designation EDT, and the composition of the system is represented by an instance of the Next_higher_assembly EDT. All of the devices have their corresponding instances of the Item_version, Item, and Item_identification EDTs.

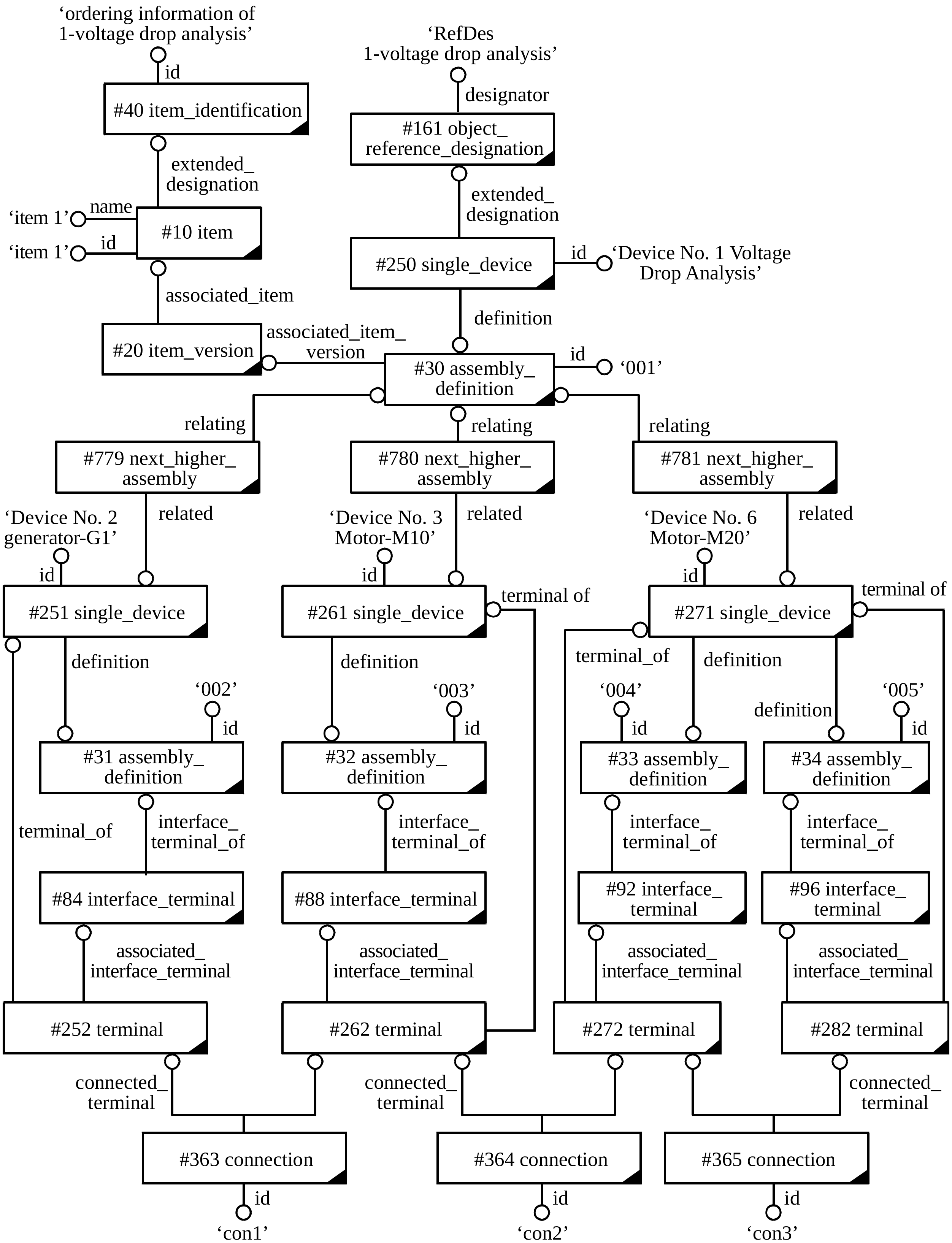

Figure A.14 — Specifying the system

An item is identified by an instance of the Item_identification EDT. An item can have many versions. The Item_identification EDT can be used to specify the component in the purchase request. All devices that can be connected to the network have terminals, which are represented by the Terminal EDT.

EXAMPLE A three-phase transformer system may consist of three delta-connected terminals or four Y-connected terminals. These would be used together and could, therefore, be represented by an instance of the Terminal EDT. The terminal provides the access points for the devices.

A terminal of one device is connected to a terminal of another. A system may have many terminal-to-terminal connections. The connection between these terminal bundles is represented by an instance of the Connection bundle EDT.

A.3.3.5.2 Specifying the voltage and factor

In Figure A.15, a user-defined data element represents the voltage at a given terminal. ISO/IEC 10303-212 provides a User_defined_data_element EDT to represent characteristics that are not coded as application objects. There are two types of data elements in ISO/IEC 10303-212; predefined and user-defined data elements. Because no predefined data element for representing voltage or voltage drop exists, the example uses the User_defined_data_element EDT. An instance (#3049) of the User_defined_data_element EDT represents the voltage at the terminal of motor 10. This terminal is represented by an instance (#262) of the Terminal EDT.

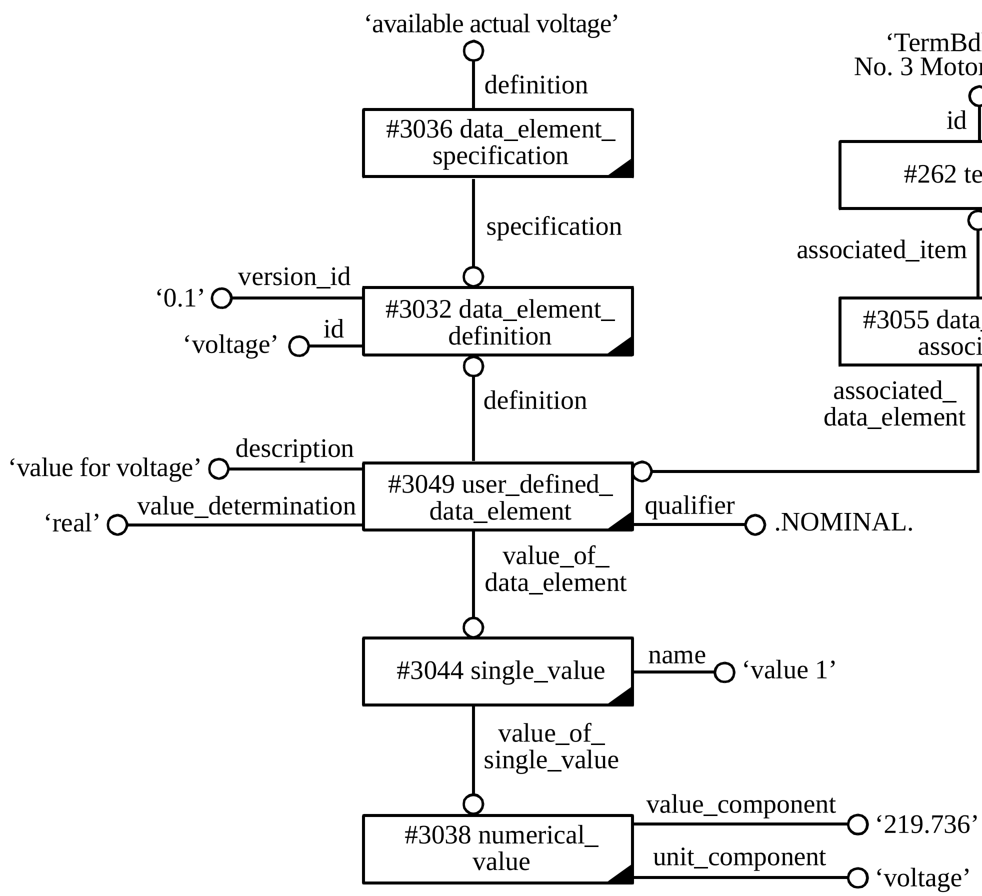

Figure A.15 — Specifying voltage

Instances of the User_defined_data_element EDT can provide properties for instances that are represented by many EDTs in ISO/IEC 10303-212. The Data_element_select SELECT type provides the list of EDTs whose instances can be associated with the instances of the User_defined_data_element EDT. The Data_element_association EDT provides the mechanism to relate the property to the object or component. The property is represented by an instance of User_defined_data_element EDT. An instance of the Data_element_association EDT relates an instance of the User_defined_data_element EDT to the instance that represents the object for which the property is being defined. The instance representing the object is an instance of an EDT that is selected from the Data_element_select group.

A Data_element_association EDT associates an item with a Data_element through the "associated_item" and "associated_data_element" attributes. An instance (#3055) of the Data_element_association EDT associates the "voltage" property with the terminal. The definition of the voltage property is provided by an instance (#3032) of the Data_element_definition EDT.

The Data_element_specification EDT, in turn, provides a description of the Data_element_definition EDT, specifying the meaning of the associated Data_element in human-interpretable language. An instance of the Data_element_definition EDT provides information to define the data element. An instance (#3036) of the Data_element_ specification EDT provides the specification for the property, the numerical value for which is provided by an instance of the Numerical_value EDT. The Numerical_value EDT has two attributes—value_component and unit_component, which specify the magnitude of the quantity being measured and the units of measurement, respectively. Instance #3038 shows a 219.736 voltage at the terminal of motor 10.

The voltage drop factor is specified similarly to the voltage (see Figure A.16).

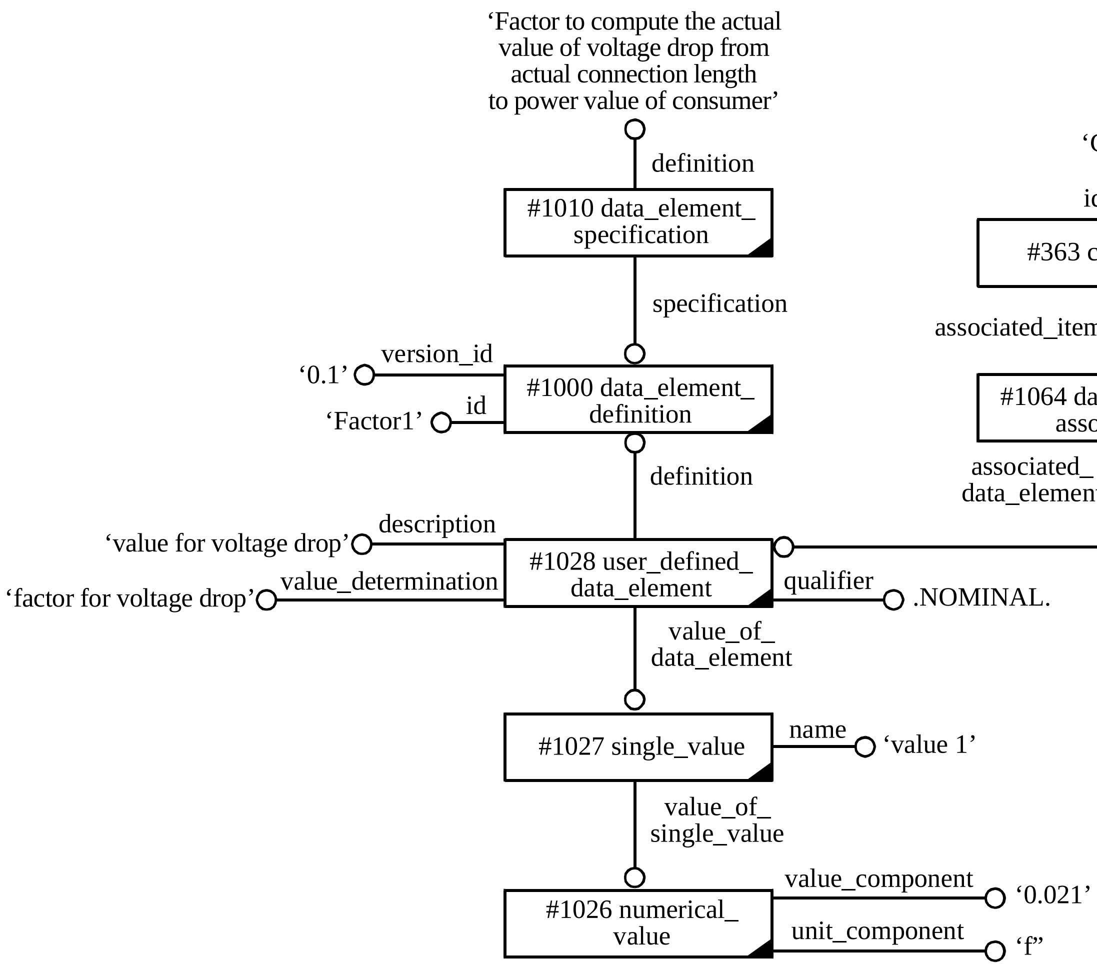

Figure A.16 — Specifying voltage drop factor

A.3.4 Fault current analysis

A.3.4.1 Purpose

This clause describes the use of ISO/IEC 10303-212 for exchanging data that are input to and output of fault current analysis. Fault current analysis ensures that an SES has minimal disruption from fault conditions. Fault current analysis determines the magnitude of available fault current throughout the system so that interrupting devices can be selected to safely open the magnitude of current. The results of this fault current analysis are then used to select the type of circuit breakers or fuses to be used at each location.

A.3.4.2 Background

This clause considers the data required for the fault current analysis, as well as the results of the analysis. Fault current analysis is conducted after the basic framework of the electrical power distribution system has been laid out. This analysis will determine the maximum available fault currents at the various distribution points of the system.

NOTE 1 Distribution points include switchboards, load centers, and panel boards.

The total capacity of generators operating in parallel must be less than the fault current interrupting capacity of the accompanying switchgear and circuit breakers.

The available short-circuit current at a given location in the power system is defined as the maximum current that the power system can deliver to a zero-impedance, three-phase fault. This capacity is calculated under the following conditions: when the power system is operating with the maximum generating capacity that can operate in parallel and when the motor load is at maximum capacity. The sources of short-circuit current are generators, synchronous motors or synchronous condensers, and induction motors that operate within the system. The connected motors function as generators for a short time after the fault occurs. The subtransient reactance may be used to determine the contribution of induction motors to the fault current during the first few cycles after the fault occurred.

The maximum available fault current can be adjusted by changing relevant generator characteristics such as the subtransient and transient reactance. The higher the subtransient and transient reactance, the lower the initial fault current. High subtransient reactance and transient reactance, however, result in larger voltage dips upon starting large motors; thus, to balance the fault currents against the voltage drops, a compromise must be reached when selecting the characteristics of the generator.

The current that will flow toward the fault depends on the power available from the sources, the voltage at the fault, which is assumed to be zero for the bolted three-phase fault, and the impedance of circuit components such as transformers, conductors, and other equipment, between the fault and power sources. During the first few cycles after the short occurs, short-circuit currents are assumed to be asymmetrical. Maximum asymmetry will be at the instant the short circuit occurs; in practical circuits containing both resistance and reactance, the current generally becomes symmetrical after several cycles. The rms value of the available asymmetrical current must be within the interrupting rating of the overcurrent device.

NOTE 2 This maximum current is the average of the three phases at a particular instant in time and is not maximum current in any phase.

Low-voltage circuit breakers operate nearly instantaneously for currents near their interrupting ratings. These breakers must be capable of interrupting the maximum current that can flow in the circuit. Because the interrupting ratings of low-voltage circuit breakers are only expressed in terms of symmetrical rms ampere, only the symmetrical currents need to be determined. The breaker frame size is selected to have a symmetrical interrupting rating at least equal to the calculated, symmetrical, short-circuit current.

A.3.4.3 Data exchange

The data required for fault current analysis consist of component specifications, connectivity data, and fault parameters. Fault parameters include the type and position of the fault. The results of the analysis include the maximum and minimum fault current in each branch of the circuit.

Data exchange can be useful for roundtrip engineering, in which electrical system design is gradually evolved through an iterative process of different types of analysis. Examples of different types of analysis include load analysis, fault current analysis, and voltage drop analysis. Together, these analyses ensure that:

— the system is able to provide requisite voltage for the load to operate satisfactorily under various operating conditions;

— the system is able to provide requisite voltage without overloading the system.

NOTE Operating conditions include those encountered during various kinds of faults.

Table 7 shows the concepts and entities used in this use case.

Table 7 — Concepts and entities used

Concept	Entities
Item	Item Item_identification Item_version
Data Element	User_defined_data_element Data_element_association Data_element_definition Data_element_specification
Device	Single_device
Value	Single_value String_value Numerical_value
Connection	Connection Terminal Terminal_designation Interface_terminal
Document	Digital_document Digital_file Document Document_assignment Document_designation Document_property Document_version
Designation	Object_reference_designation

A.3.4.4 Example

Figure A.17 shows a 480 V three-phase distribution system. A bolted three-phase fault is shown on the 480 V three-phase switchgear bus at the location F1.

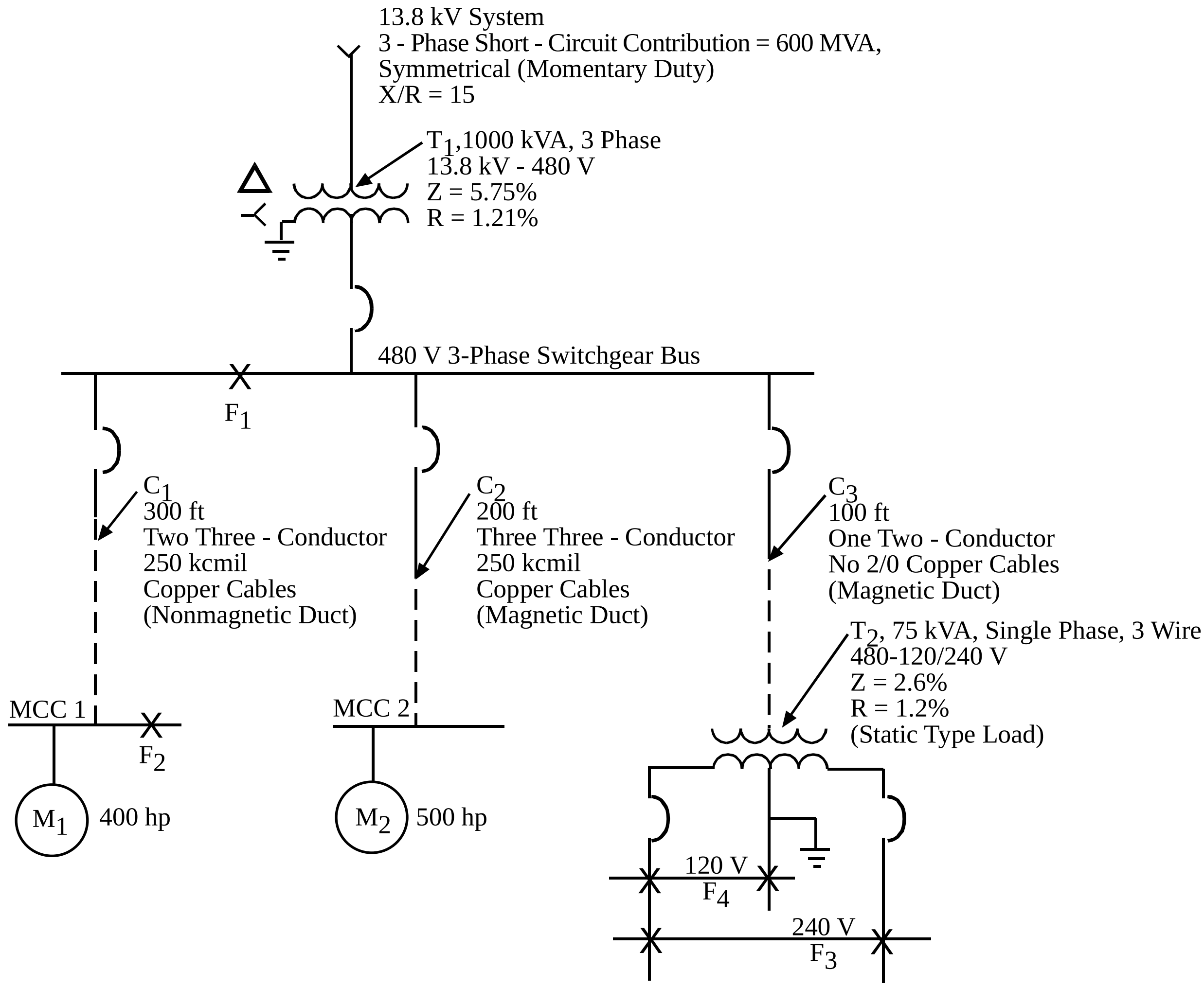

Figure A.17 — 480 V three-phase distribution system

Figure A.17 shows the portion of the distribution system. The focus of this example is on the fault F1. It is sufficient to consider a one-line diagram because of the symmetrical nature of the fault. Figure A.18 shows the portion that will be treated in the instance diagrams of this clause.

NOTE The decision about which components are to be included for fault current analysis can only be made by the engineer who is designing the system. For example, if it is assumed that the busbars are not critical for fault current analysis under fault current conditions, it is not necessary to model them. The circuit breakers and fuses have not been modeled at all in this example, as they are not critical to fault current analysis; rather, they are chosen based on the results of the fault current analysis.

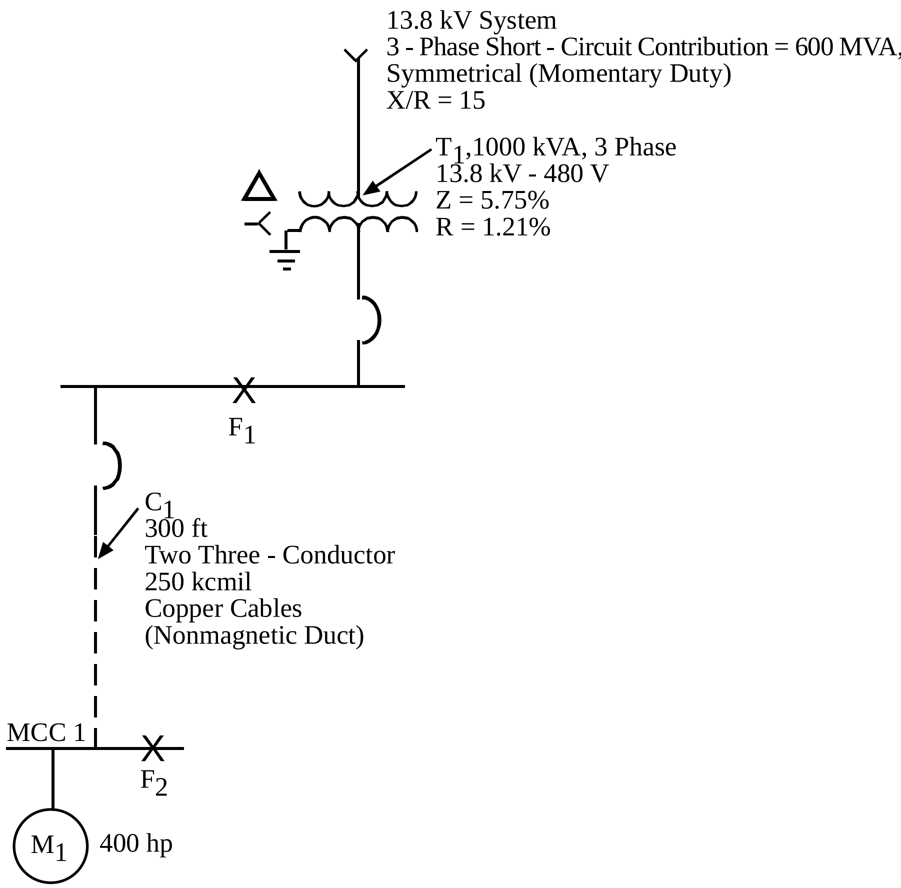

Figure A.18 — One-line diagram for fault current analysis

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A.3.4.5 Instance diagram

This clause provides instance diagrams for the fault current analysis use case.

A.3.4.5.1 Specifying the equipment

At the outset, a decision must be made to select either the functional view or the physical view. The preferred choice is the physical view. The resistance and reactance parameters that are required for the fault current analysis are only available during the physical design and would not normally be known during the functional design.

As shown in Figure A.19, the transformer T1 is represented by an instance (#291) of the Single_device EDT. The definition for the Single_device is given by Design_discipline_item_definition, which points to a catalog description of T1. The compositional detail of transformer T1 is represented by an instance (#32) of the Assembly_definition EDT, which is a type of Design_discipline_item_definition that is characterized by an assembly structure. If the assembly structure is not of interest, it may be omitted from the product model.

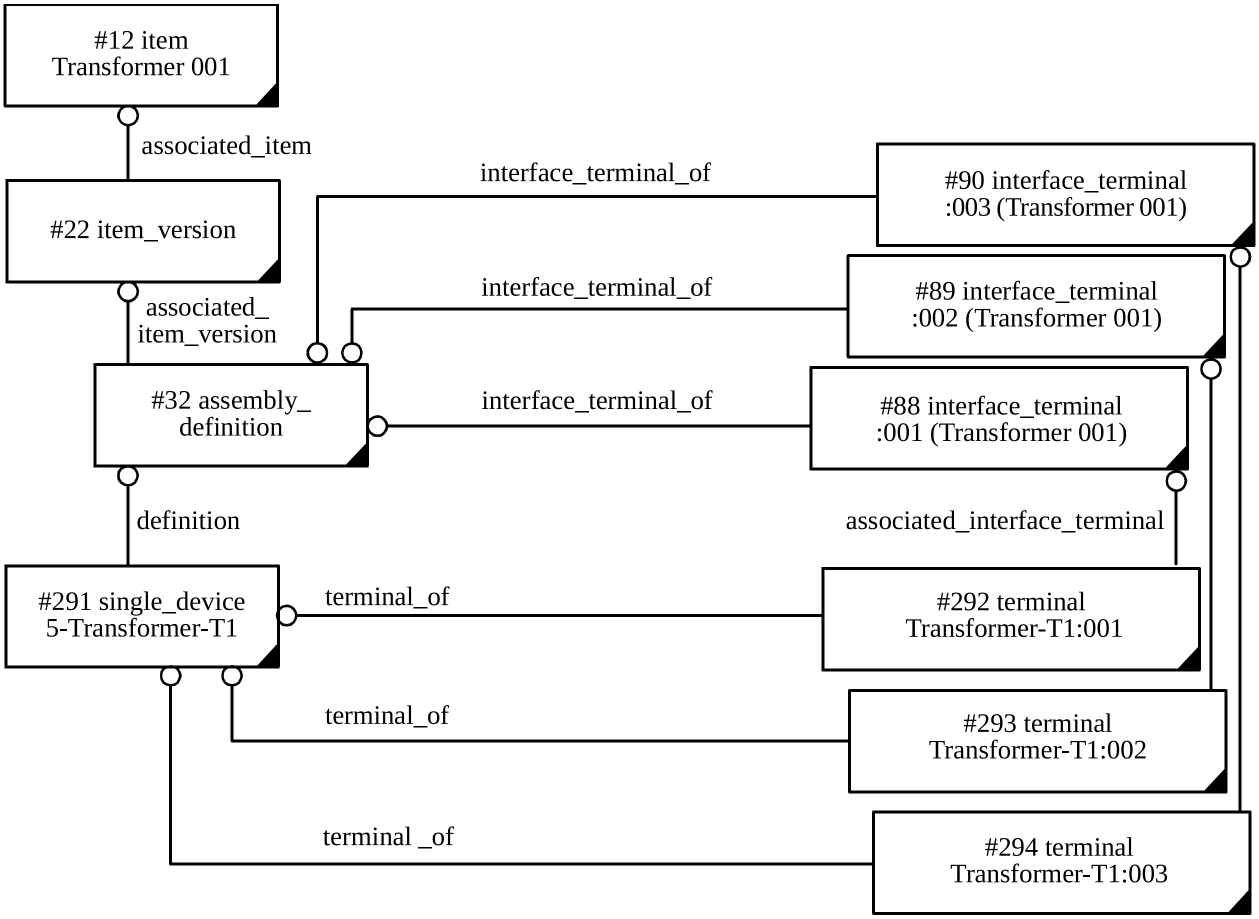


Figure A.19 — Specifying the equipment

The generic nature of transformer T1 is represented by an instance (#12) of the Item EDT. An Item_version is a variant of an associated Item. In the example, the version of the transformer T1 is represented by an instance (#22) of the Item_version EDT.

NOTE 1 Parameters, such as reactance and resistance, can be explicitly communicated using instances of Data_element. Each instance of the Data_element EDT that represented a parameter of T1 would be attached to instance (#291) using an instance of data_element_association.

NOTE 2 For a given Item_version, many Design_discipline_item_definitions can exist that provide a particular viewpoint of an item. For example, there could be many different viewpoints of a transistor. A communication perspective may show high-frequency behavior of the transistor, while a thermal analysis may present a different viewpoint. Similarly, mounting considerations may have a third viewpoint. All of these viewpoints have a one-to-one correspondence with Design_discipline_item_definitions.

NOTE 3 The representation of the other components will follow the same scheme. For this example, other components include generator (or source), switches, cables, and busbars.

A.3.4.5.2 Specifying the connectivity

As indicated earlier, transformer T1 is represented by an instance (#291) of the Single_device EDT. Figure A.20 shows the representation of the connectivity between components. The connection point on the primary side of transformer T1 is represented by an instance (#292) of the Terminal EDT. The connection point on the secondary side of transformer T1 is represented by an instance (#293) of the Terminal EDT.

An instance of the Connection EDT specifies the connection between two terminals. This is shown in Figure A.20, where the connection between transformer T1 and Generator GEN is represented by an instance (#363) of the Connection EDT. Similarly, the connection between transformer T1 and switch S1 is represented by an instance (#364) of the Connection EDT.

NOTE The access points of the devices are represented by the Terminal EDT. The connection between devices is represented by Connection EDT. Connection connects Terminals.

The ground can be modeled as a device. This is shown in our example by instance (#361) of the Single_device EDT. The fault F1 is represented by an instance (#371) of the Connection EDT, which provides the connection to the ground.

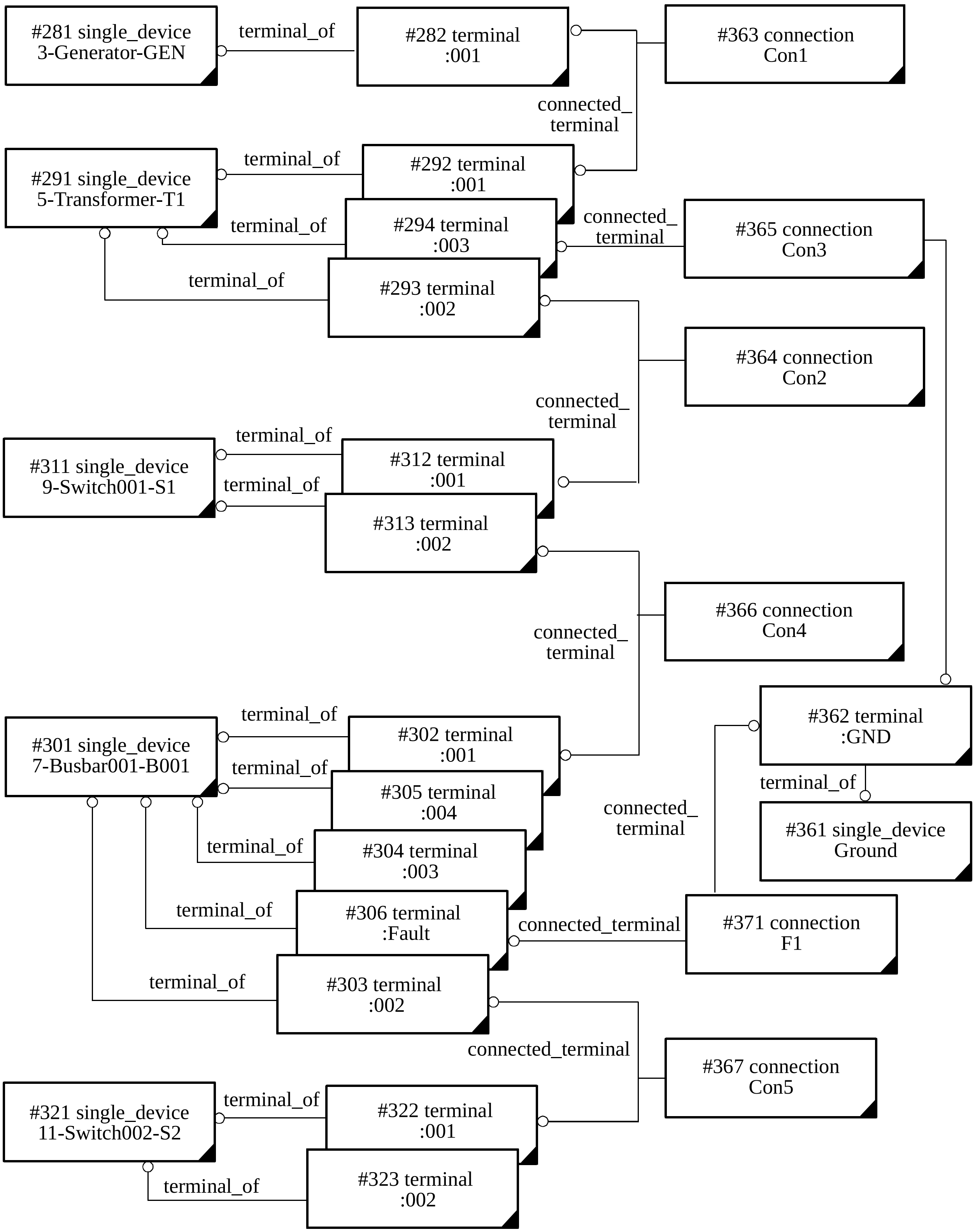


Figure A.20 — Specifying the connectivity

A.3.4.5.3 Classifying the connections

Figure A.21 shows the classification hierarchy of connections under normal and fault conditions. The instance diagram is shown in Figure A.22. The root of the connection classification hierarchy is represented by an instance (#379) of the General_classification EDT. The root of the fault classification hierarchy is represented by an instance (#374) of the General_classification EDT. The type of fault F1 is represented by an instance (#375) of the General_classification EDT. The classification relationship of fault F1 is represented by an instance (#399) of the Classification_association EDT. Through this relationship entity, the classification information is assigned to the connection.

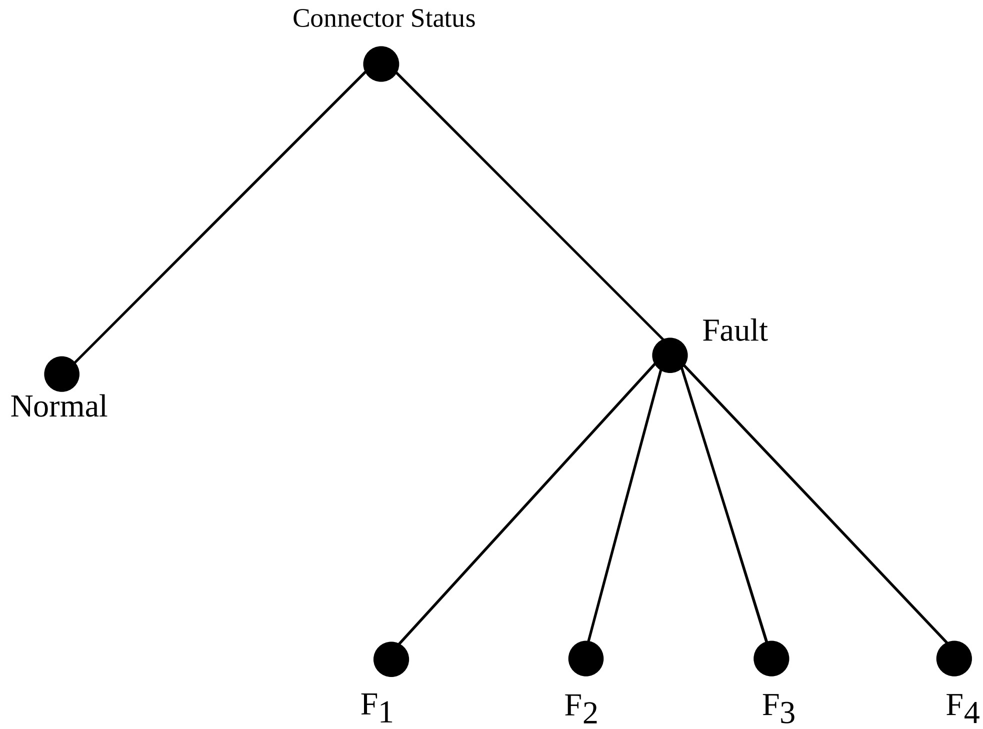


Figure A.21 — Classification hierarchy of connections under normal and fault conditions

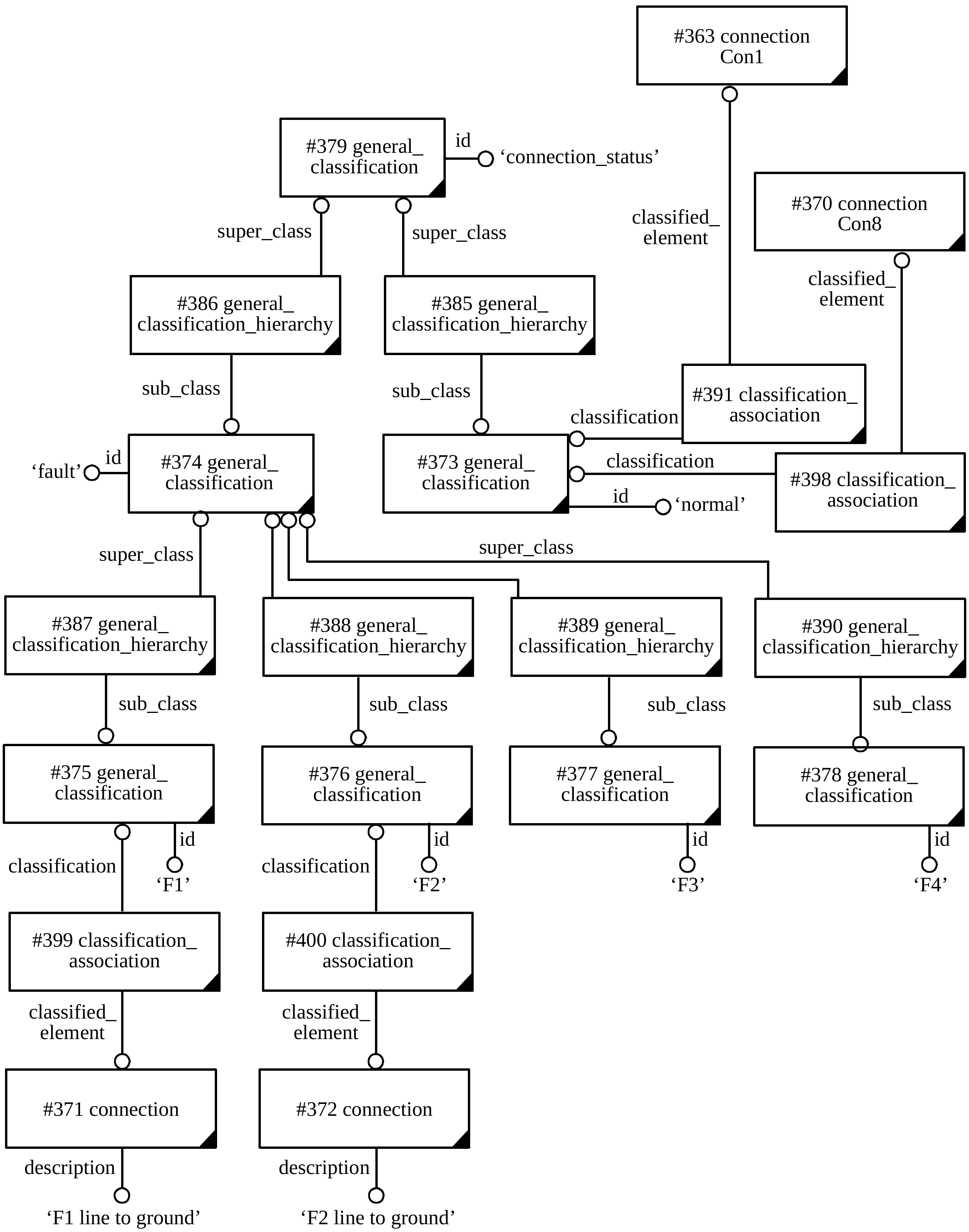


Figure A.22 — Classifying the connections

A.3.4.5.4 Computing the partial resistors within Busbar 2

As shown in Figure A.23, Busbar 2 is represented by an instance (#341) of the Single_device EDT. The behavior of the busbar under any fault condition can be provided by a behavioral model. The behavioral model may be provided in one of several ways. Here, it is provided by decomposing the busbar into resistors. This decomposition structure of Busbar 2 is represented by an instance (#37) of the Assembly_definition EDT.

Resistor R1 is the first component of the decomposition of Busbar 2 and is represented by an instance (#771) of the Single_device EDT. Similarly, resistor R2, the second component of the decomposition of Busbar 2, is represented by an instance (#776). Recall that an Assembly_definition defines an assembled module, and Next_higher_assembly associates the constituent, or constituent-related attribute, to the assembly, or relating attribute. Busbar 2 is the assembly, and resistors R1 and R2 are the constituents of the assembly. The assembly relationship between resistor R1 and Busbar 2 is represented by an instance (#789) of the Next_higher_assembly EDT. Similarly, the assembly relationship between resistor R2 and Busbar 2 is represented by an instance (#790.)

The formula for computing the value of resistor R1 is represented by an instance (#1020) of the String_value EDT. The definition of resistor R1 is represented by an instance (#1000) of the Data_element_definition EDT. The specification of resistor R1 is represented by an instance (#1010) of the Data_element_specification EDT.

In other words, instance (#1000) provides a short definition of the content of (#1022). Instance (#1000) also provides an id that can be used for searching the specification of the data element in, for example, a repository. In this example, the specification is additionally given through (#1010). This specification states that the content of (#1000) is a formula for computing the resistance of R1 under certain conditions.

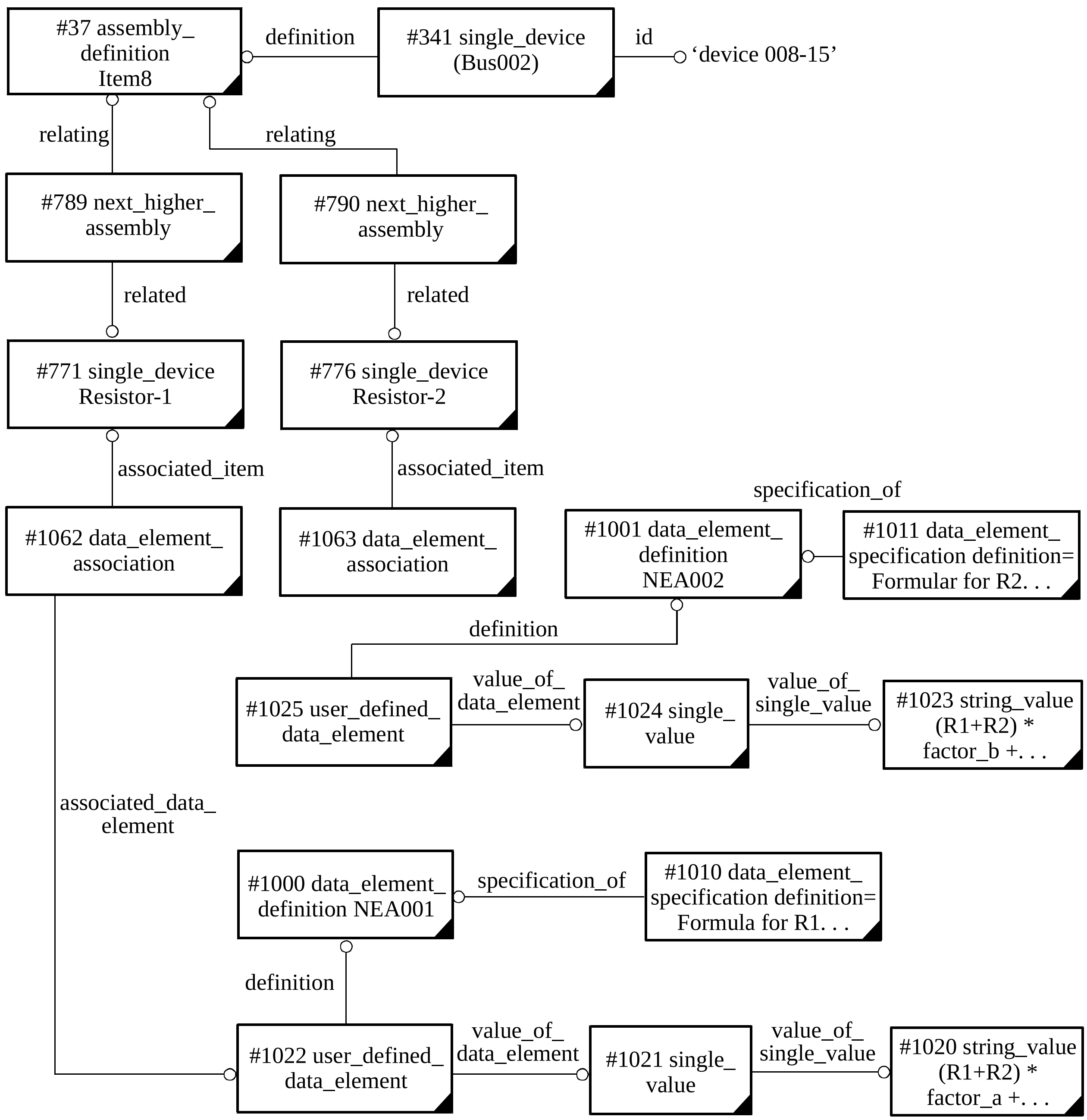


Figure A.23 — Computing the partial resistors within Busbar 2

A.3.4.5.5 Laying down the behavior of Busbar 1

As shown in Figure A.24, Busbar 1 is represented by instance (#301) of the Single_device EDT. Because the busbar is not acting as an ideal device under the fault condition, its behavior is provided by a behavioral model, which is provided by reference. The behavior of Busbar 1 depends on the location of the fault. The electronic file providing the behavior is represented by an instance (#2030) of the Digital_file EDT. The relationship between the electronic file and Busbar 1 is represented by an instance (#2034) of the Document_assignment EDT; thus, through (#2034), the electronic file is assigned to Busbar 1. Document_assignment has an attribute that defines the role of an assigned document. In the example, the role is "behavior." The electronic file is considered to be a document in digital form; therefore, it is represented by an instance (#2021) of the Digital_document EDT. The version of the document is represented by an instance (#2009) of the Document_version EDT. The versioned document is represented by an instance (#2003) of the Document EDT. Through instances (#2030), (#2021), (#2009), and (#2003), the reference to the electronic file is completely specified. All information required by a system in order to retrieve the file and to interpret its content can be specified.

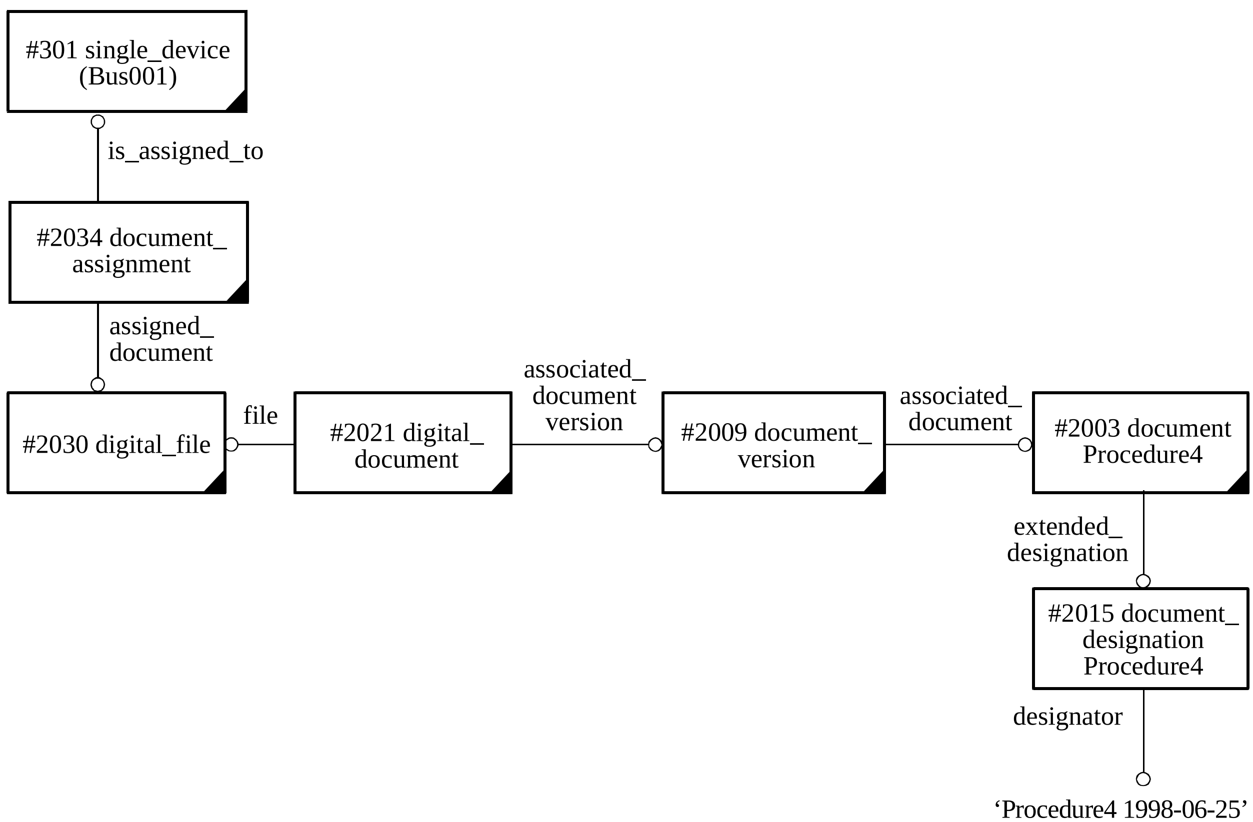


Figure A.24 — Laying down the behavior of Busbar 1

A.3.4.5.6 Assigning fault current values to connections

Figure A.25 describes how to assign properties to objects of interest. In the example, the object of interest is Busbar 1, and the properties of interest are the position of the fault and the current under fault condition.

Recall that a Data_element is a technical or administrative property that can be used to characterize any item, including associations among objects; thus, Data_element instances allow one to furnish the constructs of the model with technical or administrative data. In the example, the fault current and fault location are the properties of interest. As shown in the instance diagram, the fault current is represented by an instance (#1028) of the User_defined_data_element EDT, which is a subtype of Data_element.

Similarly, the position of the fault is also represented by instance (#1061) of the User_defined_data_element EDT.

A Data_element_relationship EDT is a dependent relationship between two Data_element objects. This defines a deriving relationship where the first Data_element is based on the second. Here, the fault current depends on the location of the fault; thus, a relationship that states that this fault current applies when the fault is at this location is represented by an instance (#1085) of the Data_element_Relationship EDT. The fault type is represented by an instance (#376) of the General_classification EDT. The relationship of the fault current to fault type is represented by an instance (#2035) of the Classification_association EDT. The relationship of the position of the fault to fault type is represented by an instance (#2045) of the Classification_association EDT.

NOTE The minimum and maximum fault current for each branch of the electrical system can be represented using the level attribute of Single_value. The level attribute is a string, but ISO/IEC 10303-212 predefines minimum, maximum, typical, and calculated. Because minimum and maximum fault currents are necessary, two Data_element instances would be pointing to the same Data_element_definition.

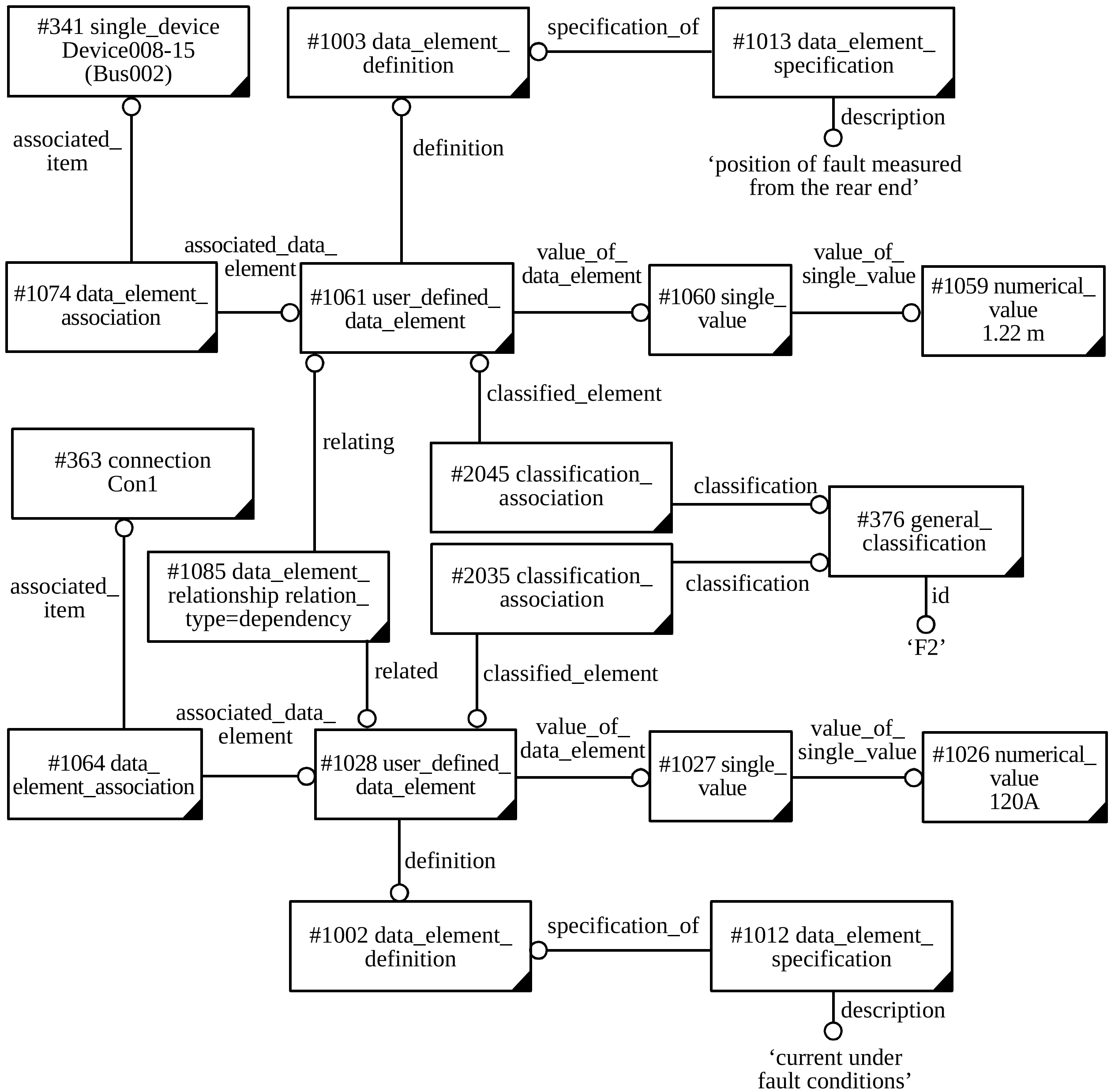


Figure A.25 — Assigning fault current values to connections

A.3.5 Circuit breaker sizing (CBS)

A.3.5.1 Purpose

This clause describes the use of ISO/IEC 10303-212 for exchanging data required in selecting circuit breakers that provide coordinated protection. Properly coordinated overcurrent protection recognizes, locates, and isolates faulted portions of power systems. This protection minimizes the damage to equipment and conductors, the danger to personnel, and the interruption of electrical power that can result from an overload, short circuit, or ground fault. It ensures a reliable, safe, and continuous supply of electrical power. Overcurrent devices—two of the most common types being fuses and circuit breakers—

protect against currents in excess of the rated current of equipment or the current-carrying capacity of a conductor.

A.3.5.2 Background

Circuit breaker sizing is part of a coordination study that determines the specifications of circuit breakers. The coordination study is performed in order that overcurrent devices can be selected or set so that the device located immediately upstream from the fault trips before devices located further upstream.

There are two types of protection schemes: fully rated selective protection and cascaded protection. A fully rated selective protection scheme requires that each circuit breaker have sufficient interrupting capacity to clear the maximum available fault current at its point of application before the nearest circuit breaker located upstream trips off the line. In a cascaded protection scheme, the maximum available fault current might exceed the interrupting capacity of certain branch circuit breakers. Under such circumstances, the circuit breaker cannot interrupt the fault current; therefore, it must rely on a larger breaker or fuse located further upstream in the distribution system to clear the fault in a backup mode. This is referred to as "backup mode," because the backup circuit breaker must provide enough time for the primary circuit breaker to react to the fault current. A fault within any branch of a cascaded system can result in the loss of power to other branches fed by the same backup circuit breaker; thus, fully rated selective protection is preferred because a fault current within any branch of the distribution system will result in the loss of that particular branch only.

Each circuit breaker has a programmable characteristic that will shift its response curve. This shift is done through the "plug." The plug rating attribute has a set of discrete values that correspond to specific response curves.

Circuit breakers permit manual opening and closing of a circuit. They open the circuit automatically for a predetermined fault condition (usually overcurrent, but sometimes reverse power flow, under-voltage, or under-frequency) without being damaged when applied within their ratings. In effect, circuit breakers are high-current interrupting switches with automatic trip elements. The most commonly found circuit breakers used in marine applications respond to overcurrent, tripping when the current magnitude exceeds a specific value for a specific length of time. Low-voltage (600 volts AC and below) circuit breakers are usually constructed with an integral overcurrent trip element within the circuit breaker housing.

In medium-voltage systems, instrument transformers and protective relays that are separate from circuit breakers are often used. Current transformers and voltage transformers are connected to the power system and allow protective relays to identify the conditions in the system without exposing them to the high current and voltage levels in the system. Protective relays interpret the information from the instrument transformers in order to discriminate between tolerable and fault/intolerable conditions. When an intolerable condition is detected, the protective relay initiates a tripping impulse to the circuit breaker, which isolates the faulted part of the power system.

When a circuit breaker opens an energized circuit, an arc is drawn between the opening contacts. This arc must be extinguished in order to interrupt the circuit. Circuit breakers are commonly classified according to the medium in which the contacts open. The common designations are air circuit breakers, which include molded-case circuit breakers, vacuum breakers, and sulfur hexafluoride, or SF6, breakers. Air circuit breakers are most commonly found in low-voltage, relatively low-current circuits for which air serves as a suitable dielectric, preventing continued arcing between the contacts after they have parted. Most air circuit breakers use a bank of metal fins around the contacts to quickly extinguish arcs. As the arc passes between the fins, it splits, cools, and extinguishes.

The Electrical Engineering Regulations, specifically 46 CFR 111.54-1(a)(4), require the use of air circuit breakers. Air has marginal insulating value to prevent ionization and continued arcing at medium-voltage and/or high-interrupting current levels. Air circuit breakers used in medium-voltage applications are large, heavy, and expensive. For nearly a decade, trial installations of vacuum circuit breakers performed satisfactorily on vessels. Vacuum circuit breakers are now accepted to provide a level of safety equivalent to air circuit breakers. Similarly, SF6 circuit breakers have demonstrated acceptable performance in medium-voltage industrial and utility service.

The contacts of vacuum circuit breakers open and close within an evacuated bottle. With very little gas available to ionize, essentially no arcing occurs between contacts. Vacuum circuit breakers can be smaller, lighter, and usually less expensive than air circuit breakers.

A.3.5.3 Data exchange

This clause considers data that are required for circuit breaker sizing, as well as the results of the analysis. The data required for circuit breaker sizing are component specifications, connectivity data, and fault current analysis data. Table 8 lists the relevant data, while Table 9 lists the ISO/IEC 10303-212 concepts and entities that are used in this example.

Table 8 — Electrical engineering concepts covered by the example

Concept	Data Elements
Input data for circuit breaker sizing	Components Load Protection devices (e.g., circuit breakers, relays, fuses) Fault current analysis result Location and type of fault Fault current distribution
Circuit breaker	Pickup current versus time response curve Type of circuit breaker Frame type Sensor rating Plug rating One-line diagram or connectivity information
Result of circuit breaker sizing	Location of circuit breakers Type of circuit breakers Setting of circuit breakers

Table 9 — ISO/IEC 10303-212 concepts and entities used in circuit breaker sizing

Concept	Entities
Item	Item Item_identification Item_version
Assembly	Assembly_definition Next_higher_assembly
Data element	User_defined_data_element Data_element_association Data_element_definition Data_element_specification
Device	Single_device
Value	Aggregated_value Single_value
Type of value	Numerical_value String_value
Classification	Classification_association General_classification
Connection	Connection Terminal Terminal_designation Interface_terminal
Note	Note
Designation	Object_reference_designation
Organizational data	Organization Person_or_organization_assignment

A.3.5.4 Example

A one-line diagram for a branch of a shipboard electrical system is shown in Figure A.26. This branch consists of ship service 600-volt, transformer primary circuit breakers, 480-volt transformer secondary main circuit breakers, downstream 480-volt panel P405 main circuit breakers, and the feeder circuit breakers. Figure A.27 shows the coordination curves for a fault at location "A" in the 350-ampere panel feeder circuit. Maximum fault current flows assume that all ship generators and AC motors are in service. Both symmetric (Isym) and asymmetric (Iasym) fault currents are shown.

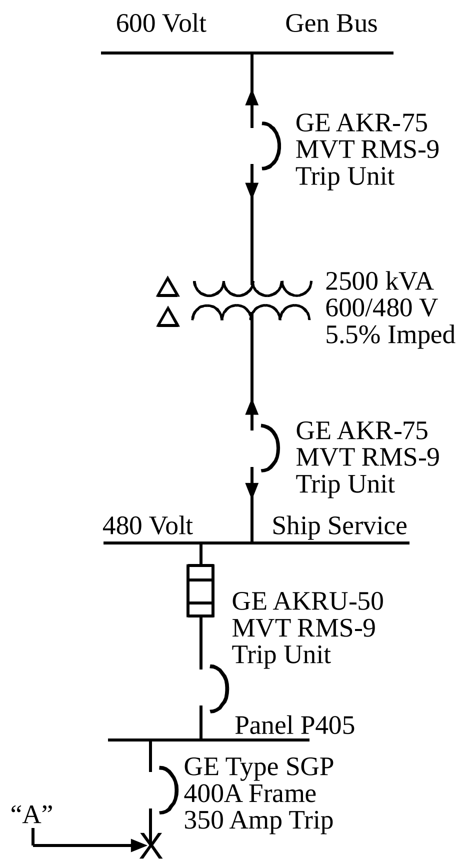


Figure A.26 — Circuit breaker characteristics

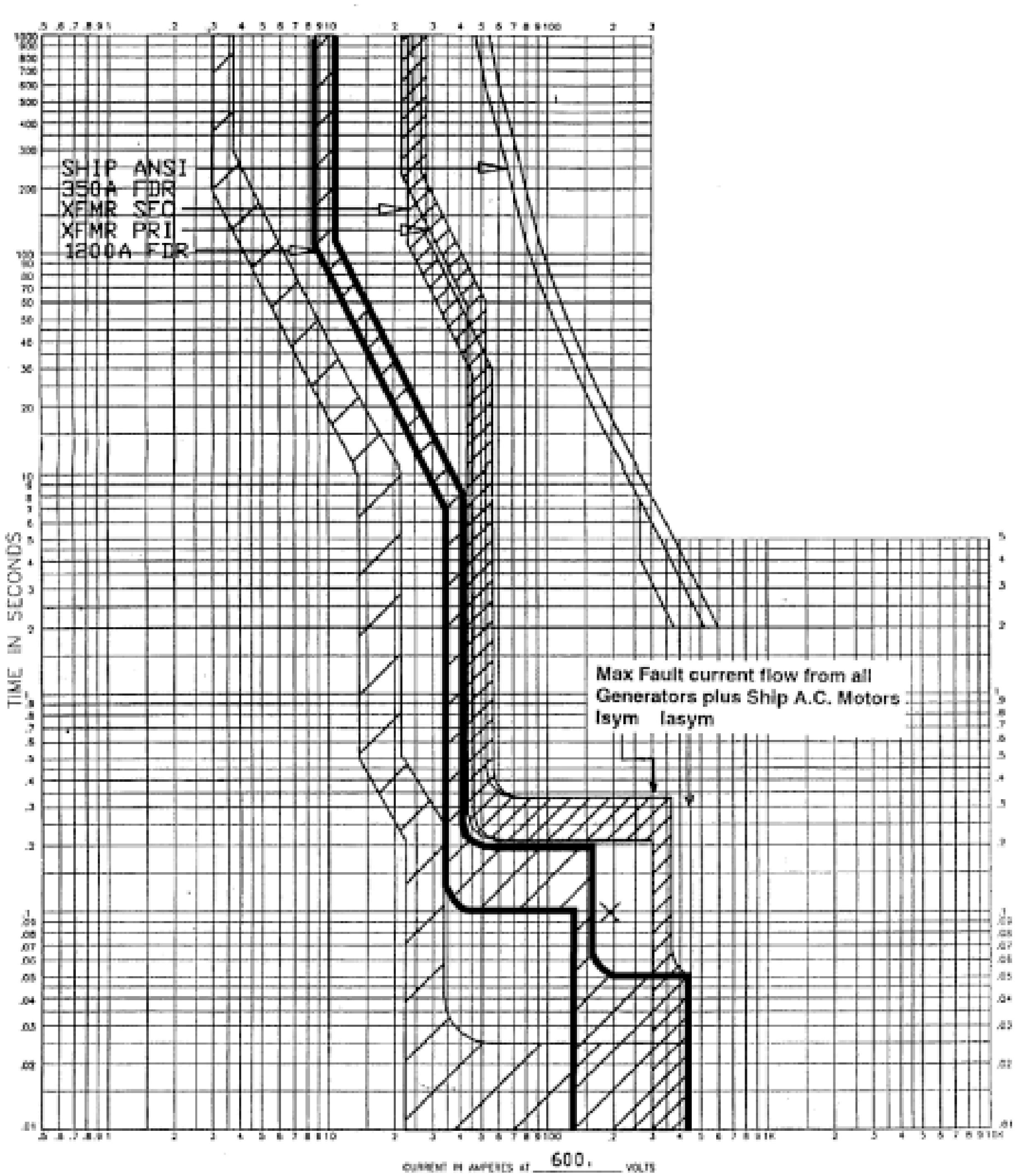


Figure A.27 — Coordination curves

The example mostly consists of instances of the Device, Connection, Terminal, and Data_element EDTs.

A.3.5.5 Instance diagram

A.3.5.5.1 Specifying the equipment

The specification of the circuit breaker consists of a time-current response curve and a set of data point specifications. For example, the frame size is a data point specification. Data point specifications can be described by simple numerical values. The time response curve in a circuit breaker data sheet is rarely a mathematical curve. Figure A.27 shows the circuit breaker characteristics chosen for representation in the example. The type of circuit breaker is GE AKRU-50, as used in the diagram for the 1200-amp panel P405 main circuit breaker. The curve can be decomposed into an ordered set of linear segments, which are characterized by two end points.

This example uses a piecewise linear approximation of the time-current response curve because, as noted previously, the curve is rarely a mathematical curve. A three-level tree structure is used to represent the curve. The leaf nodes are instances of the Single_value EDT. In addition, the leaf nodes are of type Numerical_value, which is a subtype of Single_value. The Numerical_value EDT is characterized by Value_component and Unit_component. All of the other nodes of the tree structure are instances of the Aggregated_values EDT. The top-level aggregation collects the data points, while each lower-level aggregation collects the coordinates (time and current) for a specific data point.

As shown in Figure A.28, the current coordinate of the first data point of the curve is represented by an instance (#1061) of the Single_value EDT. The value of the current of the first data point of the curve is represented by an instance (#1060) of the Numerical_value EDT. Similarly, the time coordinate of the first data point of the curve is represented by an instance (#1063) of the Single_value EDT. Correspondingly, the time value of the first data point of the curve is represented by an instance (#1062) of the Numerical_value EDT. The complete specification of the coordinates of the first data point of the curve is represented by an instance (#1088). The first data point is represented by an instance of the Aggregated_value EDT, which aggregates current and time coordinates.

Similarly, coordinates of the second, third, and fourth data points of the curve are represented by instances (#1089), (#1090), and (#1094), all of which are instances of the Aggregated_value EDT. These instances aggregate corresponding time and current coordinates.

The time-current response curve as a whole is represented by an instance (#1096). Instance (#1095) collects all of the points that make up the curve; thus, the time-current response curve is constructed by instance (#1095) of the Aggregated_value EDT. This is the highest level of aggregation in our aggregation tree. The first level of aggregation combined the time and current coordinates to form a point on the curve. The next level of aggregation then combined the points to form the curve; therefore, there are two levels of aggregation.

The type of data is represented by an instance (#1096) of the User_defined_data_element EDT. A User_defined_data_element must be associated with a definition, which is, in turn, provided by Data_element_definition. The User_defined_data_element EDT also specifies that the values given are actual values and not computed values. As shown in the instance diagram, the definition of User_defined_data_element is represented by an instance (#1001) of the Data_element_definition EDT. Similarly, the specification of the curve is represented by an instance (#1011) of the Data_element_specification EDT. This specification provides a detailed definition for the User_defined_data_element.

The type of circuit breaker is represented by an instance (#14) of the Item EDT. The version of the circuit breaker is represented by an instance (#24) of the Item_version EDT. The assembly definition of the circuit breaker is represented by an instance (#311) of the Assembly_definition EDT, which is a subtype of the Design_discipline_item_definition EDT. The identity of the manufacturer of the circuit breaker is represented by an instance (#1166) of the Person_or_organization_assignment EDT. The information about the manufacturer is represented by an instance (#1165) of the Organization EDT.

NOTE The Data_element_definition can specify that the interpolation of values of the data points is to be through straight lines. It can also specify, by attaching a document, that the curve is defined in the actual datasheet.

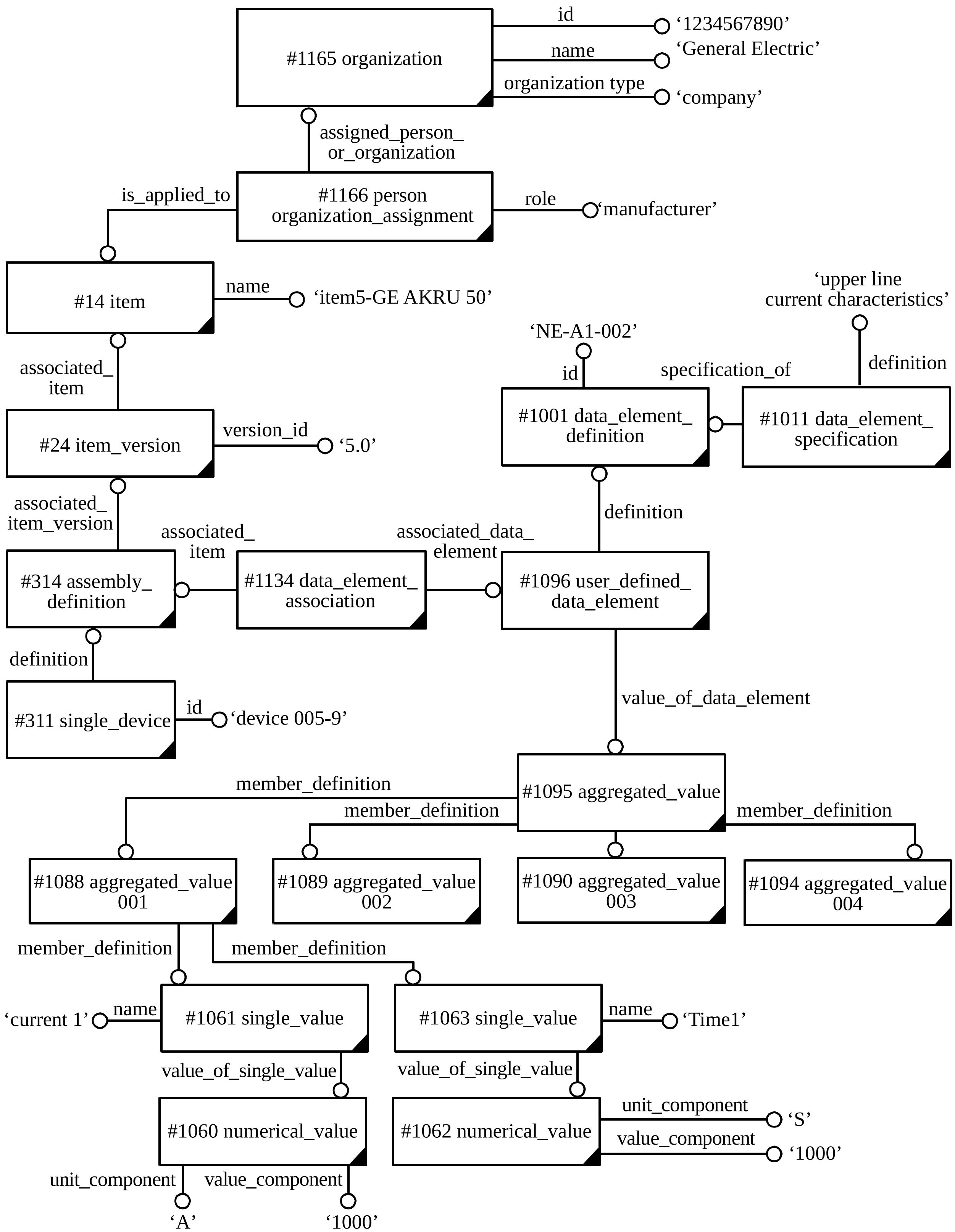


Figure A.28 — Specifying the equipment

A.3.5.5.2 Specifying the system

The instance diagram for the system as a whole is shown in Figure A.29. The system is represented by an instance (#30) of Assembly_definition, which contains all of the devices. This containing relationship is represented by an instances (#1231), (#1232), and (#1233) of the Next_higher_assembly EDT. The note stating, "coordination between ship service...." is represented by an instance (#1162) of the Note EDT. This Note is assigned to instance (#30) of Assembly_definition.

The fault is specified by having a connection from the 350 A-panel P405-feeder circuit breaker to the ground. This fault is represented by an instance (#338) of the Connection EDT. The type of fault is represented by an instance (#1163) of the General_classification EDT.

The components are represented by instances (#301), (#311), and (#321) of the Single_Device EDT. Each instance of the Single_device EDT is associated with two instances of the Terminal EDT, except for the generator and ground, which each have one. The appropriate instances of the Terminals EDT are connected by instances of the Connection EDT.

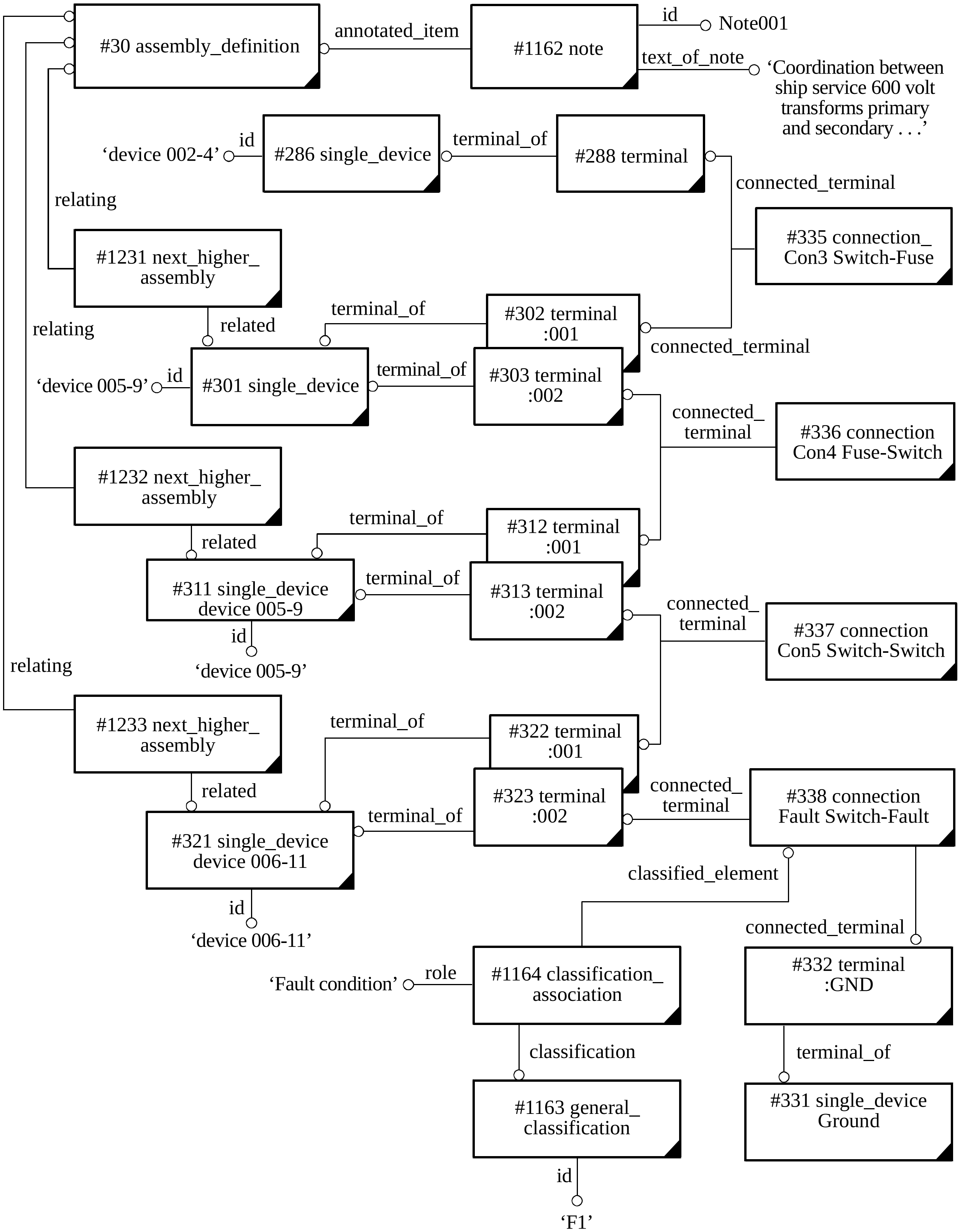


Figure A.29 — Specifying the system

A.3.5.5.3 Assigning setpoint and fault current values

The result of the circuit breaker sizing consists of setting circuit breakers, their type, and location in the one-line diagram. The type and location of the circuit breakers have been discussed in the previous two clauses. This clause will show how to represent the setpoint for the circuit breakers. This part of the instance diagram uses the concept of a data element.

The setpoint for any equipment is treated like any other property that is not hardcoded into the ARM model. Its value, therefore, can be given through an instance of the Data_element EDT. The plug setting of the circuit breaker is its setpoint. As shown in the Figure A.30, it is represented by an instance (#1222) of the User_defined_data_element EDT. User_defined_data_element is a subtype of the Data_element EDT. The symmetrical fault current is represented by an instance (#1142) of the User_defined_data_element EDT. The asymmetrical fault current is represented by an instance (#1152) of the User_defined_data_element EDT. The definition of plug setting of the circuit breaker is represented by an instance (#1002) of the Data_element_definition EDT. Similarly, the definitions of symmetrical fault current and asymmetrical fault current are represented by instances (#1005) and (#1006) of the Data_element_definition EDT.

All of the instances, (#1222), (#1142), and (#1006), of the User_defined_data_element EDT are associated to instance (#311) of the EDT. This conveys that these properties apply to this specific switch. The association is provided through instances (#1136), (#1160), and (#1162) of Data_element_association EDT. The value associated with instances (#1222), (#1142), and (#1006) of the User_defined_data_element EDT are provided by the instances of the Single_value and Numerical_value EDTs.

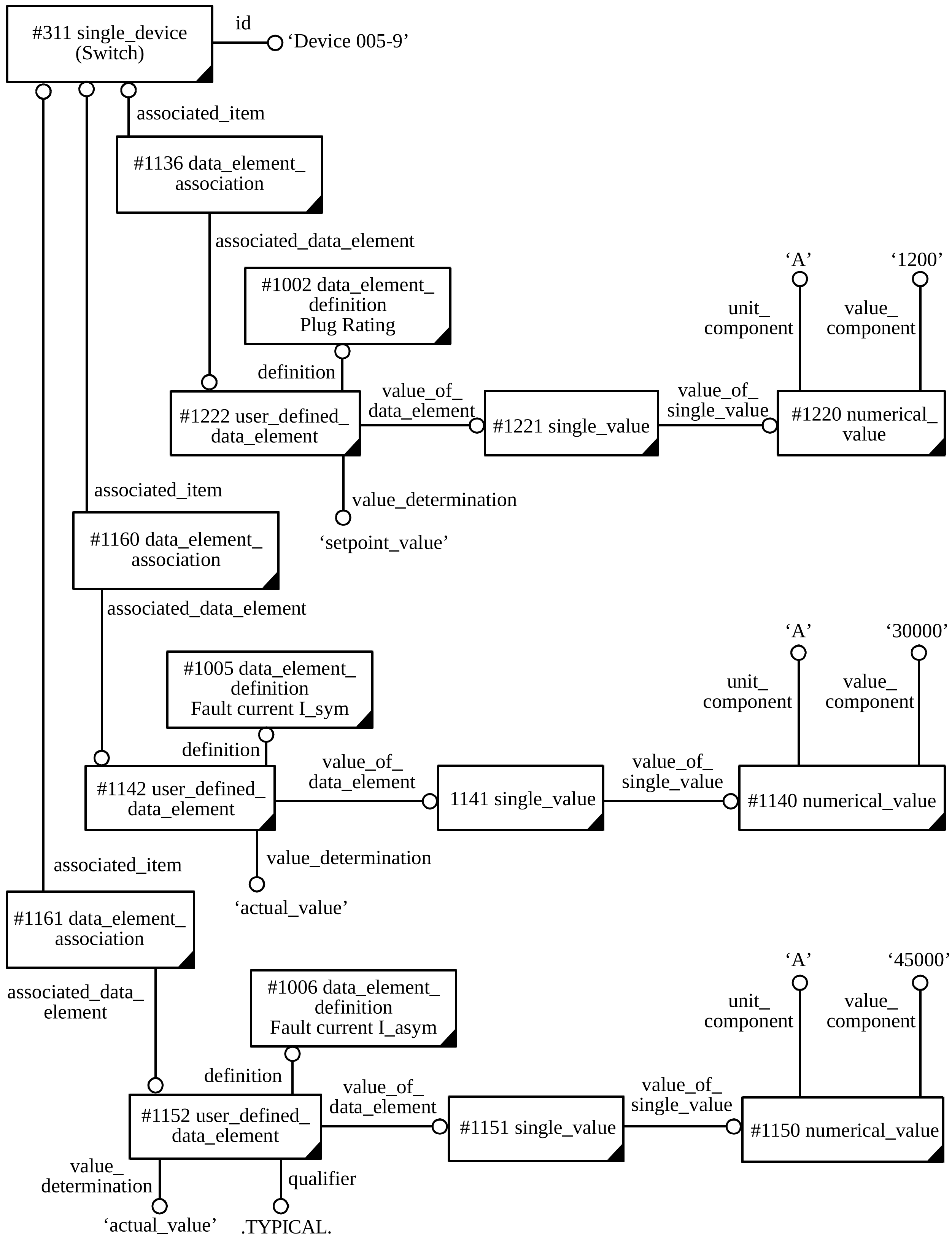


Figure A.30 — Assigning setpoint and fault current values

A.3.6 Messages

A.3.6.1 Purpose

This clause specifies the use of ISO/IEC 10303-212 to provide a basic model for representing messages. This representation can be used as a specification for the development of a control program; however, it does not show timing constraints.

A.3.6.2 Background

Messages usually consist of short communication transmitted by signals from one device to another. Messages are an integral part of automation architecture for they can be used to monitor the status of different components of a system. For example, messages can be used to monitor the condition of a shipboard electrical system.

Most ships are designed with a high degree of automation and have an integrated machinery control console located in a central, enclosed engineering operating station. Electric plant controls comprise all of the monitoring, control, and data display/logging features required to operate the generator sets (including prime movers and auxiliary support systems such as lube oil pumps), main and emergency switchboards, load-center switchboards and panel boards, and power converters.

A.3.6.3 Data exchange

Table 10 shows the main concepts and AP212 ARM-level entities that are used in this example.

Table 10 — Concepts and entities used

Concept	Entities
Item	Item Item_identification Item_version
Assembly	Assembly_definition Next_higher_assembly
Signal	Notification Signal Signal_designation Signal_system_assignment Signal_value
Value	Single_value Numerical_value
Designation	Object_reference_designation
Device	Single_device
Connection	Connection Interface_terminal Terminal Terminal_designation

A.3.6.4 Example

Figure A.31 shows the physical structure of the system that carries the signal associated with the bearing temperature. This example consists of a small electrical system that monitors the temperature of the bearing and transmits the signal from the sensor to the central control room. The system is made up of five components that connect the source of the message to the target recipient of the message. These components include a central control, terminal strip, sensor, and two cables that are designated in the system diagram as central control A1, terminal strip W1, sensor D1, cable W10, and cable W11, respectively.

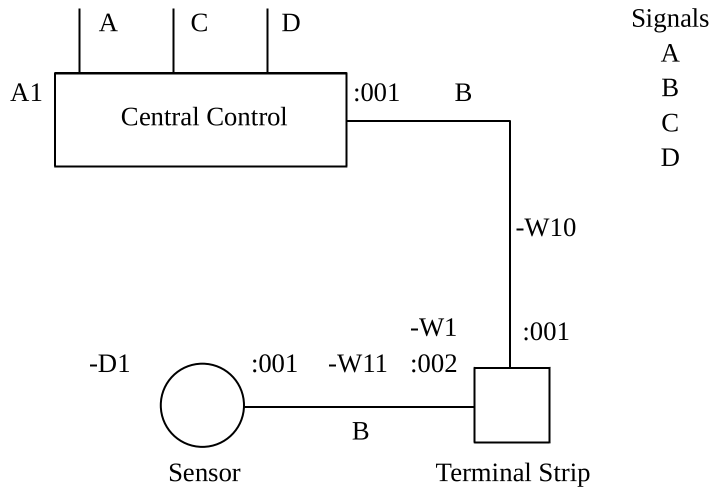


Figure A.31 — Temperature monitoring system

A.3.6.5 Instance diagram

A.3.6.5.1 Specifying the system and its components

Figure A.31 shows a small portion of a shipboard electrical system that is made up of five components, which are designated in the diagram as central control A1, terminal strip W1, sensor D1, cable W10, and cable W11, respectively. Figure A.32 shows instance diagram specifying the system.

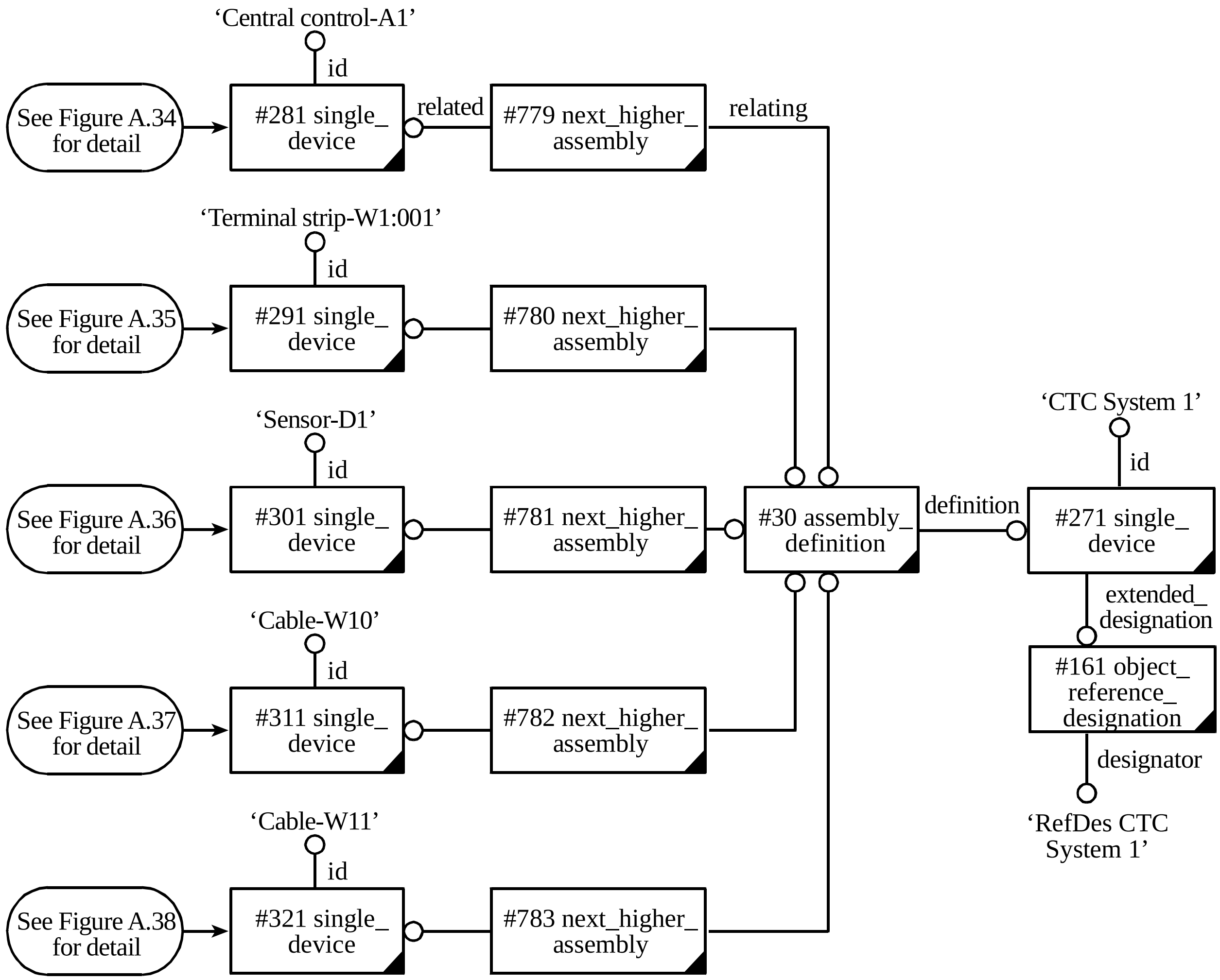


Figure A.32 — Specifying the system: an overview

The Item EDT is used to represent a thing that is produced or intended to be produced, set up, designed, and installed in an electrotechnical system. In Figure A.33, the system and its components are represented by instances of the Item EDT. System 1 is represented by an instance (#10) of the Item EDT, which references an instance (#0) of the Item_identification EDT. Central control A1 is also represented by an instance (#11) of the Item EDT, which references an instance (#1) of the Item_identification EDT. Different instances (#12, #13, #16, and #17) of the Item EDT are used to represent terminal strip W1, sensor D1, cable W10, and cable W11, which reference instances (#2, #3, #6, and #7) of the Item_identification EDT.

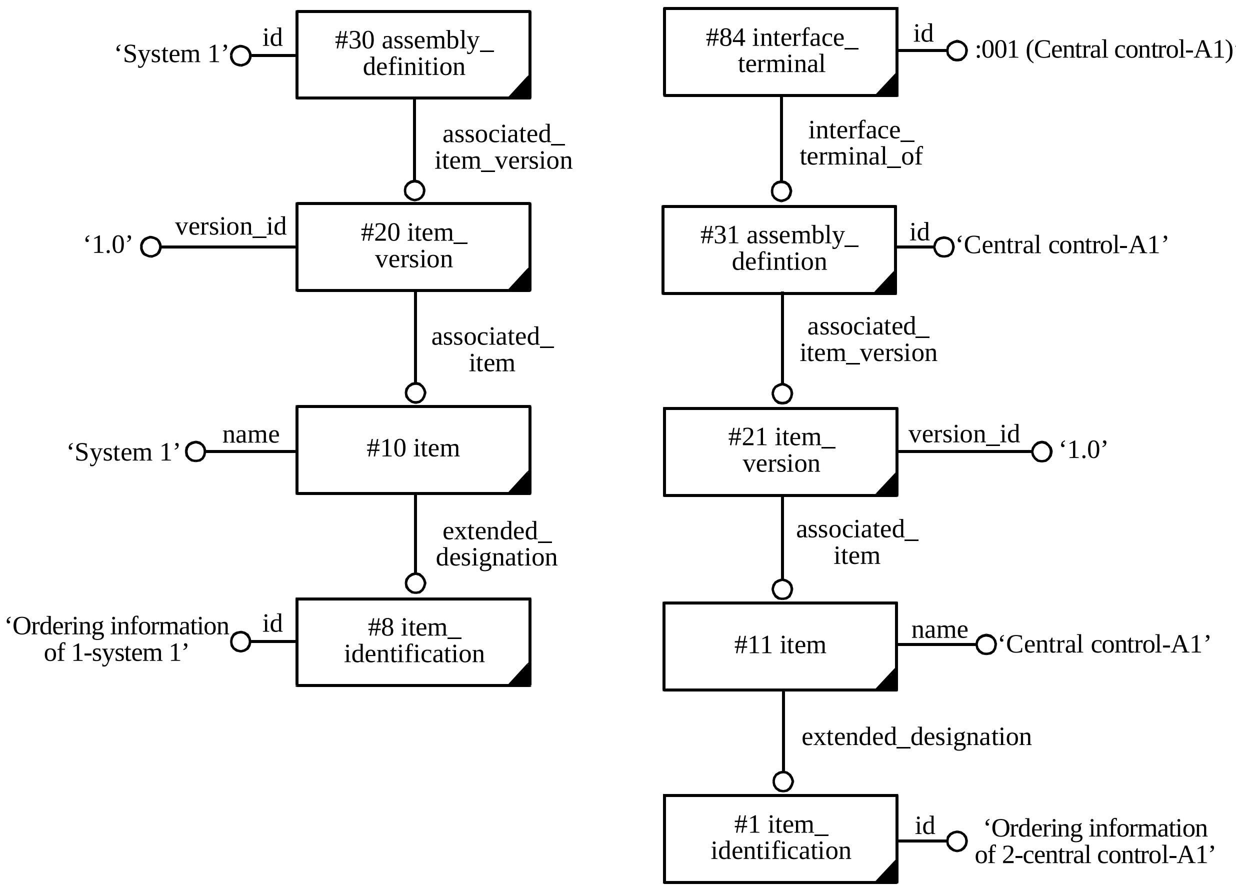


Figure A.33 — Identifying system and component

An Item_identification is a sequence of alphanumeric characters that label an Item. In Figure A.33, the system and its components can all be identified through the instances of the Item_identification EDT. The purchase ordering information of system 1 and central control A1 is represented by an instances (#0 and #1) of the Item_identification EDT. Different instances (#2, #3, #6, and #7) of the Item_identification EDT are used to represent the ordering information of terminal strip W1, sensor D1, cable W10, and cable W11.

An Item_version is a variant of the associated Item. In Figure A.33, the system and its components have their corresponding instances of the Item_version EDT. The version for system 1 is represented by an instance (#20) of the Item_version EDT, which references an instance (#10) of the Item EDT. Central control A1 is represented by an instance (#21) of the Item_version EDT, which references instance (#11) of the Item EDT. Different instances (#22, #23, #26, and #27) of the Item_version EDT are used to represent terminal strip W1, sensor D1, cable W10, and cable W11, which reference instances (#12, #13, #16, and #17) of the Item EDT.

An instance of the Assembly_definition EDT is used to define an Item_version in terms of subordinate Item_version objects. Central control A1, terminal strip W1, sensor D1, and cables W10 and W11 are all represented by instances (#31, #32, #33, #36, #37) of the Assembly_definition EDT.

System 1, central control A1, terminal strip W1, sensor D1, and cables W10 and W11 are all represented by instances #271, #281, #291, #301, #311, and #321, respectively, of the Single_device EDT. The system and its components have their corresponding instances of the Object_reference_designation EDT.

The Item_identification EDT identifies the Item, and the Object_reference_designation EDT designates the devices represented by the instances of the Object_reference_designation EDT. The system, central control A1, terminal strip W1, sensor D1, and cables W10 and W11 are all represented by instances (#161, #163, #165, #167, #169, #171) of the Object_reference_designation EDT.

The Next_higher_assembly EDT is used to represent the relationship between the assembly and its constituent. The "related" attribute of the Next_higher_assembly EDT specifies a constituent of an assembly, and the "relating" attribute specifies the immediate parent assembly of the constituent. The example uses the Next_higher_assembly EDT to define the composition of the system.

Central control A1, terminal strip W1, sensor D1, and cables W10 and W11 are all defined as constituents of the system by instances #163, #165, #167, #169, and #171, respectively, of the Next_higher_assembly EDT. All of the instances corresponding to the components refer to instance #30.

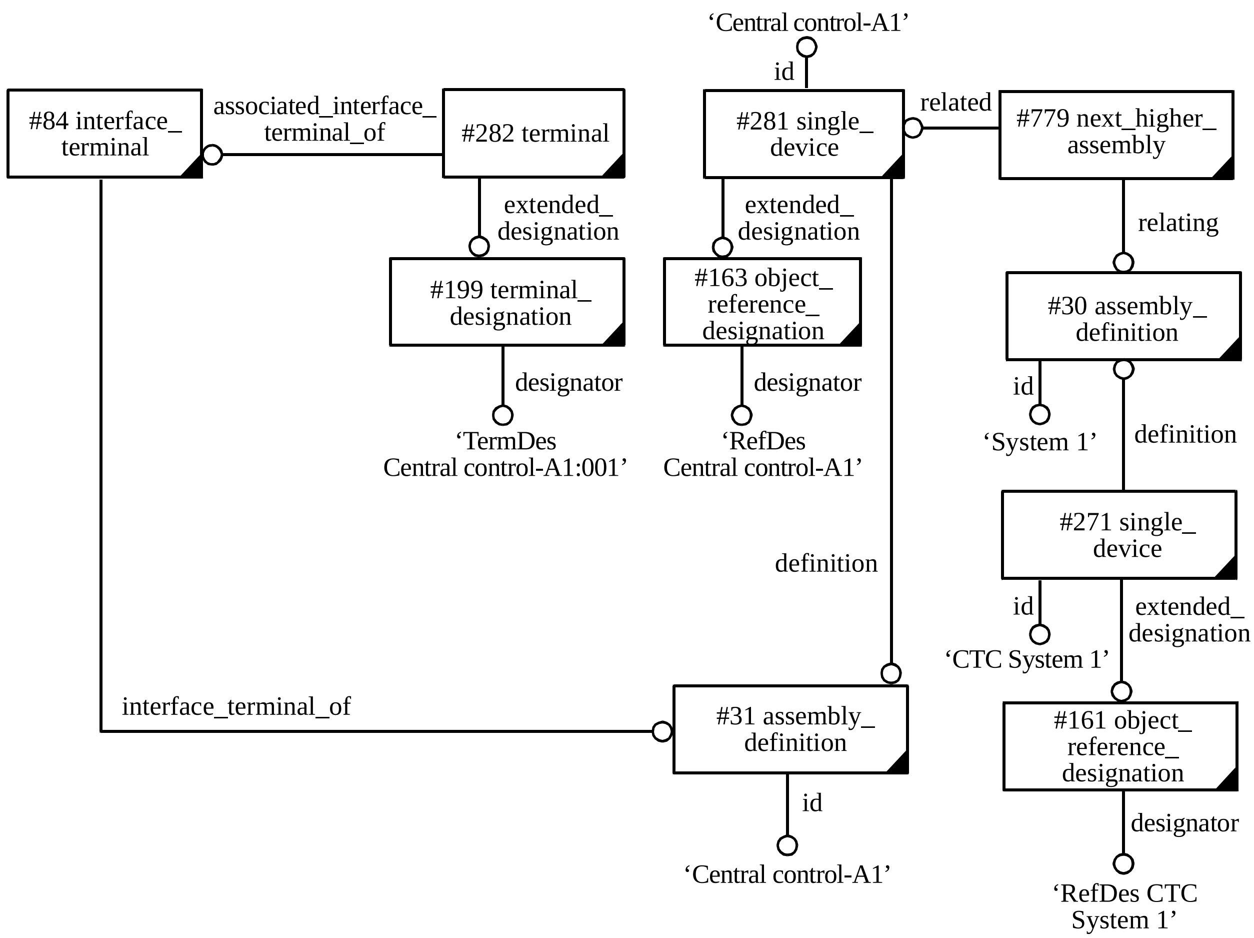


Figure A.34 — Specifying central control - A1

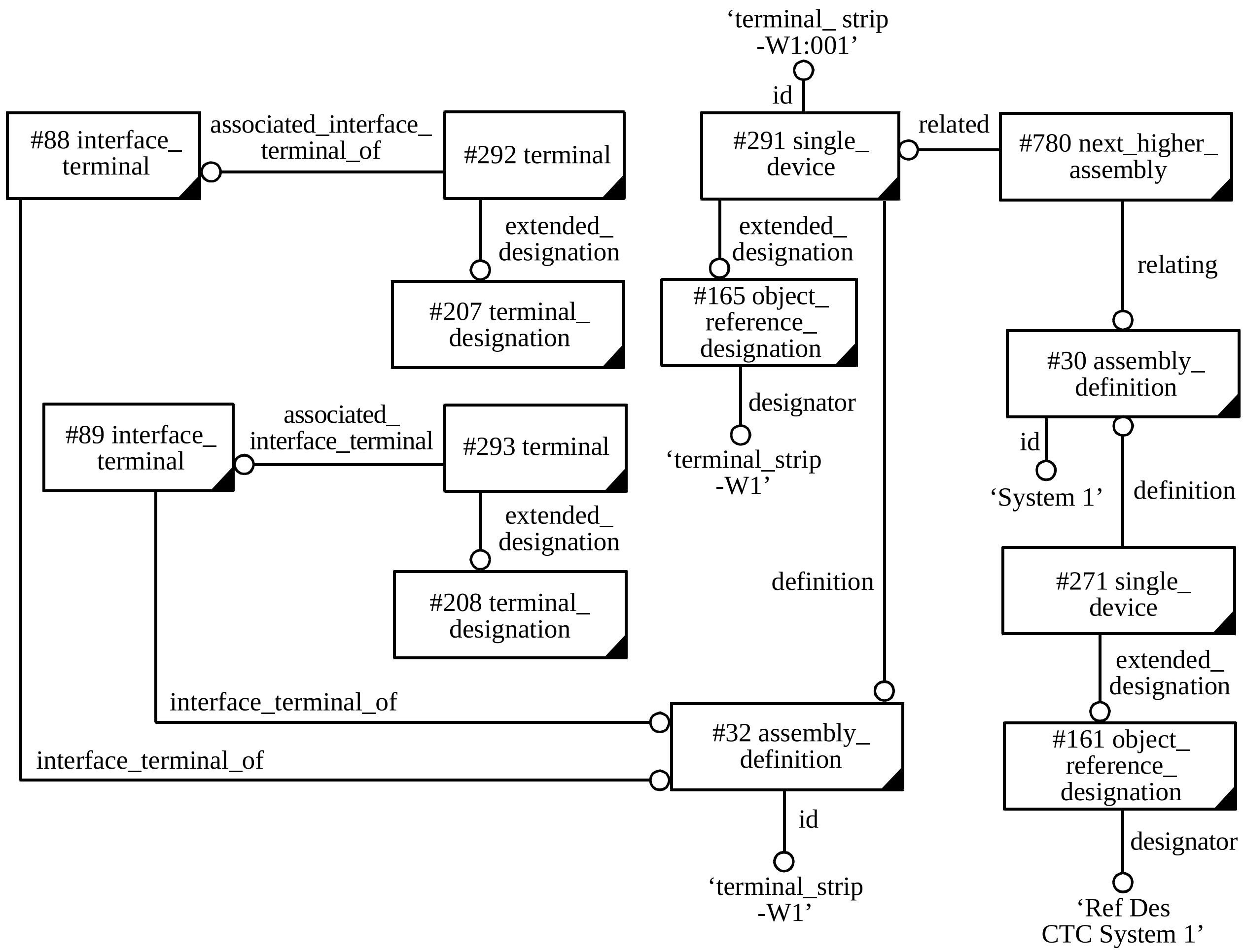


Figure A.35 — Specifying terminal strip - W1

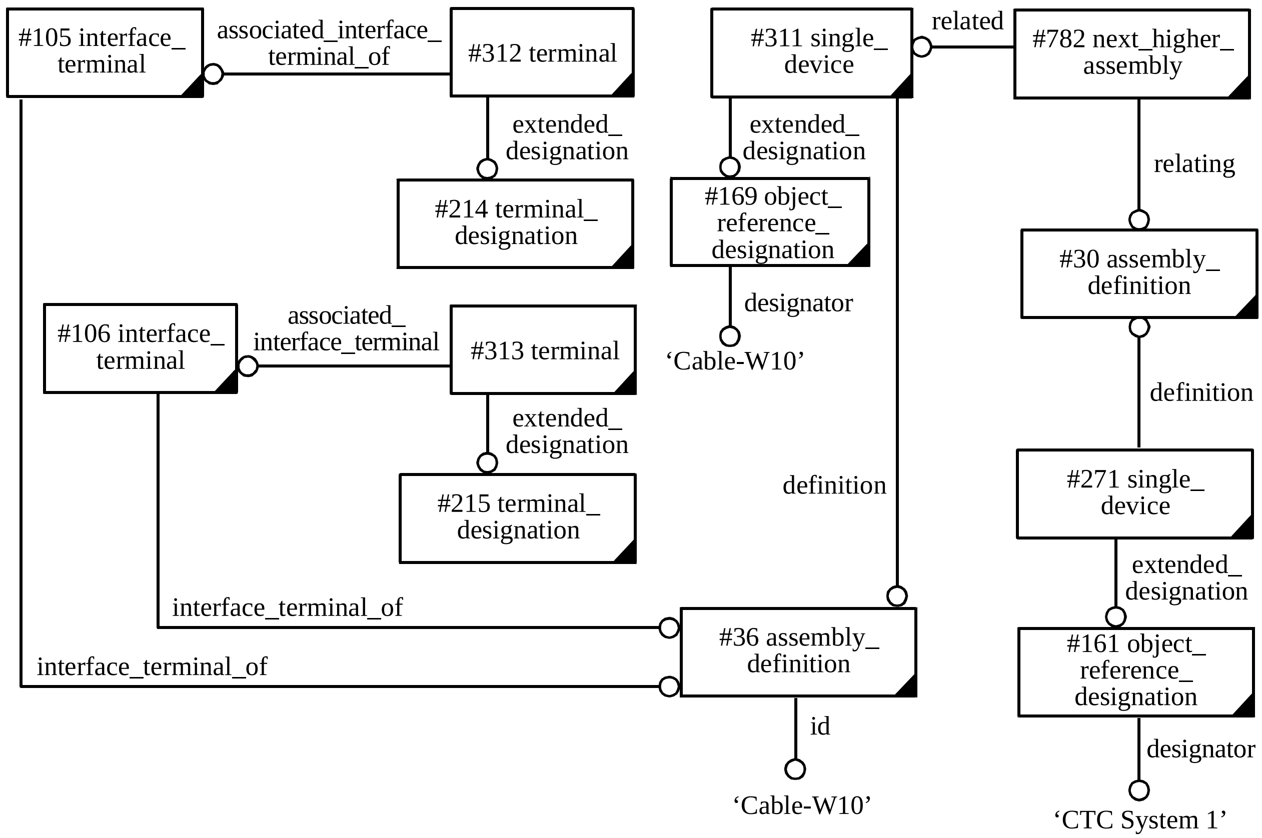


Figure A.36 — Specifying sensor - D1

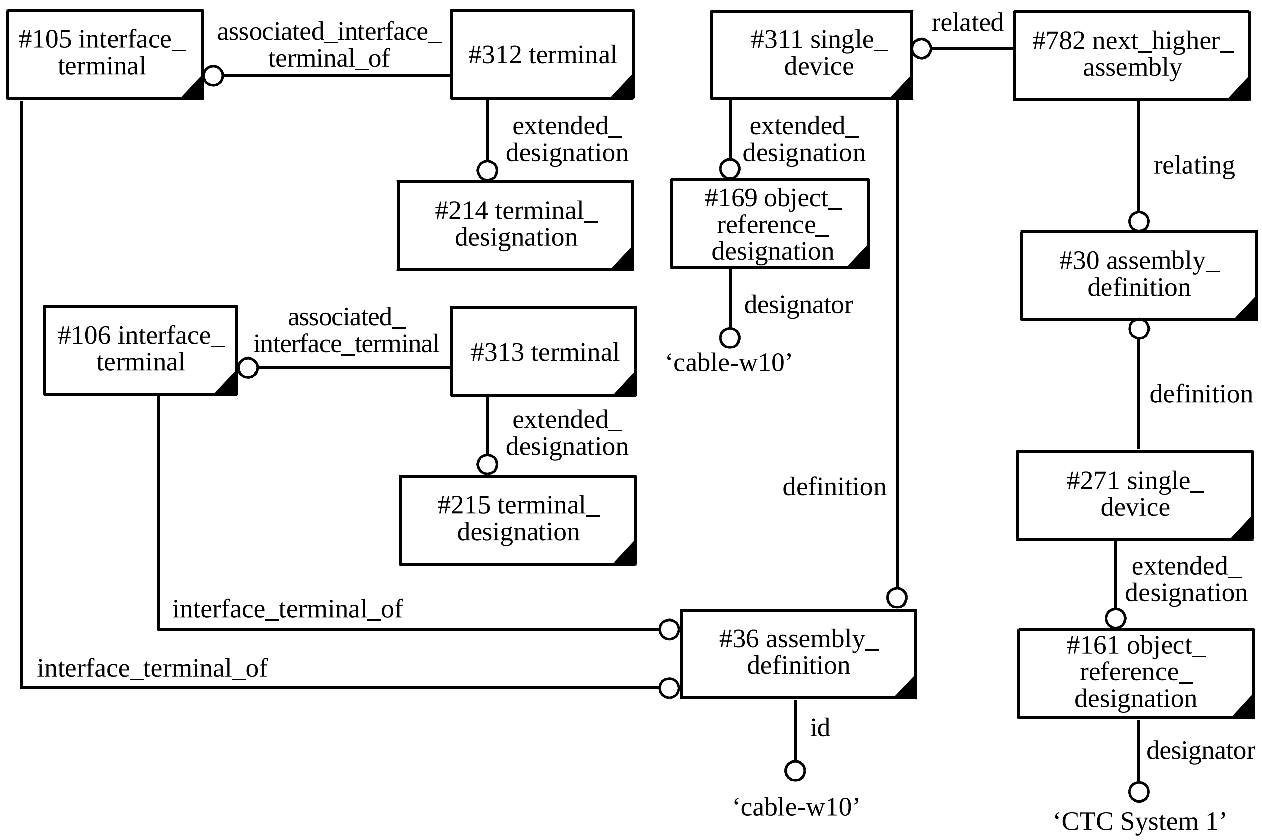


Figure A.37 — Specifying cable - W10

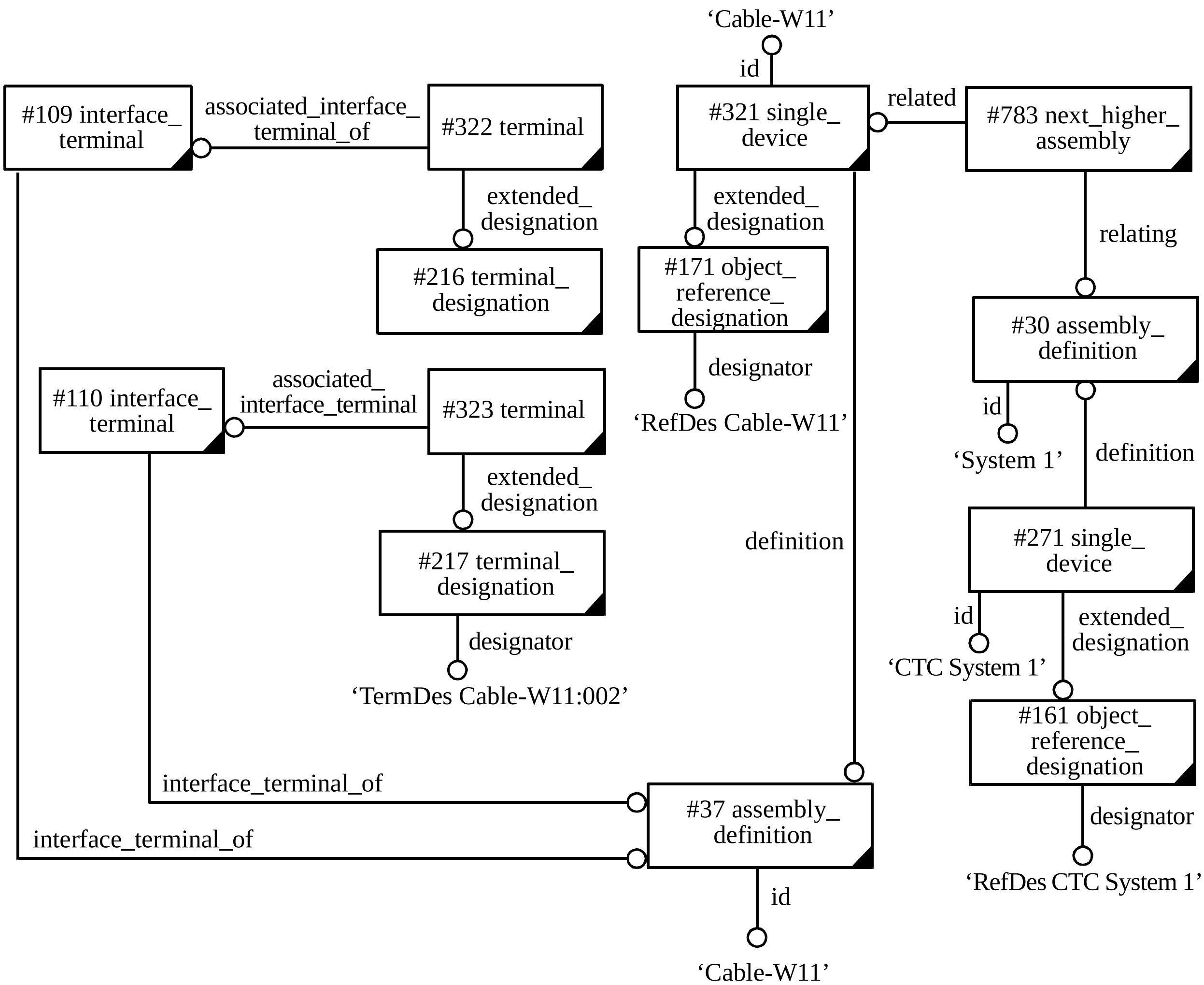


Figure A.38 — Specifying cable - W11

A.3.6.5.2 Specifying the connectivity

Figure A.39 represents how the system components are connected to form the system. All of the components that can be connected have associated terminals, which are represented by the Interface_terminal EDT. The central control and sensor have one terminal each, and the remaining components have two terminals each. These terminals are designated for identification. Terminal strip W1 has two terminals, which are designated differently (W1:001 and W1:002). These terminal designations are also incorporated into the model through the instances of the Terminal_designation EDT.

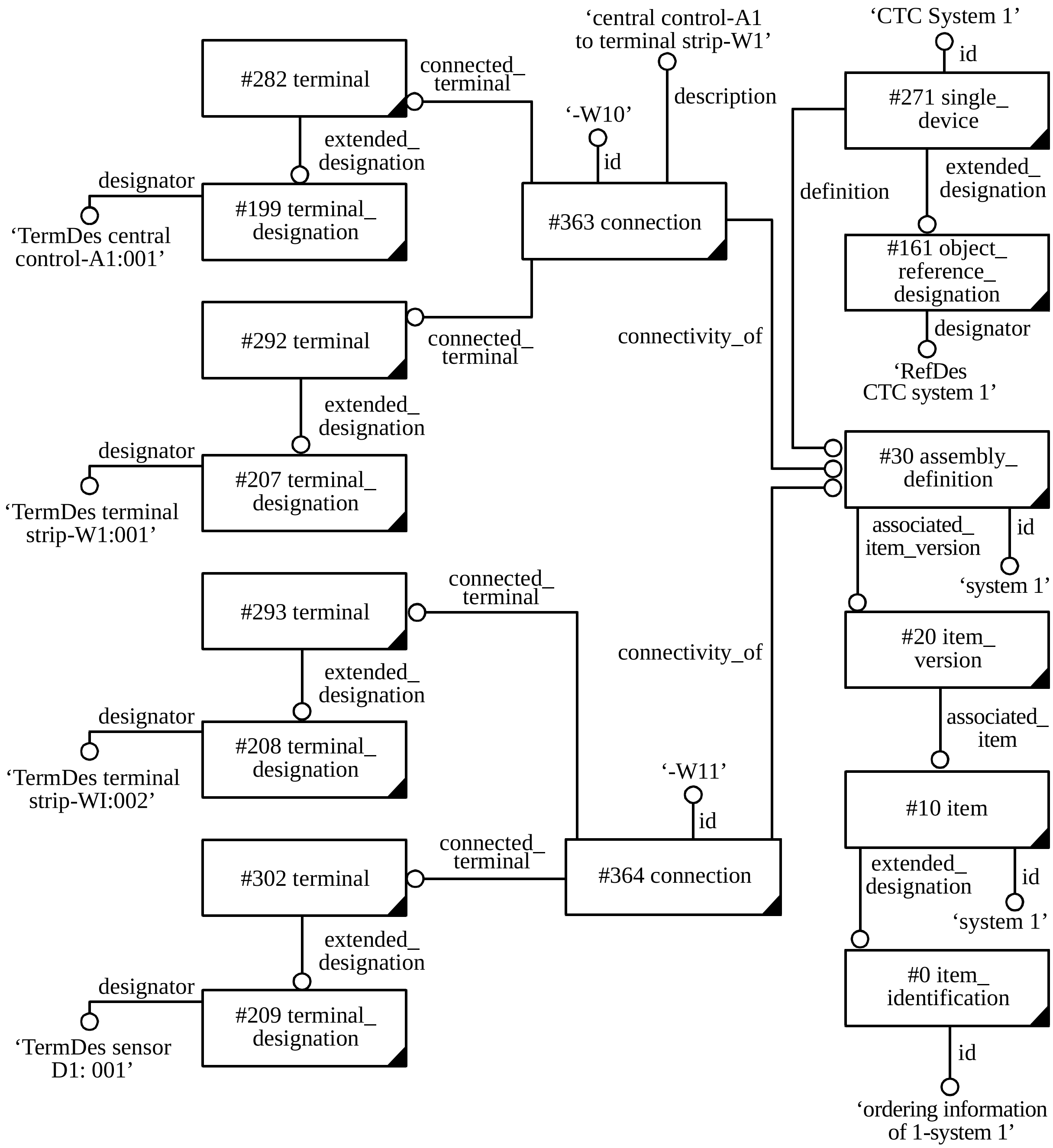


Figure A.39 — Specifying the connectivity

Terminals serve as access points of the devices. These devices are connected to form a system. The association between two or more instances of the Terminal EDT is represented by an instance of the Connection EDT. Represented by an instance (#363) of the Connection EDT, the system in the example has a connection between the central control and the terminal strip. A connection is also made between the terminal strip and the sensor. This connection is represented by an instance (#364) of the Connection EDT. The connection between the central control and the terminal strip is realized by using cable W10. The terminal bundle corresponding to instance (#282) belongs to the central control, and the terminal bundle corresponding to instance (#292) belongs to the terminal strip.

Thus, instance (#363) of the Connection EDT establishes connection between central control A1 and terminal strip W1 by connecting the terminal bundle (A1:001) corresponding to instance (#282) with the terminal bundle (W1:001) corresponding to instance (#292). The connection is established using the device designated as W10.

A.3.6.5.3 Specifying the signal

The sensor in the system is used to sense the bearing temperature of a generator. The sensor sends this information from the bearing to central control A1. The signal is designated as "*CTC* Electrical Systems–Signals." This is represented in Figure A.40 by an instance (#1001) of the Signal_designation EDT and designated as "SIGNAL B" by an instance (#1011) of the Object_reference_designation EDT. The signal is represented by an instance (#1000) of the Signal EDT, and the message corresponding to the signal is represented by an instance (#1008) of the Notification EDT.

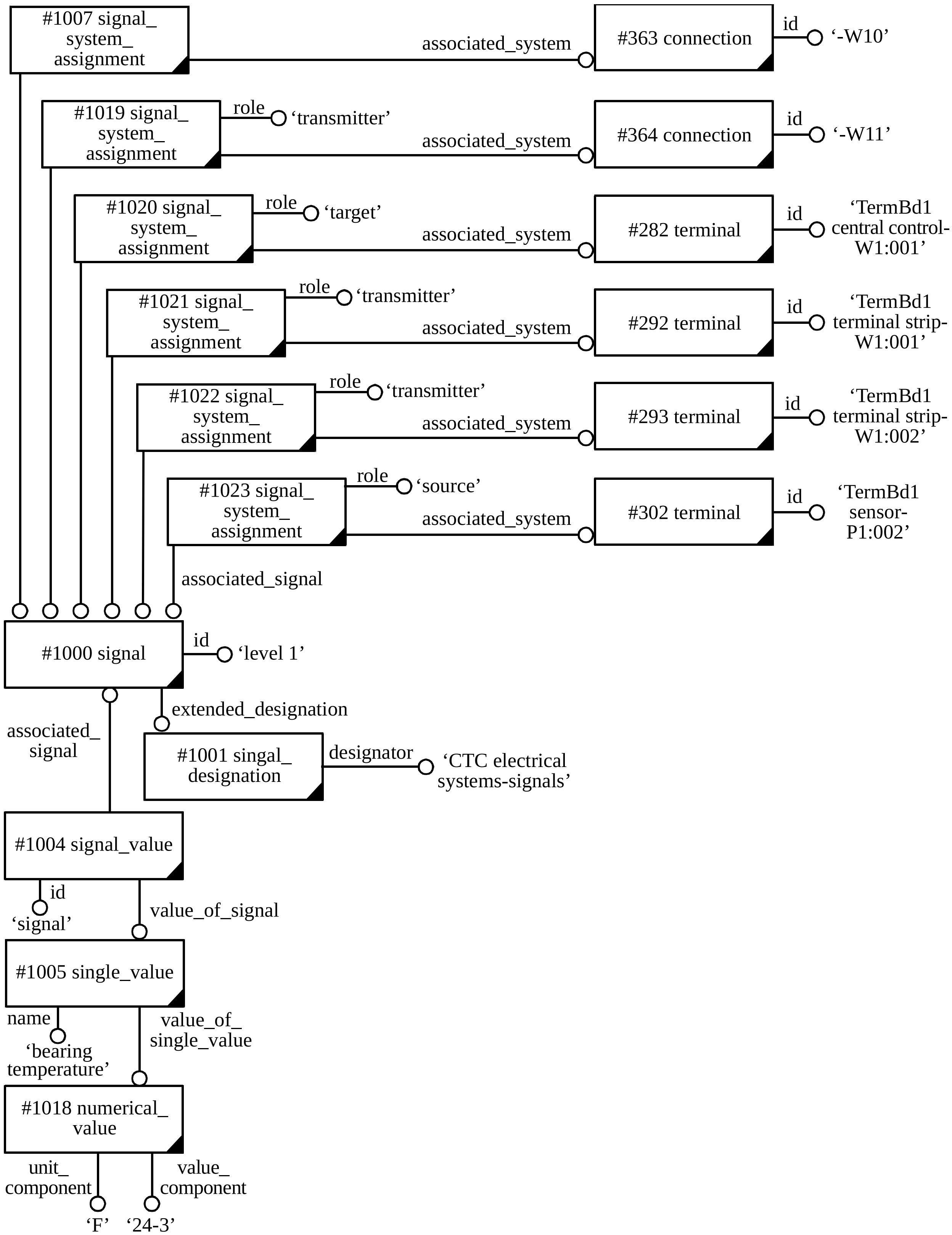


Figure A.40 — Specifying the signal

The Numerical_value EDT provides the numerical value and units of measurement. In the example, the bearing temperature is shown as 24.3 degrees Fahrenheit. This is represented by an instance (#1018) of the Numerical_value EDT. Instance #1018 is associated with the instance that represents the signal through the instances (#1004 and #1005) of the Signal_value and Single_value EDTs.

The Signal_system_assignment EDT is used to represent the association between the signal and the object that processes or transmits the signal. Instances (#1007 and #1008) of the Signal_system_assignment EDT associate the signal with W10 and W11, respectively. Other instances (#1009, #1010 and #1010) of the Signal_system_assignment EDT associate the same signal with terminals through which it passes. The remaining objects in the system assist in transmitting the signal from the source to the target. These include the terminal bundles of the terminal strip and the connection bundles that connect the terminal bundles.

A.3.7 External references

A.3.7.1 Purpose

This clause describes the use of ISO/IEC 10303-212 for referencing external sources of information.

NOTE This is particularly important because of the generic nature of ISO/IEC 10303-212.

Interoperability with libraries compliant with IEC 61360 and ISO 13584 is based on the mechanism of external references.

A.3.7.2 Background

The external reference is a way to provide additional information about an entity or object in a data transfer set. The sources of additional information can be electronic or non-electronic, standard or non-standard. Furthermore, the term "standard" covers the whole continuum from international standards to company or proprietary standards. For practical purposes, the standard is an agreed-upon definition that is known to both sending agent and receiving agent.

Four motivations exist for providing external references:

— to contain the size of a data transfer set;

NOTE 1 The SES description might be too large for a single data transfer set.

— to overcome an inability to provide a complete data transfer set.

NOTE 2 No single AP can contain all the data that is required by a ship due to limitations of the AP development methodology.

— to use other existing standards;

EXAMPLE 1 IEC 61360-4 might be used.

— to provide a means of keeping current with the technology.

EXAMPLE 2 A repository based on IEC 61360-2 [12] might be used.

Transferring product model data invariably involves references to objects not present in the transferred model. Three types of such references are further considered: reference to a catalog, reference to an object in another transfer data set, and informal reference.

A.3.7.2.1 Reference to a catalog

An important feature of ISO/IEC 10303-212 is its reliance on the availability of external (to the data transfer set) component catalogs. Entries in these catalogs can carry the vast majority of component-descriptive information, including the specification of component and geometric representation. An occurrence of a component contained in a data set compliant with ISO/IEC 10303-212 will almost exclusively refer to an external catalog entry for definitions of components. Thus, for the transfer to be effective, such catalogs must be available on both the sending and receiving site systems.

A separate standard specifies the content and format of catalog data exchanges. This type of external reference can be from an instance of the Design_discipline_item_definition EDT to the catalog. This interface is provided by the Class_reference EDT.

A.3.7.2.2 Reference to an object in another transfer data set

The reference to an object in another transfer data set is an external reference from an internal occurrence of an engineering part in the data transfer set to another related instance of the engineering part in another data transfer set. Such a reference provides additional information that is neither contained in the transfer data set nor defined in a catalog.

EXAMPLE Examples of this situation include a connection between a cable and an undefined piece of equipment, between a hanger and a piece of structure, and between a piece of equipment and the compartment where it is located.

NOTE Reference to an object in another transfer data set is not considered further in this document because the ISO 10303 architecture does not yet provide this capability.

A.3.7.2.3 Informal reference

An informal reference provides access to external descriptive data not explicitly present in the AP. This capability is provided through the attributes that name the referenced information source. The name of the information source is treated as a string by the AP. Examples of such referenced information sources include all types of physical documentation, including drawings, specifications, and publications such as training manuals and operating guides. This reference type is intended to facilitate the use of automated interfaces as well as manual cross-referencing.

There are cases where files that are computer-readable but do not conform to ISO 10303-11, documents that are not computer readable, have to be associated with an object. For those cases, ISO/IEC 10303-212 can associate an object with such information. For example, a PLC device can be associated with the process software based on IEC 61131-3 [13] or a textual document serving as an operation manual.

A.3.7.3 Data exchange

Table 11 defines the ISO/IEC 10303-212 concepts and entities that are used in this example.

Table 11 — Concepts and entities used

Concept	Entities
Item	Item Item_identification Item_version
Device	Single_device
Assembly	Assembly_definition
	Digital_document Digital_file Document Document_assignment Document_designation Document_property Document_version Hardcopy Physical_document
Designation	Object_reference_designation

A.3.7.4 Example

Sometimes it may be desirable to associate a behavioral model of some kind to an electrical device. In the fault current example (see clause 5.1.5.4) an electrical bus needs a behavioral model. The behavior model can be described by a computer procedure. It can also be documented in a standard handbook. These two cases are shown in our example.

A.3.7.5 Instance diagram

Figure A.41 shows how to associate a computer procedure and a standard handbook to "bus," represented by instance (#301) of the Single_device EDT. As stated earlier, the Document_assignment EDT can be used to associate a document with an instance of interest, which is selected through a SELECT type. In this example, the instance of interest is an instance #301 of the Single_device EDT. Instances (#2034) and (#2133) of the Document_assignment EDT establish the association between the "bus" and documents, representing a computer procedure and standard handbook, respectively. All instance diagrams have associated graphics.

The computer procedure is treated like a digital file. Furthermore, because there could be a number of versions of the digital file, a version control entity is provided. The computer procedure itself is represented by an instance (#2003) of the Document EDT. An instance (#2009) of the Document_version EDT provides support for version control. This EDT is similar to the Item_version and Function_version EDTs.

The association of a standard handbook to the "bus" is very similar. The only difference is in the type of document. This can be seen in the difference between the instances (#2021) and (#2121) of the Digital_document and Physical_document EDTs, respectively. Both are derived from the Document_representation EDT.

The Document_creation_property EDT describes the context of creation of the document. It specifies the tool used to create a document in a computer. The Data_element EDT provides additional characteristics to an instance of the Item. Document_content_property EDT provides additional characteristics to an instance of the Document EDT. In this example, an instance of the Document_creation_property EDT is used to associate the type of operating system for the computer procedure. The Document_content_property EDT is used to describe the language of the document in this example.

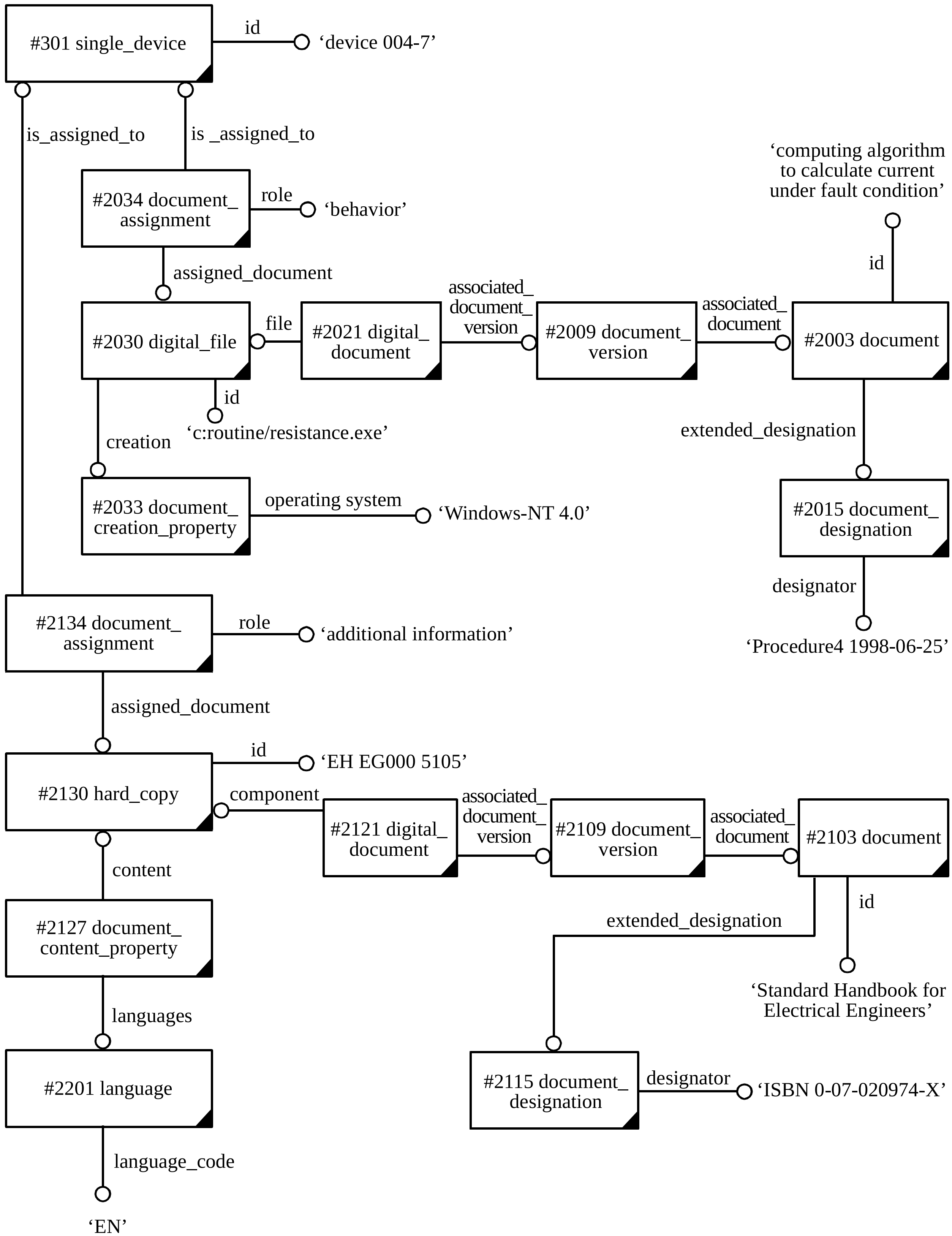


Figure A.41 — External reference to computer procedure and handbook

A.3.8 Component representation

A.3.8.1 Purpose

This clause describes the joint use of ISO/IEC 10303-212 and IEC 61360 to facilitate the modeling of electrical components and their properties.

A.3.8.2 Background

ISO/IEC 10303-212 does not model components and their properties at the ARM level; however; the standard provides a meta-model to represent components and properties. The User_defined_data_element and related EDTs attach properties to the components that are within the domain of ISO/IEC 10303-212.

This can be viewed as meta-property, because aspects (properties) of a property of a component are being specified in the ARM. Examples of aspects of a property include the definition of the property, property name, and the units for the specification of the property.

EXAMPLE It is desired to specify the output of a generator.

The value for the definition of the property can be the following text, "The output of the generator is defined as the power that is generated by the generator…" The name of the property can be the string "generator power," and the units for the property can be "megawatts."

ISO/IEC 10303-212 provides a meta-representation of properties; thus, any ISO/IEC 10303-212 object may be associated with any number of properties, all of which are represented using the Data_element EDT. The object for which these properties are applicable is selected by the Data_element_select select type. The property can be defined using the Data_element_definition EDT. Such definitions can be user-defined, or they may reference a standard. Furthermore, each property is also characterized by its value, which, in turn, can be an aggregate of subvalues. Four types of values are allowed—binary, logical, numerical, and string. The property may consist of any type of data such as commercial, technical, or administrative data.

Internationally standardized data element types may also be used to represent properties of components.

NOTE The IEC 61360 and UN/UNECE trade directories contain standardized data elements. The latter directory contains a list of data element types for the commercial and logistic fields.

In the case of using standardized data element types, only the data element code, value, and the source of the code are required.

Table 12 shows the structure of the data element type based on IEC 61360.

Table 12 — Attributes of the IEC 61360 data element

Name of the attribute	Example of the value of the attribute
Identifying attributes	
Code	AAF307
Preferred name	Temp factor of permeability
Synonymous name	Temp factor of reluctivity
Preferred letter symbol	Ag for silver
Synonymous letter symbol	
Short name	
Version number	005
Revision number	01
Identifier	
Semantic attributes	
Definition	
Note	
Remark	
Figure	
Formula	E =mc**2
Source document of data element type definition	IEC 50(221), term 02.49
Value attributes	
Value format	NR3 S..3.3ES2
Value domain	
Unit of measure	K**-1
Source document of value	IEC 50(221), term 01.14
Level	MinTypMax
Value	
Value code	SFT
Value meaning	Soft magnetic
Relationship attributes	
Component class	
Data element type class	E25
Condition data element type	

A.3.8.3 Data exchange

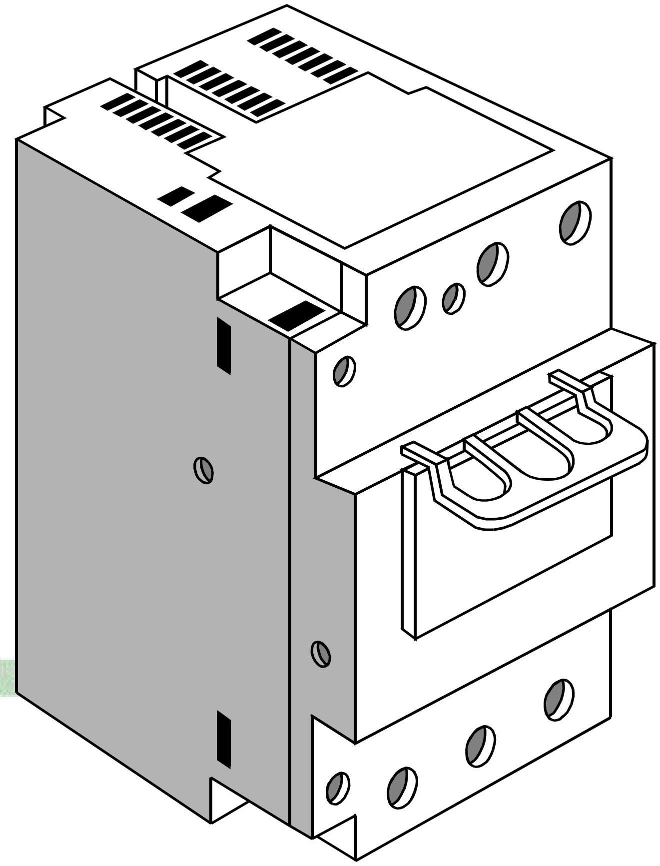
Table 13 shows the main concepts and ISO/IEC 10303-212 ARM-level entities that are used in the example. Two important concepts of data exchange in this example include the data element and the reference to a repository of data elements. User_defined_data_element, Data_element_definition, Data_element_specification, and Data_element_relationship EDTs facilitate the exchange of properties, and the Class_reference and Property_reference EDTs facilitate the exchange of reference to a repository of data elements.

Table 13 — Concepts and entities used

Concept	Entities
Item	Item Item_identification Item_version
Assembly	Assembly_definition Next_higher_assembly
Property	Class_reference Property_reference
Data_element	Data_element_definition Data_element_relationship Data_element_specification User_defined_data_element
Value	Single_value Numerical_value
Designation	Object_reference_designation
Device	Single_device

A.3.8.4 Example

Figure A.42 shows a Siemens circuit breaker and a portion of the specification sheet. The circuit breaker is designated by the manufacturer as product number 3VU16001MN00.



SIEMENS
Intranet

product database AUSTER

Technical data

Product Number: 3VU16001MN00

Show Ur-Sets

Standard-Set:

```
Specification                      : IEC 947-1, IEC 947-2, IEC 947-4-1
Rated current In.                  : 25 A
Rated operational voltage Ue       : AC, 690V
Rated frequency                    : 50/60 Hz
Rated insulation voltage Ui        : 750 V
Ambient temprature when in
operation                          : -20...+55 Cel
Ambient temprature when stored     : -50...+80 Cel
Rated ultimate short-circuit
breaking capacity Icu
 AC 50/60 Hz
  240 V                            : 100 kA
  415 V                            : 100 kA
  440 V                            : 25 kA
  500 V                            : 10 kA
  690 V                            : 4 kA

.
.
.
```

Figure A.42 — Circuit breaker

A.3.8.5 Instance diagram

A.3.8.5.1 Identifying the component

The ordering information for the circuit breaker is represented by an instance (#1) of the Item_identification EDT, and the typical characteristics of this component are given by an instance (#11) of the Item EDT. Typically, there are many versions of a given product. Different versions can result from the improvement of the product over time or from changing product requirements.

EXAMPLE Consider the relationship between Intel microprocessors. Model 8086 is a 16-bit microprocessor with a 16-bit data interface bus that was designed before Model 8088; however, a different version of Model 8086 was designed due to the lack of support chips to interface with the 16-bit data bus. Model 8088 is also a 16-bit microprocessor, but with an 8-bit data bus. In actuality, Model 8088 is an 8-bit data bus version of Model 8086. In this example, the instance of the Item EDT is qualified by an instance of the Item_version EDT.

In the instance diagram (see Figure A.43), the circuit breaker has version number 1, which is represented by an instance (#21) of the Item_version EDT. The assembly definition of the switch is provided by an instance (#31) of the Assembly_definition EDT, and the circuit breaker's product number is represented by an instance (#111) of the Object_reference_designation EDT. Whereas the Item_version and Item provide the typical characteristics of the switch, the specific device is represented by an instance (#271) of the Single_device EDT.

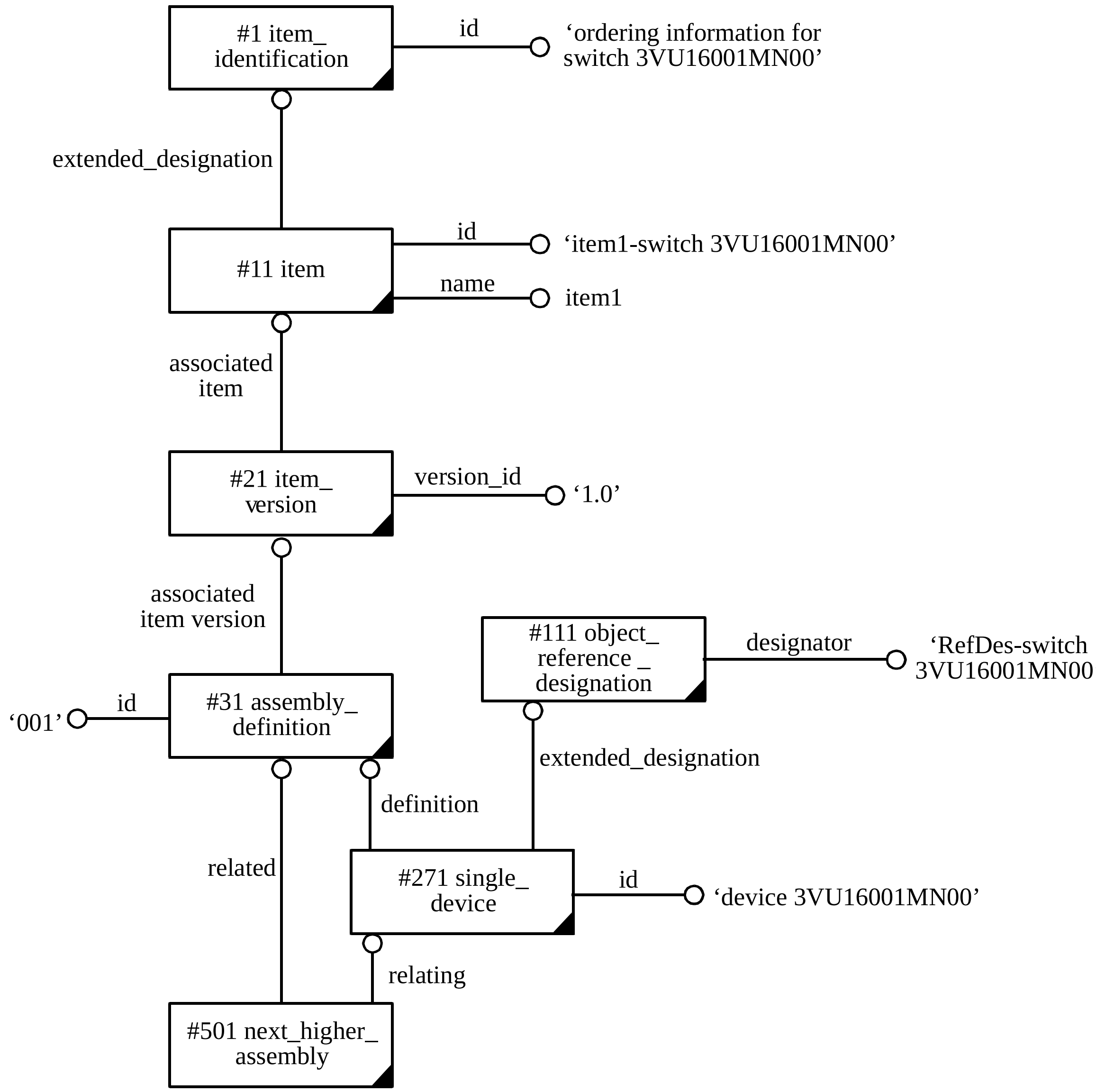


Figure A.43 — Identifying the component

A.3.8.5.2 Specifying the properties

As Figure A>43 shows, the class for the circuit breaker is represented by "fuse" in IEC 61360-4. This is represented by an instance (#602) of the Class_reference EDT. The class code for fuse, within the context of IEC 61360-4, is AAA149-001. This class code is represented by the "code" attribute of the Class_reference EDT. The property within a class is represented by the Property_reference EDT. The rated current of the circuit breaker is represented by an instance (#1001) of the Property_reference EDT. Similarly, other properties of the circuit breaker are represented by instances of the Property_reference EDT. All of the instances of the Property_reference EDT refer to instance #602 for providing the Class_reference. All of the properties of the circuit breaker and their respective codes are shown in Table 14.

Table 14 — Property codes from IEC 61360-4

Property reference	Property code from IEC 61360-4	Property name
#1001	AAE525-005 02	Rated current
#1002	AAE512-005 02	Rated operational volt
#1003	AAE339-005 02	Upper-rated frequency
#1004	AAE513-005 02	Insulation voltage
#1005	AAE891-005 01	Operating ambient temperature
#1006	AAF122-005 01	Storage ambient temperature
#1007	AAE519-005 01	Rated breaking capacity
#1008	AAE029-005 01	Nominal voltage
#1009	AAE014-005 02	Ambient temperature

The rated current of the circuit breaker is represented by an instance (#1101) of the Data_element_definition EDT.

The rated operational volt instance is represented by an instance (#1102) of the Data_element_definition EDT. An instance of the Data_element_definition EDT exists for each property type. Instance #1103 defines upper-rated frequency.

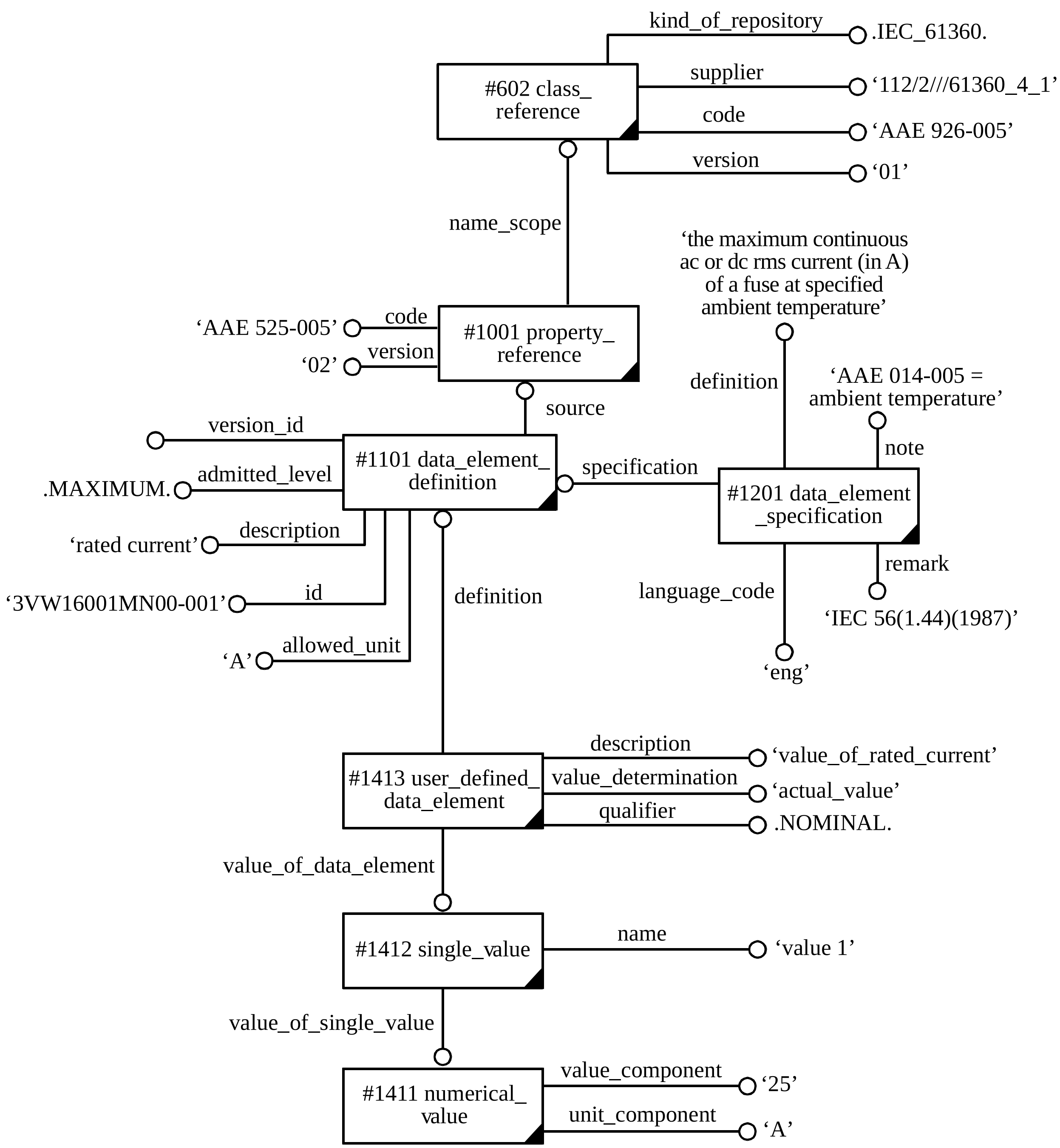


Figure A.44 — Specifying the properties and data elements

A.3.8.5.3 Specifying the data elements

In Figure A.44, an instance (#1201) of the Data_element_specification EDT specifies the rated current as "the maximum continuous AC or DC rms current (in a) of a fuse at the specified ambient temperature." The other instances of this EDT provide specification for other properties.

A.3.8.5.4 Specifying the dependence on minimum frequency

Figure A.45 shows an instance (#1301) of the Data_element_relationship EDT that represents the relationship between the breaking capacity (#1543) and the minimum frequency (#1513) when the minimum frequency is 50 Hz. The breaking capacity at this frequency is 100 kA, as given by instance #1543. A similar relationship exists between instances #1513 and #1563; #1513 and #1583; #1513 and #1613; and #1613 and #1633. These relationships are represented by instances #1303, #1305, #1307, and #1309, respectively, of the Data_element_relationship EDT.

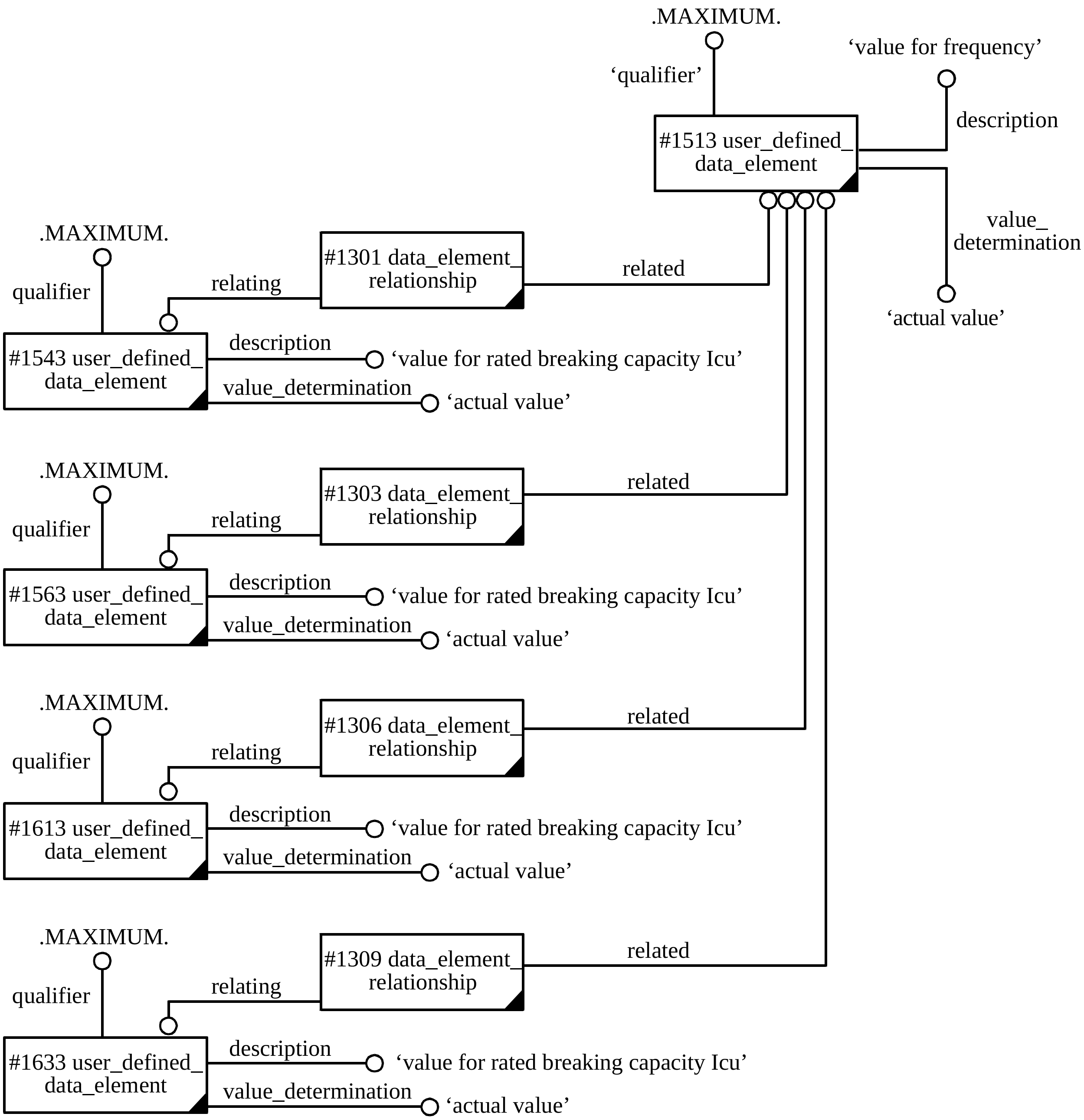


Figure A.45 — Specifying the dependence on minimum frequency

A.3.8.5.5 Specifying the dependence on maximum frequency

Instance #1302 of the Data_element_relationship EDT represents the relationship between the breaking capacity (#1543) and the maximum frequency (#1523) when the maximum frequency is 60 Hz. The breaking capacity at this frequency is 100 kA, as given by instance #1543. A relationship also exists between instances #1523 and #1563; #1523 and #1583; #1523 and #1613; and #1623 and #1633. These relationships are represented by instances #1303, #1305, #1307, and #1309, respectively, of the Data_element_relationship EDT.

A.3.8.5.6 Breaking capacity as a function of nominal voltage

An instance (#1311) of the Data_element_relationship EDT represents the relationship between the breaking capacity (#1543) and the nominal voltage (#1533) when the nominal voltage is 240 volts. The breaking capacity at this nominal voltage is 100 kA, as given by instance #1543.

A similar relationship exists between instances #1553 and #1563; #1573 and #1583; #1593 and #1613; and #1623 and #1633. These relationships are represented by instances #1312, #1313, #1314, and #1315, respectively, of the Data_element_relationship EDT, as summarized in Table 15.

Table 15 — Associating voltage with breaking capacity

Nominal voltage		Breaking capacity		Data_element_ Relationship
Value	#	Value	#	#
240 V	#1533	100 kA	#1543	#1311
415 V	#1553	100 kA	#1563	#1312
440 V	#1573	25 kA	#1583	#1313
500 V	#1593	10 kA	#1613	#1314
690 V	#1623	4 kA	#1633	#1315

A.3.8.5.7 Specifying the numerical value for the data elements

The remainder of the instance diagram specifies the numerical value for the various user-defined data element types, as shown in Figure A.46.

An instance (#1413) of the User_defined_data_element EDT specifies the rated current. The actual value of the rated current is given by an instance (#1411) of the Numerical_value EDT, which shows that a value of 25 amperes is associated with the User_defined_data_element EDT for the rated current. The physical units for the data are given by the attributes of the Numerical_value EDT. Instance #1413 of the User_defined_data_element EDT and instance #1411 of the Numerical_value EDT are associated with the help of instance #1412 of the Single_value EDT. The rest of the numeric values are specified in a similar way.

Figure A.46 — Specifying the numerical values for the data elements

The most recent version of the IEC 61360-4 does not contain all of the required data elements to represent electrical components. This example has attempted to use correct data elements; however, cases exist in which less than appropriate data elements have been chosen because no correct data element currently exists in the IEC 61360-4.

EXAMPLE Consider the reference to "upper-rated frequency" in an instance (#1003) of Property_reference. The property code in this case is "AAE339-005," with a version number of "02." One can readily examine IEC 61360-4 for this data element code and determine that upper-rated frequency specifies "the nominal upper frequency (in Hz) of a loudspeaker." Because the component in the example is a circuit breaker, rather than a loudspeaker, the use of the data element corresponding to "AAE339-005" is technically incorrect.

A.3.9 Cableway design

A.3.9.1 Purpose

This clause describes the use of ISO/IEC 10303-212 for representing cableway design information. It also describes the use of ISO 10303-227 in conjunction with ISO/IEC 10303-212 to represent the results of interference analysis between the cableway and the ship structure. While the primary focus is on cableway design for ships, it has broader applicability.

A.3.9.2 Background

Cableways are designed as part of the design of the overall electrical system. This clause provides an overview of the steps leading up to a complete cableway design.

The general steps leading to cableway design are:

— identify equipment;

— design electrical circuit;

— determine spatial layout;

— specify overall cableway;

— specify cableway installation;

— specify wire pull.

These steps are described below.

A.3.9.2.1 Identify equipment

The first step is to identify the location and attributes of all equipment that needs to be connected to the electrical system. The plant designer chooses the equipment to meet plant functional objectives, and the electrical system designer in general must accommodate the plant designer's choices. Attributes of the equipment such as power wattage, voltage, and number of phases are determined at this point. The electrical system designer may negotiate changes of equipment selection or position with the plant designer in order to reduce cost or achieve other design objectives. A list of equipment items and their electrical connection and power requirements is created.

NOTE The connections may be related to instrumentation and control, in addition to the power supply. In the remainder of this document, only the power supply is discussed.

A.3.9.2.2 Design electrical circuit

The electrical system designer designs an electrical circuit to provide the necessary power to the equipment identified in the previous step, in accordance with applicable codes and standards.

A.3.9.2.3 Determine routes and cableway layout

The layout of the connection between the devices in the plant is expressed logically via a one-line diagram in which a cableway is represented by a single line drawn through its center. Other electrical items such as switches and panels are included in this diagram as well. The electrical items are checked for interference with other plant or ship items. The items are repositioned as necessary to avoid any unacceptable interferences. The amount of power that needs to flow through each section of cableway and through each panel, switch and other electrical item, is determined. Routing of wires through the various cableway sections and details of wiring of circuit breakers, panels and switches is decided.

A.3.9.2.4 Specify overall cableway

The electrical system designer determines the sizing, material, and other specifications for each electrical system item identified in the previous step. He also specifies minimum bend radii for conduit and other constraints that must be met. The one-line representation of the cableway from the previous step is fleshed out into "multiline drawing" or three-dimensional representation. This more accurate representation is used to perform more detailed interference checks. The amount of detail depends on the type of product being built. In construction of ordinary commercial buildings or factories, it is quite common to leave details to the discretion of the electrical contractor, with only general instructions.

EXAMPLE 1 Rather than including each cableway support in the drawing, a note in the specification might state that "cableway supports shall be a maximum of 5 metres apart."

All the raceway pieces and components, such as runs, junction boxs, panels, and tees, are pieced together in a drawing to obtain information on fabrication. Fabrication information is required for the vendor for cutting raceway segments to size, bending of raceway, assembly of raceway pieces in a module as necessary. The drawings, which provide information on assembly of raceway modules, information on dimensions on individual raceways, and the manufacturing of raceway segments are obtained at this stage.

EXAMPLE 2 Manufacture of raceway segments may include bending and cutting.

A.3.9.2.5 Specify wire pull

Wire pull instructions are generated at this stage.

A.3.9.2.6 Specify cableway installation

A detailed representation of all cableway components may be generated. Individual cableway pieces, connectors, and supports may be identified. Specifying all pieces greatly raises the cost of design and is generally done only in specialized applications.

NOTE Specialized applications might include military ships, mass-produced buildings or ships, and high-security environments.

If cableway components or assemblies are to be made in a shop, the specification for each shop-made piece is developed and its location in the plant is identified.

A.3.9.3 Data exchange

This clause will be added in a later version of this document.

A.3.9.4 Example

Figure A.47 shows a room layout with a single piece of electrical equipment, a blower. Figure A.48 shows a cableway layout for the equipment and room layout in Figure A.47. Figure A.49 shows a "multiline drawing" of the cableway. The wall separating the two rooms is a firewall. Figure A.50 shows the fire-resistant wall penetration system that will be used to meet fire codes.

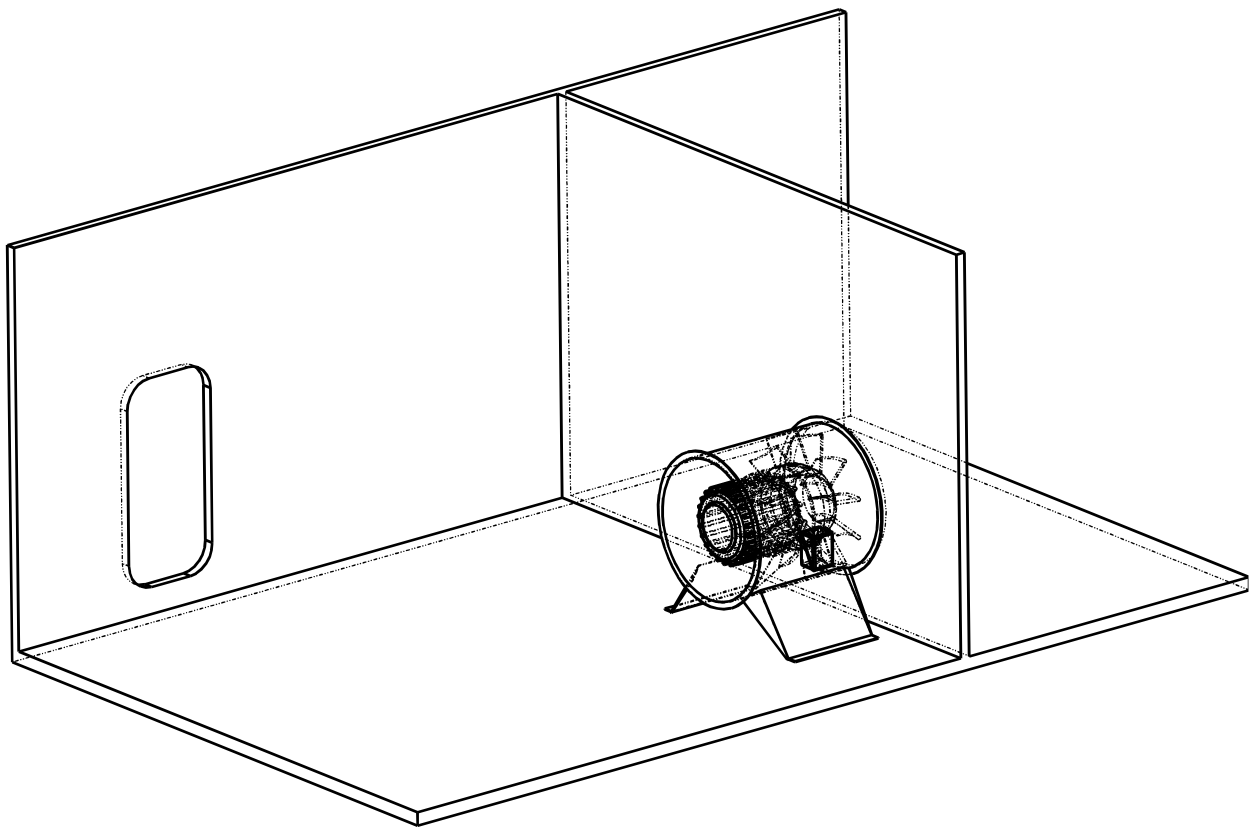


Figure A.47 — Equipment layout

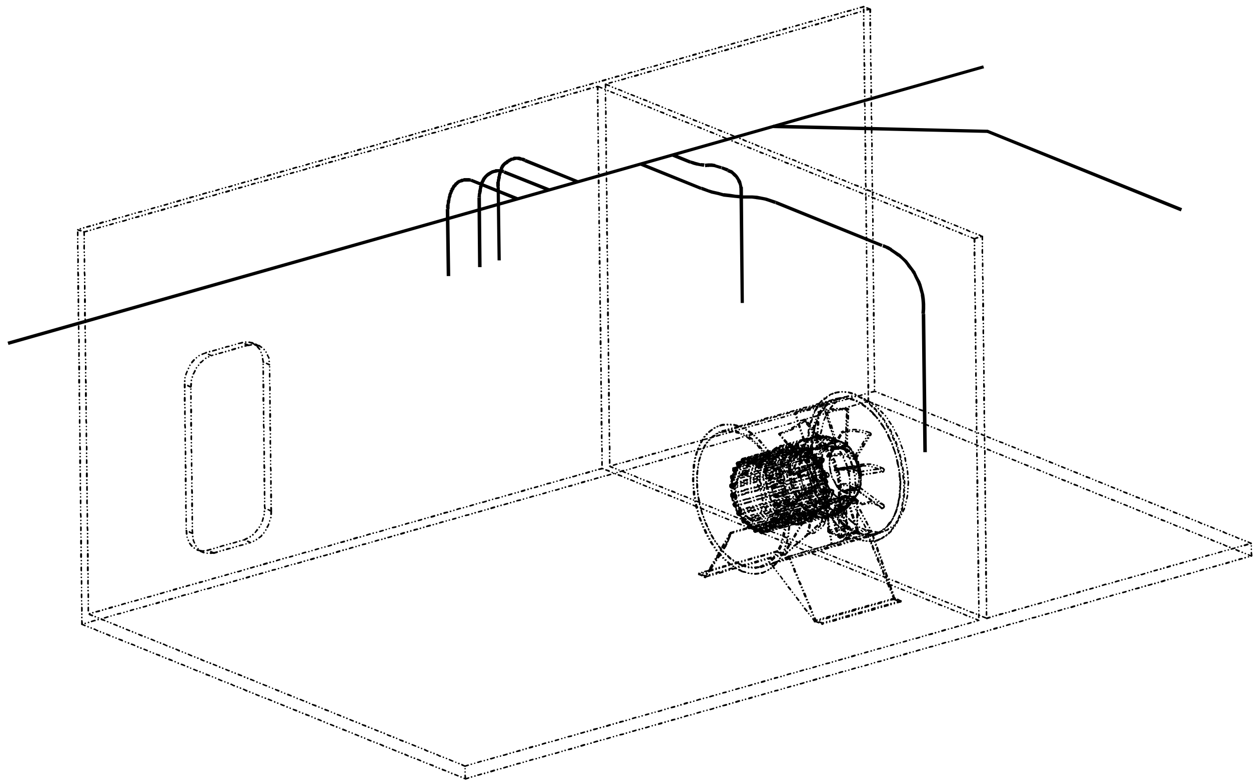


Figure A.48 — Cableway layout

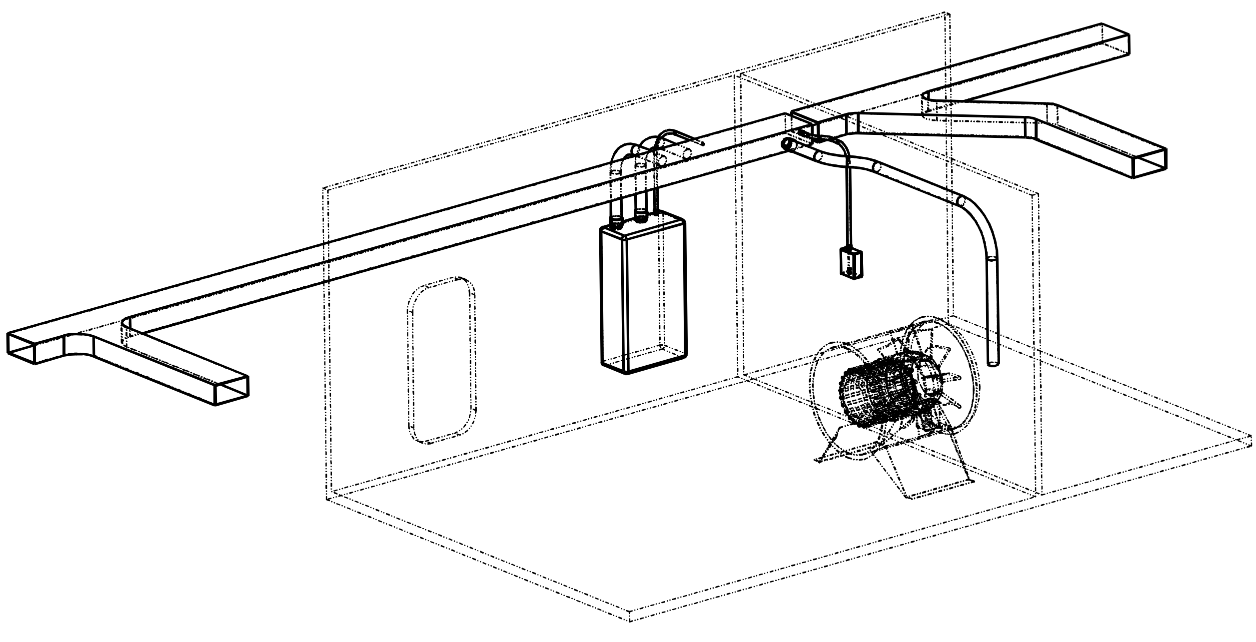


Figure A.49 — Multiline drawing

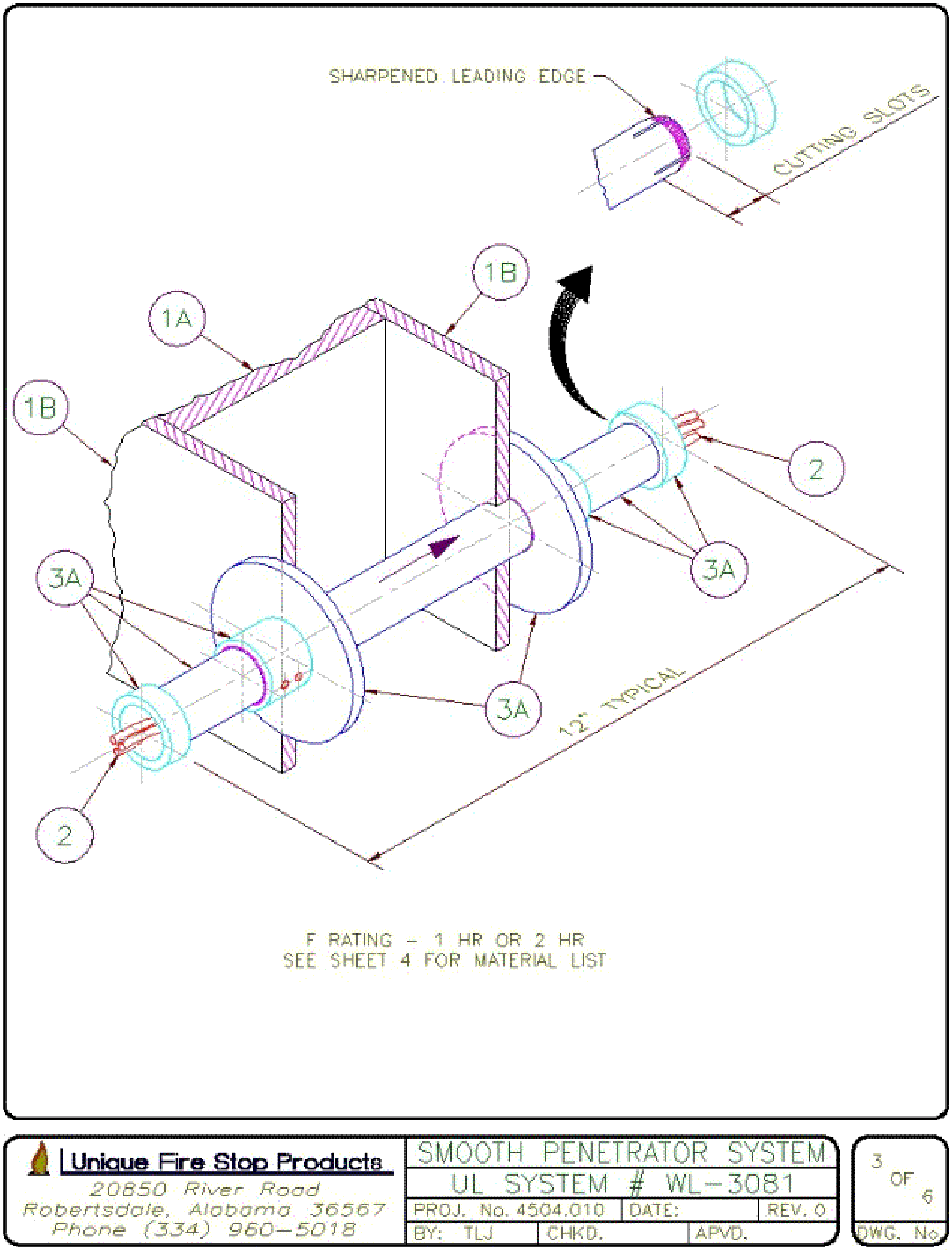


Figure A.50 — Fire-resistant wall penetration system[1]

A.3.9.5 Instance diagram

A.3.9.5.1 Specifying the routes

The Route EDT is used to specify wire paths. A route consists of one or more segments. Each segment is located at a node. Figure A.51 shows a series of nodes that will be used for this example. The location of a node may be specified approximately ("near the motor" or "in compartment 25") or precisely. Figure A.52 shows several segments. Figure A.53 shows two routes. R2 is the route for the power feed to the motor.

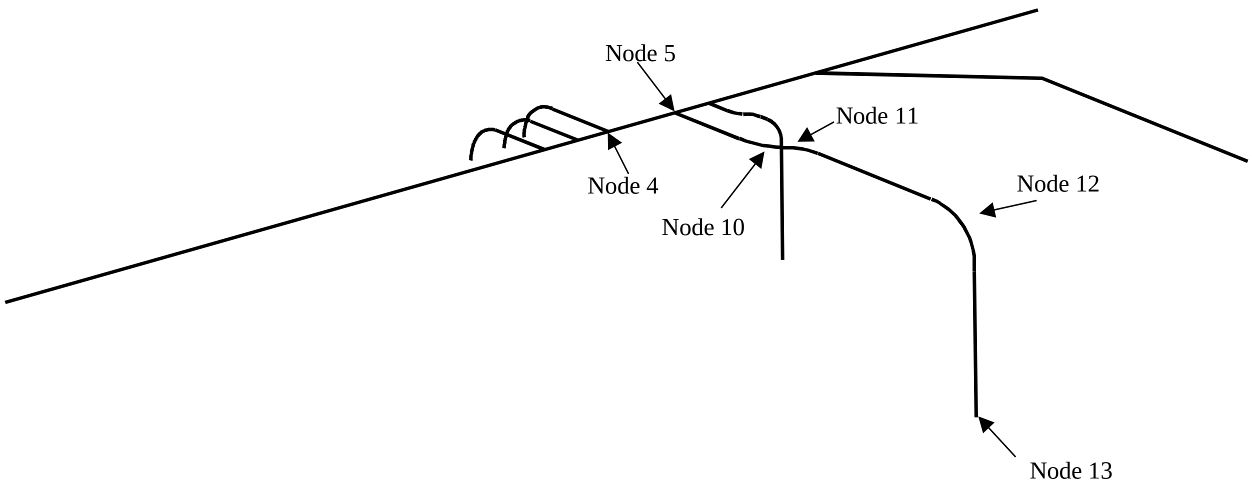


Figure A.51 — Nodes

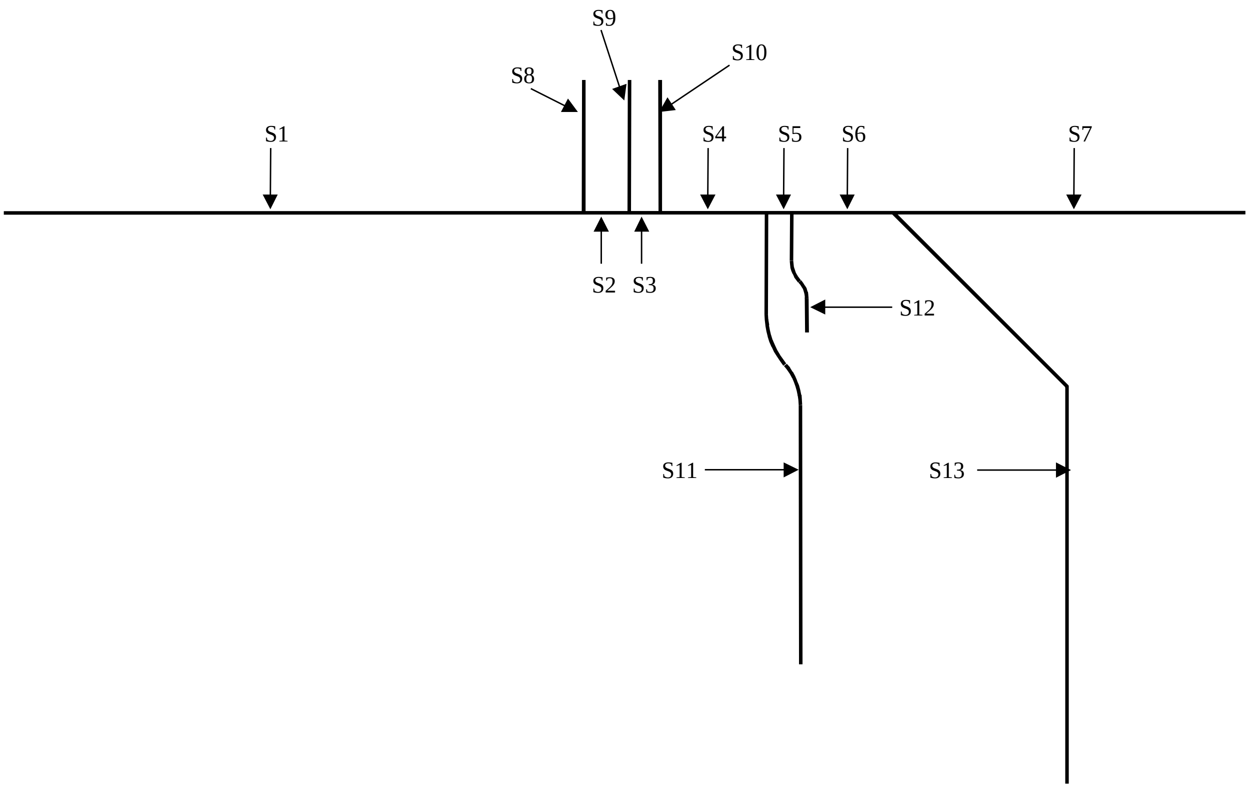


Figure A.52 — Segments

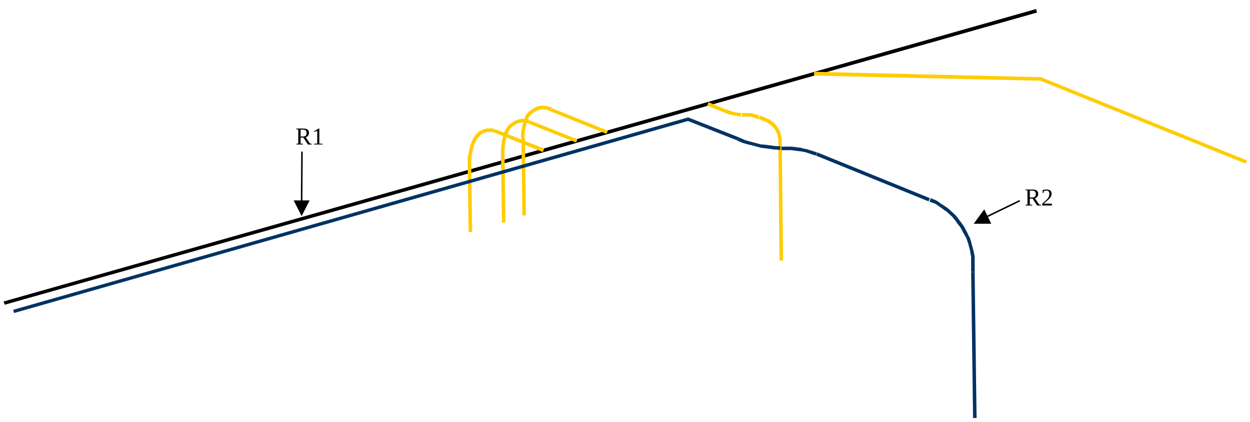


Figure A.53 — Routes

Figure A.54 shows a portion of the representation of routes R1 and R2. At this stage in the design, geometric locations are not given for the nodes.

Route R1 is represented by an instance (#110000) of the Route EDT. Route R1 consists of sections S1-S7. Section S4 is represented by an instance (#112000) of the Section EDT, and section S5 is represented by an instance (#113000) of the Section EDT. Sections S1, S2, S3, S6 and S7 are not shown in the instance diagram, but would be represented similarly. The endpoints of S4 are represented by instances (#112100 and #112200) of the Section_end EDT. By convention, the left side of a segment in Figure

A.52 is considered the "UP" side, and the right side is considered the "DN" side. The UP endpoint of S4 (#112100) is located at Node 4, which is represented by an instance (#112110) of the Node EDT. The DN endpoint of S4 (#112200) is located at Node 5, which is represented by an instance (#112210) of the Node EDT.

The UP endpoint of S5 (#113100) is also located at Node 5. Thus, the shared instance (#112210) of the Node EDT provides the connectivity between segments S4 and S5. The DN endpoint of S5 is not shown in the instance diagram, but would be represented similarly.

In order to help calculate the proper sizing of cableways, the designer can keep track of the power that each section carries. An instance (#111110) of the Rated_power EDT represents a rated power of 100 watts. This is referenced from an instance (#111100) of Pre_defined_data_element. An instance (#111000) of the Data_element_association attaches the Pre_defined_data_element to the instance (#112000) of the Section EDT representing section S4.

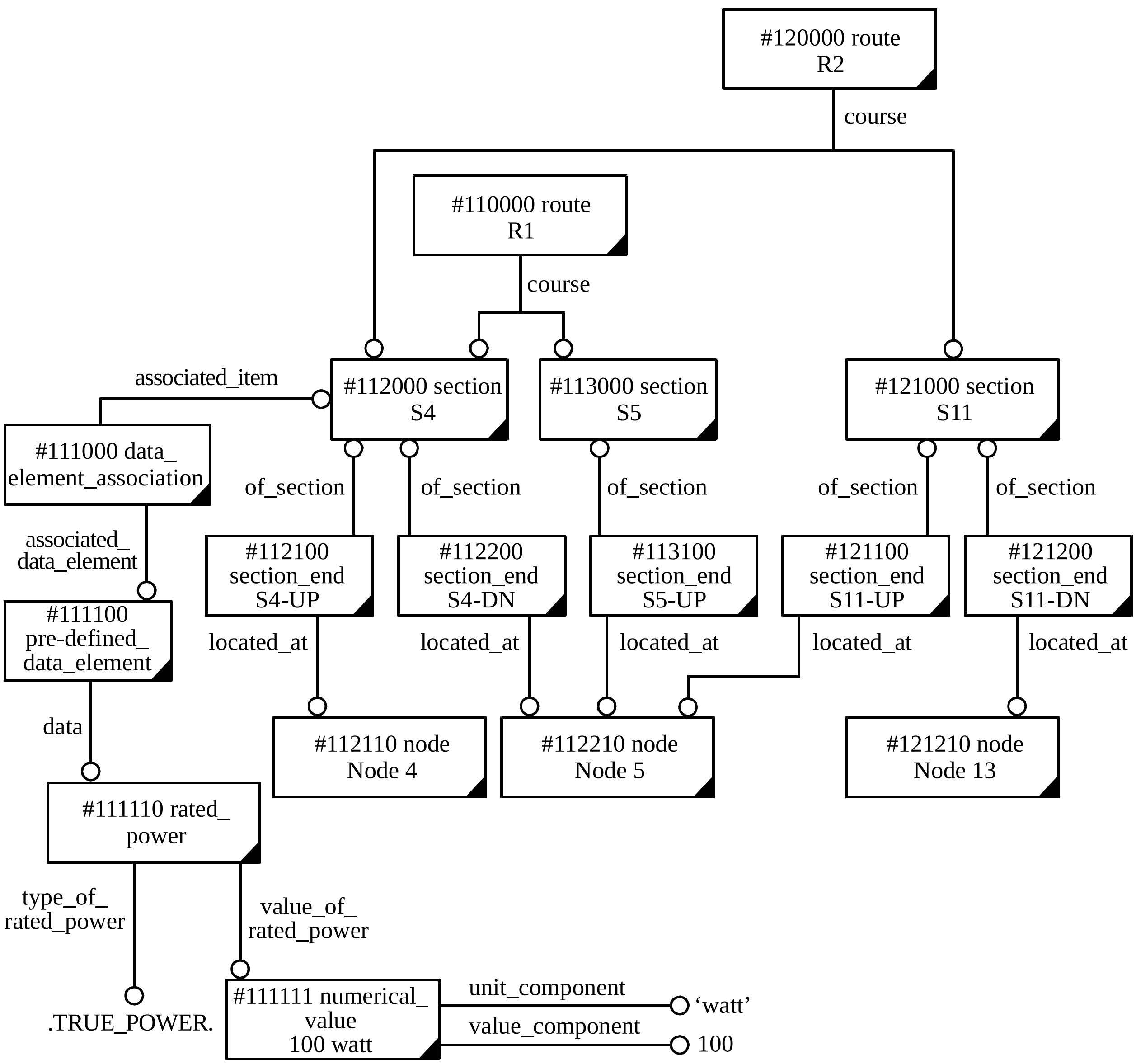


Figure A.54 — Representation of routes

A.3.9.5.2 Specifying the course of the routes

Figure A.55 shows how the overall dimensions and path through space may be given for a segment. An instance (#213000) of the Path EDT gives the path for section S11. A path consists of a course made up of path segments. Each path segment has two endpoints, which are represented by instances of the Path_node EDT. A Path_node has a position given by an instance of the Cartesian_point EDT.

An instance (#212000) of theSingle_value EDT gives the bending radius for S11. Another instance (#211000) of the Single_value EDT gives the overall length of S11.

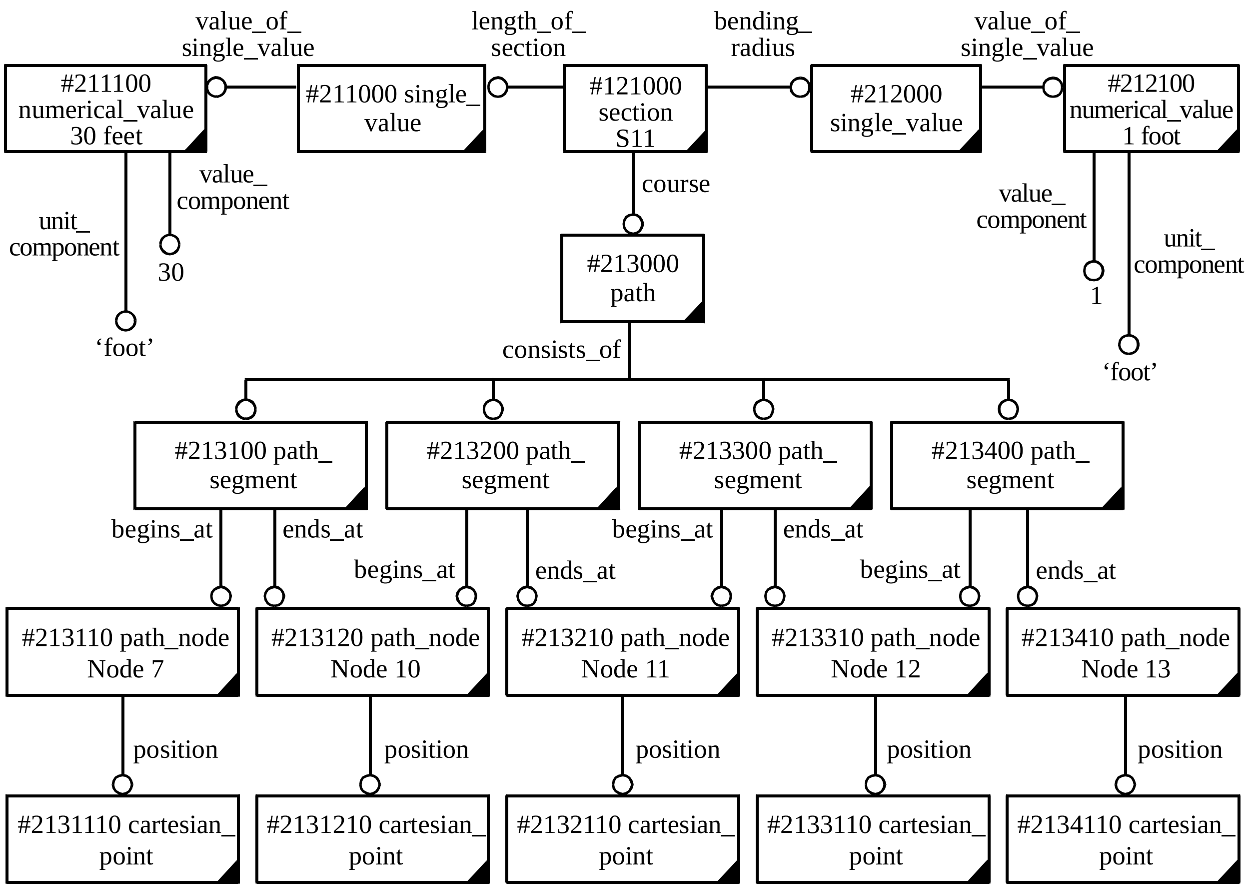


Figure A.55 — Specifying the geometry

A.3.9.5.3 Adding raceway specification

Figure A.56 shows how the specification of the raceway to be used for a portion of route R1. Sections S1-S6 are to be implemented by a raceway that is 4 inches high and 12 inches wide. An instance (#312000) of the Single_device EDT represents the raceway for S1-S6, so the instances (#310000, #320000, #330000, #112000, #113000, and #610000) representing these sections all have an implemented_by attribute pointing to the same instance (#312000) of the Single_device EDT representing the raceway.

A separate instance of the Single_device EDT is used to represent the portion of the R1 raceway on the right side of the wall.

NOTE During installation, a single instance of the Single_device EDT may be realized by more than one physical piece of raceway. Raceway comes in standard 20-ft lengths. If a longer run (say 30 feet) exists, then the logical raceway device representing the entire 30-ft run must be realized by more than one physical device. However, plant designers do not typically take the cableway design down to the level of specifying individual physical pieces of raceway.

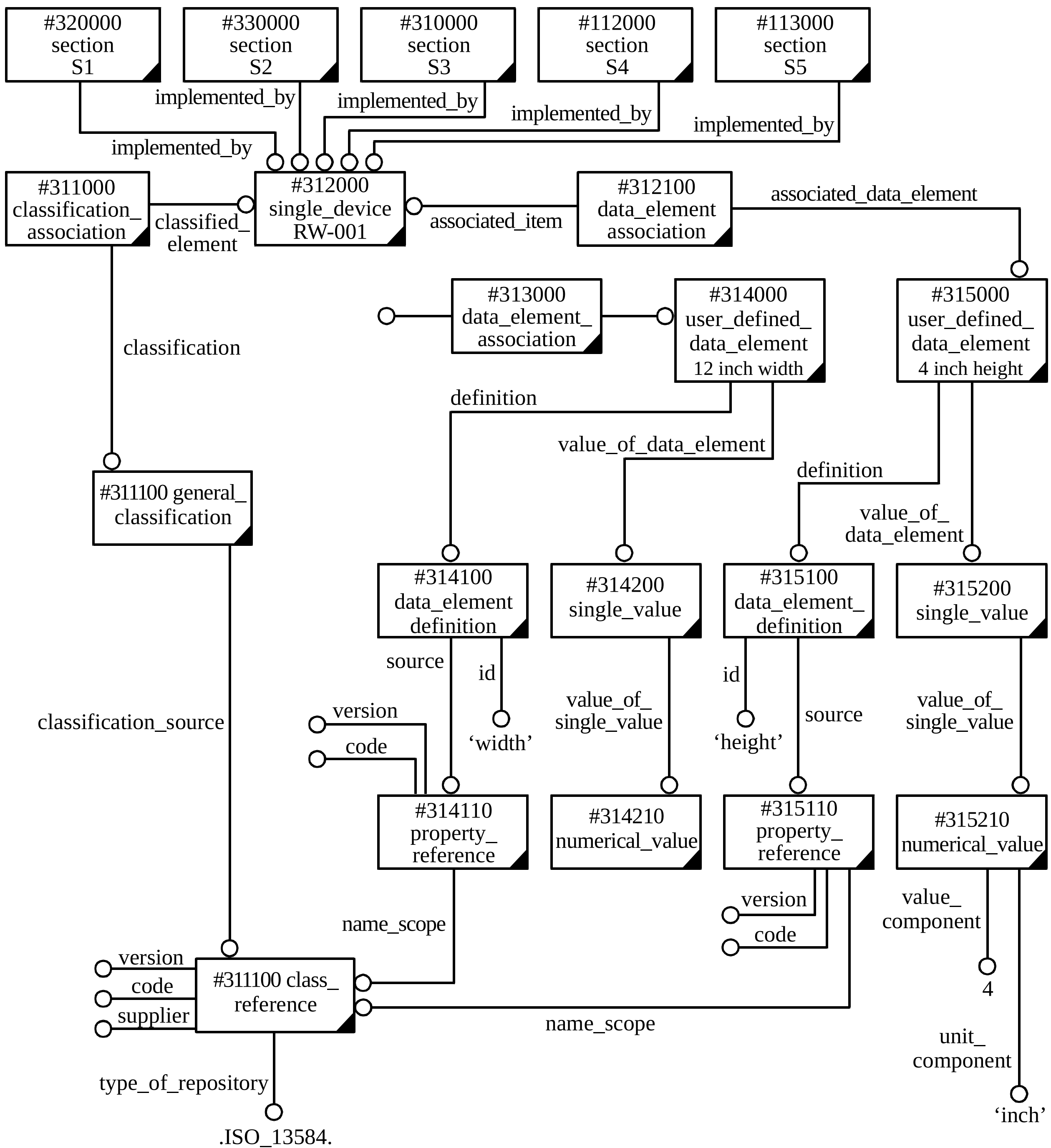


Figure A.56 — Specifying the raceway

Figure A.57 shows how the raceway sections on either side of the wall are connected. Section S6, which abuts the wall on the left side in Figure A.47, is represented by an instance (#610000) of the Section EDT. Its DN end is represented by an instance (#611000) of the Section_end EDT. Section S7, which abuts the wall on the right side in Figure A.47, is represented by an instance (#620000) of the Section EDT. Its DN end is represented by an instance (#621000) of the Section_end EDT. These section ends are joined by an instance (#611100) of the Section_interface EDT. This section interface is implemented by an instance (#611110) of the Single_device EDT, which represents all the pieces that make up the joint between the sections. The section interface is defined by an instance (#611111) of the Assembly_definition EDT. The components of the assembly would be represented by further instances of the Single_device EDT attached to the assembly definition, but these are not shown in the instance diagram.

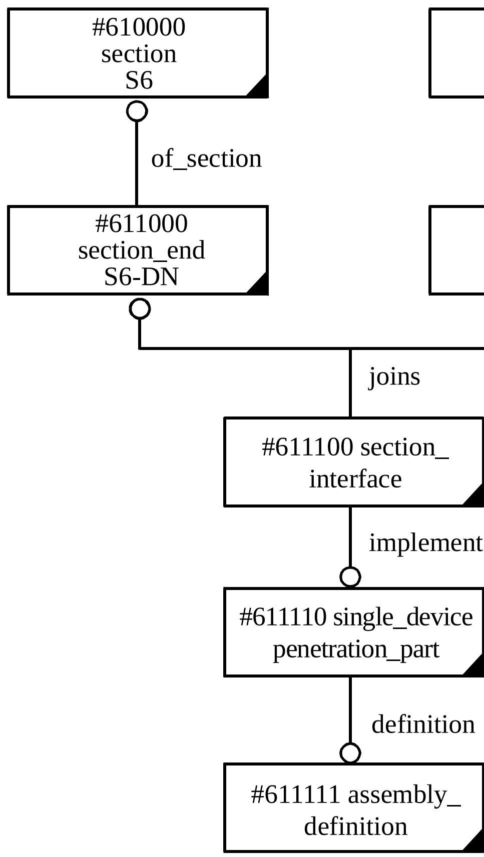


Figure A.57 — Raceway connection through wall

A.3.9.5.4 Interference check results

ISO/IEC 10303-212 does not have the ability to represent the results of interference checks. This information may be represented using another AP, that can represent interference checks. In particular, ISO 10303-227 may be used.

When product data are split across multiple physical files, there must be some means to link the data together to form an integrated whole. This is done by attaching the same identifier to instances in the various files that represent the same object. The STEP Ship Common Model [14] states that a "globally unique identifier" (GUID) shall be assigned to each "definable object" in a design. A GUID should be unique across time and space. The GUID consists of a company id and a local id connected by a separator character (a period). The company id uniquely identifies that company that originally produced the data. The local id uniquely identifies the data within the company. It is the responsibility of the company that creates the definable object to assign a local id to it that is unique within the company across all time.

ISO 13584-26 [15]specifies a code that may be used to uniquely identify a company, provided that the company is registered in a coding scheme that conforms to ISO 6523-1 [16] and is registered under ISO 6523-2 [17].

NOTE 1 The code specified by ISO 13584-26 takes the form:

<ICD>/<OI>/<OPI>/<OPIS>

where <ICD> is the international code designator, a number that uniquely identifies the coding scheme used. <OI> is the organization identifier within the coding scheme. <OPI> is the organization part identifier, and <OPIS> is the organization part identifier source.

EXAMPLE 1 The D-U-N-S® coding scheme is registered under ISO 6523-2 with the ICD of 0060. Concurrent Technologies Corporation (*CTC*) has a D-U-N-S number of 189737810. So *CTC* can be uniquely identified under ISO 13584-26 by the string "0060/189737810//."

NOTE 2 More information about D-U-N-S numbers may be obtained from http://www.dnb.com/dunsno/dunsno.htm.

The host id of the computer concatenated with the date and time can be used as the local id. The date and time can be given in the "extended" format specified in clause 5.4.1 of ISO 8601:1988. This format is yyyy-mm-ddThh:mm:ss,ffff, where yyyy is the year, mm is the month, dd is the day of the month, hh is the hour, mm is the minute, ss is the second within the minute, and ffff is a decimal fraction of seconds.

EXAMPLE 2 For a computer at *CTC* with a host id of "93a00edb," a GUID generated on August 11, 2000 at 10:45.36.1642 in the morning would have a local id of "93a00edb/2000-08-11T10:45:36,1642."

Assuming that the raceway RW-001 was defined by *CTC* as stated in Examples 1 and 2, its GUID would be "0060/189737810//.93a00edb/2000-08-11T10:45:36,1642."

Figure A.58 shows how this GUID is attached to RW-001 in ISO/IEC 10303-212.

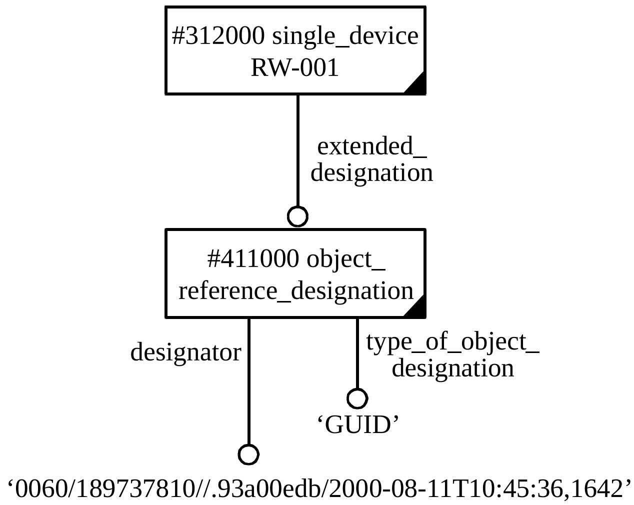


Figure A.58 — Attaching global id

In this example, the raceway interferes with a vertical water pipe. Figure A.59 shows how interference check results may be represented using ISO 10303-227. For more explanation of the meaning of this figure, see NSRP 0424.

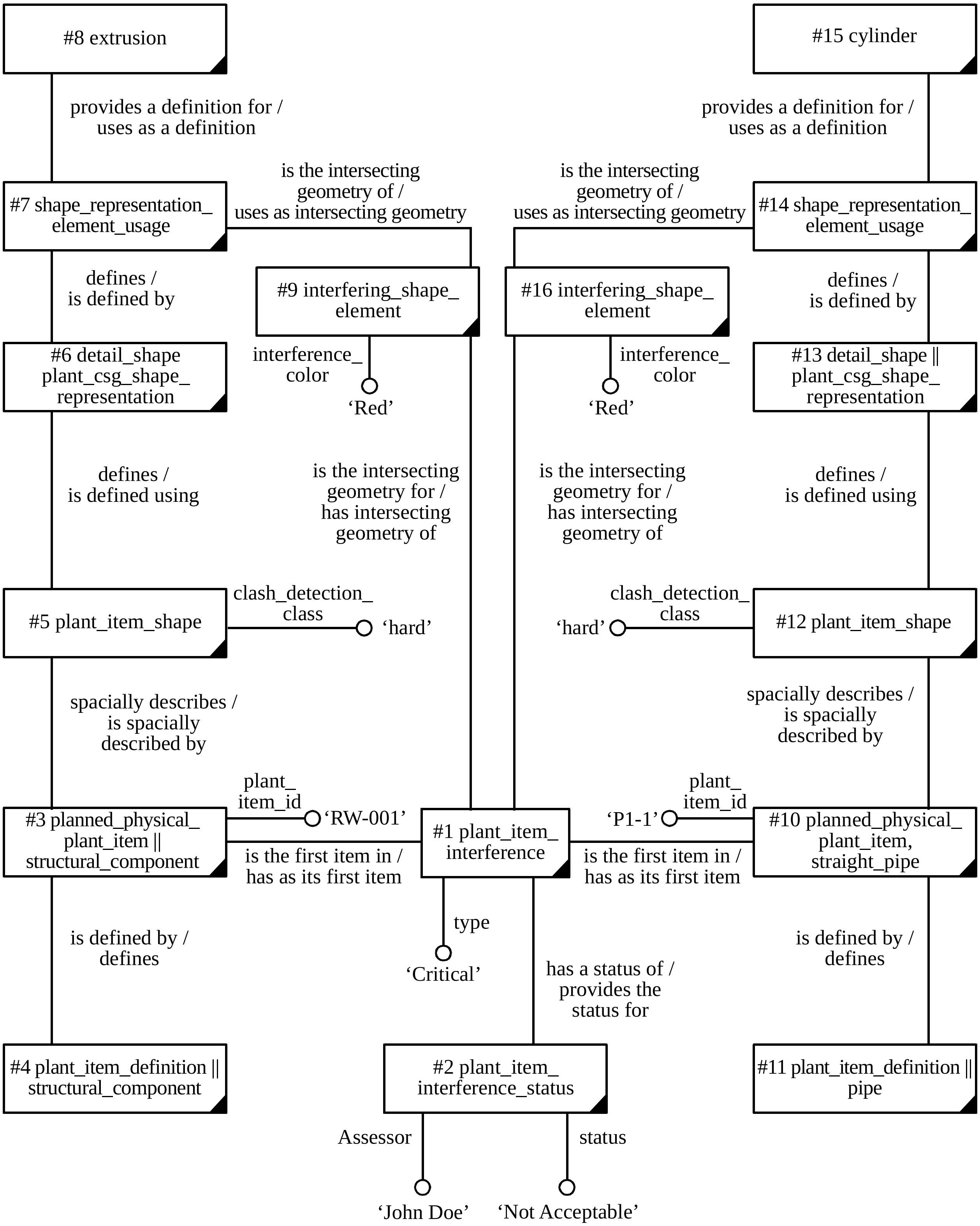


Figure A.59 — Interference check results in ISO 10303-227

A.3.9.5.5 Shop-made assembly

A portion of the cableway system is to be assembled in a shop and then shipped to the building site for installation. Figure A.60 shows how such a shop-made assembly can be represented in ISO/IEC 10303-212. An instance (#511000) of the Assembly_definition EDT represents the assembly that is to be shop-made. The extended_designation attribute of this instance points to an instance (#512000) of the Object_reference_designation EDT. The type_of_designation attribute is "shop assembly."

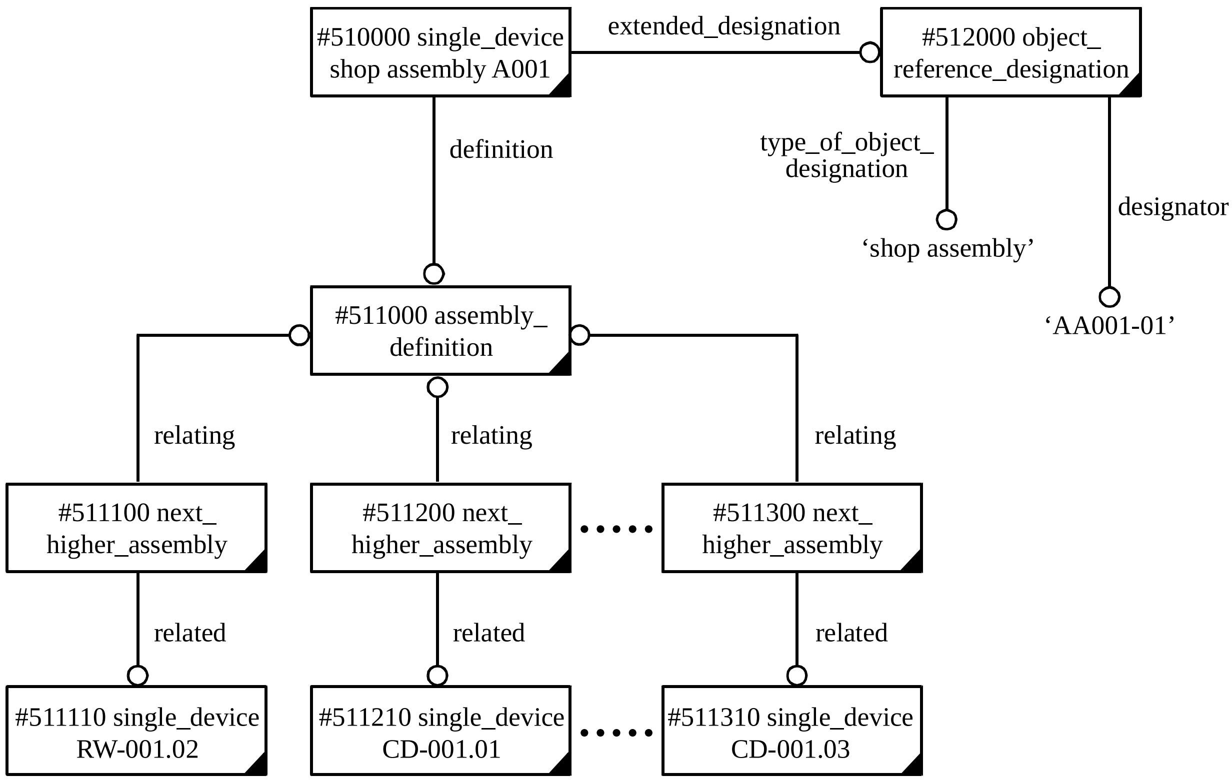


Figure A.60 — Shop-made assembly

A.3.9.5.6 Raceway details

Figure A.61 shows how raceways can be specified in detail down to individual piece-parts.

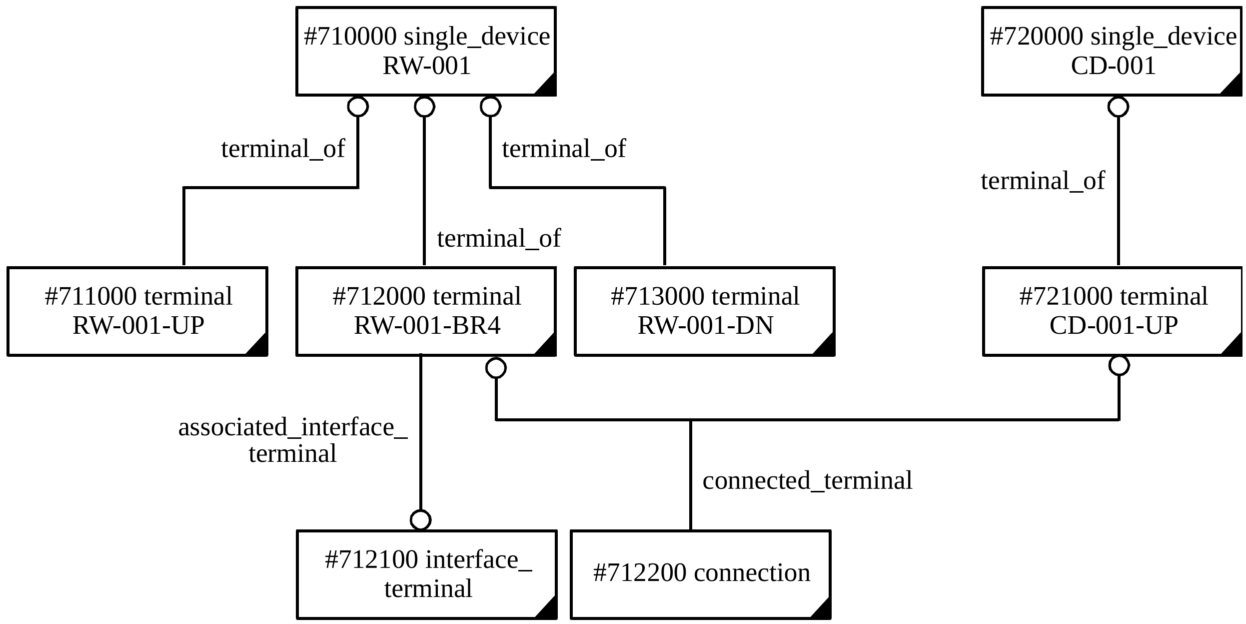


Figure A.61 — Raceway details

A.3.10 Cable and equipment installation

A.3.10.1 Purpose

This clause describes the use of ISO/IEC 10303-212 for representing cable and equipment installation data. Cable and equipment installation and planning ensure that a ship electrical system is able to supply power and carry signals between spatially located points of interest (points in space similar to coordinate points but without assigned locations). Cable spacing, cable lengths, number of cables, shielding requirements, watertight interfaces, and numerous other electrical and mechanical considerations are important for cable and equipment installation. All these information concepts are candidates for data exchange.

A.3.10.2 Background

Cable is used to distribute electrical power and is made up of one or more conductors. Fiber-optic cables are often used for communicating information. A cable is routed through a cable route, which is made up of segments. A cableway is a network of interconnected cableway segments and cableway sub-segments. A cable route is the path taken by the cable or the intended path that will be taken by a cable. Cableway is an artifact to realize the route so that cable can be laid. For example, the conduit is the cableway through which a cable is laid. Conduit is laid after the route has been finalized. A cableway segment is a section of cableway delimited by two cableway ends. The cableway segment can include one or more branch cableway ends defining logical branch points with the segment where cables can enter or exit the segment. A free cableway segment is a segment in which one end is not fixed in space. A cableway sub-segment is a portion of a cableway segment uniquely defined by two end-type cableway ends. A cableway sub-segment has no intermediate, branch-type cableway ends. Cableway sub-segment definitions are derived from cableway end definitions. They represent the basic level of a cable routing element. A series of cable route segments defines a feasible path through a network of cable sub-segments or free cable segments.

A cableway end is a logical point where a cableway segment or sub-segment can either terminate or interconnect with another segment or sub-segment. A cableway end cross-section defines the shape and size of the cross-section of a cableway segment at its cableway end. A cableway joint defines the logical association of two or more cableway ends with different cableway part joined at a common location. A cableway part occurrence is used to contain and distribute one or more cable occurrences. Examples of cableway part include conduit, tray, and channel.

Cable pull identifies the beginning and ending cable route segments between which the cable is pulled. A cable pull tag provides an identifier for locating a reference point used to ensure proper positioning of a cable installed via a cable pull. The cableway segment interface is the logical association of two or more cableway ends associated with different cableway segments or sub-segments joined at a common location. A routed cable segment defines the association between one cable occurrence and one cable route segment. The collection of all routed cable segments for a particular cable occurrence defines that cable's route.

The cable route tier position is an intersection element defining the cross-reference between a cableway segment and a cable occurrence. A cableway segment tier uniquely defines a level or tier within a multi-level cableway sub-segment. A cableway segment tier is uniquely identified by the ID of the cableway sub-segment containing it, plus a cableway segment tier number. It is used in the cable routing application to specify the tier on which a cable is arranged.

A.3.10.3 Data exchange

This clause defines the ISO/IEC 10303-212 concepts and entities used to represent the data required for cable and equipment installation (see Table 16).

Table 16 — Concepts and entities used in the example

Concept	Entities
Device	Specified_device Quantified_device Single_device
Value	Numerical_value Single_value
Assembly	Assembly_definition Next_higher_assembly
Coordinates	Cartesian_coordinate_space_3d Cartesian_point
Location	Location Location_assignment Hierarchical_location_relationship
Path	Node Path Path_node Path_segment
Route	Route Routed_object Routed_segment
Section	Section Section_end

	Section_interface Section_interface_relationship Section_relationship
Shape	Shape Shape_assignment

A.3.10.4 Example

Figure A.62 shows a portion of a cable and equipment installation diagram for a ship. Cargo hold 2 and auxiliary machinery room are the primary areas of interest. Three different pieces of equipment have been chosen for representation. They are identified as FCU 18, a fan coil unit; PB, a typical item such as Panel Board; and FFS1, a connection box. All three pieces of equipment are located in cargo hold 2.

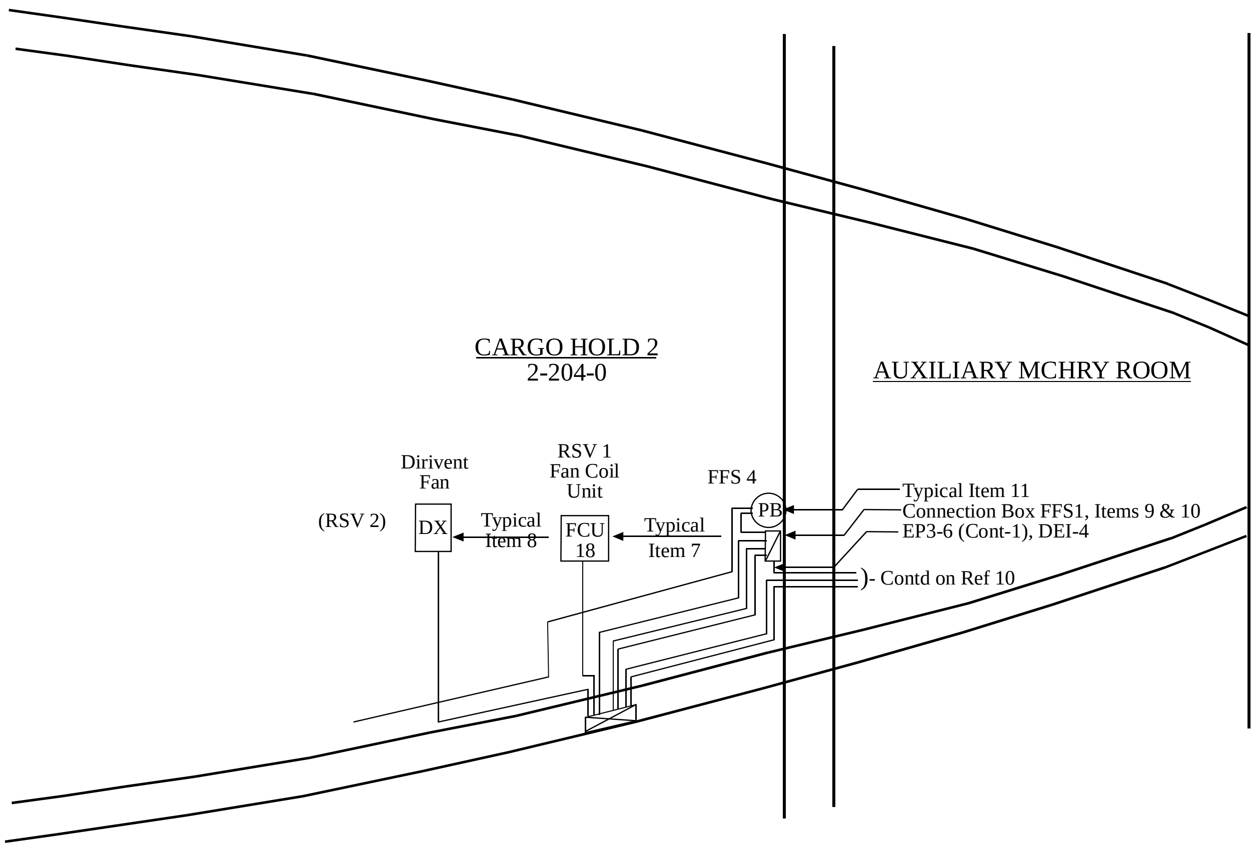


Figure A.62 — Cable and equipment installation

The example shows two routes for laying the cable. They are designated as "UP wireway" and "DN wireway." The rest of the example concentrates on the UP wireway, which is identified as R001. This route is made up of five sections and an interface point, where the cable penetrates the bulkhead. As identified in the diagram, this route also has six nodes: A, B, C, D, E, and F, all connected by sections.

Six cables and their routing through the cableway are shown in the example. They are identified as P6-204, P7-101, P7-102, P7-201, P7-202, and P7-300. P7-300 has been divided into two segments connected by a splice.

Also shown is the penetration through the bulkhead. The example shows a case of three cables penetrating the bulkhead.

A.3.10.5 Instance diagram

A.3.10.5.1 Specifying locations and routes

As shown in Figure A.63, the location of cargo hold 2 in the example is represented by an instance (#420) of the Location EDT, which is characterized by an identifier and description attributes. In the example, the identifier is "2-204-0" and the description is "cargo hold 2." Similarly, instances (#430) and (#410) represent the location of "auxiliary machinery room" and ship.

One can assign coordinates to a Location EDT through the optional Position attribute. The Location is always relative to a coordinate system. Coordinates for a position are always given in three dimensions. In the example, Position instances (#400) and (#431) provide the coordinates for cargo hold 2 and the auxiliary machinery room.

NOTE Although there can be multiple coordinate systems, there must be an overall coordinate system to which all the other subordinate coordinate systems relate. This can be a coordinate system for the ship.

A Route is a sequence of logical 3D vertices and edges. A Node represents the logical vertex. A Section represents the edge between two Nodes. Thus, Section is a segment of a Route. A Section can be curved. The Section_end EDT specifies an extremity of the associated Section EDT. Section_ends are actually located at logical vertices, Nodes. A Section_interface joins two or more Sections by connecting Section_ends. A Section_interface_relationship is a relation between two Section_interface objects. Similarly, Section_relationship is a relation between two Section objects. The Section_end can be identified by its id attribute. The kind attribute specifies the type of the Section_end. Its value can be round, flat oval, or u-shape. Also, agreement between sending and receiving parties can extend the list. The of_section attribute specifies the Section to which the Section_end belongs. The located_at attribute specifies the position of the Section_end.

A Route is an identified or named path through the system. It does not necessarily have spatial information. In the example, there are two routes: the "up wireway" and the "down wireway." The instance diagram only shows "up wireway." As shown in the diagram, "R002" is the value of the id attribute of an instance (#920) of the Route EDT.

A Route consists of a number of Sections, as shown in our example in the diagram as the association between the Route instance (#920) and instances of Sections (#702) and (#705). A Section goes from one point of interest to the next. The points of interest are the locations of bend and the bulkhead penetrations.

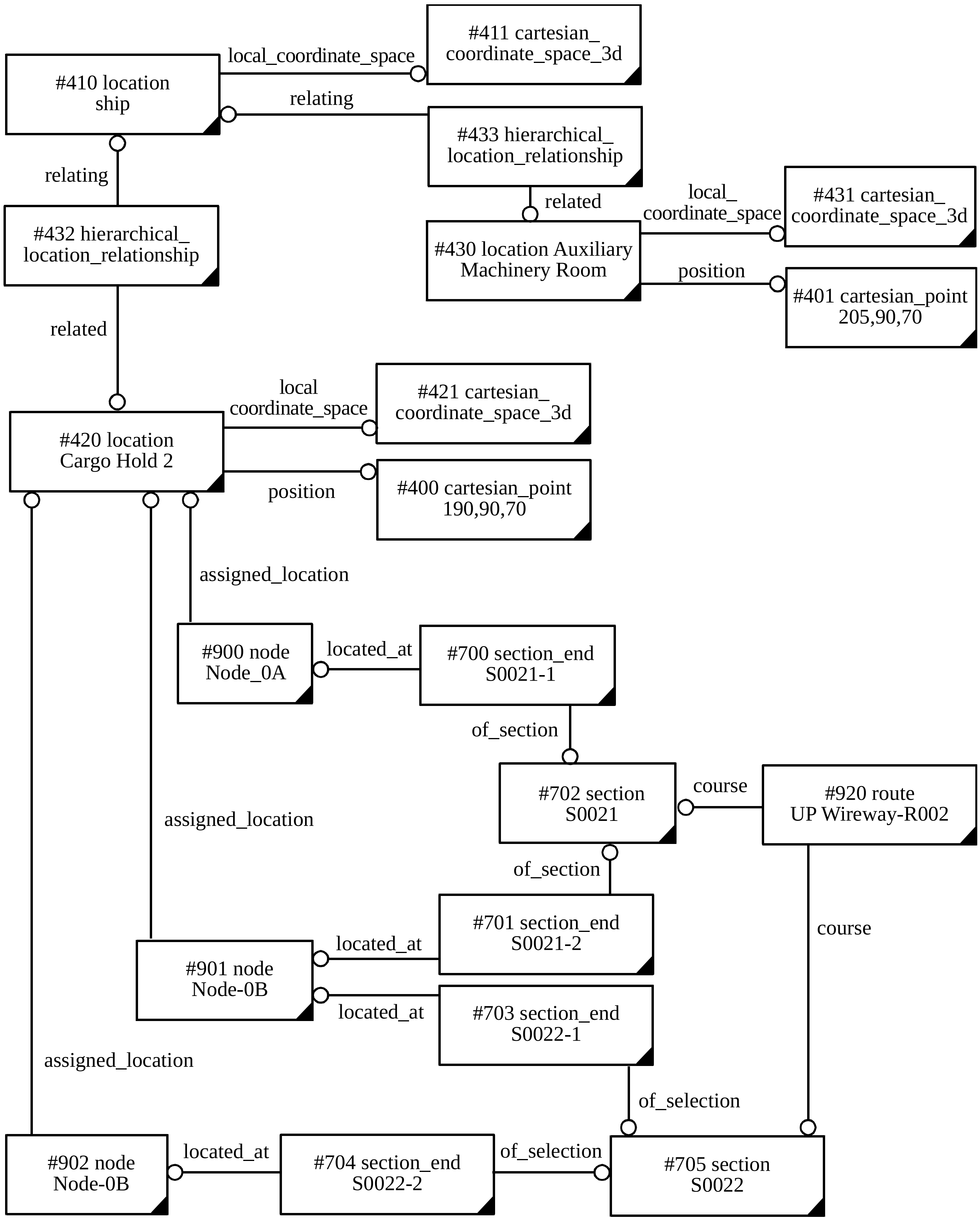


Figure A.63 — Specifying locations and routes

A.3.10.5.2 Assigning real-world paths and positions

Figure A.64 adds 3D spatial information to the Route and Nodes by assigning 3D coordinates.

Recall that a Route is characterized by a number of points of interest called Nodes. A spatially defined realization of Route is characterized by coordinates in 3D space. Such a realization is called Path, and Path_node EDT provides the coordinates. Thus Path and Path_node are analogous to Route and Node, but they are also qualified by 3D coordinates.

In this example, there are six instances of the Path_node EDT and each has a Cartesian_point as its Position attribute. Figure A.64 shows three instances of Path_node (#1050, #1051, and #1052). The defined_in attribute provides the coordinate system for the definition of the Cartesian points. Recall that Location is used to define a region of space. For example, "cargo hold-2" and "auxiliary machinery room" are two different regions of space. Each region of space can define its own local coordinate system. This coordinate system is specified by local_coordinate_system attribute of Location EDT.

Just as Route is analogous to Path, so Section is analogous to Path_segment. A Path_segment can be associated with a Section to specify the geometry of the Section.

A Path consists of a list of Path_segments; however, the Path instance (#1100) consists of only one Path_segment (#1082). A Section can have a course called a Path.

NOTE A curved Section can be represented by more than one Path_segment. This is not shown in the example.

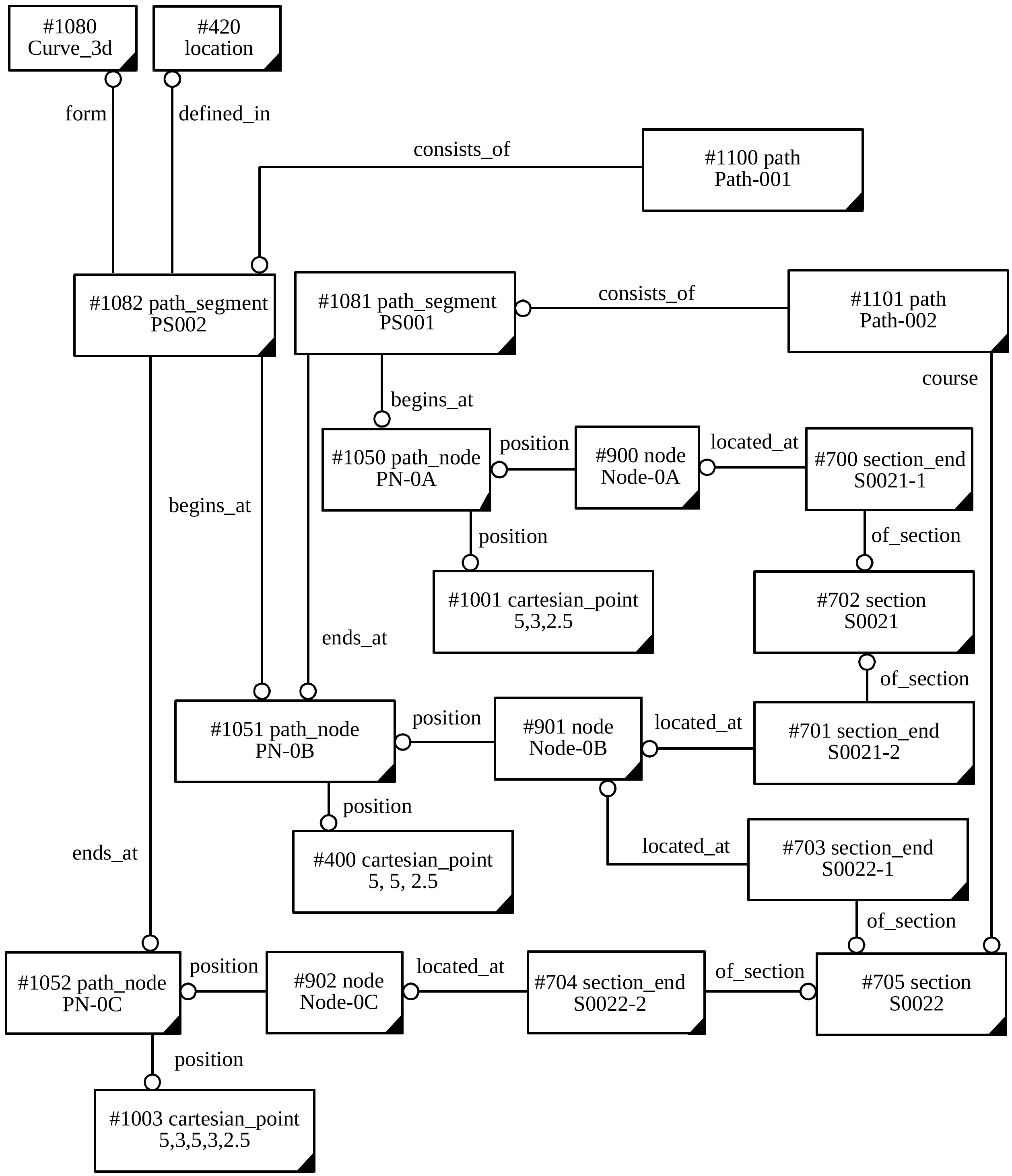


Figure A.64 — Assigning real-world paths and positions

A.3.10.5.3 Bending radius and section length

Figure A.65 shows how the bending radius and section length can easily be assigned to a Section through the attributes of Section. These attributes are bending_radius and length_of_section. Section #705 is shown with these attributes.

NOTE Data_element EDT would have been used in the absence of these attributes.

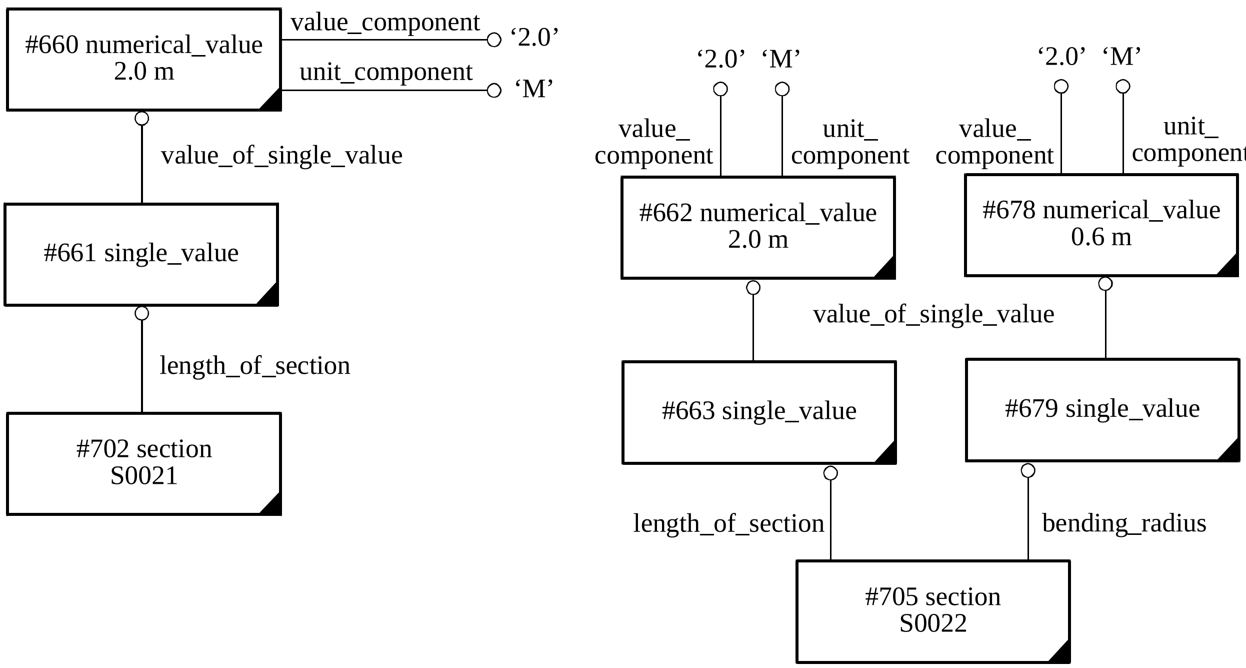


Figure A.65 — Bending radius section length

A.3.10.5.4 Assigning cables to routes

Figure A.66 of the instance diagram specifies the cables actually laid in the cableways. Six cables are modeled in the example, identified as P6-204, P7-101, P7-102, P7-201, P7-202, and P7-300. The instance diagram actually shows four cables, each modeled as an instance (#4060, #332, #333, and #334) of the Device EDT. For each Device, there exists an instance of Routed_object (#1121, #1123, #1125, and #1127) pointing to an instance of Routed_segment (#1120, #1122, #1124, and #1126), which in turn points to a Route entity (#920).

Cable routing through the cableway is shown. P7-300 has been divided into two segments connected by a splice. This has not been shown in the instance diagram.

NOTE It is interesting to observe two cases: first, a Device can implement a Node, and second, a Device can be located at a Node. A Node is implemented by a Device if the device is central to the definition of the Node. A Device is located at a Node if the device is not crucial to the definition of the Node. In the second case, the node still exists after the device is removed. In the first case, however, the node is destroyed after the device is removed.

EXAMPLE A nametag to physically identify the Node is an example of a device located at the Node. A fastener or binder to attach a cable is an example of a device that implements the Node. Nametag is secondary to the existence of the Node. Node can exist without the nametag. However, fastener is not secondary to the existence of Node.

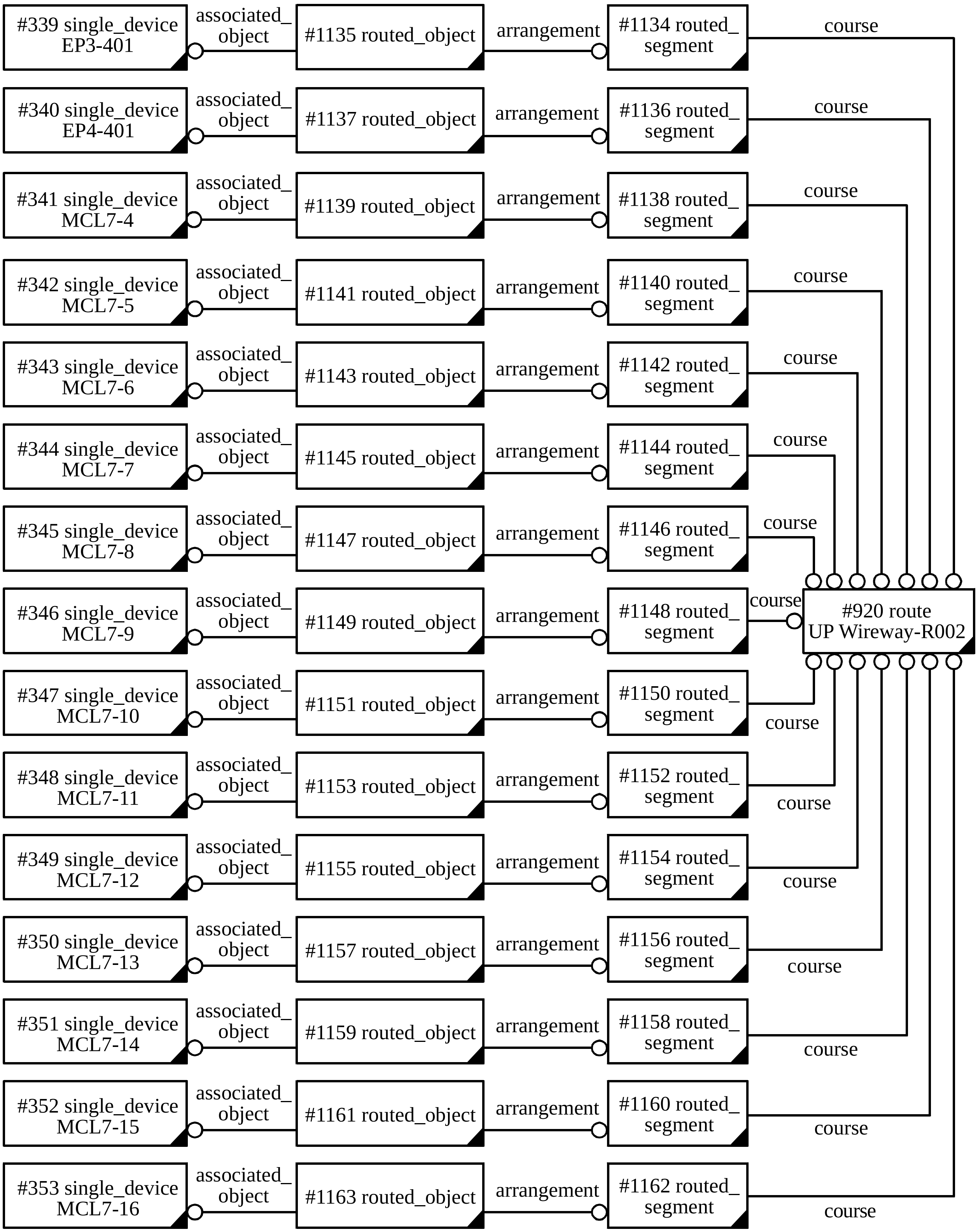


Figure A.66 — Assigning cables to routes

A.3.10.5.5 Section_interface

This clause explains the instance diagram for the stuffing tube, shown in Figure A.67. Figure A.68 of the instance diagram shows the representation of a stuffing tube. This has electrical as well as mechanical aspects and can be considered as a Section_interface. The Device that implements the Section_interface has four parts. They are nut, inner tube, outer tube and collar. Shapes can also be assigned through the shape_representation EDT.

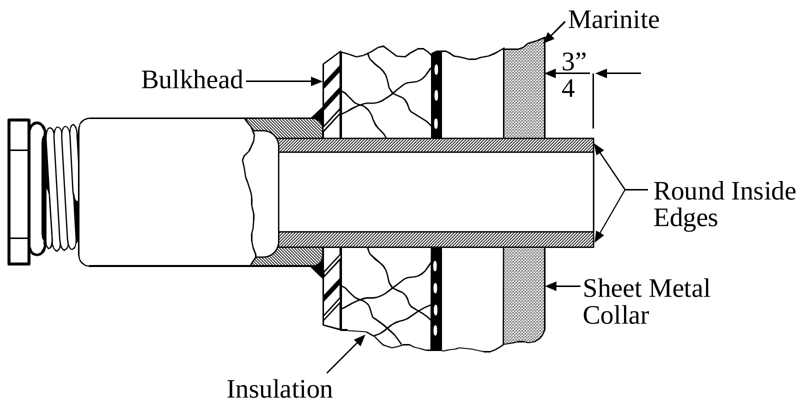


Figure A.67 — Stuffing tube

A Section_interface_relationship is between two Section_interface objects. The type of relationship is provided by the relation_type attribute. Similarly, Section_relationship can be used for sections. Possible relationship types are "alternate," "decomposition," "derivation," "substitution," and "version hierarchy." Agreement between the sender and receiver can extend this list. The alternate relationship type differs from substitution relationship type because it defines a possible set of alternatives, whereas the substitution relationship type defines the actual substitution. There can be many alternatives but only one substitution.

A Section_interface can be decomposed into other Section_interfaces through the Section_interface_relationship EDT. This is useful to represent the structure of a section interface. Figure A.68 shows such a decomposition, where Section_interface (#914) is decomposed into three other Section_interfaces (#911, #912, and #913). A Section_interface (#911) can join section_ends (#722 and #724).

NOTE 1 Spare parts numbers and manufacturing and ordering information can be assigned to these individual parts.

NOTE 2 It is advisable to use a mechanical AP to provide a real mechanical description. For example, a mechanical AP would better handle the description of the round edges of the collar.

Three cables go through the bulkhead. A cable going through a bulkhead is represented as a Section_interface. A Section_interface can be implemented by zero to many Devices. Each device is described by an instance of the Design_discipline_item_definition EDT. Recall that a Design_discipline_item_definition represents the typical or "catalog" item. Many penetration devices can point to the same catalog entry. In other words, many devices in the SES design can be realizations of the same typical device and, therefore, point to the same instance of Design_discipline_item_definition EDT.

The stuffing tube installation consists of four parts: inner tube, outer tube, sheet metal collar, and nut. All are represented in Figure A.69 by instances (#355, #356, #357, and #358) of the Single_device EDT.

NOTE 3 The part of ISO/IEC 10303-212 that deals with the structure of Device is harmonized with ISO 10303-214. Furthermore, ISO 10303-214 is harmonized with ISO 10303-203.

NOTE 4 The representation of an item as an Accessory depends on the viewpoint. For example, from the viewpoint of an overall shipboard electrical system design, the stuffing tube can be just an accessory, but from the installation viewpoint, it might not be an Accessory.

Assigning a Device to the Section and then associating Shape to the Device can represent the shape of the Section. The Device is assigned to the Section through the implemented_by attribute of the Section EDT.

NOTE 5 In ISO/IEC 10303-212, the shape entity contains just the identifier of the shape description, not the actual shape, which must be in a separate file.

The stuffing tube installation uses some sealant to prevent water from going through the tube. Sealant is represented by an instance (#360) of the Quantified_device EDT, which is not shown in the diagram.

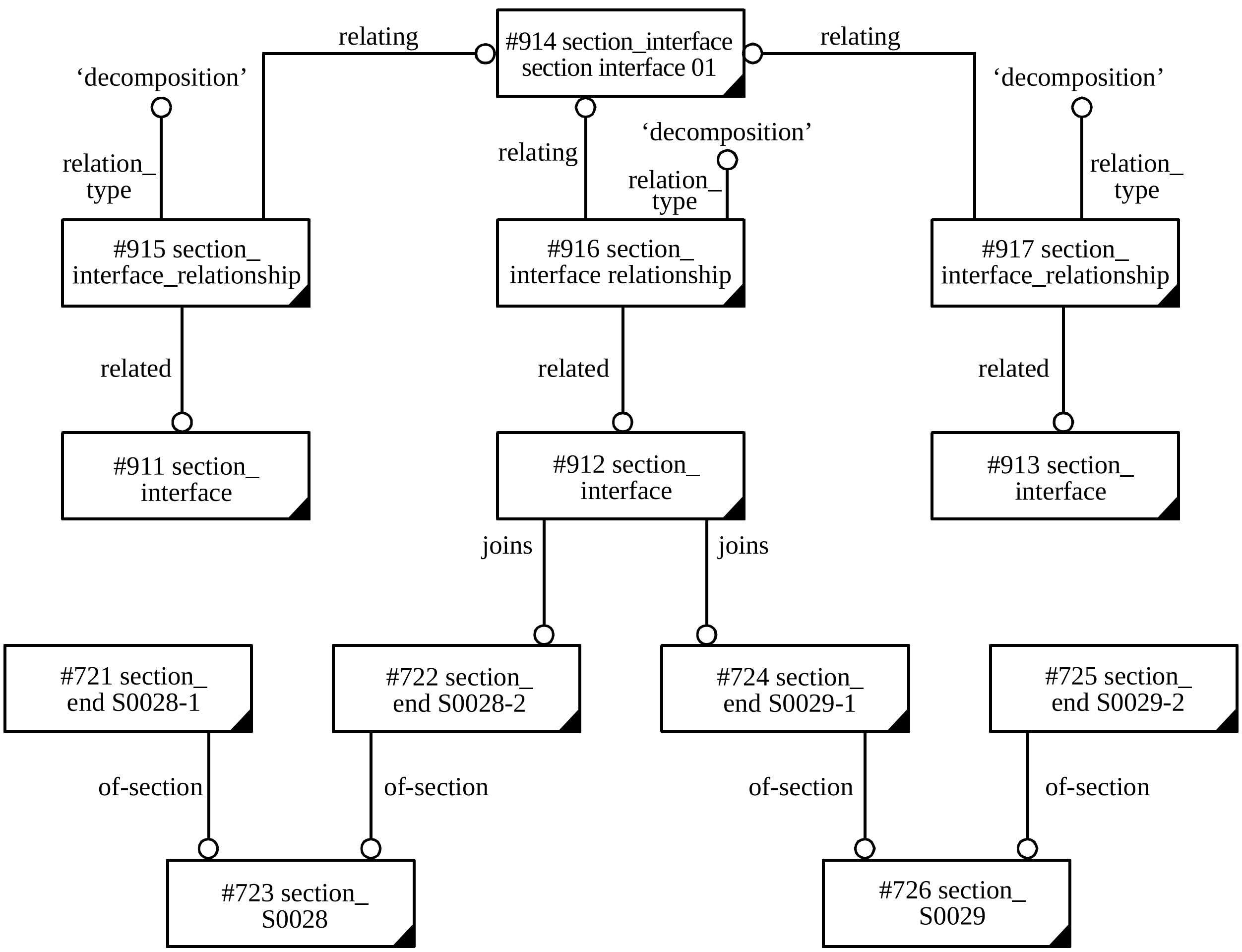


Figure A.68 — Section interface

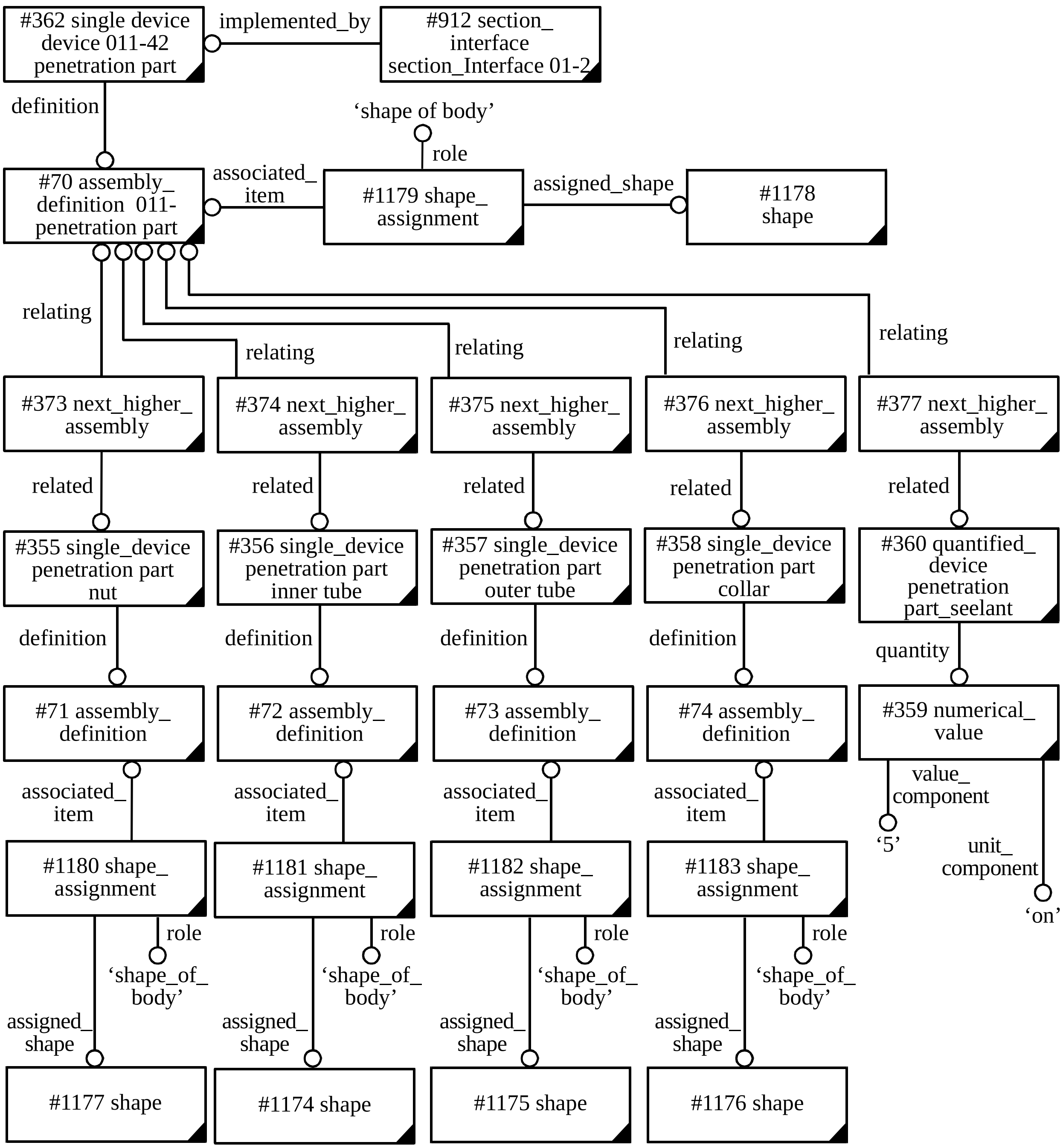


Figure A.69 — Section interface

A.3.10.5.6 Structure of cableways

This clause explains the instance diagram for the cableway, shown in Figure A.70. Figure A.71 of the instance diagram describes the cable installation.

The cableway is represented by an instance (#832) of the Section EDT. The cableway consists of two tiers modeled as subordinate Sections of the main Section (#832) that represents the cableway. This decomposition is represented by the instances of section_relationship EDT with the relation_type set to decompose the cableway into tiers that are laid one on top of another. Each tier (section) provides three routes.

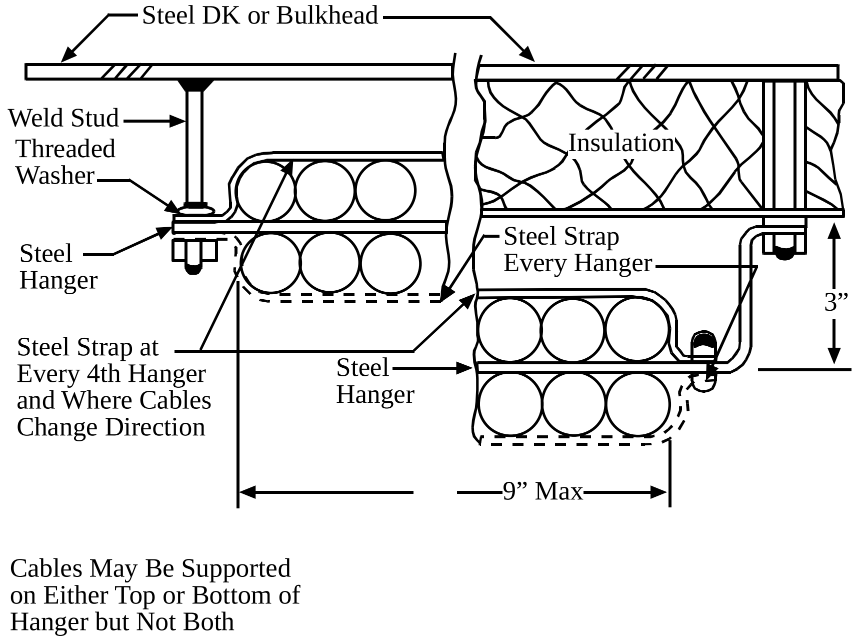


Figure A.70 — Structure of cableway

NOTE ISO/IEC 10303-212 provides the facility to associate the document to most of the EDTs. However, unless some standard or agreement between sender and receiver assigns a precise meaning, the document will not be machine understandable. This detracts from the benefits of product data exchange. ISO/IEC 10303-212 permits an assignment of a 2D drawing to the Section using Annotation_element. This allows us to put a 2D drawing of the installation into the ISO/IEC 10303-212 file.

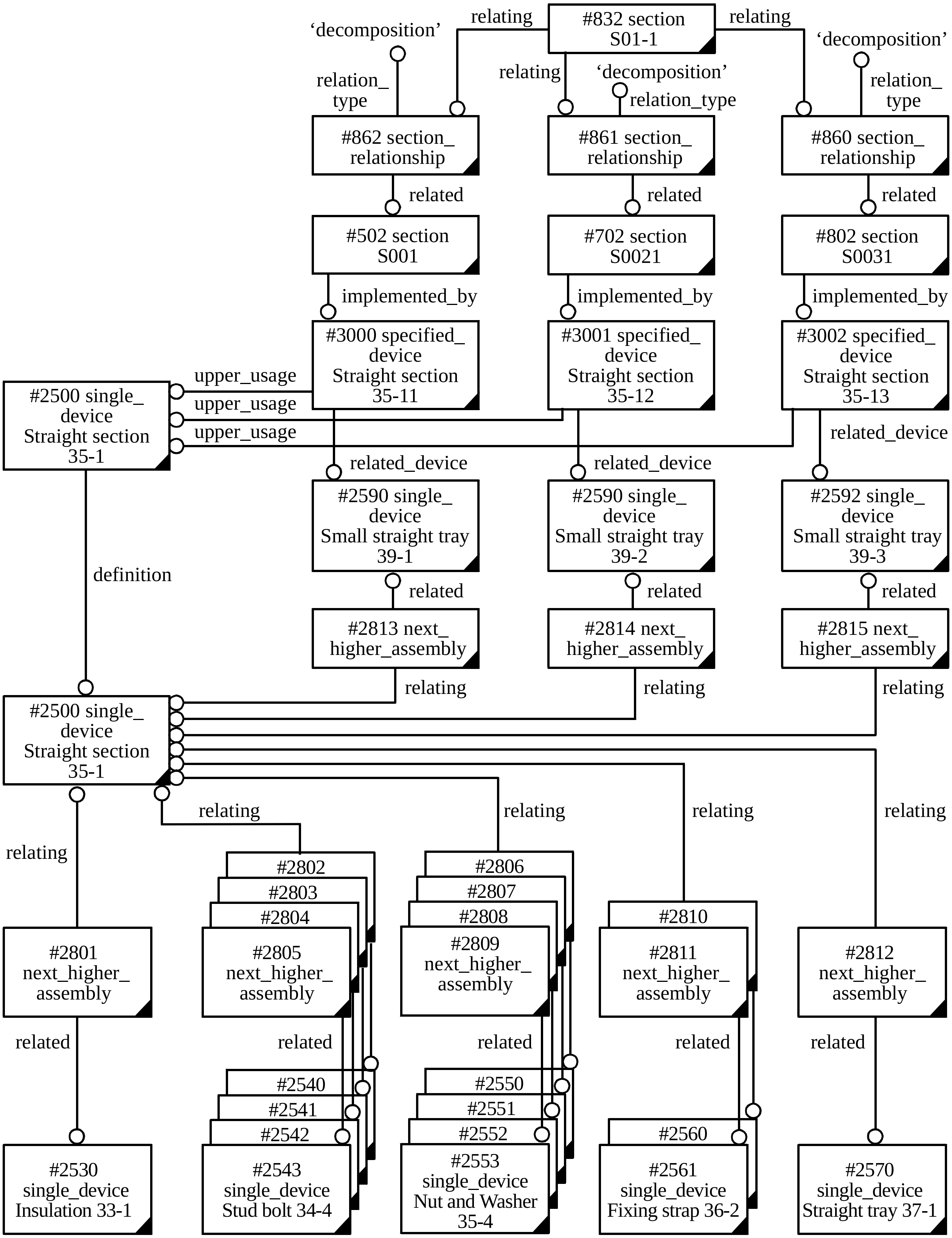


Figure A.71 — Structure of cableways

A.3.10.5.7 Location assignment

As shown in Figure A.72, Location EDT is used to represent the location of an object. Instance #420 represents the location of cargo hold 2. The Location_assignment EDT is useful for assigning items to instances of the Location EDT. Location_assignment instances (#4413) and (#4414) are used to associate instances of Single_device (#301) and (#311) with instance (#420) of Location EDT

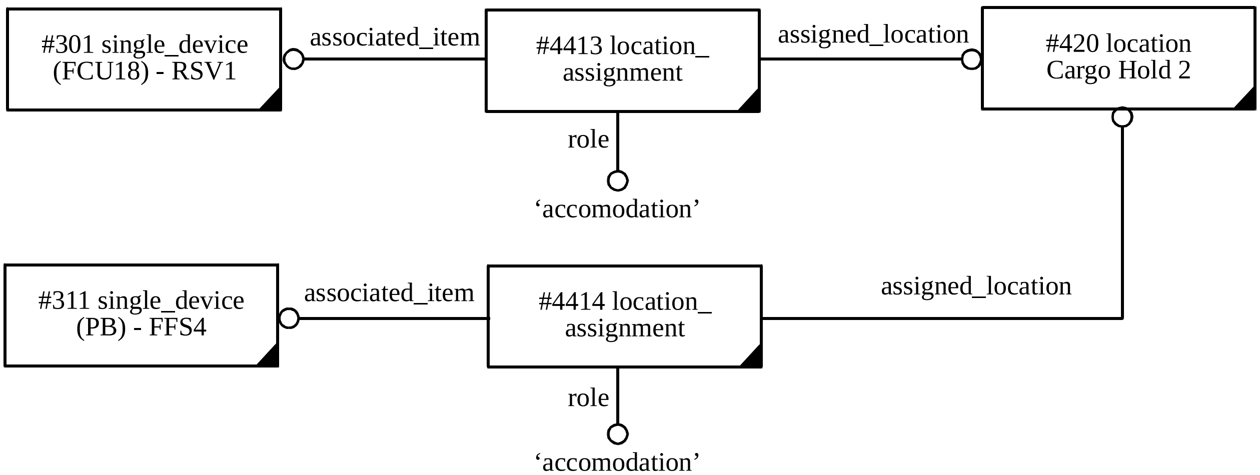


Figure A.72 — Location assignment

A.3.11 Drawing

A.3.11.1 Purpose

This clause describes how ISO/IEC 10303-212 can be used to represent a drawing and its important characteristics.

A.3.11.2 Background

Although the use of computer models is increasing, drawings remain a part of the engineering process, and drawing-centric legacy systems will continue to be used for the foreseeable future. Drawings, such as a circuit diagram printed on the back of a refrigerator or printed circuit board, are often the most effective way to communicate important information.

A drawing can be paper based or created electronically and stored as a computer digital file. A paper drawing can be derived from a manual drafting process or by electronic means, such as an architectural drawing generated by a plotter. Printed copies of drawings are often used by companies to track approval and configuration management information and are especially useful for providing information to the shop floor worker. Drawings in electronic format, however, make the design and production process more efficient and are easier to manipulate than paper-based drawings.

A.3.11.3 Data exchange

This clause explains the ISO/IEC 10303-212 concepts and entities that represent the data required to create a drawing (See Table 17). This example shows the exchange of work and document management information through a suite of related concepts. Examples of work management-related concepts include the requirements, work order, date and time stamping, approval, organization, and person. Some document-related concepts include electronic and non-electronic documents, drawings and drawing sheets, and the elements of a document.

Table 17 — Concepts and entities used for drawings

Concept	Entity
Alias	Alias_designation Alias_identification
Approval	Approval Approval_status
Assembly	Assembly_definition Next_higher_assembly
Coordinate	Cartesian_coordinate_space_with_grid Rectangular_area Coded_size
Date	Date_and_person_or_organization Date_time
Document	Digital_document Digital_file Document Document_designation Document_property Document_version Physical_document
Drawing	Drawing Drawing_sheet
Item	Item Item_identification Item_version
Note	Note
Precision	Numerical_precision
Party	Organization Organization_in_contract Person Person_in_organization Person_or_organization_assignment
Requirement	Requirement Requirement_document_assignment
Object	Object_reference_designation Physical_instance Single_device
Work	Activity Contract Work_order Work_request

A.3.11.4 Example

The drawing sheet in Figures A.73, A.74 and A.75 has been abstracted from a U.S. Navy ship that was fabricated at Avondale Shipyards Division. The example does not cover the complete drawing set for the project but consists of one sheet, which shows an ISO/IEC 10303-212 representation of important information about that project.

NOTE Figures A.73, A.74, and A.75 all show the same drawing sheet, with different labels (not part of the original sheet) attached.

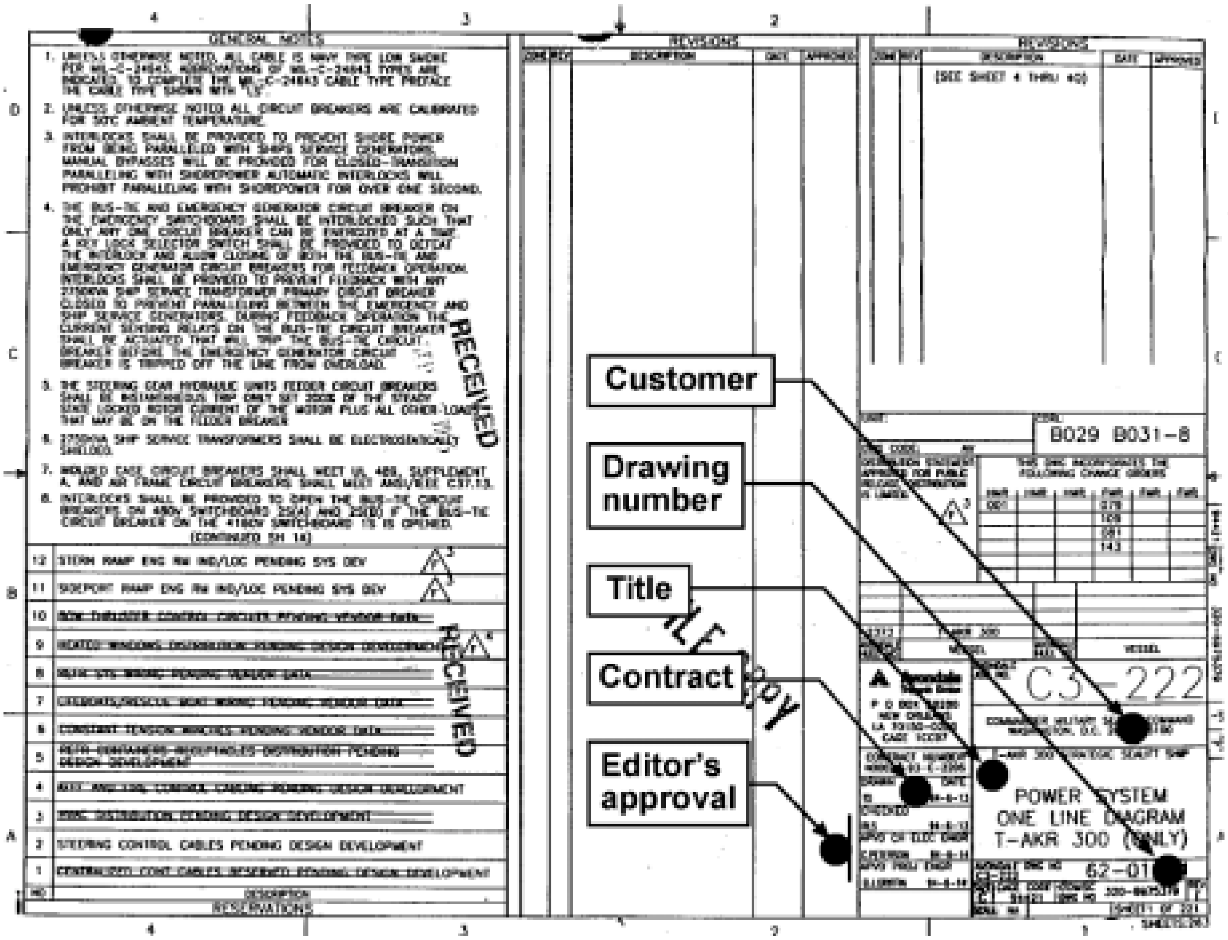


Figure A.73 — Drawing (markup 1)

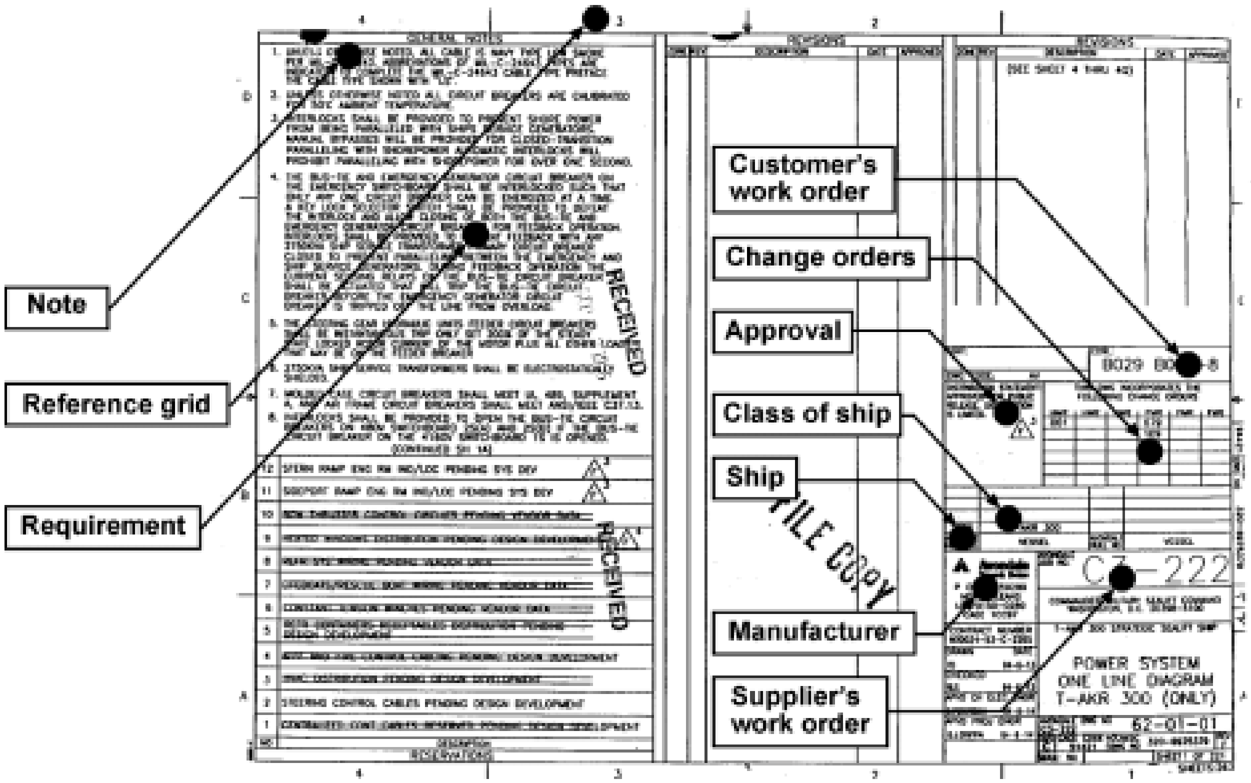


Figure A.74 — Drawing (markup 2)

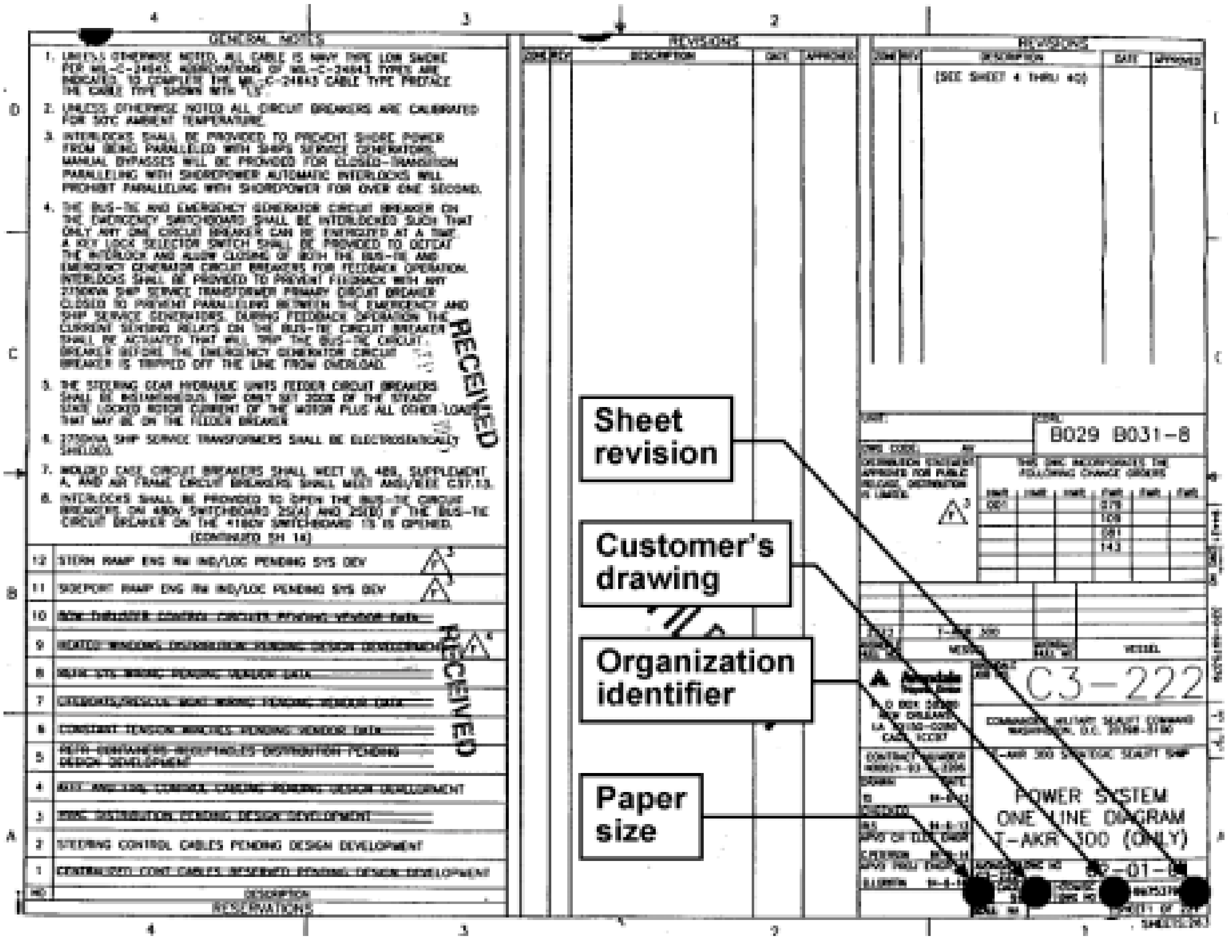


Figure A.75 — Drawing (markup 3)

A.3.11.5 Instance diagram

A.3.11.5.1 Specifying the title

Drawings are generally identified by a title. The title of the drawing in the example, "Power system one line diagram T-AKR 300 (only)," is represented in FigureA.76 by an instance (#15) of the Drawing EDT. The "drawing_specification" attribute of the Drawing EDT specifies the identification of the standard to which the drawing conforms. This standard specifies the presentation forms used in the drawing. An instance (#15) of the Drawing EDT identifies the drawing specification as ISO 129 [18], the standard for technical drawings. The "name" attribute of the Drawing EDT contains the title of the drawing and specifies an identifier consisting of alphanumerical characters using human-interpretable language.

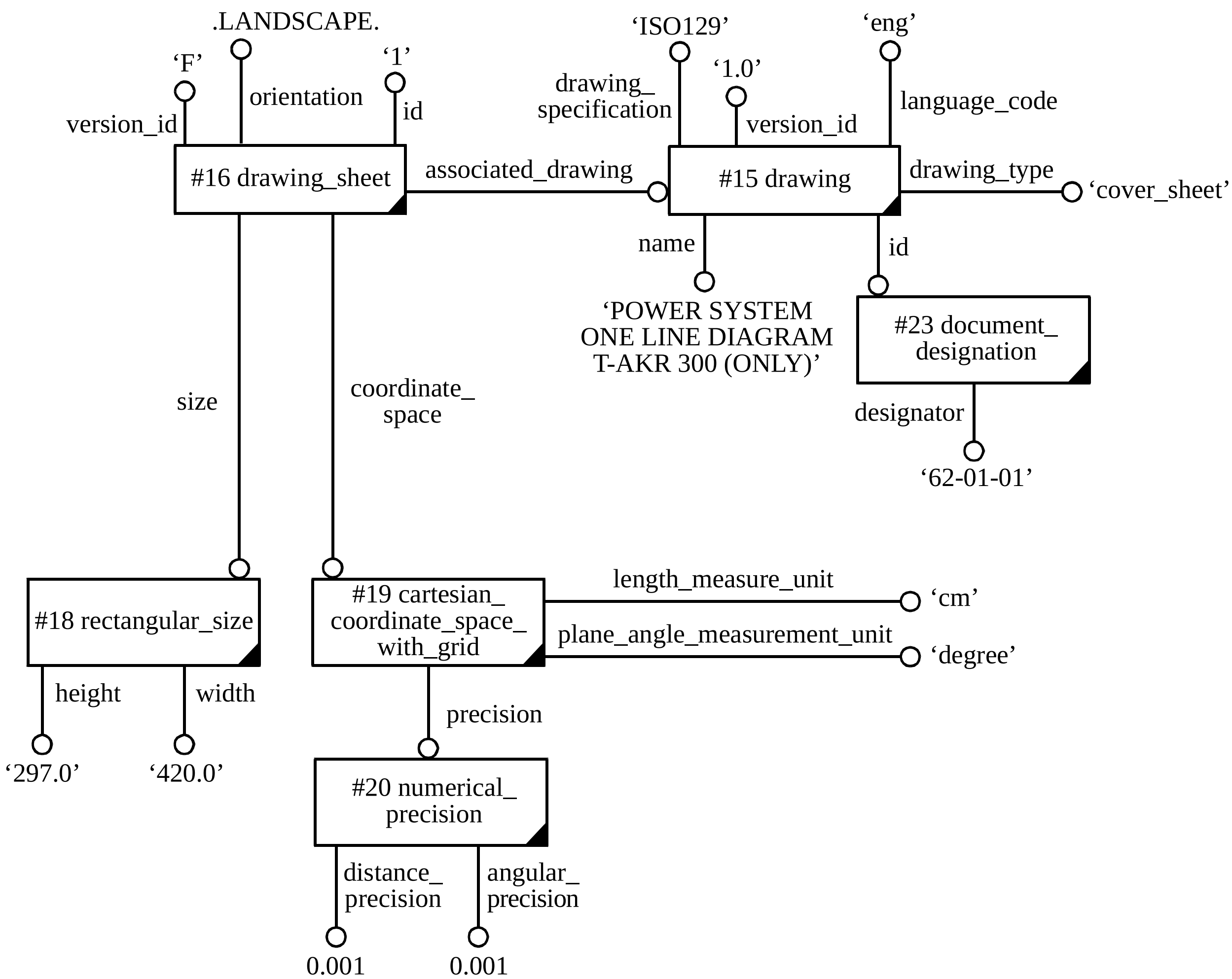


Figure A.76 — Specifying the title, reference grid, paper size, and sheet revision

A.3.11.5.2 Specifying the contract number

In the example, the contract number is designated as "N00024-93-C-2205" and is represented in Figure A.77 by an instance (#81) of the Contract EDT. The organization in the contract is represented by an instance (#82) of the Organization_in_contract EDT, and an instance (#82) of the Organization_in_contract EDT refers to instance (#81) of the Contract EDT.

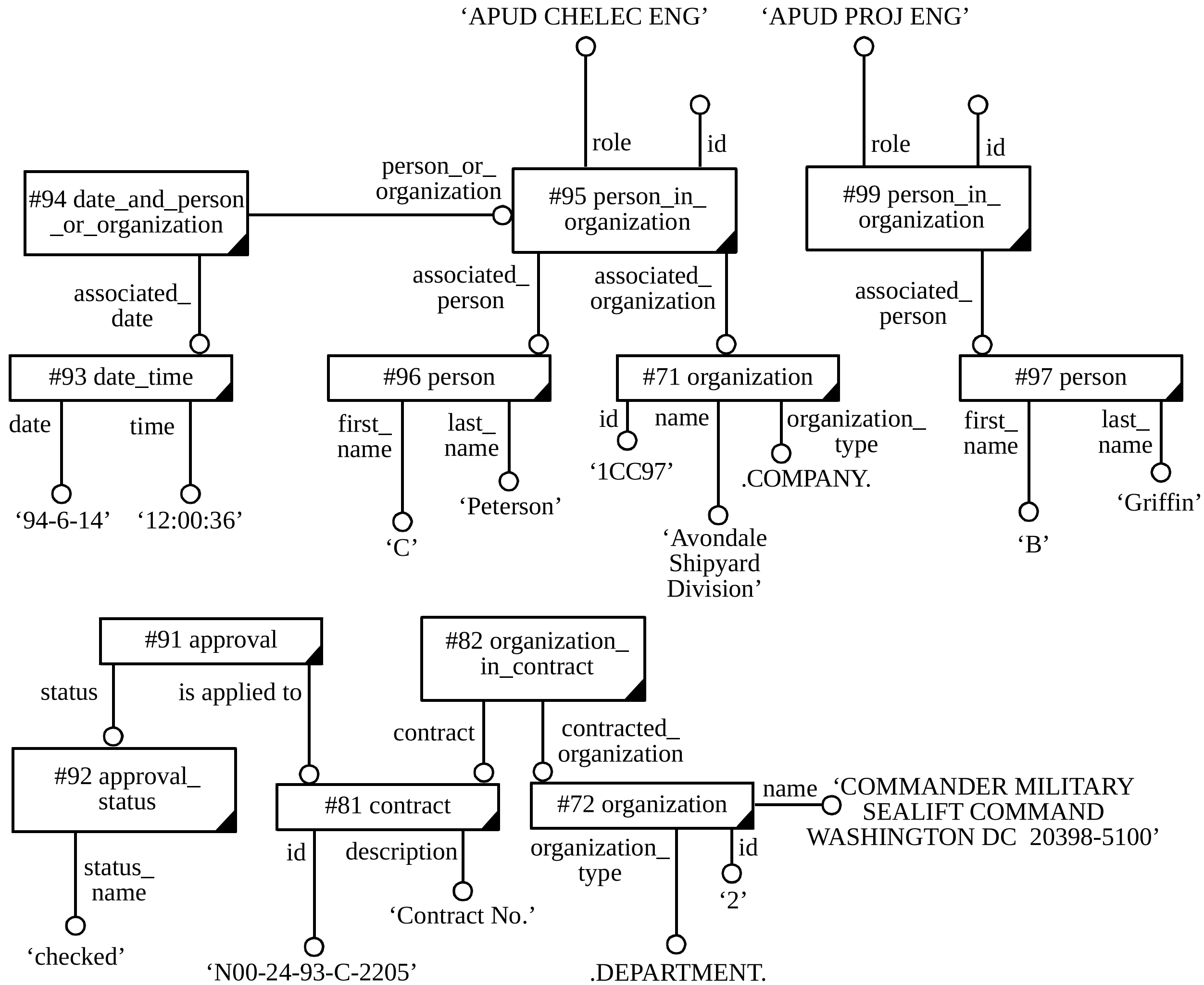


Figure A.77 — Specifying the contract number and organization

A.3.11.5.3 Specifying the document

The concept of a "document" in ISO/IEC 10303-212 includes both hardcopy and digital files. In Figure A.78, an instance (#24) of the Physical_document EDT refers to the hardcopy document, and an instance (#25) of the Digital_document EDT refers to the electronic file. Instances #24 and #25 are associated with their respective instances (#26 and #28) of the Document_property EDT. The Data_element EDT provides additional characteristics to the item, and the Document_property EDT provides additional characteristics to the document. In the example, the Document_property EDT is used to associate the operating system with the digital file. The operating system in this case is "Windows-NT4.0," as represented by instance (#28) of the Document_property EDT.

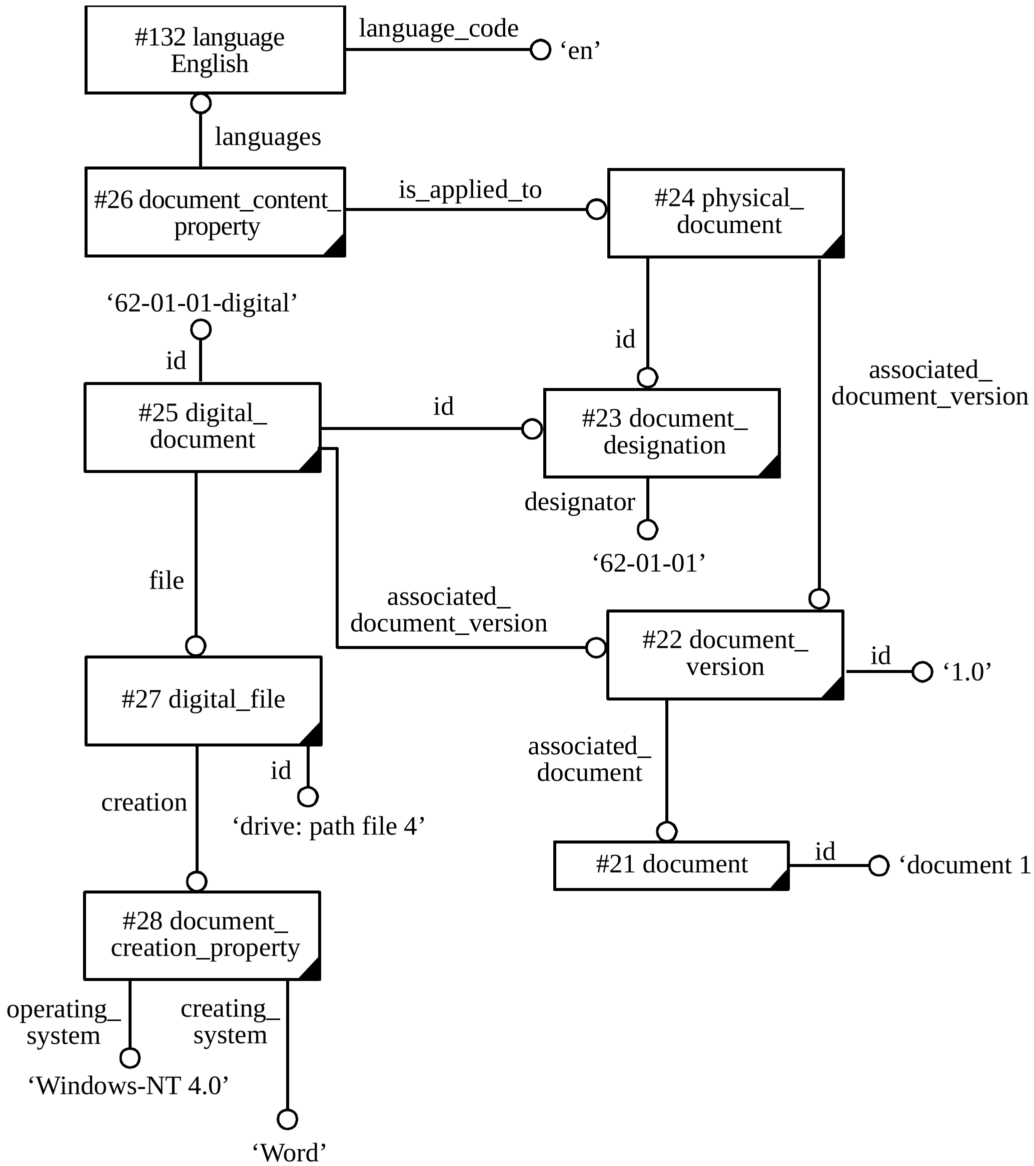


Figure A.78 — Specifying the document

The function of any document is to provide the user with information. The defining characteristic of a document is the information contained in that document. This information may be in graphical or textual form, handwritten or printed by a printer. The document may be stored electronically as a file capable of being processed by a word processor and printed as a hard copy. ISO/IEC 10303-212 recognizes these two forms of the document by providing a Physical_document EDT to represent a nondigital document. The Physical_document EDT represents a document that is archived in nondigital form. Paper plots of technical drawings, microfiche, or paper documents, such as calculations or test reports, are examples of a Physical_document. An instance (#24) the Physical_document EDT represents the nondigital form of the document, and an instance (#25) the Digital_document EDT represents the digital form of the document.

The Document_representation EDT is an abstraction that represents the defining characteristic of the document. The Physical_document and Digital_document EDTs are subtypes of the Document_representation EDT.

The example further shows that instances #24 and #25 of the Physical_document EDT refer to an instance (#22) of the Document_version EDT. The Document_version EDT specifies the variant of the Document EDT. This is required because many versions of a document may exist. The document is represented by an instance (#21) of the Document EDT, and the document designation is represented by an instance (#23) of the Document_designation EDT. This instance designates the document as "62-01-01," which refers to the Avondale drawing number, as shown in the lower, right corner of the drawing in Figure A.73.

A.3.11.5.4 Specifying the note

A number of notes are usually attached to a drawing. Note 1 in the drawing in Figure A.74 is represented by an instance (#111) of the Note EDT.

A.3.11.5.5 Specifying the reference grid

A drawing sheet usually contains reference grids that are useful for locating an object in the drawing. ISO/IEC 10303-212 provides the Cartesian_coordinate_space_with_grid EDT to specify the framework of equally spaced vertical and horizontal lines used to position a drawing element. An instance (#19) of the Cartesian_coordinate_space_with_grid EDT specifies the reference grid for the drawing, which, in this case, consists of a centimeter-based grid system. The numerical precision is specified by an instance (#20) of the Numerical_precision EDT.

A.3.11.5.6 Specifying the requirement

Note 4 on the drawing in Figure A.74, represented by instance (#101) of the Requirement EDT, provides an important piece of information, or requirement. An instance (#102) of the Requirement_document_assignment EDT associates the requirement with the document.

A.3.11.5.7 Specifying the work order

Drawings may be produced as a result of activity relating to a work order or as part of a contract that formally describes a work order. For example, a shipyard may contract out the fabrication of a shipboard electrical system by supplying the contract party with the drawings of the proposed electrical system. Both organizations will have work orders authorizing the completion of this work. ISO/IEC 30303-212 provides a Work_order EDT that represents the authorization for some work to be performed. The work to be performed is specified by the "is_controlling" attribute of the Work_order EDT. Figure A.79 shows that the customer and supplier's work orders are both represented by instances (#123, #121) of the Work_order EDT.

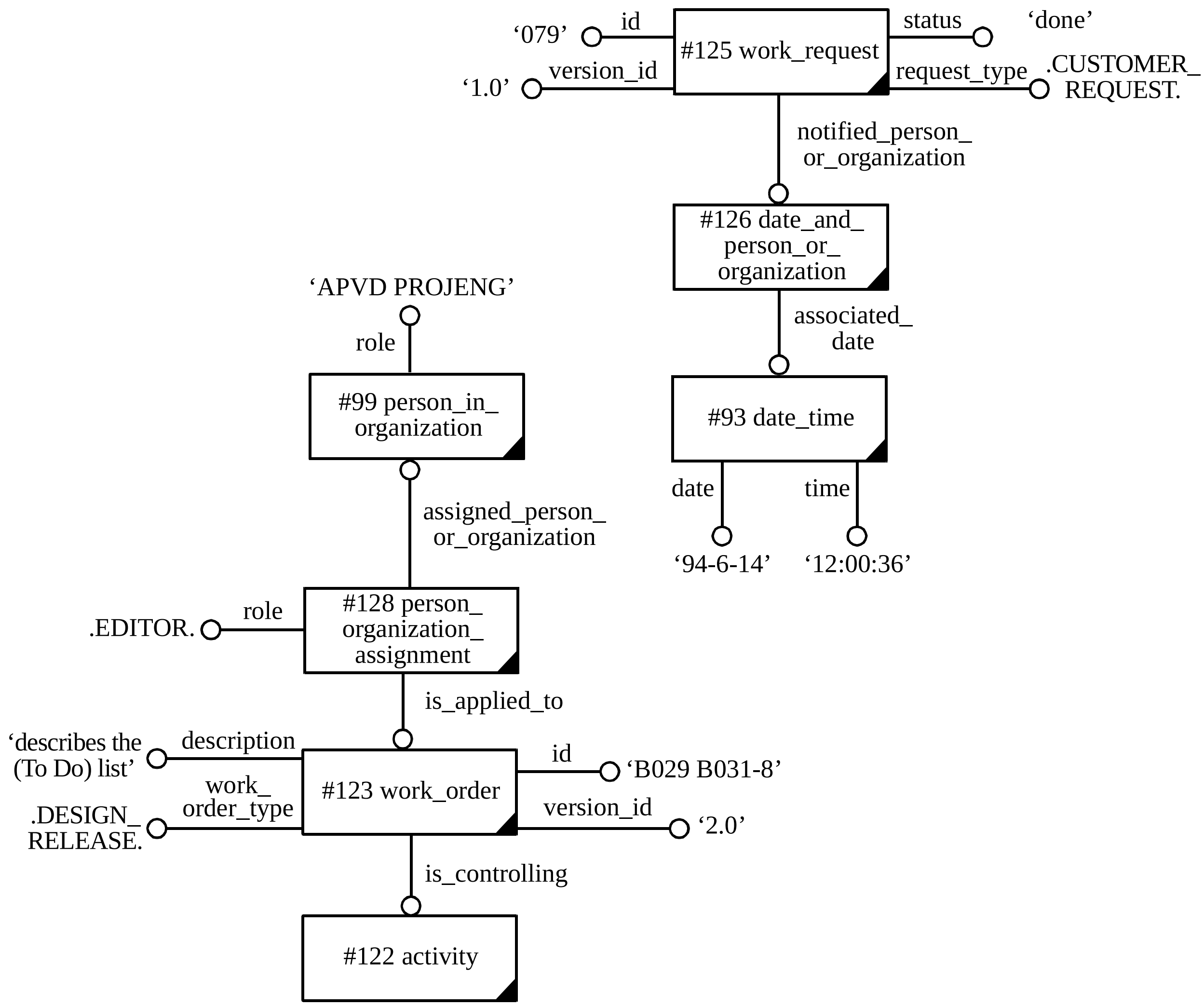


Figure A.79 — Specifying the work order and change order

ISO/IEC 30303-212 provides an Activity EDT to represent the work that is authorized by a work order. Each instance of the Work_order EDT has a related instance of the Activity EDT. Instance (#121) of the Work_order EDT authorizes the work that is represented by an instance (#122) of the Activity EDT, and instance (#123) of the Work_order EDT authorizes the work that is represented by instance (#124) of the Activity EDT.

A.3.11.5.8 Specifying the change orders

The change order is represented in Figure A.79 by an instance (#125) of the Work_request EDT. The date of the change order is given by an instance (#93) of the Date_time EDT, and the party responsible for the change order, designated as "APVD PROJ ENG" in the drawing, is represented by an instance (#99) of the person_in_organization EDT.

A.3.11.5.9 Specifying the approval

The drawing has been approved by an electrical engineer, as shown by an instance (#95) of the Person_in_organization EDT in Figure A.80. The name of the electrical engineer is provided by instance (#96) of the Person EDT.

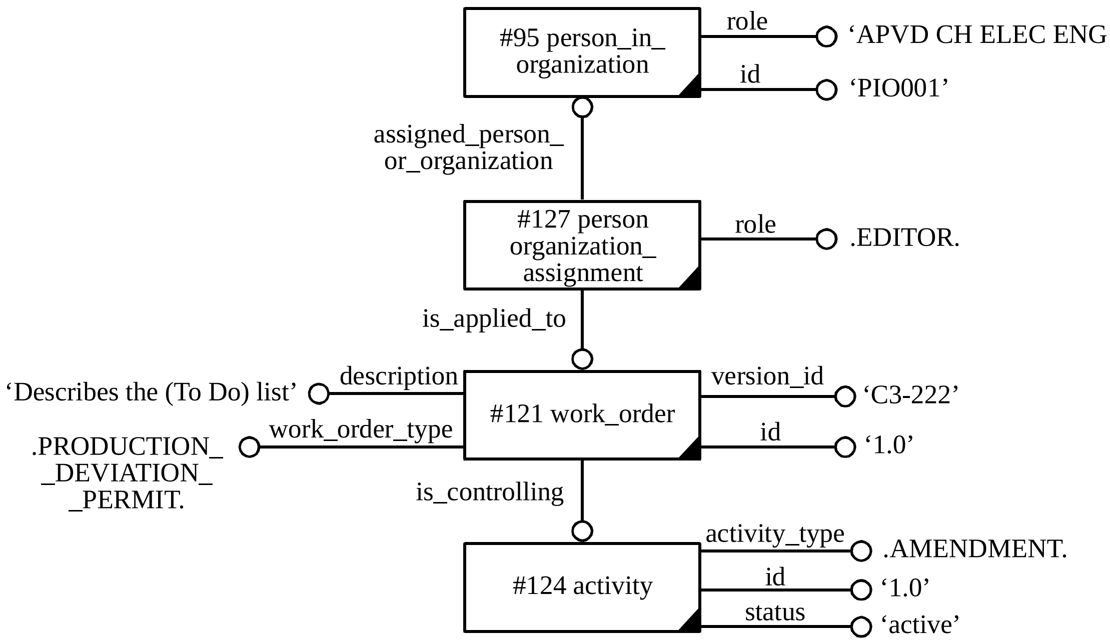


Figure A.80 — Specifying the approval

The drawing has also been approved by a project engineer, as shown by an instance (#99) of the Person_in_organization EDT. The name of the project engineer is provided by instance (#97) of the Person EDT. The status of the approval is shown by an instance (#92) of the Approval_status EDT, and the approval time stamp is represented by an instance (#93) of the Date_time EDT.

A.3.11.5.10 Specifying the class of ship

In Figure A.74, the class of ship is designated as "T-AKR 300." This is represented by an instance (#54) of the Object_reference_designation EDT. The Item EDT represents the typical nature of the ship, and the Single_device EDT represents the abstraction of the ship that is used at the design stage. The same ship design may be used to manufacture several different ships. These would be represented by instances of the Physical_instance EDT. Figure A.81 shows that an instance (#55) of the Single_device EDT is used to represent this information.

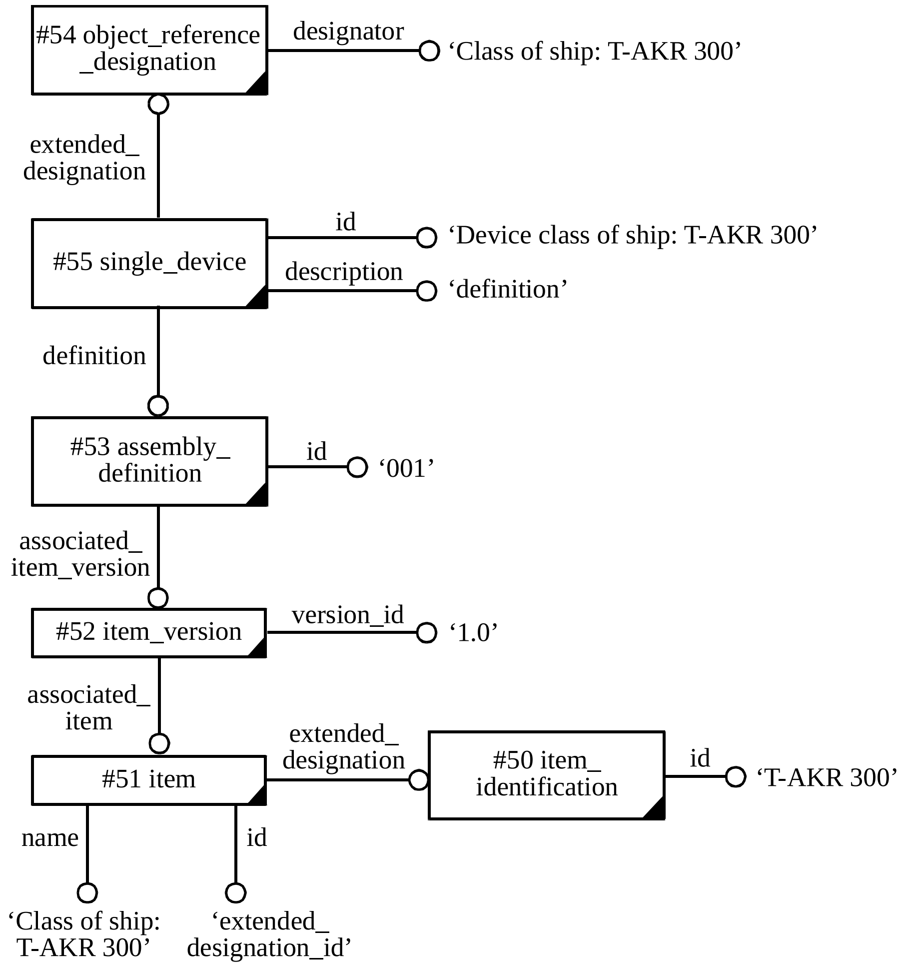


Figure A.81 — Specifying the class of ship

A.3.11.5.11 Specifying the ship hull number

A number of ships may be based on a given class of design. A particular ship is identified by an instance of the Physical_instance EDT. In Figure A.82, an instance (#129) of the Physical_instance EDT identifies the physical instance of the ship as "Avondale Hull No. 2373."

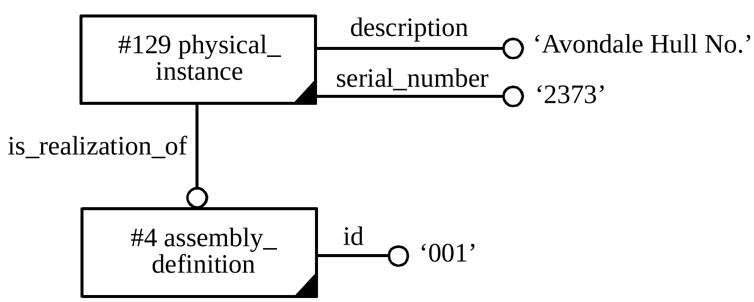


Figure A.82 — Specifying the ship hull number

A.3.11.5.12 Specifying the sheet revision

Drawings, which may consist of many drawing sheets, are frequently revised for various reasons. For example, a drawing may be modified in order to refine the object shown or to illustrate a required change in the drawing object. Each drawing sheet may be revised individually. In such cases, these revisions must be tracked to represent and exchange the drawing information. In the example, the revision is designated as "F" in the right corner of the drawing sheet. The revision of the sheet is represented by an instance (#16) of the Drawing_sheet EDT. The revision number is the first attribute of the Drawing_sheet EDT. The "associated_drawing" attribute specifies the instance of the Drawing EDT to which the Drawing_sheet instance belongs.

A.3.11.5.13 Identifying the organizations

The supplier and customer organizations are given by instances of the Organization EDT. Instance (#71) identifies "Avondale Shipyards Division" as the supplier of the drawing, and instance (#72) identifies "Commander Military Sealift Command" as the customer.

A.3.11.5.14 Specifying the customer's drawing

Customers and suppliers typically designate their drawings differently. ISO/IEC 10303-212 provides the Alias_identification EDT to associate an object with additional information that identifies the object in a different context. An instance (#62) of the Alias_identification EDT represents the alias for the drawing document. This alias provides the customer's designation for the drawing. In the example in Figure A.83, the customer designates the drawing as "320-6975379," and the supplier designates the drawing as "62-01-01." The supplier's document designation is given by an instance (#23) of the Document_designation EDT. This instance designates the document as "62-01-01," which refers to the Avondale drawing number, as shown in the lower right corner of Figure A.73.

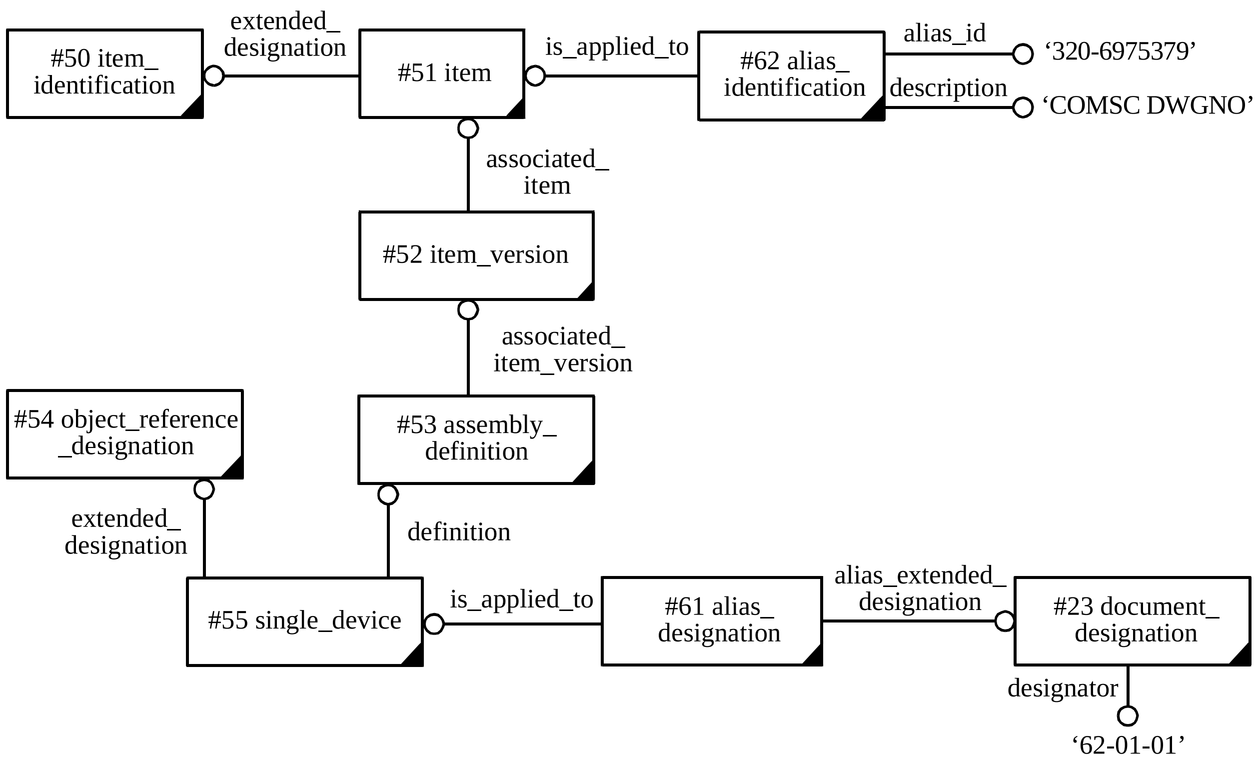


Figure A.83 — Specifying the customer's drawing

A.3.11.5.15 Specifying the paper size

ISO/IEC 10303-212 provides an EDT to represent paper size. In Figure A.75, the paper size is "C," as shown in the lower, right corner of the drawing sheet. The Rectangular_area EDT provides the area of the paper, and the Coded_size EDT specifies the paper size of a sheet in an abbreviated form. The paper size is represented by an instance (#17) of the Coded_size EDT. The first attribute of the Coded_size EDT refers to an instance (#18) of the Rectangular_area EDT, and the second attribute refers to the revision number.

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