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SHIP PIPING
APPLICATION PROTOCOL

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Contractor/Contract Identification

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Contents

Figures

Tables

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 world-wide federation of national standards bodies.

This document is a user guide for ISO 10303-227:2000 (AP 227), 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 227 is the Application Protocol (AP) for Plant Spatial Configuration. ISO 10303-227:2000 provides the ship industry with a useful mechanism for exchanging piping information.

Annex A is for information only.

Background

ISO (the International Organization for Standardization) is a world-wide 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 modeling* T23 *Ships*.

The following product data standards are principally relevant to ship industry. 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 Molded 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 3 ISO 10303-227 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 that 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 AP for ship molded forms and related hydrostatic properties. The AP supports hull molded forms and molded forms for structures internal to the ship, and supports surface and underwater ships for commercial and military use.

In this context:

— a ship molded 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 (PLIB), 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 organized as a series of separately published parts. 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 10303-227:2000 for representing and exchanging product data about ship piping systems.

ISO 10303-227:2000 is an AP for the exchange of spatial configuration information of process plants. The spatial configuration information focuses on the shape and spatial arrangement of the components of the plant piping systems. Components of the plant piping system include pipes, fittings, pipe supports, valves, in-line equipment, and in-line instruments; however, shape and spatial configuration information for equipment and non-piping plant systems are also included in this document.

There is an industrial need to exchange information about ship piping functional design, detail design, production engineering, fabrication, assembly, and testing.

Ship piping systems and process plants are similar in terms of functionality, component classes used, analysis methods, design considerations, and fabrication techniques.

Several of the U. S. Navy-Industry Digital Data Exchange Standards Committee (NIDDESC) specifications have served as input for the development of shipbuilding ISO 10303 application protocols. Version 1.0 of this document was a specification for shipboard piping 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 early 2000 and instead T23 began working with T20 to enable the use of ISO 10303-227 for ship piping systems data. The purpose of this document is to provide guidance on the use of ISO 10303-227 as a solution for the core requirements of exchanging data about shipboard piping systems.

This document provides a series of ship piping use cases. Each use case contains a fragment of a ship piping system design and its representation as a series of instances of elements from the ISO 10303-227:2000 Application Reference Model (ARM) and Application Interpreted Model (AIM). These use cases help to validate ISO 10303-227:2000 as a vehicle for exchanging ship piping information, and can serve as a reference for someone who is implementing ISO 10303-227:2000 for ship piping data exchange. This document also bridges the semantic gap between the shipbuilding application domain and the process plant application domain by providing the mapping between shipbuilding terminology and process plant terminology where differences exist.

The mapping between shipbuilding terminology and process plant terminology will be added in a future version of this document.

NOTE Because ISO 10303-227:2000 does not provide the ARM in a formal modeling language, the instance diagram notation used in this document to display the ARM representation of a use case is also informal.

This document provides guidelines for using ISO 10303-227:2000 to exchange shipboard piping system data. It is written primarily for people implementing ISO 10303-227:2000 within the shipbuilding industry. It also would be useful to anyone who wants to learn more about ISO 10303-227:2000; however, it does not provide any formal models, nor does it discuss piping system design issues.

Inputs for the use cases in this document were derived from the following sources:

— ISO 10303-217 working draft;

— Annex K (Application protocol usage guide) of ISO 10303-227:2000;

— MariSTEP program test data [1].

1 Scope

This document provides guidance on the use of ISO 10303-227:2000 for shipbuilding.

The following are within the scope of this document:

— recommended practices for exchanging ship piping information;

— use cases for representing ship piping information using ISO 10303-227:2000.

NOTE It is intended to add a mapping between shipbuilding terminology and process plant terminology for piping in a future version of this document.

The following are outside the scope of this document:

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

— requirements for ship piping systems.

2 Normative references

The following normative documents contain provisions that, 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 10303-11:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual*.

ISO 10303-21:1994, *Industrial automation systems and integration — Product data representation and exchange — Part 21: Implementation methods: Clear text encoding of the exchange structure*.

ISO 10303-227:2000, *Industrial automation systems and integration — Product data representation and exchange — Part 227: Application protocol: Plant spatial configuration*.

3 Terms, definitions, and abbreviations

3.1 Terms defined in ISO 10303-227

For the purposes of this document, the terms and definitions given in ISO 10303-227:2000 apply.

3.2 Abbreviations

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

AO application object

AP application protocol

ASTM American Society for Testing and Materials

ATS abstract test suite

CD committee draft

DIS draft international standard

(E) English

EDT entity data type

FDIS Final Draft International Standard

GUID globally unambiguous id

HVAC heating, ventilation, and air conditioning

id identifier

IR integrated resource

IS International Standard

ISO International Organization for Standardization

NIST National Institute of Standards and Technology

NSRP National Shipbuilding Research Program

OSI open system interconnection

SC subcommittee

TC technical committee

UoF unit of functionality

WD working draft

4 Overview of the AP

4.1 Scope of ISO 10303-227:2000

ISO 10303-227:2000 specifies the use of the integrated resources necessary for the scope and information requirements for the exchange of spatial configuration information of process plants. The spatial configuration information focuses on the shape and spatial arrangement of the components of the plant piping systems. Components of the plant piping system include pipes, fittings, pipe supports, valves, in-line equipment, and in-line instruments; however, shape and spatial configuration information for equipment and non-piping plant systems are also included in ISO 10303-227:2000. The spatial configuration information principally supports the plant engineering design life-cycle phases, but may be useful in the downstream life-cycle phases of installation and maintenance.

4.2 Plant items

The contents of this clause will be added in a future version of this document.

4.3 Complex instances

To fully classify an object using ISO 10303-227:2000, several independent classifications may need to be applied. These classifications can be combined to form a single hierarchy, so that any occurrence belongs to exactly one leaf class in the hierarchy.

EXAMPLE 1 A piping connector may be characterized by its end type as being a female end, a branch hole, a male end, or a flanged end. It may also be characterized by its end engagement type as being a pressure fit, butt weld, flanged, socket, or threaded. To fully specify a piping connector, both characterizations should be applied. This dual characterization is modeled as shown in Figure 1.

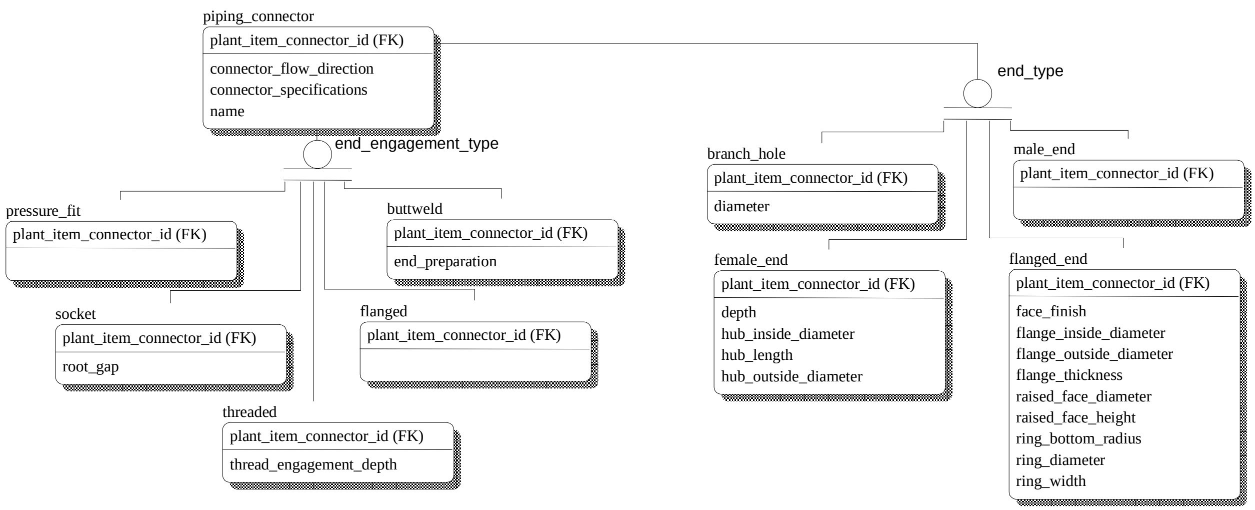

Figure 1 — Model of piping_connector using dual classification

It would be possible to combine end_engagement_type and end_type hierarchies into a single hierarchy, by first branching based on end_engagement_type and then on end_type (see Figure 2).

This approach, however, can lead to a very large classification hierarchy. At each level of the model, the choice of criterion to be used for classification is arbitrary. This can lead to inflexibility in the model. Therefore, the developers of ISO 10303:227 chose to keep separate classification hierarchies for each independent classification criterion.

EXAMPLE 2 For the case described in Example 1, using the multiple hierarchy approach leads to the model shown in Figure 2.

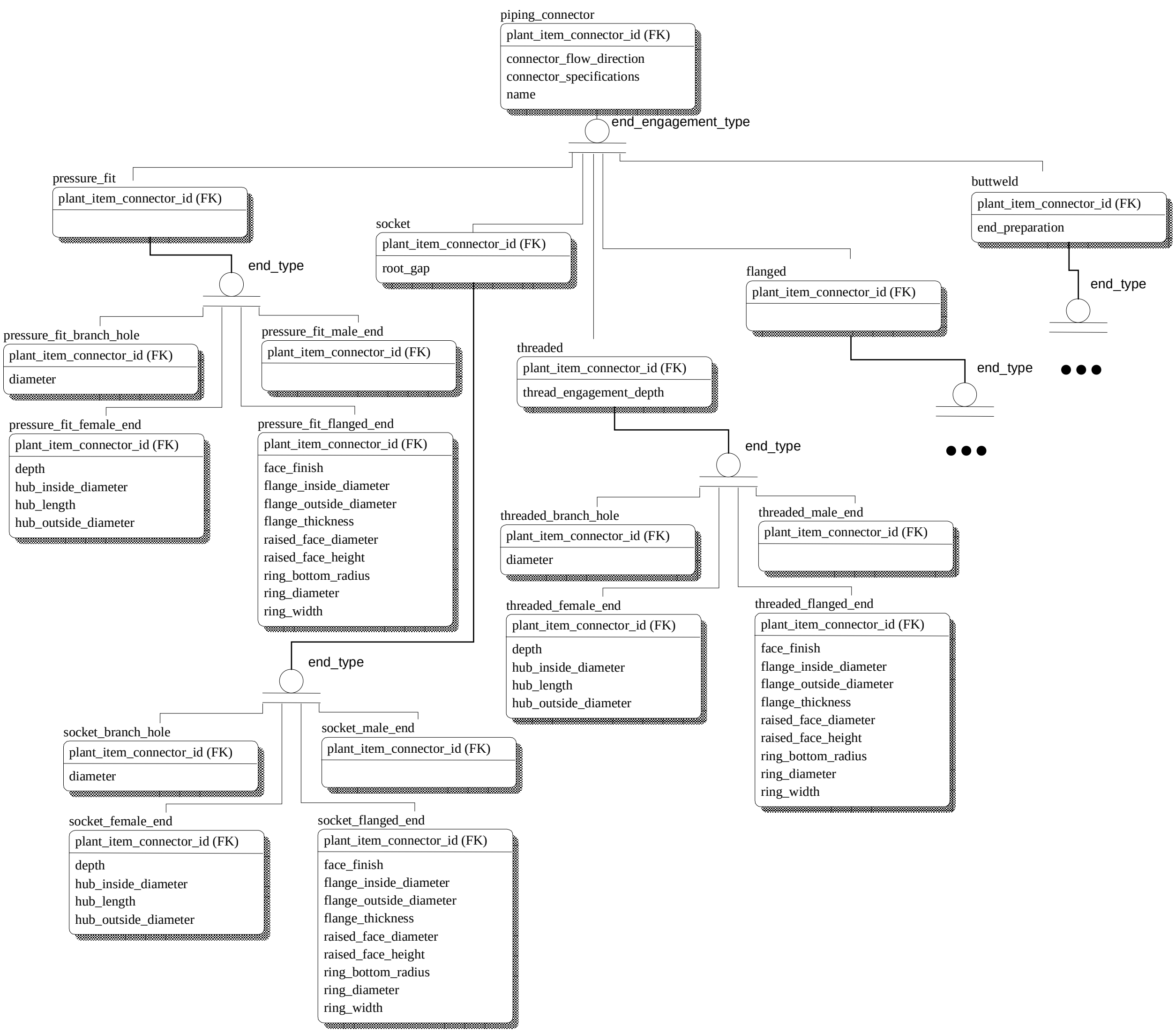

Figure 2 — Multiple classifications

To fully characterize an item using the multiple hierarchy approach, one can specify a member of each hierarchy to which it belongs. This results in a complex entity data type (EDT).

EXAMPLE 3 A pressure-fit female end is characterized as a complex entity instance that is a member of the Pressure_fit EDT and the Female_end EDT.

5 Conventions in this document

This clause provides the conventions that apply to this document.

5.1 Instance identification

Although the ARM of ISO 10303-227:2000 is written in IDEF1X, this document will use the term “entity data type” (EDT) at the ARM level to refer to the set of all possible values for an application object.

Throughout this document, names of EDTs begin with a capital letter. Names of AIM EDTs are in boldface type as well. For example, “Pipe” refers to the Pipe application object; “Pipe” refers to a construct in the AIM; and “pipe” refers to the concept of a pipe independent of its computer representation.

Instances of EDTs are identified by #nnn where nnn is an integer. The symbol #nnn identifies an instance of an EDT in an instance diagram. If several instance diagrams show the boxes with the same number, these boxes capture the same instance even though the attributes shown may be different.

NOTE Some attributes may be suppressed from diagrams to improve readability.

Where the AIM is concerned, #nnn is an “entity instance name” (see Clause 7.3.4 of ISO 10303-11:1994) corresponding to a line in an ISO 10303-21 physical file.

An attribute “att” of an EDT “Ent” may be referred to as “Ent.att” or as “the att attribute of Ent.”

5.2 Notation for ARM instance diagrams

This clause gives the notation for the ARM instance diagrams in the use cases.

NOTE 1 The diagram notation described in this clause is intended to be compatible with the IDEF1X modeling notation used in the ISO 10303-227 ARM. EXPRESS and EXPRESS-G versions of the ISO 10303-227:2000 ARM have been created. The physical files for Annex A are based on the EXPRESS version of the ARM.

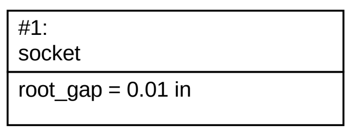

Figure 3 — Entity instance

An instance of an EDT is shown as a box consisting of two smaller boxes, stacked vertically (see Figure 3). The upper box consists of:

— Line 1: the entity instance name followed by a colon (“:”);

NOTE 2 As defined in ISO 10303-21, the entity instance name consists of a pound sign (“#”) followed by an unsigned integer.

— Lines 2-n: the names of the EDTs to which the instance belongs, separated by commas.

The lower box consists of lines of the form “att = val” where “att” is the name of an attribute of one of the EDTs of the instance, and “val” is the value. If a value is unknown, it is omitted, leaving just “att =” on the line.

EXAMPLE 1 With reference to the IDEF1X model in Figure 2, a complex entity instance of Socket and Branch_hole (subtypes of Piping_connector) with a plant_connector_id of “PC1,” a root_gap of 0.01 inch and a diameter of 2.1 inches is shown in Figure 4.

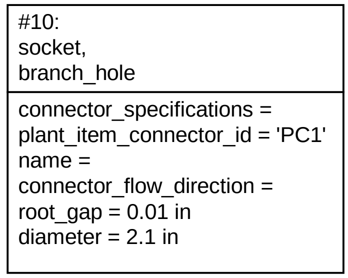

Figure 4 — Complex entity instance

A solid line shows a relationship between two instances. Text adjacent to the line gives the reading for the relationship in the forward and backward directions, separated by slashes. The relationship is read from left to right and from top to bottom.

EXAMPLE 2 An instance diagram for a simple employer-employee relationship is shown in Figure 5.

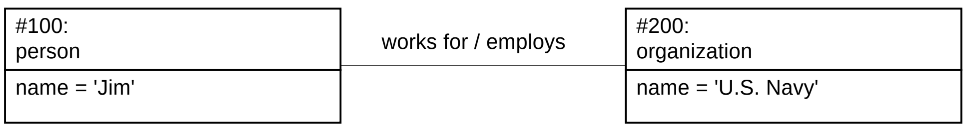

Figure 5 — Notation for relationship

If instances A and B play the same role with respect to an instance C, separate lines are drawn from A to C and from B to C. The additional notation "[*m*/*n*]" is attached to a line, where *m* is the element number and *n* is the total number of instances playing the role (see Figure 6).

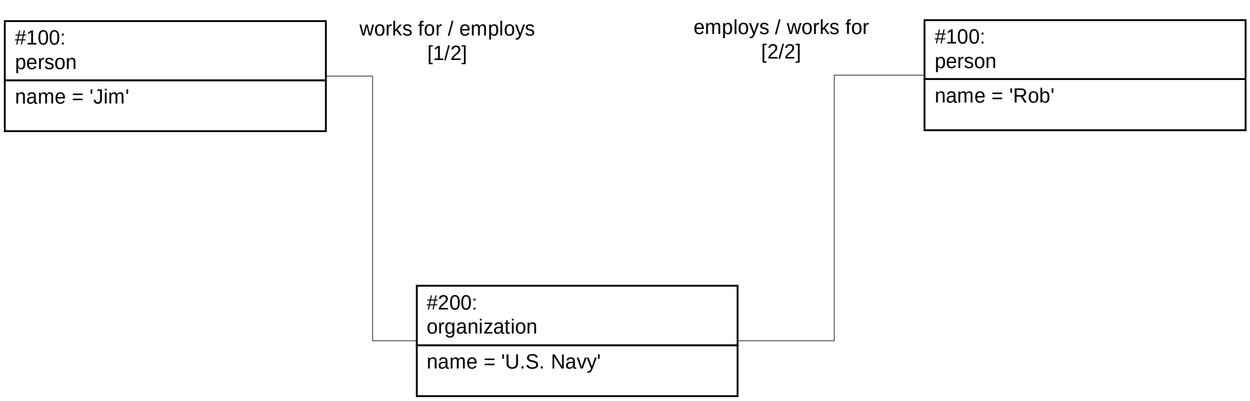

Figure 6 — Notation for relationships with multiple entities playing the same role

A note is shown as an oval, attached by a line to the item being notated (see Figure 7).

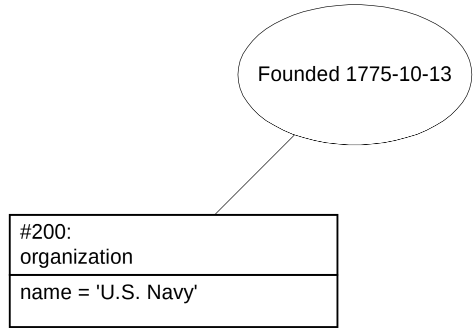

Figure 7 — Notes

5.3 Notation for AIM instance diagrams

The contents of this clause will be added in a future version of this document.

6 Recommended practices

RP 0424-1

Capture loosely connected components using a Hierarchically_organized_collection.

Additional recommended practices will be added in a future version of this document.

Annex A
(informative)

Users guide

A.1 Technical discussion

An introduction to process plant and piping design may be found in [2].

A.1.1 Overview

Piping systems are used to convey and process fluids or gases within a variety of engineering products. Generally, a piping system is comprised of a network of pipe, pipe components (fittings and valves), and is attached to processing equipment such as pressure vessels and pumps. Large piping systems are generally attached to some supporting structure through the use of pipe supports and hangers. Insulation, heat tracing, and vibration or sound damping parts (attaching parts) are often attached to piping systems.

A piping system is a type of distribution system, which in turn is a type of engineering system, which is in turn a type of system. Much of the information pertinent to a piping system is applicable to general distribution systems, or to engineering systems, and so should be represented at these higher (supertype) levels, as applicable, rather than at the piping system level.

Four major application areas corresponding to major stages of piping product life cycle are:

— contract/functional design;

— detail design;

— production engineering;

— support engineering.

Users/developers of piping product information in these stages of product life cycle have different information requirements and views of the product. In the contract design stage, users view a piping system principally as a functional network of equipment.

Functional design stage designers see piping in much the same way but develop and use much more detailed information concerning operating states of a system, and the characteristics of subnetworks of piping within an overall system (pipelines) in terms of material specifications and flow characteristics. They also, for some systems, develop and use data concerning the loading on, and fixity of, portions of the system in order to evaluate stress levels. The functional view 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 stage view is also the one which, along with contract specifications, is used in formulating and performing systems testing following installation.

Because of the commonality of views in the contract and functional design stages, they can be combined into a single application area. Detail design users have a 3-D arrangements view of piping. They are concerned with the arrangement in 3-D space of piping components meeting the applicable system specification and in insuring the arranged components are free from interference with the surrounding environment. This view of the data is also the view typically supporting the final purchasing bills of material.

Production engineering stage users are concerned with defining piping assemblies and the information needed to fabricate the pieces of these assemblies. This information can consist of bending instructions, joining instructions/specifications and coating instructions. They also specify the installation processes to be used to install such assemblies in the final product and the post-installation tasks to be carried out. The production engineering function creates and makes use of the production bill of material view.

The piping product view taken by users in the support engineering stage 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.

A.1.2 Connectivity

A key feature of piping and all distribution products is the connectivity of components of the product to form networks. In general, connectivity between piping objects is established by defining a relationship between the distribution ends of connecting objects and a distribution interface.

A second type of general connectivity used throughout applications is the attachment. An attachment defines a joining of an attached/penetrating_object such as an engineering_part or a pipe run with an attaching/penetrated_object at their attachment_ends. Attachments are not used in establishing network connectivity.

A.1.3 External references

Transfers of product model data invariably involve references to objects not present in the transferred model. Three types of such references are handled by this AP. The first type of such external reference is from an internal occurrence of an engineering part to an external catalog of such parts containing the geometry and other data describing the part. In this case, the referencing part (occurrence) must carry sufficient information to allow the geometry of the part to be created at the same location and orientation in the receiver's model that it had in the sender's, and to maintain its connectivity to adjoining parts.

The second type of external reference is from an internal occurrence of an engineering part, distribution interconnection (e.g., pipeline) or engineering system to another such object (or space) with which it is topologically or spatially related, but which is not present in the transferred model nor is it defined in a catalog. Examples of this situation include a connection between a pipe and an undefined piece of equipment, between a hanger and a piece of structure, and between an equipment and the compartment where it is located. The referenced object may or may not have been received previously and, therefore, may or may not be available when the model is received. In this situation, the referencing object must preserve the ability to identify correctly and, if required, locate its connection with the referenced object until such time as the referenced object is integrated with the referencing object's database.

The third external reference type is a logical reference to an object that is not a product model object. Examples of such referenced objects include all types of physical documentation including drawings, specifications, and publications (e.g., training manuals or operating guides). This reference type is intended to facilitate both the use of automated interfaces to other information systems at the receiving site and manual cross referencing.

A.2 Implementation agreements

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

1	INTRODUCTION
1.1	Scope
1.2	Identification of the System
1.3	System Overview
1.4	Requirements Document Overview
2	APPLICABLE DOCUMENTS, REFERENCE, AND GLOSSARY
2.1	Terms and definitions
2.2	References
2.3	Document Notation
3	SYSTEM REQUIREMENTS
3.1	Schema Requirements
3.1.1	Compilation
3.1.2	Geometry
3.1.3	Global Unambiguous Identifier (GUID) Defined
3.1.4	External Instance Reference Defined
3.1.5	Versioning Defined
3.1.6	Library Part References Defined
3.2	Functional Requirements
3.2.1	Interoperability
3.2.2	Conformance
3.2.3	Parts Libraries
3.2.4	Native Product Model and System
3.3	User Interface Requirements
3.4	Diagnostic Requirements
3.4.1	Translation Status
3.4.2	Unresolved References
3.4.3	Missing or Anomalous Data
3.4.4	Unsupported Data
3.4.5	Message Content
3.5	Metrics Collection
3.5.1	Effectiveness
3.6	Test and Evaluation Requirements
3.6.1	Test Data
3.6.2	Testing Methods
3.6.3	Test Criteria
3.6.4	Test Results
3.7	Usage Requirements
3.7.1	Global Unambiguous Identifier (GUID) Company IDs
3.7.2	Indeterminate Values
3.7.3	Exchange Contents
3.7.4	Part 21 File Header
3.7.5	Parts Library
3.7.6	Deviations from the Schema
3.7.7	Common
3.8	Project Quality Assurance
3.8.1	Requirement Traceability
Annex A	INSTANTIABLE STEP ENTITIES
A.1	AP Instantiable STEP Entities
INDEX	
REVISION HISTORY	

Figure A.1 — Table of contents of implementation agreement

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

A.3 Use cases

A.3.1 Connections

A.3.1.1 Purpose

This clause describes the use of ISO 10303-227:2000 to exchange information about the characteristics of piping components, their spatial arrangement, and how they are connected to form a piping system.

A.3.1.2 Background

The contents of this section will be added in a future version of this document.

A.3.1.3 Example

Figure A.2 shows a portion of a piping system that will serve as the basis for the example in this use case. The piping system and its components were chosen to help demonstrate the capture of components, their spatial arrangement, and their interconnection. While all components and connection types shown are possible, the design shown is not a part of a real ship piping system design.

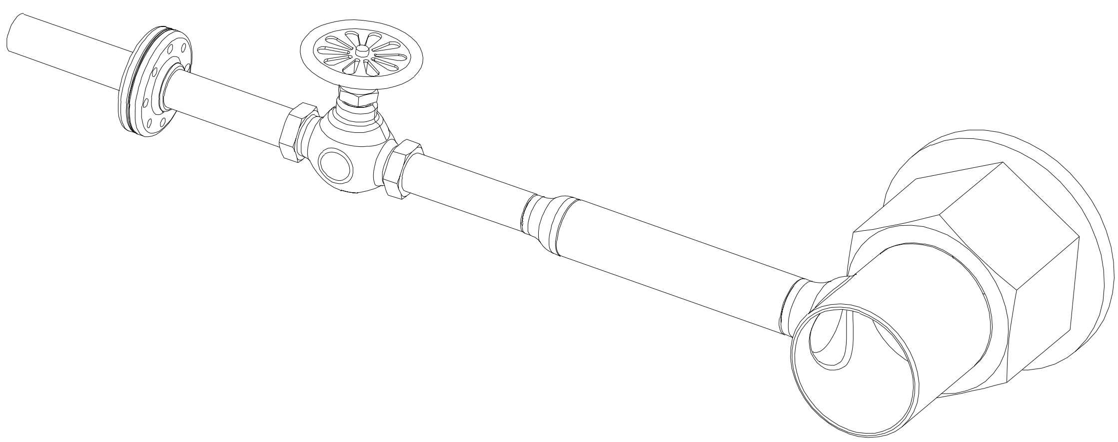

Figure A.2 — Portion of a piping system for the connections use case

The component types included in this example are pipe, valve, flange, gasket, reducer, tee, and threaded union. The connection types included in this example are butt weld, socket weld, threaded, and flanged.

NOTE This example is derived from MariSTEP test case AP217-3-2.

Figure A.3 shows an exploded view of the components of the system with labels attached. Table A.1 gives labels and descriptions of the components in the example. In Table A.2, P1 represents a set of pipes with some common characteristics, P2 represents another set of pipes with common characteristics, etc. P1-1 is a particular pipe that belongs to set P1.

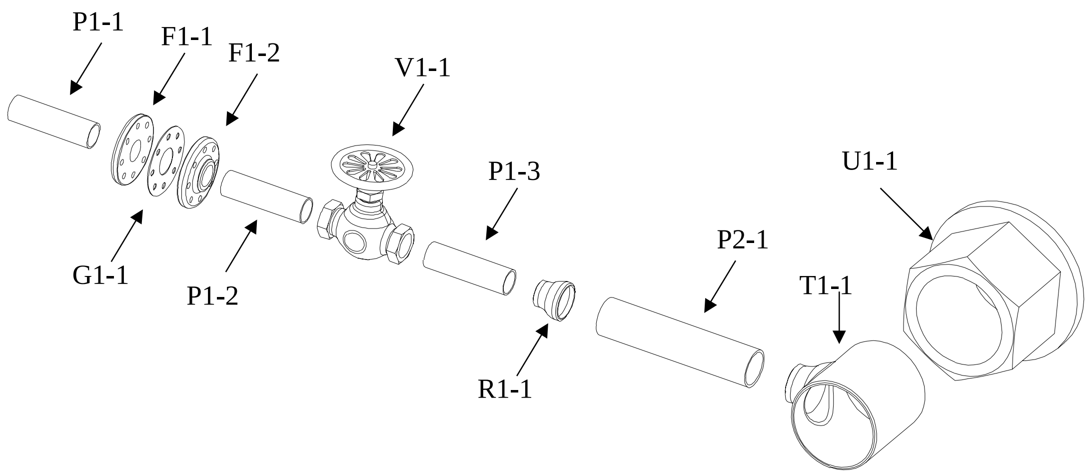

Figure A.3 — Exploded view with components labeled

Table A.1 — Components for the connections use case

Label	Type
P1-1	straight pipe
F1-1	socket welded flange
F1-2	socket welded flange
G1-1	gasket
P1-2	straight pipe
V1-1	valve
P1-3	straight pipe
R1-1	reducer
P2-1	straight pipe
T1-1	tee
U1-1	union

Table A.2 — Component definitions for the connections use case

Part	Type	Definition
P1	pipe	2-inch diameter
F1	socket welded flange	pressure rating 300 pounds, nominal size 2 inch
G1	gasket	pressure rating 300 pounds, nominal size 2 inch
V1	valve	
R1	reducer	
P2	pipe	2.375-inch diameter
T1	tee	
U1	union	

A.3.1.4 Instance diagram

Figures A.4-A.14 contain the instance diagrams for this use case.

A piping system can be represented in ISO 10303-227:2000 through a functional description and/or a physical description. In this use case, a physical description is presented.

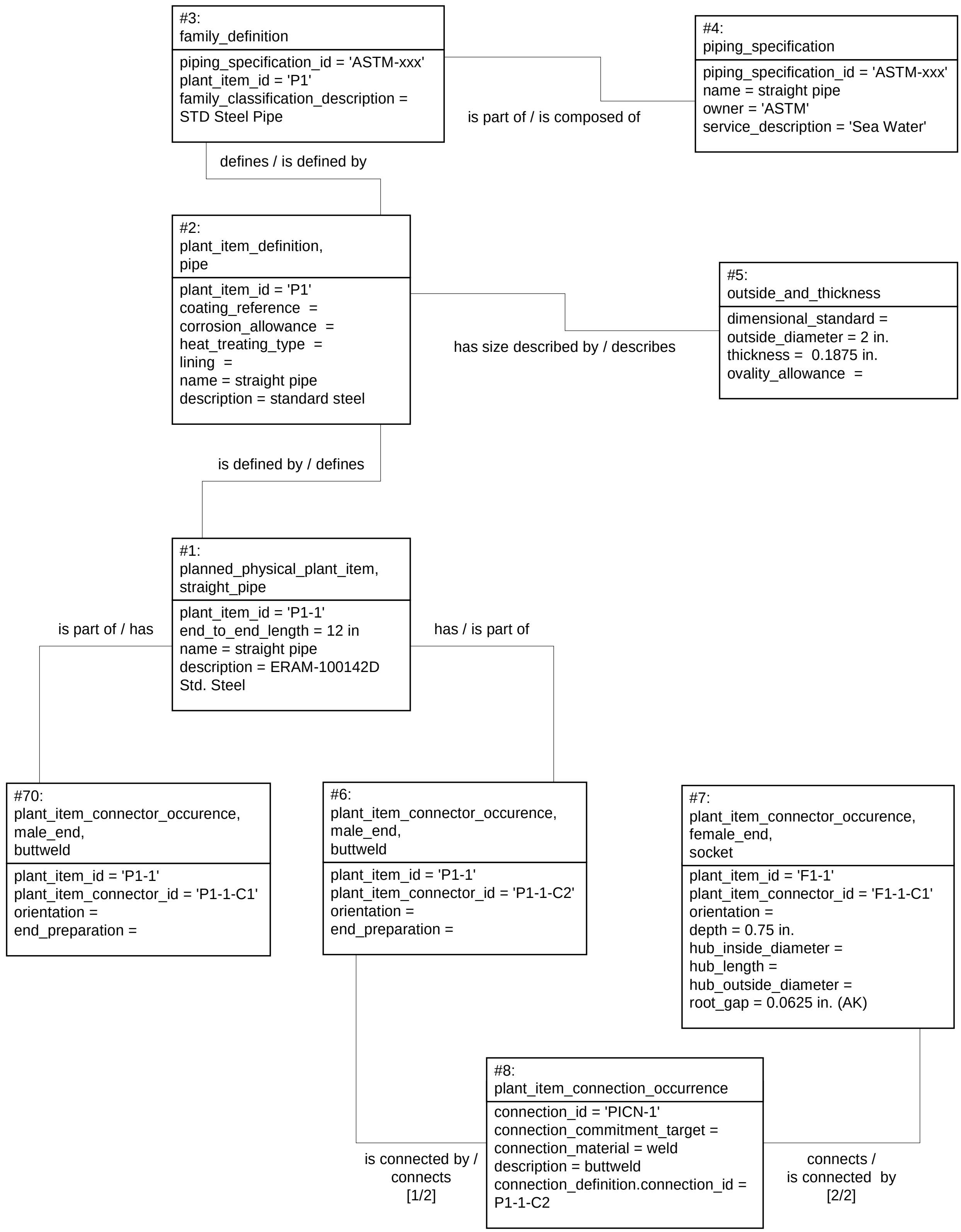

Figure A.4 — Instance diagram for the Connections use case (1 of 11)

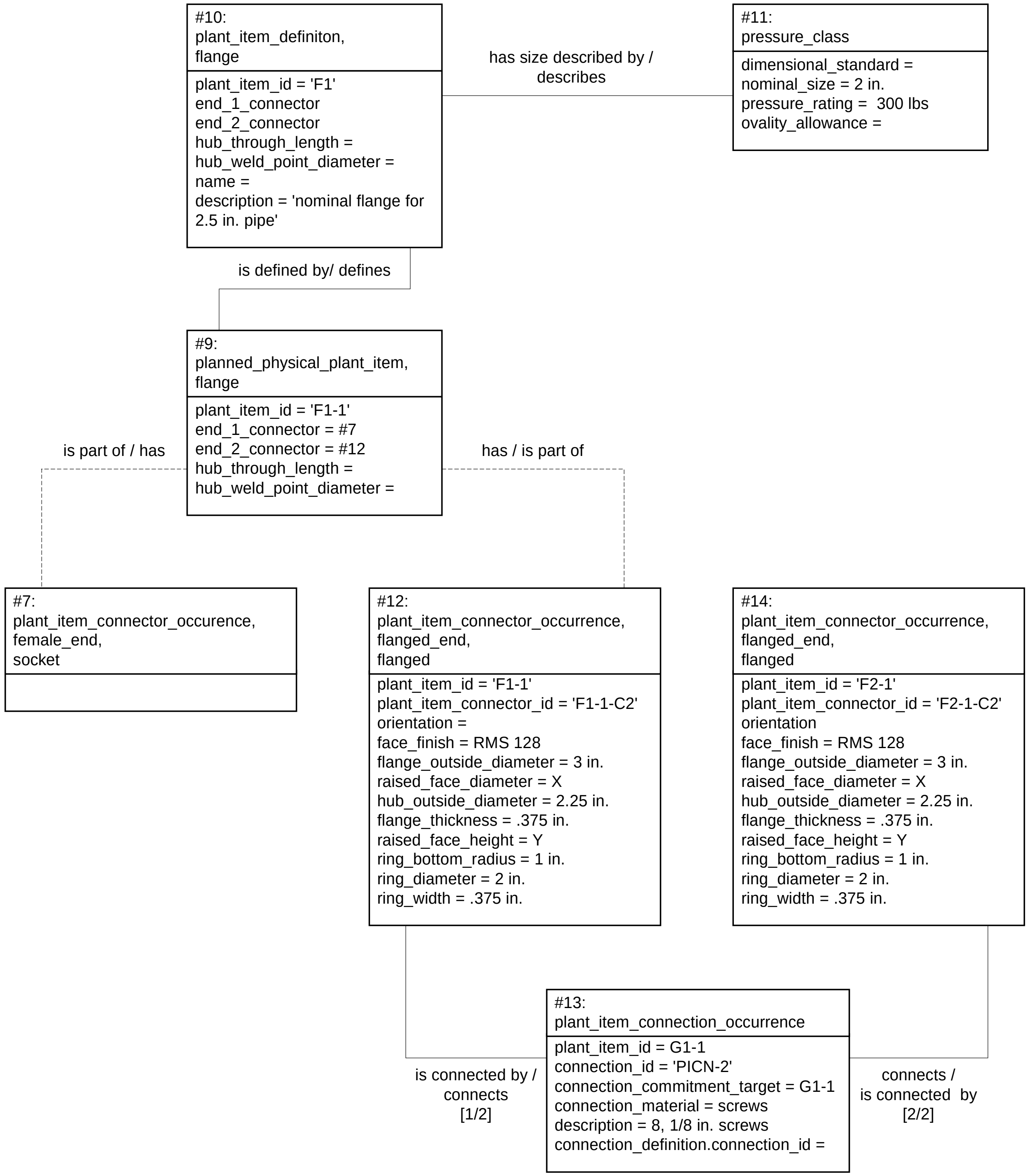

Figure A.5 — Instance diagram for the Connections use case (2 of 11)

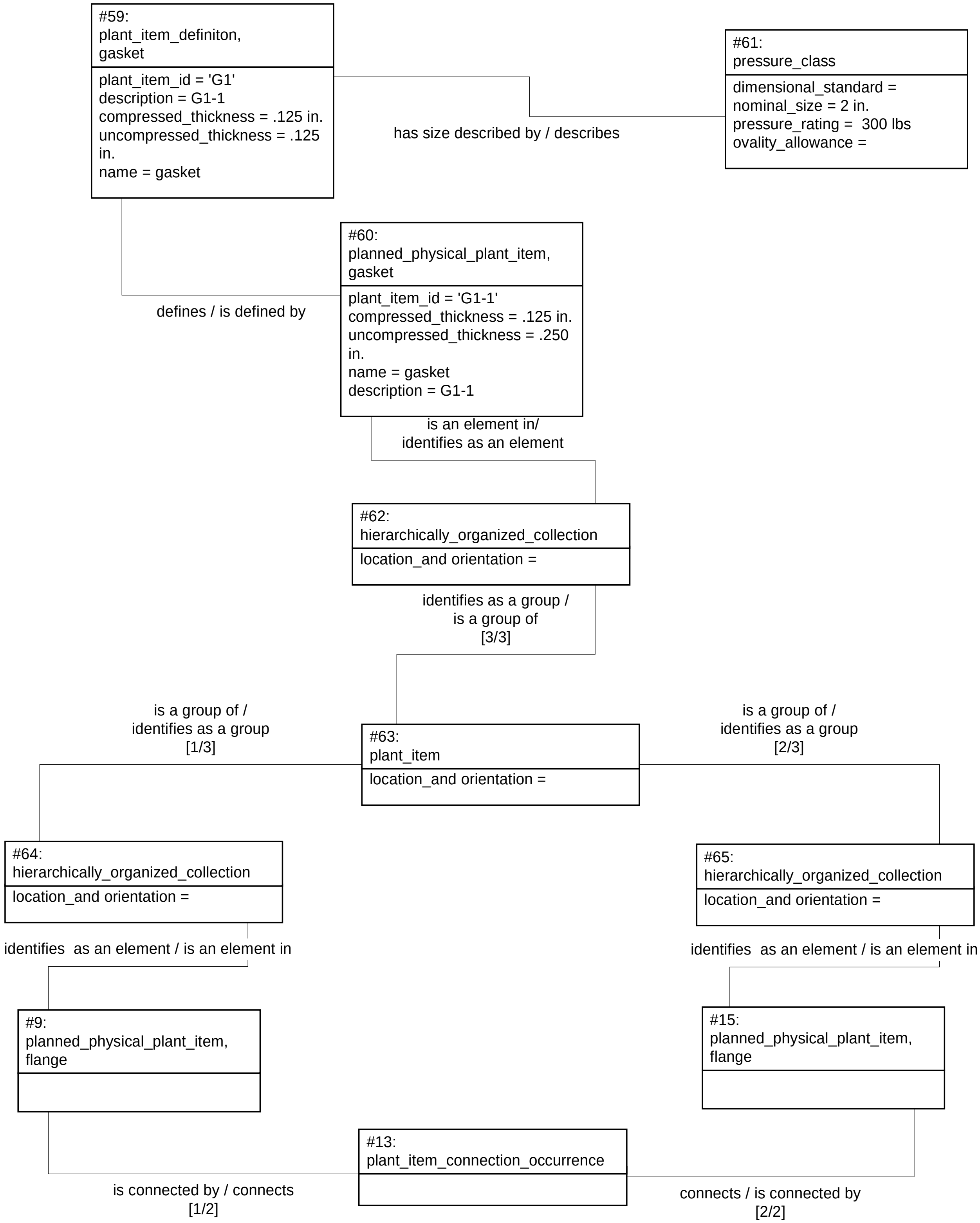

Figure A.6 — Instance diagram for the Connections use case (3 of 11)

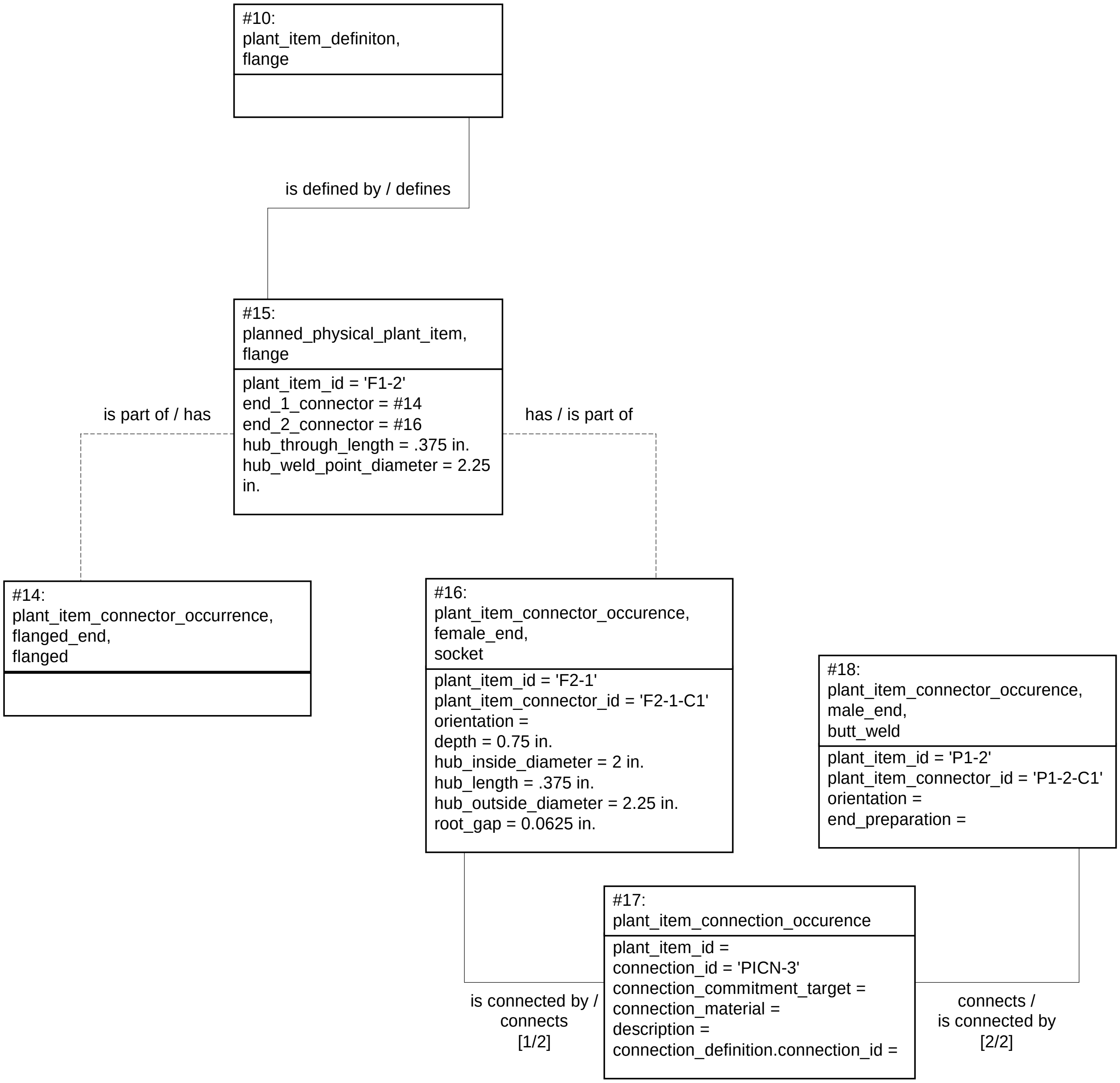

Figure A.7 — Instance diagram for the Connections use case (4 of 11)

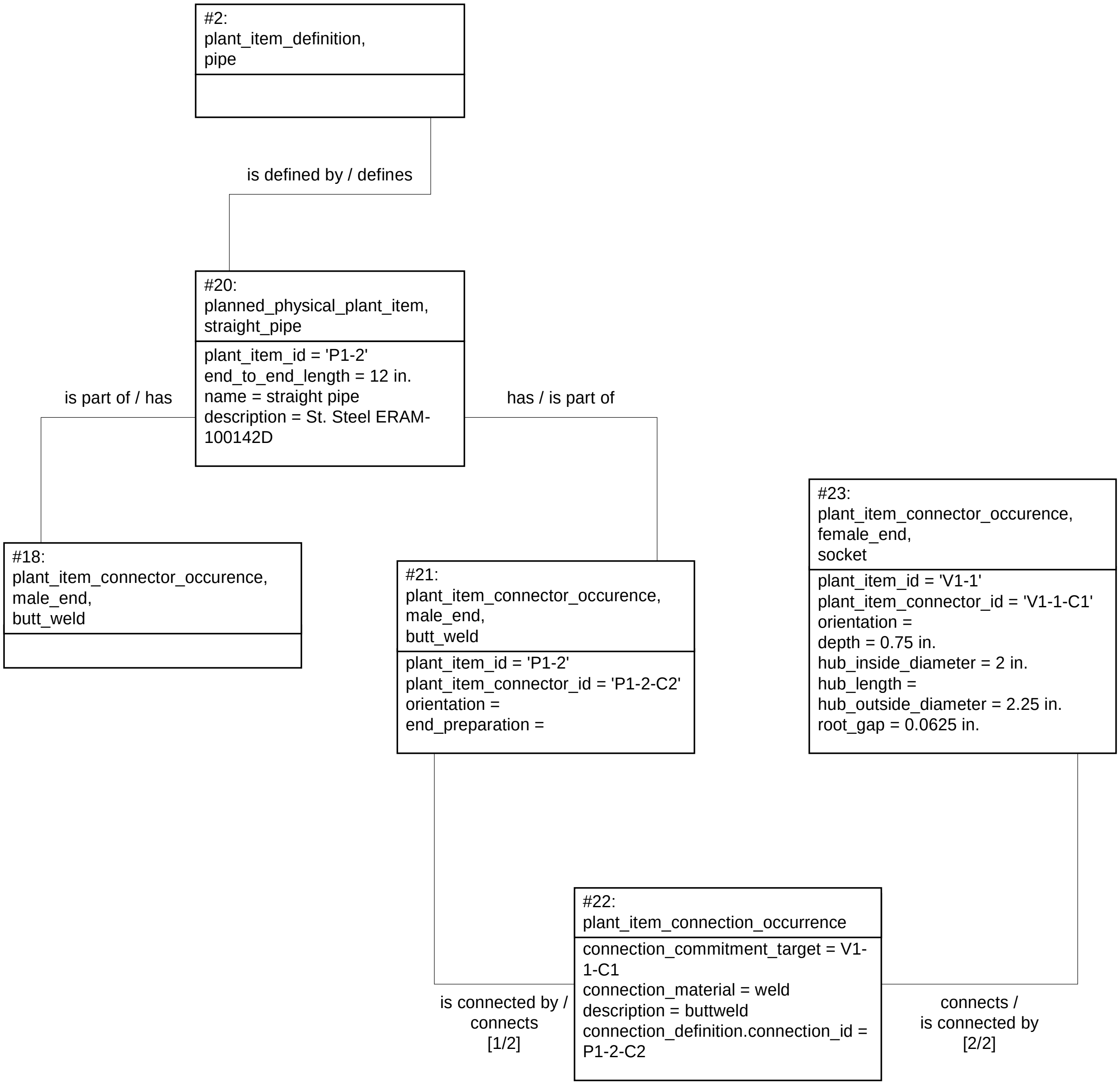

Figure A.8 — Instance diagram for the Connections use case (5 of 11)

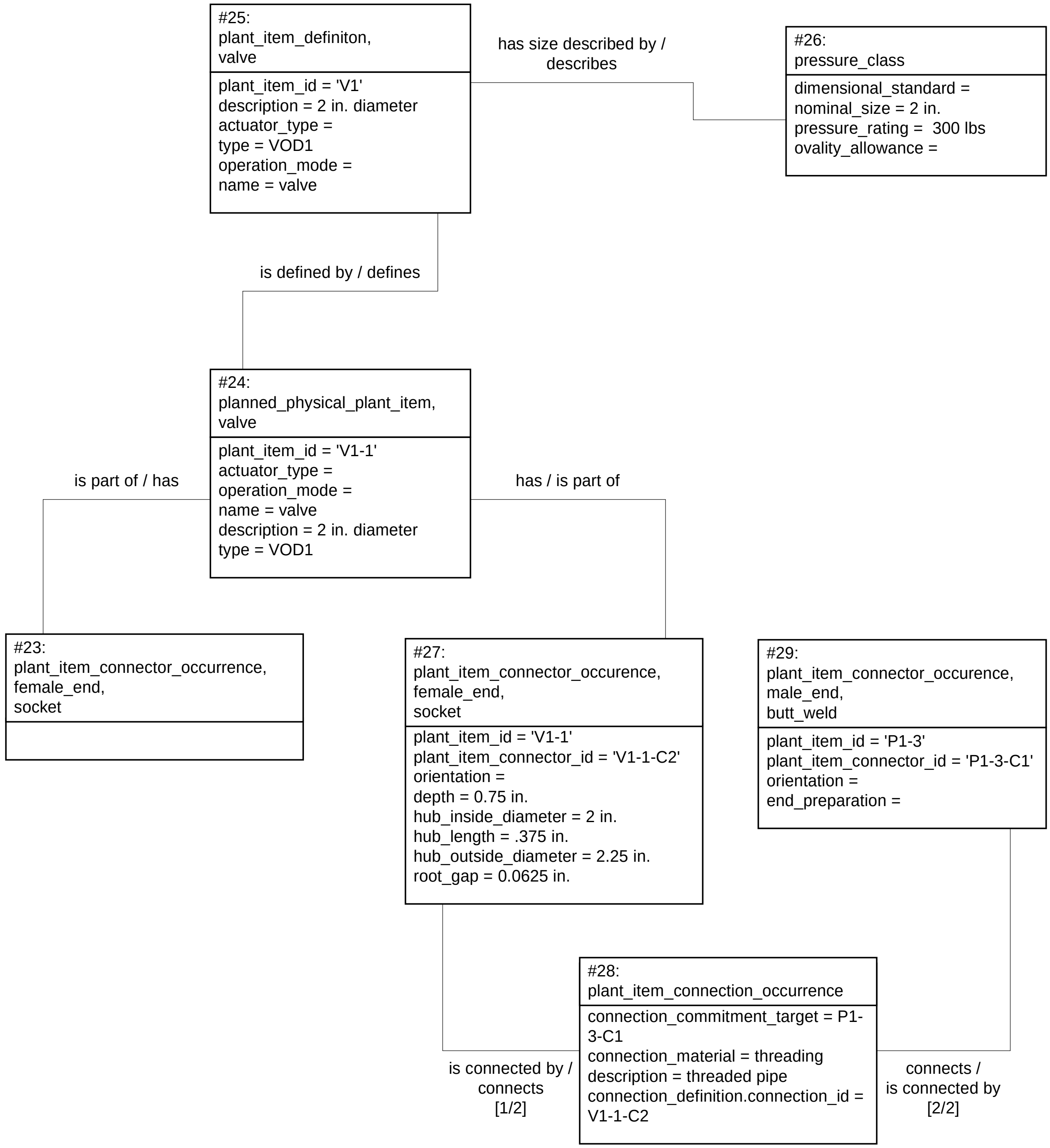

Figure A.9 — Instance diagram for the Connections use case (6 of 11)

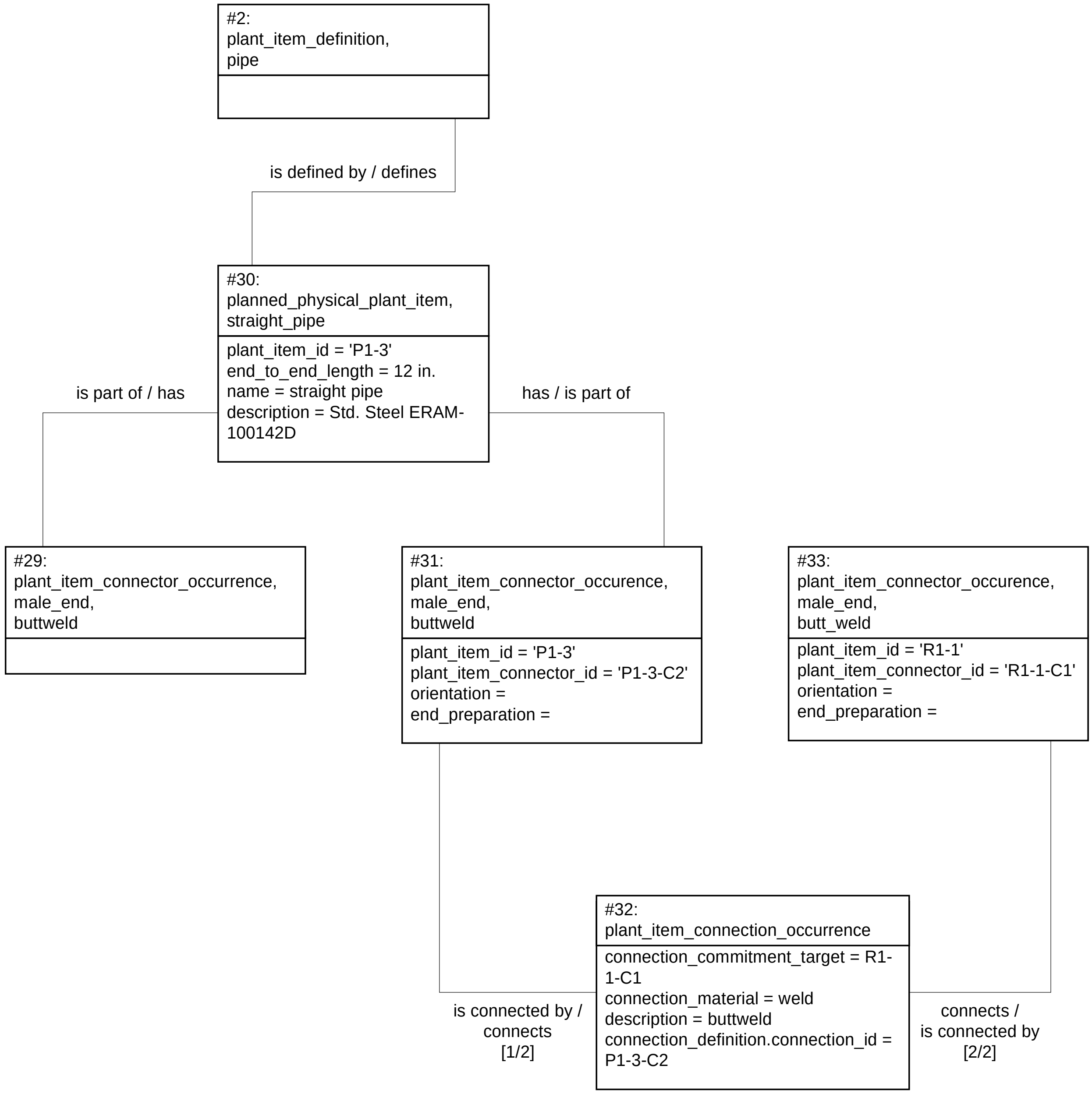

Figure A.10 — Instance diagram for the Connections use case (7 of 11)

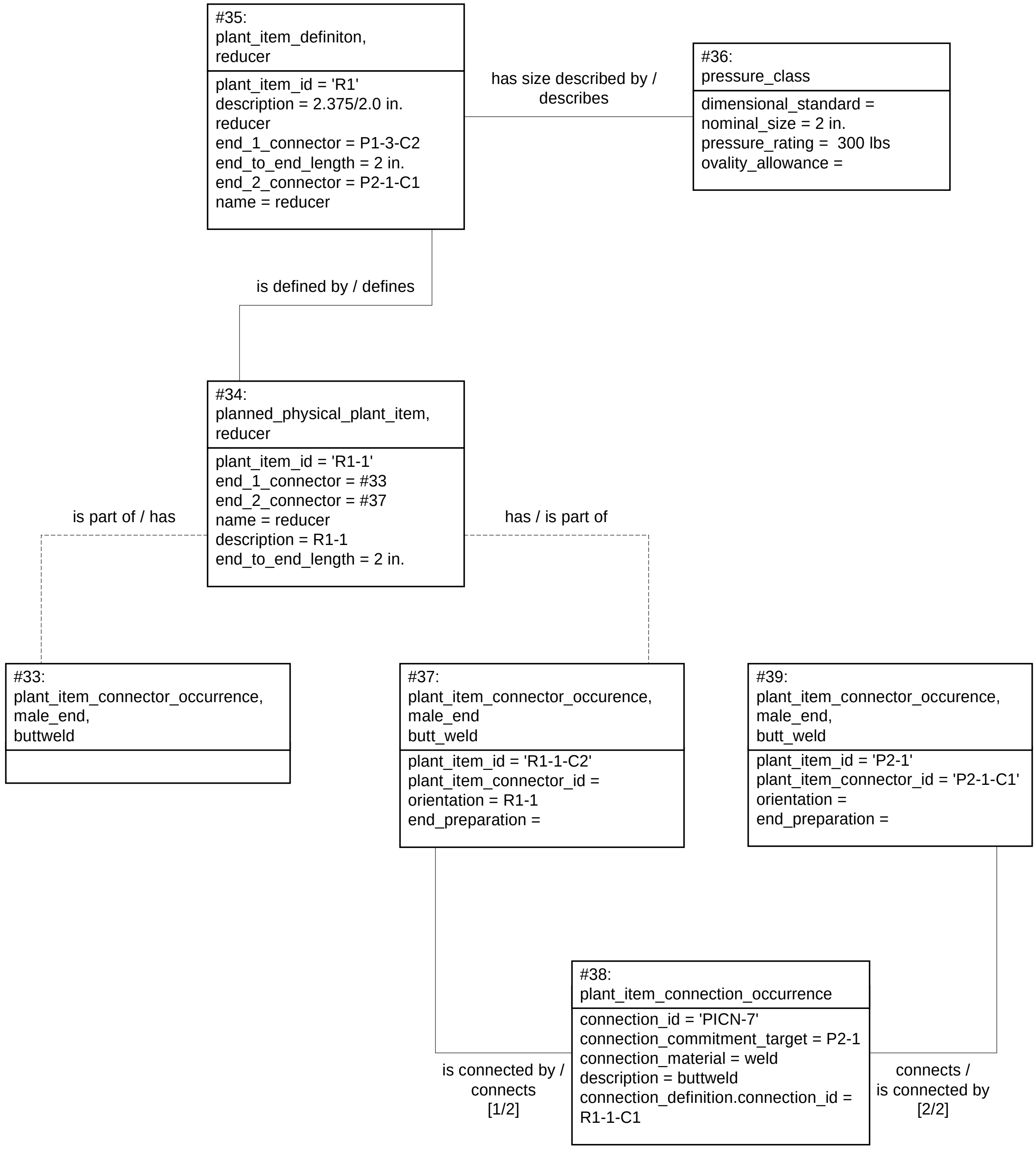

Figure A.11 — Instance diagram for the Connections use case (8 of 11)

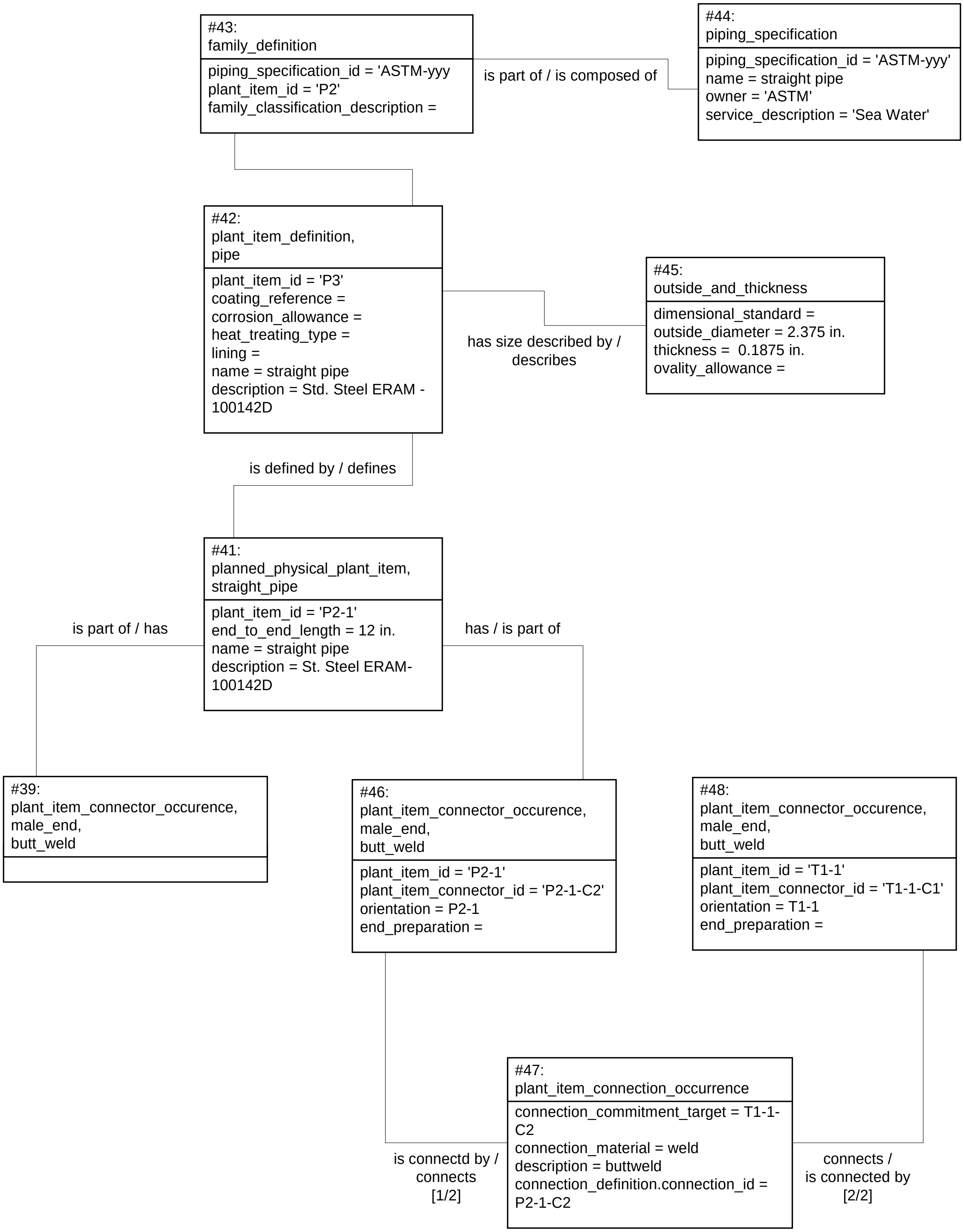

Figure A.12 — Instance diagram for the Connections use case (9 of 11)

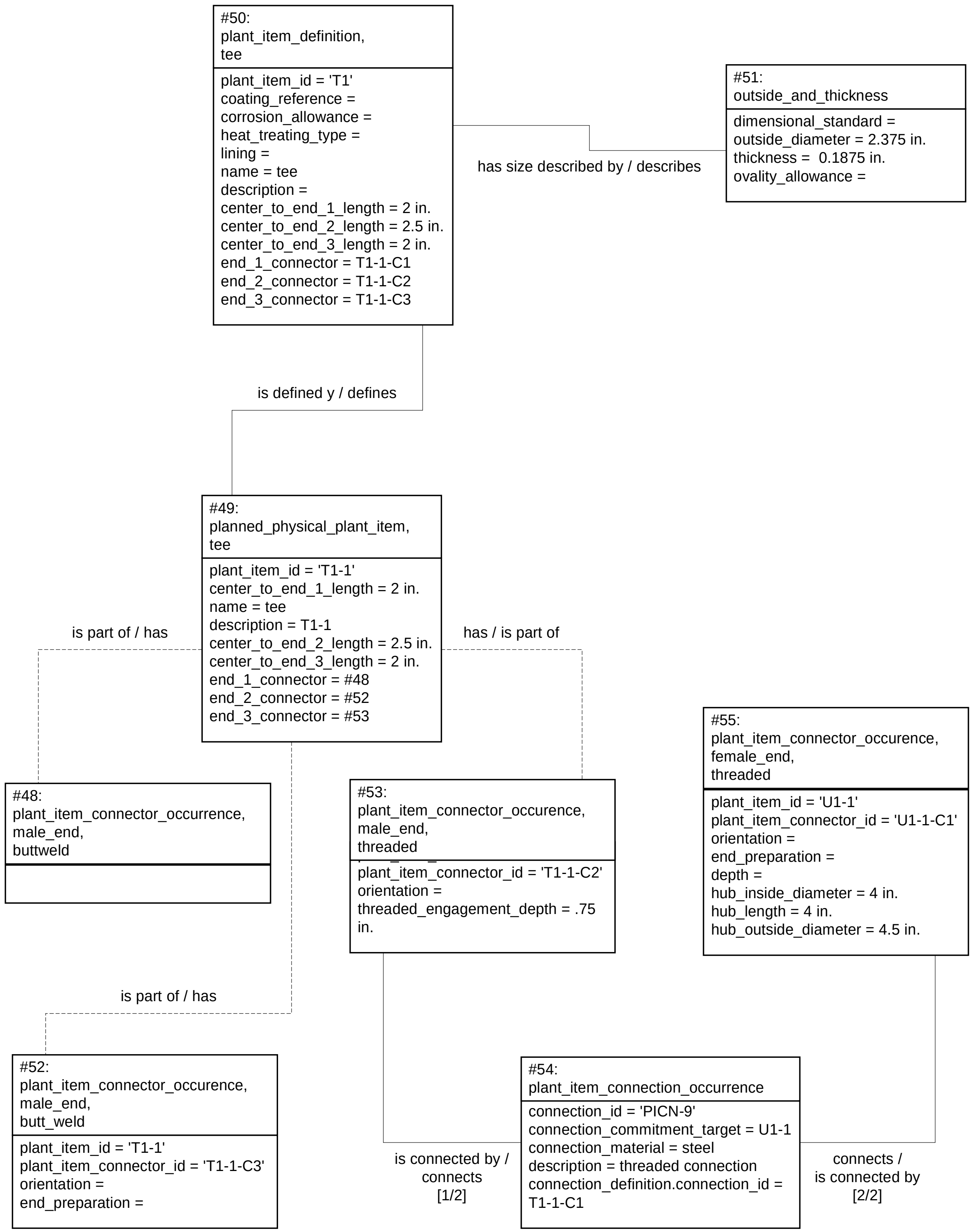

Figure A.13 — Instance diagram for the Connections use case (10 of 11)

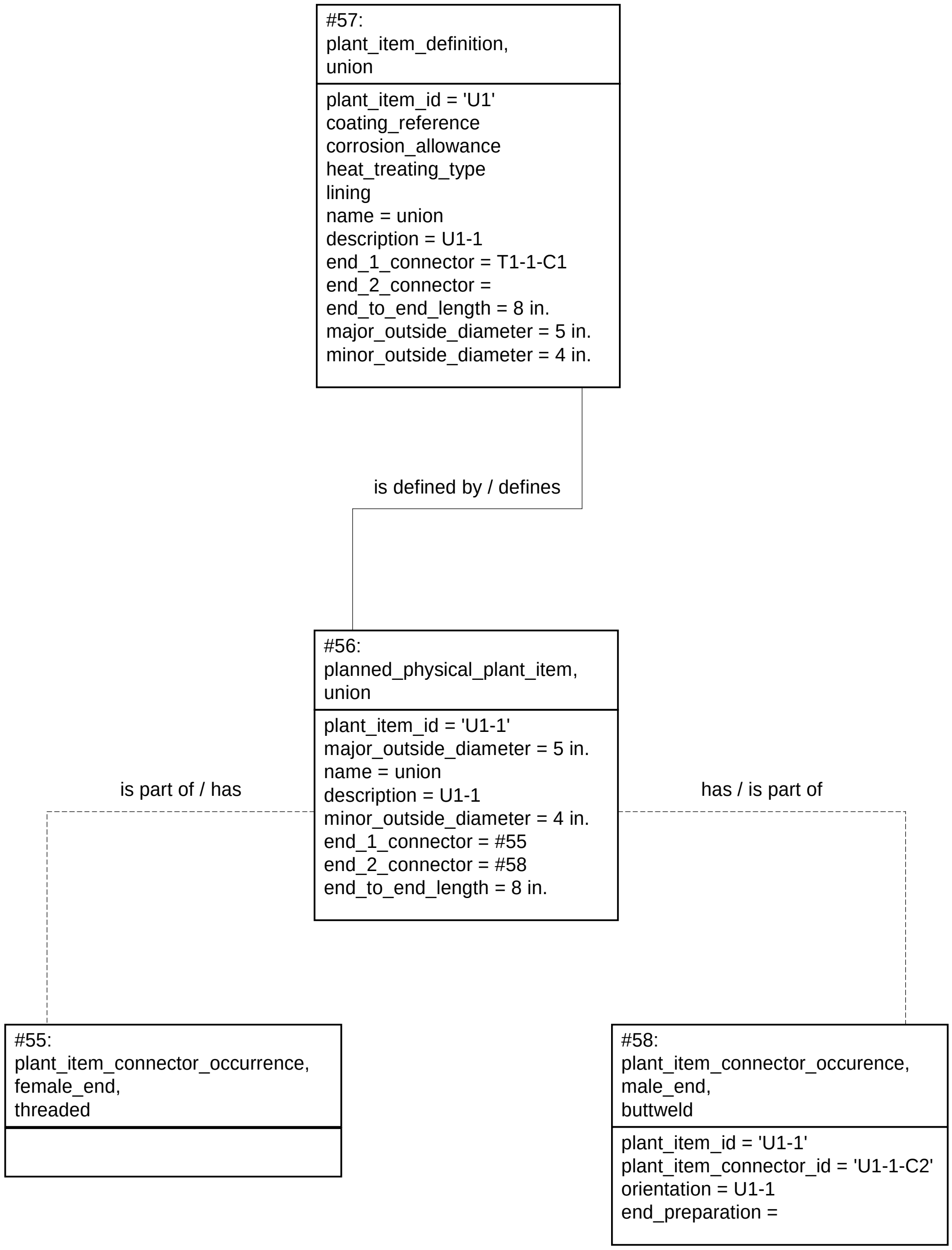

Figure A.14 — Instance diagram for the Connections use case (711 of 11)

A.3.1.4.1 Representing a component

Pipe P1-1 is captured by a complex entity instance (#1) of the Planned_physical_plant_item and Straight_pipe application objects (AOs). ISO 10303-227:2000 provides the means to associate all characteristics of the pipe directly with the occurrence (#1); however, this is not always desirable.

It is common in ship design to have many parts with common characteristics. In this example, P1-1, P1-2, and P1-3 are different lengths of the same kind of 2-inch, steel straight pipe. Rather than repeat these common properties for each of P1-1, P1-2, and P1-3, the common characteristics are gathered into a "template" that is shared by P1-1, P1-2, and P1-3. On a ship drawing, this grouping of common characteristics is identified by the label "P1." Using ISO 10303-227:2000, this template is captured by a complex entity instance (#2) of the Plant_item_definition and Pipe AOs.

The Piping_component AO has four subtypes (Fitting, Pipe, Valve, and Gasket) which correspond to the four major types of piping components. Each of these is further subtyped to represent specific piping components. For example, Fitting has subtypes such as Flange, Tee, and Reducer; Pipe has subtypes such as Pipe_bend and Straight_pipe. These subtypes can be instantiated at both the definition and occurrence level to specify the kind of piping component being referred to. If an object is also an instance of Planned_physical_plant_item, it represents an occurrence; however, if it is an instance of Plant_item_definition, it represents a definition.

In this use case, all the occurrences have definitions associated with them. The complex entity instance (#2) of the Plant_item_definition and Pipe AOs that captures P1 has two additional entity instances associated with it. The family of pipes to which P1 belongs is captured by an instance (#3) of the Family_definition AO. The standard or other specification to which the family is built is captured by an instance (#4) of the Piping_specification AO. A definition for a family of pipes was created (instance #3) and associated to instance #4. The Schedule AO can be used instead of the Family_definition AO to characterize a group of pipes. The outside diameter and thickness of the pipe are specified by an instance (#5) of Outside_and_thickness. An instance of Outside_and_thickness may describe more than one Plant_item_definition.

NOTE 1 Every occurrence of a piping component need not have a definition associated with it. For example, only a single heat exchanger of a given kind might appear on a ship. In such a situation, ISO 10303-227:2000 does not require the user to create a separate definition; rather, all characteristics can be associated directly with the Plant_item_instance (in this case, the Planned_physical_plant_item).

NOTE 2 When an item has a definition associated with it, and the same property is given different values in the definition and the occurrence objects, the value in the occurrence object takes precedence.

NOTE 3 Any properties that cannot be captured using attributes of AOs built into the ISO 10303-227:2000 ARM can be captured as user-defined attributes.

Flange F1-1 is captured similarly to pipe P1-1, except that the flange definition F1 has its size described by an instance (#11) of Pressure_class, rather than Outside_and_thickness, as was used for P1. Pressure_class and Outside_and_thickness are alternative ways to specify the size of the pipe.

A.3.1.4.2 Representing connections

To be part of a functioning system, a piping component must be connected to other piping components. The number and location of connections depend on the type of component. Figure 21 shows the components for this use case, with connectors labeled. The convention used is to add "-C1" to the end of a component label to designate the component's first connector, "-C2" to designate its second connector, etc.

NOTE In Figure A.15, connectors are sequenced from left to right.

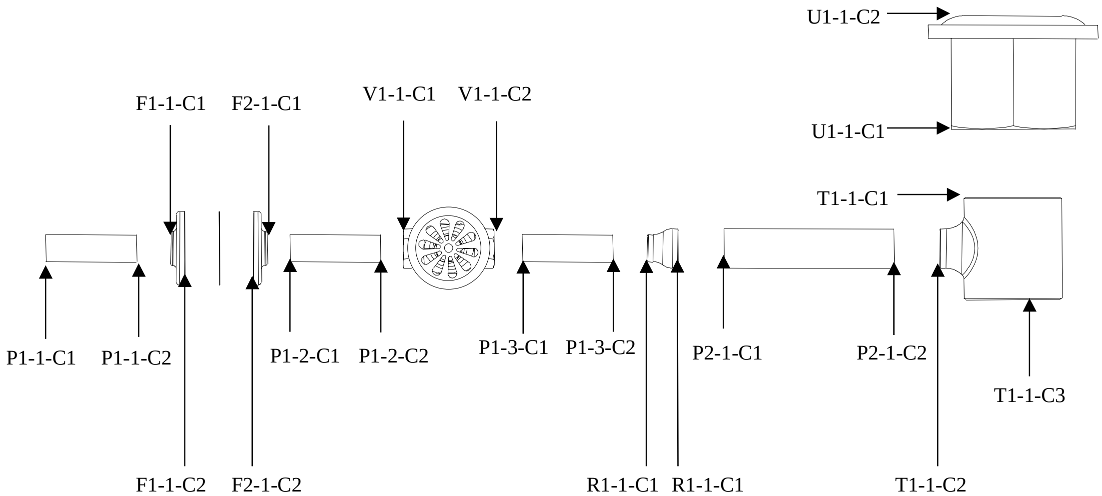

Figure A.15 — Connections for the Connections use case

In ISO 10303-227:2000, a Plant_item_connector is a feature of a Plant_item that represents its ability to be connected to other Plant_item objects. A piping connector object is characterized by an end type and an end engagement type. The end type refers to the shape of the connector, whereas the end engagement type refers to the method used to attach to a connector to another piping component. The subtypes of the End_type AO represent various end types such as “flange end,” “male end,” and “female end.” The subtypes of End_engagement_type AO represent various end engagement types such as “butt weld” and “socket.” At the occurrence level, a connector is captured by an instance of Plant_item_connector_occurrence. Plant_item_connector_occurrence is a subtype of Plant_item_connector.

The connection between pipe P1-1 and flange F1-1 is categorized as a flanged connection.

The connector P1-1-C2 is captured by a complex entity instance (#6) of Plant_item_connector_occurrence, Male_end and Buttweld. The connector F1-1-C1 is captured by a complex entity instance of Plant_item_connector_occurrence, Female_end, and Socket.

The Plant_item_connection_occurrence AO is used to capture the joining of two or more piping components at sites designated by instances of the Plant_item_connector_occurrence AO.

In this example, the connection between P1-1-C2 and F1-1-C1 is captured by an instance (#8) of Plant_item_connection_occurrence.

NOTE 1 An instance of Plant_item_connector_occurence is not required if no connection between two Plant_item objects exists. For example, in Figure A.21, P1-1 is not connected to anything on the left side; therefore, instance (#0) of Plant_item_connector_occurrence, Male_end, and Butt_weld representing P1-1-C1 could be omitted.

NOTE 2 All subtypes of the Fitting AO have attributes to represent connectors. For example, the Elbow AO has attributes end_1_connector and end_2_connector, and the Cross AO has attributes end_1_connector, end_2_connector, end_3_connector, and end_4_connector. This differs from the modeling style used in the rest of the ISO 10303-227:2000 ARM, where relationships (pointers) to other AOs are generally not modeled as attributes. In ISO 10303-227:2000, relationships are stated as information requirements only in Clause 4.3 (Application assertions). Some, but not all, relationships are also modeled by foreign keys in the ARM diagrams. In the case of subtypes of the Fitting AO, the end_*x*_connector attributes actually specialize the relationship between Planned_physical_plant_item and Plant_item_connector_occurrence, which is defined in Clause 4.3.75 as "Each Planned_physical_plant_item has zero, one, or many Plant_item_connector_occurrence objects. Each Plant_item_connector_occurrence is part of exactly one Planned_physical_plant_item." The ISO 10303-227:2000 development team introduced the end_*x*_connector attributes for the subtypes of the Fitting AO to avoid cluttering the ARM diagram with relationship lines; however, this has created a source of confusion to people reading ISO 10303-227:2000.

NOTE 3 Each relationship between an instance of a subtype of Fitting and an instance of Plant_item_connector_occurrence is shown as a dotted line in the instance diagrams to emphasize the fact that it is subsumed by the values of the end_*x*_connector attributes.

A.3.1.4.3 Representing the flanged connection with gasket

The connection between flanges F1-1 and F1-2 is slightly different from the connections described in Clause A.3.1.4.2 because of the introduction of a gasket G1-1 between the two flanges. G1-1 and its associated definition G1 are modeled like any other piping component, as described in Clause A.3.1.4.1 (see Figure A.10.) Because the gasket does not figure in the connectivity model, however, the instance (#60) of Gasket is not connected to either flange (#9 and #15) by an instance of Plant_item_connection_occurrence. The connection between Flanges F1-1 and F1-2 is captured by an instance (#13) of the Plan_item_connector_occurrence AO. The linkage between F1-1, G1-1, and F1-2 is captured by an instance (#63) of Plant_item_collection.

The collection of F1-1, G1-1, and F1-2, captured by instance #63 of Plant_item_collection, is built using instances (#62, #64, and #65) of the Hierarchically_organized_collection AO. The Hierarchically_organized_collection EDT associates an element with a collection (group). A separate instance of Hierarchically_organized_collection is used to capture the membership of each element in the collection.

NOTE 1 The object playing the role of element for Hierarchically_organized_collection can itself be a collection. This chaining can go in any arbitrary number of levels. In this example, no "hierarchy" exists; the three elements F1-1, G1-1, and F1-2 all belong directly to the same Plant_item_collection (#63).

NOTE 2 The bolts holding the two flanges together are not captured in this example.

NOTE 3 The relationship between F1-1, G1-1, and F1-2 could have been modeled as an assembly, but Hierarchically_organized_collection was chosen because the objects are loosely connected.

A.3.2 Component geometry

A.3.2.1 Purpose

This clause describes the use of ISO 10303-227:2000 to exchange information about the characteristics of piping components, their spatial arrangement, and how they are connected to form a piping system.

A.3.2.2 Background

It is often necessary to specify different types of shapes for items making up a piping system. Depending on the use for the shape, different levels of accuracy may be required. A highly accurate representation may be needed to create photorealistic renderings of the piping system, e.g., for a virtual plant walk-through. Less detailed representations may be used for interference checking or quick display on a CAD workstation. In ISO 10303-227:2000, a Plant_item_shape can be a Detail_shape, an Envelope_shape, or an Outline_shape. Detail_shape is the most accurate representation of an item's shape; Outline_shape is the least accurate. The actual shape of an item is captured by an instance of the Shape_representation_element EDT. ISO 10303-227:2000 allows shape to be specified using either a boundary representation or constructive solid geometry (CSG).

Location of a piping arrangement within a plant can be very important for determining interference of components. As referenced from ISO 10303-227:2000, Location_in_plant will give information on the location of a component in a plant layout. The Location_in_plant entity gives coordinates for the actual location of a specific item in the plant.

This use case takes the elements of the previous Connections use case and adds shape detail. Most of the components that are used are the same as the previous use case; however, shape information is added. Only one connection type is used, so that shape can be emphasized. Along with the shape detail, location of each component is specified. In this use case, the described piping system is to be located in a plant. Coordinates are given to show the location of the components. This location will be pertinent to determine interference in the following use case.

The scenario for this use case is as follows:

Prior to this use case, the designer has specified a functional design of a piping system, including a general description of the components to be used and their connections.

In this use case, the designer adds geometry and location information to the components.

In the next use case, this information will be used to check for interference between the piping system and other systems being designed.

A.3.2.3 Example

Figure A.16 shows a portion of a piping system that will serve as the basis for the example in this use case.

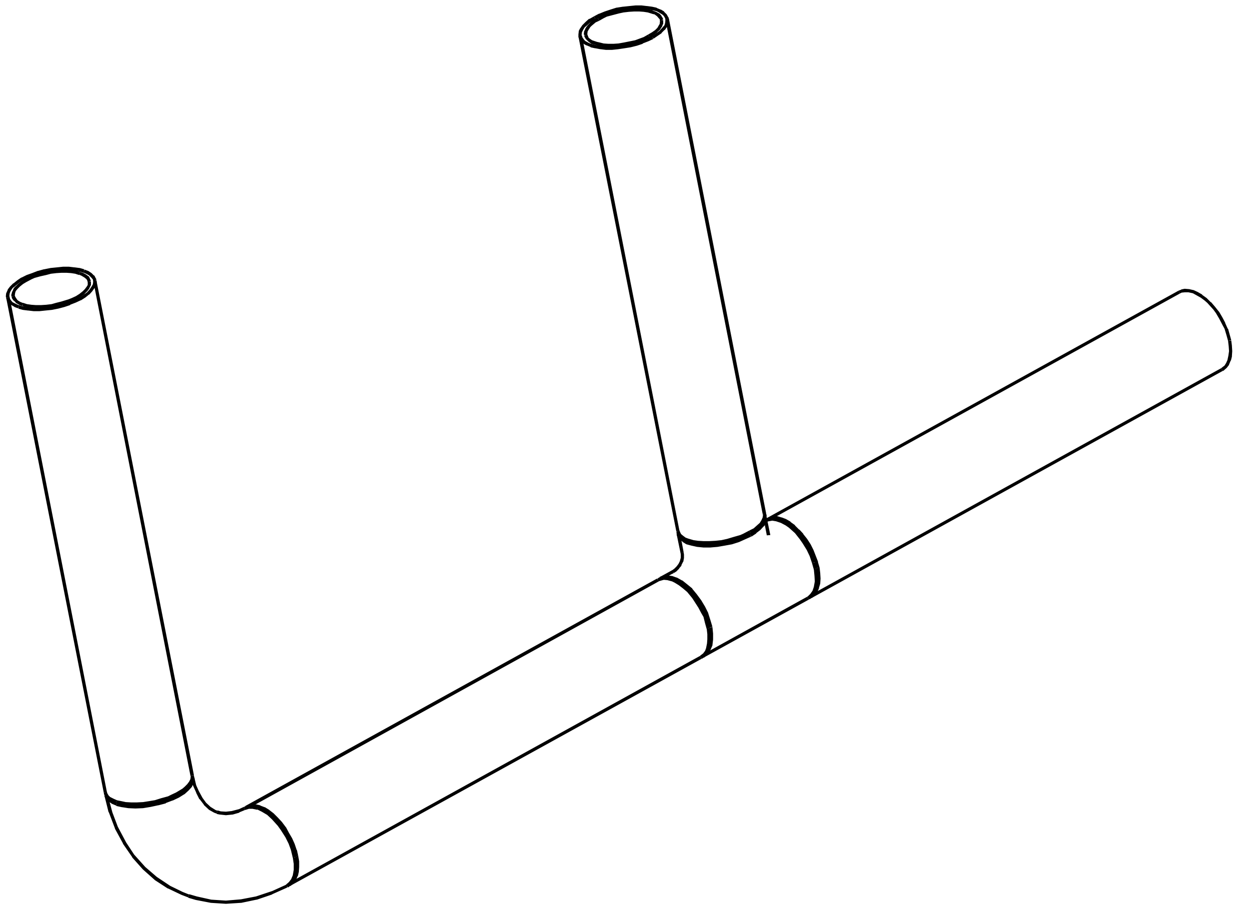

Figure A.16 — Portion of a piping system for the Component Geometry use case

The component types included in this example are Pipe, Elbow, and Tee. The connection type included in this example is Butt_weld. The component geometry included in this example is Cylinder and Solid_of_revolution.

Figure A.17 shows an exploded view of the components of the piping system with labels attached. Table A.3 gives labels and actual names of the components in the example. Table A.4 lists each component and the specifications of that component.

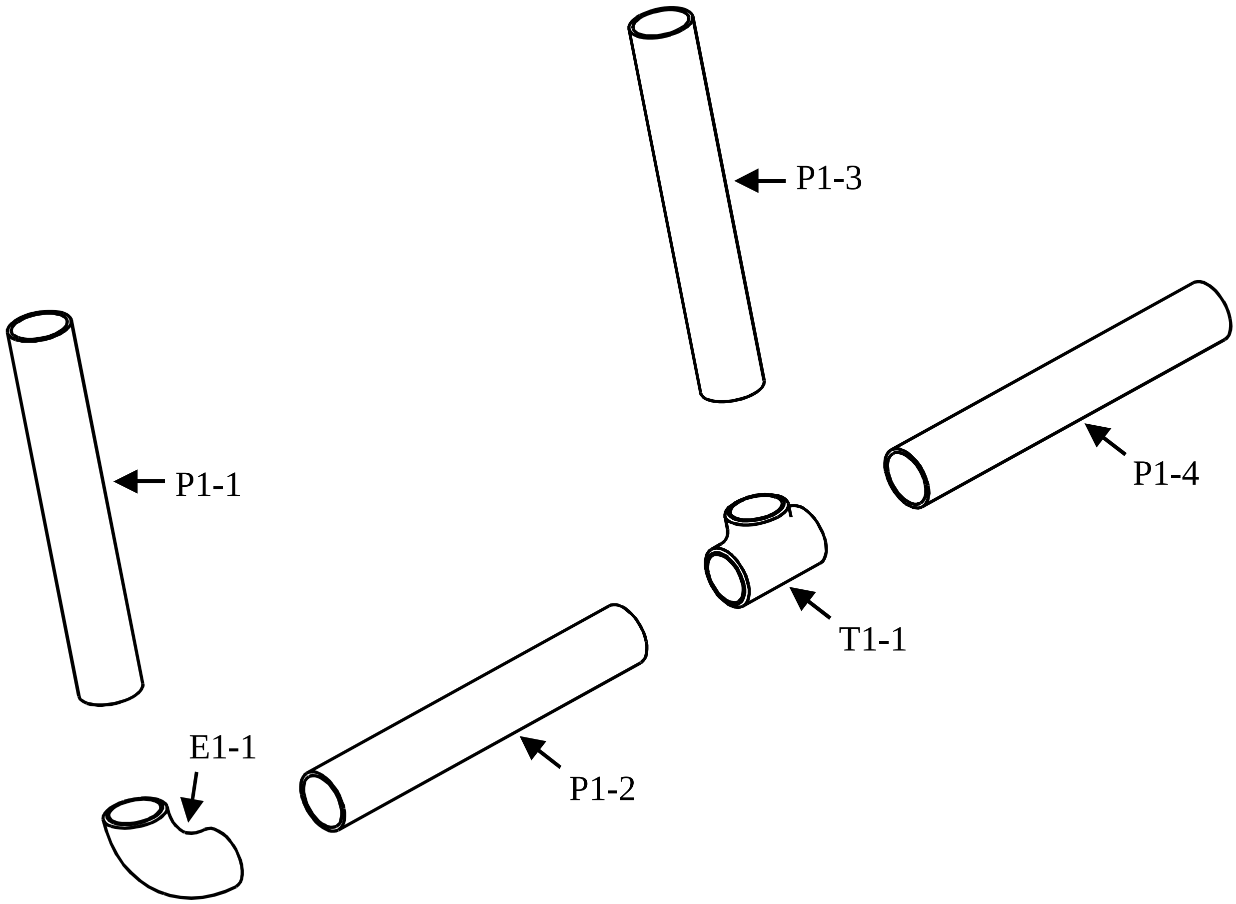

Figure A.17 — Exploded view with components labeled

Table A.3 — Components for the Component Geometry use case

Label	Type
P1-1	straight pipe
E1-1	elbow
P1-2	straight pipe
T1-1	tee
P1-3	straight pipe
P1-4	straight pipe

Table A.4 — Component definitions for the Component Geometry use case

Part	Type	Definition
P1	pipe	carbon steel, 2.5-inch diameter, 2-inch nominal size, 3-inch long, cylinder
E1	elbow	90-degrees carbon steel, solid of revolution
T1	tee	carbon steel

A.3.2.4 Instance diagram

Figures A.18-A.30 contain the instance diagrams for this use case.

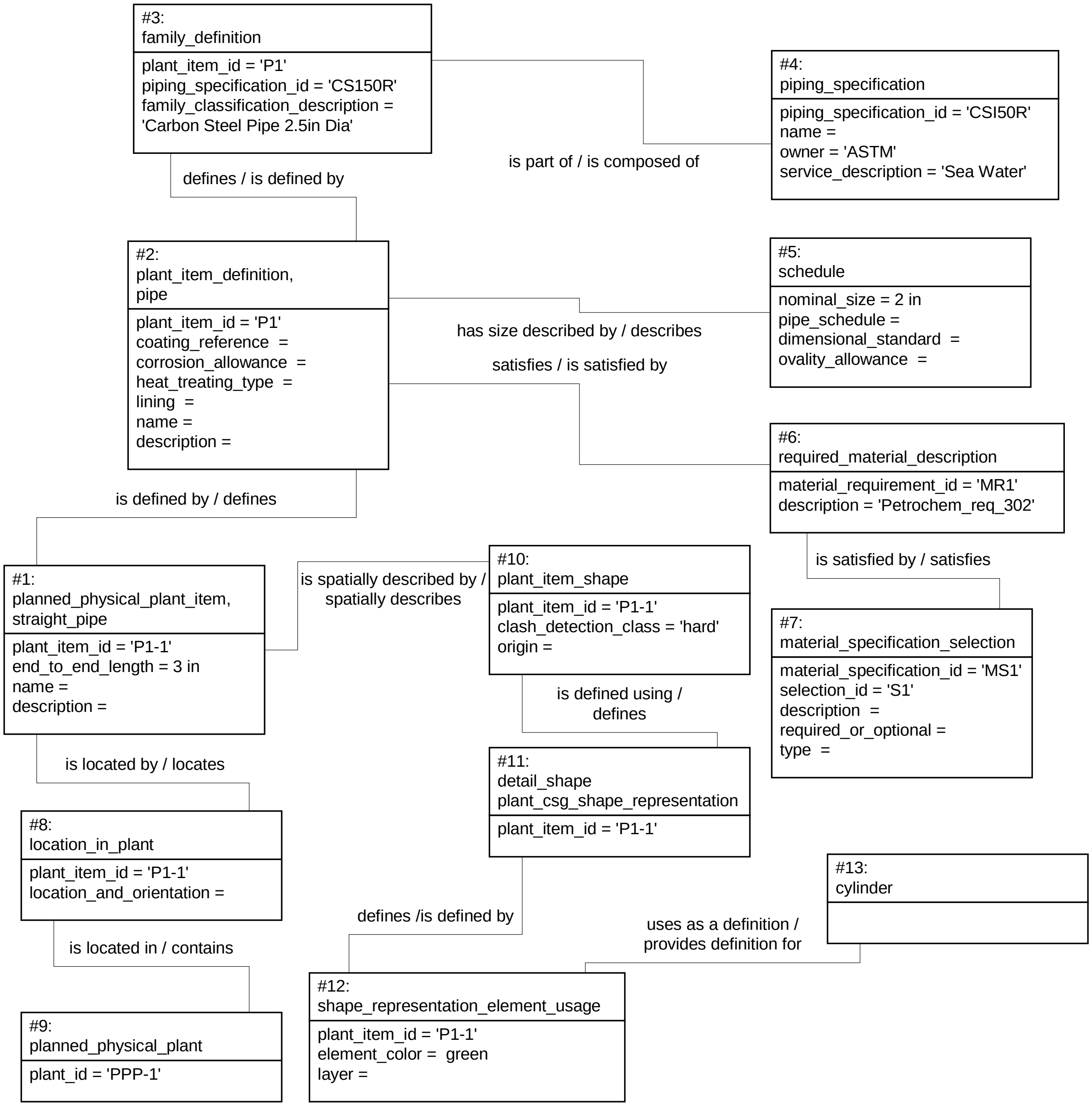

Figure A.18 — Instance diagram for the Component Geometry use case (1 of 13)

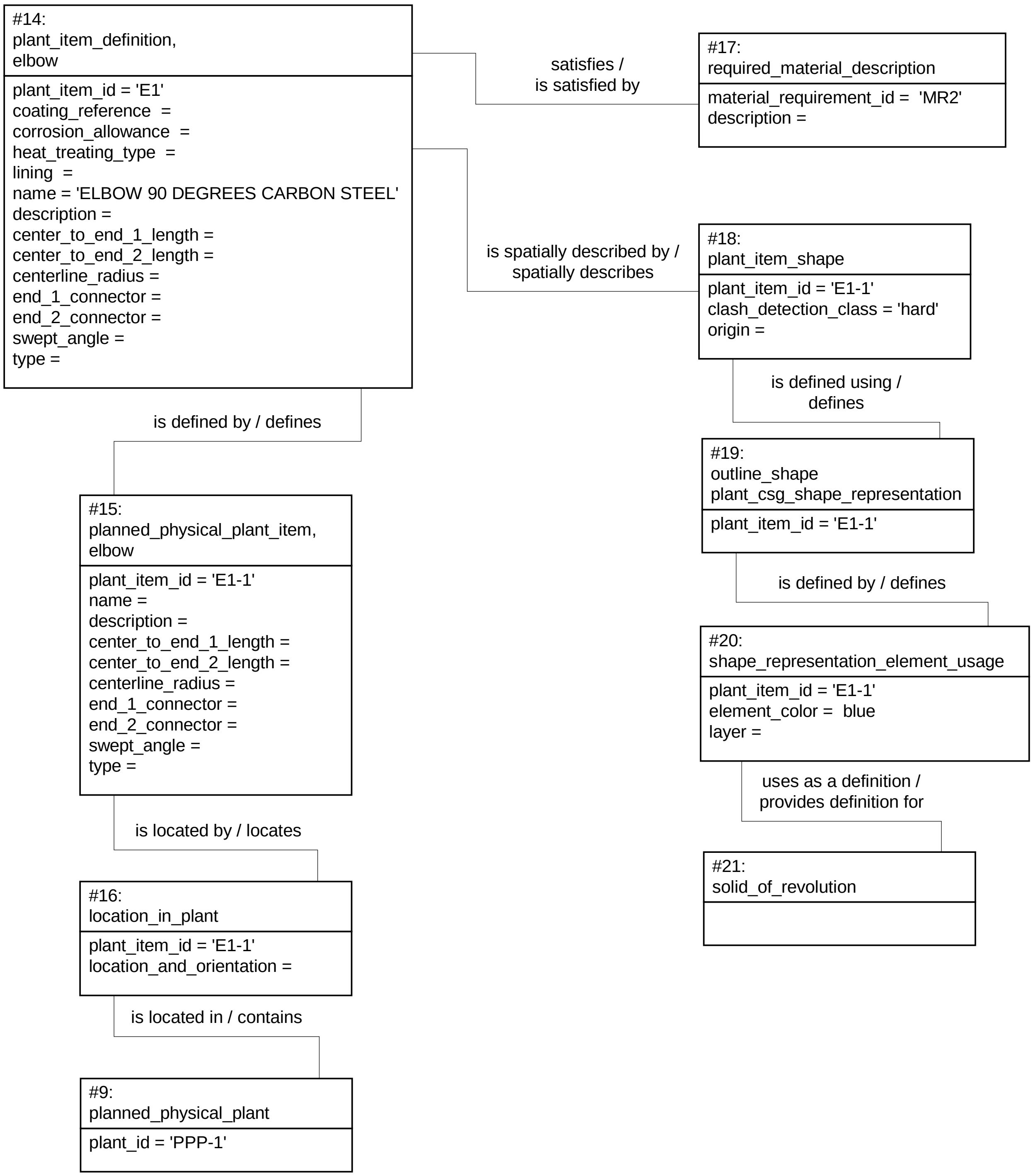

Figure A.19 — Instance diagram for the Component Geometry use case (2 of 13)

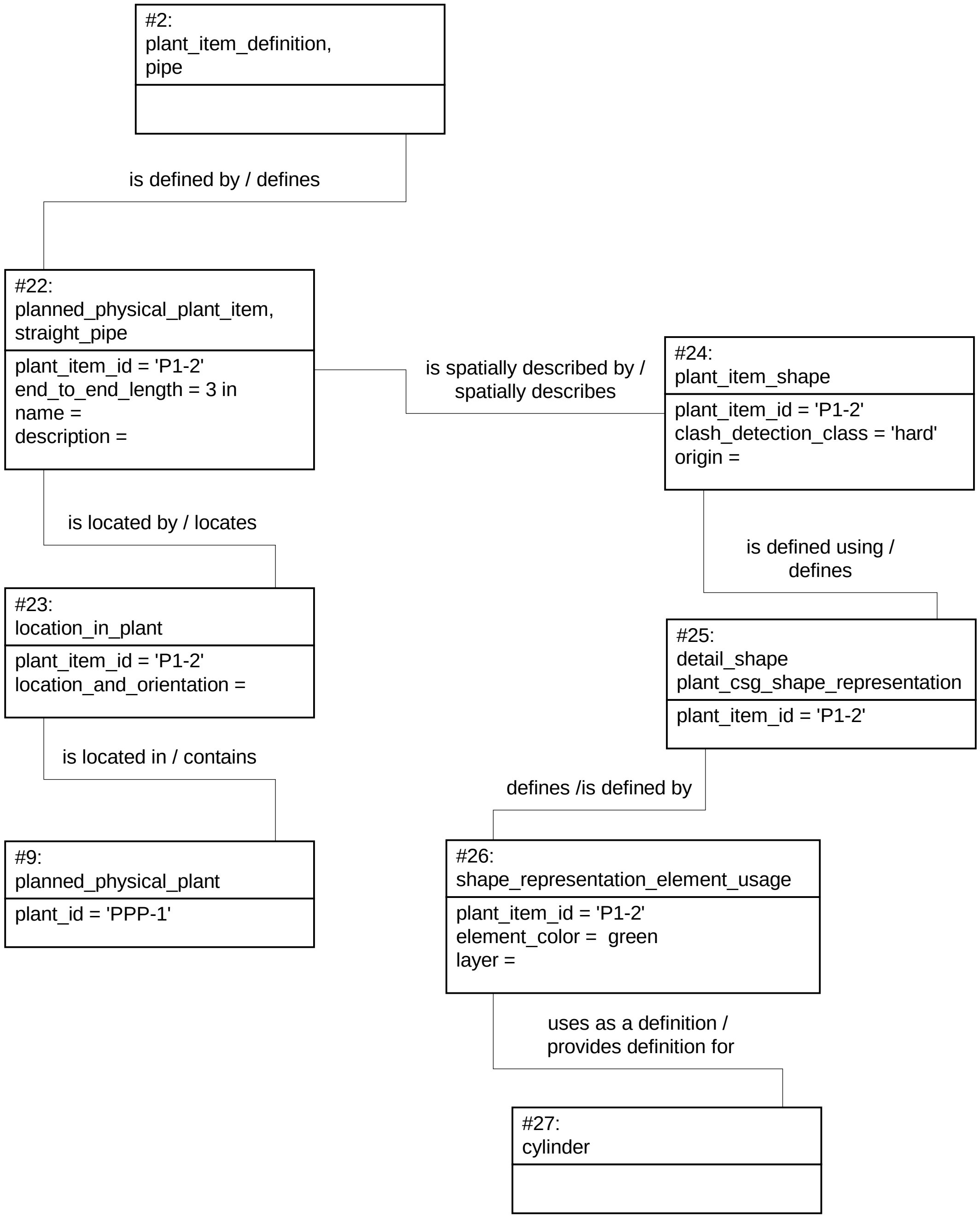

Figure A.20 — Instance diagram for the Component Geometry use case (3 of 13)

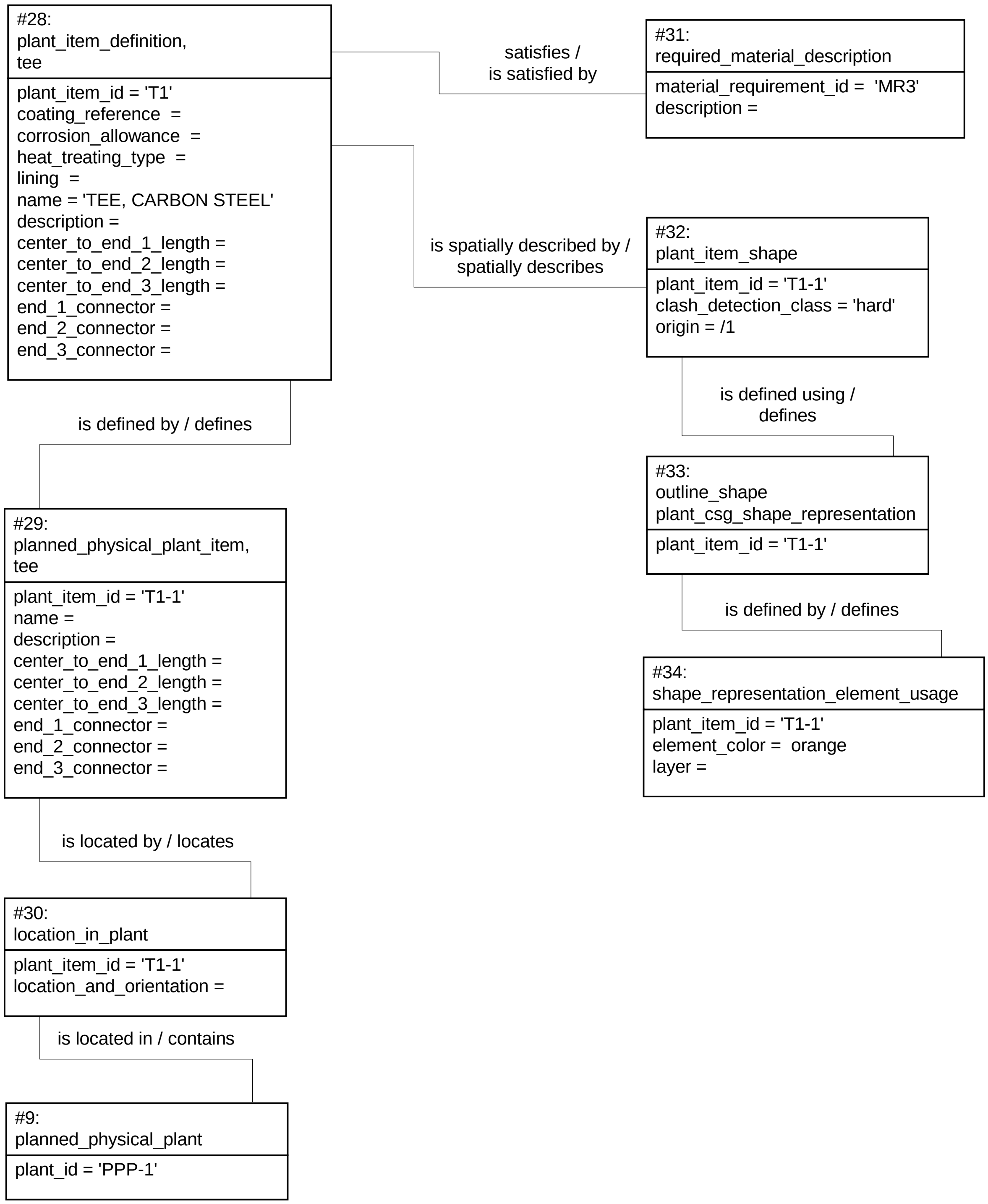

Figure A.21 — Instance diagram for the Component Geometry use case (4 of 13)

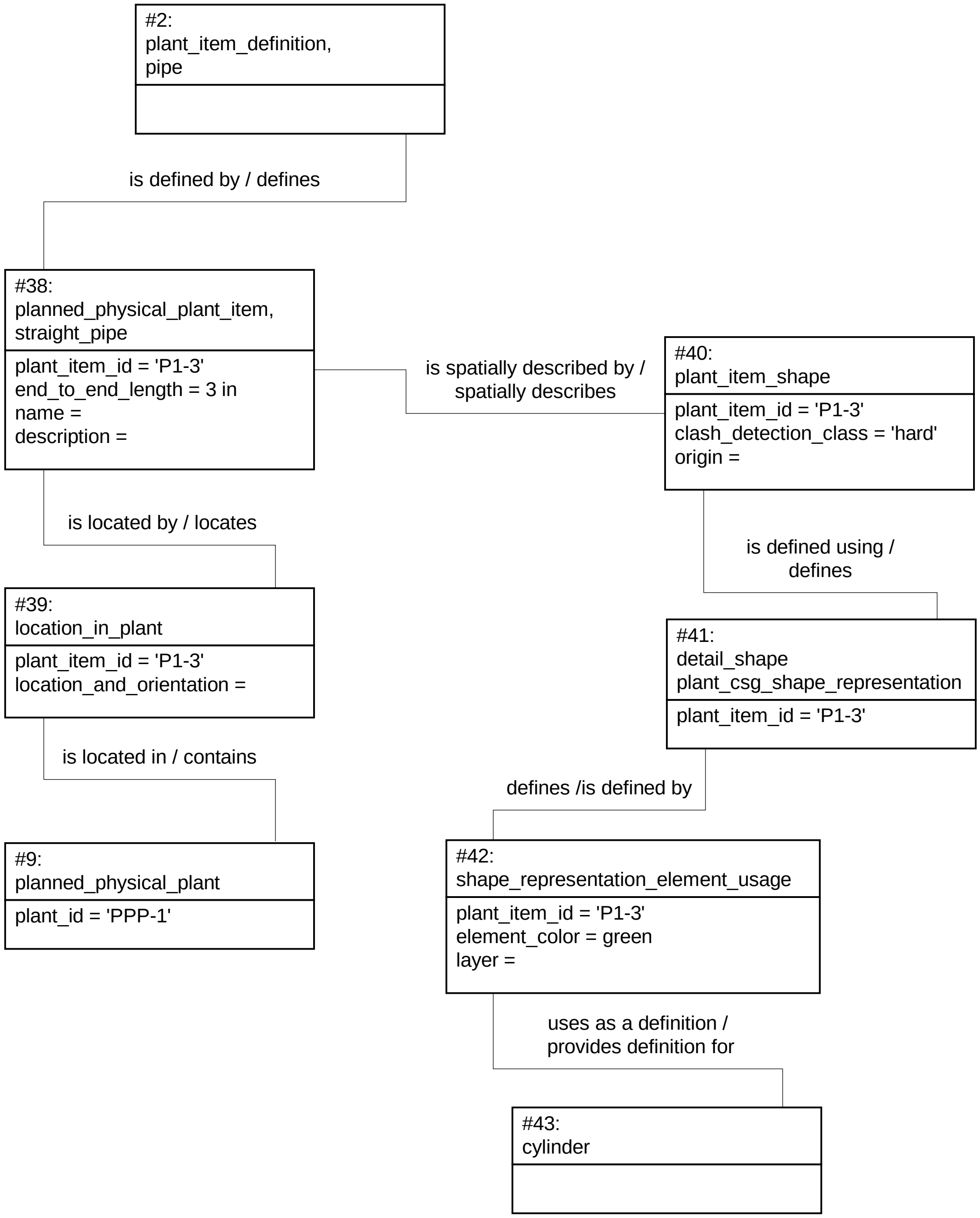

Figure A.22 — Instance diagram for the Component Geometry use case (5 of 13)

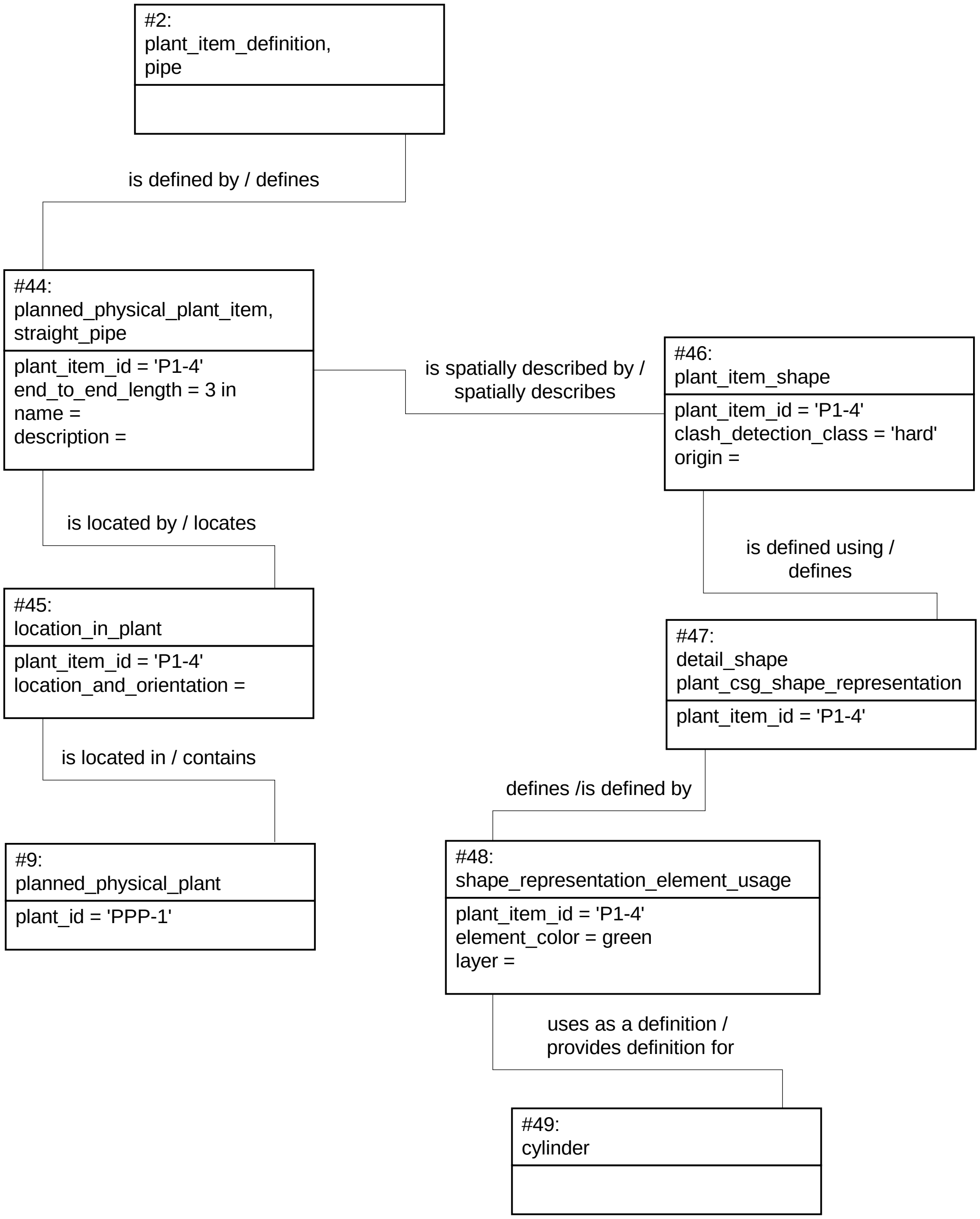

Figure A.23 — Instance diagram for the Component Geometry use case (6 of 13)

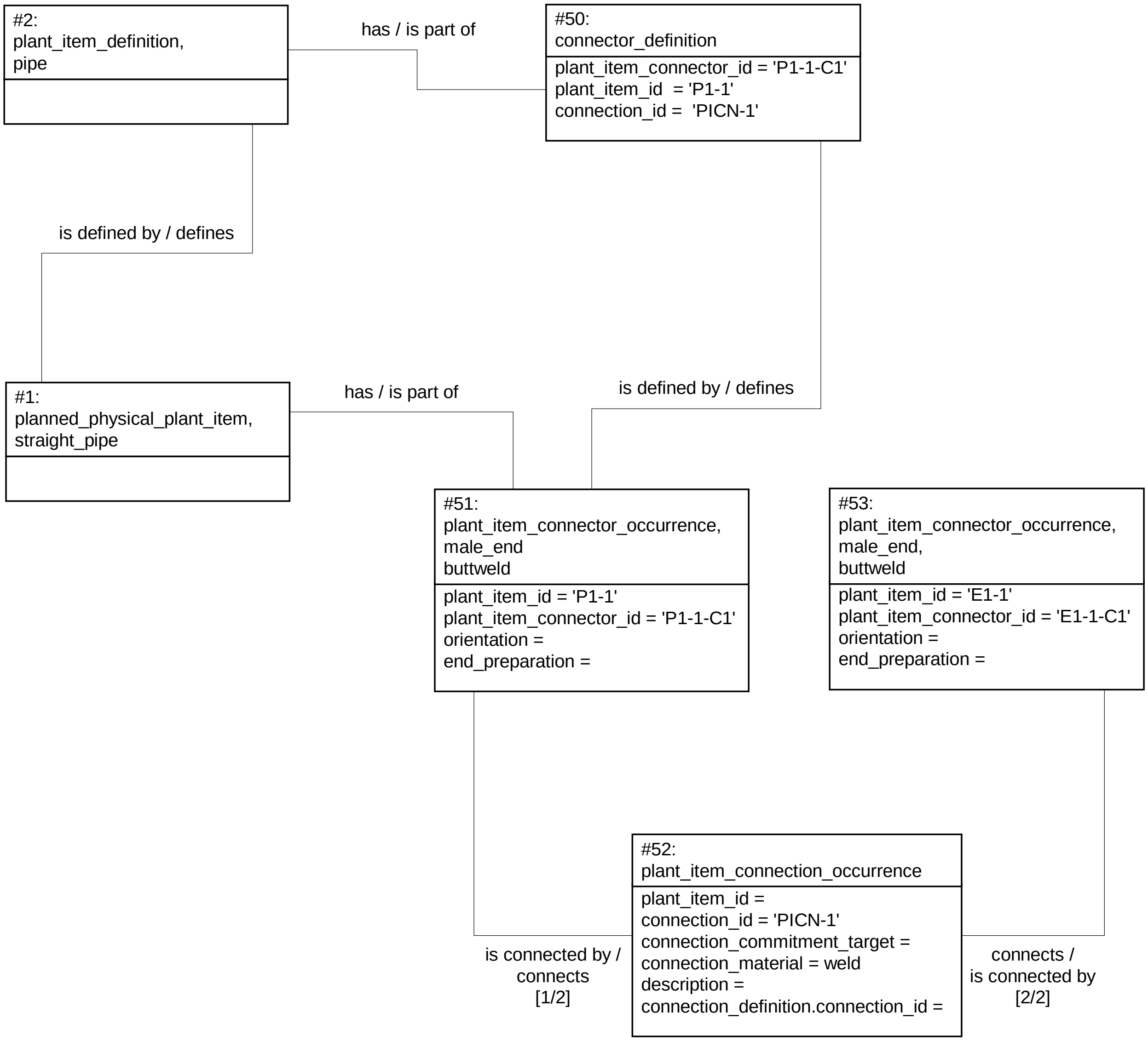

Figure A.24 — Instance diagram for the Component Geometry use case (7 of 13)

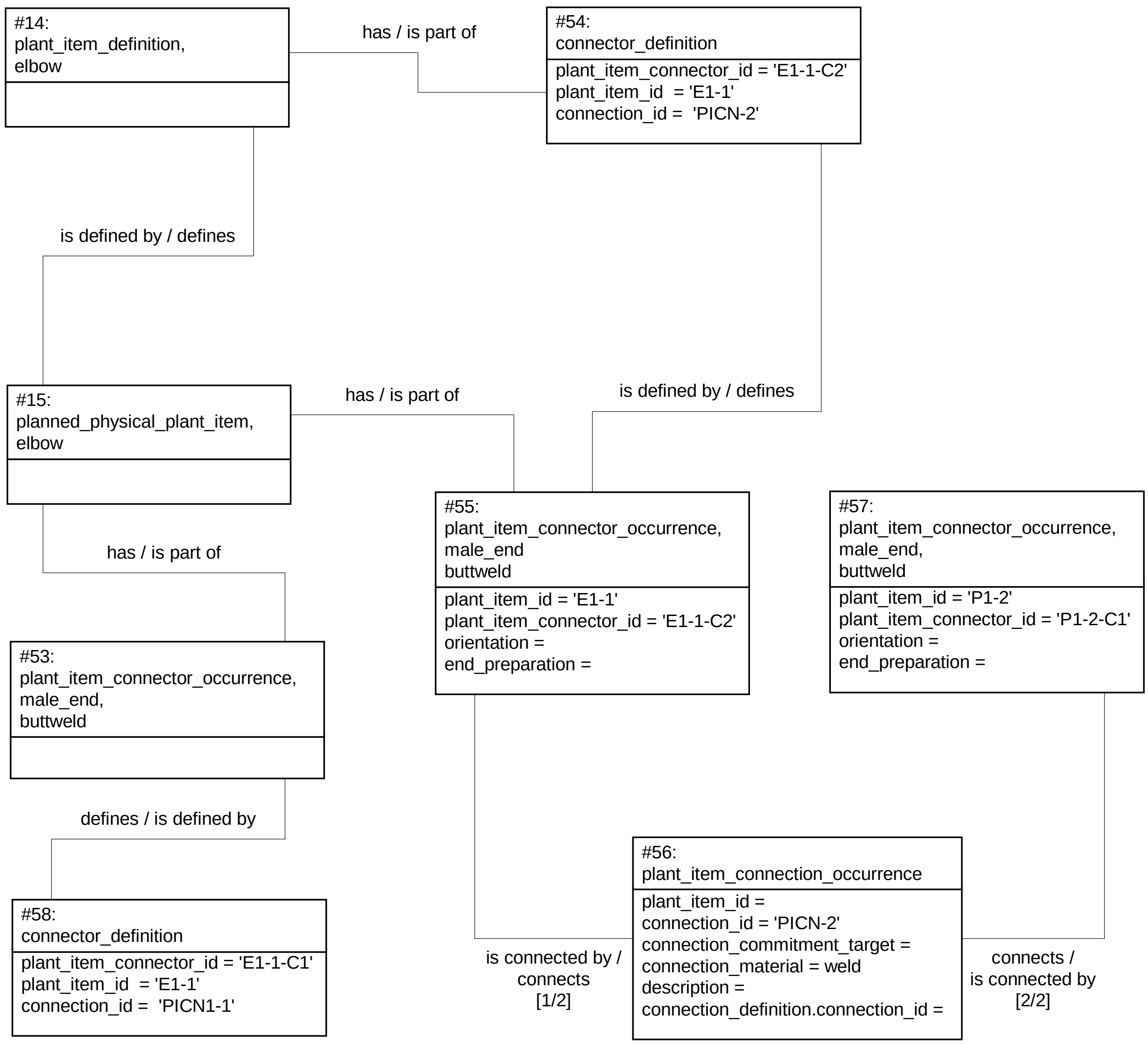

Figure A.25 — Instance diagram for the Component Geometry use case (8 of 13)

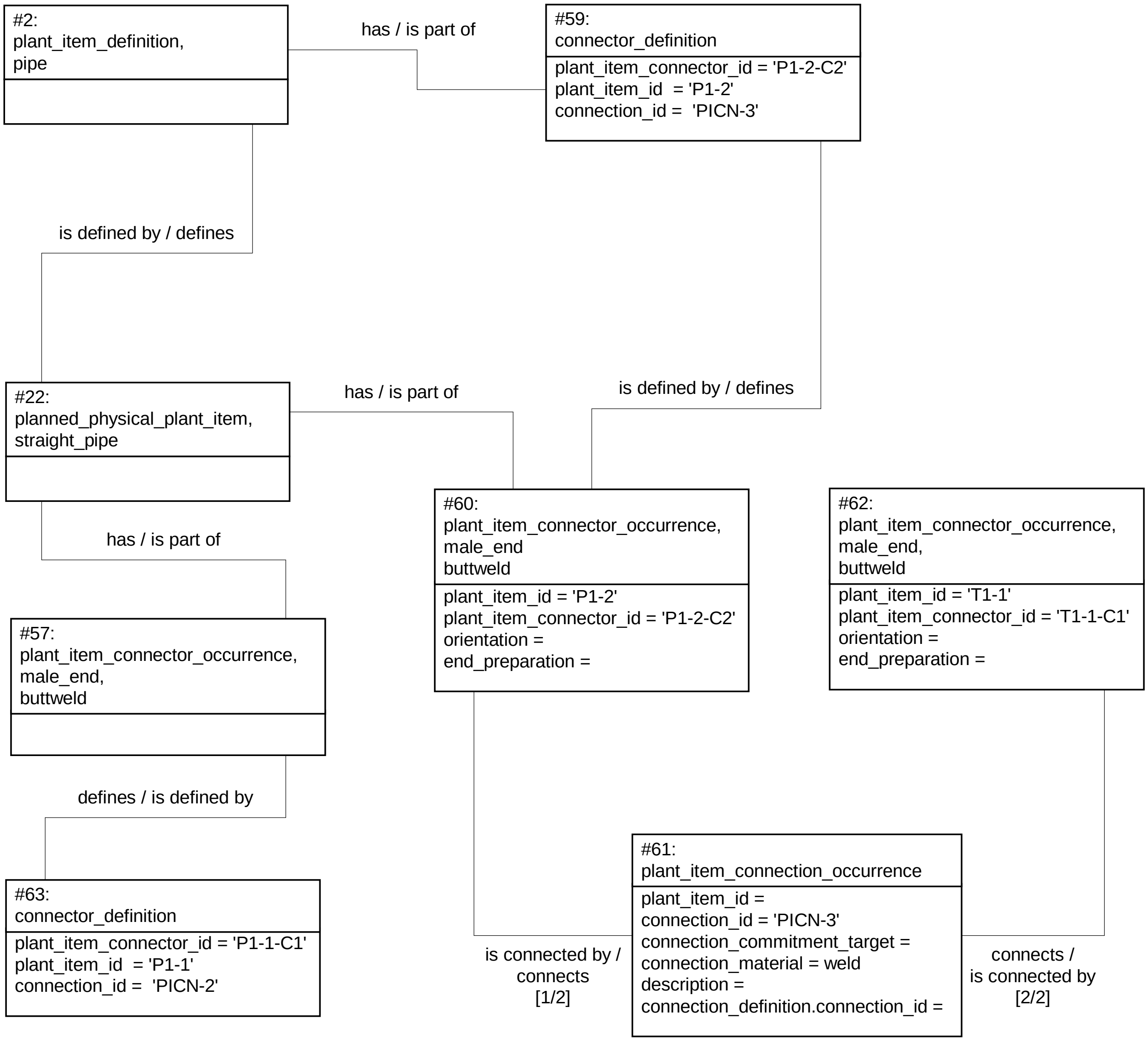

Figure A.26 — Instance diagram for the Component Geometry use case (9 of 13)

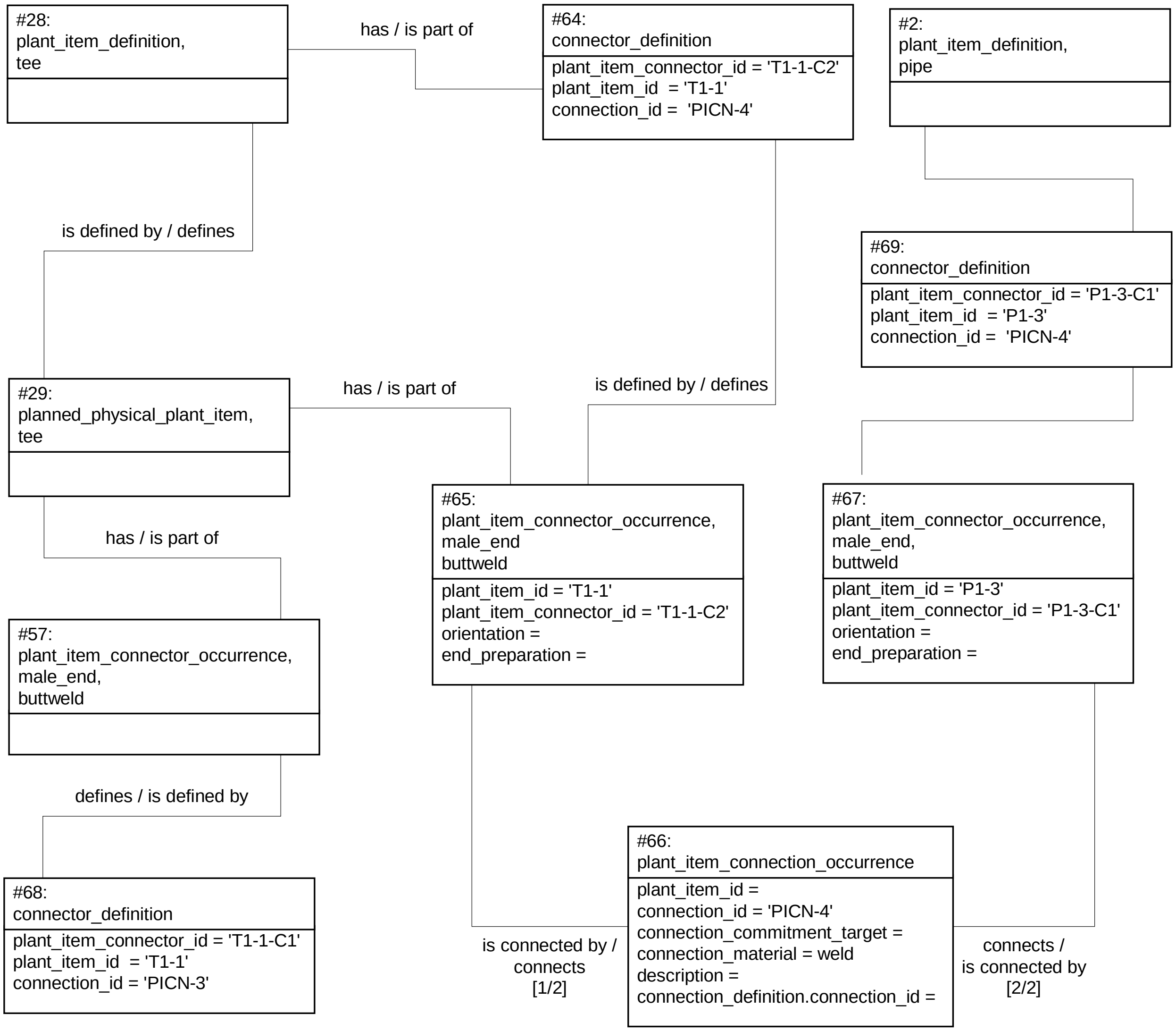

Figure A.27 — Instance diagram for the Component Geometry use case (10 of 13)

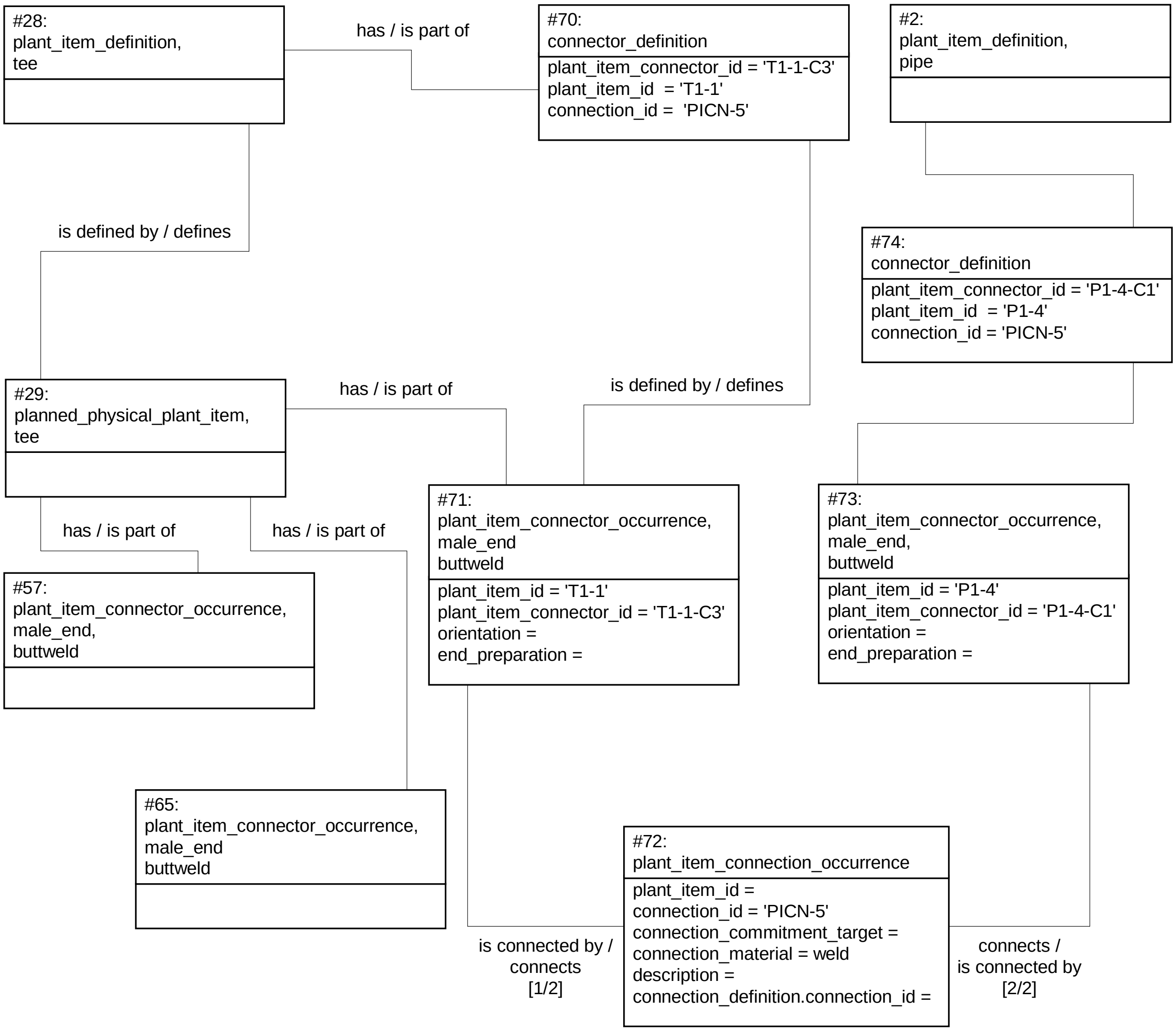

Figure A.28 — Instance diagram for the Component Geometry use case (11 of 13)

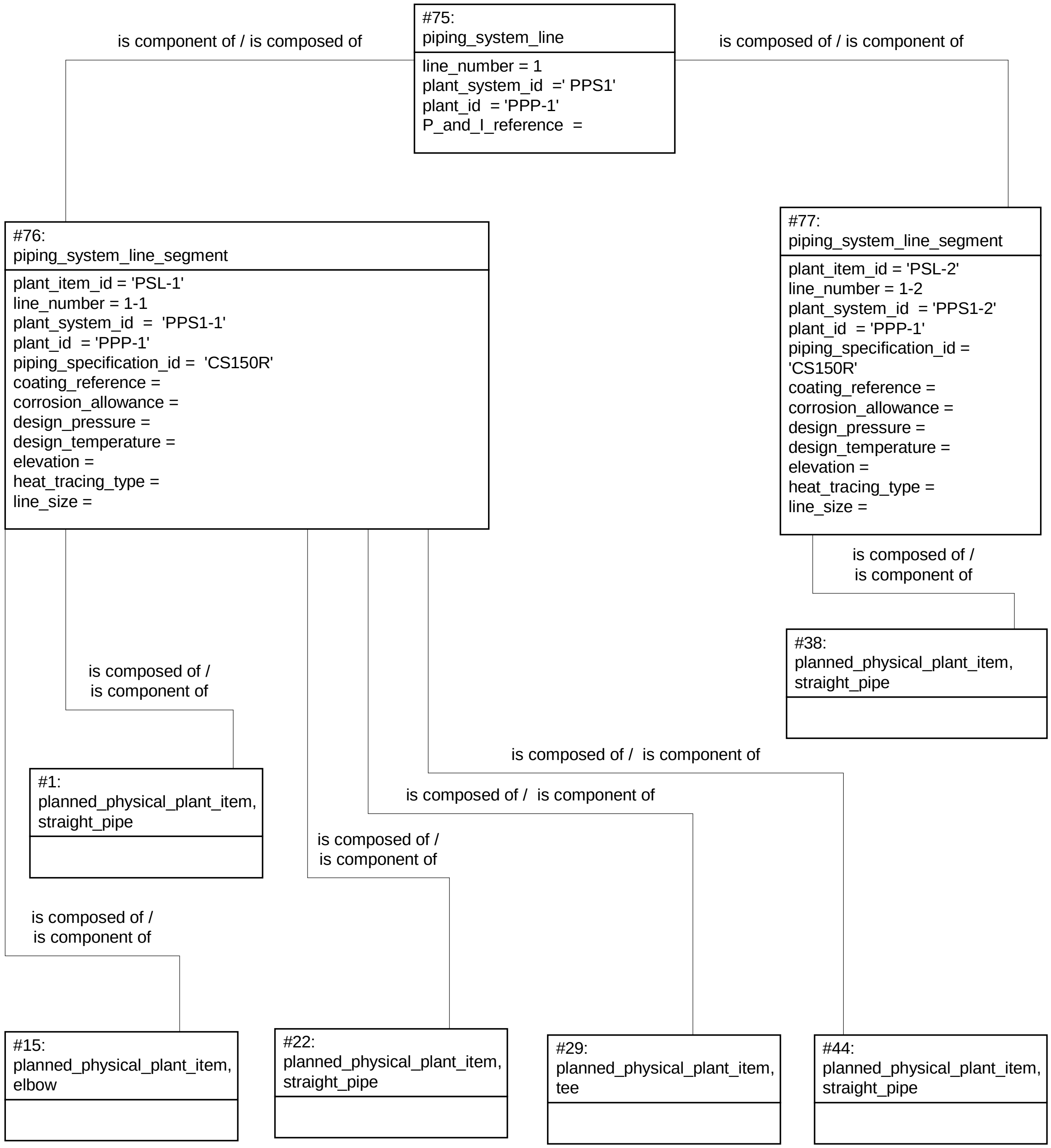

Figure A.29 — Instance diagram for the Component Geometry use case (12 of 13)

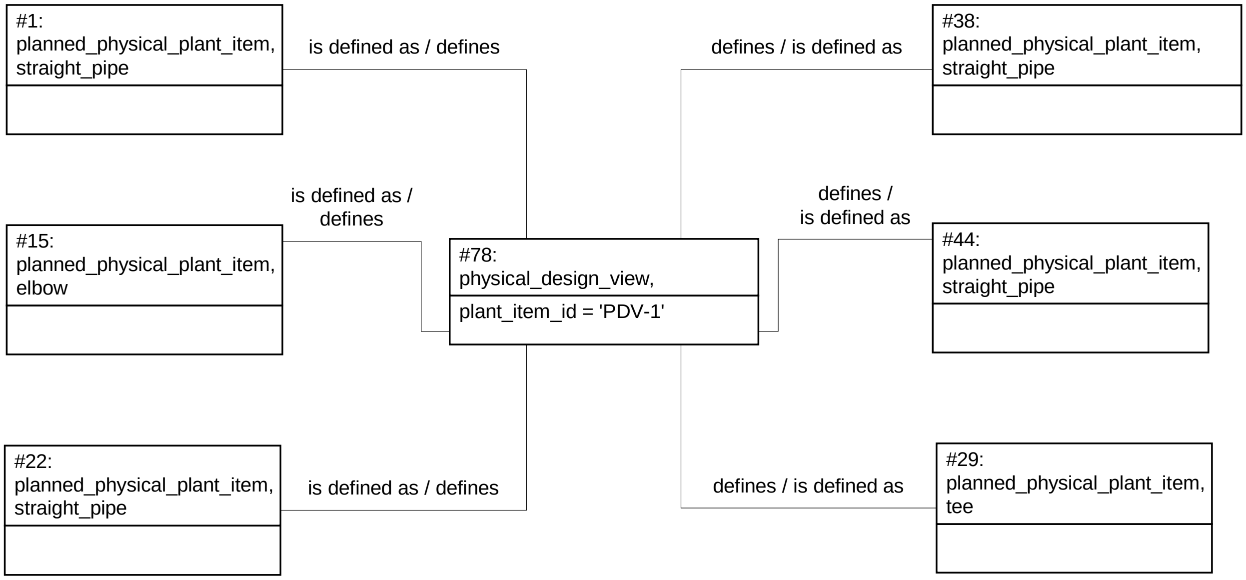

Figure A.30 — Instance diagram for the Component Geometry use case (13 of 13)

A.3.2.4.1 Representing a component

The complex entity instance (#2) of the Plant_item_definition and Pipe AOs that captures P1 has additional occurrences associated with it. The family of pipes to which P1 belongs is captured by an instance (#3) of the Family_definition AO. The standard or other specification to which the family is built is captured by an instance (#4) of the Piping_specification AO. A definition for a family of pipes (instance #3) was associated to instance #4. The Schedule AO can be used instead of the Family_definition AO to characterize a group of pipes. The Schedule and Required_material_description are specified by instances (#5) and (#6) of Schedule and Required_material_description AOs. The Material_specification_selection is captured by an instance (#7) of the Material_specification_selection AO. The Material_specification_selection is the candidate material specifications for piping system design.

EXAMPLE The Material_specification_selection for this use case piping component would have a type of “Carbon Steel,” a Material_specification_id of “ASTM A403,” a Selection_id of “CS150R,” a Description of “standard material callout,” and be required.

The Material_specification_selection (#7) satisfies the Required_material_description (#6), which is a specification of the substances or the requirements of the substances of which a component is to be made. The required material is chosen from the candidate materials given by the Material_specification_selection. This Required_material_description satisifies the specifications for the Pipe.

This use case takes a step up from the Connections use case, by adding component geometry to the piping arrangement. There is a shape associated with pipe P1-1 that is described by an instance (#10) of Plant_item_shape. The standard or other specification to which the shape is built is captured by instances (#11), (#12), and (#13) of Detail_shape, Shape_representation_element_usage, and Cylinder. Elbow E1-1 is captured similarly to pipe P1-1, except that the elbow definition E1 has its shape described by an instance (#18) of Plant_item_shape, which is further specified by complex instances #19, #20, and #21 of

Outline_shape, Shape_representation_element_usage, and Solid_of_revolution. The shape of P1-1 is a Cylinder. The Cylinder is a Csg_element that is a 3D cylindrical solid whose end surfaces are parallel and perpendicular to an axis. The Shape_representation_element_usage is the mechanism that describes the elements that make up the shape of the specified Plant_item. Occurrence #11 is a Detail_shape. The Detail_shape specifies the external shape of the plant item, but does not give any information on the internal shape of the Plant_item.

NOTE Contrast Detail_shape with Outline_shape and Envelope_shape. A Detail_shape more closely approximates the actual shape of the Plant_item than either Outline_shape or Envelope_shape, and is therefore more complex than either one.

A Detail_shape is a Shape representation that describes the specific surface boundaries of a Plant_item. There is a slight difference between a Shape_representation and a Plant_item shape. A Plant_item_shape is the volumetric representation of the Plant_item. Plant_item_shape also has a Clash_detection_class associated with it. This attribute will be discussed further in the Interference Checking use case. Plant_item E1-1 also has a shape associated with it. The definitions for this component are similar to those of P1-1, except that this component is a Solid_of_revolution. A Solid_of_revolution is a type of Csg_element that is formed by sweeping a 2D shape about an axis. The component E1-1 is also an Outline_shape instead of a Detail_shape. An Outline_shape is a 3D spatial volume that corresponds to the bounding surface features of a Plant_item.

NOTE An Outline_shape is a simple geometric representation of Plant_item. An Outline_shape is more detailed than an Envelope_shape, but is not as complex as a Detail_shape.

The rest of the definitions for component E1-1 (Elbow) are the same as P1-1. Component P1-2 has the same associations as component P1-1. Component T1-1 (Tee) is an Outline_shape, similar to E1-1, but does not give detail on the specific shape of the Tee.

All occurrences in this use case have a position relative to a plant. The location of the object in the plant is captured by an instance (#8) of the Location_in_plant AO. This is the same for all the occurrences. The Location_in_plant states the position of the Plant_item in a plant. The coordinates for each Plant_item will be given to set the position of that specific Plant_item in the plant. The location of a Plant_item in a plant is determined by the Planned_physical_plant occurrence. The Planned_physical_plant gives a set of characteristics that a plant can have. This information is used to determine the best placement of a piping arrangement.

A.3.2.4.2 Representing connections

Refer to the Connections used case (#1), for details on the general information for connections.

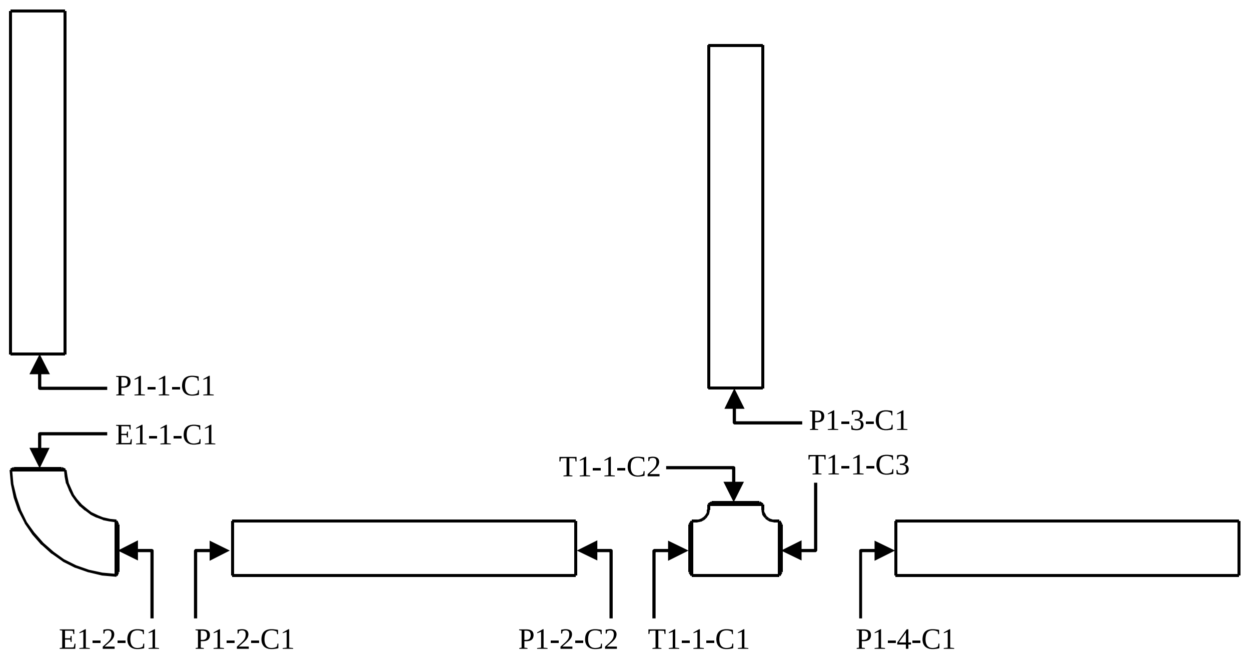

Figure A.31 — Connections for the Component Geometry use case

The connector P1-1-C1 is captured by a complex entity instance (#51) of Plant_item_connector_occurrence, Male_end, and Buttweld. The connector E1-1-C1 is captured by a complex entity instance (#53) of Plant_item_connector_occurrence, Male_end, and Buttweld.

The Plant_item_connection_occurrence AO is used to capture the joining of two or more piping components at sites designated by instances of the Plant_item_connector_occurrence AO.

In this use case, the connection between P1-1-C1 and E1-1-C1 is captured by an instance (#52) of Plant_item_connection_occurrence.

NOTE Refer to notes given for the Connections use case (#1).

The connections between the rest of the components for this use case are the same as the connection between P1-1 and E1-1, using Male_end and Butt_welds.

A.3.2.4.3 Location characteristics of components

A Piping_system_line is a component of a piping system, and is composed of a collection of interconnected Piping_system_line_segment objects. In this use case, the Piping_system_line_segment objects are the components P1-1, E1-1, P1-2, T1-1, P1-3, and P1-4. Because this piping arrangement is in a branch, there are two occurrences of Piping_system_line_segments. One is composed of P1-5 and the other contains the rest of the components.

The components in this use case have an association to an instance (#75) of the Piping_system_line. All the components are associated to an instance (#76 and #77) of the Piping_system_line_segment AO.

The components in this use case are all part of an instance (#78) of the Physical_design_view (PDV-1). The Physical_design_view is a type of Plant_item_design_view that describes the physical and spatial characteristics of a Plant_item. A Plant_item_design_view is a collection of information about a Plant_item that is associated to the Physical_design_view phase. The Physical_design_view gives information on specific details of the physical characteristics of a plant_item. This information includes lengths, widths, coatings, material type, component type, etc.

A.3.3 Interference checking

A.3.3.1 Purpose

This clause describes the use of ISO 10303-227:2000 to exchange information about the interference of two plant items in one spatial area of the plant.

A.3.3.2 Background

Interference occurs when volumes associated with two or more items intersect. These volumes could be approximations of the actual shape of the items, in which case the interference would be interpreted as two items trying to occupy the same space. In addition, the volume associated with an item may be expanded to represent space reserved around the item for some purpose, e.g., to allow for maintenance. When it is determined that there is an interference between one or more components, steps must be taken to first determine how critical the interference is, and then how to resolve the interference if necessary. The resolution for an interference may range from a change in shape of one of the components, to a change in piping arrangement, to a change in location of the components, or be simply to leave it as it is. The resolution depends on the type of clash the components have, and whether it is critical or not. This is discussed in more detail in clause A.3.3.4.1.

The scenario for this use case is as follows:

In the previous use case, a set of components with connection, geometry, and location information was given.

In this use case, an interference check is performed to see whether elements of the piping system clash with other elements of the plant or ship design. It is discovered that the heating, ventilation, and air conditioning (HVAC) system contains a plenum that interferes with a straight pipe. This interference is highlighted in red and described as critical.

In the next use case, the straight pipe will be changed to a swept-bend pipe to resolve the interference of the plenum and the pipe.

A.3.3.3 Example

Figure A.32 shows a portion of a piping system, in which straight pipe P1-3 interferes with plenum PLE1-1.

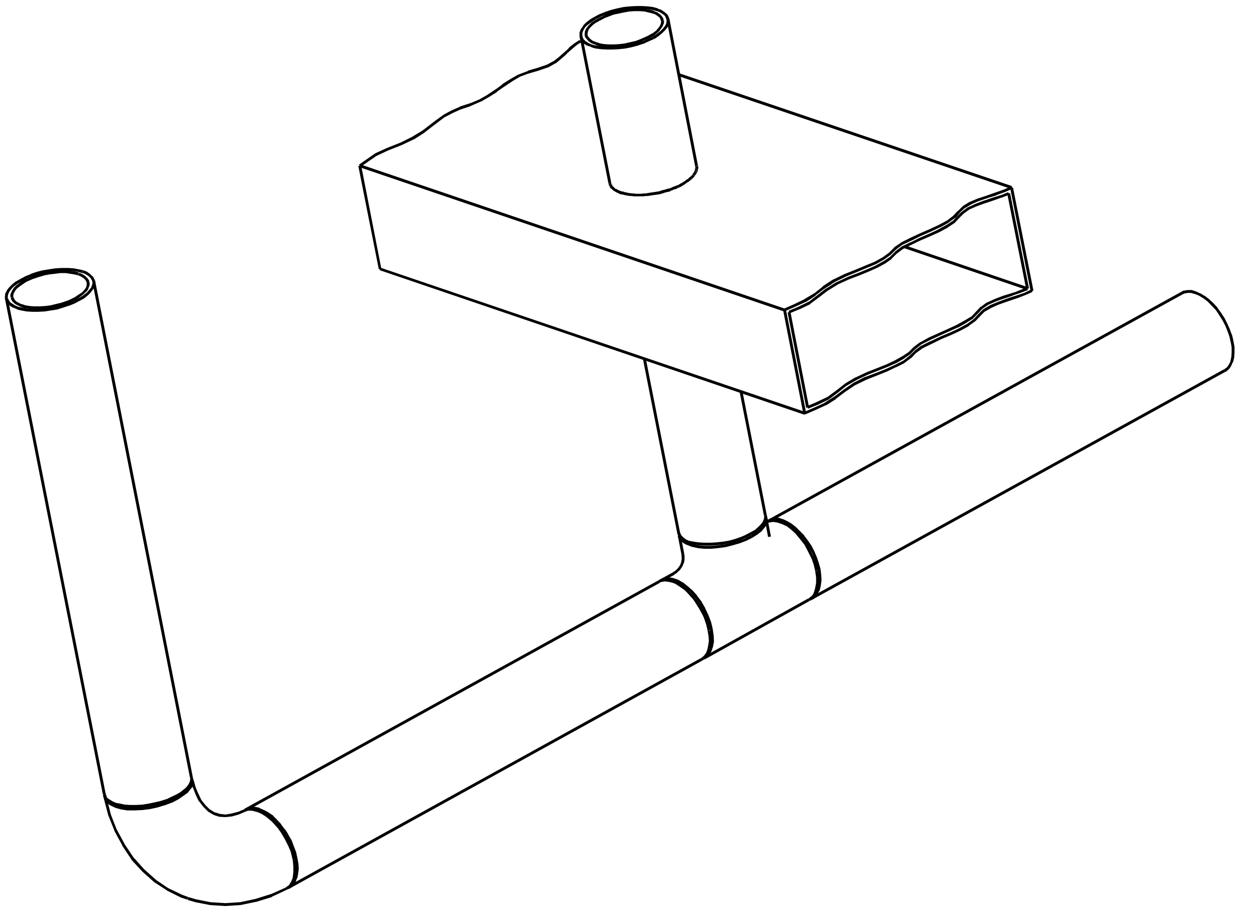

Figure A.32 — Portion of a piping system, with straight pipe interfering with plenum

Table A.5 gives labels and actual names of the components in the example. Table A.6 gives definitions of the components.

Table A.5 — Components for the Interference Checking use case

Label	Type
P1-3	straight pipe
PLE1-1	structural component

Table A.6 — Component definitions for the Interference Checking use case

Part	Type	Definition
P1	pipe	3-inch long, cylinder
PLE1	Structural component	extrusion

A.3.3.4 Instance diagram

Figure A.33 contains the instance diagram for this use case.

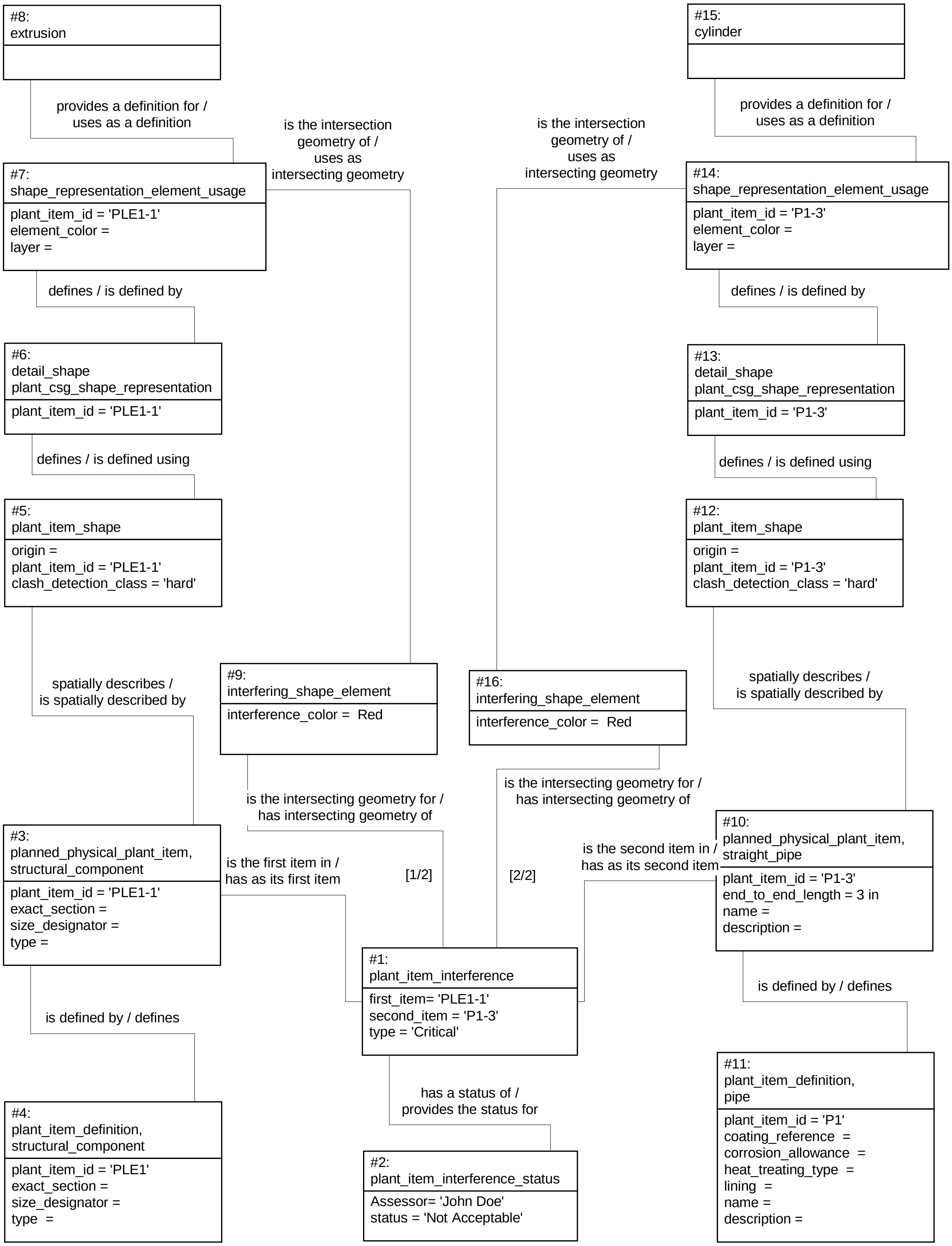

Figure A.33 — Instance diagram for the Interference Checking use case

A.3.3.4.1 Representing a component

This use case is built on the Component Geometry use case. The piping arrangement for the Component Geometry use case is used, with interference added in. The use case shows the occurrence of an interference between component P1-3 and component PLE1-1 (Structural_component, Plenum). A Plant_item_interference occurs when a volume associated with one Plant_item overlaps a volume associated with one or more other Plant_item objects. In this use case, the Plant_item_interference is stated to be a critical interference by assessor John Doe. The Plant_item_interference_status specifies the state of the resolution of the Plant_item_interference. There is a Clash_detection_class associated with Plant_item_shape. This Clash_detection_class designates a value to a Plant_item for the purpose of interference checking. The Plant_item_interference tells us that there is an interference between two or more objects, however it does not tell us what kind of interference it is. The Clash_detection_class states exactly what kind of interference is taking place, and whether it is critical enough to be resolved. There are three Clash_detection_class values: hard, ignore, and soft. These values are assigned to Plant_items, and are compared to determine which items clash. A hard clash specifies that two Plant_items critically clash. A soft clash specifies that at least one Plant_item is a soft clash, specifying a non-critical clash. An ignore clash refers to no clash between any Plant_item objects, and can therefore be ignored. Table A.7, taken from ISO 10303-227:2000, shows how clash detection classes are combined to determine the nature of a clash.

Table A.7 — Comparison of Clash_detection_class

	Hard	**Ignore**	**Soft**
Hard	hard clash	no clash	soft clash
Ignore	no clash	no clash	no clash
Soft	soft clash	no clash	soft clash

In the given scenario, a hard clash occurs between the pipe P1-3 and the plenum PLE1-1. This clash_detection_class was determined by taking the clash of the first component, and taking the clash of the second component and determining where they cross on the above table. This shows that both components had hard clashes, therefore there was a hard clash_detection_class overall. If one component had a soft clash and the other had a hard clash, there would only be a soft clash_detection_class overall, which would not be as critical. The two components in this use case (P1-3 and PLE1-1) both have hard clashes, which causes a critical clash_detection_class. The resolution of this clash will be further described in the Pipe Change use case.

In this use case, all the occurrences have definitions associated with them. A complex entity instance (#3) of the Planned_physical_plant_item and Structural_component AOs captures PLE1-1. A complex entity instance (#10) of the Planned_physical_plant_item and Straight_pipe AO captures P1-3. An instance (#1) of the Plant_item_interference AO represents the interference between PLE1-1 and P1-3. An instance (#2) of the Plant_item_interference_status AO indicates the fact that John Doe has assessed the interference, and that it is not acceptable. In this case, the shape of the interference zone has not been calculated. An instance (#9) of the Interfering_shape_element AO provides the link to the portion of the plenum geometry that is interfering with the pipe geometry. In this case, the geometry of the plenum is represented by a single instance (#8) of the extrusion AO, so the Interfering_shape_element points to the entire geometry of the plenum. However, this need not be the case. An instance (#16) of the Interfering_shape_element AO provides the link to the portion of the pipe geometry that is interfering with the pipe geometry. In this case, the geometry of the pipe is represented by a single instance (#8) of the Cylinder AO, so the Interfering_shape_element points to the entire geometry of the pipe. However, this need not be the case.

A.3.3.4.2 Representing connections

Refer to the Component Geometry use case for details on the connections for this use case.

A.3.3.5 Globally unambiguous identifier

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 states that a "globally unambiguous 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 the 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 [3]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 [4] and is registered under ISO 6523-2 [5].

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. It is recommended that the <OPI> and <OPIS> fields be omitted.

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.

EXAMPLE 2 *CTC* might use the host id of the computer concatenated with the date and time, as the local id. For a computer 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 plenum PLE1-1 was defined by *CTC* as stated in Examples 1 and 2, its GUID would be "0060/189737810//.93a00edb/2000-08-11T10:45:36,1642." This would be set as the value of the plant_item_id attribute of the Plant_item_instance EDT.

A.3.4 Pipe change

A.3.4.1 Purpose

This clause describes the use of ISO 10303-227:2000 to exchange information about the implementation and process of a change due to the interference of two Plant_item objects.

A.3.4.2 Background

A change is necessary when there is an interference or other conflict within a plant. A change has a life cycle characterized by a well-defined process. First, some problem is detected that requires a change. A change to solve the problem is proposed. The change must be approved before implementation can occur. An approval gives the endorsement by an authority that the change can change status. A date when the approval is given will be assigned to the change approval. Once a change is approved, it may be implemented. A time period is given for how long the change will take to complete.

The scenario for this use case is as follows:

In the previous use cases, detailed information was given on a piping arrangement, the connections that made up the arrangement, the shapes of the components in the arrangement, and interference of two components within a plant.

This use case resolves the previously discovered interference by implementing a change. After an interference is detected, a resolution must be determined. The interference for this use case involves a Plenum and a Straight_pipe. John Doe, who determined that there was an interference, suggests a resolution: to change the straight pipe into a swept-bend pipe, so that the pipe can go around the plenum. This suggestion is given to John Doe’s manager, Jim Smith. Jim Smith must approve the resolution before any change can be made in manufacturing. Once Jim reviews the interference and resolution, he approves the change, and then the change will be implemented to amend the interference.

A.3.4.3 Example

Figure A.34 shows a portion of the piping system. Straight pipe P1-3 (see Figure A.34) has been changed to a swept bend pipe (P1-5).

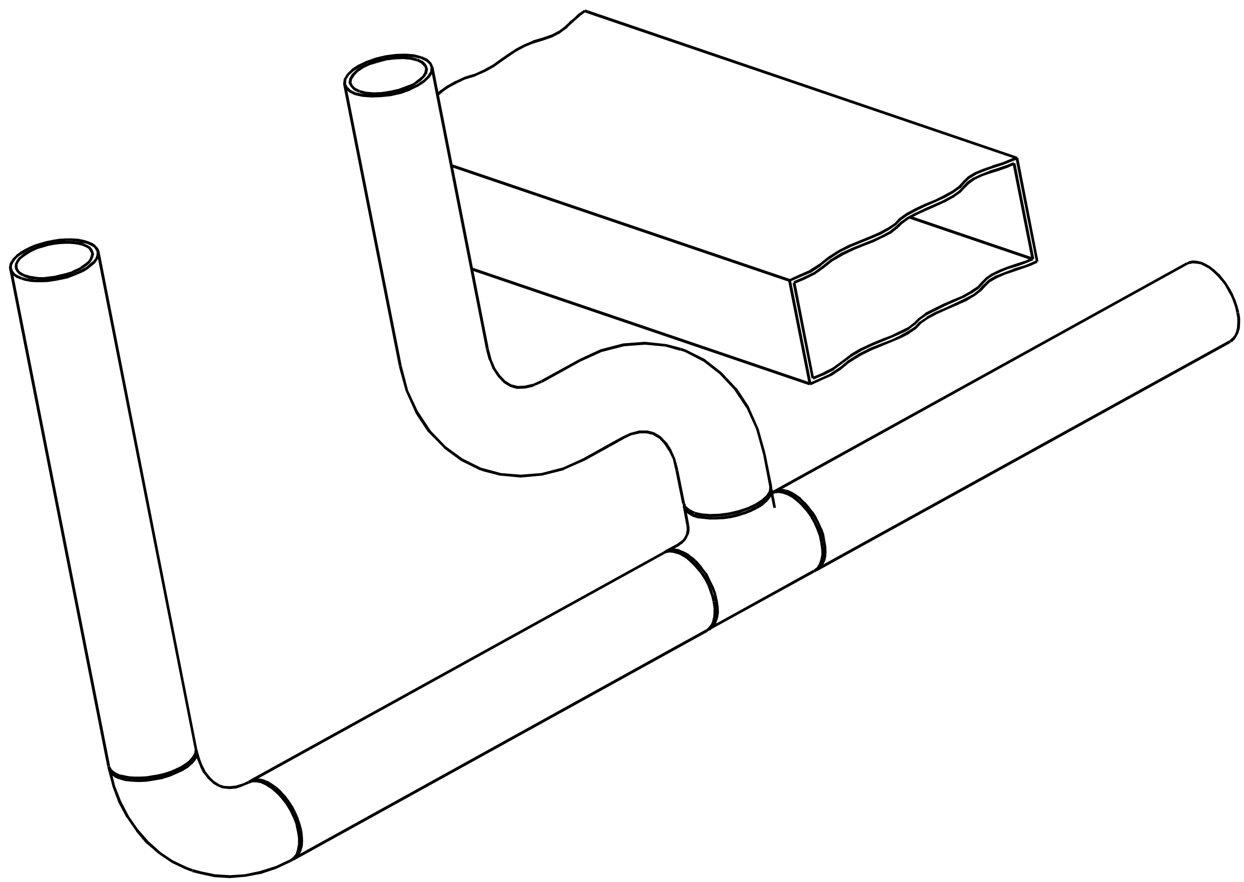

Figure A.34 — Portion of piping system with interference resolved

Table A.8 gives labels and names of the components in the example. Table A.9 gives specifications of the components.

Table A.8 — Components for the Pipe Change use case

Label	Type
P1-3	straight pipe
P1-5	swept-bend pipe
PLE1-1	plenum

Table A.9 — Component definitions for the Pipe Change use case

Part	Type	Definition
P1-3	pipe	straight, 3-inch long, cylinder
P1-5	pipe	swept-bend pipe
PLE1-1	hvac component	plenum

A.3.4.4 Instance diagram

Figure A.35 contains the instance diagram for this use case.

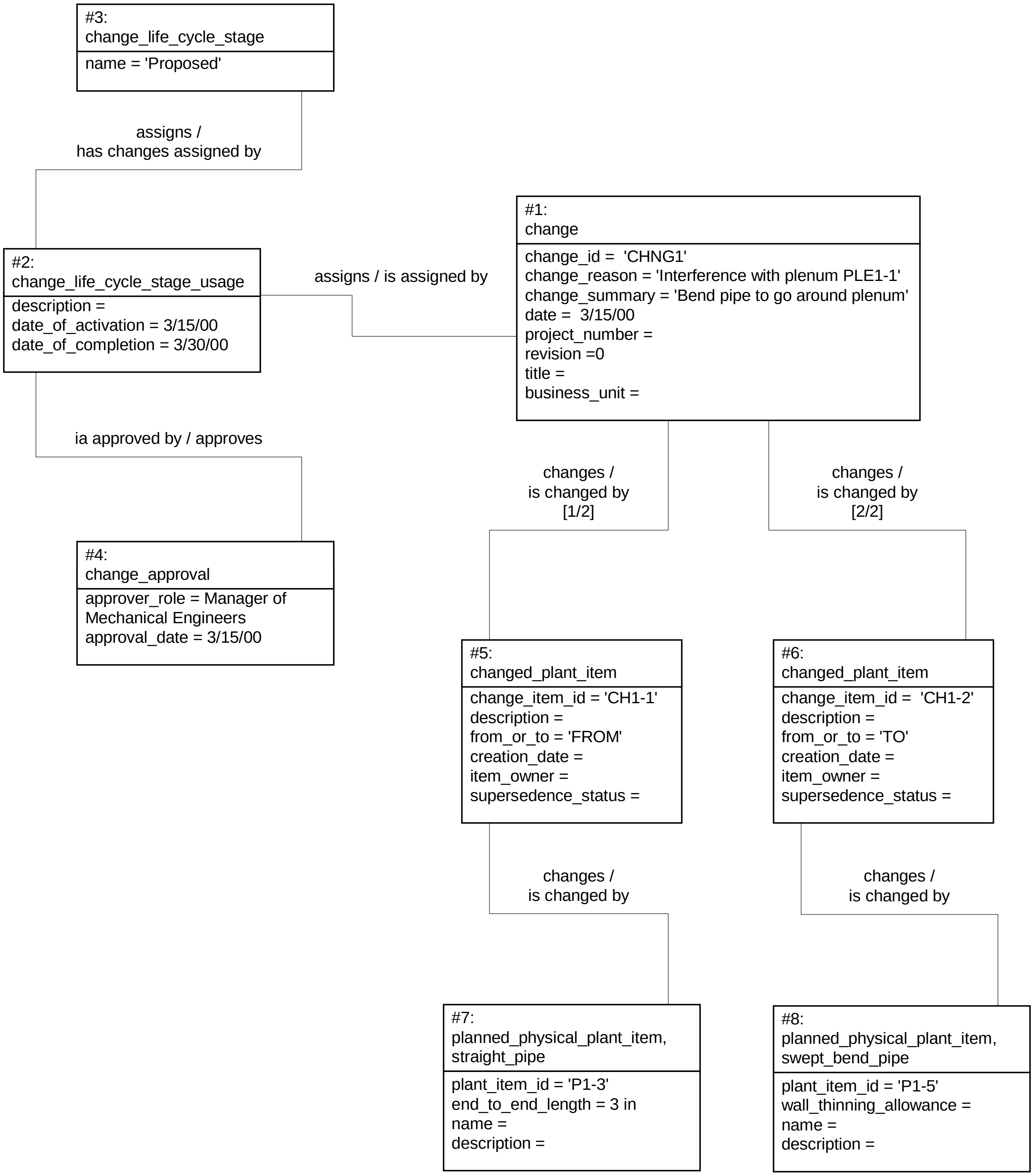

Figure A.35 — Instance diagram for the Pipe Change use case

A.3.4.4.1 Representing the change

This use case resolves the interference that occurs in the Interference Checking use case. An instance (#1) of the Change AO documents the reason for the change and some summary information. This change requests a modification of the piping arrangement, by bending the component P1-3 to go around the plenum (PLE1-1). An instance (#2) of Change_life_cycle_stage_usage collects information about the status of the change. The Change_life_cycle_stage_usage is the assignment of a particular Change to a Change_life_cycle_stage. Change_life_cycle_stage represents the status of a change within its particular life cycle. A manager must approve this particular change. This is captured by an instance (#4) of Change_approval. A Change_approval gives the authority for a change to take place. In this use case, the component P1-3 will be changed to a Swept_bend_pipe (P1-5), to allow for no interference of Plant_items. A Swept_bend_pipe is a pipe that is bent to alter the flow of its contents.

NOTE A Swept_bend_pipe is made up of one or more Pipe_bend objects.

An instance (#5) of the Changed_plant_item AO associates the Change (#1) with the original straight pipe (#7). Another instance (#6) of the Changed_plant_item AO associates the Change (#1) with the new bent pipe (#8).

A.3.5 Cableway installation

A.3.5.1 Purpose

This clause describes the use of ISO 10303-227 for representing cableway installation information. It also describes the use of ISO 10303-227 to represent the results of interference analysis between the cableway and the piping system. While the primary focus is on cableway design for ships, it has broader applicability.

A.3.5.2 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.3.5.2.1 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.

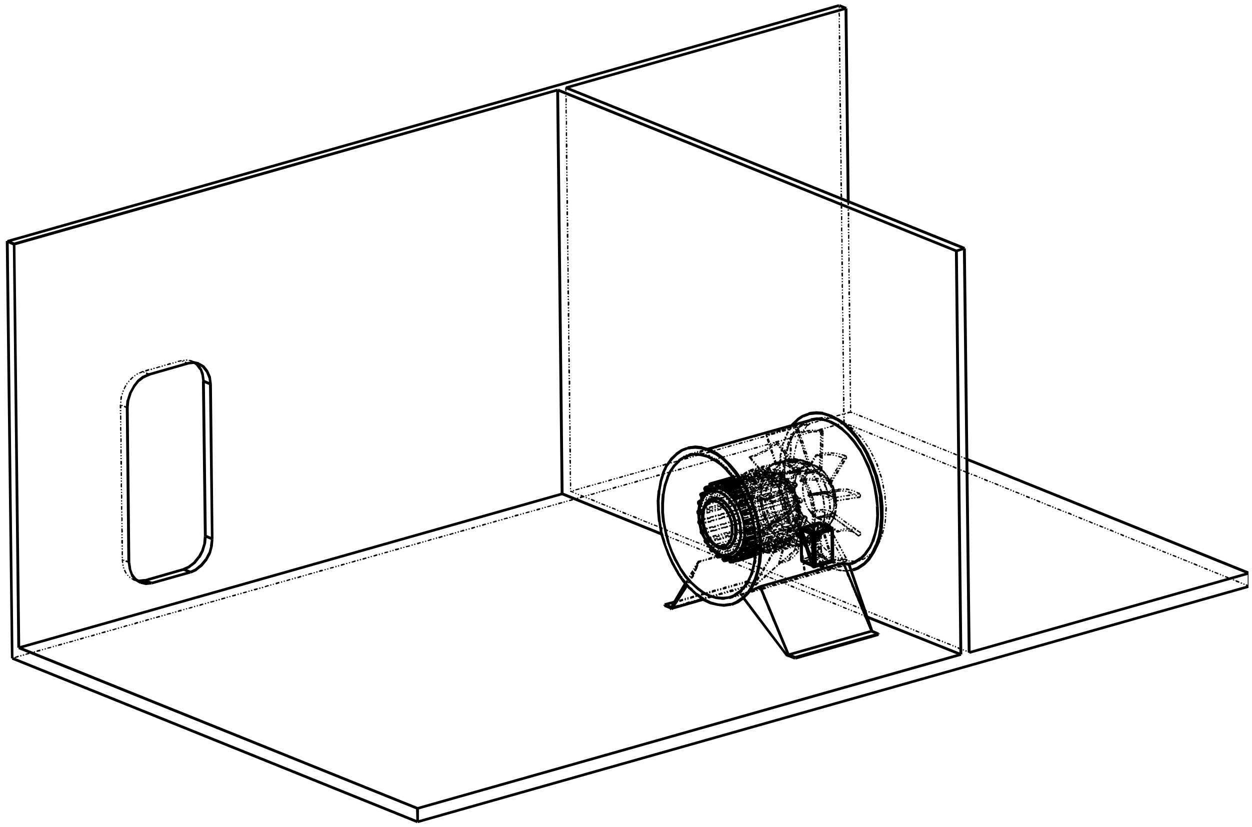

Figure A.36 — Equipment layout

A.3.5.3 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.3.5.4 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.

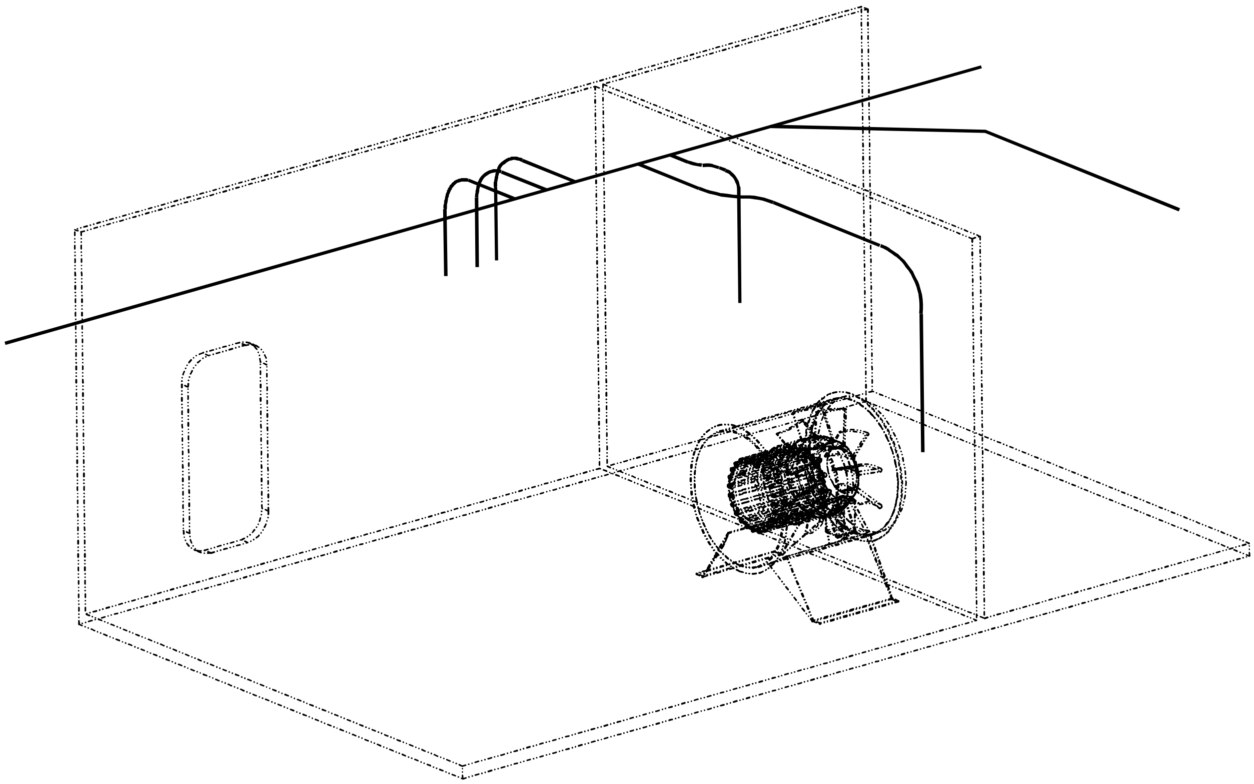

Figure A.37— Cableway layout

A.3.5.5 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 "multi-line 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.

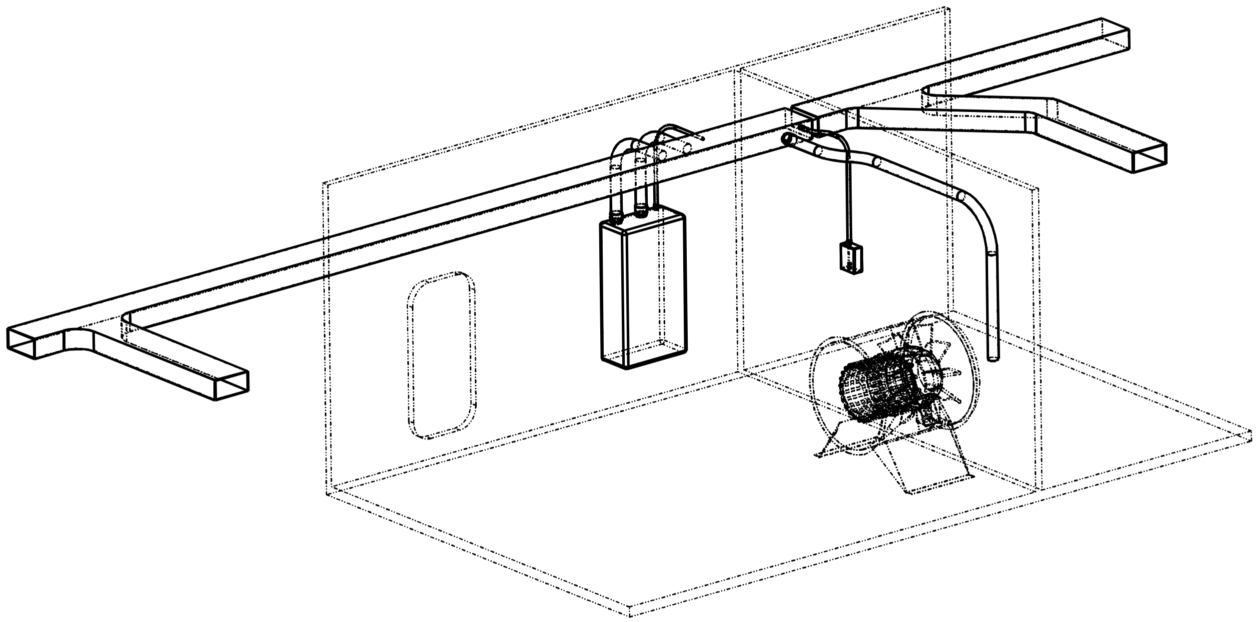

Figure A.38 — Multiline drawing

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 boxes, 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, assembling 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.3.5.6 Specify wire pull

Wire pull instructions are generated at this stage.

A.3.5.7 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.3.5.8 Example

Figure 51 shows a room layout with a single piece of electrical equipment, a blower.

Figure 52 shows a cableway layout for the equipment and room layout in Figure 51.

Figure 53 shows a "multiline drawing" of the cableway.

A.3.5.9 Instance diagram

A.3.5.9.1 Specifying the routes

A "route" is used to specify wire paths. A route consists of one or more segments. Each segment is located at a node. Figure A.39 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.40 shows several segments. Figure A.41 shows two routes. R2 is the route for the power feed to the motor.

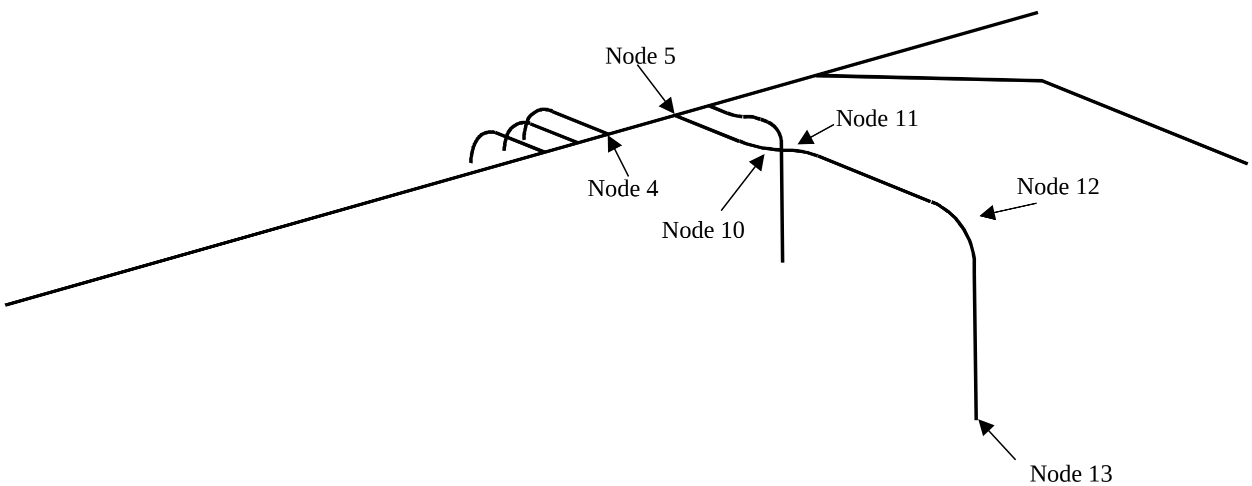

Figure A.39 — Nodes

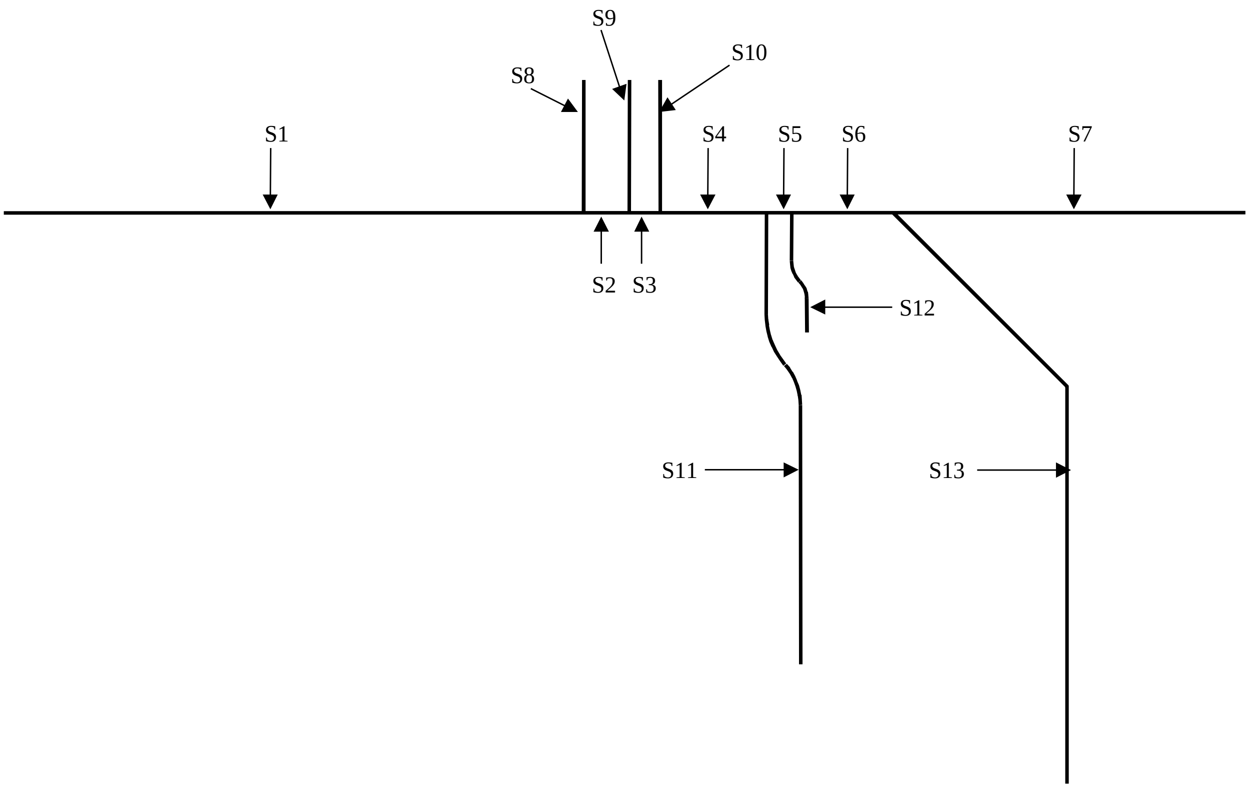

Figure A.40 — Segments

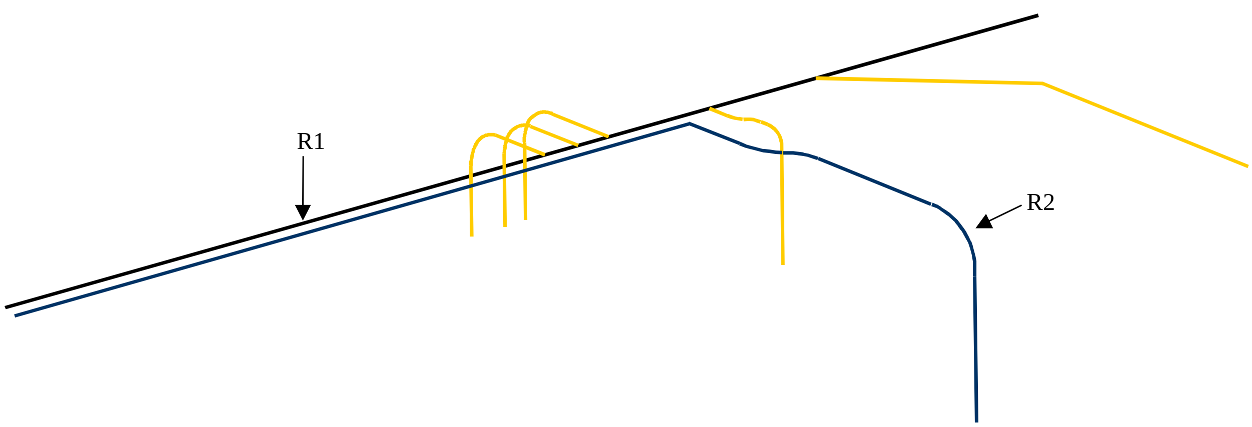

Figure A.41 — Routes

A.3.5.9.2 Specifying the course of the routes

The contents of this clause will be added in a future version of this document.

The contents of this figure will be added in a future version of this document.

Figure A.42 — Specifying the geometry

A.3.5.9.3 Adding raceway specification

Figure A.43 shows the specification of the raceway. The raceway is specified at the "generic" level.

A separate instance of the Planned_physical_plant_item EDT is used to represent the raceway segments on either side of the wall.

NOTE During installation, a single instance of the Planned_physical_plant_item EDT for a raceway 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.

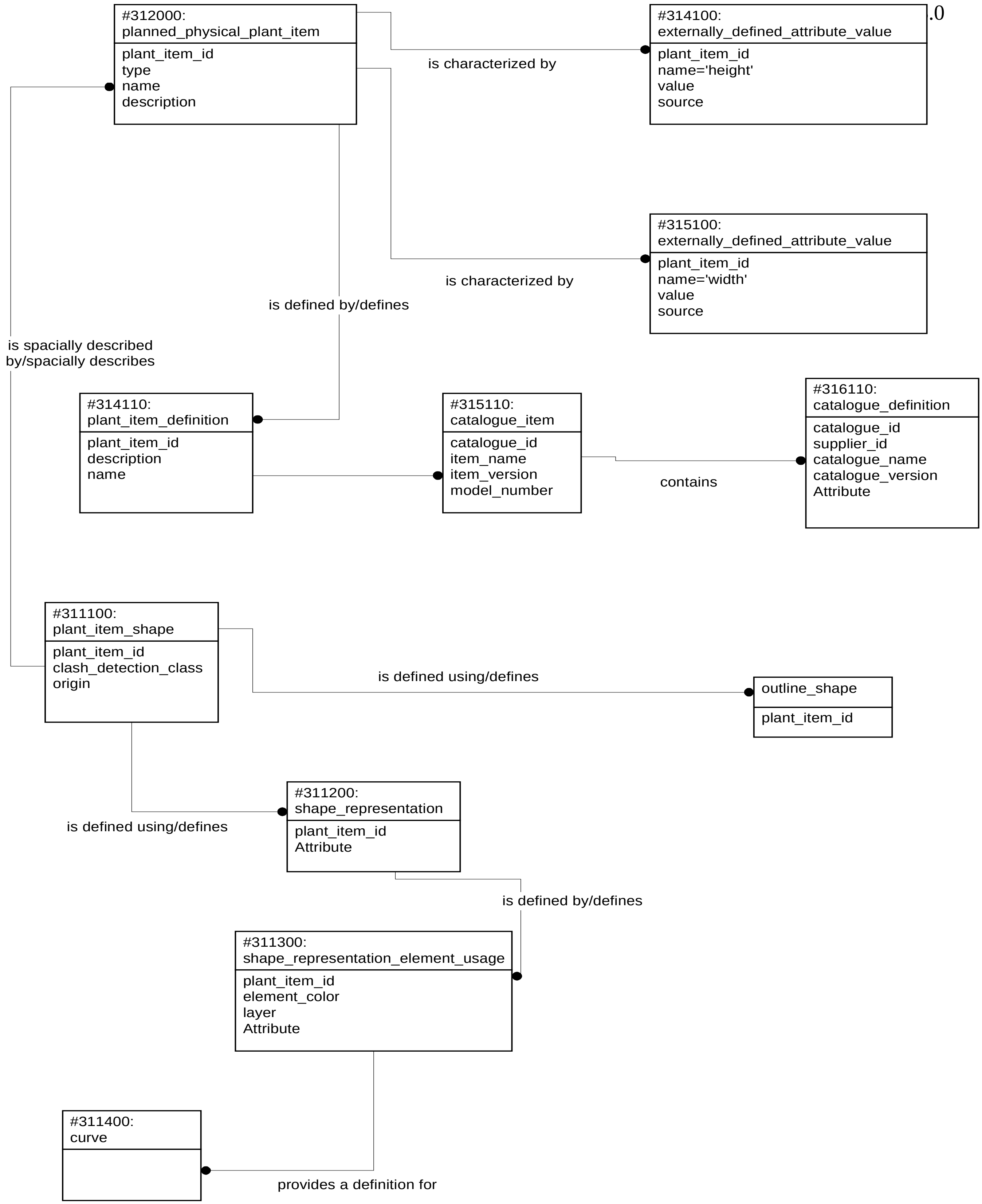

Figure A.43 — Specifying the raceway

Figure A.44 shows how the raceway sections on either side of the wall are connected. An instance (#611100) of the Planned_physical_plant_item EDT represents the grouping of the two raceway segments that abut the wall with the penetration system.

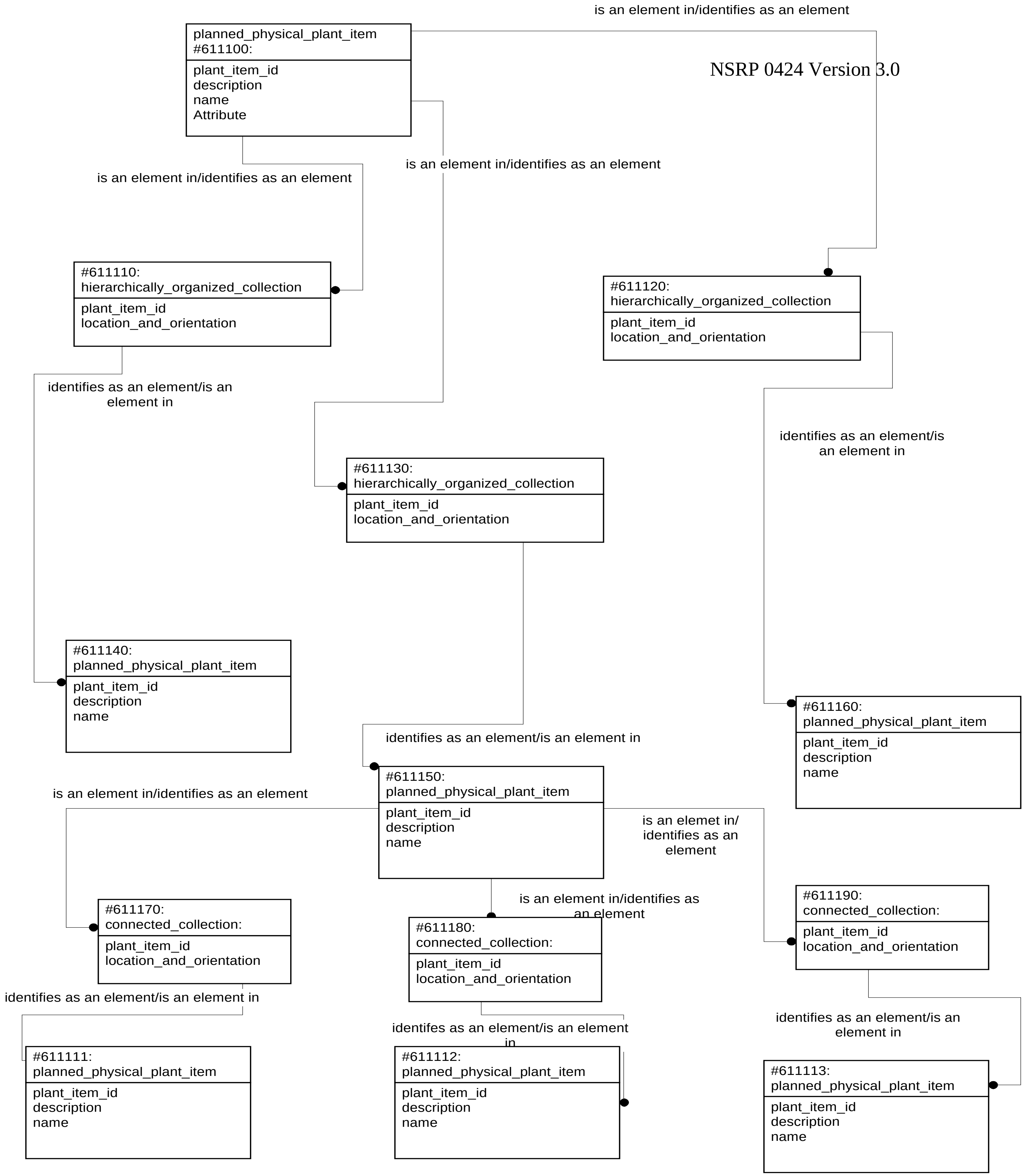

Figure A.44 — Raceway connection through wall

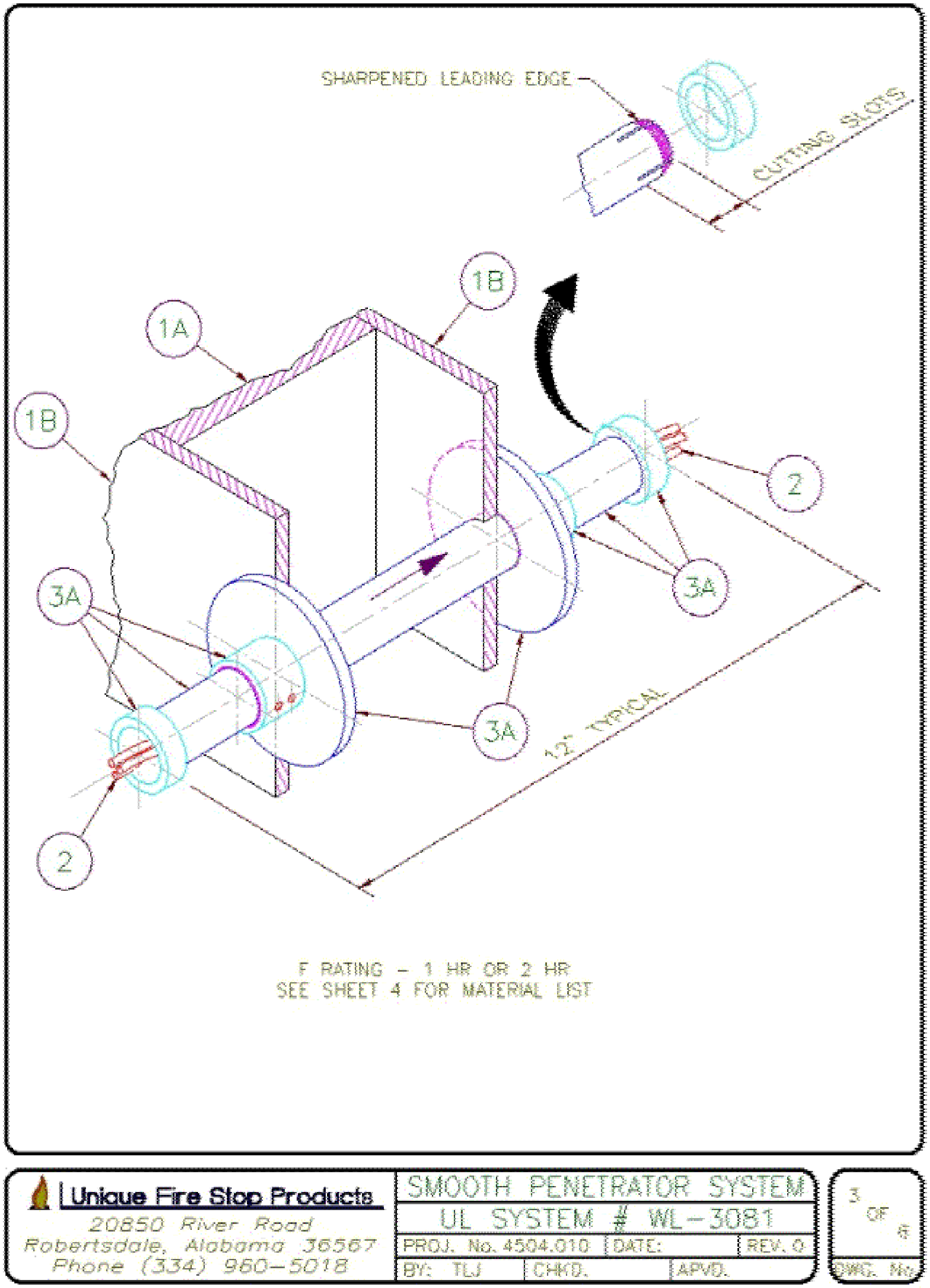

Figure A.45 — Fire-resistant wall penetration system[1]

[1] STI Smooth Penetrator-Block System from Unique Fire Stop Products Company, http://www.uniquefirestop.com/.

A.3.5.9.4 Interference check results

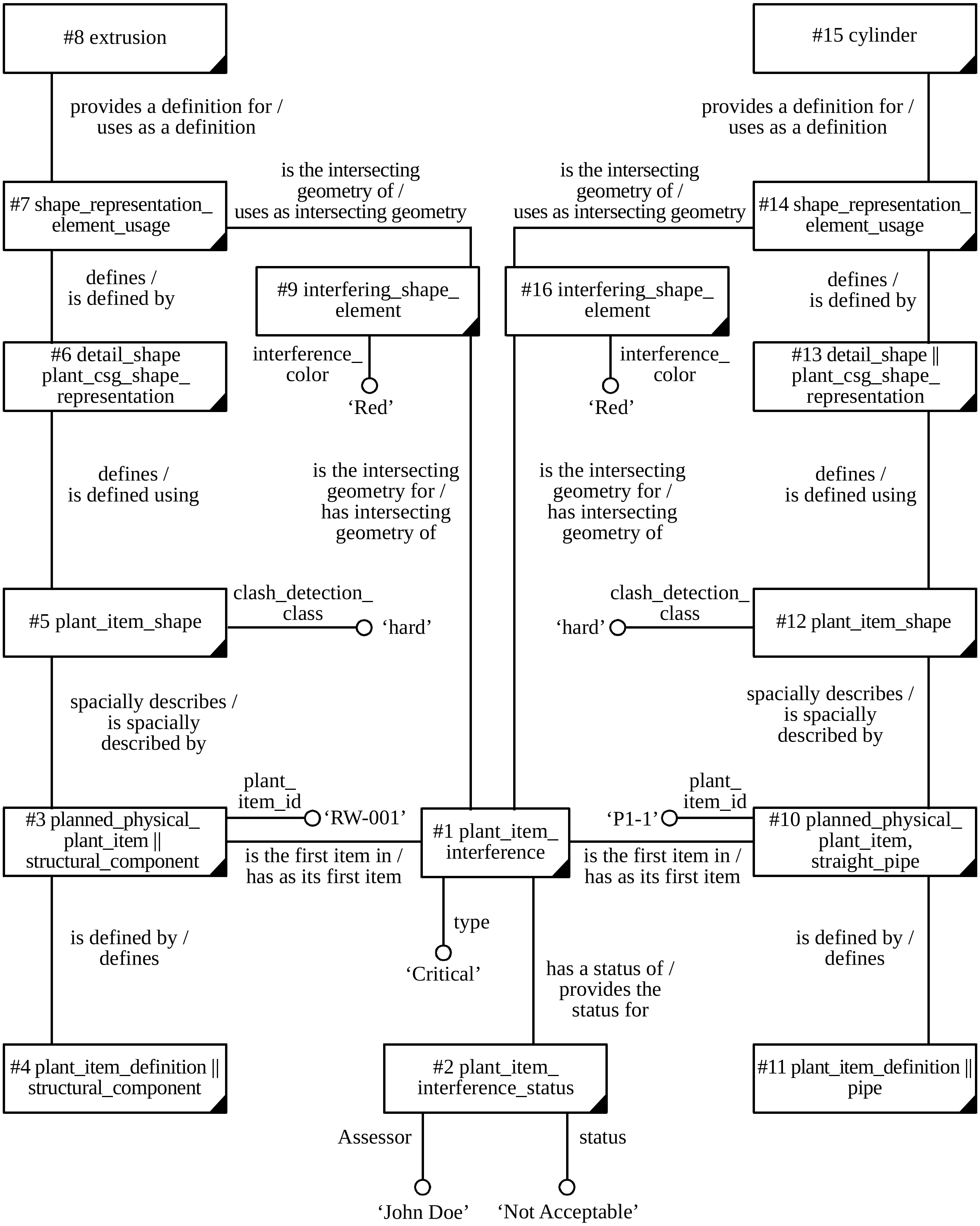

Figure A.46 — Interference check results

A.3.5.9.5 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.47 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."

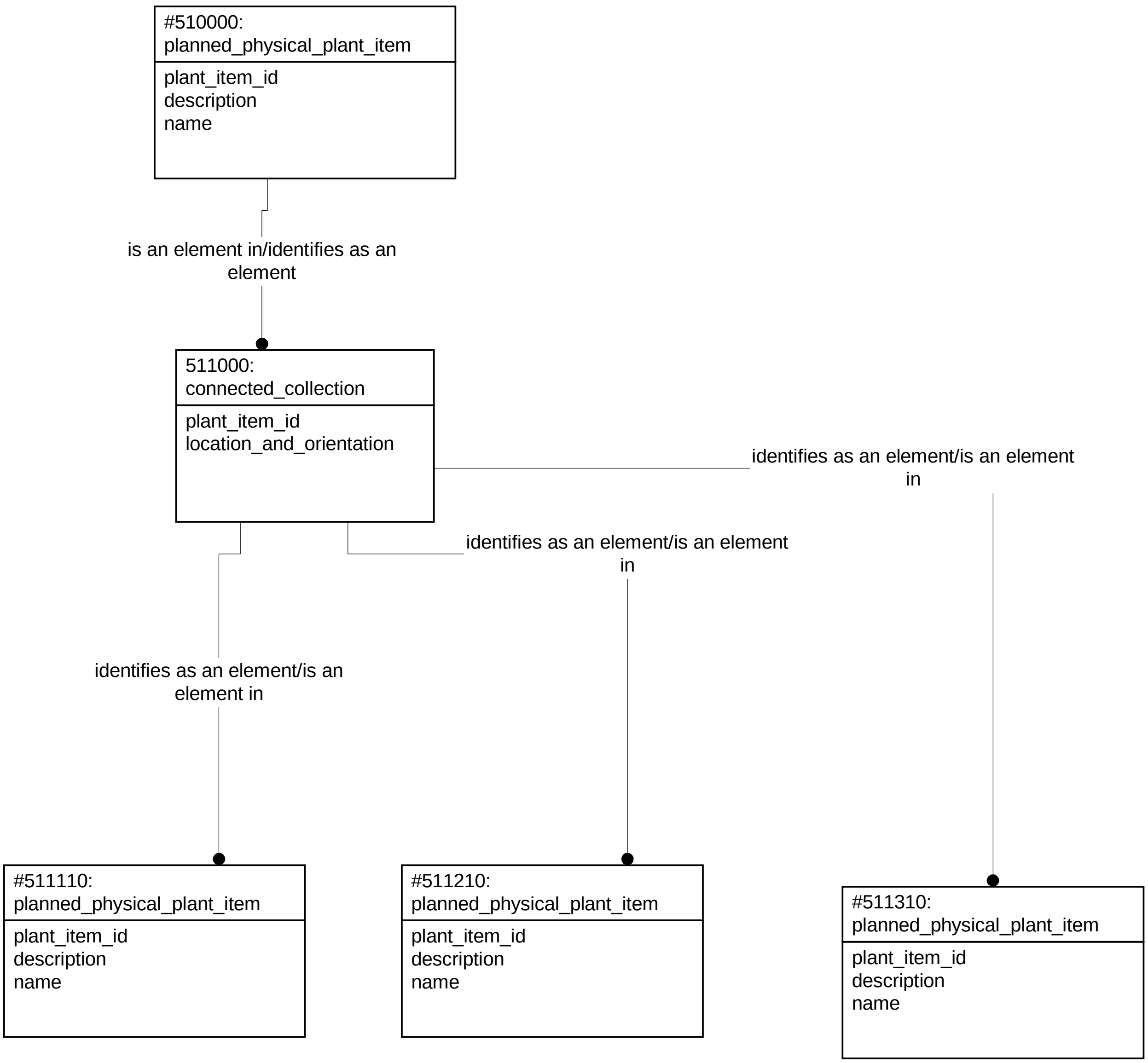

Figure A.47 — Shop-made assembly

A.3.5.9.6 Raceway details

Figure A.48 shows how raceways can be specified in detail down to individual piece-parts.

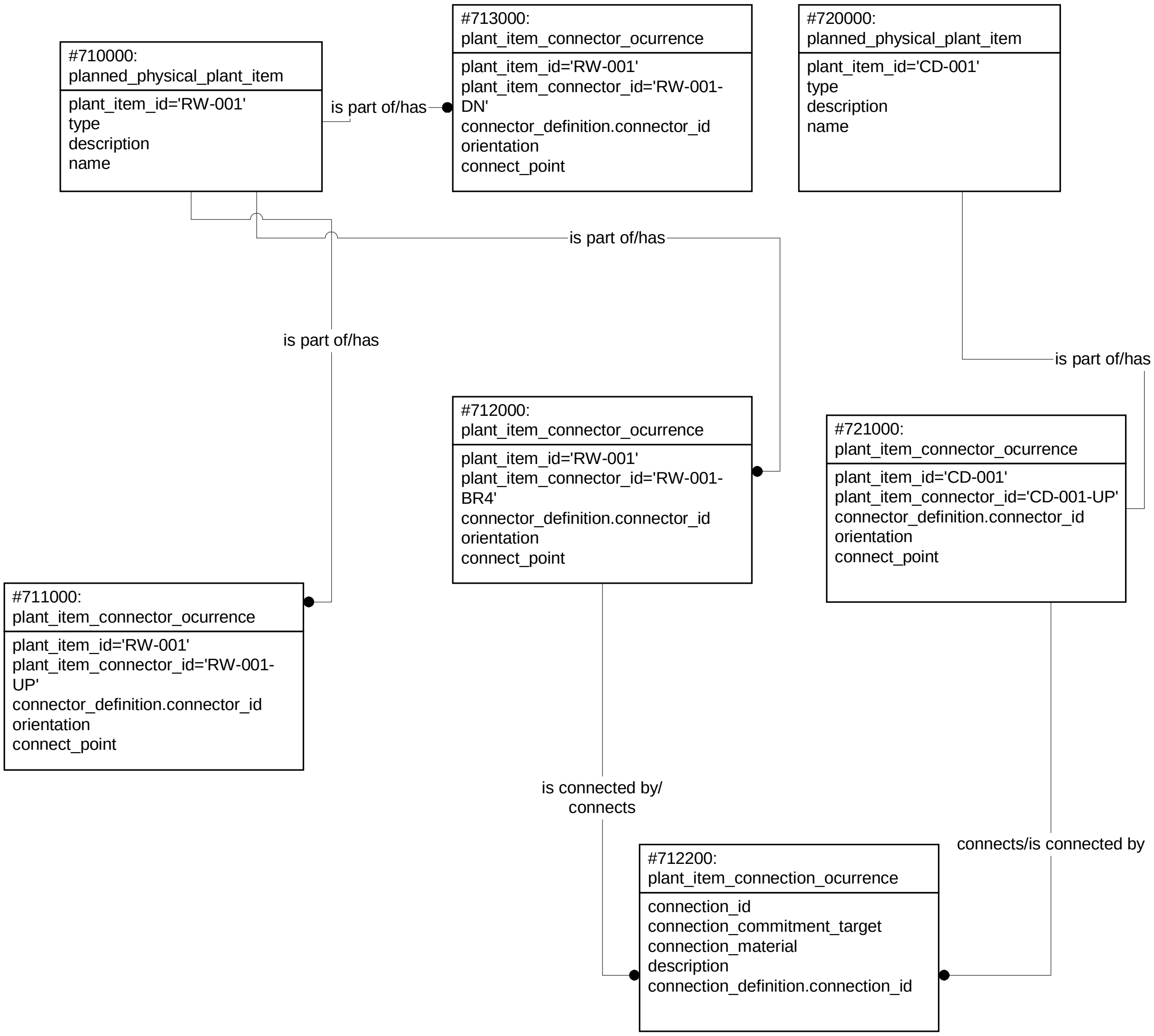

Figure A.48 — Raceway details

Bibliography

[1] MariSTEP program test data, http://www.ingr.com/federal2/projects/step/.

[2] Bausbacher, Ed and Roger Hunt, *Process plant layout and piping design*, Upper Saddle River, P T R Prentice Hall, 1993.

[3] ISO 13584-26:2000, *Industrial automation systems and integration — Parts library — Part 26: Logical resource: Information supplier identification*.

[4] ISO/IEC 6523-1:1998, *Information technology — Structure for the identification of organizations and organization parts — Part 1: Indentification of organization identification schemes*.

[5] ISO/IEC 6523-2:1998, *Information technology — Structure for the identification of* organizations *and organization parts — Part 2: Registration of organization identification schemes*.