Usage Guide for ISO 10303-227 for Ship Piping Systems

Version 0.1
1999-11-20

Comments to Reader:
This version is a draft for industry review. It presents one use case, entitled Connections. Additional use cases will be added in future versions. Readers are requested to provide feedback on the structure and organization of the document, the notation used, as well as the details of the use case presented.

Send comments to:
Dr. Gerald M. Radack
Concurrent Technologies Corporation
100 *CTC* Drive
Johnstown, PA 15904
radack@ctc.com
+1 814-269-2679
FAX +1-814-269-6885

CONTENTS PAGE

Foreword 1
Introduction 3
1 Scope 5
2 Normative references 5
3 Terms, definitions and abbreviations 5
3.1 Terms defined in ISO 10303-1 5
3.2 Terms defined in ISO 10303-11 6
3.3 Terms defined in ISO 10303-227:1999 7
3.4 Definitions 7
3.5 Abbreviations 7
4 Overview of ISO 10303-227:1999 8
4.1 Scope of ISO 10303-227:1999 8
4.2 Plant items 8
4.3 Complex instances 8
5 Conventions 9
5.1 Instance identification 10
5.2 Notation for ARM instance diagrams 10
6 Use Cases 12
6.1 Connections 12
6.1.1 Purpose 12
6.1.2 Background 12
6.1.3 Example 12
6.1.4 Instance diagram 14
6.1.5 Recommended practices 28
Bibliography 29

FIGURES

Figure 1 – Classifications hierarchy based on head type then end type 8
Figure 2 – Multiple classifications 9
Figure 3 – Model of Piping_connector from ISO 10303-227:1999 ARM 9
Figure 4 – Notation for instance 11
Figure 5 – Notation for relationship 11
Figure 6 – Notation for relationships with multiple entities playing the same role 11
Figure 7 – Notes 12

Figure 8 – Portion of a piping system for the Connections use case 13
Figure 9 – Exploded view with components labeled 13
Figure 10 – Instance diagram for the Connections use case (1 of 11) 15
Figure 11 – Instance diagram for the Connections use case (2 of 11) 16
Figure 12 – Instance diagram for the Connections use case (3 of 11) 17
Figure 13 – Instance diagram for the Connections use case (4 of 11) 18
Figure 14 – Instance diagram for the Connections use case (5 of 11) 19
Figure 15 – Instance diagram for the Connections use case (6 of 11) 20
Figure 16 – Instance diagram for the Connections use case (7 of 11) 21
Figure 17 – Instance diagram for the Connections use case (8 of 11) 22
Figure 18 – Instance diagram for the Connections use case (9 of 11) 23
Figure 19 – Instance diagram for the Connections use case (10 of 11) 24
Figure 20 – Instance diagram for the Connections use case (11 of 11) 25
Figure 21 – Connections for the Connections use case 27

TABLES

Table 1 – Components for the Connections use case 14
Table 2 – Component definitions for the Connections use case 14

Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75% of the member bodies casting a vote.

ISO/TS 10303-xxx, was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration*, Subcommittee SC4, *Industrial data*.

This document is written as if it is an ISO technical report that is part of the ISO 10303 series of documents. Hence, throughout the document, "this International Standard" refers to ISO 10303, and "this part of ISO 10303" refers to this document; however, this document is not currently an ISO standard, nor has it been submitted to ISO as a work item.

This International Standard is organized 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. The series are described in ISO 10303-1.

A complete list of parts of ISO 10303 is available from the Internet:

http://www.nist.gov/sc4/editing/step/titles/

The structure of this International Standard is described in ISO 10303-1. The numbering of the parts of this International Standard reflects its structure:

— Parts 11 and 12 specify the description methods,

— Parts 21 to 26 specify the implementation methods,

— Parts 31 to 35 specify the conformance testing methodology and framework,

— Parts 41 to 49 specify the integrated generic resources,

— Parts 101 to 106 specify the integrated application resources,

— Parts 201 to 232 specify the application protocols,

— Parts 301 to 332 specify the abstract test suites, and

— Parts 501 to 518 specify the application interpreted constructs.

Should further parts of ISO 10303 be published, they will follow the same numbering pattern.

Annex A is for information only.

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.

This International Standard is organized 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. The series are described in ISO 10303-1. This part of ISO 10303 is a member of the Usage Guide series.

This part of ISO 10303 provides guidance on the usage of ISO 10303-227:1999 for shipbuilding.

ISO 10303-227:1999 is an Application Protocol 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 nonpiping plant systems are also included in this part of ISO 10303.

There is an industrial need to exchange information about ship piping functional design, detail design, production engineering, fabrication, assembly, and testing. ISO 10303-217 is currently being developed to meet this need; however, it is not ready for use.

Ship piping systems and process plants are similar in terms of functionality, component classes used, analysis methods, design considerations, and fabrication techniques. Because ISO 10303-227:1999 is an International Standard, it makes sense to use it as an interim solution for ship piping data exchange until ISO 10303-217 is complete.

This part of ISO 10303 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 10303-227:1999 Application Reference Model (ARM) and Application Interpreted Model (AIM). These use cases help to validate ISO 10303-227:1999 as a vehicle for exchanging ship piping information, and can serve as a reference for someone who is implementing ISO 10303-227:1999 for ship piping data exchange. This usage guide 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.

> NOTE: Because ISO 10303-227:1999 does not provide the ARM in a formal modeling language, the instance diagram notation used in this part of ISO 10303 to display the ARM representation of a use case is also informal.

This part of ISO 10303 provides guidelines for using ISO 10303-227:1999 to exchange shipboard piping system data. It is written primarily for people implementing ISO 10303-227:1999 within the shipbuilding industry. It also would be useful to anyone who wants to learn more about ISO 10303-227:1999; 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;
- Annex K (Application protocol usage guide) of ISO 10303-227:1999;
- MariSTEP program test data.

1 Scope

This part of ISO 10303 provides guidance on the use of ISO 10303-227:1999 for shipbuilding.

The following are within the scope of this part of ISO 10303:

— Use cases for representation of ship piping information using ISO 10303-227:1999;

— Mapping between shipbuilding and process plant terminology for piping.

The following are outside the scope of this part of ISO 10303:

— Formal mappings between ship piping models and ISO 10303-227:1999;

— Requirements for ship piping systems.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13584. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13584 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 10303-227:1999:1999, *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 10303-1

This part of ISO 10303 makes use of the following terms defined in ISO 10303-1.

3.1.1 Application Object (AO)

an atomic element of an application reference model that defines a unique concept of the application and contains attributes specifying the data elements of the object.

3.1.2 Application Protocol (AP)

a part of this International Standard that specifies an application interpreted model satisfying the scope and information requirements for a specific application.

> NOTE: This definition differs from the definition used in open system interconnection (OSI) standards. However, since this International Standard is not intended to be used directly with OSI communications, no confusion should arise.

3.1.3 Product Data

a representation of information about a product in a formal manner suitable for communication, interpretation, or processing by human beings or by computers

3.1.4 Unit of Functionality (UoF)

a collection of application objects and their relationships that defines one or more concepts with the application context such that removal of any component would render the concepts incomplete or ambiguous

3.2 Terms defined in ISO 10303-11

This part of ISO 10303 makes use of the following terms defined in ISO 10303-11:

a class of information defined by common properties

3.2.1 complex entity data type

a representation of an entity. A complex entity data type establishes a domain of values defined by the common attributes and constraints of an allowed combination of entity data types within a particular subtype/supertype graph

3.2.2 complex entity (data type) instance

a named unit of data which represents a unit of information within the class defined by an entity. It is a member of the domain established by a complex entity data type

3.2.3 entity

a class of information defined by common properties

3.2.4 entity data type (EDT)

a representation of an entity. An entity data type establishes a domain of values defined by common attributes and constraints

3.2.5 entity instance

a named unit of data that represents a unit of information within the class defined by an entity. It is a member of the domain established by an entity data type

3.3 Terms defined in ISO 10303-227:1999

This part of ISO 10303 makes use of the following terms defined in ISO 10303-227:1999.

3.4 Definitions

For the purpose of this part of ISO 10303, the following definitions apply:

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

3.5 Abbreviations

For the purposes of this part of ISO 10303, the following abbreviations apply:

AO application object

AP application protocol

ATS abstract test suite

CD committee draft

DIS Draft International Standard

(E) English

EDT entity data type

FDIS Final Draft International Standard

IR integrated resource

IS International Standard

ISO International Organization for Standardization

SC4 Subcommittee 4

TC Technical Committee

UoF Unit of Functionality

WD working draft

4 Overview of ISO 10303-227:1999

4.1 Scope of ISO 10303-227:1999

ISO 10303-227:1999 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 nonpiping plant systems are also included in ISO 10303-227:1999. 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

4.3 Complex instances

To fully classify an object using ISO 10303-227:1999, 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 machine screw may be characterized by its head type as being either round head, flat head, or hexagon head. It may be characterized by its end type as being either flat end or conical end. These two classifications can be combined to form the hierarchy of entities shown in EXPRESS-G in Figure 1.

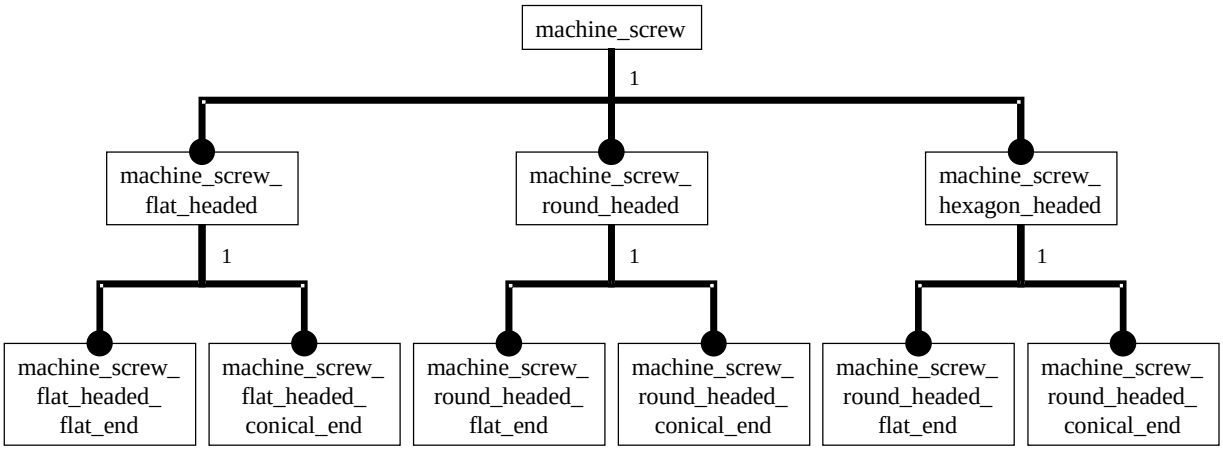

Figure 1 – Classification hierarchy based on head type then end type

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. Another approach is 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 EXPRESS-G model shown in Figure 2.

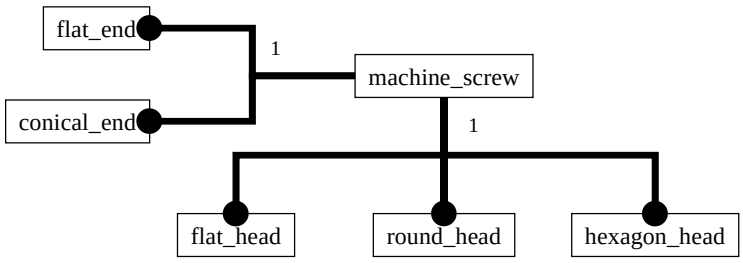

Figure 2 – Multiple classifications

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.

EXAMPLE 3: A round-headed conical bottom screw is characterized as a complex entity instance that is a member of the round_headed EDT and the conical_bottom EDT.

A good example of the use of this modeling style in ISO 10303-227:1999 is shown in Figure 3. A piping connector may be characterized by its end type as being either 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.

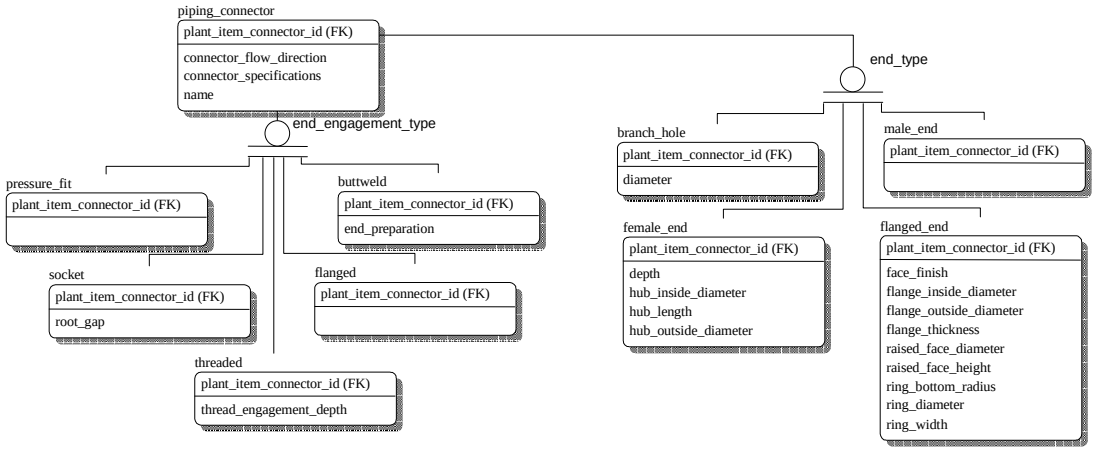

Figure 3 – Model of Piping_connector from ISO 10303-227:1999 ARM

5 Conventions

This clause provides the conventions that apply to this part of ISO 10303.

5.1 Instance identification

Although the ARM of ISO 10303-227:1999 is written in IDEF1X, this part of ISO 10303 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 part of ISO 10303, 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

The ARM of ISO 10303-227:1999 is modelled using the IDEF1X modelling notation. Because the ARM is modelled in IDEF1X rather than in EXPRESS, it is not practical to use an EXPRESS instance notation, such as EXPRESS-I or EXPRESS-I-G, because the use of such notation would require an EXPRESS ARM. Instead, the notation described in this clause will be used.

> NOTE: At the time this document was written, the ISO 10303-227 development team was considering the possibility of converting the ARM into EXPRESS for the second edition.

An instance of an EDT is shown as a box consisting of two smaller boxes, stacked vertically (see Figure 4). The upper box consists of:

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

> NOTE: 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 3, 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 as shown in Figure 4.

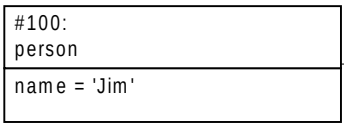

Figure 4 – Notation for instance

A relationship between two instances is shown by a solid line. Text adjacent to the line gives the reading for the relationship in the forward and backward direction, 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.

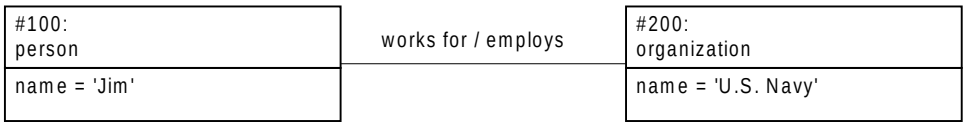

Figure 5 – Notation for relationship

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).

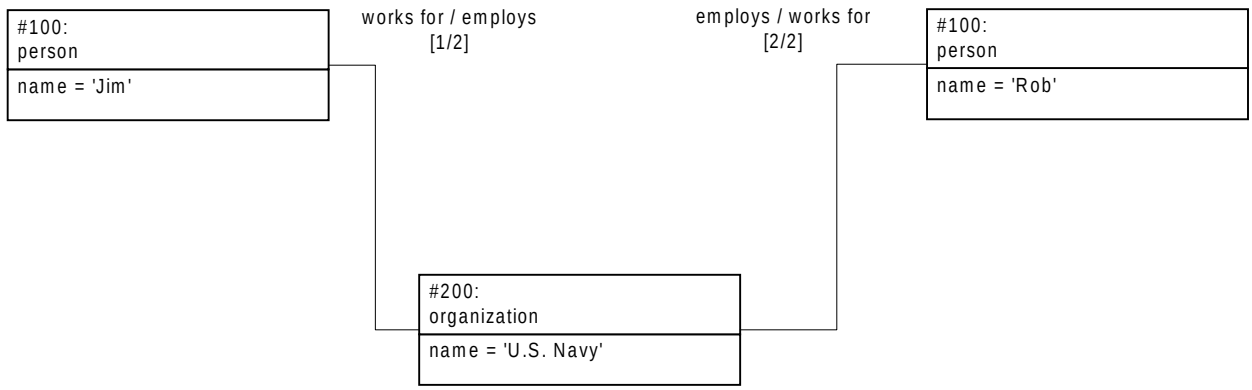

Figure 6 – Notation for relationships with multiple entities playing the same role

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

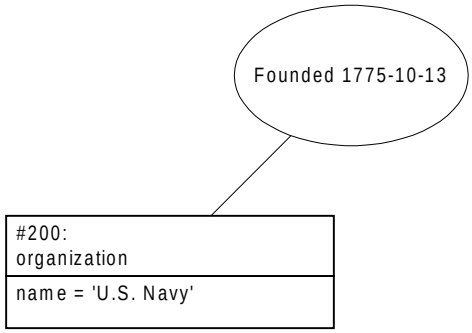

Figure 7 – Notes

6 Use Cases

This version of the document contains a single use case. Additional use cases will be added in later versions.

6.1 Connections

6.1.1 Purpose

This clause describes the use of ISO 10303-227:1999 to exchange information about the characteristics of piping components, their spatial arrangement, and how they are connected to form a piping system.

6.1.2 Background

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

6.1.3 Example

Figure 8 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 legal, the design shown is not a part of a real ship piping system design.

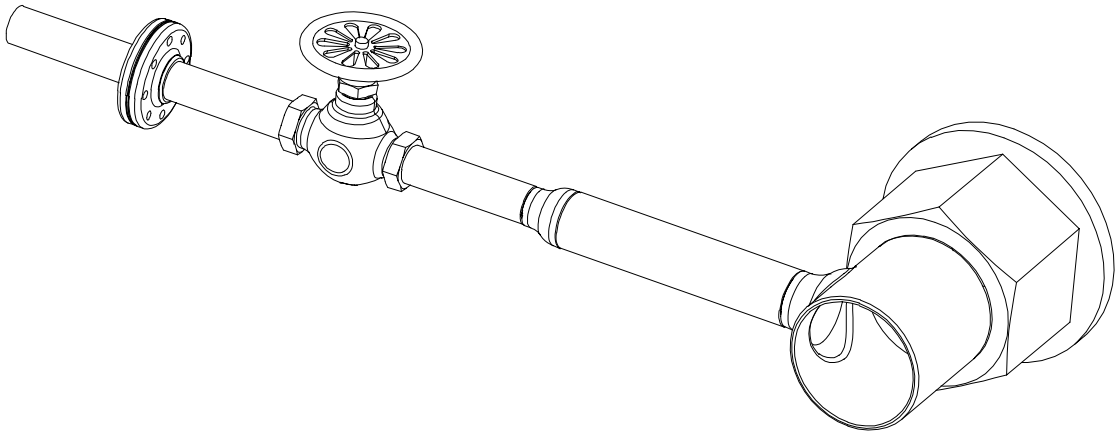

Figure 8 – Portion of a piping system for the Connections use case

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 9 shows an exploded view of the components of the system with labels attached. Table 1 gives labels and descriptions of the components in the example. In Table 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.

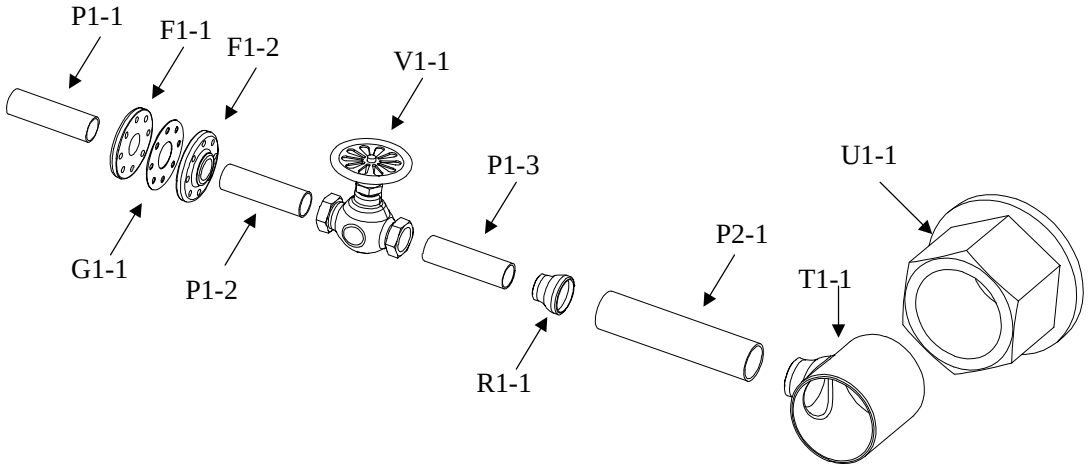

Figure 9 – Exploded view with components labeled

Table 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 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	

6.1.4 Instance diagram

Figures 10–20 contain the instance diagrams for this use case.

A piping system can be represented in ISO 10303-227:1999 through a functional description and/or a physical description. In this use case, a physical description is presented.

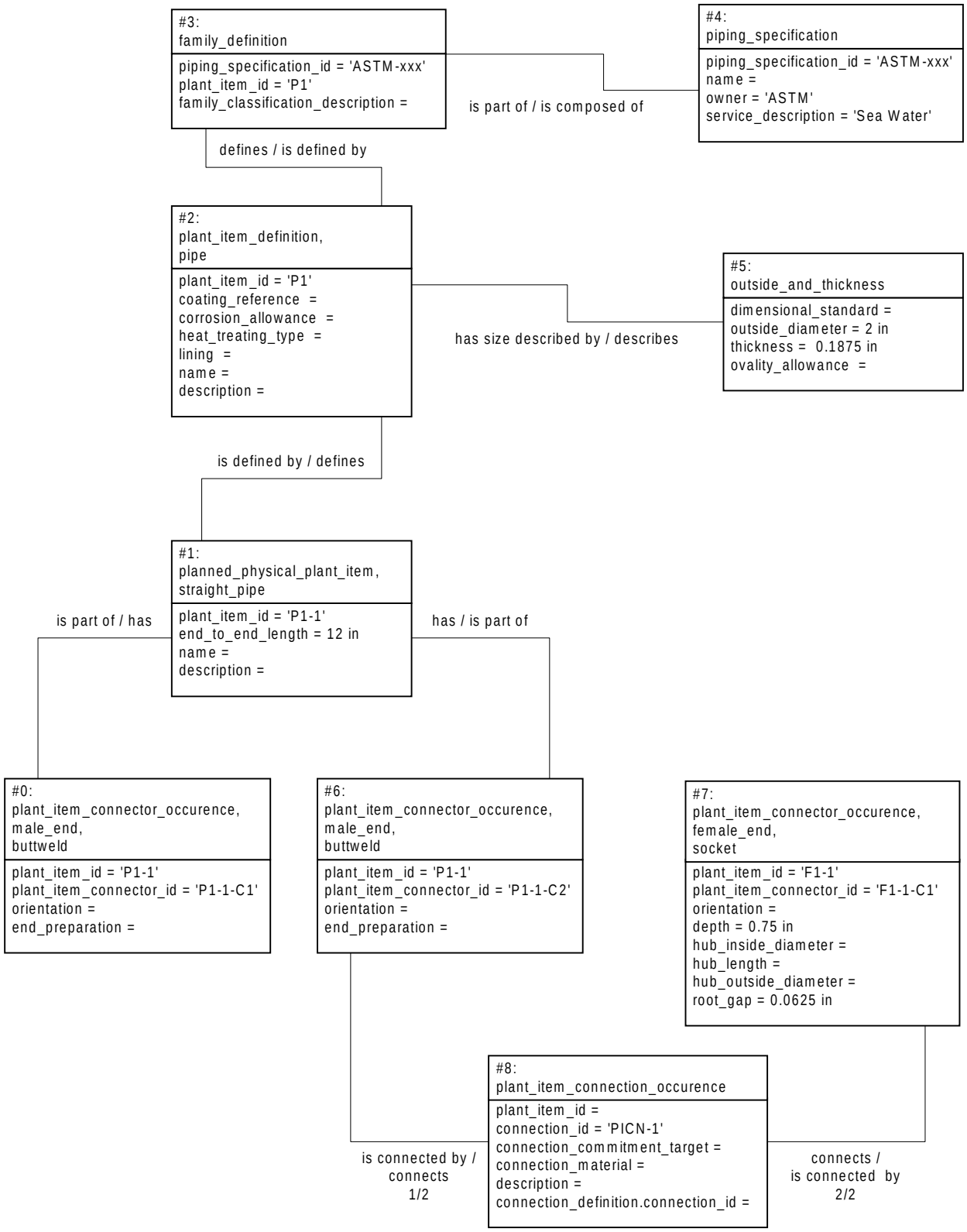

Figure 10 – Instance diagram for the Connections use case (1 of 11)

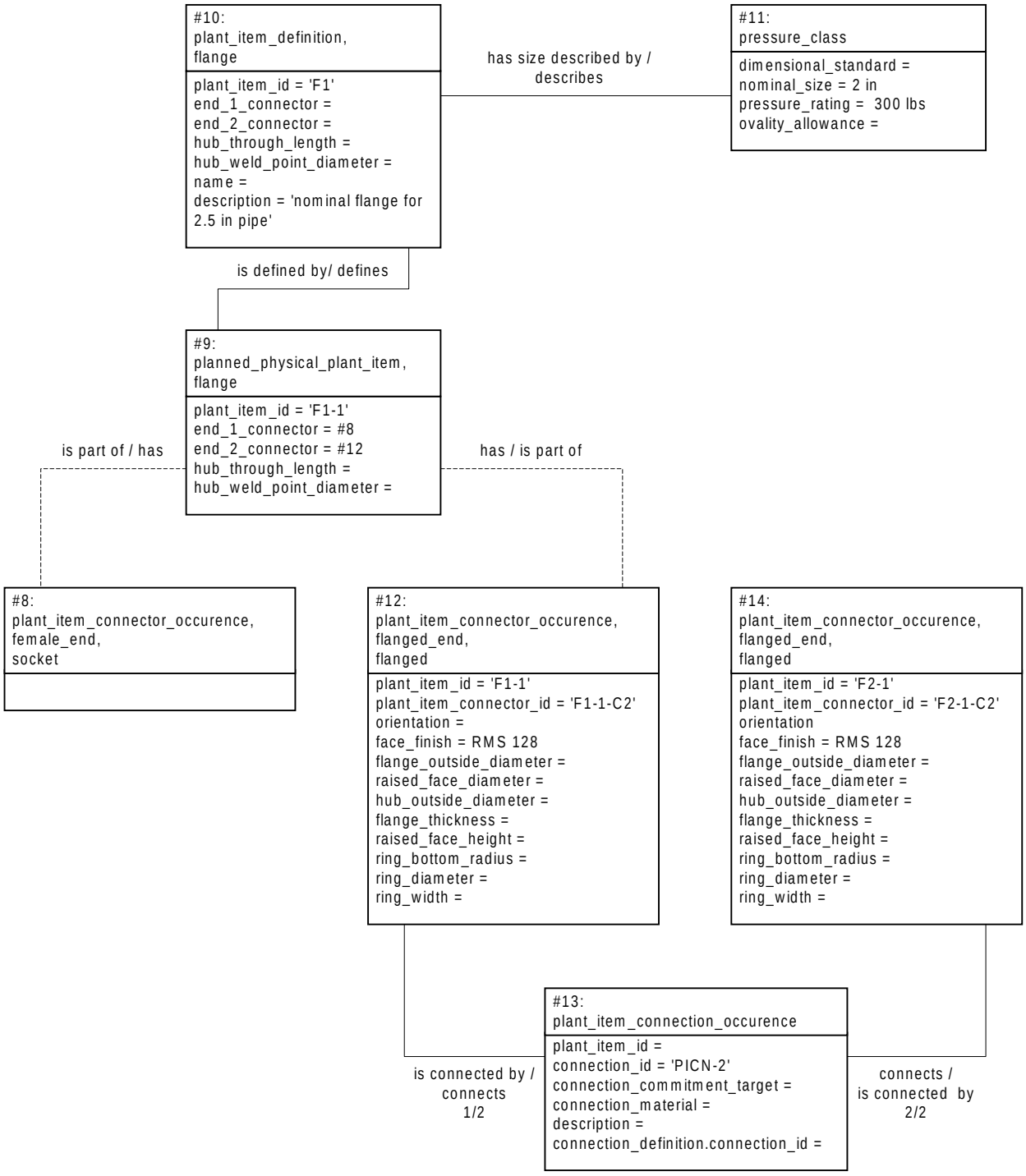

Figure 11 – Instance diagram for the Connections use case (2 of 11)

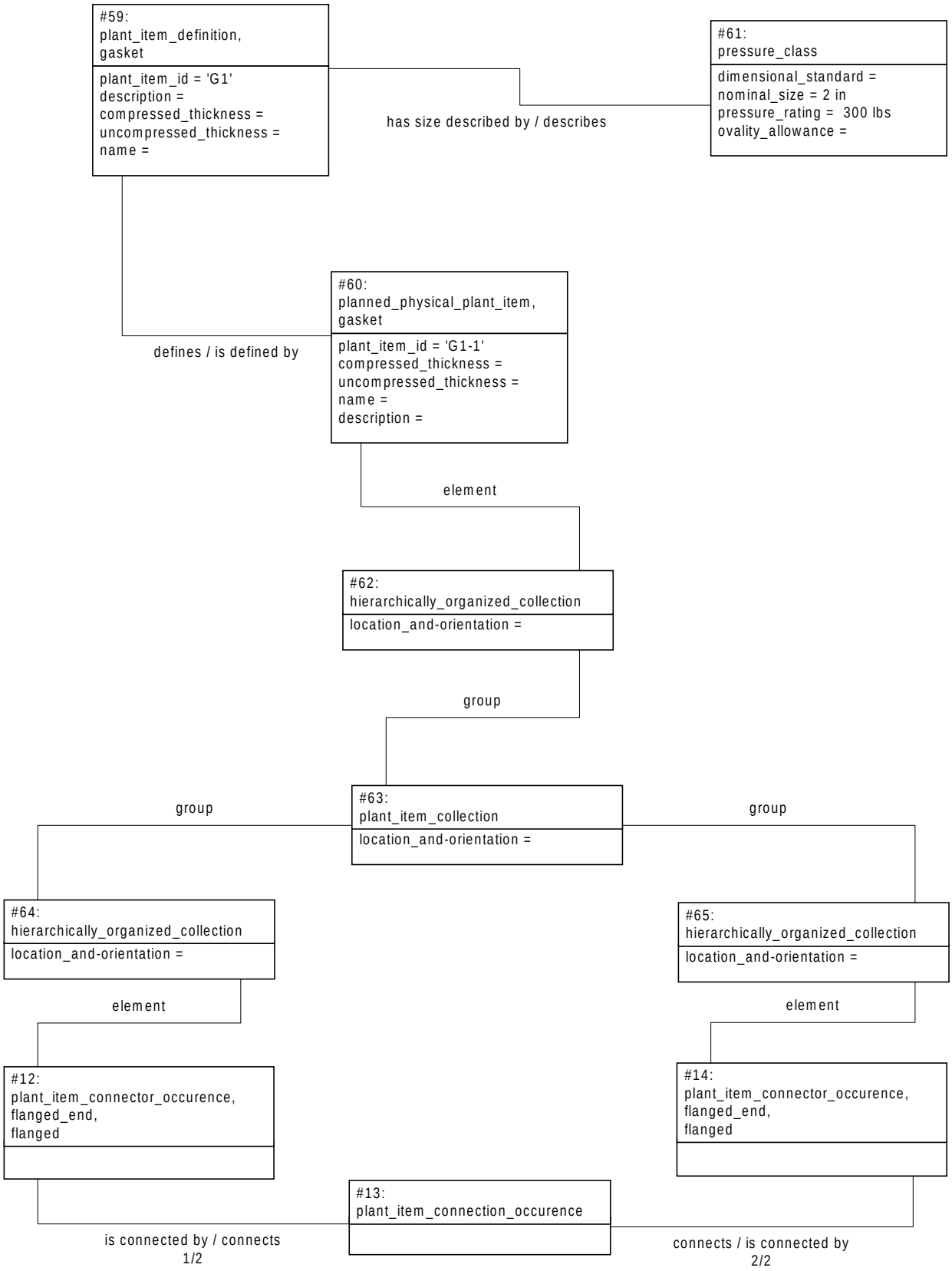

Figure 12 – Instance diagram for the Connections use case (3 of 11)

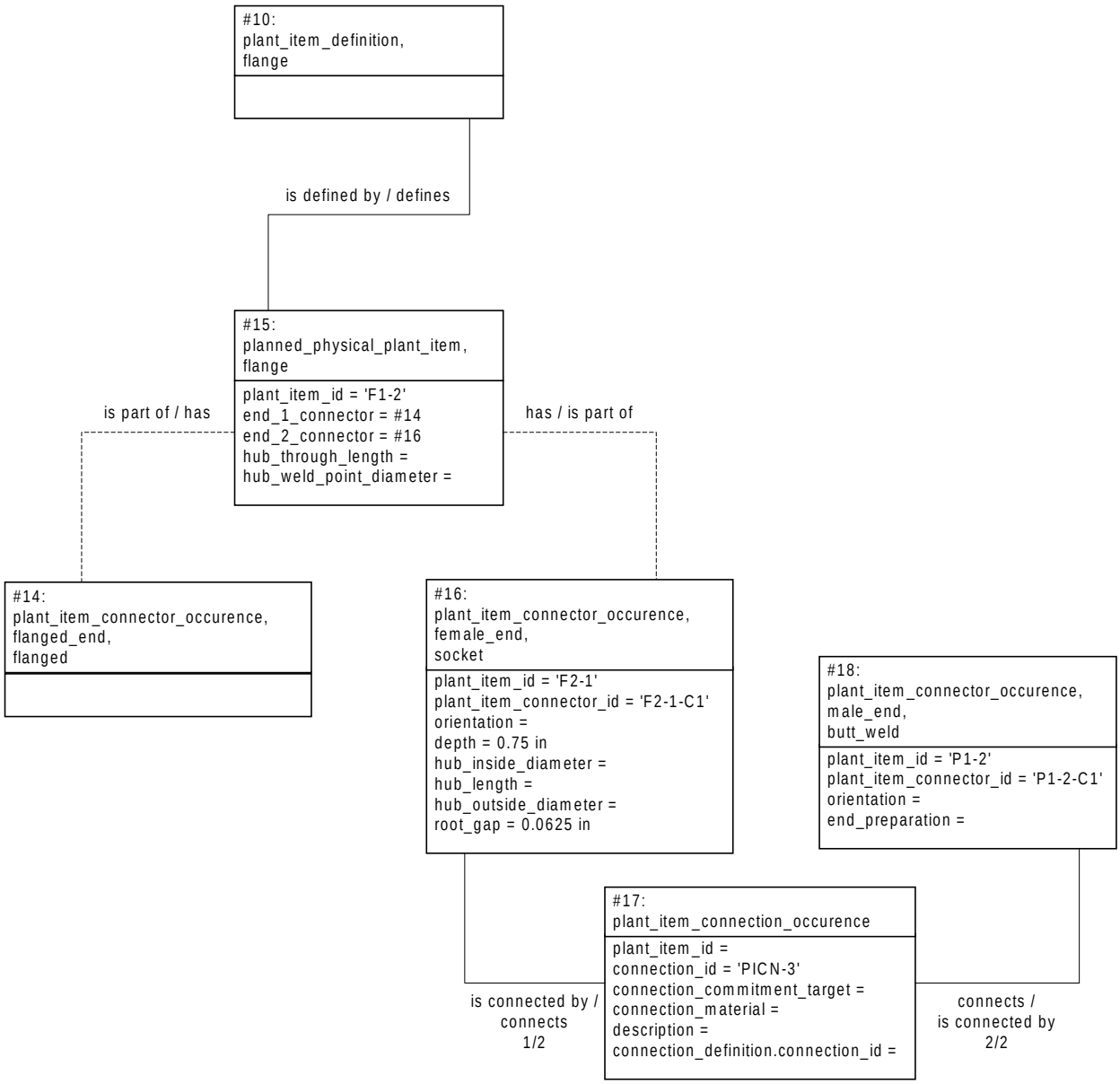

Figure 13 – Instance diagram for the Connections use case (4 of 11)

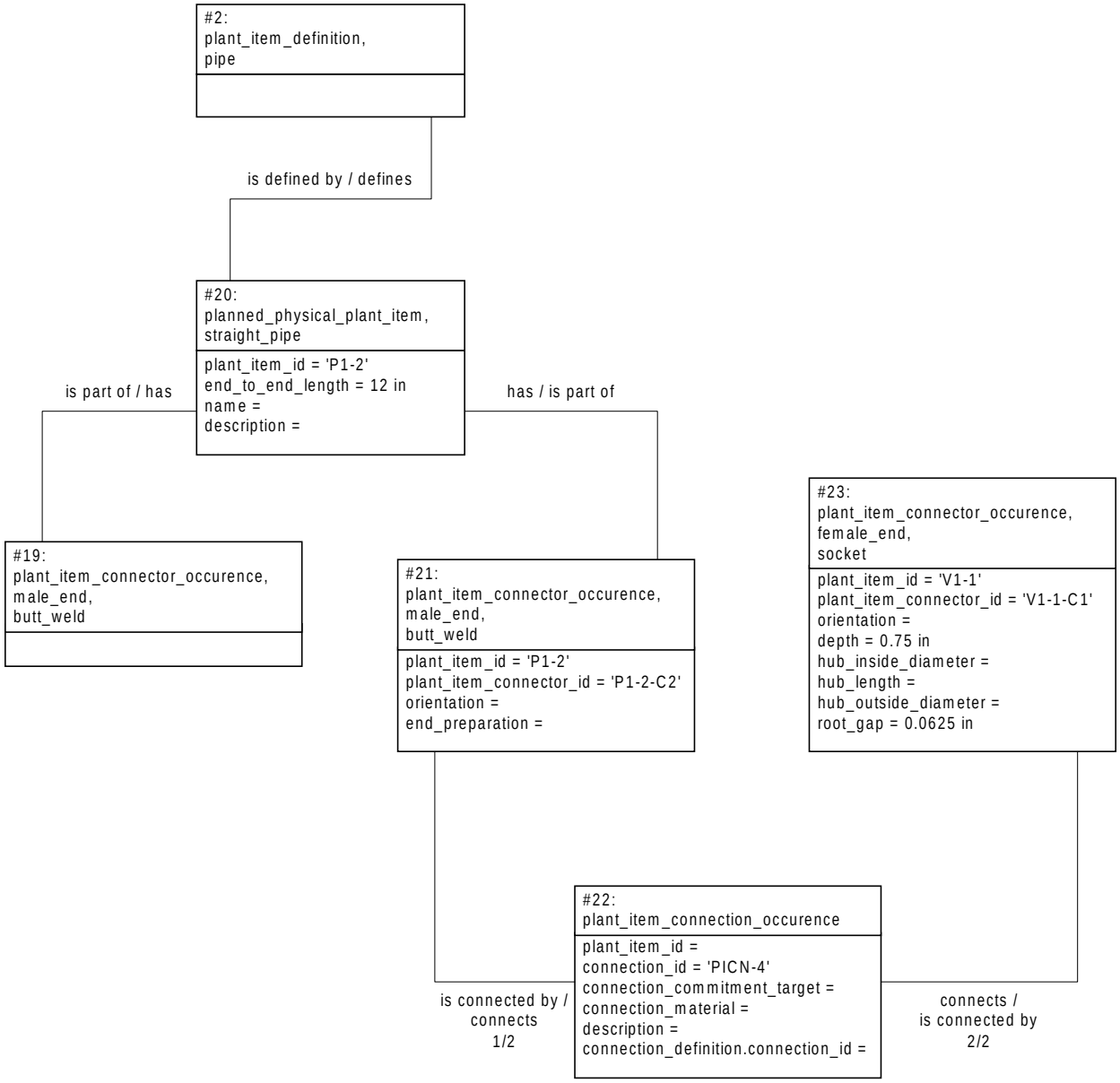

Figure 14 – Instance diagram for the Connections use case (5 of 11)

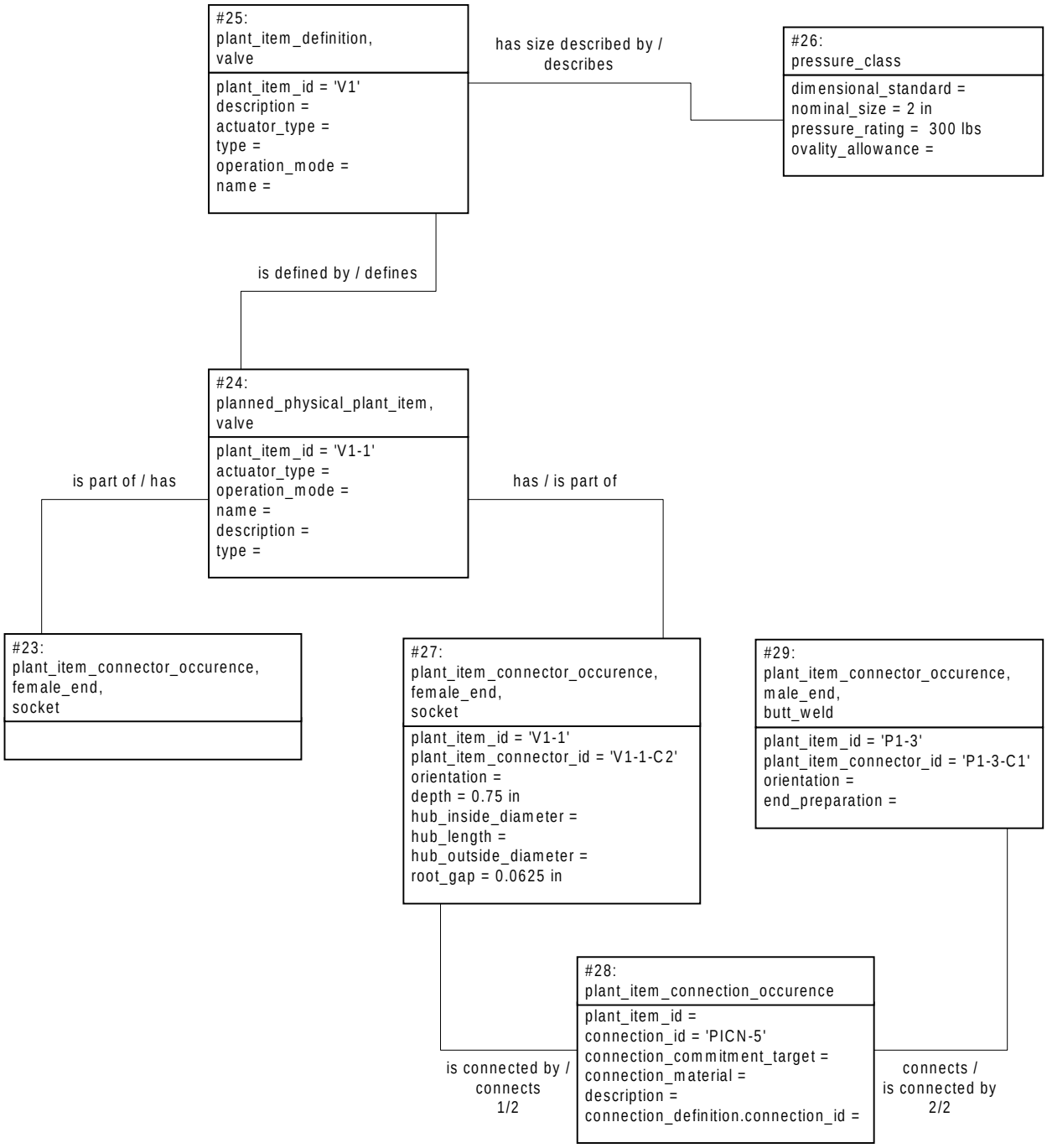

Figure 15 – Instance diagram for the Connections use case (6 of 11)

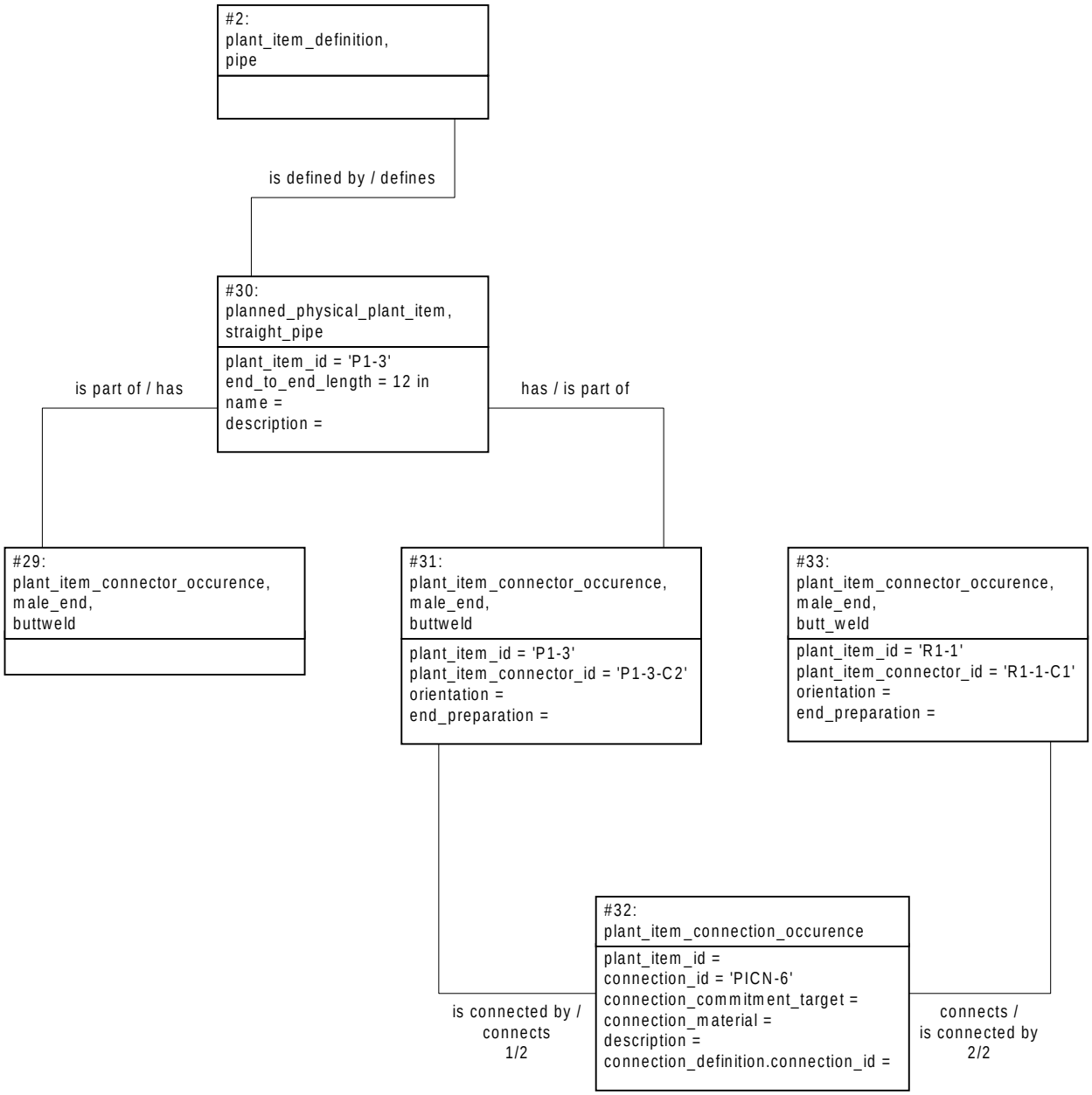

Figure 16 – Instance diagram for the Connections use case (7 of 11)

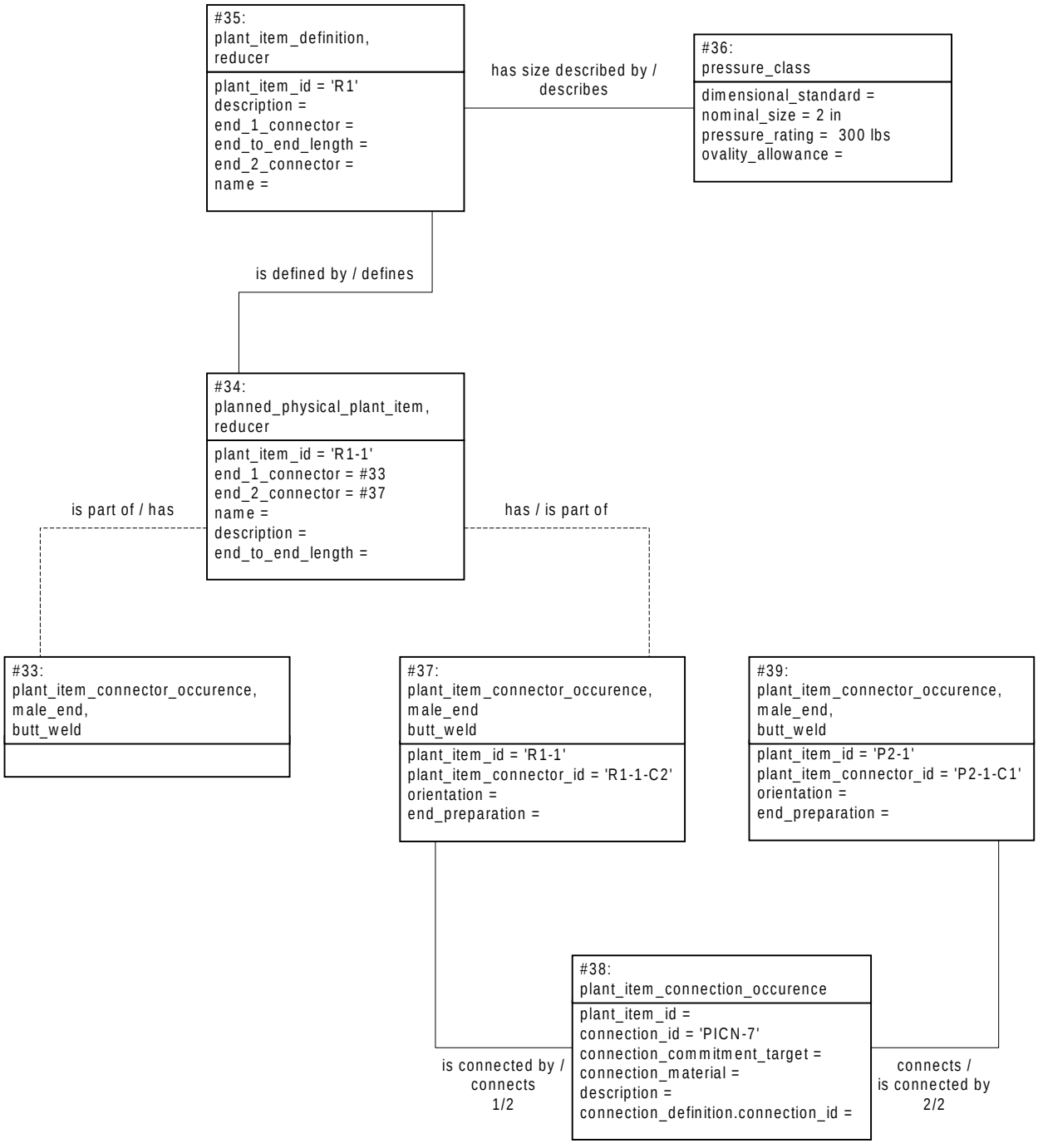

Figure 17 – Instance diagram for the Connections use case (8 of 11)

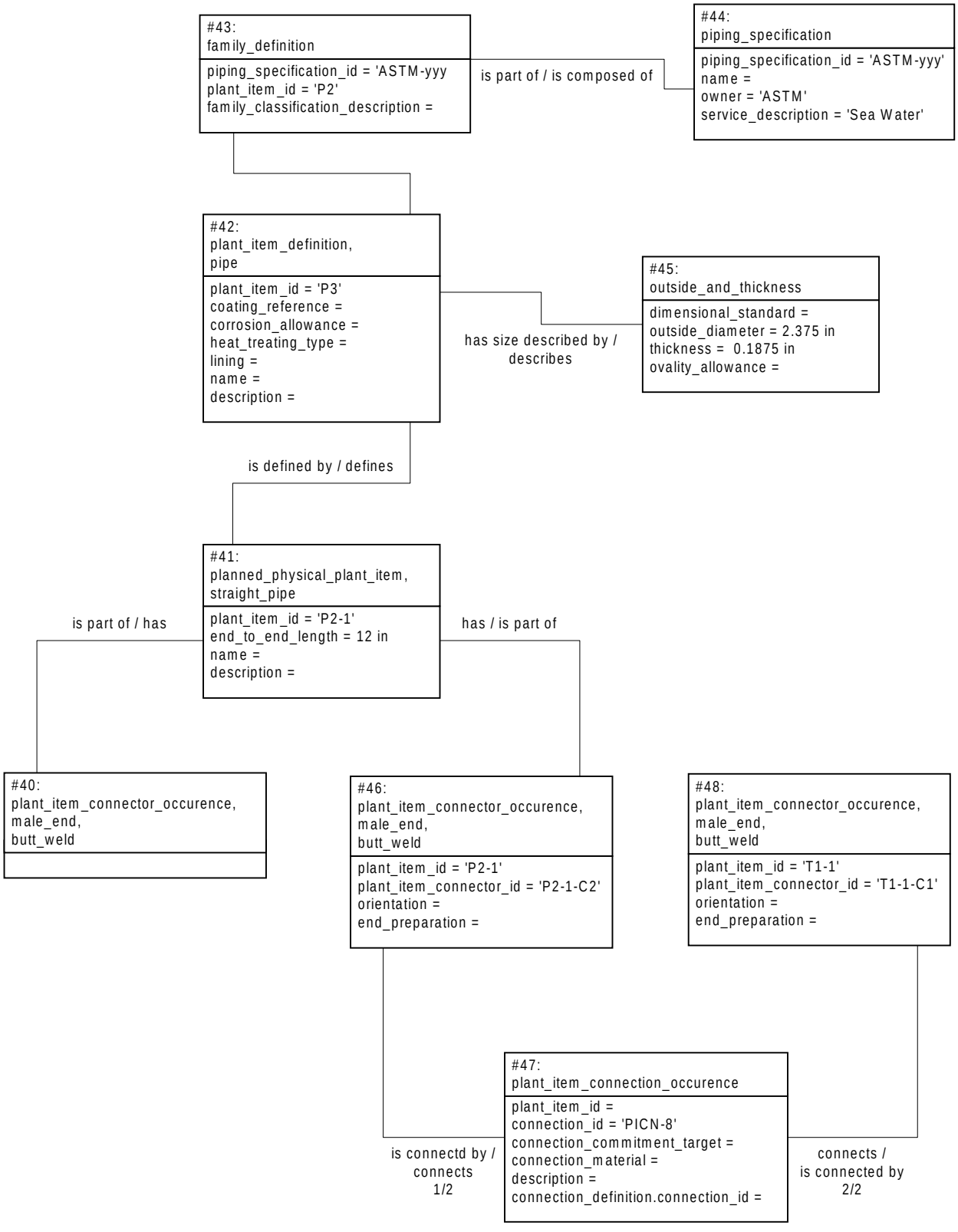

Figure 18 – Instance diagram for the Connections use case (9 of 11)

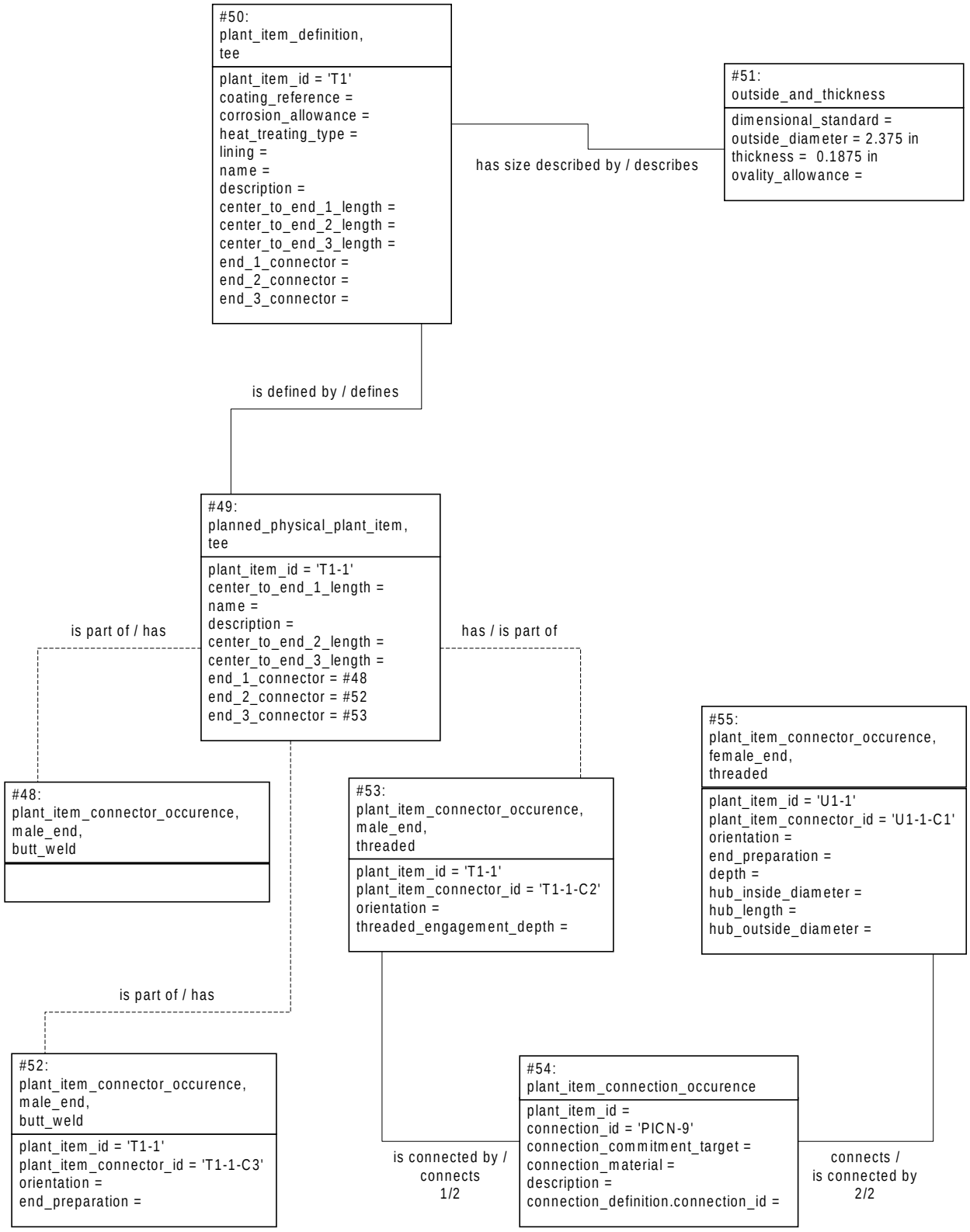

Figure 19 – Instance diagram for the Connections use case (10 of 11)

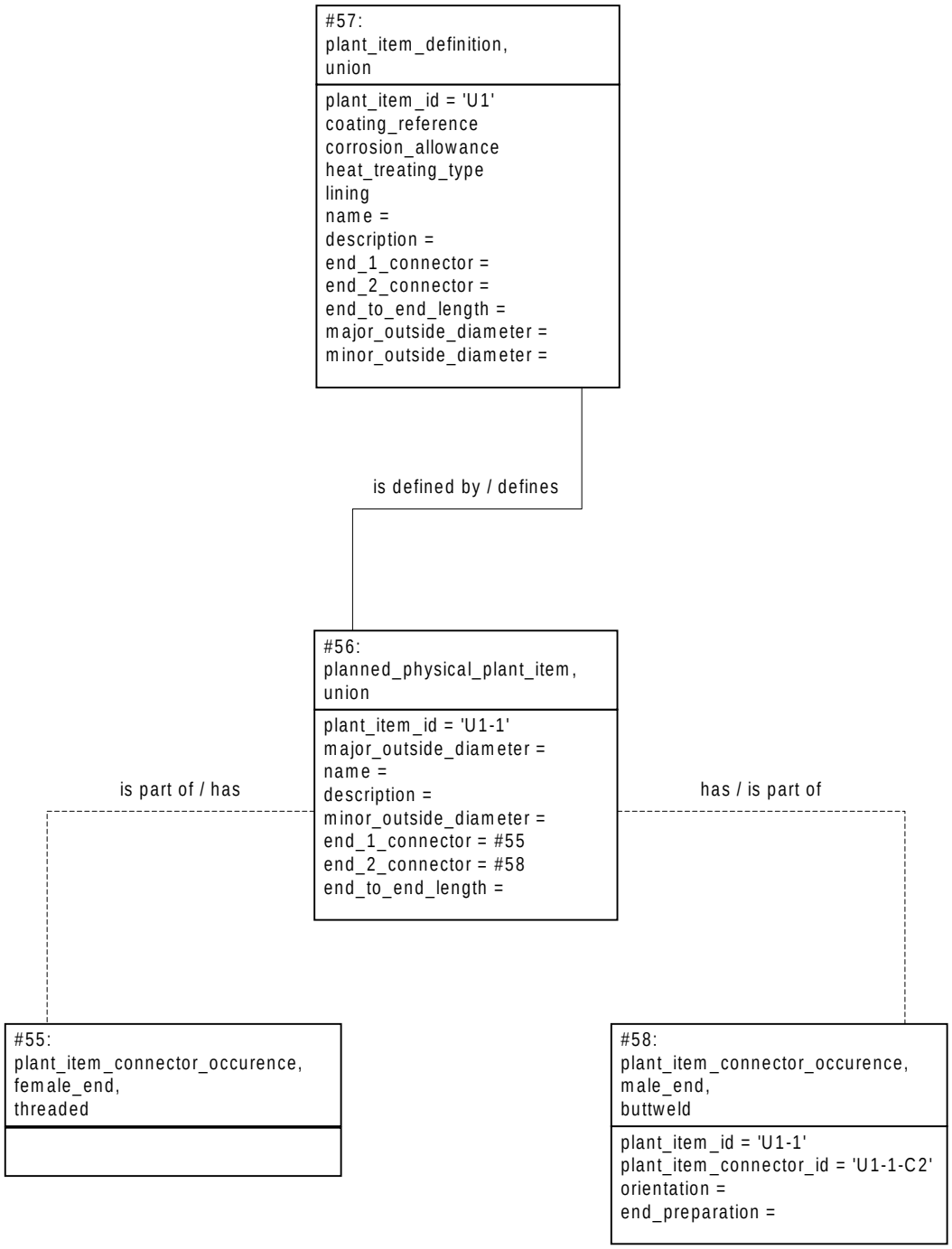

Figure 20 – Instance diagram for the Connections use case (11 of 11)

6.1.4.1 Representing a component

Pipe P1-1 is captured by a complex entity instance (#1) of the Planned_physical_plant_item and Straight_pipe AOs. ISO 10303-227:1999 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 10303-227:1999, 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, and 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 10303-227:1999 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 10303-227:1999 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.

6.1.4.2 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 labelled. 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 21, connectors are sequenced from left to right.

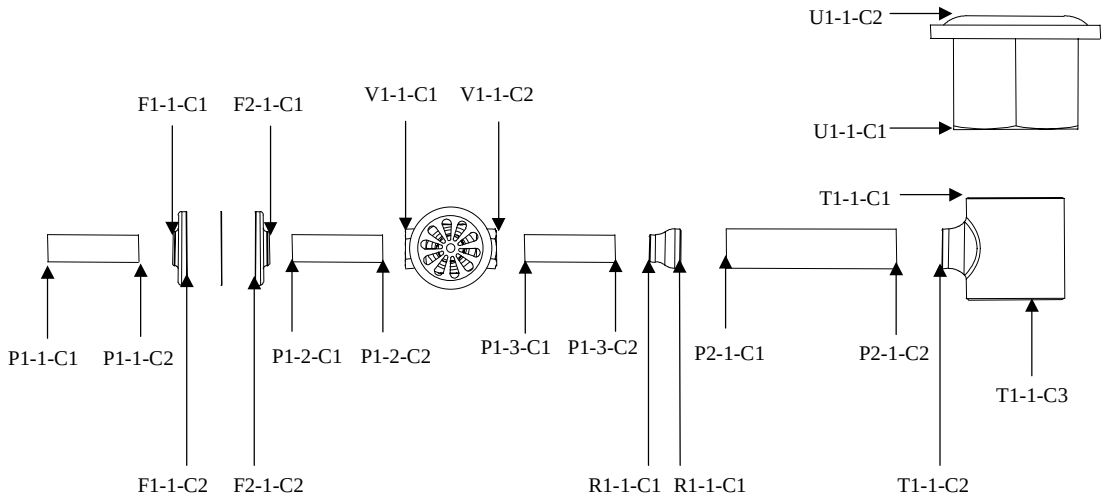

Figure 21 – Connections for the Connections use case

In ISO 10303-227:1999, 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 on 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 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 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 10303-227:1999 ARM, where relationships (pointers) to other AOs are generally not modeled as attributes. In ISO 10303-227:1999, 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 10303-227:1999 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 10303-227:1999.

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.

6.1.4.3 Representing the flanged connection with gasket

The connection between flanges F1-1 and F1-2 is a little different from the connections described in Clause 6.1.4.2 because of the introduction of a gasket G1-1 between the two flanges. G1-1 and its associated definition G1 are modelled like any other piping component, as described in Clause 6.1.4.1 (see Figure 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, 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 together.

6.1.5 Recommended practices

Capture loosely connected components using a Hierarchically_organized_collection.

Bibliography

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

NSRP 0424, NSRP piping application protocol, version 1.0, 1995-09-15.