NSRP 0426
SHIP HVAC
APPLICATION PROTOCOL

Version 2.1
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Foreword

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

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

This document is a usage guide for ISO 10303-227 (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 provides the ship industry with a useful mechanism for exchanging piping information.

Preparation of this document was a cooperative effort with the Defense Electronic Business Program Office at Defense Logistics Agency (DLA), Naval Sea Systems Command (NAVSEA), National Institute of Standards and Technology (NIST), Navy/Industry Digital Data Exchange Standards Committee (NIDDESC), National Shipbuilding Research Program Advanced Shipbuilding Enterprise (NSRP ASE) Evolution of STEP (ESTEP) project, and the Electronic Commerce Promotion Council of Japan (ECOM).

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 also is 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.

NOTE 2 ISO 10303-212 is being used in accordance with NSRP 0425 to represent ship electrical and cableway information.

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

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

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

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

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

NOTE 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 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, cableway, and heating, ventilation, and air conditioning (HVAC) data needed to support functional design, detail design, production engineering, fabrication, assembly, and testing.

ISO 13584

ISO 13854, PLIB, is a companion standard to STEP. Before a product model exchange can take place successfully, 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 for representing and exchanging product data about ship HVAC systems.

ISO 10303-227 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 also are included in this document.

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

Ship HVAC 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. NIDDESC specifications have served as input for the development of shipbuilding ISO 10303 application protocols.

The original intent was to make an ISO ship HVAC AP; however, that plan was abandoned in early 2000 and instead T23 began working with T20 to enable the use of ISO 10303-227 for ship HVAC 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 HVAC systems.

This document provides a series of ship HVAC test cases. Each test 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 Application Reference Model (ARM) and Application Interpreted Model (AIM). These test cases help to validate ISO 10303-227 as a vehicle for exchanging ship piping information, and can serve as a reference for someone who is implementing ISO 10303-227 for ship piping data exchange.

NOTE Because ISO 10303-227 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 test case is also informal.

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

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

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

— ESTEP program test data [1].

1 Scope

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

The following are within the scope of this document:

— recommended practices for exchanging ship HVAC information;

— test cases for representing ship HVAC information using ISO 10303-227.

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 HVAC models and ISO 10303-227;

— 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:—[1], *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 apply.

3.2 Abbreviations

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

[1] To be published. This is the second edition of ISO 10303-227.

AO	application object
AP	application protocol
ASTM	American Society for Testing and Materials
ATS	abstract test suite
AWG	American wire gauge
CPO	chief petty officer
CD	committee draft
cfm	cubic feet per minute
DIS	draft international standard
(E)	English
EDT	entity data type
FDIS	Final Draft International Standard
GUID	globally unambiguous identifier
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
PSIG	pounds per square inch gage
PWL	power level
SC	subcommittee
TC	technical committee
UoF	unit of functionality
WD	working draft

w.g.	inches of water

4 Overview of the AP

4.1 Scope of ISO 10303-227

ISO 10303-227 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 also are included in ISO 10303-227. 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 Definitions and occurrences

Within ISO 10303-227, a definition of a thing is a group of characteristics that apply to a set of similar things. An instance of an item is a planned or actual occurrence of that thing at a specific location in a spatial, functional, or other design.

EXAMPLE	A ship uses four pumps with the following characteristics: flow rate 100 gallons per minute, head 500 feet, temperature 200 ºF, pressure 200 pounds per square inch gage (PSIG). The pumps are located at the intakes to the primary 1, primary 2, secondary 1 and secondary 2 boilers. The common characteristics of the pumps (flow rate 100 GPM, etc.), can be captured by an instance of the appropriate definition Application Object (AO)—in this case, Plant_item_definition. The occurrences of the pump at the intakes to the four boilers can be captured by an instance of the appropriate instance AO—in this case, Plant_item_instance.

NOTE	The word “instance” has two different meanings in the above example. An instance of an AO is a member of the class of data objects defined by the AO. An instance of an item is a member of a class or set of similar items. An instance of the ISO 10303-227 Plant_item_definition AO is the data object that represents a definition of a set of similar items. An instance of the ISO 10303-227 Plant_item_instance AO is the data object that represents a member of that set (an instance of the item).

4.3 Complex instances

To fully classify an object using ISO 10303-227, 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 also may 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.

NOTE	Figures 1 and 2 are based on edition 1 of ISO 10303-227 [2]. Several additional subtypes have been added for edition 2.

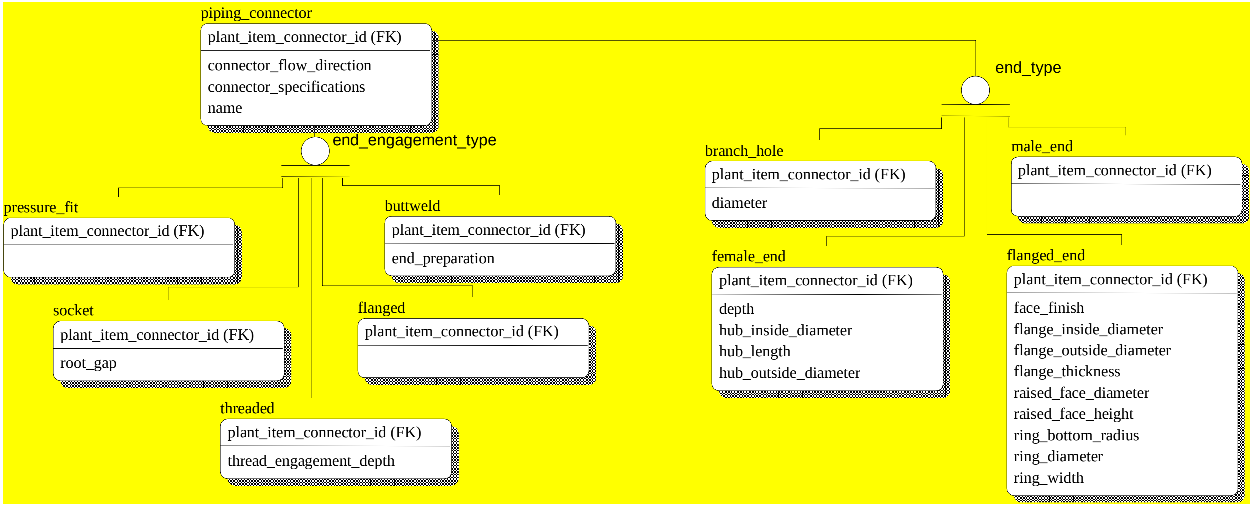

Figure 1 — Model of piping_connector using dual classification

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 (refer to 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.

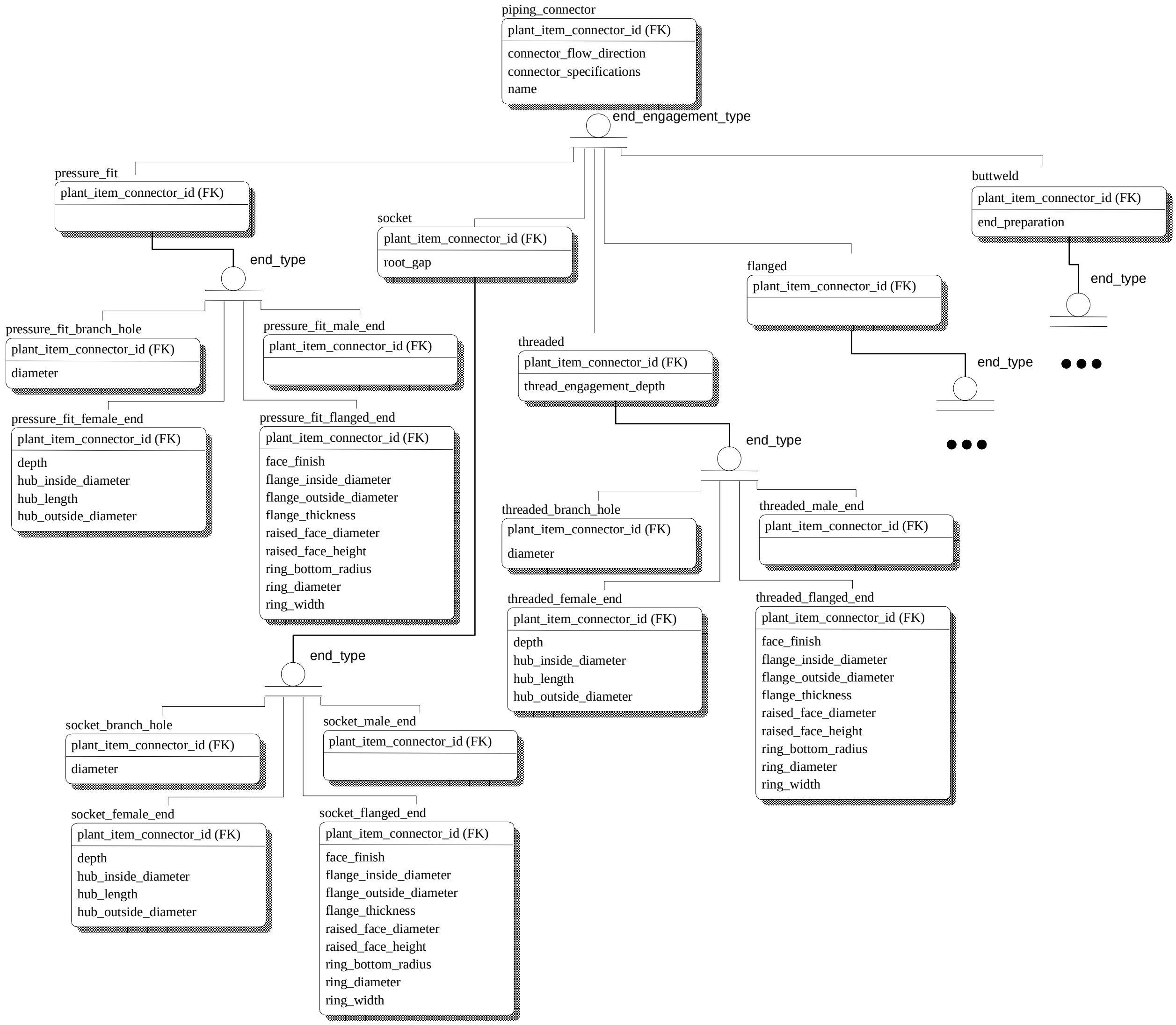

Figure 2 — Multiple classifications

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 instance.

EXAMPLE 3 A pressure-fit female end is characterized as a complex entity instance of the Pressure_fit and Femal_end AOs. That is, the instance simultaneously belongs to the class of pressure fit piping connectors and the class of female end piping connectors.

5 Conventions in this document

This clause provides the conventions that apply to this document.

5.1 Instance identification

Names of AOs begin with capital letters. If an AO name consists of more than one word, the words are separated by underscores. Names of AIM entity data types (EDTs) are given in boldface and are not capitalized.

EXAMPLE "Piping component" refers to the concept of a component of a piping system, independent of its computer representation; "Piping_component" refers the AO that represents that concept in the ISO 10303-227 ARM; and "**piping_component_class**" refers to an entity data type in the ISO 10303-227 AIM.

Instances of AOs are identified by "@*n*" where *n* is a positive integer. The number *m* is the "entity instance name" (see Clause 7.3.4 of ISO 10303-11:1994) corresponding to a line in the ARM physical file.

Instances of AIM EDTs are identified by "#*m*" where *m* is a positive integer. The number *m* is the entity instance name corresponding to a line in the AIM physical file.

AIM EDTs will be referenced, and the AIM physical files for test cases will be provided in a future version of this document.

An attribute *att* of an AO *Obj* may be referred to as *Obj.att* or as "the *att* attribute of the *Obj* AO."

5.2 Notation for ARM instance diagrams

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

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

NOTE 2 The diagram notation described in this clause is intended to be compatible with the IDEF1X modeling notation used in the ISO 10303-227 ARM. An EXPRESS version of the ISO 10303-227 ARM is attached to this document. The physical files for Annex A are based on the EXPRESS version of the ARM.

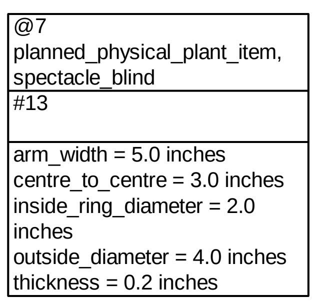

Figure 3 — Entity instance

An instance of an AO is shown as a box consisting of three smaller boxes, stacked vertically (refer to Figure 3). The upper box consists of:

— Line 1: the instance number of the object within the ARM population for the test case

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

The middle box consists of the entity instance name within the AIM physical file for the test case.

AIM instance names and the AIM physical files for test cases will be provided in a future version of this document. In the current version of this document, the middle box always will be blank.

NOTE 3 As defined in ISO 10303-21, the entity instance name consists of a pound sign ("#") followed by an unsigned integer.

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_item_connector_id of "PC1," a root_gap of 0.01 inch and a diameter of 2.1 inches is shown in Figure 4.

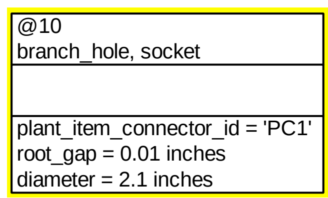

Figure 4 — Complex entity instance

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.

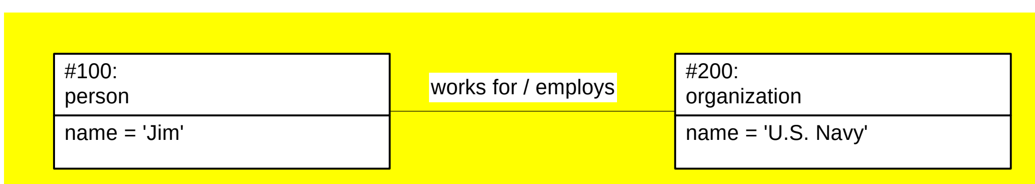

Figure 5 — Notation for relationship

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 (refer to Figure 6).

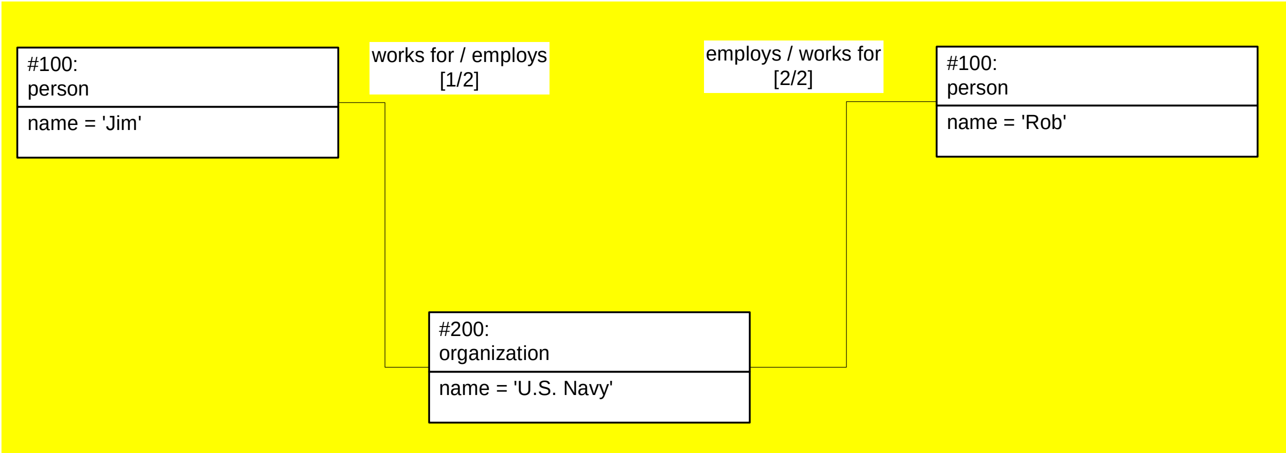

Figure 6 — Notation for relationships with multiple entities playing the same role

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

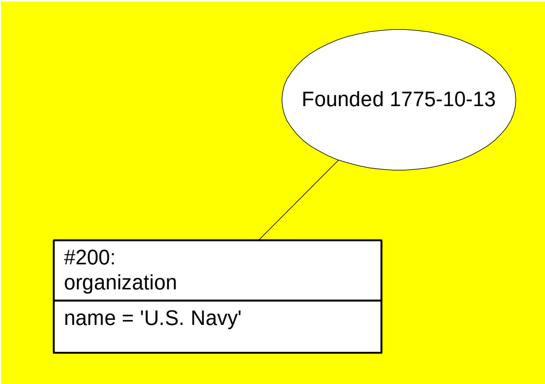

Figure 7 — Notes

EXAMPLE 3 Figure 8 contains a portion of the ISO 10303-227 ARM diagram showing the Site, Building, and Site_feature AOs. A site whose name is "Johnstown-Cambria County Airport," elevation is 696.2 metres, coordinates are 40.3161111 north latitude -78.8339444 west longitude, owners are the Johnstown Cambria County Airport Authority, and site identifier is "JST." The site contains the following buildings: Hangar 10, Hangar 12, the Terminal and the Control Tower. The airport has two runways: Runway 10/28 and Runway 5/23. Figure 9 shows the instance diagram to represent the aspects of the airport covered by the AOs in Figure 8.

NOTE 4 In fact, the airport has more buildings. There is no requirement that the physical file for a test case completely describes the real world; it need only be complete enough for the purpose of the test case. In addition, some details in the physical files may be omitted from the diagrams.

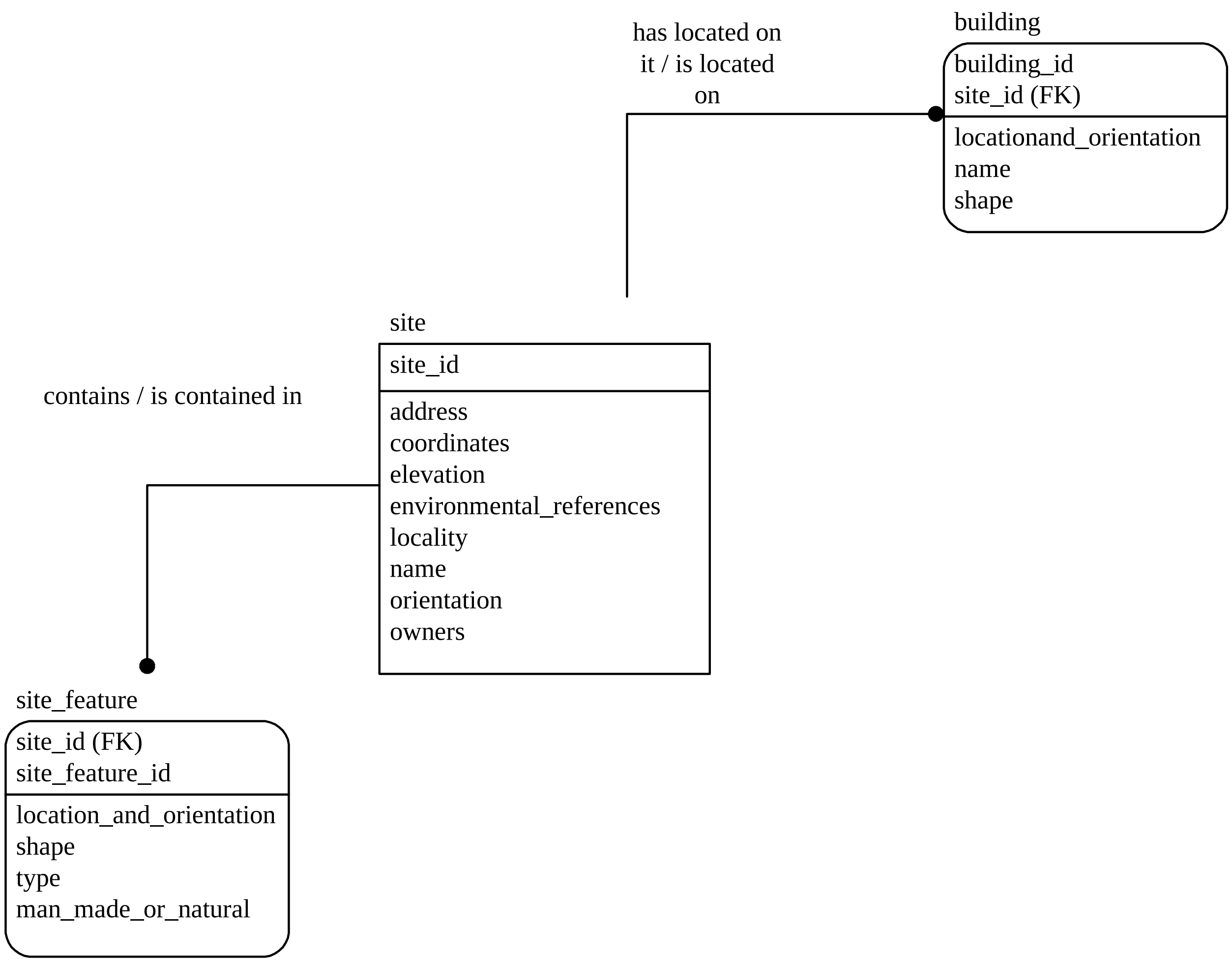

Figure 8 — Excerpt from ISO 10303-227 ARM with Site, Site_feature, and Building

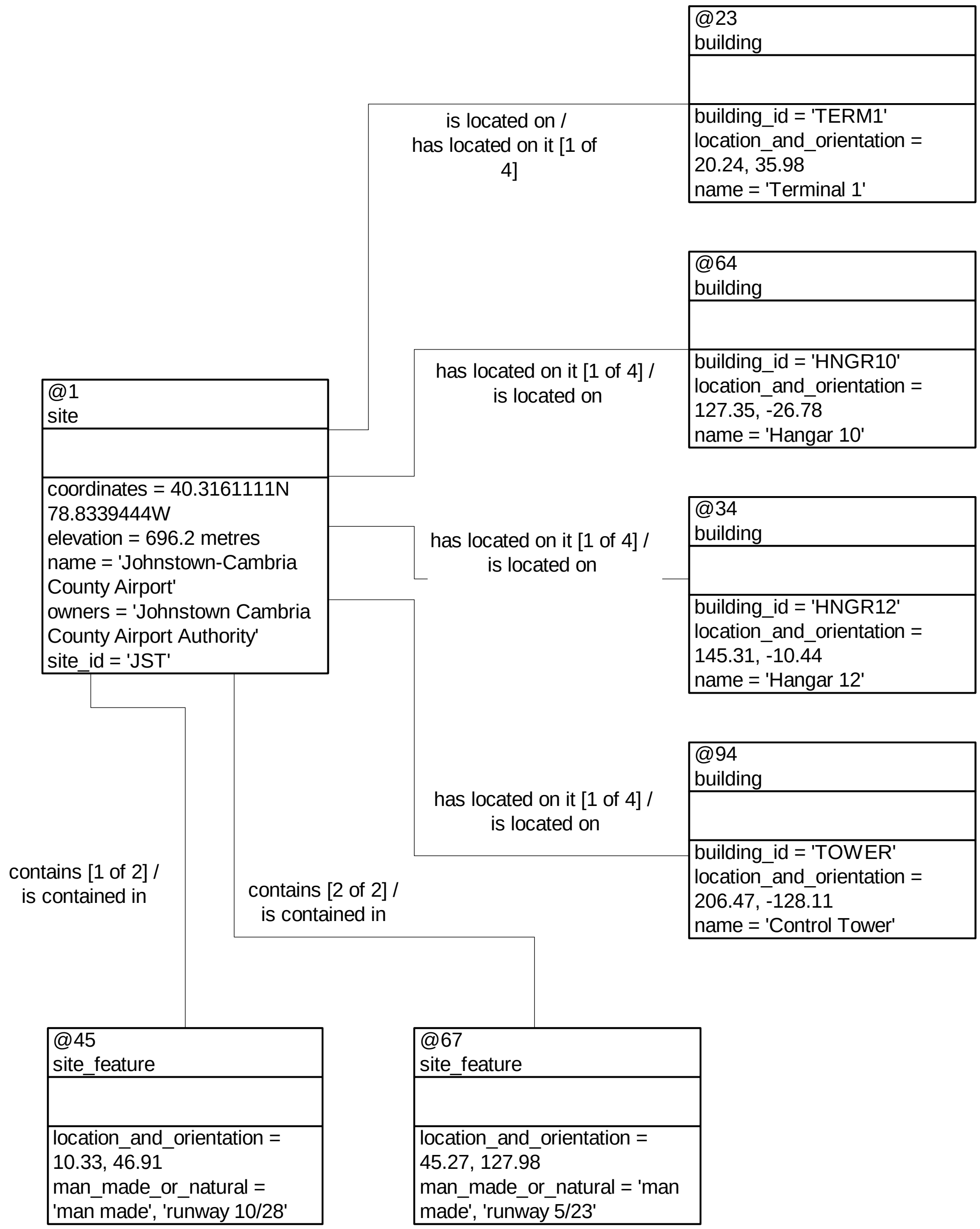

Figure 9 — Instance diagram for airport example

6 Recommended practices

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

Annex A
(informative)

Usage guide

A.1 Technical discussion

A.1.1 Use of external catalogues

A key feature of this AP is its reliance on the availability of external (to the transfer dataset) component catalogs. Entries in these catalogs carry the vast majority of component descriptive information including the specification of component geometric representation. An occurrence of a component contained in the transfer data set described by this AP almost exclusively will refer ("point") to an external catalog entry for its definition.

Thus, such catalogs must be available on both the sending and receiving site systems for the transfer to be effective. ISO 10303-227 does not specify the content or format of external catalogues. It supports the use of both ISO 13584-format parts libraries and ISO 15926-format reference data libraries.

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 (refer to Figure A.1).

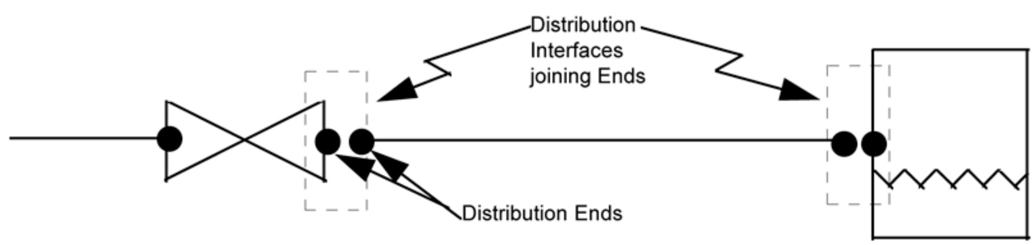

Figure A.1 — Network connectivity

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 (refer to Figure A.2). Attachments are not used in establishing network connectivity.

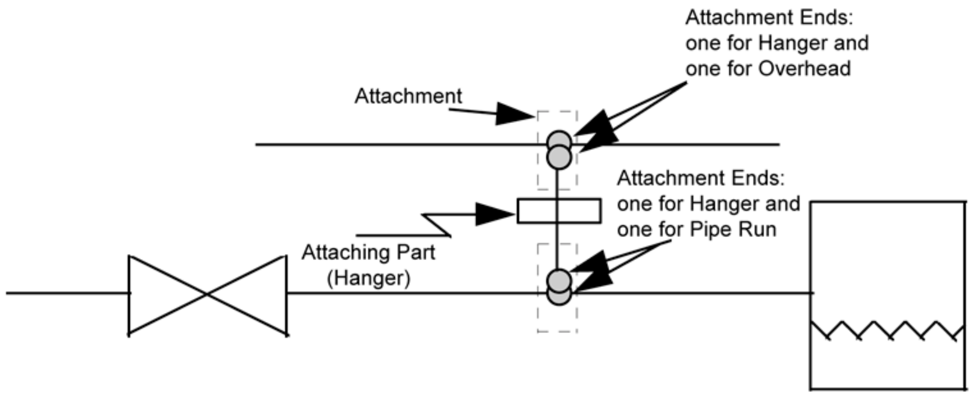

Figure A.2 — Attachment connectivity

A.1.3 External references

Transfers of product model data invariably involve references to objects not present in the transferred model. This AP handles three types of such references. 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 a piece of 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.1.4 Noise analysis

This clause provides an overview of the data requirements for calculating noise level in a compartment at an early stage of ship design. For more information, see references [6] to [10].

The noise level for a compartment is calculated from the following data:

— Compartment dimensions
- o Height
- o Length
- o Width

— Room constant

— Noise contribution
- o Contribution from sources in the room
- o HVAC contribution
- o Structureborne contribution
- o Contribution from adjacent compartments

The room constant is equal to the equivalent square meter area of a perfectly absorbing surface. The room constant and noise contributions are vectors of values, giving octave band sound pressure levels at frequencies 31.5, 63, 125, 250, 500, 1000, 2000, 4000 and 8000 hertz.

For the purposes of this usage guide, only the HVAC and ship arrangement contributions will be considered.

A.1.4.1 Ship arrangement contribution

The ship arrangement model contains the following information necessary for a noise analysis:

— relationships with adjacent compartments;

— characteristics of the compartment;
- a. size;
- b. shape;
- c. noise category.

A.1.4.2 HVAC contribution

The HVAC contribution consists of the following components:

— HVAC duct breakout power level (PWL)

— HVAC duct opening PWL

HVAC duct breakout PWL measures the power level of sound energy transmitted through the walls of the HVAC ducts into the compartment being analyzed. HVAC duct opening PWL measures the power level of sound energy transmitted through duct openings into the compartment being analyzed.

For the purposes of the analysis, HVAC noise originates from the following sources:

— fans;

— duct turn flow;

— branch points;

— diffuser flow;

— damper flow.

NOTE In the following, typical units metric and English are given in parentheses after each item.

The noise generated by air flow through a diffuser depends on:

— pressure loss at the diffuser (Pa or in H_2O);

— surface area (M^2 or ft^2);

— volume flow rate (L/s or cfm);

— diffuser configuration.

The noise generated by air flow through a turn depends on:

— cross sectional area (M^2 or ft^2);

— volume flow rate (L/s or cfm);

— radius of curvature (mm or in);

The noise generated by air flow at a branch depends on:

— branch cross sectional area (M^2 or ft^2);

— branch volume flow rate (L/s or cfm);

— main cross sectional area (M^2 or ft^2);

— main volume flow rate (L/s or cfm);

— radius of curvature (mm or in);

— turn/junction type.

The noise generated by air flow through a damper depends on:

— volume flow rate (L/s or cfm);

— cross sectional area (M^2 or ft^2);

— pressure loss at the damper (Pa or in H_2O);

— duct height normal to damper axis;

— damper blade type.

HVAC noise is attenuated, by varying amounts, as it flows through the ducting system. Separate formulas are used to calculate the attenuation for each type of component. Typical components are:

— straight sections;

— turns;

— branches;

— splitters.

The designer can increase the sound attenuation of the ducting system by specifying that it be lined with sound-absorbent material.

A.2 Implementation agreements

Figure A.3 shows the table of contents of a typical implementation agreement.

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    - 3.7.4 Part 21 File Header
    - 3.7.5 Parts Library
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Figure A.3 — 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 Test cases

A.3.1 HVAC Functional and Spatial

A.3.1.1 Purpose

This clause describes the use of ISO 10303-227 to exchange the functional and spatial characteristics of HVAC components as well as their connectivity.

A.3.1.2 Exchange context

The context for this test case is the exchange of HVAC configuration information between an HVAC engineer and an installer.

A.3.1.3 Test data

Figure A.4 shows a portion of an HVAC system that will serve as the basis for this test case. The HVAC system and its components were chosen to demonstrate the capture of cylindrical and rectangular components, their functional characteristics, their spatial arrangement, and their functional and spatial interconnection.

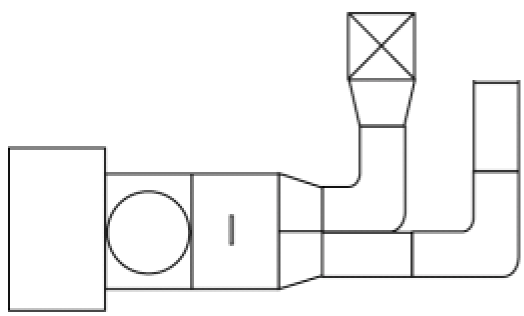

Figure A.4 — Portion of an HVAC system for the HVAC Functional and Spatial test case

The component types included in this example are diffusers, dampers, ducting, ducting elbows, flow control devices, ducting transitions, air condensers, and duct heaters. Figure A.5 shows the components of the system with labels attached. Table A.1 gives the labels, types and attributes for the components.

Damper DAM-001 fits inside duct DUCT-007, and is installed through a rectangular hole cut in the side of the duct.

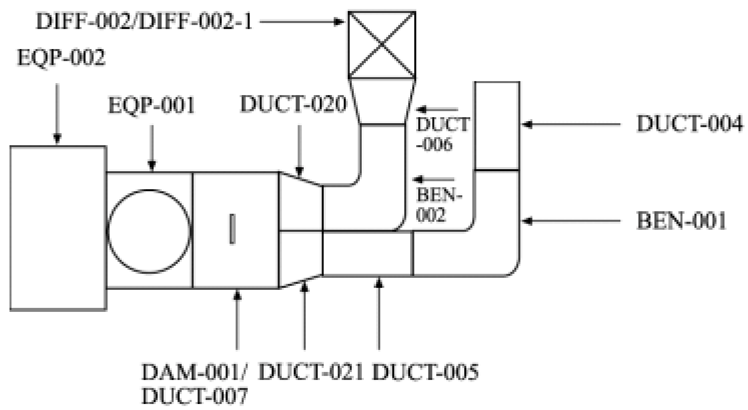

Figure A.5 — HVAC system with components labeled

Table A.1 — Components for the HVAC Functional and Spatial test case

Label	**Type**	**Attributes**
DUCT-004	ducting	cylindrical 6” spool
BEN-001	bend	cylindrical 6” spool bend
DUCT-005	ducting	cylindrical 6” spool
BEN-002	bend	cylindrical 6” spool bend
DUCT-006	transition	rectangular 12” to cylindrical 6”
DIFF-002	diffuser	9” x 9” diffuser with a damper
DIFF-002-1	damper	rectangular
DUCT-020	transition	rectangular 12” to cylindrical 6”
DUCT-021	transition	rectangular 12” to cylindrical 6”
DAM-001	control damper	damper 3/8” axle
DUCT-007	ducting	rectangular duct with damper 12” x 4”
EQP-001	air cooling condenser	8” air cooling condenser
EQP-002	duct heater	12” x 6” 35kW

A.3.1.4 ARM representation

Figures A.9 to A.24 contain the instance diagrams for this test case.

An HVAC system can be represented in ISO 10303-227 through a functional description and/or a physical description. In this test case, functional and physical descriptions are presented. The functional description is given in Figures A.9 to A.11. The physical description is given in Figures A.12 to A.24.

NOTE Some properties, such as flow rate, can be specified in either the functional or physical model. In this test case, the flow rate of 160 cfm is specified in both the functional and physical models.

A.3.1.4.1 Representing components

Duct DUCT-004 is captured by an instance (@6) of the Hvac_ducting application object (see Figure A.12). Each instance representing a component has associated with it an instance of the Physical_design_view AO. The location of duct DUCT-004 is represented by an instance (@306) of the Location_in_plant AO (see Figure A.22). Its geometry is represented by a complex instance of the Detail_shape and Hybrid_shape_representation AOs.

The other components in this test case are represented similarly.

Duct DUCT-007 has damper DAM-001 installed inside, and thus acts as a flow control device. However, it also has the characteristics of a duct. Therefore, the combination of DUCT-007 and DAM-001 is represented by a complex entity instance (@16) of the Hvac_ducting, Hvac_flow_control_device, and Planned_physical_plant_item AOs (see Figure A.15).

NOTE Damper DAM-001 is not captured as a separate plant item in this model. If it were desired to capture DAM-001 as a separate plant item (e.g., to specify its geometry, location, or a reference to a catalog item), then the DAM-001/DUCT-007 combination would be represented as an assembly using instances of the Connected_collection AO to relate the subassemblies (DAM-001 and DUCT-001) to the superassembly (the DAM-001/DUCT-007 combination).

A.3.1.4.2 Representing connections

Figures A.6 and A.7 show the components for this test case, with connectors labeled.

Connector DUCT-004-C2 is captured by a complex entity instance (@80) of the Physical_connector and Hvac_connector AOs (see Figure A.16). According to ISO 10303-227, a Physical_connector is a type of Plant_item_connector_occurrence that represents the physical aspects of the Plant_item_connector_occurrence.

BEN-001-C1 is captured by a complex entity instance (@81) of the Physical_connector and Hvac_connector AOs.

The connection between DUCT-004-C2 and BEN-001-C1 is captured by an instance (@110) of the Plant_item_connection_occurrence AO.

The remaining connectors and connections in this test case are represented similarly.

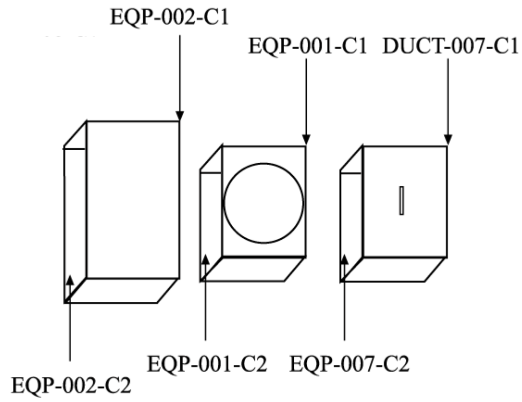

Figure A.6 — Connections for the HVAC Functional and Spatial test case (1 of 2)

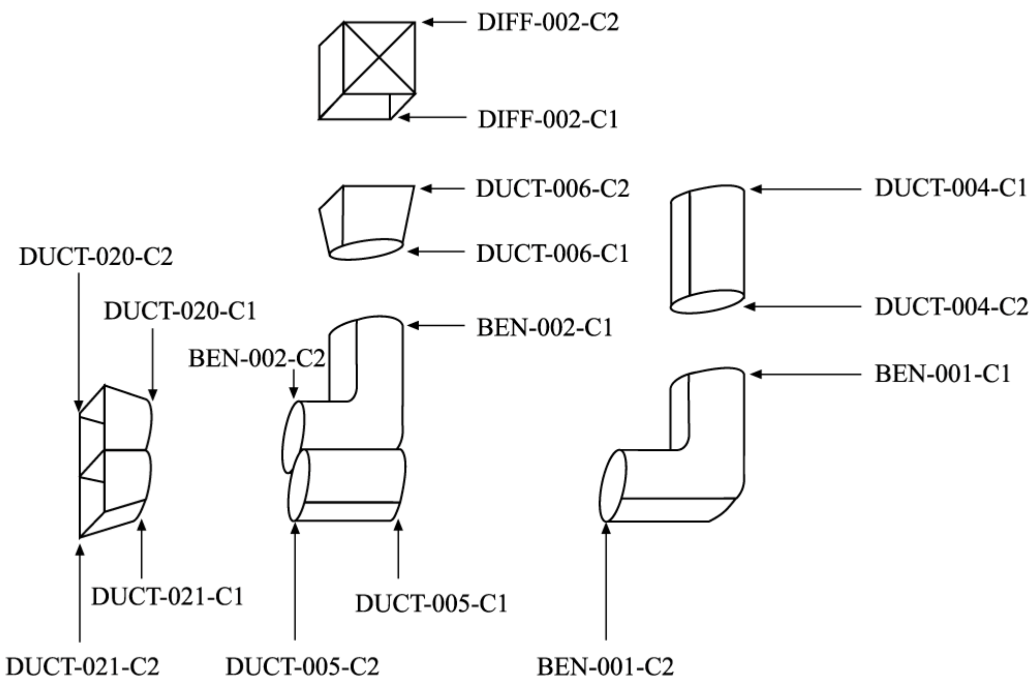

Figure A.7 — Connections for the HVAC Functional and Spatial test case (2 of 2)

A.3.1.4.2 Functional characteristics

A functional representation involves a functional description of the system. To functionally describe a system, functional entities are used. Hvac_run and Hvac_section are considered functional entities.

The system in this test case is broken into sections as a part of the functional design. There are three sections in this test case. Each of these sections has two terminations. A termination is the point where one section ends and another begins. Figure A.8 shows a schematic drawing of the HVAC system with labels indicating the sections and terminations contained in the system.

The HVAC configuration in this test case is represented by an instance (@39) of Hvac_run. This instance of Hvac_run has three instances (@40, @41, @42) of Hvac_section AO (see Figure A.9).

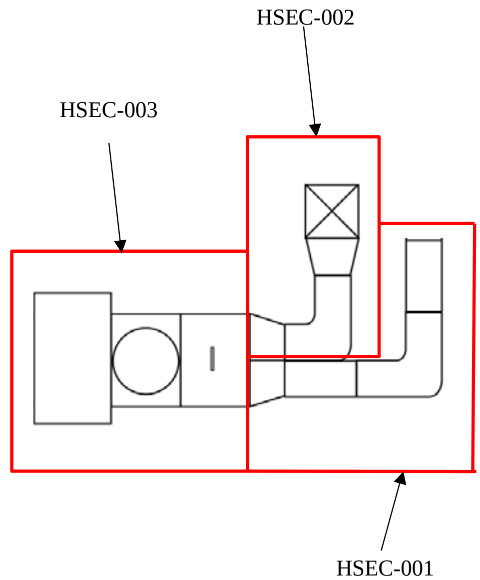

Figure A.8 — HVAC system sections and terminations

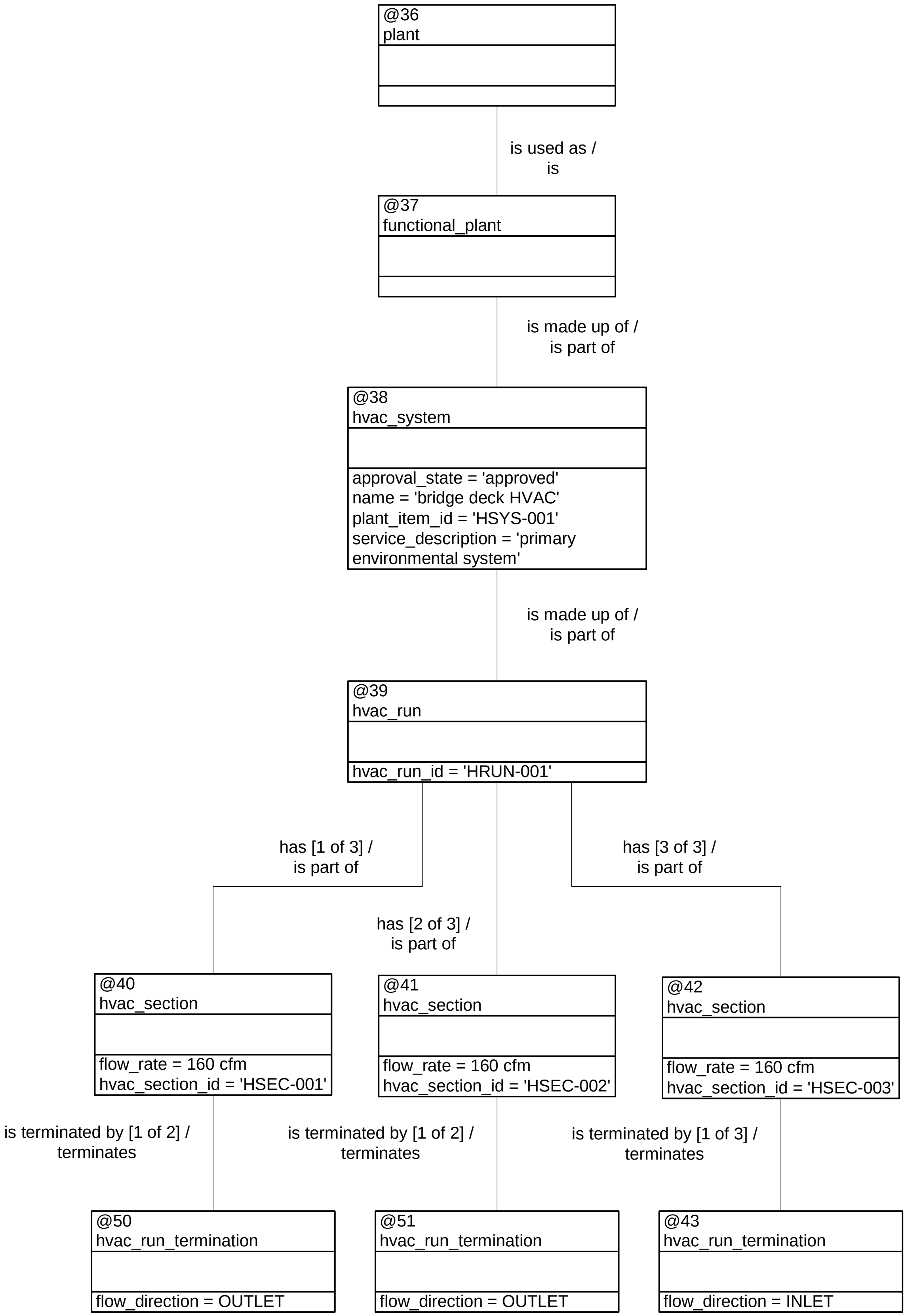

Figure A.9 — Instance diagram for the HVAC Functional and Spatial test case (1 of 16)

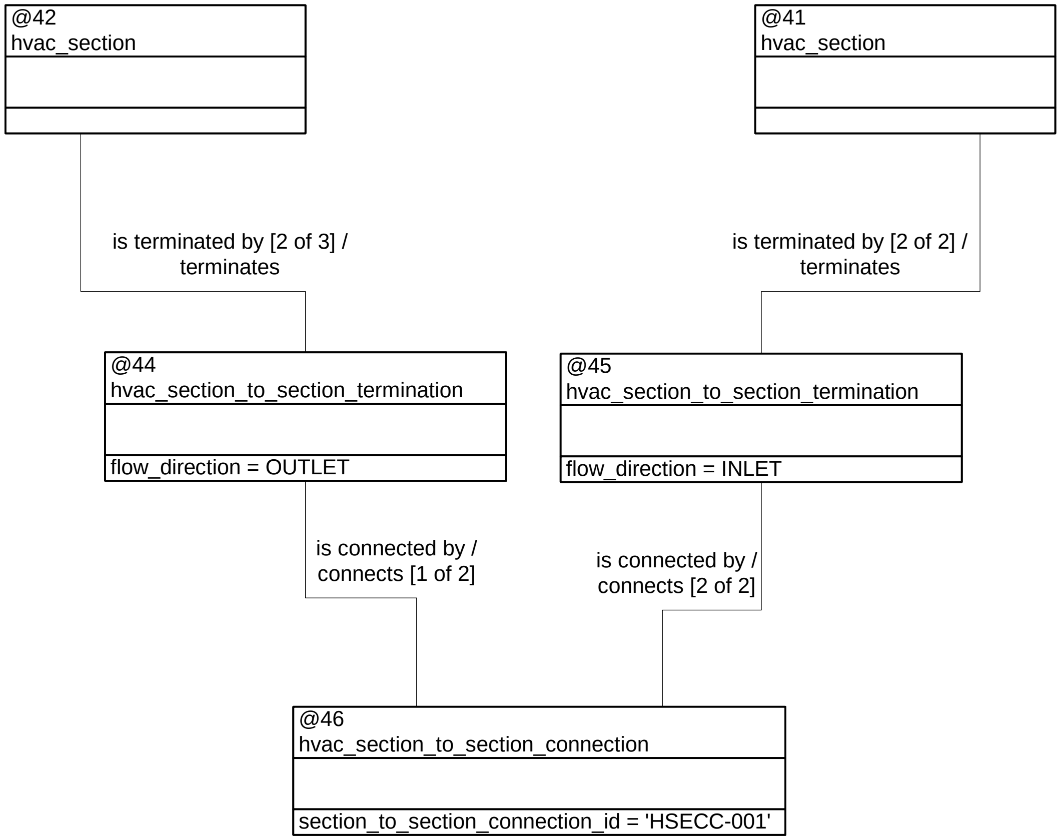

Figure A.10 — Instance diagram for the HVAC Functional and Spatial test case (2 of 16)

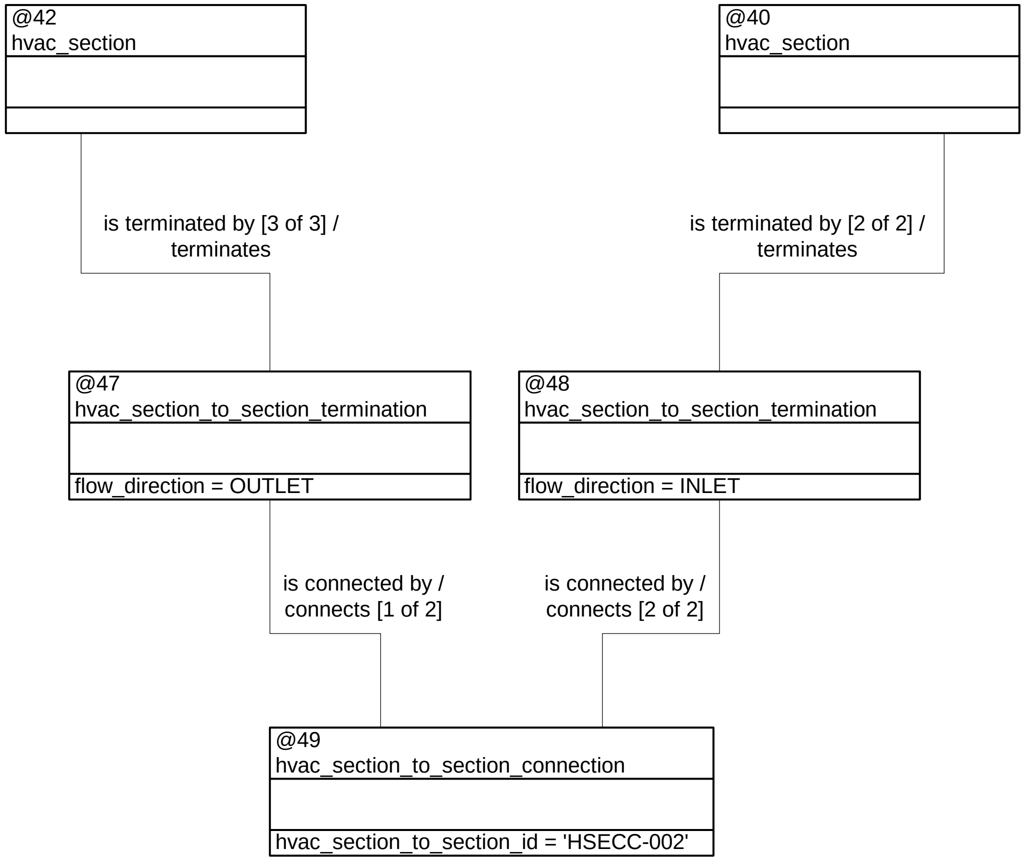

Figure A.11 — Instance diagram for the HVAC Functional and Spatial test case (3 of 16)

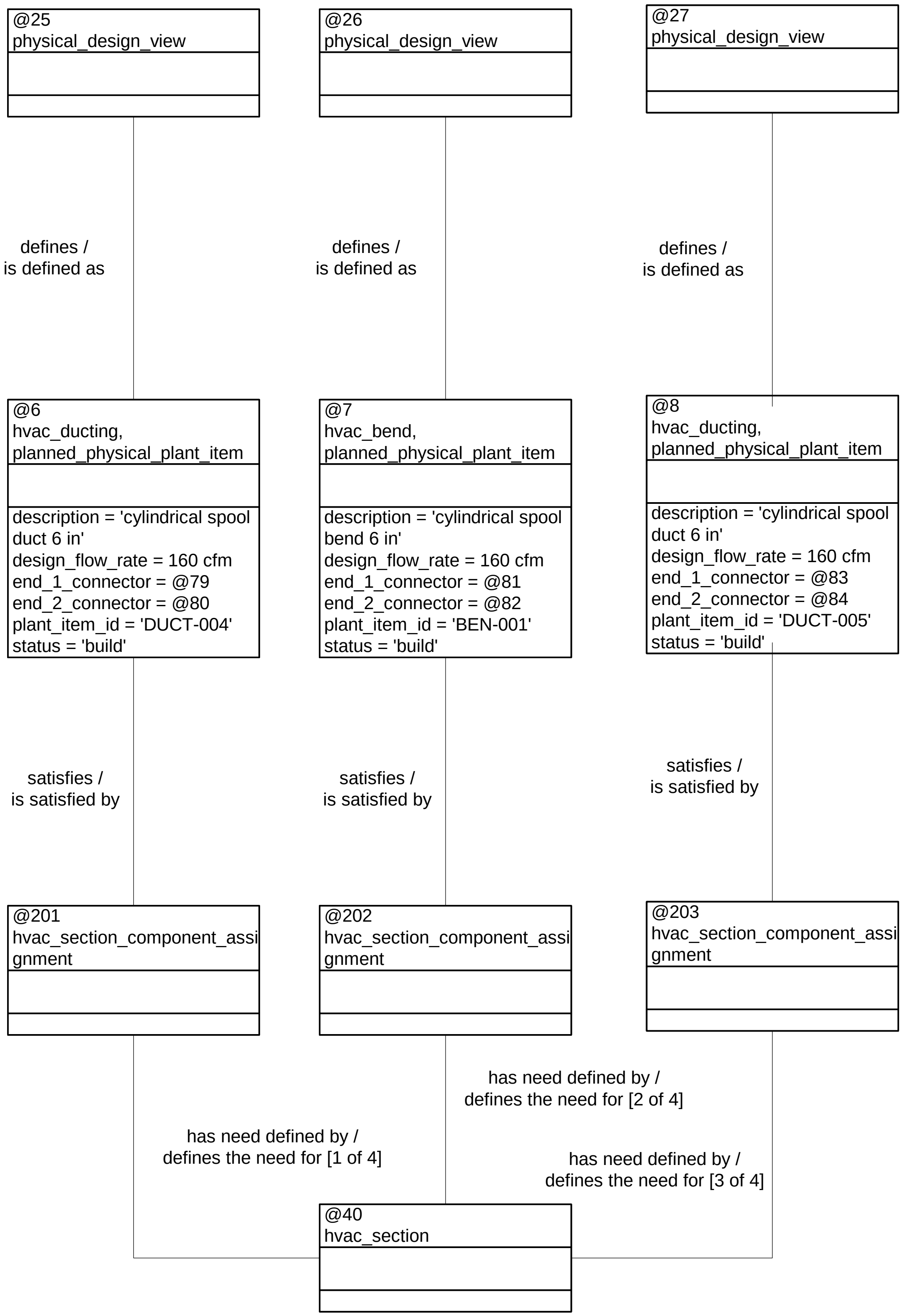

Figure A.12 — Instance diagram for the HVAC Functional and Spatial test case (4 of 16)

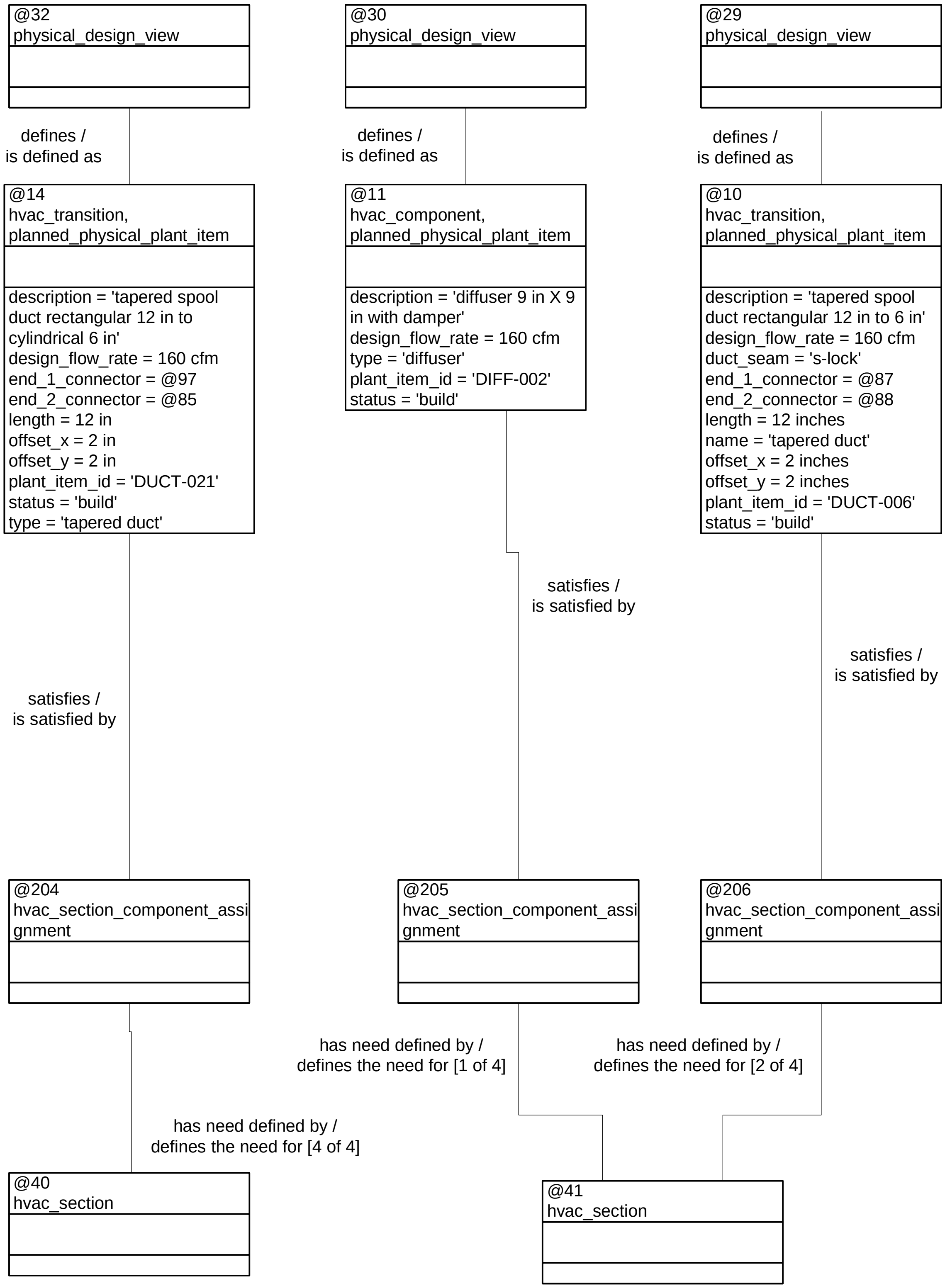

Figure A.13 — Instance diagram for the HVAC Functional and Spatial test case (5 of 16)

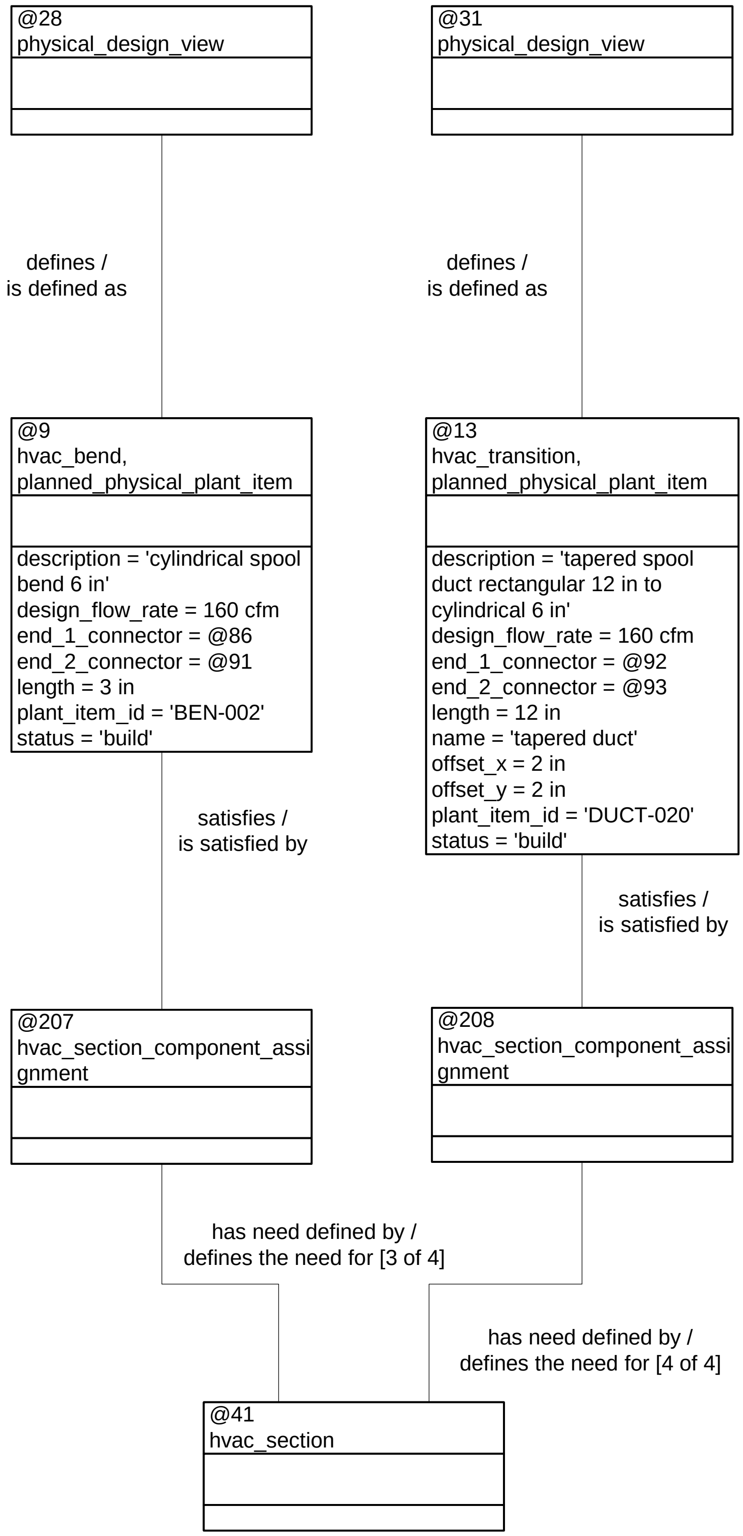

Figure A.14 — Instance diagram for the HVAC Functional and Spatial test case (6 of 16)

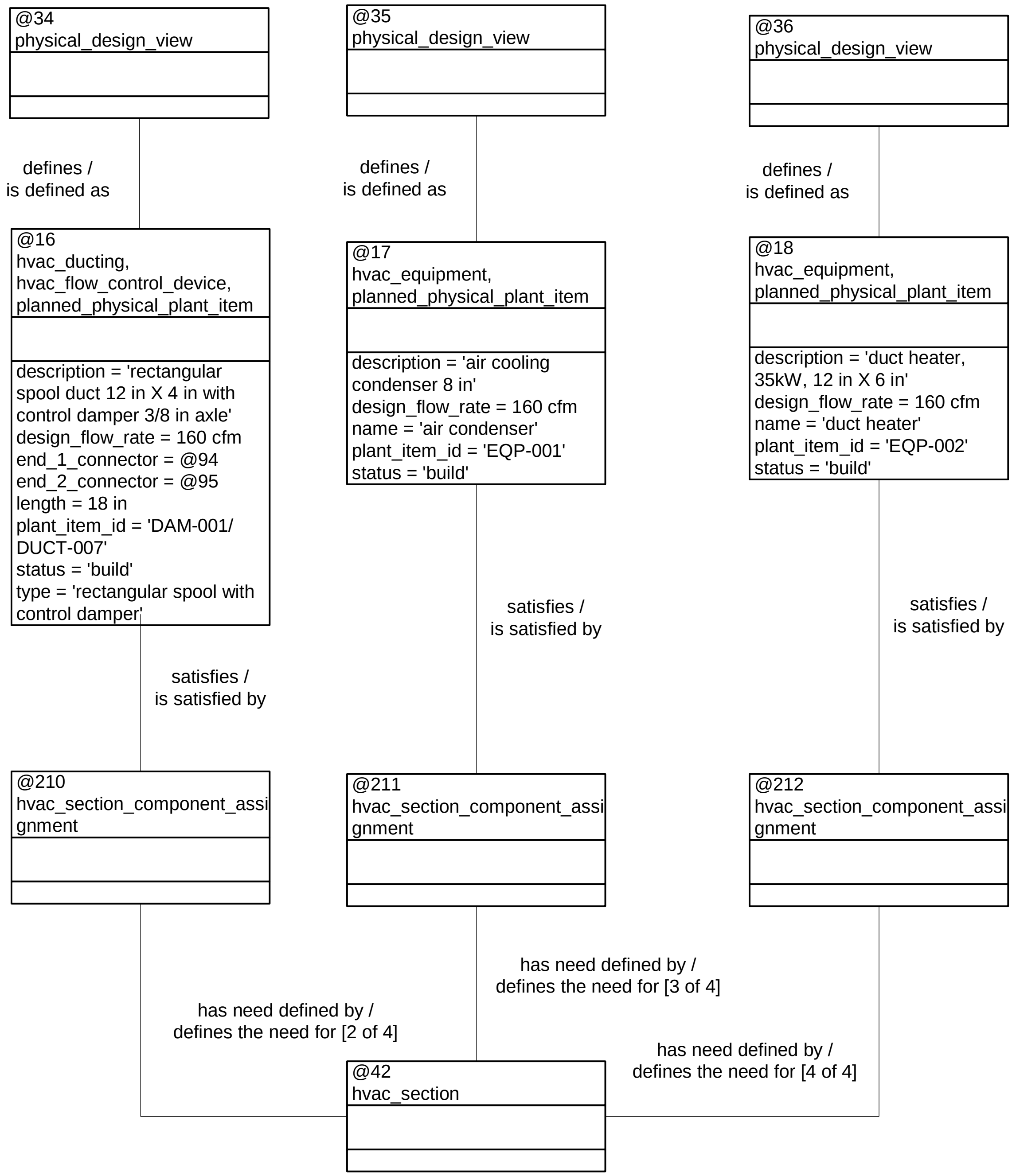

Figure A.15 — Instance diagram for the HVAC Functional and Spatial test case (7 of 16)

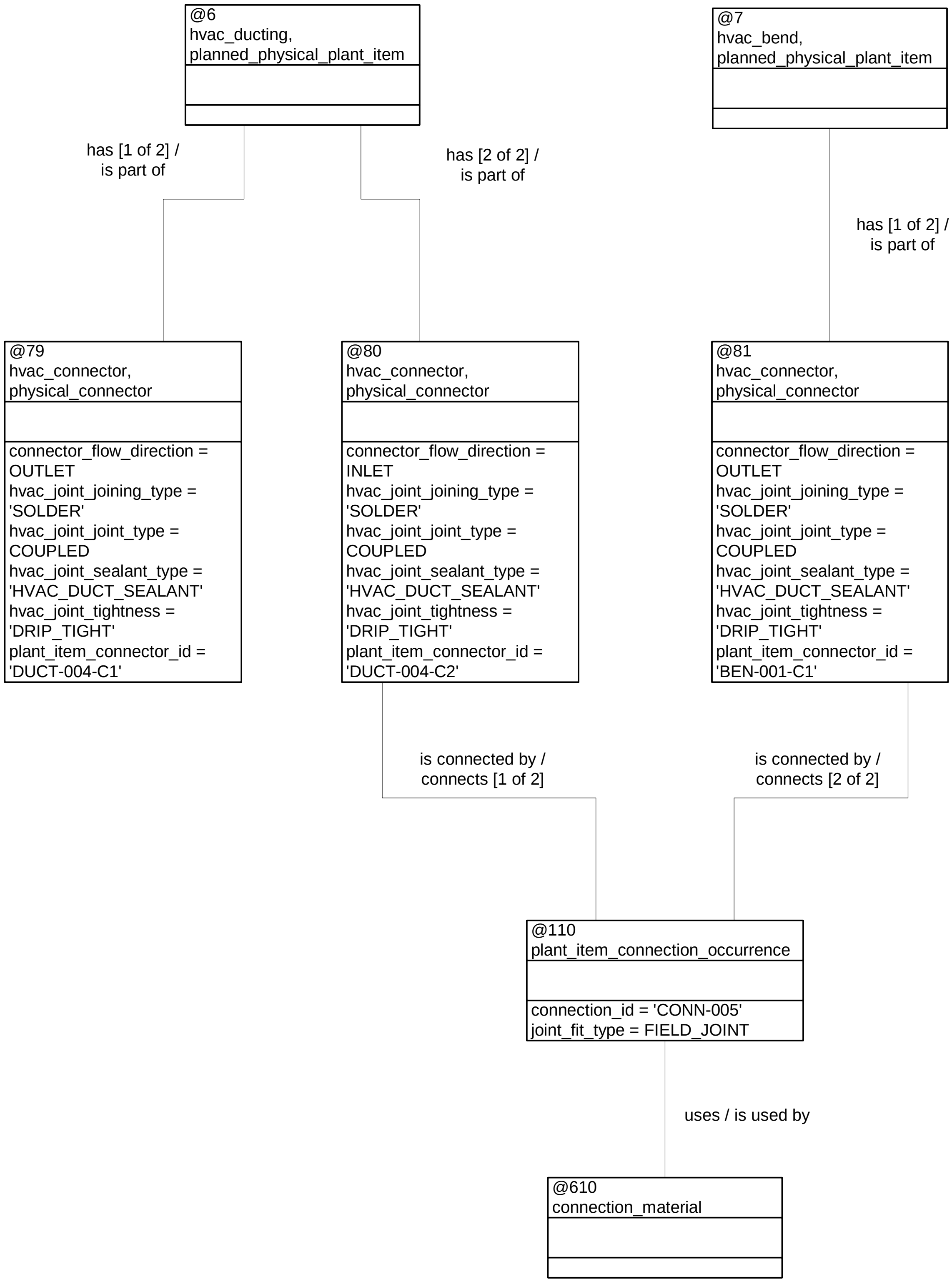

Figure A.16 — Instance diagram for the HVAC Functional and Spatial test case (8 of 16)

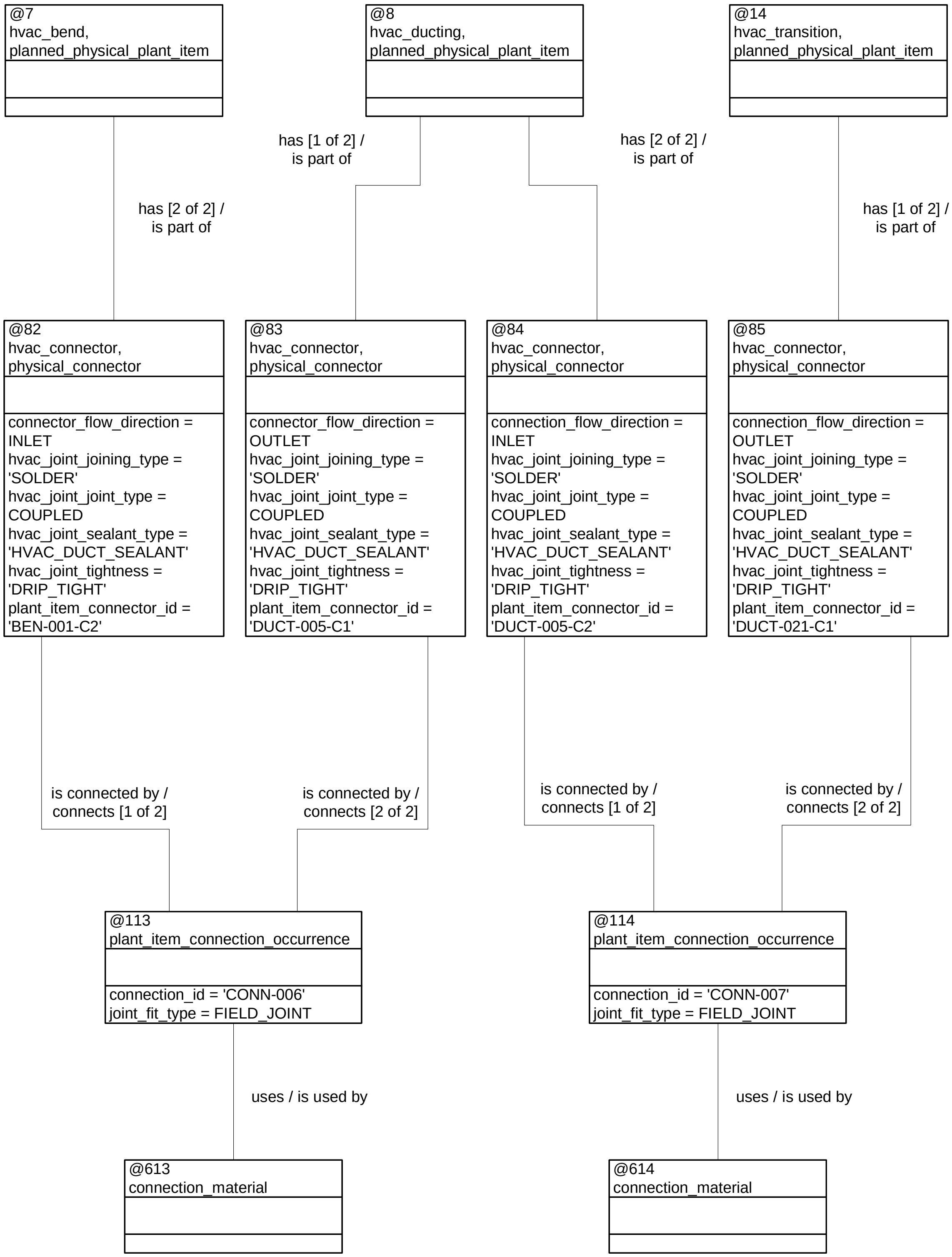

Figure A.17 — Instance diagram for the HVAC Functional and Spatial test case (9 of 16)

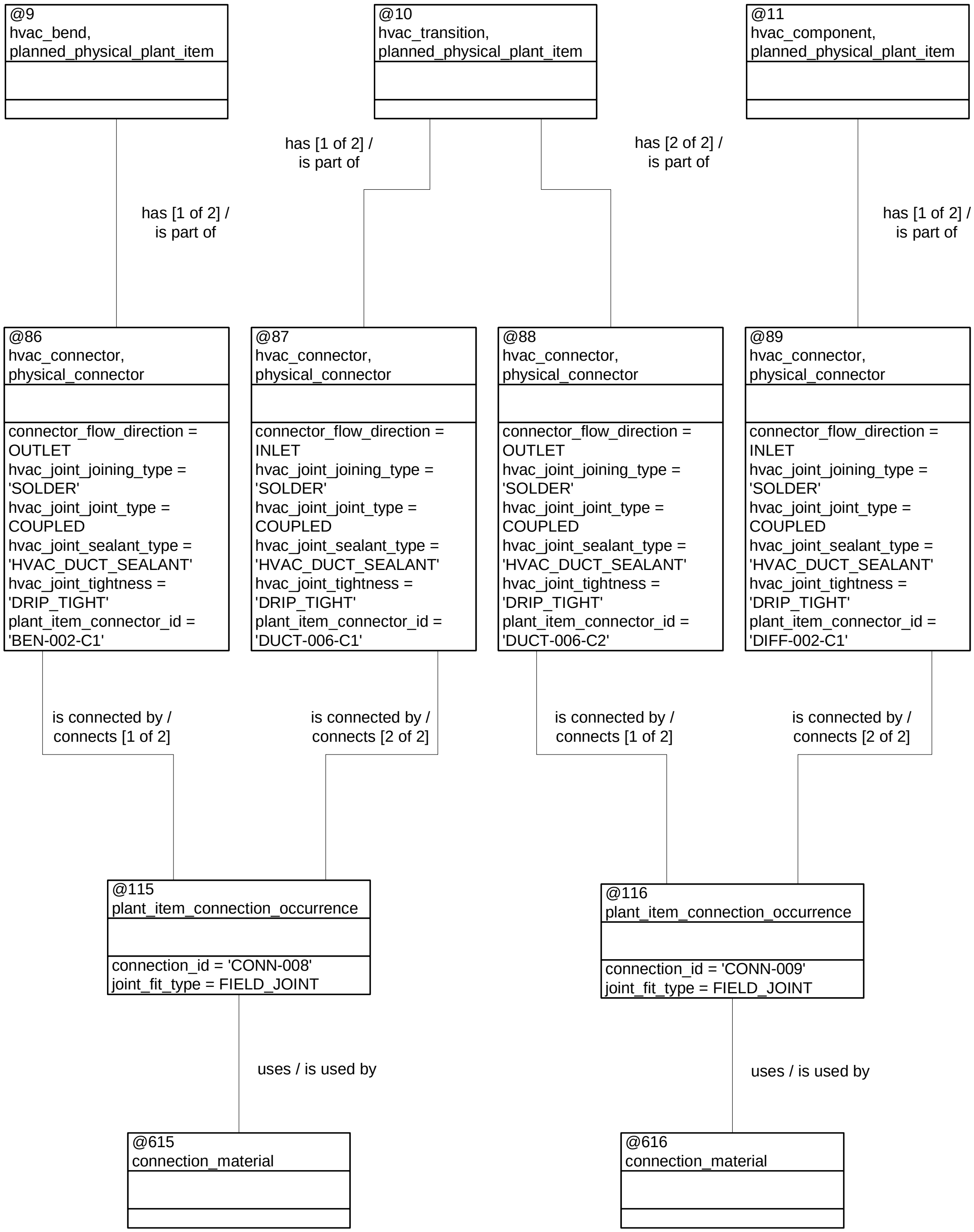

Figure A.18 — Instance diagram for the HVAC Functional and Spatial test case (10 of 16)

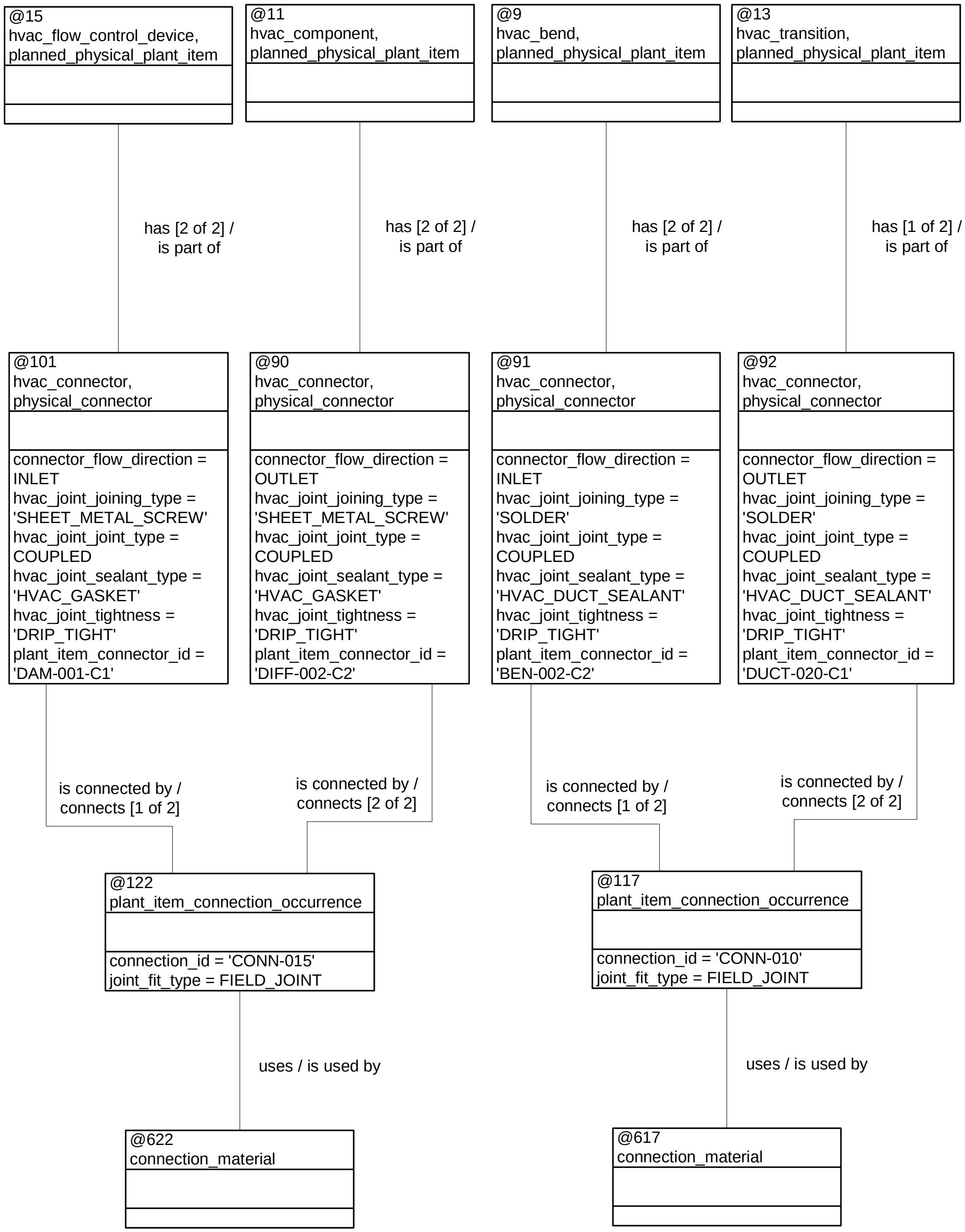

Figure A.19 — Instance diagram for the HVAC Functional and Spatial test case (11 of 16)

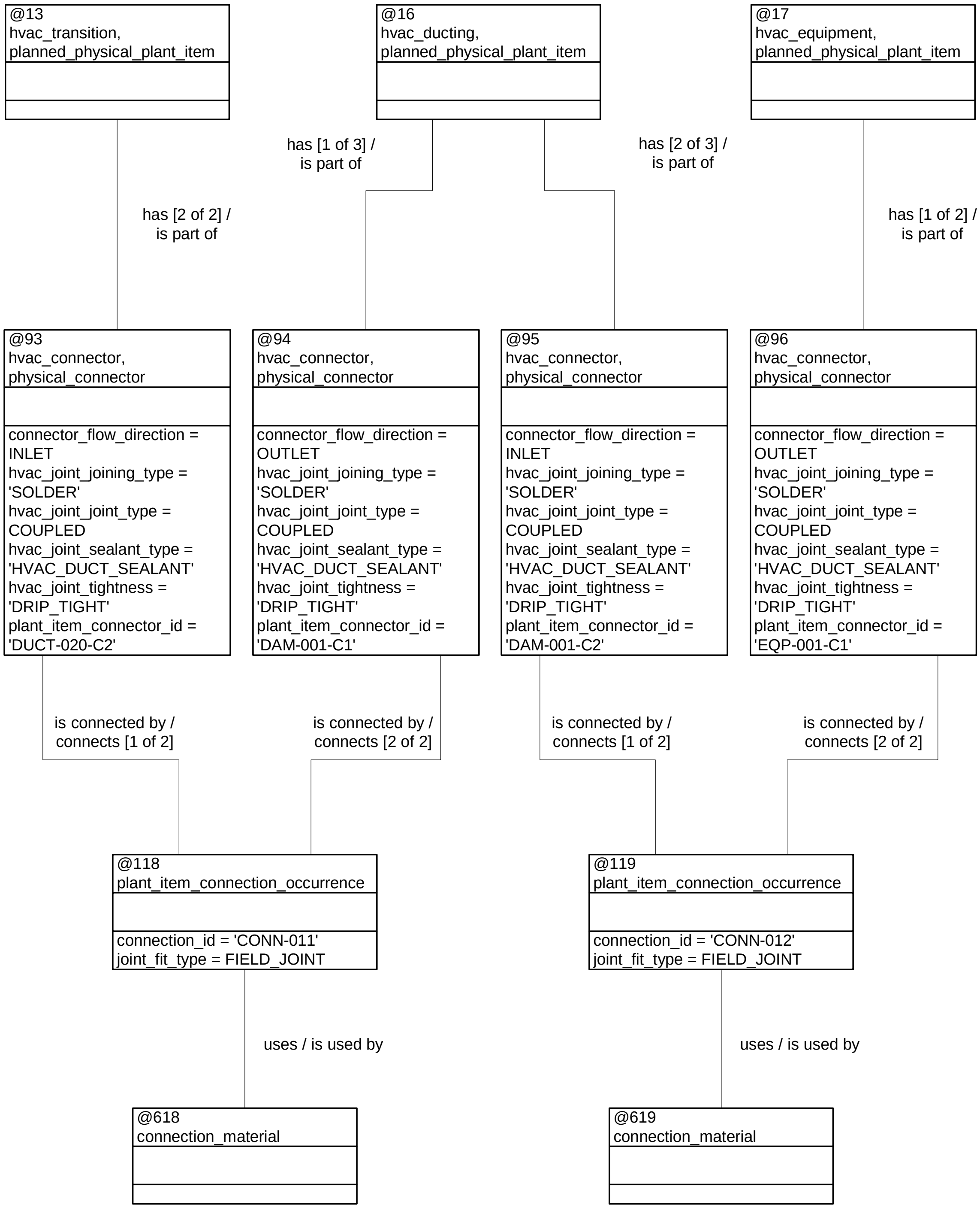

Figure A.20 — Instance diagram for the HVAC Functional and Spatial test case (12 of 16)

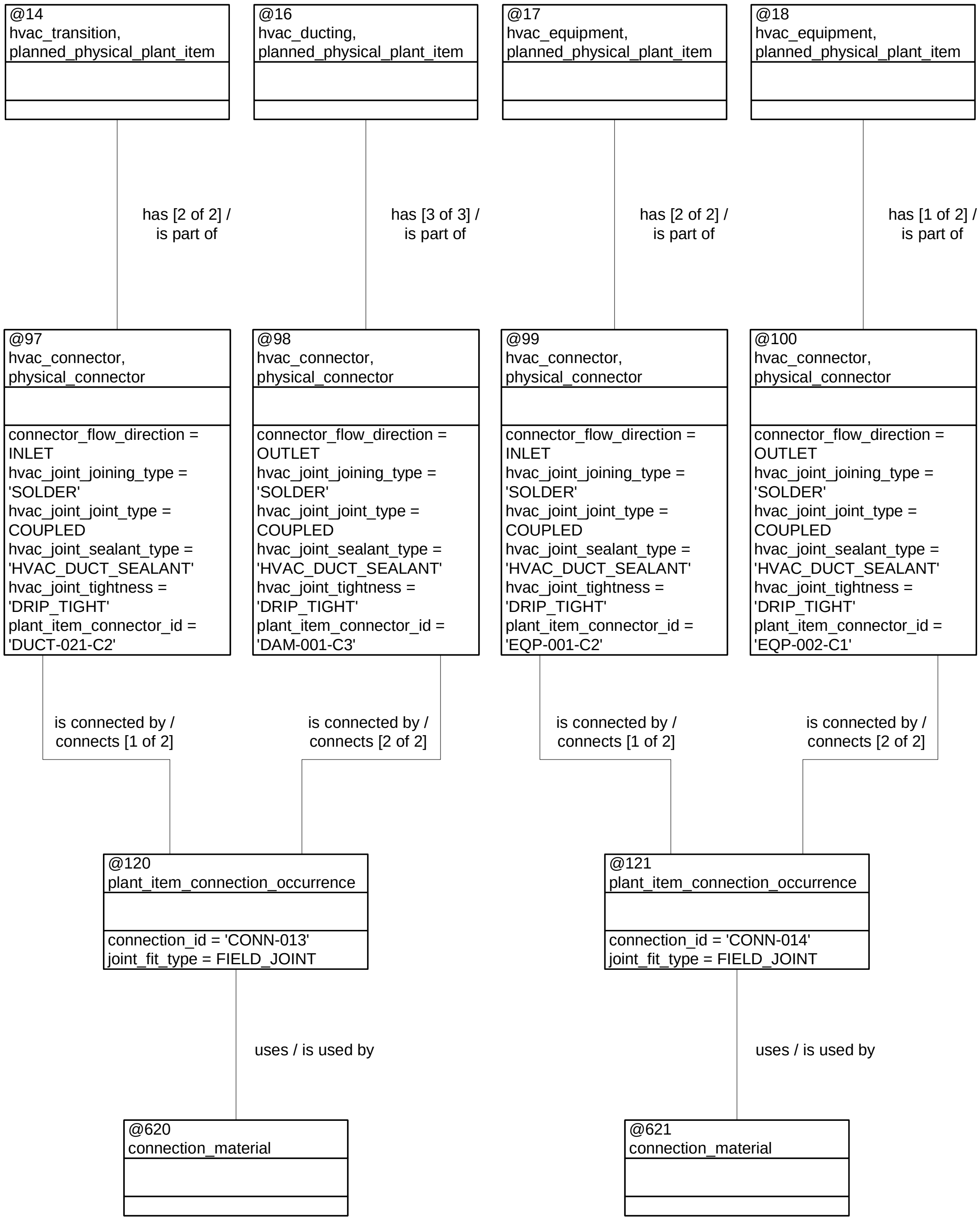

Figure A.21 — Instance diagram for the HVAC Functional and Spatial test case (13 of 16)

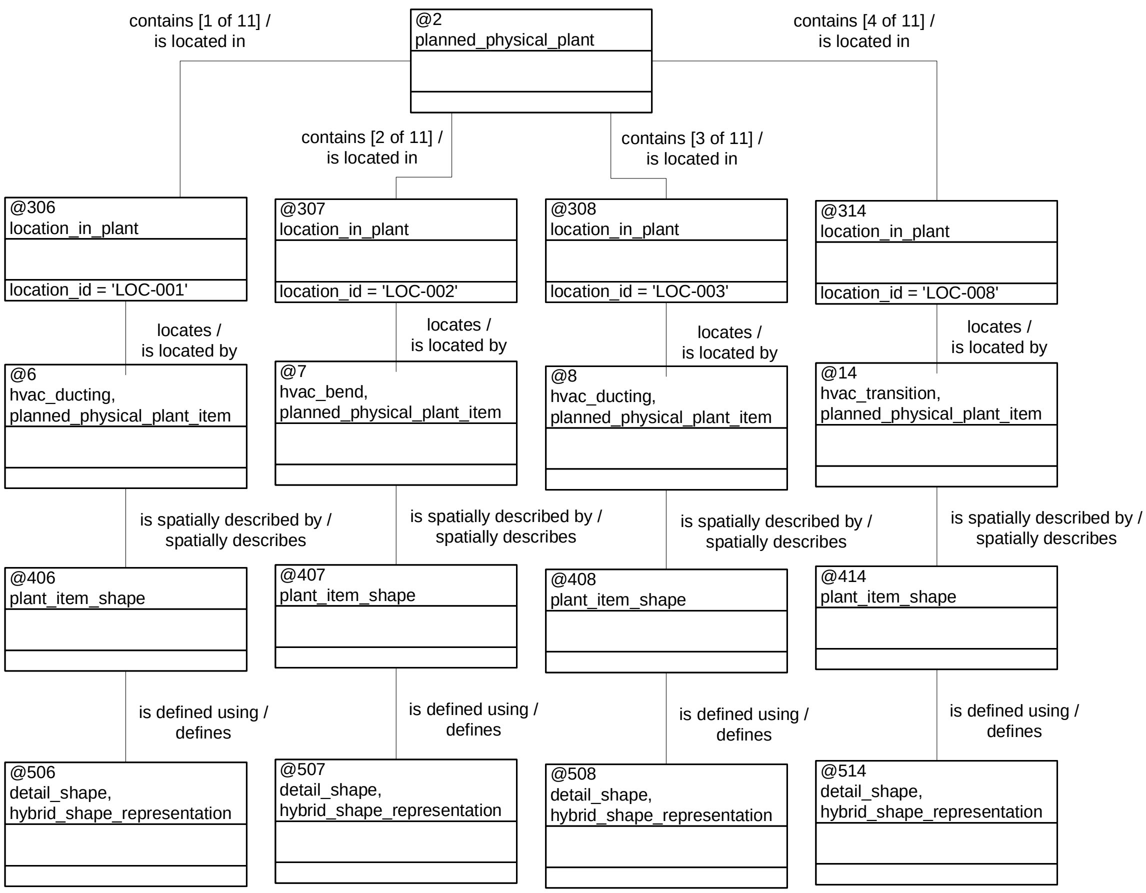

Figure A.22 — Instance diagram for the HVAC Functional and Spatial test case (14 of 16)

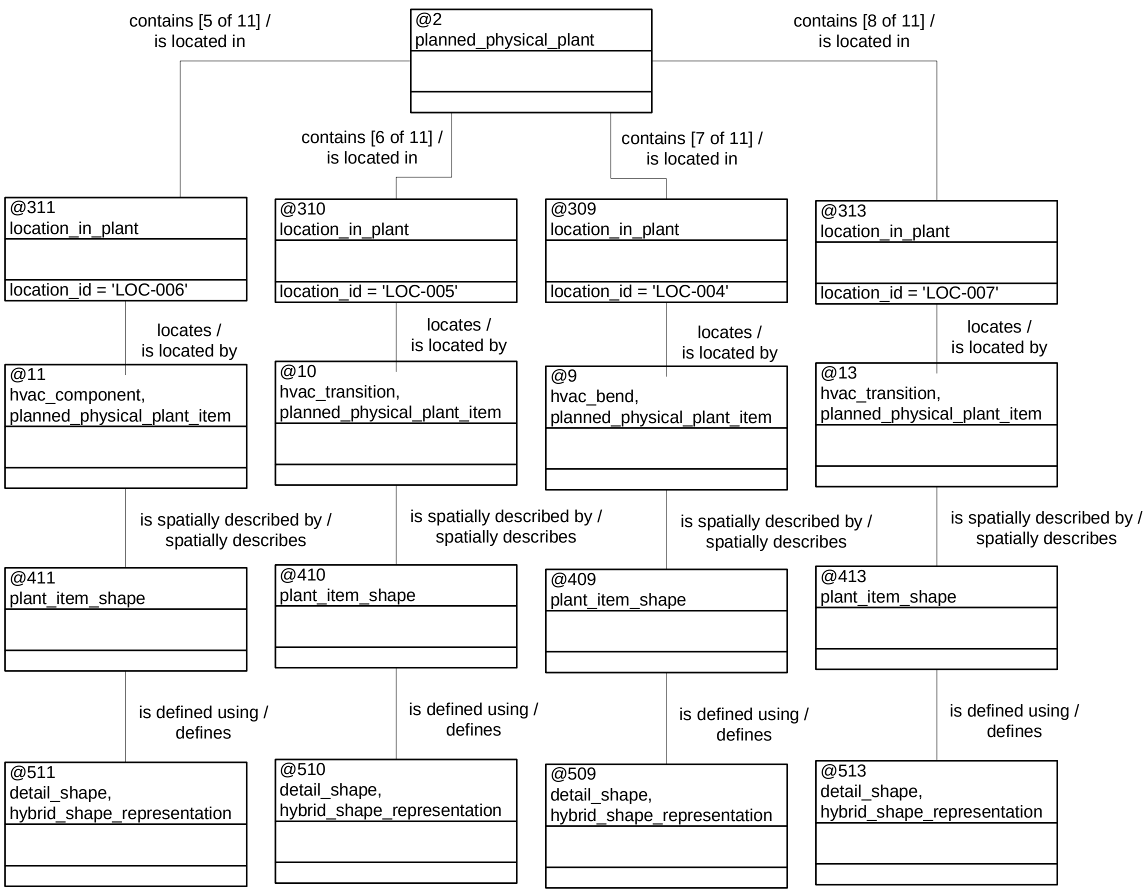

Figure A.23 — Instance diagram for the HVAC Functional and Spatial test case (15 of 16)

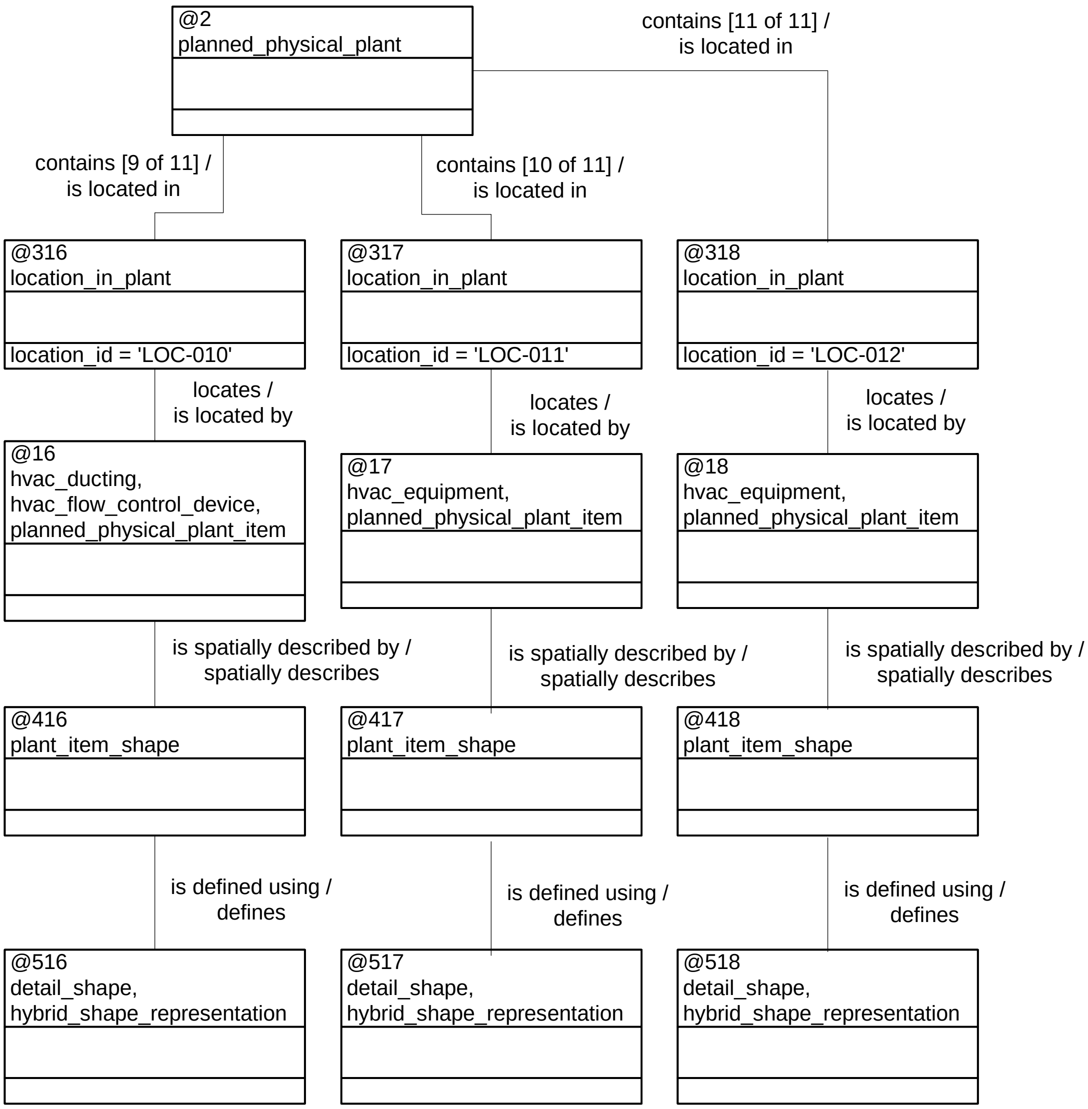

Figure A.24 — Instance diagram for the HVAC Functional and Spatial test case (16 of 16)

A.3.2 HVAC Transition

A.3.2.1 Purpose

This clause describes the use of ISO 10303-227 to exchange spatial characteristics for HVAC components as well as their connectivity.

A.3.2.2 Exchange context

The context for this test case is the exchange of HVAC configuration information between an HVAC engineer and an installer.

A.3.2.3 Test data

Figure A.25 shows a portion of an HVAC system that will serve as the basis for this test case.

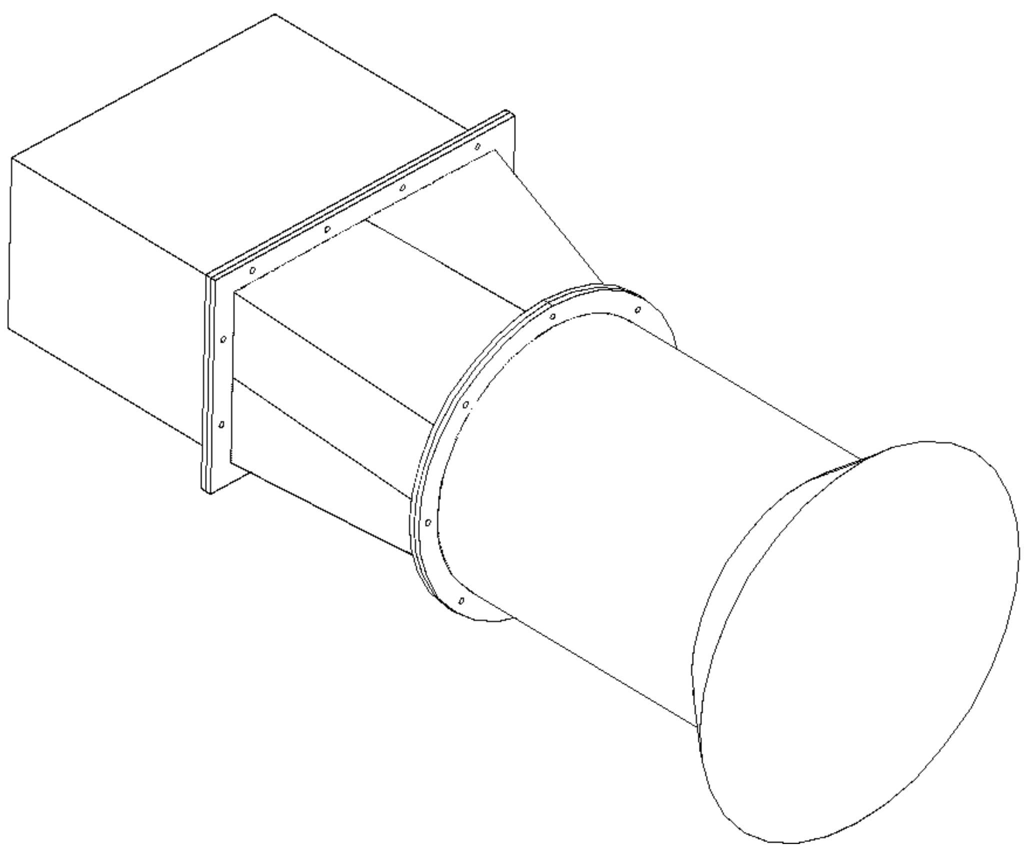

Figure A.25 — Portion of an HVAC system for the HVAC Transition test case

The component types included in this example are diffusers, dampers, ducting, ducting elbows, flow control devices, ducting transitions, air condensers, and duct heaters. Figure A.26 shows the components of the system with labels attached. Table A.2 gives the component types and the attributes of the components. Table A.3 gives the attributes of the connectors. Table A.4 gives the attributes of the runs and sections, and Table A.5 gives the attributes of the connections.

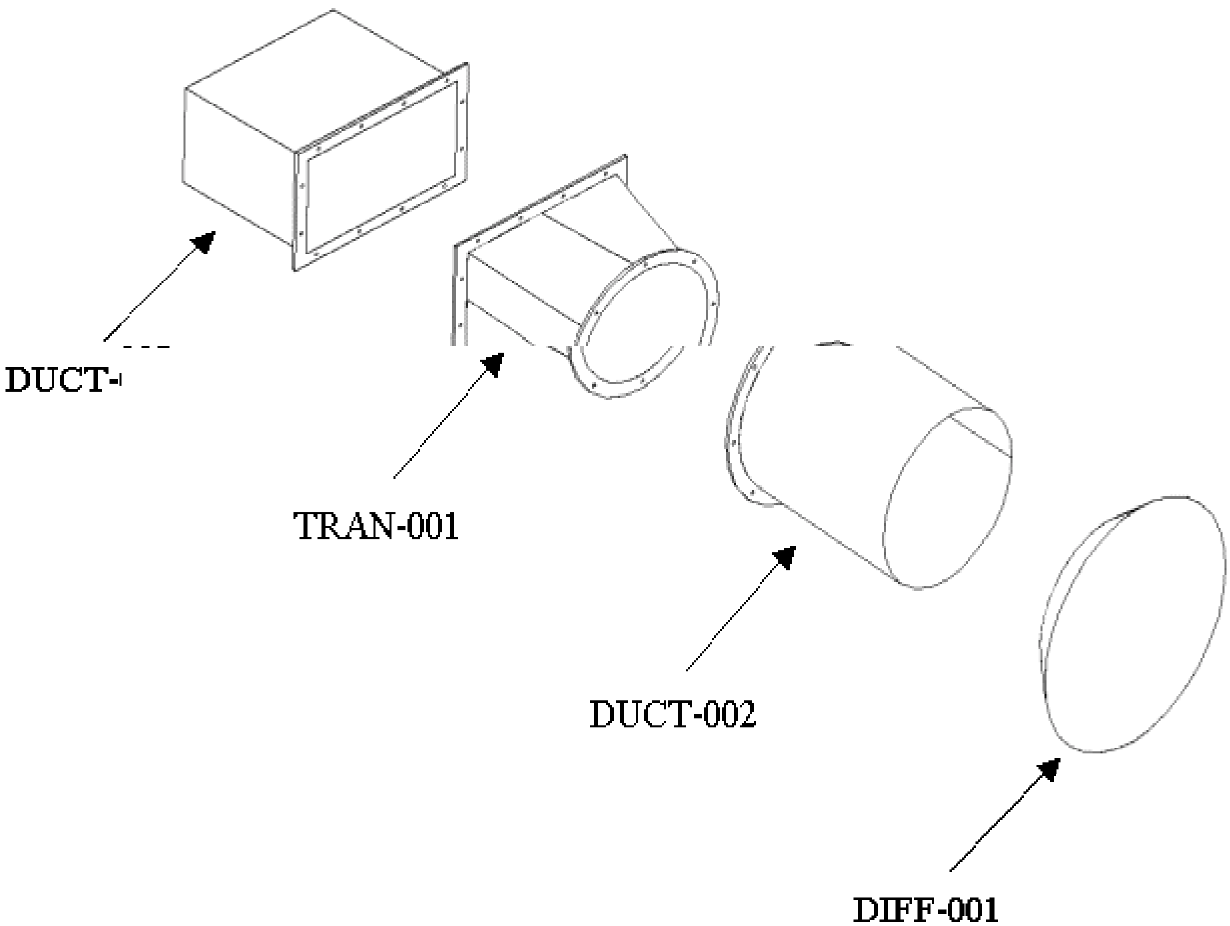

Figure A.26 — HVAC system with components labeled for the HVAC Transition test case

Table A.2 — Components for the HVAC Transition test case

Component	Description	heel radius (in)	throat radius (in)	correction factor	pressure loss coefficient	friction factor (in. w.g. / 100 ft)	design pressure (psi)	design temperature (deg F)
DUCT-001	Duct, rectangular			0.95		1.2	0.0072	100
TRAN-001	Transition, rectangular to round	9.00	3.00	0.95	0.24		0.0072	100
DUCT-002	Duct, round			0.95		1	0.0072	100
DIFF-002	Exit, conical round, without wall			0.95	0.44		0.0072	100

Table A.3 — Connector attributes for the HVAC Transition test case

Component	Connector	X (in)	Y (in)	Z (in)	Height (in)	Width (in)	Velocity (fpm)	Equivalent diameter (in)
DUCT-001	C1	0.00	0.00	0.00	8.00	14.00	3214.286	11.46
	C2	12.00	0.00	0.00	8.00	14.00	3214.286	11.46
TRAN-001	C1	12.00	0.00	0.00	8.00	14.00	3214.286	11.46
	C2	22.00	0.00	0.00	12.00	12.00	3184.713	12.00
DUCT-002	C1	22.00	0.00	0.00	12.00	12.00	3184.713	12.00
	C2	38.00	0.00	0.00	12.00	12.00	3184.713	12.00
DIFF-001	C1	38.00	0.00	0.00	12.00	12.00	3184.713	12.00

Table A.4 — Run and section attributes for the HVAC Transition test case

Run	Flow rate (cfm)	Equivalent length (in)	Roughness (in)
HVAC-01-01	2500	12.00	0.0003
HVAC-01-02	2500	16.00	0.0003

Table A.5 — Connection attributes for the HVAC Transition test case

Connection	End 1 connector	End 2 connector	Joint type	Joint joining type	Joint tightness	Joint sealant
CONN-1	DUCT-001-C2	TRAN-002-C1	flange	nut and bolt	drip	gasket
CONN-2	TRAN-002-C2	DUCT-002-C1	flange	nut and bolt	drip	gasket
CONN-3	DUCT-002-C2	DIFF-001-C1	weld	weld	drip	null

All components have a sheet metal thickness of 20 AWG.

A.3.2.4 ARM representation

Figures A.28 to A.35 contain the instance diagrams for this test case.

An HVAC system can be represented in ISO 10303-227 through a functional description and/or a physical description. In this test case, a physical description is used.

A.3.2.4.1 Representing components

Duct DUCT-001 is captured by an instance (@20) of the Hvac_ducting application object. The specified design flow rate, design temperature, and velocity are specified as attributes of this instance.

The other components in this test case are represented similarly.

A.3.2.4.2 Representing connections

Figure A.27 shows the components for this test case, with connectors labeled.

Connector DUCT-001-C2 is captured by a complex entity instance (@40) of the Physical_connector and Hvac_connector AOs (see Figure A.31). According to ISO 10303-227, a Physical_connector is a type of Plant_item_connector_occurrence that represents the physical aspects of the Plant_item_connector_occurrence. An Hvac_connector is any material used to connect two or more Hvac_component objects. This test case will utilize solder and HVAC duct sealant to secure the connections made.

Connector DUCT-001-C2 is captured by a complex entity instance (@41) of the Functional_connector and Hvac_connector AOs.

The connection between DUCT-001-C2 and TRAN-001-C1 is captured by an instance (@50) of Plant_item_connection_occurrence. The remaining connectors and connections in this test case are represented similarly.

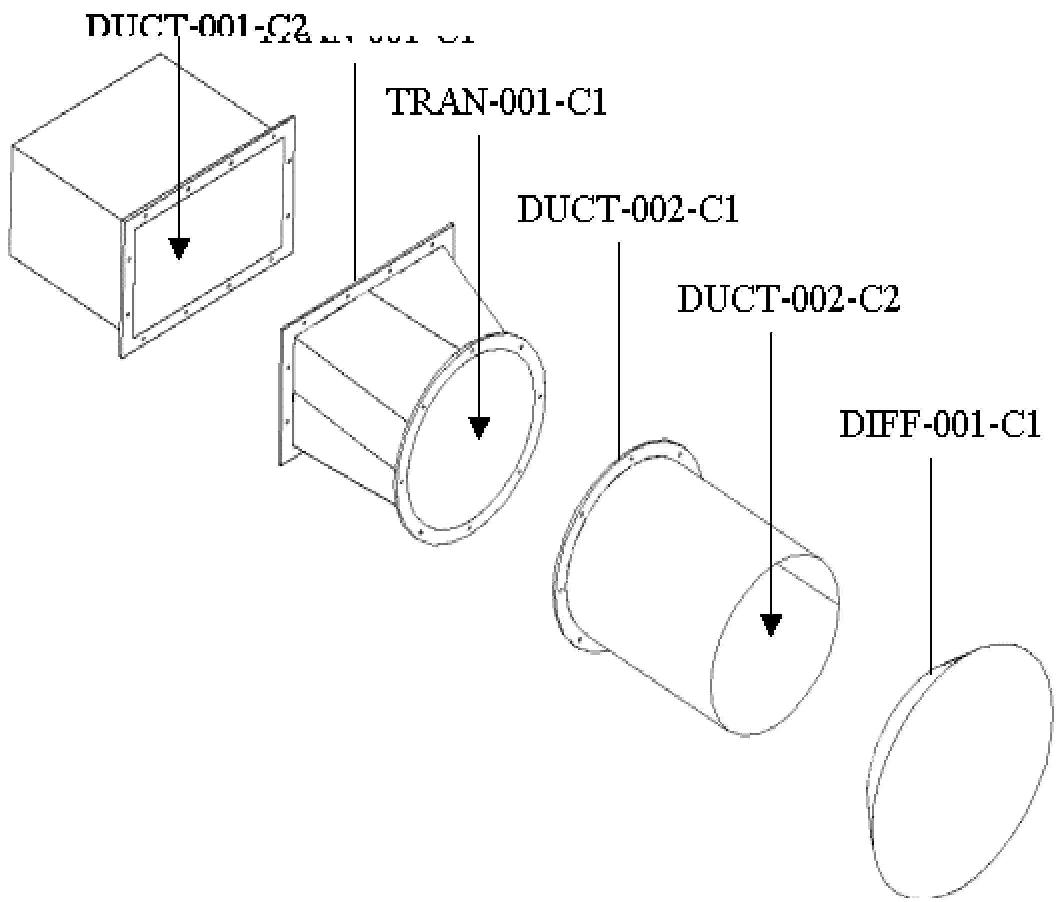

Figure A.27 — Connectors for the HVAC Transition test case

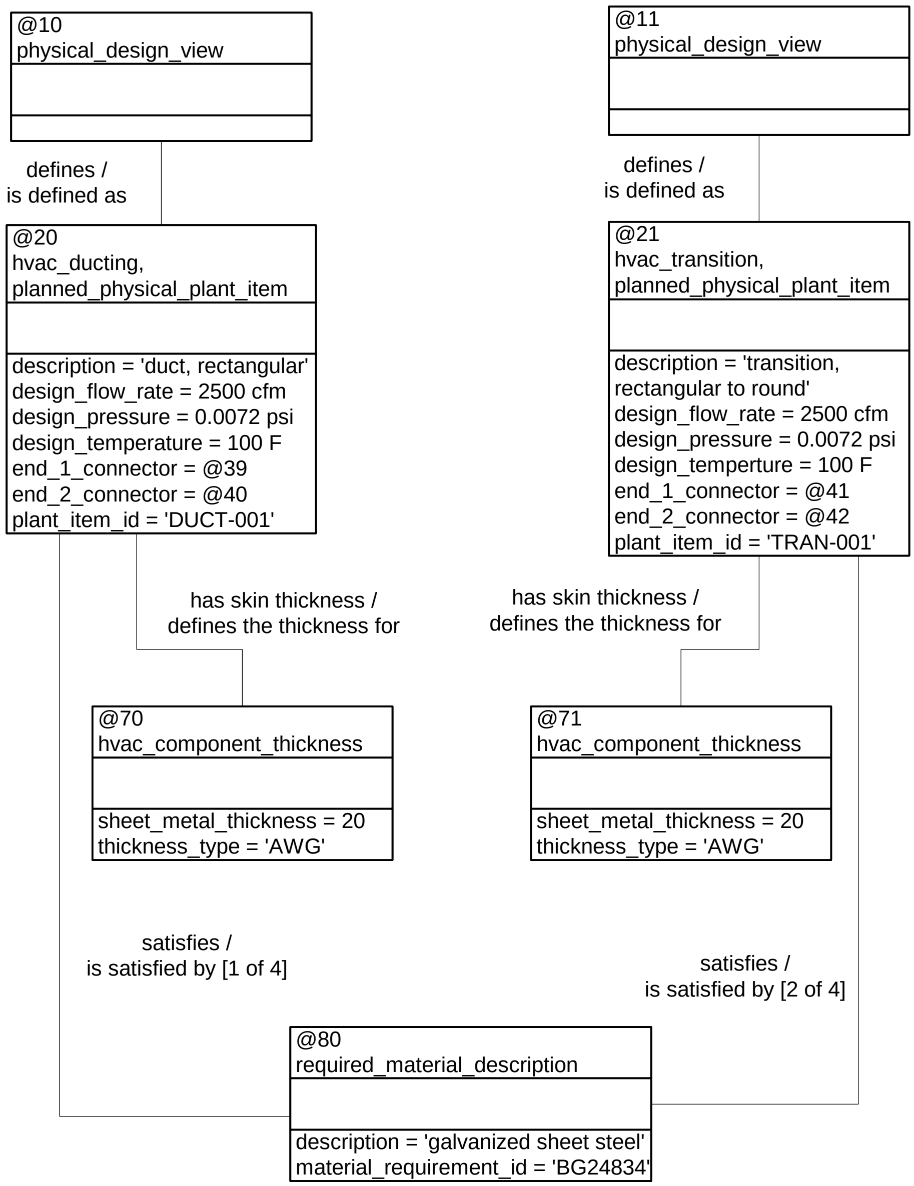

Figure A.28 — Instance diagram for the HVAC Transition test case (1 of 8)

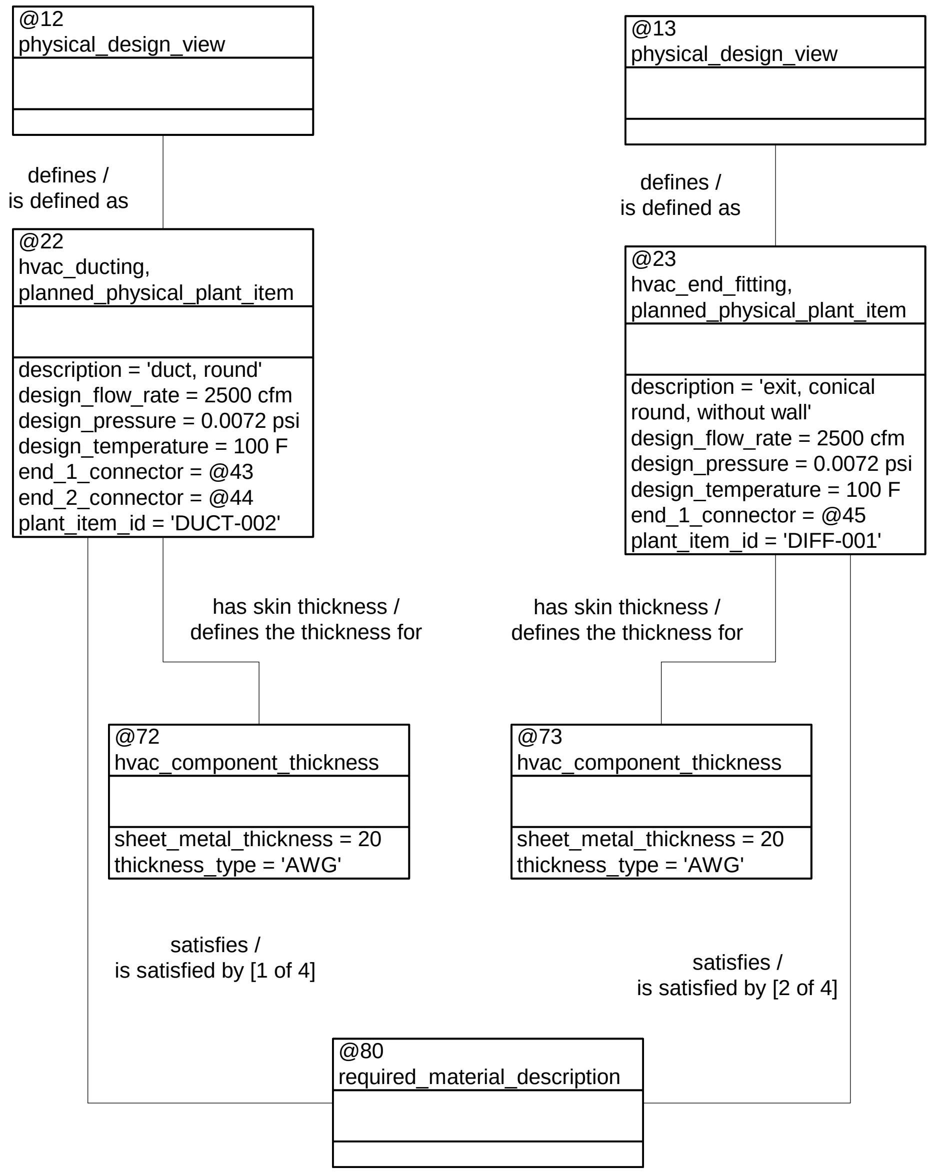

Figure A.29 — Instance diagram for the HVAC Transition test case (2 of 8)

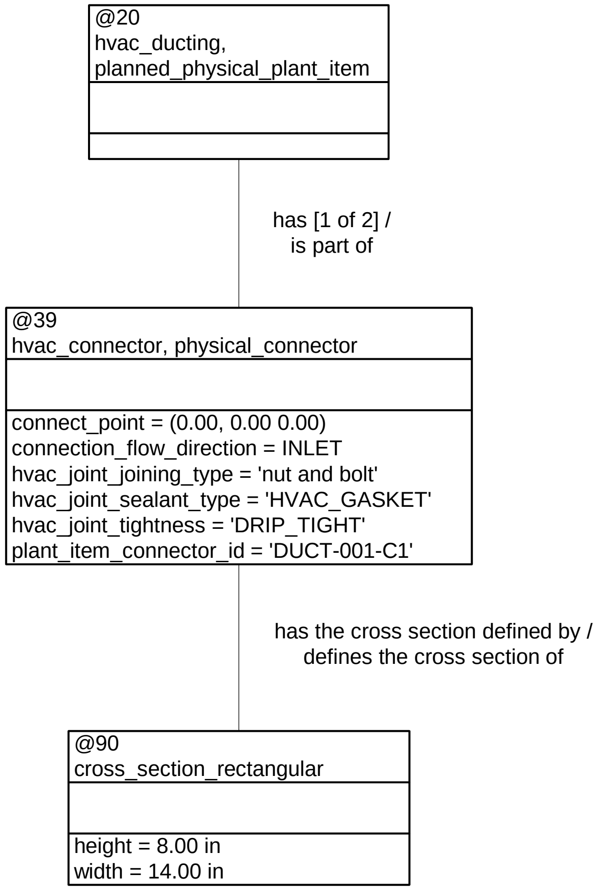

Figure A.30 — Instance diagram for the HVAC Transition test case (3 of 8)

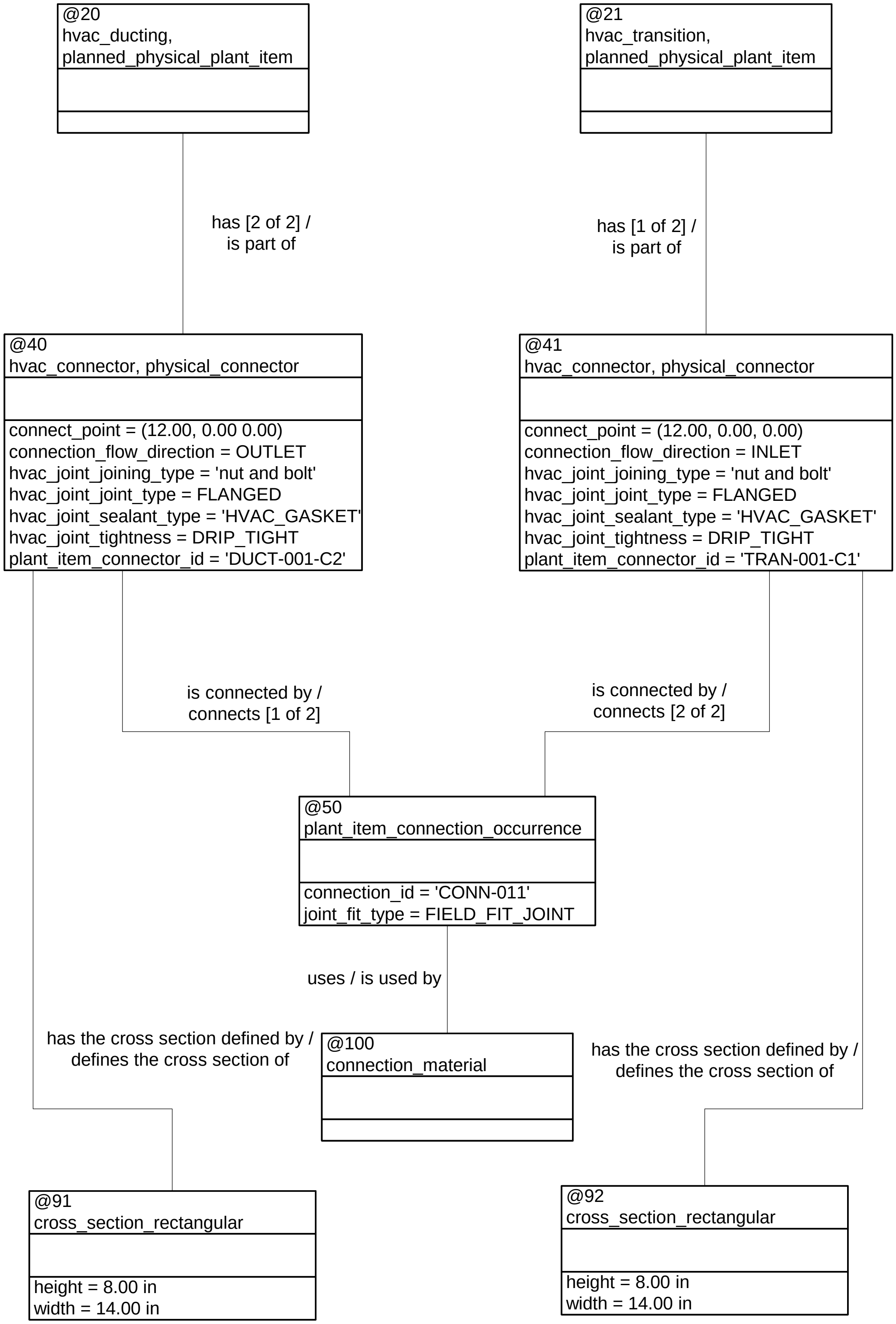

Figure A.31 — Instance diagram for the HVAC Transition test case (4 of 8)

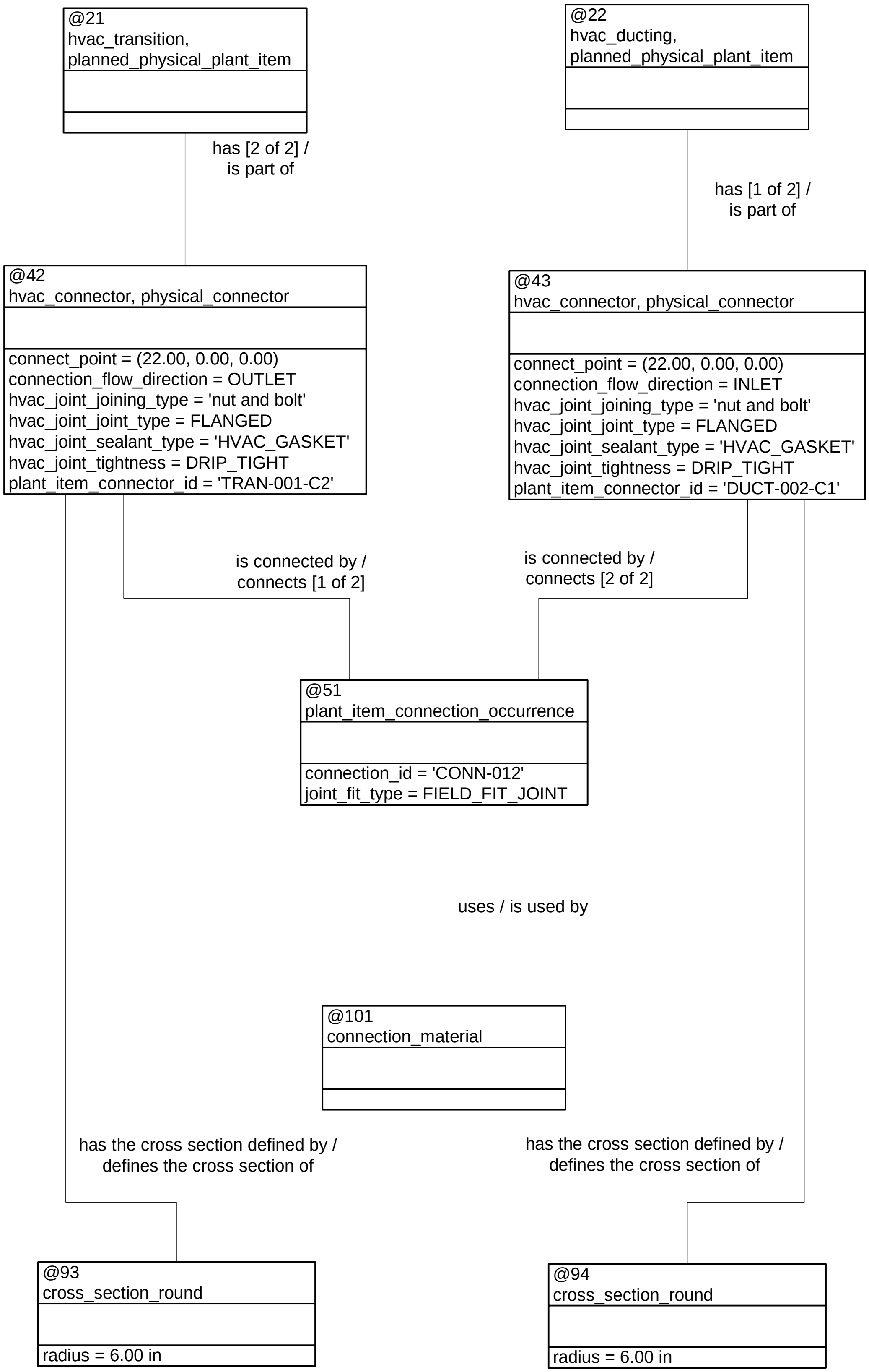

Figure A.32 — Instance diagram for the HVAC Transition test case (5 of 8)

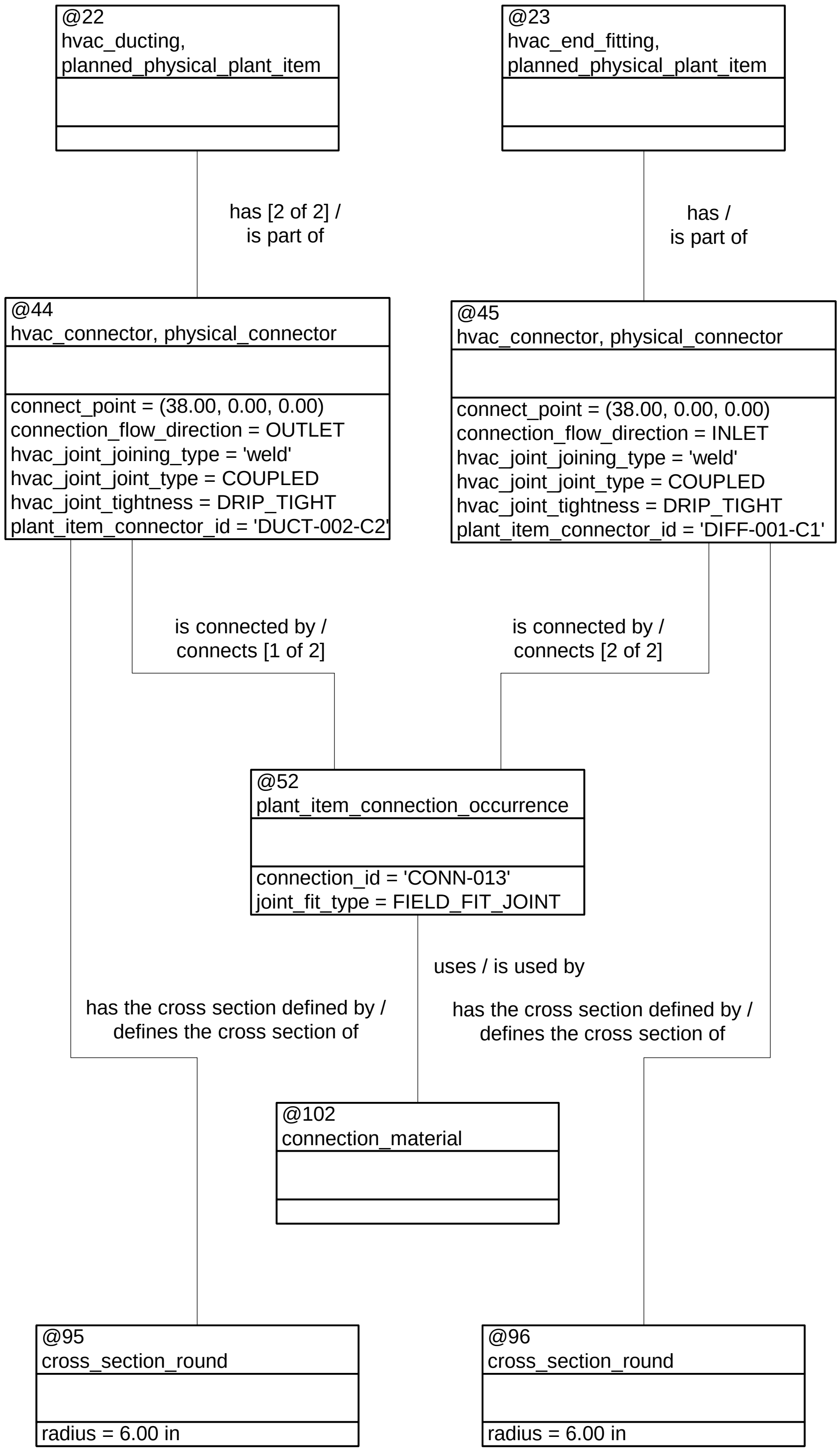

Figure A.33 — Instance diagram for the HVAC Transition test case (6 of 8)

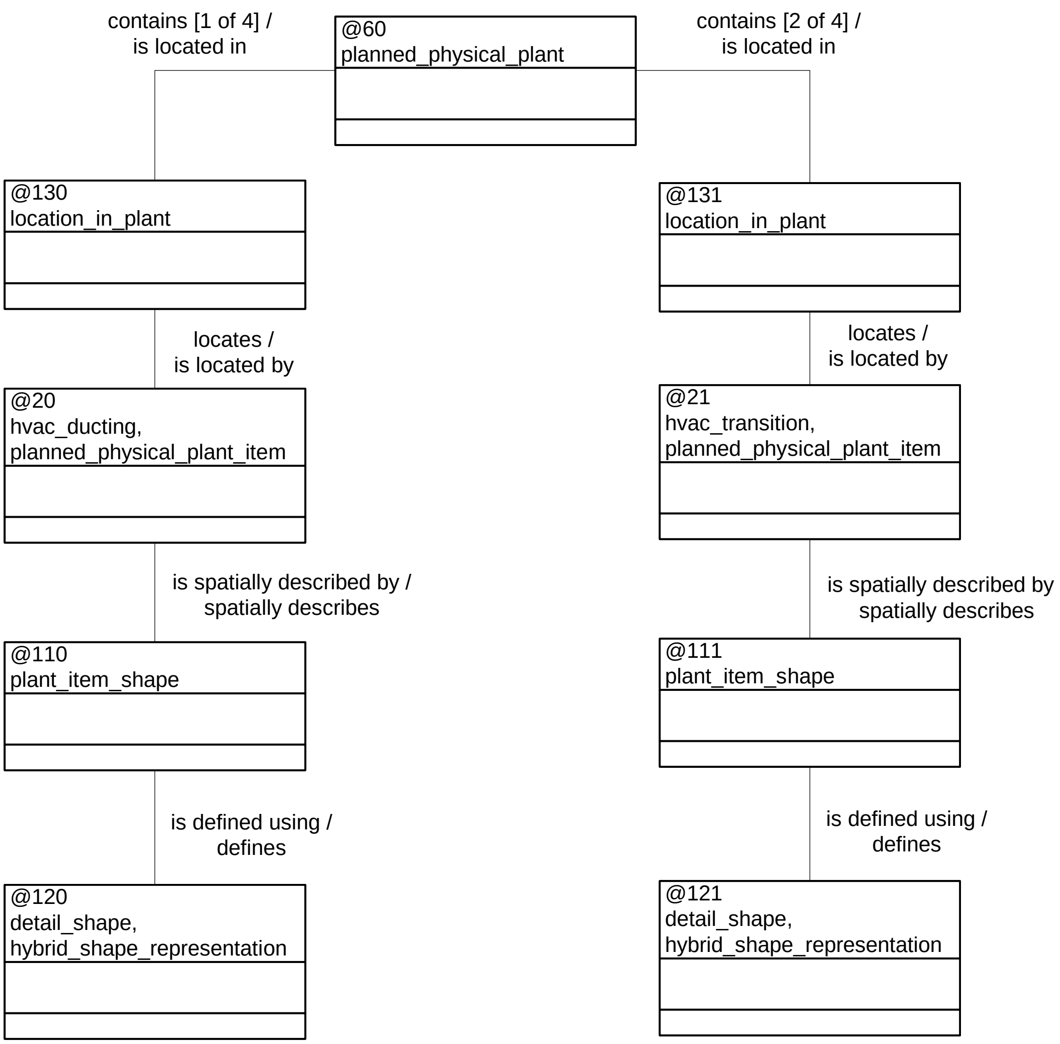

Figure A.34 — Instance diagram for the HVAC Transition test case (7 of 8)

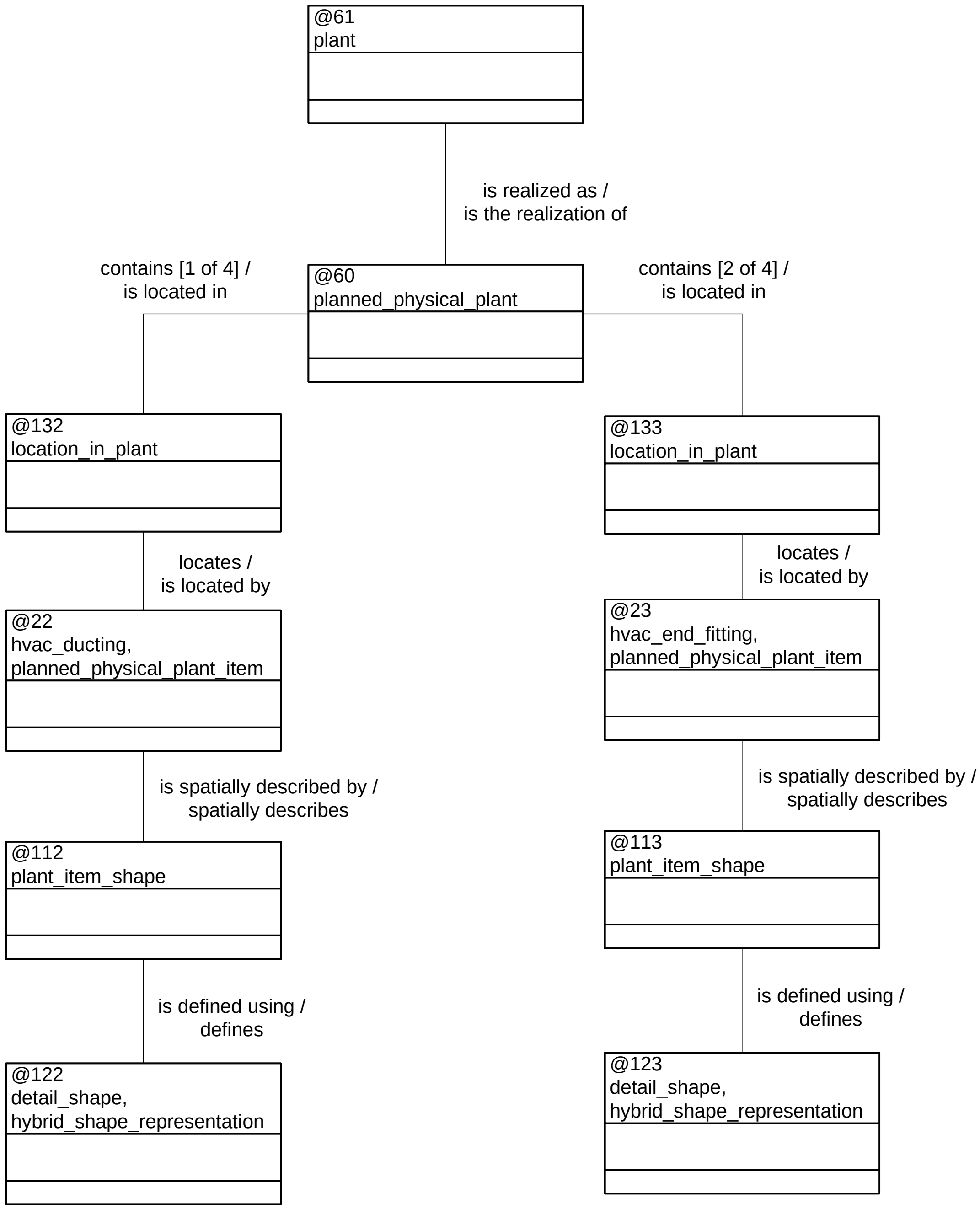

Figure A.35 — Instance diagram for the HVAC Transition test case (8 of 8)

A.3.3 HVAC Rectangular

A.3.3.1 Purpose

This clause describes the use of ISO 10303-227 to represent geometry and connections for rectangular HVAC components.

This test case represents geometry using a plant CSG shape representation and detail shape.

A.3.3.2 Exchange context

The context for this test case is the exchange of spatial configuration information for an HVAC system between an HVAC engineer, other spatial layout disciplines, and the HVAC fabricator and installer.

A.3.3.3 Test data

Figure A.36 shows a portion of an HVAC system that will serve as the basis for this test case. The HVAC system and its components were chosen to demonstrate the capture of rectangular components, their spatial arrangement, their interconnection, and their geometry with the use of various components.

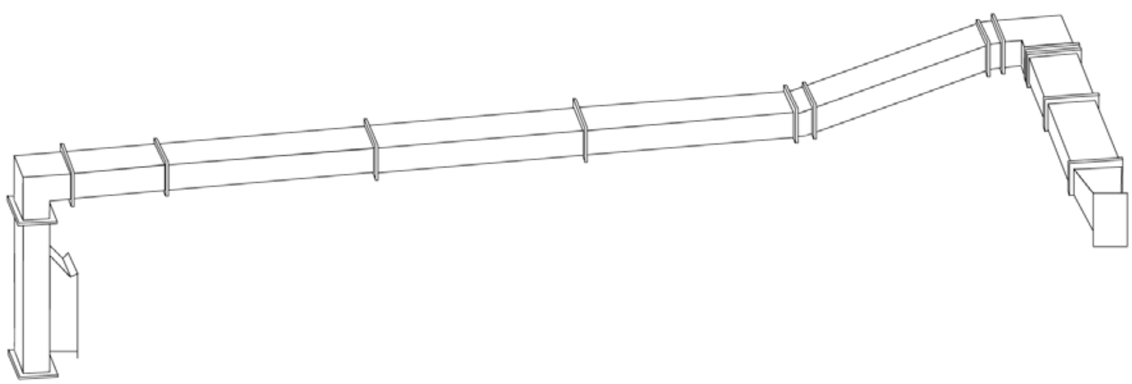

Figure A.36 — Portion of an HVAC system for the HVAC Rectangular test case

The component types included in this example are ducting transitions, ducting, ducting elbows, and splitters.

Figure A.37 shows the HVAC system with the components of the system labeled. Table A.6 gives labels to the components, as well as listing the types of component and their properties.

Figure A.38 shows a splitter with labels attached. The splitters are contained inside the ducting elbows. A splitter is a non-adjustable sheet metal divider installed in an elbow. The splitter helps to reduce dynamic losses in elbows by providing a more uniform air velocity through the bend.

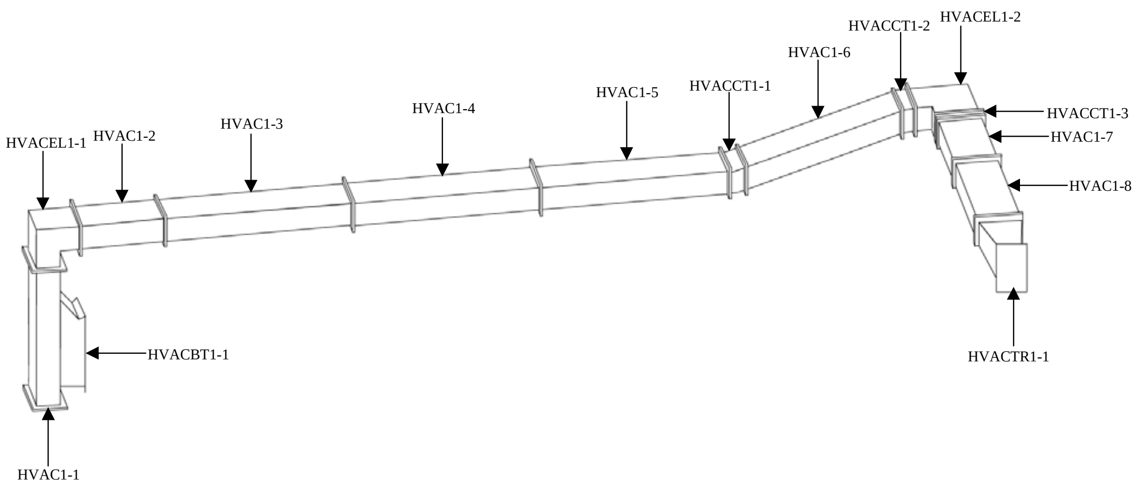

Figure A.37 — HVAC system with components labeled

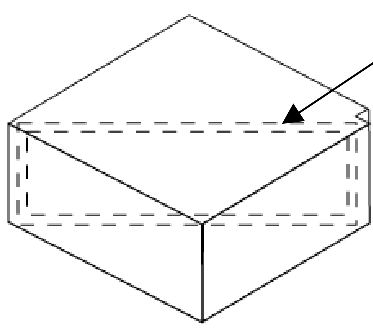

Figure A.38 — Splitter

Table A.6 — Components for the HVAC Rectangular test case

Label	Type	Attributes
HVACBT1-1	boot	2400 ft^3/min, 55 °F
HVAC1-1	ducting	2400 ft^3/min, 55 °F
HVACEL1-1	elbow	2400 ft^3/min, 55 °F
HVAC1-2	ducting	2400 ft^3/min, 55 °F
HVAC1-3	ducting	2400 ft^3/min, 55 °F
HVAC1-4	ducting	2400 ft^3/min, 55 °F
SPLT1-1	splitter	
HVAC1-5	ducting	2400 ft^3/min, 55 °F
HVACT1-1	elbow	2400 ft^3/min, 55 °F
HVAC1-6	ducting	2400 ft^3/min, 55 °F
HVACCT1-2	elbow	2400 ft^3/min, 55 °F
SPLT1-2	splitter	
HVACEL1-2	elbow	2400 ft^3/min, 55 °F
HVACCT1-3	ducting	2400 ft^3/min, 55 °F

Label	Type	Attributes
HVAC1-7	ducting	2400 ft^3/min, 55 °F
HVAC1-8	ducting	2400 ft^3/min, 55 °F
HVACTR1-1	transition	2400 ft^3/min, 55 °F

Figures A.39 and A.40 show the components for this test case, with connectors labeled.

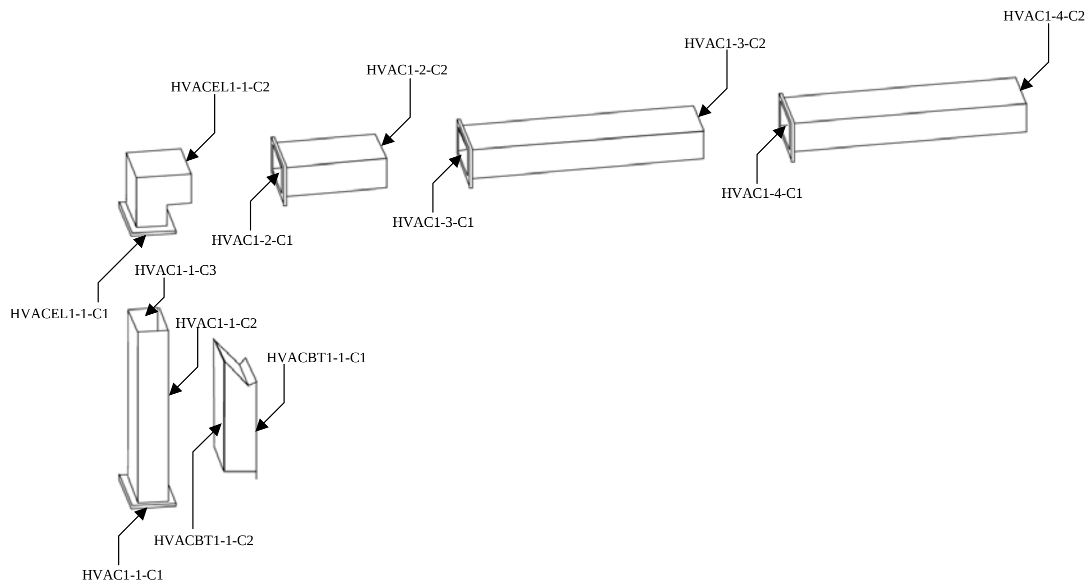

Figure A.39 — Connections for the HVAC Rectangular test case (1 of 2)

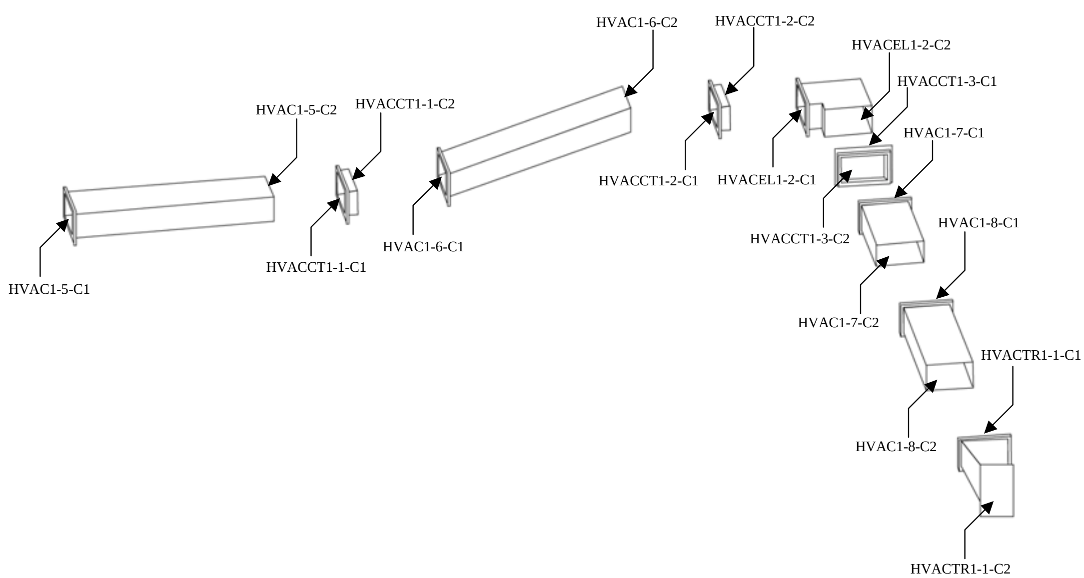

Figure A.40 — Connections for the HVAC Rectangular test case (2 of 2)

A.3.3.4 ARM representation

Figures A.41 to A.48 contain the instance diagrams for this test case.

An HVAC system can be represented in ISO 10303-227 through a functional description and/or a physical description. In this test case, a physical description is presented.

A.3.3.4.1 Representing a component

Transition HVACBT1-1 is captured by an instance (@1) of the Hvac_transition AO. The Hvac_transition defines an instance (@22) of the Physical_design_view AO. A Physical_design_view is used when the system is made up of physical components; i.e., components that can be made or purchased. A functional design view is used when the system is made up of functional components; i.e., components that represent functional capabilities. A physical representation involves the use of entities that have a physical value, such as, Planned_physical_plant_item, Plant_item_connection_occurrence, Plant_item_connector_occurrence, and Plant_item_shape.

The other components in this test case are represented similarly with the use of instances of Hvac_transition, Hvac_ducting, Hvac_elbow_centered, Splitter, Hvac_elbow_mitre, and Hvac_transition.

All the components in this test case (except for the splitters) are galvanized metal. This material is represented by an instance (@81) of Required_material_description AO. This instance is satisfied by an instance (@82) of the Material_specification_selection AO (see Figure A.55).

A.3.3.4.2 Representing connections

There are two connectors for the ducting boot that is represented by an instance (@1) of Hvac_transition. The first connector is represented by a complex entity instance (@18) of the Physical_connector and Hvac_connector AOs. The second connector is represented by a complex entity instance (@19) of the Physical_connector and Hvac_connector AOs. An Hvac_connector is any material used to connect two or more Hvac_components. This test case will utilize lapped rivets and HVAC tape to secure the connections made.

An instance (@21) of Plant_item_connection_occurrence AO represents the connection between complex entity instances (@18 and @19) of the Physical_connector and Hvac_connector AOs. The remaining connectors in this test case are represented similarly.

A.3.3.4.3 Representing geometry

The shape of a component is represented by an instance of a subtype of the Plant_item_shape AO. This test case uses Detail_shape and Plant_csg_shape_representation. According to ISO 10303-227 a Plant_csg_shape_representation is a type of Shape_representation. This requirement is for a "pure CSG" shape, and a complex CSG will be accomplished using the hybrid representation. According to ISO 10303-227 a Detail_shape is a type of Shape_representation that is the actual or intended external shape of a Plant_item. A Detail_shape does not include the description of voids or other internal details of the shape of the Plant_item.

The instance (@1) of Hvac_transition (HVACBT1-1) is spatially described by an instance (@200) of the Plant_item_shape AO. This instance of Plant_item_shape is defined using a complex entity instance (@201) of the Plant_csg_shape_representation and Detail_shape AOs. The remaining component geometry is represented similarly.

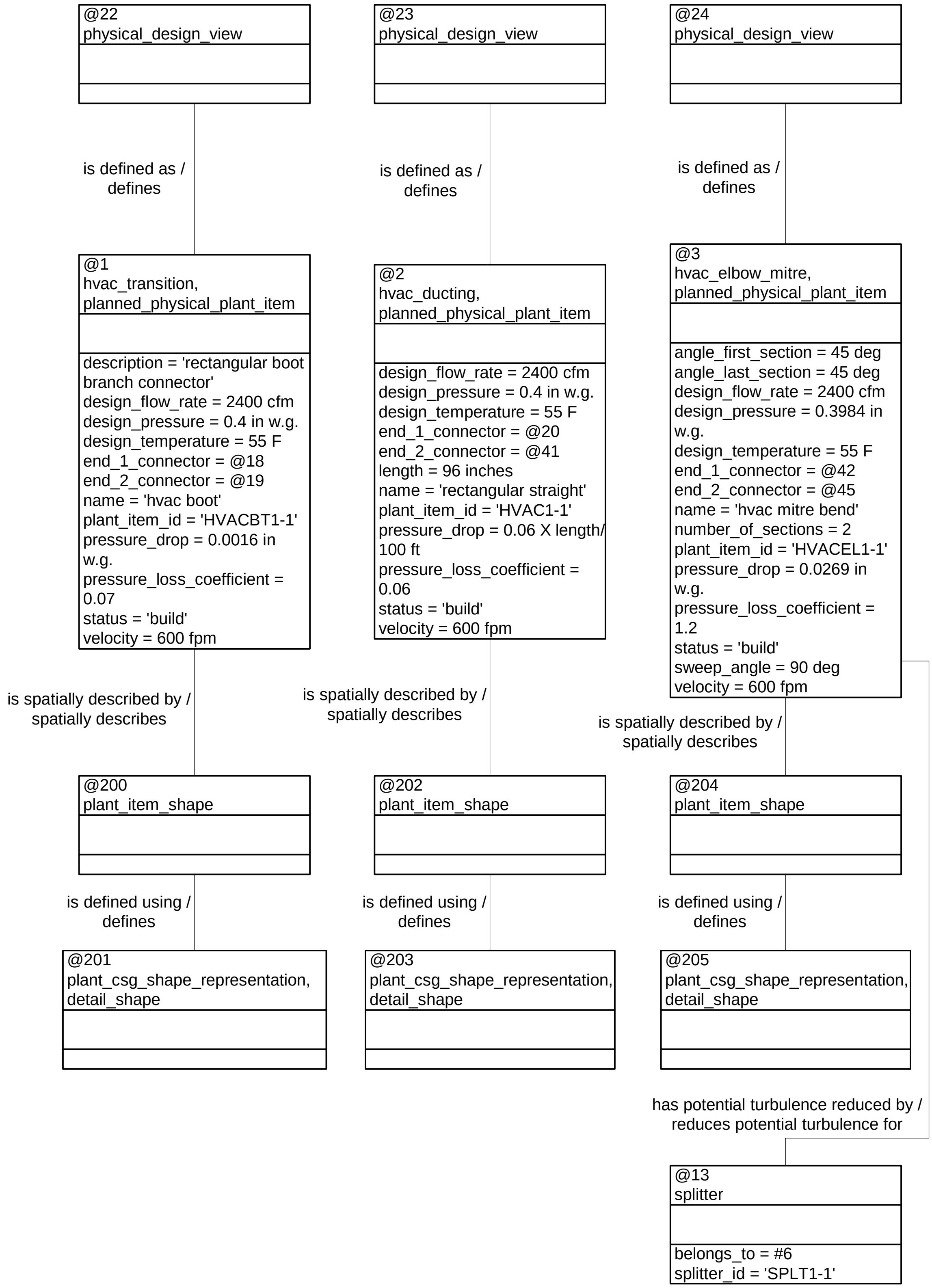

Figure A.41 — Instance diagram for the HVAC Rectangular test case (1 of 16)

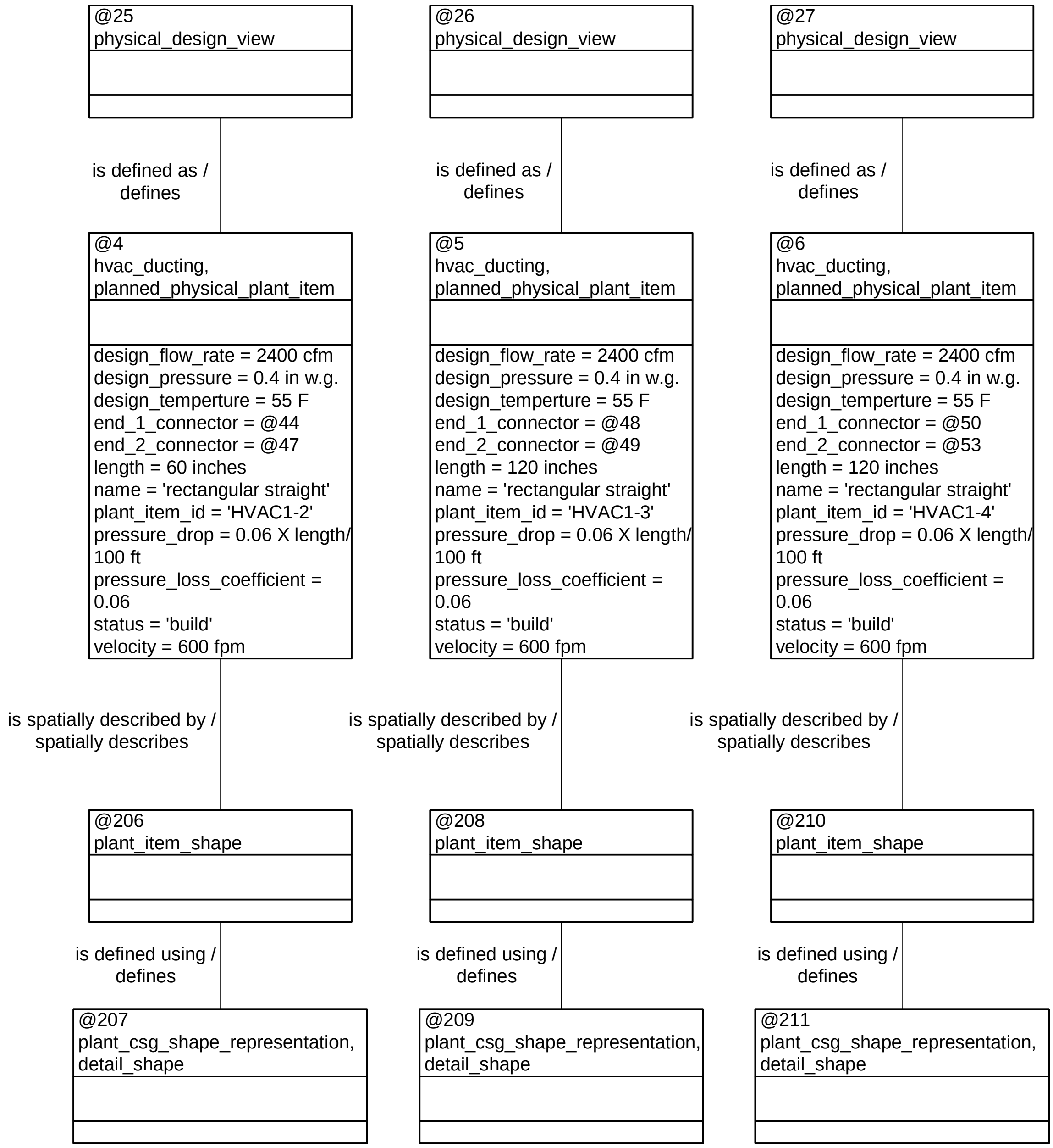

Figure A.42 — Instance diagram for the HVAC Rectangular test case (2 of 16)

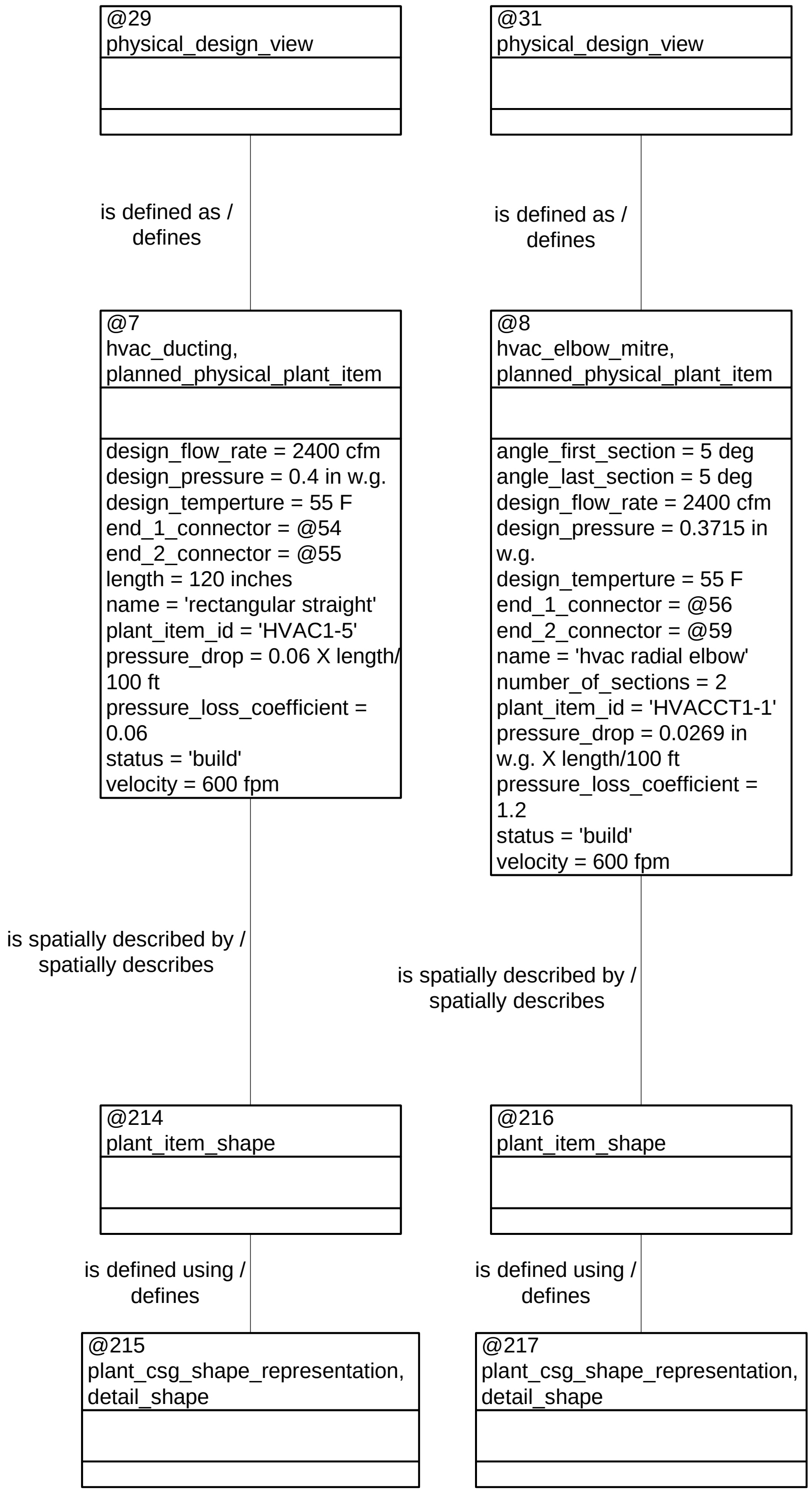

Figure A.43 — Instance diagram for the HVAC Rectangular test case (3 of 16)

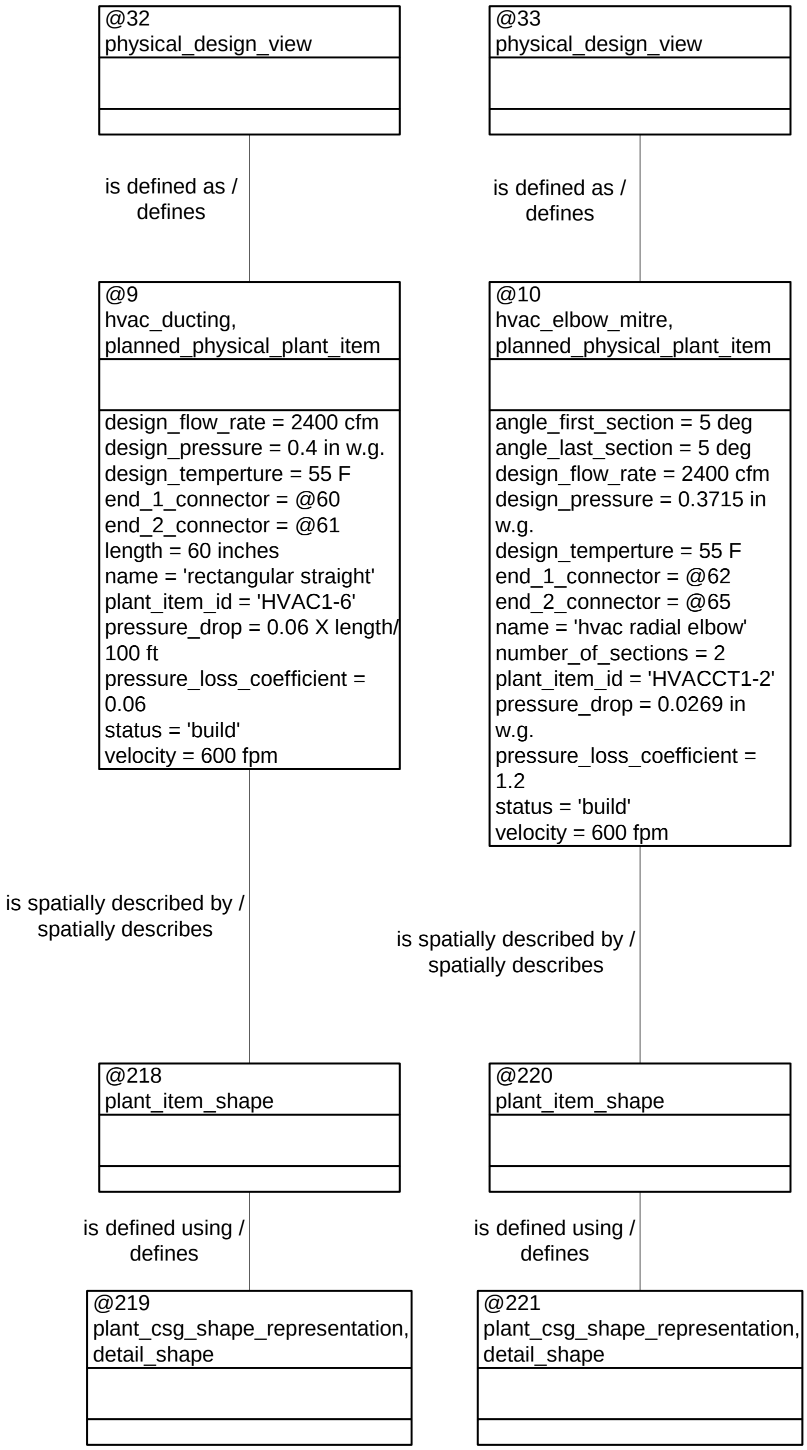

Figure A.44 — Instance diagram for the HVAC Rectangular test case (4 of 16)

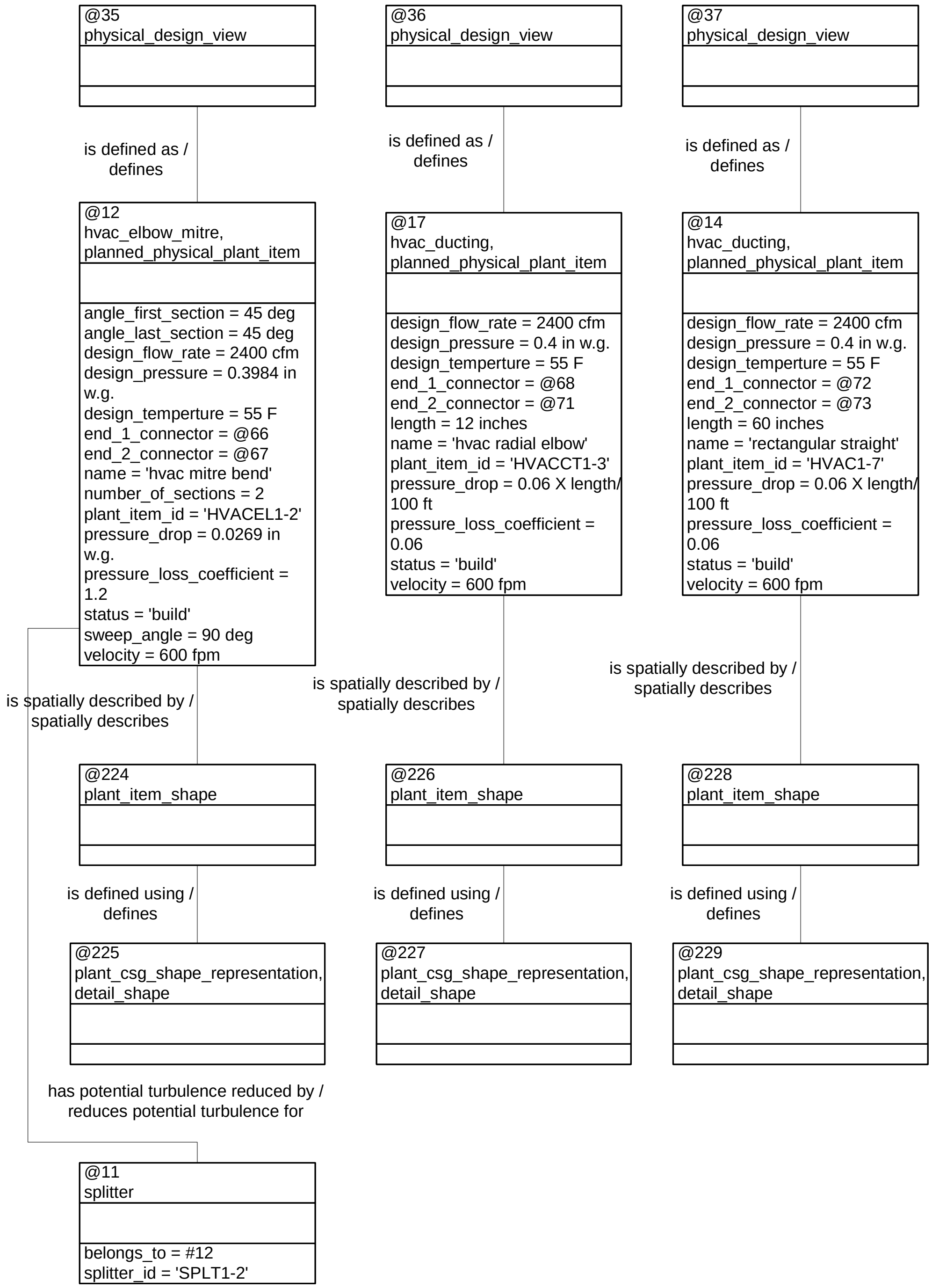

Figure A.45 — Instance diagram for the HVAC Rectangular test case (5 of 16)

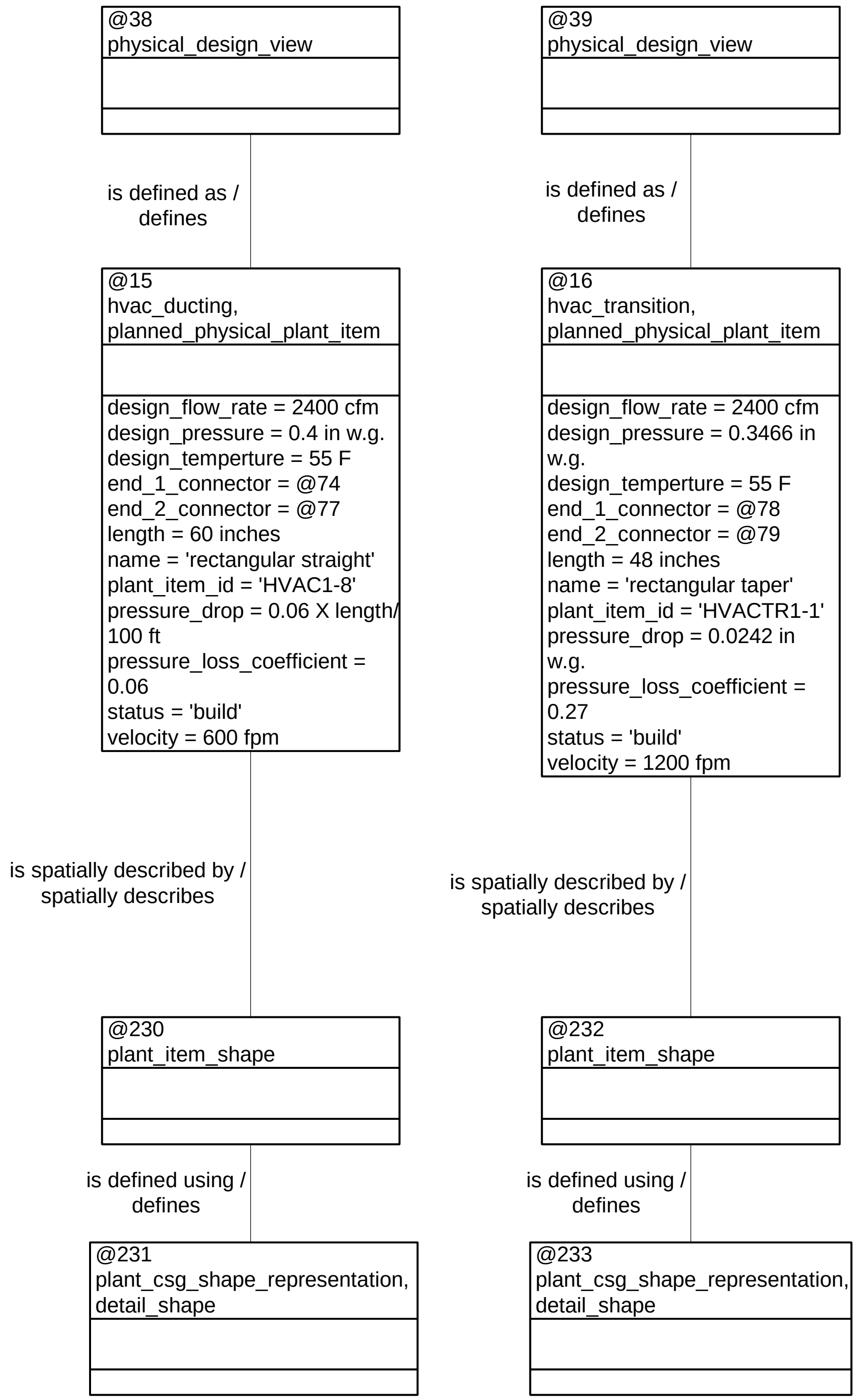

Figure A.46 — Instance diagram for the HVAC Rectangular test case (6 of 16)

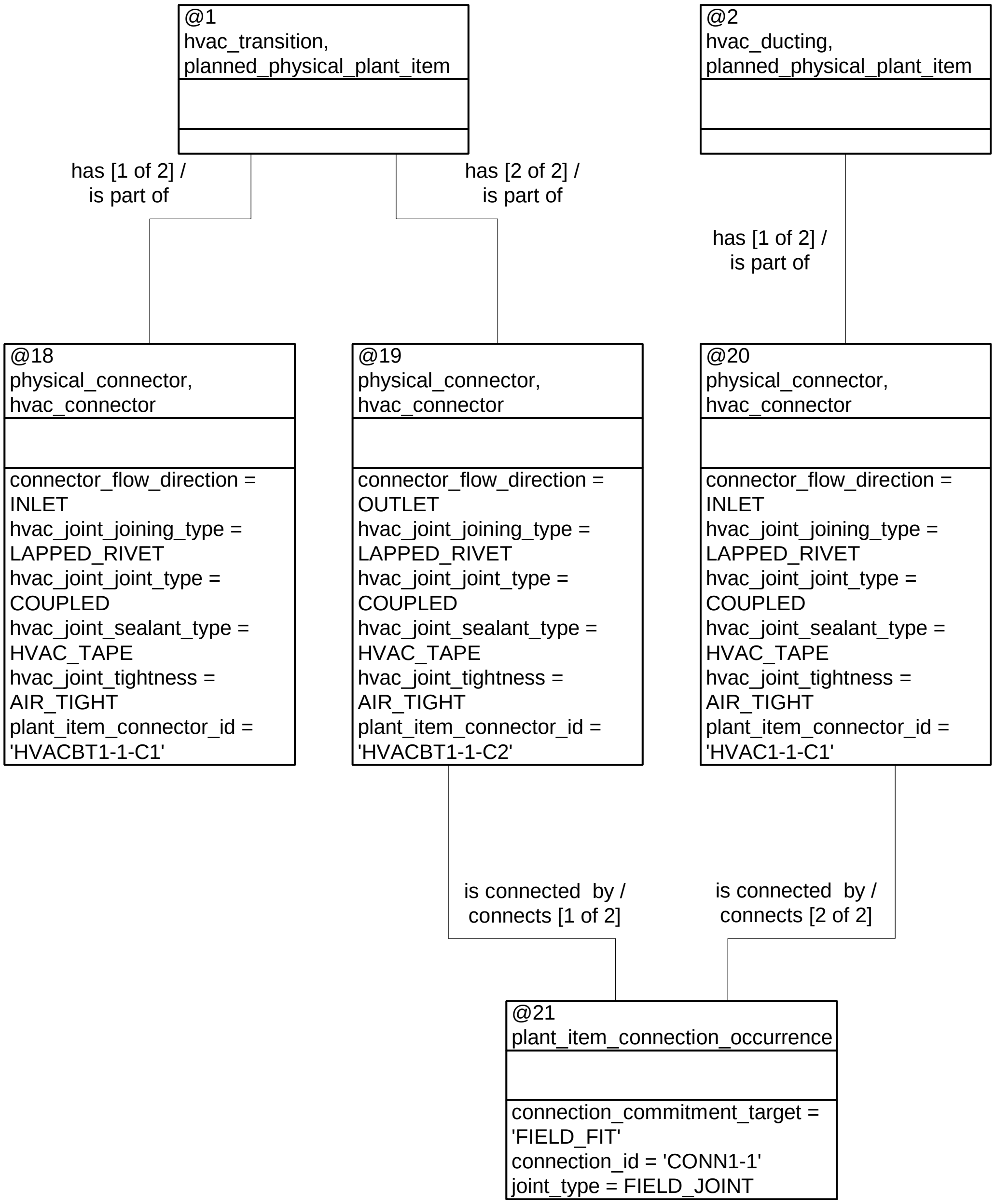

Figure A.47 — Instance diagram for the HVAC Rectangular test case (7 of 16)

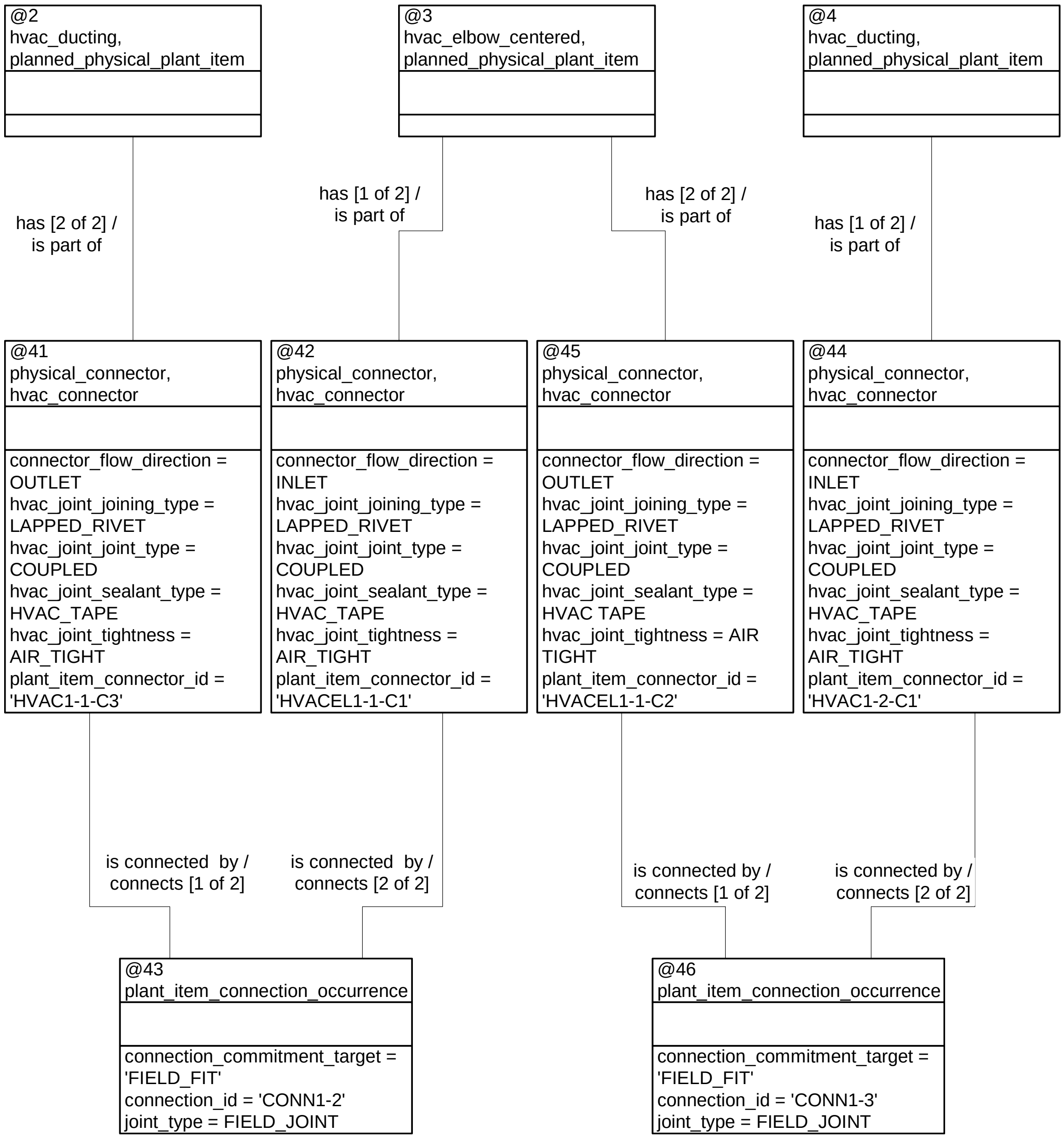

Figure A.48 — Instance diagram for the HVAC Rectangular test case (8 of 16)

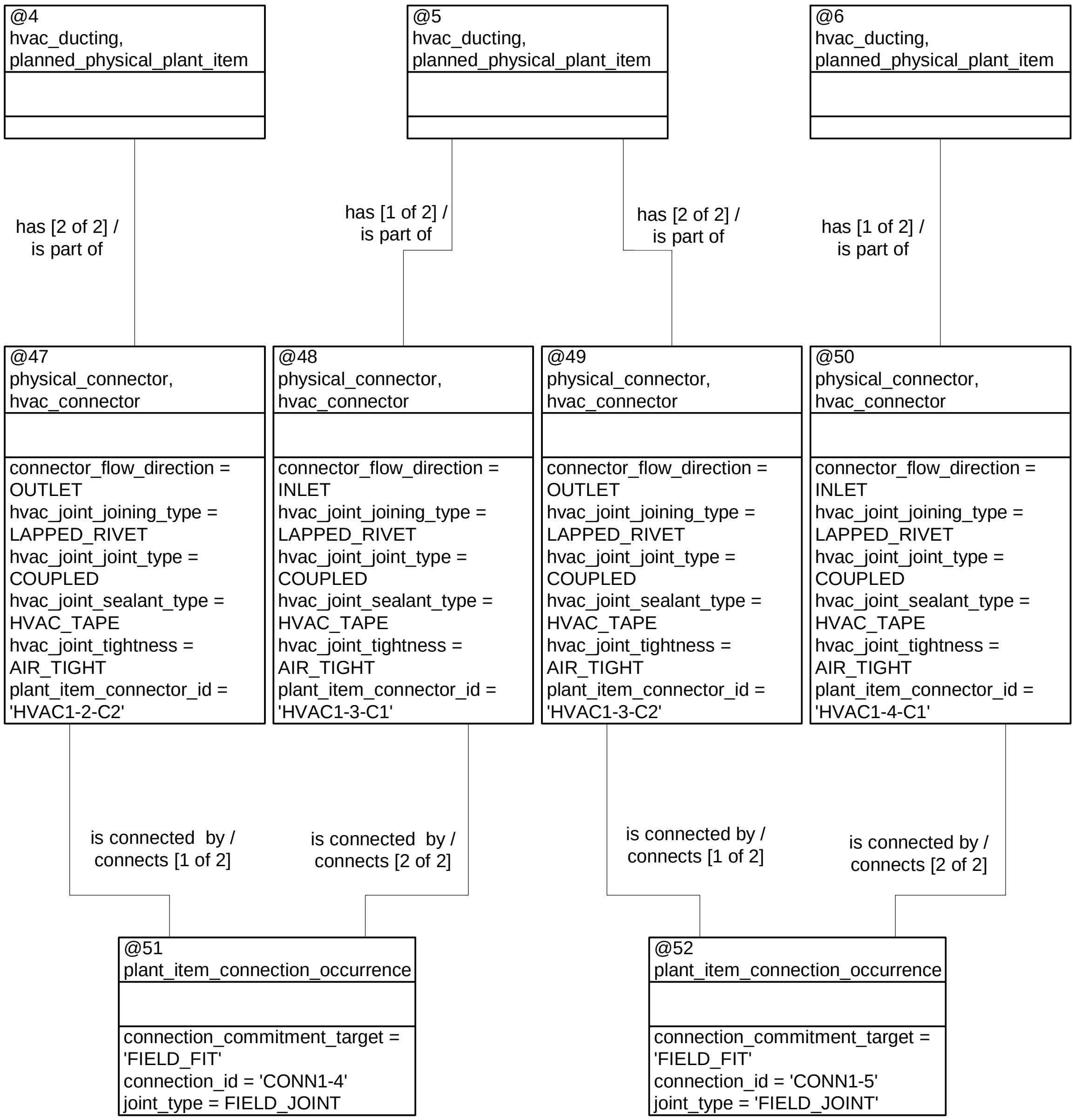

Figure A.49 — Instance diagram for the HVAC Rectangular test case (9 of 16)

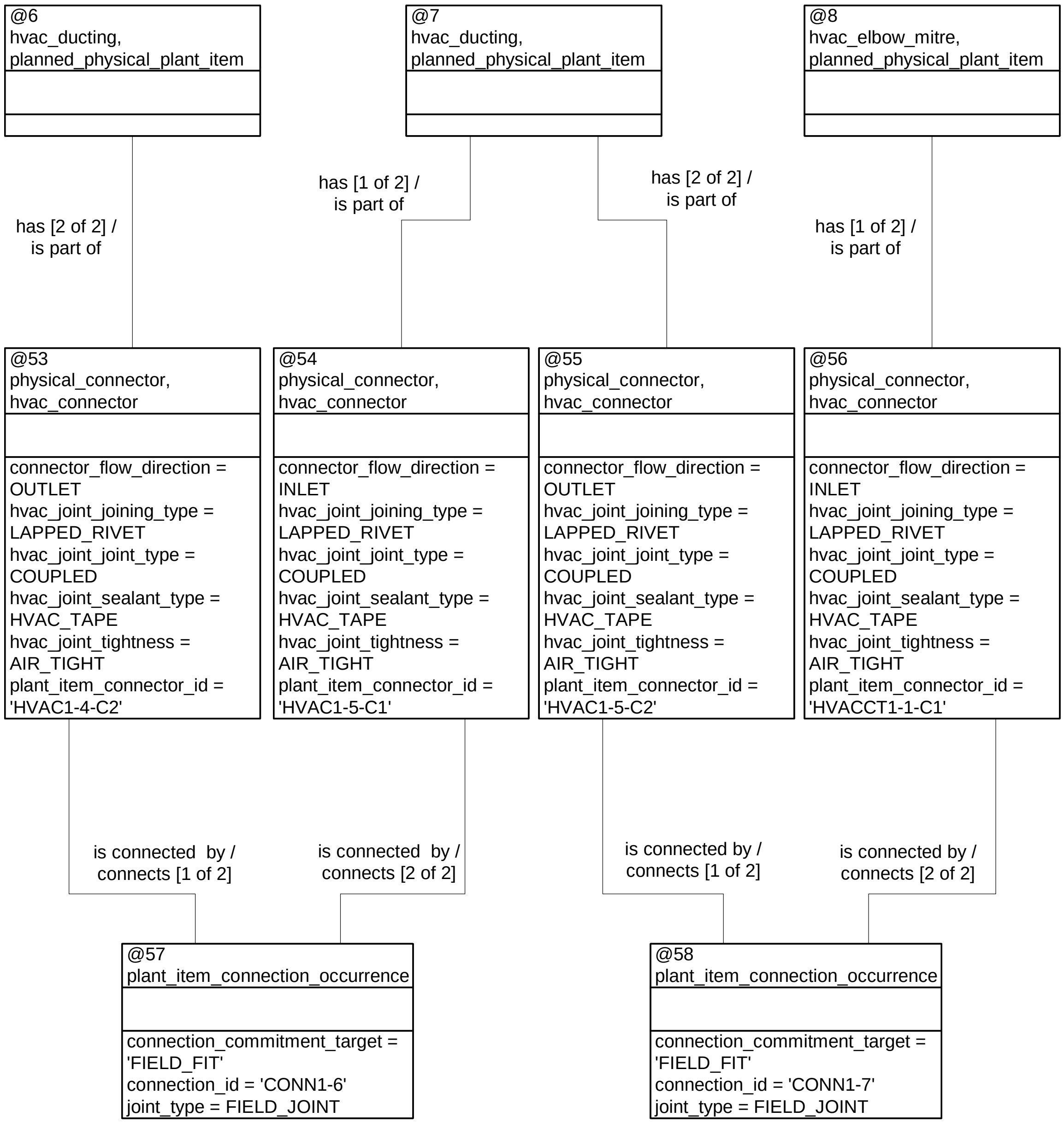

Figure A.50 — Instance diagram for the HVAC Rectangular test case (10 of 16)

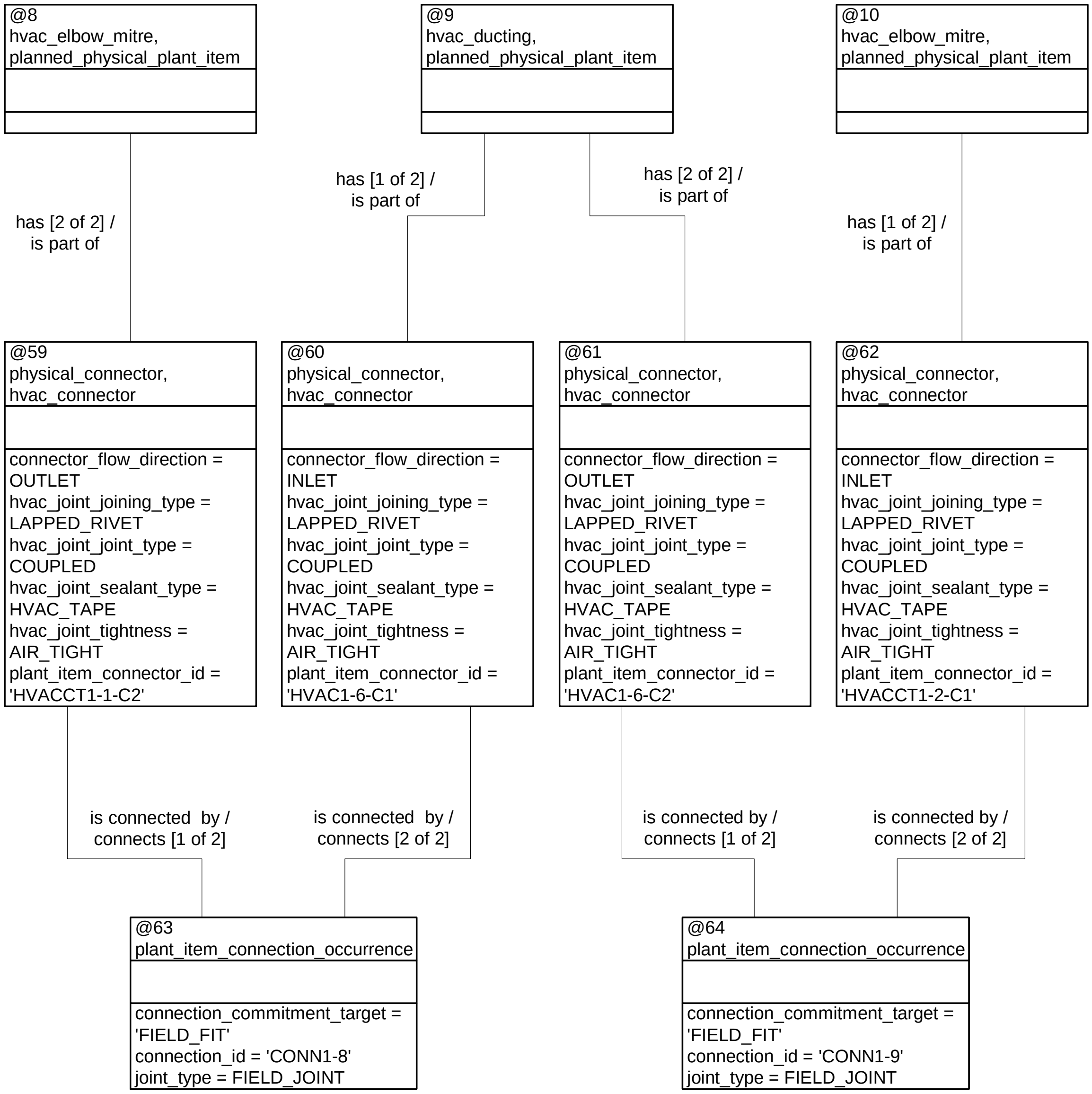

Figure A.51 — Instance diagram for the HVAC Rectangular test case (11 of 16)

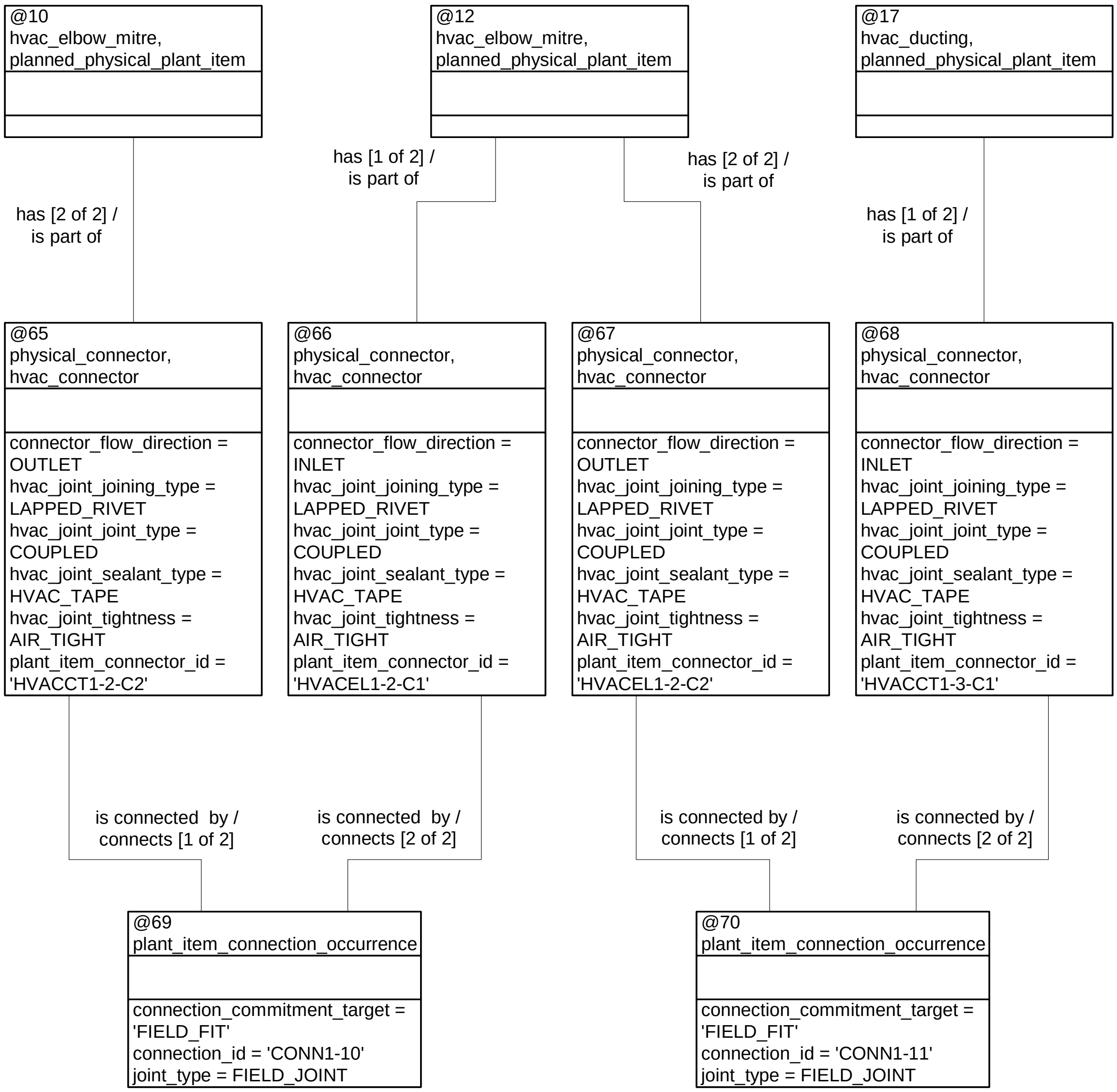

Figure A.52 — Instance diagram for the HVAC Rectangular test case (12 of 16)

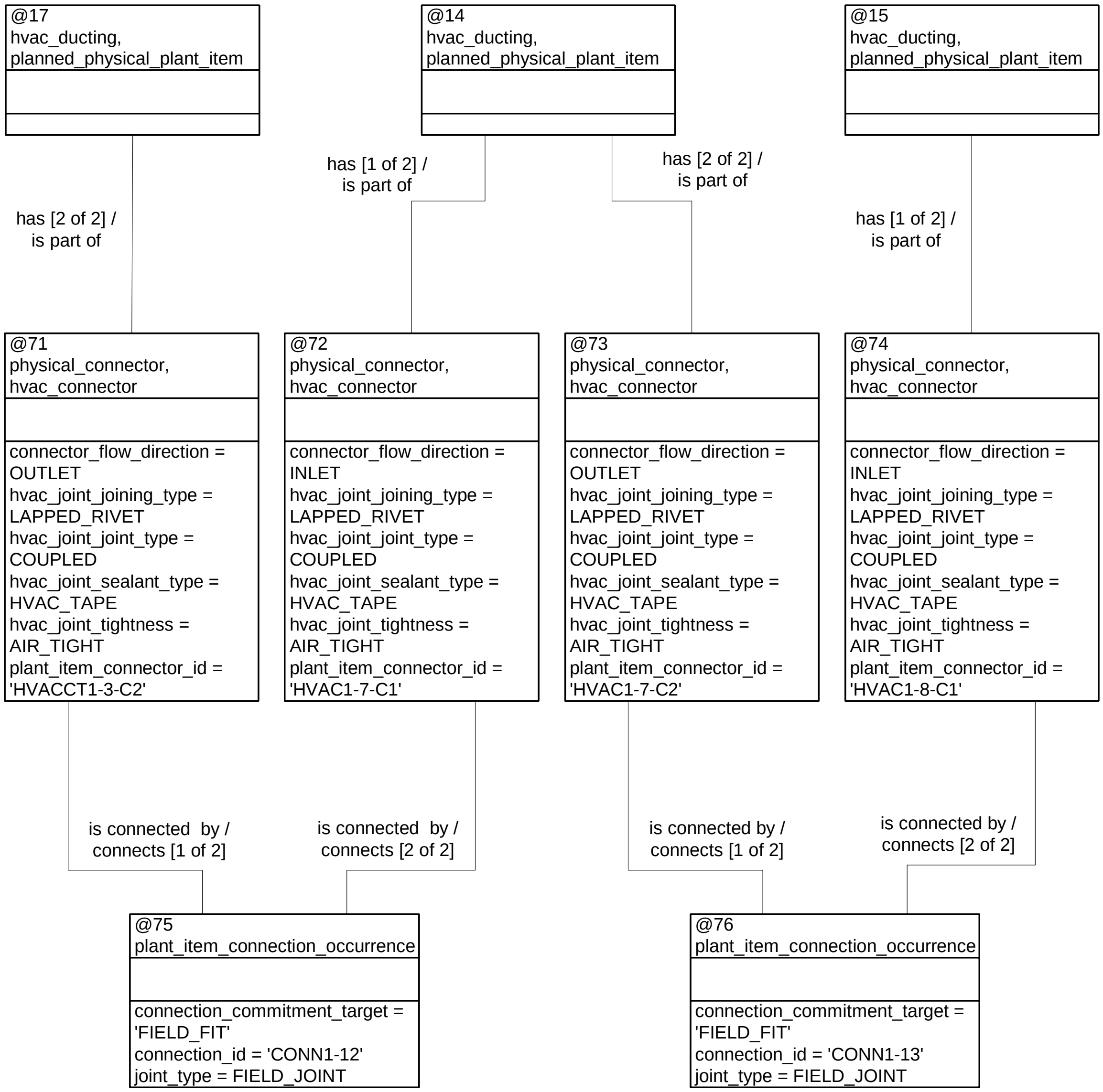

Figure A.53 — Instance diagram for the HVAC Rectangular test case (13 of 16)

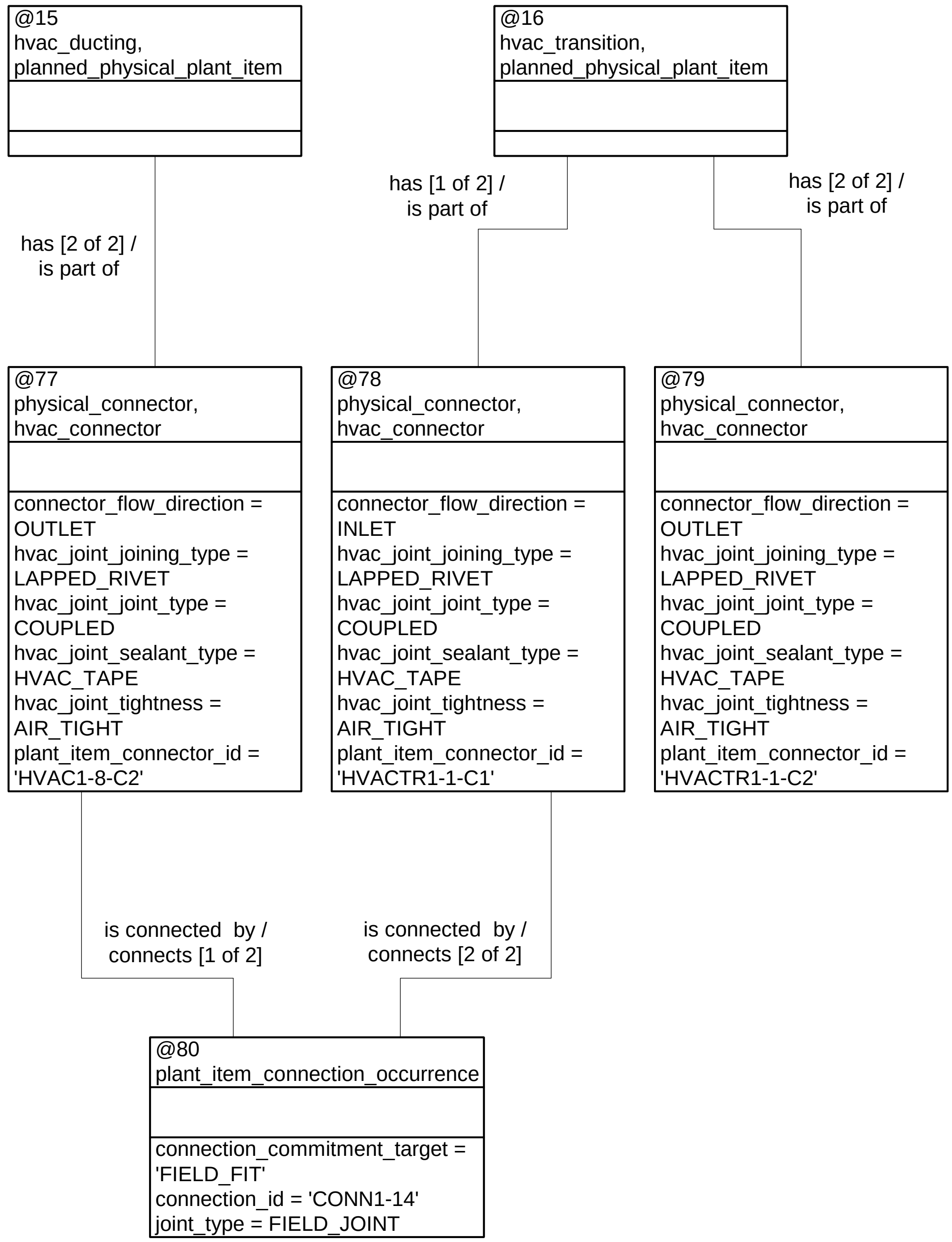

Figure A.54 — Instance diagram for the HVAC Rectangular test case (14 of 16)

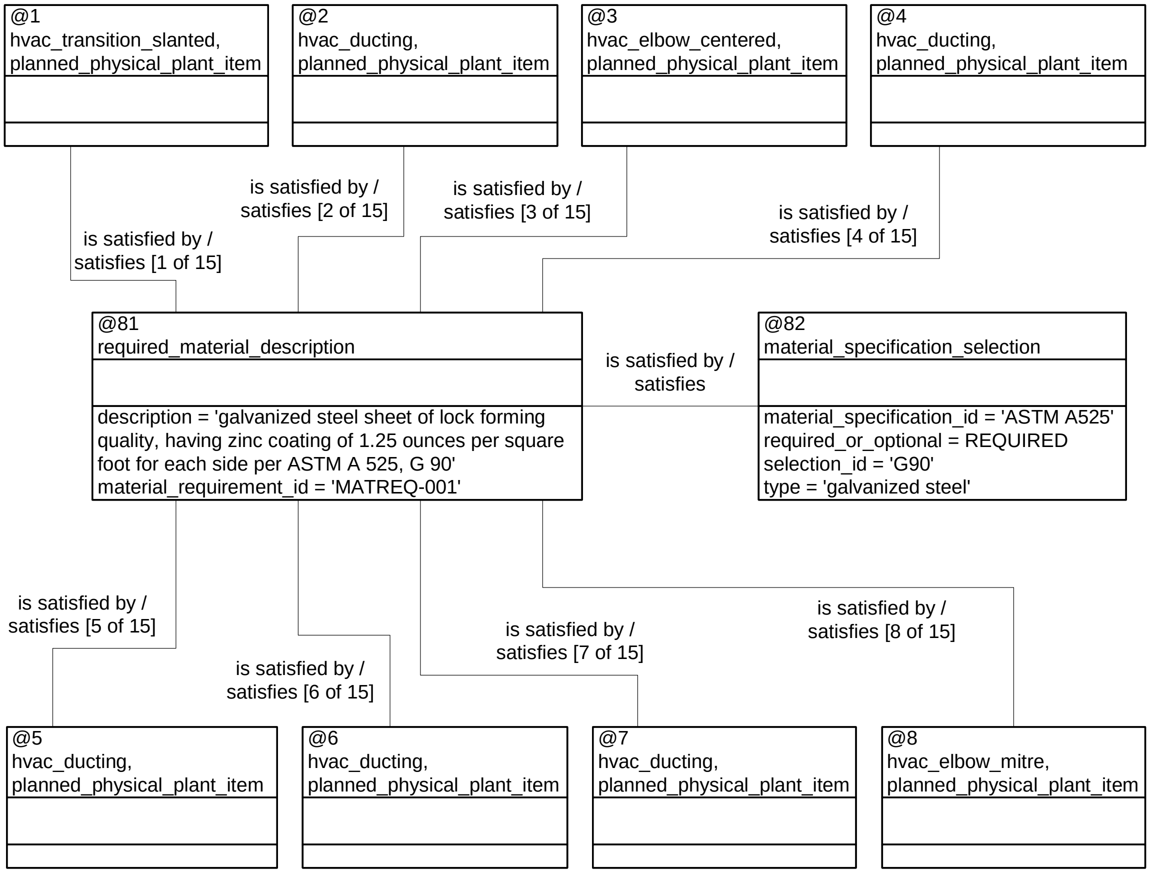

Figure A.55 — Instance diagram for the HVAC Rectangular test case (15 of 16)

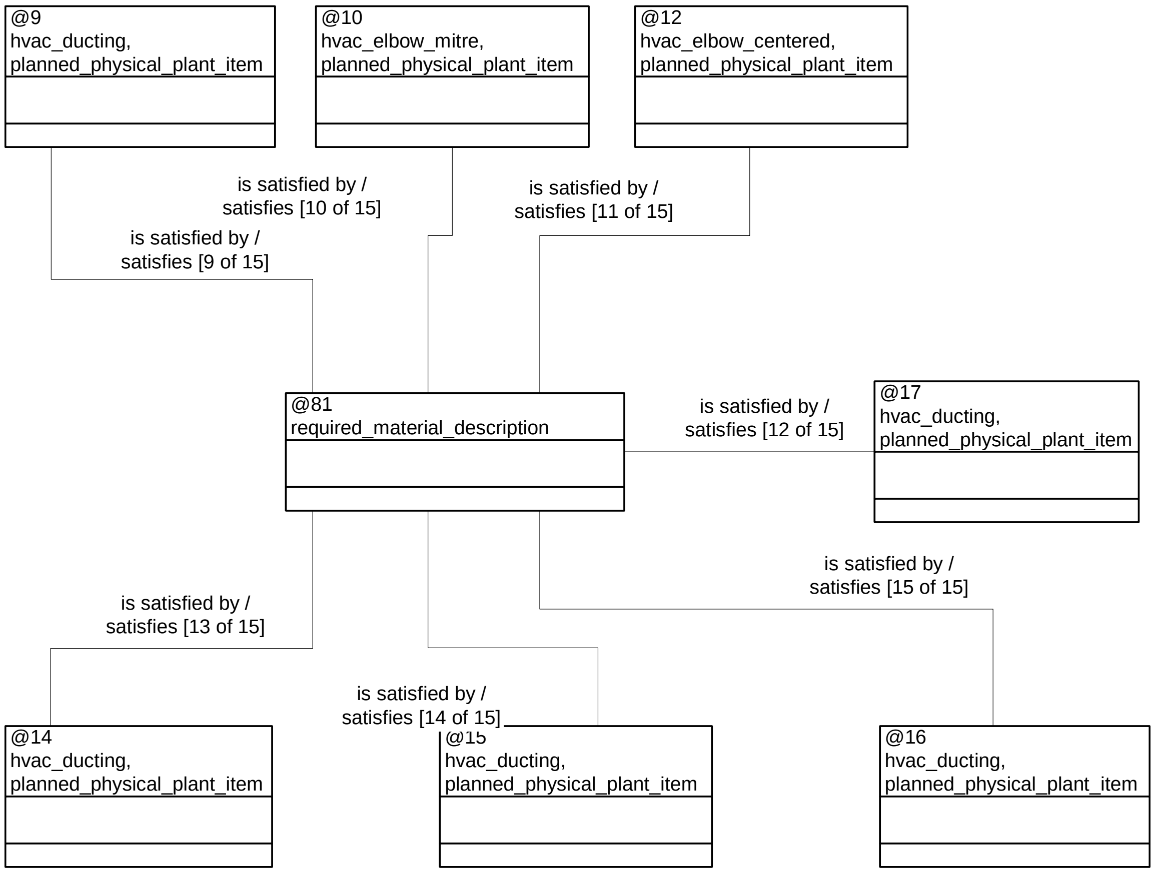

Figure A.56 — Instance diagram for the HVAC Rectangular test case (16 of 16)

A.3.4 HVAC Flow Analysis

A.3.4.1 Purpose

This clause describes the use of ISO 10303-227 to exchange flow analysis of an HVAC system.

A.3.4.2 Exchange context

The context for this test case is the exchange of HVAC flow analysis information between an HVAC engineer and an installer.

A.3.4.3 Test data

Figure A.57 shows a portion of an HVAC system that will serve as the basis for this test case.

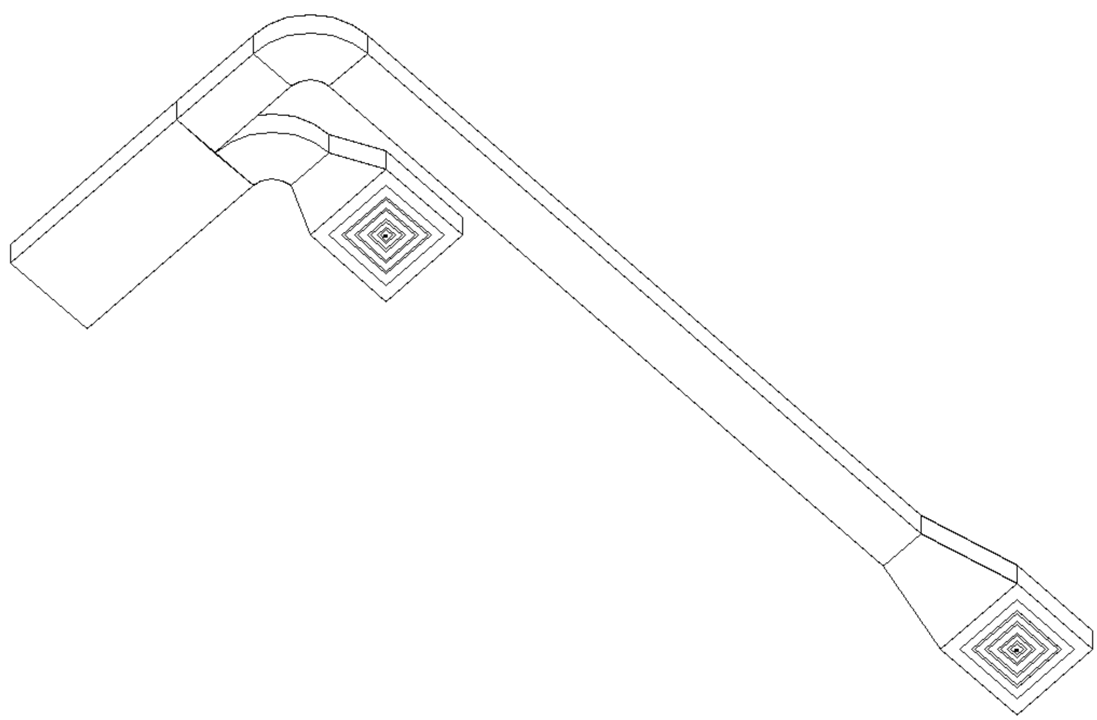

Figure A.57 — HVAC system for the HVAC Flow Analysis test case

This system consists of three runs, labeled HVAC-01-01, HVAC-01-02 and HVAC-01-03. These are shown in Figure A.58.

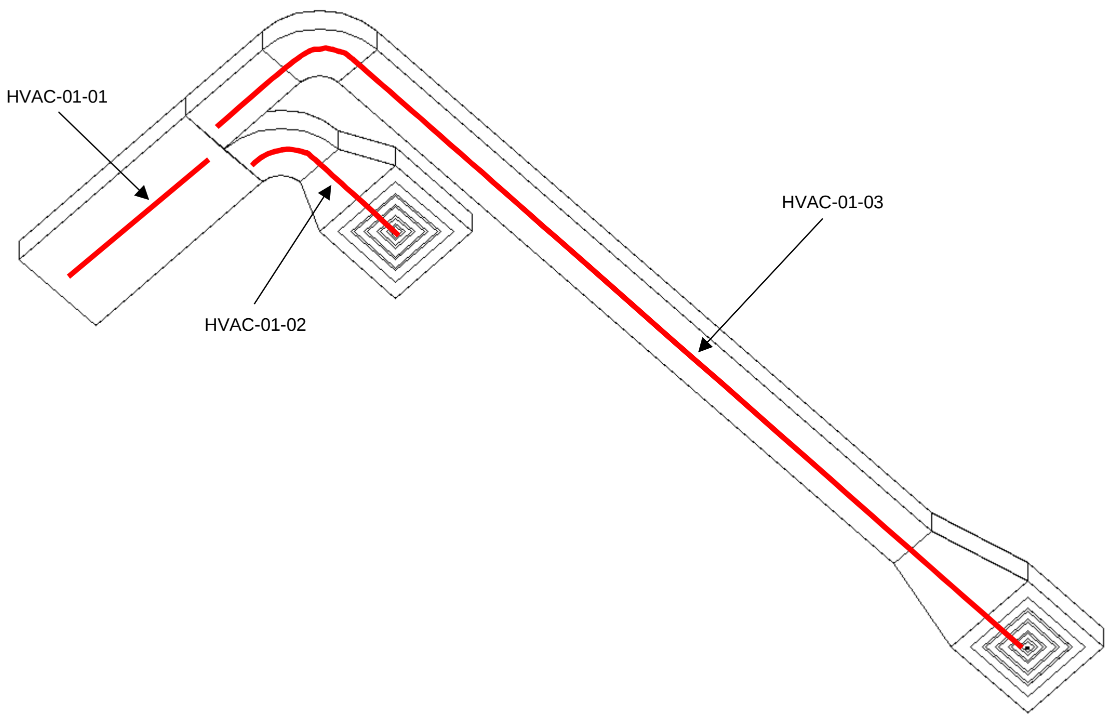

Figure A.58 — Runs for the HVAC Flow Analysis test case

Run HVAC-01-01 consists of one section, HVAC-01-01-01. Each of the other two runs consists of three sections. The sections are shown in Figure A.59.

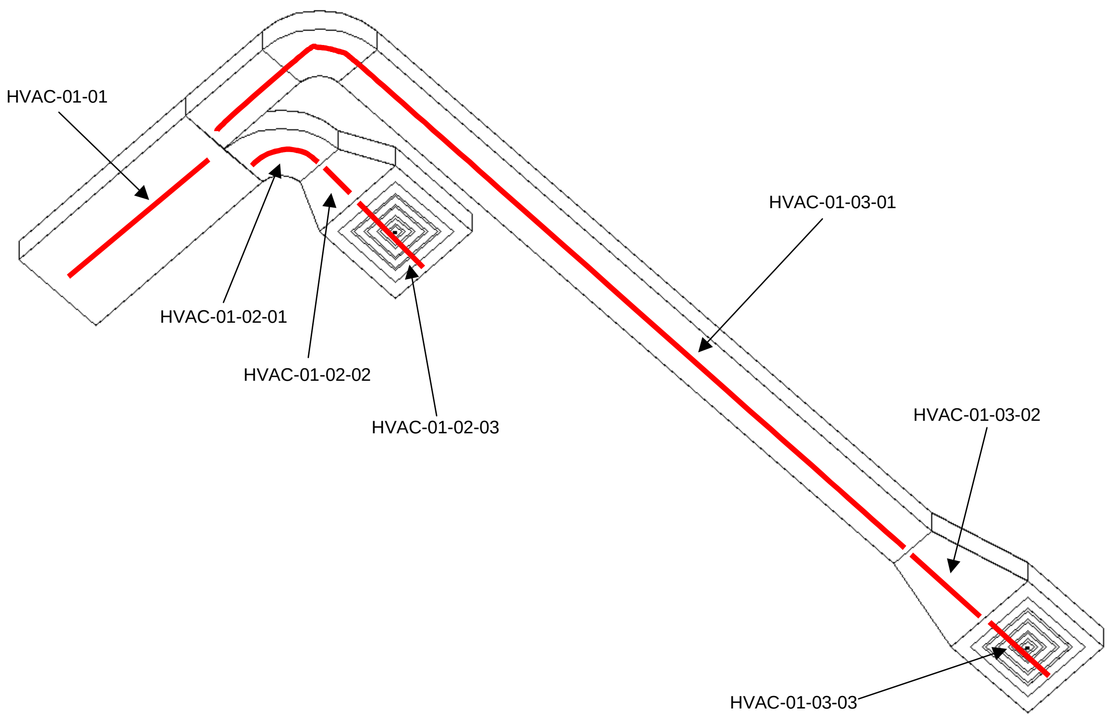

Figure A.59 — Sections for the HVAC Flow Analysis test case

Figure A.60 shows dimensions for the system. Note that only the circled part of the system is included in this test case.

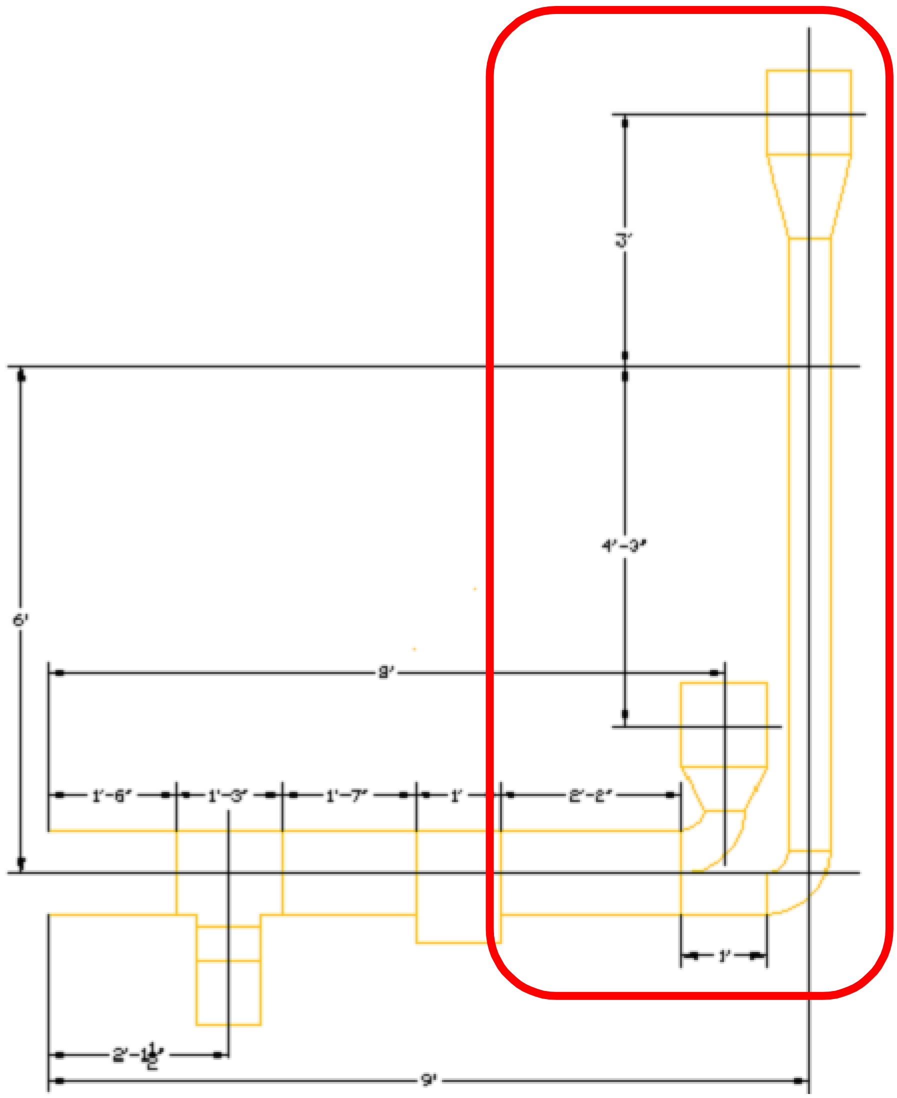

Figure A.60 — Dimensions for the HVAC Flow Analysis test case

The component types included in this test case are ducting, transition, elbow, and diffusers. Figure A.61 shows the components of the system with labels attached.

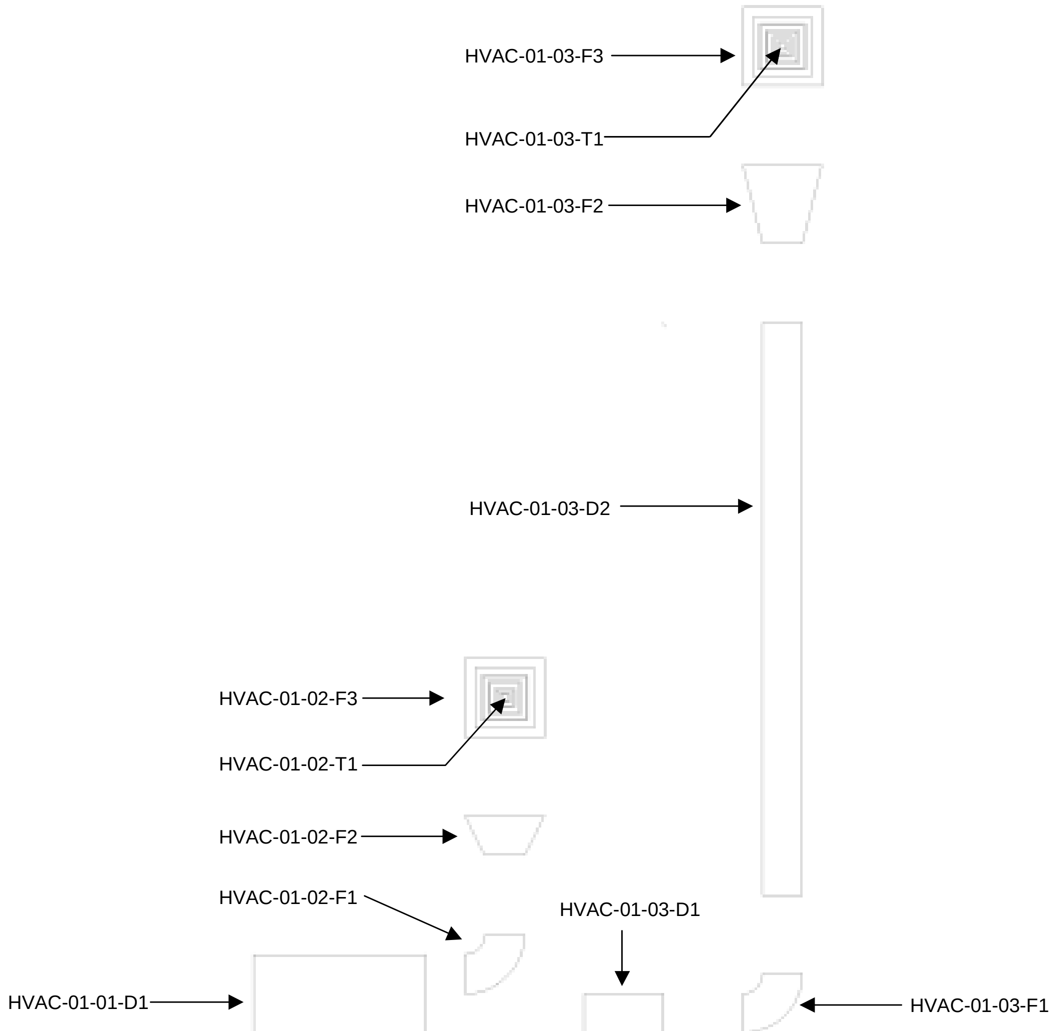

Figure A.61 — HVAC system with components labeled

Table A.7 gives the component types and attributes of the components. All components are made of galvanized sheet steel, thickness AWG 20. Table A.8 gives the connectors and their attributes. Table A.9 gives the runs. In this test case, the attributes shown in Table A.9 for the runs apply to all sections within the runs. Table A.10 gives the connections and their attributes.

Table A.7 — Components for the HVAC Flow Analysis test case

Component ID	Type	Heel radius (in)	Throat radius (in)	Equivalent length (in)	Correction factor	Pressure loss coefficient	Friction factor (w.g. / 100 ft)	Design pressure (psi)	Design temperature (deg F)
HVAC-01-01-D1	Duct, rectangular			26.00	0.98		0.18	0.0072 psi	100
HVAC-01-02-F1	Elbow, rectangular, 90 degrees, smooth without vanes	9.00	3.00	35.00	0.98	0.24		0.0072 psi	100
HVAC-01-02-F2	Ducting transition, rectangular to rectangular			5.00	0.98	0.36		0.0072 psi	100
HVAC-01-02-F3	Elbow, mitre, 90 degrees			15.00	1.00	1.3		0.0072 psi	100
HVAC-01-02-T1	Register			0.00	1.00	0.13		0.0072 psi	100
HVAC-01-03-D1	Duct, rectangular			12.00	0.98		0.28	0.0072 psi	100
HVAC-01-03-F1	Elbow, rectangular, 90 degrees, smooth without vanes	9.00	3.00	35.00	0.98	0.24		0.0072 psi	100
HVAC-01-03-D2	Duct, rectangular			87.00	0.98		0.28	0.0072 psi	100
HVAC-01-03-F2	Ducting transition, rectangular to rectangular			5.00	0.98	0.19		0.0072 psi	100
HVAC-01-03-F3	Elbow, mitre, 90 degrees			15.00	1.00	1.3		0.0072 psi	100
HVAC-01-03-T1	Register			0.00	1.00	0.13		0.0072 psi	100

Table A.8 — Connectors for the HVAC Flow Analysis test case

System	Connector	X	Y	Z	Height	Width	Velocity (fpm)	Equivalent diameter (in)
HVAC-01-01-D1	A	0.00	0.00	0.00	4.00	12.00	930	7.31
	B	26.00	0.00	0.00	4.00	12.00	930	7.31
HVAC-01-02-F1	A	26.00	3.00	0.00	4.00	6.00	960	5.33
	B	32.00	9.00	0.00	4.00	6.00	960	5.33
HVAC-01-02-F2	A	32.00	9.00	0.00	4.00	6.00	960	5.33
	B	32.00	15.00	0.00	4.00	12.00	480	7.31
HVAC-01-02-F3	A	32.00	15.00	0.00	4.00	12.00	480	7.31
	B	32.00	21.00	-2.00	9.00	9.00	284.4444	9.84
HVAC-01-02-T1	A	32.00	21.00	-2.00	9.00	9.00	284.4444	9.84
HVAC-01-03-D1	A	26.00	-3.00	0.00	4.00	6.00	900	5.33
	B	38.00	-3.00	0.00	4.00	6.00	900	5.33
HVAC-01-03-F1	A	38.00	-3.00	0.00	4.00	6.00	900	5.33
	B	44.00	3.00	0.00	4.00	6.00	900	5.33
HVAC-01-03-D2	A	44.00	3.00	0.00	4.00	6.00	900	5.33
	B	44.00	90.00	0.00	4.00	6.00	900	5.33
HVAC-01-03-F2	A	44.00	90.00	0.00	4.00	6.00	900	5.33
	B	44.00	102.00	0.00	4.00	12.00	450	7.31
HVAC-01-03-F3	A	44.00	102.00	0.00	4.00	12.00	450	7.31
	B	44.00	108.00	-2.00	9.00	9.00	266.6667	9.84
HVAC-01-03-T1	A	44.00	108.00	-2.00	9.00	9.00	266.6667	9.84

Table A.9 — Runs for the HVAC Flow Analysis test case

Run	Flow rate (cfm)	Roughness (in)
HVAC-01-01	310	0.0003
HVAC-01-02	160	0.0003
HVAC-01-03	150	0.0003

Table A.10 — Connections for the HVAC Flow Analysis test case

Connection	End 1 connector	End 2 connector	Joint joining type	Joint tightness	Joint sealant
1	HVAC-01-01-D1-B	HVAC-01-02-F1-A	S lock and drive	drip	caulk, white latex
2	HVAC-01-02-F1-B	HVAC-01-02-F2-A	S lock and drive	drip	caulk, white latex
3	HVAC-01-02-F2-B	HVAC-01-02-F3-A	S lock and drive	drip	caulk, white latex
4	HVAC-01-02-F3-B	HVAC-01-02-T1-A	sheet metal screw	null	gasket
5	HVAC-01-01-D1-B	HVAC-01-03-D1-A	S lock and drive	drip	caulk, white latex
6	HVAC-01-03-D1-B	HVAC-01-03-F1-A	S lock and drive	drip	caulk, white latex
7	HVAC-01-03-F1-B	HVAC-01-03-D2-A	S lock and drive	drip	caulk, white latex
8	HVAC-01-03-D2-B	HVAC-01-03-F2-A	S lock and drive	drip	caulk, white latex
9	HVAC-01-03-F2-B	HVAC-01-03-F3-A	S lock and drive	drip	caulk, white latex
10	HVAC-01-03-F3-B	HVAC-01-03-T1-A	sheet metal screw	null	gasket

A.3.4.4 ARM representation

Figures A.62 to A.95 show the instance diagrams for this test case.

An HVAC system can be represented in ISO 10303-227 through a functional description and/or a physical description. In this test case, a functional and physical description is presented.

NOTE The test data specify different velocities at the different connectors of various components. The Draft International Standard version of the ISO 10303-227 ed. 2 ARM only allows velocity to be specified for a section. This will likely be addressed as a ballot comment for the Draft International Standard version.

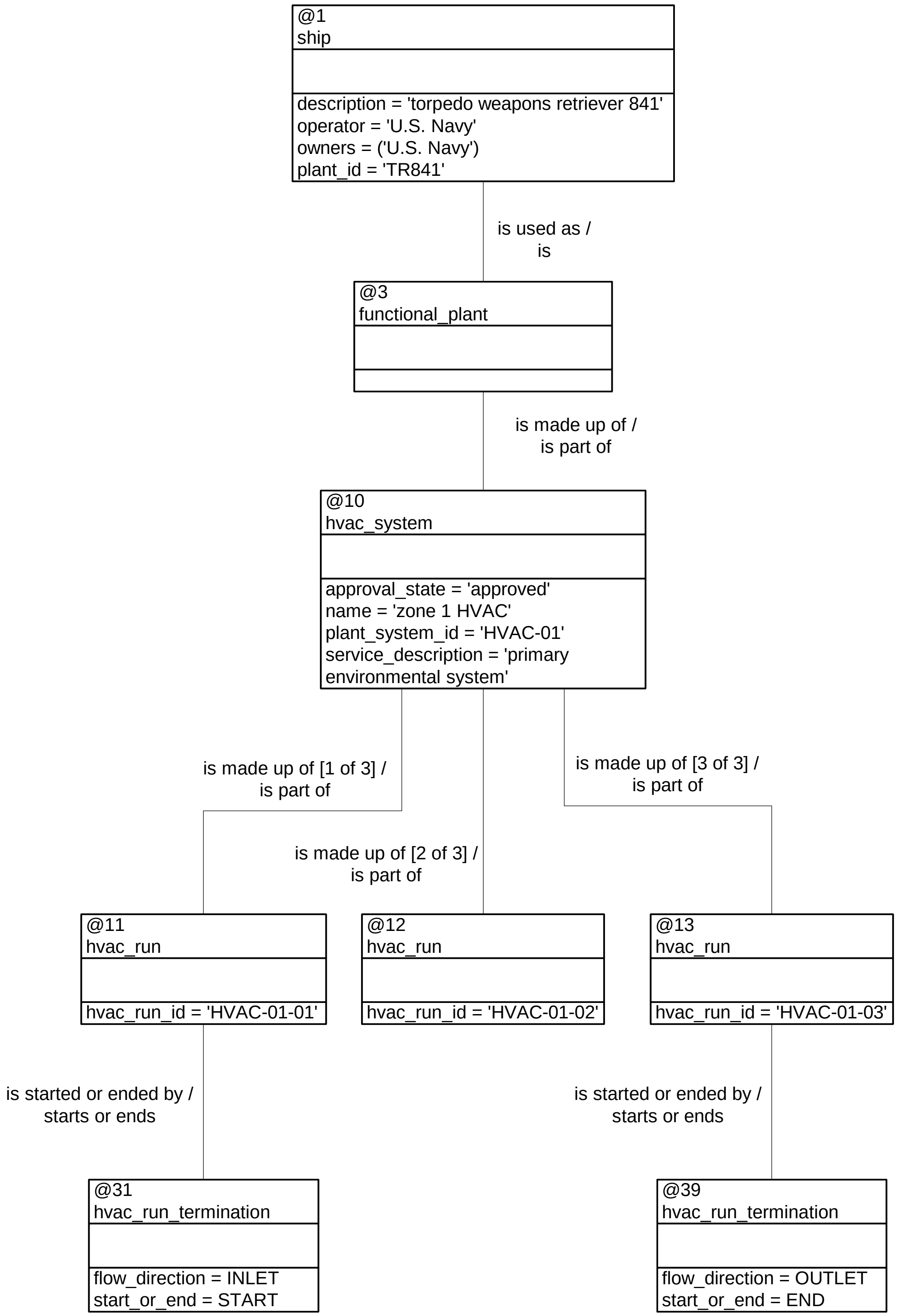

Figure A.62 — Instance diagram for the HVAC Flow Analysis test case (1 of 34)

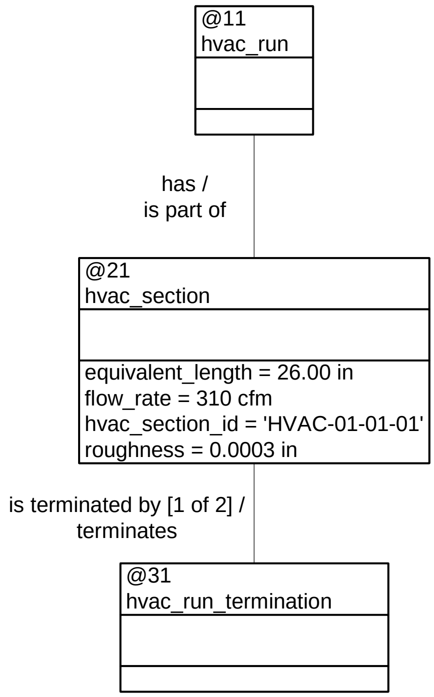

Figure A.63 — Instance diagram for the HVAC Flow Analysis test case (2 of 34)

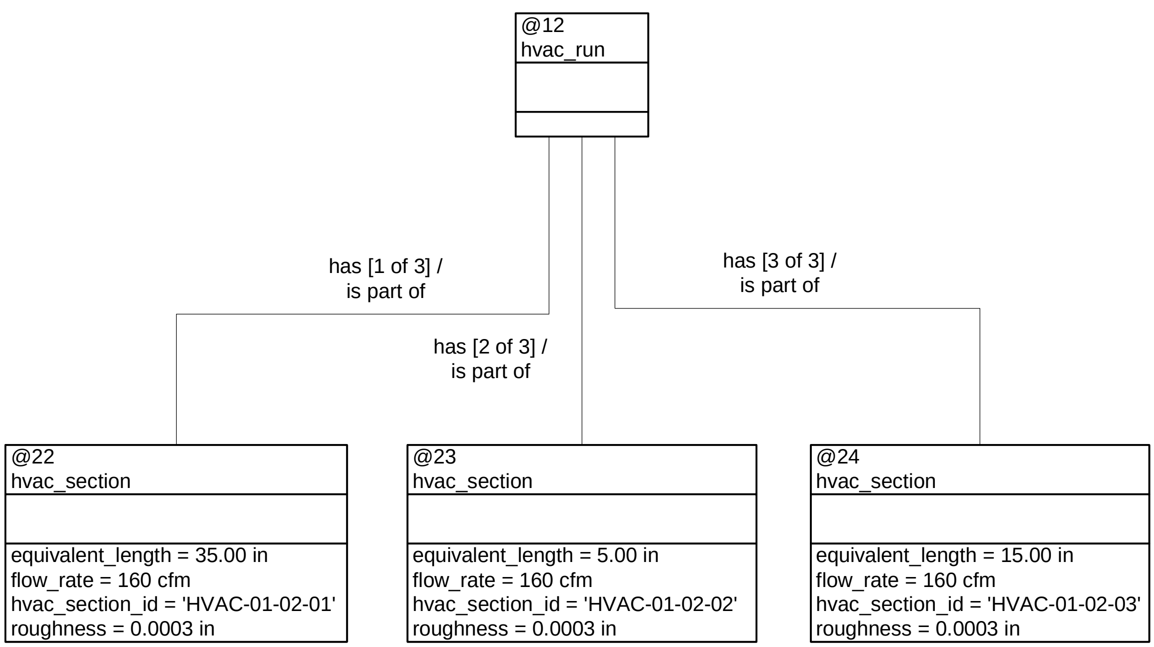

Figure A.64 — Instance diagram for the HVAC Flow Analysis test case (3 of 34)

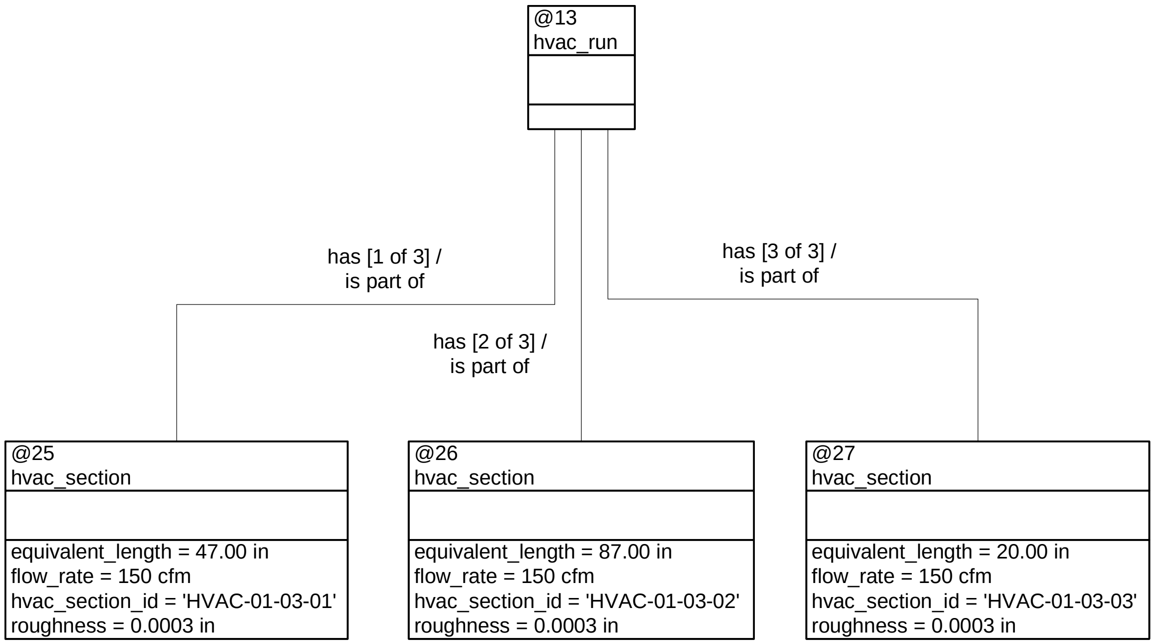

Figure A.65 — Instance diagram for the HVAC Flow Analysis test case (4 of 34)

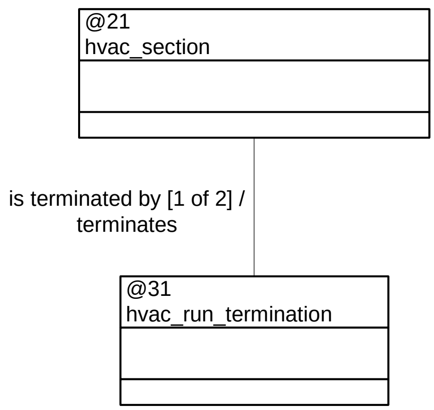

Figure A.66 — Instance diagram for the HVAC Flow Analysis test case (5 of 34)

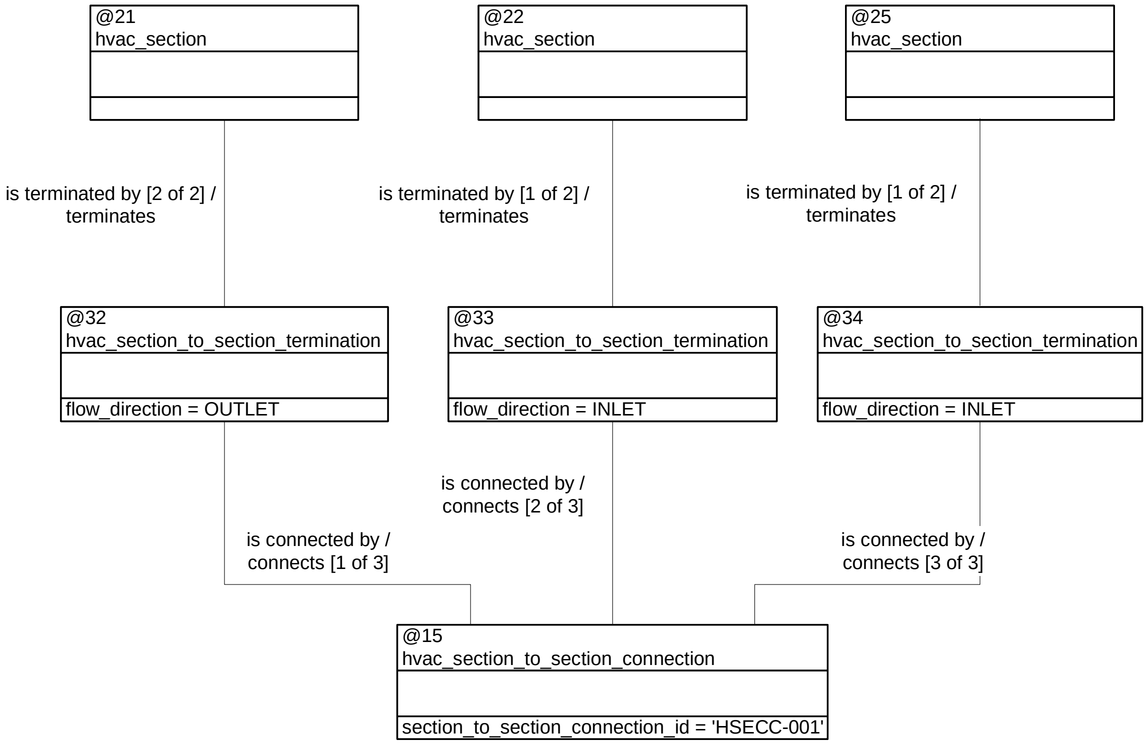

Figure A.67 — Instance diagram for the HVAC Flow Analysis test case (6 of 34)

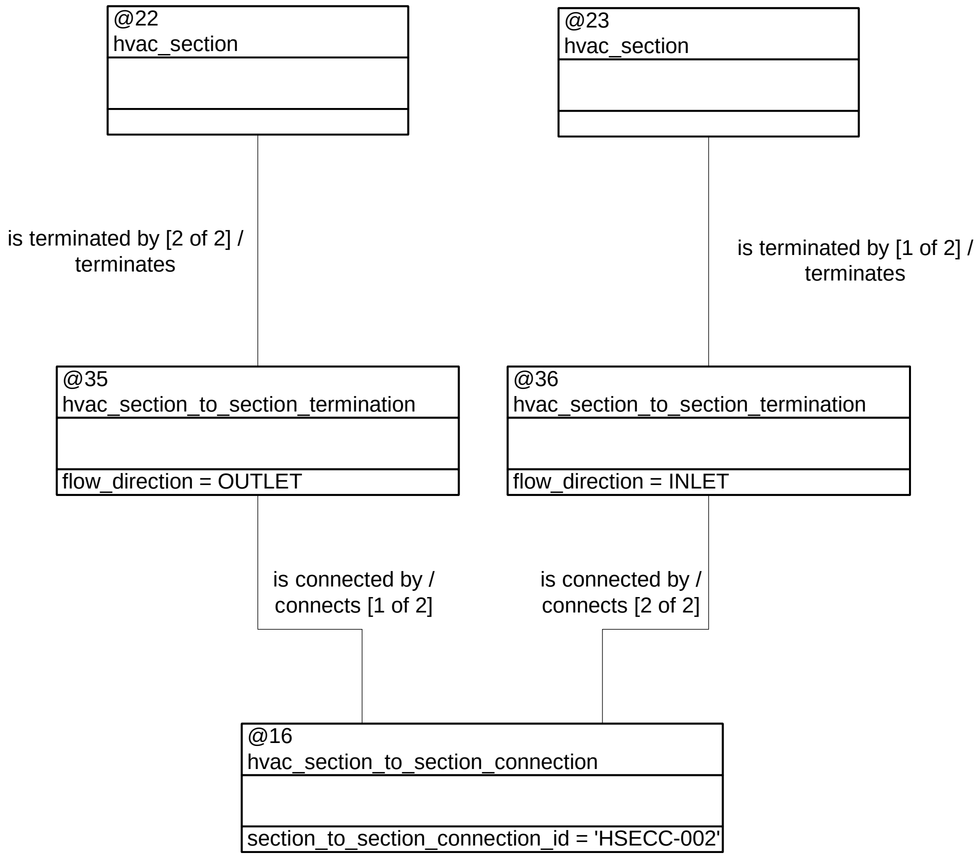

Figure A.68 — Instance diagram for the HVAC Flow Analysis test case (7 of 34)

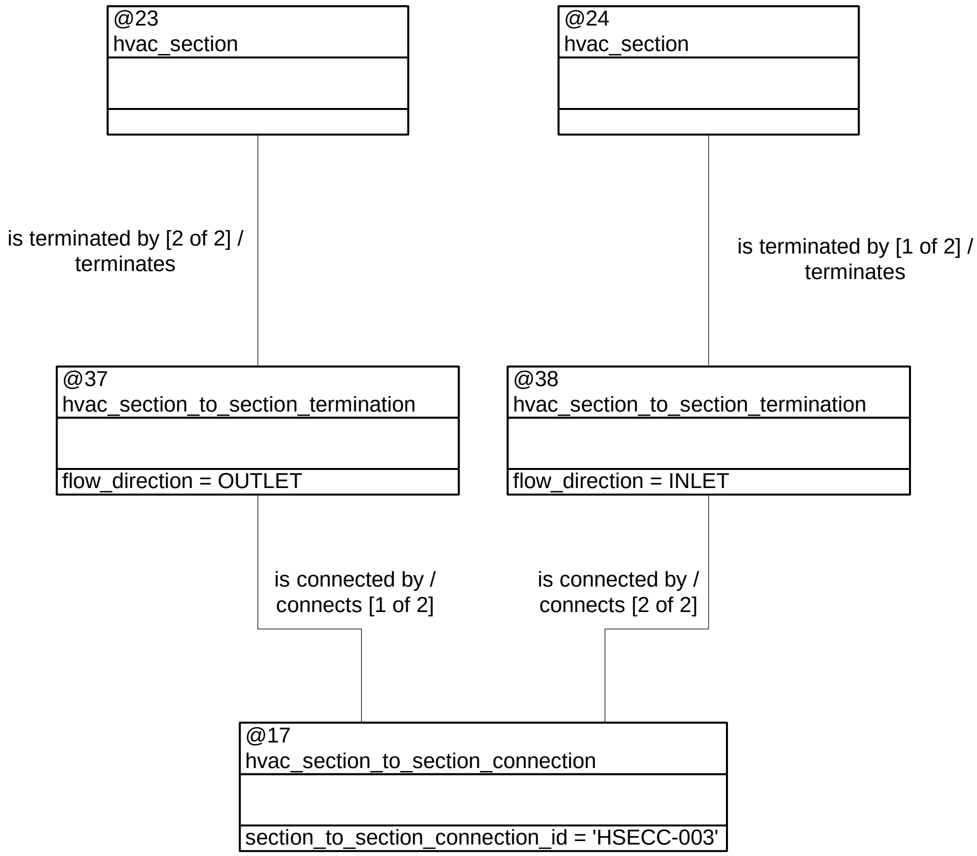

Figure A.69 — Instance diagram for the HVAC Flow Analysis test case (8 of 34)

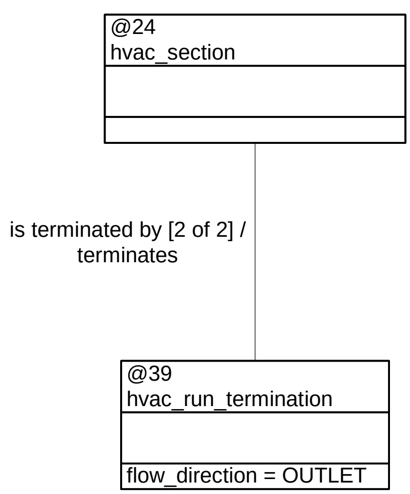

Figure A.70 — Instance diagram for the HVAC Flow Analysis test case (9 of 34)

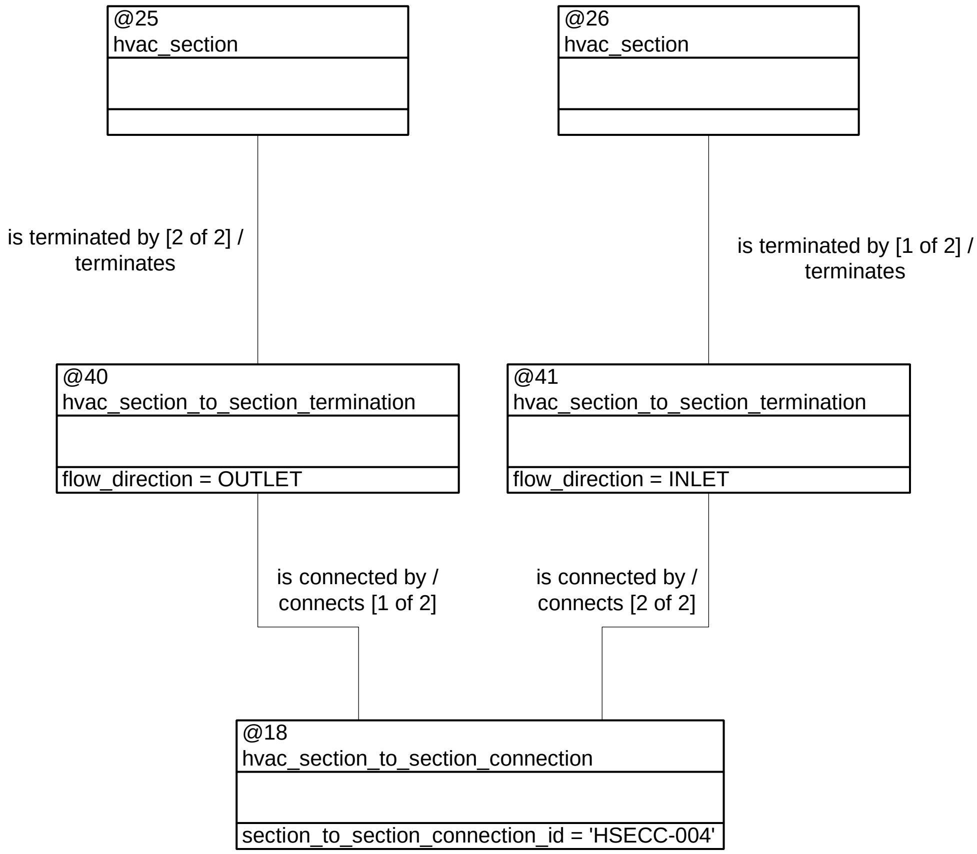

Figure A.71 — Instance diagram for the HVAC Flow Analysis test case (10 of 34)

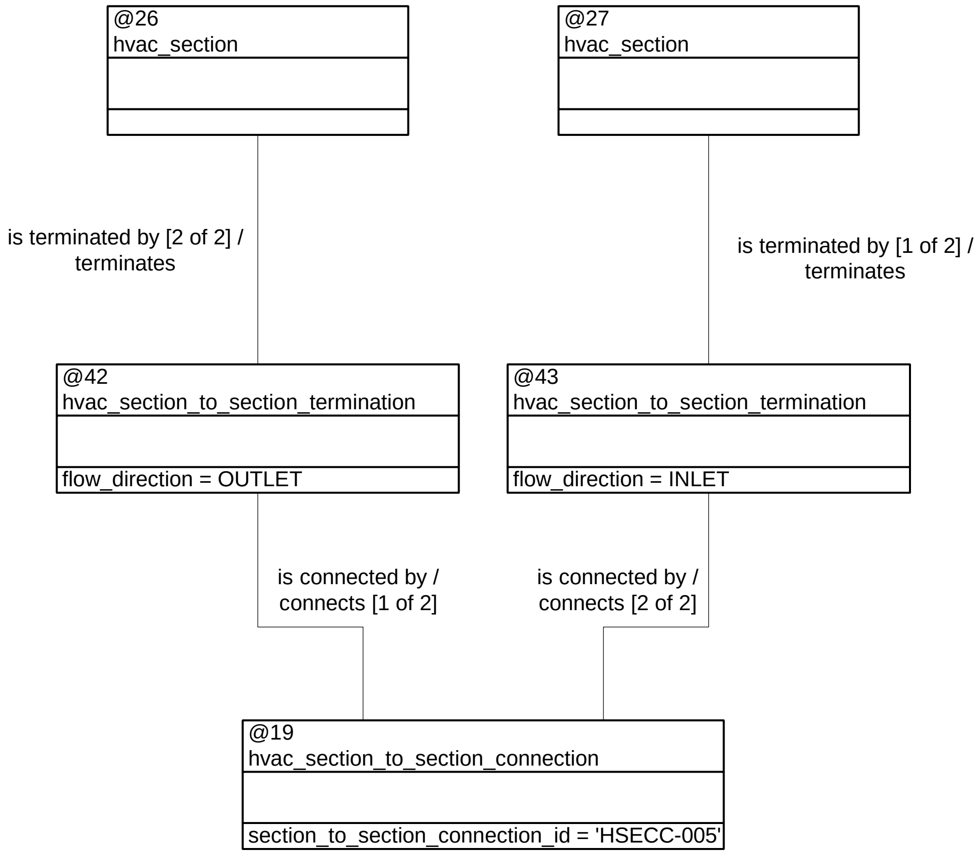

Figure A.72 — Instance diagram for the HVAC Flow Analysis test case (11 of 34)

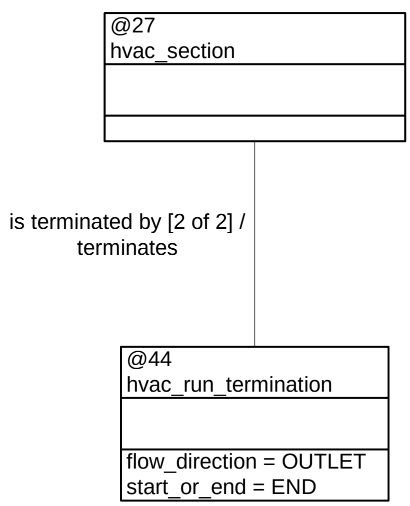

Figure A.73 — Instance diagram for the HVAC Flow Analysis test case (12 of 34)

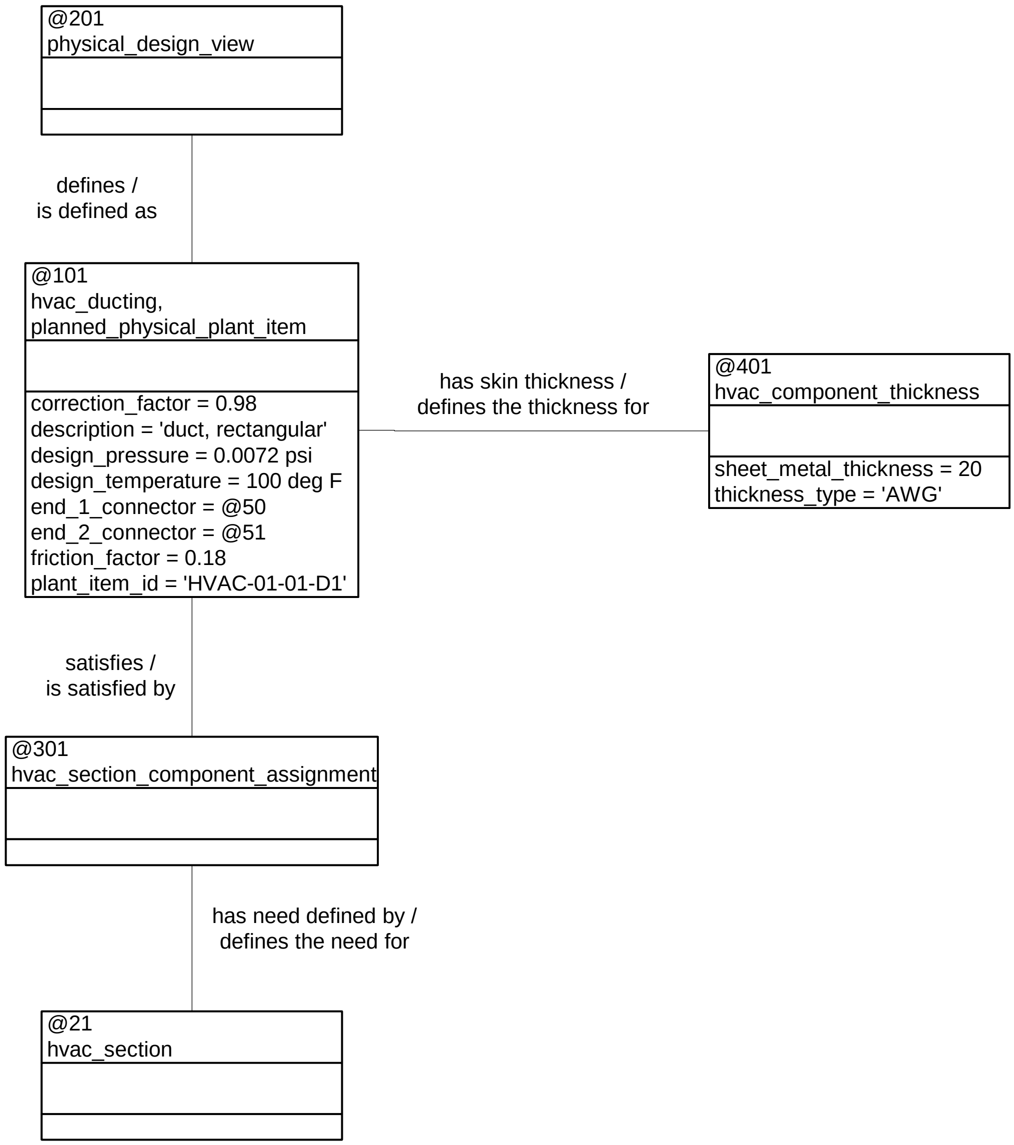

Figure A.74 — Instance diagram for the HVAC Flow Analysis test case (13 of 34)

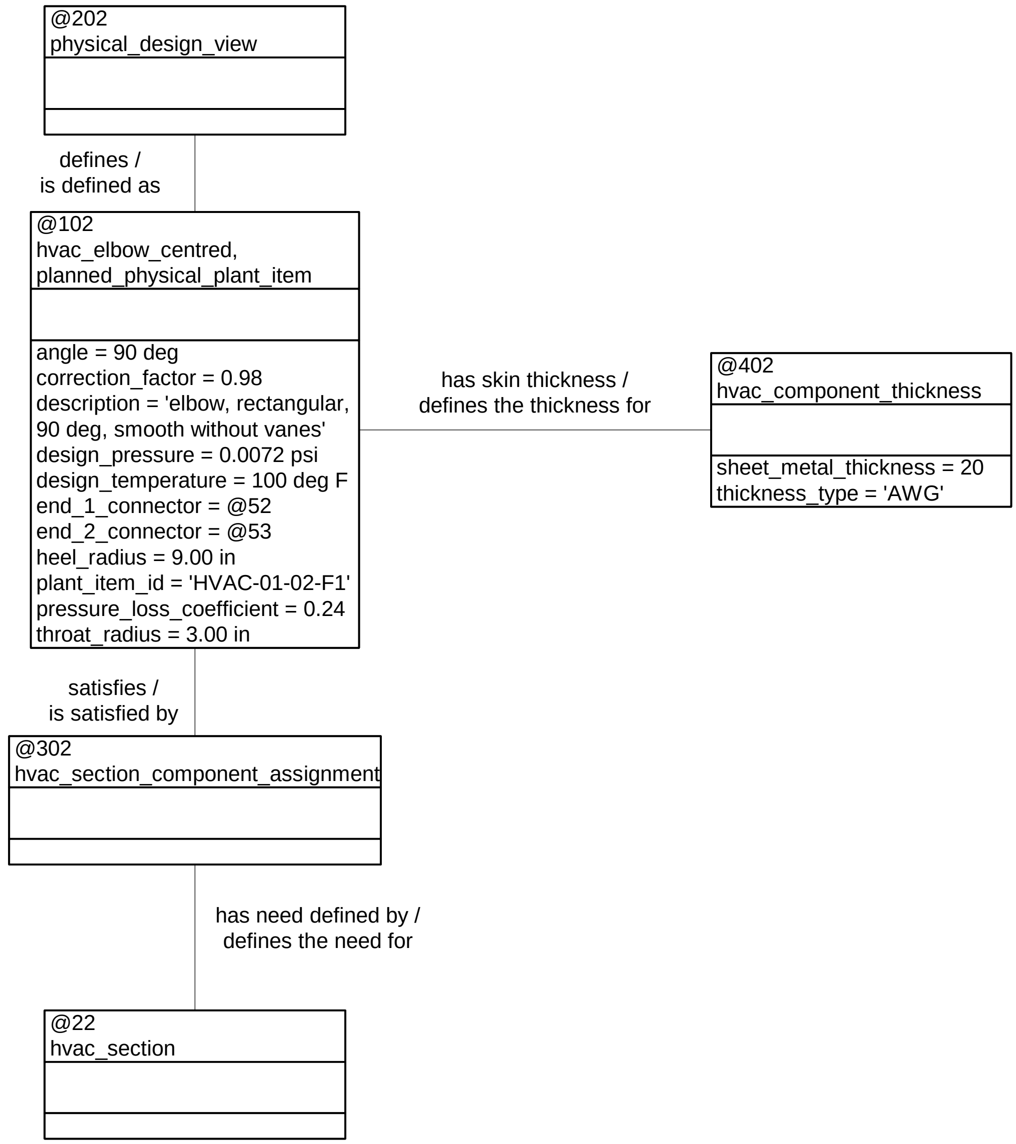

Figure A.75 — Instance diagram for the HVAC Flow Analysis test case (14 of 34)

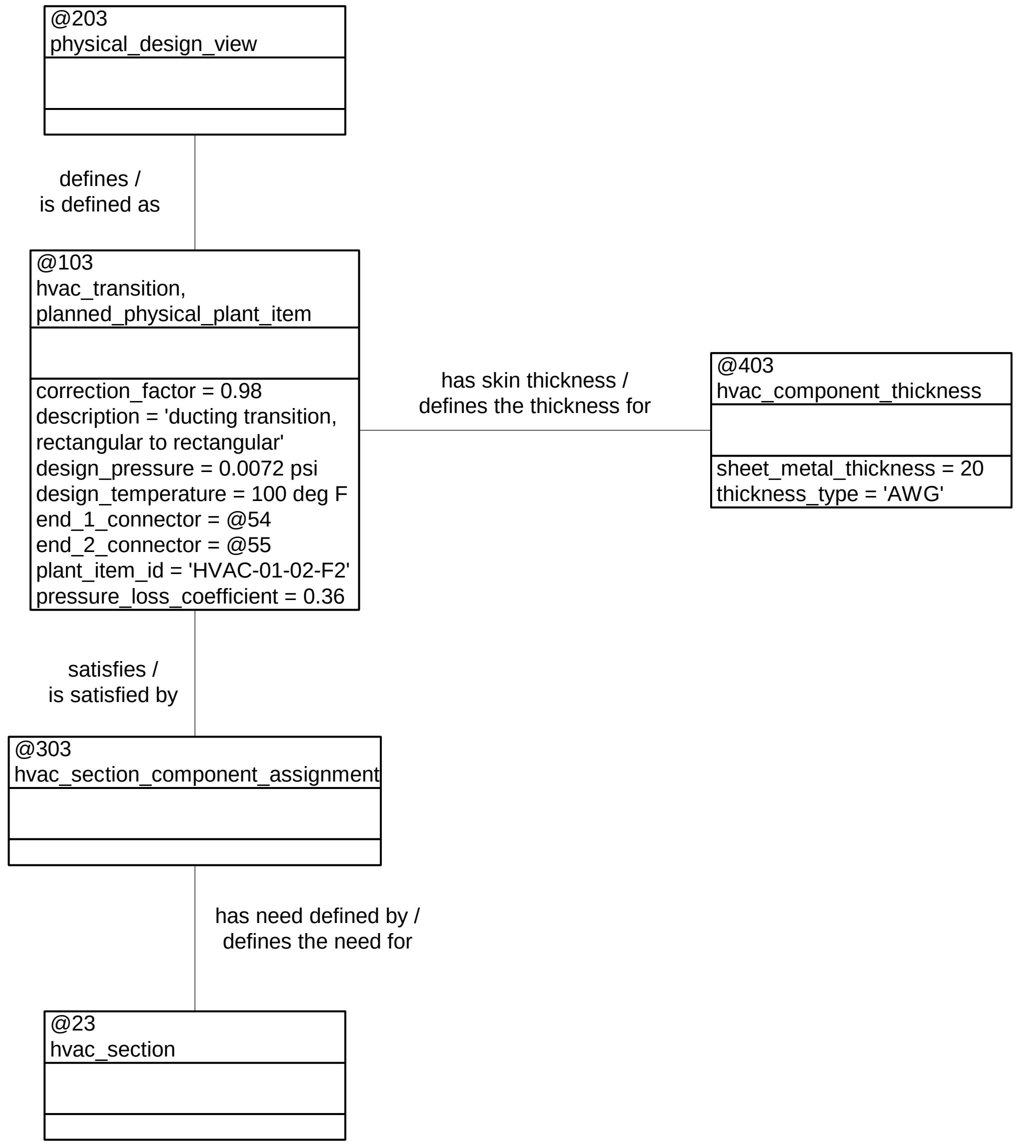

Figure A.76 — Instance diagram for the HVAC Flow Analysis test case (15 of 34)

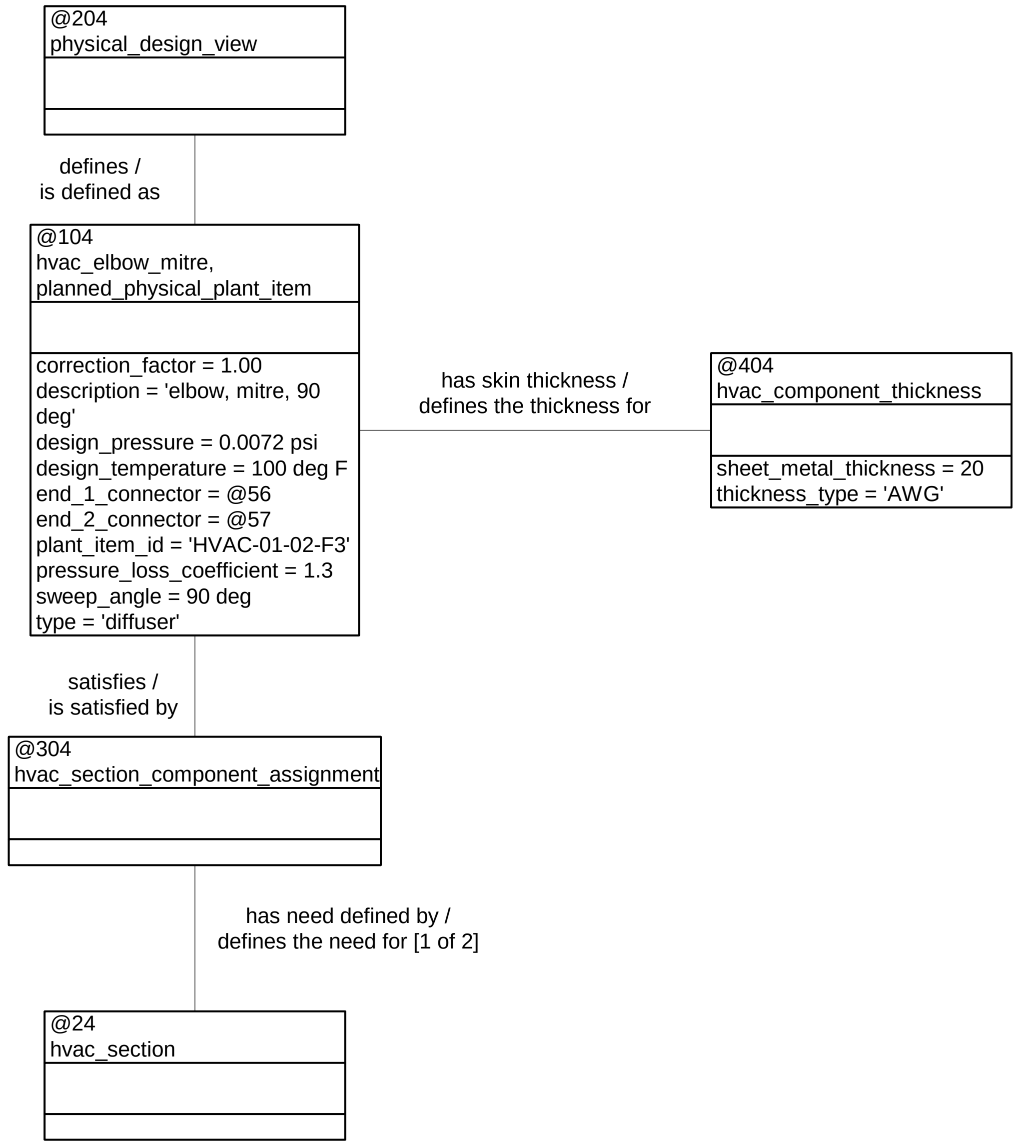

Figure A.77 — Instance diagram for the HVAC Flow Analysis test case (16 of 34)

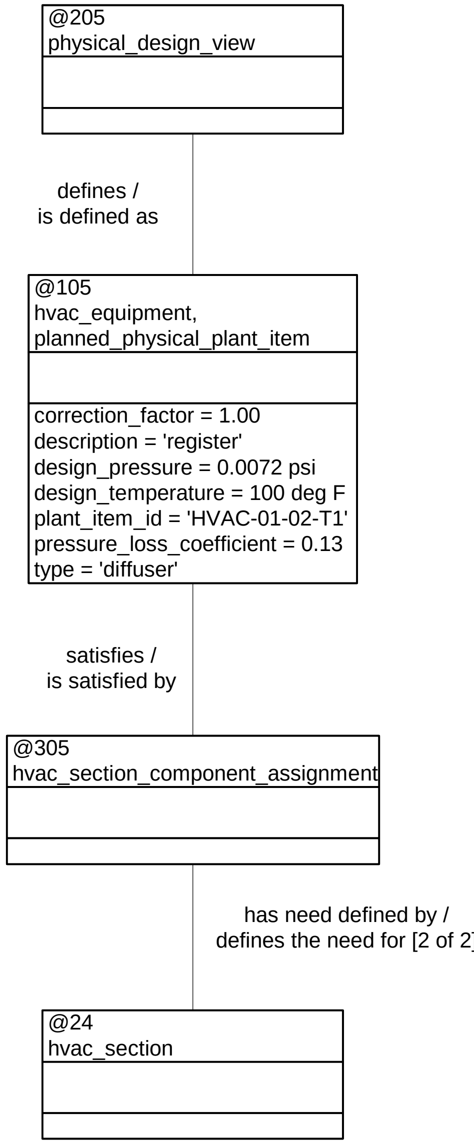

Figure A.78 — Instance diagram for the HVAC Flow Analysis test case (17 of 34)

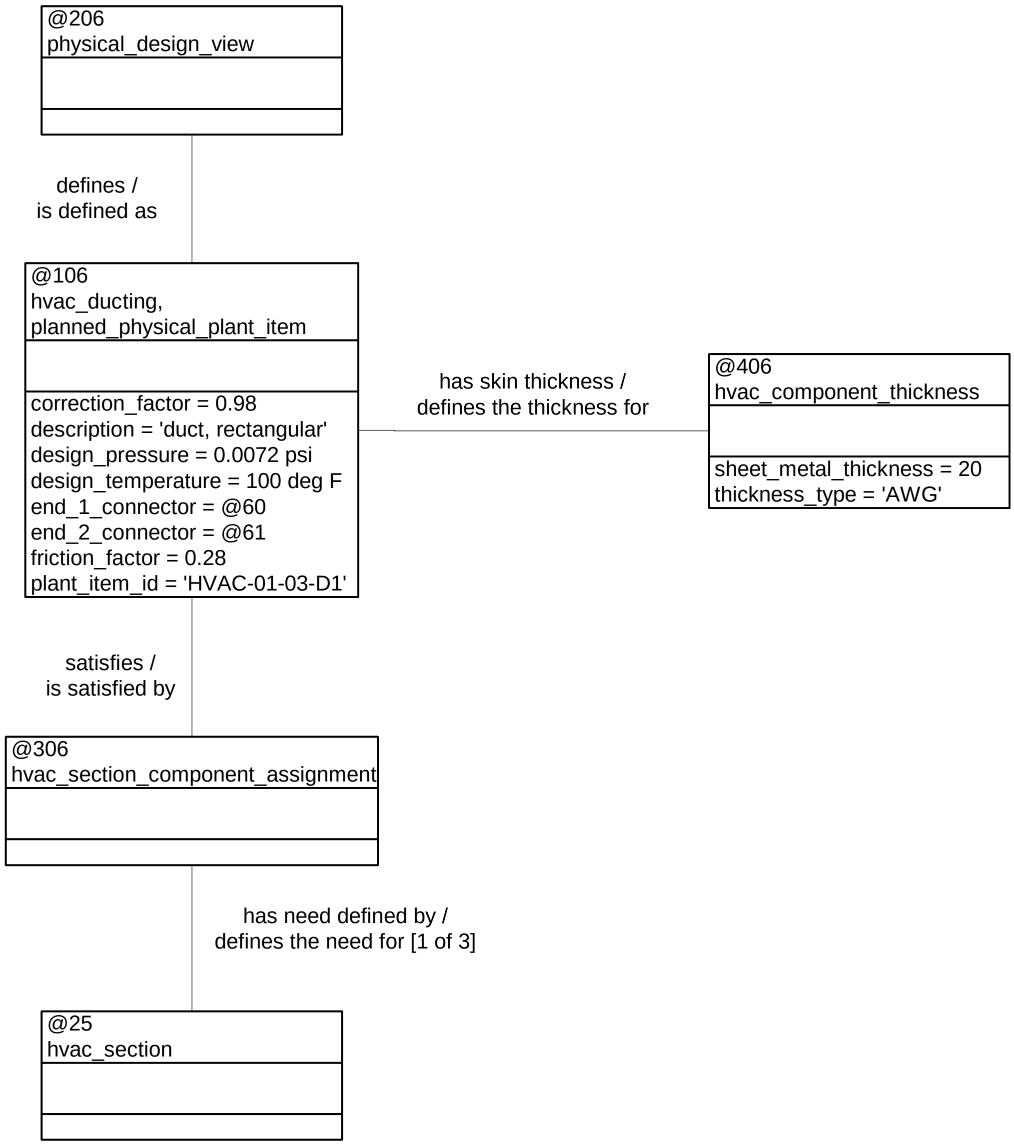

Figure A.79 — Instance diagram for the HVAC Flow Analysis test case (18 of 34)

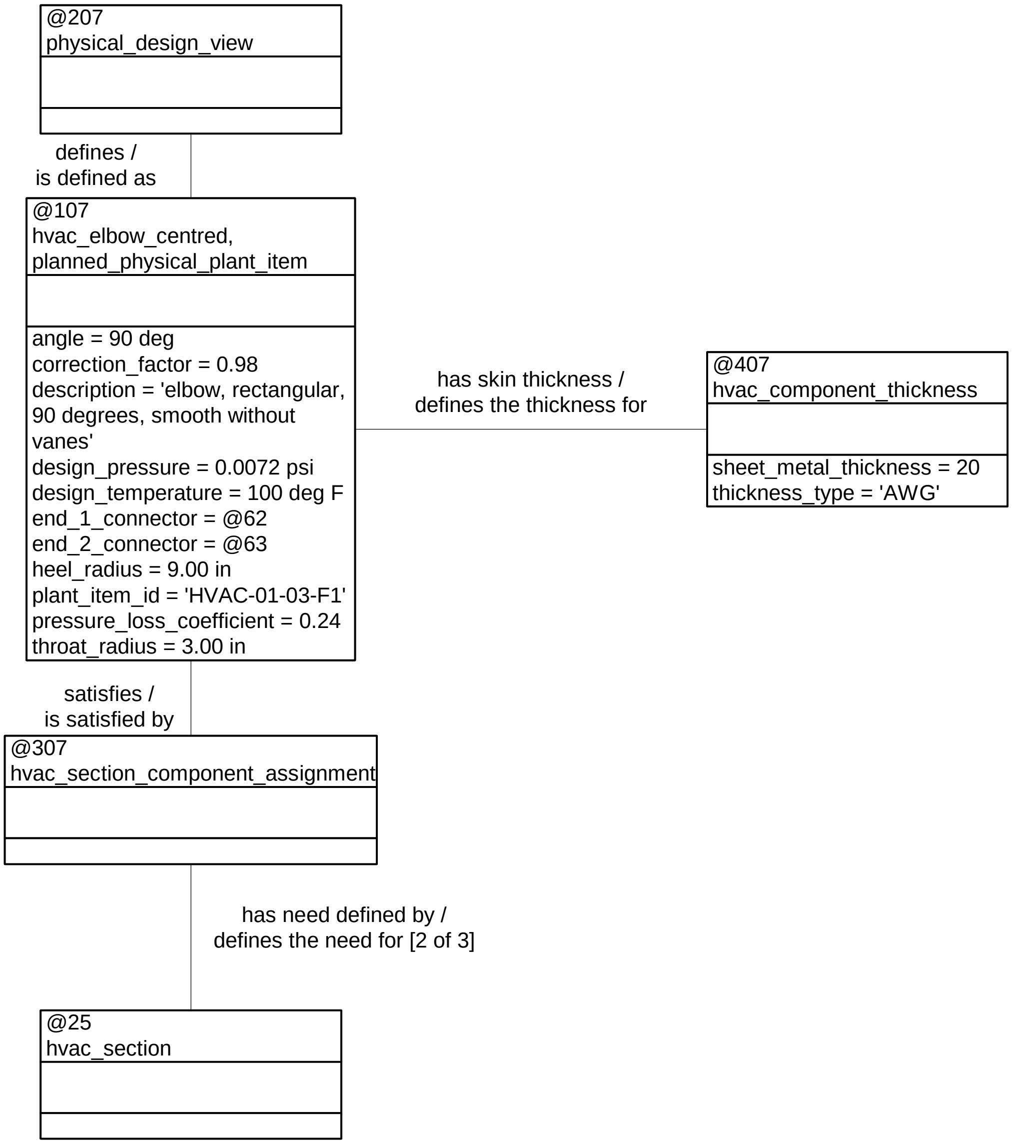

Figure A.80 — Instance diagram for the HVAC Flow Analysis test case (19 of 34)

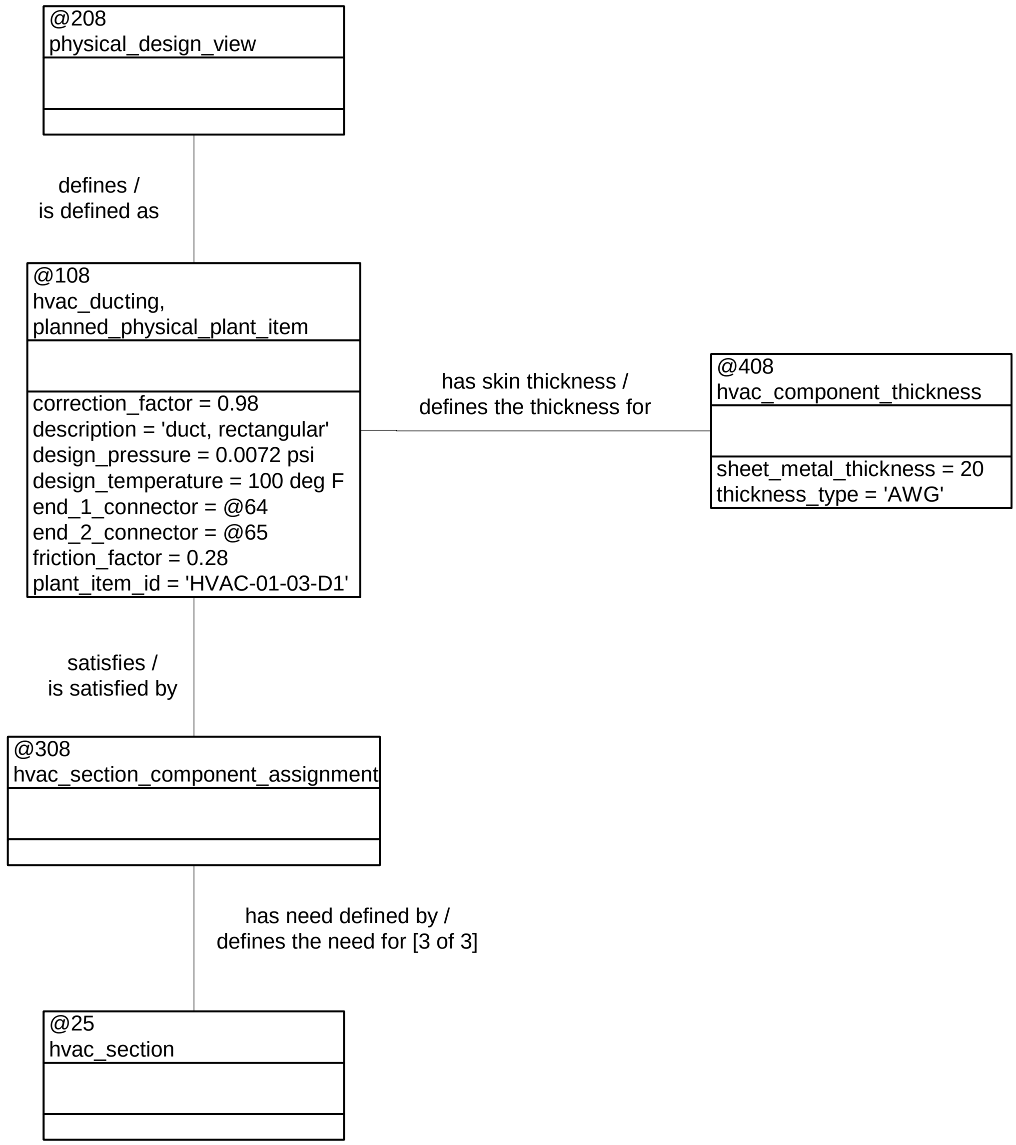

Figure A.81 — Instance diagram for the HVAC Flow Analysis test case (20 of 34)

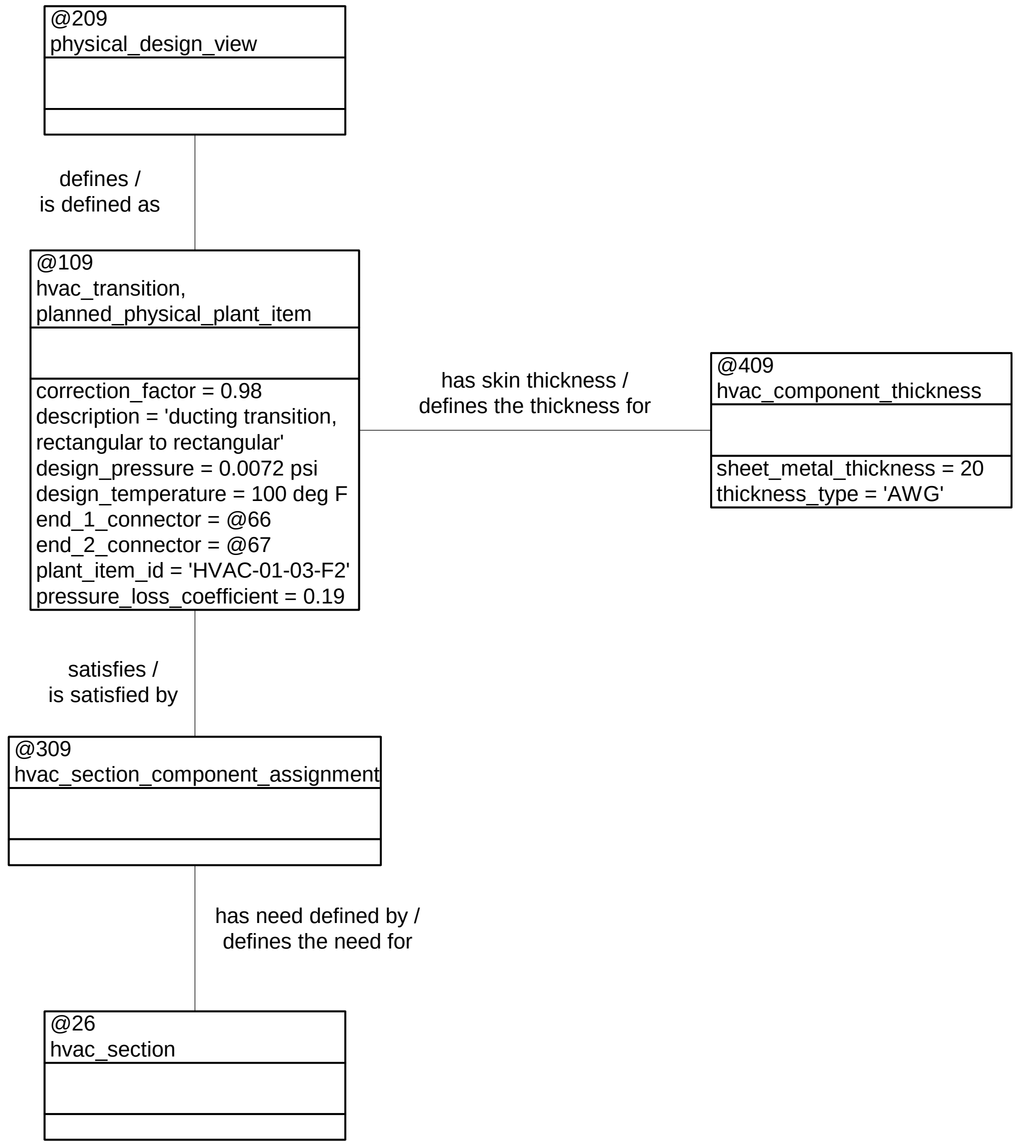

Figure A.82 — Instance diagram for the HVAC Flow Analysis test case (21 of 34)

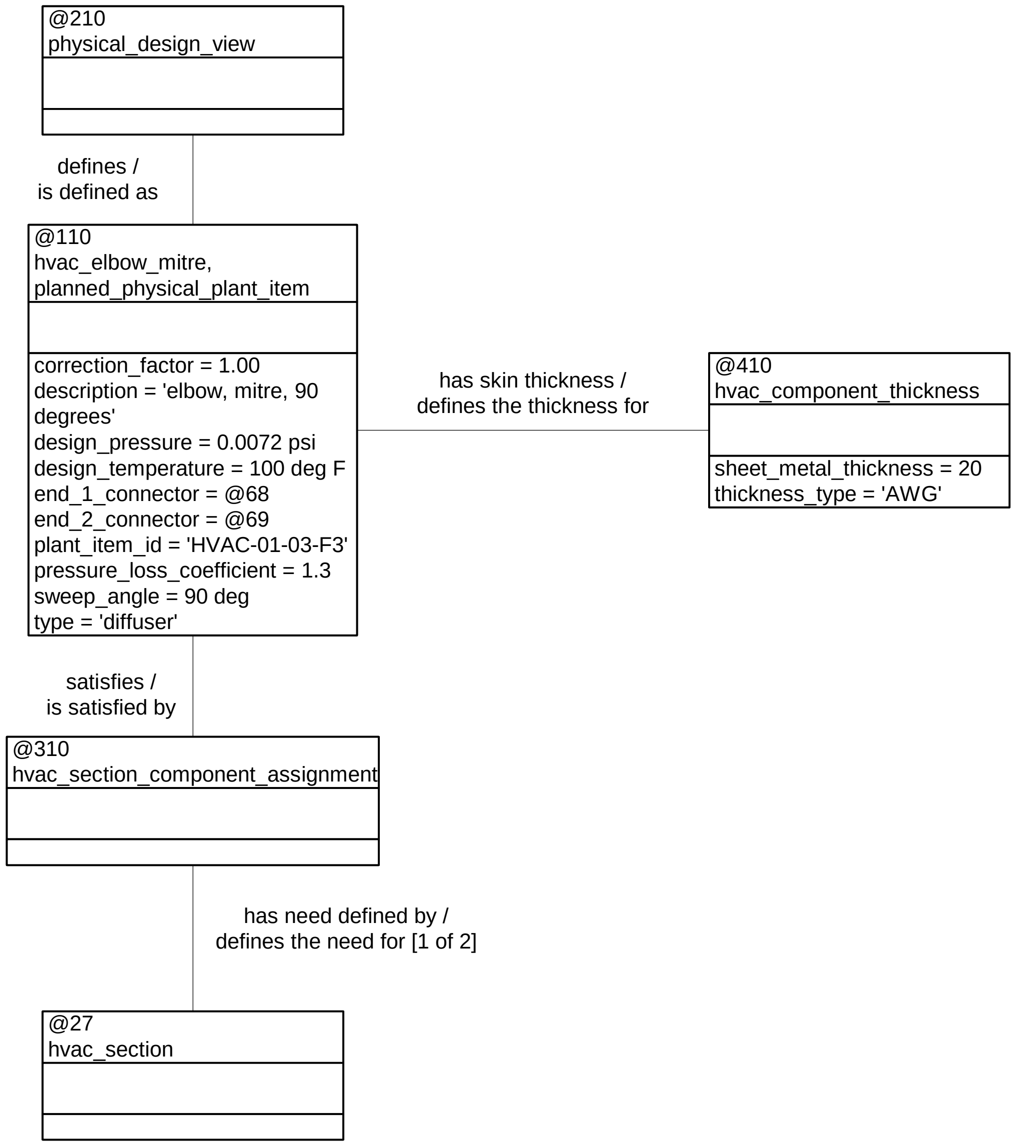

Figure A.83 — Instance diagram for the HVAC Flow Analysis test case (22 of 34)

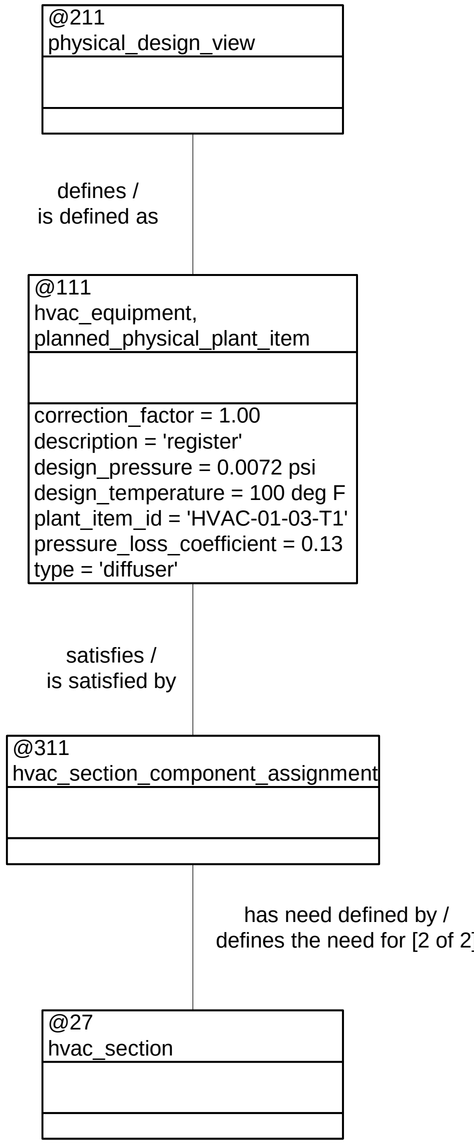

Figure A.84 — Instance diagram for the HVAC Flow Analysis test case (23 of 34)

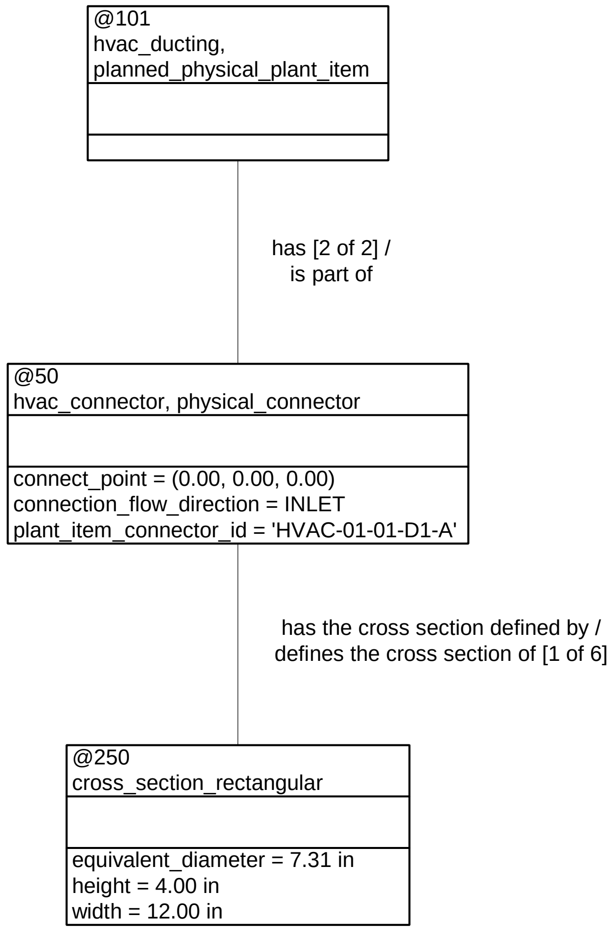

Figure A.85 — Instance diagram for the HVAC Flow Analysis test case (24 of 34)

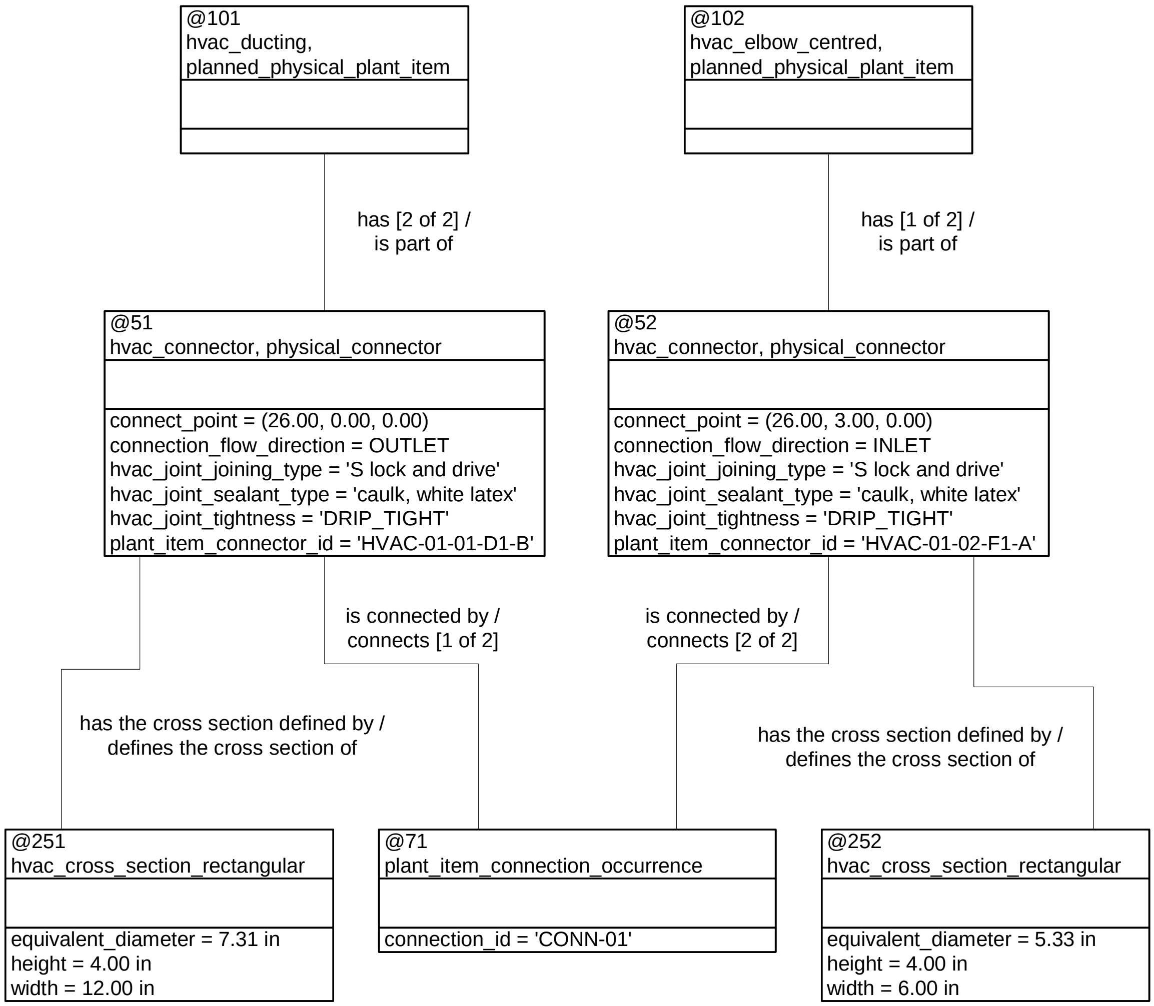

Figure A.86 — Instance diagram for the HVAC Flow Analysis test case (25 of 34)

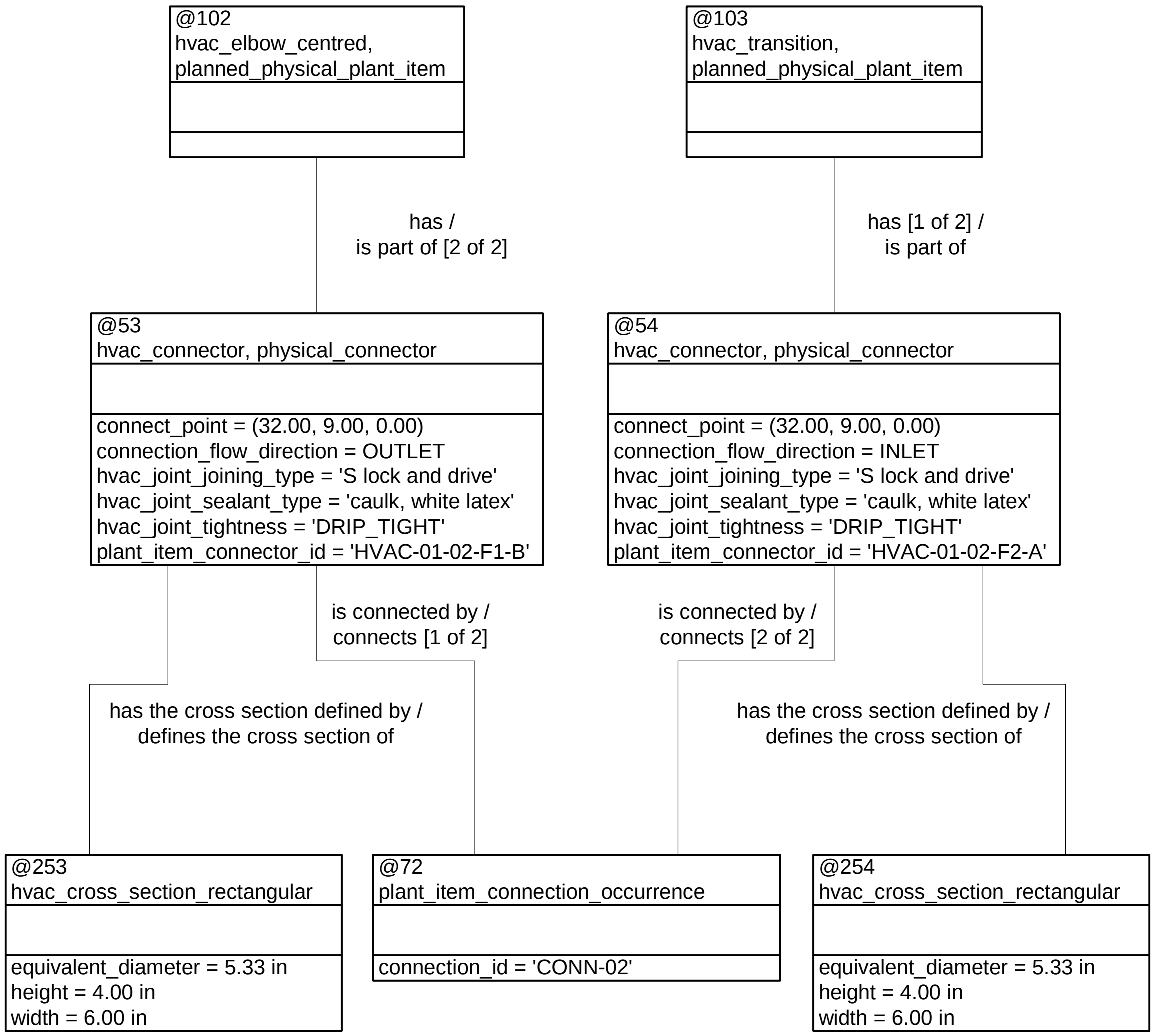

Figure A.87 — Instance diagram for the HVAC Flow Analysis test case (26 of 34)

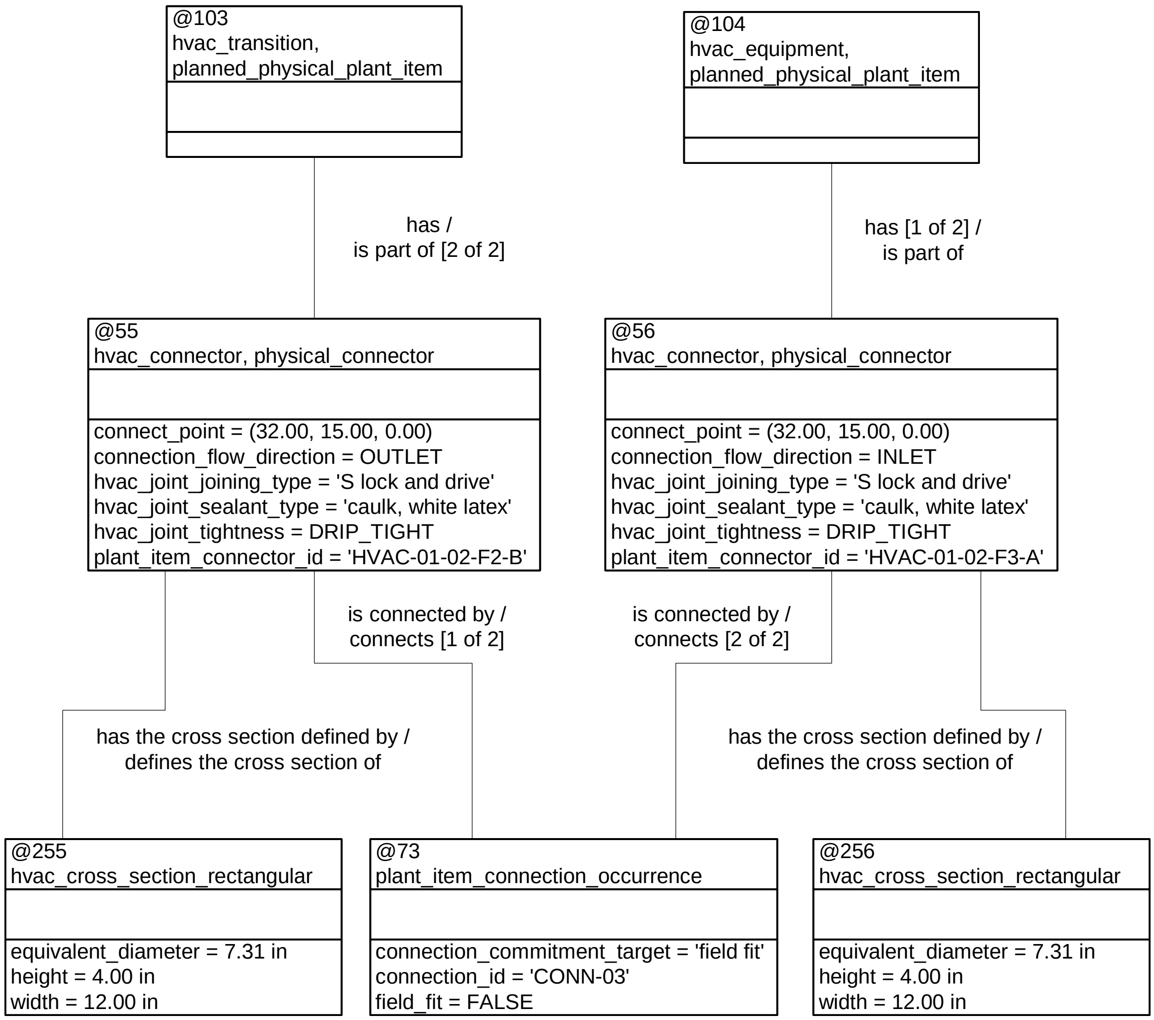

Figure A.88 — Instance diagram for the HVAC Flow Analysis test case (27 of 34)

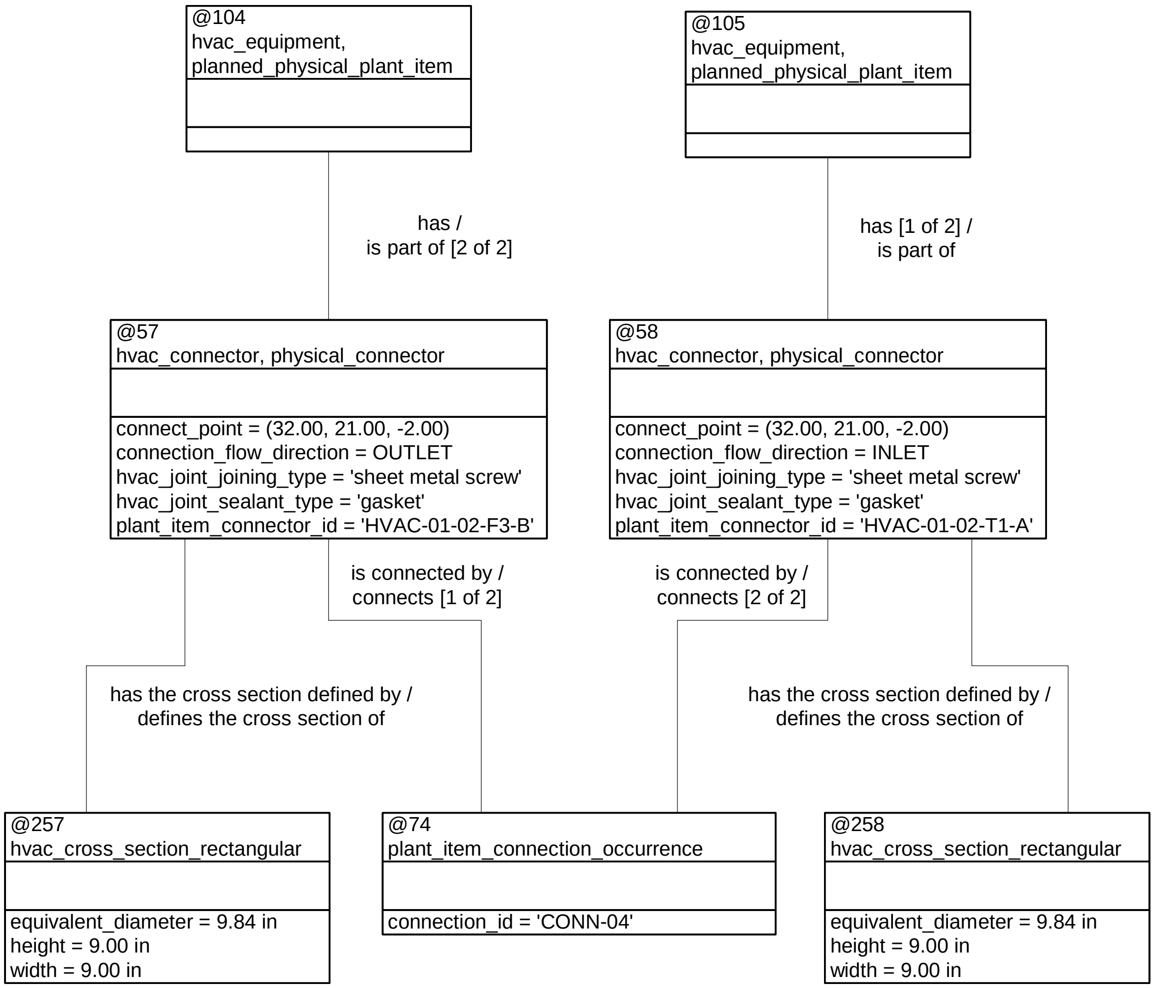

Figure A.89 — Instance diagram for the HVAC Flow Analysis test case (28 of 34)

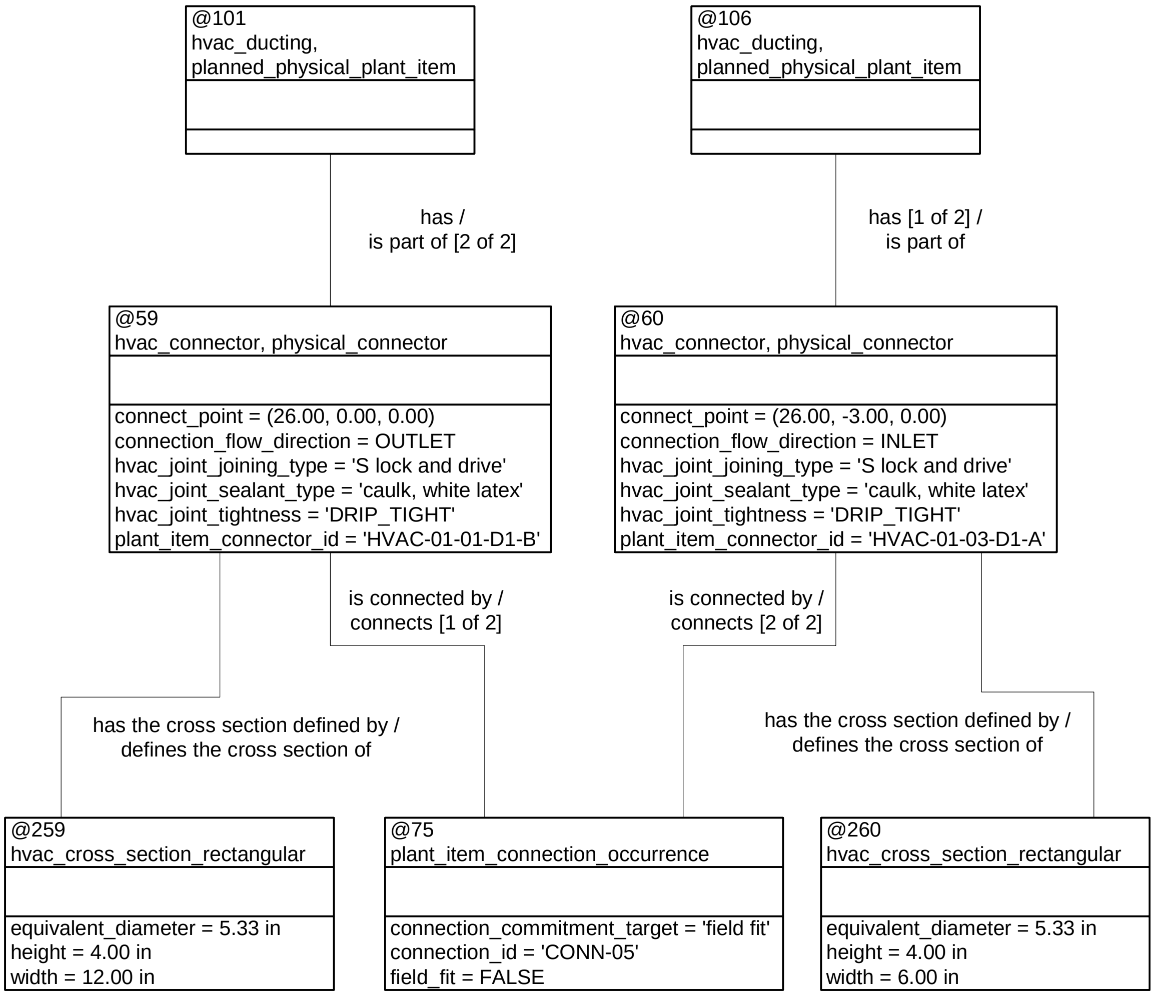

Figure A.90 — Instance diagram for the HVAC Flow Analysis test case (29 of 34)

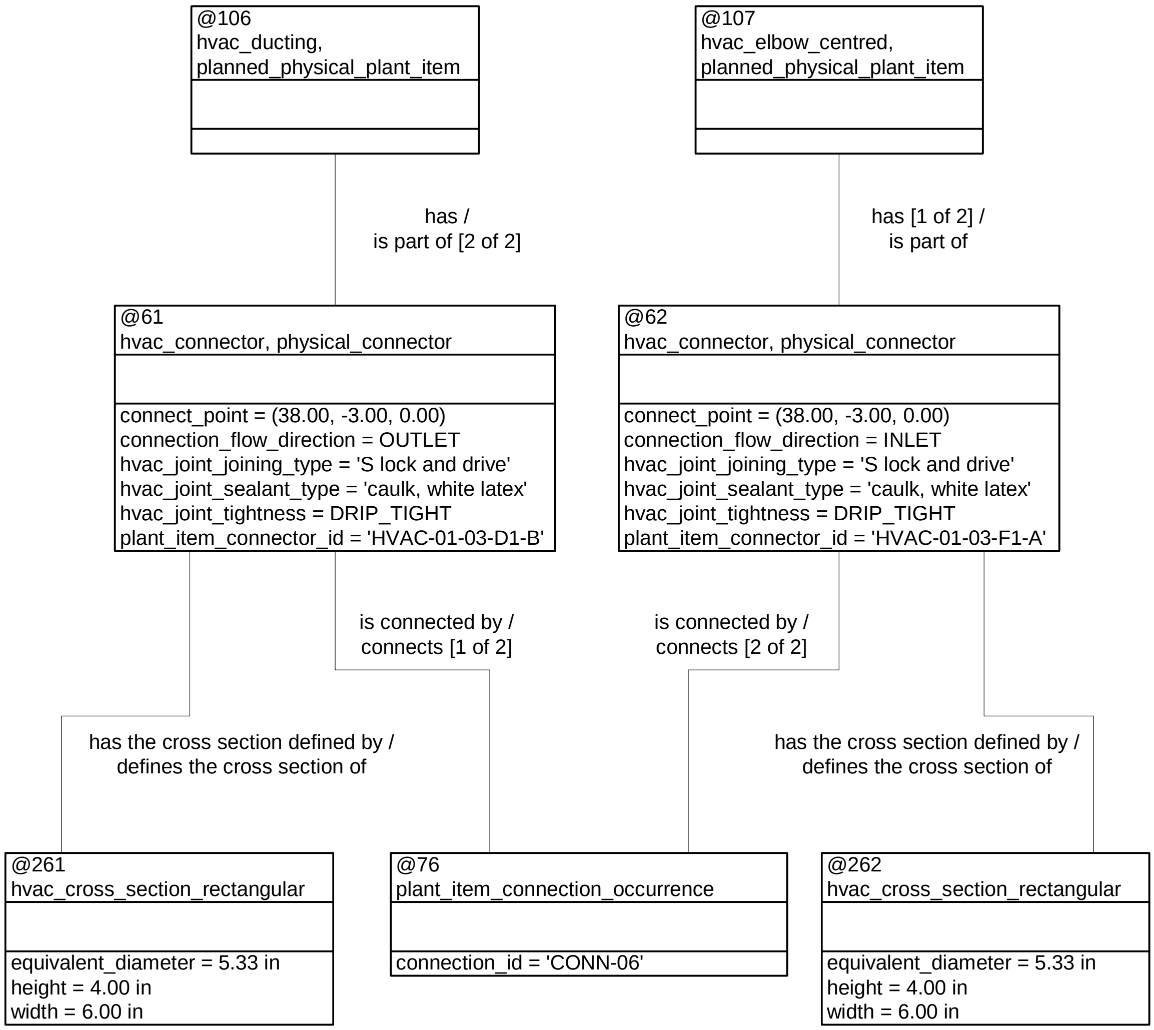

Figure A.91 — Instance diagram for the HVAC Flow Analysis test case (30 of 34)

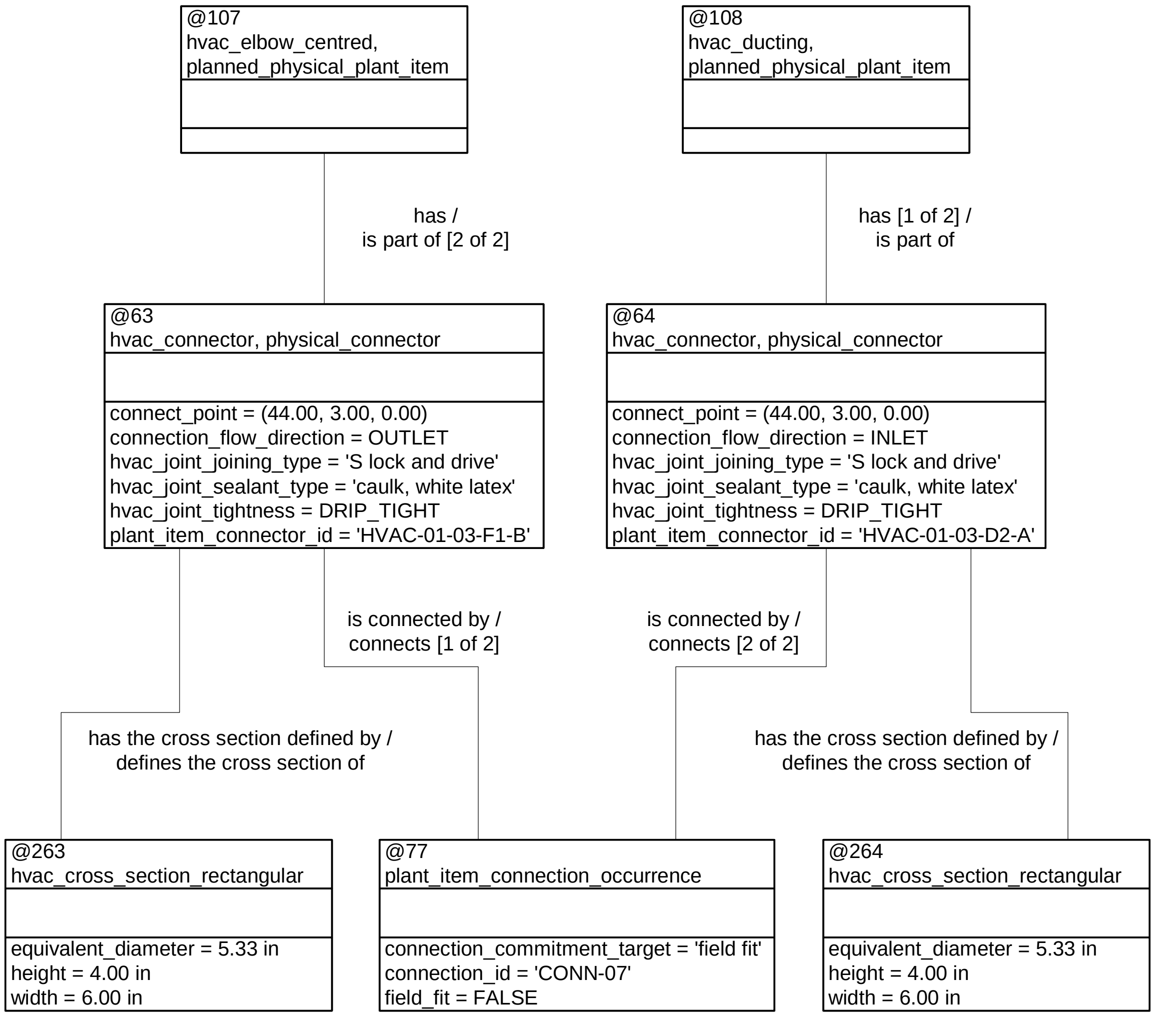

Figure A.92 — Instance diagram for the HVAC Flow Analysis test case (31 of 34)

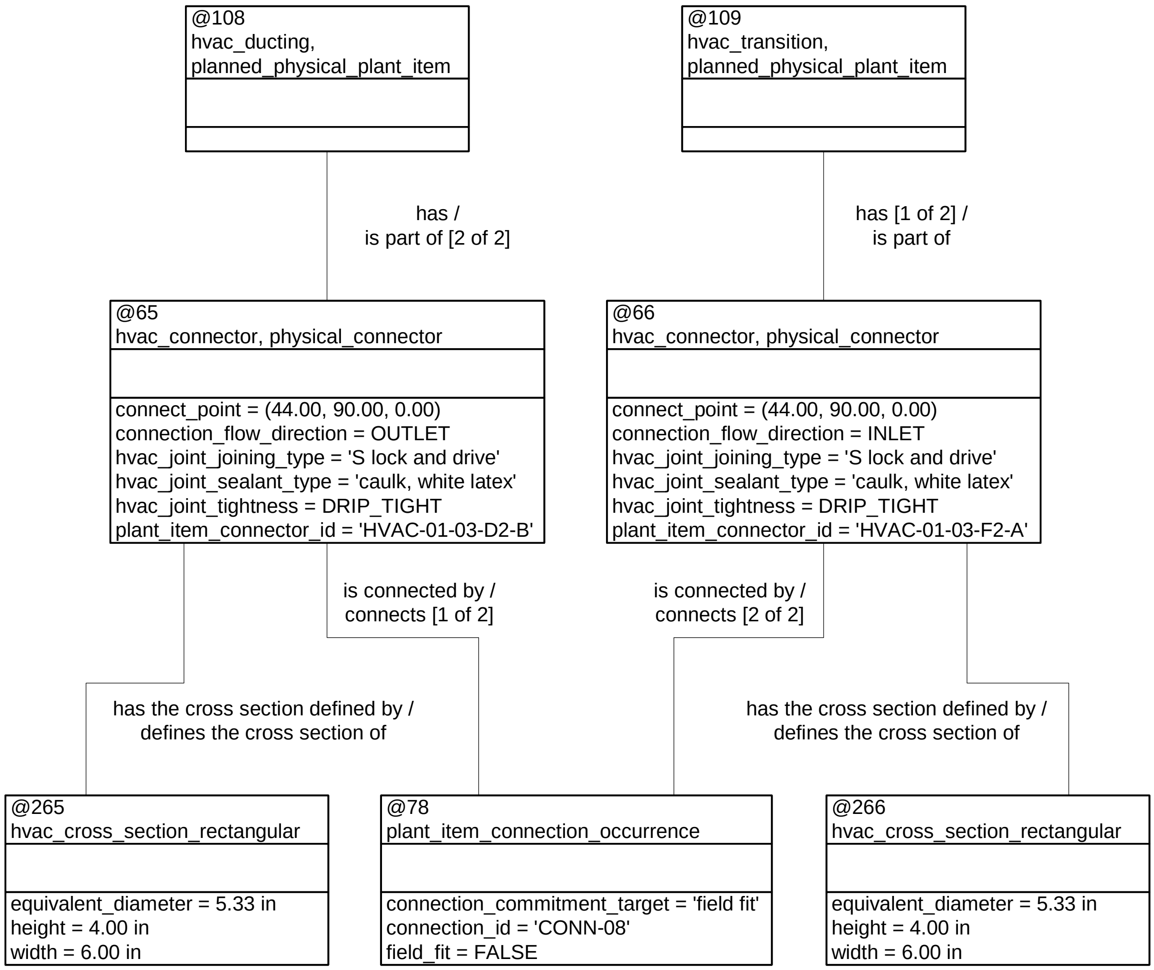

Figure A.93 — Instance diagram for the HVAC Flow Analysis test case (32 of 34)

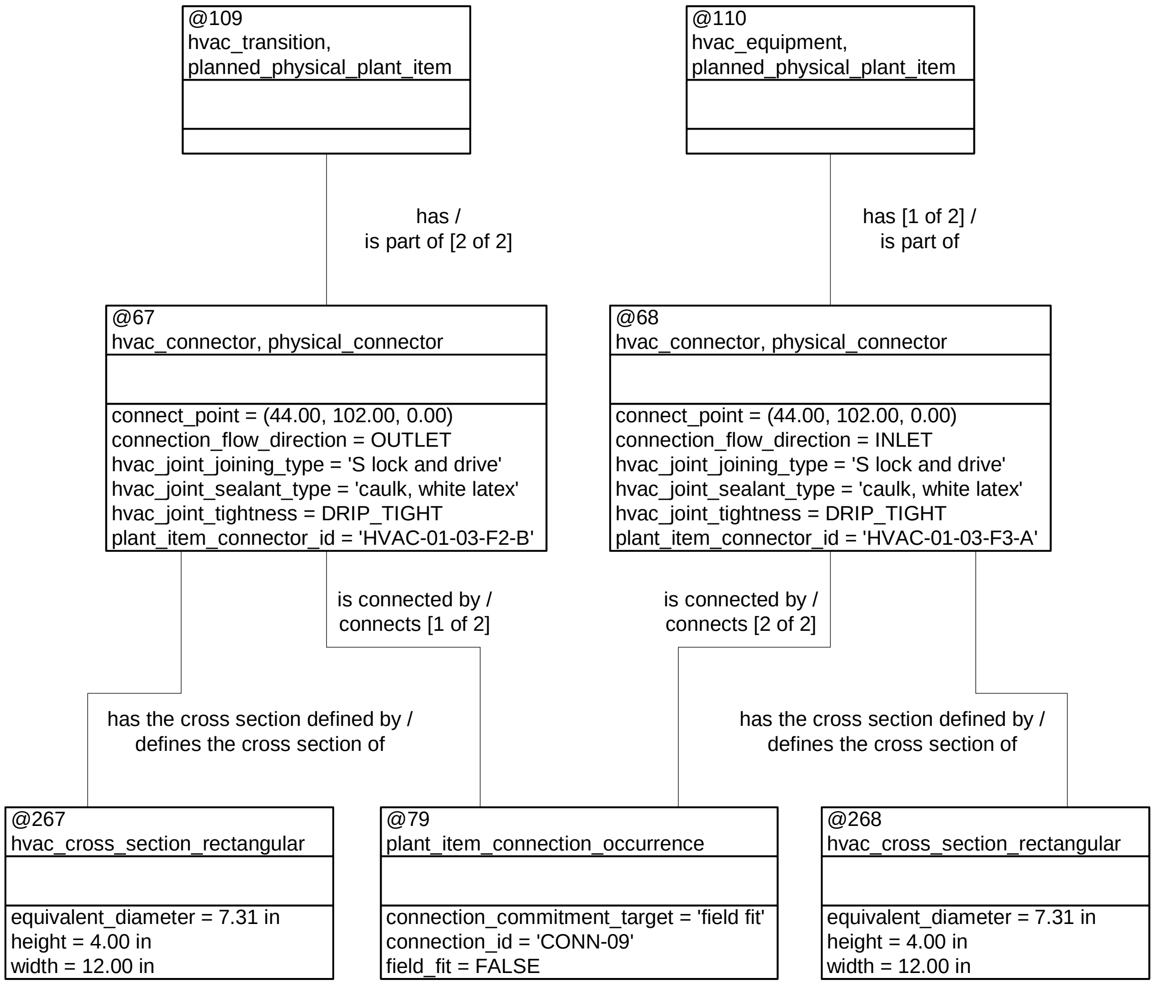

Figure A.94 — Instance diagram for the HVAC Flow Analysis test case (33 of 34)

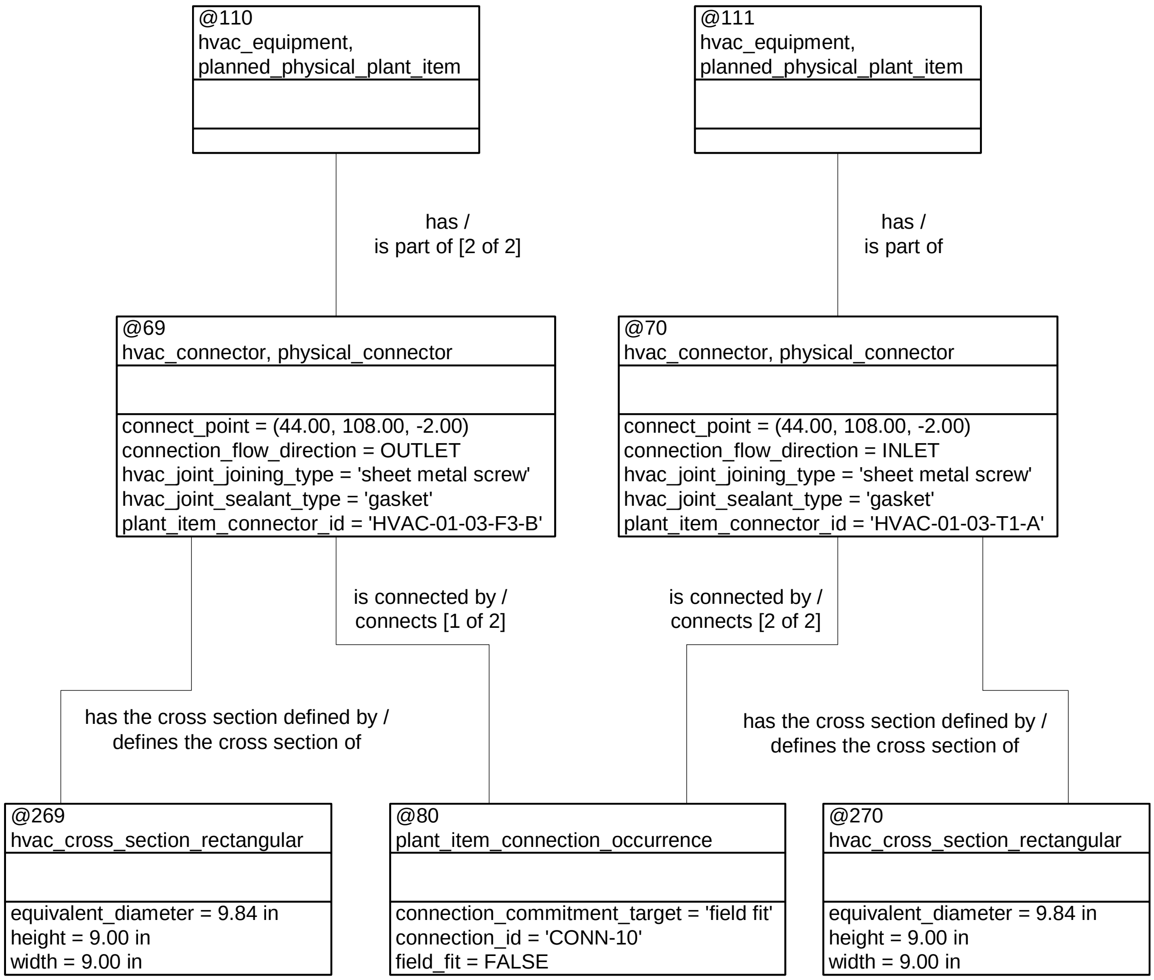

Figure A.95 — Instance diagram for the HVAC Flow Analysis test case (34 of 34)

A.3.5.1 HVAC Noise Analysis

A.3.5.2 Purpose

This clause describes the use of ISO 10303-227 to exchange the information necessary as input to an HVAC noise analysis. This information consists of a high-level physical description of an HVAC system layout.

A.3.5.3 Exchange context

The context for this test case is the exchange of HVAC configuration information between an HVAC designer and an acoustic engineer.

A.3.5.4 Test data

Figure A.96 shows a portion of an HVAC system that will serve as the basis for this test case. This test case illustrates the exchange of information necessary to calculate the contribution of the HVAC system to the noise level in a single compartment, the chief petty officer (CPO) stateroom.

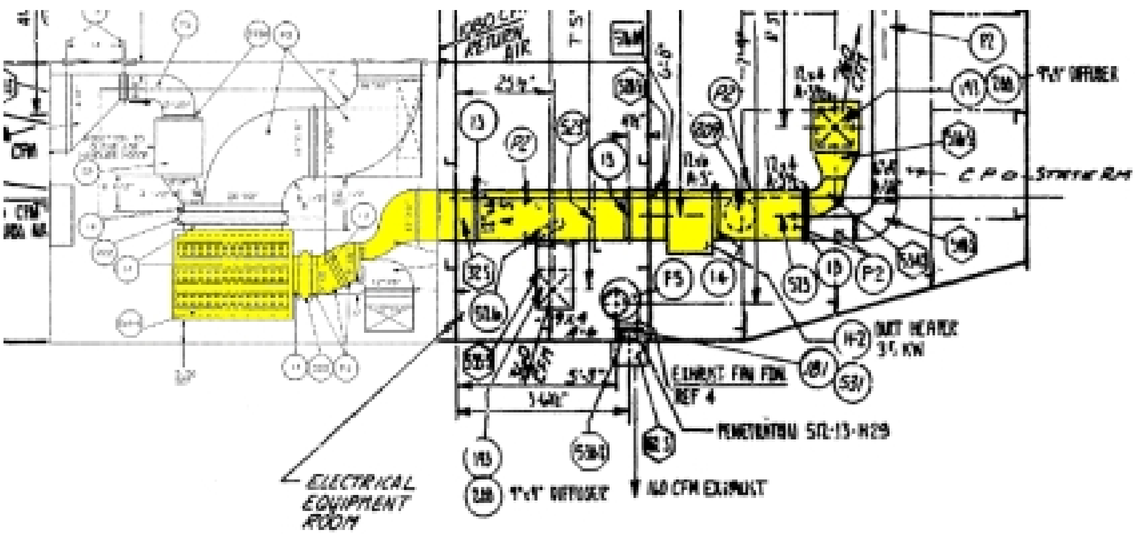

Figure A.96 — Portion of an HVAC system for the HVAC Noise Analysis test case

The component types included in this example are diffusers, dampers, ducting, ducting elbows, flow control devices, ducting transitions, air condensers, and duct heaters. Figure A.97 shows the components of the system with labels attached. Table A.11 gives labels to the components, as well as listing the type of component they are and their attributes for this example. Only the components from EQP-002 to DIFF-002 will be discussed in this test case.

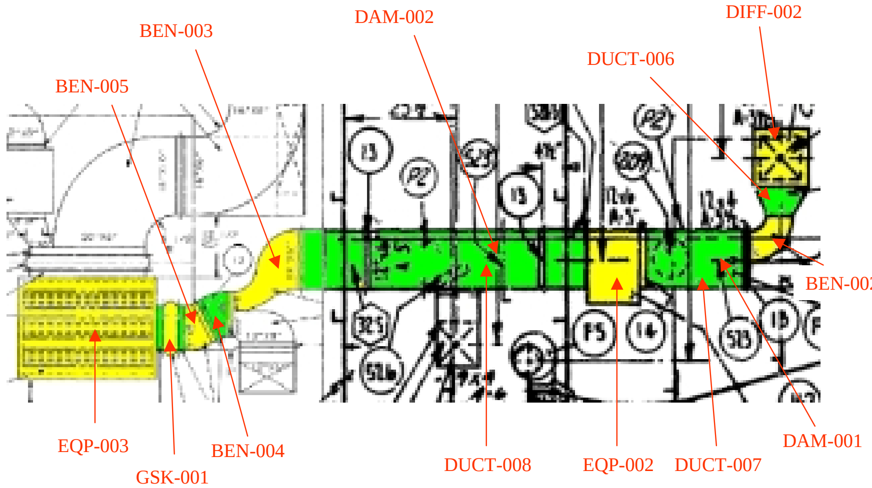

Figure A.97 — HVAC system with components labeled

Table A.11 — Components for the HVAC Noise Analysis test case

Label	Type	Attributes
DIFF-002	diffuser	diffuser 9” x 9” opening with damper
DUCT-006	transition	rectangular 6” x 4” to 12” x 4”
BEN-002	bend	cylindrical 6” spool bend
DAM-001	control damper	3/8” damper
DUCT-007	ducting	rectangular duct with damper 12” x 4”
EQP-001	air cooling condenser	8” air cooling condenser
EQP-002	duct heater	12” x 6” 35kW
DUCT-008	ducting	
BEN-003	transition, compound bend	12" x 8" to 4" x 8"
BEN-004	bend	9" x 8"
BEN-005	bend	9" x 8"
GSK-001	gasket	flexible joint material "U"
EQP-003	air handler	1000 cfm

Air flow between BEN-003 and DIFF-002 is 160 cfm.

Table A.12 shows the noise produced by air handler EQP-003, by octave band.

Table A.12 — Noise produced by equipment EQP-003

Band	31.5	63	125	250	500	1000	2000	4000	8000
PWL re 10^{-12} w	60.0	65.0	70.0	68.0	65.0	63.0	60.0	59.0	58.0

A.3.5.5 ARM representation

Figures A.98 to A.105 contain the instance diagrams for this test case.

An HVAC system can be represented in ISO 10303-227 through a functional description and/or a physical description. Since component information is needed to calculate HVAC noise, a physical description is used.

A.3.5.5.1 Representing components

Figures A.98 to A.101 provide the representation of the components of the HVAC system and their attributes.

NOTE Components DUCT-008 to GSK-001 are not shows in the instance diagrams, but would be represented similarly.

Duct DUCT-006 is represented by a complex entity instance (@2) of the Hvac_transition and Planned_physical_plant_item entity data types. The following information is needed for a straight duct in order to perform the noise analysis:

- cross-section dimensions
- length
- type of lining (if any)

The length of the duct is given in the "length" attribute of entity instance (@2). The aspects of the duct that are capable of connecting with other HVAC components are represented by complex entity instances (@6021 and @6022) of the Hvac_connector and Physical_connector entity data types (see Figure A.6). Associated with these instances are instances (@7021 and @7022) of the Cross_section_rectangular entity data type, which give the height and width of the cross-section at the duct's connectors (in the case of a duct, the two ends). This duct has no lining.

The location of duct DUCT-006 is represented by an instance (@302) of the Location_in_plant AO (see Figure A.8). Its geometry is represented by a complex instance (@502) of the Detail_shape and Hybrid_shape_representation AOs. An instance (@402) of the Plant_item_shape EDT links the instance (@2) representing the component with its geometry.

Damper DAM-001 is represented by a complex entity instance of the Hvac_flow_control_device and Planned_physical_plant_item EDTs. The following information is needed to calculate the noise contribution of a damper:

- volume flow rate
- cross sectional area
- pressure loss at the damper
- duct height normal to the damper axis

- damper blade type

The volume flow rate is captured by the "design flow rate" attribute of @21. Since the damper is the full height and width of the duct in which it is contained, it is not necessary to capture the cross sectional area. The pressure loss at the damper is captured by the "pressure_drop" attribute. Since there is no built-in attribute for damper blade type, an instance (@20221) of user_defined_attribute_value is used. The "name" attribute is "blade type" and the "value" attribute is "single."

The other components in this test case are represented in a similar manner.

The combination of DAM-001 and DUCT-007 is represented by a complex entity instance (@4) of the Hvac_flow_control_device, Hvac_ducting, and Planned_physical_plant_item EDTs. This is associated with instances (@23 and @21) representing DUCT-007 and DAM-001 by instances (@8001 and @8002) of the Hierarchically_organized_collection EDT.

The noise levels produced by equipment must be provided as input to the noise analysis. In this test case, EQP-003 is the only significant noise producer. The power levels produced by EQP-003 were given in Table A.12. Since ISO 10303-227 does not have entity data types or attributes to specifically capture noise levels, the User_defined_attribute_value EDT must be used. An instance of the User_defined_attribute_value EDT associates an attribute name and attribute value pair to an instance of the Plant_item EDT. Unfortunately, the attribute value must be scalar, so to represent the data in Table A.12, a separate instance of User_defined_attribute_value must be used for each data value in the table (see Figure A.100).

A.3.5.5.2 Representing connections

Figure A.102 and A.103 show the connections between components. A "connector" is an aspect of a component that is capable of being connected to aspects of other components. Connector DUCT-006-C1 is captured by a complex entity instance (@6021) of the Physical_connector and Hvac_connector AOs (see Figure A.102). Connector BEN-002-C2 is captured by a complex entity instance (@6032) of the Physical_connector and Hvac_connector AOs.

The connection between DUCT-006-C1 and BEN-002-C2 is captured by an instance (@114) of the Plant_item_connection_occurrence EDT. The remaining connectors and connections in this test case are represented similarly.

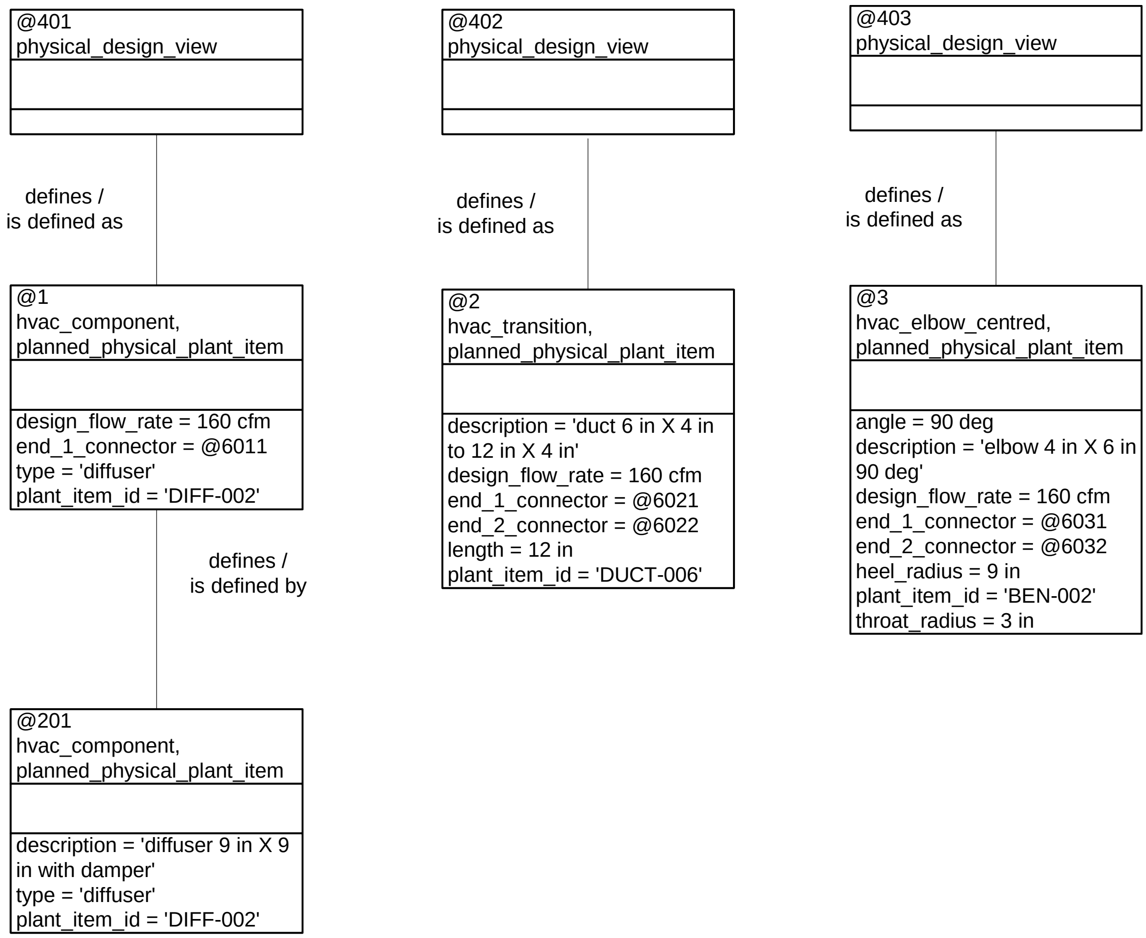

Figure A.98 — Instance diagram for the HVAC Noise Analysis test case (1 of 8)

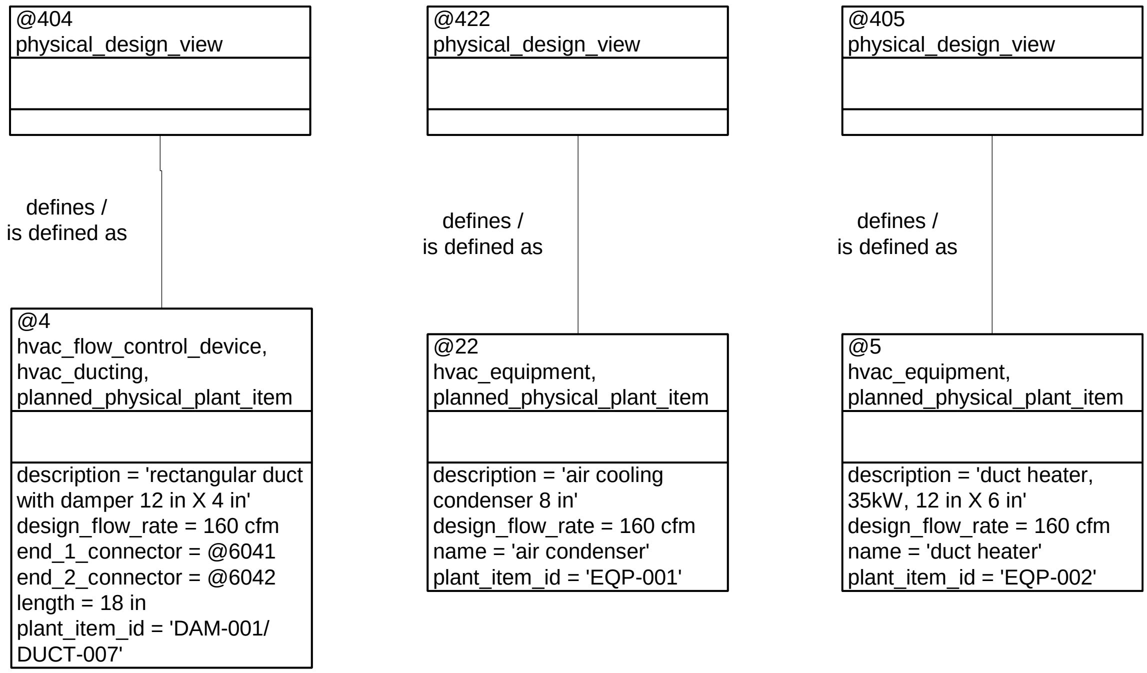

Figure A.99 — Instance diagram for the HVAC Noise Analysis test case (2 of 8)

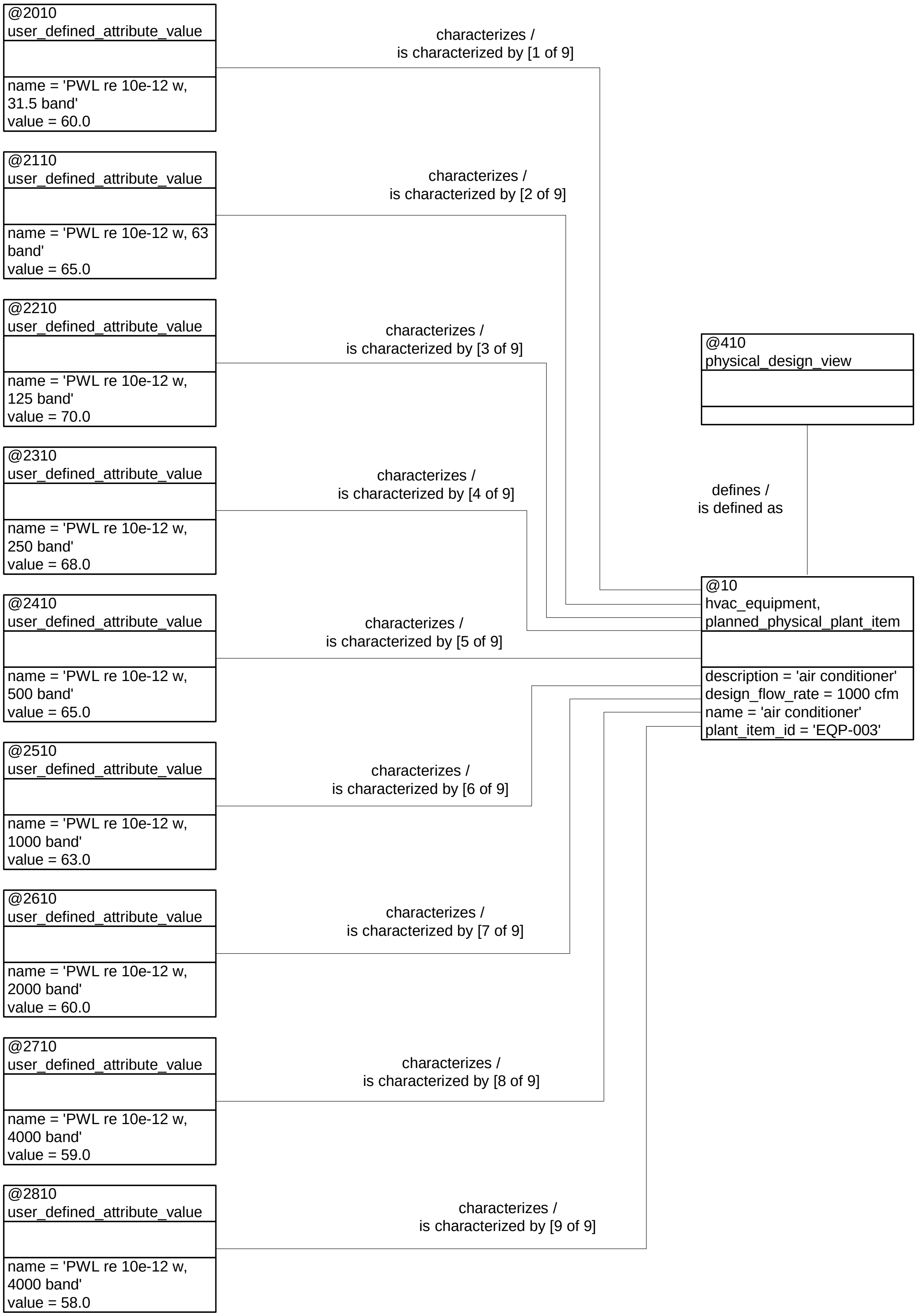

Figure A.100 — Instance diagram for the HVAC Noise Analysis test case (3 of 8)

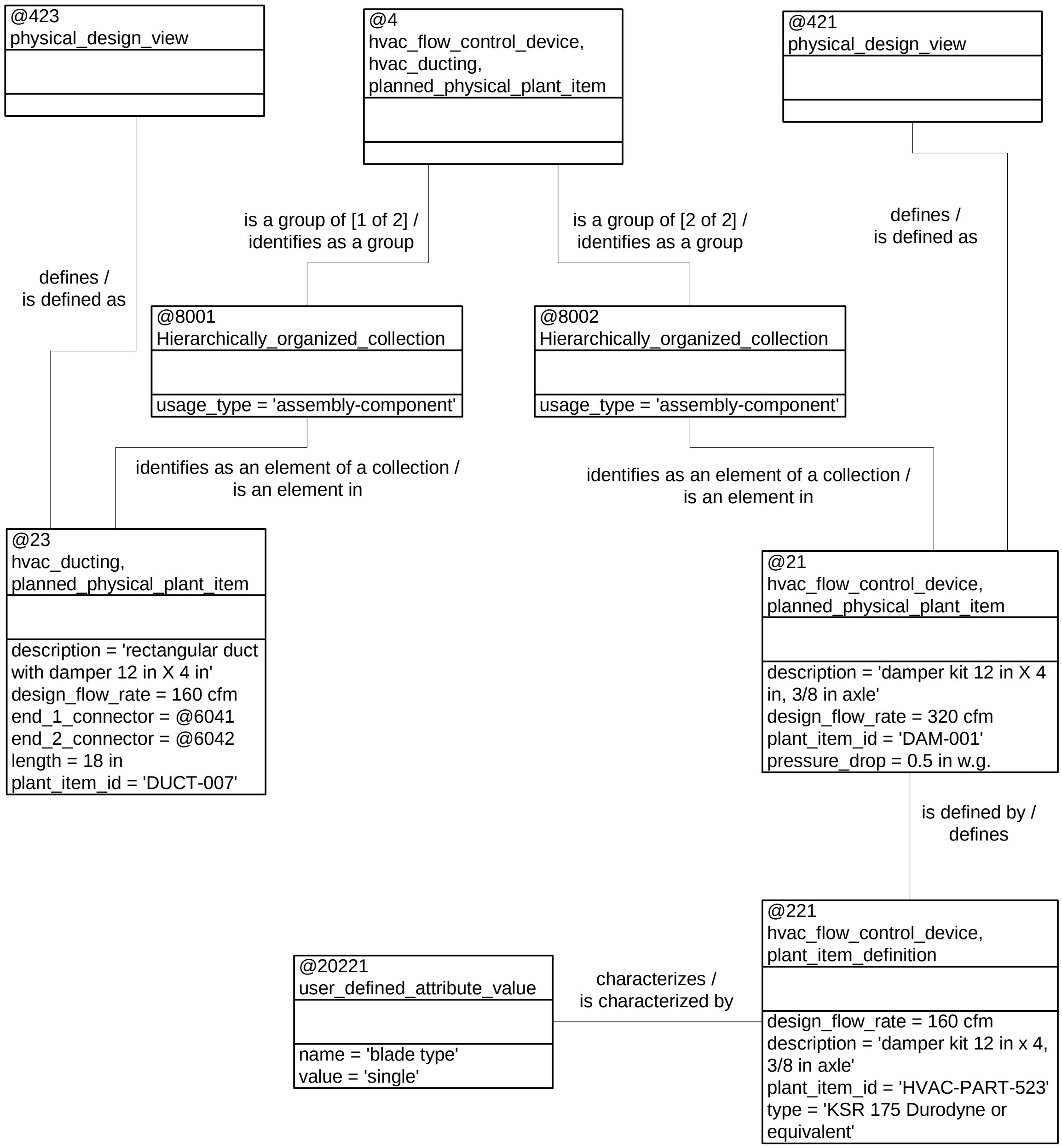

Figure A.101 — Instance diagram for the HVAC Noise Analysis test case (4 of 8)

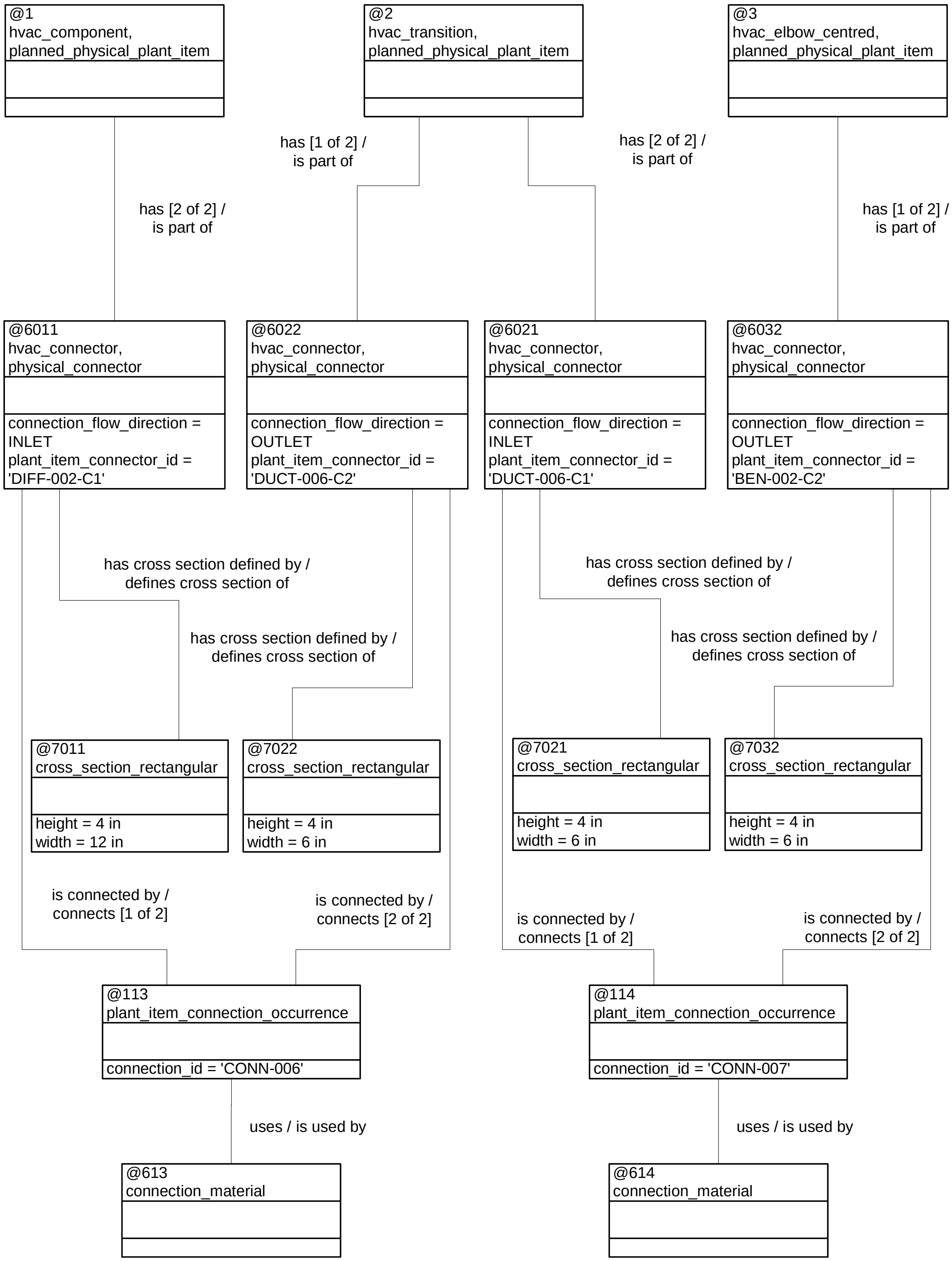

Figure A.102 — Instance diagram for the HVAC Noise Analysis test case (5 of 8)

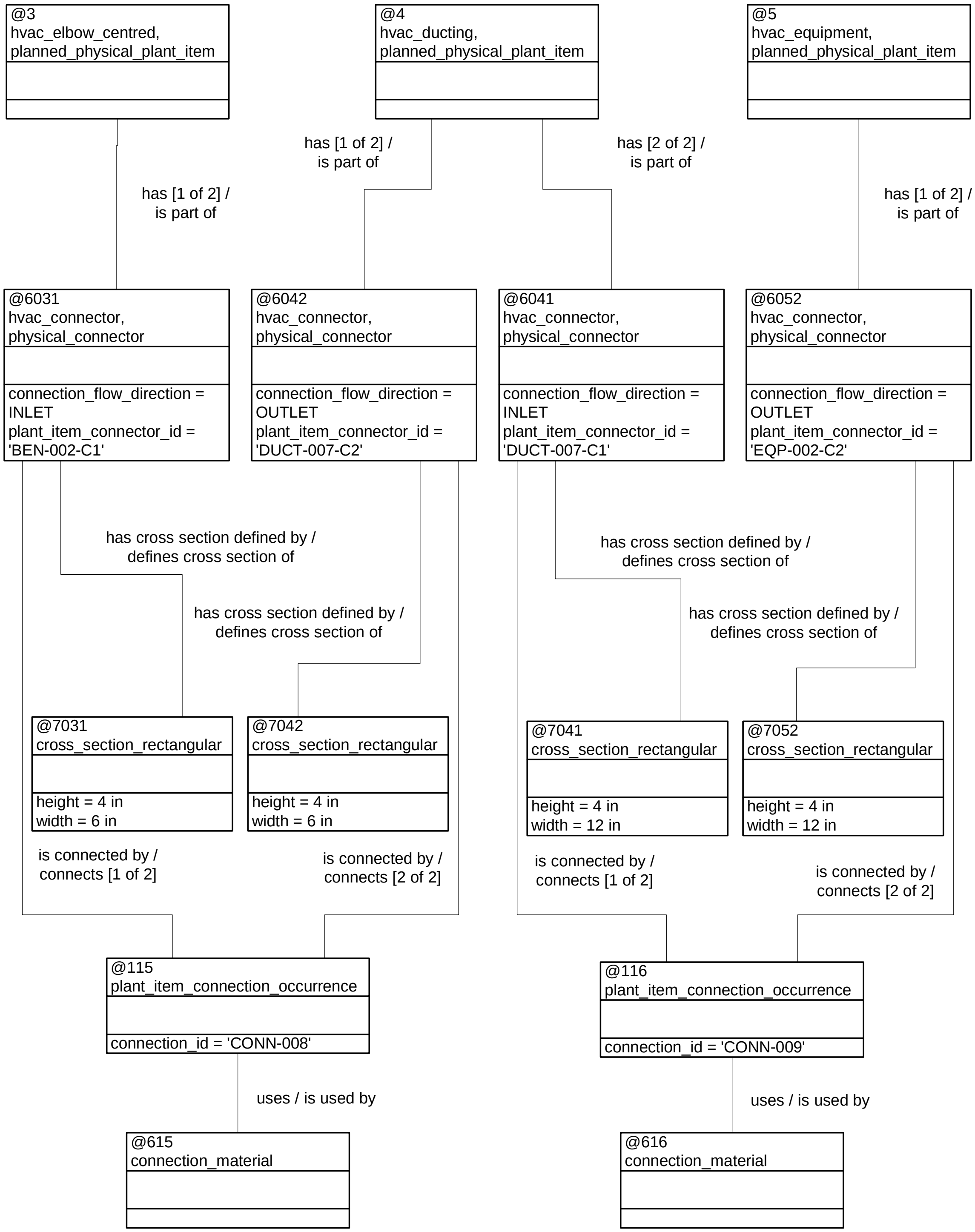

Figure A.103 — Instance diagram for the HVAC Noise Analysis test case (6 of 8)

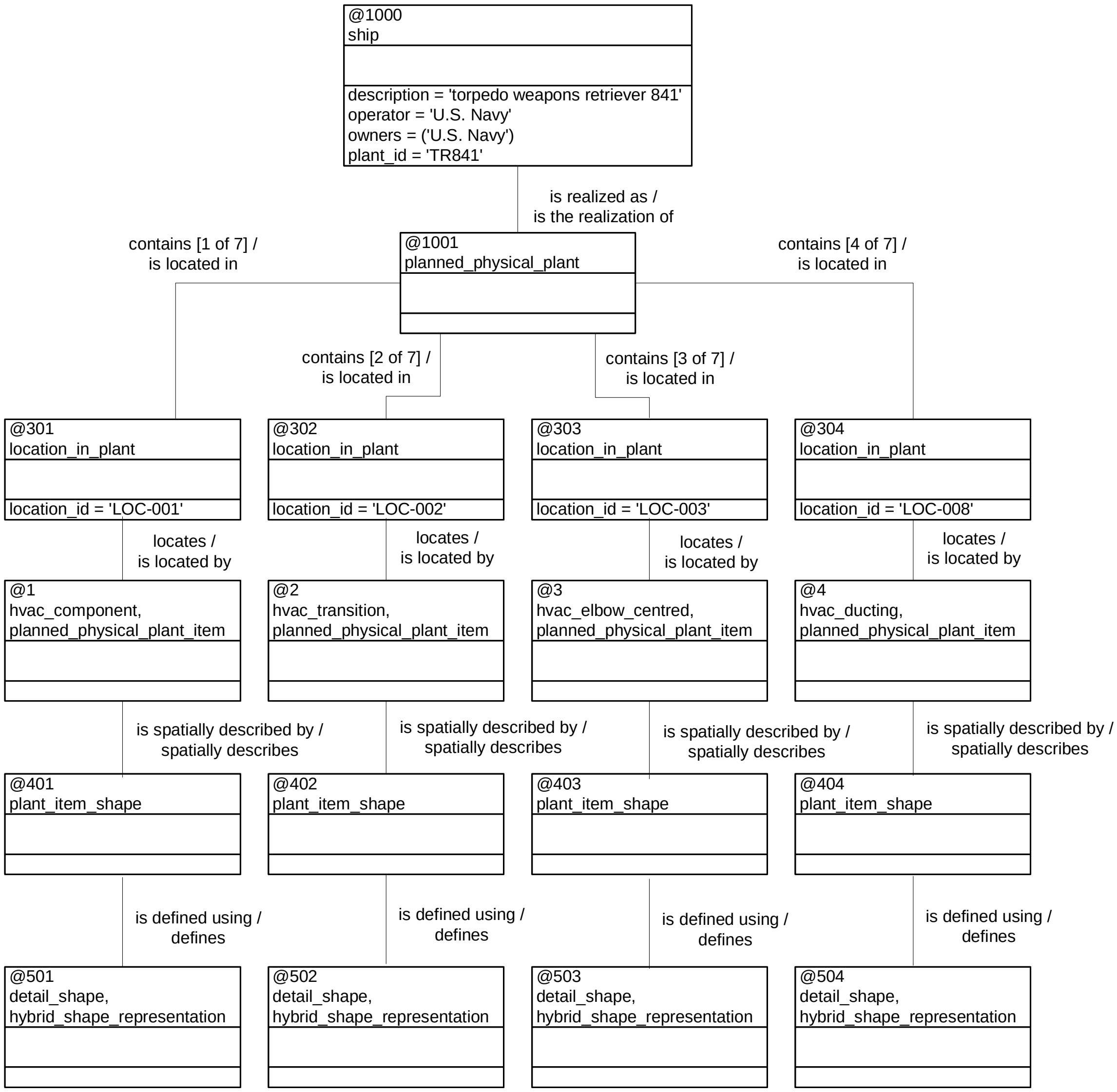

Figure A.104 — Instance diagram for the HVAC Noise Analysis test case (7 of 8)

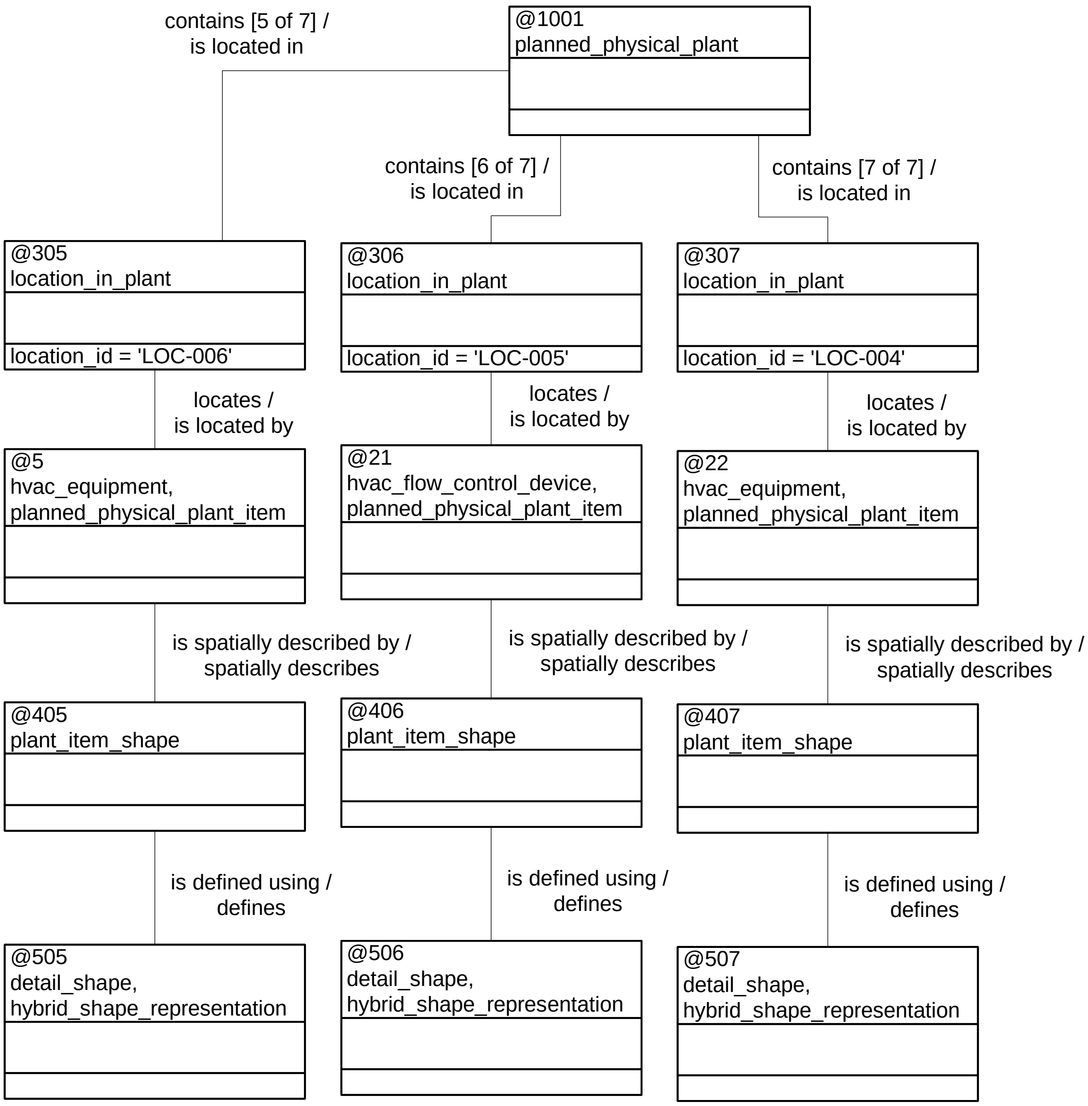

Figure A.105 — Instance diagram for the HVAC Noise Analysis test case (8 of 8)

A.3.6.1 HVAC Schematic

A.3.6.2 Purpose

This clause describes the use of ISO 10303-227 to exchange schematics associated with a functional description of a portion of an HVAC system.

A.3.6.3 Exchange context

The context for this test case is the exchange of HVAC schematics between a shipyard and a client.

A.3.6.4 Test data

Figure A.106 shows a portion of schematic drawing of an HVAC system.

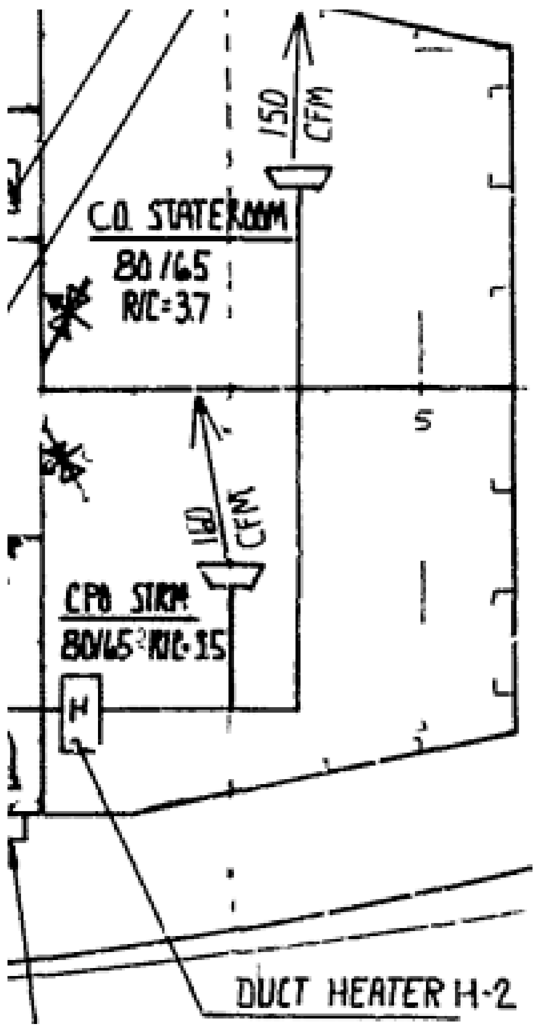

Figure A.106 — Portion of an HVAC system for the HVAC Schematic test case

Figure A.107 shows the schematic drawing that will be represented in this test case.

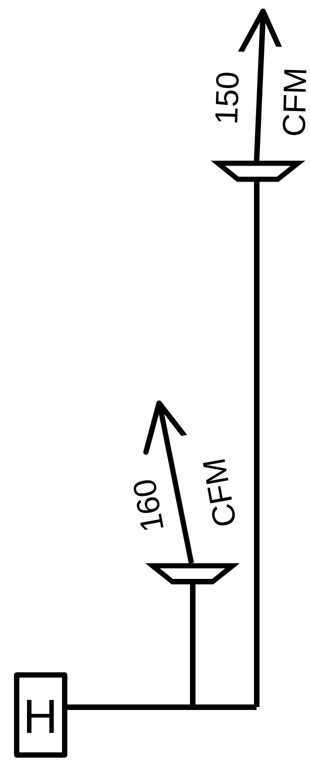

Figure A.107 — HVAC system with components labeled

Figure A.108 shows the title block for the drawing.

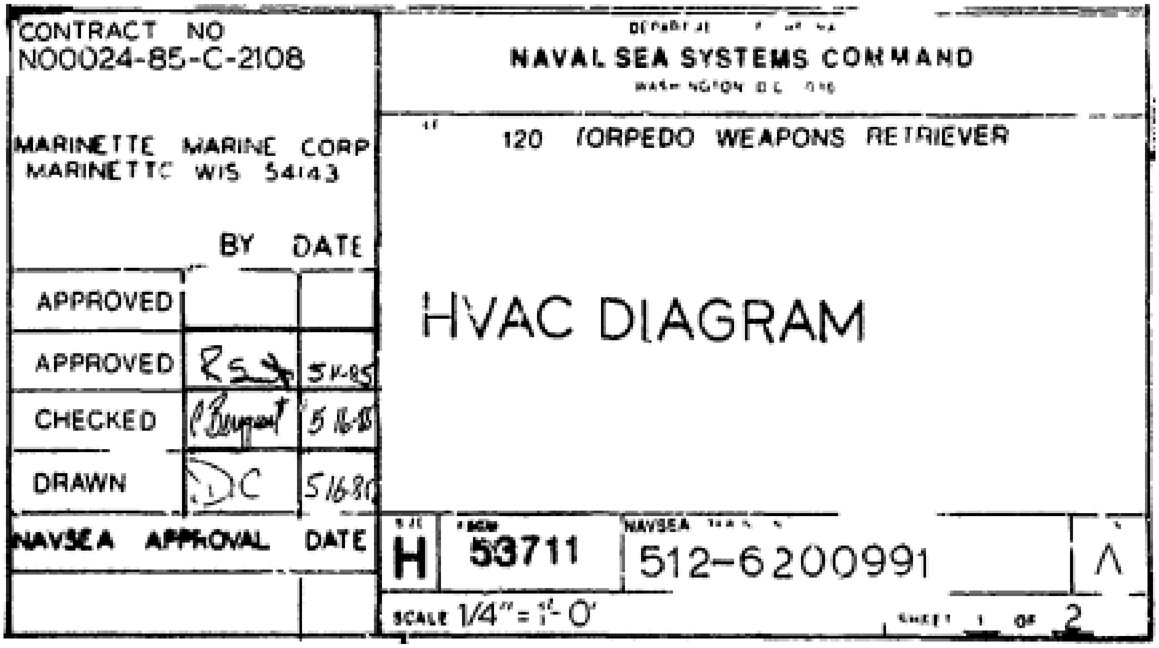

Figure A.108 — Title block

Table A.13 contains the attributes of the components.

Table A.13 — Components for the HVAC Schematic test case

Label	Type	Attributes
HVAC-01-01-E1	diffuser	diffuser 9” x 9” opening with damper
HVAC-01-02-T1	duct heater	12” x 6” 35kW
HVAC-01-03-T1	duct heater	12” x 6” 35kW

A.3.6.5 ARM representation

Figures A.109 to A.111 contain the instance diagrams for this test case.

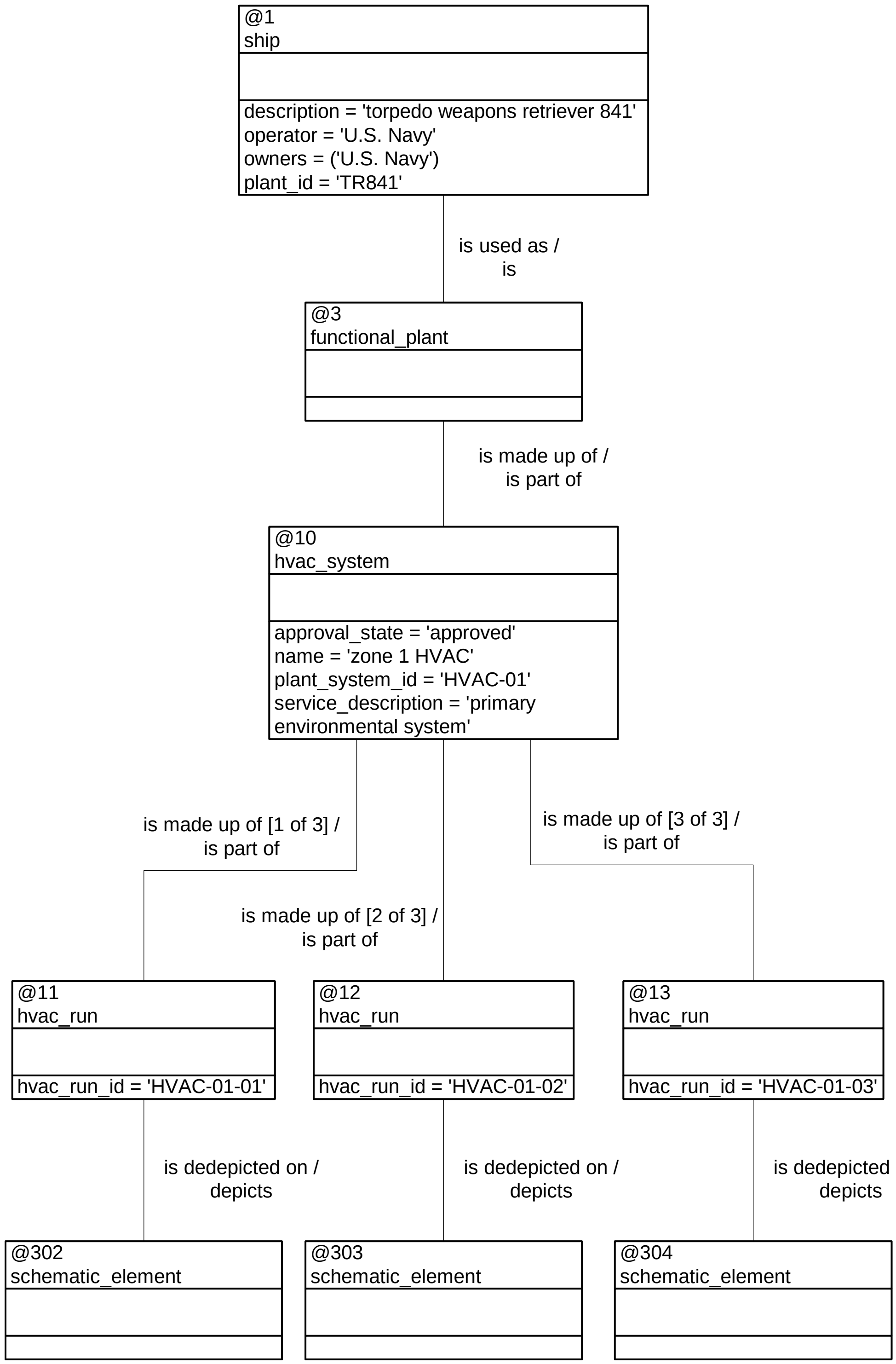

Figure A.109 — Instance diagram for the HVAC Schematic test case (1 of 3)

Figure A.110 — Instance diagram for the HVAC Schematic test case (2 of 3)

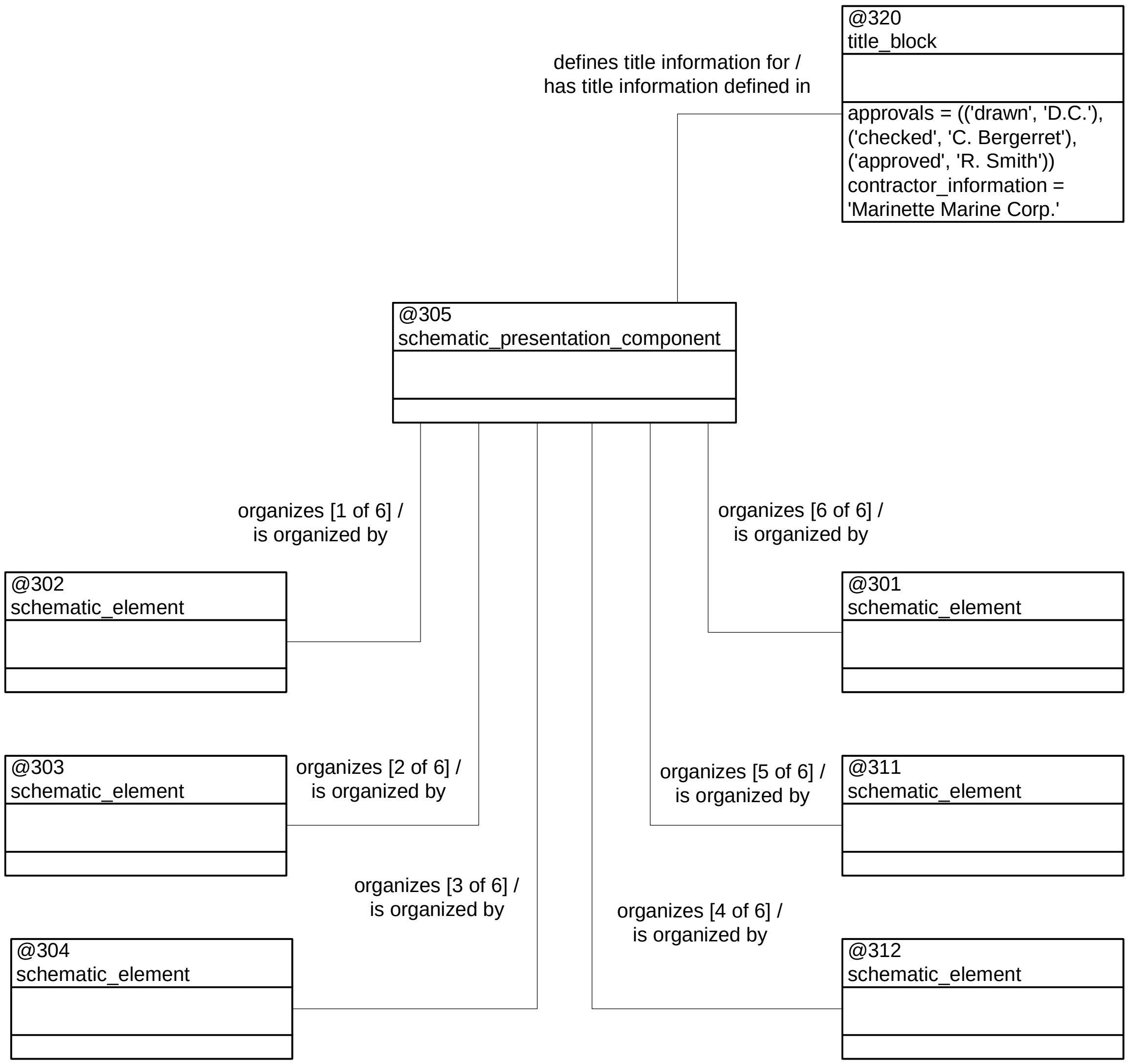

Figure A.111 — Instance diagram for the HVAC Schematic test case (3 of 3)

A.3.7 Cableway System Installation

A.3.7.1 Purpose

This clause describes the use of ISO 10303-227 to exchange information about the installation of a cableway system.

A.3.7.2 Exchange context

The context for this test case is the exchange of cableway installation information between an electrical engineer and a cableway installer.

A.3.7.3 Test data

Figure A.112 shows a room containing a blower and a cableway system.

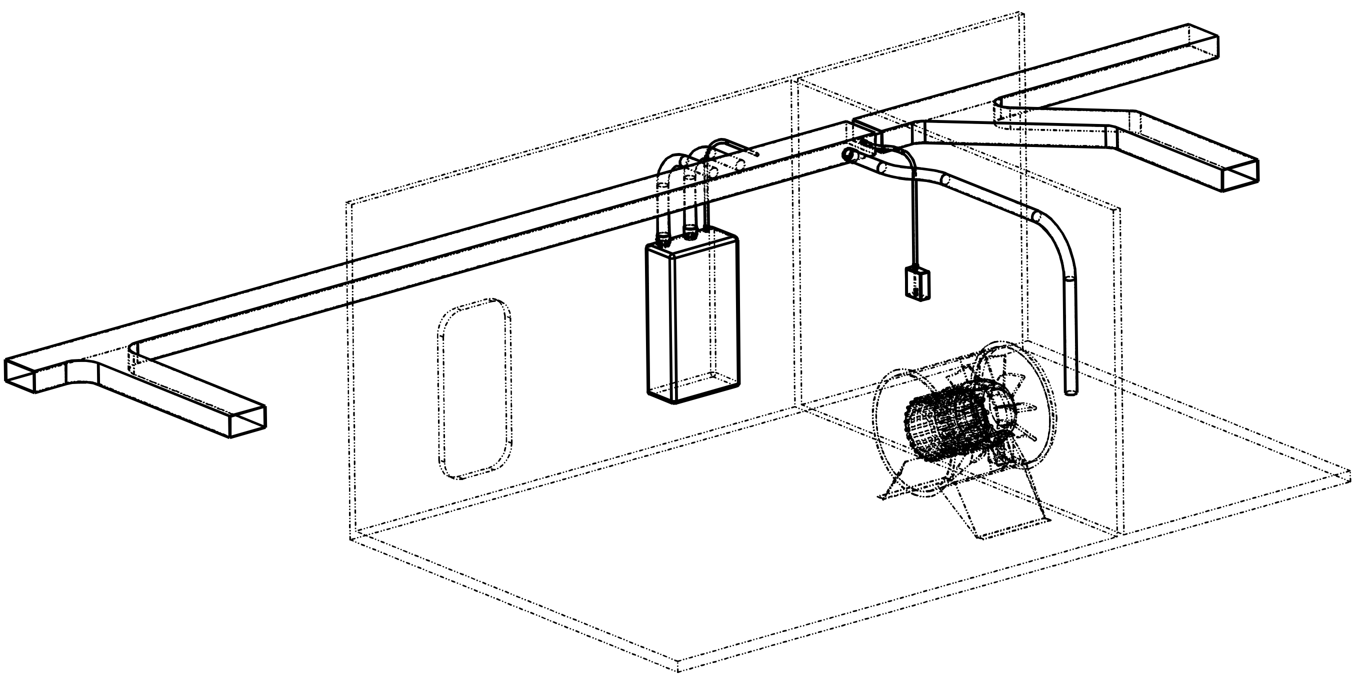

Figure A.112 — Room with blower and cableway system

Figure A.113 shows a top view of a portion of the cableway system in Figure A.96 with the components labeled. The components in Figure A.113 will form the basis for this test case.

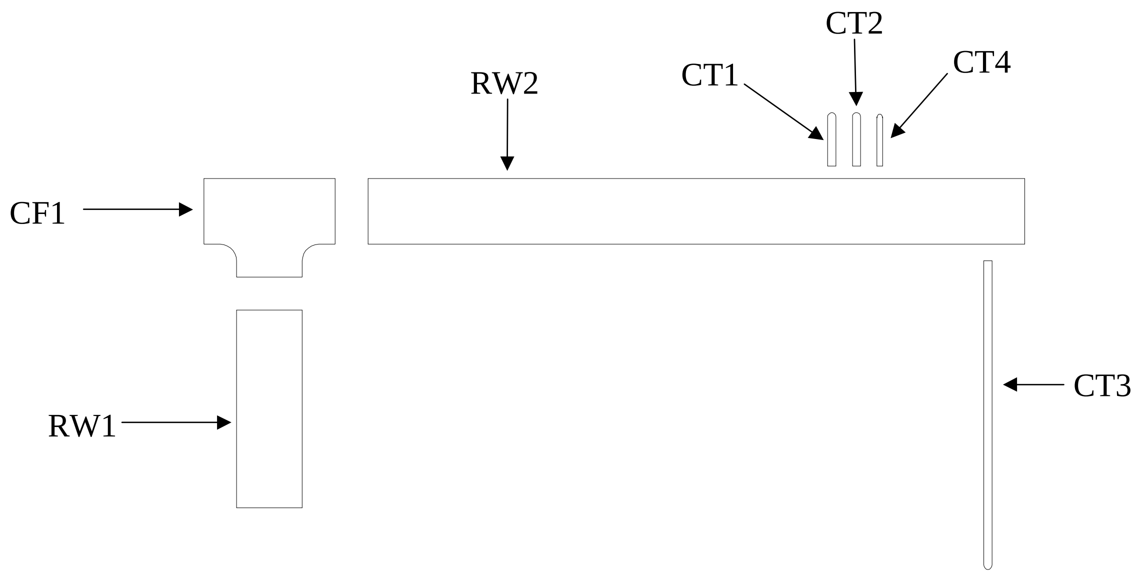

Figure A.113 — Top view of cableway system with components labeled for the Cableway System Installation test case

Table A.14 lists the components, their identifiers, types and descriptions.

Table A.14 — Component specifications for the Cableway System Installation test case

Part	Type	Description
CF1	tee	tee, rectangular cross section, 1 in × 2.5 in
RW1	raceway	raceway, rectangular cross section, 1 in × 2.5 in
RW2	raceway	raceway, rectangular cross section, 1 in × 2.5 in
CT1	conduit	conduit, outer diameter 1.9 in, thickness .145 in
CT2	conduit	conduit, outer diameter 1.9 in, thickness .145 in
CT3	conduit	conduit, outer diameter 1.9 in, thickness .145 in
CT4	conduit	conduit, outer diameter 1.0 in

Figure A.114 shows a top view of the portion of the cableway system in Figure A.112, with the connectors labeled. Table A.15 shows the connections for this test case.

Table A.15 — Connections for the Cableway System Installation test case

Connector 1	Connector 2	Type of connection
RW1-2	CF1-3	tongue and groove snap connection
CF1-2	RW2-1	tongue and groove snap connection
RW2-2	CT1-1	tongue and groove snap connection
RW2-3	CT2-1	tongue and groove snap connection
RW2-4	CT4-1	tongue and groove snap connection
RW2-5	CT3-1	tongue and groove snap connection

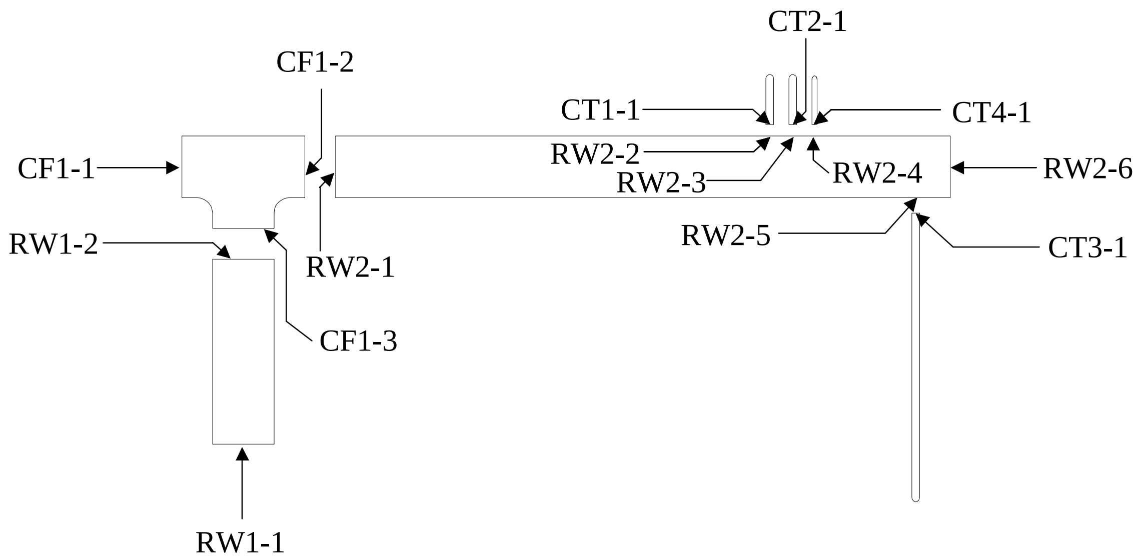

Figure A.114 — Top view of cableway system with connectors labeled for the Cableway System Installation test case

In this test case, cables follow two paths, Path 1 and Path 2 (see Figure A.115). In addition, the rectangular raceways (RW1 and RW2) each contain two lanes for wires. The lanes for RW1 are RW1-LA and RW1-LB. The lanes for RW2 are RW2-LA and RW2-LB. Table A.16 shows the cables for this test case, along with their assignments to paths and raceway lanes.

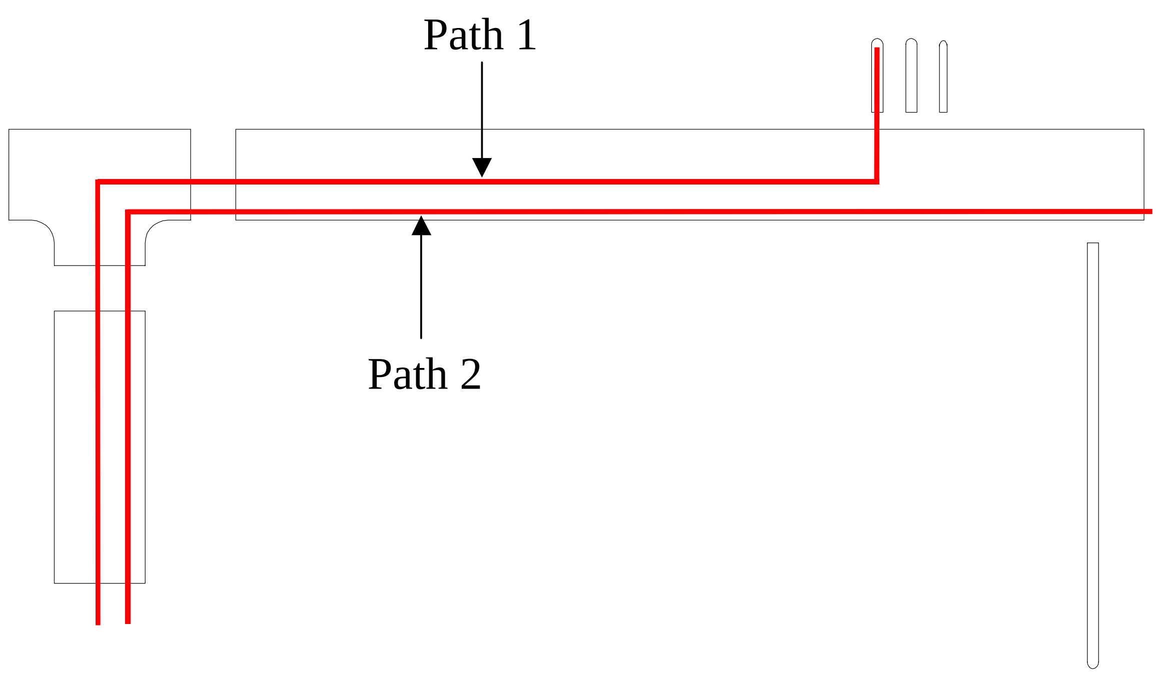

Figure A.115 — Paths for the Cableway System Installation test case

Table A.16 — Cables for the Cableway System Installation test case

Cable	Path	Raceway lanes
BLU-1	Path 1	RW1-LA, RW2-LA
RED-1	Path 2	RW1-LA, RW2-LA
BLU-2	Path 2	RW1-LB, RW2-LB
RED-2	Path 1	RW1-LB, RW2-LB
YELL-2	Path 1	RW1-LB, RW2-LB
GREN-2	Path 1	RW1-LB, RW2-LB

A.3.7.4 ARM representation

Figures A.116 to A.129 show the ARM instance diagrams for this test case.

A.3.7.4.1 Representing the cableway system

Figures A.116 shows the representation of the overall cableway system. An instance (@1) of the Cableway_system AO represents the cableway system. It is related to an instance (@200) of the Functional_plant AO. The instance (@200) of Functional_plant is in turn related to an instance (@201) of the Ship AO. In ISO 10303-227, a Ship is a kind of Plant.

A.3.7.4.2 Representing the components and their geometry

Figures A.117 through A.103 show the representation of the components and their locations. Raceway RW-1 is represented by a complex entity instance (@3) of the Raceway and Planned_physical_plant_item AOs. The size of the raceway is specified by an instance (@21) of the Raceway_size_description AO. The raceway's shape is represented by an instance (@53) of Hybrid_shape_representation, linked to @3 via an instance (@52) of Plant_item_shape. Raceway RW-2 and conduits CT1 through CT4 are represented similarly.

A.3.7.4.3 Representing connections

Figures A.120 through A.125 show the connections between the components. As shown in Figure A.114, raceway RW2 has five connectors. Each of these is represented by a complex entity instance of the Cableway_connector and Plant_item_connector_occurrence AOs. Connector RW2-1 of raceway RW2 and CF1-2 of tee CF1are represented by complex entity instances (@13 and @19) of the Cableway_connector and Plant_item_connector_occurrence AOs. The connection between these is represented by an instance(@72) of the Plant_item_connector_occurrence AO. Other connectors and connections are represented similarly.

A.3.7.4.4 Representing cable paths

Electrical system design is not within the scope of ISO 10303-227; therefore, the ability to represent electrical wiring is quite limited. ISO 10303-227 simply allows one to specify which electrical cables run through which cableway components. In particular, there is no AO in ISO 10303-227 to represent a wiring path.

Figures A.126 through A.129 show how the cables and paths given in Figure A.99 and Table A.13 can be represented using ISO 10303-227. In ISO 10303-227, an instance of the Cable AO can be related directly to an instance of the Cableway_component AO through the runs "through/contains" relation.

In this test case, both raceways have two lanes. Lanes RW1-LA and RW1-LB of raceway RW1 are represented by complex entity instances (@48 and @49) of the Raceway_lane and Planned_physical_plant_item AOs (see Figure A.111). Cables BLU-1 and RED-1, represented by complex entity instances (@22 and @23) of the Cable and Planned_physical_plant_item AOs, are linked to the instance (@24) representing lane RW1-LA. Cables BLU-2, RED-2, YELL-2 and GREN-2, represented by complex entity instances (@30, @31, @32 and @33) of the Cable and Planned_physical_plant_item AOs, are linked to the instance (@29) representing lane RW1-LB.

Figure A.127 shows that all the cables from both Path 1 and Path 2 run through tee CF1.

Figure A.128 shows that cables BLU-1 and RED-1 run through lane RW2-LA of raceway RW2, and cables BLU-2, RED-2, YELL-2 and GREN-2 run through lane RW2-LB of raceway RW2.

Figure A.129 shows that cables RED-1 and BLU-2 run through conduit CT1.

The path that a particular cable takes can be inferred from the cableway components that it runs through. Note that ISO 10303-227 has no way to represent the geometry of a cable path.

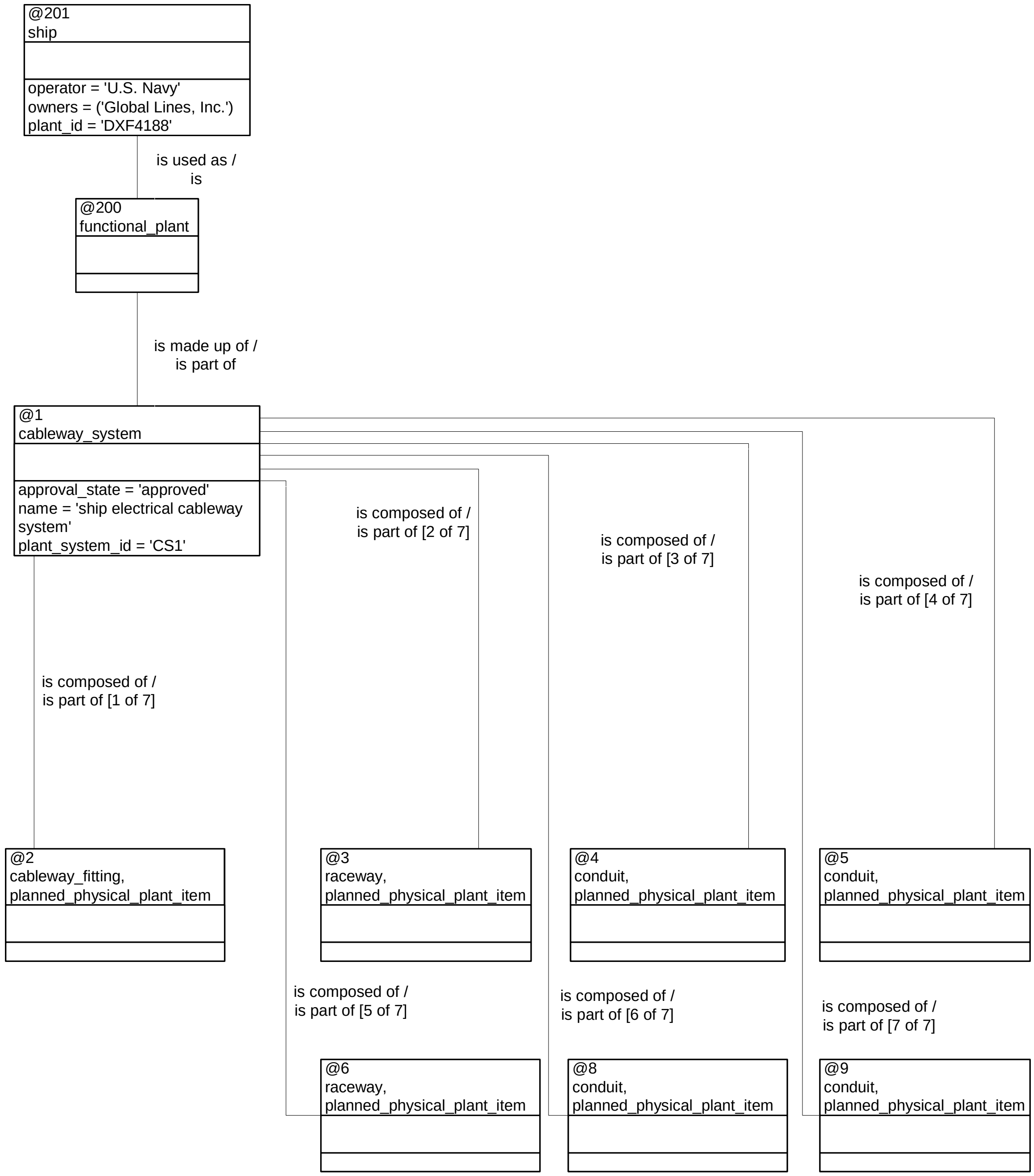

Figure A.116 — Instance diagram for the Cableway System Installation test case (1 of 14)

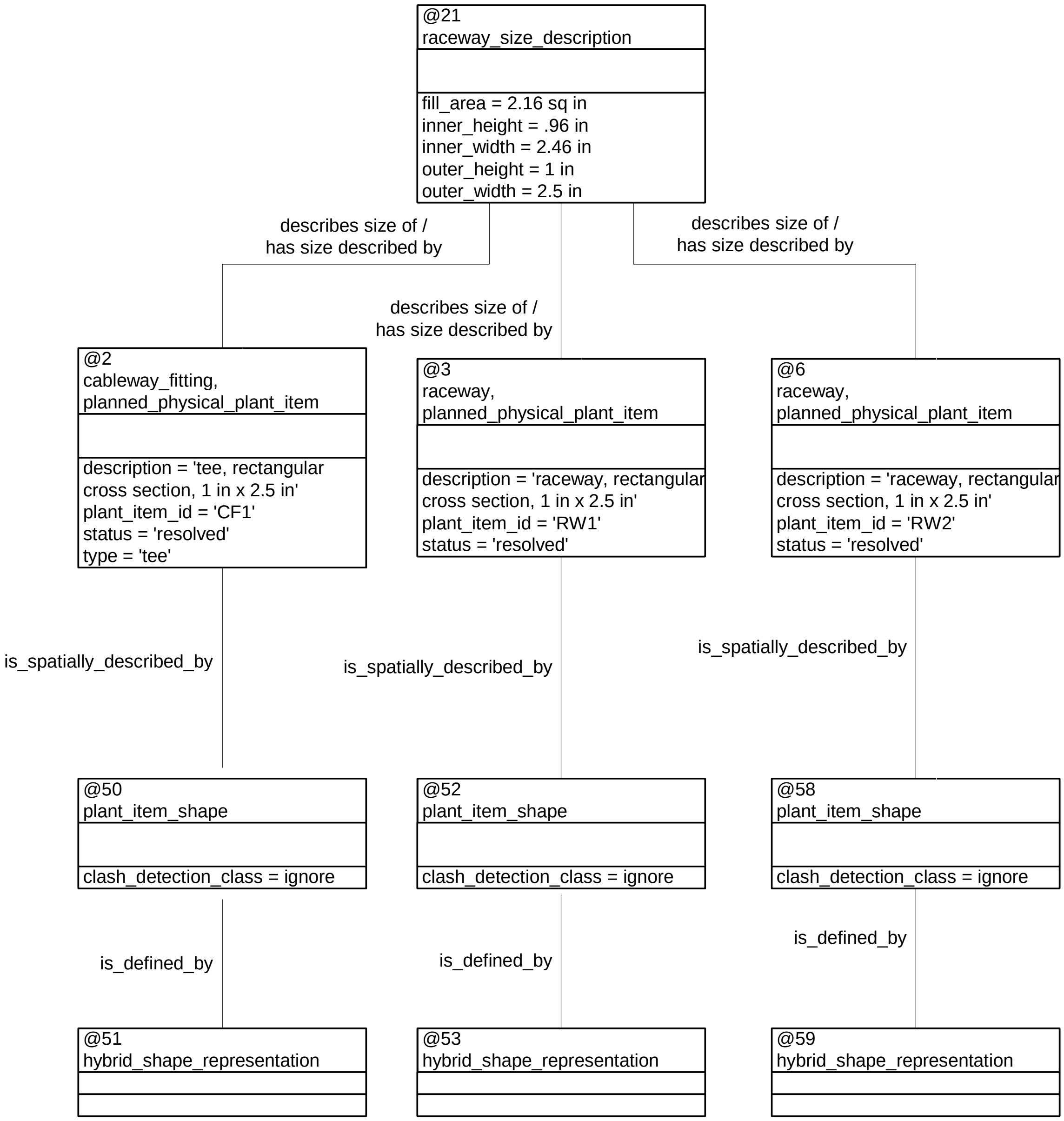

Figure A.117 — Instance diagram for the Cableway System Installation test case (2 of 14)

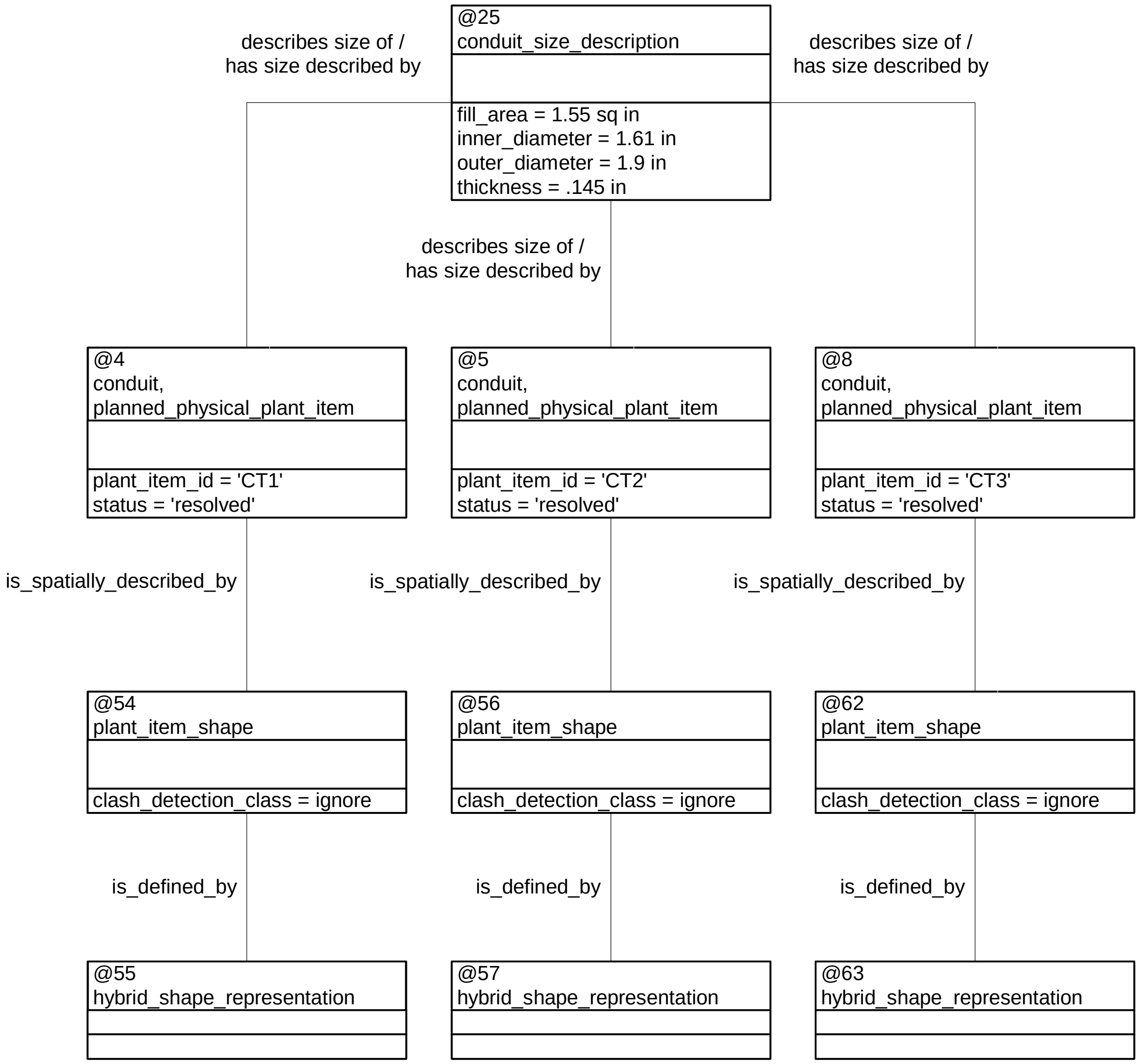

Figure A.118 — Instance diagram for the Cableway System Installation test case (3 of 14)

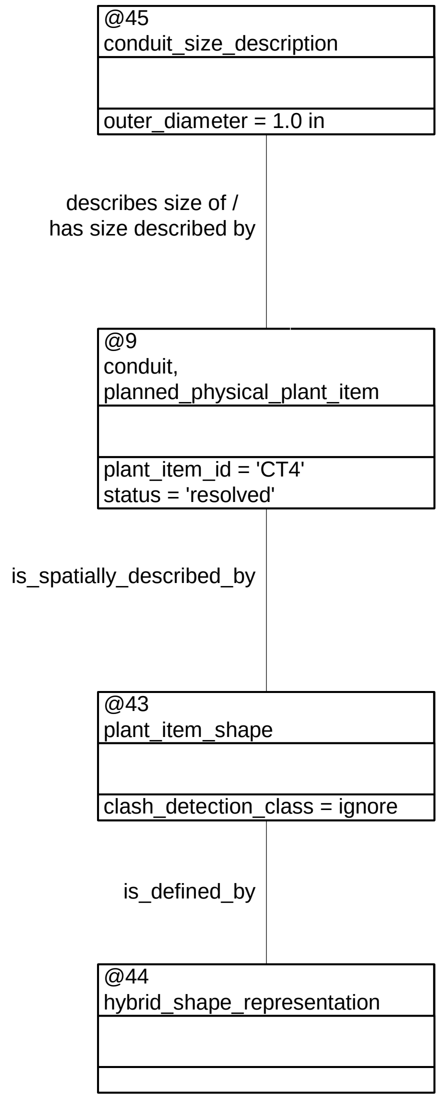

Figure A.119 — Instance diagram for the Cableway System Installation test case (4 of 14)

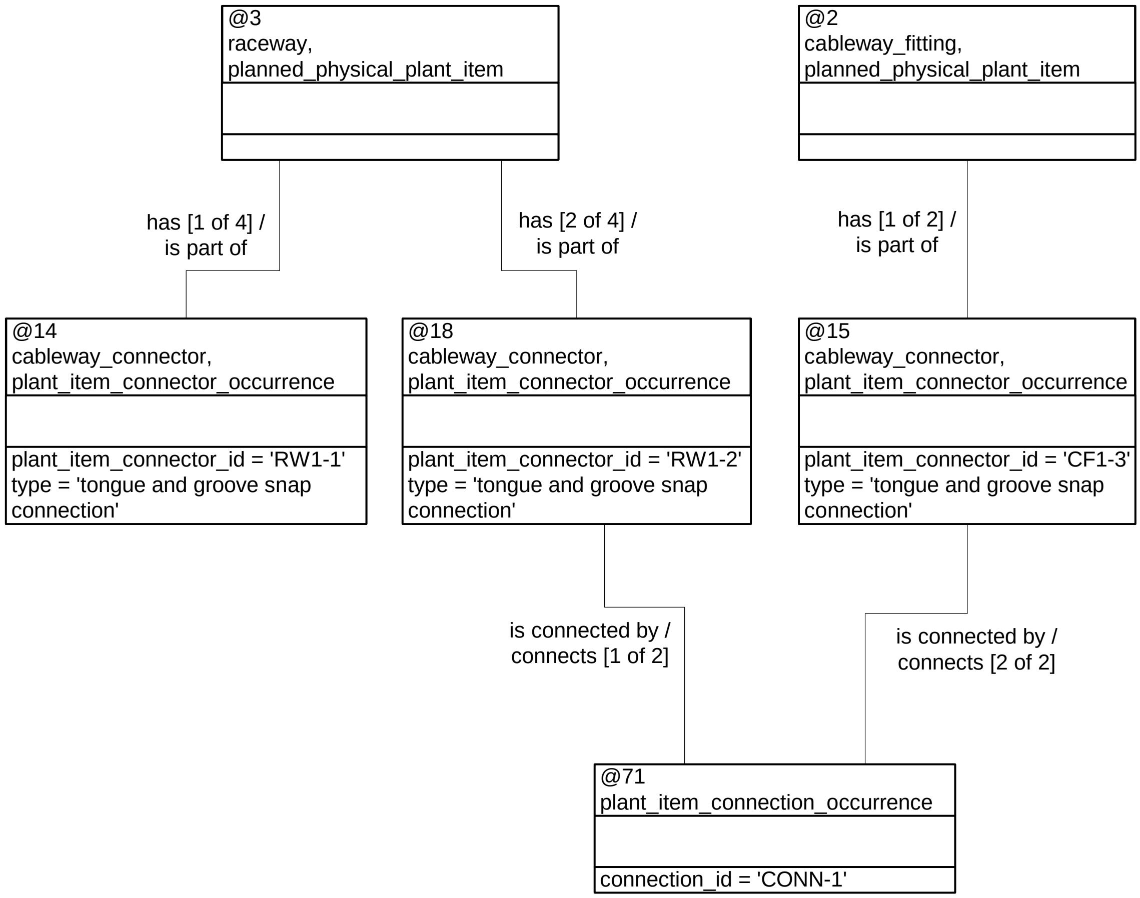

Figure A.120 — Instance diagram for the Cableway System Installation test case (5 of 14)

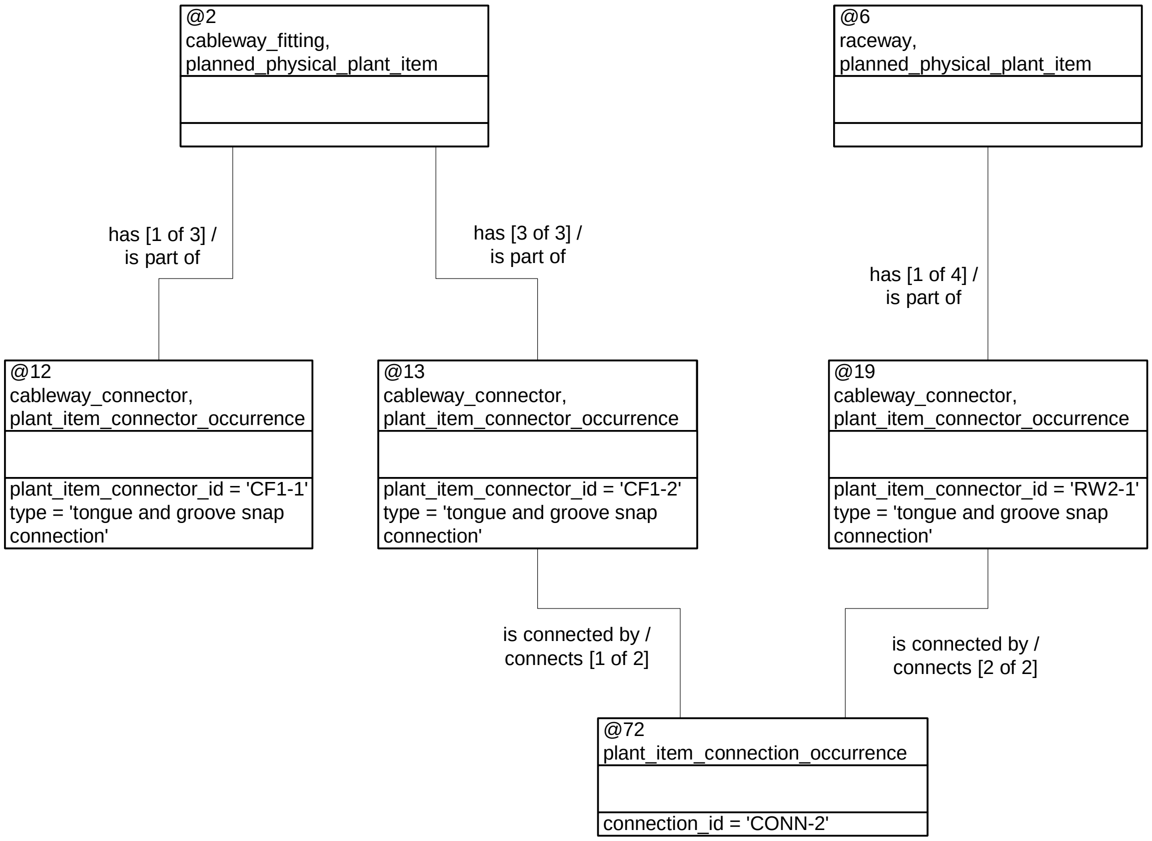

Figure A.121 — Instance diagram for the Cableway System Installation test case (6 of 14)

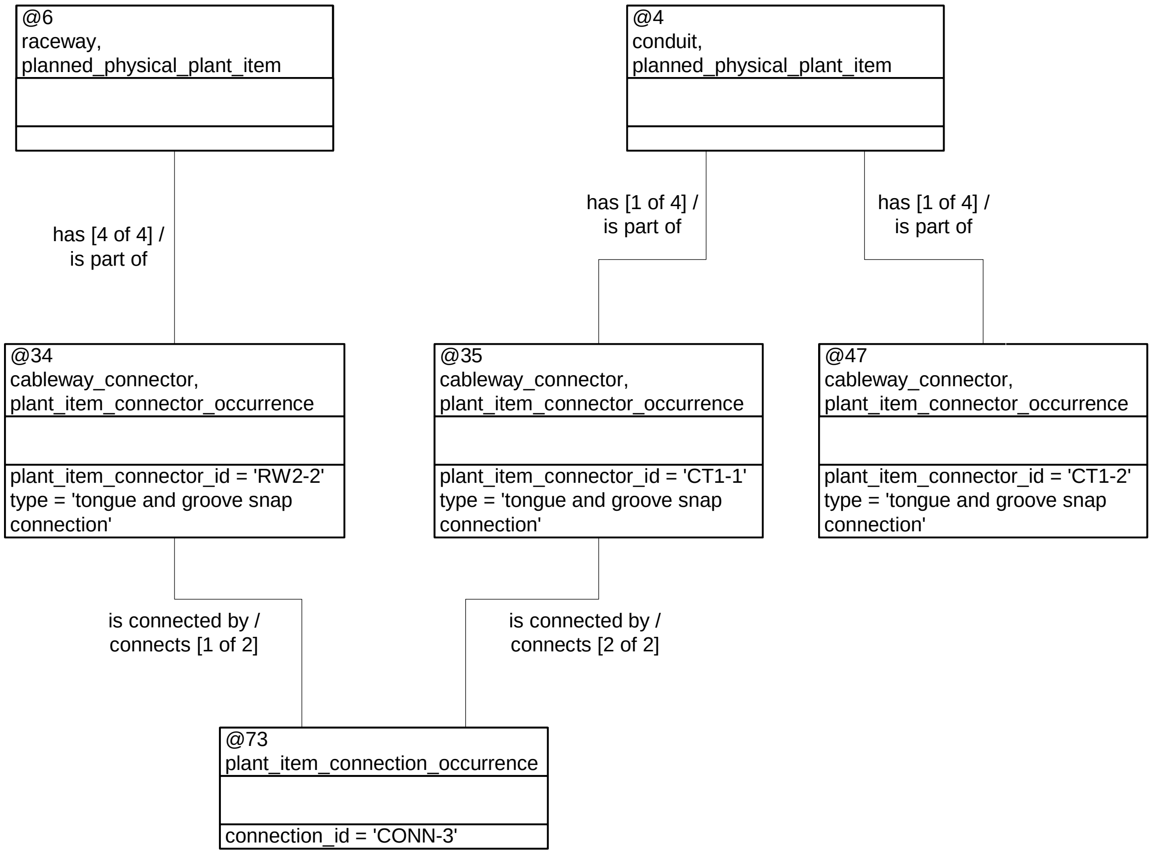

Figure A.122 — Instance diagram for the Cableway System Installation test case (7 of 14)

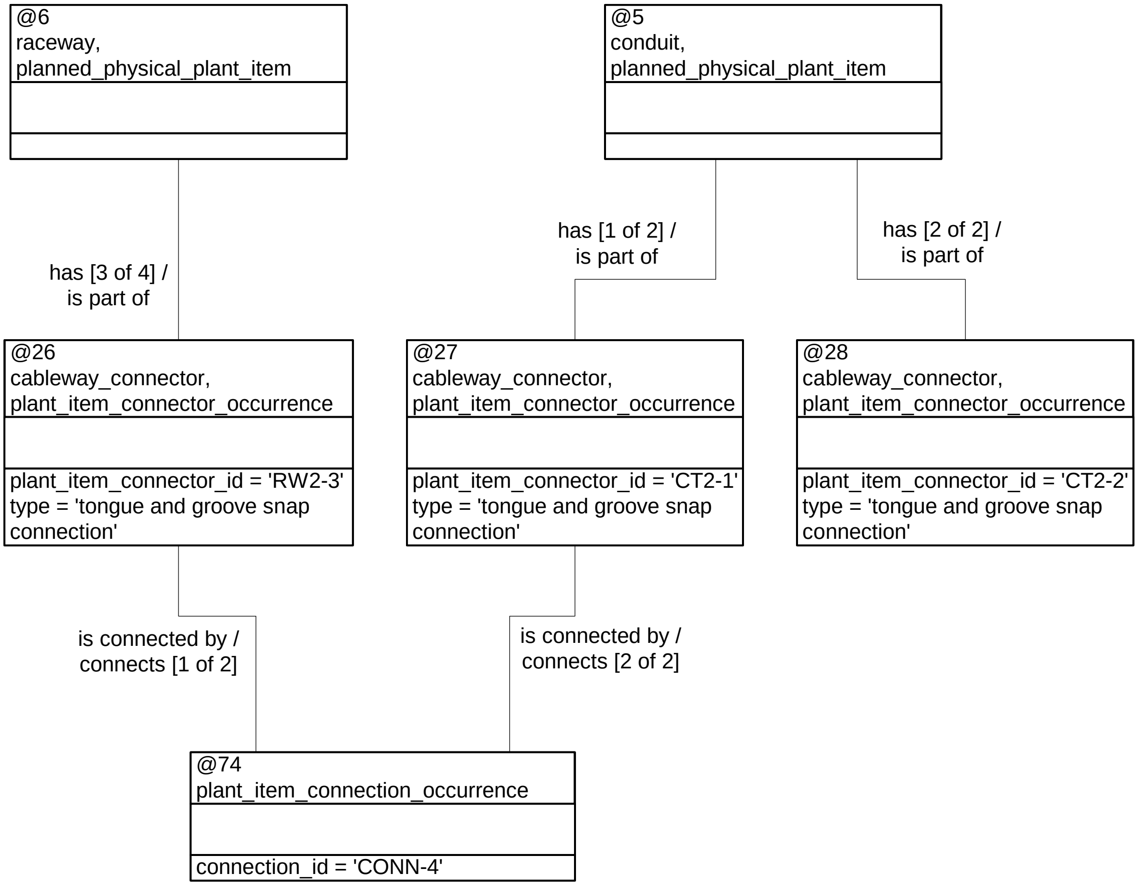

Figure A.123 — Instance diagram for the Cableway System Installation test case (8 of 14)

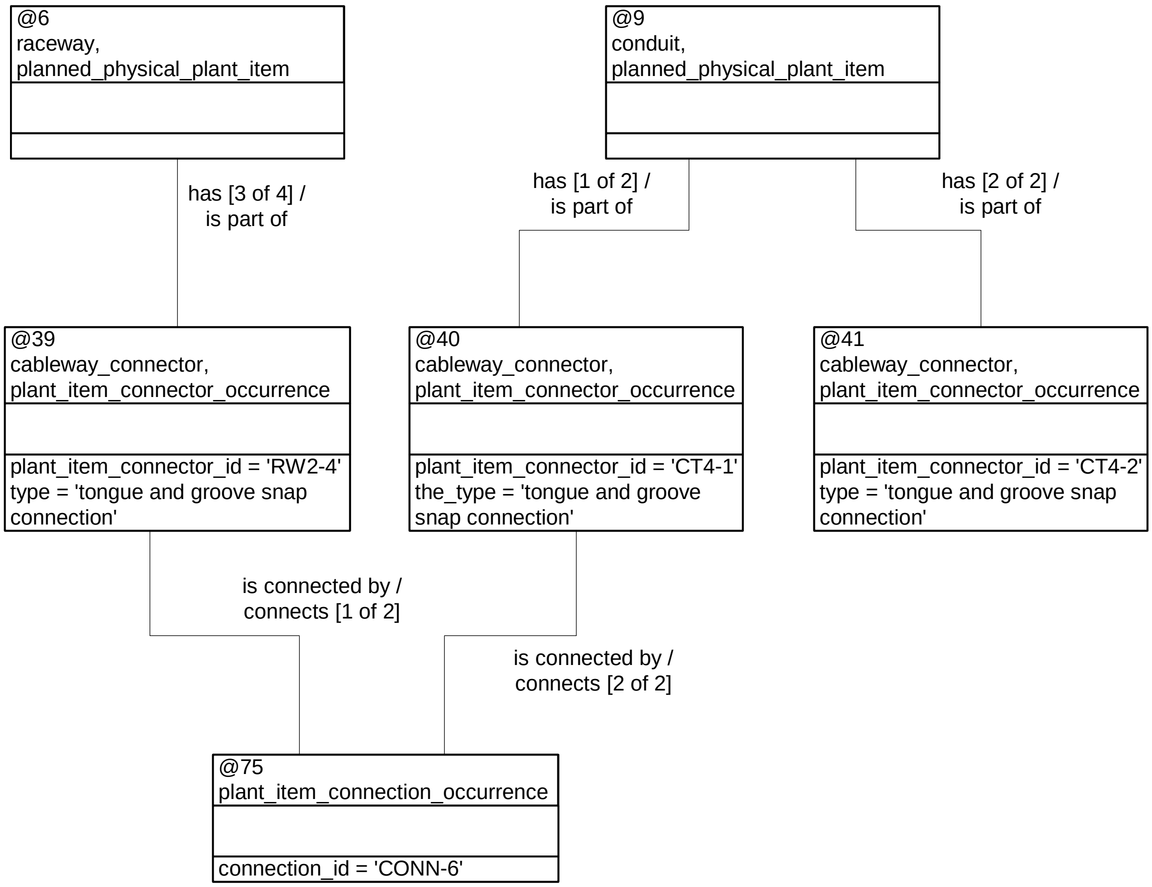

Figure A.124 — Instance diagram for the Cableway System Installation test case (9 of 14)

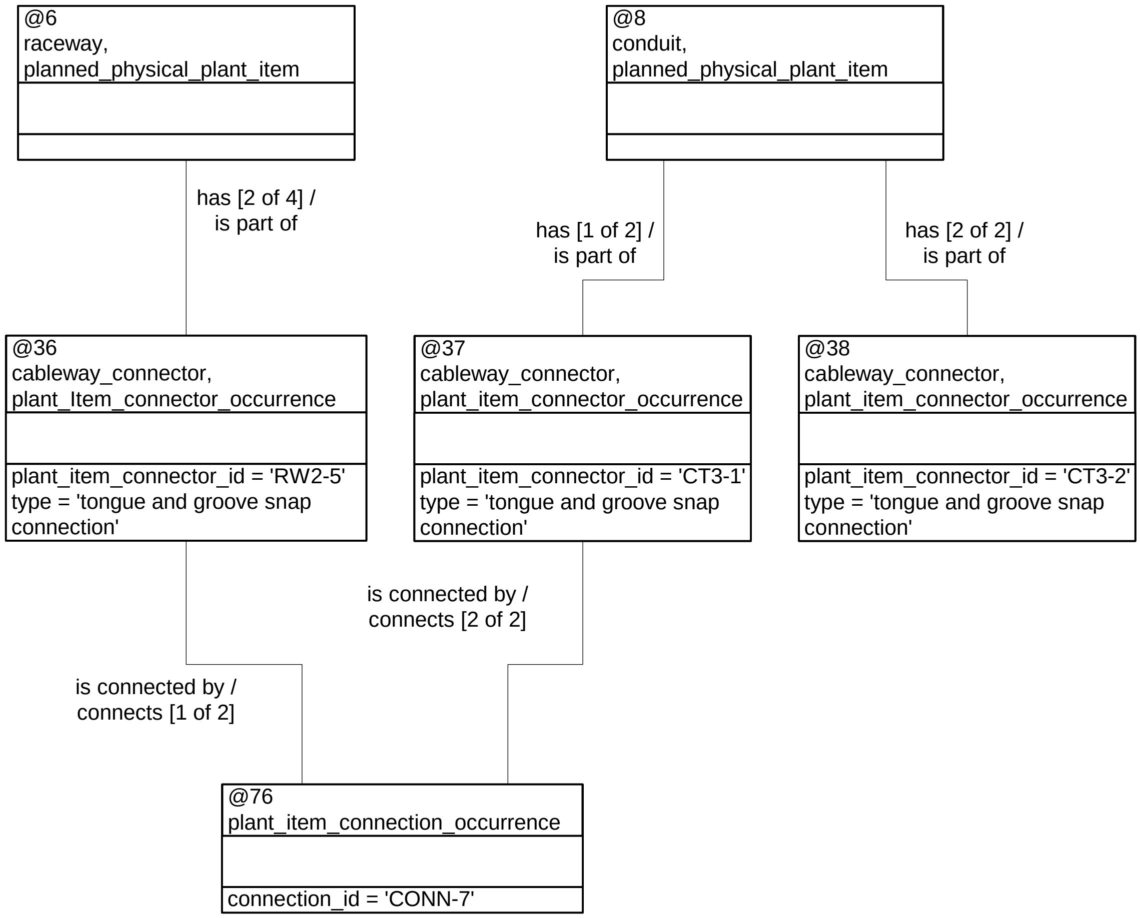

Figure A.125 — Instance diagram for the Cableway System Installation test case (10 of 14)

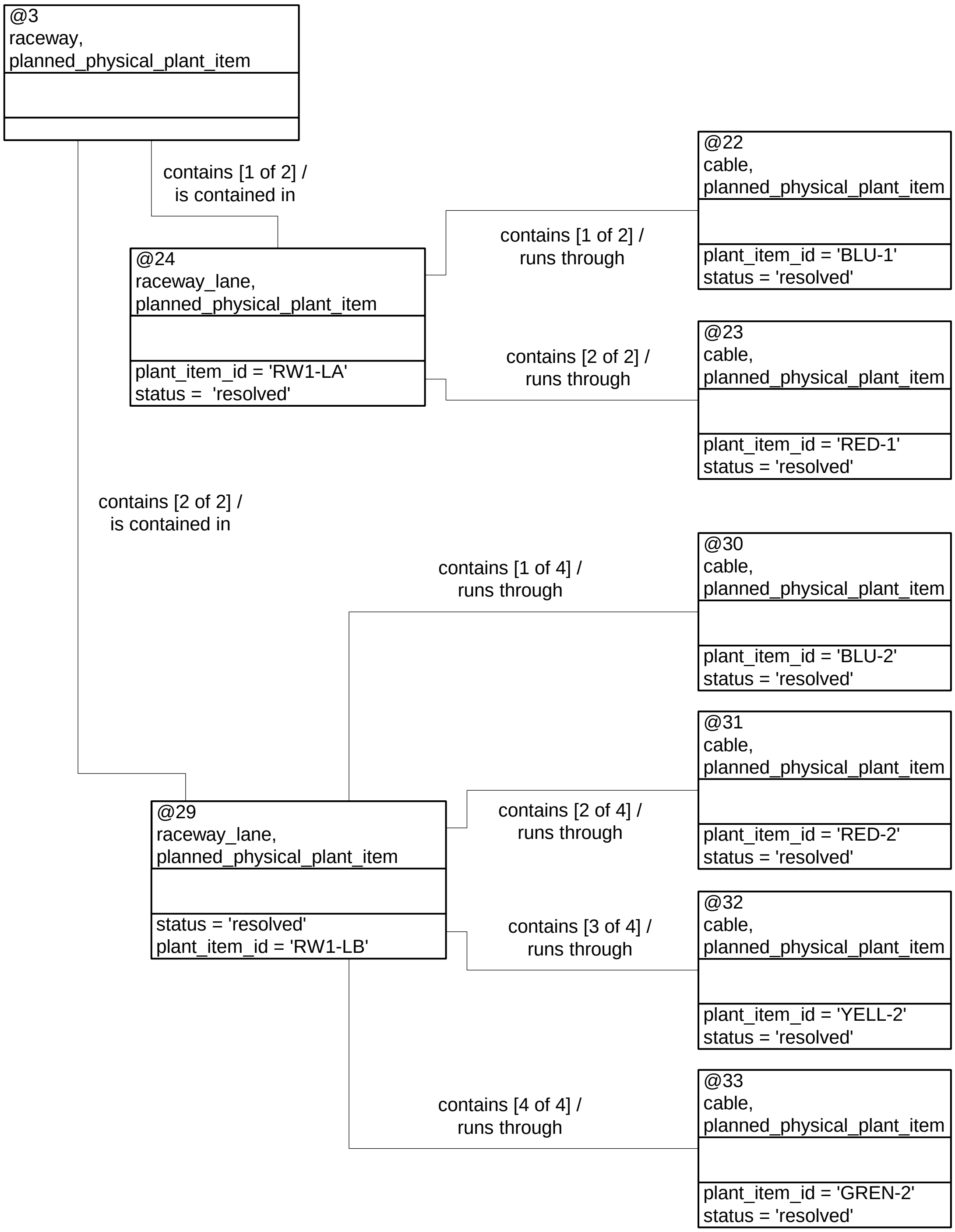

Figure A.126 — Instance diagram for the Cableway System Installation test case (11 of 14)

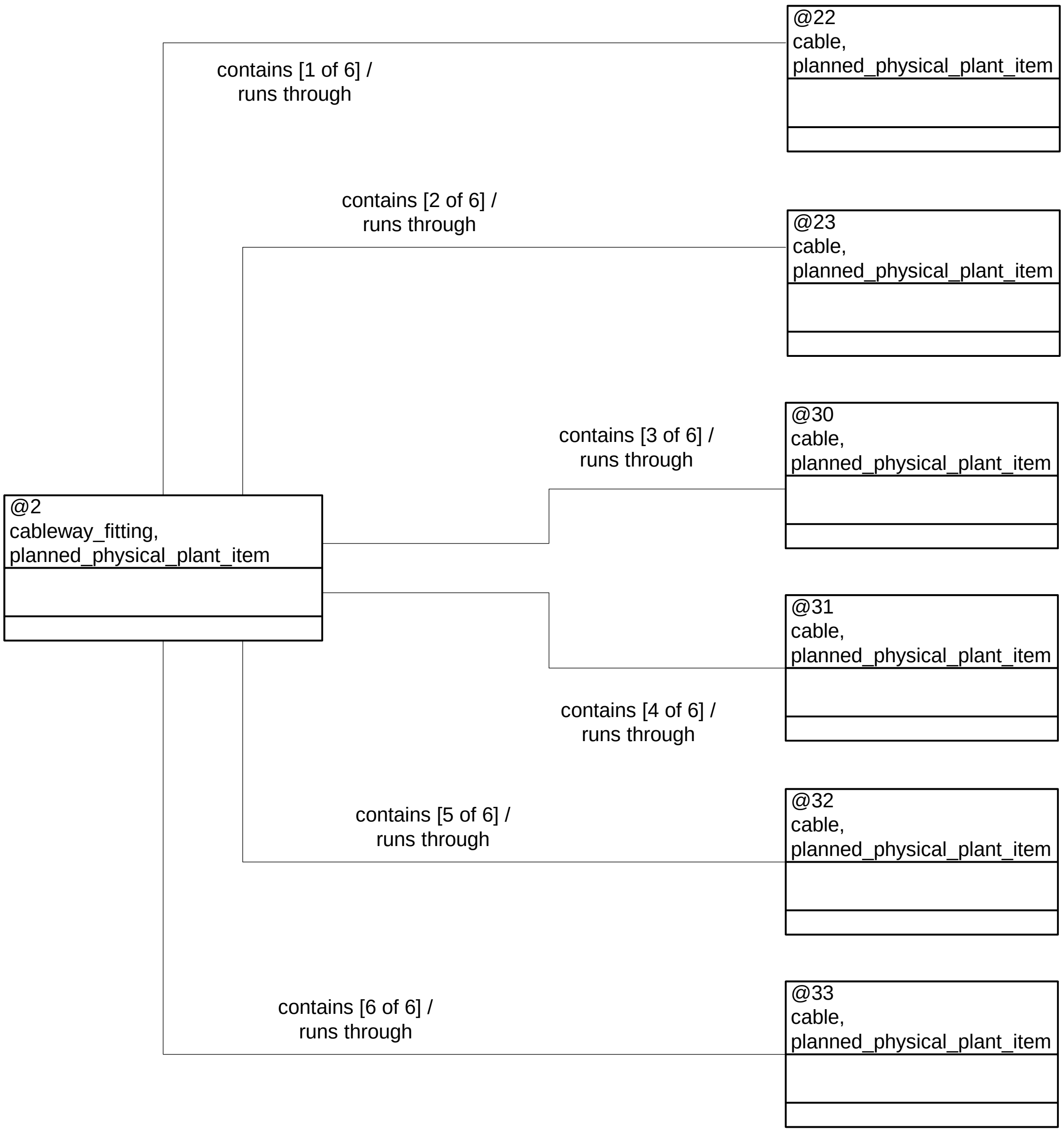

Figure A.127 — Instance diagram for the Cableway System Installation test case (12 of 14)

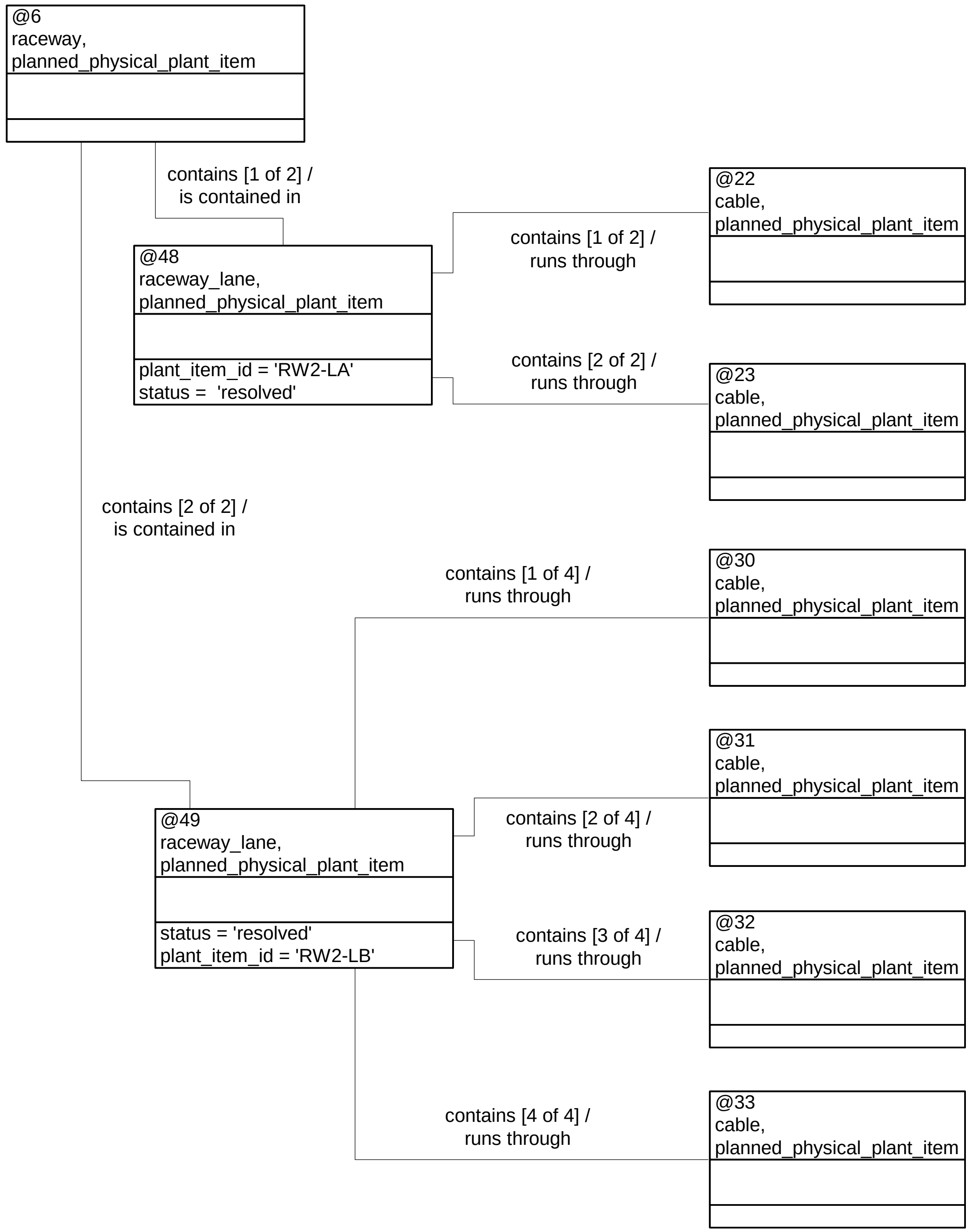

Figure A.128 — Instance diagram for the Cableway System Installation test case (13 of 14)

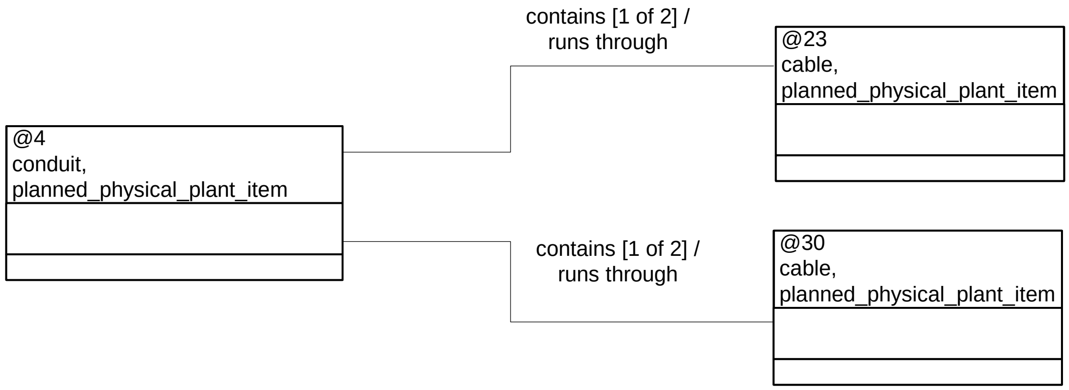

Figure A.129 — Instance diagram for the Cableway System Installation test case (14 of 14)

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[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: Identification of organization identification schemes*.

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[6] Parking, P.H., and H.R. Humphreys, Acoustics Noise and Buildings, New York, Frederick A. Praeger, 1958.

[7] "Design Guide for Shipboard Airborne Noise Control, Technical & Research Bulletin 3-37, Society of Naval Architects and Marine Engineers, January 1983

[8] "Algorithms for HVAV Acoustics", Reynolds, D. D. and Bledsoe, J. M., ASHRAE Publications 1991.

[9] "Sound and Vibration Design and Analysis." National Environmental Balancing Bureau, May, 1994.

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[2] This is edition 1 of ISO 10303-227.

A.3.1 Noise Analysis

A.3.1.1 Purpose

This clause describes the use of ISO 10303-215 to exchange the ship arrangement information necessary as input to a noise analysis. This information consists of a high-level physical description of the compartments and their adjacency.

A.3.1.2 Exchange context

The context for this test case is the exchange of ship arrangement configuration information between a naval engineer and an acoustic engineer.

A.3.1.3 Test data

Figure A.1 shows a portion of a ship that will serve as the basis for this test case. This test case illustrates the exchange of information necessary to calculate the noise level in the Chief Petty Officer (CPO) Stateroom and to determine whether the noise level is within acceptable range. Information transmitted using ISO 10303-215 will be used to calculate the contribution of structureborne and airborne (non-HVAC) noise to the noise level in the CPO Stateroom.

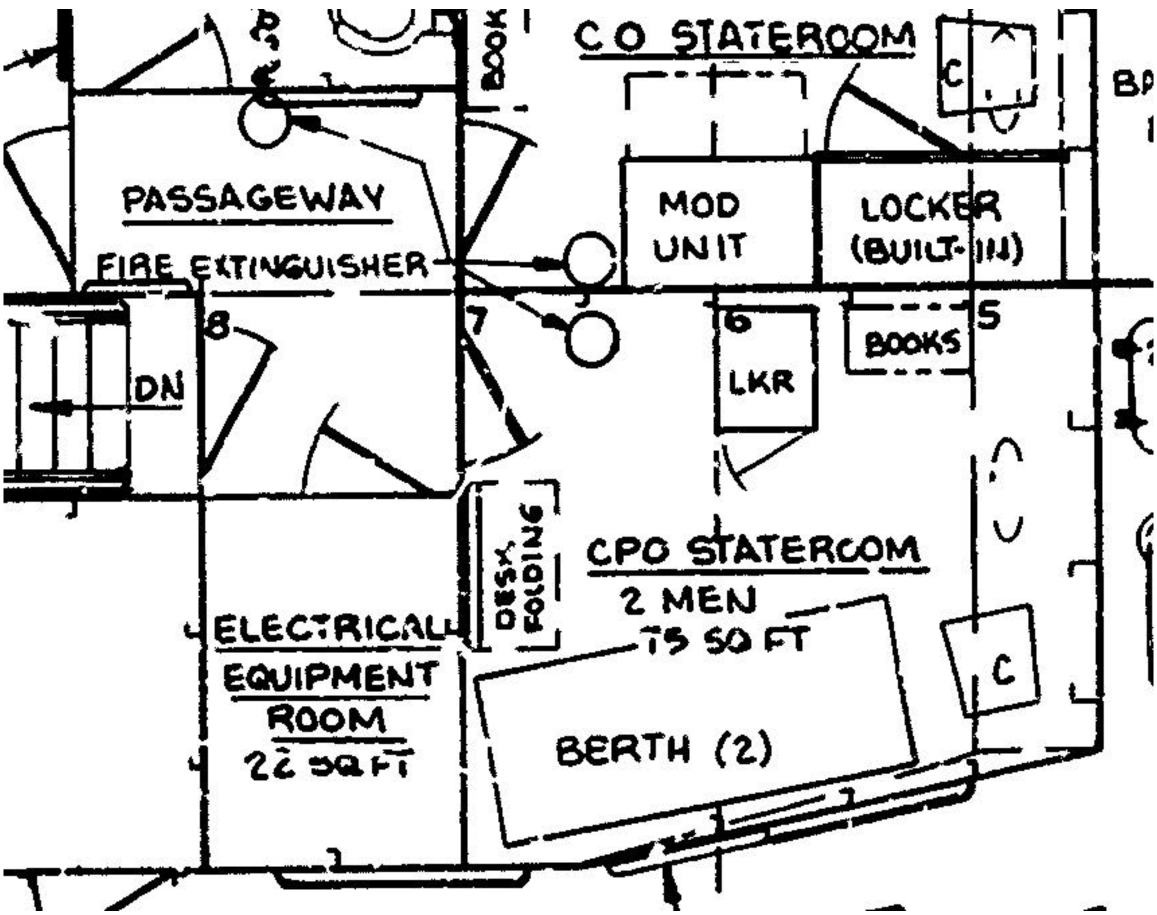

Figure A.1 — Portion of a ship for the Noise Analysis test case

Figure A.2 shows the bulkheads that enclose the CPO stateroom.

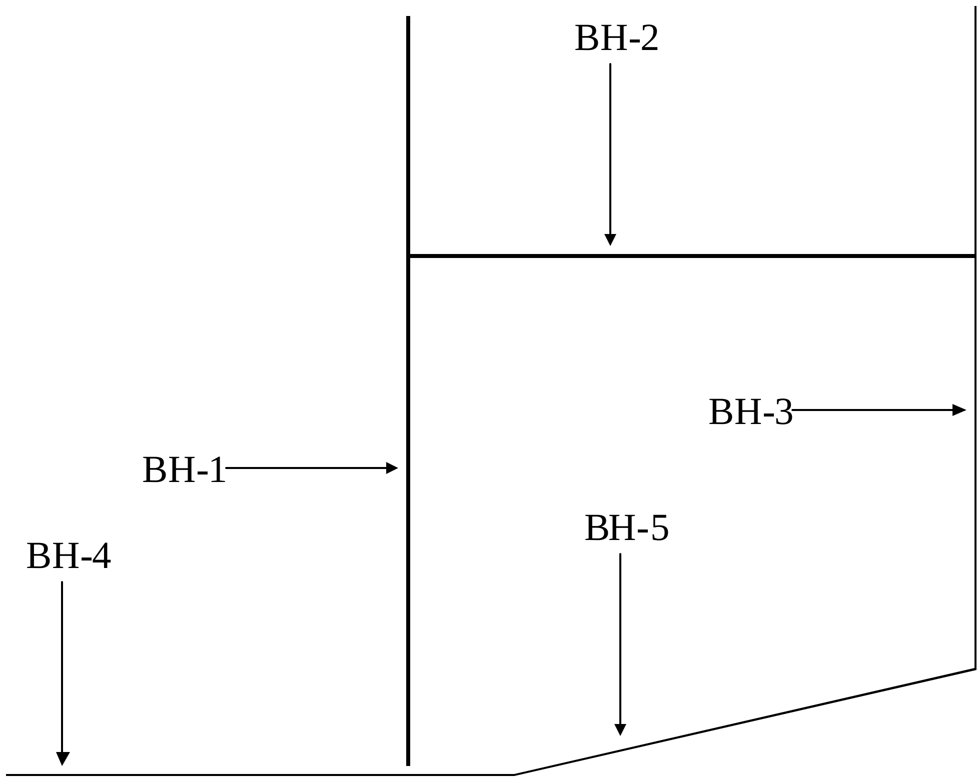

Figure A.2 — Bulkheads for the Noise Analysis test case

A.3.1.4 ARM representation

Figures A.3 to A.6 contain the instance diagrams for this test case.

The CPO stateroom is represented by an instance (@2) of the Compartment entity data type (EDT). An instance (@3) of the Compartment_design_definition EDT provides the boundaries, properties and geometric representation for the compartment. For this test case, one property is specified, the noise category, through an instance (@4) of Compartment_noise_category (see Figure A.3).

The other compartments are represented in a similar manner.

ISO 10303-215 defines the boundaries of a compartment by external reference to structural systems defined in a ISO 10303-218 data set and/or moulded forms defined in an ISO 10303-216 data set. In this test case, the boundaries of the CPO stateroom are specified as external instance references to moulded forms representing bulkheads BH-1, BH-2, BH-3 and BH-5 (see Figure A.4).

NOTE The references is based on globally unambiguous identifier, not an item id such as "BH-1."

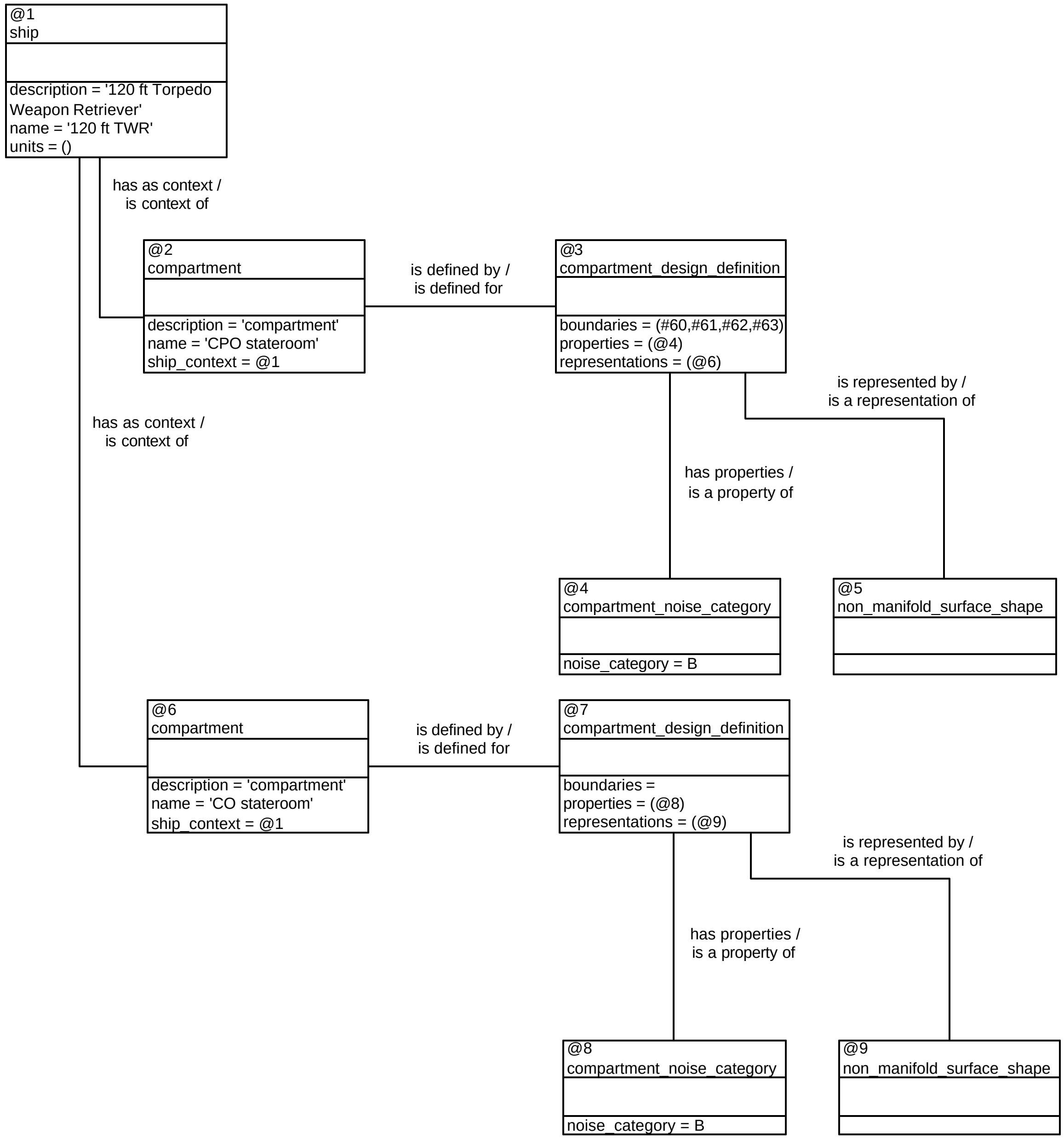

Figure A.3 — Instance diagram for the Noise Analysis test case (1 of 4)

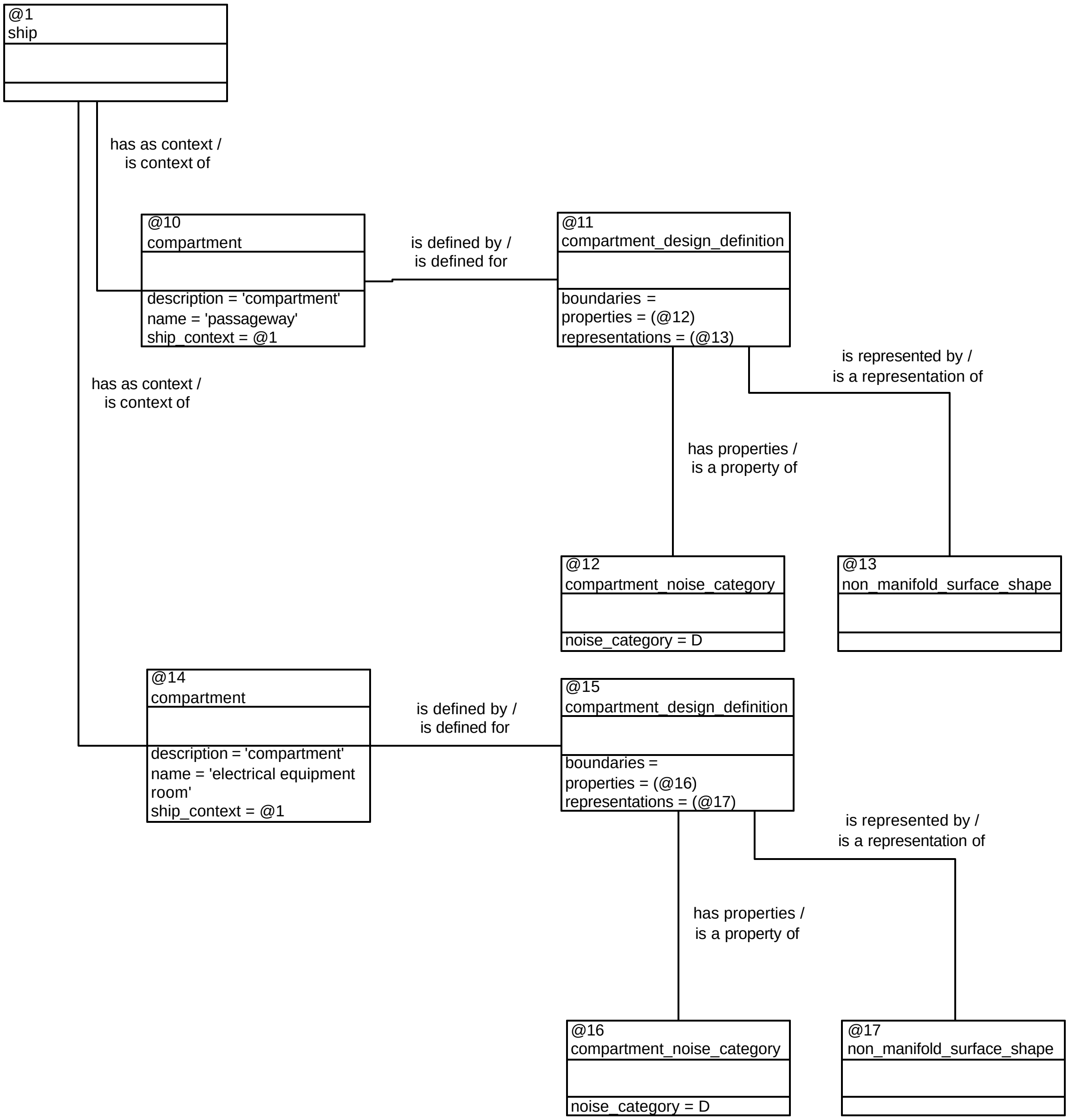

Figure A.4 — Instance diagram for the Noise Analysis test case (2 of 4)

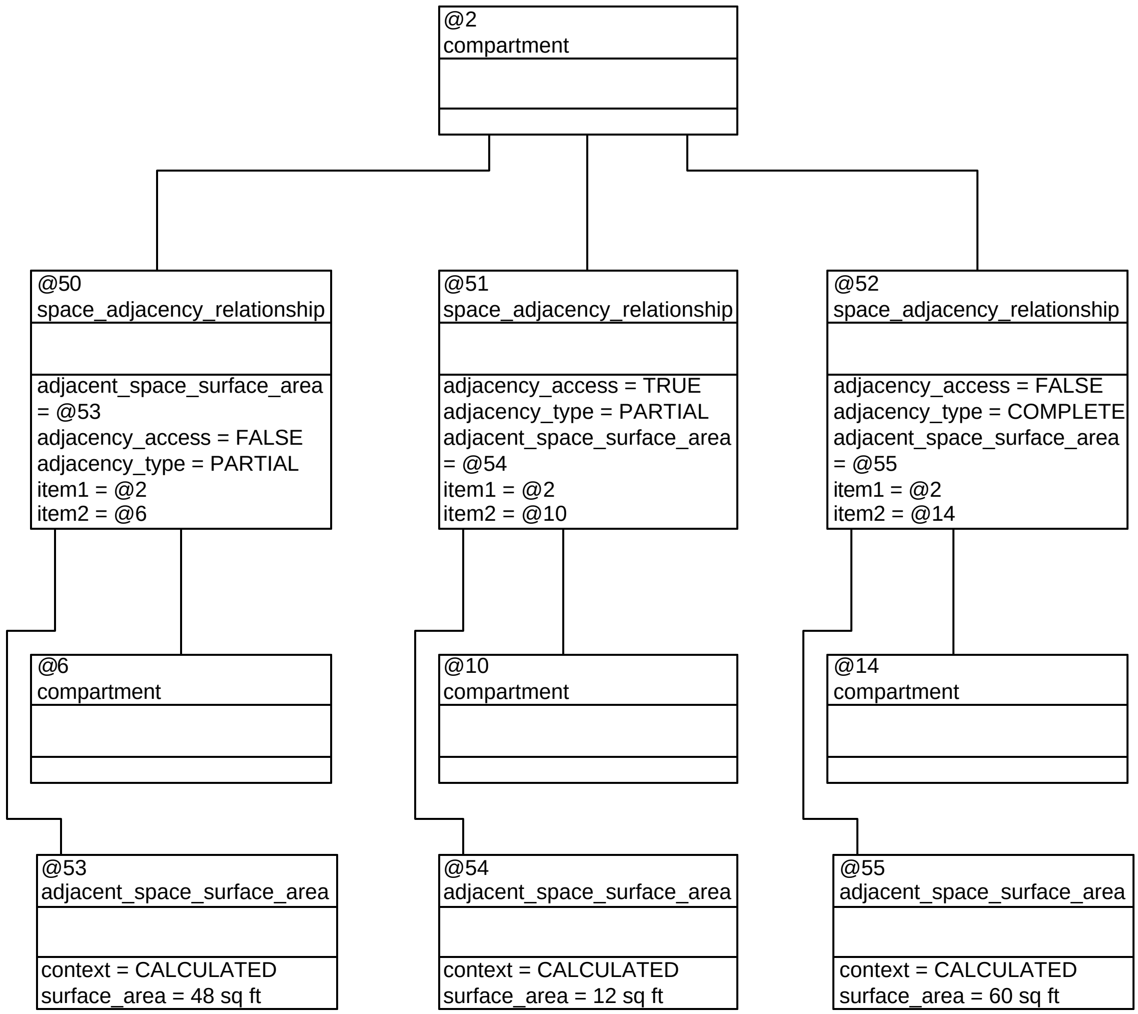

Figure A.5 — Instance diagram for the Noise Analysis test case (3 of 4)

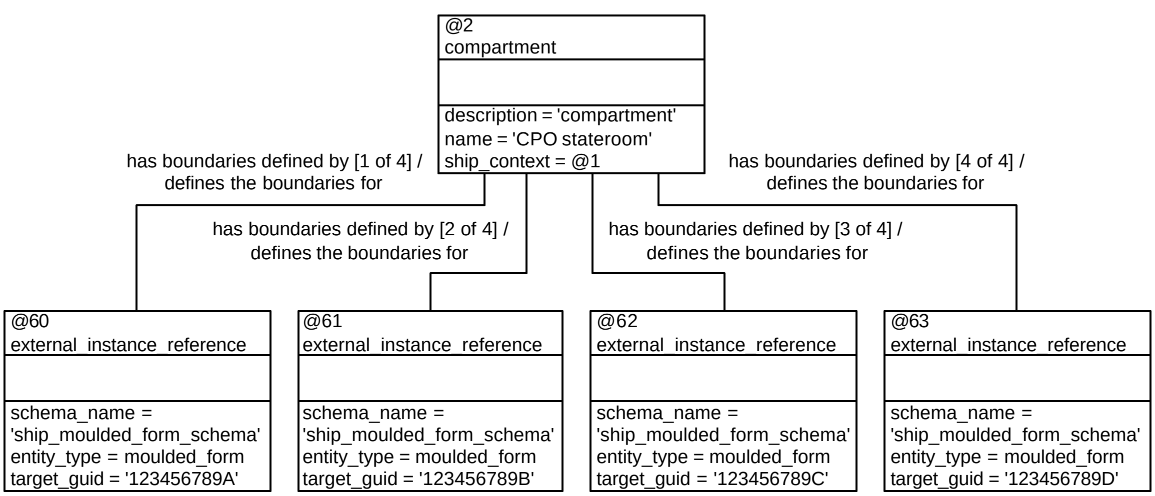

Figure A.5 — Instance diagram for the Noise Analysis test case (4 of 4)

Acronyms

CPO	Chief Petty Officer
EDT	Entity Data Type
GUID	Globally Unambiguous Identifer
HVAC	Heating, Ventilation, and Air Conditioning