BSR/ASHRAE Standard 223P

Public Review Draft

Semantic Data Model for Analytics and Automation Applications in Buildings

First Advisory Public Review (March 2024)
(Draft shows Proposed Changes to Current Standard)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

This standard is under continuous maintenance. To propose a change to the current standard, use the change submittal form available on the ASHRAE website, www.ashrae.org.

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[This foreword, the table of contents, the introduction, and the "rationales" on the following pages are not part of this standard. They are merely informative and do not contain requirements necessary for conformance to the standard.]

FOREWORD

The purpose of this document is to present a proposed standard for public review. These modifications are the result of a change proposal made pursuant to the ASHRAE continuous maintenance procedures and of deliberations within Standing Standard Project Committee 135. The proposed changes are summarized below.

223p-1 Semantic Data Model for Analytics and Automation Applications in Buildings

In the following document, all language is entirely new and plain type is used throughout. All material is open for comment.

The use of placeholders like XX, YY, ZZ, X1, X2, NN, x, n, ? etc. should not be interpreted as literal values of the final published version. These placeholders will be assigned actual numbers/letters only after final publication approval of the addendum.

223p-1 Semantic Data Model for Analytics and Automation Applications in Buildings

Semantic Data Model for Analytics and Automation Applications in Buildings

Contents

1 PURPOSE

The purpose of this standard is to define formal knowledge concepts and a methodology to apply them to create interoperable, machine-readable semantic frameworks for representing building automation and control data, and other building system information.

2 SCOPE

This standard provides a comprehensive way to apply semantic formalisms to represent the context of building system data and relationships between the associated building mechanical system components so that software applications can find and understand the information in an automated way. It is intended to facilitate the development and implementation of building analytics tools and enterprise knowledge applications that can implement many building system functions, including:

(a) automated fault detection and diagnostics,
(b) building system commissioning,
(c) digital twins,
(d) optimization of energy use, and
(e) smart grid interactions.

3 DEFINITIONS

3.1 Terms Defined for this Standard

Connectable: an abstract class that represents a thing (Equipment or DomainSpace) that can be connected via ConnectionPoints and Connections.

Connection: the modeling construct used to represent a physical thing (e.g., pipe, duct, or wire) that is used to convey some Medium (e.g., water, air, or electricity) between two Connectable things.

ConnectionPoint: an abstract modeling construct used to represent the fact that one Connectable thing can be connected to another Connectable thing using a Connection. It is the abstract representation of the flange, wire terminal, or other physical feature where a connection is made.

Domain: a categorization of building service or specialization used to characterize equipment or spaces in a building. Example domains include HVAC, lighting, and plumbing.

DomainSpace: a portion or the entirety of a PhysicalSpace that is associated with a Domain, such as lighting, HVAC, or physical security. DomainSpaces can be combined to form a Zone.

Duct: a subclass of Connection that represents a conduit through which air is conveyed.

ElectricWire: a subclass of Connection that represents one or more electrical conductors used to convey electricity.

Equipment: the modeling construct used to represent a mechanical device designed to accomplish a specific task that one might buy from a vendor. Examples include a pump, fan, heat exchanger, luminaire, temperature sensor, or flow meter. A piece of equipment can contain another piece of equipment. For example, an air handling unit can contain a cooling coil.

PhysicalSpace: an architectural concept that can represent a room, a collection of rooms such as a floor, a part of a room, or any physical space that might not even be thought of as a room, such as a patio.

Pipe: a subclass of Connection that represents a hollow cylinder of metal or other material used to convey a Medium.

System: a task-oriented collection of interacting or interrelated Equipment defined by the modeler. Examples of possible systems are an air distribution system, or a hot water system. Systems can contain other Systems.

Zone: a collection of DomainSpaces of a specific domain that are grouped together from the perspective of building services or controls.

3.2 Abbreviations and Acronyms Used in this Standard

IFC	Industry Foundation Class
RDF	Resource Description Framework
SHACL	Shapes Constraint Language
SPARQL	SPARQL Protocol and RDF Query Language
Turtle	Terse RDF Triple Language W3C Worldwide Web Consortium

4 CONCEPTUAL FRAMEWORK FOR SEMANTIC MODELING OF BUILDING SYSTEMS AND DATA

This standard defines modeling constructs for use in creating a machine-readable representation of building systems, the building spaces that they serve, and the measurement and control points used to provide a safe and comfortable environment for the building occupants. The standard can be considered a toolkit of components and rules for using them to create a semantic model of a particular building or campus of buildings. The resulting model provides a way for software applications to determine the relationships between the mechanical equipment in the building (i.e., AHU 1 gets chilled water from CH 3 and provides conditioned air to VAV Boxes 12 through 15 serving rooms on the third floor) and the meaning of measurements that are available (i.e., T16 is a temperature sensor measuring the temperature of the air stream exiting AHU 1).

The model does not directly provide telemetric data about the real-time operation or past operation of the building systems. It does provide information about the meaning or context of that data and can point to a source of the data values so that an analytics application can find them. If the building has a BACnet building automation and control system, the model can provide the necessary information for analytic software to learn which BACnet object and property corresponds to the desired piece of information.

These capabilities are achieved by applying concepts, standards, and query tools developed and deployed for information and data science applications outside the building domain. A primary commercial driver for developing these standards and tools is the Semantic Web, an extension of the World Wide Web that was created to make the semantic meaning of data accessible from the Internet machine readable.

This standard uses Resource Description Framework (RDF) (W3C) and its extended schema (RDFS) to represent the semantic ideas in the model. RDF is a general method for representing semantic ideas as of a triple. A triple consists of a subject, a predicate, and either a literal or an object. For example:

Jane hasFriend Dave

Jane hasSupervisor Mary

In this example Jane is the subject of both triples, there are two different predicates, hasFriend and hasSupervisor, and there are two different objects, Dave and Mary. The number of triples can be expanded as needed to capture the desired information. The collection of triples represents a directed multi-graph that can be searched or queried to answer questions or infer information that may not be explicit in the graph. Figure 4-1 is a graph that corresponds to this example.

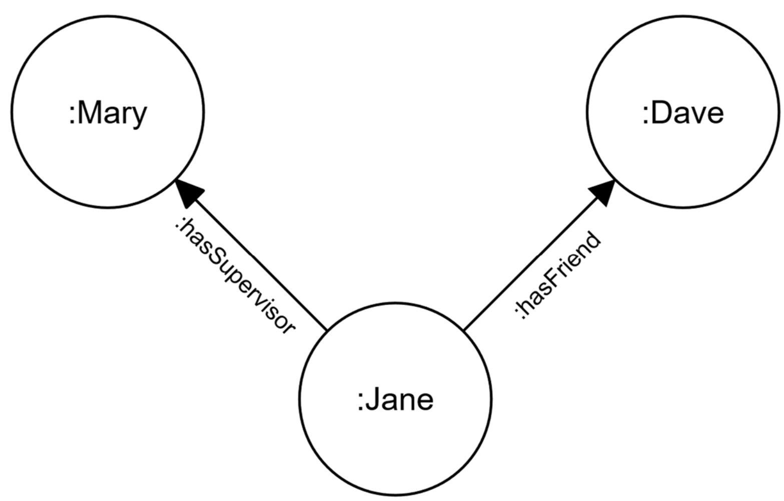

Figure 4-1. Example triple graph.

This standard defines subjects, predicates, and objects relevant to the building space that can then be used to build a multi-graph representing a specific building or group of buildings. This graph-based approach is compelling because semantic graphs can be connected to other semantic graphs. This means that a semantic graph complying with this standard can be linked to an RDF representation of a different semantic graph containing additional information about the same building that is represented in a complementary semantic model. For example, a RealEstateCore model that captures how spaces are assigned to different tenants in a building can be linked to the spaces represented in a Standard 223 model.

A model constructed from this standard describes the topology of the equipment and spaces in a building but not the geometric details. Linking a Standard 223 model with an RDF representation of a building information model can add that geometric information. In this way, other semantic modeling efforts in the building space can complement and enhance a Standard 223 model making it possible to take advantage of the combined information from these distinct domains. In a similar way, it is possible to link information from a computerized maintenance management system or an asset management system to the semantic graph of a Standard 223 model by adding a triple that binds a piece of equipment to its representation in the other system.

Another advantage of using RDF to model building systems is that a query language standard, SPARQL (W3C SPARQL), exists and tools that implement SPARQL are readily available. A building analytics tool developer needs only to create a library of queries relevant to their application, and these queries can then be used to interrogate any Standard 223 conformant model to find what they need from that building for their application.

Using RDF also provides a way to build conformance constraints into this standard in a way that enables conformance to be algorithmically verified. This is done by using a different W3C standard, Shapes Constraints Language (SHACL) (W3C SHACL). SHACL defines a way to constrain how RDF graphs can be constructed through the application of custom developed rules called shapes. The normative constraints described in this standard are formalized in SHACL shapes. The description of each concept defined in this standard includes a table that lists related conformance constraints defined by these SHACL shapes. Readily available SHACL reasoners can use the shapes defined in this standard to determine if a particular model instance conforms to the standard.

SHACL is also used in this standard to derive implicit information. The triples generated from this inference process enhance the ability to make useful queries without the burden of a modeler crafting each one. The goal is to make model development easier without sacrificing the utility application developers need to find what they are looking for. The description of each concept defined in this standard with related inference rules includes a table that lists the relevant SHACL shapes that apply the inferencing.

The Terse RDF Triple Language (W3C Turtle) defines a textual syntax to represent and exchange RDF models.

Because this standard includes references to measurements of physical properties, it is necessary to provide a model representation of units of measure as well as what those units are quantifying (e.g. temperature, power, etc.). This standard builds upon the “Quantities, Units, Dimensions and Types” (QUDT) ontology which is the leading open-source model expressed in RDF/SHACL. The QUDT model is documented at https://qudt.org. The key concepts used here are the classes qudt:Unit and qudt:QuantityKind.

The normative content of this standard is documented in an RDF model textualized using Turtle (see Clause 15). All models conforming to this standard shall be textualized using Turtle.

Because it is anticipated that models conforming to this standard will be combined with other semantic models, it is necessary to define a namespace for the concepts defined by this standard to avoid any possible ambiguities that might arise from a similar name used in the complementary model. In this standard and all conforming models, the prefix “s223:” shall be used in the name of each concept (class and property) defined by this standard, e.g., s223:Equipment.

The concepts and properties mentioned below were designed to aid in standard development using RDF and SHACL exclusively and avoiding any dependence on OWL axioms.

4.1 s223:Class

This is a modeling construct. All classes defined in the 223 standard are instances of s223:Class rather than owl:Class.

Related Constraints

Description	Link
Every class of the 223 standard must be a direct or indirect subclass of s223:Concept. Every class of the 223 standard must also be an instance of sh:NodeShape. Every class of the 223 standard must have an rdfs:comment. Ensure that any property shape must have an rdfs:comment. Ensure that any property shape must have an rdfs:comment. Every Class must have a label. Ensure that every TripleRule must have an rdfs:comment. Ensure that every SPARQLRule must have an rdfs:comment.	Link

4.2 s223:Concept

All classes defined in the 223 standard are subclasses of s223:Concept.

Related Constraints

Description	Link
A Concept must be associated with at least one label using the relation label.	Link
If the relation hasProperty is present, it must associate the concept with a Property.	Link
Ensure that all instances of a class use only the properties defined for that class.	Link

4.2.1 s223:hasProperty

The relation hasProperty associates any 223 Concept with a Property.

4.3 s223:SymmetricProperty

A SymmetricProperty is modeling construct used to define symmetric behavior for certain properties in the standard such as cnx and connected.

4.4 s223:inverseOf

The relation inverseOf is a modeling construct to associate relations that are inverses of one another, such as connectedTo and connectedFrom.

4.5 s223:abstract

If the relation abstract has a value of true, the associated class cannot be instantiated.

5 EQUIPMENT

This clause is the top level of the hierarchical structure of the portion of the model that represents the characteristics and features of physical equipment that make up the building systems being modeled. Equipment can be connected to other Equipment or DomainSpaces (See Clause 6.5).Equipment can optionally contain other pieces of equipment, providing a way to represent its constituent parts within the model (see Clause 7.1). Equipment can also be grouped together to define a System (see Clause 8).

5.1 s223:Equipment

An Equipment is the modeling construct used to represent a mechanical device designed to accomplish a specific task, or a complex device that contains component pieces of Equipment. Unlike a System, Equipment can have ConnectionPoints and participate in the flow of one or more kinds of Medium. Examples of possible equipment include a Pump, Fan, HeatExchanger, Luminaire, TemperatureSensor, FlowSensor or more complex examples such as a chilled water plant. The graphical depiction of Equipment used in this standard is a rounded cornered rectangle as show in Figure 5-1.

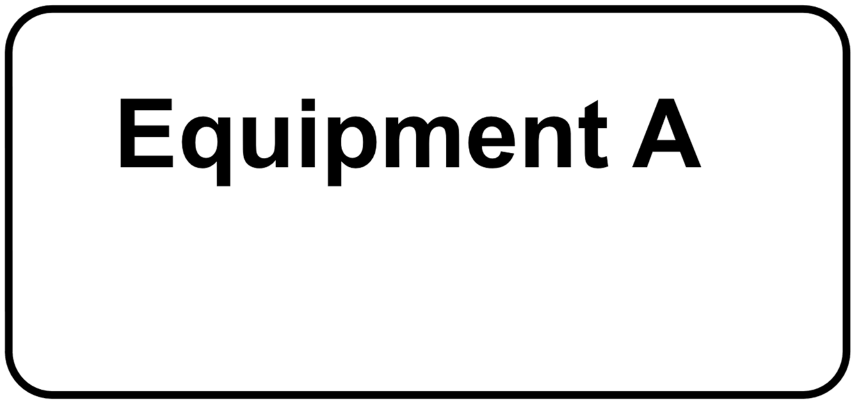

Figure 5-1. Graphical depiction of Equipment.

Related Constraints

Description	Link
Disallow contained equipment from having external outgoing connections.	Link
If the relation commandedByProperty is present it must associate the Equipment with a ActuatableProperty.	Link
Disallow contained equipment from having external incoming connections.	Link
If the relation hasPhysicalLocation is present it must associate the Equipment with a PhysicalSpace.	Link
Warning about a subClass of Equipment of type A containing something that is in the same subClass branch.	Link
If the relation contains is present it must associate the Equipment with either Equipment or Junction.	Link
If the relation executes is present it must associate the Equipment with a FunctionBlock.	Link
If the relation hasRole is present it must associate the Equipment with a EnumerationKind-Role.	Link

Related Inference Rules

Description	Link
For equipment containing another piece of equipment, use the mapsTo relation to infer a Medium from the contained equipment.	Link
For equipment contained within another piece of equipment use the mapsTo relation to infer a Medium from the containing equipment.	Link

5.2 s223:contains

The relation contains associates a PhysicalSpace or a piece of Equipment to a PhysicalSpace or another piece of Equipment, respectively.

5.3 s223:hasRole

The relation hasRole is used to indicate the role of an Equipment, Connection, ConnectionPoint, or System within a building (e.g., a heating coil will be associated with Role-Heating). Possible values are defined in EnumerationKind-Role (see Clause 11.13).

5.4 s223:hasPhysicalLocation

The relation hasPhysicalLocation is used to indicate the PhysicalSpace (see Clause 9.2.1) where a piece of Equipment (see Clause 5.1) is located.

5.5 Measuring equipment

This clause is the top level of the hierarchical structure of the model portion that represents the characteristics of a piece of equipment that measures something.

5.5.1 Abstract Sensor

This is an abstract class that represents properties that are common to all sensor types.

Related Constraints

Description	Link
If the relation hasMeasurementResolution is present it must associate the AbstractSensor with a QuantifiableProperty.	Link
An AbstractSensor must be associated with exactly one ObservableProperty using the relation observes.	Link

5.5.1.1 s223:hasMeasurementResolution

The hasMeasurementResolution relation is used to link to a numerical property whose value indicates the smallest recognizable change in engineering units that the sensor can indicate.

5.5.1.2 s223:observes

The relation observes binds a sensor to one ObservableProperty `see s223:ObservableProperty` which is used by the sensor to generate a measurement value (ex. a temperature) or a simple observation of a stimulus causing a reaction (a current binary switch that closes a dry contact when a fan is powered on).

5.5.1.3 s223:hasObservationLocation

The relation hasObservationLocation associates a sensor to the topological location where it is observing the property (see Clause 5.5.1.2). The observation location can be a Connectable (see Clause 6.1), Connection (see Clause 6.3), or ConnectionPoint (see ?).

5.5.2 s223:Sensor

A Sensor observes an ObservableProperty (see Clause 12.3) which may be quantifiable (see Clause 12.7), such as a temperature, flowrate, or concentration, or Enumerable (see Clause 12.8), such as an alarm state or occupancy state.

Related Constraints

Description	Link
A Sensor must be associated with exactly 1 of Connectable, Connection, or ConnectionPoint using the relation hasObservationLocation.	Link
A Sensor must be associated with exactly 1 of QuantifiableObservableProperty or EnumeratedObservableProperty using the relation observes.	Link

Related Inference Rules

Description	Link
Infer the hasObservationLocation relation for a Sensor from the Property that it is observing, only if that property is associated with a single entity.	Link

5.5.2.1 s223:FlowSensor

A FlowSensor is a specialization of a Sensor that produces an ObservableProperty that is quantifiable and represents a flow measurement.

5.5.2.2 s223:HumiditySensor

A HumiditySensor is a specialization of a Sensor that observes a QuantifiableObservableProperty that represents a humidity measurement.

Related Inference Rules

Description	Link
A HumiditySensor must always observe a Property that has a QuantityKind of RelativeHumidity.	Link

5.5.2.3 s223:PressureSensor

A PressureSensor is a specialization of a Sensor that observes a QuantifiableObservableProperty that represents a pressure measurement.

5.5.2.4 s223:TemperatureSensor

A TemperatureSensor is a specialization of a Sensor that observes a QuantifiableObservableProperty that represents a temperature measurement.

Related Constraints

Description	Link
A TemperatureSensor must always observe a Property that has a QuantityKind of Temperature.	Link

5.5.2.5 s223:ConcentrationSensor

A ConcentrationSensor is a specialization of a Sensor that observes a QuantifiableObservableProperty that represents the concentration of a substance in a medium.

5.5.2.6 s223:LightSensor

A LightSensor is a specialization of a Sensor that observes a QuantifiableObservableProperty that represents a luminance measurement.

5.5.2.6.1 s223:CorrelatedColorTemperatureSensor

A subclass of LightSensor that observes the color of light.

Related Constraints

Description	Link
A CorrelatedColorTemperatureSensor must always observe a Property that has a QuantityKind of ThermodynamicTemperature.	Link

5.5.2.6.2 s223:DuvSensor

A subclass of LightSensor that observes the deviation of the light spectrum from pure blackbody.

Related Constraints

Description	Link
A DuvSensor must always observe a Property that has a QuantityKind of Duv.	Link

5.5.2.6.3 s223:IlluminanceSensor

A subclass of LightSensor that observes the level of illuminance.

Related Constraints

Description	Link
An IlluminanceSensor will always observe a Property that has a QuantityKind of Illuminance.	Link

5.5.2.7 s223:ParticulateSensor

A ParticulateSensor is a specialization of a Sensor that observes a QuantifiableObservableProperty that represents a particulate concentration measurement.

Related Constraints

Description	Link
If the relation ofSubstance is present it must associate the ParticulateSensor with a Substance-Particulate.	Link

5.5.2.8 s223:OccupancySensor

An OccupancySensor is a subclass of a Sensor that observes a Property that represents measurement of occupancy in a space.

5.5.2.8.1 s223:OccupantCounter

A subclass of OccupancySensor that counts the population within its sensing region.

Related Constraints

Description	Link
An OccupantCounter must always observe a QuantifiableObservableProperty that has a QuantityKind of Population and a Unit of unit:NUM.	Link

5.5.2.8.2 s223:OccupantMotionSensor

A subclass of OccupancySensor that observes motion within its sensing region.

Related Constraints

Description	Link
An OccupantMotionSensor must always observe an EnumeratedObservableProperty that has an EnumerationKind of Occupancy-Motion.	Link

5.5.2.8.3 s223:OccupantPresenceSensor

A subclass of OccupancySensor that observes presence within its sensing region.

Related Constraints

Description	Link
An OccupantPresenceSensor will always observe an EnumeratedObservableProperty that has an EnumerationKind of Occupancy-Presence.	Link

5.5.3 Differential Sensor

A sensor that measures the difference of a quantity between any two points in the system.

Related Constraints

Description	Link
A Differential Sensor must have different values for hasObservationLocationHigh and hasObservationLocationLow.	Link
A Differential Sensor must be defined in terms of the QuantityKind that is being measured.	Link
A DifferentialSensor must be associated with exactly 1 of Connectable, Connection, or ConnectionPoint using the relation hasObservationLocationHigh.	Link
A DifferentialSensor must be associated with exactly 1 of Connectable, Connection, or ConnectionPoint using the relation hasObservationLocationLow.	Link

5.5.3.1 s223:hasObservationLocationHigh

The relation hasObservationLocationHigh associates a differential sensor to one of the topological locations where a differential property is observed (see Clause 5.5.1.2).

5.5.3.2 s223:hasObservationLocationLow

The relation hasObservationLocationLow associates a differential sensor to one of the topological locations where a differential property is observed (see Clause 5.5.1.2).

5.6 Actuator

Actuators are physical entities that receive control signals and actuate equipment.

A piece of equipment, either electrically, pneumatically, or hydraulically operated, that makes a change in the physical world, such as the position of a valve or damper.

Related Constraints

Description	Link
If the relation actuates is present it must associate the Actuator with a Equipment.	Link
An Actuator must be associated with at least one ActuatableProperty using the relation commandedByProperty.	Link

5.6.1 s223:actuates

The relation actuates binds an Actuator to the Equipment that it actuates. The Equipment will have the ActuatableProperty that commands the Actuator (see Clause 5.6.2).

5.6.2 s223:commandedByProperty

The relation commandedByProperty binds an Actuator to the ActuatableProperty that it responds to. This Property will be owned by the equipment that it actuates (see Clause 5.6.1).

5.7 Controller

A device for regulation of a system or component in normal operation, which executes a FunctionBlock.

Related Constraints

Description	Link
If the relation executes is present it must associate the Controller with a FunctionBlock.	Link

Related Inference Rules

Description	Link
Infer the hasRole s223:Role-Controller relation for every instance of Controller	Link

5.7.1 s223:FunctionBlock

A FunctionBlock is used to model transfer and/or transformation of information (i.e. Property). It has relations to input Properties and output Properties. The actual algorithms that perform the transformations are described in CDL and are out of scope of the 223 standard.

Related Constraints

Description	Link
A Function block must be associated with at least one Property using the relation hasOutput.OR A Function block must be associated with at least one Property using the relation hasInput.	Link

5.7.2 Function Input

5.7.2.1 s223:hasInput

The relation hasInput is used to relate a FunctionBlock (see Clause 5.7.1) to a Property (see Clause 12.1) that is used as input.

5.7.3 Function Output

5.7.3.1 s223:hasOutput

The relation hasOutput is used to relate a FunctionBlock (see Clause 5.7.1) to a Property (see Clause 12.1) that is calculated by the FunctionBlock.

5.7.4 s223:executes

The relation executes is used to specify that a Controller (see Clause 5.7) is responsible for the execution of a FunctionBlock (see Clause 5.7.1).

6 CONNECTION

This clause is the top level of the hierarchical structure of the portion of the model that represents the characteristics and features of connections that provide a means for a medium such as air, water, or electricity, to flow from one place to another. Examples of connections are ducts, pipes, and wires.

6.1 s223:Connectable

Connectable is an abstract class representing a thing such as, Equipment (see Clause 5.1), DomainSpace (see Clause 9.1.1), or Junction (see Clause 6.4) that can be connected via ConnectionPoints and Connections.

Related Constraints

Description	Link
For a Connectable, cnx relation must associate the Connectable to a ConnectionPoint	Link
If the relation connected is present it must associate the Connectable with a Connectable.	Link
If the relation connectedThrough is present it must associate the Connectable with a Connection.	Link
If the relation cnx is present it must associate the Connectable with a ConnectionPoint.	Link
If a Connectable has s223:connected or s223:connectedTo (i.e. high-level connection specification), it must also have the supporting cnx relations (low-level connection specification).	Link
If the relation connectedFrom is present it must associate the Connectable with a Connectable.	Link
If the relation hasConnectionPoint is present it must associate the Connectable with a ConnectionPoint.	Link
If the relation connectedTo is present it must associate the Connectable with a Connectable.	Link

Related Inference Rules

Description	Link
Infer the connected relation for BiDirectional connections	Link
Infer the connected relation using connectedFrom	Link
Infer the hasConnectionPoint relation using cnx	Link
Infer the connectedFrom relations using connectsThrough and connectsFrom.	Link
Infer the connectedTo relation using connectsThrough and connectsTo.	Link
Infer the connected relation using connectedTo	Link
Infer the cnx relation using isConnectionPointOf.	Link
Infer the cnx relationship using hasConnectionPoint.	Link

Description	Link
Infer the connectedThrough relation using hasConnectionPoint and connectsThrough	Link

6.2 s223:ConnectionPoint

A ConnectionPoint is an abstract modeling construct used to represent the fact that one connectable thing can be connected to another connectable thing using a Connection. It is the abstract representation of the flange, wire terminal, or other physical feature where a connection is made. Equipment, DomainSpaces and Junctions can have one or more ConnectionPoints (see Clause 6.1).

A ConnectionPoint is constrained to relate to a specific medium such as air, water, or electricity which determines what other things can be connected to it. For example, constraining a ConnectionPoint to be for air means it cannot be used for an electrical connection.

A ConnectionPoint belongs to exactly one connectable thing (see `s222:Connectable').

ConnectionPoints are represented graphically in this standard by a triangle with the point indicating a direction of flow, or a diamond in the case of a bidirectional flow as shown in Figure 6-1.

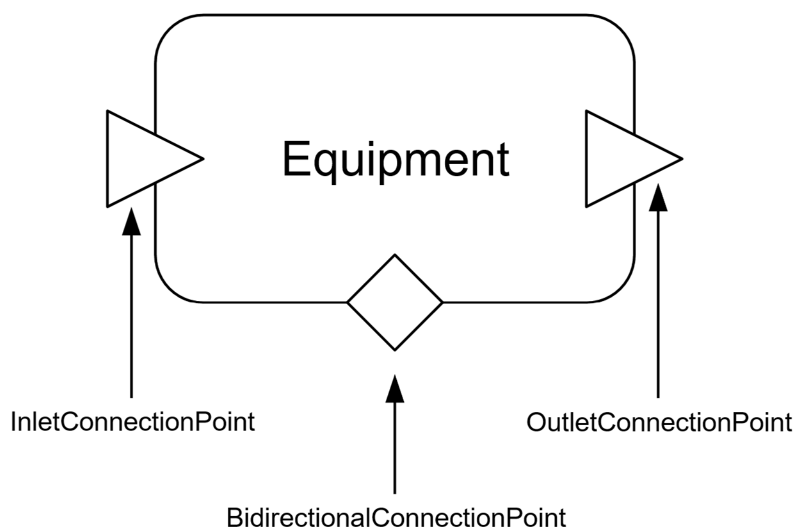

Figure 6-1. Graphical Representation of a ConnectionPoint.

Related Constraints

Description	Link
A ConnectionPoint must be associated with at most one Connection using the relation connectsThrough.	Link
If the relation hasRole is present it must associate the ConnectionPoint with an EnumerationKind-Role.	Link
A ConnectionPoint must be associated with at most one Connectable using the cnx relation.	Link
If a ConnectionPoint lacks a connectsThrough and mapsTo relation, but is associated with a Junction or Equipment that is contained by an Equipment, then suggest that the ConnectionPoint might need a mapsTo relation to a ConnectionPoint of the containing Equipment.	Link
A ConnectionPoint must be associated with at most one Connection using the cnx relation	Link
A ConnectionPoint can be associated with at most one other ConnectionPoint using the relation mapsTo	Link
If a ConnectionPoint lacks a connectsThrough and mapsTo relation, and is not associated with a Junction or Equipment that is contained by an Equipment, then suggest that the ConnectionPoint probably needs an association with a Connection.	Link
If a ConnectionPoint mapsTo another ConnectionPoint, the respective Equipment should have a contains relation.	Link
A ConnectionPoint must be associated with exactly one Substance-Medium using the relation hasMedium.	Link
A ConnectionPoint can be associated with at most one other ConnectionPoint using the inverse of relation mapsTo	Link
Ensure that the Medium identified by a ConnectionPoint via the s223:hasMedium relation is compatible with the Medium identified by the entity identified by the mapsTo+ relation.	Link
A ConnectionPoint must be associated with exactly one Connectable using the relation isConnectionPointOf.	Link
A ConnectionPoint must not have both a mapsTo and a connectsThrough relation.	Link
If the relation hasElectricalPhase is present it must associate the ConnectionPoint with an ElectricalPhaseIdentifier or ElectricalVoltagePhases.	Link

6.2.1 s223:BidirectionalConnectionPoint

A BidirectionalConnectionPoint is a predefined subclass of ConnectionPoint. Using a BidirectionalConnectionPoint implies that the flow direction is not fixed in one direction. It depends on the status of some other part of the system, such as a valve position, that is expected to change during operation (see ?) or to model energy transfer occurring without specific flow direction.

6.2.2 s223:InletConnectionPoint

An InletConnectionPoint indicates that a substance must flow into the equipment or domain space at this connection point and cannot flow the other direction. An IntletConnectionPoint is a subclass of ConnectionPoint.

Related Constraints

Description	Link
Ensure an InletConnectionPoint has a mapsTo relation to its containing Equipment if it has an external Connection	Link
If the relation mapsTo is present it must associate the InletConnectionPoint with an InletConnectionPoint.	Link

6.2.3 s223:OutletConnectionPoint

An OutletConnectionPoint indicates that a substance must flow out of a Connectable (see 's223:Connectable') at this connection point and cannot flow in the other direction. An OutletConnectionPoint is a predefined subclass of ConnectionPoint.

Related Constraints

Description	Link
Ensure an OutletConnectionPoint has a mapsTo relation to its containing Equipment if it has an external Connection	Link
If the relation mapsTo is present it must associate the OutletConnectionPoint with an OutletConnectionPoint.	Link

6.2.4 s223:mapsTo

The relation mapsTo is used to associate a ConnectionPoint of a Connectable to a corresponding ConnectionPoint of the one containing it (see Clause 7.1). The associated ConnectionPoints must have the same direction (see Clause 11.4) and compatiable medium Substance-Medium.

6.2.5 s223:hasMedium

The relation hasMedium is used to indicate what medium is flowing through the connection (e.g., air, water, electricity). The possible values are defined in EnumerationKind-Medium (see ?).

6.3 s223:Connection

A Connection is the modeling construct used to represent a physical thing (e.g., pipe, duct, or wire) that is used to convey some Medium (e.g., water, air, or electricity), or a virtual connection to convey electromagnetic radiation (e.g. light or wifi signal) between two connectable things. All Connections have two or more ConnectionPoints bound to either Equipment (see Clause 5.1), DomainSpace (see Clause 9.1.1), or Junction (see Clause 6.4) See Figure 6-2. If the direction of flow is constrained, that constraint is indicated by using one or more

InletConnectionPoints (see Clause 6.2.2) to represent the inflow points and OutletConnectionPoints (see Clause 6.2.3) to represent the outflow points.

A Connection may contain branches or intersections. These may be modeled using Junctions if it is necessary to identify a specific intersection. (see Clause 6.4).

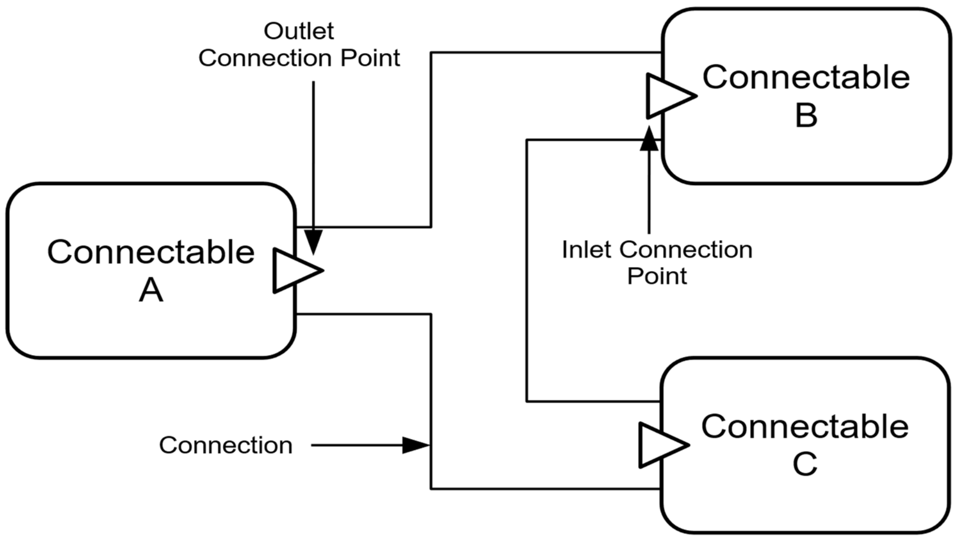

Figure 6-2. Graphical Depiction of Connection.

Related Constraints

Description	Link
Ensure that the Medium identified by all the associated ConnectionPoints via the s223:hasMedium relation are compatible with one another.	Link
A Connection must be associated with exactly one EnumerationKind-Medium using the relation hasMedium.	Link
If the relation connectsTo is present it must associate the Connection with a Connectable.	Link
Ensure that the Medium identified by a ConnectionPoint via the s223:hasMedium relation is compatible with the Medium identified by the associated Connection.	Link
If the relation connectsAt is present it must associate the Connection with a ConnectionPoint.	Link
A Connection must have two or more cnx relations to ConnectionPoints	Link
If the relation hasRole is present it must associate the Connection with an EnumerationKind-Role.	Link
A Connection must only have a cnx relation with a ConnectionPoint	Link

Description	Link
If the relation hasThermodynamicPhase is present it must associate the Connection with an EnumerationKind-Phase.	Link
If the relation connectsFrom is present it must associate the Connection with a Connectable.	Link
A Connection shall have at least two cnx relations allowing flow in and out of the Connection.	Link

Related Inference Rules

Description	Link
Infer cnx relation using connectsThrough	Link
Infer the connectsFrom relation using connectsAt	Link
Infer the connectsAt relation using cnx	Link
Infer cnx relation using connectsAt	Link
Infer the connectsTo relation using connectsAt	Link

6.3.1 s223:Pipe

A Pipe is a subclass of Connection, that represents a hollow cylinder of metal or other material used to convey a Medium.

6.3.2 s223:Duct

A Duct is a subclass of Connection, that represents a conduit through which air is conveyed.

6.3.3 s223:ElectricWire

An ElectricWire is a subclass of Connection, that represents one or more electrical conductors used to convey electricity.

Related Constraints

Description	Link
If the relation hasElectricalPhase is present it must associate the ElectricWire with an ElectricalPhaseIdentifier or ElectricalVoltagePhases.	Link
An ElectricWire must be associated with exactly one Medium-Electricity using the relation hasMedium.	Link

6.4 s223:Junction

A Junction is a modeling construct used when a branching point within a Connection (see Clause 6.3) is of significance, such as specifying the observation location of a Sensor. When a Junction is used, what might have been modeled as a single, branched Connection is separated into three or more separate Connections, all tied together with the Junction and its associated ConnectionPoints.

Related Constraints

Description	Link
A Junction must be associated with exactly one EnumerationKind-Medium using the relation hasMedium.	Link
Ensure that the Medium identified by all the associated ConnectionPoints via the s223:hasMedium relation are compatible with one another.	Link
Ensure that the Medium identified by a ConnectionPoint via the s223:hasMedium relation is compatible with the Medium identified by the associated Junction.	Link
A Junction shall have at least three ConnectionPoints including (a) at least one inlet and one outlet, or (b) at least one bidirectional connection point.	Link

6.5 Relations Describing Connectedness

The collection of relations defined for Connectable, ConnectionPoint, and Connection is intended to facilitate model queries that answer questions about how equipment is connected and to what it is connected. These relations are shown in Figure 6-3.

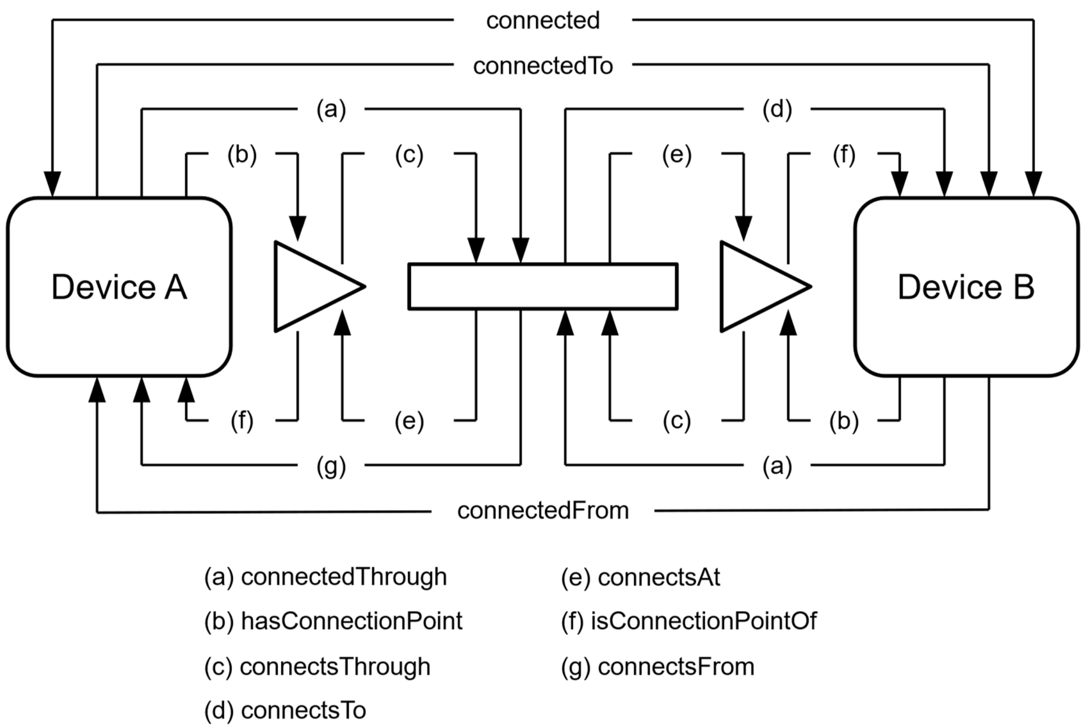

Figure 6-3. Connection Relations.

It is not necessary for a model developer to create each of these relations individually. A model can be created using a simpler construct shown in Figure 6-4 using the cnx relation. Inference rules can then be applied to generate the complete set shown in Figure 6-3. The intent is to simplify model development without losing the connectedness relationships that facilitate model queries.

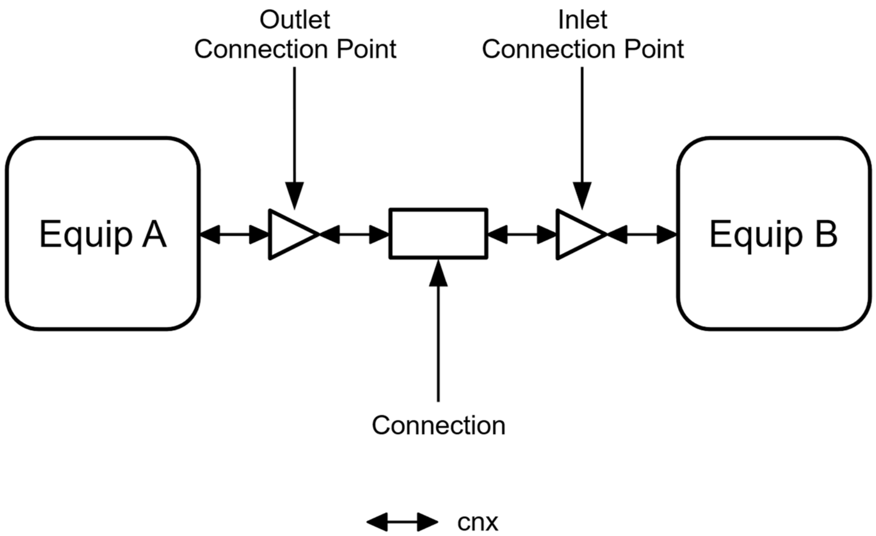

Figure 6-4. CNX Relations.

6.5.1 s223:connected

The relation connected indicates that two connectable things are connected without regard to any directionality of a process flow.

6.5.2 s223:connectedTo

The relation connectedTo indicates that connectable things are connected with a specific flow direction. A is connectedTo B, means a directionality beginning at A and ending at B. The inverse direction is indicated by connectedFrom (see Clause 6.5.3).

6.5.3 s223:connectedFrom

The relation connectedFrom means that connectable things are connected with a specific flow direction. B is connectedFrom A, means a directionality beginning at A and ending at B. The inverse direction is indicated by connectedTo (see Clause 6.5.2).

6.5.4 s223:connectedThrough

The relation connectedThrough associates a Connectable with a Connection.

6.5.5 s223:connectsAt

The connectsAt relation binds a Connection to a specific ConnectionPoint. See Figure x.y.

6.5.6 s223:connectsTo

The relation connectsTo binds a Connection to a Connectable thing to a Connection with an implied directionality. A connectsTo B indicates a flow from A to B.

6.5.7 s223:connectsThrough

The relation connectedThrough binds a Connectable thing to a Connection without regard to the direction of flow. It is used to discover what connection links two connectable things.

6.5.8 s223:connectsFrom

The relation connectsFrom binds a Connectable thing to a Connection with an implied directionality. B connectsFrom A indicates a flow from A to B.

6.5.9 s223:hasConnectionPoint

The relation hasConnectionPoint is part of a pair of relations that bind a Connectable thing to a ConnectionPoint. It is the inverse of the relation isConnectionPointOf (see Clause 6.5.10).

6.5.10 s223:isConnectionPointOf

The relation isConnectionPointOf is part of a pair of relations that bind a ConnectionPoint to a Connectable thing. It is the inverse of the relation hasConnectionPoint (see Clause 6.5.9).

6.6 s223:hasMedium

The relation hasMedium is used to indicate what medium is flowing through the connection (e.g., air, water, electricity). The possible values are defined in EnumerationKind-Medium (see 11.16.1).

7 GROUPING

This clause is the top level of the hierarchical structure of the portion of the model that represents the general concept that some modeling elements can be grouped together using several different concepts. This standard describes these concepts and constrains their use.

7.1 Equipment Containment

A piece of equipment can only contain other pieces of equipment. For example, a fan can be contained by an air handling unit. The relation contains is used to describe a piece of equipment containing another piece of equipment (see relevant clause). The relationship mapsTo relates a ConnectionPoint of a contained equipment to the ConnectionPoint of a containing equipment (see Clause 6.2.4). For example, the inlet to a heating coil contained in a fan coil unit may map to the inlet of the fan coil unit. Any air connection to the fan coil unit inlet is supplying air to the inlet of the heating coil as well. Multiple pieces of equipment contained by the same piece of equipment may connect to each other, however, they may not connect to equipment that are not also contained. To indicate how a contained piece of equipment connects to an external piece of equipment, the relationship mapsTo is used. MapsTo will relate the connection point of a contained equipment to the connection point of the containing equipment, then the connection point of the containing equipment may connect to the external equipment.

7.2 System Membership

A system can group other pieces of equipment and sub-systems together using the relation hasMember (see Clause 8.2).

7.3 Physical Space Containment

A physical space (see Clause 9.2.1) can contain other physical spaces. This containment relationship is used to represent collections of rooms that make up a floor in a building, a building that contains a collection of rooms or floors, a campus that contains a collection of buildings or some other nested grouping of physical spaces. Physical spaces may also enclose domain spaces (see Clause 9.1.1). Enclosement indicates that the domain space is completely within a physical space. A physical space may enclose one or more domain spaces. For example, an auditorium may have several different lighting domain spaces with independently controlled lights.

7.4 Domain Space Containment

Physical spaces may enclose domain spaces, indicating their physical location and borders. Zones may also group domain spaces together using the relationship hasDomainSpace (see Clause 10.2). This grouping is from the perspective of building controls rather than physical location.

7.5 Zone Containment

ZoneGroups are collections of zones. ZonesGroups may relate to Zones using the relation hasZone (see Clause 7.5.2).

7.5.1 s223:ZoneGroup

A ZoneGroup is a logical grouping (collection) of Zones for some functional or system reason, to identify a domain of control, such as a Lighting Zone, or a heating zone.

Related Constraints

Description	Link
A ZoneGroup must be associated with exactly one EnumerationKind-Domain using the relation hasDomain.	Link
A ZoneGroup must be associated with at least one Zone using the relation hasZone.	Link

Related Inference Rules

Description	Link
Infer a hasDomain relation by checking any enclosed Zones to determine the domain.	Link

7.5.2 s223:hasZone

The relation hasZone is used to associate a ZoneGroup with the Zones that make up that ZoneGroup.

8 SYSTEM

A System is a task-oriented collection of interacting or interrelated Equipment defined by the modeler. Examples of possible systems are an air distribution system, or a hot water system. Systems can be associated with other Systems using the relation hasMember (see Clause 7.2) A System may be associated with an EnumerationKind-Role (see Clause 5.3).

8.1 s223:System

A System is a logical grouping (collection) of Equipment for some functional or system reason, such as a chilled water system, or HVAC system. A System does not participate in Connections.

Related Constraints

Description	Link
If the relation hasRole is present, it must associate the System with an EnumerationKind-Role.	Link
A System can be associated with at least two instances of Equipment or System using the relation hasMember	Link

8.2 s223:hasMember

The relation hasMember associates a System with its component Equipment and/or Systems.

9 SPACE

There are two types of spaces. Physical spaces represent the architectural constructs in a building like rooms, auditoriums, corridors, etc. Physical spaces enclose (see Clause 9.2.3) domain spaces. Domain spaces represent portions of a physical space that pertain to different building services. A physical space may represent a kitchen, but the lighting domain space it encloses describes the lighting area within the kitchen.

9.1 Domain Space

A DomainSpace is a subclass of Connectable (see Clause 6.1) and represents atomic subdivision (or component) of a Zone and is associated with a domain such as Lighting, HVAC, etc. (see Clause 11.5). DomainSpaces can be viewed as the endpoints of building services. A lighting domain space may be a part of an auditorium that receives light from a group of luminaires. An occupancy space may be a building area that is measured by occupancy sensors (see Clause 5.5.2.8). An HVAC domain space may be part of an office or room that receives air from a VAV (see ?). An HVAC domain space may also be a significant waypoint in an air distribution system, like a plenum. Domain spaces generally have properties that pertain to control of the systems serving them (e.g., a lighting domain space may have an occupancy property for when the space is occupied).

9.1.1 s223:DomainSpace

A DomainSpace is a member (or component) of a Zone and is associated with a Domain such as Lighting, HVAC, PhysicalSecurity, etc. Physical spaces enclose Domain spaces.

Related Constraints

Description	Link
A DomainSpace must be enclosed by a PhysicalSpace.	Link
A DomainSpace must be associated with exactly one EnumerationKind-Domain using the relation hasDomain.	Link

Related Inference Rules

Description	Link
Infer a hasDomain relation by checking any enclosing Zone to determine the domain.	Link

9.1.2 s223:hasDomain

The relation hasDomain is used to indicate what domain a Zone or DomainSpace pertains to (e.g. HVAC, lighting, electrical, etc.). Possible values are defined in EnumerationKind-Domain (see Clause 11.5).

9.2 Physical Space

A portion of an enclosure that is distinct from other physical spaces.

9.2.1 s223:PhysicalSpace

A PhysicalSpace is an architectural concept representing a room, a collection of rooms such as a floor, a part of a room, or any physical space that might not even be thought of as a room, such as a patio space or a roof.

Related Constraints

Description	Link
If the relation contains is present it must associate the PhysicalSpace with a PhysicalSpace.	Link
If the relation encloses is present it must associate the PhysicalSpace with a DomainSpace.	Link

9.2.2 s223:contains

The relation contains associates a PhysicalSpace or a piece of Equipment to a PhysicalSpace or another piece of Equipment, respectively.

9.2.3 s223:encloses

The relation encloses is used to indicate that a domain space (see: Clause 9.1.1) can be found inside a physical space (see Clause 9.2.1).

10 ZONE

Zones are collections of domain spaces of a specific domain grouped together from the perspective of building services or controls. Zones can be collected together into groups (see Clause 7.5).

10.1 s223:Zone

A Zone is a logical grouping (collection) of domain spaces for some functional or system reason, to identify a domain of control, such as a Lighting Zone, or a heating zone

Related Constraints

Description	Link
A Zone must be associated with exactly one EnumerationKind-Domain using the relation hasDomain.	Link
A Zone must be associated with at least one DomainSpace using the relation hasDomainSpace.	Link
The associated Domain of a Zone and the Domain of the DomainSpaces it contains must be the same.	Link

Related Inference Rules

Description	Link
Infer a hasDomain relation by checking any enclosed DomainSpaces to determine the domain.	Link
Infer a hasDomain relation by checking any enclosing ZoneGroup to determine the domain.	Link

10.2 s223:hasDomainSpace

The relation hasDomainSpace is used to associate a Zone with the DomainSpace(s) that make up that Zone.

11 ENUMERATIONS

Enumerations are sets of closed values (they cannot take on values outside of what is explicitly listed in the definition) and named (each value has a unique name). The values within an enumeration share a “kind,” which communicates how the enumerations are intended to be used.

The standard uses enumerations to convey groups of useful values for describing attributes of Properties, Equipment, and other things in the model.

11.1 s223:EnumerationKind

This is the encapsulating class for all EnumerationKinds. EnumerationKinds define the (closed) set of permissible values for a given purpose. For example, the DayOfWeek EnumerationKind enumerates the days of the week and allows no other values.

EnumerationKinds are arranged in a tree hierarchy, with the root class named EnumerationKind. Each subclass is named starting with its immediate superclass, followed by a hyphen and a name that is unique among the sibling superclasses. Certain validation constraints exist in the standard that evaluate compatibility of EnumerationKinds. Two values are deemed compatible if they are the same or if one is a direct ancestor (or descendant) of the other.

Related Constraints

Description	Link
An EnumerationKind must not use the generalized hasProperty relation. Some EnumerationKinds have specifically-defined relations to Property.	Link

11.2 s223:EnumerationKind-Aspect

This class has enumerated subclasses usually used to specify the context of a s223:Property. The following table lists all of the defined enumerations for Aspect. Some Aspect enumerations have subclasses for more specific use. Those subclasses are not shown in the table but each of them are defined in Clause 11.2.1 - Clause 11.2.4. The following table lists all of the defined enumerations for Aspect.

Aspect Enumerations

Enumeration
Aspect-Alarm
Aspect-CatalogNumber
Aspect-Command
Aspect-DayOfWeek
Aspect-Deadband
Aspect-Delta
Aspect-DryBulb
Aspect-Effectiveness
Aspect-Efficiency

Enumeration
Aspect-ElectricalPhaseIdentifier
Aspect-ElectricalVoltagePhases
Aspect-Face
Aspect-Fault
Aspect-HighLimit
Aspect-Latent
Aspect-Loss
Aspect-LowLimit
Aspect-Manufacturer
Aspect-Maximum
Aspect-Minimum
Aspect-Model
Aspect-Nominal
Aspect-NominalFrequency
Aspect-PhaseAngle
Aspect-PowerFactor
Aspect-Rated
Aspect-Sensible
Aspect-SerialNumber
Aspect-ServiceFactor
Aspect-Setpoint
Aspect-StandardConditions
Aspect-Standby
Aspect-StartupValue
Aspect-Threshold
Aspect-Total
Aspect-WetBulb
Aspect-Year

11.2.1 s223:Aspect-DayOfWeek

This class has enumerated subclasses of Monday, Tuesday, Wednesday, Thursday, Friday, Saturday and Sunday. The Weekend and Weekday EnumerationKinds define subsets of this EnumerationKind for Mon-Fri and Sat,Sun, respectively

11.2.1.1 s223:DayOfWeek-Weekday

This class defines the EnumerationKind values of Monday, Tuesday, Wednesday, Thursday, and Friday

Weekday Enumerations

Enumeration
Weekday-Friday
Weekday-Monday
Weekday-Thursday
Weekday-Tuesday
Weekday-Wednesday

11.2.1.2 s223:DayOfWeek-Weekend

This class defines the EnumerationKind values of Saturday and Sunday

Weekend Enumerations

Enumeration
Weekend-Saturday
Weekend-Sunday

11.2.2 s223:Aspect-Effectiveness

This class enumerates the possible states of effectiveness

Effectiveness Enumerations

Enumeration
Effectiveness-Active

11.2.3 s223:Aspect-ElectricalPhaseIdentifier

The value of the associated Property identifies the electrical phase of the Connection.

Electrical Phase Identifier Enumerations

Enumeration
ElectricalPhaseIdentifier-A
ElectricalPhaseIdentifier-AB
ElectricalPhaseIdentifier-ABC
ElectricalPhaseIdentifier-B
ElectricalPhaseIdentifier-BC
ElectricalPhaseIdentifier-C
ElectricalPhaseIdentifier-CA

11.2.3.1 s223:hasElectricalPhase

The relation hasElectricalPhase is used to indicate the electrical phase identifier or the relevant electrical phases for a voltage difference for AC electricity inside a Connection.

11.2.4 s223:Aspect-ElectricalVoltagePhases

This class enumerates the relevant electrical phases for a voltage difference for AC electricity inside a Connection.

Electrical Voltage Phases Enumerations

Enumeration
ElectricalVoltagePhases-ABLineLineVoltage
ElectricalVoltagePhases-ANLineNeutralVoltage
ElectricalVoltagePhases-BCLineLineVoltage
ElectricalVoltagePhases-BNLineNeutralVoltage
ElectricalVoltagePhases-CALineLineVoltage
ElectricalVoltagePhases-CNLineNeutralVoltage

11.3 s223:EnumerationKind-Binary

This class has enumerated subclasses of True, False and Unknown used to describe the possible values of a binary property.

Binary Enumerations

Enumeration
Binary-False
Binary-True
Binary-Unknown

11.4 s223:EnumerationKind-Direction

This class has enumerated subclasses of Bidirectional, Inlet and Outlet used to qualify ConnectionPoints.

Direction Enumerations

Enumeration
Direction-Bidirectional
Direction-Inlet
Direction-Outlet

11.5 s223:EnumerationKind-Domain

A Domain represents a categorization of building services or specialization used to characterize equipment or spaces in a building. Example domains include HVAC, Lighting, and Plumbing.

Domain Enumerations

Enumeration
Domain-ConveyanceSystems
Domain-Electrical
Domain-Fire
Domain-HVAC
Domain-Lighting
Domain-Networking
Domain-Occupancy
Domain-PhysicalSecurity
Domain-Plumbing
Domain-Refrigeration

11.6 s223:EnumerationKind-HVACOperatingMode

HVACOperatingMode has enumerated subclasses of the policy under which the HVAC system or equipment is operating.

HVAC Operating Mode Enumerations

Enumeration
HVACOperatingMode-Auto
HVACOperatingMode-CoolOnly
HVACOperatingMode-FanOnly
HVACOperatingMode-HeatOnly
HVACOperatingMode-Off

.

11.7 s223:EnumerationKind-HVACOperatingStatus

HVACOperatingStatus has enumerated subclasses of the HVAC system/equipment operating status.

HVAC Operating Status Enumerations

Enumeration
HVACOperatingStatus-Cooling
HVACOperatingStatus-Dehumidifying
HVACOperatingStatus-Heating
HVACOperatingStatus-Off
HVACOperatingStatus-Ventilating

11.8 s223:EnumerationKind-Numerical

Numerical enumeration kinds are used to support the definitions of the Electricity medium. The enumerations instances in these classes have names that are recognizable by humans but are just a string for a computer application. To avoid the need to parse strings, each of these enumeration kinds have properties associated with the enumeration that represent electrical phase, voltage, and frequency. The purpose of these properties is to enable a machine to query them and obtain the same information that a person would associate with the sting

11.8.1 s223:Numerical-DCVoltage

This class has enumerated instances of common positive and negative voltages, plus zero volts.

DC Voltage Enumerations

Enumeration
DCVoltage-DCNegativeVoltage
DCVoltage-DCPositiveVoltage
DCVoltage-DCZeroVoltage

Related Constraints

Description	Link
A DC-Voltage must have a voltage	Link

11.8.1.1 s223:DCVoltage-DCNegativeVoltage

This class has enumerated instances of common negative voltages.

DC Negative Voltage Enumerations

Enumeration
DCNegativeVoltage-12.0V
DCNegativeVoltage-190.0V
DCNegativeVoltage-2.5V
DCNegativeVoltage-24.0V
DCNegativeVoltage-3.0V
DCNegativeVoltage-380.0V
DCNegativeVoltage-48.0V
DCNegativeVoltage-5.0V
DCNegativeVoltage-6.0V

11.8.1.2 s223:DCVoltage-DCPositiveVoltage

This class has enumerated instances of common positive voltages.

DC Positive Voltage Enumerations

Enumeration
DCPositiveVoltage-12.0V
DCPositiveVoltage-190.0V
DCPositiveVoltage-2.5V
DCPositiveVoltage-24.0V
DCPositiveVoltage-3.0V
DCPositiveVoltage-380.0V
DCPositiveVoltage-48.0V
DCPositiveVoltage-5.0V
DCPositiveVoltage-6.0V

11.8.2 s223:Numerical-Frequency

This class has enumerated instances of common electrical frequencies.

Frequency Enumerations

Enumeration
Frequency-50Hz
Frequency-60Hz

Related Constraints

Description	Link
A Numerical-Frequency must have a Quantity Kind of Frequency	Link
A Numerical-Frequency must have a unit of Hertz	Link

11.8.3 s223:Numerical-LineLineVoltage

This class has enumerated instances of common line-line voltages.

Line-Line Voltage Enumerations

Enumeration
LineLineVoltage-10000V
LineLineVoltage-190V
LineLineVoltage-208V
LineLineVoltage-220V
LineLineVoltage-240V
LineLineVoltage-3000V
LineLineVoltage-3300V
LineLineVoltage-380V

Enumeration
LineLineVoltage-400V
LineLineVoltage-415V
LineLineVoltage-4160V
LineLineVoltage-480V
LineLineVoltage-6000V
LineLineVoltage-600V
LineLineVoltage-6600V

Related Constraints

Description	Link
An AC-Numerical-LineLineVoltage must have a voltage	Link

11.8.4 s223:Numerical-LineNeutralVoltage

This class has enumerated instances of common line-neutral voltages.

Line Neutral Voltage Enumerations

Enumeration
LineNeutralVoltage-110V
LineNeutralVoltage-120V
LineNeutralVoltage-127V
LineNeutralVoltage-139V
LineNeutralVoltage-1730V
LineNeutralVoltage-1900V
LineNeutralVoltage-208V
LineNeutralVoltage-219V
LineNeutralVoltage-231V
LineNeutralVoltage-2400V
LineNeutralVoltage-240V
LineNeutralVoltage-24V
LineNeutralVoltage-277V
LineNeutralVoltage-3460V
LineNeutralVoltage-347V
LineNeutralVoltage-3810V
LineNeutralVoltage-5770V

Related Constraints

Description	Link
An AC-Numerical-LineNeutralVoltage must have a voltage	Link

11.8.5 s223:Numerical-NumberOfElectricalPhases

This class has enumerated instances of number of electrical phases. The s223:hasNumberOfElectricalPhases relation points to one of the values of this enumeration.

Number Of Electrical Phases Enumerations

Enumeration
NumberOfElectricalPhases-SinglePhase
NumberOfElectricalPhases-ThreePhase

11.8.6 s223:Numerical-Voltage

This class has enumerated instances of common voltages.

Voltage Enumerations

Enumeration
Voltage-0V
Voltage-10000V
Voltage-110V
Voltage-120V
Voltage-127V
Voltage-12V
Voltage-139V
Voltage-1730V
Voltage-1900V
Voltage-190V
Voltage-208V
Voltage-219V
Voltage-220V
Voltage-231V
Voltage-2400V
Voltage-240V
Voltage-24V
Voltage-277V
Voltage-2V

Enumeration
Voltage-3000V
Voltage-3300V
Voltage-3460V
Voltage-347V
Voltage-380V
Voltage-3810V
Voltage-3V
Voltage-400V
Voltage-415V
Voltage-4160V
Voltage-480V
Voltage-48V
Voltage-5770V
Voltage-5V
Voltage-6000V
Voltage-600V
Voltage-6600V
Voltage-6V

Related Constraints

Description	Link
A Numerical-Voltage must have a unit of Volts	Link
A Numerical-Voltage must have a Quantity Kind of Voltage	Link

11.8.7 s223:hasFrequency

The relation hasFrequency is used to identify the frequency of an AC electricity enumeration kind.

11.8.8 s223:hasVoltage

The relation hasVoltage is used to identify the voltage of an electricity enumeration kind.

11.9 s223:EnumerationKind-Occupancy

This class has enumerated subclasses of occupancy status, i.e. the state of being used or occupied. Some Occupancy enumerations have subclasses for more specific use.

11.9.1 s223:Occupancy-Motion

This class has enumerated subclasses indicating whether motion is detected or not.

Motion Enumerations

Enumeration
Motion-False
Motion-True

11.9.2 s223:Occupancy-Presence

This class has enumerated subclasses indicating whether physical presence is detected or not.

Presence Enumerations

Enumeration
Presence-False
Presence-True

11.10 s223:EnumerationKind-OnOff

This class has enumerated subclasses of states of either on or off.

On Off Enumerations

Enumeration
OnOff-Off
OnOff-On
OnOff-Unknown

11.11 s223:EnumerationKind-Phase

This class has enumerated subclasses of thermodynamic phase, i.e. states of matter.

11.11.1 s223:Phase-Gas

This class has enumerated subclasses of gas in various thermodynamic states.

Gas Enumerations

Enumeration
Gas-SuperHeated

11.11.2 s223:Phase-Liquid

This class has enumerated subclasses of liquid in various thermodynamic states.

Liquid Enumerations

Enumeration
Liquid-SubCooled

11.11.3 s223:Phase-Solid

Phase-Solid

11.11.4 s223:Phase-Vapor

Phase-Vapor

11.11.5 s223:hasThermodynamicPhase

The relation hasThermodynamicPhase is used to indicate the thermodynamic phase of the Medium inside a Connection.

11.12 s223:EnumerationKind-Position

This class has enumerated subclasses of position such as closed or open.

Position Enumerations

Enumeration
Position-Closed
Position-Open
Position-Unknown

11.13 s223:EnumerationKind-Role

This class has enumerated subclasses of roles played by entities, such as cooling, generator, relief, return.

Role Enumerations

Enumeration
Role-Condenser
Role-Controller
Role-Cooling
Role-Discharge
Role-Economizer
Role-Evaporator
Role-Exhaust
Role-Expansion
Role-Generator
Role-HeatRecovery
Role-Heating
Role-Load
Role-Primary
Role-Recirculating

Enumeration
Role-Relief
Role-Return
Role-Secondary
Role-Supply

11.14 s223:EnumerationKind-RunStatus

This class is a more general form of EnumerationKind-OnOff, allowing for additional status values beyond on or off.

Run Status Enumerations

Enumeration
RunStatus-Off
RunStatus-On
RunStatus-Unknown

11.15 s223:EnumerationKind-Speed

This class has enumerated subclasses of speed settings of High, Medium, Low (plus Off).

Speed Enumerations

Enumeration
Speed-High
Speed-Low
Speed-Medium
Speed-Off

11.16 s223:EnumerationKind-Substance

This class has enumerated subclasses of the substances that are consumed, produced, transported, sensed, controlled or otherwise interacted with (e.g. water, air, etc.).

Related Constraints

Description	Link
A substance may only have atomic constituents, it may not have a constituent that also has constituents.	Link
If the relation hasConstituent is present, it must associate an EnumerationKind-Substance with one or more Properties that identify and characterize those constituents.	Link

11.16.1 s223:Substance-Medium

This class has enumerated subclasses of a physical substance or anything that allows for the transfer of energy or information.

11.16.1.1 s223:Medium-Air

This class has enumerated subclasses of Air in various states.

11.16.1.2 s223:Medium-EM

This class has enumerated subclasses of electromagnetic energy at any frequency range.

11.16.1.2.1 s223:EM-Light

The EM-Light class has enumerated subclasses of what are considered visible or near-visible light.

Light Enumerations

Enumeration
Light-Infrared
Light-Ultraviolet
Light-Visible

11.16.1.3 s223:Medium-Electricity

This class has enumerated subclasses of all forms of electricity, including AC and DC.

11.16.1.3.1 s223:Electricity-AC

This class has enumerated instances of all AC forms of electricity.

AC Enumerations

Enumeration
AC-10000VLL-1Ph-60Hz
AC-10000VLL-3Ph-60Hz
AC-10000VLL-5770VLN-1Ph-60Hz
AC-10000VLL-5770VLN-3Ph-60Hz
AC-110VLN-1Ph-50Hz
AC-120VLN-1Ph-60Hz
AC-127VLN-1Ph-50Hz
AC-139VLN-1Ph-50Hz
AC-1730VLN-1Ph-60Hz
AC-1900VLN-1Ph-60Hz
AC-190VLL-110VLN-1Ph-50Hz

Enumeration
AC-190VLL-110VLN-3Ph-50Hz
AC-190VLL-1Ph-50Hz
AC-190VLL-3Ph-50Hz
AC-208VLL-120VLN-1Ph-60Hz
AC-208VLL-120VLN-3Ph-60Hz
AC-208VLL-1Ph-60Hz
AC-208VLL-3Ph-60Hz
AC-219VLN-1Ph-60Hz
AC-220VLL-127VLN-1Ph-50Hz
AC-220VLL-127VLN-3Ph-50Hz
AC-220VLL-1Ph-50Hz
AC-220VLL-3Ph-50Hz
AC-231VLN-1Ph-50Hz
AC-2400VLN-1Ph-60Hz
AC-240VLL-120VLN-1Ph-60Hz
AC-240VLL-139VLN-1Ph-50Hz
AC-240VLL-139VLN-3Ph-50Hz
AC-240VLL-1Ph-50Hz
AC-240VLL-1Ph-60Hz
AC-240VLL-208VLN-120VLN-1Ph-60Hz
AC-240VLL-208VLN-120VLN-3Ph-60Hz
AC-240VLL-3Ph-50Hz
AC-240VLL-3Ph-60Hz
AC-240VLN-1Ph-50Hz
AC-24VLN-1Ph-50Hz
AC-24VLN-1Ph-60Hz
AC-277VLN-1Ph-60Hz
AC-3000VLL-1730VLN-1Ph-60Hz
AC-3000VLL-1730VLN-3Ph-60Hz
AC-3000VLL-1Ph-60Hz
AC-3000VLL-3Ph-60Hz
AC-3300VLL-1900VLN-1Ph-60Hz
AC-3300VLL-1900VLN-3Ph-60Hz
AC-3300VLL-1Ph-60Hz
AC-3300VLL-3Ph-60Hz
AC-3460VLN-1Ph-60Hz

Enumeration
AC-347VLN-1Ph-60Hz
AC-380VLL-1Ph-60Hz
AC-380VLL-219VLN-1Ph-60Hz
AC-380VLL-219VLN-3Ph-60Hz
AC-380VLL-3Ph-60Hz
AC-3810VLN-1Ph-60Hz
AC-400VLL-1Ph-50Hz
AC-400VLL-231VLN-1Ph-50Hz
AC-400VLL-231VLN-3Ph-50Hz
AC-400VLL-3Ph-50Hz
AC-415VLL-1Ph-50Hz
AC-415VLL-240VLN-1Ph-50Hz
AC-415VLL-240VLN-3Ph-50Hz
AC-415VLL-3Ph-50Hz
AC-4160VLL-1Ph-60Hz
AC-4160VLL-2400VLN-1Ph-60Hz
AC-4160VLL-2400VLN-3Ph-60Hz
AC-4160VLL-3Ph-60Hz
AC-480VLL-1Ph-60Hz
AC-480VLL-277VLN-1Ph-60Hz
AC-480VLL-277VLN-3Ph-60Hz
AC-480VLL-3Ph-60Hz
AC-5770VLN-1Ph-60Hz
AC-6000VLL-1Ph-60Hz
AC-6000VLL-3460VLN-1Ph-60Hz
AC-6000VLL-3460VLN-3Ph-60Hz
AC-6000VLL-3Ph-60Hz
AC-600VLL-1Ph-60Hz
AC-600VLL-347VLN-1Ph-60Hz
AC-600VLL-347VLN-3Ph-60Hz
AC-600VLL-3Ph-60Hz
AC-6600VLL-1Ph-60Hz
AC-6600VLL-3810VLN-1Ph-60Hz
AC-6600VLL-3810VLN-3Ph-60Hz
AC-6600VLL-3Ph-60Hz

Related Constraints

Description	Link
An electricity AC medium must have a number of electrical phases.	Link
An electricity AC medium must have a frequency	Link
An electricity AC medium must have a voltage.	Link

11.16.1.3.1.1 s223:hasNumberOfElectricalPhases

The relation hasNumberOfElectricalPhases is used to identify the number of electrical phases in an AC electricity enumeration kind.

11.16.1.3.1.2 1-Phase 3-Wire (LLN) Delta 240V L-L

This is an example Delta 240 V transformer.

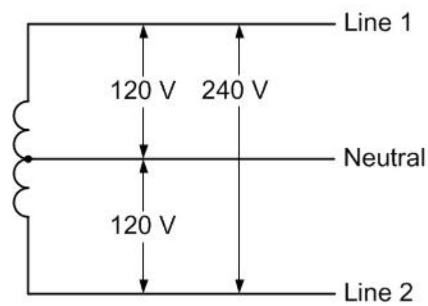

Figure 11-1. 1-Phase 3-Wire (LLN) Delta 240V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-240VLL-120VLN-3PH-60Hz	3	240	120	US	AN, BN, AB, ABN
AC-240VLL-1PH-60Hz	2	240	-	US	AB
AC-120VLN-1PH-60Hz	2	-	120	US	AN, BN

11.16.1.3.1.3 3-Phase 3-Wire (LLL) Delta 480V L-L

This is an example Delta 480 V transformer.

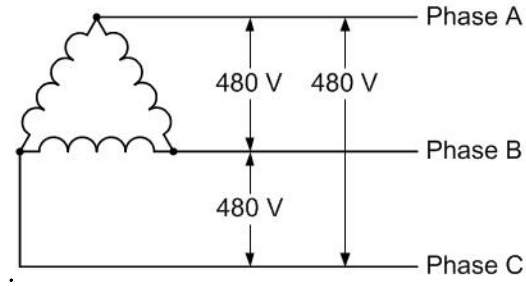

Figure 11-2. 3-Phase 3-Wire (LLL) Delta 480V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-480VLL-3PH-60Hz	3	480	-	US	ABC, AB, BC, AC
AC-480VLL-1PH-60Hz	2	480	-	US	AB, BC, AC

11.16.1.3.1.4 3-Phase 3-Wire (LLL) Delta 600V L-L

This is an example Delta 600 V transformer.

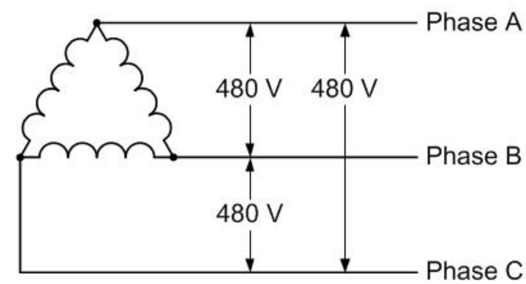

Figure 11-3. 3-Phase 3-Wire (LLL) Delta 600V L-LTransformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-600VLL-3PH-60Hz	3	600	-	US	ABC, AB, BC, AC
AC-600VLL-1PH-60Hz	2	600	-	US	AB, BC, AC

11.16.1.3.1.5 3-Phase 4-Wire (LLLN) Delta 240V L-L

This is an example 3-Phase 4-Wire Delta 240 V transformer.

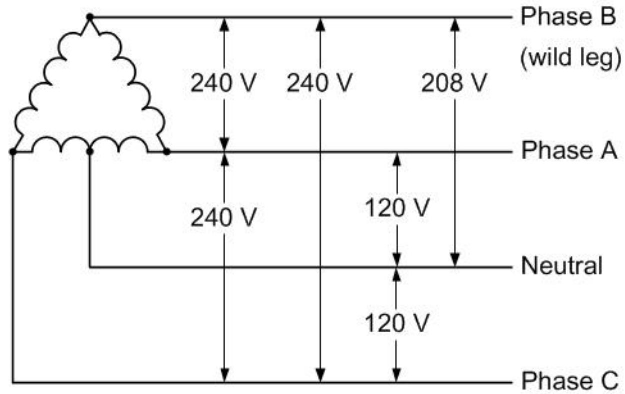

Figure 11-4. 3-Phase 4-Wire Delta 240V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-240VLL-208VLN-120VLN-3PH-60Hz	4	240	208, 120	US	AN, BN, CN, AB, BC, AC, ABN, BCN, ACN, ABC, ABCN
AC-240VLL-3PH-60Hz	3	240	-	US	ABC
AC-240VLL-120VLN-1PH-60Hz	3	240	120	US	ABN, BCN, AN, BN
AC-240VLL-1PH-60Hz	2	240	-	US	AB, BC, AC
AC-120VLN-1PH-60Hz	2	-	120	US	AN, BN

11.16.1.3.1.6 3-Phase 4-Wire (LLLN) Delta 480V L-L

This is an example 3-Phase 4-Wire Delta 480 V transformer.

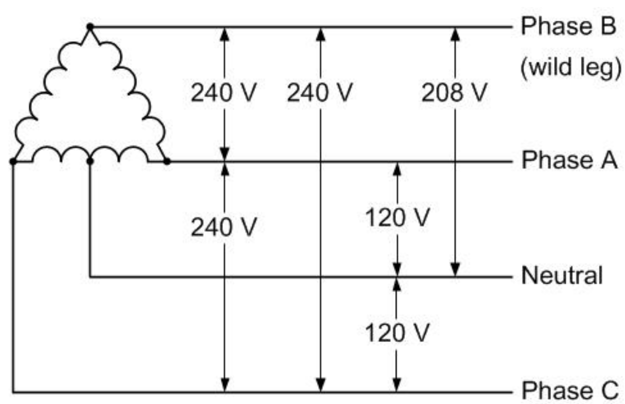

Figure 11-5. 3-Phase 4-Wire Delta 480V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-480VLL-415VLN-240VLN-3PH-60Hz	4	480	415, 240	US	AN, BN, CN, AB, BC, AC, ABN, BCN, ACN, ABC, ABCN
AC-480VLL-3PH-60Hz	3	480	-	US	ABC
AC-480VLL-240VLN-1PH-60Hz	3	480	240	US	ABN, BCN, AN, BN
AC-480VLL-1PH-60Hz	2	480	-	US	AB, BC, AC
AC-240VLN-1PH-60Hz	2	-	240	US	AN, BN

11.16.1.3.1.7 3-Phase 4-Wire (LLLN) Wye 208V L-L

This is an example 3-Phase 4-Wire Wye 208 V transformer.

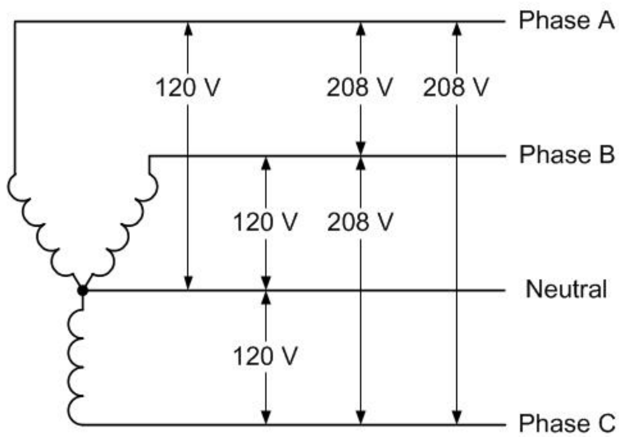

Figure 11-6. 3-Phase 4-Wire (LLLN) Wye 208V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-208VLL-120VLN-3PH-60Hz	4	208	120	US	AN, BN, CN, AB, BC, AC, ABN, BCN, ACN, ABC, ABCN
AC-208VLL-3PH-60Hz	3	208	-	US	ABC
AC-208VLL-120VLN-1PH-60Hz	3	208	120	US	ABN, BCN, ACN
AC-208VLL-1PH-60Hz	2	208	-	US	AB, BC, AC
AC-120VLN-1PH-60Hz	2	-	120	US	AN, BN, CN

11.16.1.3.1.8 2-Phase 4-Wire (LLLN) Wye 415V L-L

This is an example 2-Phase 4-Wire Wye 415 V transformer.

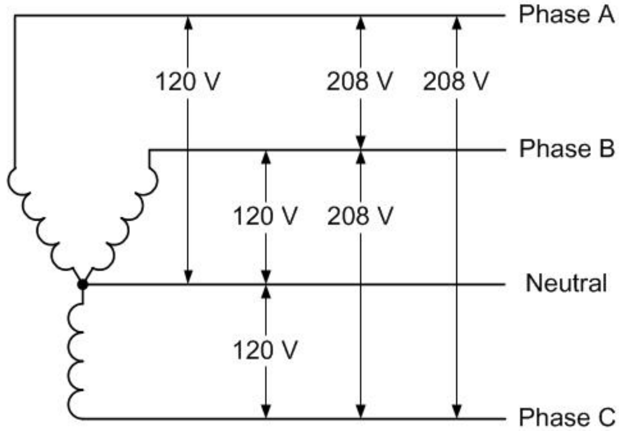

Figure 11-7. Phase 4-Wire (LLLN) Wye 415V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-415VLL-240VLN-3PH-60Hz	4	415	240	ASTL	AN, BN, CN, AB, BC, AC, ABN, BCN, ACN, ABC, ABCN
AC-415VLL-3PH-60Hz	3	415	-	ASTL	ABC
AC-415VLL-240VLN-1PH-60Hz	3	415	240	ASTL	ABN, BCN, ACN
AC-415VLL-1PH-60Hz	2	415	-	ASTL	AB, BC, AC
AC-240VLN-1PH-60Hz	2	-	240	ASTL	AN, BN, CN

11.16.1.3.1.9 2-Phase 4-Wire (LLLN) Wye 480V L-L

This is an example 2-Phase 4-Wire Wye 480 V transformer.

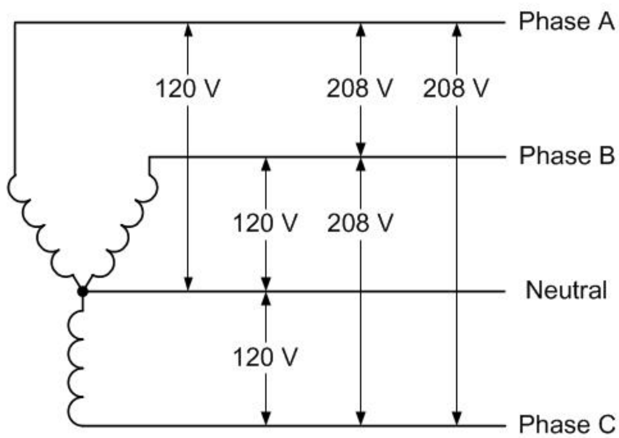

Figure 11-8. 2-Phase 4-Wire (LLLN) Wye 480V L-L Transformer.

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-480VLL-277VLN-3PH-60Hz	4	480	27	US	AN, BN, CN, AB, BC, AC, ABN, BCN, ACN, ABC, ABCN
AC-480VLL-3PH-60Hz	3	480	-	US	ABC
AC-480VLL-277VLN-1PH-60Hz	3	480	277	US	ABN, BCN, ACN
AC-480VLL-1PH-60Hz	2	480	-	US	AB, BC, AC
AC-277VLN-1PH-60Hz	2	-	277	US	AN, BN, CN

11.16.1.3.2 s223:Electricity-DC

This class has enumerated instances of all DC forms of electricity.

Related Constraints

Description	Link
An electricity DC medium must have two reference voltages.	Link

11.16.1.3.2.1 s223:DC-12V

This class has enumerated instances of all polarities of 12 V electricity.

DC-12V Enumerations

Enumeration
12V-12V-Neg
12V-12V-Pos
12V-6V-Neg-6V-Pos

11.16.1.3.2.2 s223:DC-24V

This class has enumerated instances of all polarities of 24 V electricity.

DC-24V Enumerations

Enumeration
24V-12V-Neg-12V-Pos
24V-24V-Neg
24V-24V-Pos

11.16.1.3.2.3 s223:DC-380V

This class has enumerated instances of all polarities of 380 V electricity.

DC-380V Enumerations

Enumeration
380V-190V-Neg-190V-Pos
380V-380V-Neg
380V-380V-Pos

11.16.1.3.2.4 s223:DC-48V

This class has enumerated instances of all polarities of 48 V electricity.

DC-48V Enumerations

Enumeration
48V-24V-Neg-24V-Pos
48V-48V-Neg
48V-48V-Pos

11.16.1.3.2.5 s223:DC-5V

This class has enumerated instances of all polarities of 5 V electricity.

DC-5V Enumerations

Enumeration
5V-2.5V-Neg-2.5V-Pos
5V-5V-Neg
5V-5V-Pos

11.16.1.3.2.6 s223:DC-6V

This class has enumerated instances of all polarities of 6 V electricity.

DC-6V Enumerations

Enumeration
6V-3V-Neg-3V-Pos
6V-6V-Neg
6V-6V-Pos

11.16.1.3.3 s223:Electricity-Signal

This class has enumerated subclasses of common communication protocols.

11.16.1.3.3.1 s223:Signal-Modulated

This class has enumerated subclasses of electric signals at various voltage ranges.

Modulated Enumerations

Enumeration
Modulated-0-10V
Modulated-4-20mA

11.16.1.4 s223:Medium-NaturalGas

This class has enumerated subclasses of natural gas in various states.

11.16.1.5 s223:Medium-Refrigerant

This class has enumerated subclasses of commonly used refrigerants.

Refrigerant Enumerations

Enumeration
Refrigerant-R-22
Refrigerant-R-410A

11.16.1.6 s223:Medium-Water

This class has enumerated subclasses of water and aqueous solutions in various states.

11.16.1.6.1 s223:Water-GlycolSolution

This class has enumerated subclasses of water-glycol solutions in various concentrations.

Glycol Solution Enumerations

Enumeration
GlycolSolution-15Percent
GlycolSolution-30Percent

Related Constraints

Description	Link
There must be at least two QuantifiableProperties that characterize the constituents of a Water-GlycolSolution.	Link
One of the constituents of a Water-GlycolSolution must be Medium-Water.	Link
One of the constituents of a Water-GlycolSolution must be Medium-Glycol.	Link

11.16.2 s223:Substance-Particulate

This class has enumerated subclasses of particulates in various size ranges.

Particulate Enumerations

Enumeration
Particulate-PM1.0
Particulate-PM10.0
Particulate-PM2.5

12 PROPERTIES AND VALUES

Things have properties, and properties have values.

12.1 s223:Property

An attribute, quality, or characteristic of a feature of interest.

The Property class is the parent of all variations of a property, which are: ActuatableProperty - parent of subclass of properties that can be modified by user or machine outside of the model (typically command); ObservableProperty - parent of subclass of properties that can not be modified by user or machine outside of the model (typically measures); EnumerableProperty - parent of subclass of properties defined by EnumerationKind; QuantifiableProperty - parent of subclass of properties defined by numerical values.

And their different associations : QuantifiableActuatableProperty, QuantifiableObservableProperty, EnumeratedObservableProperty, EnumeratedActuatableProperty.

A QuantifiableProperty (or subClass thereof) must always be associated with a Unit and a QuantityKind, either explicitly from the Property, or through the associated Value. If the Unit is defined, the SHACL reasoner (if invoked) will figure out and assert the QuantityKind (the most general version).

Enumerable properties must be associated with an EnumerationKind.

Related Constraints

Description	Link
A Property can be associated with at most one EnumerationKind-Medium using the relation ofMedium.	Link
Name/Label:None Path:ofSubstance	Link
A Property can use at most one relation hasValue if it is required to provide a static value in the model. It is not meant for real-time value (see Clause 12.18).	Link
If the relation hasExternalReference is present it must associate the Property with an ExternalReference.	Link
If the relation hasAspect is present, it must associate the Property with an EnumerationKind.	Link
A Property can be associated with at most one FunctionBlock using the inverse relation hasOutput.	Link
A Property can be associated with at most one EnumerationKind-Substance using the relation ofSubstance.	Link

12.2 s223:ActuatableProperty

This class describes non-numeric properties of which real-time value can be modified by a user or a machine outside of the model.

12.3 s223:ObservableProperty

This class describes non-numeric properties of which real-time value cannot be modified by a user or a machine outside of the model. Sensor readings are typically observable properties as their values naturally fluctuate, but are not meant to be modified by a user.

12.4 s223:EnumerableProperty

An EnumerableProperty is a property with an enumerated (fixed) set of possible values.

Related Constraints

Description	Link
Checks for valid enumeration value consistent with the stated EnumerationKind.	Link
An EnumerableProperty must be associated with exactly one EnumerationKind using the relation hasEnumerationKind.	Link

12.4.1 s223:hasEnumerationKind

The relation hasEnumerationKind associates an EnumerableProperty with a class of enumeration values. This is used to, for example, identify what kind of substance is transported along a Connection or which day of the week a setpoint is active.

12.5 s223:QuantifiableProperty

This class is for quantifiable values that describe an object (System, Equipment, etc.) that are typically static (hasValue). That is, they are neither measured nor specified in the course of operations.

Related Constraints

Description	Link
This QuantifiableProperty uses a different Unit than the Setpoint associated with it.	Link
A QuantifiableProperty must be associated with at least one QuantityKind using the relation hasQuantityKind.	Link
A QuantifiableProperty can be associated with a decimal value using the relation hasValue.	Link
A QuantifiableProperty must be associated with at least one Unit using the relation hasUnit.	Link
This QuantifiableProperty and the associated Setpoint use non-commensurate Units.	Link
This QuantifiableProperty and the Setpoint associated with it have non-commensurate QuantityKinds.	Link

Related Inference Rules

Description	Link
Infer the hasQuantityKind relation if it is unambiguous.	Link

12.6 s223:QuantifiableActuatableProperty

This class is for quantifiable properties of which numerical values are specified to be modifiable by a user or a machine outside of the model, like a setpoint.

12.7 s223:QuantifiableObservableProperty

This class is for quantifiable properties of which numerical values cannot be modified by a user or a machine outside of the model, but only observed, like a temperature reading or a voltage measure.

12.8 s223:EnumeratedObservableProperty

An EnumeratedObservableProperty is a property with an enumerated (fixed) set of possible values that cannot be changed (can only be observed).

12.9 s223:EnumeratedActuatableProperty

An EnumeratedActuatableProperty is a property with an enumerated (fixed) set of possible values that can be changed (actuated).

12.10 s223:ExternalReference

ExternalReference is an abstract class that represents a thing that contains API or protocol parameter values necessary to associate a property with a value.

12.10.1 s223:BACnetExternalReference

BACnetExternalReference is a subclass of ExternalReference that contains BACnet protocol parameter values necessary to associate a property with a value.

Related Constraints

Description	Link
If the relation property-identifier is present it is either a decimal number or exactly equal to the ASHRAE 135-2020 Clause 21 identifier text of BACnetPropertyIdentifier. If it is omitted, it defaults to “present-value” except for BACnet File objects, where absence of property-identifier refers to the entire content of the file accessed with Stream Access.	Link
If the relation object-identifier is present it associates the external reference with the BACnet object having the specific object identifier.	Link
If the relation object-name is present it associates the external reference with the BACnet object having the specific object name.	Link
If the relation priority-for-writing is present it provides the priority for writing values to the object.	Link
If the relation property-array-index is present it provides the index for reading items from a property that is an array.	Link
If the relation device-name is present it associates the external reference with a BACnet device having the specific device name.	Link
If the relation device-identifier is present it associates the external reference with a BACnet device having the specific device identifier.	Link

12.10.1.1 bacnet:device-name

The name of the BACnet device being referenced, more formally the Object_Name property of the device object within the BACnet device. See ASHRAE 135-2020 Clause 12.11.2.

12.10.1.2 bacnet:device-identifier

The Object_Identifier property of the device object within the BACnet device. See ASHRAE 135-2020 Clause 12.11.1.

12.10.1.3 bacnet:object-name

The Object_Name property of the object being referenced. For example, for the object name of an Analog Value Object, see ASHRAE 135-2020 Clause 12.4.2.

12.10.1.4 bacnet:object-identifier

The Object_Identifier property of the object being referenced. For example, for the object identifier of an Analog Value Object, see ASHRAE 135-2020 Clause 12.4.1.

12.10.1.5 bacnet:property-identifier

The Object_Identifier property of the object being referenced. For example, for the object identifier of an Analog Value Object, see ASHRAE 135-2020 Clause 12.4.1.

12.10.1.6 bacnet:property-array-index

If the property identified is of datatype array, this optional property of type Unsigned shall indicate the array index of the element of the property referenced by the ReadProperty service or the Read Access Specification of the ReadPropertyMultiple service. If the bacnet:property-array-index is omitted, this shall mean that the entire array shall be referenced. See ASHRAE 135-2020 Clause 15.5.1.1.3 and Clause 15.7.1.1.1.

12.10.1.7 bacnet:priority-for-writing

This parameter shall be an integer in the range 1..16, which indicates the priority assigned to the WriteProperty service. If an attempt is made to write to a commandable property without specifying the bacnet:priority-for-writing, a default priority of 16 (the lowest priority) shall be assumed. If an attempt is made to write to a property that is not commandable with a specified priority, the priority shall be ignored. See ASHRAE 135-2020 Clause 15.9.1.1.5.

12.11 s223:hasValue

hasValue is used to contain a fixed value that is part of a 223 model, rather than a computed, measured, or externally derived variable.

12.12 qudt:hasUnit

A reference to the unit of measure of a QuantifiableProperty of interest.

12.13 qudt:hasQuantityKind

A reference to the QuantityKind of a QuantifiableProperty of interest,
e.g. quantitykind:Temperature.

12.14 s223:hasAspect

hasAspect is used to establish the context of a Property. The value must be an instance of EnumerationKind. For example, if a Property has a Temperature value of 45.3, the hasAspect relation is used to state what that represents, such as a Temperature limit during working hours, etc. A Property can have any number of hasAspect relations, as needed to establish the context.

12.15 s223:ofSubstance

The relation ofSubstance is used to associate a Property with a specific Substance.

12.16 s223:ofMedium

The relation ofMedium is used to associate a Property with a specific Medium.

12.17 s223:hasConstituent

The relation hasConstituent is used to indicate what substances constitute a material. The possible values are defined in EnumerationKind-Substance (see Clause 11.16).

12.18 s223:hasExternalReference

The relation hasExternalReference is used to relate a Property to an external telemetry source.

13 DEVELOPING BUILDING SPECIFIC SEMANTIC MODELS

This is a high level discussion of connecting things together, along with details of connecting things together.

14 REFERENCE FOR EQUIPMENT AND SYSTEMS

This clause contains component model templates for commonly found equipment in building.

14.1 s223:AirHandlingUnit

An assembly consisting of sections containing a fan or fans and other necessary equipment to perform one or more of the following functions: circulating, filtration, heating, cooling, heat recovery, humidifying, dehumidifying, and mixing of air. It is usually connected to an air-distribution system.

Related Constraints

Description	Link
An AirHandlingUnit shall have at least one inlet using the medium Air.	Link
An AirHandlingUnit shall have at least one outlet using the medium Air.	Link

14.2 s223:Battery

A container consisting of one or more cells, in which chemical energy is converted into electricity and used as a source of power.

Related Constraints

Description	Link
A Battery shall have at least one outlet or bidirectional ConnectionPoint using the medium Electricity.	Link

14.3 s223:Boiler

A closed, pressure vessel that uses fuel or electricity for heating water or other fluids to supply steam or hot water for heating, humidification, or other applications.

Related Constraints

Description	Link
A Boiler shall have at least one outlet using the medium Water.	Link
A Boiler shall have at least one inlet using the medium Water.	Link

14.4 s223:ChilledBeam

A structure with a colder surface temperature where air passes through, and air movement is induced in the room to achieve cooling. Cooling medium is generally water.

Related Constraints

Description	Link
A ChilledBeam shall have at least one outlet using the medium Water.	Link
A ChilledBeam must be associated with the Role-Cooling using the relation hasRole	Link
A ChilledBeam shall have at least one inlet using the medium Water.	Link

14.5 s223:Chiller

A refrigerating machine used to transfer heat from fluids.

Related Constraints

Description	Link
A Chiller shall have at least one outlet using the medium Water.	Link
A Chiller shall have at least one inlet using the medium Water.	Link

14.6 s223:Compressor

A device for mechanically increasing the pressure of a gas.

Related Constraints

Description	Link
A Compressor shall have at least one outlet.	Link
A Compressor shall have at least one inlet.	Link

14.7 s223:CoolingTower

A heat transfer device in which atmospheric air cools warm water, generally by direct contact via evaporation.

Related Constraints

Description	Link
A CoolingTower shall have at least one inlet using the medium Water.	Link
A CoolingTower shall have at least one outlet using the medium Water.	Link

14.8 s223:Damper

An element inserted into an air-distribution system or element of an air-distribution system permitting modification of the air resistance of the system and consequently changing the airflow rate or shutting off the airflow.

Related Constraints

Description	Link
A Damper shall have at least one inlet using the medium Air.	Link
A Damper shall have at least one outlet using the medium Air.	Link

14.8.1 s223:MotorizedDamper

14.8.2 s223:ManualDamper

14.9 s223:Door

A hinged, sliding, or revolving barrier at the entrance to a building or room.

Related Constraints

Description	Link
A Door shall have at least two bidirectional connection points using the medium Air.	Link

14.10 s223:ElectricBreaker

A piece of equipment designed to open the circuit automatically at a predetermined overcurrent without damage to itself (when properly applied within its rating).

Related Constraints

Description	Link
An ElectricBreaker shall have at least one outlet using the medium Electricity.	Link

14.11 s223:ElectricMeter

A device that measures the properties of electric energy.

14.12 s223:ElectricOutlet

A device to which a piece of electrical equipment can be connected in order to provide it with electricity

Related Constraints

Description	Link
An ElectricOutlet shall have at least one outlet using the medium Electricity.	Link
An ElectricOutlet shall have exactly one inlet using the medium Electricity.	Link

14.13 s223:ElectricTransformer

A piece of electrical equipment used to convert alternative current (AC) electric power from one voltage to another voltage.

Related Constraints

Description	Link
An ElectricTransformer shall have at least one outlet using the medium Electricity.	Link
An ElectricTransformer shall have at least one inlet using the medium Electricity.	Link

14.14 s223:EthernetSwitch

A device that connects wired devices such as computers, laptops, routers, servers, and printers to one another.

Related Constraints

Description	Link
An EthernetSwitch shall have at least one BidirectionalConnectionPoint using the medium Electricity.	Link

14.15 s223:Fan

A machine used to create flow within a gas such as air.

Related Constraints

Description	Link
A Fan shall have at least one inlet using the medium Air.	Link
A Fan shall have at least one outlet using the medium Air.	Link

14.16 s223:FanCoilUnit

A device consisting of a heat exchanger (coil) and a fan to regulate the temperature of one or more spaces.

Related Constraints

Description	Link
A FanCoilUnit must at least have the role Role-Heating or Role-Cooling.	Link
A FanCoilUnit shall have at least one outlet using the medium Air.	Link
A FanCoilUnit must be associated with at least 1 Fan using the relation contains.	Link
A FanCoilUnit must be associated with at least 1 Coil using the relation contains.	Link
A FanCoilUnit shall have at least one inlet using the medium Air.	Link

14.17 s223:Filter

A device that removes contaminants from gases or liquids.

Related Constraints

Description	Link
A Filter shall have at least one inlet ConnectionPoint.	Link
A Filter shall have at least one outlet.	Link
A filter should have one common constituent between the inlet and outlet	Link

14.17.1 s223:AirFilter

14.17.2 s223:WaterFilter

14.18 s223:FumeHood

A fume-collection device mounted over a work space, table, or shelf and serving to conduct unwanted gases away from an area.

Related Constraints

Description	Link
A FumeHood shall have at least one inlet using the medium Air.	Link
A FumeHood shall have at least one outlet using the medium Air.	Link

14.19 s223:Furnace

An enclosed chamber or structure in which heat is produced, as by burning fuel or by converting electrical energy.

Related Constraints

Description	Link
A Furnace shall have at least one outlet using the medium Air.	Link
A Furnace shall have at least one inlet using the medium Air.	Link

14.20 s223:Generator

An energy transducer that transforms non-electric energy into electric energy.

Related Constraints

Description	Link
A Generator must be associated with at least one ConnectionPoint using the relation hasConnectionPoint.	Link
A Generator shall have at least one outlet using the medium Electricity.	Link

14.21 s223:HeatExchanger

A component intended to transfer heat from one medium to another while keeping the two media separate.

Related Constraints

Description	Link
Heat Exchangers should have the same number of non-electrical inlet and outlet connection points.	Link
A heat exchanger shall have at least 4 connection points.	Link
If the relation hasRole is present it must associate the HeatExchanger with a EnumerationKind-Role.	Link

14.21.1 s223:Coil

A cooling or heating element made of pipe or tube that may or may not be finned and formed into helical or serpentine shape.

Related Constraints

Description	Link
A Coil shall have at least one outlet using the medium Air.	Link
A Coil shall have at least one inlet using the medium Air.	Link

14.21.2 s223:CoolingCoil

A coil that provides cooling.

Related Constraints

Description	Link
A cooling coil must be related to the role ‘Role-Cooling’ using the relation ‘hasRole’.	Link

Related Inference Rules

Description	Link
Cooling coils will always have the role Role-Cooling	Link

14.21.3 s223:HeatingCoil

A coil that provides heating.

Related Constraints

Description	Link
A heating coil must be related to the role ‘Role-Heating’ using the relation ‘hasRole’.	Link

Related Inference Rules

Description	Link
Heating coils will always have the role Role-Heating	Link

14.22 s223:HeatPump

A device that can heat or cool by transferring thermal energy using a reversible refrigeration cycle.

Related Constraints

Description	Link
A HeatPump shall have at least one inlet using the medium Air.	Link
A HeatPump shall have at least one outlet using the medium Air.	Link

14.23 s223:Humidifier

A piece of equipment to add moisture to a gas such as air.

14.24 s223:Humidistat

An automatic control device used to maintain humidity at a fixed or adjustable setpoint.

14.25 s223:Inverter

An electric energy converter that changes direct electric current to alternating current.

Related Constraints

Description	Link
An Inverter shall have at least one outlet using the medium Electricity-AC.	Link
An Inverter shall have at least one inlet using the medium Electricity-DC.	Link

14.26 s223:Motor

A machine in which power is applied to do work by the conversion of various forms of energy into mechanical force and motion.

Related Constraints

Description	Link
A Motor shall have at least one inlet using the medium Electricity.	Link

14.27 s223:Luminaire

A complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.

Related Constraints

Description	Link
A Luminaire shall have at least one inlet using the medium Electricity.	Link
A Luminaire shall have at least one outlet using the medium EM-Light.	Link

14.28 s223:PhotovoltaicModule

A piece of equipment that converts sunlight into electricity.

Related Constraints

Description	Link
An PhotovoltaicModule shall have at least one outlet using the medium Electricity.	Link
An PhotovoltaicModule must have at least one inlet using the medium EM-Light.	Link

14.29 s223:Pump

A machine for imparting energy to a fluid, drawing a fluid into itself through an entrance port, and forcing the fluid out through an exhaust port.

Related Constraints

Description	Link
A Pump shall have at least one outlet using the medium Water, Oil or Refrigerant.	Link
The non-electrical ConnectionPoints of a Pump must have compatible Media.	Link
A Pump shall have at least one inlet using the medium Water, Oil or Refrigerant.	Link

14.30 s223:RadiantPanel

A heating or cooling surface that delivers 50% or more of its heat transfer by radiation.

Related Constraints

Description	Link
A radiant panel must hasRole Role-Heating.	Link
A radiant panel shall have at least one inlet using the medium Electricity, NaturalGas, or Water.	Link

14.31 s223:Radiator

A radiator provides heating to a room using electricity, steam or water (e.g., electric baseboard heaters).

Related Constraints

Description	Link
Radiators must have the role Role-Heating.	Link
A Radiator shall have at least one inlet using the medium Electricity or Water.	Link

14.32 s223:ResistanceHeater

Resistance heaters provide electrical resistance heating, for example an electric heating coil within a Fan Coil Unit.

Related Constraints

Description	Link
ResistanceHeaters must have the role Role-Heating.	Link
A ResistanceHeater shall have at least one inlet using the medium Electricity.	Link

14.33 s223:SolarThermalCollector

A device that converts sunlight into thermal energy.

Related Constraints

Description	Link
A SolarThermalCollector shall have at least one outlet using the medium Water.	Link
A SolarThermalCollector shall have at least one inlet using the medium EM-Light.	Link

14.34 s223:TerminalUnit

An air terminal that modulates the volume of air delivered to a space.

Related Constraints

Description	Link
A TerminalUnit shall have at least one inlet ConnectionPoint using the medium Air.	Link
A TerminalUnit shall have at least one outlet ConnectionPoint using the medium Air.	Link

14.34.1 s223:DualDuctTerminal

A dual duct air terminal mixes two independent sources of primary air.

Related Constraints

Description	Link
A DualDuctTerminal shall have at least two inlets using the medium Air.	Link

14.34.2 s223:FanPoweredTerminal

An air terminal containing a fan. Airflow may pass through or be parallel to the fan. These units may also have supplemental heating or cooling.

Related Constraints

Description	Link
A FanPoweredTerminal must be associated with at least one Fan by using the relation contains.	Link

14.34.3 s223:SingleDuctTerminal

An air-terminal unit assembly having one ducted air inlet and a damper for regulating the airflow rate.

Related Constraints

Description	Link
A SingleDuctTerminal must be associated with at least one Damper using the relation contains.	Link

14.35 s223:Thermostat

An automatic control device used to maintain temperature at a fixed or adjustable setpoint.

14.36 s223:Turbine

An energy transducer that converts mechanical energy into electric energy.

Related Constraints

Description	Link
A Turbine must be associated with at least one ConnectionPoint using the relation hasConnectionPoint.	Link
A Turbine shall have at least one outlet using the medium Electricity.	Link

14.37 s223:Valve

A device to regulate or stop the flow of fluid in a pipe or a duct by throttling.

Related Constraints

Description	Link
A Valve shall have at least one inlet and one outlet or two bidirectional connection points.	Link

14.37.1 s223:ManualValve

14.37.2 s223:ThreeWayValve

A Valve that can divert a fluid in one of three directions.

Related Constraints

Description	Link
A ThreeWayValve must have at least three ConnectionPoints using the relation hasConnectionPoint.	Link

14.37.3 s223:TwoWayValve

A Valve that can divert a fluid in one of two directions.

Related Constraints

Description	Link
A TwoWayValve shall have at least one inlet.	Link
A TwoWayValve shall have at least one outlet.	Link

14.37.4 s223:MotorizedValve

14.37.5 s223:MotorizedThreeWayValve

14.37.6 s223:MotorizedTwoWayValve

14.38 s223:VariableFrequencyDrive

An electronic device that varies its output frequency to vary the rotating speed of a motor, given a fixed input frequency. Used with fans or pumps to vary the flow in the system as a function of a maintained pressure.

Related Constraints

Description	Link
If the relation connectedTo is present it must associate the VariableFrequencyDrive with a Equipment.	Link
A VariableFrequencyDrive shall have at least one outlet using the medium Electricity.	Link
A VariableFrequencyDrive shall have at least one inlet using the medium Electricity.	Link

14.39 s223:Window

A daylight opening on a vertical or nearly vertical area of a room envelope.

Related Constraints

Description	Link
A Window shall have at least one outlet using the medium Light.	Link
A Window shall have at least one inlet using the medium Light.	Link

14.40 s223:WindowShade

A window covering that can be moved to block out or allow in light.

15 RDF REPRESENTATION OF THIS STANDARD (NORMATIVE)

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