BSR/ASHRAE Standard 223P

Public Review Draft

Semantic Data Model for Analytics and Automation Applications in Buildings

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(Draft shows Proposed New Standard)

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Note to reviewers: *Additional material is available that may be very helpful in reviewing this proposed standard including:*

- *An online user's guide;*
- *Example models built using the draft standard;*
- *A query interface to try generating queries of the example models; and*
- *Tools for exploring the Standard 223P ontology.*

All of this can be found at http://open223.info

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

The motivation for this standard is to facilitate the deployment and use of software tools that leverage the data available from building automation systems to improve building system operation in a variety of ways. This standard builds upon standards and tools developed by the World Wide Web Consortium (W3C). Using those general tools, this standard defines modeling constructs for use in creating machine-readable representations 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 result is a searchable knowledge graph that can be used to automate the data mapping and configuration needed to deploy analytical, management, and control tools for the built environment.

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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 connection points and connections.

Connection: the modeling construct used to represent a physical thing (e.g., pipe, duct, or conductor) 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. `DomainSpace`s can be combined to form a `Zone`.

Equipment: the modeling construct used to represent a device designed to accomplish a specific task. 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.

Medium: a substance used to convey mass, energy, or information through Equipment or a System. Examples include air, water, refrigerant, and electricity.

PhysicalSpace: an architectural concept that represents 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.

System: a logical grouping (collection) of `Equipment` for some functional purpose. Examples of possible systems include an air distribution system or a hot water system. Systems can contain other Systems. A `System` does not participate in connections.

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

Acronym	Definition
AHU	Air Handling Unit
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
BACnet	Building Automation and Control Networks
CDL	Control Description Language
HVAC	Heating, Ventilation, and Air Conditioning
IFC	Industry Foundation Class
IRI	Internationalized Resource Identifier
LAN	Local Area Network
LL	Line-Line
LN	Line-Neutral
OWL	Web Ontology Language
PM	Particulate Matter
PoE	Power over Ethernet
QUDT	Quantities, Units, Dimensions, and Types
RDF	Resource Description Framework
RDFS	RDF Schema
SHACL	Shapes Constraint Language
SPARQL	SPARQL Protocol and RDF Query Language
USB	Universal Serial Bus
VAV	Variable Air Volume
W3C	World Wide 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 semantic building blocks 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 contain 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 defines external references that are used to point to a source of the data values, thus enabling analytics applications to find them. If the data source is a BACnet building automation and control system, the external reference contains the necessary information for analytic software to learn which BACnet device, object, and property corresponds to the desired piece of information. This enables construction of a BACnet message used to read the value.

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 is 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 to infer information that may not be explicit in the graph. Figure 4-1 is a graph that corresponds to this example.

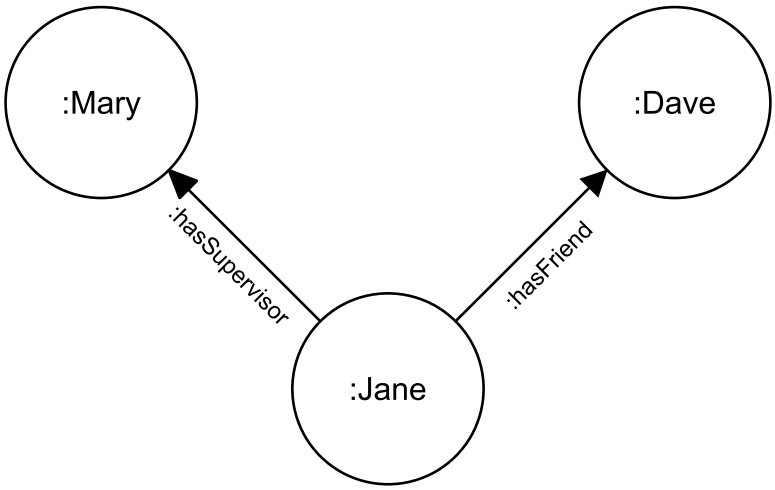


Figure 4-1. Example triple graph.

This standard defines subjects, predicates, and objects relevant to the building space that are used to build a multi-graph representing a specific building or group of buildings. A compelling advantage of this graph-based approach is the ability to combine semantic graphs derived from complementary semantic models that apply to the same building. This makes it possible to take advantage of the combined information from distinct domains. For example, a RealEstateCore model that captures how spaces are assigned to different tenants in a building linked to the spaces represented in a Standard 223 model results in a semantic model containing the combined information. 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.

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 would add that geometric information.

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 use these queries 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 the construction of RDF graphs 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 check whether or not a particular model instance conforms to the shapes defined in this standard.

The concepts and relations mentioned below were designed to aid in standard development using RDF and SHACL exclusively and avoiding any dependence on OWL axioms. This approach was chosen to avoid some of the shortcomings of using OWL in industrial settings, such as the open world assumption, the many flavors of OWL and their support, and the sometimes counterintuitive implications of OWL reasoning for non-ontologists. (For example, if an instance satisfies the OWL axioms for a class, then it is inferred to be an instance of that class). The use of SHACL shapes to define constraints and inferencing rules is a more intuitive way to define intended model behavior and to verify conformance to the standard. The two most-used OWL inferences, supporting symmetric and inverse relations, are redefined in this standard using SHACL rules.

4.1 Conformance Constraints and Validation

In this standard, SHACL shapes are used to define conformance constraints. When a SHACL reasoner is applied to a model, discrepancies from the conformance constraints result in a message from the reasoner with one of three levels of severity (sh:severity).

A message with a severity sh:Info means that a model construct is incomplete.

A message with a severity sh:Warning means that a model construct is used in an unexpected way.

A message with a severity sh:Violation means a model construct is invalid and does not comply with the standard.

4.2 Deriving Implicit Information from Inference Rules

SHACL is used in this standard to derive implicit information via a process called inferencing. Inference rules are used to define how new triples are generated. 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 specify the inferencing.

4.3 Textual Serialization

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

The Turtle serialization format specifies that IRIs may be written as relative or absolute IRIs or prefixed names. The prefix label is defined by using the "@prefix" directive followed by a colon followed by a partial IRI. The encoding examples used in this document assume the following prefix statements:

```
@prefix s223: <http://data.ashrae.org/standard223#> .
@prefix bacnet: <https://data.ashrae.org/bacnet/> .
@prefix qudt: <http://qudt.org/schema/qudt/> .
```


A prefixed name is turned into an IRI by concatenating the IRI associated with the prefix and the local part. The '@prefix' directive associates a prefix label with an IRI, e.g., `s223:Equipment` expands to `<http://data.ashrae.org/standard223#Equipment>`. The scope of a prefix label is only within the Turtle file that it appears. It is encouraged to use the prefix statements above when exchanging models.

4.4 Units of Measure

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). This standard builds upon the "Quantities, Units, Dimensions, and Types" (QUDT) ontology which is an 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 223 standard is compatible with Version 3.1.1 of QUDT and is expected to be compatible with all newer versions as well.

4.5 Namespace

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 relation) defined by this standard, e.g., s223:Equipment.

4.6 s223:Concept

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

Related Constraints

Description	Link
Ensure that all instances of an s223 class use only the relations defined for that class. Note that this only applies to QUDT relations.	Link
Ensure that all instances of an s223 class use only the relations defined for that class. Note that this only applies to s223 relations.	Link
If the relation `hasProperty` is present, it shall associate the concept with a `Property`.	Link
Incompatible Medium. Case1: An entity with a pure medium and an associated `Property` with a different pure medium.	Link
Incompatible Medium. Case2: An entity with a pure medium and an associated `Property` with constituents.	Link
Incompatible Medium. Case3: An entity with constituents and an associated `Property` with a pure medium.	Link
Incompatible Medium. Case4: An entity with constituents and an associated `Property` with constituents.	Link

Related Inference Rules

Description	Link
Add an rdfs:label if it is missing.	Link
Declare the inverse triples for relations that have defined inverse relations	Link
Declare the inverse triples for symmetric relations	Link

4.6.1 s223:Class

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

Related Constraints

Description	Link
A `Class` shall be associated with at least one label using the relation `rdfs:label`.	Link
Every SHACL property shape must have an rdfs:comment.	Link
Every SPARQLConstraint must have an rdfs:comment.	Link
Every SPARQLRule must have an rdfs:comment.	Link
Every TripleRule must have an rdfs:comment.	Link
Every class of the 223 standard must also be an instance of sh:NodeShape.	Link
Every class of the 223 standard must be a direct or indirect subclass of s223:Concept.	Link
Every class of the 223 standard must have an rdfs:comment.	Link

4.6.1.1 s223:AbstractClass

This is a modeling construct. Instances of abstract classes cannot be created. All abstract classes in this standard have a more specific subclass.

4.6.2 s223:Relation

A `Relation` associates the subject and the object in an RDF triple, the *predicate* portion of a *(subject, predicate, object)* triple.

Related Constraints

Description	Link
A `Relation` shall be associated with at least one label using the relation `rdfs:label`.	Link

4.6.2.1 s223:RelationWithInverse

An `RelationWithInverse` is modeling construct used to define symmetric behavior for certain relations in the standard such as `connectedTo` and `connectedFrom`.

Related Constraints

Description	Link
An `RelationWithInverse` shall be associated with exactly one other `RelationWithInverse` using the relation `inverseOf`.	Link

4.6.2.1.1 s223:inverseOf

A `Relation` that associates `Relation`s that are inverses of one another, such as `connectedTo` and `connectedFrom`.

4.6.2.2 s223:SymmetricRelation

A modeling construct used to define symmetric behavior for certain relations in the standard such as `cnx`, `connected`, and `pairedConnectionPoint`.

4.7 s223:hasProperty

A `Relation` that associates a `Concept` with a `Property`.

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 5.2). `Equipment` can also be grouped together to define a `System` (see Clause 7).

5.1 s223:Equipment

`Equipment` is the modeling construct used to represent a thing designed to accomplish a specific task, or a complex thing that contains component pieces of `Equipment` that are connected to each other and work together to accomplish a task. `Equipment` can have `Connections` and `ConnectionPoints` through which one or more kinds of medium (see Clause 10.12.1) might flow. Examples of possible `Equipment` include a `Pump`, `Fan`, `HeatExchanger`, `Luminaire`, and `Sensor`, as well as more complex things like a heat pump, a chilled water plant, or a utility meter. `Equipment` is distinct from a `System`, which is simply a logical grouping or collection of (only) `Equipment`.

In common usage, terms like equipment and system have a variety of ambiguous and possibly conflicting interpretations. A semantic model is an attempt to eliminate such ambiguities and conflicts. If the thing being modeled involves `Connections` and `ConnectionPoints`, it must be modeled as `Equipment` and not a `System`. Thus, a model of a chilled water plant that includes external connections to things beyond the plant must be modeled as `Equipment`. Any contained `Equipment` within the chilled water plant (i.e., the pumps, valves, filters, and other things) may alternatively or in addition be logically grouped and modeled as a `System`.

The graphical depiction of Equipment used in this document is a round-cornered rectangle as shown in Figure 5-1.

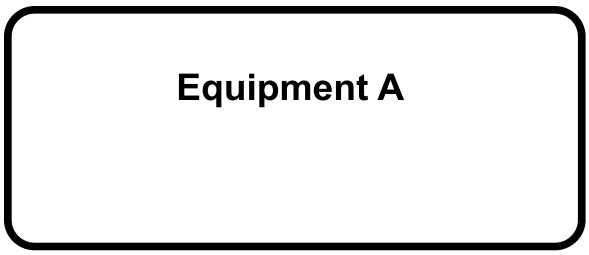


Figure 5-1. Graphical Depiction of Equipment.

Related Constraints

Description	Link
Disallow contained equipment from having external incoming connections.	Link
Disallow contained equipment from having external outgoing connections.	Link
If the relation `actuatedByProperty` is present it shall associate the `Equipment` with a `ActuatableProperty`. Note that any `Equipment` may use this relation, not just `Actuator`.	Link
If the relation `contains` is present it shall associate the `Equipment` with either `Equipment` or `Junction`.	Link
If the relation `executes` is present it shall associate the `Equipment` with a `Function`.	Link
If the relation `hasPhysicalLocation` is present it shall associate the `Equipment` with a `PhysicalSpace`.	Link
If the relation `hasRole` is present it shall associate the `Equipment` with a `EnumerationKind-Role`.	Link
Warning about a subClass of `Equipment` of type A containing something that is in the same subClass branch.	Link

Related Inference Rules

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

5.2 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 Clause 5.3). The relationship `mapsTo` relates a `ConnectionPoint` of a contained `Equipment` to the `ConnectionPoint` of a containing `Equipment` (see Clause 6.2.5). For example, the air inlet to a heating coil contained in a fan coil unit may map to the air 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.

It may be desirable for a piece of containing equipment to have a `Property` that has a value representing something that is associated with a contained piece of equipment. For example, consider a fan coil unit that contains a fan and a coil. The fan may have a `Property` that represents the speed of the fan. To make this fan speed visible as a `Property` of the fan coil unit, a fan speed `Property` would be added to the fan coil unit and its value would be an internal reference (see Clause 11.20) to the speed `Property` of the contained motor.

5.3 s223:contains

A `Relation` that associates a piece of `Equipment` with its component pieces of `Equipment`, or a `PhysicalSpace` (see Clause 8.1.1) with its component `PhysicalSpaces`.

5.4 s223:hasRole

A `Relation` that associates a role with of a piece of `Equipment`, a `Connection`, `ConnectionPoint`, or `System` within a building (e.g., a heating coil might be associated with `Role-Heating`). Possible values are defined in `EnumerationKind-Role` (see Clause 10.11).

5.5 s223:hasPhysicalLocation

A `Relation` that associates a piece of `Equipment` with its physical location (i.e., in a `PhysicalSpace`.) The physical location of a piece of `Equipment` is not necessarily the same as the location affected by the operation of the `Equipment`. For example, an air handler may physically be located on the roof, but its effect is to provide conditioned air to a `Zone` or `DomainSpace` within the building. By following the path of connections, it can be determined what other equipment or spaces are possibly impacted by the `Equipment`.

5.6 s223:Sensor

A `Sensor` `observes` an `ObservableProperty` (see Clause 11.3) which may be quantifiable (see Clause 11.7), such as a temperature, flow, or concentration, or enumerable (see Clause 11.8), such as an occupancy state.

If a `Sensor` observes a `QuantifiableObservableProperty` relative to an assumed or common reference point, it can be modeled with only an observation location. For example:


```
@prefix : <http://example.com/> .

:example1 a s223:TemperatureSensor ;
    s223:hasObservationLocation :location1 ;
    qudt:hasQuantityKind quantitykind:Temperature ;
.
```

If a `Sensor` observes a `QuantifiableObservableProperty` relative to a unique or specified reference point, it can be modeled with an observation location and a reference location, and indicating the difference between two values by setting `isDeltaQuantity` to `true`. For example:

```
@prefix : <http://example.com/> .

:example2 a s223:TemperatureSensor ;
    s223:hasObservationLocation :location1 ;
    s223:hasReferenceLocation :location2 ;
    qudt:hasQuantityKind quantitykind:Temperature ;
    qudt:isDeltaQuantity true ;
.
```

Related Constraints

Description	Link
A `Sensor` can be associated with a maximum of one `Connectable`, `Connection`, or `ConnectionPoint` using the relation `hasReferenceLocation`.	Link
A `Sensor` shall be associated with exactly 1 of `Connectable`, `Connection`, or `ConnectionPoint` using the relation `hasObservationLocation`.	Link
A `Sensor` shall be associated with exactly 1 of `QuantifiableObservableProperty` or `EnumeratedObservableProperty` using the relation `observes`.	Link
A `Sensor` shall be associated with exactly one `ObservableProperty` using the relation `observes`.	Link
A `Sensor` shall be associated with exactly one location using the relation `hasObservationLocation`.	Link
If a `Sensor` measures a differential property, it shall be associated with exactly 1 of `Connectable`, `Connection`, or `ConnectionPoint` using the relation `hasReferenceLocation`.	Link
If the relation `hasMeasurementResolution` is present it shall associate a `Sensor` with a `QuantifiableProperty`.	Link
s223: If the `hasReferenceLocation` relation exists, the observed `Property` shall have isDeltaQuantity true.	Link
s223: If the observed `Property` has isDeltaQuantity true, the `Sensor` shall have a `hasReferenceLocation` relation.	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

5.6.1 s223:ConcentrationSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a concentration of a miscible constituent in a medium, in contrast to a `ParticulateSensor` that `observes` a `QuantifiableObservableProperty` that represents an amount of a particulate in a medium (see Clause 5.6.7). The 223 standard does not constrain the `Unit` or `QuantityKind` reported by a `ConcentrationSensor`, but possible `QuantityKind`s include `Concentration` (moles per volume), `Density` (mass per volume), `MoleFraction`, and `VolumeFraction`.

5.6.2 s223:ElectricCurrentSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of electric current.

Related Constraints

Description	Link
An `ElectricCurrentSensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of `ElectricCurrent`.	Link

5.6.3 s223:FlowSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of flow of fluid, typically with a `QuantityKind` of `VolumeFlowRate`.

5.6.4 s223:HumiditySensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of relative or absolute humidity.

Related Constraints

Description	Link
A `HumiditySensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of either `RelativeHumidity` or `AbsoluteHumidity`.	Link

5.6.5 s223:LightSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents an attribute of light, as specified by the `QuantityKind` of the `Property` being observed, as described below.

5.6.5.1 s223:IlluminanceSensor

A `LightSensor` that `observes` a `QuantifiableObservableProperty` that represents an illuminance, defined as the areal density of the luminous flux incident at a point on a surface.

Related Constraints

Description	Link
An `IlluminanceSensor` shall `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of `Illuminance`.	Link

5.6.5.2 s223:CorrelatedColorTemperatureSensor

A `LightSensor` that `observes` a `QuantifiableObservableProperty` that represents a correlated color temperature (CCT) of a light source, defined as the absolute temperature of a blackbody whose chromaticity most nearly resembles that of the light source.

Related Constraints

Description	Link
A `CorrelatedColorTemperatureSensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of `CorrelatedColorTemperature`.	Link

5.6.5.3 s223:DuvSensor

A `LightSensor` that `observes` a `QuantifiableObservableProperty` that represents a Duv of a light source, defined as the distance between the chromaticity of the light source and a blackbody radiator of equal correlated color temperature (CCT).

Related Constraints

Description	Link
A `DuvSensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of `Duv`.	Link

5.6.6 s223:OccupancySensor

A `Sensor` that `observes` an `ObservableProperty` that represents an attribute of occupancy in a space.

5.6.6.1 s223:OccupantMotionSensor

An `OccupancySensor` that `observes` a `ObservableProperty` that represents motion within a sensing region.

Related Constraints

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

5.6.6.2 s223:OccupantPresenceSensor

An `OccupancySensor` that `observes` a `ObservableProperty` that represents presence within a sensing region.

Related Constraints

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

5.6.6.3 s223:OccupantCountSensor

An `OccupancySensor` that `observes` a `QuantifiableObservableProperty` that represents a population, usually of humans, within a sensing region.

Related Constraints

Description	Link
An `OccupantCountSensor` shall always observe a `QuantifiableObservableProperty` that has a `QuantityKind` of `Population` and a `Unit` of `NUM`.	Link

5.6.7 s223:ParticulateSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents an amount of a particulate in a medium, in contrast to a `ConcentrationSensor` that `observes` a `QuantifiableObservableProperty` that represents a concentration of a miscible constituent in a medium (see Clause 5.6.1). The 223 standard does not constrain the `Unit` or `QuantityKind` reported by a `ParticulateSensor`, but possible `QuantityKinds` include `Density` (mass per volume), `ParticleNumberDensity` (count per volume), and `DimensionlessRatio` (with units such as `PPM` or `PPB`). Some particulate sensors may claim to report a raw count of particles, for which a `QuantityKind` of `Count` could be used, but the required context for such a measurement should be provided in the sensor's documentation to specify if it in fact measures a count per volume (e.g. `ParticleNumberDensity`), time (e.g., `CountRate` or `ParticleCurrent`), or some other combination. Explicitly declaring the `QuantityKind` of a sensor's output is preferable to relying on implicit assumptions.

Related Constraints

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

5.6.8 s223:PressureSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of pressure.

Related Constraints

Description	Link
A `PressureSensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of Pressure.	Link

5.6.8.1 s223:GaugePressureSensor

A `PressureSensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of pressure relative to atmospheric pressure. Such sensors are commonly used to monitor compressed gas cylinders, for example, where a gauge reading of zero signifies that the measured pressure is equal to the atmospheric pressure, not a vacuum.

Related Constraints

Description	Link
A `GaugePressureSensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of GaugePressure.	Link
A `GaugePressureSensor` shall always `observe` a `QuantifiableObservableProperty` that has a value of true for qudt:isDeltaQuantity.	Link

5.6.9 s223:TemperatureSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of temperature.

Related Constraints

Description	Link
A `TemperatureSensor` shall always observe a `QuantifiableObservableProperty` that has a `QuantityKind` of `Temperature`.	Link

5.6.10 s223:VoltageSensor

A `Sensor` that `observes` a `QuantifiableObservableProperty` that represents a measure of voltage.

Related Constraints

Description	Link
A `VoltageSensor` shall always `observe` a `QuantifiableObservableProperty` that has a `QuantityKind` of Voltage.	Link

5.6.11 s223:hasMeasurementResolution

A `Relation` that associates a `Sensor` with the `QuantifiableProperty` whose value indicates the smallest recognizable change in engineering units that the `Sensor` is able to measure.

5.6.12 s223:observes

A `Relation` that associates a `Sensor` with one `ObservableProperty` (see Clause 11.3) which is used by the sensor to generate a measurement value (e.g., a temperature) or a simple observation of a stimulus causing a reaction (e.g., a current binary switch that closes a dry contact when a fan is powered on).

5.6.13 s223:hasObservationLocation

A `Relation` that associates a `Sensor` with the topological location where it is observing a `Property` (see Clause 5.6.12). The observation location shall be a `Connectable` (see Clause 6.1), `Connection` (see Clause 6.3), or `ConnectionPoint` (see Clause 6.2).

5.6.14 s223:hasReferenceLocation

A `Relation` that associates a differential sensor with the topological location of the baseline (reference) `Property` (see Clause 5.6.12).

5.7 s223:Actuator

A piece of `Equipment` that receives control signals and electrically, pneumatically, or hydraulically makes changes in the physical world, such as the position of a valve or damper.

Related Constraints

Description	Link
An `Actuator` shall be associated with at least one `ActuatableProperty` using the relation `actuatedByProperty`.	Link
If the relation `actuates` is present it shall associate the `Actuator` with a piece of `Equipment`.	Link

5.7.1 s223:actuates

A `Relation` that associates an `Actuator` with the `Equipment` that it actuates.

5.7.2 s223:actuatedByProperty

A `Relation` that associates a piece of `Equipment` with the `ActuatableProperty` that it responds to. If the `Equipment` is an `Actuator` (a subclass of `Equipment`), `actuatedByProperty` is a

required relation. An `Actuator` may also identify another piece of `Equipment` being actuated. (see Clause 5.7.1).

5.8 s223:Controller

A piece of equipment for regulation of a system or component in normal operation, which executes one or more `Functions`.

Related Constraints

Description	Link
If the relation `executes` is present it shall associate the `Controller` with a `Function`.	Link

5.8.1 s223:Function

A `Function` 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` must be associated with at least one `Property` using either the relation `hasInput` or `hasOutput`.	Link
If the relation `hasInput` is present it shall associate a `Function` with a `Property`.	Link
If the relation `hasOutput` is present it shall associate a `Function` with a `Property`.	Link

5.8.1.1 s223:hasInput

A `Relation` that associates a `Function` (see Clause 5.8.1) with a `Property` (see Clause 11.1) that is used as input to the `Function`.

5.8.1.2 s223:hasOutput

A `Relation` that associates a `Function` (see Clause 5.8.1) with a `Property` (see Clause 11.1) that is calculated by the `Function`.

5.8.2 s223:executes

A `Relation` that associates a `Controller` (see Clause 5.8) with the `Functions` (see Clause 5.8.1) that it executes.

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 `ConnectionPoint` to another. Examples of connections are ducts, pipes, and conductors.

6.1 s223:Connectable

`Connectable` is an abstract class representing a thing such as, `Equipment` (see Clause 5.1), `DomainSpace` (see Clause 8.2.1), or `Junction` (see Clause 6.4) that can be `connected` via connection points and connections.

Related Constraints

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

Related Inference Rules

Description	Link
Infer the `cnx` relation using `isConnectionPointOf`.	Link
Infer the `cnx` relationship using `hasConnectionPoint`.	Link
Infer the `connectedFrom` relations using `connectsThrough` and `connectsFrom`.	Link
Infer the `connectedThrough` relation using `hasConnectionPoint` and `connectsThrough`	Link
Infer the `connectedTo` relation using `connectsThrough` and `connectsTo`.	Link
Infer the `connected` relation for BiDirectional connections	Link
Infer the `connected` relation for BiDirectional connections	Link
Infer the `connected` relation using `connectedFrom`	Link
Infer the `connected` relation using `connectedTo`	Link
Infer the `hasConnectionPoint` relation using `cnx`	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 Clause 6.1).

`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.

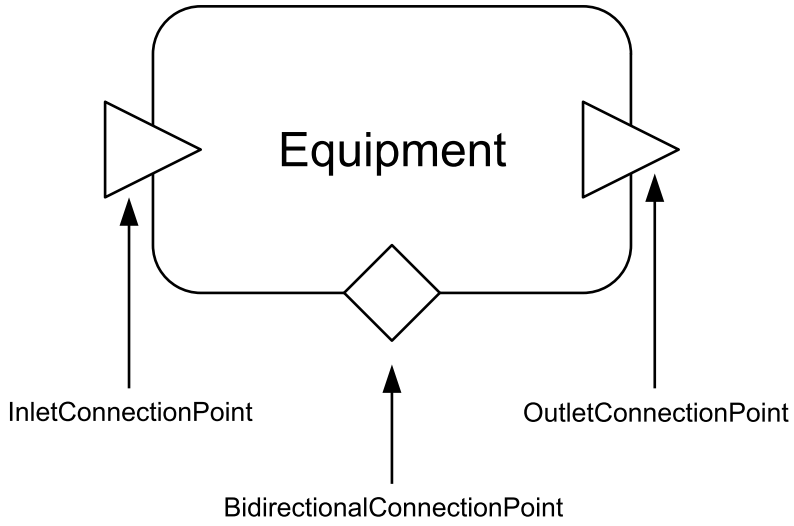


Figure 6-1. Graphical Representation of a ConnectionPoint.

Related Constraints

Description	Link
A `ConnectionPoint` can be associated with at most one other `ConnectionPoint` using the inverse of relation `mapsTo`	Link

Description	Link
A `ConnectionPoint` can be associated with at most one other `ConnectionPoint` using the relation `mapsTo`	Link
A `ConnectionPoint` must not have both a `mapsTo` and a `connectsThrough` relation.	Link
A `ConnectionPoint` shall be associated with at most one `Connectable` using the `cnx` relation.	Link
A `ConnectionPoint` shall be associated with at most one `Connection` using the `cnx` relation	Link
A `ConnectionPoint` shall be associated with at most one `Connection` using the relation `connectsThrough`.	Link
A `ConnectionPoint` shall be associated with exactly one `Connectable` using the relation `isConnectionPointOf`.	Link
A `ConnectionPoint` shall be associated with exactly one `Substance-Medium` using the relation `hasMedium`.	Link
Ensure that the Medium identified by a `ConnectionPoint` via the `hasMedium` relation is compatible with the Medium identified by the entity identified by the `mapsTo` relation.	Link
If a `ConnectionPoint` `mapsTo` another `ConnectionPoint`, the respective `Equipment` should have a `contains` relation.	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` 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
If the relation `hasElectricalPhase` is present it shall associate the `ConnectionPoint` with an ElectricalPhaseIdentifier or ElectricalVoltagePhases.	Link
If the relation `hasRole` is present it shall associate the `ConnectionPoint` with an `EnumerationKind-Role`.	Link
Subclasses of ConnectionPoint are Disjoint. An instance of a subclass of ConnectionPoint cannot be an instance of multiple such subclasses.	Link

Related Inference Rules

Description	Link
Infer the `hasElectricalPhase` value from any connected `Conductor`.	Link

6.2.1 s223:BidirectionalConnectionPoint

A `BidirectionalConnectionPoint` is a `ConnectionPoint` for which a medium (`Substance-Medium`) is expected to flow either into or out of the associated `Connectable`.

Related Constraints

Description	Link
If the relation `mapsTo` is present it shall associate the `BidirectionalConnectionPoint` with a `BidirectionalConnectionPoint`.	Link
If the relation `pairedConnectionPoint` is present it shall associate the `BidirectionalConnectionPoint` with a `ConnectionPoint`.	Link

6.2.2 s223:InletConnectionPoint

An `InletConnectionPoint` is a `ConnectionPoint` for which a medium (`Substance-Medium`) is expected to flow into the associated `Connectable`.

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 shall associate the `InletConnectionPoint` with an `InletConnectionPoint`.	Link
If the relation `pairedConnectionPoint` is present it shall associate the `InletConnectionPoint` with an `OutletConnectionPoint` or `BidirectionalConnectionPoint`.	Link

6.2.3 s223:OutletConnectionPoint

An `OutletConnectionPoint` is a `ConnectionPoint` for which a medium (`Substance-Medium`) is expected to flow out of the associated `Connectable`.

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 shall associate the `OutletConnectionPoint` with an `OutletConnectionPoint`.	Link
If the relation `pairedConnectionPoint` is present it shall associate the `OutletConnectionPoint` with an `InletConnectionPoint` or `BidirectionalConnectionPoint`.	Link

6.2.4 s223:pairedConnectionPoint

A `Relation` that associates two `ConnectionPoints` where an `InletConnectionPoint` shares the same `Medium` with an `OutletConnectionPoint`.

6.2.5 s223:mapsTo

A `Relation` that associates a `ConnectionPoint` of a `Connectable` with a corresponding `ConnectionPoint` of the one containing it (see Clause 5.2). The associated `ConnectionPoints` shall have the same direction (see ?) and compatible medium (see Clause 10.12.1).

6.2.6 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 `Substance-Medium` (see Clause 10.12.1).

6.3 s223:Connection

A `Connection` is the modeling construct used to represent the thing (e.g., pipe, duct, conductor, or free space) that is used to convey some Medium (e.g., water, air, electricity, light, wi-fi) between two connectable things. All connections have two or more connection points bound to either `Equipment` (see Clause 5.1), `DomainSpace` (see Clause 8.2.1), 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).

The constraint to maintain compatible mediums among a `Connection` and all of its associated `ConnectionPoints` gives rise to multiple validation test cases, where the specified medium might be a pure medium, or a mixture with constituents. See Clause 10.12.1 for more details.

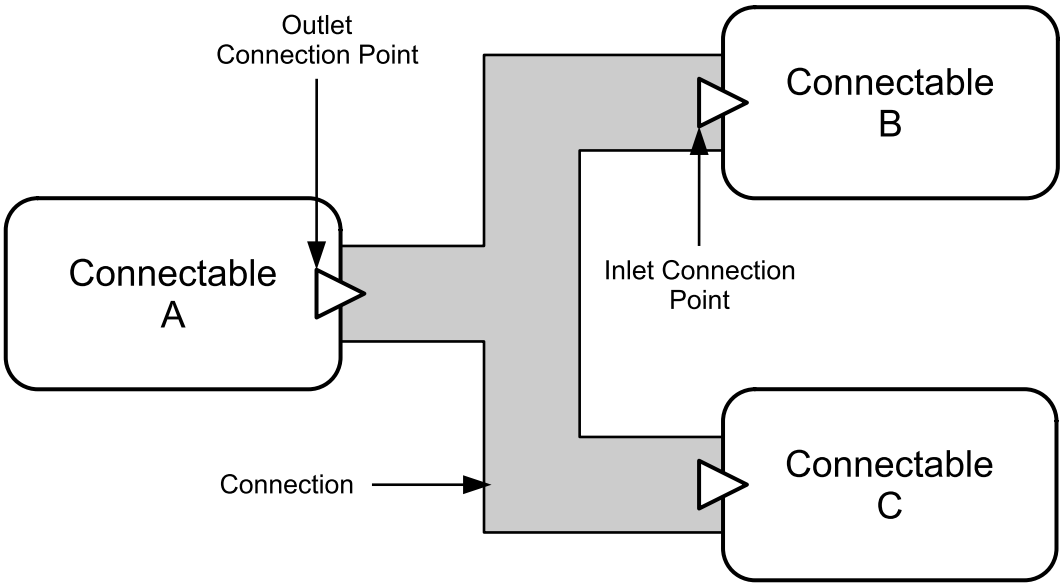


Figure 6-2. Graphical Depiction of Connection.

Related Constraints

Description	Link
A `Connection` must only have a `cnx` relation with a `ConnectionPoint`	Link
A `Connection` shall be associated with exactly one `Substance-Medium` using the relation `hasMedium`.	Link
A `Connection` shall have two or more `cnx` relations to connection points	Link
A `Connection` shall have two or more `connectsAt` relations to connection points	Link
If the relation `connectsFrom` is present it shall associate the `Connection` with a `Connectable`.	Link
If the relation `connectsTo` is present it shall associate the `Connection` with a `Connectable`.	Link
If the relation `hasRole` is present it shall associate the `Connection` with an `EnumerationKind-Role`.	Link
If the relation `hasThermodynamicPhase` is present it shall associate the `Connection` with at most one `EnumerationKind-ThermodynamicPhase`.	Link
Incompatible Medium. Case 1: A `Connection` with a pure medium and an associated `ConnectionPoint` with a pure medium.	Link
Incompatible Medium. Case 2: A `Connection` with constituents and an associated `ConnectionPoint` with a pure medium.	Link

Description	Link
Incompatible Medium. Case 3: `Connection` with a pure medium and an associated `ConnectionPoint` with constituents.	Link
Incompatible Medium. Case 4: A `Connection` with constituents and an associated `ConnectionPoint` with constituents.	Link
Incompatible Medium. Case 5: Two `ConnectionPoints` with pure mediums.	Link
Incompatible Medium. Case 6: Two `ConnectionPoints`, one with a medium with constituents and one with a pure medium.	Link
Incompatible Medium. Case 7: Two `ConnectionPoints` with mediums with constituents.	Link
You need either an `InletConnectionPoint` and an `OutletConnectionPoint`, or at least one `BidirectionalConnectionPoint` and another `ConnectionPoint` of any type.	Link

Related Inference Rules

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

6.3.1 s223:Pipe

A `Connection` that is used primarily to transport liquids and gases such as water, sewage, natural gas, and compressed air.

6.3.2 s223:Duct

A `Connection` that is used to transport air such as supply, return, and exhaust in HVAC (Heating, Ventilation, and Air Conditioning) systems.

6.3.3 s223:Conductor

A `Connection` that represents one or more wires used to convey electricity, with the electricity conceptualized as flowing through a `Conductor` like water through a pipe. Each instance of `Conductor` applies to no more than one electrical circuit.

Related Constraints

Description	Link
A `Conductor` shall be associated with exactly one `Constituent-Electricity` using the relation `hasMedium`.	Link

Description	Link
Ensure the electrical phase is the same as all connected `ConnectionPoints`	Link
If the relation `hasElectricalPhase` is present it shall associate the `Conductor` with a single ElectricalPhaseIdentifier or ElectricalVoltagePhases value.	Link

Related Inference Rules

Description	Link
Infer the `hasElectricalPhase` value from any connected `ConnectionPoints`.	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`, or when a modeler wants to expose a branch point within a containing piece of `Equipment`. 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 connection points.

`Junction` is a subClassOf `Connectable`, which gives it the ability to have connection points, but unlike Equipment (and like Connection), it is not allowed to change the Medium that passes through it. This is why `Junction` is a sibling class to `Equipment` and not a subclass. This constraint to maintain compatible mediums among a `Junction` and all of its associated `ConnectionPoints` gives rise to multiple validation test cases, where the specified medium might be a pure medium, or a mixture with constituents. See Clause 10.12.1 for more details.

Related Constraints

Description	Link
A `Junction` shall be associated with exactly one `Substance-Medium` using the relation `hasMedium`.	Link
A `Junction` shall have at least two `ConnectionPoints` including (a) at least one inlet and one outlet, or (b) at least one bidirectional connection point.	Link
Incompatible Medium. Case 2: A `Junction` with constituents and an associated `ConnectionPoint` with a pure medium.	Link
Incompatible Medium. Case 3: `Junction` with a pure medium and an associated `ConnectionPoint` with constituents	Link
Incompatible Medium. Case 6: Two `ConnectionPoints`, one with a medium with constituents and one a pure medium.	Link
Incompatible Medium. Case 7: Two `ConnectionPoints` with mediums with constituents.	Link
Incompatible Medium. Case1: A `Junction` with a pure medium and an associated `ConnectionPoint` with a pure medium.	Link

Description	Link
Incompatible Medium. Case4: `Junction` with constituents and an associated `ConnectionPoint` with constituents.	Link
Incompatible Medium. Case5: Two `ConnectionPoints` with pure mediums.	Link
This `Junction` is not used to model significant details of a branching point in a connection, and may not be required.	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.

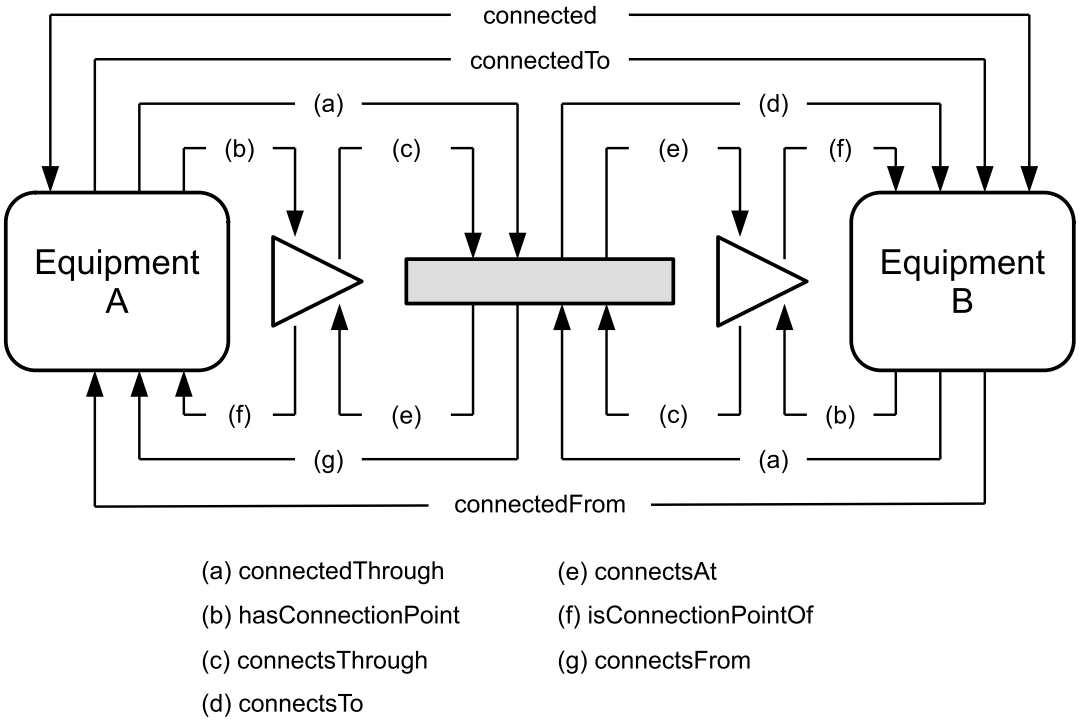


Figure 6-3. Connection Relations.

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.

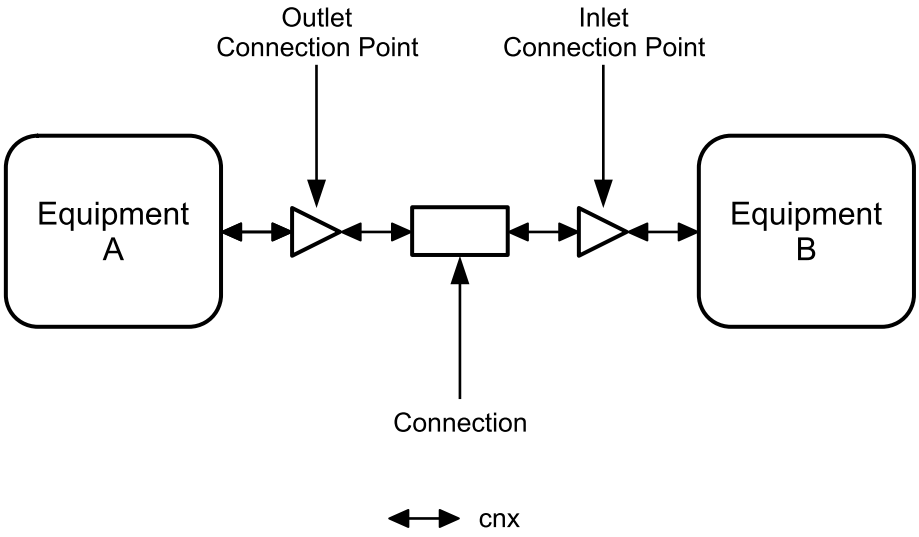


Figure 6-4. CNX Relations.

6.5.1 s223:connected

The relation `connected` indicates that two connectable things are `connected` without regard to the direction of flow.

6.5.2 s223:connectedTo

The relation `connectedTo` indicates that connectable things are `connected` with a specific direction of flow. A is `connectedTo` B, means a direction of flow from A to B. The inverse direction is indicated by `connectedFrom` (see Clause 6.5.3).

6.5.3 s223:connectedFrom

The relation `connectedFrom` indicates that connectable things are `connected` with a specific direction of flow. B is `connectedFrom` A, means that the direction of flow is from A to B. The inverse direction is indicated by `connectedTo` (see Clause 6.5.2).

6.5.4 s223:connectedThrough

A `Relation` that associates a `Connectable` thing with a `Connection`, without regard to the direction of flow. It is used to discover what connection links two connectable things.

6.5.5 s223:connectsTo

A `Relation` that associates a `Connection` with a `Connectable` thing, with an implied direction of flow. A `connectsTo` B indicates a flow from A to B.

6.5.6 s223:connectsFrom

A `Relation` that associates a `Connectable` thing with a `Connection`, with an implied direction of flow. B `connectsFrom` A indicates a flow from A to B.

6.5.7 s223:connectsThrough

A `Relation` that associates a `ConnectionPoint` with a `Connection`, without regard to the direction of flow.

6.5.8 s223:connectsAt

A `Relation` that associates a `Connection` with a specific `ConnectionPoint`.

6.5.9 s223:hasConnectionPoint

One of two `Relations` that associates `Connectable` thing with a `ConnectionPoint`. It is the inverse of the relation `isConnectionPointOf` (see Clause 6.5.10).

6.5.10 s223:isConnectionPointOf

One of two `Relations` that associates a `ConnectionPoint` with a `Connectable` thing. It is the inverse of the relation `hasConnectionPoint` (see Clause 6.5.9).

6.5.11 s223:cnx

A `Relation` that associates adjacent entities in a connection path, comprised of Equipment-ConnectionPoint-Connection-ConnectionPoint-Equipment sequences.

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 `Substance-Medium` (see Clause 10.12.1).

7 SYSTEM

A `System` is a logical grouping of one or more pieces of `Equipment` or other `Systems` defined by the modeler for some functional purpose. Examples of possible systems are an air distribution system, or a hot water system. Systems can be associated with other `Systems` or `Equipment` using the relation `hasMember` (see Clause 7.2) A `System` may be associated with an `EnumerationKind-Role` (see Clause 10.11).

7.1 s223:System

A logical grouping of one or more `Equipment` or other `Systems` for some functional purpose.

Related Constraints

Description	Link
A `System` may be defined with a number of connection points that are the "boundary" of the equipment. The `hasBoundaryConnectionPoint` relation is used to reference those connection points of its equipment that must be connected, but in the context of validating the model with the system by itself, the "dangling connection point" should not generate a validation error.	Link
A `System` may be defined with a number of connection points that are the "boundary" of the equipment. The `hasOptionalConnectionPoint` relation is used to reference those connection points of its equipment that may not be connected, the "dangling connection point" should not generate a validation error.	Link
A `System` shall be associated with at least one instance of `Equipment` or `System` using the relation `hasMember`.	Link
Ensure that the boundary `ConnectionPoints` of a `System` belong to only members of that `System`	Link
If the relation `hasRole` is present, it shall associate the `System` with an `EnumerationKind-Role`.	Link

Related Inference Rules

Description	Link
Infer the `hasBoundaryConnectionPoint` relation using `hasOptionalConnectionPoint`.	Link

7.2 s223:hasMember

A `Relation` that associates a `System` with its component `Equipment` and/or `Systems`.

7.3 s223:hasBoundaryConnectionPoint

The `hasBoundaryConnectionPoint` relation means the `ConnectionPoint` represents the boundary of a `System` (see Clause 7.1) defined by the modeler, such as a model fragment provided by the vendor of a collection of equipment intended for integration with another model. The presence of this relation is used to indicate that such a "dangling connection point" should not generate a validation error in a non-integrated context but should generate an error in an integrated context.

7.4 s223:hasOptionalConnectionPoint

The `hasOptionalConnectionPoint` relation means the `ConnectionPoint` represents the boundary of a `System` (see Clause 7.1) defined by the modeler, such as a model fragment provided by the vendor of a collection of equipment intended for integration with another model. The presence of this relation is used to indicate that such a "dangling connection point" should not generate a validation error in an integrated or non-integrated context.

8 SPACE

There are two types of spaces: `PhysicalSpace`and `DomainSpace`. `PhysicalSpaces` represent the building from the architectural and occupant perspective. A `PhysicalSpace` may represent a room (e.g., an office or conference room), a part of a room (e.g., a foyer), a collection of rooms (e.g., a floor or the entire building), or any other physical region in a building (e.g., a patio or a roof), or a whole campus.

A `DomainSpace` is a subclass of `Connectable` (see Clause 6.1) that represents some portion of a `PhysicalSpace` that is affected by a building service associated with a particular domain (e.g., HVAC, lighting, see Clause 10.5). `DomainSpaces` can be viewed as the endpoints of building services.

`DomainSpaces` can represent an entire `PhysicalSpace` or a portion of a `PhysicalSpace`, and thus `PhysicalSpaces` enclose `DomainSpaces`. An instance of a `PhysicalSpace` may enclose `DomainSpaces` from different domains and may also enclose multiple `DomainSpaces` of the same domain. For example, a `PhysicalSpace` may represent an office that `encloses` a single HVAC `DomainSpace` and multiple lighting `DomainSpaces`. This would indicate a single HVAC service is provided to the office, along with multiple lighting services (e.g., one that provides lighting to the area of the office that receives daylight, and another that provides lighting to the area of the office that does not receive daylight). Multiple `DomainSpaces` of the same domain may overlap. For example, a `DomainSpace` affected by lighting devices that provide general lighting service to a room may overlap with the `DomainSpace` affected by the lighting devices that provide emergency lighting service to a room.

8.1 Physical Space

8.1.1 s223:PhysicalSpace

A `PhysicalSpace` is an architectural concept representing a room, a part of a room, a collection of rooms, or any other physical region in a building. PhysicalSpaces may be grouped to define larger `PhysicalSpaces` using the relation `contains` (see Clause 5.3).

Related Constraints

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

8.1.2 s223:encloses

A `Relation` that associates a `PhysicalSpace` with one or more `DomainSpaces`.

8.1.3 s223:OutdoorPhysicalSpace

A `PhysicalSpace` that is outside of the building where, for example, outdoor ambient properties might be measured, within a suitably defined `DomainSpace`.

8.2 Domain Space

8.2.1 s223:DomainSpace

A `DomainSpace` represents some portion of a `PhysicalSpace` that is affected by a building service associated with a domain. `DomainSpaces` may represent an entire `PhysicalSpace` or any portion of a `PhysicalSpace` (see Clause 8.1.1). Multiple `DomainSpaces` of the same domain may overlap, and `DomainSpaces` of different domains may also overlap. `DomainSpaces` may be grouped into `Zones` using the relation `hasDomainSpace` (see Clause 9.2).

Related Constraints

Description	Link
A `DomainSpace` must be enclosed by a `PhysicalSpace`.	Link
A `DomainSpace` shall 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

8.2.2 s223:hasDomain

A `Relation` that associates a `Zone` or `DomainSpace` with an `EnumerationKind-Domain` (e.g., `Domain-HVAC`, `Domain-Lighting`).

9 ZONE

A `Zone` is a logical grouping of one or more `DomainSpaces` of a specific domain for some building service or control-related purpose. Multiple `Zones` of the same domain may overlap. For example, a `Zone` that defines `DomainSpaces` that are subject to an occupancy-control strategy may overlap with a `Zone` that defines `DomainSpaces` that are subject to a supervisory scheduled-control strategy.

9.1 s223:Zone

A logical grouping of one or more `DomainSpaces` for a specific domain for some building service or control-related purpose. Zones may be grouped into ZoneGroups (see Clause 9.3).

Related Constraints

Description	Link
A `Zone` shall be associated with at least one `DomainSpace` using the relation `hasDomainSpace`.	Link
A `Zone` shall be associated with exactly one `EnumerationKind-Domain` using the relation `hasDomain`.	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
If an instance of `Zone` matches the constraints defined by g36:Zone, it will be declared as an instance of that class.	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

9.2 s223:hasDomainSpace

A `Relation` that associates a `Zone` with its component `DomainSpaces`.

9.3 s223:ZoneGroup

A logical grouping of one or more `Zones` (e.g., to define a supervisory building control strategy that overrides one or more system controls).

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of `ZoneGroup` matches the constraints defined by g36:ZoneGroup, it will be declared as an instance of that class.	Link
Infer a `hasDomain` relation by checking any enclosed `Zones` to determine the domain.	Link

9.4 s223:hasZone

A `Relation` that associates a `ZoneGroup` with its component `Zones`.

10 ENUMERATIONS

Enumerations are sets of values that are closed (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 things e.g., `Properties`, `Equipment`.

10.1 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 class hierarchy tree, 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 classes. Each class is also an instance of itself. This unusual modeling pattern was used to achieve:

- The ability to set an EnumerationKind value that is more general, or not yet fully specified at the time of modeling, such as s223:Electricity-AC without having to state exactly what voltage or frequency it is.
- The ability to use the sh:class SHACL predicate at any level in the EnumerationKind hierarchy to constrain a value in the s223 specification, even if it is a more general one such as s223:Electricity-AC in the above example.

Certain validation constraints exist in the standard that evaluate compatibility of EnumerationKinds. Two values are deemed compatible if they are the same, if one is a direct ancestor (or descendant) of the other, or if they are mixtures sharing at least one constituent.

10.2 s223:EnumerationKind-Aspect

Aspect enumerations provide context to the meaning of a `Property` that would otherwise not be apparent.

10.2.1 Equipment Information

These aspects are used on properties that provide static information about something e.g., a `System`, or `Equipment`. These aspects are typically used on properties of type `Property`. The property value is typically stored as a string.

Aspect Equipment Information Enumerations

Enumeration	Description
`Aspect-CatalogNumber`	The property value is a name or other identifier of the product's manufacturer.
`Aspect-Manufacturer`	The property value is a name or other identifier of the product's manufacturer.
`Aspect-Model`	The property value is a model identifier of the product.
`Aspect-SerialNumber`	The property value is the serial number assigned by the manufacturer to the system or equipment.

10.2.2 Equipment Operation

These aspects are used on properties that provide dynamic information about something e.g., a `System`, or `Equipment`. These aspects are typically used on properties of type `EnumeratedProperty` and subtypes thereof.

Aspect Equipment Operation Enumerations

Enumeration	Description
`Aspect-Alarm`	The property value indicates whether an alarm condition is active or provides details about an active alarm.
`Aspect-Fault`	The property value is a fault indicator or code that signals a malfunction or issue with the system or equipment.
`Aspect-OperatingMode`	The property value is the current intended mode of operation, such as 'Automatic', 'On', or 'Off'.
`Aspect-OperatingStatus`	The property value is the current operational status of the system or equipment, such as 'Running,' 'Stopped,' or 'Maintenance Mode.'

10.2.3 Operational Limits

These aspects are used on properties that define the range of another `Property`. These aspects are used on properties of type `QuantifiableObservableProperty`.

Aspect Operational Limits Enumerations

Enumeration	Description
`Aspect-Maximum`	The property value is a highest specified or observed value. (Examples: upper limit of the specified operating voltage range; maximum measured temperature.)
`Aspect-Minimum`	The property value is a lowest specified or observed value. (Examples: lower limit of the specified operating voltage range; minimum measured temperature.)

Enumeration	Description
`Aspect-Nominal`	The property value is a value that is expected or desired under normal operating conditions, but may not reflect the actual value at all times. (Example: nominal voltage.)
`Aspect-Rated`	The property value indicates a limit for continuous safe operation set by the manufacturer, but may not reflect the actual value at all times (Example: rated voltage)

10.2.4 Control Parameters

These aspects are used on properties that define the limits for control and alarm algorithms. These aspects are used on properties of type `QuantifiableActuatableProperty`.

Aspect Control Parameters Enumerations

Enumeration	Description
`Aspect-Deadband`	The property value is a range around a setpoint where no control action is taken to avoid unnecessary corrections.
`Aspect-HighLimit`	The property value is an upper threshold used in a control or alarm detection algorithm.
`Aspect-LowLimit`	The property value is a lower threshold used in a control or alarm detection algorithm.
`Aspect-Setpoint`	The property value is a target value for a control algorithm.
`Aspect-Threshold`	The property value is a threshold used in a control algorithm.

10.2.5 Delta Quantities

These aspects are used on properties to modify the quantity kind. These aspects are used on properties of type `QuantifiableProperty` and subtypes thereof.

Aspect Delta Quantities Enumerations

Enumeration	Description
`Aspect-Delta`	The property value is a differential value (e.g., pressure difference) instead of an absolute value.

10.3 s223:EnumerationKind-Binary

This class and its enumerated subclasses represent common binary values.

EnumerationKind-Binary Enumerations

Enumeration
`Binary-Logical`

Enumeration
`Binary-OnOff`
`Binary-Position`

10.3.1 s223:Binary-Logical

This class and its enumerated subclasses represent the possible values of a logical `Property` i.e., True or False.

Binary-Logical Enumerations

Enumeration
`Logical-True`
`Logical-False`

10.3.2 s223:Binary-OnOff

This class and its enumerated subclasses represent basic operational states i.e., On and Off.

Binary-OnOff Enumerations

Enumeration
`OnOff-Off`
`OnOff-On`

10.3.3 s223:Binary-Position

This class and its enumerated subclasses represent basic positional states i.e., Closed and Open.

Binary-Position Enumerations

Enumeration
`Position-Closed`
`Position-Open`

10.4 s223:EnumerationKind-DayOfWeek

This class and its enumerated subclasses represent the days of the week, according to the Gregorian calendar i.e., 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.

EnumerationKind-DayOfWeek Enumerations

Enumeration
`DayOfWeek-Weekday`
`DayOfWeek-Weekend`

10.4.1 s223:DayOfWeek-Weekday

This class and its enumerated subclasses represent weekdays, according to the Gregorian calendar i.e., Monday, Tuesday, Wednesday, Thursday, and Friday.

DayOfWeek-Weekday Enumerations

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

10.4.2 s223:DayOfWeek-Weekend

This class and its enumerated subclasses represent weekend days, according to the Gregorian calendar i.e., Saturday and Sunday.

DayOfWeek-Weekend Enumerations

Enumeration
Weekend-Saturday
Weekend-Sunday

10.5 s223:EnumerationKind-Domain

This class and its enumerated subclasses represent building systems and services e.g., HVAC, Lighting, and Plumbing.

EnumerationKind-Domain Enumerations

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

10.6 s223:EnumerationKind-ElectricalPhaseIdentifier

This class and its enumerated subclasses represent all possible electrical phases for AC electricity service.

EnumerationKind-ElectricalPhaseIdentifier Enumerations

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

10.6.1 s223:hasElectricalPhase

A `Relation` that associates an AC electricity `Medium` with its electrical phase identifier.

10.7 s223:EnumerationKind-ElectricalVoltagePhases

This class and its enumerated subclasses represent all possible phase pairs for AC electricity service voltages.

EnumerationKind-ElectricalVoltagePhases Enumerations

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

10.8 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 string.

Related Constraints

Description	Link
An `EnumerationKind-Numerical` can be associated with a decimal value using the relation `hasValue`.	Link
An `EnumerationKind-Numerical` shall be associated with at least one QuantityKind using the relation `hasQuantityKind`.	Link
An `EnumerationKind-Numerical` shall be associated with at least one Unit using the relation `hasUnit`.	Link

10.8.1 s223:Numerical-Frequency

This class and its enumerated subclasses represent common frequencies for AC electricity service.

Numerical-Frequency Enumerations

Enumeration
`Frequency-50Hz`
`Frequency-60Hz`

Related Constraints

Description	Link
A `Numerical-Frequency` shall have a `QuantityKind` of `Frequency`	Link
A `Numerical-Frequency` shall have a `Unit` of `Hertz`	Link

10.8.2 s223:Numerical-LineLineVoltage

This class and its enumerated instances represent common line-line voltages for AC electricity service.

Numerical-LineLineVoltage Enumerations

Enumeration
`LineLineVoltage-10000V`
`LineLineVoltage-190V`
`LineLineVoltage-208V`
`LineLineVoltage-220V`
`LineLineVoltage-240V`
`LineLineVoltage-3000V`
`LineLineVoltage-3300V`
`LineLineVoltage-380V`
`LineLineVoltage-400V`
`LineLineVoltage-415V`

Enumeration
`LineLineVoltage-4160V`
`LineLineVoltage-480V`
`LineLineVoltage-6000V`
`LineLineVoltage-600V`
`LineLineVoltage-6600V`

Related Constraints

Description	Link
A Numerical-LineLineVoltage shall have a `Numerical-Voltage`	Link

10.8.3 s223:Numerical-LineNeutralVoltage

This class and its enumerated subclasses represent common line-neutral voltages for AC electricity service.

Numerical-LineNeutralVoltage Enumerations

Enumeration
`LineNeutralVoltage-110V`
`LineNeutralVoltage-120V`
`LineNeutralVoltage-127V`
`LineNeutralVoltage-139V`
`LineNeutralVoltage-1730V`
`LineNeutralVoltage-1900V`
`LineNeutralVoltage-208V`
`LineNeutralVoltage-219V`
`LineNeutralVoltage-230V`
`LineNeutralVoltage-2400V`
`LineNeutralVoltage-240V`
`LineNeutralVoltage-24V`
`LineNeutralVoltage-277V`
`LineNeutralVoltage-3460V`
`LineNeutralVoltage-347V`
`LineNeutralVoltage-3810V`
`LineNeutralVoltage-5770V`

Related Constraints

Description	Link
A Numerical-LineNeutralVoltage shall have a `Numerical-Voltage`	Link

10.8.4 s223:Numerical-NumberOfElectricalPhases

This class and its enumerated subclasses represent all possible service phases for AC electricty service i.e., one or single-phase, and three-phase. The `s223:hasNumberOfElectricalPhases` relation points to one of the values of this enumeration.

Numerical-NumberOfElectricalPhases Enumerations

Enumeration
`NumberOfElectricalPhases-SinglePhase`
`NumberOfElectricalPhases-ThreePhase`

10.8.5 s223:Numerical-Voltage

This class and its enumerated subclasses represent common voltages for electricty service.

Numerical-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-230V`
`Voltage-2400V`
`Voltage-240V`
`Voltage-24V`
`Voltage-277V`
`Voltage-2V`
`Voltage-3000V`

Enumeration
`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`
`Voltage-DCVoltage` (see Clause 10.8.5.1)
`Voltage-PoE` (see Clause 10.8.5.2)

Related Constraints

Description	Link
A `Numerical-Voltage` shall have a `QuantityKind` of `Voltage`	Link
A `Numerical-Voltage` shall have a `Unit` of `Volts`	Link

10.8.5.1 s223:Voltage-DCVoltage

This class and its enumerated subclasses represent all possible DC voltage polarities (i.e., positive, negative, and zero) for DC electricity service.

Voltage-DCVoltage Enumerations

Enumeration
`DCVoltage-DCNegativeVoltage` (see Clause 10.8.5.1.1)
`DCVoltage-DCPositiveVoltage` (see Clause 10.8.5.1.2)
`DCVoltage-DCZeroVoltage`

Related Constraints

Description	Link
A DC-Voltage shall have a `Numerical-Voltage`	Link

10.8.5.1.1 s223:DCVoltage-DCNegativeVoltage

This class and its enumerated subclasses represent common negative voltages for DC electricity service.

DCVoltage-DCNegativeVoltage 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`

10.8.5.1.2 s223:DCVoltage-DCPositiveVoltage

This class and its enumerated subclasses represent common positive voltages for DC electricity service.

DCVoltage-DCPositiveVoltage 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`
`DCPositiveVoltage-PoE`

10.8.5.2 s223:Voltage-PoE

This class represents the standardized 44-57VDC range that is produced by PoE Power Sourcing Equipment

10.8.6 s223:hasFrequency

A `Relation` that associates an AC electricity `Medium with its electrical frequency.

10.8.7 s223:hasVoltage

A `Relation` that associates an electricity `Medium` with an electrical voltage.

10.9 s223:EnumerationKind-Occupancy

This class and its enumerated subclasses represent the occupancy status of a space within a building, i.e., the state of being used or occupied by a human being. Some occupancy enumerations have subclasses for more specific use.

EnumerationKind-Occupancy Enumerations

Enumeration
`Occupancy-Occupied`
`Occupancy-Unoccupied`

10.9.1 s223:Occupancy-Motion

This class and its enumerated subclasses represent the detection of motion in a space.

Occupancy-Motion Enumerations

Enumeration
`Motion-False`
`Motion-True`

10.9.2 s223:Occupancy-Presence

This class and its enumerated subclasses represent the detection of physical presence in a space.

Occupancy-Presence Enumerations

Enumeration
`Presence-False`
`Presence-True`

10.10 s223:EnumerationKind-ThermodynamicPhase

This class and its enumerated subclasses represent thermodynamic phases, also referred to as states of matter.

EnumerationKind-Thermodynamic-Phase Enumerations

Enumeration
`ThermodynamicPhase-Gas` (see Clause 10.10.1)
`ThermodynamicPhase-Liquid` (see Clause 10.10.2)
`ThermodynamicPhase-Solid`
`ThermodynamicPhase-Vapor`

10.10.1 s223:ThermodynamicPhase-Gas

This class and its enumerated subclasses represent gas in various thermodynamic states.

ThermodynamicPhase-Gas Enumerations

Enumeration
`Gas-SuperHeated`

10.10.2 s223:ThermodynamicPhase-Liquid

This class and its enumerated subclasses represent liquid in various thermodynamic states.

ThermodynamicPhase-Liquid Enumerations

Enumeration
`Liquid-SubCooled`

10.10.3 s223:hasThermodynamicPhase

A `Relation` that associates a Medium with its thermodynamic phases.

10.11 s223:EnumerationKind-Role

This class and its enumerated subclasses represent roles played by entities, such as cooling, generator, relief, and return. These enumeration kinds are intended to indicate the capability of an entity to play a given role, rather than the role being actively played at any given point in time. For example, a reversible piece of equipment might play a role of `Role-Cooling` at one time, and `Role-Heating` at another time. Such an entity would be modeled using the `hasRole` relation with both role values. The active role at a particular time can be modeled as a `Property` with an ExternalReference to telemetry data.

EnumerationKind-Role Enumerations

Enumeration
`Role-Condenser`
`Role-Cooling`
`Role-Dehumidifying`
`Role-Discharge`

Enumeration
Role-Economizer
Role-Evaporator
Role-Exhaust
Role-Expansion
Role-Generator
Role-HeatRecovery
Role-HeatTransfer
Role-Heating
Role-Load
Role-OutdoorAirIntake
Role-Primary
Role-Recirculating
Role-Relief
Role-Return
Role-Secondary
Role-Supply
Role-Ventilating

10.12 s223:EnumerationKind-Substance

This class and its enumerated subclasses represent things that are produced, conveyed, sensed, controlled, or consumed. Its enumerated subclasses differentate between mediums, particulates, and soot.

EnumberationKind-Substance Enumerations

Enumeration
Substance-Medium (see Clause 10.12.1)
Substance-Particulate (see Clause 10.12.2)
Substance-Soot (see Clause 10.12.3)

Related Constraints

Description	Link
If a substance has a constituent, that constituent may not itself have constituents.	Link
If the relation composedOf is present, it shall associate an EnumerationKind-Substance with one or more Properties that identify and characterize its constituents. The Property identifies the constituent using the relation ofConstituent. If appropriate, a QuantifiableProperty may be used to also specify the amount of the	Link

Description	Link
constituent using the relations `qudt:hasQuantityKind`, `qudt:hasUnit`, and `qudt:hasValue`. For example, see Clause 10.12.1.2.1.2.1.	

10.12.1 s223:Substance-Medium

This class and its enumerated subclasses represent substances that facilitate the conveyance of matter, energy, or information. It is used to qualify `Connection`s and `ConnectionPoint`s with the relation `hasMedium` (see Clause 6.6).

`Substance-Medium` is also the root of the medium hierarchy that is used to ensure compatibility of different medium designations. For example, `Fluid-Water` and `Water-ChilledWater` are alternative but compatible ways of identifying what is flowing in a pipe, using different degrees of specificity. `Water-ChilledWater` and `Water-HotWater` are not compatible. Compatibility is determined by testing if one medium is a subclass of the other. This gets a bit more complicated in the case of mixtures, where at least one of the constituents of a mixture must be compatible with at least one of the constituents of the other medium.

Testing for medium compatibility is done in the context of entities that have a `hasMedium` relation, such as

- `Connection` and its associated `ConnectionPoint`s. See Clause 6.3.
- `Junction` and its associated `ConnectionPoint`s See Clause 6.4.
- `Filter` and its associated `ConnectionPoint`s. See Clause 12.34.
- Any `Concept` that has a `hasMedium` relation, compared with an associated `Property` with an `ofMedium` relation. See Clause 4.6.

These tests are listed in the constraint tables for the respective classes listed above, identified as Case 1, Case 2, etc.

Substance-Medium Enumerations

Enumeration
`Medium-Constituent` (see Clause 10.12.1.1)
`Medium-Mix` (see Clause 10.12.1.2)
`Medium-ThermalContact`

10.12.1.1 s223:Medium-Constituent

This class and its enumerated subclasses represent substances that may be combined to form a `Medium-Mix`. Constituents are distinguished from `Medium-Mix` and its subclasses in that constituents cannot use the `composedOf` relation to reference a concentration of other constituents.

Medium-Constituent Enumerations

Enumeration
`Constituent-CO2`
`Constituent-CO`
`Constituent-Electricity` (see Clause 10.12.1.1.1)
`Constituent-EM` (see Clause 10.12.1.1.2)
`Constituent-Glycol`
`Constituent-H2O`
`Constituent-H2S`
`Constituent-CH4`
`Constituent-NOX` (see Clause 10.12.1.1.3)
`Constituent-O3`
`Constituent-Radon`
`Constituent-SO2`
`Constituent-VolatileOrganicCompounds`

10.12.1.1.1 s223:Constituent-Electricity

This class and its enumerated subclasses represent common forms of electrical energy, including AC, DC, and electrical communication signals.

Constituent-Electricity Enumerations

Enumeration
`Electricity-AC` (see Clause 10.12.1.1.1.1)
`Electricity-DC` (see Clause 10.12.1.1.1.2)
`Electricity-Earth`
`Electricity-Neutral`
`Electricity-Signal` (see Clause 10.12.1.1.1.3)

10.12.1.1.1.1 s223:Electricity-AC

This class and its enumerated subclasses represent common AC electricity services.

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`

Enumeration
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
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-208VLN-1Ph-60Hz
AC-219VLN-1Ph-60Hz
AC-220VLL-127VLN-1Ph-50Hz
AC-220VLL-127VLN-3Ph-50Hz
AC-220VLL-1Ph-50Hz
AC-220VLL-3Ph-50Hz
AC-230VLN-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

Enumeration
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
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-230VLN-1Ph-50Hz
AC-400VLL-230VLN-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

Enumeration
AC-6600VLL-1Ph-60Hz
AC-6600VLL-3810VLN-1Ph-60Hz
AC-6600VLL-3810VLN-3Ph-60Hz
AC-6600VLL-3Ph-60Hz

Related Constraints

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

10.12.1.1.1.1.1 s223:hasNumberOfElectricalPhases

A `Relation` that associates an AC electricity `Medium` with its number of electrical phases.

10.12.1.1.1.1.2 1-Phase 3-Wire (LLN) 120V/240V

A 1-phase (also referred to as split-phase), 3-wire, 120V/240V transformer, the 3 electricity services it is capable of providing, and their associated mediums.

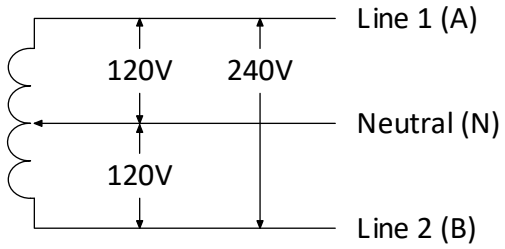


Figure 10-1. 1-Phase 3-Wire (LLN) 120V/240V

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

10.12.1.1.1.1.3 3-Phase 3-Wire (LLL) 480V Delta

A 3-phase, 3-wire, 480V Delta transformer, the 2 AC electricity services it is capable of providing, and their associated mediums.

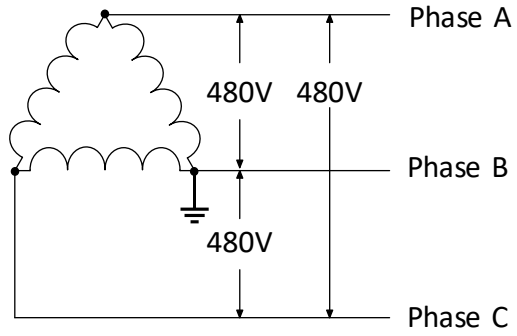


Figure 10-2. 3-Phase 3-Wire (LLL) 480V Delta

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

10.12.1.1.1.1.4 3-Phase 4-Wire (LLLN) 347V/600V Wye

A 3-phase, 4-Wire, 347V/600V Wye transformer, the 3 AC electricity services it is capable of providing, and their associated mediums.

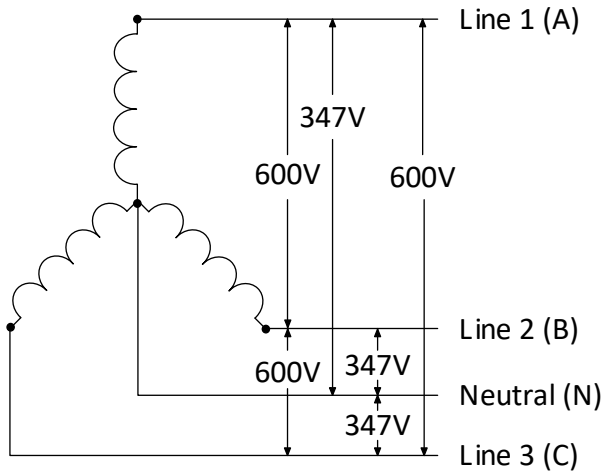


Figure 10-3. 3-Phase 4-Wire (LLLN) 347V/600V Wye

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-600VLL-347VLN-3Ph-60Hz	3	600	347	US, Canada	ABCN
AC-600VLL-1Ph-60Hz	2	600	-	US, Canada	AB, BC, AC
AC-347VLN-1Ph-60Hz	2	-	347	US, Canada	AN, BN, CN

10.12.1.1.1.1.5 3-Phase 4-Wire (LLLN) 120V/208V/240V High Leg Delta

A 3-Phase, 4-Wire, 120V/208V/240V High Leg Delta transformer, the 6 AC electricity services it is capable of providing, and their associated mediums.

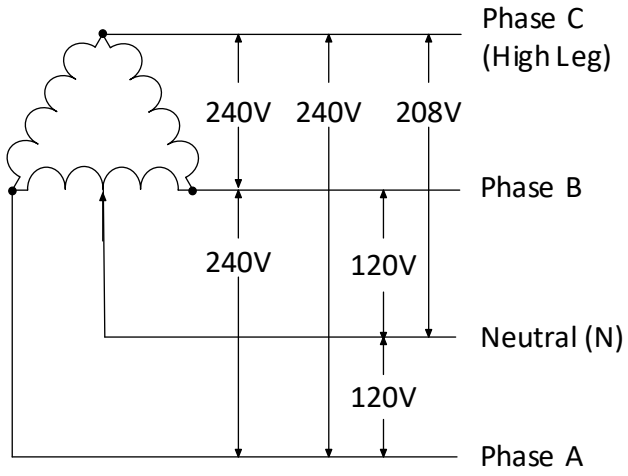


Figure 10-4. 3-Phase 4-Wire (LLLN) 120V/208V/240V High Leg Delta

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

10.12.1.1.1.1.6 3-Phase 4-Wire (LLLN) 120V/208V Wye

A 3-phase, 4-wire 120V/208V Wye transformer, the 5 AC electricity services it is capable of providing, and their associated mediums.

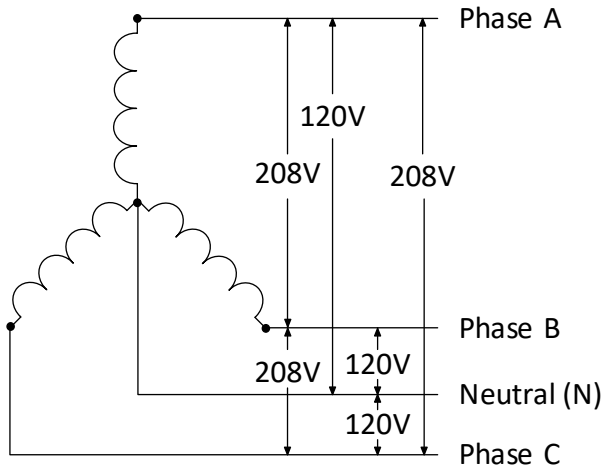


Figure 10-5. 3-Phase 4-Wire (LLLN) 120V/208V Wye

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

10.12.1.1.1.1.7 3-Phase 4-Wire (LLLN) 230V/400V Wye

A 3-phase, 4-wire 230V/400V Wye transformer, the 5 AC electricity services it is capable of providing, and their associated mediums.

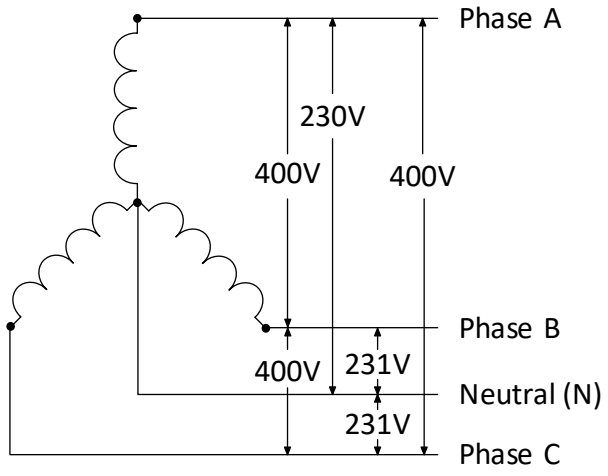


Figure 10-6. 3-Phase 4-Wire (LLLN) 230V/400V Wye

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-400VLL-230VLN-3Ph-50Hz	4	400	230	EU	ABCN
AC-400VLL-230VLN-1Ph-50Hz	4	400	230	EU	ABN, BCN, ACN
AC-400VLL-3Ph-50Hz	3	400	-	EU	ABC
AC-400VLL-1Ph-50Hz	2	400	-	EU	AB, BC, AC
AC-230VLN-1Ph-50Hz	3	-	230	EU	AN, BN, CN

10.12.1.1.1.1.8 3-Phase 4-Wire (LLLN) 240V/415V Wye

A 3-phase, 4-wire, 240V/415V Wye transformer, the 5 AC electricity services it is capable of providing, and their associated mediums.

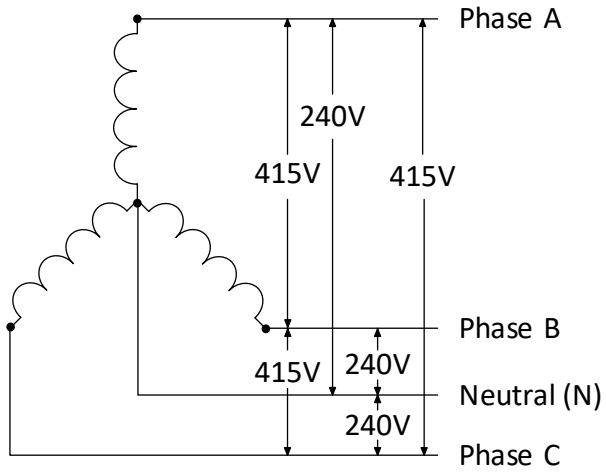


Figure 10-7. 3-Phase 4-Wire (LLLN) 240V/415V Wye

Medium	# wires	L-L	L-N	Countries	Phase Possibilities
AC-415VLL-240VLN-3Ph-50Hz	4	415	240	Australia	ABCN
AC-415VLL-240VLN-1Ph-50Hz	3	415	240	Australia	ABN, BCN, ACN
AC-415VLL-3Ph-50Hz	3	415	-	Australia	ABC
AC-415VLL-1Ph-50Hz	2	415	-	Australia	AB, BC, AC
AC-240VLN-1Ph-50Hz	2	-	240	Australia	AN, BN, CN

10.12.1.1.1.2 s223:Electricity-DC

This class and its enumerated subclasses represent common DC electricity services.

Electricity-DC Enumerations

Enumeration
DC-12V
DC-24V

Enumeration
DC-380V
DC-48V
DC-5V
DC-6V
DC-PoE

Related Constraints

Description	Link
A DC electricity medium shall have one or two reference voltages.	Link

10.12.1.1.1.2.1 s223:DC-12V

This class and its enumerated subclasses represent all polarities of 12 volt DC electricity.

DC-12V Enumerations

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

10.12.1.1.1.2.2 s223:DC-24V

This class and its enumerated subclasses represent all polarities of 24 volt DC electricity.

DC-24V Enumerations

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

10.12.1.1.1.2.3 s223:DC-380V

This class and its enumerated subclasses represent all polarities of 380 volt DC electricity.

DC-380V Enumerations

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

10.12.1.1.1.2.4 s223:DC-48V

This class and its enumerated subclasses represent all polarities of 48 volt DC electricity.

DC-48V Enumerations

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

10.12.1.1.1.2.5 s223:DC-5V

This class and its enumerated subclasses represent all polarities of 5 volt DC electricity.

DC-5V Enumerations

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

10.12.1.1.1.2.6 s223:DC-6V

This class and its enumerated subclasses represent all polarities of 6 volt DC electricity.

DC-6V Enumerations

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

10.12.1.1.1.2.7 s223:DC-PoE

This class and its enumerated subclasses represent standardized types of PoE DC electricity.

DC-PoE Enumerations

Enumeration
PoE-802.3af-1
PoE-802.3at-2
PoE-802.3bt-3
PoE-802.3bt-4

10.12.1.1.1.3 s223:Electricity-Signal

This class and its enumerated subclasses represent the use of electricity for creating communication signals, and common communication protocols.

Electricity-Signal Enumerations

Enumeration
`Signal-EIA485`
`Signal-WiredEthernet` (see Clause 10.12.1.1.1.3.1)
`Signal-IEC14908`
`Signal-Modulated` (see Clause 10.12.1.1.1.3.2)
`Signal-USB`

10.12.1.1.1.3.1 s223:Signal-WiredEthernet

This class and its enumerated subclasses represent common wired Ethernet protocols.

Signal-WiredEthernet Enumerations

Enumeration
`WiredEthernet-Cat1`
`WiredEthernet-Cat2`
`WiredEthernet-Cat3`
`WiredEthernet-Cat4`
`WiredEthernet-Cat5`
`WiredEthernet-Cat5e`
`WiredEthernet-Cat6`
`WiredEthernet-Cat6a`
`WiredEthernet-Cat7`
`WiredEthernet-Cat7a`
`WiredEthernet-Cat8`

10.12.1.1.1.3.2 s223:Signal-Modulated

This class and its enumerated subclasses represent common analog communication protocols.

Signal-Modulated Enumerations

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

10.12.1.1.2 s223:Constituent-EM

This class and its enumerated subclasses represent electromagnetic energy at commonly defined frequency ranges.

Constituent-EM Enumerations

Enumeration
`EM-Light` (see Clause 10.12.1.1.2.1)
`EM-Microwave`
`EM-RF` (see Clause 10.12.1.1.2.2)

10.12.1.1.2.1 s223:EM-Light

This class and its enumerated subclasses represent light at commonly defined frequency or wavelength ranges.

EM-Light Enumerations

Enumeration
`Light-Infrared` (see Clause 10.12.1.1.2.1.1)
`Light-Ultraviolet`
`Light-Visible`

10.12.1.1.2.1.1 s223:Light-Infrared

This class and its enumerated subclasses represent the use of electromagnetic energy in the infrared frequency range for multiple purposes, including communication signals.

Light-Infrared Enumerations

Enumeration
`Infrared-Signal` (see Clause 10.12.1.1.2.1.1.1)

10.12.1.1.2.1.1.1 s223:Infrared-Signal

This class and its enumerated subclasses represent common infrared communication protocols.

Infrared-Signal Enumerations

Enumeration
`Signal-FiberEthernet` (see Clause 10.12.1.1.2.1.1.1.1)

10.12.1.1.2.1.1.1.1 s223:Signal-FiberEthernet

This class and its enumerated subclasses represent common fiber Ethernet communication protocols.

Signal-FiberEthernet Enumerations

Enumeration
FiberEthernet-OM1
FiberEthernet-OM2
FiberEthernet-OM3
FiberEthernet-OM4
FiberEthernet-OM5
FiberEthernet-OS1
FiberEthernet-OS2

Signal-FiberEthernet

10.12.1.1.2.2 s223:EM-RF

This class and its enumerated subclasses represent the use electromagnetic energy in the radio frequency range for multiple purposes, including communication signals.

EM-RF Enumerations

Enumeration
RF-Signal

10.12.1.1.3 s223:Constituent-NOX

This class and its enumerated subclasses represent common Nitrogen Oxides (NOx).

Constituent-NOX Enumerations

Enumeration
NOX-NO
NOX-NO2

10.12.1.2 s223:Medium-Mix

This class and its subclasses represent substances that are composed of constituents. The components of a Medium-Mix can be modeled using the relations composedOf and ofConstituent. See Figure 10-8a and Figure 10-8b.

Figure 10-8a shows GlycolSolution-30Percent, itself a subclass of Water-GlycolSolution, Fluid-Water, and Mix-Fluid, with a *Water Concentration* property referencing 70% Constituent-H2O by the relation ofConstituent and a *Glycol Concentration* property referencing 30% Constituent-Glycol also Property referencing 70% Constituent-Water by the relation ofConstituent and a *Glycol Concentration* Property referencing 30% Constituent-Glycol also by the relation ofConstituent.

Figure 10-8b shows `PowerandSignal-PoE`, itself a subclass of `Mix-PowerAndSignal`, composed of a *Power* `Property` referencing `Fluid-DC` and a *Communications* `Property` referencing `Signal-WiredEthernet`.

Medium-Mix Enumerations

Enumeration
`Mix-Fluid` (see Clause 10.12.1.2.1)
`Mix-PowerAndSignal` (see Clause 10.12.1.2.2)

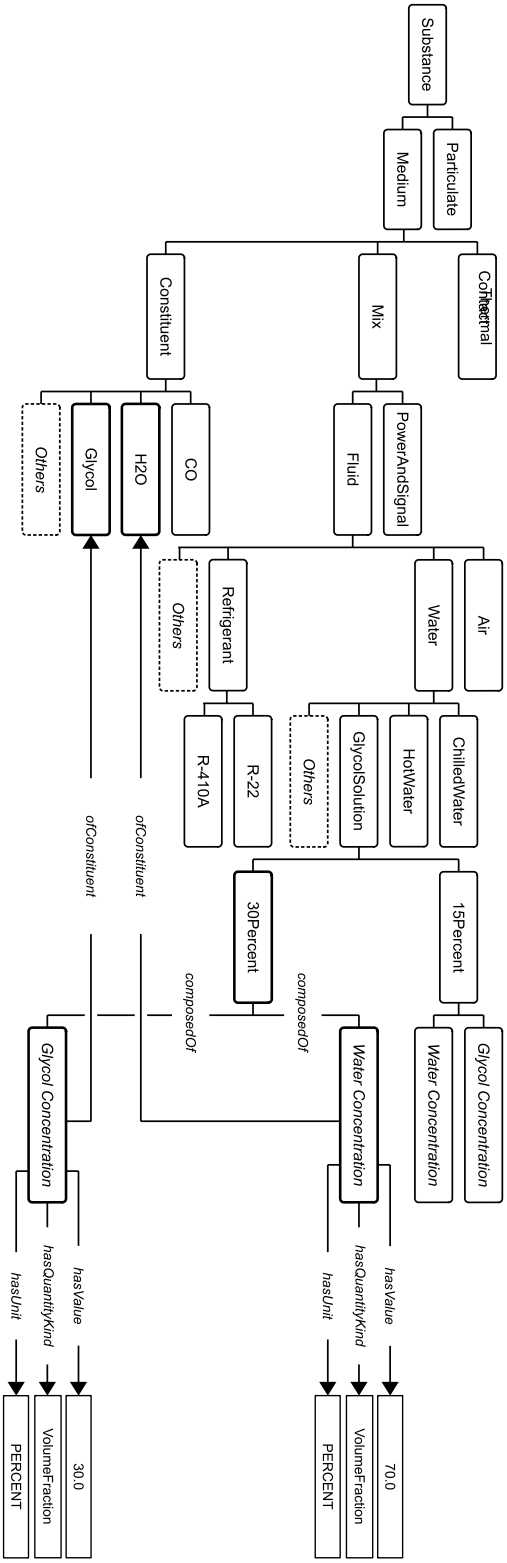


Figure 10-8a, Constituents of 30% Glycol Solution

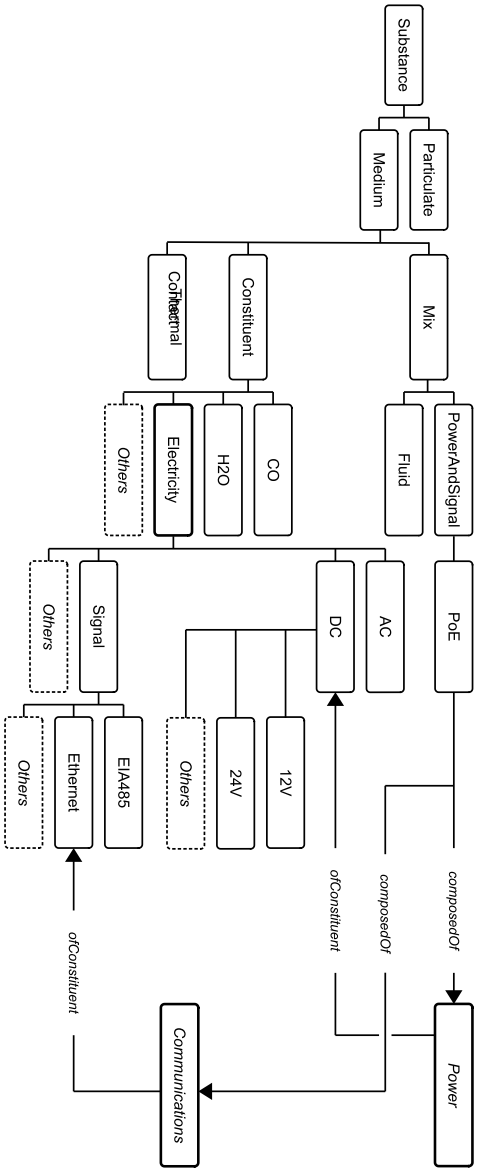


Figure 10-8b, Constituents of Power over Ethernet

Figure 10-8.

10.12.1.2.1 s223:Mix-Fluid

This class and its enumerated subclasses represent substances that are commonly used to convey liquids or gases.

Mix-Fluid Enumerations

Enumeration
`Fluid-Air`
`Fluid-NaturalGas`
`Fluid-Oil`
`Fluid-Refrigerant` (see Clause 10.12.1.2.1.1)
`Fluid-Water` (see Clause 10.12.1.2.1.2)

10.12.1.2.1.1 s223:Fluid-Refrigerant

This class and its enumerated subclasses represent commonly used refrigerants.

Fluid-Refrigerant Enumerations

Enumeration
`Refrigerant-R-123`
`Refrigerant-R-134A`
`Refrigerant-R-22`
`Refrigerant-R-290`
`Refrigerant-R-404A`
`Refrigerant-R-407C`
`Refrigerant-R-410A`
`Refrigerant-R-600A`
`Refrigerant-R-717`
`Refrigerant-R-744`

10.12.1.2.1.2 s223:Fluid-Water

This class and its enumerated subclasses represent water and aqueous solutions in various states.

Fluid-Water Enumerations

Enumeration
`Water-ChilledWater`
`Water-GlycolSolution` (see Clause 10.12.1.2.1.2.1)
`Water-HotWater`
`Water-Steam`

10.12.1.2.1.2.1 s223:Water-GlycolSolution

This class and its enumerated subclasses represent common concentrations of water-glycol solution.

Water-GlycolSolution Enumerations

Enumeration
`GlycolSolution-15Percent`
`GlycolSolution-30Percent`

Related Constraints

Description	Link
If the relation `hasFreezingPoint` is used, the object shall be a `QuantifiableProperty` with a `QuantityKind` of `Temperature`.	Link
One of the constituents of a `Water-GlycolSolution` shall be `Constituent-Glycol`.	Link
One of the constituents of a `Water-GlycolSolution` shall be `Constituent-H2O`.	Link
There shall be at least two QuantifiableProperties that characterize the constituents of a `Water-GlycolSolution`.	Link

10.12.1.2.1.2.1.1 s223:hasFreezingPoint

The relation `hasFreezingPoint` is used to associate a freezing point with a glycol solution, but could be used with other Mediums as appropriate.

10.12.1.2.2 s223:Mix-PowerAndSignal

This class and its enumerated subclasses represent substances that are used to convey the combination of electrical power and electrical communication signals.

Mix-PowerAndSignal Enumerations

Enumeration
`PowerAndSignal-PoE`

10.12.2 s223:Substance-Particulate

This class and its enumerated subclasses represent common size thresholds of interest for particulate matter that is suspended in a medium in a way that maintains the physical and chemical properties of the medium.

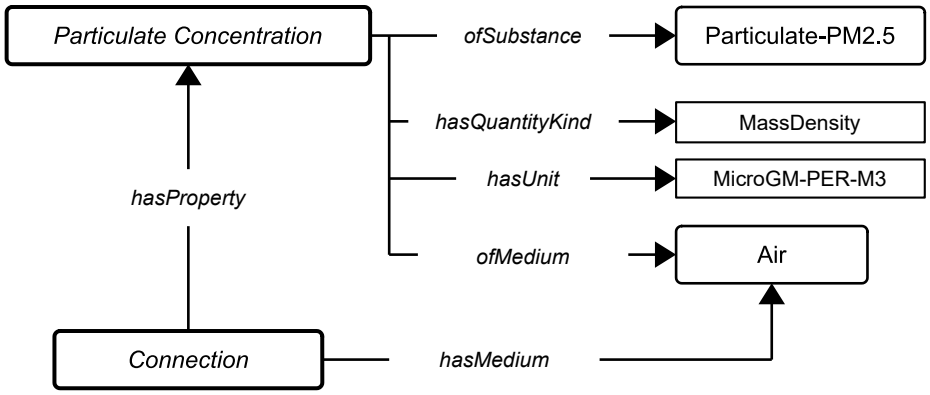


Figure 10-9. Particulate Concentration

Figure 10-9 shows an instance of a `Connection` with `hasMedium` referencing `Fluid-Air` that has a `Property` *Particulate Concentration* of particles with a diameter of 2.5 micrometres (0.0025 mm) or smaller in units of micrograms per cubic meter.

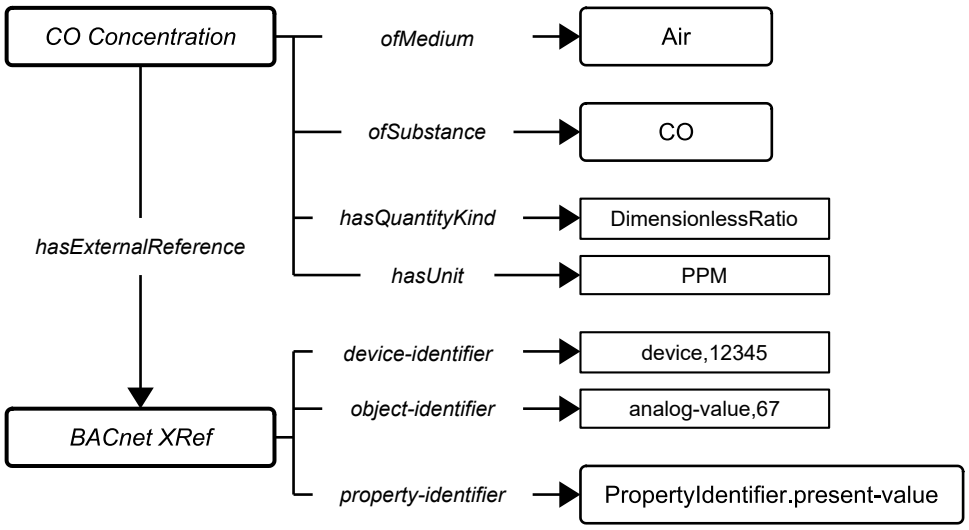


Figure 10-10. Carbon Monoxide Concentration

Figure 10-10 shows an instance of a `Property` *CO Concentration* with `ofSubstance` referencing carbon monoxide `Constituent-CO` and `ofMedium` referencing `Fluid-Air` measured in parts-per-

million. This figure also shows that the value of this `Property` can be obtained by using the BACnet protocol via the external reference to get the `present-value` of `analog-value,67` in the device with an instance number `12345`.

Substance-Particulate Enumerations

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

10.12.3 s223:Substance-Soot

Carbon particles resulting from the incomplete combustion of hydrocarbons. Soot is considered a hazardous substance with carcinogenic properties.

11 PROPERTIES AND VALUES

Things have properties, and properties have values.

11.1 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` - subclass of `Property` that can be modified by user or machine outside of the model (typically command); `ObservableProperty` - subclass of `Property` that are observed (typically measures); `EnumerableProperty` - subclass of `Property` defined by `EnumerationKind`; `QuantifiableProperty` - subclass of `Property` defined by numerical values.

And their subclass combinations : `QuantifiableActuatableProperty`, `QuantifiableObservableProperty`, `EnumeratedObservableProperty`, `EnumeratedActuatableProperty`.

A `QuantifiableProperty` (or subClass thereof) shall 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 a `QuantityKind` if it is unambiguous.

Enumerable properties shall be associated with an `EnumerationKind`. Different flavors of properties are shown in Figure 11-1.

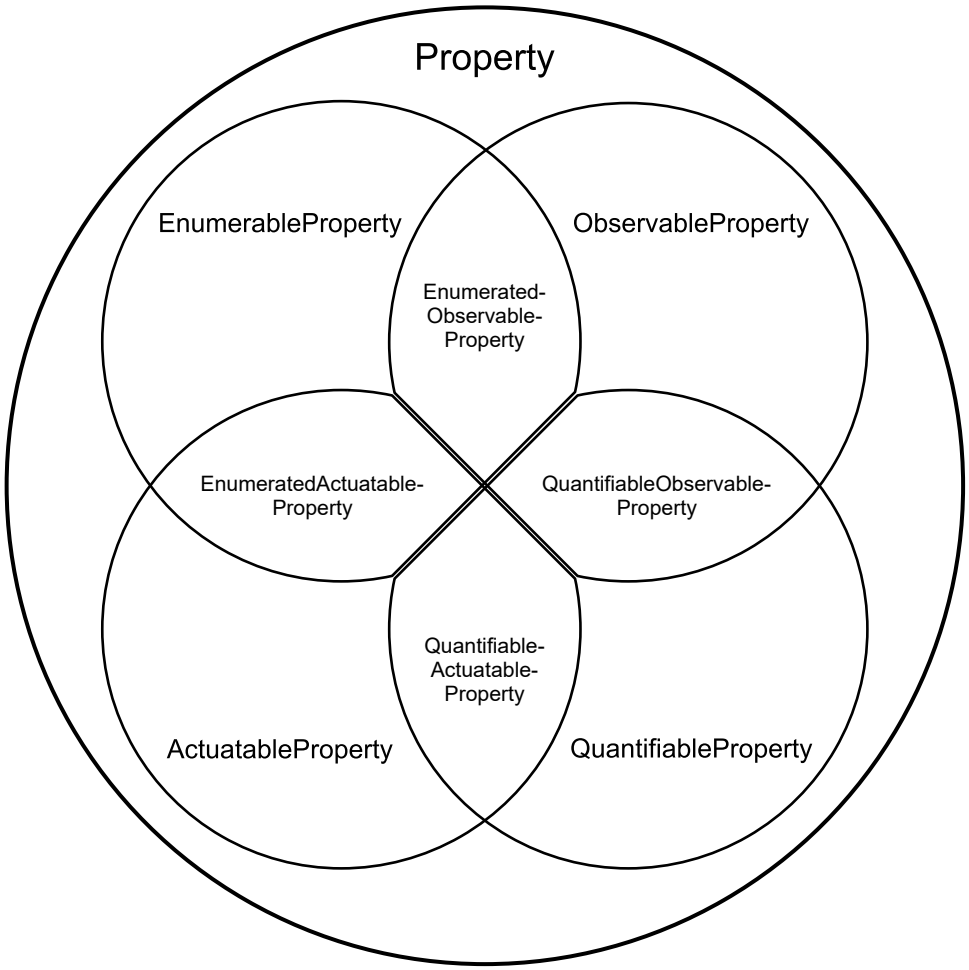


Figure 11-1. Different flavors of Properties

A `Property` instance that is not an instance of one of the subclasses is unconstrained with respect to its value.

Related Constraints

Description	Link
A `Property` can be associated with at most one `EnumerationKind-Substance` using the relation `ofSubstance`.	Link
A `Property` can be associated with at most one `Function` using the inverse relation `hasOutput`.	Link
A `Property` can be associated with at most one `Substance-Medium` using the relation `ofMedium`.	Link

Description	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 11.19).	Link
A `Property` cannot be declared an instance of both an `ActuatableProperty` and an `ObservableProperty`.	Link
A `Property` must not be observed (set) by more than one entity.	Link
A `Property` must not have both a `hasExternalReference` and a `hasValue` relation.	Link
A `Property` must not have both a `hasInternalReference` and a `hasExternalReference` relation.	Link
A `Property` must not have both a `hasInternalReference` and a `hasValue` relation.	Link
If a `Property` has an `ofSubstance` relation, it should also have an `ofMedium` relation.	Link
If an incoming relation `composedOf` exists, then the `Property` must have a declared substance using the relation `ofConstituent`.	Link
If the relation `hasAspect` is present, it shall associate the `Property` with an `EnumerationKind`.	Link
If the relation `hasExternalReference` is present it shall associate the `Property` with an `ExternalReference`.	Link
If the relation `hasInternalReference` is present it shall associate the `Property` with at most one other `Property`.	Link

11.2 s223:ActuatableProperty

The term “actuatable” implies that writing to the `ActuatableProperty` value will directly trigger a physical actuation by either an `Actuator` or `Equipment`. In contrast, the term “observable” (see Clause 11.3) implies that reading the `ObservableProperty` value will return the result of a physical observation.

Related Constraints

Description	Link
An `ActuatableProperty` normally is referred to by `Equipment` using the relation `actuatedByProperty`.	Link

11.3 s223:ObservableProperty

The term “observable” implies that reading the `ObservableProperty` value will return the result of a physical observation, usually by a `Sensor`.
In contrast, the term “actuatable” (see Clause 11.2) implies that writing to the `ActuatableProperty` value will directly trigger a physical actuation.

Related Constraints

Description	Link
An `ObservableProperty` is usually referred to by a `Sensor` using the relation `observes`.	Link

11.4 s223:EnumerableProperty

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

Related Constraints

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

11.4.1 s223:hasEnumerationKind

A `Relation` that 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.

11.5 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
A `QuantifiableProperty` can be associated with a `QuantifiableProperty` using the relation `hasDeadband`.	Link
A `QuantifiableProperty` can be associated with a `QuantifiableProperty` using the relation `hasSetpoint`.	Link
A `QuantifiableProperty` can be associated with a`QuantifiableProperty` using the relation `hasThreshold`.	Link
A `QuantifiableProperty` can be associated with an `EnumerableProperty` using the relation `hasAlarmStatus`.	Link
A `QuantifiableProperty` can be associated with an optional Boolean flag using the relation isDeltaQuantity. If the relation isDeltaQuantity has a value of true, the associated value should be interpreted as a difference reading, such as a temperature difference. This is needed to distinguish between a temperature reading and a temperature difference reading, which affects unit conversion calculations.	Link

Description	Link
A `QuantifiableProperty` can be associated with at most one `Unit` using the relation `hasUnit`.	Link
A `QuantifiableProperty` shall be associated with a `QuantityKind` using the relation `hasQuantityKind`.	Link
A `QuantifiableProperty` should use `s223:hasValue` instead of `qudt:value`.	Link
Checks for consistent dimension vectors for a `QuantityKind` and the `Unit`	Link
Normally, a `QuantifiableProperty` is associated with a static decimal value using `hasValue`, along with a single `Unit` and `QuantityKind`. However, in some cases, a `QuantifiableProperty` may instead be associated with a `QuantityValue` using the relation `quantityValue`. This allows the `QuantityValue` to express multiple equivalent combinations of `Unit` and value.	Link
This `QuantifiableProperty` and the Setpoint associated with it have non-commensurate `QuantityKind`s.	Link
This `QuantifiableProperty` and the associated deadband use non-commensurate `Unit`s.	Link
This `QuantifiableProperty` and the associated setpoint use non-commensurate `Unit`s.	Link
This `QuantifiableProperty` and the associated threshold use non-commensurate `Unit`s.	Link
This `QuantifiableProperty` and the deadband associated with it have non-commensurate `QuantityKind`s.	Link
This `QuantifiableProperty` and the threshold associated with it have non-commensurate `QuantityKind`s.	Link
This `QuantifiableProperty` cannot have a value without a `Unit`.	Link
This `QuantifiableProperty` uses a different `Unit` than the deadband associated with it.	Link
This `QuantifiableProperty` uses a different `Unit` than the setpoint associated with it.	Link
This `QuantifiableProperty` uses a different `Unit` than the threshold associated with it.	Link

Related Inference Rules

Description	Link
Infer the `hasAspect s223:Aspect-Deadband` for properties referred to by `hasDeadband`	Link
Infer the `hasAspect s223:Aspect-Setpoint` for properties referred to by `hasSetpoint`	Link
Infer the `hasAspect s223:Aspect-Threshold` for properties referred to by `hasThreshold`	Link

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

11.5.1 s223:hasAlarmStatus

A `Relation` that associates an `EnumerableProperty` that describes an Alarm or Status with a `QuantifiableProperty`.

11.5.2 s223:hasDeadband

This relation binds a control setpoint to the `QuantifiableProperty` indicating the range of values within which a sensed variable can vary without indicating a condition has changed.

11.5.3 s223:hasSetpoint

A `Relation` that associates a control setpoint with the `QuantifiableProperty` indicating the desired value which the control process is trying to maintain.

11.5.4 s223:hasThreshold

A `Relation` that associates a threshold with the `QuantifiableProperty` indicating a specific value at which an action may be taken, distinguished from an offset or a range.

11.6 s223:QuantifiableActuatableProperty

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

11.7 s223:QuantifiableObservableProperty

This class is for instances of `QuantifiableProperty` for which numerical values are observed, like a temperature reading or a voltage measure.

Related Constraints

Description	Link
A `QuantifiableObservableProperty` can be associated with zero or more `QuantifiableProperty`(s) indicating the desired value(s) which the control process is trying to maintain using the relation `hasSetpoint`.	Link

11.8 s223:EnumeratedObservableProperty

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

11.9 s223:EnumeratedActuatableProperty

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

11.10 s223:hasValue

A `Relation` that associates something with a fixed value, as opposed to a computed, measured, or externally derived value.

11.11 qudt:hasUnit

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

11.12 qudt:hasQuantityKind

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

11.13 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.

11.14 s223:ofSubstance

A `Relation` that associates a `Property` being observed by a `Sensor` with the `Substance` it characterizes within a specific `Medium`. For example, to denote the concentration of a `Substance` in a `Medium`, `ofSubstance` is used. Typically, there is also an `ofMedium` relation between the observed `Property` and the `Medium`, (see Figures 10-9 and 10-10). For example, to represent the concentration of CO2 in air, we use `ofSubstance` to relate to CO2 and `ofMedium` to relate to air. The term `ofSubstance` is broad enough to include situations where a sensor is used to detect constituents that should not be present in a medium, such as ammonia in air. Therefore, `ofSubstance` is used to indicate the substance of interest, while `ofConstituent` would indicate a constituent that is normally present in the composition of the mix.

11.15 s223:ofMedium

A `Relation` that associates a `Property` with the specific Medium it describes. A `Property` corresponding to the temperature of a medium would be associated with this medium using the relation `ofMedium`.

11.16 s223:ofConstituent

A `Relation` that associates a `Property` that characterizes a `Medium-Mix` with one of the constituents of that mix. (e.g., `Fluid-Water composedOf Property ofConstituent Constituent-H2O`.

11.17 s223:composedOf

The relation `composedOf` is used to indicate what substances constitute a material. Allowable values are instances of `Property` that in turn identify constituents defined in `Medium-Constituent` (see Clause 10.12.1.1) via the relation `ofConstituent`.

11.18 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.

11.18.1 s223:BACnetExternalReference

An `ExternalReference` that contains BACnet protocol parameter values necessary to associate a `Property` with a value.

Related Constraints

Description	Link
If the relation `device-identifier` is present it associates the external reference with a BACnet device having the specific device identifier.	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 `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 `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

11.18.1.1 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.

11.18.1.2 bacnet:device-identifier

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

11.18.1.3 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.

11.18.1.4 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.

11.18.1.5 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.

11.18.1.6 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.

11.18.1.7 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.

11.19 s223:hasExternalReference

A `Relation` that associates a `Property` with an external telemetry source.

11.20 s223:hasInternalReference

A `Relation` that associates a `Property` with another equivalent `Property`. For example, a `Property` that represents a `Zone` temperature could have at most one `hasInternalReference` relation to another `Property` that is a temperature measurement from one room in the zone (see Figure 11-2).

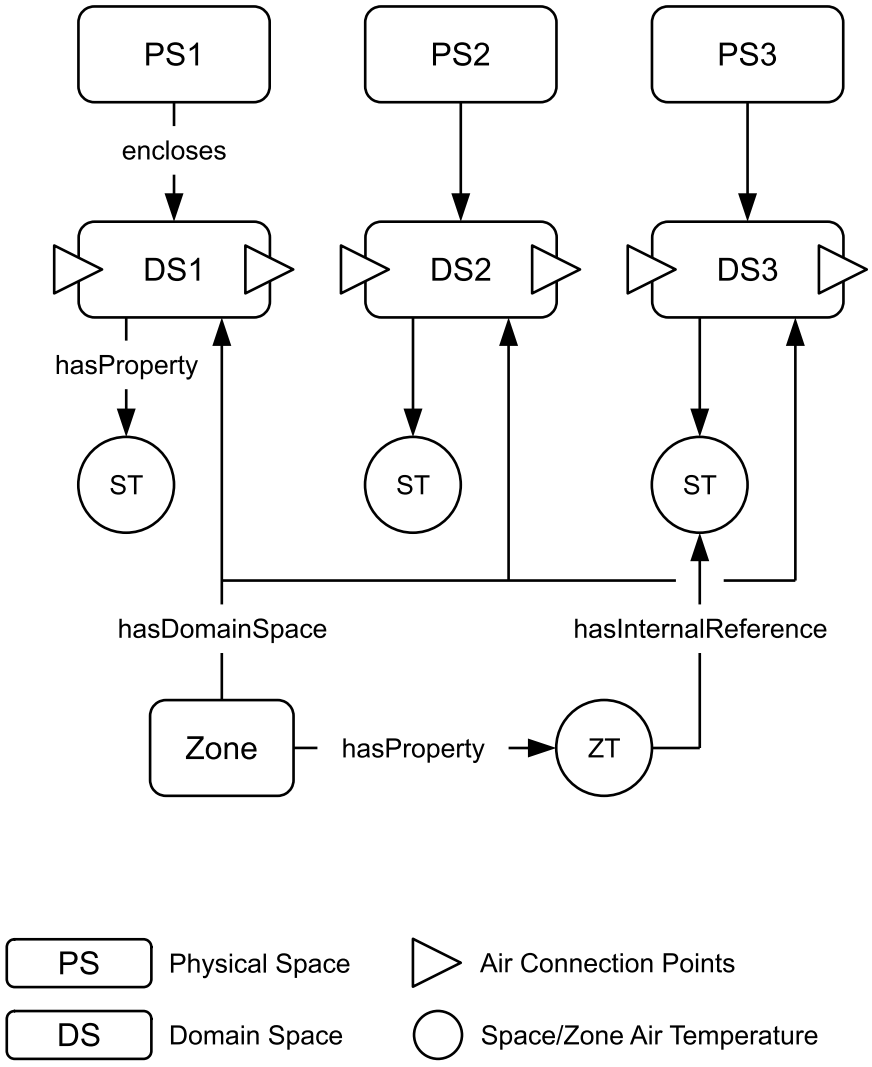


Figure 11-2. Zone Internal Reference.

Another use of `hasInternalReference` is to make a `Property` of a piece of equipment visible as a `Property` of a piece of containing equipment (see Clause 5.2). This is illustrated in Figure 11-3.

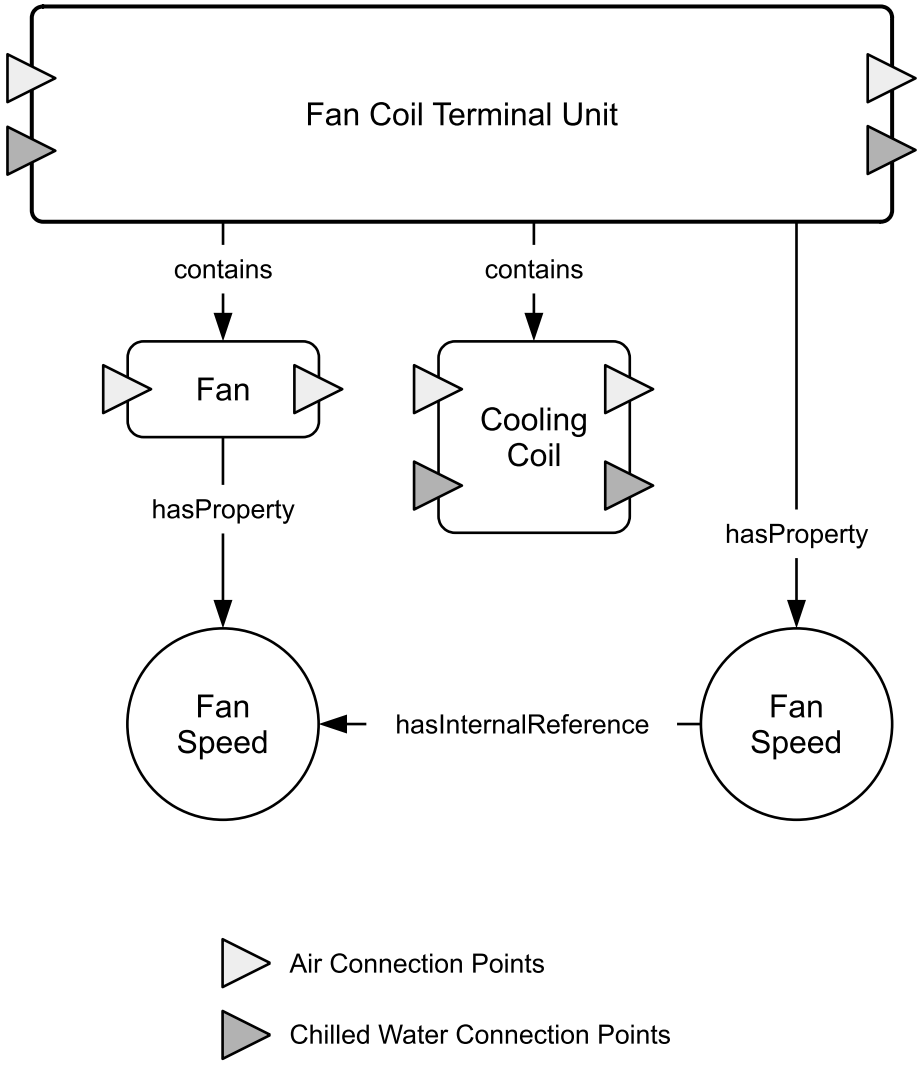


Figure 11-3. Equipment Containment.

Note that the hasInternalReference relation is transitive.

12 REFERENCE FOR EQUIPMENT

This section contains component model templates for equipment that is commonly found in buildings.

12.1 s223:AirHandlingUnit

A piece of `Equipment` consisting of a fan or fans and other equipment necessary to perform one or more of the following functions: circulating, filtration, heating, cooling, heat recovery, humidifying, dehumidifying, and mixing of air.

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:DualFanDualDuctAirHandlingUnit, it will be declared as an instance of that class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a common economizer/minimum outdoor air damper, it will be declared as an instance of this class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a relief damper, it will be declared as an instance of this class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a relief fan, it will be declared as an instance of this class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a return fan, it will be declared as an instance of this class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit, it will be declared as an instance of that class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit-OADandAFMS, it will be declared as an instance of that class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit-OADandDP, it will be declared as an instance of that class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit and has a relief fan, it will be declared as an instance of this class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit and has a return fan, it will be declared as an instance of that class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit, it will be declared as an instance of that class.	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit-WithReliefDamperFan, it will be declared as an instance of that class.	Link

12.2 s223:AirHeatExchanger

A piece of `Equipment` that transfers heat from one air stream to another while keeping the two media separate.

Related Constraints

Description	Link
An `AirHeatExchanger` shall have at least two air inlets, each paired with an outlet.	Link
An `AirHeatExchanger` shall have at least two air outlets, each paired with an inlet.	Link
An `AirHeatExchanger` shall have no `BidirectionalConnectionPoints`.	Link

Related Inference Rules

Description	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.3 s223:Battery

A piece of `Equipment` that stores a defined amount of chemical energy that can be converted to electrical energy via a chemical process. This process, typically referred to as discharging, produces a specific electrical voltage and current.

Related Constraints

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

12.4 s223:Boiler

A piece of `Equipment` that uses fuel or electricity to heat water or other fluids and supply steam or hot water for heating, humidification, or other applications.

Related Constraints

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

12.5 s223:ChilledBeam

A piece of `Equipment` 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 be associated with the `Role-Cooling` using the relation `hasRole`	Link
A `ChilledBeam` shall have at least one bidirectional connection point using the medium `Fluid-Air`.	Link
A `ChilledBeam` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `ChilledBeam` shall have at least one outlet using the medium `Fluid-Water`.	Link

Related Inference Rules

Description	Link
A `ChilledBeam` must always have the role `Role-Cooling`	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.6 s223:Chiller

A piece of `Equipment` that removes heat from a liquid coolant via a vapor-compression, adsorption refrigeration, or absorption refrigeration cycles.

Related Constraints

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

12.7 s223:ClothesWasher

A piece of `Equipment` that automatically cleans a load of textiles (e.g., clothing, bedding).

Related Constraints

Description	Link
A `ClothesWasher` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
A `ClothesWasher` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `ClothesWasher` shall have at least one outlet using the medium `Fluid-Water`.	Link

12.8 s223:CoffeeMaker

A piece of `Equipment` that automatically brews coffee.

Related Constraints

Description	Link
A `CoffeeMaker` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.9 s223:Coil

A piece of `Equipment` consisting of a pipe or tube that is formed into a helical or serpentine shape, may or may not be finned, and is used in cooling or heating equipment.

A `Coil` shall conform to exactly one of the following patterns:

- **Pattern 1:**
  - The `Coil` has exactly two inlet connection points using the medium `Mix-Fluid`, with exactly one being `Fluid-Air`.
  - The `Coil` has exactly two outlet connection points using the medium `Mix-Fluid`, with exactly one being `Fluid-Air`.
- **Pattern 2:**
  - The Coil has exactly one inlet connection point using the medium `Mix-Fluid`.
  - The Coil has exactly one outlet connection point using the medium `Mix-Fluid`.
  - The Coil has one or two bidirectional connection points using the medium `Mix-Fluid` or `Medium-ThermalContact`.
- **Pattern 3:**
  - The Coil has exactly three bidirectional connection points using the medium `Mix-Fluid` or `Medium-ThermalContact`.

Related Constraints

Description	Link
Pattern 1: A `Coil` shall have two inlets using the medium `Mix-Fluid`.	Link
Pattern 1: A `Coil` shall have two outlets using the medium `Mix-Fluid`.	Link
Pattern 1: For one of the two inlets the Fluid is Air.	Link
Pattern 1: For one of the two outlets the Fluid is Air.	Link
Pattern 2: A `Coil` shall have one inlet using the medium `Mix-Fluid`.	Link
Pattern 2: A `Coil` shall have one or two bidirectionals using the medium `MixFluid` or `Medium-ThermalContact`.	Link
Pattern 2: A `Coil` shall have one outlet using the medium `Mix-Fluid`.	Link
Pattern 3: A `Coil` shall have three bidirectionals using the medium `Mix-Fluid` or `Medium-ThermalContact`.	Link

Related Inference Rules

Description	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.9.1 s223:CoolingCoil

A `Coil` that is specifically used to cool air.

Related Constraints

Description	Link
A cooling coil shall be related to the role '`Role-Cooling`' using the relation '`hasRole`'.	Link

Related Inference Rules

Description	Link
A `CoolingCoil` must always have the role `Role-Cooling`	Link
If an instance of s223:CoolingCoil matches the constraints defined by g36:ChilledWaterCoil, it will be declared as an instance of that class.	Link

12.9.2 s223:HeatingCoil

A `Coil` that is specifically used to heat air.

Related Constraints

Description	Link
A heating coil shall be related to the role '`Role-Heating`' using the relation '`hasRole`'.	Link

Related Inference Rules

Description	Link
Heating coils must always have the role `Role-Heating`	Link
If an instance of s223:HeatingCoil matches the constraints defined by g36:HotWaterCoil, it will be declared as an instance of that class.	Link

12.10 s223:Compressor

A piece of `Equipment` that mechanically increases the pressure of a gas.

Related Constraints

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

12.11 s223:Computer

A piece of `Equipment` that can be programmed to automatically carry out sequences of arithmetic or logical operations (computation). Modern digital electronic computers can perform generic sets of operations known as programs. These programs enable computers to perform a wide range of tasks.

Related Constraints

Description	Link
A `Computer` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.11.1 s223:PersonalComputer

A `Computer` designed primarily used by a single person.

Related Constraints

Description	Link
A `PersonalComputer` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.11.2 s223:ServerComputer

A `Computer` that is primarily used by multiple people, or for the execution of tasks not directly coupled to human interaction.

Related Constraints

Description	Link
A `ServerComputer` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.12 s223:ComputerPrinter

A piece of `Equipment` that processes an input electrical or RF signal, typically from a `Computer`, and outputs a durable representation of information, typically text and/or graphics, typically on paper.

Related Constraints

Description	Link
A `ComputerPrinter` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
A `ComputerPrinter` shall have at least one inlet using the medium `Electricity-Signal` or `EM-RF`.	Link

12.13 s223:CoolingTower

A piece of `Equipment` that uses atmospheric air to cool warm water, generally by direct contact via evaporation.

Related Constraints

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

12.14 s223:CopyMachine

A piece of `Equipment` that processes an input of one or more durable representation(s) of information, typically text and/or graphics and typically on paper, and outputs one or more reproductions of the information for each input, typically on paper.

Related Constraints

Description	Link
A `CopyMachine` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.15 s223:Damper

A piece of `Equipment` inserted into 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 `Fluid-Air`.	Link
A `Damper` shall have at least one outlet using the medium `Fluid-Air`.	Link

Related Inference Rules

Description	Link
If an instance of s223:Damper matches the constraints defined by g36:Damper, it will be declared as an instance of that class.	Link
If an instance of s223:Damper matches the constraints defined by g36:TwoPositionDamper, it will be declared as an instance of that class.	Link

12.16 s223:Dishwasher

A piece of `Equipment` that automatically cleans dishware, cookware, and cutlery.

Related Constraints

Description	Link
A `Dishwasher` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
A `Dishwasher` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `Dishwasher` shall have at least one outlet using the medium `Fluid-Water`.	Link

12.17 s223:Door

A piece of `Equipment` consisting of 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 `Fluid-Air`.	Link

12.18 s223:ElectricityBreaker

A piece of equipment that automatically opens an electric circuit automatically at a predetermined overcurrent, so as to prevent damage to the circuit, the equipment connected to the circuit, and the building containing the circuit.

Related Constraints

Description	Link
An `ElectricityBreaker` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
An `ElectricityBreaker` shall have at least one outlet using the medium `Constituent-Electricity`.	Link

12.19 s223:ElectricClothesDryer

A piece of `Equipment` that automatically removes moisture from a load of textiles (e.g., clothing, bedding), typically after they are washed in a `ClothesWasher`.

Related Constraints

Description	Link
A `ElectricClothesDryer` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.20 s223:ElectricCooktop

A piece of `Equipment` with a flat surface containing one or more heat sources designed for cooking with pots and pans.

Related Constraints

Description	Link
A `ElectricCooktop` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.21 s223:ElectricEnergyConverter

A piece of `Equipment` that converts one form of electric power to another form of electric power.

Related Constraints

Description	Link
A `ElectricEnergyConverter` shall have at least two connection points using the medium `Constituent-Electricity`.	Link

12.21.1 s223:ElectricEnergyDCDCConverter

An `ElectricEnergyConverter` that transforms direct current (DC) electric power from one voltage to another voltage.

Related Constraints

Description	Link
An `ElectricEnergyDCDCConverter` shall have at least two connection points using the medium `Electricity-DC`.	Link

12.21.2 s223:ElectricEnergyInverter

An `ElectricEnergyConverter` that tranforms direct current (DC) electric power to alternating current (AC) electric power, or vice versa.

Related Constraints

Description	Link
An `ElectricEnergyInverter` shall have at least one connection point that uses the medium `Electricity-AC`.	Link
An `ElectricEnergyInverter` shall have at least one connection point that uses the medium `Electricity-DC`.	Link

12.21.3 s223:ElectricEnergyTransformer

An `ElectricEnergyConverter` that transforms alternating current (AC) electric power from one voltage to another voltage.

Related Constraints

Description	Link
An `ElectricEnergyTransformer` shall have at least two connection points using the medium `Electricity-AC`.	Link

12.22 s223:ElectricityMeter

A piece of `Equipment` that contains at least one `VoltageSensor` and one `ElectricCurrentSensor`, and reports one or more properties of electricity. Example reported properties include the following `QuantityKinds:`Voltage`,`ElectricCurrent`,`ActiveEnergy`,`ActivePower`,`ReactivePower`,`Appare ntPower`,`PowerFactor`, and`Frequency`with unit`Hertz`. An`ElectricityMeter`may optionally contain a`Function` that represents the mathematical calculations of the reported properties of electricity.

Related Constraints

Description	Link
An `ElecticityMeter` shall contain at least one `ElectricCurrentSensor`.	Link
An `ElecticityMeter` shall contain at least one `VoltageSensor`.	Link
An `ElecticityMeter` shall contain at least two `Sensors`.	Link
An `ElectricityMeter` shall contain a `VoltageSensor` and `ElectricCurrentSensor` with the same observation location.	Link
Placeholder: The medium observed by the sensors contained by an `ElectricityMeter` shall be within the `Constituent-Electricity` hierarchy.	Link
The observation location of the contained `VoltageSensor`(s) and `ElectricCurrentSensor`(s) shall be a single instance of either a `Connection` or a `ConnectionPoint`.	Link

12.23 s223:ElectricityOutlet

A piece of `Equipment` that contains one or more receptacles for connecting electrical equipment to electrical power, typically via a plug and cord. Not to be confused with an `OutletConnectionPoint` with the medium Constituent-Electricity.

Related Constraints

Description	Link
An `ElectricityOutlet` shall have at least one outlet using the medium `Constituent-Electricity`.	Link
An `ElectricityOutlet` shall have exactly one inlet using the medium `Constituent-Electricity`.	Link

12.24 s223:ElectricOven

A piece of `Equipment` with an enclosed chamber designed for baking, roasting, and other cooking methods that rely on circulating heat.

Related Constraints

Description	Link
A `ElectricOven` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.25 s223:ElectricResistanceElement

A piece of `Equipment` that provides electrical resistance heating, for example, an electric heating coil within a Fan Coil Unit. It shall have one electricity `InletConnectionPoint` and fit one of the following two patterns:

- Pattern 1: An `ElectricResistanceElement` shall have exactly one Bidirectional `ConnectionPoint` using the medium `Mix-Fluid`.
- Pattern 2: An `ElectricResistanceElement` shall have one inlet and one outlet using the medium `Mix-Fluid`.

Related Constraints

Description	Link
An `ElectricResistanceElement` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
An `ElectricResistanceElement` shall have the role `Role-Heating`.	Link
Pattern 1: An `ElectricResistanceElement` shall have exactly one Bidirectional `ConnectionPoint` using the medium `Mix-Fluid`.	Link
Pattern 2: An `ElectricResistanceElement` shall have one inlet using the medium `Mix-Fluid`.	Link

Description	Link
Pattern 2: An `ElectricResistanceElement` shall have one outlet using the medium `Mix-Fluid`.	Link

Related Inference Rules

Description	Link
If an instance of s223:ElectricResistanceElement matches the constraints defined by g36:ElectricHeatingCoil, it will be declared as an instance of that class.	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.26 s223:ElectricWaterDispenser

A piece of `Equipment` that dispenses water and optionally heats and/or cools the water prior to dispensing.

Related Constraints

Description	Link
An `ElectricWaterDispenser` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
An `ElectricWaterDispenser` shall have at least one inlet using the medium `Fluid-Water`.	Link

12.27 s223:ElectronicDisplay

A piece of `Equipment` that receives an input electrical signal and outputs information, typically text and/or graphics, in a visual form.

Related Constraints

Description	Link
A `ElectronicDisplay` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
A `ElectronicDisplay` shall have at least one inlet using the medium `Electricity-Signal`.	Link

12.27.1 s223:Monitor

An `ElectronicDisplay` designed primarily for the output of visual information supplied by a `Computer`.

12.27.2 s223:Television

An `ElectronicDisplay` that is designed primarily for the output of visual information supplied by a media broadcaster, and that typically has an integral tuner that is capable of selecting a single channel for display from the available input channel range.

12.28 s223:Elevator

A piece of `Equipment` that vertically transports people or freight between floors or levels of a building via a vertical shaft commonly referred to as a hoistway. The people or freight are typically situated on a platform, or in a container commonly referred to as a car, cab, cabin, cage, or carriage.

Related Constraints

Description	Link
A `Elevator` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.29 s223:Escalator

A piece of `Equipment` that vertically transports people between floors or levels of a building via a moving staircase.

Related Constraints

Description	Link
A `Escalator` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.30 s223:EthernetSwitch

A piece of `Equipment` that connects electrical equipment, such as `Computer`s and Wi-Fi access points, to an Ethernet network so they can communicate with each other and, optionally, to the Internet.

Related Constraints

Description	Link
An `EthernetSwitch` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
An `EthernetSwitch` shall have at least two `BidirectionalConnectionPoint`s using the medium `Signal-Ethernet`.	Link

12.31 s223:Fan

A piece of `Equipment` that causes a gas (e.g., air) to flow.

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of s223:Fan matches the constraints defined by g36:Fan, it will be declared as an instance of that class.	Link
If an instance of s223:Fan matches the constraints defined by g36:FanWithVFD, it will be declared as an instance of that class.	Link

12.32 s223:FanCoilUnit

A piece of `Equipment` consisting of a `Coil` and a `Fan` that regulates the temperature of one or more spaces.

Related Constraints

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

12.33 s223:FiberEthernetOutlet

A piece of `Equipment` that contains one or more receptacles for connecting electrical equipment to a fiber Ethernet communication network, typically via a fiber Ethernet cable.

Related Constraints

Description	Link
A `FiberEthernetOutlet` shall have at least one outlet using the medium `Signal-FiberEthernet`.	Link
A `FiberEthernetOutlet` shall have exactly one inlet using the medium `Signal-FiberEthernet`.	Link

12.34 s223:Filter

A piece of `Equipment` that removes contaminants from gases or liquids. See Clause 10.12.1 for more details on validating compatible mediums upstream and downstream of a `Filter`.

Related Constraints

Description	Link
A `Filter` shall have at least one inlet `ConnectionPoint`.	Link
A `Filter` shall have at least one outlet.	Link
Incompatible Medium. Case 1: Associated `ConnectionPoints` with two pure mediums.	Link
Incompatible Medium. Case 2: Associated `ConnectionPoints`, one with a pure medium and one with a medium having constituents..	Link
Incompatible Medium. Case 3: Associated `ConnectionPoints` with mediums having constituents.	Link

12.35 s223:FlushToilet

A piece of `Equipment` that collects human waste (i.e., urine and/or feces, and sometimes toilet paper) in a chamber containing water, and contains an integral manual or automatic actuator that triggers the release of an additional volume of water that flushes everything from the chamber into a drainage system that typically carries the mixture to a sewer system or septic tank.

Related Constraints

Description	Link
A `FlushToilet` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `FlushToilet` shall have at least one outlet using the medium `Fluid-Water`.	Link

12.36 s223:Freezer

A piece of `Equipment` that maintains an internal temperature below the freezing point of water.

Related Constraints

Description	Link
A `Freezer` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.37 s223:FumeHood

A piece of `Equipment` that is typically mounted over a work area (e.g., a space, table, or shelf) and conducts unwanted gases away from the area.

Related Constraints

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

12.38 s223:Furnace

A piece of `Equipment` that converts fuel or electrical energy into heat.

Related Constraints

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

12.39 s223:Generator

A piece of `Equipment` that converts non-electric energy into electric energy.

Related Constraints

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

12.40 s223:HeatPump

A piece of `Equipment` that heats or cools spaces by transferring thermal energy from one thermal environment to another using a reversible refrigeration cycle.

12.40.1 s223:AirToAirHeatPump

A `HeatPump` that transfers thermal energy between two bodies of air.

Related Constraints

Description	Link
An `AirToAirHeatPump` shall have at least two inlets using the medium `Fluid-Air`.	Link
An `AirToAirHeatPump` shall have at least two outlets using the medium `Fluid-Air`.	Link

12.40.2 s223:GroundToAirHeatPump

A `HeatPump` that transfers thermal energy between air and the ground.

Related Constraints

Description	Link
A `GroundToAirHeatPump` shall have at least one `BidirectionalConnectionPoint` using `Medium-ThermalContact`.	Link
A `GroundToAirHeatPump` shall have at least one inlet using the medium `Fluid-Air`.	Link

Description	Link
A `GroundToAirHeatPump` shall have at least one outlet using the medium `Fluid-Air`.	Link

12.40.3 s223:WaterToAirHeatPump

A `HeatPump` that transfers thermal energy between air and a body of water.

Related Constraints

Description	Link
A `WaterToAirHeatPump` shall have at least one inlet using the medium `Fluid-Air`.	Link
A `WaterToAirHeatPump` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `WaterToAirHeatPump` shall have at least one outlet using the medium `Fluid-Air`.	Link
A `WaterToAirHeatPump` shall have at least one outlet using the medium `Fluid-Water`	Link

12.40.4 s223:WaterToWaterHeatPump

A `HeatPump` that transfers thermal energy between two flows of water.

Related Constraints

Description	Link
A `WaterToWaterHeatPump` shall have at least two inlets using the medium `Fluid-Water`.	Link
A `WaterToWaterHeatPump` shall have at least two outlets using the medium `Fluid-Water`.	Link

12.41 s223:Humidifier

A piece of equipment that adds moisture to a gas (e.g., air).

12.42 s223:Humidistat

A piece of equipment that measures the relative humidity of the air and then uses this information to automatically adjust the amount of moisture in air.

12.43 s223:HydronicHeatExchanger

A piece of equipment that transfers heat from one liquid stream to another while keeping the two media separate.

Related Constraints

Description	Link
A `HydronicHeatExchanger` shall have at least two liquid inlets, each paired with an outlet.	Link

Description	Link
A `HydronicHeatExchanger` shall have at least two liquid outlets, each paired with an inlet.	Link
A `HydronicHeatExchanger` shall have no `BidirectionalConnectionPoints`.	Link
A `HydronicHeatExchanger` shall have no `ConnectionPoints` using the medium `Fluid-Air`.	Link

Related Inference Rules

Description	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.44 s223:IceMaker

A piece of `Equipment` that makes ice.

Related Constraints

Description	Link
An `IceMaker` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
An `IceMaker` shall have at least one inlet using the medium `Fluid-Water`.	Link

12.45 s223:Luminaire

A piece of `Equipment` consisting of a light source(s) and ballast(s) or driver(s) (when applicable), together with the parts designed to distribute the light, to position and protect the light source(s), and to connect the light source(s) to the power supply. Also known as a light fixture.

Related Constraints

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

12.46 s223:MicrowaveOven

An `ElectricOven` that cooks food by exposing it to electromagnetic radiation in the microwave frequency range.

Related Constraints

Description	Link
A `MicrowaveOven` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.47 s223:Motor

A piece of `Equipment` that converts electrical energy into mechanical energy.

Related Constraints

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

12.48 s223:PhotovoltaicModule

A piece of equipment that converts sunlight into electricity.

Related Constraints

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

12.49 s223:PowerOverEthernetSwitch

A piece of `Equipment` that connects and is capable of powering electrical equipment, such as `Computers` and Wi-Fi access points, to an Ethernet network so they can communicate with each other and, optionally, to the Internet.

Related Constraints

Description	Link
A `PowerOverEthernetSwitch` shall have at least one `BidirectionalConnectionPoint` using the medium `PowerAndSignal-PoE`.	Link
A `PowerOverEthernetSwitch` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.50 s223:Pump

A piece of `Equipment` that imparts energy to a fluid, drawing a fluid into itself through an inlet port, and forcing the fluid out through an outlet port.

Related Constraints

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

12.51 s223:RadiantHeater

A piece of `Equipment` with heating or cooling surface that delivers 50% or more of its heat transfer by radiation. A `RadiantHeater` shall:

- Have the role `Role-Heating`.
- Have at least one outlet connection point using the medium `Light-Infrared`.
- Conform to exactly one of the following patterns:
  - **Pattern 1:**
    - Exactly one inlet connection point using the medium `Constituent-Electricity` or `Fluid-NaturalGas`.
  - **Pattern 2:**
    - Exactly one inlet connection point using the medium `Fluid-Water`.
    - Exactly one outlet connection point using the medium Fluid-Water.

Related Constraints

Description	Link
A `RadiantHeater` shall have at least one outlet connection point using the medium `Light-Infrared`.	Link
A radiant heater shall have the role `Role-Heating`.	Link
Pattern 1: A radiant heater shall have at least one inlet using the medium `Constituent-Electricity` or `Fluid-NaturalGas`.	Link
Pattern 2: A radiant heater shall have an inlet using the medium `Fluid-Water`.	Link
Pattern 2: A radiant heater shall have an outlet using the medium `Fluid-Water`.	Link

Related Inference Rules

Description	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.52 s223:Radiator

A piece of `Equipment` that provides primarily convective heating to a room using electricity, steam, or water (e.g., electric baseboard heaters, heated floors, or traditional radiators).

Related Constraints

Description	Link
A `Radiator` shall have at least one bidirectional connection point using the medium `Fluid-Air`.	Link
A `Radiator` shall have at least one inlet using the medium Electricity or inlet and outlet of Water.	Link
Radiators shall have the role `Role-Heating`.	Link

Related Inference Rules

Description	Link
Infer the `hasRole` s223:Role-HeatTransfer relation for every instance of the listed targetClass values.	Link

12.53 s223:Refrigerator

A piece of `Equipment` that maintains an internal temperature below the surrounding ambient temperature but above the freezing point of water.

Related Constraints

Description	Link
A `Refrigerator` shall have at least one inlet using the medium `Constituent-Electricity`.	Link

12.54 s223:RFOutlet

A piece of `Equipment` that contains one or more receptacles for connecting electrical equipment to a radio frequency (RF) communication network, via, for example, a coaxial cable.

Related Constraints

Description	Link
A `RFOutlet` shall have at least one outlet using the medium `RF-Signal`.	Link
A `RFOutlet` shall have exactly one inlet using the medium `RF-Signal`.	Link

12.55 s223:Sink

A piece of `Equipment` for manually washing hands, dishes, or other items that receives as an input hot or cold water dispensed from one or two `Faucet`s, and is designed to hold a specific volume of water and release the held water through a `Drain`.

Related Constraints

Description	Link
A `Sink` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `Sink` shall have at least one outlet using the medium `Fluid-Water`.	Link

12.56 s223:SolarThermalCollector

A piece of `Equipment` that converts sunlight into thermal energy.

Related Constraints

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

12.57 s223:TerminalUnit

A piece of `Equipment` 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 `Fluid-Air`.	Link
A `TerminalUnit` shall have at least one outlet `ConnectionPoint` using the medium `Fluid-Air`.	Link

12.57.1 s223:DualDuctTerminal

A `TerminalUnit` that mixes two independent sources of primary air.

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of s223:DualDuctTerminal matches the constraints defined by g36:DualDuctTerminalWithDischargeSensor, it will be declared as an instance of that class.	Link
If an instance of s223:DualDuctTerminal matches the constraints defined by g36:DualDuctTerminalWithInletSensors, it will be declared as an instance of that class.	Link

12.57.2 s223:FanPoweredTerminal

A `TerminalUnit` that contains a fan, and optionally has supplemental heating or cooling. Airflow may pass through or be parallel to the fan.

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of s223:FanPoweredTerminal matches the constraints defined by g36:FanPoweredTerminal, it will be declared as an instance of that class.	Link

12.57.3 s223:SingleDuctTerminal

A `TerminalUnit` unit that has one ducted air inlet and a damper for regulating the flow of air.

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of s223:SingleDuctTerminal matches the constraints defined by g36:VAVTerminalCoolingOnly, it will be declared as an instance of that class.	Link
If an instance of s223:SingleDuctTerminal matches the constraints defined by g36:VAVTerminalWithReheat, it will be declared as an instance of that class.	Link

12.58 s223:ThermalEnergyStorageUnit

A device that stores thermal energy.

Related Constraints

Description	Link
A Thermal Energy Storage Unit shall have at least two connection points.	Link

12.59 s223:Thermostat

A piece of `Equipment` that maintains temperature at a fixed or adjustable setpoint.

12.60 s223:Turbine

A piece of `Equipment` that converts mechanical energy into electric energy.

Related Constraints

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

12.61 s223:USBOutlet

A piece of `Equipment` that contains one or more receptacles for connecting electrical equipment to a USB communication network, typically via a USB cable.

Related Constraints

Description	Link
A `USBOutlet` shall have at least one outlet using the medium `Signal-USB`.	Link
A `USBOutlet` shall have exactly one inlet using the medium `Signal-USB`.	Link

12.62 s223:Valve

A piece of `Equipment` that can be adjusted to allow, regulate, or stop the flow of fluid in a pipe or a duct.

Related Constraints

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

Related Inference Rules

Description	Link
If an instance of s223:Valve matches the constraints defined by g36:ChilledWaterValve, it will be declared as an instance of that class.	Link
If an instance of s223:Valve matches the constraints defined by g36:HotWaterValve, it will be declared as an instance of that class.	Link

12.62.1 s223:Drain

A `Valve` that allows, regulates, or stops the flow of water from a `Sink`, `Shower`, `Bathtub`, or other plumbing service equipment into a plumbing drainage system that typically carries the mixture to a sewer system or septic tank.

Related Constraints

Description	Link
A `Drain` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `Drain` shall have at least one outlet using the medium `Fluid-Water`.	Link

12.62.2 s223:Faucet

A `Valve` that allows, regulates, or stops the flow of hot or cold water from a plumbing supply system into a `Sink`, `Shower`, `Bathtub`, or other plumbing service equipment.

Related Constraints

Description	Link
A `Faucet` shall have at least one inlet using the medium `Fluid-Water`.	Link
A `Faucet` shall have at least one outlet using the medium `Fluid-Water`.	Link

12.62.3 s223:ThreeWayValve

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

Related Constraints

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

12.62.4 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

12.63 s223:VariableFrequencyDrive

A piece of `Equipment` that varies its output frequency to vary the rotating speed and torque 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
A `VariableFrequencyDrive` shall have at least one inlet using the medium `Constituent-Electricity`.	Link
A `VariableFrequencyDrive` shall have at least one outlet using the medium `Constituent-Electricity`.	Link
If the relation `connectedTo` is present it shall associate the `VariableFrequencyDrive` with a `Equipment`.	Link

12.64 s223:WaterOutlet

A piece of `Equipment` that contains one or more pipe fittings for connecting plumbing equipment (e.g., `Faucet`) to a plumbing system.

Related Constraints

Description	Link
A `WaterOutlet` shall have at least one outlet using the medium `Fluid-Water`.	Link
A `WaterOutlet` shall have exactly one inlet using the medium `Fluid-Water`.	Link

12.65 s223:Window

A piece of `Equipment` that provides a pathway for `EM-Light` or `Fluid-Air` (or both) to flow from a room to another room or the building exterior through a vertical or nearly vertical area of the room envelope.

Related Constraints

Description	Link
A `Window` shall have at least one inlet using the medium `EM-Light` or `Fluid-Air`.	Link
A `Window` shall have at least one outlet using the medium `EM-Light` or `Fluid-Air`.	Link

12.66 s223:WindowShade

A piece of `Equipment` that can be adjusted to allow, regulate, or stop the flow of light through a `Window`.

12.67 s223:WiredEthernetOutlet

A piece of `Equipment` that contains one or more receptacles for connecting electrical equipment to a wired Ethernet communication network, typically via a wired Ethernet cable.

Related Constraints

Description	Link
A `WiredEthernetOutlet` shall have at least one outlet using the medium `Signal-WiredEthernet`.	Link
A `WiredEthernetOutlet` shall have exactly one inlet using the medium `Signal-WiredEthernet`.	Link

Annex A - RDF REPRESENTATION OF THIS STANDARD (NORMATIVE)

The text of this standard was generated from an RDF Model. An electronic repository containing a normative Turtle representation of the model can be found at (https://data.ashrae.org/bacnet/223p/223p.ttl). A user may wish to use electronic tools to browse and study the details of the standard, use the equipment types defined in the standard to build a building-specific information model, apply the SHACL constraints to test a building specific model for conformance to the standard, or other uses.

Annex B - ASHRAE GUIDELINE 36 EXTENSION (INFORMATIVE)

This extension uses the concepts defined in the 223 Standard to model the ASHRAE Guideline 36 data requirements for air-side equipment, defined in Section 4 of Guideline 36 (ASHRAE, 2018). These requirements are modeled as classes that use SHACL constraints to define how the equipment should be modeled in 223, focusing on the data points needed for Guideline 36 control sequences. These classes can be used to ensure that a model has the metadata necessary to support Guideline 36 sequences. They can be used to validate existing models against the requirements of Guideline 36 or to support modeling of compliant systems. They can also be used to create templates or support tooling that creates models to match the defined constraints. We have also included SHACL inference rules to infer labels for equipment within an existing 223 model, where modeling of the equipment satisfies the constraints defined for the Guideline 36 classes. This can support querying and semantic interoperability between models created with and without use of this extension. Additionally, this section includes example models of the systems presented in the Informative Appendix A of Guideline 36. This content is intended to serve as an example of how the 223 standard can be extended to create higher level classes specific to an application that can be useful for both validation and inference. It is also intended to provide examples of how equipment can be modeled using 223.

Annex B.1 Model Components

This section describes the classes representing common components used in this extension. These components are not directly defined within Section 4 of Guideline 36, but are shared between the many systems described. For example, g36:VAVTerminalCoolingOnly (see Clause Annex B.2.1), g36:VAVTerminalWithReheat (see Clause Annex B.3.1), g36:FanPoweredTerminal (see Clause Annex B.4.1), g36:DualDuctTerminalWithInletSensors (see Clause Annex B.5.1), and g36:DualDuctTerminalWithDischargeSensor (see Clause Annex B.6.1) all share requirements for what properties a Zone must have. The Guideline 36 classes defined in subsequent sections are composed of the following components.

Annex B.1.1 g36:Damper

A damper with an analog or two binary position command properties.

Related Constraints

Description	Link
A damper shall have at least one analog damper command property or at least two binary damper command properties using the relation hasProperty.	Link

Annex B.1.2 g36:DamperAnnotation

Related Inference Rules

Description	Link
If an instance of s223:Damper matches the constraints defined by g36:Damper, it will be declared as an instance of that class.	Link

Annex B.1.3 g36:TwoPositionDamper

A damper that can take two positions: fully open and fully closed.

Related Constraints

Description	Link
A Two Position Damper shall have at least one open-and-close damper command property using the relation hasProperty.	Link

Annex B.1.4 g36:TwoPositionDamperAnnotation

Related Inference Rules

Description	Link
If an instance of s223:Damper matches the constraints defined by g36:TwoPositionDamper, it will be declared as an instance of that class.	Link

Annex B.1.5 g36:HotWaterCoil

A hot water coil connected to a control valve.

Related Constraints

Description	Link
The HotWaterCoil shall be connected to a HotWaterValve using the relation connectedTo.	Link

Annex B.1.6 g36:HotWaterCoilAnnotation

Related Inference Rules

Description	Link
If an instance of s223:HeatingCoil matches the constraints defined by g36:HotWaterCoil, it will be declared as an instance of that class.	Link

Annex B.1.7 g36:ElectricHeatingCoil

An electrical heating element with an analog heating command.

Related Constraints

Description	Link
An electric heating coil shall have at least one analog heating command property using a relation hasProperty.	Link

Annex B.1.8 g36:ElectricHeatingCoilAnnotation

Related Inference Rules

Description	Link
If an instance of s223:ElectricResistanceElement matches the constraints defined by g36:ElectricHeatingCoil, it will be declared as an instance of that class.	Link

Annex B.1.9 g36:HotWaterValve

A valve that controls the flow of hot water through a hot water coil.

Related Constraints

Description	Link
A HotWaterValve shall have at least one analog valve command property or at least two binary valve command properties using the relation hasProperty.	Link

Annex B.1.10 g36:HotWaterValveAnnotation

Related Inference Rules

Description	Link
If an instance of s223:Valve matches the constraints defined by g36:HotWaterValve, it will be declared as an instance of that class.	Link

Annex B.1.11 g36:ChilledWaterCoil

A cooling coil with a connected chilled water valve.

Related Constraints

Description	Link
The ChilledWaterCoil shall be connected to a ChilledWaterValve using the relation connectedTo.	Link

Annex B.1.12 g36:ChilledWaterCoilAnnotation

Related Inference Rules

Description	Link
If an instance of s223:CoolingCoil matches the constraints defined by g36:ChilledWaterCoil, it will be declared as an instance of that class.	Link

Annex B.1.13 g36:ChilledWaterValve

A valve that controls the flow of chilled water through a chilled water coil.

Related Constraints

Description	Link
A ChilledWaterValve shall have at least one analog valve command property or at least two binary valve command properties using the relation hasProperty.	Link

Annex B.1.14 g36:ChilledWaterValveAnnotation

Related Inference Rules

Description	Link
If an instance of s223:Valve matches the constraints defined by g36:ChilledWaterValve, it will be declared as an instance of that class.	Link

Annex B.1.15 g36:Zone

A thermal zone with the points required for Guideline 36 control sequences. It is a collection of s223:DomainSpace instances.

Related Constraints

Description	Link
A Zone shall have a zone temperature setpoint adjustment property using the relation hasProperty, if applicable.	Link
A Zone shall have at least a zone CO2 concentration property using the relation hasProperty, if applicable control is used.	Link
A Zone shall have at least one Domain-HVAC using the relation hasDomain.	Link
A Zone shall have at least one binary zone occupancy property using the relation hasProperty	Link
A Zone shall have at least one window switch on-off property using the relation hasProperty.	Link

Annex B.1.16 g36:ZoneAnnotation

Related Inference Rules

Description	Link
If an instance of Zone matches the constraints defined by g36:Zone, it will be declared as an instance of that class.	Link

Annex B.1.17 g36:ZoneGroup

A ZoneGroup is a grouping of zones that may be scheduled together. Zone groupings must be assigned based on rules in Section 3.1.3 of Guideline 36.

Related Constraints

Description	Link
A ZoneGroup shall contain at least one Zone using the relation contains.	Link
A ZoneGroup shall have the Domain HVAC using the relation hasDomain.	Link

Annex B.1.18 g36:ZoneGroupAnnotation

Related Inference Rules

Description	Link
If an instance of `ZoneGroup` matches the constraints defined by g36:ZoneGroup, it will be declared as an instance of that class.	Link

Annex B.1.19 g36:Fan

A fan with a start/stop command.

Related Constraints

Description	Link
A Fan shall have at least one Start/Stop command using the relation hasProperty.	Link

Annex B.1.20 g36:FanAnnotation

Related Inference Rules

Description	Link
If an instance of s223:Fan matches the constraints defined by g36:Fan, it will be declared as an instance of that class.	Link

Annex B.1.21 g36:FanWithVFD

A fan controlled by a VFD.

Related Constraints

Description	Link
A fan with VFD shall have at least one fan speed command using the relation hasProperty.	Link

Annex B.1.22 g36:FanWithVFDAnnotation

Related Inference Rules

Description	Link
If an instance of s223:Fan matches the constraints defined by g36:FanWithVFD, it will be declared as an instance of that class.	Link

Annex B.2 VAV Terminal Unit - Cooling Only

This section describes the VAV Terminal Unit - Cooling Only class defined by this extension. Constraints are based on Guideline 36 Section 4.1.

Annex B.2.1 g36:VAVTerminalCoolingOnly

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

Related Constraints

Description	Link
The VAVTerminalCoolingOnly OutletConnectionPoint shall have at least one discharge airflow property using the relation hasProperty.	Link
The VAVTerminalCoolingOnly connects to Domain Space in a g36:Zone	Link
The VAVTerminalCoolingOnly shall contain exactly one Damper using the relation contains.	Link

Annex B.2.2 g36:VAVTerminalCoolingOnlyAnnotation

Related Inference Rules

Description	Link
If an instance of s223:SingleDuctTerminal matches the constraints defined by g36:VAVTerminalCoolingOnly, it will be declared as an instance of that class.	Link

Annex B.2.3 Example VAV Terminal Unit - Cooling Only

VAV Terminal Unit - Cooling Only based on Figure A-1. Link to Model

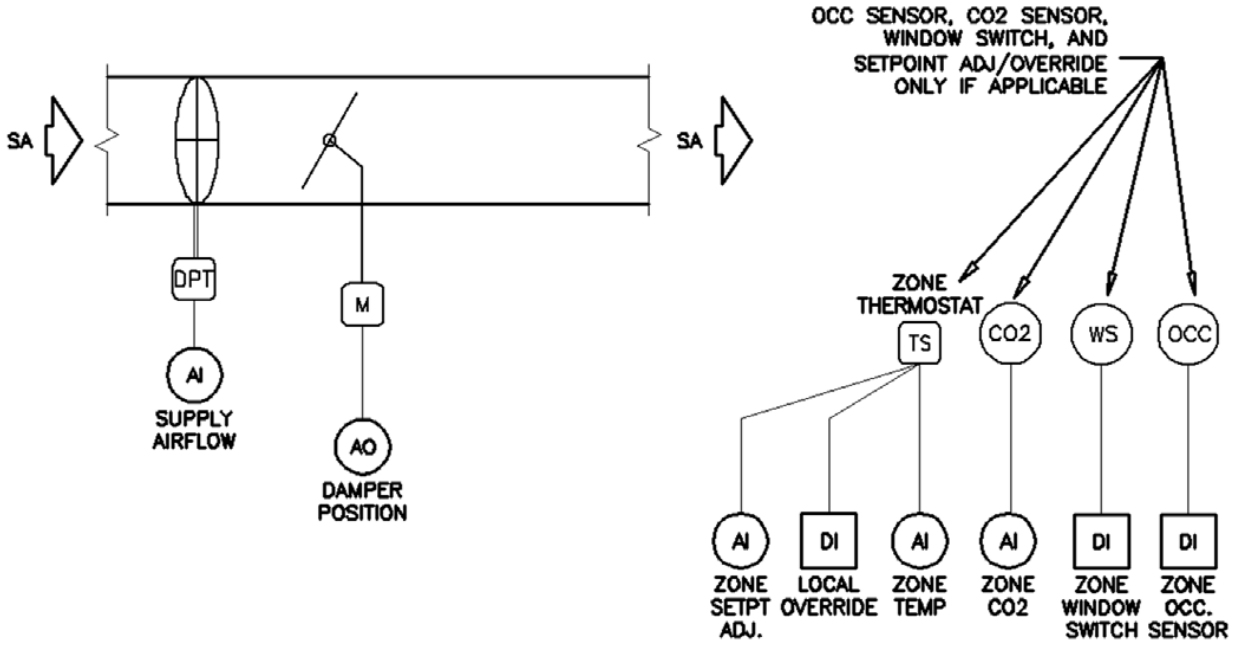


Figure Annex B-1. Guideline 36 Figure A-1.

Annex B.3 VAV Terminal Unit with Reheat

This section describes the VAV Terminal Unit with Reheat described in Section 4.2 and Appendix A, Figure A-2 (ASHRAE Guideline 36-2024).

Annex B.3.1 g36:VAVTerminalWithReheat

An air-terminal unit assembly having one ducted air inlet, a damper, and a reheat coil for regulating the airflow rate and discharge air temperature.

Related Constraints

Description	Link
The VAVTerminalWithReheat OutletConnectionPoint shall have at least one discharge air temperature property using the relation hasProperty.	Link
The VAVTerminalWithReheat connects to Domain Space in a g36:Zone	Link
The VAVTerminalWithReheat shall contain at least one hot water coil or at least one electric heating coil for heating using the relation contains.	Link

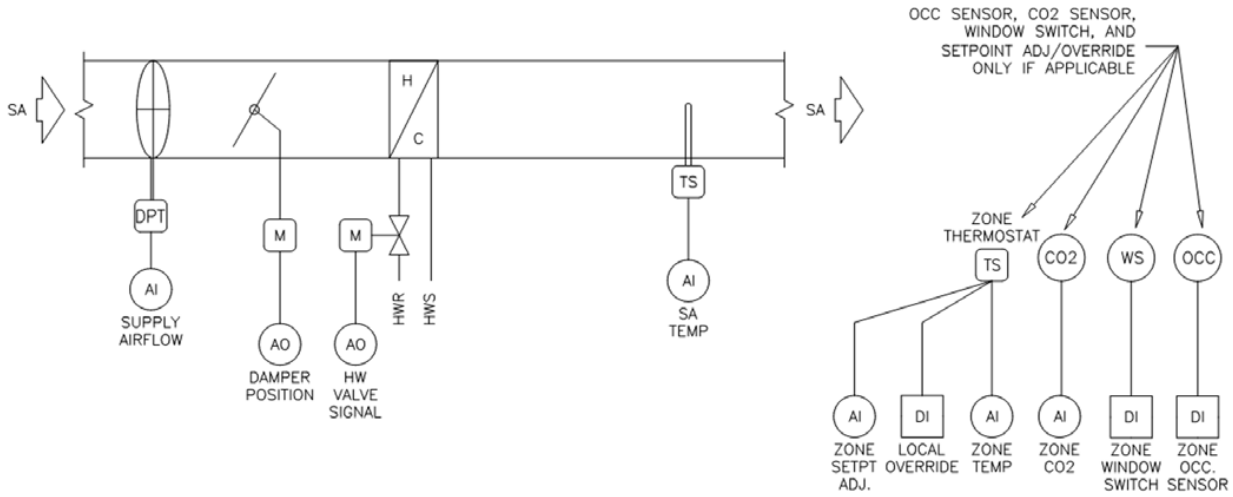
Annex B.3.2 g36:VAVTerminalWithReheatAnnotation

Related Inference Rules

Description	Link
If an instance of s223:SingleDuctTerminal matches the constraints defined by g36:VAVTerminalWithReheat, it will be declared as an instance of that class.	Link

Annex B.3.3 Example VAV Terminal Unit With Reheat

VAV Terminal Unit With Reheat based on Figure A-2. Link to Model



Annex B.4 Fan Powered Terminal Unit

This section describes the classes and example model of the Fan Powered Terminal Unit (Series or Parallel, Constant, or Variable Speed Fan) described in Section 4.3.

Annex B.4.1 g36: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 shall contain at least one hot water coil or at least one electric heating coil for heating using the relation contains.	Link
A FanPoweredTerminal shall have exactly one Damper using the relation contains.	Link
A FanPoweredTerminal shall have exactly one Fan or FanWithVFD using the relation contains.	Link
The FanPoweredTerminal InletConnectionPoint shall have at least one supply airflow property using the relation hasProperty.	Link
The FanPoweredTerminal OutletConnectionPoint shall have at least one discharge air temperature property using the relation hasProperty.	Link

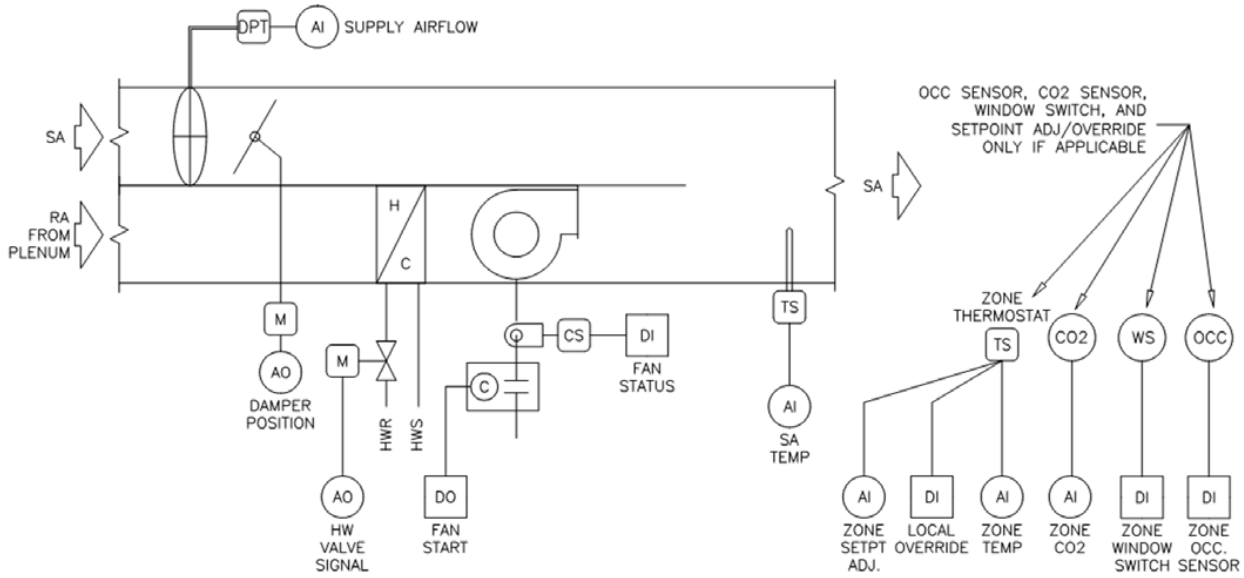
Annex B.4.2 g36:FanPoweredTerminalAnnotation

Related Inference Rules

Description	Link
If an instance of s223:FanPoweredTerminal matches the constraints defined by g36:FanPoweredTerminal, it will be declared as an instance of that class.	Link

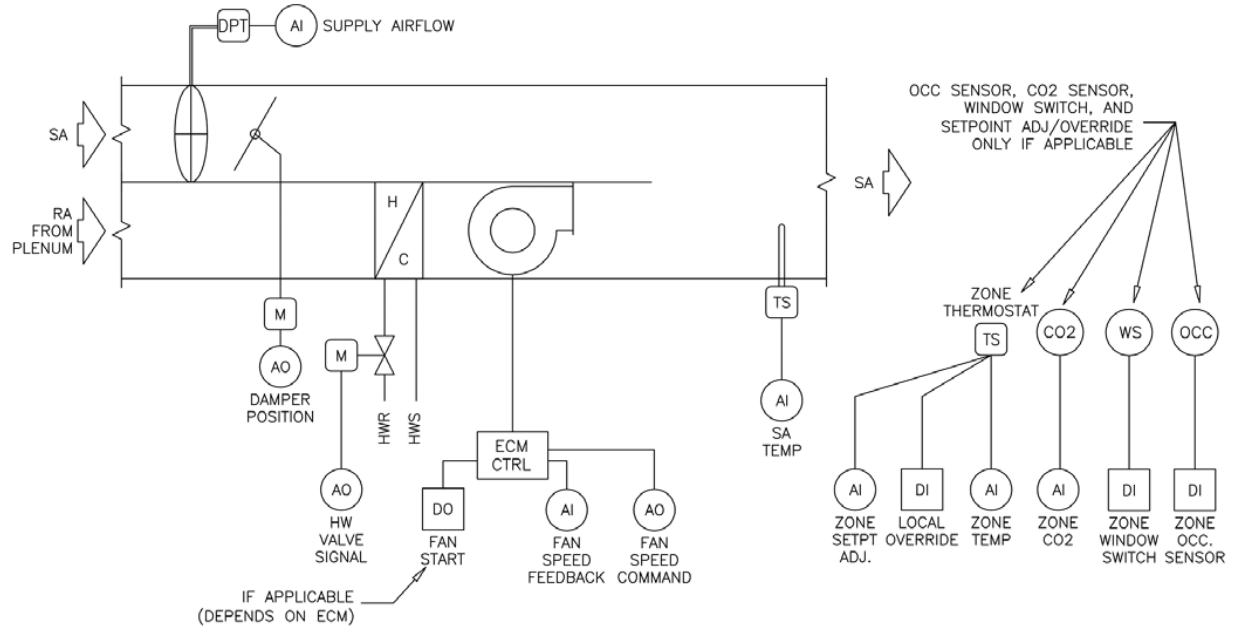
Annex B.4.3 Example Fan Powered Terminal Unit

Example Fan Powered Terminal Unit based on Figure A-3. Link to Model



Annex B.4.4 Example Parallel Fan Powered Terminal Unit

Example Parallel Fan Powered Terminal Unit based on Figure A-4. Link to Model



Annex B.5 Dual Duct Terminal Unit with Inlet Sensors

This section describes the classes and example model of the Dual Duct Terminal Unit with InleI at Sensors described in Section 4.4 and Appendix A, Figure A-7 (ASHRAE Guideline 36-2024)

Annex B.5.1 g36:DualDuctTerminalWithInletSensors

A dual duct air terminal mixes two independent sources of primary air. This terminal uses two inlet sensors.

Related Constraints

Description	Link
DualDuctTerminalWithInletSensors shall contain 1 damper that has the Role Cooling using the relation contains.	Link
DualDuctTerminalWithInletSensors shall contain 1 damper that has the Role Heating using the relation contains.	Link
DualDuctTerminalWithInletSensors shall contain 2 dampers using the relation contains	Link
The DualDuctTerminalWithInletSensors InletConnectionPoint shall have at least one cooling supply airflow property using the relation hasProperty.	Link
The DualDuctTerminalWithInletSensors InletConnectionPoint shall have at least one heating supply airflow property using the relation hasProperty.	Link

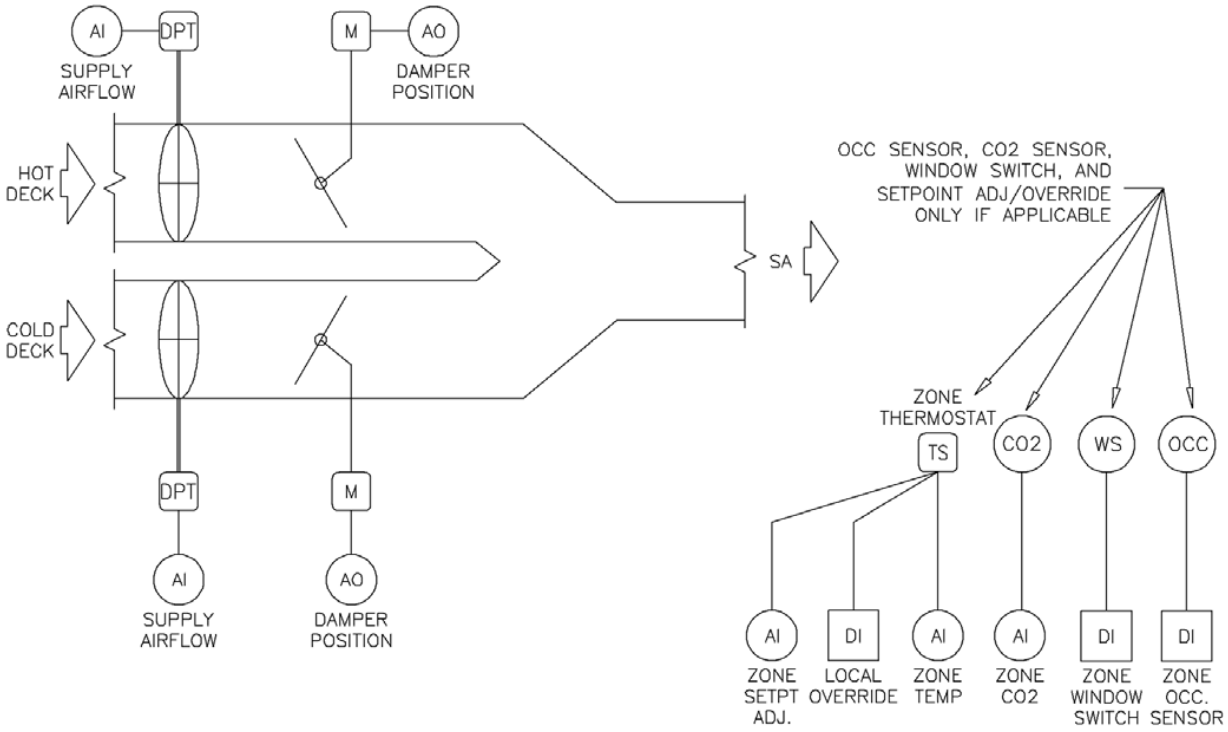
Annex B.5.2 g36:DualDuctTerminalWithInletSensorsAnnotation

Related Inference Rules

Description	Link
If an instance of s223:DualDuctTerminal matches the constraints defined by g36:DualDuctTerminalWithInletSensors, it will be declared as an instance of that class.	Link

Annex B.5.3 Example Dual Duct Terminal Unit With Inlet Sensors

Dual Duct Terminal Unit based on Figure A-7. Link to Model



Annex B.6 Dual Duct Terminal Unit with Discharge Sensor

This section describes the classes and example model of the Dual Duct Terminal Unit with Discharge Sensor described in Section 4.5 and Appendix A, Figure A-8 (ASHRAE Guideline 36-2024)

Annex B.6.1 g36:DualDuctTerminalWithDischargeSensor

A dual duct air terminal mixes two independent sources of primary air. This terminal uses one discharge sensor.

Related Constraints

Description	Link
In the DualDuctTerminalWithDischargeSensor, one Damper has Role Cooling using the relation hasRole.	Link
In the DualDuctTerminalWithDischargeSensor, one Damper has Role Heating using the relation hasRole.	Link
The DualDuctTerminalWithDischargeSensor OutletConnectionPoint shall have at least one discharge airflow property using the relation hasProperty.	Link
The DualDuctTerminalWithDischargeSensor shall contain 2 dampers using the relation contains.	Link

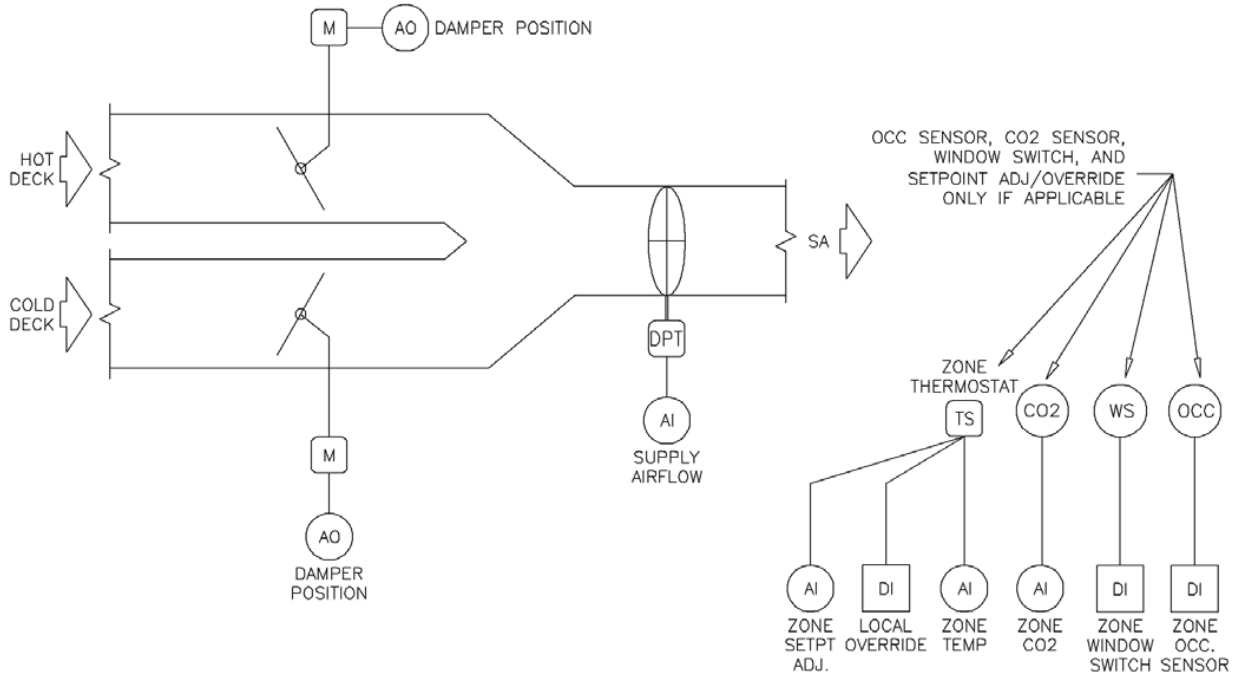
Annex B.6.2 g36:DualDuctTerminalWithDischargeSensorAnnotation

Related Inference Rules

Description	Link
If an instance of s223:DualDuctTerminal matches the constraints defined by g36:DualDuctTerminalWithDischargeSensor, it will be declared as an instance of that class.	Link

Annex B.6.3 Example Dual Duct Terminal Unit With Discharge Sensors

Dual Duct Terminal Unit With Discharge Sensors based on Figure A-8. Link to Model

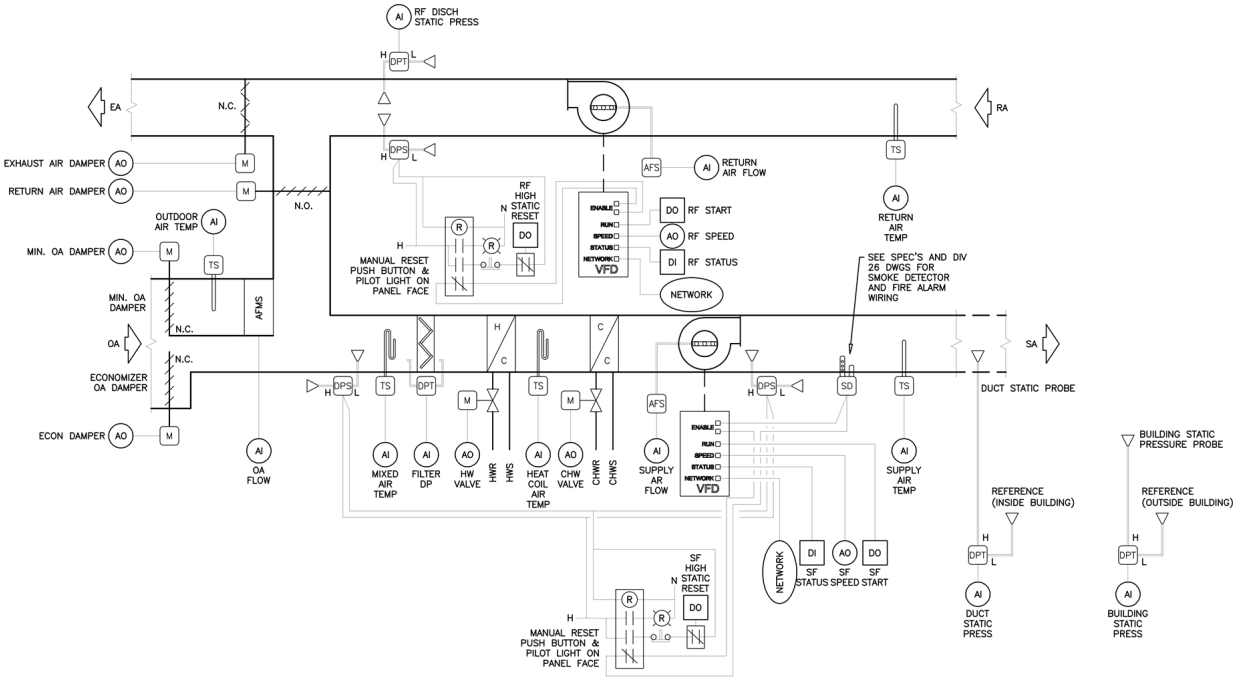


Annex B.7 Multiple Zone VAV Air Handling Unit

This section describes the classes and example model of the Multiple Zone VAV Air Handling Unit described in Section 4.6 and Appendix A, Figures A-9 and A-10 (ASHRAE Guideline 36-2024)

Annex B.7.1 Example Multiple Zone VAV Air Handling Unit

Multiple Zone VAV Air Handling Unit based on Figure A-9. Link to Model.



Annex B.7.2 g36:MultipleZoneVAVAirHandlingUnit

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. This air handling unit serves multiple zones.

Related Constraints

Description	Link
One MultipleZoneVAVAirHandlingUnit InletConnectionPoint shall have at least one outdoor air temperature property using the relation hasProperty.	Link
One MultipleZoneVAVAirHandlingUnit InletConnectionPoint shall have at least one return air temperature property using the relation hasProperty.	Link
One MultipleZoneVAVAirHandlingUnit OutletConnectionPoint shall have at least one supply air temperature property using the relation hasProperty.	Link
The MultipleZoneVAVAirHandlingUnit shall contain at least one ChilledWaterCoil for cooling using the relation contains.	Link
The MultipleZoneVAVAirHandlingUnit shall contain at least one HotWaterCoil or at least one ElectricHeatingCoil for heating using the relation contains.	Link
The MultipleZoneVAVAirHandlingUnit OutletConnectionPoint shall have at least one supply duct static pressure property using the relation hasProperty.	Link

Description	Link
The MultipleZoneVAVAirHandlingUnit shall contain at least one return air damper using the relation contains.	Link
The MultipleZoneVAVAirHandlingUnit shall contain at least one supply fan with a VFD that has the role Supply using the relation contains	Link

Annex B.7.3 g36:MultipleZoneVAVAirHandlingUnitAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit, it will be declared as an instance of that class.	Link

Annex B.7.4 g36:MultipleZoneVAVAirHandlingUnit-CommonDamper

For units with a common economizer/minimum OA damper, include the following points

Related Constraints

Description	Link
For units with a common economizer/minimum OA damper, MultipleZoneVAVAirHandlingUnit InletConnectionPoint must have at least one outdoor airflow property.	Link
For units with a common economizer/minimum OA damper, must have exactly one economizer/minimum outdoor air damper.	Link

Annex B.7.5 g36:MultipleZoneVAVAirHandlingUnit-CommonDamperAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a common economizer/minimum outdoor air damper, it will be declared as an instance of this class.	Link

Annex B.7.6 g36:MultipleZoneVAVAirHandlingUnit-OADandAFMS

A unit with a separate minimum outdoor air damper and AFMS

Related Constraints

Description	Link
For units with a separate minimum outdoor air damper and AFMS, MultipleZoneVAVAirHandlingUnit must contain a modulating outdoor air damper with a minimum airflow property.	Link

Annex B.7.7 g36:MultipleZoneVAVAirHandlingUnit-OADandAFMS

A unit with a separate minimum outdoor air damper and AFMS

Related Constraints

Description	Link
For units with a separate minimum outdoor air damper and AFMS, MultipleZoneVAVAirHandlingUnit must contain a modulating outdoor air damper with a minimum airflow property.	Link

Annex B.7.8 g36:MultipleZoneVAVAirHandlingUnit-OADandAFMSAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit-OADandAFMS, it will be declared as an instance of that class.	Link

Annex B.7.9 g36:MultipleZoneVAVAirHandlingUnit-OADandAFMSAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit-OADandAFMS, it will be declared as an instance of that class.	Link

Annex B.7.10 g36:MultipleZoneVAVAirHandlingUnit-OADandDP

A unit with a separate minimum outdoor air damper and DP sensor

Related Constraints

Description	Link
For units with a separate minimum outdoor air damper and DP sensor, MultipleZoneVAVAirHandlingUnit must contain a two-position outdoor air damper with a differential pressure property.	Link

Annex B.7.11 g36:MultipleZoneVAVAirHandlingUnit-OADandDPAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit-OADandDP, it will be declared as an instance of that class.	Link

Annex B.7.12 g36:MultipleZoneVAVAirHandlingUnit-WithReliefDamper

A unit with an actuated relief damper but no relief fan

Related Constraints

Description	Link
For units with actuated relief dampers but no relief fan, the MultipleZoneVAVAirHandlingUnit must be connectedTo at least one VAV, which connectedTo at least one HVAC DomainSpace, which is contained by at least one Zone, which has a building static pressure property.	Link
For units with actuated relief dampers but no relief fan, the MultipleZoneVAVAirHandlingUnit must contain a relief air damper with an analog damper command property.	Link

Annex B.7.13 g36:MultipleZoneVAVAirHandlingUnit-WithReliefDamper

A unit with an actuated relief damper but no relief fan

Related Constraints

Description	Link
For units with actuated relief dampers but no relief fan, the MultipleZoneVAVAirHandlingUnit must be connectedTo at least one VAV, which connectedTo at least one HVAC DomainSpace, which is contained by at least one Zone, which has a building static pressure property.	Link
For units with actuated relief dampers but no relief fan, the MultipleZoneVAVAirHandlingUnit must contain a relief air damper with an analog damper command property.	Link

Annex B.7.14 g36:MultipleZoneVAVAirHandlingUnit-WithReliefDamperAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a relief damper, it will be declared as an instance of this class.	Link

Annex B.7.15 g36:MultipleZoneVAVAirHandlingUnit-WithReliefDamperAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:MultipleZoneVAVAirHandlingUnit and has a relief damper, it will be declared as an instance of this class.	Link

Annex B.7.16 g36:MultipleZoneVAVAirHandlingUnit-WithReliefFan

A unit with a relief fan

Related Constraints

Description	Link
For units with both a relief air damper and a relief fan, the MultipleZoneVAVAirHandlingUnit must have a relief air damper with a two-position damper command property.	Link
For units with both a relief air damper and a relief fan, the MultipleZoneVAVAirHandlingUnit must have a relief fan with a VFD.	Link

Annex B.7.17 g36:MultipleZoneVAVAirHandlingUnit-WithReturnFan

A unit with a return fan

Related Constraints

Description	Link
For units with a return fan, if airflow tracking logic is used, the OutletConnectionPoint of the return fan in the MultipleZoneVAVAirHandlingUnit must have a return airflow property.	Link
For units with a return fan, if airflow tracking logic is used, the OutletConnectionPoint of the supply fan in the MultipleZoneVAVAirHandlingUnit must have a supply airflow property.	Link
For units with a return fan, if direct building pressure logic is used, the MultipleZoneVAVAirHandlingUnit must be connectedTo at least one VAV, which connectedTo at least one HVAC DomainSpace, which is contained by at least one Zone, which has a building static pressure property.	Link
For units with a return fan, if direct building pressure logic is used, the OutletConnectionPoint of the return fan in the MultipleZoneVAVAirHandlingUnit must have a return fan discharge static pressure property.	Link
For units with a return fan, the MultipleZoneVAVAirHandlingUnit must contain an exhaust air damper.	Link
For units with a return fan, the MultipleZoneVAVAirHandlingUnit must indeed contain a return fan.	Link

Annex B.7.18 g36:SingleZoneVAVAirHandlingUnit-WithReliefDamper

A SingleZoneVAVAirHandlingUnit with a relief air damper and no relief fan

Related Constraints

Description	Link
the SingleZoneVAVAirHandlingUnit contains a relief air damper with a modulating actuator.	Link

Annex B.8 Dual Fan Dual Duct Air Handling Unit

This section describes the classes and example model of the Dual Fan Dual Duct Air Handling Unit described in Section 4.7 and Appendix A, Figure A-11 (ASHRAE Guideline 36-2024)

Annex B.8.1 g36:DualFanDualDuctAirHandlingUnit

DualFanDualDuctAirHandlingUnit

Related Constraints

Description	Link
A DualFanDualDuctAirHandlingUnit OutletConnectionPoint shall have at least one supply air temperature property using the relation hasProperty.	Link
A DualFanDualDuctAirHandlingUnit OutletConnectionPoint shall have at least one supply duct static pressure property using the relation hasProperty.	Link
The DualFanDualDuctAirHandlingUnit shall contain at least one HotWaterCoil or at least one ElectricHeatingCoil for heating using the relation contains.	Link
The DualFanDualDuctAirHandlingUnit shall contain at least one supply fan with a VFD that has the role Supply using the relation contains.	Link

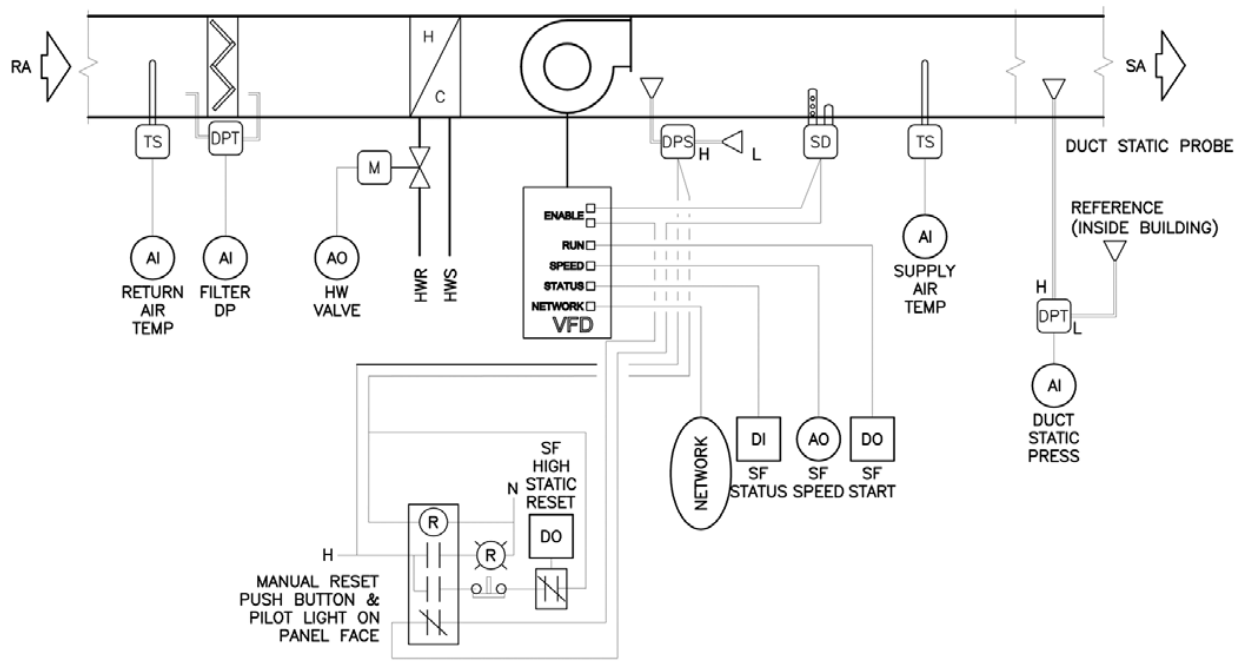
Annex B.8.2 g36:DualFanDualDuctAirHandlingUnitAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:DualFanDualDuctAirHandlingUnit, it will be declared as an instance of that class.	Link

Annex B.8.3 Example Dual Fan Dual Duct Air Handling Unit.

Dual Fan Dual Duct Air Handling Unit based on Figure A-11. Link to Model



Annex B.9 Single Zone VAV Air Handling Unit

This section describes the classes and example model of the Single Zone VAV Air Handling Unit described in Section 4.8 and Appendix A, Figure A-12 (ASHRAE Guideline 36-2024)

Annex B.9.1 g36:SingleZoneVAVAirHandlingUnit

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. This air handling unit that serves one zone only.

Related Constraints

Description	Link
A SingleZoneVAVAirHandlingUnit OutletConnectionPoint shall have at least one supply air temperature property using the relation hasProperty.	Link
The SingleZoneVAVAirHandlingUnit shall contain at least one ChilledWaterCoil for cooling using the relation contains.	Link
The SingleZoneVAVAirHandlingUnit shall contain at least one HotWaterCoil or at least one ElectricHeatingCoil for heating using the relation contains.	Link
The SingleZoneVAVAirHandlingUnit shall contain at least one supply fan with a VFD that has the role Supply using the relation contains.	Link

Description	Link
The SingleZoneVAVAirHandlingUnit shall have at least one outdoor air damper using the relation contains.	Link
The SingleZoneVAVAirHandlingUnit shall have at least one return air damper using the relation contains.	Link

Annex B.9.2 g36:SingleZoneVAVAirHandlingUnitAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit, it will be declared as an instance of that class.	Link

Annex B.9.3 g36:SingleZoneVAVAirHandlingUnit-NoReliefFan

Annex B.9.4 g36:SingleZoneVAVAirHandlingUnit-NoReliefFanAnnotation

Annex B.9.5 g36:SingleZoneVAVAirHandlingUnit-WithReliefFan

A SingleZoneVAVAirHandlingUnit with a relief fan and relief dampers

Related Constraints

Description	Link
For the case where the SingleZoneVAVAirHandlingUnit has both a relief air damper and a relief fan, the SingleZoneVAVAirHandlingUnit must be connectedTo at least one VAV, which is connectedTo at least one HVAC DomainSpace or Zone, which has a building static pressure property.	Link
For the case where the SingleZoneVAVAirHandlingUnit has both a relief air damper and a relief fan, the SingleZoneVAVAirHandlingUnit must indeed have a relief air damper with a two-position damper command property.	Link
For the case where the SingleZoneVAVAirHandlingUnit has both a relief air damper and a relief fan, the SingleZoneVAVAirHandlingUnit must indeed have a relief fan.	Link

Annex B.9.6 g36:SingleZoneVAVAirHandlingUnit-WithReliefFanAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit and has a relief fan, it will be declared as an instance of this class.	Link

Annex B.9.7 g36:SingleZoneVAVAirHandlingUnit-WithReturnFan

A SingleZoneVAVAirHandlingUnit with a Return fan

Related Constraints

Description	Link
For the case where the SingleZoneVAVAirHandlingUnit has a return fan, the SingleZoneVAVAirHandlingUnit must contain an exhaust air damper with either an analog or two-position damper command property.	Link
For the case where the SingleZoneVAVAirHandlingUnit has a return fan, the SingleZoneVAVAirHandlingUnit must indeed contain a return fan.	Link

Annex B.9.8 g36:SingleZoneVAVAirHandlingUnit-WithReturnFanAnnotation

Related Inference Rules

Description	Link
If an instance of s223:AirHandlingUnit matches the constraints defined by g36:SingleZoneVAVAirHandlingUnit and has a return fan, it will be declared as an instance of that class.	Link

Annex B.9.9 Example Single Zone VAV Air Handling Unit Unit

Single Zone VAV Air Handling Unit Unit based on Figure A-12. Link to Model