AUTODESK UNIVERSITY

MEP19658-L

Perfecting the System for Revit

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Learning Objectives

- Learn comprehensive steps for controlling project system settings, including mechanical and electrical system project settings
- Understand how to create the target and source relationship between equipment without routing a duct, pipe, or wire
- Learn how to capitalize on the system sizing and analysis tools, and learn how to maximize project performance when you don't need these features
- Learn how to improve the quality of your construction documents by capitalizing on system-based features

Description

Revit software systems help us to define the MEP (mechanical, electrical, and plumbing) design in several ways, but the main purpose is to understand the relationships between system equipment, such as air terminals to air handling units, or from light fixture to panel. This hands-on lab will teach you the comprehensive steps needed for controlling project system settings, and then it will demonstrate how to capitalize on (or disable) sizing and analysis tools related to the system. We'll cover creating the target-source relationship between parts, and then we'll review using the systems to improve the quality of your documentation. On top of this, you'll get a project template that already defines everything in the class, so you can take advantage of these topics right away. The class will cover HVAC (heating, ventilating, and air conditioning), piping, and electrical items, so come and join us for this fast-paced but thorough lab—you'll be glad you did! This session features Revit MEP and Revit.

Your AU Expert

David Butts is an Autodesk Expert Elite Team member and Building Information Modeling (BIM) specialist for Gannett Fleming with over 30 years of experience in the architecture, engineering, and construction field. He is responsible for implementation, training, BIM project support, and management for engineering design applications, including Revit software, AutoCAD P&ID software, AutoCAD MEP software, Navisworks software, and more. He was an Autodesk Authorized Training Center (ATC) training manager and application engineer for an Autodesk Reseller for 13 years, providing implementation and training services across the United States, and serving as a subject matter expert for Autodesk, Inc.'s, Building Design Solutions. He has design experience for a variety of project types, and he was the Autodesk University 2011 top-rated speaker for labs and lectures. He authors training videos for 4D Technologies, and he presents BIM topics for other industry associations annually.

Perfecting the System for Revit

When you are designing a project, there's a big difference in how you approach your work in CAD project versus a BIM project. In BIM there are tasks you have to complete that never came up in a 2D project, but then there was a high likelihood of signals getting crossed, and systems being incorrectly defined. Revit's system and circuit tools, which have been around since the beginning of the MEP tools, continue to be refined and improved. That is the focus of this session, and hopefully you will take away some information to help you leverage the benefits for these tools.

The System Rules and the Four Step Process

The methods used by engineers and designers to create HVAC, plumbing, piping and electrical systems has not changed since the days of hand drawing, other than the improvements to equipment. The work process follows a straightforward approach, where the building requirements are assessed first. The necessary equipment types are selected and located, and then the connecting components, such as duct, pipe and wiring are added.

Once these are added, critical data and directions are provided in the construction documents in the form of specifications, schedules, and annotations on drawings that identify and label the components. While there are occasional points where you step outside of the process (such as locating critical duct/pipe items in a chase), the process stays the same.

Using Revit for MEP design works best when you implement a four-step process that emulates this approach. By following the same repeatable process, you can get more efficient at completing our projects on time and under budget. The primary steps are:

- **Select and Locate Equipment** – the *targets* and *sources* that define a system;
- **Define and Refine the System** – creating the system that connects the equipment together;
- **Connecting Geometry** – adding the ducts, pipe, conduit, cable tray and wire;
- **Annotating the Model** – adding tags, schedules and other annotations in views for the construction documents.

The logic in this approach is to create a consistent method of approaching work. The second step, defining the system, is a task they typically is not accounted for in most projects budgets, since it was not required for plain AutoCAD or AutoCAD MEP.

The system is what links the sources, which are the end-of-line equipment that provide air, fluid and power to the targets. The targets include items such as air terminals, motors, sinks, and more, and are what is used to define the system. These items are usually placed at the same time as the primary equipment, after the overall assessment of the building needs are determined.

When you are defining systems, there are few key items you need to review prior to adding anything to a model.

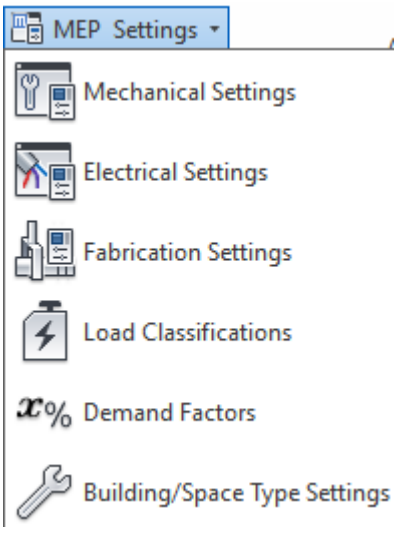
1. **Always start from a template.** The template can be discipline specific, but Revit works best when all disciplines are defined within a single model. While this obviously can't occur when the disciplines are divided up between firms, internal projects should follow this workflow. **Systems cannot be directly connected across linked files**, and require a **connector element** to be added when the disciplines are separated.
2. Your template should include key families that require predefined **type marks**, such as light fixtures, air terminals and receptacles. Traditional construction documents label these items by **type mark**, which is a default parameter in Revit. Since the type mark can only be defined after the family is loaded into the project, get these loaded first.
3. The template should also include predefined **system types**. Based on predefined classifications, such as HVAC supply air and plumbing domestic cold water, the system types allow you to create more specialized systems.
4. The **Target** always *defines* the system, and in order for sizing to be used, you need to have a **Source** – but a source is *not required* to define a system.

NOTE: IMAGES IN THIS DOCUMENT MAY INCLUDE RIBBON TABS THAT ARE NOT PART OF THE SHIPPING VERSION OF REVIT. PLEASE REFER TO THE TEXT INSTRUCTIONS FOR REFERENCES TO THE DEFAULT INTERFACE LOCATIONS.

Defining Project System Settings

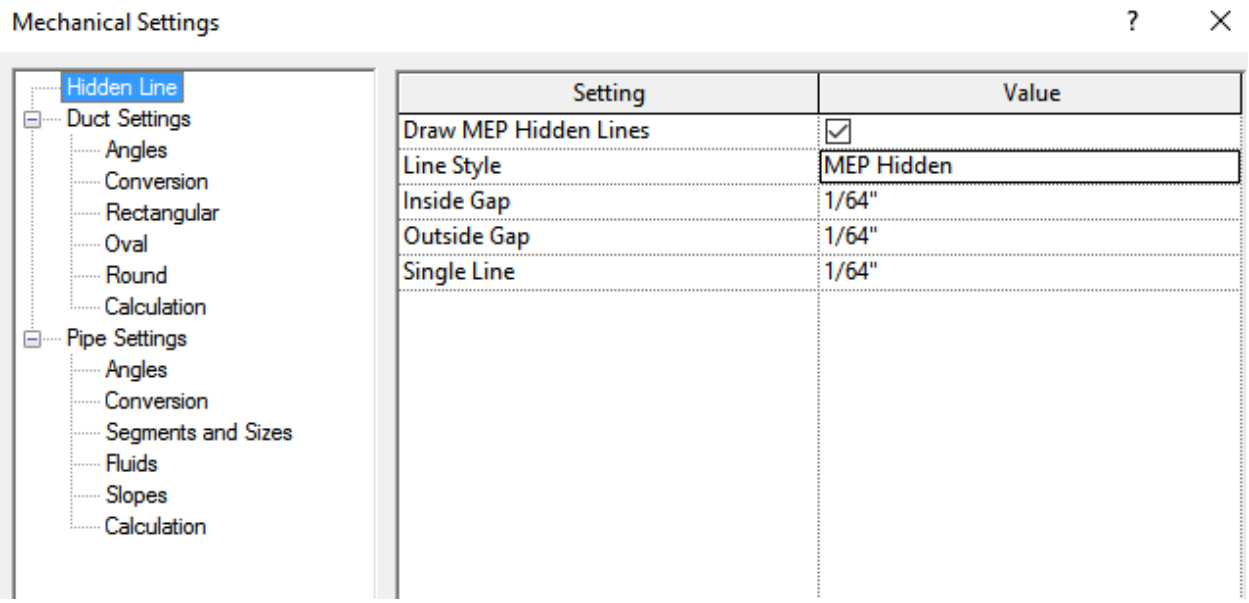
When you start from a template, you can include predefined settings that apply to the most common project types. Behind the scenes, there are common project tools that impact how duct, pipe, circuiting and more are defined in the project model, so it is a logical place to start when working with systems.

From the **Manage** tab, settings panel, click **MEP Settings**:



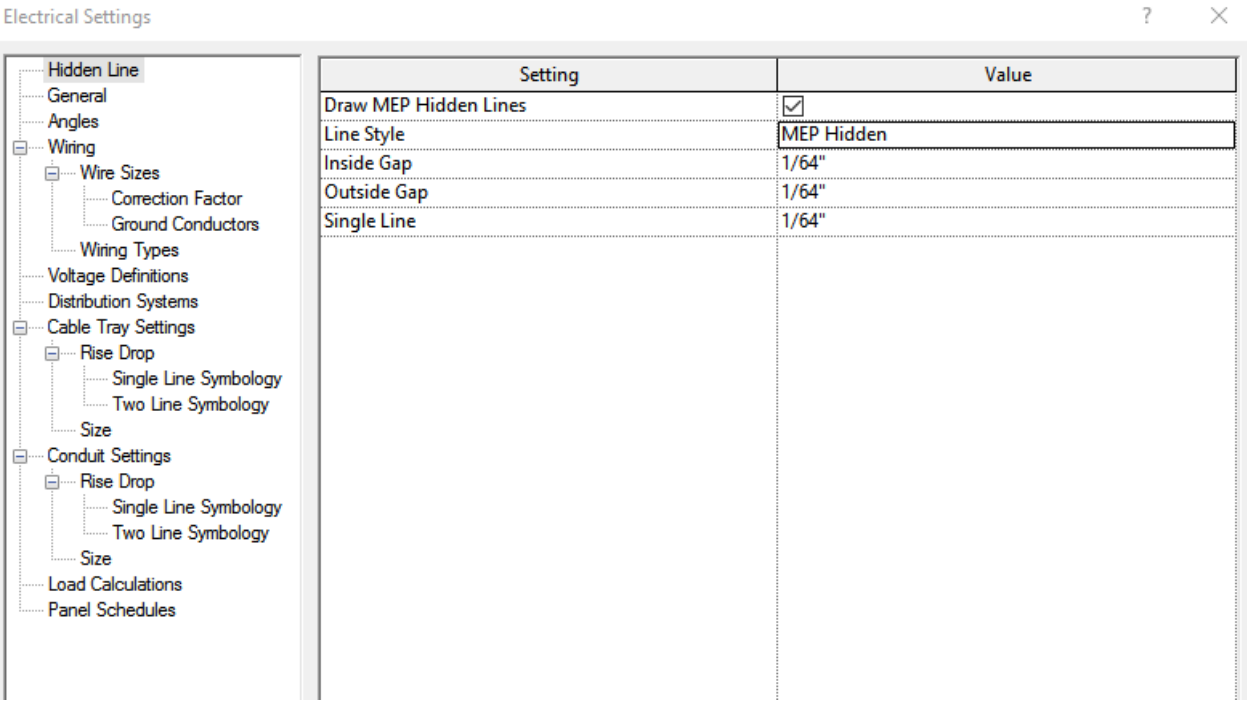
MEP Settings include tools that control project specific settings. These can be defined in your project template, and edited in a project after it's started. We're focusing on mechanical and electrical systems, so let's start by examining these values.

Mechanical settings control duct and pipe settings, including:



- **Hidden Line** settings for crossed duct and pipe objects;
- **Duct** and **Pipe** settings for annotations, and for project wide sizing tools;
- **Angle** settings that are applied to duct and pipe fittings
- Duct and pipe default **materials** and **elevations**, based on system classifications
- Predefined **sizes** based on duct shapes, and pipe materials, including inside/outside dimensions
- **Calculation methods** used for duct and pipe sizing
- Pipe specific settings for **fluid** data and predefined **slope** values.

Electrical settings cover a wide range of project specific settings, including:



- **Hidden Line** settings for crossed cable tray and conduit objects;
- **Circuit** settings for annotations, and for project wide sizing tools;
- **Angle** settings that are applied to cable tray and conduit fittings
- Project **wiring** settings for tick marks, circuit wire sizing and other annotation settings
- **Wire size** default values based on material, insulation and temperature rating
- **Correction factors** and **ground conductor** settings for wiring, based on temperature and ampacity
- **Wiring Types** that can be assigned to a circuit, and are sized based on the load/breaker rating
- **Voltage definitions** that allow a range of assigned voltages (such as 110-130) to be assigned to a common voltage (120)
- **Distribution systems** that set the configuration type (wye or delta), phase and number of wires
- **Cable tray** and **conduit** routing settings for annotations, rise drop symbols and sizes;
- **Load calculation** settings for enabling the loads to be associated with a corresponding space, settings for project load classifications, demand factors, and apparent load calculation methods (including true and reactive load);
- **Panel schedule** settings that apply to all schedules, including space and spare labels, load totals and cell formatting.

All of these settings are global to the project; in other words, changing values here affects all examples of objects, except where object specific overrides are defined.

Defining System Types

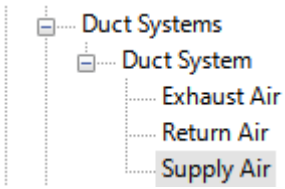
Beyond the overall project settings, each class of items include specific settings. Revit begins with system classifications, which are used to control duct and piping systems. These are hard-coded items that are associated with the formulas for deriving duct and pipe sizes. While you cannot edit the system classifications, you can edit the *system types* using the Project Browser. Examples of system types would include domestic cold water supply, hot water return, makeup supply air and more. These should be defined in your template, so the user has a starting point for their systems.

The equivalent to the system classification for electrical is the distribution system, which based on the system voltage. Each voltage can be assigned a range, but only items that fall within that range can be associated with that “voltage” system. Transformers are required to create the relationship between lower and higher voltage distribution systems.

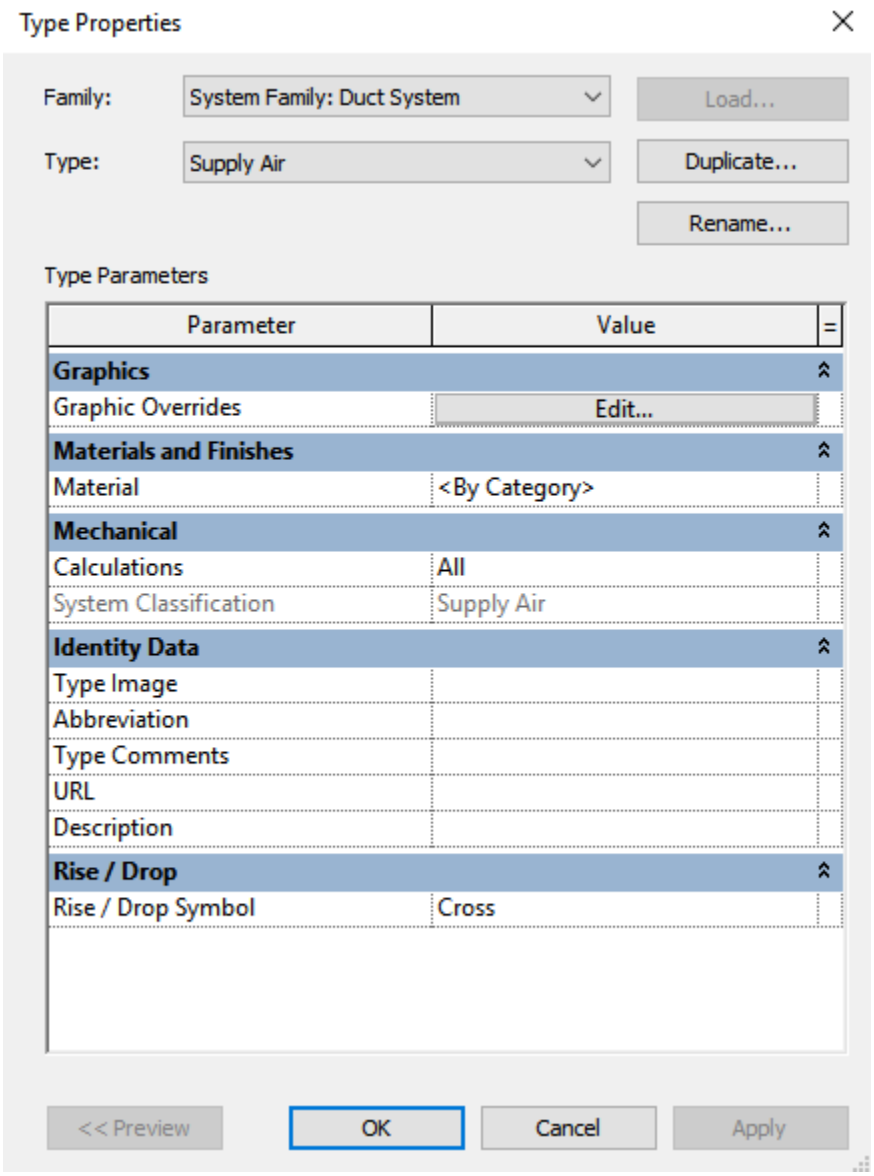
For all system types, you must have a corresponding connector defined in the target and source family. Duct, pipe and circuits do not have to be added to create a relationship between the target and source, but the connectors must use the same type and/or system classification, or voltage.

Duct System Characteristics

From the **Project Browser**, expand the **Families** section. Expand **Duct Systems**, and select **Supply Air**:



You can edit system types by **double-clicking** the name, or by using the right click option to open a menu and selecting **Type Properties**.



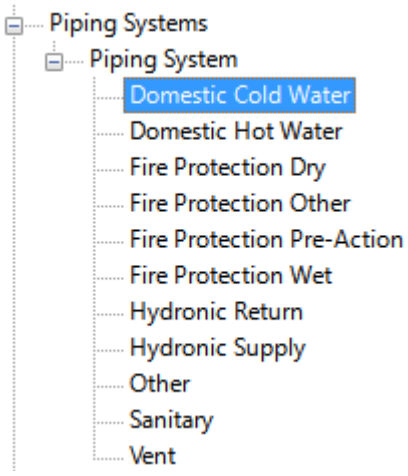
A **duct system** controls the following items:

- **Graphic Overrides** – assigned a color, linetype and hatch pattern to the duct and duct fittings, when the system type is selected;

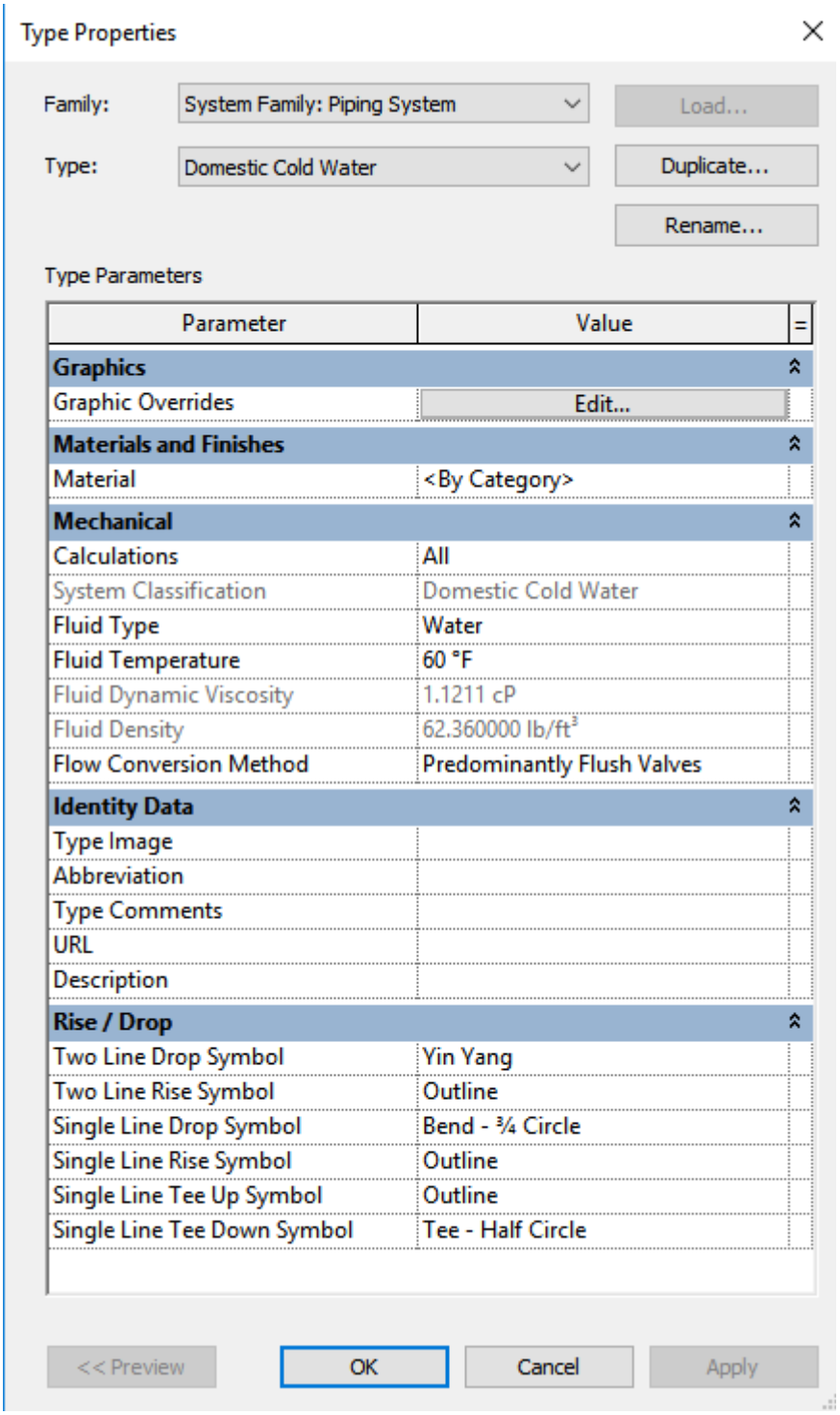
- **Material** – assigns the material applied to the duct which controls the color and rendered surface when using shaded or realistic views;
- **Calculations** – controls whether calculations are performed as the duct is placed, and attached to target/source equipment. You can choose between All, Flow Only, None and Performance
- **System Classification** – default setting that controls the calculation method, based on the type of system, such as supply or return air;
- **Type Image** – location and image file used in a legend to describe the type – note that the raster image used must be in a location that is accessible to all team members, so it's best to place these with the project
- **Abbreviation** – used to label the system, such as SUPP for supply air duct
- **Type Comments** – comments that are specific to all examples of the duct system
- **URL** – hyperlink to a website or file, such as a specification for the duct material used for this system
- **Description** – text value that can be used in a tag or schedule to expand information that might be included with an abbreviation
- **Rise / Drop Symbol** – displayed on a vertical section of duct, that indicates the type of duct system

Pipe System Characteristics

Piping systems are also defined in your project template. From the **Project Browser**, expand the **Families** section. Expand **Pipe Systems**, and select **Domestic Cold Water**:



You can edit system types by **double-clicking** the name, or by using the right click option to open a menu and selecting **Type Properties**.



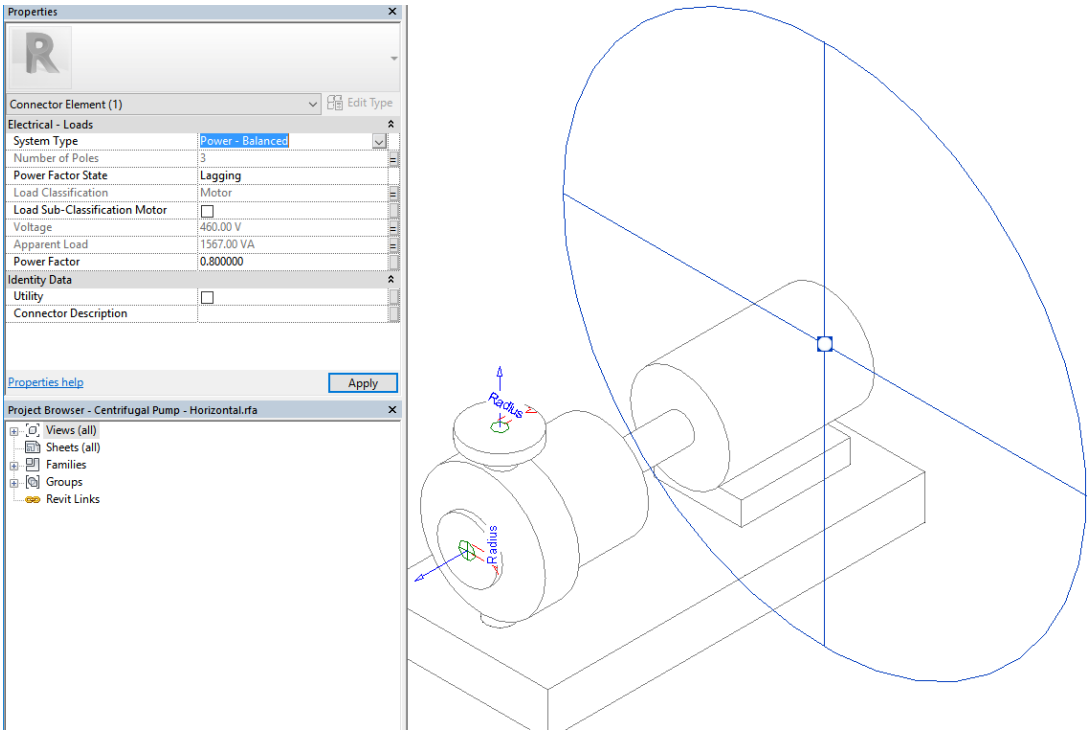
A **pipe system** controls the following items:

- **Graphic Overrides** – assigned a color, linetype and hatch pattern to the pipe and pipe fittings, when the system type is selected;
- **Material** – assigns the material applied to the pipe which controls the color and rendered surface when using shaded or realistic views;

- **Calculations** – controls whether calculations are performed as the pipe is placed, and attached to target/source equipment. You can choose between *All, Flow Only, None* and *Performance*. The options will vary based on the type of system – for example, *Sanitary* does not include an *All* option, while *Other* is for non-calculated systems, such as *Compressed Air*.
- **System Classification** – default setting that controls the calculation method, based on the type of system, such as domestic cold water, sanitary and hydronic supply.
- **Fluid Type and Fluid Temperature** – these options only appear with water and glycol pressurized systems. This includes domestic water and hydronic systems.
- **Fluid Dynamic Viscosity and Fluid Density** – these settings are determine by the project fluid settings, and controlled by the temperature assigned to the system. Editing the temperature and fluid type will change these settings.
- **Flow Conversion Method** – these settings appear as part of the domestic water systems, allowing you to choose between *flush valve* and *flush tank* systems.
- **Type Image** – location and image file used in a legend to describe the type – note that the raster image used must be in a location that is accessible to all team members, so it's best to place these with the project
- **Abbreviation** – used to label the system, such as DHW for domestic hot water
- **Type Comments** – comments that are specific to all examples of the pipe system
- **URL** – hyperlink to a website or file, such as a specification for the pipe material used for this system
- **Description** – text value that can be used in a tag or schedule to expand information that might be included with an abbreviation
- **Rise / Drop Symbols** – displayed on a vertical section of pipe that indicates the type of pipe system, based on single line, two line and tee up/down locations on a pipe.

Electrical System Characteristics

Electrical Systems aren't developed the same way as duct and pipe. Revit includes a series of electrical systems that are based on electrical connection settings in a family. Electrical systems are made of the following types:



- **Power** connections – made up of *balanced* and *unbalanced* loads, based on single or three phase systems;
- **Communication**
- **Control**
- **Data**
- **Nurse Call**
- **Fire Alarm**
- **Security**
- **Telephone**
- **Switch**

These are used to define circuits and other relationships, such as communication network or control system. All non-power electrical systems exist to only show the relationship between a target, such as flow switch, and a source, such as a control panel.

Power systems are electrical circuits that are based on voltage systems, and provide device load data that is modified by number of poles, load classification, demand factor and power factor. The **electrical fixture device**, or **light fixture**, typically defines a power system or circuit. The **panel** is defined as the source, since it provides the power to the target. A panel can be both a target and source, but a transformer must be placed in order to connected lower voltage (120/208, 120/240) to a higher (277/480).

Switch systems are used to associate a primary light switch with light fixtures. Since only one switch defines a switch system, three pole fixtures are added to a system as another device.

Creating the Target Source Relationship

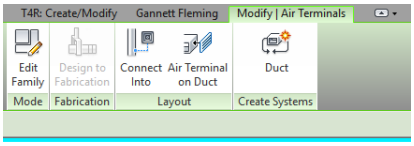
MEP systems in Revit boil down to a simple task. A relationship, which is defined by a target, is established be creating a connection to a source. In traditional CAD documentation, it's demonstrated by following the routing of duct, pipe and wire between these items. But after the building is finished, after the slab is poured, the ceilings and wall finishes in place, and the roof topping the building how, most of these items remain invisible to the occupant.

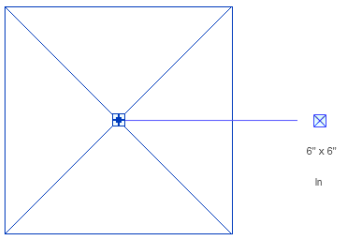
In Revit, they're never invisible. This relationship can be made by either routing the duct, pipe or wire, or by simply using the system tools to create it. There are several key advantages for using the system tools first:

- The best indicator is the **tab selection** tool, which allows the user to place their cursor over a device, tap the tab key, and see the structure of the system.
- The system can be used for **simple** duct, pipe and wire layouts, based on preset preferences for materials and routing elevations.
- The system can also be used to control **visibility properties** throughout a project, based on **system type settings** or **view filters.**
- You can select several targets at once, and use them to define a system – for example, selecting several lights that will all belong to the same circuit saves several steps.
- The system tracks the **load information** from the **target** devices back to the sources, exposing overall system data. But a source is not always required…wait…what? We'll come back to this….
- While conduit and cable tray geometry can also be added using this system relationship, let's focus on the basic MEP connections first.

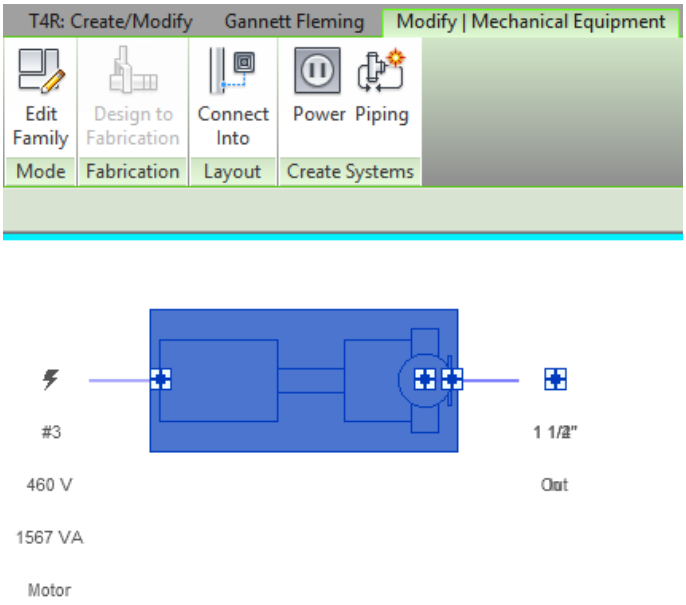
Defining the System by Target

To create a system in Revit, select any one of these devices:

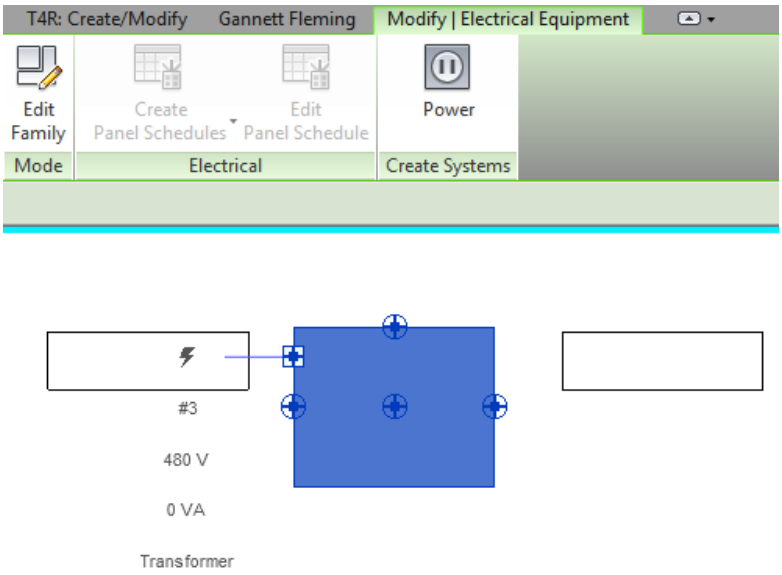




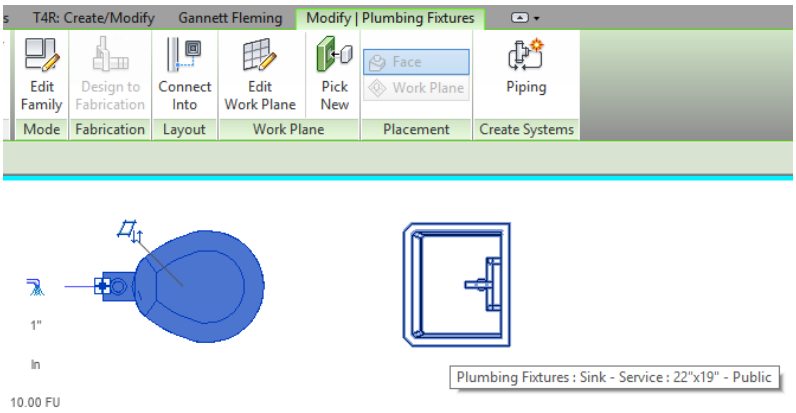
TARGET: AIR TERMINAL – DUCT SYSTEM



TARGET: PUMP – POWER SYSTEM/PIPING SYSTEM WITH MULTIPLE CONNECTIONS



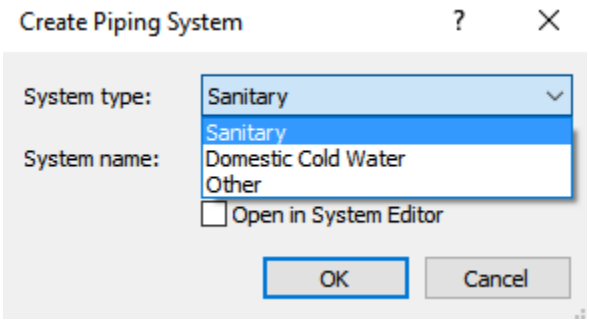
TARGET/SOURCE – TRANSFORMER (TARGET FOR 480/277V PANEL, SOURCE FOR 120/208V PANEL)



TARGET: PLUMBING FIXTURE – SOURCE NOT REQUIRED (I.E. WASTE, FOR A VARIETY OF REASONS)

In all cases, the system is defined by the **connector**, the **role** the part plays in the system and the defined Revit **family category**.

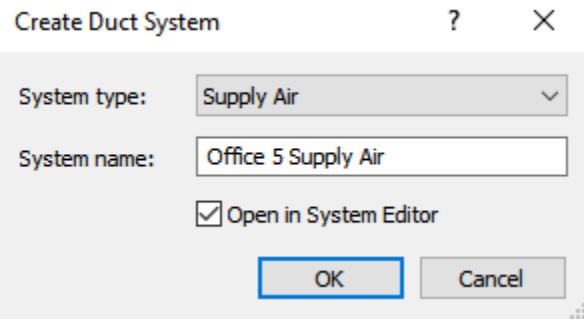
To create the system, you simply choose the system type from the ribbon. If a part has more than one connection, such as with the sink, you may be prompted to select the connector and **system type** (in this case, piping):



You would also be prompted to specify a system name, which helps you identify the system in the project.

Duct Systems Defined

Once you select the HVAC component that contains the duct connector, selecting the Duct system causes the **Create Duct System** dialog to appear:

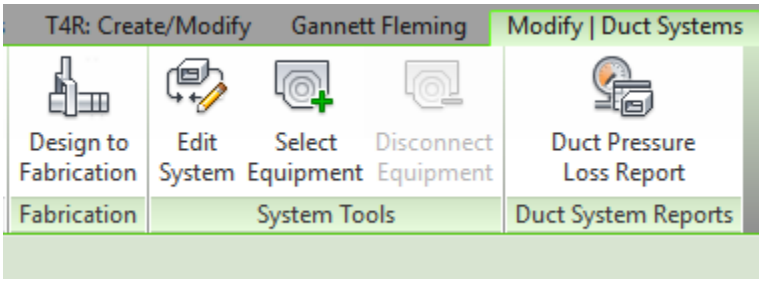


When only option, such as Supply Air, is available, it's because the connector has a **preassigned system classification** – in this case, *Supply Air*. If multiple Supply Air systems are listed, it's because you may have more than one Supply Air duct system defined – but only systems that are tied to the Supply Air classification can be used.

The only time you will see all system types appear is when the connector is set to Global or Other.

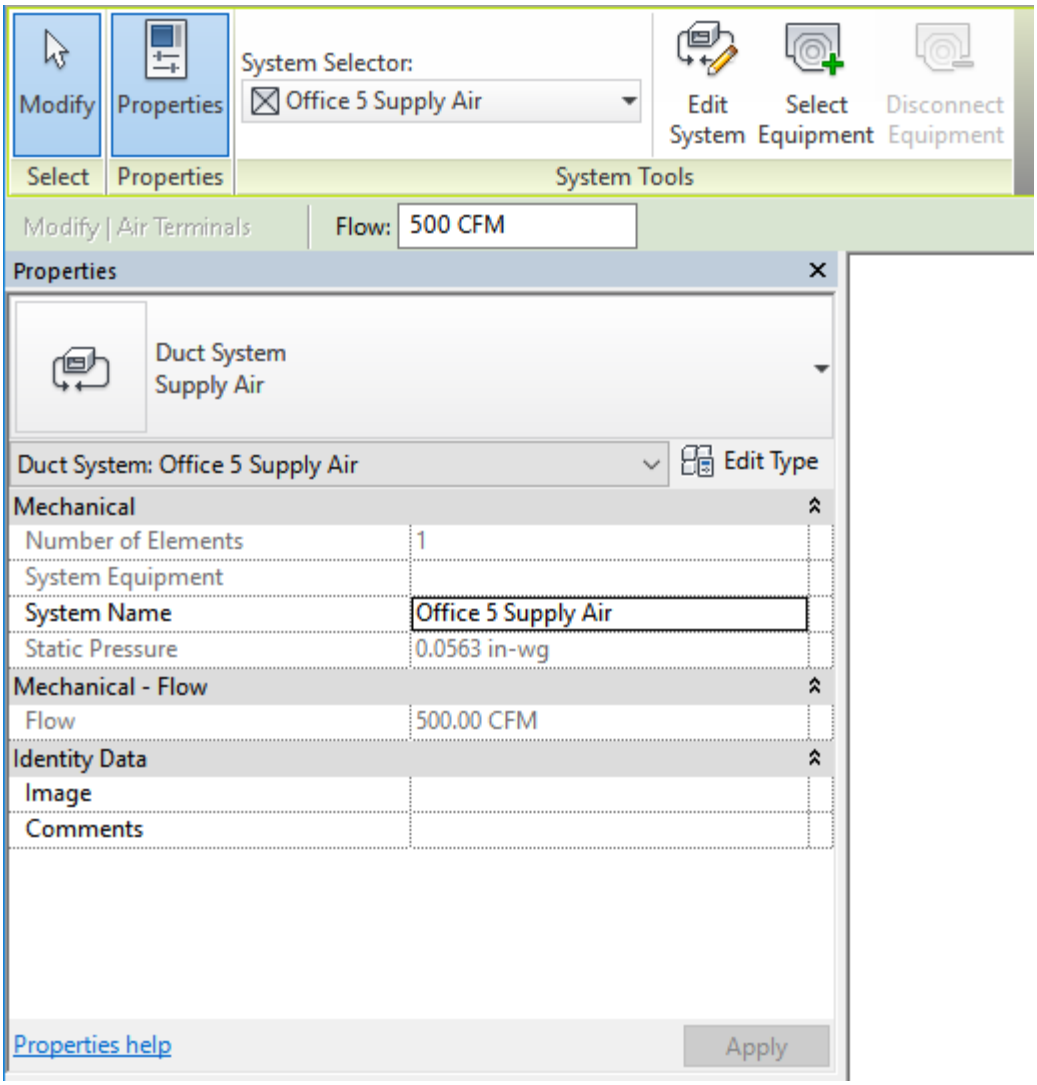
Here's an important note: **NAME YOUR SYSTEM**. This will help you clearly identify what the target is servicing – such as the OFFICE 5 SUPPLY AIR system name.

Selecting **Open in System Editor** will open the entire set of system tools. Leaving this option deselected only opens the **Modify | Duct Systems** tab of the ribbon:



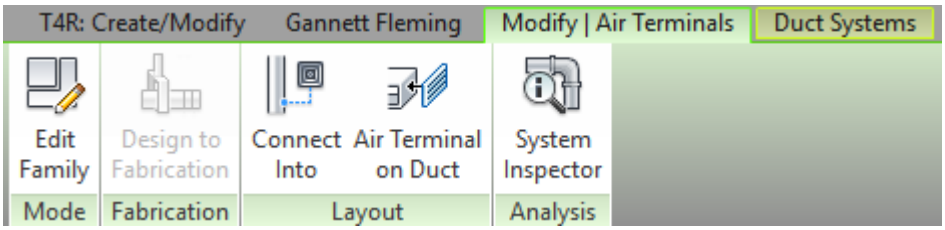
This tool still allows you to edit the *system*, select the Source *Equipment* or *disconnect equipment*. Based on the connector type, you may also see additional options, such as the *Duct Pressure Loss Repor*t.

If you select the **Open in System Editor** tool, or the **Edit System** tool, a new ribbon tab will appear:



DUCT SYSTEM TAB

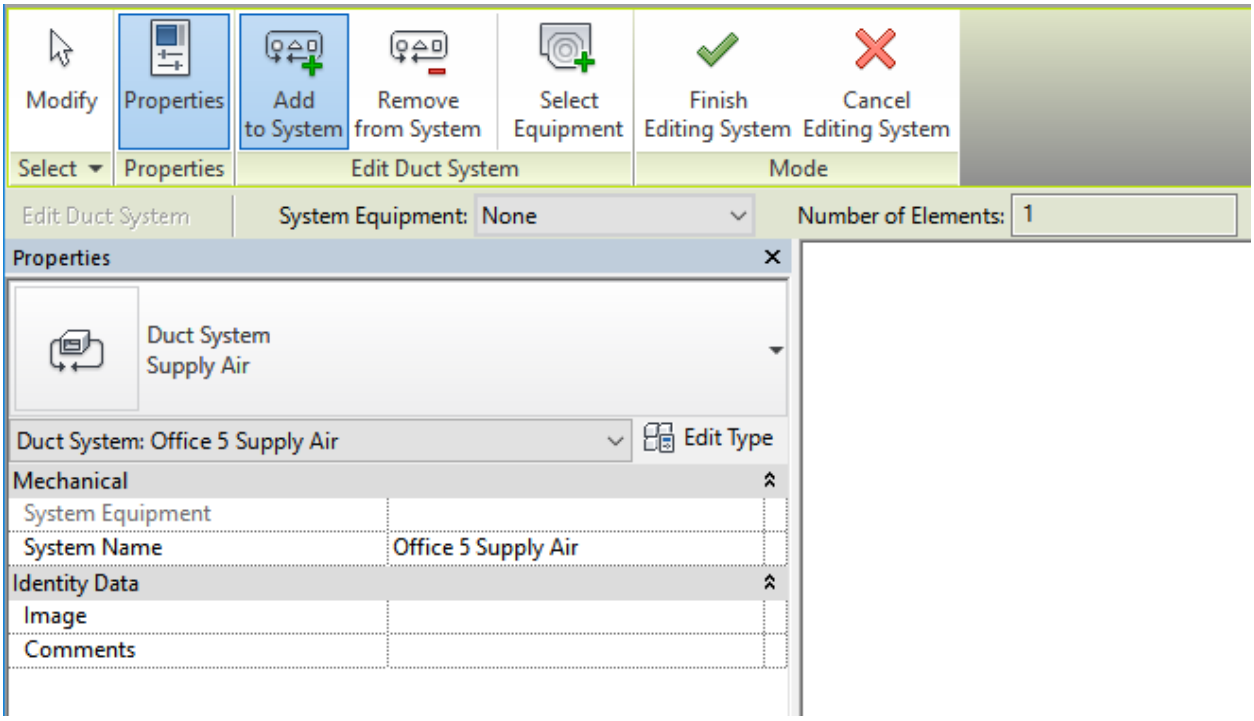
Keep in mind – you can select any target that has been defined to a system after it has been defined, but you will get two modify tabs:



Modify Air Terminals will you get you the *Edit Family*, *Layout* and *Analysis* tools, while **Duct Systems** will display the tab above.

Make sure you are selecting the right tab based on the changes you are making!

The **Edit Duct System** (or **Edit System**) tool, located on the Duct Systems tab, opens the system up for editing:

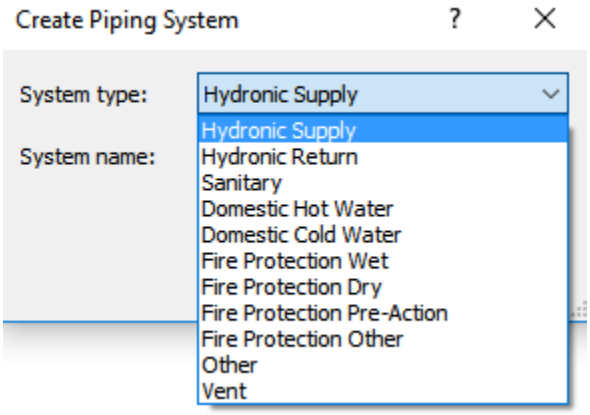


This tool allows you to:

- Review and set system **properties** such as the system name, image and comments that can be used in a schedule, and edit the system **Type**, which controls the graphic overrides, materials, calculations, identity data and rise drop symbols;
- **Add** other targets to the system (the system type must match);
- **Remove** targets from the system;
- Select the Source **Equipment** from a drop down list or by selecting the equipment family in the model view;
- See the **number of elements** that are included in the system;
- **Finish** and **Cancel** editing the system – note that you HAVE to close this tool by selecting one of the options before moving on to another task.

Pipe Systems Defined

Similar to the duct systems, you select the equipment component that contains the pipe connector, and selecting the system makes the **Create Pipe System** dialog appear:

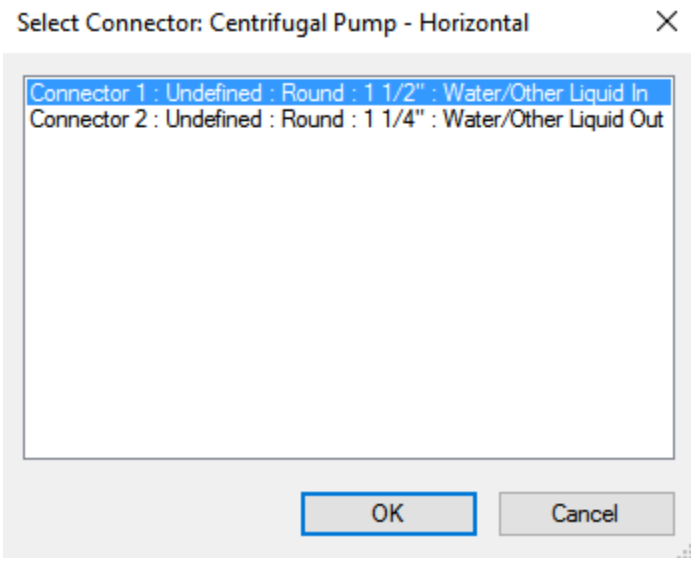


In this case, the connector is set to global, so you can select any system type or classification. Keep in mind that once the connector is set to a specific system classification, only system types in the same classification can be used.

As with duct, make sure **NAME YOUR SYSTEM** to clearly identify what it is servicing.

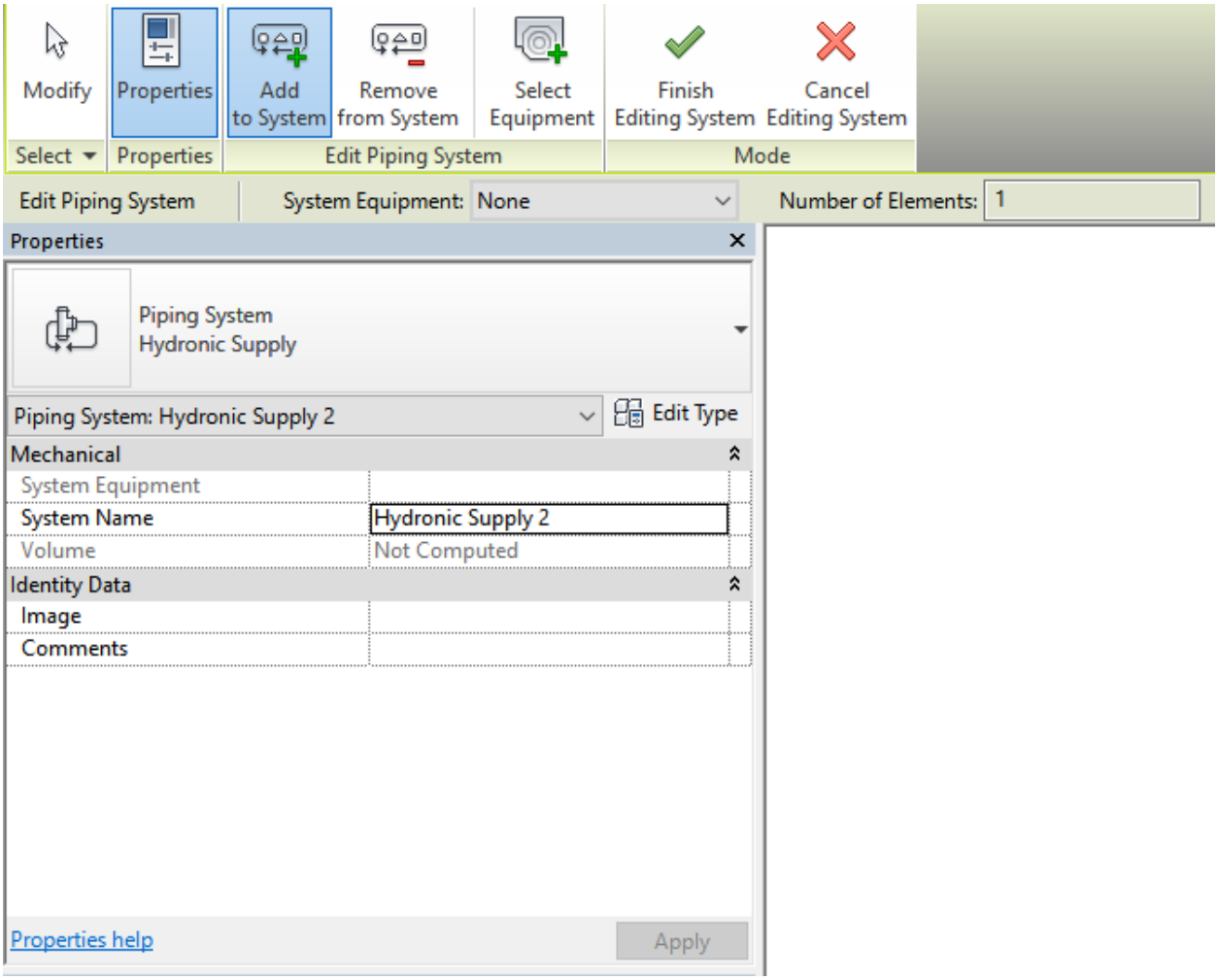
Selecting **Open in System Editor** will open the entire set of system tools.

In some cases, if you have **more than one connector** assigned to the **same system classification**, you will be prompted to select a **connector** – all **unconnected** connectors will appear in the list (…get the connection???):



Select the connector you wish to use, and then click OK.

Leaving this option selected opens the **Edit Piping Systems** tab of the ribbon:

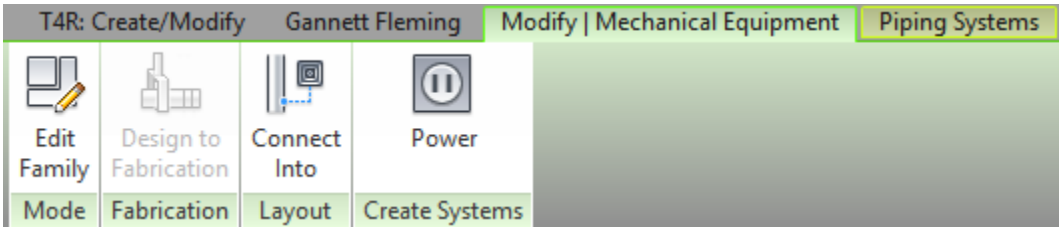


PIPE SYSTEM TAB

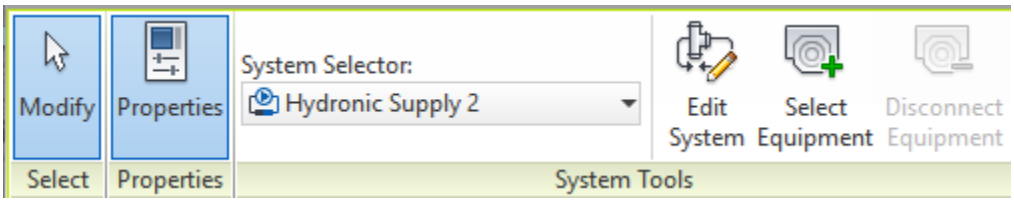
This tool allows you to:

- Review and set system **properties** such as the system name, image and comments that can be used in a schedule, and edit the system **Type**, which controls the graphic overrides, materials, calculations, fluid mechanical properties, identity data and rise drop symbols;
- **Add** other targets to the system (the system type must match);
- **Remove** targets from the system;
- Select the Source **Equipment** from a drop down list or by selecting the equipment family in the model view;
- See the **number of elements** that are included in the system;
- **Finish** and **Cancel** editing the system – note that you HAVE to close this tool by selecting one of the options before moving on to another task.

Keep in mind – you can select any target that has been defined to a system after it has been defined, but you will get two modify tabs:



Modify Mechanical Equipment will you get you the *Edit Family*, *Layout* and *additional Create Systems* tools (if additional connections are available), while the **Piping Systems** tab will display to the right:

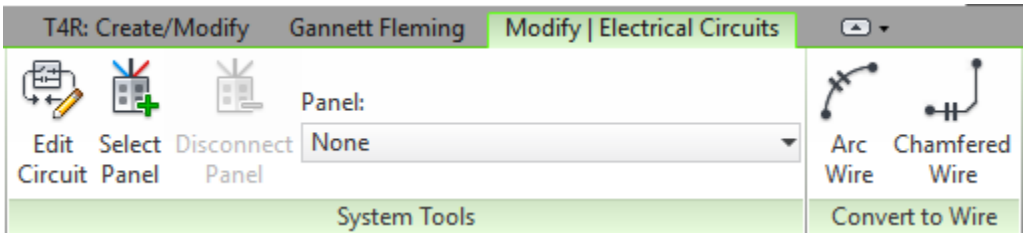


Make sure you are selecting the right tab based on the changes you are making!

Electrical Circuits Defined

Electrical circuits have similar behavior to pipe and duct connectors in that the system (or circuit) is defined the same way. You select target devices, such as lights, and then use the **Power** tool to define the circuit. An option also exists to create a switch system when lighting fixtures are selected, but that's for another lesson.

When the Power system tool is selected, the **Modify | Electrical Circuits** tab appears:

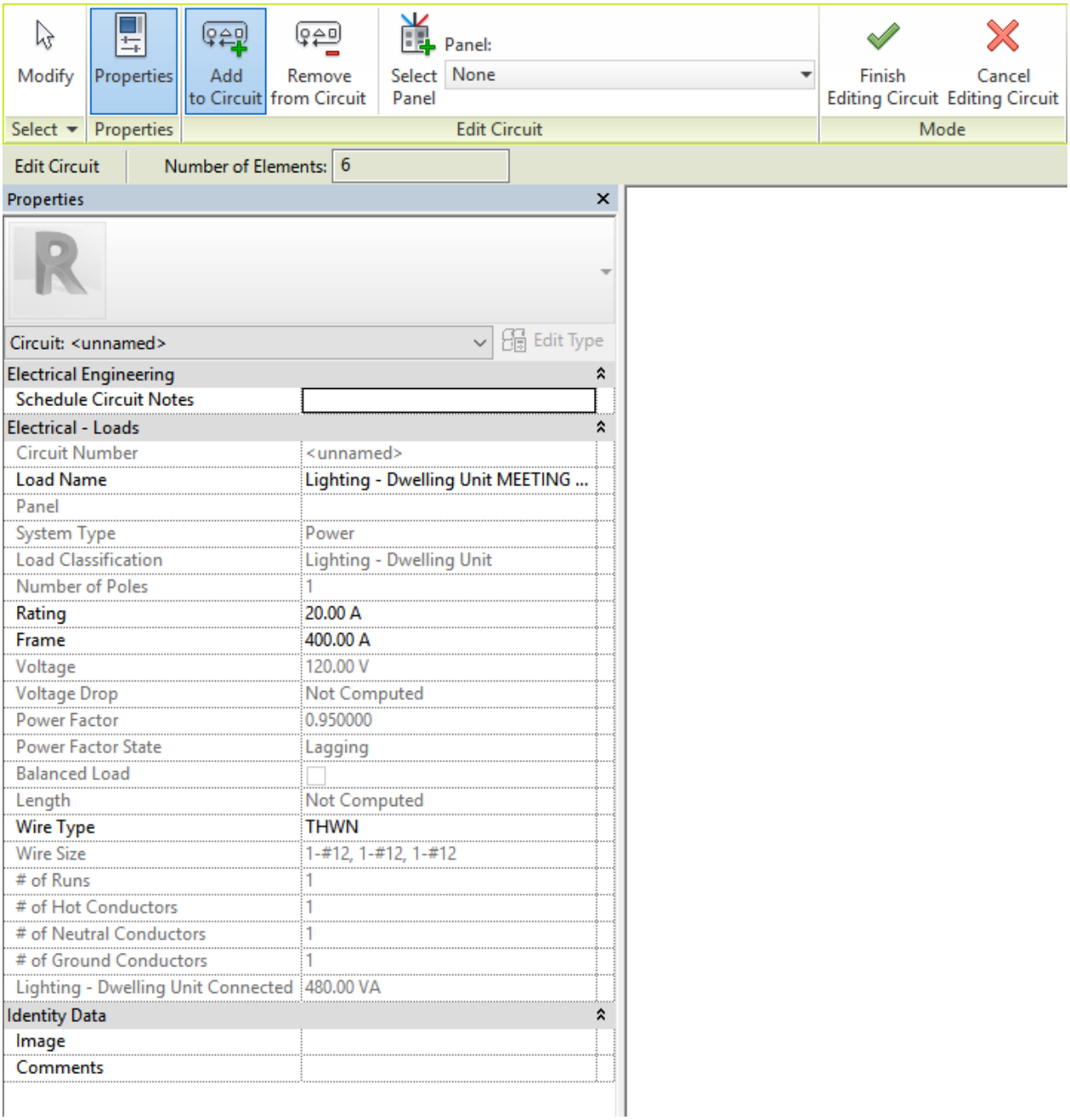


The tab includes system tools for editing the circuit and selecting a panel.

Here's an important feature: If you create a circuit using devices that have the same voltage definition, the panel selected for the previous circuit will become the default, and the new circuit will automatically be assigned to that panel.

The tab also includes the option to add arc or chamfer wire to the connected device. The wire type is determined by the circuit.

When you select the **Edit Circuit** tool, the **Edit Circuit** tab appears:



There's a lot more detail included in the properties palette, with a large amount of data determined by the **connector** in the family and the connected panel. Some information will be populated by the initial act of creating the circuit, while others are populated when the panel is selected.

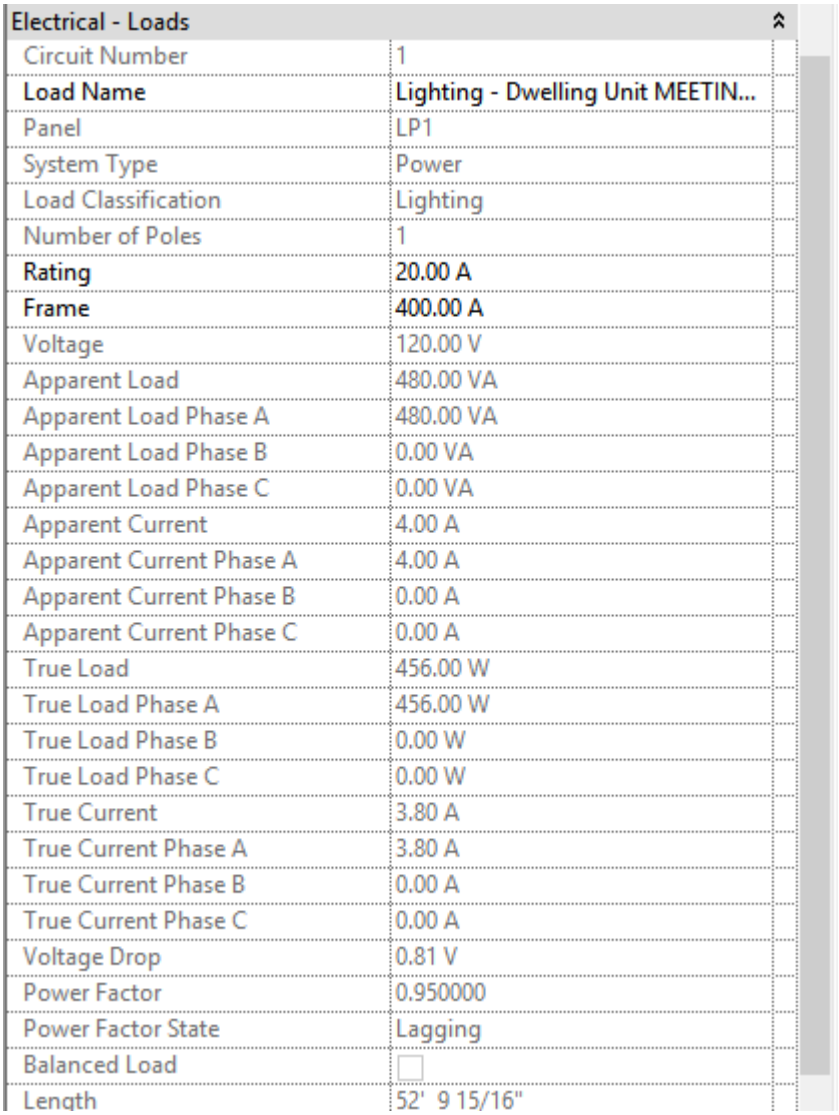
For target devices such as receptacles and lights, the *Electrical loads* include the following properties:

- **Circuit Number** – determined when the panel is selected *(note: if a device has more than one electrical connector, this can cause the Circuit Number value to be blank, and to incorrectly populate a tag. If you need to have multiple power connections on the same device, use an external hosted power connection, based on the Revit category for the part)*;

- **Load Name** – determined by the *Load Classification* assigned to the electrical connector, and the *Space Name* where the device is located (note: the device has to be completed encompassed by the space in order for this value to be used)
- **Panel** – determined when the *panel* is selected.
- **System Type** – default *system type* that is assigned by the *load classification*, and can be *power, lighting* or *other*.
- **Load Classification** – value associated with the electrical connector, which sets the *demand factor* rating, and what *load class* is used for space calculations, including *power, lighting* or *other*.
- **Number of poles** – determined by the electrical connector, only devices with the *same number of poles* can be assigned to a circuit.
- **Rating** – circuit specific setting that can be changed, this value is the rating for the *circuit breaker* in the panel. The value is not calculated by the circuit tool, so it is up to the user to review the loads assigned to the circuit, and set the breaker value. This value can also be changed on a panel schedule.
- **Frame** – circuit setting that can be changed, this value represents the *maximum* value a breaker trip rating can be set to. It is not used in calculation, but will limit the value if the user tries to change the breaker rating to something greater than the frame allows.
- **Voltage** – value associated with the electrical connector, this is normally a type value, and any devices that are added to the circuit must match this value.
- **Voltage drop** – this value is computed when the circuit is assigned to a panel.
- **Power Factor** – value associated with the connector, this numeric item is part of the load calculation for the circuit, and is multiplied times the actual value when the load classification and demand factor is taken into consideration.
- **Power Factor State** – value associated with the electrical connector, this sets whether the power values are lagging or leading, and affects the load calculation on the circuit.
- **Balanced Load** – determined by the connector, this value indicates if the load on the circuit is balanced across all phases.
- **Length** – determined by the placement of the fixtures relative to the connected panel, this value shows the *overall distance* between the farthest device and the panel, including X, Y and Z axis values.
- **Wire Type** – defined by the project settings, the user can edit the wire type used by the circuit. The wire settings will affect the number of tick marks that appear when used, and will be used to determine the following settings for *wire size, # of runs, # of hot conductors, # of neutral conductors,* and *# of ground conductors*.
- **Load Classification Connected** – defined by the load classification assigned to the connector, and the defined apparent load assigned to the connector (whether by instance or type), this value shows the *total load by classification* that is assigned to the circuit.

*Note that several items have been highlighted in **Red** – these are electrical connector parameters that should use an **associated parameter**, which is assigned to the connector. When the connector's parameter is associated with a family or shared parameter, that value becomes exposed in the project. This allows you to change these values without having to open the family and edit the connector. When defined as a **shared parameter**, the value can also be used in a schedule or tag, and exported to an external database.*

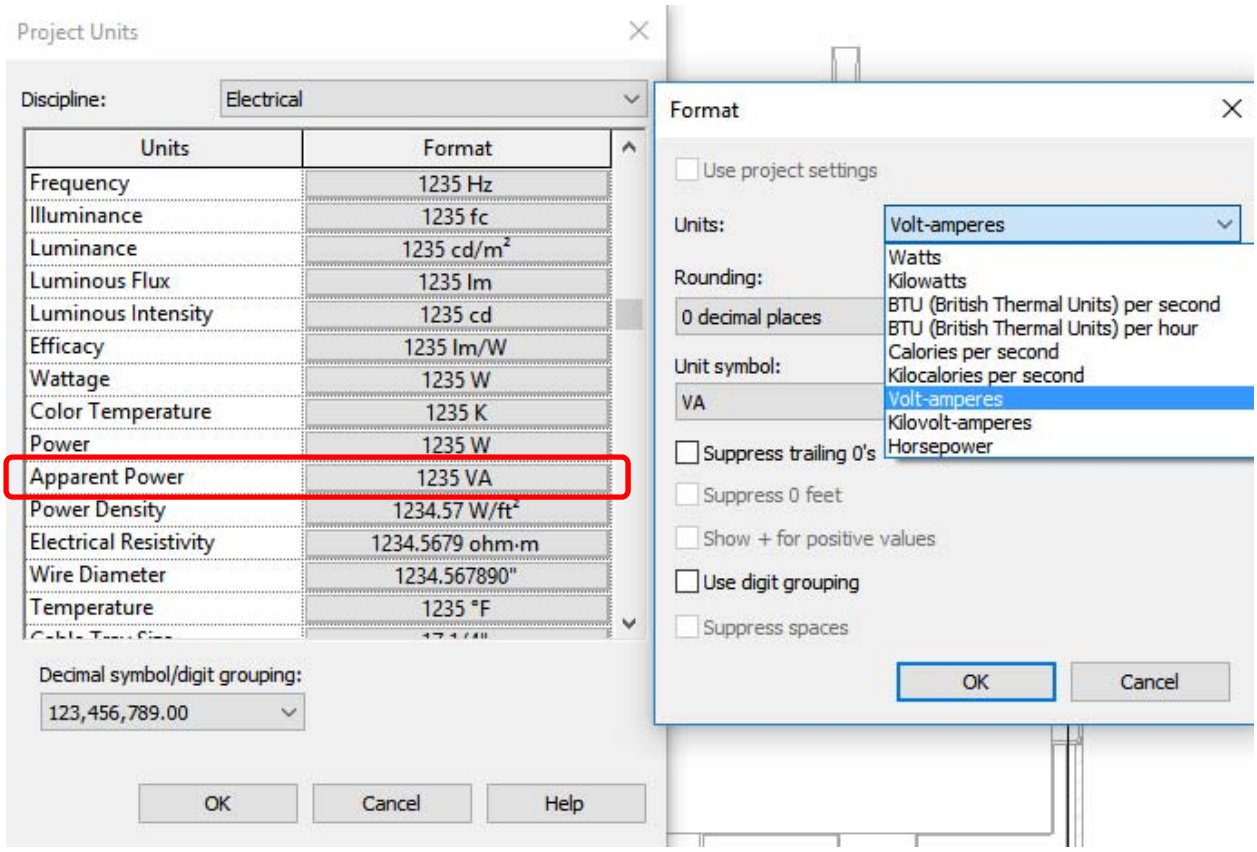
As much information that you see when edit a circuit's type properties, the properties palette will display additional instance properties about the circuit from the **Electrical Circuits** tab.



Electrical - Loads	
Circuit Number	1
Load Name	**Lighting - Dwelling Unit MEETIN...**
Panel	LP1
System Type	Power
Load Classification	Lighting
Number of Poles	1
Rating	**20.00 A**
Frame	**400.00 A**
Voltage	120.00 V
Apparent Load	480.00 VA
Apparent Load Phase A	480.00 VA
Apparent Load Phase B	0.00 VA
Apparent Load Phase C	0.00 VA
Apparent Current	4.00 A
Apparent Current Phase A	4.00 A
Apparent Current Phase B	0.00 A
Apparent Current Phase C	0.00 A
True Load	456.00 W
True Load Phase A	456.00 W
True Load Phase B	0.00 W
True Load Phase C	0.00 W
True Current	3.80 A
True Current Phase A	3.80 A
True Current Phase B	0.00 A
True Current Phase C	0.00 A
Voltage Drop	0.81 V
Power Factor	0.950000
Power Factor State	Lagging
Balanced Load	
Length	52' 9 15/16"

Three main areas related to the circuit are displayed:

Apparent Load – values are derived from the load on the circuit, as defined by the electrical connector in the family. If the circuit is a 2 or 3 pole circuit, then the load per phase is displayed. The value is measure as real and reactive power using *Apparent Current X Voltage*. The default units are volt amperes, but other forms can be set on the *Manage* tab, *Settings* panel, *Project Units*:



Apparent Current – measured in amps, value derived from the *apparent load* divided by the *voltage*, is based on properties assigned to the connector. *Three phase* values for Apparent Current are set by *Apparent Load* \ (*Voltage X* $\sqrt{3}$).
True Load – measured in watts, this value is derived from the actual power used by the circuit. The value is measured the formula *Voltage* X *True Current* (including by phase)X *Power Factor.*
True Current – displays the actual current in amps for the circuit, based on values assigned to the connector, where *True Load / Voltage*.

Leveraging Systems for Sizing and Analysis

The key to understanding how to use Revit for duct, pipe and circuit sizing and analysis begins by understanding how the connectors embedded in MEP families work. When the connector is not properly defined, the system tools are ineffective. Understanding items such as flow direction, system settings and associated parameters help the tools work smoothly in a project.

The Connector Rules!

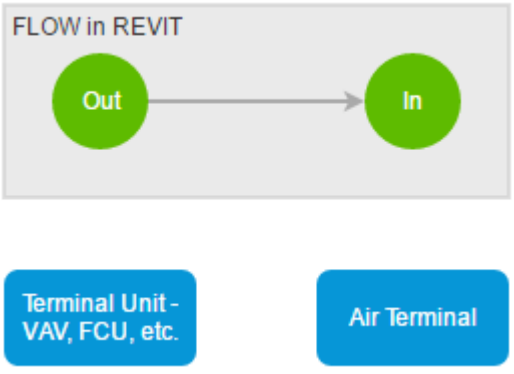
The MEP connector is what separates MEP families from architectural and structural families. The connector is used to create a starting (or ending) point of a system. Connectors use a combination of predefined parameters, based on the part type, that setup information for the sizing and analysis tools. While the connectors each have specific settings, you need to understand a few rules first.

Flow Settings

In order to understand the best practices for connectors in Revit, you need to understand how flow is handled. Flow is explained as the movement of air, fluid or power between a source and target.

Flow direction, a parameter that is assign to a connector, is critical, but may be counterintuitive to how we think. For example, the suction connection on a pump is considered an “in” connection, while the discharge connection is out. In this case, the source (pump) is both a target and source, since it receives fluid and also provides it to other devices. But if you are connecting a pipe to a target, such as a spray nozzle, the flow direction remains as “in”, since it is a target of the source. The fluid is not flowing out of the nozzle, but instead is in to the nozzle from the pump.

Here’s another example from an air system. If you are designing an air handling system, the **source** equipment is providing air out to a target, while the target is receiving air into the terminal or equipment:



Even though we think of air flowing out of the air terminal into the room, this is not how Revit treats the interaction. Most system errors we have encountered have occurred were a result of flow direction being mislabeled, so make sure you understand this behavior first.

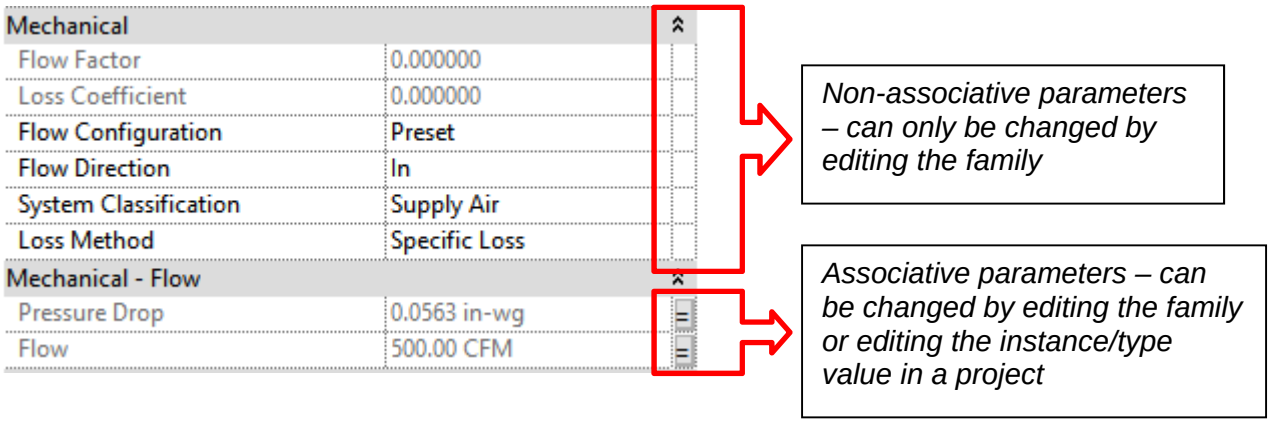
Connector System Relationships/Associated Parameters

With all connectors, you have a couple of options. You can predefine a **system classification**, such as *supply air, domestic cold water*, or *balanced power*. In some cases, a **global** or **other** option will be available. While it's a best practice to use a predefined system, you may have some parts that are used across several system types. When a connector, such as a pipe or duct connector is assigned as global, the initial connection defines the system classification.

Example: If you select the duct tool, and then set the system to *Supply* air, if the connector is set to *global*, then the system is defined as supply air. You could use the same family again, selecting *Return* air as the system – when you select the connector, the system will be assigned as return air.

The scenario for using a global connection is when you are NOT performing air flow calculations in a Revit model. Since the connector is global, some settings, such as loss method, loss coefficient, and more cannot be used, since these are specifically related to the connector in the part.

The way to check this? Review the properties of the part – if there is an associate parameter icon next to the parameter, the data can be exposed and edited in the Revit project file:

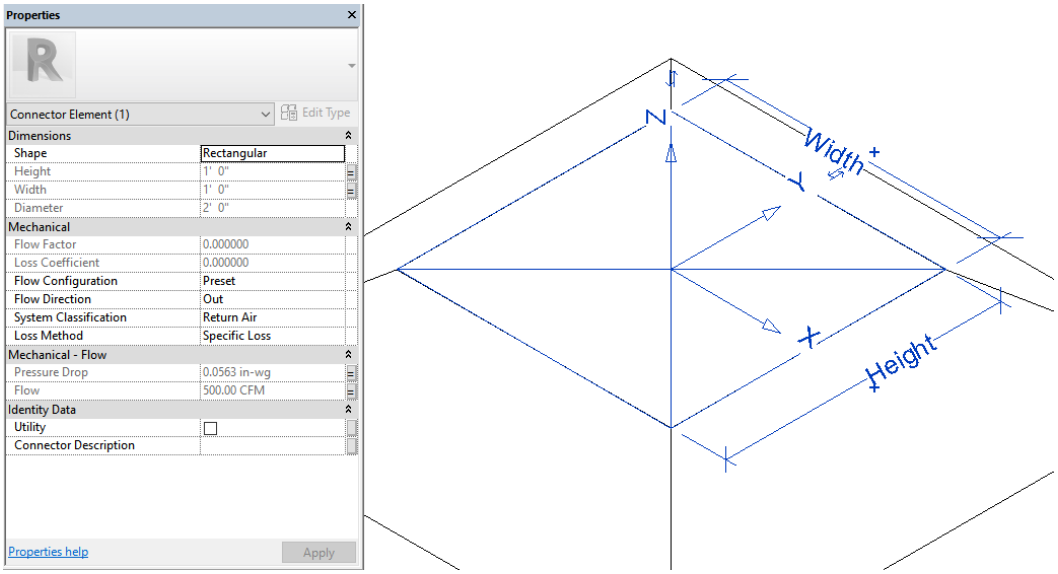


Understanding Connector Types

The connector is always defined in a family, and includes several properties that must be correctly defined in order for a system to work correctly.

Let's examine the main connector types:

The Duct Connector



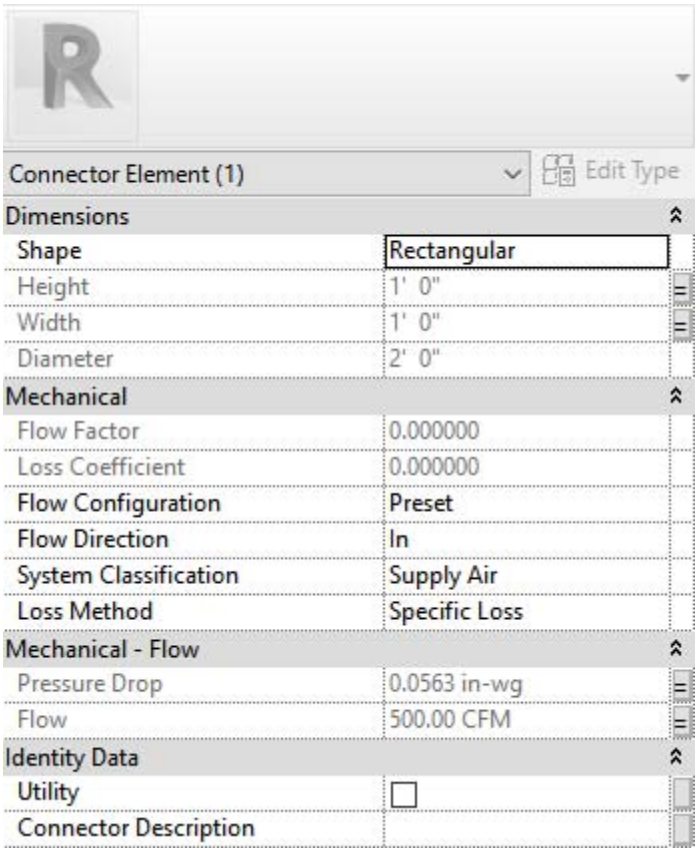
The duct connector is assigned by **system classification** first, such as *Supply*, *Return* and *Exhaust* air. It can also be set to *Other Air* or *Global* (which includes the same parameters as the first three, but is not calculated in a model). Other Air allows any system classification to be associated with the duct connector – but once it is set, it cannot be changed to a different system classification – only a different type within that system classification.

One note about connectors – if the system classification is set to **global** or **other**, Revit will use the last system type that was added in the model, as the default type, when the Add Duct grip is used to place a duct. Always check your system type first on your connector first when using the grip – or use the Add Duct tool from the ribbon, and select the system type you want to use prior to placing the duct.

Duct connectors can be defined as **rectangular**, **round** or **oval** shapes.

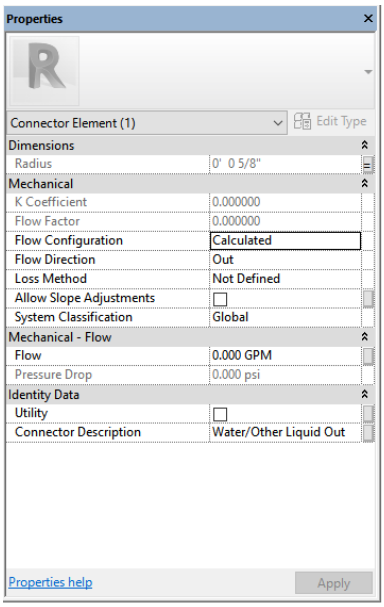
Duct connections can be **linked** together, such as those in a terminal unit.

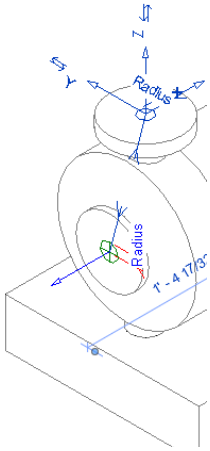
The connection includes built in parameters for the following mechanical properties:



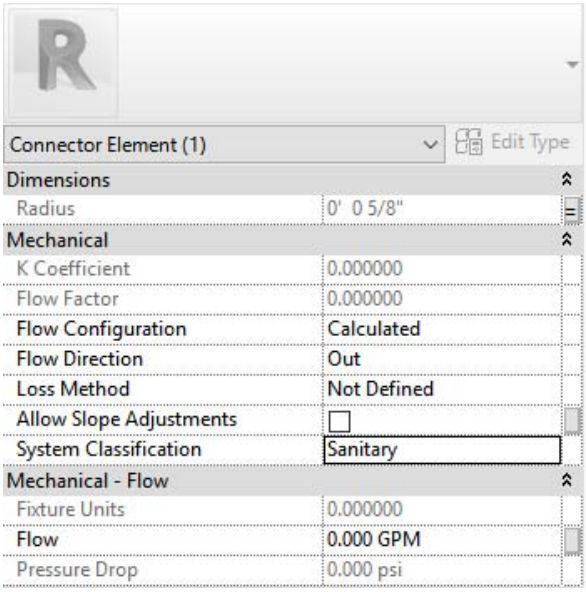
- **Flow Configuration** – Select from three values – Preset, System and Calculated, for measuring airflow in duct sizing
- **Flow Factor** – this percentage of system flow is used when the flow configuration is set to System.
- **Loss Coefficient** – value becomes active when the loss method is set to Coefficient.
- **Flow direction** – sets the flow direction relative to the connector – In, Out and Bidirectional
- **System Classification** – default system values for supply/return/exhaust/other/global, or fitting depending on family type
- **Pressure Drop** – value becomes active when the loss method is set to Specific Loss
- **Flow** – default value assigned to the connector for air flow, and is included in the system properties.

The Pipe Connector

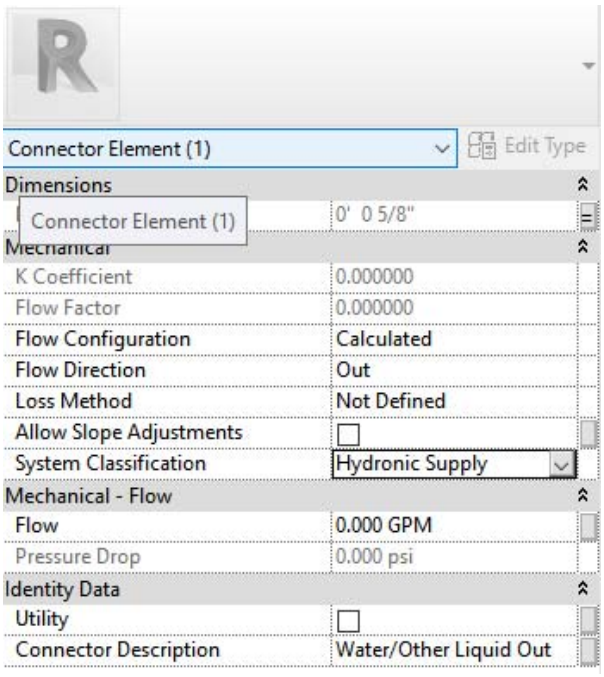




Changing the connector can change the available properties:

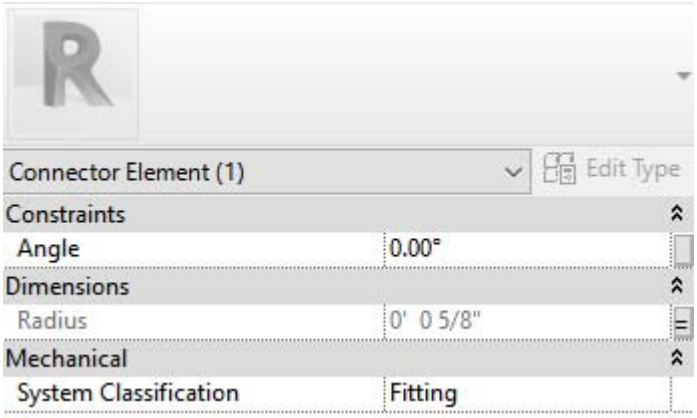


SANITARY PIPE CONNECTION



HYDRONIC SUPPLY PIPE CONNECTION

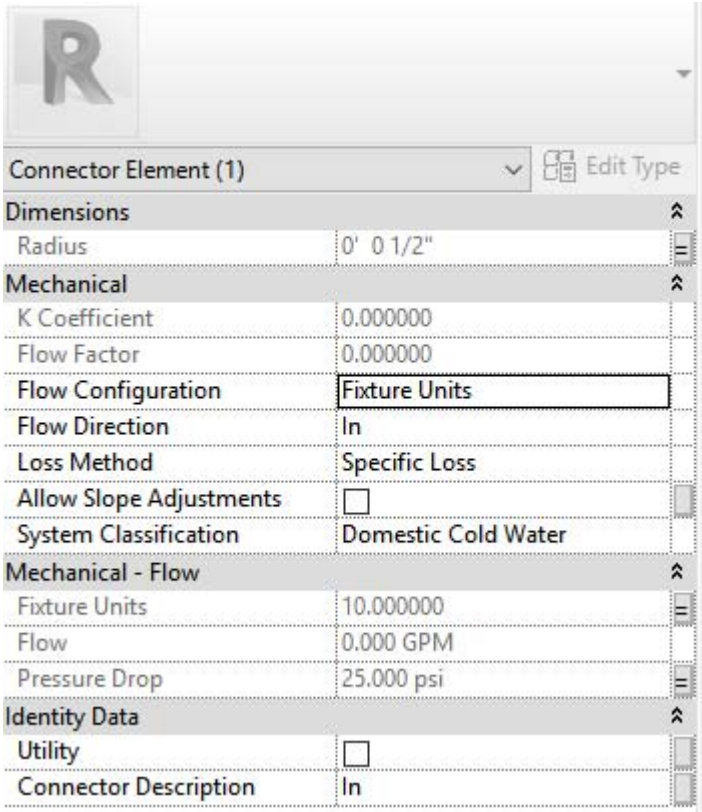
Pipe Fittings require their own connector:



Using an incorrect system classification on a fitting can impact the correct behavior of the part, such as not allowing the pipe to deflect in small angles, such as with mechanical joint connections that flex when placed underground.

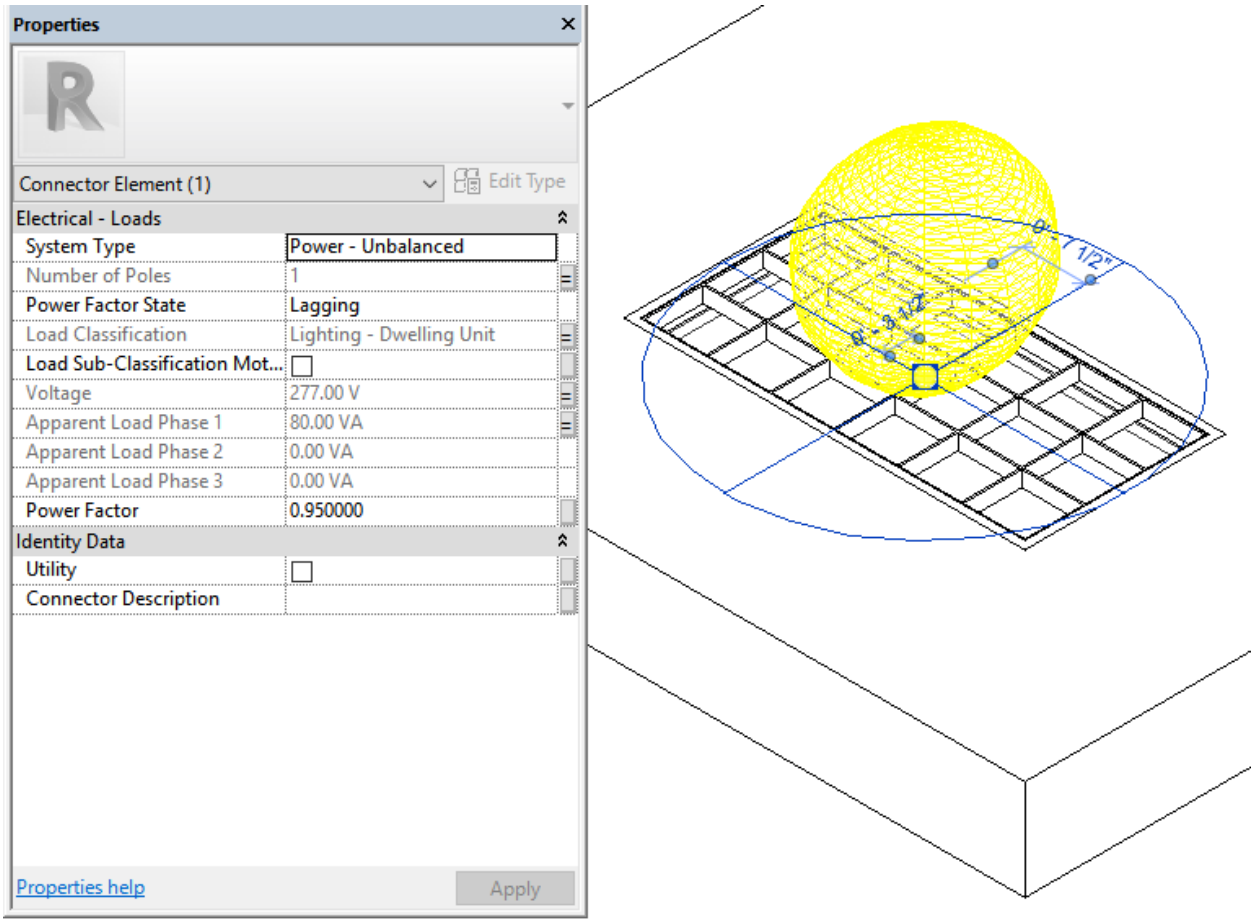
Pipe connections can also be **linked** to each other. This only occurs when the connector is set to global, and works best with inline components such as valves. The system type, flow direction and flow values are carried from one connector to the next in a family when they are linked. Either connector in a family can be designate as the primary, which also establishes the direction a part will be placed during layout. The primary connector should always be placed on the X-Axis in a family, when defining fittings.

The connection includes built in **parameters** for the following mechanical properties, which vary based on the type of *system classification* and *flow configuration*:

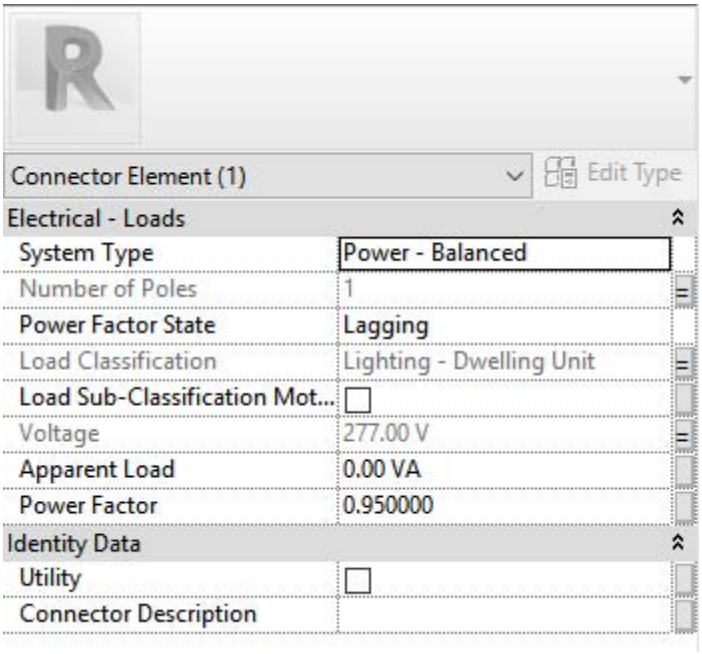


- **Radius** – size of the connection – can be set to measure as diameter or radius
- **K coefficient** – value is used when loss method is set to K coefficient
- **Flow Factor** – value is used with flow configuration is set to system, measures percentage of system flow from connector
- **Flow Configuration** – predefined values for calculated, preset, system and fixture units form of measurement, for pipe sizing
- **Flow Direction** - sets the flow direction relative to the connector – In, Out and Bidirectional
- **Loss Method** – measures pressure loss based on specific loss, K coefficient, or not defined
- **Allow slope adjustments** – toggle that allows connected pipe to include a non-perpendicular connection
- **System Classification** - default system values for domestic hot/cold water, sanitary waste/vent, fire protection, hydronic, other global or fitting, depending on family type and use
- **Fixture Units** – used with sanitary, vent, and domestic water systems when the flow configuration is set to fixture units
- **Flow** – value measured as volume rate for fluids
- **Pressure Drop** – calculated pressure drop based on settings defined for Mechanical Settings for a project
- **Utility** – toggle that defines a connection to a site utility, when exported as an ADSK file

The Electrical Connector

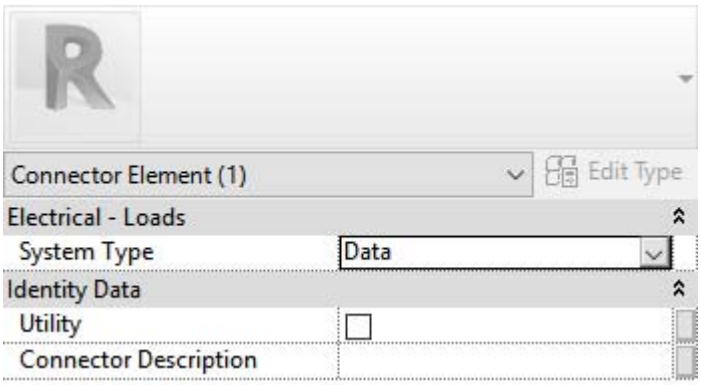


The electrical connector includes a wide range of *power* and *non-power* electrical categories, but only the power connections track *load*. Changing the connector changes the available properties:



Balanced power assumes the apparent load is *evenly* distributed between the poles, while *un-balanced* power allows the user to assign load individually to each phase.

- **System Type** – defines the type of electrical connector
- **Number of Poles** – number of electrical pole connections in a panel – 1, 2 or 3
- **Power Factor State** – Lagging (inductive loads where current lags voltage) or Leading (capacitive loads where current leads voltage) value
- **Load Classification** – specifies the primary power classification related to demand factor, including HVAC, Power, Lighting and more – can be defined by the user
- **Load Sub-Classification Motor** – yes/no parameter that defines whether a load classification is associated with a motor
- **Voltage** – sets the voltage rating for the connector, such as 120, 208, 277, 480
- **Apparent Load (by phase)** – calculated based on voltage x current, active when Power-Balanced is selected – when Power-Unbalanced is the assigned system time, apparent load per phase 1, 2 and 3 is available
- **Power Factor** – numeric value assigned to connector and multiplied to the apparent load value
- **Utility** – indicates is a connector is designated as an ADSK connector element, allowing connections to site utilities in other programs that can read/import ADSK files
- **Connector Description** – common with all connectors, is used to add a description to the connector, helping identify connectors – especially helpful when multiple connectors of the same type are used in a family.



Non-power connections, such as data, nurse call, communication, controls, security, fire alarm and telephone only carry a connector description.

Sizing Tools in Revit

Systems are defined by a target (or multiple targets) but work best when associated with a source. Revit includes several tools that can used to size pipe, duct and wiring. Prior to using the sizing tools, there are a few rules you need to know about each tool.

Duct Sizing

Duct can be sized using two different methods – friction loss and/or velocity sizing.

HVAC Supply, return and exhaust systems are sized based on the combination of project mechanical settings (air density, dynamic viscosity and calculation method for straight segment pressure drop), duct system settings, duct properties, and connector properties.

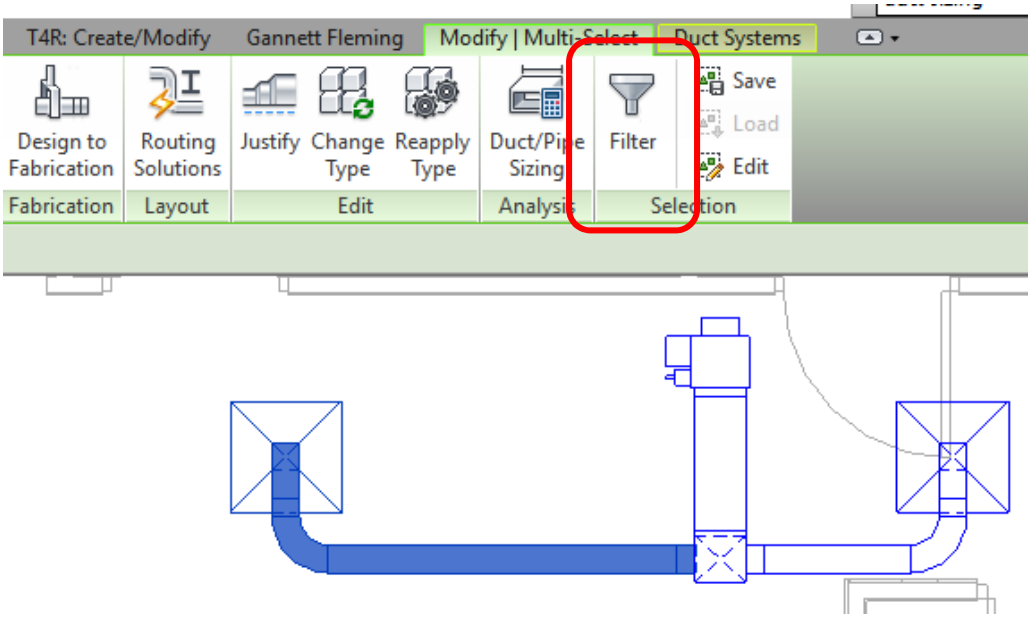
To size a duct:

- You must have the system defined between a **target** and **source**;
- The **connector** properties must include the proper values;
- The system type must have calculations **enabled**, and mechanical properties assigned;
- The sizing tools do not work on an "other" duct system – it is designed to work only with pressurized systems.

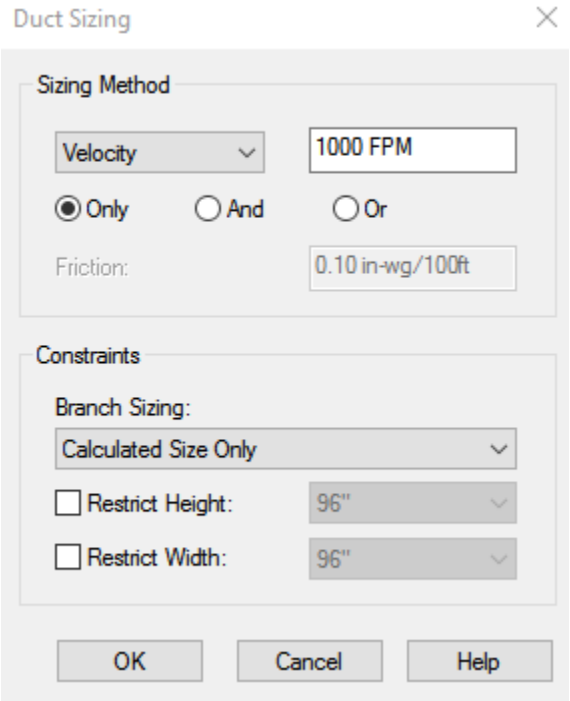
1. Once the settings are defined, select a duct in a run. You can also select an entire run by placing your mouse over a duct, and then tapping the tab key (without moving the mouse).

2. When the entire run is highlighted, you select with the left mouse button.

3. The **Duct/Pipe Sizing** tool will appear on the ribbon, **Modify** tab, **Analysis** panel:

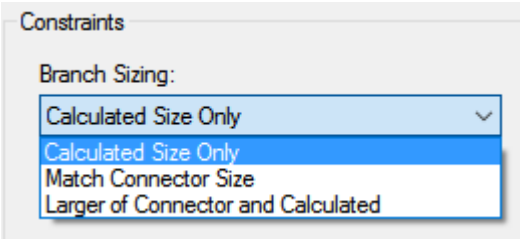


4. The **Duct Sizing** dialog will appear, if duct is selected:



5. The dialog allows you to select the sizing **method** and default **value**. It also allows you to choose between one method, both methods, and an "or" option for either type.

6. **Constraints** place limits on branch sizing, allowing you to choose between the calculated size only, matching the connector's assigned size, or the larger of the connector size and calculated value:



7. You can also **restrict sizing** to a specified value that sets the absolute limit of a duct height and width size.

Pipe Sizing

Pipe can also be sized using two different methods – friction loss and/or velocity sizing.

Domestic Cold Water systems which include fixture units are converted to flow (gpm/lps, etc.) using a general conversion method based on the *2006 International Plumbing Code, Table E103.3.* You must specify a *flow conversion method* in a pipe system's type properties, as we covered earlier. This can be set to predominately *flush valve* or *flush tank* toilets.

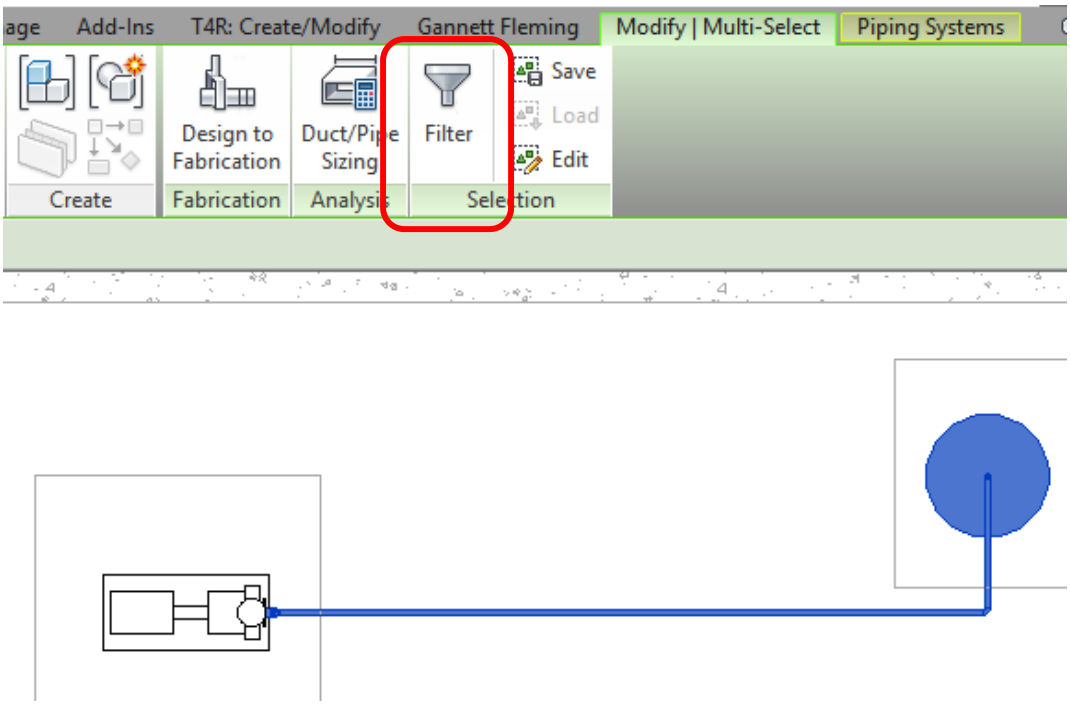
To size a pipe:

- You must have the system defined between a **target** and **source**;
- The **connector** properties must include the proper values;
- The system type must have calculations **enabled**, and fluid mechanical properties assigned;
- The sizing tools do not work on a Sanitary (gravity) pipe system – it is designed to work only with pressurized systems.

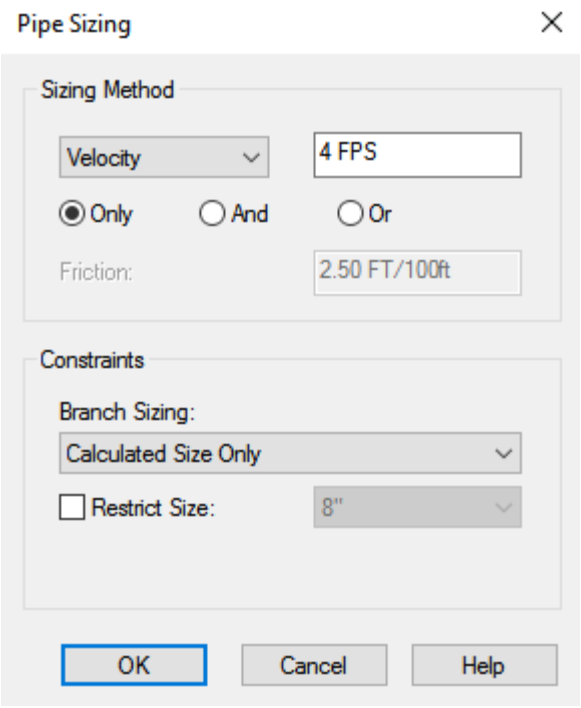
1. Once the settings are defined, select a pipe in a run. You can also select an entire run by placing your mouse over a pipe, and then tapping the tab key (without moving the mouse).

2. When the entire run is highlighted, you select with the left mouse button.

3. The **Duct/Pipe Sizing** tool will appear on the ribbon, **Modify** tab, **Analysis** panel:

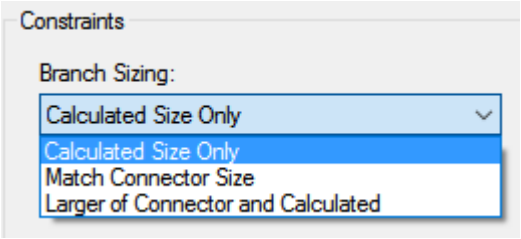


4. The **Pipe Sizing** dialog will appear, if pipe is selected:



5. The dialog allows you to select the sizing **method** and default **value**. It also allows you to choose between one method, both methods, and an “or” option for either type.

6. **Constraints** place limits on branch sizing, allowing you to choose between the calculated size only, matching the connector’s assigned size, or the larger of the connector size and calculated value:



7. You can also **restrict sizing** to a specified value that sets the absolute limit of a pipe size.

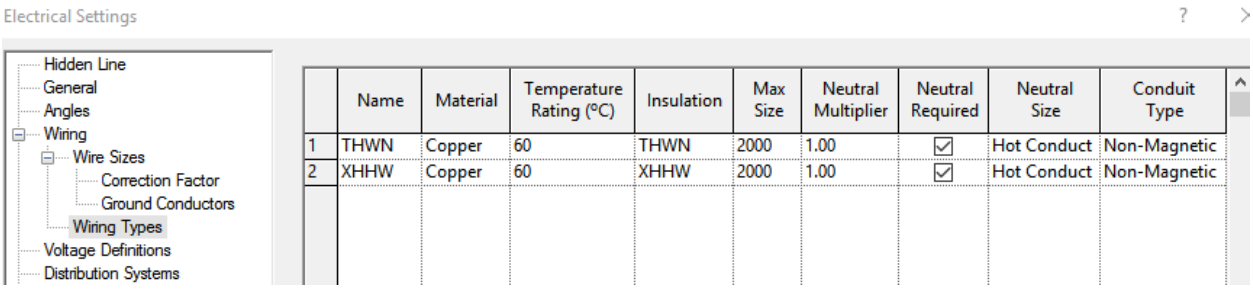
Wire Sizing

Sizing wire in Revit is a completely different ballgame that duct or pipe. The program performs the calculations based on circuit protection, voltage drop and correction factor settings. The following rules apply for sizing wire:

- The device has to be assigned a **circuit**, and then connected to a **panel**
- The devices on the circuit must have **load** assigned to connector, and have **number of poles, load classification, demand factor** and **power factor** defined;
- The **wire types** must be defined in project MEP settings, including the material, temperature rating, insulation, number of wires, ground conductor option, and correction factor.
- The **circuit breaker** on the panel must be set to a specific rating
- The project must have the correct **ambient temperature** rating
- **Circuit Length** is calculated based on distances from the farthest device based on X, Y and Z axes.
- **Voltage Drop** will be automatically calculated once the devices on the circuit are connected to the panel.
- Finally, the **wire type** must be assigned using the **Circuit Properties** – the wire will be sized based on the circuit properties described above.

To size the wire, review the wire types first, under the **Manage** tab, **Settings** panel, **MEP Settings** tool – click **Electrical Settings**.

Select **Wiring Types** under **Wiring**:



From here, you can edit specific values under each column, including

- **Name** – usually based on the insulation value, this can be any value, as long as the user know what the specific settings are for the type.
- **Material** – wire material, either copper or aluminum
- **Temperature Rating** – maximum temperature rating of wire material
- **Insulation** – insulation material used for wire, can select from a default list
- **Max Size** – maximum conductor size – measure in MCM, controls when wires start being sized in parallel runs rather than increasing the wire size; based on cross sectional area rather than ampacity
- **Neutral Multiplier** – all neutral fields control how the neutral conductor will be sized – increases or decreases size, allows for larger size
- **Neutral Required** – determines of all wires of this type include a neutral
- **Neutral Size** – allows user to set size based on the hot conductor or by unbalanced current

- **Conduit Type** – steel or non-magnetic, the material can affect the impedance of wire

A Revit project includes the following default settings:

Wire Impedance Factors:

Conduit	Wire Size	Three Phase					Single Phase				
Power Factor (%)		100	90	80	70	60	100	90	80	70	60
Steel	14	5.369	4.887	4.371	3.848	3.322	6.2	5.643	5.047	4.444	3.836
	12	3.464	3.169	2.841	2.508	2.172	4	3.659	3.281	2.897	2.508
	10	2.078	1.918	1.728	1.532	1.334	2.4	2.214	1.995	1.769	1.54
	8	1.35	1.264	1.148	1.026	0.9	1.56	1.46	1.326	1.184	1.04
	6	0.848	0.812	0.745	0.673	0.597	0.98	0.937	0.86	0.777	0.69
	4	0.536	0.528	0.491	0.45	0.405	0.62	0.61	0.568	0.519	0.468
	3	0.433	0.434	0.407	0.376	0.341	0.5	0.501	0.47	0.434	0.394
	2	0.346	0.354	0.336	0.312	0.286	0.4	0.409	0.388	0.361	0.331
	1	0.277	0.292	0.28	0.264	0.245	0.32	0.337	0.324	0.305	0.283
	1/0	0.207	0.228	0.223	0.213	0.2	0.24	0.263	0.258	0.246	0.232
	2/0	0.173	0.196	0.194	0.188	0.178	0.2	0.227	0.224	0.217	0.206
	3/0	0.136	0.162	0.163	0.16	0.154	0.158	0.187	0.188	0.184	0.178
	4/0	0.109	0.136	0.14	0.139	0.136	0.126	0.157	0.162	0.161	0.157
	250	0.093	0.132	0.128	0.129	0.128	0.108	0.142	0.148	0.149	0.148
	300	0.077	0.108	0.115	0.117	0.117	0.09	0.125	0.133	0.135	0.135
	350	0.067	0.098	0.106	0.109	0.109	0.078	0.113	0.122	0.126	0126
	400	0.06	0.091	0.099	0.103	0.104	0.07	0.105	0.114	0.118	0.12
	500	0.05	0.081	0.09	0.094	0.096	0.058	0.094	0.104	0.109	0.111
	600	0.043	0.075	0.084	0.089	0.092	0.05	0.086	0.097	0.103	0.106
	750	0.036	0.068	0.078	0.084	0.088	0.042	0.079	0.091	0.097	0.102
	1000	0.031	0.062	0.072	0.078	0.082	0.036	0.072	0.084	0.09	0.095
Non-Magnetic	14	5.369	5.876	4.355	3.83	3.301	6.2	5.63	5.029	4.422	3.812
	12	3.464	3.158	2.827	2.491	2.153	4	3.647	3.264	2.877	2.486
	10	2.078	1.908	1.714	1.516	1.316	2.4	2.203	1.98	1.751	1.52
	8	1.35	1.255	1.134	1.01	0.882	1.56	1.449	1.31	1.166	1.019
	6	0.848	0.802	0.731	0.657	0.579	0.98	0.926	0.845	0.758	0.669
	4	0.536	0.519	0.479	0.435	0.388	0.62	0.599	0.553	0.502	0.448
	3	0.433	0.425	0.395	0.361	0.324	0.5	0.49	0.456	0.417	375
	2	0.329	0.33	0.31	0.286	0.259	0.38	0.381	0.358	0.33	0.3
	1	0.259	0.268	0.255	0.238	0.219	0.3	0.31	0.295	0.275	0.253
	1/0	0.207	0.22	0.212	0.199	0.185	0.24	0.254	0.244	0.23	0.214
	2/0	0.173	0.188	0.183	0.174	0.163	0.2	0.217	0.211	0.201	0.188
	3/0	0.133	0.151	0.15	0.145	0.138	0.154	0.175	0.173	0.167	0.159
	4/0	0.107	0.127	0.128	0.125	0.121	0.124	0.147	0.148	0.145	0.14
	250	0.09	0.112	0.114	0.113	0.11	0.104	0.129	0.132	0.131	0.128
	300	0.076	0.099	0.103	0.104	0.102	0.088	0.114	0.119	0.131	0.128
	350	0.065	0.089	0.094	0.095	0.094	0.076	0.103	0.108	0.11	0.109
	400	0.057	0.081	0.087	0.089	0.089	0.066	0.094	0.1	0.103	0.103
	500	0.046	0.071	0.077	0.08	0.082	0.054	0.082	0.09	0.093	0.094
	600	0.039	0.065	0.072	0.076	0.077	0.046	0.075	0.083	0.087	0.09
	750	0.032	0.058	0.065	0.07	0.072	0.038	0.067	0.076	0.08	0.083
	1000	0.025	0.051	0.059	0.063	0.066	0.03	0.059	0.068	0.073	0.077

Wire Types:

Copper			Aluminum		
60 C	75 C	90 C	60 C	75 C	90 C
TW	FEPW	TA	TW	RH	TA
UF	RH	TBS	UF	RHW	TBS
	RHW	SA		THHW	SA
	THHW	SIS		THW	SIS
	THW	FEP		THWN	THHN
	THWN	FEPB		XHHW	THHW
	USE	MI		USE	THW-2
	ZW	RHH			THWN-2
		RHW-2			RHH
		THHN			RHW-2
		THHW			USE-2
		THW-2			XHH
		THWN-2			XHHW-2
		USE-2			ZW-2
		XHH			
		XHHW			
		XHHW-2			
		ZW-2			

Wire Sizes:

Copper				Aluminum			
Size	Temperature Rating			Temperature Rating			Size
	60 C	75 C	90 C	60 C	75 C	90 C	
	TW, UF	FEPW, RH, RHW, THHW, THW, THWN, USE, ZW	TA, TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW	TW, UF	FEPW, RH, RHW, THHW, THW, THWN, USE, ZW	TA, TBS, SA, SIS, FEP, FEPB, MI, RHH, RHW-2, THHN, THHW, THW-2, THWN-2, USE-2, XHH, XHHW, XHHW-2, ZW	
18	--	--	14	--	--	--	18
16	--	--	18	--	--	--	16
14	15	15	15	--	--	--	14
12	20	20	20	15	15	15	12
10	30	30	30	25	25	30	10
8	40	50	55	30	40	45	8
6	55	65	75	40	50	60	6
4	70	85	95	55	65	75	4
3	85	110	110	65	75	85	3
2	95	115	130	75	90	100	2
1	110	130	150	85	100	115	1
0	125	150	170	100	120	135	0
00	145	175	195	115	135	150	00
000	165	200	225	130	155	175	000
0000	195	230	260	150	180	205	0000
250	215	255	290	170	205	230	250
300	240	285	320	190	230	255	300
350	260	310	350	210	250	280	350
400	280	335	380	225	270	305	400
500	320	380	430	260	310	350	500
600	355	420	475	285	340	385	600
700	385	460	520	310	375	420	700
750	400	475	535	320	385	435	750
800	410	490	555	330	395	450	800
900	435	520	585	355	425	480	900
1000	455	545	615	375	445	500	1000
1250	495	590	665	405	485	545	1250
1500	520	625	705	435	520	585	1500
1750	545	650	735	455	545	615	1750
2000	560	665	750	470	560	630	2000

Wire Size Correction Factors:

Ambient Temperature C	Ambient Temperature F	60 C	75 C	90 C
21-25	70-77	1.08	1.05	1.04
26-30	78-86	1	1	1
31-35	87-95	0.91	0.94	0.96
36-40	96-104	0.82	0.88	0.91
41-45	105-113	0.71	0.82	0.87
46-50	114-122	0.58	0.75	0.82
51-55	123-132	0.41	0.67	0.76
56-60	132-140	--	0.58	0.71
61-70	141-158	--	0.33	0.58
71-80	159-176	--	--	0.41

Ground Wire Sizing:

Size	Copper	Aluminum	Size	Copper	Aluminum
14	15	--	250	2000	1200
12	20	15	300	2000	1200
10	60	20	350	2500	1600
8	100	60	400	3000	2000
6	200	100	500	4000	2000
4	300	200	600	5000	3000
3	400	200	700	5000	3000
2	500	300	750	5000	3000
1	600	400	800	6000	4000
1/0	800	500	900	6000	4000
2/0	1000	600	1000	6000	4000
3/0	1200	800	1250	6000	5000
4/0	1600	1000			

Neutral Wire Sizing:

Size (AWG/kcmil)	Diameter (in.)	Area (sq. in.)	Size (AWG/kcmil)	Diameter (in.)	Area (sq. in.)
14	0.064080	0.0032250357	300	0.5477226	0.2356194490
12	0.080810	0.0015288468	350	0.5916079	0.2748893572
10	0.101900	0.0081552613	400	0.6324555	0.3141592653
8	0.128500	0.0129686799	500	0.7071068	0.3929660816
6	0.162000	0.0206119720	600	0.7745967	0.4712388980
4	0.204300	0.0327813057	700	0.8366600	0.5497787144
3	0.229400	0.0413310408	750	0.8660254	0.5890486225
2	0.257600	0.0521172118	800	0.8944271	0.6283185307
1	0.289300	0.0657664432	900	0.9486833	0.7068583471
0	0.324900	0.0829065680	1000	1	0.785398163
00	0.364800	0.1045199453	1250	1.118034	0.981747704
000	0.409600	0.1317678350	1500	1.224745	1.178097245
0000	0.460000	0.1661901110	1750	1.322876	1.374446786
250	0.5	0.19634954085	2000	1.414214	1.570796327

References:

Since the amount of detail needed to cover all aspects of wire sizing is more in depth that we have time to cover in the lab, follow this link for the full reference of wire sizing in a Revit project:

http://help.autodesk.com/view/RVT/2017/ENU/?guid=GUID-0F801DCD-18CD-4B7A-A64F-D4D9E8A4CEA9

Also, you can access information about pipe sizing from this link:

http://help.autodesk.com/view/RVT/2017/ENU/?guid=GUID-687B295F-42A9-400E-B3E3-D8977F53DDFF

Piping pressure drop calculation methods are located here:

http://help.autodesk.com/view/RVT/2017/ENU/?guid=GUID-B3A3BB94-5223-4318-8DB4-E1CDE85C62E0

For duct sizing, you can find more information here:

http://help.autodesk.com/view/RVT/2017/ENU/?guid=GUID-99B57EF9-BBDD-4C34-8AE2-50EA6AE446E7

Key Tips and Benefits

Systems provide greater benefits that sizing duct, pipe and wire, or tracking load. Systems can help you select items easily, and can also be used to help quickly create groups. You can also control object display in a view using the Filter tool using a system, and can associate data from system objects with spaces. We will wrap this session up by taking a quick look at leveraging the systems for these actions.

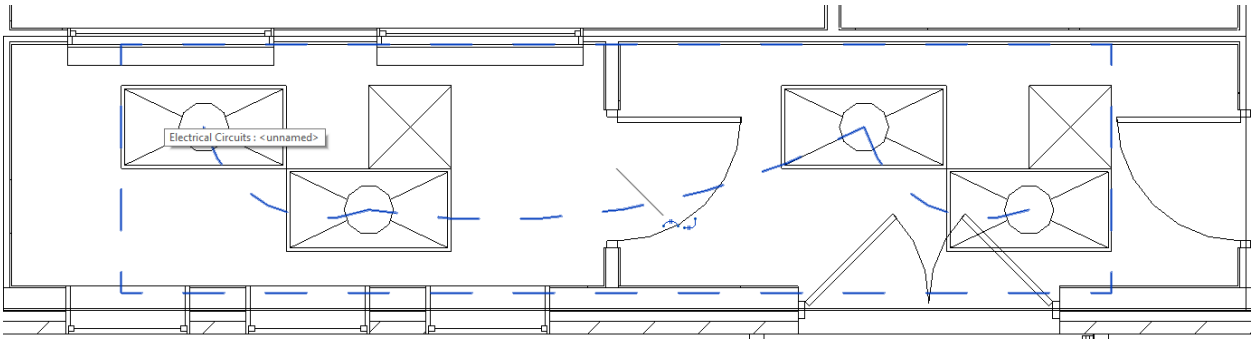
Selecting Systems

If you've worked with AutoCAD or Revit for a while, you have an idea of how items are selected. Left mouse click selections are common, along with crossing and selection windows. Revit has had a selection method that takes you beyond the left mouse click to a multiple object selection method that doesn't require dragging a mouse across the screen – but it can take a little practice.

The **TAB** selection method is accomplished by hovering your cursor over an object, and then tapping the TAB key to cycle through selection options. When using this over a wall, the program will start by highlighting the first object the cursor is placed over. A second tab highlights all of the connected walls, creating a great selection set for adding a roof or slab.

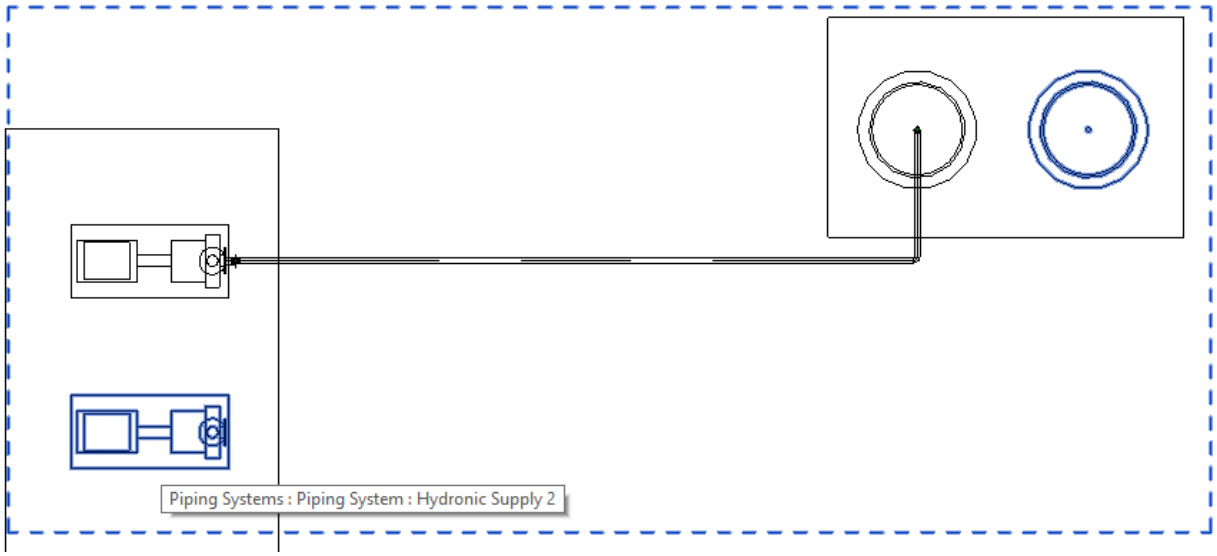
TAB selection works the same way with MEP systems. The *first TAB* highlights the MEP object, then cycles through the connected devices. Here's the best part – if you defined your systems prior to adding duct, pipe or wire, the *second TAB* highlights all devices connected in a system or circuit. Continuing to press the TAB key will cycle through *higher level systems*, systems associated with additional *connectors* in a model, and previews for duct, pipe and wire *layouts* that can be generated by the system settings.

Here are some examples of tab-selected systems:



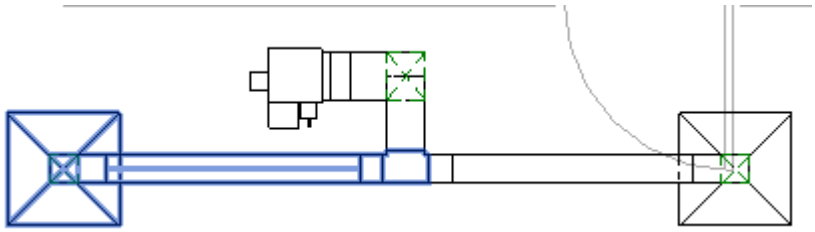
LIGHT FIXTURES CONNECTED ON SAME CIRCUIT, WITH WIRING PREVIEW ICONS

PIPING SYSTEM WITH ROUTED PIPE



PIPING SYSTEM WITH UNCONNECTED PIPE

AIR SYSTEM WITH UNCONNECTED DUCT

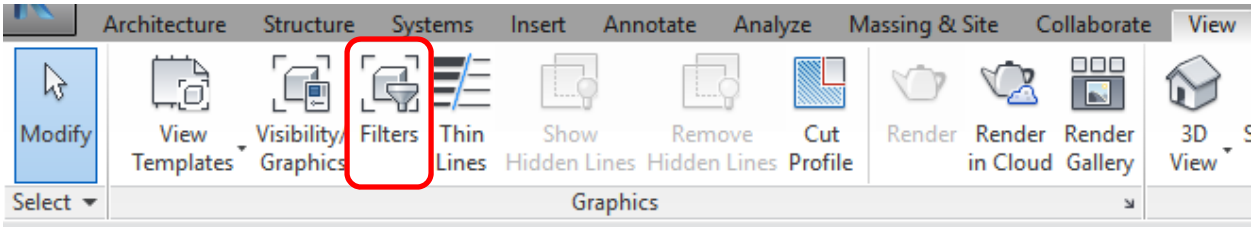


PARTIAL TAB SELECTION OF DUCT SYSTEM

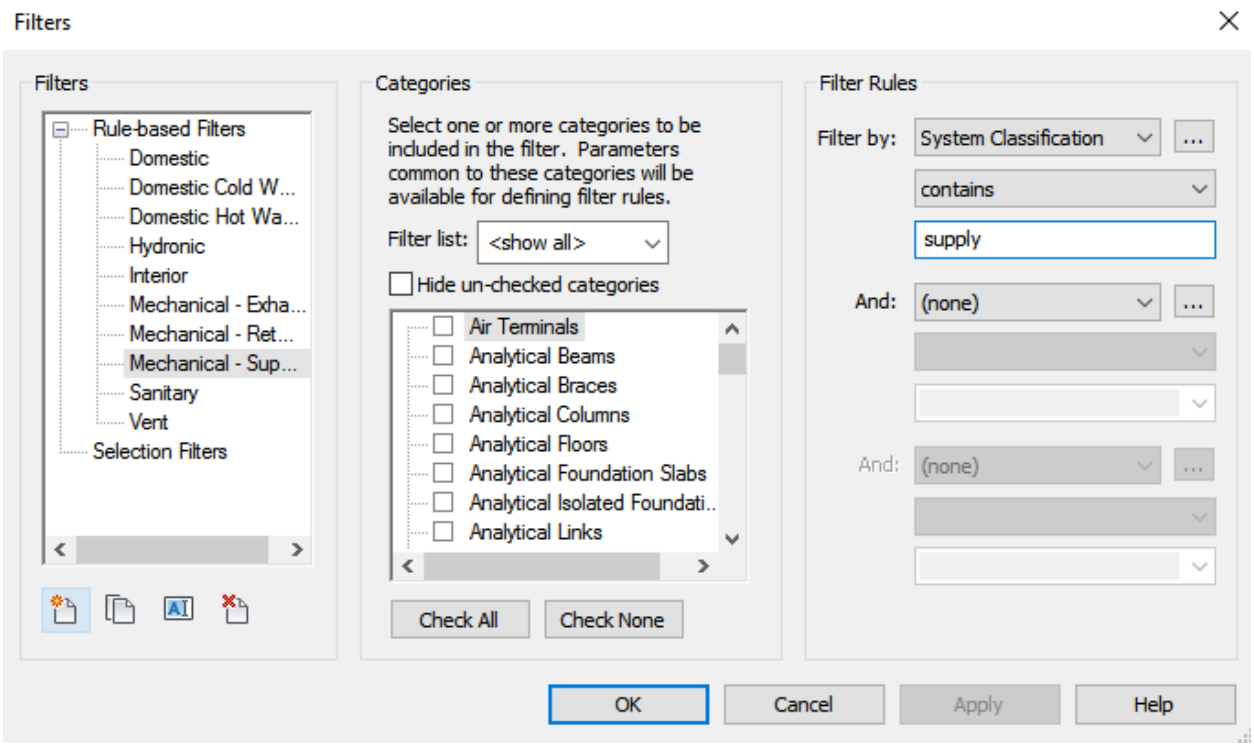
Leveraging Systems for View Filters

A key benefit for defined systems in a Revit model includes the ability to control the visibility of associated objects by the system definition. A view filter applies a series of rules based on system properties, and allows you to control the visibility of duct, pipe and electrical items.

To use the filter, open the tool from the **View** tab, **Graphics** panel, **Filters** tool:



The **Filters** dialog appears:

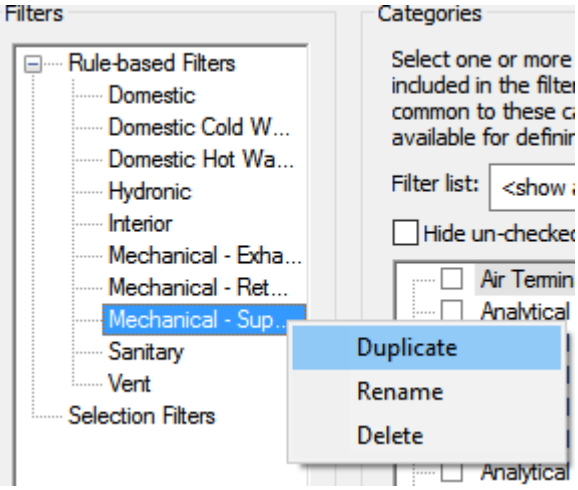


The dialog includes three main areas:
Filters – defines rule or selection based filters;
Categories – defines what objects the filter will be applied to;
Filter Rules – defines the rule based on the Revit tool, and what criteria define the rule.

There are two types of filters – **rule-based** and **selection** filters.

Rule-based filters can be defined by selecting an existing filter and duplicating it, or by creating a new filter.

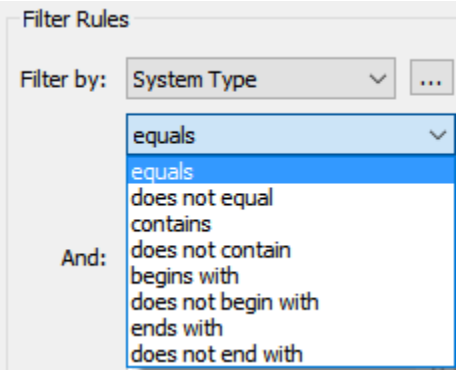
To base a rule on a system type, select one of the existing examples, such as **Mechanical – Supply**. Right click and select **Duplicate**.



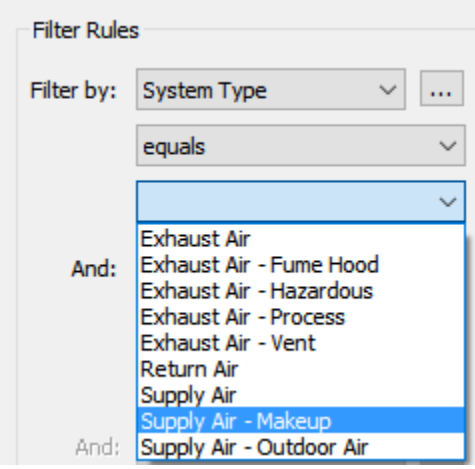
Once the new filter is defined, you can rename it, such as **HVAC Supply – Makeup Air**.

The advantage to duplicating an existing filter is that the categories and filter rules are already defined, so it's easier to modify. Review the categories, where specific duct categories are selected, and then review the rule.

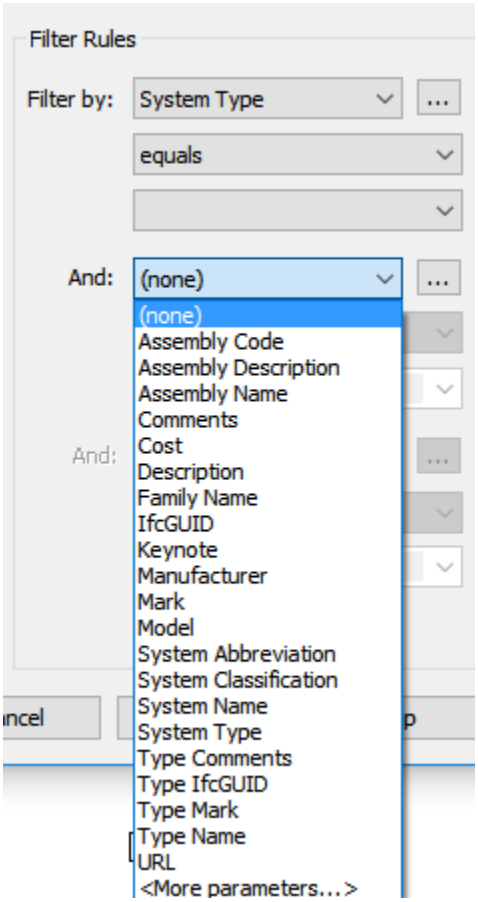
Selecting **System Type** changes the rule to match the **type**, which is the most likely item to be modified by a user. Select the rule and choose between the following options:



When you select an item such as **equals**, you can then select the list of available **system types,** where the System Type must exactly match this criteria:

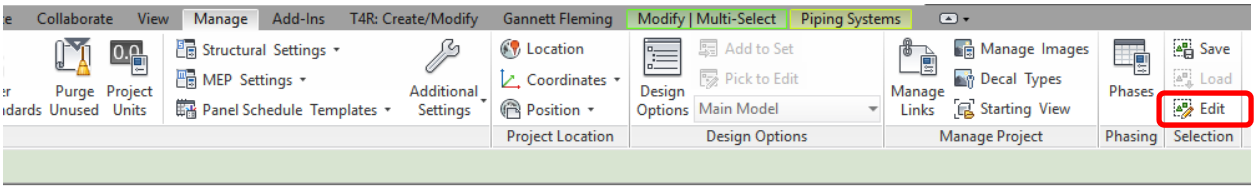


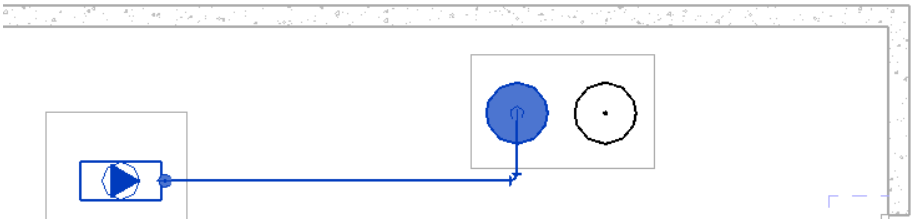
The filter tool allows up to **three** different rules to be applied, so it could be a good idea to add rules for items such as *System name, type mark* and more.



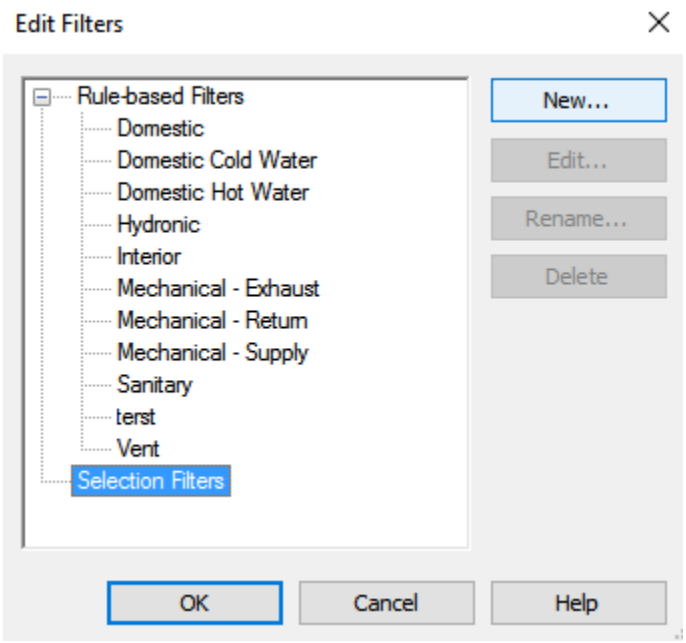
The other filter type includes a **selection filter**. This method works by letting the user select items in a system, using the *tab selection* method (or any other selection method), and then using the **selection edit** tool to create the filter.

For example, you can use tab selection to pick all of the items in a piping system. Once the items are selection, click **Manage**, **Selection** and **Edit**. :

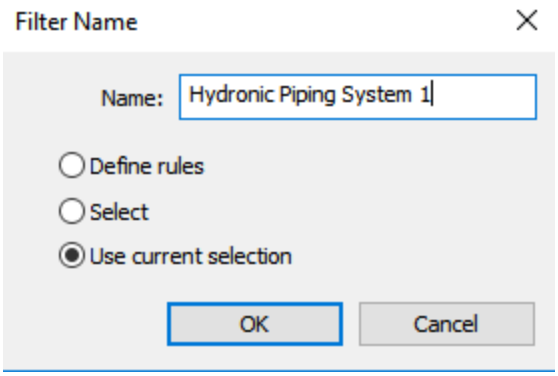




The **Edit Filters** dialog appears, and you can choose to create a rule based filter or selection filter. Click **Selection Filter** and then click **New**:

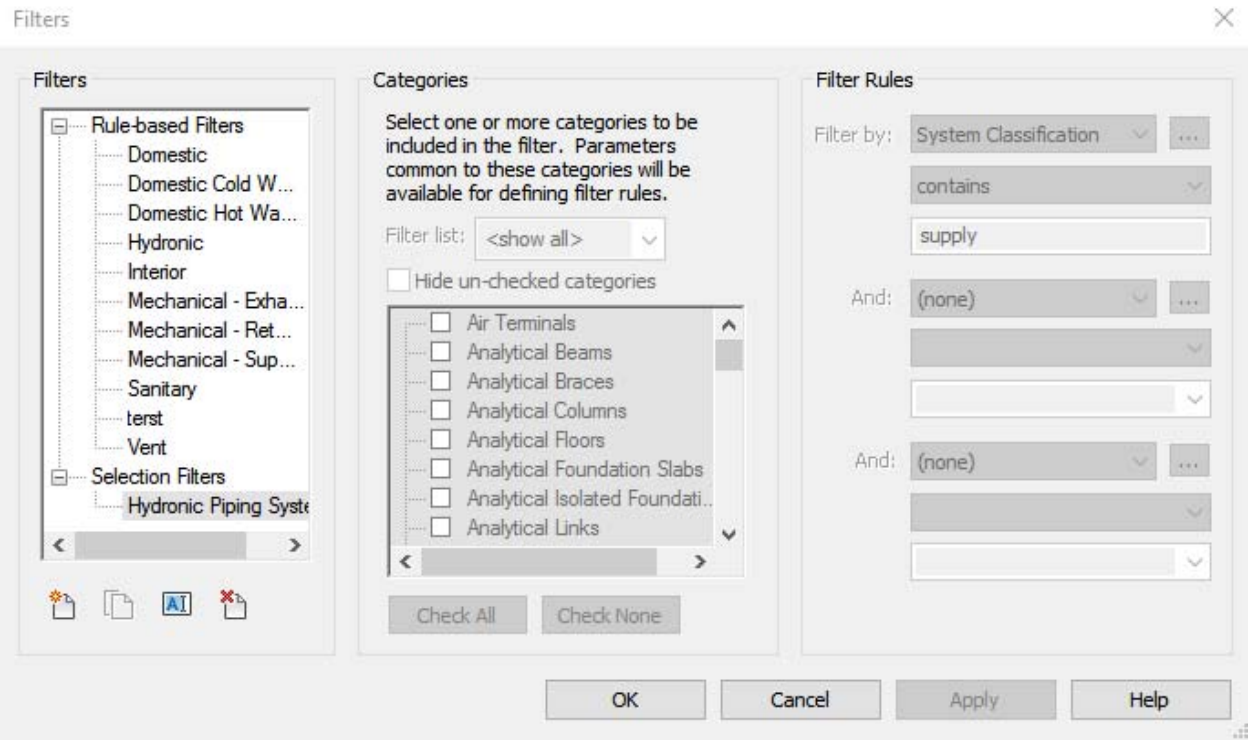


The **Filter Name** dialog appears, so add a name, such as *Hydronic Piping System 1*:

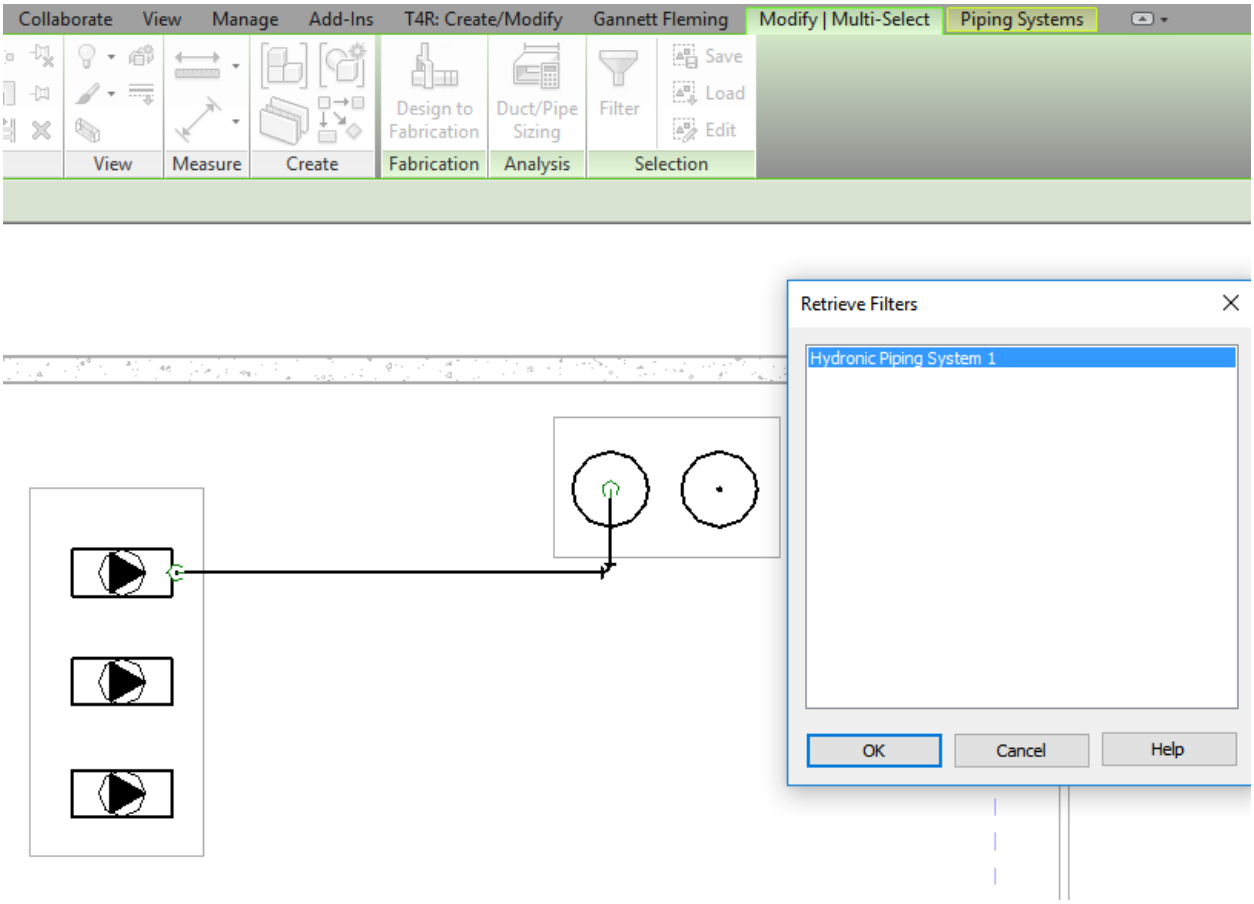


You can then choose to **define the rules**, **select** a new group of items or **use the current selection**.

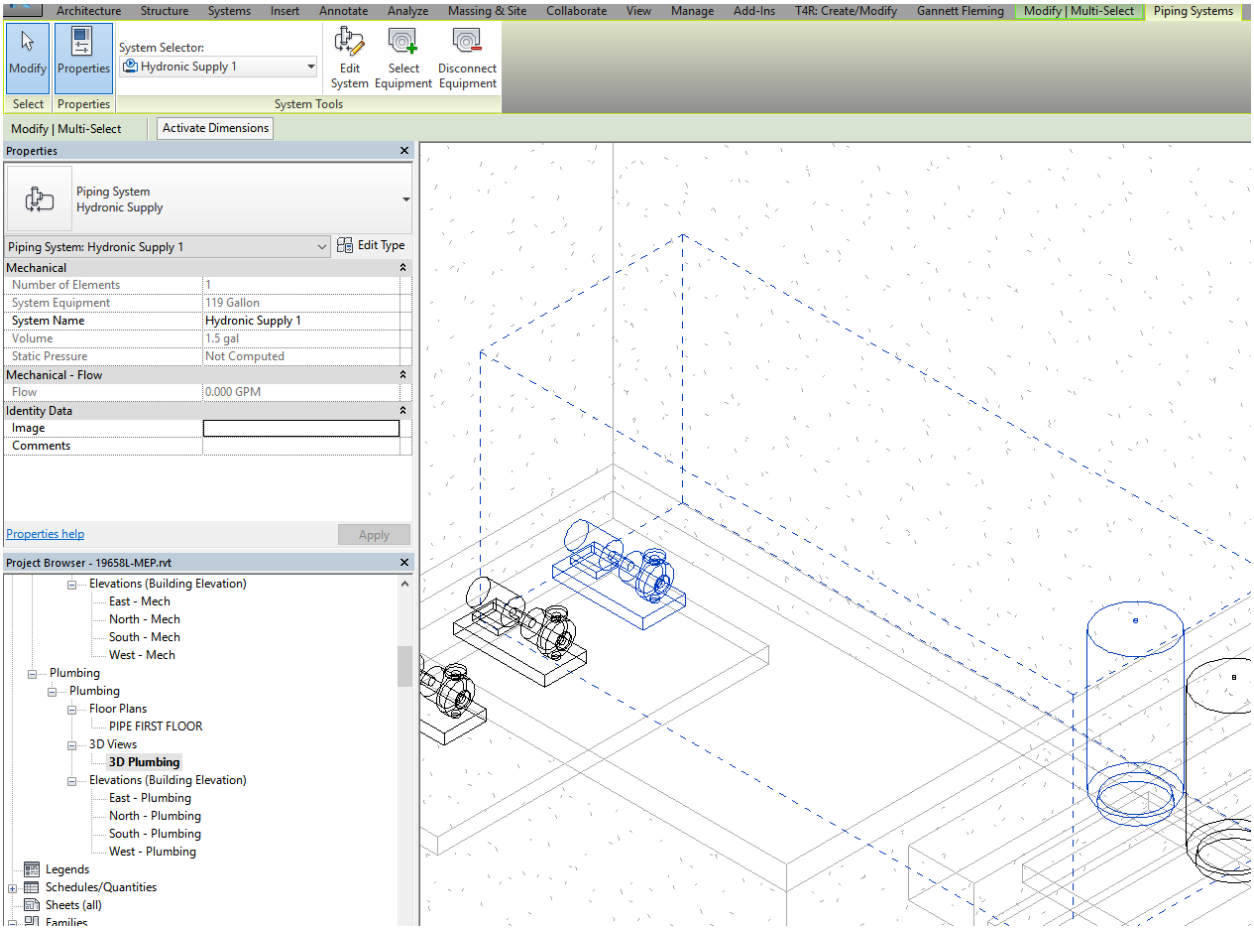
If you select the last option, the filter will become available under *selection filters*, and can be reused. When you return to the **Filters** dialog, the selection is available from the dialog, but the categories and rules are set by the selection set.



Here's where this gets fun – a quick way to select this group again, is to use the **Selection**, **Load** tool to reselect the same items (you can also run this tool from the **Manage** tab):

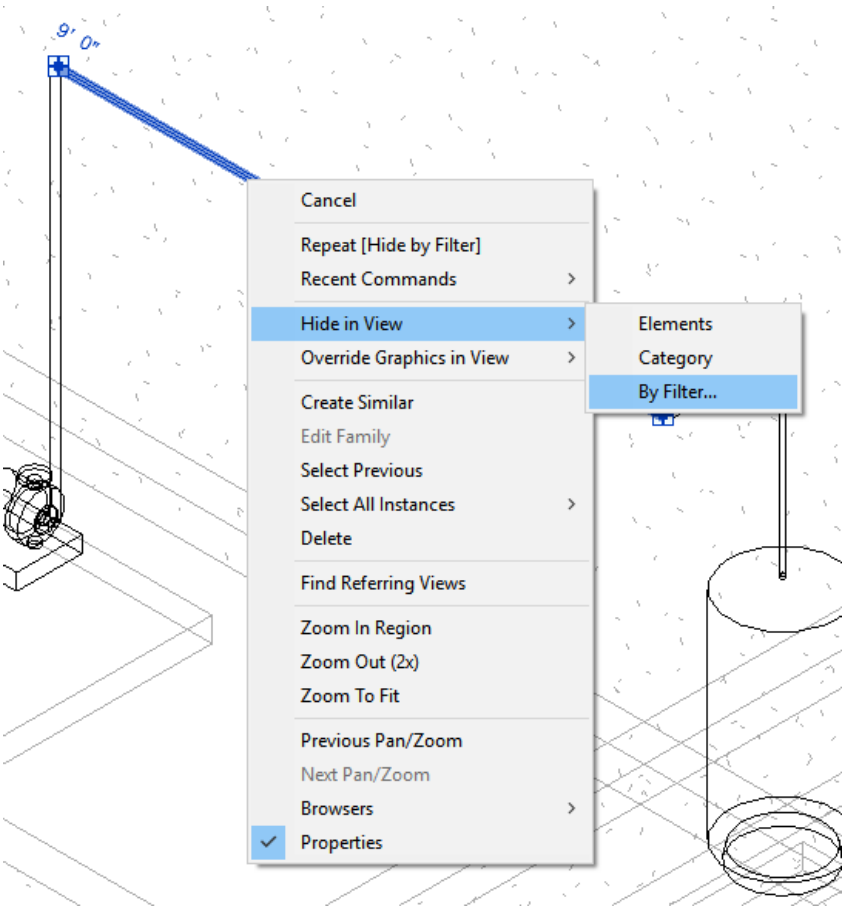


It doesn't matter what view you are in when you **load** the selection filter – the items will remain highlighted, so changing to another view, such as a 3D view, will keep the items selected:

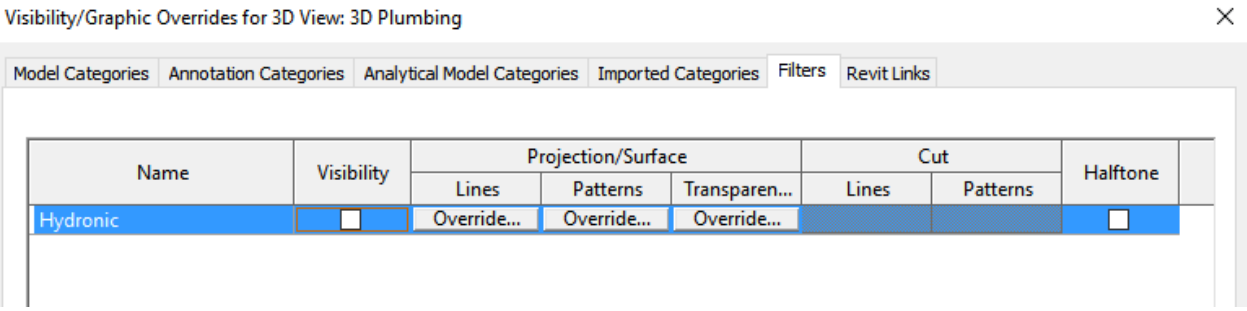


You can use these items with the *copy* or *move* commands, or *edit the system*, regardless of where the original *tab selection* – based on the system – was defined.

BONUS TIP – Select any object that belongs to a system, such as a pipe or duct. Right click, and choose the Hide in View > By Filter option:



The VG Filter tab will appear, and allow you turn anything associated with a filter related to that object on or off. Deselecting the visible option will turn ALL connected pipe in the system off, based on the categories associated with the filter, and the assigned rule:

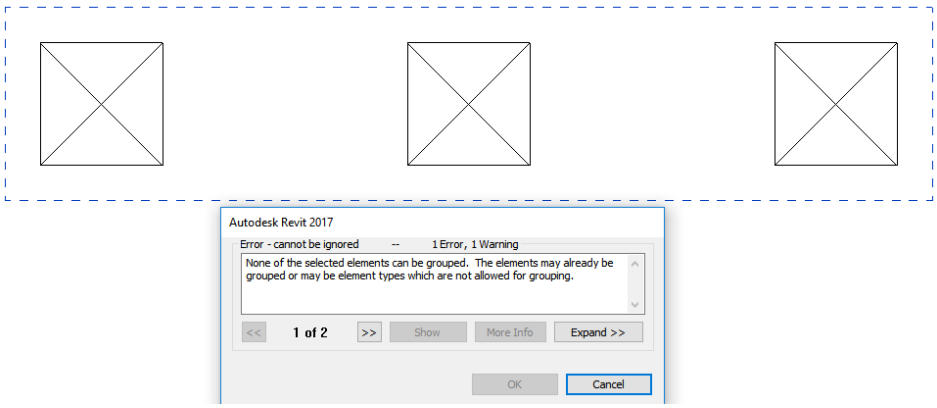


You can also override other graphics settings for projection/surface, cut and half tone from this tool (or the Override Graphics in View option).

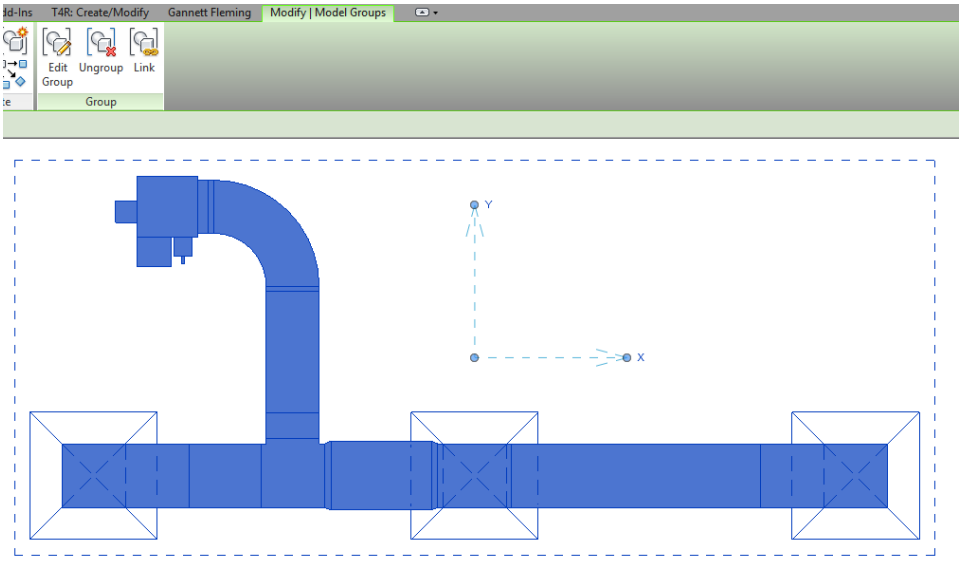
Using Systems with Groups

On some projects, systems can be repeated in several locations in a project. If you plan on using a typical system as a copy for others, you should consider using the **group** tool first. But there are a few rules you need to know before you get started.

1. When selecting items for a group using the tab selection method, the system must not contain **open systems**, or unconnected devices or circuits.



Select items that are well-connected, such as a completed duct system layout that includes targets and sources, or a fully circuited system that includes wiring.

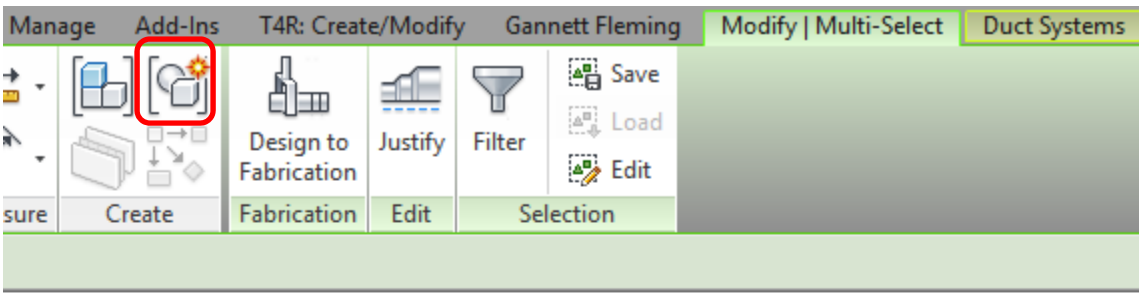


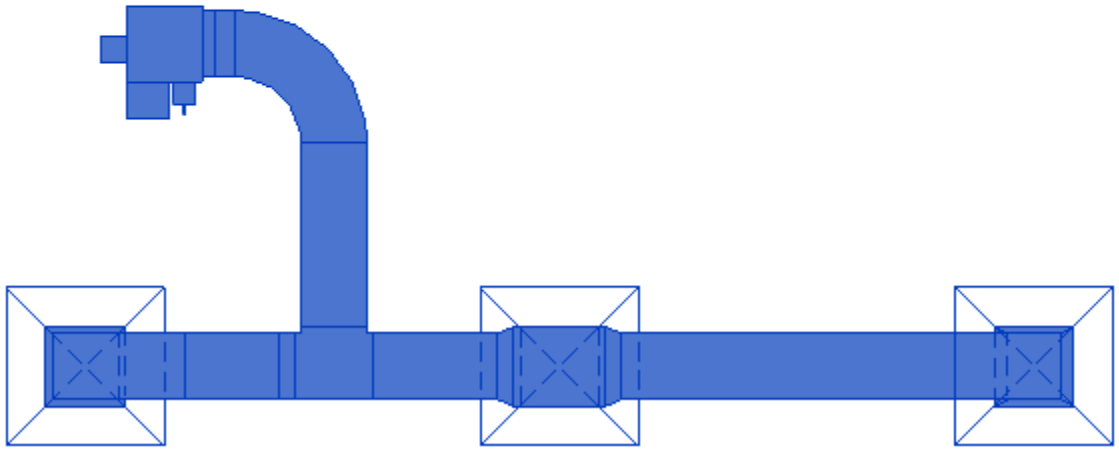
2. Once in a group, you can **edit** the group, and create systems/circuits for items which belong in the group.
3. When using groups to copy to other locations in a project, when the items are ungrouped, they are automatically assigned to a **new system**, provided the previous items were well-connected.
4. Creating connections to items in a group is limited. Since the group is contained as one entity, you would need to edit the group in order to add, remove or edit items within a system. However, you can connect to **other connectors** on a family (such as a duct or pipe connector) that is not already assigned to another system.
5. When copying systems from level to level, these systems work best when **non-hosted** target and source families are used, and the items placed in a group. When the items are ungrouped, they will automatically be associated with the corresponding level. When a hosted item is added to the group, the association to the original host is lost, but the

group can still be defined. You would have to re-associate the hosted families to their new host (which is one of the reasons why we rarely use hosted MEP families!).

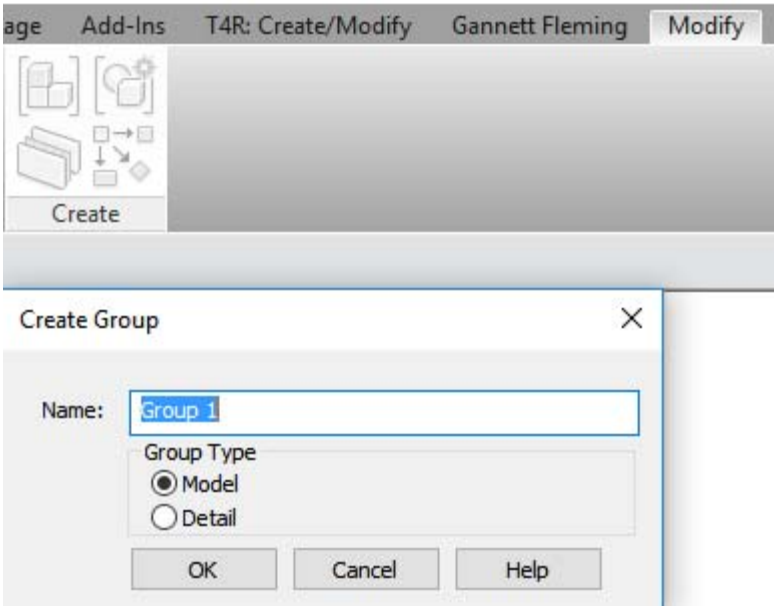
6. If you are planning to use the same layout in other projects, create a model group first. Once the items are grouped, they can be saved as a Revit project file (.RVT). The group can then be imported into another project. The rules apply – the group must be well-connected! Use the **Insert** > **Load as Group** tool to bring the group into a new project.

The grouping tools are located on the Modify tab, when items are selected:

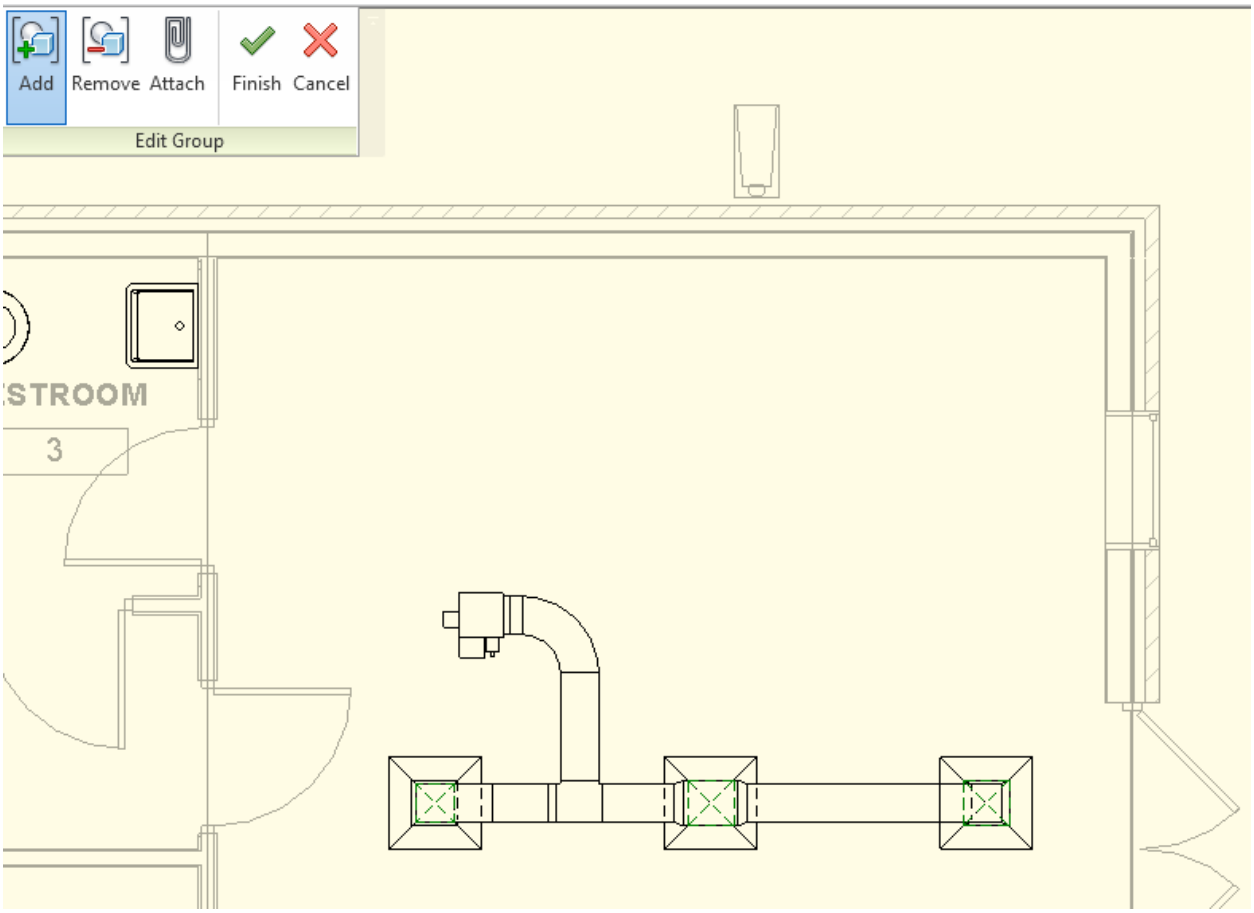




You can also create groups by selecting the tool from the Modify tab, Create panel, when items are not selected:



Once the tool is started, the Edit Group tool opens, allowing you to use **window** or **pick** selections, but not tab selections for systems:



So it's best to select the items by the well-formed system first, and then use the group tool

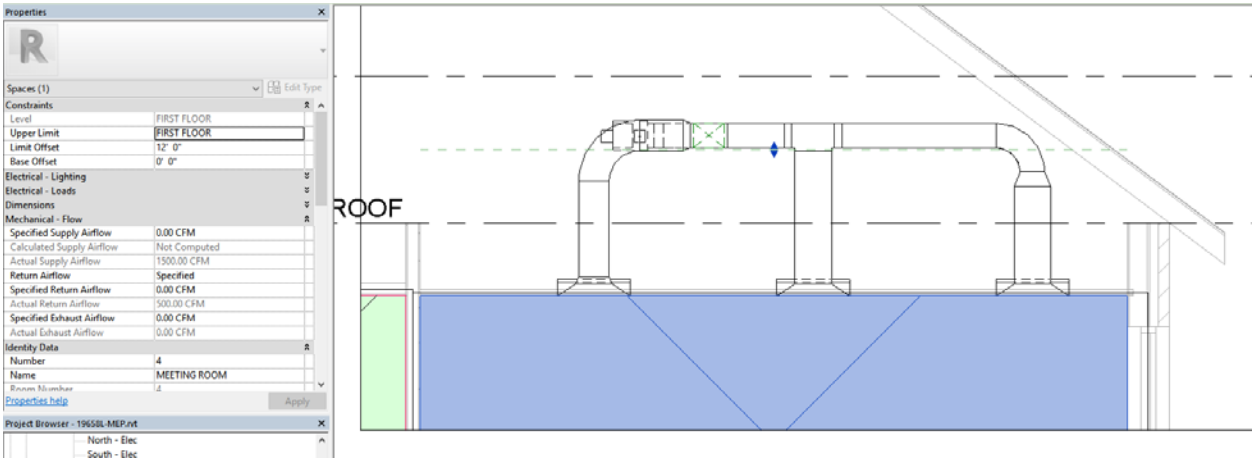
BIG TIME NOTE: Groups can affect project performance if used in great numbers. Use the groups instead to create duplicates, or move to different levels or areas of the project, and then UNGROUP the items. This also makes sure the systems are correctly defined.

Tracking System Equipment Data with Spaces

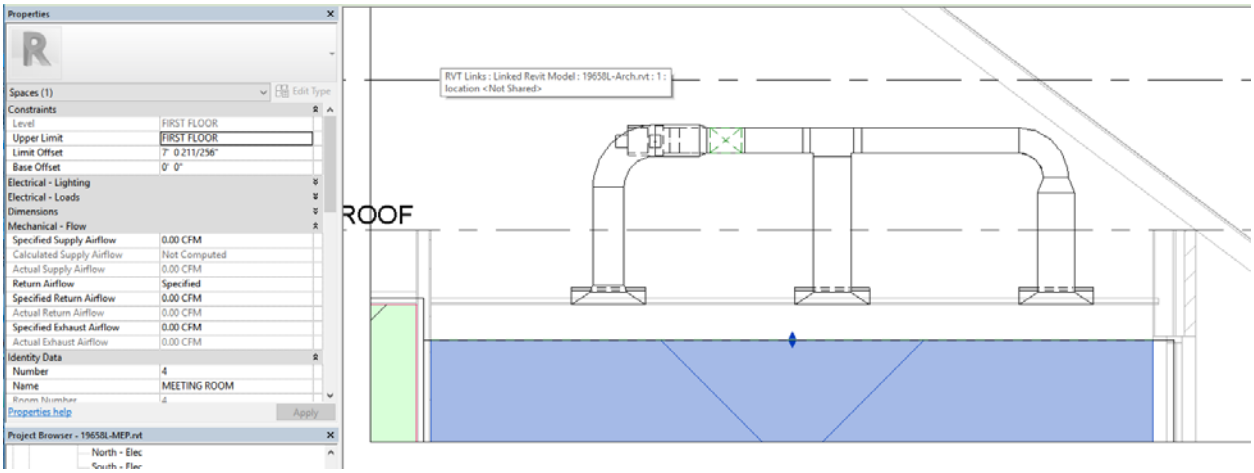
Our last segment covers how data that is associated with system objects can be related to the space associated with the room. In some cases, you may want to know what the airflow is for a room, or the total lighting/receptacle load is for a space. Space objects in Revit can track this data easily, so it's important to understand where you can review and control this data.

Duct System Data

When a duct is placed in a room where a Revit space object is located, the space will track the flow assigned to the air terminal(s) as long as the air terminal falls within the vertical boundary of the space. Here's an example from a section view showing this correctly defined:



Note the properties of the space – even though the limit offset is set to be higher that the terminals, the space is limited by the ceiling object. As long as the terminal is in contact with the ceiling face on the side of the space, the space will track the airflow. But if the space upper limit offset is not set high enough to intersect the air terminals, the airflow will not be included:

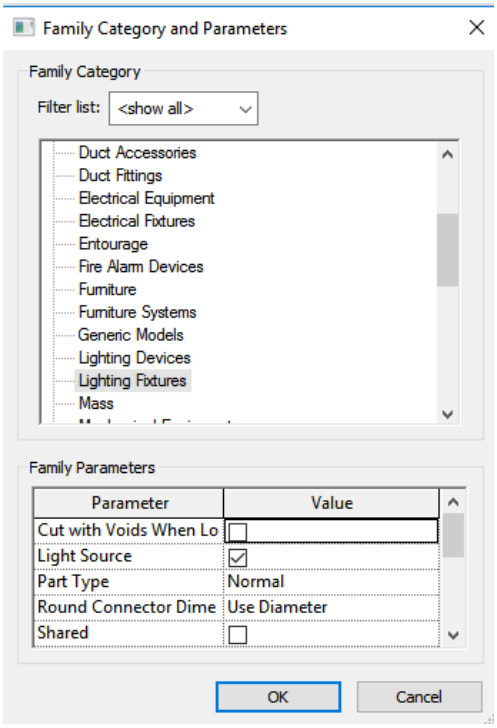


The **calculated** value will be populated after the duct sizing tool is used. You can then create a **space schedule** that tracks the actual supply airflow per room.

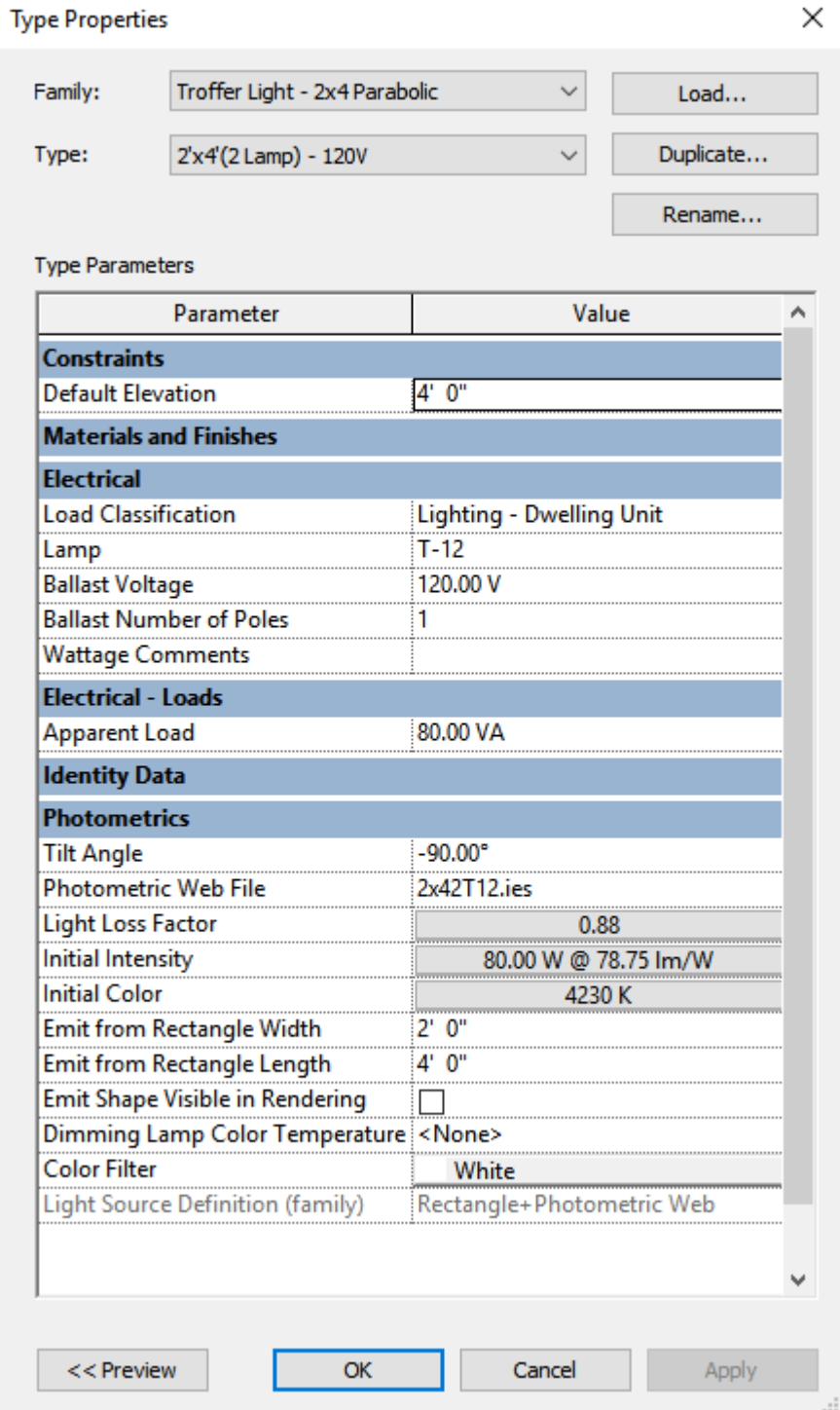
Electrical Power/Lighting Data

Similar to the mechanical flow data, a space can track electrical loads, based on power, lighting or other load types. For example, if a light is placed in a space and is defined as a light source, the space will automatically calculated the **average estimated illumination**. This load can be reported in a **space schedule**, and compared to the circuit load values.

To enable the light source in a fixture, edit the family. Open the Family Category and Parameters – under Family Parameters, make sure Light Source is checked:



When the light is added to the room, the **photometric values** are used in association with the **light fixture type** are used to calculate the average estimated illumination.



In this case, the **Initial Intensity** overrides the **apparent load** value, which is used to define the circuit load. It's important to understand how these two items differ, and how both are used to define information about your circuits and systems,

Conclusions

Understanding how to leverage systems within your project can significantly improve the quality of your design. Learning how to account for these tasks to improve the project quality isn't as complicated as it seems, as long as you understand the ground rules and benefits.