Determining Water Flow Requirements based on Air Flow and

This article will help you understand Revit math to the extent that you may need to be able to compute the flow rates through a coil to meet a given load.

Heat Transfer Principles

The liquid flow required through a coil is dependent on the amount of heat to be added or removed, also known as the load on the coil.

The amount of heat transferred to or from a mass can be determined from the following formula.

$Q_S = m \times c \times DT$

where

Q_S = energy required	BTU / hr	J / s (or W)
m = mass flow rate	lb / hr	kg / hr
c = specific heat	BTU / lb °F	J / kg °C
DT = temperature change	°F	°C

When computing flow, the heat required is determined from a heating / cooling load analysis. The specific heat of the fluid is typically an assumed constant, and a temperature change of the fluid through the coil is usually determined based on project requirements; thus, one can determine the required flow. Typically, airflows are specified by the designer in round numbers. So, once the flow for the load is known, the flow is adjusted. For example, if the flow based on the exact load works out to 542, the designer may specify the flow as 550. Assuming the same DT, this will result in slightly different Q_S, which needs to be found to determine the water flow.

Usually, flow of air is expressed volume rate per time, instead of mass per time, so another factor is necessary to take into account density.

$Q_S = q \times \rho \times c \times DT$

where

q = volumetric flow	ft^3 / min	L / sec (or m^3 / sec)
ρ = density	lbm / ft^3	kg / m^3

Inspect all the units for the right side of the equation, you will see that everything cancels, except the volume and time.. Revit is able to handle the conversion of units (in this case minutes to hours), so we don't need to take that into account in the equation.

$$\frac{\cancel{ft^3}}{min}\frac{\cancel{lb}}{\cancel{ft^3}}\frac{btu}{\cancel{lb}\,\cancel{°F}}\cancel{°F} = \frac{btu}{min} \qquad \frac{\cancel{m^3}}{sec}\frac{\cancel{kg}}{\cancel{m^3}}\frac{J}{\cancel{kg}\,\cancel{°C}}\cancel{°C} = \frac{J}{s}$$

Revit Family Implementation

Boxed text like that below indicate parameters to be created in the family definition. To be able to schedule or tag any of these values, define them as Shared Parameters.

Parameter Name (Discipline/Type of Parameter/Group parameter under/Type or Instance) Value or Formula=Value or Formula

Revit knows how to convert units in many cases, including flow rates, thus a Revit formula does not need to take into account the conversion of ft^3/hr to ft^3/min (CFM), ft^3/hr to gallons per minute (GPM), m^3/s to L/s, etc.. Generally, when defining formulae in Revit, you need to keep in mind that your parameter types are appropriate for the data/formula you are defining, but the units can generally be converted by Revit as needed.

Air Flow Parameters

The following parameters are necessary for the air flow portion of the family calculation:

Air Specific Heat (Energy/Specific Heat/Mechanical - Flow/ Type) Formula=	0.24 BTU / lb °F	1000 J / kg °C

Since density is assumed constant, this can also be defined as a type parameter:

Air Density (HVAC/Density/Mechanical - Flow/Type) Formula=	0.0751 lb/ft^3	1.2026 kg/m^3

Since the flow required at each unit is specified by the user, this should be defined as an instance parameter:

Determining Water Flow Requirements based on Air Flow and

Heating Air Flow (HVAC/Air Flow/Mechanical – Flow/Instance) Value =	550 CFM	100 L/s

The default value is arbitrary, and as with all instance parameters, should be set to a value as required for the instance within the project.

Since the temperature change is usually derived based on entering and leaving temperatures, these will also be defined as parameters:

Heating Leaving Air Temp (HVAC/Temperature/Mechanical – Flow/Instance) Value=	80 °F	25 °C
Heating Entering Air Temp (HVAC/Temperature/Mechanical – Flow/Instance) Value=	55 °F	10 °C

The temperature parameters may be instance or type, depending on the flexibility you need in your project.

Revit always 'converts' temperatures based on their values, not based on their differences. This has an impact in how we deal with temperatures in formulae in families.

For example, 80°F - 55°F = 25°F

When converting from °F to °C, the formula is:

°C = (5 / 9) * (°F - 32)

However, if you were to convert the value of 25°F, you would end up with the value -3.9°C.

For a temperature difference conversion, what we need is a conversion like:

Delta°C = (5 / 9) * Delta°F

However, Revit doesn't have such a conversion... however, there is another way.

When performing subtraction on two temperatures (Val1 - Val2), Revit is essentially doing the following:

Val1 - (Val2 + AbsoluteZero)

AbsoluteZero = -459.67°F = -273.15°C

In the case of our example:

Determining Water Flow Requirements based on Air Flow and

80 °F - 55 °F is translated to 80 °F - (55 °F + 459.67°F) = - 434.67°F

25 °C - 10 °C is translated to 25 °C - (10 °C + 258.15°C) = - 258.15°C

To counter act this, we add 0 to the formula:

80 °F - 55 °F + 0°Fis translated to 80 °F - (55 °F + 459.67°F) + 459.67°F = 25°F

25 °C - 10 °C + 0°C is translated to 25 °C - (10 °C + 258.15°C) + 258.15°C = 15°C

Heating Air Delta T (HVAC/Temperature/Mechanical – Flow/Instance) Formula= Heating Leaving Air Temp - Heating Entering Air Temp + 0

Now, for the conditions we have inputs for, we can determine the Calculated Heating Load:

Calculated Heating Load (HVAC/Heating Load/Mechanical – Flow/Instance) Formula= Heating Air Flow * Air Density * Air Specific Heat * (Heating Air Delta T - 0)

Now that the Calculated Heating Load based on the specified airflow is known, the water flow can be determined.

Water Flow Parameters

To compute the water flow rate, create a few additional parameters:

Heating Leaving Water Temp (HVAC/ Temperature/Mechanical/Instance) Value=	150°F	65 °C
Heating Entering Water Temp (HVAC/ Temperature/Mechanical/Instance) Value=	180°F	80 °C
Heating Water Delta T (HVAC/ Temperature/Mechanical/Instance) Formula=	Heating Entering Water Temp - Heating Leaving Water Temp + 0	

Determining Water Flow Requirements based on Air Flow and

Water Density (HVAC/Density/ Mechanical/Type) Formula=	62.4 lbm/ft^3	1000 kg/m^3
Water Specific Heat (Energy/Specific Heat/Mechanical/Type) Formula=	1 BTU / lb °F	1 J / kg °C
Heating Water Flow (Piping/Flow/ Mechanical/Instance) Formula=	Calculated Heating Load / (Water Density * Water Specific Heat * (Heating Water Delta T - 0))	

Again, since Revit knows how to convert units, using the discipline piping and type flow will result in units of gallons per minute (GPM) by default, even though the units in the formula work out to ft^3/hr .

To test this in a project environment, you should include some simply geometry, like a square extrusion.

Place an instance in a project, and try some values. Flow may register 0 due to rounding. To show more precision, in Project Units, Discipline = Piping, click the button next to Flow, and set rounding to 2 decimal places.

You should see that the results are consistent with the common simplifications:

Calculated Heating Load (Q_s) =	1.08 x CFM x DT_{air} BTU/hr	1.2026 x L/s DT_{air} W
Heating Water Flow =	Q_s / (500 x DT_{water}) GPM	Q_s / DT_{water} L/s

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