

Phius Domestic Hot Water (DHW) Piping Modeling Protocol

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1 - About this Protocol

The modeling protocol in this document is a supplement to Section 1.4.4.19 of the [Phius 2024 Certification Guidebook \(v26.1.0\)](#). It addresses the modeling protocol for the following sections in WUFI Passive & METr:

- Systems
 - System 1 (User Defined)
 - Distribution (tab)
 - DHW (tab)
 - General (tab)
 - Hot Water Piping (tab)

Process Tip: Specific to WUFI Passive, the DHW tab will only appear if there is a device assigned to DHW on the System 1 > General tab.

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2 - Distribution > DHW > General

Completion of the DHW Distribution table depends on the project type and controls of recirculation systems (if applicable).

Design Flow Temperature: Input a value between 120-140°F. This should be verifiable via a note on the plumbing drawings.

Circulation Pipes: This section should **only** be filled out if time-based or continuous recirculation is planned. This recirculation strategy is permitted in multifamily projects >5 stories and non-residential projects.

Exception: Centralized systems only. Per Section 1.4.1.2 of the Phius 2024 Certification Guidebook, decentralized (in-unit) DHW recirculation systems must provide on-demand controls.

- **Length of Circulation Pipes:** The full length of continuous or time-based circulation pipes should be entered here.
- **Heat loss coefficient per ft pipe [Btu/hr.ft. °F]:** Input the nominal pipe diameter, insulation thickness, and conductivity by opening calculator built-in to the energy modeling software:
 - **WUFI Passive:** Click the [. . .] button in the cell to open the built-in calculator
 - **METr:** Change the in-line dropdown from User Defined to Calculated. Additional fields will populate below the table

Process Tip: If there are multiple pipe diameters, conduct a weighted average calculation to determine the input in the heat loss coefficient calculator.

- **Daily running hours of the circulation:** 24 hours for continuous, or lower for time-based.

Process tip: Phius strongly discourages, but shall **not** prevent, the use of continuous or time-based hot water circulation systems in multifamily projects greater than 5 stories or non-residential projects.

Individual Pipes > Calculation Method

- **Non-Residential:** Set to Simplified Individual Pipes

Process Tip: This calculation method does **not** work in combination with the Drain Water Heat Recovery device type.

- **Length of Individual Pipes:** Determine the distance from the water heater to each individual hot water tap. Sum these distances to find the total length of individual pipes.

Exception: Taps that are **not** exposed to the air such as clothes washers and dishwashers should **not** be included.

- **Exterior Pipe Diameter:** Add 1/8" inch to the nominal pipe dimension to determine the exterior dimension. Use a weighted average value for piping networks with a variety of pipe sizes.

- **Residential:** Set to Hot Water Piping Calculator (unit method)

Process Tip: This calculator estimates hot water distribution losses, as well as 'time to hot' used to aid in the design of a DHW distribution network. Do **not** use the Hot Water Piping Calculator (Floor Method) for Phius Certification.

3 - Distribution > DHW > Hot Water Piping

Process tips: The Hot Water Piping tab is **only** applicable to *residential* projects. When considering how to enter the DHW distribution network, consider the source of the hot water, as well as the full path from the source of the hot water to each individual tap.

Refer to the [Hot Water Piping Protocols Update](#) webinar and review the [Sample DHW Distribution Layouts + Entries for WUFI Passive](#)

Step 1: Define General Information

- **Preselection Effectiveness:** Determined by the type of hot water fixtures used in the project. If low-flow fixtures are used as defined by [EPA WaterSense](#), choose **Low Flow**. This should be verifiable in the fixture schedule or via a note in the plumbing plans.
- ☐ **All Pipes Insulated:** Check this box if all hot water piping will be insulated. This should be verifiable via a note in the plumbing plans.
- **Count of Units or Floors:** PH Case Setting is the default and can be used for projects with a **single** unit configuration for water distribution.

Examples: Single-family and multifamily projects with identical dwelling units with individual water heaters.

Exception: For all other cases, this entry should be set to **User Defined** so that the actual quantity of unique units can be input in Step 3A or 3B.

Step 2: Identify Distribution Configuration

Follow the path that corresponds to the DHW distribution configuration according to the table below:

Recirculation Type	Path
No On-Demand Recirculation	<u>A</u>
On-Demand Recirculation	<u>B</u>

Process Tip: Projects with continuous- or time-based recirculations should follow the protocol outlined in [Section 2](#). Residential projects should then proceed to [Path A](#).

PATH A: No Demand Recirculation

Step 3A: Summarize DHW Trunks

Create a list of each unique unit type (if applicable). A unit type is designated as 'unique' if it has a unique DHW layout.

- **Name:** Name trunk(s) based on Unit Type (i.e. A, B, C, etc).

Process Tip: For single family projects, only one trunk should be included from the water heater to where the first branch diverges.

- ☐ **Demand Recirculation:** Do **not** check this box.

- **Length:** The trunk always starts at the water heater and ends where the first branch diverges from it.

Exception: Measure from the recirculation loop if a continuous- or time-based recirculation system is planned.

- **Count of Units or Floors:** Number of times this unique unit occurs. Override this input as needed as noted in Step 1.
- **Pipe Characteristics:** Review definitions in [Appendix D](#). Complete the inputs for:

- **Pipe Material**
- **Piping Diameter**

The following information is automatically calculated by the software:

- **Heat Capacity**
- **Volume [oz]**
- **Cumulative Volume [oz]**

[Proceed to Steps 4-8.](#)

PATH B: On-Demand Recirculation

Step 3B: Designate Trunk(s) for Recirculation Loop vs. Fixtures:

Create a list of:

- Unique segments of recirculation loop piping (i.e., segments of different diameters)
- Each unique unit type. A unit type is designated as 'unique' if it has a unique DHW layout. Specific to multifamily projects.

Process Tips: On-demand trunk entries are the only type of trunk that do **not** require branches to be attached to it. This is applicable to multifamily buildings with a **centralized recirculation loop** (i.e., serving multiple units). Trunks that branch off of the centralized recirculation loop to serve individual units **must** be modeled as separate line items to account for unique dwelling unit configurations.

Recirculation loops that serve a **single** unit (i.e., single family, duplexes, townhouses, or multifamily projects with decentralized recirculation systems) should have branches and twigs modeled directly off of the recirculation loop trunk entry.

- **Name:** Varies by trunk type.
 - **Recirculation Loop Trunks:** Name 'On-Demand'
 - **Trunks to individual units, off of the centralized recirculation loop:** Name based on unit number or type (e.g., 401, 402)

- ☒ **Demand Recirculation:** Check this box and review [Appendix D](#) for definition.

Exception: Do **not** check the box for trunks to individual units that branch off of the centralized recirculation loop.

- **Length:** Varies by trunk type.
 - **Recirculation Loop Trunks:** Input the total length of the Supply side of the loop **only**
Process Tip: Omit the return portion: downstream of the last fixture and recirculation pump temperature sensor.
 - **Trunks to individual units, off of the centralized recirculation loop:** Input the length of the trunk that connects the recirculation loop to the unit's fixture branches (refer to [Step 5](#))
- **Count of Units or Floors:** Number of times this unique trunk condition occurs. Override this input as needed as noted in [Step 1](#).
 - **Recirculation Loop Trunks:** Input 1 for each line item
Process Tip: Multiple demand recirculation trunks are required if the pipe diameter varies along the on-demand loop.
 - **Trunks to individual units, off of the centralized recirculation loop:** Input the quantity of each unique unit type.

[Proceed to Steps 4-8.](#)

Step 4: Summarize DHW Twigs

Create a list of hot water fixtures in each unique unit type. The twig is the small diameter piping that serves an individual fixture.

Exception: Clothes washers and dishwashers should **not** be included.

- **Name:** Name based on DHW tap in the unique units listed above, with a 'T' at the front or end.
- **Length:** A twig only serves one fixture. To determine twig length, work from the fixture back to a central pipe that serves more than one fixture (branch).

Process Tip: Enter the entire twig length from the adjoining branch for each fixture no matter how many turns/twists.

Step 5: Summarize DHW Branches

Create a list of branches that connect the trunk to the twigs. Each twig should have its own branch.

- **Name:** Name based on DHW tap in the unique units listed above, with a 'B' at the front or end.
- **Length:** Total length between twigs and trunks.

Exception: If a twig connects directly to a trunk, enter a branch with a length of '0' and connect the twig to that branch.

Process Tip: A branch off the trunk may only serve one fixture. In that case, it could all be considered a twig or could be split into a branch and a twig. If the pipe dimension and material are the same, either method will yield the same results.

Step 6: Enter in WUFI Passive or METr

Enter information collected in **Steps (3A/3B) - 5** in the energy model.

Process Tip: A segment must be entered first with the trunk, then connecting branch, then connecting twig. Be careful to connect the appropriate segments.

Step 7: Check Compliance

Use the Watersense Met? column in the Twigs section to estimate whether all fixtures will pass the EPA WaterSense Hot Water Delivery requirement.

Process Tip: This tool is used to aid in the design of a DHW distribution network that will pass on-site testing, but does **not** guarantee it. If a twig is **not** passing in the model, it is recommended to revise the tap location or circulation strategy for that tap.

The limits in **METr** are accurate and based on the Certificate Criteria defined in the PH Cases branch of the modeling tree.

Exceptions: The limit built into **WUFI Passive** is 0.5 gal, which is an option from DOE's Efficient New Homes V2 for single-family, duplex and townhouse projects. Alternative compliance paths taken should be communicated to Phius.

Multifamily projects with individual water heaters have a limit of 1.8 gallons (230.4 oz).

Step 8: Double Check Inputs

Verify that:

- All trunks have branch entries

Exception: Review Process Tip in [Step 3B](#).

- All branches have twigs connected
- Quantities appropriately represent the building distribution network

Appendix D - Definitions

Demand Circulation: Checking this box resets the 'up-stream volume' for any branch connected to that trunk. It will assume the branch will always be served with hot water and the trunk length should **not** be considered when estimating the 'time to hot' for the EPA WasterSense Hot Water Delivery test.

Process Tip: The on-demand recirculation pipes must still be entered to accurately account for DHW pipe distribution losses, even though it resets the volume in the trunk for the 'time to hot' calculation.

Pipe material: Update the pipe material as shown in the floor plans. The most common pipe types are Copper L and PEX-AL-PEX.

Pipe diameter: This should be verifiable from the floor plans and input in WUFI Passive to match.

Heat Capacity: This is calculated based on the type of piping chosen, piping diameter and piping length.

Volume [oz]: The calculated total volume of water stored in this pipe based on the pipe material, piping diameter and piping length.

Cumulative volume [oz]: This calculated volume is used to determine a project's compliance with the Watersense. If 'Demand recirculation' is checked for a trunk, the cumulative volume of that pipe will be zeroed out and **not** count towards the volume of water stored in the pipe.

Time to "hot" @ 1 gpm [s]: Calculates an estimate of how long it will take the water to rise 10F in seconds based on the cumulative volume of water in the pipes. 60 seconds coincides with failing the Watersense test.

Ounces of Water per Foot of Hot Water Piping [oz] by Pipe Material

Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
3/8"	1.06	0.97	0.84	n/a	1.17	0.63	0.63	0.64
1/2"	1.69	1.55	1.45	1.25	1.89	1.31	1.31	1.18
5/8"	n/a	2.32	2.22	n/a	n/a	2.12	n/a	1.72
3/4"	3.43	3.22	2.9	2.67	3.38	3.39	3.39	2.35
1"	5.81	5.49	5.17	4.43	5.53	5.56	5.56	3.91
1 1/4"	8.70	8.36	8.09	6.61	9.66	8.49	8.49	5.81
1 1/2"	12.18	11.83	11.45	9.22	13.20	13.88	13.88	8.09
2"	21.08	20.58	20.04	15.79	21.88	21.48	21.48	13.86

Outside Pipe Diameter [in] by Pipe Material

Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
3/8"	0.50	0.50	0.50	n/a	0.68	0.47	0.47	0.50
1/2"	0.63	0.63	0.63	0.63	0.84	0.63	0.63	0.63
5/8"	n/a	0.75	0.75	n/a	n/a	0.79	n/a	0.75
3/4"	0.88	0.88	0.88	0.88	1.05	0.98	0.98	0.88
1"	1.13	1.13	1.13	1.13	1.32	1.26	1.26	1.13
1 1/4"	1.38	1.38	1.38	1.38	1.66	1.58	1.58	1.38
1 1/2"	1.63	1.63	1.63	1.63	1.90	1.97	1.97	1.63
2"	2.13	2.13	2.13	2.13	2.38	2.48	2.48	2.13

Inside Pipe Diameter [in] by Pipe Material								
Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
⅜"	0.45	0.43	0.40	n/a	0.49	0.35	0.35	0.36
½"	0.57	0.55	0.53	0.51	0.62	0.50	0.50	0.49
⅝"	n/a	0.67	0.65	n/a	n/a	0.64	n/a	0.58
¾"	0.81	0.79	0.75	0.72	0.82	0.81	0.81	0.68
1"	1.06	1.03	1.00	0.92	1.05	1.03	1.03	0.88
1 ¼"	1.29	1.27	1.25	1.13	1.38	1.28	1.28	1.07
1 ½"	1.53	1.51	1.48	1.33	1.61	1.63	1.63	1.26
2"	2.01	1.99	1.96	1.74	2.07	2.03	2.03	1.65

Weight Empty [lb/ft] by Pipe Material								
Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
⅜"	0.14	0.20	0.27	n/a	0.12	0.06	0.07	0.05
½"	0.20	0.29	0.34	0.08	0.18	0.07	0.10	0.06
⅝"	n/a	0.36	0.42	n/a	n/a	0.10	n/a	0.08
¾"	0.33	0.46	0.64	0.14	0.24	0.15	0.14	0.11
1"	0.47	0.66	0.84	0.23	0.35	0.23	0.23	0.17
1 ¼"	0.68	0.88	1.04	0.35	0.48	0.39	0.38	0.26
1 ½"	0.94	1.14	1.36	0.49	0.57	0.55	0.55	0.36
2"	1.46	1.75	2.06	0.83	0.76	0.92	0.91	0.61

Empty Pipe Heat Capacity [Btu/ft.F] by Pipe Material

Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
3/8"	0.01	0.02	0.02	n/a	0.02	0.04	0.04	0.02
1/2"	0.02	0.03	0.03	0.02	0.04	0.04	0.06	0.03
5/8"	n/a	0.03	0.04	n/a	n/a	0.06	n/a	0.05
3/4"	0.03	0.04	0.06	0.03	0.05	0.08	0.08	0.06
1"	0.04	0.06	0.08	0.05	0.07	0.13	0.13	0.09
1 1/4"	0.06	0.08	0.09	0.07	0.10	0.21	0.21	0.14
1 1/2"	0.08	0.10	0.12	0.10	0.11	0.30	0.30	0.20
2"	0.13	0.16	0.19	0.17	0.15	0.50	0.50	0.34

Pipe & Water Heat Capacity [Btu/ft.F] by Pipe Material

Nominal Diameter	Copper M	Copper L	Copper K	CPVC CTS SDR 11	CPVC SCH 40	PEX-AL-PEX	PE-AL-PE	PEX CTS SDR 9
3/8"	0.08	0.08	0.08	n/a	0.11	0.08	0.08	0.07
1/2"	0.13	0.13	0.13	0.10	0.17	0.12	0.14	0.11
5/8"	n/a	0.18	0.18	n/a	n/a	0.19	n/a	0.16
3/4"	0.25	0.25	0.25	0.20	0.28	0.30	0.30	0.22
1"	0.42	0.42	0.41	0.33	0.44	0.49	0.49	0.35
1 1/4"	0.63	0.62	0.62	0.50	0.74	0.76	0.76	0.53
1 1/2"	0.87	0.87	0.87	0.70	0.99	1.20	1.20	0.74
2"	1.50	1.49	1.49	1.19	1.60	1.90	1.89	1.26