Chapter 8:

Radiant floor system design

Although it is easiest to quickly and accurately create a radiant design with a software program, it's essential to understand how to design a system manually to help make decisions and alterations to optimize system performance.

To design a radiant floor system, one must determine the:

- BTU/h/ft^2 heat loss for each room
- Floor surface temperature
- Project installation method
- Piping type and size
- Finished floor material R-value
- Piping on-center distance
- Supply water temperature
- Loop length, including leader distance
- Fluid flow in gpm
- Pressure loss or head

Radiant floor design tutorial

To demonstrate radiant floor design, this tutorial moves step by step through the design of a single room (Bedroom 1) in the Uponor Training House. The complete Training House radiant floor heat loss and design information is provided on **pages 72-85**.

Figure 8-1 shows a partial floor plan for the Uponor Training House including Bedroom 1.

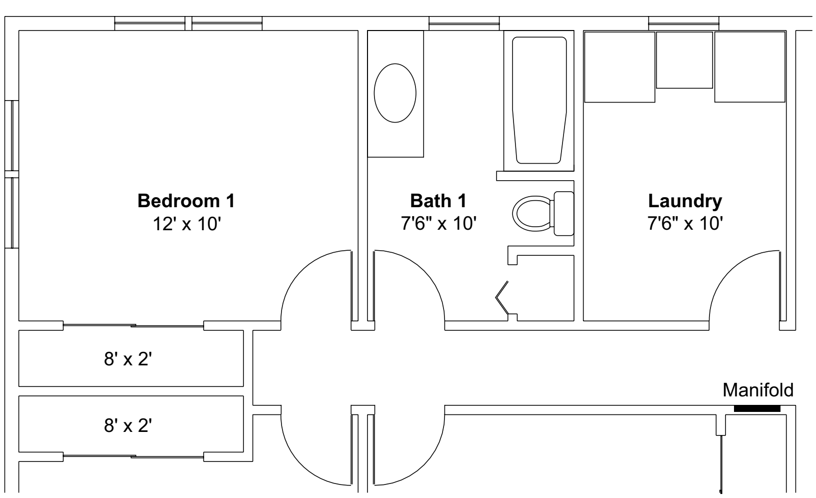


Figure 8-1: Uponor training house (partial)

Step 1: Heat-loss analysis

The radiant floor design worksheet provides a format to organize the building's raw heat-loss information. A copy of this worksheet is available in **Appendix A**. Copy as necessary. Fill out the worksheet for the project, and then enter the information into the computer heat-loss program. Entering the data into the computer will go much faster if you complete the worksheet first. Take special note of the input for floor covering R-values and the different floor insulation types and values.

Figure 8-2 shows heat-loss data from the design program for Bedroom 1.

Note: When determining system performance data, note which load to use: upward, downward or total. All load-related entries require the upward load value. The total load value is only used when calculating flow information.

Bedroom 1 (floor plan 1)	
Total area	136 ft^2
Average height	8 ft
Volume	1,088 ft^2
Air changes	0.35/hr
Room temperature	65°F
Components	1,841 BTU/hr
Infiltration	348 BTU/hr
Ceiling upward	236 BTU/hr
Floor downward	1,020 BTU/hr
Total heat loss	3,279 BTU/hr
Supplemental	0 BTU/hr
Total room loss	3,279
Radiant to room load	2,607 BTU/hr
Unit load	19.8 BTU/ft^2/hr
Total radiant load	3,279 BTU/hr
Unit load	24.8 BTU/ft^2/hr

Figure 8-2: Heat-loss data for bedroom 1

Radiant floor design worksheet

Project name: Training House main level

			Loop 1
	A	Room name	Bedroom 1
Step 1	B	Room setpoint temp. (°F)	65°F
	C	Zone number	1
	D	Upward load (BTU/h/ft^2)	19.8
	E	Total load (BTU/h/ft^2)	24.8
	F	Floor surface temp. (°F)	
	G	Installation method	
	H	Piping size	
	I	Floor covering R-value	
	J	Differential temp. (°F)	
	K	Piping o.c. distance (in)	
	L	Supply water temp. (°F)	
	M	Active loop length	
	N	Leader loop length	
	O	Total loop length	
	P	Loop flow in gpm	
	Q	Loop head pressure (ft)	
	R	Loop balancing turns	

Manifold totals

S	Supply water temp. (°F)	
T	Manifold flow in gpm	
U	Highest pressure head (ft)	

Figure 8-3: Radiant floor design worksheet

Use the radiant floor worksheet (**Appendix B**) when manually designing a system. Note that this appendix also contains worksheets for radiant ceiling and Quik Trak® designs. Make a copy of the worksheet prior to beginning this tutorial.

From the selected heat-loss information given for Bedroom 1, enter the following information into the appropriate cell on the worksheet:

- Room name
- Room setpoint temperature
- Upward BTU/h/ft² load
- Total BTU/h/ft² load (upward and downward added together)

Note: Obtain BTU/h/ft² values either from the design printout or calculate manually by dividing the BTU/h by the floor area (in square feet) where piping can be installed. Remember to subtract areas where piping will not be installed. All load values in this tutorial are BTU/h/ft².

Step 2: Floor surface temperature

The floor surface temperature is the temperature at the top of the floor needed to transfer the calculated BTU/h into the room at the maximum designed heat load. This surface temperature is based solely on the floor area. Floor covering, construction or piping on-center distances do not influence the required surface temperature. If conditions are milder than design, the floor surface temperature will be lower. Surface temperature is based on a simple relationship between the room setpoint temperature and the required upward BTU/h/ft² load. Do not include downward BTU/h/ft² loss when calculating floor surface temperature. Areas with differing BTU/h/ft² requirements or setpoint requirements have different surface temperatures.

The coefficient of radiant floor thermal transfer is 2.0 BTU/h/ft²/°F. This transfer coefficient changes as the position of the radiant panel changes in the room. Radiant wall has a transfer coefficient of 1.8, and radiant ceiling has a transfer coefficient of 1.6. Simply put, the floor surface temperature is equal to the room setpoint temperature plus half the required upward BTU/h/ft² load.

For bedroom 1: (19.8 BTU/h/ft² ÷ 2 BTU/h/ft²) + 65°F = 74.9°F floor surface temperature.

The formula used to calculate the floor surface temperature is precise and is supplied by the design program. If manually designing the system, use the formula or the floor surface temperature chart found in **Appendix C**. This chart is also shown in **Figure 8-4**. This chart quickly brackets the floor surface temperature to determine if the temperature is within requirements.

Floor surface temperature limitations — Hardwood floors have a maximum floor surface temperature of 80°F. Please consult the wood flooring manufacturer for their recommendations. All other flooring types have a maximum floor surface temperature of 87.5°F.

Using the floor surface temperature chart:

Find: The required floor surface temperature.

Procedure:

1. Find the desired room setpoint temperature in the first column of the table; for this example, use 65°F.
2. Move right until you reach the correct upward BTU/h/ft² requirement (19.8). The chart is divided into five BTU/h/ft² increments. If between values, round to the next higher value. For this example of 19.8 BTU/h/ft², use the 20 BTU/h/ft² entry.
3. The temperature found at the intersection of the two values is the bracketed floor surface temperature.

Keep in mind this chart is used to quickly assess whether the floor surface temperature is within limitations. At 75°F floor surface temperature, the room floor surface temperature is well within all limitations. Actual floor surface temperature is 74.9°F.

If the design does not use wood flooring, and the required surface temperature exceeds 87.5°F, reduce the heat loss of the room or add

Radiant floor surface temperatures

Room setpoint										
75°F	80.0	82.5	85.0	87.5	90.0	92.5	95.0	97.5	100.0	102.5
72°F	77.0	79.5	82.0	84.5	87.0	89.5	92.0	94.5	97.0	99.5
70°F	75.0	77.5	80.0	82.5	85.0	87.5	90.0	92.5	95.0	97.5
68°F	73.0	75.5	78.0	80.5	83.0	85.5	88.0	90.5	93.0	95.5
65°F (1)	70.0	72.5	75.0 (3)	77.5	80.0	82.5	85.0	87.5	90.0	92.5
60°F	65.0	67.5	70.0	72.5	75.0	77.5	80.0	82.5	85.0	87.5
BTU/h/ft²	**10.0**	**15.0**	**20.0** (2)	**25.0**	**30.0**	**35.0**	**40.0**	**45.0**	**50.0**	**55.0**

Exceeds the maximum recommended surface temperature for all floors.

Exceeds the maximum recommended surface temperature for hardwood floors.

Figure 8-4: Excerpt from radiant floor surface temperatures chart

supplemental heat. Take the same action for wood flooring applications when the floor surface temperature exceeds 80°F.

Reversing the floor surface temperature formula determines the maximum load in BTU/h/ft² for a room. To calculate the maximum upward BTU/h/ft² at a given room setpoint temperature, use this equation:

(87.5°F - room setpoint) x 2 = maximum BTU/h/ft²

Using this formula, a room with a setpoint temperature of 65°F will support 45 BTU/h/ft² for a maximum upward BTU/h/ft² load. Conversely, if the room setpoint temperature is 70°F, then 35 BTU/h/ft² is the maximum upward load. Obviously, if wood flooring is used, the BTU/h/ft² capability is less. Remember, these loads are maximum capabilities and may be reduced by floor construction and floor covering selections.

Enter 74.9°F in the floor surface temperature cell on the worksheet.

Step 3: Installation method

Next, determine which installation method to use for the particular job. Of all the options outlined in **Chapter 6**, the most common are:

- Slab on or below grade
- Poured-floor underlayment
- Quik Trak
- Joist Trak
- Joist heating

Sometimes the decision is obvious, but other times the designer may help influence the decision. For instance, does the actual heat source have a fixed water temperature that must be designed around? Has the building already been framed, making poured-floor underlayment impractical? What is the project budget? Consider all these factors when determining an installation method.

One final note: there really is no best or preferred installation method. All have their applications, advantages and limitations. In addition, the superior efficiency of radiant floor heating in general makes any installation method preferable over other heat-delivery options.

For this tutorial, use the poured-floor underlayment for the type of installation method. In the floor construction cell on the worksheet, enter "Poured Floor."

Step 4: Piping size

People often ask, "Do you get more heat out of ½" piping than ⅜" piping?" The surprising answer is no, not really. The most common piping sizes used in radiant floor heating are ⅜" and ½". Both are fairly equal in terms of heat output per square foot when installed in a radiant mass. Remember, the floor — not the piping — is the heat emitter. The piping merely carries water to the heat emitter.

Larger piping sizes do allow for longer loop lengths due to lower friction losses at the same flow rates, but do not increase the actual per square foot heat output of a radiant system to any extent. Other factors, such as installation method, piping spacing, water temperature, finished floor materials and flow are more important factors in determining performance capabilities.

The biggest difference between piping sizes is pressure loss. Smaller piping produces much greater pressure loss than larger piping. Therefore, shorter loop lengths are suggested for smaller-diameter piping. This pressure loss, rather than heat output, is the determining factor when it comes to selecting a piping size.

Enter ½" Wirsbo hePEX in the piping size cell on the worksheet.

Radiant floor design worksheet

Project name: Training House main level

			Loop 1
	A	**Room name**	**Bedroom 1**
	B	Room setpoint temp. (°F)	65°F
	C	Zone number	1
	D	Upward load (BTU/h/ft²)	19.8
	E	Total load (BTU/h/ft²)	24.8
Step 2	F	**Floor surface temp. (°F)**	**74.9°F**
Step 3	G	**Installation method**	**Poured floor**
Step 4	H	**Piping size**	**½" Wirsbo hePEX**
	I	Floor covering R-value	
	J	Differential temp. (°F)	
	K	Piping o.c. distance (in)	
	L	Supply water temp. (°F)	
	M	Active loop length	
	N	Leader loop length	
	O	Total loop length	
	P	Loop flow in gpm	
	Q	Loop head pressure (ft)	
	R	Loop balancing turns	

Manifold totals

S	Supply water temp. (°F)	
T	Manifold flow in gpm	
U	Highest pressure head (ft)	

Figure 8-5: Radiant floor design worksheet

Step 5: Finished floor covering R-value

The next step is to determine the type of finished flooring material and its corresponding R-value. This information is needed to determine the appropriate supply water temperature. **Appendix D** includes a chart listing a variety of common floor coverings and their R-values; an excerpt of the chart is shown in **Figure 8-7**.

Use the chart to select the floor covering closest to the proposed floor covering.

Many times the finished floor material is unknown at the time of design. People will question, “Shouldn’t I simply design for the worst possible case?” This approach may prevent a potential under-design problem. However, it frequently leads to over-design issues, where more piping or excessive supply water temperatures may be needlessly factored into a job, adding to the overall design cost. Designers must carefully weigh the overall results of their design decisions, especially with floor coverings.

Find: The R-value of ¼-inch nylon saxony carpet with ¼-inch bonded urethane padding (4-lb. density).

Procedure:

1. In the R-value table, find the type of carpeting to be installed.
2. Move to the right and read the value for the appropriate thickness.
3. In this example, the R-value of ¼-inch nylon saxony is 0.88.
4. In the R-value table, find the type of carpet pad to be installed.
5. Move to the right and read the value for the appropriate thickness.
6. In this example, the R-value of ¼-inch bonded urethane is 1.04.
7. Add the two values together to obtain the total R-value: 0.88 + 1.04 = 1.92
8. Enter 1.92 in the floor covering R-value cell on the worksheet.

Step 6: Determining differential temperature

The supply and return differential temperature is the temperature drop from the supply manifold to the return manifold. A supply and return differential temperature of 10°F is ideal for residential radiant floors. A 20°F differential temperature is common for commercial projects. For the exercise, use a supply and return differential temperature of 10°F.

Enter 10°F in the differential temperature cell on the worksheet.

Step 7: On-center distance

Piping on-center distance is a function of flow, temperature and comfort. You must deliver the required flow through the piping at the selected piping on-center distance and be within the operational temperature range of the floor construction medium (e.g., concrete, underlayment, etc.).

Decreasing the piping spacing (bringing the piping closer together) will lower the required supply water temperature and produce a more even surface temperature, but increases the amount of piping used in the project.

For poured-floor underlayments, the maximum on-center distance is

Radiant floor design worksheet

Project name: Training House main level

			Loop 1
	A	**Room name**	**Bedroom 1**
	B	Room setpoint temp. (°F)	65°F
	C	Zone number	1
	D	Upward load (BTU/h/ft²)	19.8
	E	Total load (BTU/h/ft²)	24.8
	F	Floor surface temp. (°F)	74.9°F
	G	Installation method	Poured floor
	H	Piping size	½" Wirsbo hePEX
Step 5	I	**Floor covering R-value**	**1.92**
Step 6	J	**Differential temp. (°F)**	**10°F**
Step 7	K	**Piping o.c. distance (in)**	**9"**
Step 8	L	**Supply water temp. (°F)**	**132°F**
	M	Active loop length	
	N	Leader loop length	
	O	Total loop length	
	P	Loop flow in gpm	
	Q	Loop head pressure (ft)	
	R	Loop balancing turns	

Manifold totals

S	Supply water temp. (°F)	
T	Manifold flow in gpm	
U	Highest pressure head (ft)	

Figure 8-6: Radiant floor design worksheet

Carpeting	⅛"	¼"	⅜"	½"	⅝"	¾"
Commercial glue down		0.60	0.90			
Acrylic level loop		1.04	1.56	2.08	2.60	3.12
Acrylic plush		0.83	1.25	1.66	2.08	2.49
Polyester plush		0.96	1.44	1.92	2.40	2.88
Nylon saxony		0.88	1.32	1.76	2.20	2.64
Nylon shag		0.54	0.81	1.08	1.35	1.62
Wool plush		1.10	1.65	2.20	2.75	3.30
Carpet pads						
Rubber (solid)		0.31	0.47	0.62	0.78	0.93
Rubber (waffled)		0.62	0.93	1.24	1.55	1.86
Hair and jute		0.98	1.47	1.96	2.45	2.94
Prime urethane (2-lb. density)		1.08	1.62	2.16	2.70	3.24
Bonded urethane (4-lb. density)		1.04	1.56	2.08	2.60	3.12
Bonded urethane (8-lb. density)		1.10	1.65	2.20	2.75	3.30

Figure 8-7: Excerpt from floor covering R-value chart

9 inches. Due to the shallow depth of the pour, install the piping closer together to avoid possible striping, which creates warm and cool spots across the floor. If the supply water temperature is found to be too high later in the design process, reduce the on-center distances.

Enter 9 inches in the on-center distance cell on the worksheet.

Step 8: Supply water temperature

The required supply water temperature is the temperature necessary to provide the amount of energy required to create the floor surface temperature as it relates to the upward resistance of floor coverings. Supply water temperature is based on a complex relationship between the conditions above and below the radiant mass and several other characteristics of the installation.

The factors required to calculate supply water temperature are:

- Installation method
- Required upward BTU/h/ft² load
- Room setpoint temperature
- Floor covering R-value
- Supply and return differential temperature

The required information to determine the supply water temperature is known. Use the appropriate chart in **Appendix E** (see **Figure 8-8**).

Find: The required supply water temperature for a load of 19.8 BTU/h/ft² using poured-floor underlayment construction with piping at 9 inches on center with a floor covering R-value of 1.92.

Procedure:

1. Find the appropriate supply water temperature chart (poured-floor underlayment with piping 9 inches on center).
2. Enter the chart in the BTU/h/ft² column for the given load (19.8 BTU/h/ft²).
3. Move to the right until intersecting the approximate R-value slope line. The slope line for this R-value (1.92) falls between the published lines in the chart.
4. Move straight down from the intersecting point of the 1.92 R-value line and the 19.8 BTU/h/ft² line.
5. Read the required supply water temperature at the appropriate differential temperature. The required water temperature for Bedroom 1 is 132°F.

Enter 132°F in the supply water temperature cell on the worksheet.

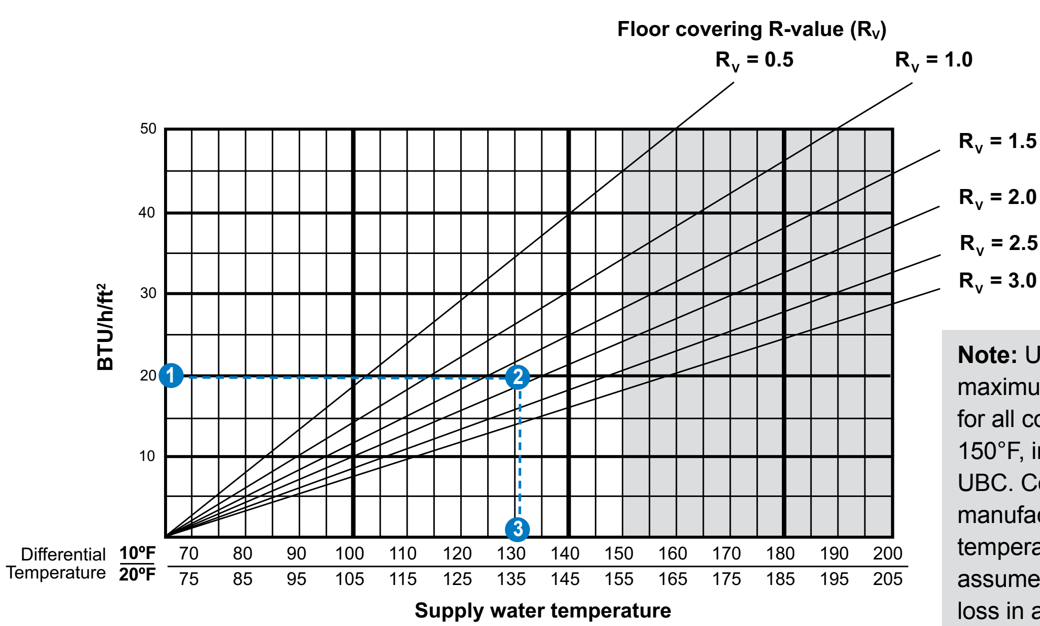
Note: If the calculated downward loss in BTU/h/ft² exceeds the upward load requirement, use the greater of the two values when calculating the supply water temperature.

Concrete slabs and poured-floor underlayments thicker than the depth shown on the charts in **Appendix E** require slightly higher supply water temperatures.

If the supply water temperature exceeds the piping's sustained operating temperature or the floor construction limitation, the best ways to decrease the water temperature are to:

- Reduce the piping on-center distance
- Reduce the floor covering R-value
- Reduce the upward heat loss through improved insulation
- Provide supplemental heat

The maximum operating water temperature for concrete is 150°F and 140°F for poured-floor underlayment (verify with the product manufacturer). When installing piping between floor joists, with or without heat emission plates, limit the supply water design temperature to 165°F.



Note: Uponor's recommended maximum fluid temperature for all concrete applications is 150°F, in accordance with the UBC. Consult underlayment manufacturer's recommended temperature limitations. This data assumes negligible downward loss in accordance with good insulation practices.

Figure 8-8: Excerpt from supply water temperature chart

Step 9: Determine loop length

Loop length is a function of room size, piping on-center distance and the length of the piping that runs to and from the manifold (leader distance).

Active loop length — To determine the amount of piping to be installed in a room, use the following multipliers:

12" o.c. Multiply the square footage of the room by 1.0

10" o.c. Multiply the square footage of the room by 1.2

9" o.c. Multiply the square footage of the room by 1.33

8" o.c. Multiply the square footage of the room by 1.5

7" o.c. Multiply the square footage of the room by 1.7

6" o.c. Multiply the square footage of the room by 2.0

These factors determine the amount of active piping to install in the room.

Find: The active loop length for Bedroom 1 with the piping installed at 9 inches on center.

Procedure:

1. Multiply the square footage of the room by the appropriate multiplier: 132 ft^2 x 1.33 = 176 feet
2. The active loop length for Bedroom 1 is 176 feet.

Enter 176 feet in the active loop length cell on the worksheet.

Leader length — To determine the leader length for the loop, add the horizontal distance from the room to the manifold to include any vertical distance. Multiply this value by two (supply and return) to obtain the leader length for the loop. To determine the total loop length, add the active loop length to the leader length.

Find: The leader length for Bedroom 1.

Procedure:

1. Add the horizontal distance from the room to the manifold location and back to the amount of vertical distance at the manifold location.
2. The manifold location is approximately 20 feet from Bedroom 1. Multiply this distance by 2 (to account for supply and return piping) to obtain the amount of horizontal piping in the leader length: 20 x 2 = 40 feet
3. At the manifold location, this example will require approximately 5 feet of piping to run from the floor to the manifold and back to the floor (roughly 2 feet on one side with 3 feet on the other). Add the horizontal and vertical piping amounts together: 40 + 5 = 45 feet
4. The total leader length for Bedroom 1 is 45 feet.

Enter 45 feet in the leader length cell on the worksheet.

Find: The total loop length for Bedroom 1.

Procedure:

1. Add the active loop length to the leader length to obtain the total loop length: 176 + 45 = 221
2. The total loop length for Bedroom 1 is 221 feet.

Enter 221 feet in the total loop length cell on the worksheet.

Radiant floor design worksheet

Project name: Training House main level

			Loop 1
	A	**Room name**	**Bedroom 1**
	B	Room setpoint temp. (°F)	65°F
	C	Zone number	1
	D	Upward load (BTU/h/ft²)	19.8
	E	Total load (BTU/h/ft²)	24.8
	F	Floor surface temp. (°F)	74.9°F
	G	Installation method	Poured floor
	H	Piping size	½" Wirsbo hePEX
	I	Floor covering R-value	1.92
	J	Differential temp. (°F)	10°F
	K	Piping o.c. distance (in)	9"
	L	Supply water temp. (°F)	132°F
Step 9	M	**Active loop length**	**176'**
	N	**Leader loop length**	**45'**
	O	**Total loop length**	**221'**
Step 10	P	**Loop flow in gpm**	**0.67**
Step 11	Q	**Loop head pressure (ft)**	**4.6'**
	R	Loop balancing turns	

Manifold totals

S	Supply water temp. (°F)	
T	Manifold flow in gpm	
U	Highest pressure head (ft)	

Figure 8-9: Radiant floor design worksheet

Step 10: Calculating fluid flow

To satisfy the calculated heat load, the system must provide adequate fluid flow through each loop of the hydronic radiant floor system. Fluid flow is based on a relationship between the heat load, active loop length and the supply and return differential temperature. The information required to calculate fluid flow includes:

- Required total BTU/h/ft² load (upward and downward combined)
- Piping on-center distance
- Active loop length

For Bedroom 1 of the Training House, the total load from the heat loss is 24.8 BTU/h/ft². The active loop length, based on 9 inches on-center spacing, is 176 feet.

Use the charts in **Appendix F** to calculate flow for each loop in the system. Select the appropriate chart for the water or water-and-glycol mixture when calculating flow.

Find: The required flow per loop.

Procedure:

1. Find the appropriate chart based on the type of fluid used. In this tutorial, use the 100% water chart (see **Figure 8-10**).
2. Enter the chart at the total BTU/h/ft² load (24.8) in the BTU/h/ft² column. In small applications, round to the nearest BTU/h/ft² value (25 BTU/h/ft²) or use the formula in **Step 3** to determine the flow per foot value for the actual BTU/h/ft².
3. For actual flow value, move to the right until you intersect the column for 9 inches on center for 25 BTU/h/ft².
4. The flow value is 0.00380 gpm per foot of piping.
5. Using the actual flow, multiply it by the active loop length: 0.00380 x 176 = 0.67 gpm

Enter 0.67 gpm in the flow per loop cell in the worksheet.

Step 11: Pressure loss

To calculate the feet of pressure head drop (ft hd) for the loop, use the following information: flow per loop, total loop length, size of piping, type of piping, supply water temperature and fluid concentration.

The flow for this loop is 0.67 gallons per minute. The total loop length is 221 feet. The type and size of piping is ½" Wirsbo hePEX. The supply water temperature is 132°F. The fluid concentration is 100% water.

Find: Feet of head drop.

Procedure:

1. Find the appropriate chart in **Appendix G** (100% water using ½" Wirsbo hePEX).
2. Enter the gpm column and round to the nearest flow for the loop (0.72 gpm).
3. Move right to the closest supply water column for the manifold (130ºF).

> **Note:** If the system water temperature is between two columns, round up or down to the nearest temperature. If the temperature falls exactly between two columns (110°F for example), use the lower temperature column (100°F). For this example, use the 130°F column.

4. Read the feet of head drop per foot (0.02094).
5. Multiply the feet of head value per foot by the total loop length to determine total feet of head for the loop. (0.02094 x 221 = 4.6')

Normally, the feet of head calculations are completed only after the manifold supply water temperature is known (after the project design is completed). The feet of head loss is completed now for training purposes.

If the head loss is higher than desired after completing the pressure-loss calculation, you may need to decrease loop length(s), add loops or increase the PEX piping size.

If the piping size or total loop length change, recalculate pressure loss using the new loop length or piping size (and corresponding water temperature).

Enter 4.6 feet of head in the loop head pressure cell in the worksheet.

This completes the design of Bedroom 1. Once all rooms are designed and calculated for the Training House tutorial, perform the initial flow balancing and determine the system totals. The answers for the tutorial are on **page 88**.

100% Water | 10º Supply/return differential flow in GPM per foot of piping.

	Piping on-center distances					
BTU/h/ft²	**6" o.c.**	**7" o.c.**	**8" o.c.**	**9" o.c.**	**10" o.c.**	**12**
50	0.00507	0.00591	0.00676	0.00760	0.00845	0.
49	0.00497	0.00579	0.00662	0.00745	0.00828	0.
48	0.00487	0.00568	0.00649	0.00730	0.00811	0.
47	0.00476	0.00556	0.00635	0.00715	0.00476	0.
46	0.00466	0.00544	0.00622	0.00699	0.00777	0.
45	0.00456	0.00532	0.00608	0.00684	0.00760	0.
44	0.00446	0.00520	0.00595	0.00669	0.00743	0.
43	0.00436	0.00508	0.00581	0.00654	0.00726	0.
42	0.00426	0.00497	0.00568	0.00639	0.00709	0.
41	0.00416	0.00485	0.00554	0.00623	0.00693	0.
40	0.00405	0.00473	0.00541	0.00608	0.00676	0.
39	0.00395	0.00461	0.00527	0.00593	0.00659	0.
38	0.00385	0.00449	0.00513	0.00578	0.00642	0.
37	0.00375	0.00437	0.00500	0.00563	0.00625	0.
36	0.00365	0.00426	0.00486	0.00547	0.00608	0.
35	0.00355	0.00414	0.00473	0.00532	0.00591	0.
34	0.00345	0.00402	0.00459	0.00517	0.00574	0.
33	0.00334	0.00390	0.00446	0.00502	0.00557	0.
32	0.00324	0.00378	0.00432	0.00487	0.00541	0.
31	0.00314	0.00367	0.00419	0.00471	0.00524	0.
30	0.00304	0.00355	0.00405	0.00456	0.00507	0.
29	0.00294	0.00343	0.00392	0.00441	0.00490	0.
28	0.00284	0.00331	0.00378	0.00426	0.00473	0.
27	0.00274	0.00319	0.00365	0.00410	0.00456	0.
26	0.00264	0.00307	0.00351	0.00395	0.00439	0.
25	0.00253	0.00296	0.00338	0.00380	0.00422	0.
24	0.00243	0.00284	0.00324	0.00365	0.00405	0.
23	0.00233	0.00272	0.00311	0.00350	0.00389	0.
22	0.00223	0.00260	0.00297	0.00334	0.00372	0.
21	0.00213	0.00248	0.00284	0.00319	0.00355	0.
20	0.00203	0.00236	0.00270	0.00304	0.00338	0.

Figure 8-10: Excerpt from 100% water flow chart on page 194

System reminders

Water temperature

When designing a radiant system, a situation may arise where different loops serving different rooms on the same manifold have different required water temperatures. Typically, if this difference is no greater than 20°F to 25°F, it will not impact the system. This, of course, will vary depending on room traffic patterns and floor coverings.

However, if the difference is greater than 25°F, consider some design changes to reduce the temperature differential.

First, in wet applications (poured-floor underlayment), decrease the piping spacing of the loops requiring higher water temperatures. This will lower the required water temperature in those loops while maintaining the same output and floor surface temperature. However, loop length and pressure loss will increase, which may necessitate adding a second loop to that area.

Second, in dry installations (between the joists), you may choose to add aluminum heat emission plates to lower the water temperature.

Third, decreasing the finished floor R-value will lead to lower required water temperatures.

Last, move the higher supply water temperature loops to another manifold and run appropriate water temperature to that manifold.

Head and GPM

When calculating the flow and head total for a system, gpm (or total flow) is cumulative. The flow of all loops served by a single circulator should be added together. Head (or pressure loss) is not cumulative. Simply select the highest pressure drop of all the loops per manifold served by that circulator. Remember to add in the supply and return mechanical piping and any other appliances the circulator will push flow through.

When selecting a circulator, consult the manufacturer's published performance curves, and select the circulator that best fits the specific gpm and head requirements for the project.

The complete design

The following is the entire room schedule for the Uponor Training House. The floor plans and heat-loss information appear on **pages 72 to 85**. Finish the design with the worksheet started by Bedroom 1. See **page 88** for the completed tutorial design calculations.

Room schedule		
Bedroom 1	136 ft²	¼" nylon saxony with ¼" bonded urethane
Bedroom 2	160 ft²	¼" nylon saxony with ¼" bonded urethane
Bedroom 3	183 ft²	¼" nylon saxony with ¼" bonded urethane
Living room	260 ft²	¾" oak
Kitchen/dining	260 ft²	¾" oak
Bath/laundry	150 ft²	¼" ceramic tile with ¼" underlayment
Bedroom 4	209 ft²	¼" nylon saxony with ¼" bonded urethane
Bath 2	75 ft²	¼" ceramic tile with ¼" underlayment
Family room	270 ft²	¼" nylon saxony with ¼" bonded urethane
Recreation room	270 ft²	¼" nylon saxony with ¼" bonded urethane
Storage	383 ft²	No floor covering

Window schedule		
Window 1 — 2'6" x 4'0"	Double pane, wood frame	R-1.81
Window 2 — 5'0" x 4'0"	Double pane, wood frame	R-1.81

Door schedule		
Door 1 — 6'0" x 7'0"	Sliding, double pane, wood frame	R-1.82
Door 2 — 3'0" x 7'0"	Metal with urethane core	R-5.29

Figure 8-11: Room, window and door schedules

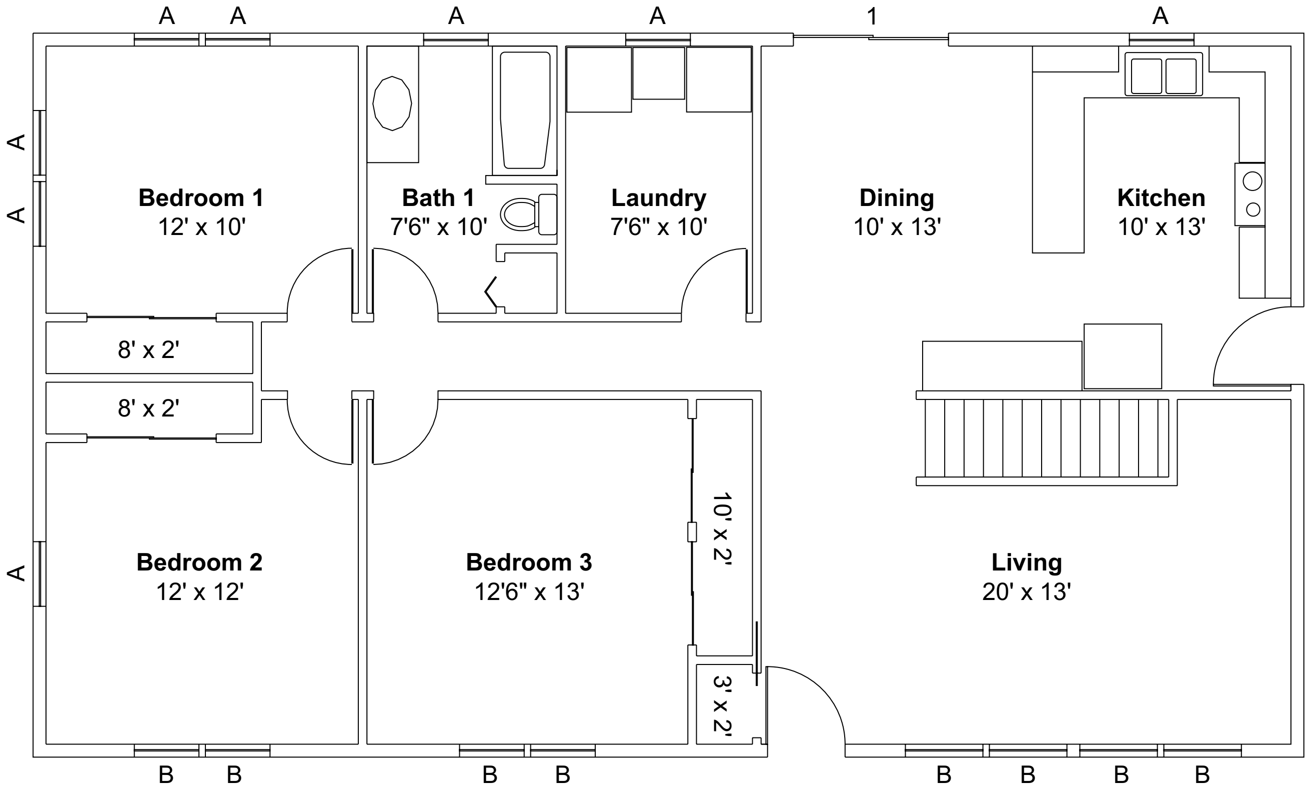


Figure 8-12: Main-level floor plan (no scale)

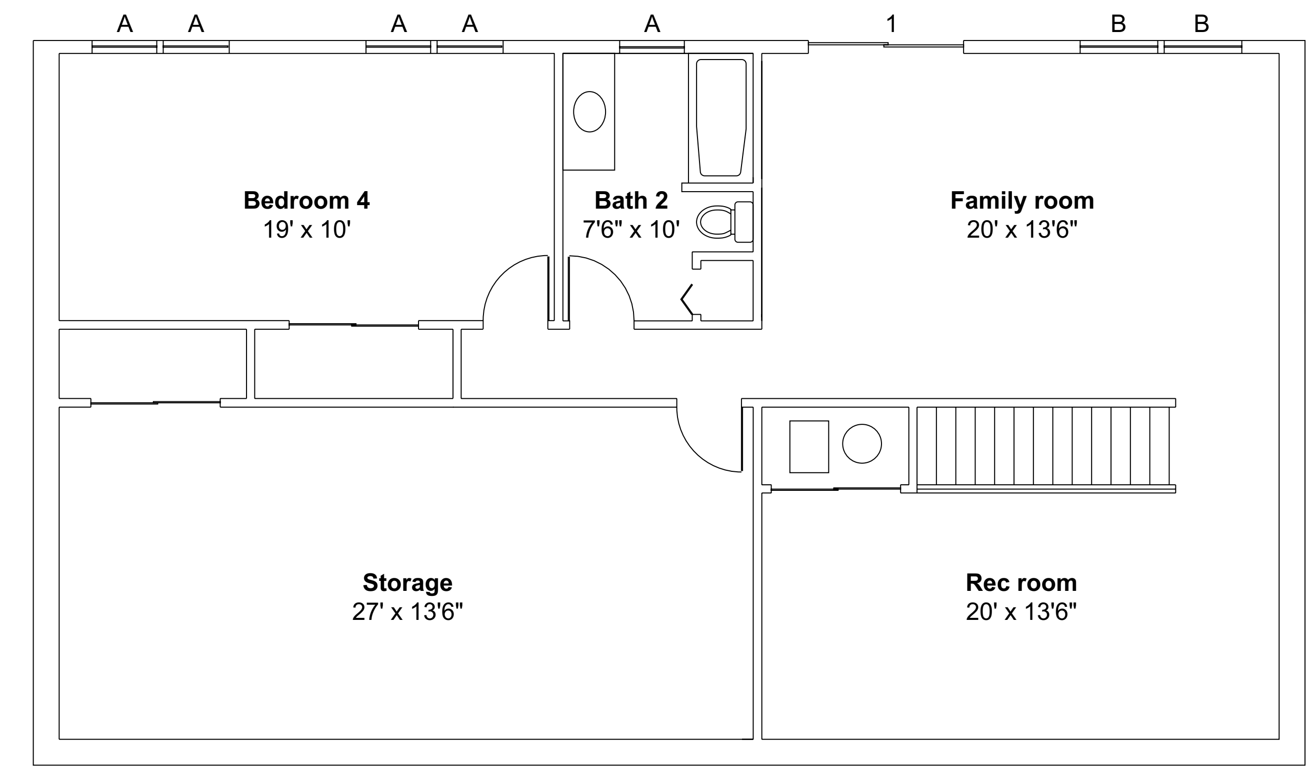


Figure 8-13: Lower-level floor plan (no scale)

Heat Loss Detail

ASHRAE Load Calculation

Project #:A- Z Heating Supply

July 08, 2020

Project Information

Project #: A- Z Heating Supply

Name: Training House

Location:

Notes:

Load Calculation Summary

Design Location:	CHICAGO O'HARE INTL, Illinois	Component Losses:	19,866 Btu/hr
Load Calculation Method:	ASHRAE	Infiltration/Ventilation:	5,451 Btu/hr
Outdoor Temperature:	4.5 °F	Radiant Back Losses:	3,331 Btu/hr
Floorplans / Levels:		Total Heating Load:	28,649 Btu/hr
Basement	1,246 ft²		
Main Floor1	1,259 ft²	Radiant Heating:	25,317 Btu/hr
Total Area:	2,505 ft²	Radiant Back Losses:	3,331 Btu/hr
		Other:	0 Btu/hr
		Total Heating Load:	28,649 Btu/hr
		Surface Temperature:	71 - 82 °F

Load Calculation Data

Project Summary

Room	Area	Heating Type	Room Temp	Walls	Windows	Doors	Skylights	Floor	Ceiling	Infiltration	Additional	Recovered Panel Loss	Design Load	Unit Loss
Basement	1,246	RH	65.0	2,460	2,416	3,026	0	3,164	0	2,531	0	0	13,596	11.6
Main Floor1	1,259	RH	65.0	4,051	5,521	412	0	4,248	1,981	2,921	0	-4,081	15,053	13.2
Total For Project	2,505	RH	65.0	6,511	7,937	3,437	0	7,413	1,981	5,451	0	-4,081	28,649	12.4

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Basement

Bath 2

Total Area:	97 ft²	Infiltration/Ventilation Load:	198 Btu/hr
Ceiling Height:	8' ft	Component Losses:	625 Btu/hr
Volume:	681 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	8' ft	Total Room Loss:	823 Btu/hr
		Recovered Floor Loss:	0 Btu/hr
Room Temperature:	65 °F	Net Room Load:	823 Btu/hr
Space Above:	Main Floor1		

Heating System

Heating Type:	Radiant	Surface Temp:	69 °F
Floor Area:	89 ft²	Net Room Load:	823 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	173 Btu/hr
Net Heated Area:	89 ft²	Recovered Floor Loss:	0 Btu/hr
Floor Cover Rv:	0.6 hr·ft²·°F/btu	Gross Upward Load:	650 Btu/hr
Panel Type:	Embedded Slab		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	650 Btu/hr
Required Supply Temp:	80 °F	Total Radiant Load:	823 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	2'-6"	4'	10	C2	1.8	345	3.9
Exposed Walls Above Grade	8'	0'	11	-	-	0	0.0
Basement with Walls	-	-	97	C1	Exterior Wall Insulation: 10.0 hr·ft²·°F/btu Slab Insulation: 10.0 hr·ft²·°F/btu	280	3.1
Exposed Ceiling	-	-	0	-	38.5	0	0.0
Total	-	-	-	-	-	625	7.0

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Bedroom 4

Total Area:	233 ft²	Infiltration/Ventilation Load:	473 Btu/hr
Ceiling Height:	8' ft	Component Losses:	2,644 Btu/hr
Volume:	1,632 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	31'-4" ft	Total Room Loss:	3,117 Btu/hr
		Recovered Floor Loss:	0 Btu/hr
Room Temperature:	65 °F	Net Room Load:	3,117 Btu/hr
Space Above:	Main Floor1		

Heating System

Heating Type:	Radiant	Surface Temp:	71 °F
Floor Area:	218 ft²	Net Room Load:	3,117 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	709 Btu/hr
Net Heated Area:	218 ft²	Recovered Floor Loss:	0 Btu/hr
Floor Cover Rv:	1.9 hr·ft²·°F/btu	Gross Upward Load:	2,408 Btu/hr
Panel Type:	Embedded Slab		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	2,408 Btu/hr
Required Supply Temp:	98 °F	Total Radiant Load:	3,117 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	2'-6"	4'	10	C2	1.8	345	1.6
Window	2'-6"	4'	10	C2	1.8	345	1.6
Window	2'-6"	4'	10	C2	1.8	345	1.6
Window	2'-6"	4'	10	C2	1.8	345	1.6
Exposed Walls Above Grade	31'-4"	0'	43	-	-	0	0.0
Basement with Walls	-	-	233	C1	Exterior Wall Insulation: 10.0 hr·ft²·°F/btu Slab Insulation: 10.0 hr·ft²·°F/btu	1,263	5.8
Exposed Ceiling	-	-	0	-	38.5	0	0.0
Total	-	-	-	-	-	2,644	12.1

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Family Room

Total Area:	286 ft²	Infiltration/Ventilation Load:	580 Btu/hr
Ceiling Height:	8' ft	Component Losses:	3,444 Btu/hr
Volume:	2,000 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	34'-4" ft	Total Room Loss:	4,024 Btu/hr
		Recovered Floor Loss:	0 Btu/hr
Room Temperature:	65 °F	Net Room Load:	4,024 Btu/hr
Space Above:	Main Floor1		

Heating System

Heating Type:	Radiant	Surface Temp:	71 °F
Floor Area:	269 ft²	Net Room Load:	4,024 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	847 Btu/hr
Net Heated Area:	269 ft²	Recovered Floor Loss:	0 Btu/hr
Floor Cover Rv:	1.9 hr·ft²·°F/btu	Gross Upward Load:	3,177 Btu/hr
Panel Type:	Embedded Slab		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	3,177 Btu/hr
Required Supply Temp:	100 °F	Total Radiant Load:	4,024 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	5'	4'	20	C2	1.8	690	2.6
Door	6'	6'-8"	40	C5	1.8	1,331	5.0
Exposed Walls Above Grade	34'-4"	0'	49	-	-	0	0.0
Basement with Walls	-	-	286	C1	Exterior Wall Insulation: 10.0 hr·ft²·°F/btu Slab Insulation: 10.0 hr·ft²·°F/btu	1,423	5.3
Exposed Ceiling	-	-	0	-	38.5	0	0.0
Total	-	-	-	-	-	3,444	12.8

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Rec Room

Total Area:	245 ft²	Infiltration/Ventilation Load:	498 Btu/hr
Ceiling Height:	8' ft	Component Losses:	1,189 Btu/hr
Volume:	1,718 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	32'-4" ft	Total Room Loss:	1,688 Btu/hr
		Recovered Floor Loss:	0 Btu/hr
Room Temperature:	65 °F	Net Room Load:	1,688 Btu/hr
Space Above:	Main Floor1		

Heating System

Heating Type:	Radiant	Surface Temp:	67 °F
Floor Area:	229 ft²	Net Room Load:	1,688 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	623 Btu/hr
Net Heated Area:	229 ft²	Recovered Floor Loss:	0 Btu/hr
Floor Cover Rv:	1.9 hr·ft²·°F/btu	Gross Upward Load:	1,065 Btu/hr
Panel Type:	Embedded Slab		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	1,065 Btu/hr
Required Supply Temp:	80 °F	Total Radiant Load:	1,688 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Exposed Walls Above Grade	32'-4"	0'	65	-	-	0	0.0
Basement with Walls	-	-	245	C1	Exterior Wall Insulation: 10.0 hr·ft²·°F/btu Slab Insulation: 10.0 hr·ft²·°F/btu	1,189	5.2
Exposed Ceiling	-	-	0	-	38.5	0	0.0
Total	-	-	-	-	-	1,189	5.2

Storage

Total Area:	385 ft²	Infiltration/Ventilation Load:	781 Btu/hr
Ceiling Height:	8' ft	Component Losses:	3,164 Btu/hr
Volume:	2,694 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	41'-4" ft	Total Room Loss:	3,945 Btu/hr
		Recovered Floor Loss:	0 Btu/hr
Room Temperature:	65 °F	Net Room Load:	3,945 Btu/hr
Space Above:	Main Floor1		

Heating System

Heating Type:	Radiant	Surface Temp:	69 °F
Floor Area:	364 ft²	Net Room Load:	3,945 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	812 Btu/hr
Net Heated Area:	364 ft²	Recovered Floor Loss:	0 Btu/hr
Floor Cover Rv:	0.0 hr·ft²·°F/btu	Gross Upward Load:	3,133 Btu/hr
Panel Type:	Embedded Slab		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	3,133 Btu/hr
Required Supply Temp:	80 °F	Total Radiant Load:	3,945 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Door	7'	6'-8"	47	C4	1.7	1,695	4.7
Exposed Walls Above Grade	41'-4"	0'	71	-	-	0	0.0
Basement with Walls	-	-	385	C1	Exterior Wall Insulation: 10.0 hr·ft²·°F/btu Slab Insulation: 10.0 hr·ft²·°F/btu	1,468	4.0
Exposed Ceiling	-	-	0	-	38.5	0	0.0
Total	-	-	-	-	-	3,164	8.7

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Main Floor1

Bath Laundry

Total Area:	184 ft²	Infiltration/Ventilation Load:	426 Btu/hr
Ceiling Height:	8' ft	Component Losses:	1,720 Btu/hr
Volume:	1,470 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	15' ft	Total Room Loss:	2,146 Btu/hr
		Recovered Floor Loss:	-315 Btu/hr
Room Temperature:	65 °F	Net Room Load:	1,832 Btu/hr
Space Above:	Not Heated		
Space Below:	Basement/Open or Vented Crawlspace		

Heating System

Heating Type:	Radiant	Surface Temp:	70 °F
Floor Area:	167 ft²	Net Room Load:	1,832 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	329 Btu/hr
Net Heated Area:	167 ft²	Recovered Floor Loss:	-315 Btu/hr
Floor Cover Rv:	0.6 hr·ft²·°F/btu	Gross Upward Load:	1,817 Btu/hr
Panel Type:	Lightweight Over-pour		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	1,817 Btu/hr
Required Supply Temp:	93 °F	Total Radiant Load:	2,146 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	2'-6"	4'	10	C2	1.8	345	2.1
Window	2'-6"	4'	10	C2	1.8	345	2.1
Exposed Walls Above Grade	15'	8'	100	C6	14.7	412	2.5
Floor	-	-	184	C7	5.0 (panel Insulation)	329	2.0
Exposed Ceiling	-	-	184	C3	38.5	289	1.7
Total	-	-	-	-	-	1,720	10.3

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Bedroom 1

Total Area:	150 ft²	Infiltration/Ventilation Load:	348 Btu/hr
Ceiling Height:	8' ft	Component Losses:	3,279 Btu/hr
Volume:	1,200 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	24'-6" ft	Total Room Loss:	3,627 Btu/hr
		Recovered Floor Loss:	-985 Btu/hr
Room Temperature:	65 °F	Net Room Load:	2,642 Btu/hr
Space Above:	Not Heated		
Space Below:	Basement/Open or Vented Crawlspace		

Heating System

Heating Type:	Radiant	Surface Temp:	75 °F
Floor Area:	132 ft²	Net Room Load:	2,642 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	1,020 Btu/hr
Net Heated Area:	132 ft²	Recovered Floor Loss:	-985 Btu/hr
Floor Cover Rv:	1.9 hr·ft²·°F/btu	Gross Upward Load:	2,607 Btu/hr
Panel Type:	Lightweight Over-pour		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	2,607 Btu/hr
Required Supply Temp:	132 °F	Total Radiant Load:	3,627 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	2'-6"	4'	10	C2	1.8	345	2.6
Window	2'-6"	4'	10	C2	1.8	345	2.6
Window	2'-6"	4'	10	C2	1.8	345	2.6
Window	2'-6"	4'	10	C2	1.8	345	2.6
Exposed Walls Above Grade	24'-6"	8'	156	C6	14.7	642	4.9
Floor	-	-	150	C7	5.0 (panel Insulation)	1,020	7.7
Exposed Ceiling	-	-	150	C3	38.5	236	1.8
Total	-	-	-	-	-	3,279	24.8

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

See end of report for important Notes and Disclaimers.

Bedroom 2

Total Area:	175 ft²	Infiltration/Ventilation Load:	405 Btu/hr
Ceiling Height:	8' ft	Component Losses:	3,026 Btu/hr
Volume:	1,397 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	26'-6" ft	Total Room Loss:	3,431 Btu/hr
		Recovered Floor Loss:	-932 Btu/hr
Room Temperature:	65 °F	Net Room Load:	2,499 Btu/hr
Space Above:	Not Heated		
Space Below:	Basement/Open or Vented Crawlspace		

Heating System

Heating Type:	Radiant	Surface Temp:	73 °F
Floor Area:	155 ft²	Net Room Load:	2,499 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	967 Btu/hr
Net Heated Area:	155 ft²	Recovered Floor Loss:	-932 Btu/hr
Floor Cover Rv:	1.9 hr·ft²·°F/btu	Gross Upward Load:	2,464 Btu/hr
Panel Type:	Lightweight Over-pour		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	2,464 Btu/hr
Required Supply Temp:	127 °F	Total Radiant Load:	3,431 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	5'	4'	20	C2	1.8	690	4.4
Window	2'-6"	4'	10	C2	1.8	345	2.2
Exposed Walls Above Grade	26'-6"	8'	182	C6	14.7	749	4.8
Floor	-	-	175	C7	5.0 (panel Insulation)	967	6.2
Exposed Ceiling	-	-	175	C3	38.5	275	1.8
Total	-	-	-	-	-	3,026	19.5

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

See end of report for important Notes and Disclaimers.

Bedroom 2

Total Area:	175 ft²	Infiltration/Ventilation Load:	405 Btu/hr
Ceiling Height:	8' ft	Component Losses:	3,026 Btu/hr
Volume:	1,397 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	26'-6" ft	Total Room Loss:	3,431 Btu/hr
		Recovered Floor Loss:	-932 Btu/hr
Room Temperature:	65 °F	Net Room Load:	2,499 Btu/hr
Space Above:	Not Heated		
Space Below:	Basement/Open or Vented Crawlspace		

Heating System

Heating Type:	Radiant	Surface Temp:	73 °F
Floor Area:	155 ft²	Net Room Load:	2,499 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	967 Btu/hr
Net Heated Area:	155 ft²	Recovered Floor Loss:	-932 Btu/hr
Floor Cover Rv:	1.9 hr·ft²·°F/btu	Gross Upward Load:	2,464 Btu/hr
Panel Type:	Lightweight Over-pour		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	2,464 Btu/hr
Required Supply Temp:	127 °F	Total Radiant Load:	3,431 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	5'	4'	20	C2	1.8	690	4.4
Window	2'-6"	4'	10	C2	1.8	345	2.2
Exposed Walls Above Grade	26'-6"	8'	182	C6	14.7	749	4.8
Floor	-	-	175	C7	5.0 (panel Insulation)	967	6.2
Exposed Ceiling	-	-	175	C3	38.5	275	1.8
Total	-	-	-	-	-	3,026	19.5

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

See end of report for important Notes and Disclaimers.

Dining / Kitchen

Total Area:	289 ft²	Infiltration/Ventilation Load:	670 Btu/hr
Ceiling Height:	8' ft	Component Losses:	2,544 Btu/hr
Volume:	2,308 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	34'-6" ft	Total Room Loss:	3,213 Btu/hr
		Recovered Floor Loss:	-493 Btu/hr
Room Temperature:	65 °F	Net Room Load:	2,720 Btu/hr
Space Above:	Not Heated		
Space Below:	Basement/Open or Vented Crawlspace		

Heating System

Heating Type:	Radiant	Surface Temp:	70 °F
Floor Area:	263 ft²	Net Room Load:	2,720 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	526 Btu/hr
Net Heated Area:	263 ft²	Recovered Floor Loss:	-493 Btu/hr
Floor Cover Rv:	0.7 hr·ft²·°F/btu	Gross Upward Load:	2,687 Btu/hr
Panel Type:	Lightweight Over-pour		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	2,687 Btu/hr
Required Supply Temp:	92 °F	Total Radiant Load:	3,213 Btu/hr

Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Door	3'	6'-8"	20	C8	5.9	206	0.8
Window	2'-6"	4'	10	C2	1.8	345	1.3
Exposed Walls Above Grade	34'-6"	8'	246	C6	14.7	1,013	3.8
Floor	-	-	289	C7	5.0 (panel Insulation)	526	2.0
Exposed Ceiling	-	-	289	C3	38.5	454	1.7
Total	-	-	-	-	-	2,544	9.7

Length = ft Area = ft² Temperature = °F Flowrate = USGPM Air Flow = cfm Heat Loss = Btu/hr Unit Heat Loss = Btu/(hr·ft²) Rv = hr·ft²·°F/btu
Head Loss = ft water RH = Radiant Floor Heating BB = Baseboard FA = Forced Air OTH = Other Heating SM = Snowmelt N = Not Heated

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Version:20.0.0094 R

See end of report for important Notes and Disclaimers.

Living Room

Total Area:	248 ft²	Infiltration/Ventilation Load:	576 Btu/hr
Ceiling Height:	8' ft	Component Losses:	3,452 Btu/hr
Volume:	1,984 ft³	Additional Losses:	0 Btu/hr
Exposed Perimeter:	32'-6" ft	Total Room Loss:	4,028 Btu/hr
		Recovered Floor Loss:	-619 Btu/hr
Room Temperature:	65 °F	Net Room Load:	3,409 Btu/hr
Space Above:	Not Heated		
Space Below:	Basement/Open or Vented Crawlspace		

Heating System

Heating Type:	Radiant	Surface Temp:	73 °F
Floor Area:	224 ft²	Net Room Load:	3,409 Btu/hr
Unheated Area:	0 ft²	Floor Back Loss:	652 Btu/hr
Net Heated Area:	224 ft²	Recovered Floor Loss:	-619 Btu/hr
Floor Cover Rv:	0.7 hr·ft²·°F/btu	Gross Upward Load:	3,376 Btu/hr
Panel Type:	Lightweight Over-pour		
		Supplemental Heat Supply:	0 Btu/hr
Supplemental Heating Type:	Other	Net Upward Load:	3,376 Btu/hr
Required Supply Temp:	105 °F	Total Radiant Load:	4,028 Btu/hr

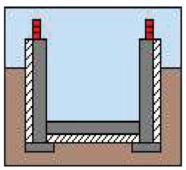
Component Losses

Component	Length	Width/Height	Area	Construction	Rv	Heat Loss	Unit Loss
Window	5'	4'	20	C2	1.8	690	3.1
Window	5'	4'	20	C2	1.8	690	3.1
Door	3'	6'-8"	20	C8	5.9	206	0.9
Exposed Walls Above Grade	32'-6"	8'	200	C6	14.7	823	3.7
Floor	-	-	248	C7	5.0 (panel Insulation)	652	2.9
Exposed Ceiling	-	-	248	C3	38.5	390	1.7
Total	-	-	-	-	-	3,452	15.4

Construction Legend

Construction Code	Component	R-Value	Source	Description
C2	Window	1.8	Manual J 8th Edition V2	Double pane operable window or sliding glass door, with Clear Glass - Wood, Wood with Metal Clad or Vinyl Framing
C3	Ceiling	38.5	Manual J 8th Edition V2	No radiant barrier over ceiling or same type of air space behind an attic knee wall; R-38 Insulation; Materials: Asphalt Shingles(a), Metal(m), Wood Shakes(w), Tar / Gravel(x), Membrane(z), Tile, Slate or Concrete; Colors: Dark(d), Light(l), White(w);
C4	Door	1.7	Manual J 8th Edition V2	Metal Door with Fiberglass Core
C5	Door	1.8	User Specified	Sliding Wood Frame
C6	Wall	14.7	Manual J 8th Edition V2	Frame Wall or Partition; Wood Framing; R-19 Insulation in 2 x 6 Stud Cavity; Stucco or Wood Siding; Plus Interior Finish
C7	Heated Floor	5.0 (panel Insulation)	User Specified	Lightweight Over-pour
C8	Door	5.9	Manual J 8th Edition V2	Metal Door with Polyurethane Core with Storm

CSA Construction Legend



C1

Description

BCEB_1
- concrete walls and floor
- exterior surface of wall insulated over full-height
- sub-surface of floor slab fully insulated but no insulation under footings
- first storey brick veneer placed directly on basement's concrete walls

Options

Exterior Wall Insulation: 10.0 hr·ft²·°F/btu
Slab Insulation: 10.0 hr·ft²·°F/btu

Disclaimers

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Cold weather humidification, or some lifestyles that produce excessive moisture, may cause condensation to occur if the absolute humidity of the indoor air is too high for the momentary circumstances. Condensation can occur on surfaces or concealed within the structure, and can lead to mold, mildew, frost damage, and moisture damage. The software does not perform calculations for the estimation or detection of possible condensation problems, and it is the designers (i.e. software users) responsibility to do so independently if required.

The calculated values shown in this report are based on the data input by the user of the software. Inaccurate or erroneous data input will result in inaccurate or erroneous results. You are strongly advised to review all input data carefully, and to have the calculated results reviewed by an experienced heating professional to ensure reasonableness and suitability for your application.

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Radiant floor design worksheet

Project name: Training House lower level **Manifold number:** 1

		Loop 1	Loop 2	Loop 3	Loop 4	Loop 5	Loop 6	Loop 7	Loop 8	Loop 9	Loop 10
A	Room name	Bedroom 4	Bath 2	Family	Rec room	Storage					
B	Room setpoint temp. (°F)	65°F	65°F	65°F	65°F	65°F					
C	Zone number	1	7	8	9	10					
D	Upward load (BTU/h/ft²)	18.2	8.7	13.6	6.6	5.6					
E	Total load (BTU/h/ft²)	21.9	11.1	17.8	10.1	8.6					
F	Floor surface temp. (°F)	74.1	69	71	67	67					
G	Installation method	Poured floor	Poured floor	Poured floor	Poured floor	Poured floor					
H	Piping size	½"	½"	½"	½"	½"					
I	Floor covering R-value	1.92	0.56	1.92	1.92	0.0					
J	Differential temp. (°F)	10°F	10°F	10°F	10°F	10°F					
K	Piping o.c. distance (in)	9"	12"	12"	12"	12"					
L	Supply water temp. (°F)	125ºF	80	105	84	80					
M	Active loop length (ft)	181'	90	269	230	183					
N	Leader loop length (ft)	35'	3	8	9	3					
O	Total loop length (ft)	216'	96	285	248	189					
P	Loop flow in gpm	0.60	0.43	0.81	0.67	0.4					
Q	Loop head pressure (ft)	2.76'	0.9	7.8	4.9	1.7					

Manifold totals

R	Supply water temp. (°F)	133°F
S	Manifold flow in gpm	2.97
T	Highest pressure head (ft)	13.2

A Enter the name of the room. The room may have more than one loop.

B Room setpoint temperature is normally 65°F for radiant floor.

C Zone is equal to thermostat.

D Enter the "Floor unit load to room" value from design software printout (upward load).

E Enter the "Floor unit load" value from design software printout (total load).

F (**Row D**/2) + **Row B** = floor surface temperature. Do not exceed 87.5°F for all floors (exception: wood floor limit is 80°F).

G Enter the installation method.

H Enter the size of PEX piping for project.

I Refer to **Appendix D** for floor covering information.

J Indicate differential temperature (10°F for residential; 15°F for light commercial; 20°F for commercial).

K Maximum piping o.c. distance is 12" for residential. Do not exceed 9" o.c. under tile or linoleum.

L Use information from **Rows D, G, I, K** with **Appendix E** to obtain the supply water temperature.

M Enter the length of piping installed within the room (i.e., active loop).

N Enter the length of the piping from the room being heated to the respective manifold and multiply by 2 to account for both the supply and return.

O Use formula: (**Row M** + **Row N**) = total loop length.

x

P Use the values in **Rows E** and **M** with **Appendix F** to obtain the flow per loop.

Q Use the values in **Rows H** and **P** with **Appendix G** to obtain the head pressure per loop. Choose the appropriate solution (water or water/glycol solution).

R Enter highest temperature from **Row L**.

S Add and enter all values from **Row P**.

T Enter highest value from **Row Q**.

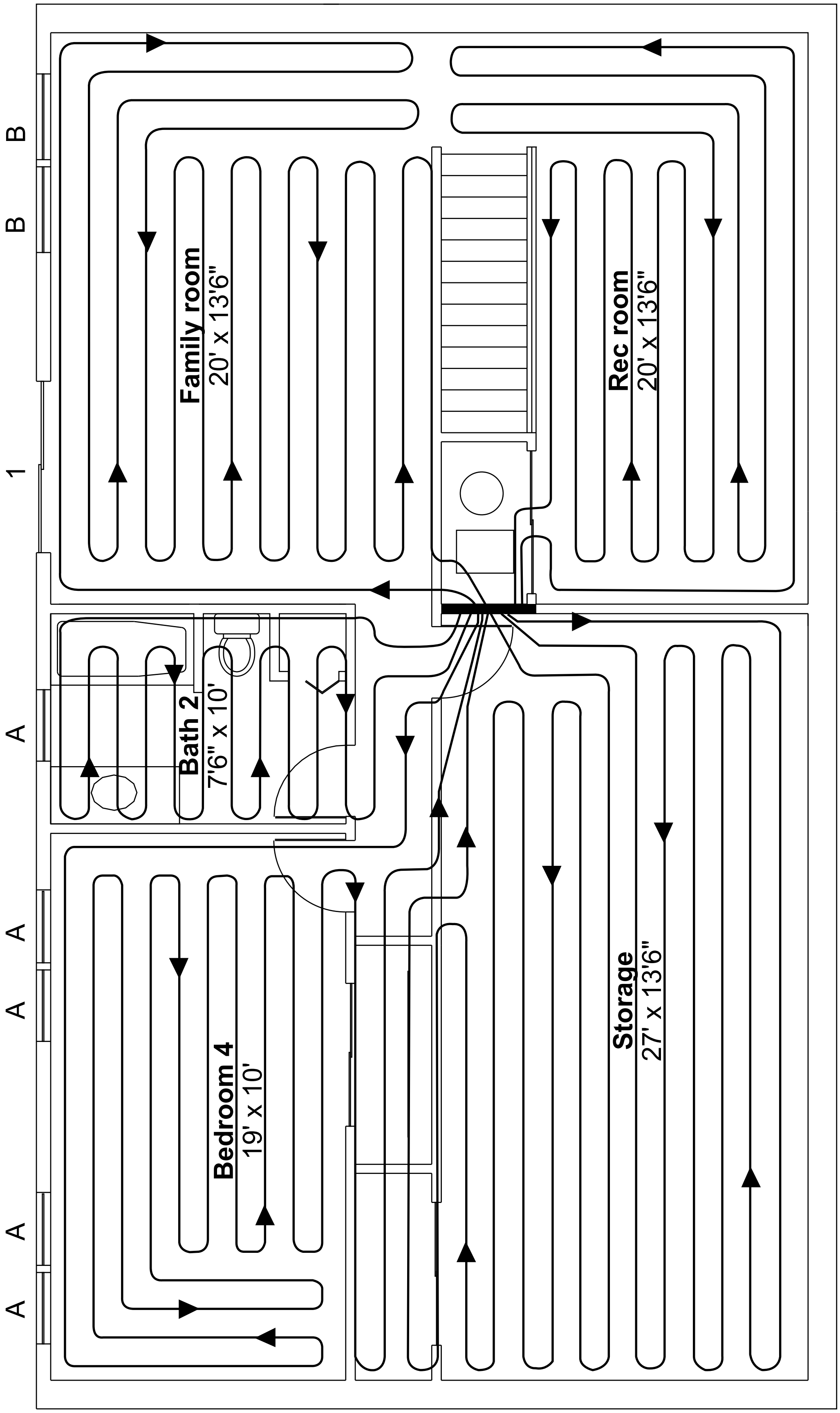

Figure 8-14: Lower-level floor plan (no scale)

Radiant floor design worksheet

Project name: Training house main level **Manifold number:** 2

		Loop 1	Loop 2	Loop 3	Loop 4	Loop 5	Loop 6	Loop 7	Loop 8	Loop 9	Loop 10
A	Room name	Bedroom 1	Bath/Ldry	Din/Kit	Living Room	Bedroom 3	Bedroom 2				
B	Room setpoint temp. (°F)	65°F	65°F	65°F	65°F	65°F	65°F				
C	Zone number	1	2	3	4	6	7				
D	Upward load (BTU/h/ft²)	18.2	10.9	10.4	15.2	10.0	16.0				
E	Total load (BTU/h/ft²)	21.9	13.0	12.4	18.2	13.9	22.3				
F	Floor surface temp. (°F)	74.1	70	70	73	70	73				
G	Installation method	Poured Floor	Poured Floor	Poured Floor	Poured Floor	Poured Floor	Poured Floor				
H	Piping size	½"	½"	½"	½"	½"	½"				
I	Floor covering R-value	1.92	0.56	0.67	0.67	1.92	1.92				
J	Differential temp. (°F)	10°F	10°F	10°F	10°F	10°F	10°F				
K	Piping o.c. distance (in)	9"	12"	12"	12"	12"	12"				
L	Supply water temp. (°F)	132°F	93	92	105	104	127				
M	Active loop length (ft)	176'	167	263	224	196	175				
N	Leader loop length (ft)	45'	6	12	12	6	24				
O	Total loop length (ft)	221'	173	275	236	202	199				
P	Loop flow in gpm	0.67	0.94	1.45	1.28	0.83	0.74				
Q	Loop head pressure (ft)	4.6'	5.6	18.9	13.0	5.3	4.2				

Manifold totals

R	Supply water temp. (°F)	132°F
S	Manifold flow in gpm	5.97
T	Highest pressure head (ft)	18.9

A Enter the name of the room. The room may have more than one loop.

B Room setpoint temperature is normally 65°F for radiant floor.

C Zone is equal to thermostat.

D Enter the "Floor Unit Load to Room" value from design program printout (upward load).

E Enter the "Floor Unit Load" value from design program printout (total load).

F (**Row D**/2) + **Row B** = floor surface temperature. Do not exceed 87.5°F for all floors (exception: wood floor limit is 80°F).

G Enter the installation method.

H Enter the size of PEX piping for project.

I Refer to **Appendix D** for floor covering information.

J Indicate differential temperature (10°F for residential; 15°F for light commercial; 20°F for commercial).

K Maximum piping o.c. distance is 12" for residential. Do not exceed 9" o.c. under tile or linoleum.

L Use information from **Rows D, G, I, K** with **Appendix E** to obtain the supply water temperature.

M Enter the length of piping installed within the room (i.e., active loop).

N Enter the length of the piping from the room being heated to the respective manifold and multiply by 2 to account for both the supply and return.

O Use formula: (**Row M** + **Row N**) = total loop length.

P Use the values in **Rows E** and **M** with **Appendix F** to obtain the flow per loop.

Q Use the values in **Rows H** and **P** with **Appendix G** to obtain the head pressure per loop. Choose the appropriate solution (water or water/glycol solution).

R Enter highest temperature from **Row L**.

S Add and enter all values from **Row P**.

T Enter highest value from **Row Q**.

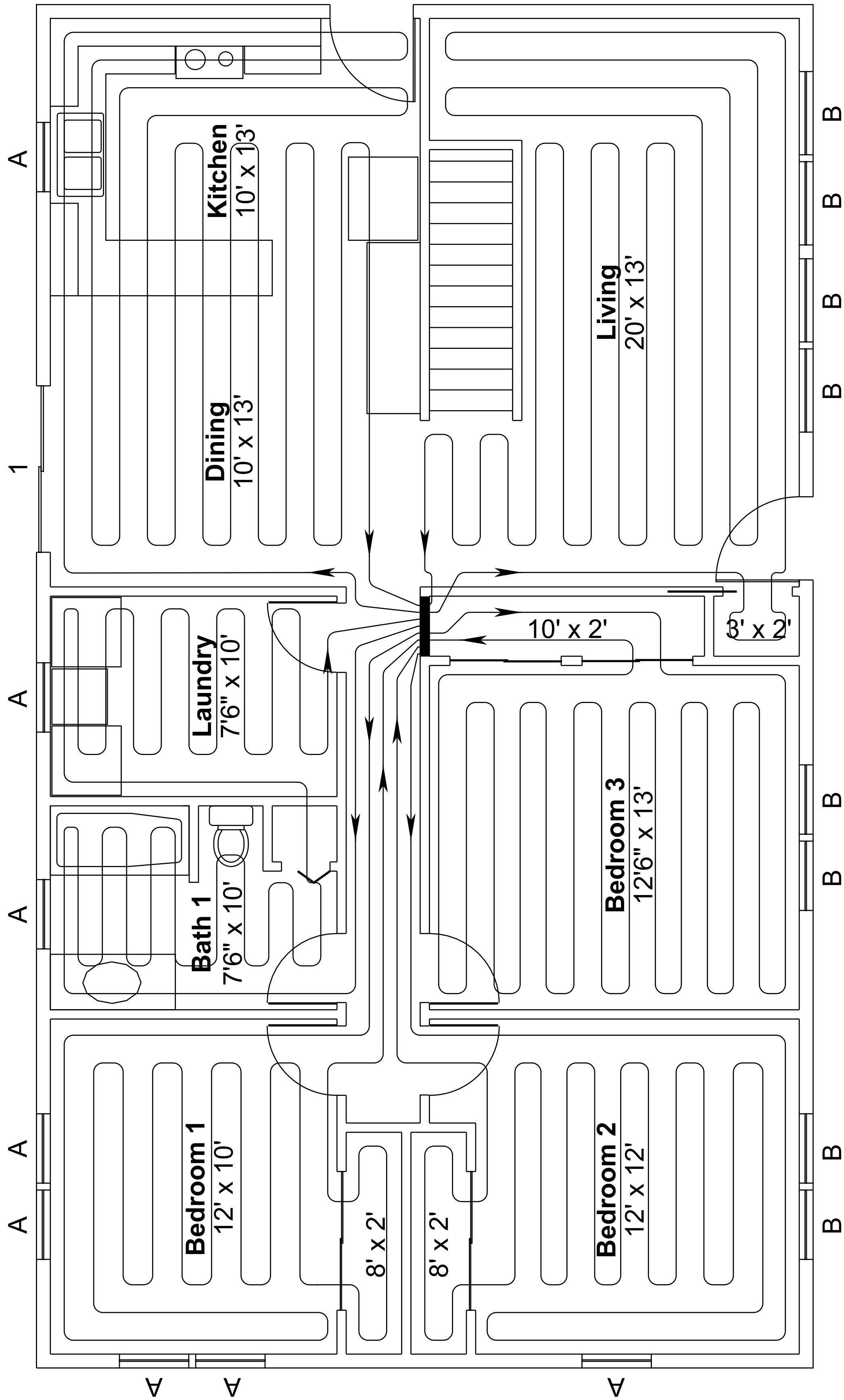

Figure 8-15: Main-level floor plan (no scale)

Radiant floor design worksheet

Project name: ______________________ **Manifold number:** __________

		Loop 1	Loop 2	Loop 3	Loop 4	Loop 5	Loop 6	Loop 7	Loop 8	Loop 9	Loop 10
A	**Room name**										
B	Room setpoint temp. (°F)										
C	Zone number										
D	Upward load (BTU/h/ft²)										
E	Total load (BTU/h/ft²)										
F	Floor surface temp. (°F)										
G	Installation method										
H	Piping size										
I	Floor covering R-value										
J	Differential temp. (°F)										
K	Piping o.c. distance (in)										
L	Supply water temp. (°F)										
M	Active loop length (ft)										
N	Leader loop length (ft)										
O	Total loop length (ft)										
P	Loop flow in gpm										
Q	Loop head pressure (ft)										

Manifold totals

R	Supply water temp. (°F)	
S	Manifold flow in gpm	
T	Highest pressure head (ft)	

A Enter the name of the room. The room may have more than one loop.

B Room setpoint temperature is normally 65°F for radiant floor.

C Zone is equal to thermostat.

D Enter the "Floor Unit Load to Room" value from design program printout (upward load).

E Enter the "Floor Unit Load" value from design program printout (total load).

F (**Row D**/2) + **Row B** = floor surface temperature. Do not exceed 87.5°F for all floors (exception: wood floor limit is 80°F).

G Enter the installation method.

H Enter the size of PEX piping for project.

I Refer to **Appendix D** for floor covering information.

J Indicate differential temperature (10°F for residential; 15°F for light commercial; 20°F for commercial).

K Maximum piping o.c. distance is 12" for residential. Do not exceed 9" o.c. under tile or linoleum.

L Use information from **Rows D, G, I, K** with **Appendix E** to obtain the supply water temperature.

M Enter the length of piping installed within the room (i.e., active loop).

N Enter the length of the piping from the room being heated to the respective manifold and multiply by 2 to account for both the supply and return.

O Use formula: (**Row M** + **Row N**) = total loop length.

P Use the values in **Rows E** and **M** with **Appendix F** to obtain the flow per loop.

Q Use the values in **Rows H** and **P** with **Appendix G** to obtain the head pressure per loop. Choose the appropriate solution (water or water/glycol solution).

R Enter highest temperature from **Row L**.

S Add and enter all values from **Row P**.

T Enter highest value from **Row Q**.