Radiant Floor Heating

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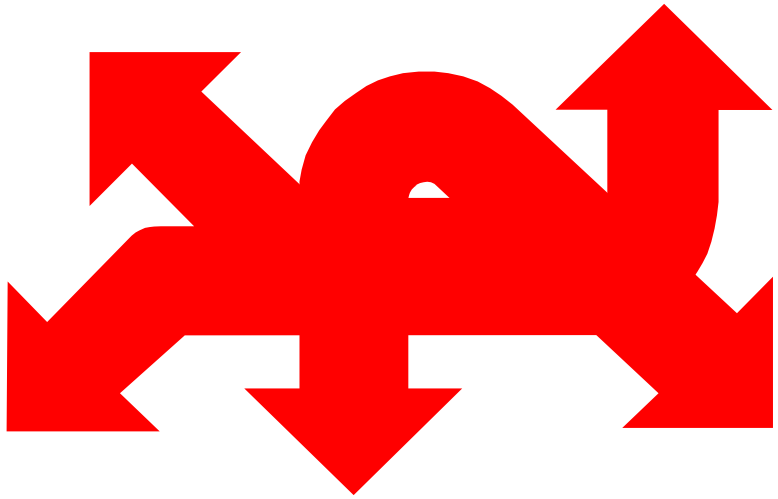
ASHRAE
Distinguished Lecturer

What is Radiant Heat ?

- The Sun
- Camp Fire
- Wood Stove

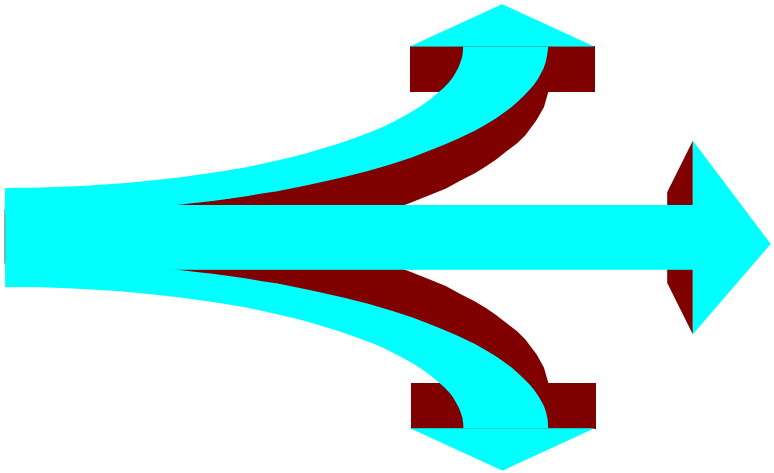
Modes of Radiant Heat

- Convection
- Conduction
- Radiation



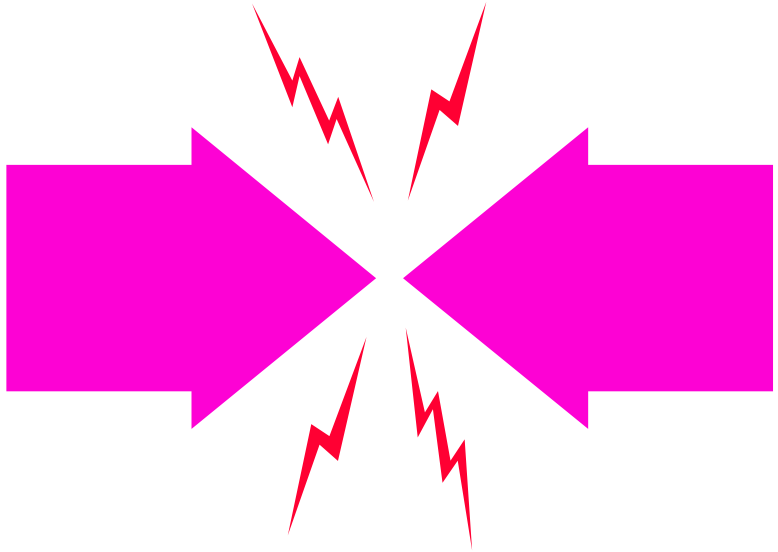
Heat loss Parameters

- Amount of Heat Lost to Cold
- R- Values
- Air Infiltration



Goal for Heating

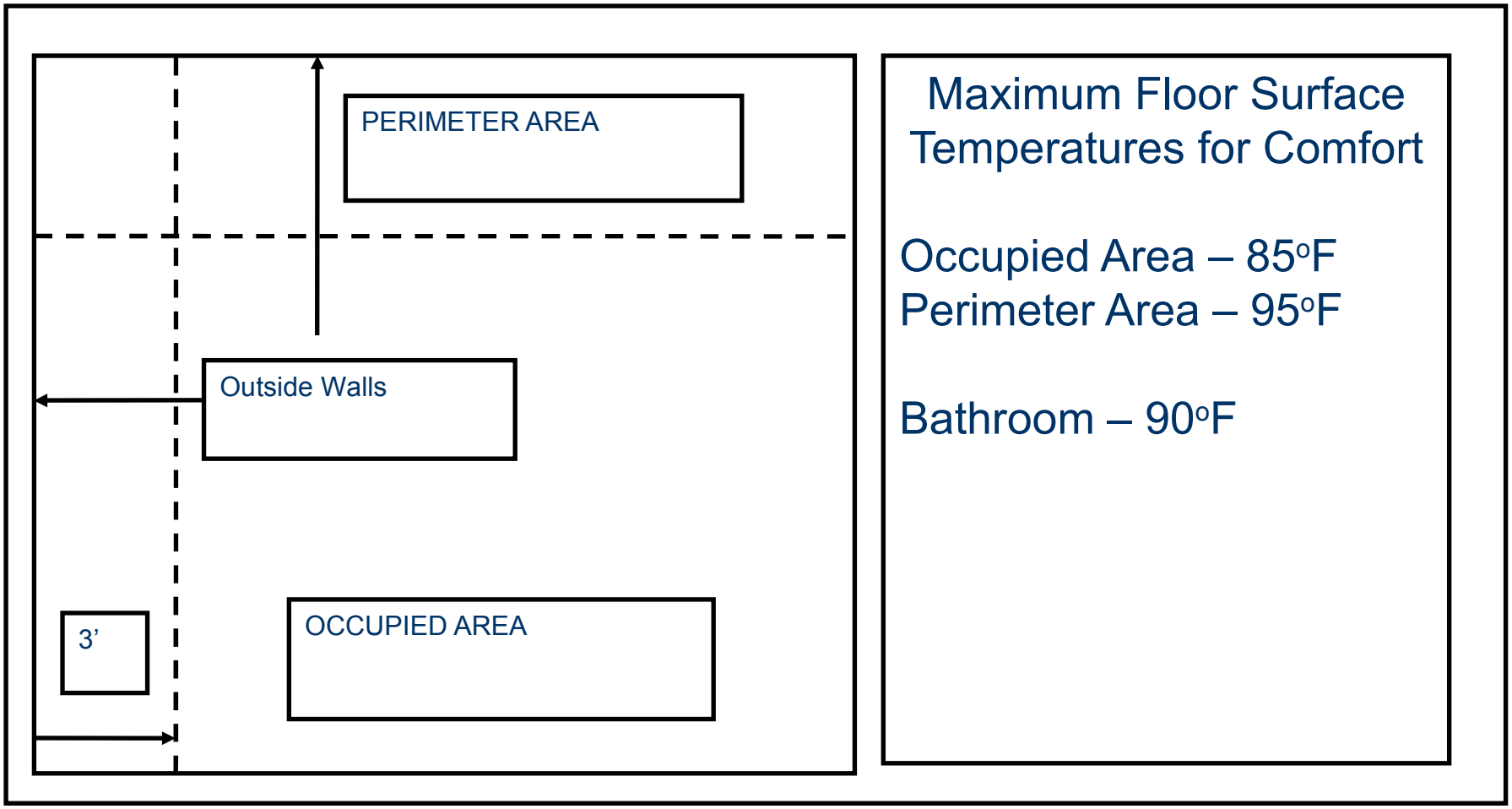
Heat loss = Heating Capacity



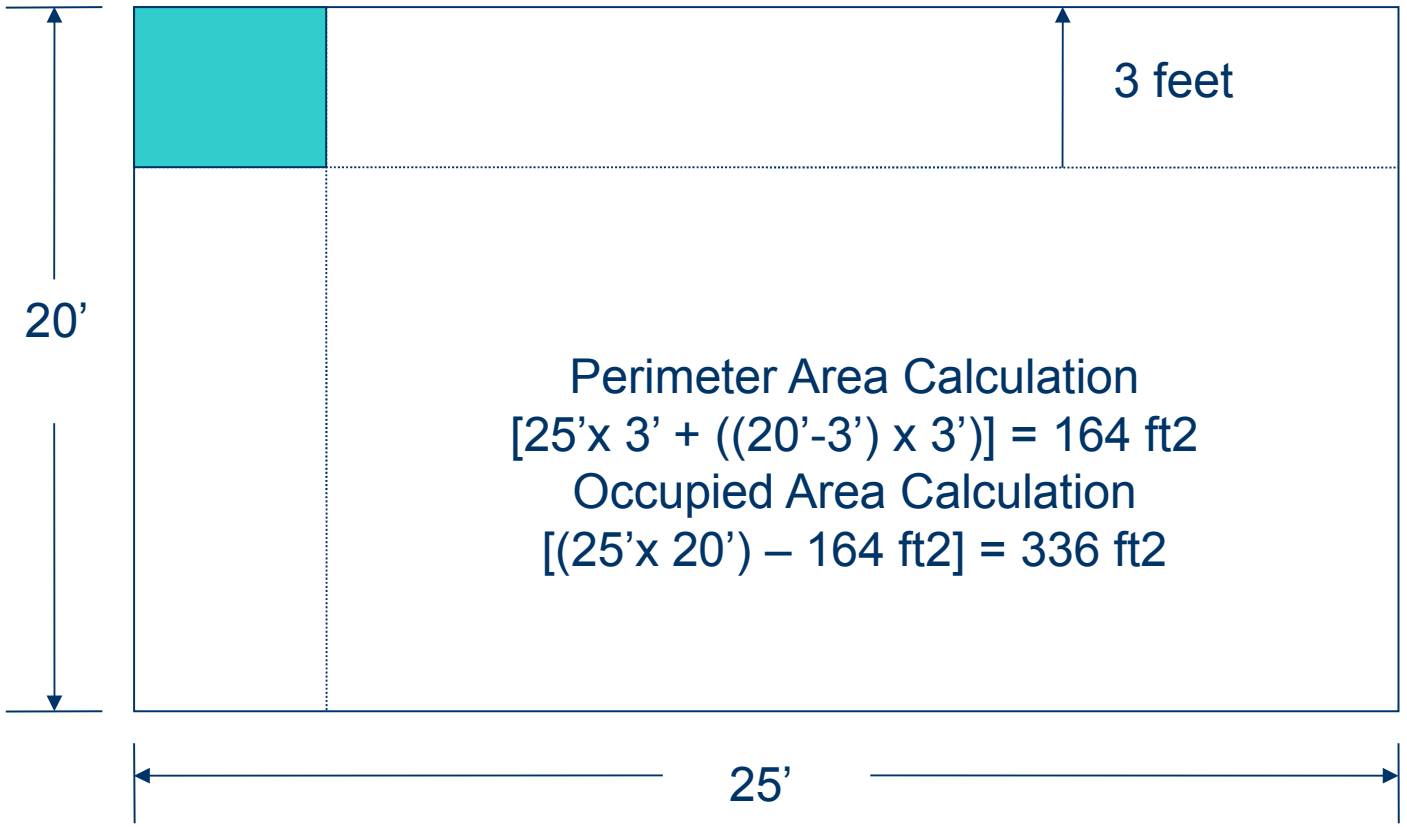
Surface Temperatures

Ideal Comfort Based Environment			
Condition		Mode	
		Heating	Cooling
Floor Surface Temperatures		> 75°F and < 84°F	> 65°F and <75°F
Air Temperature Difference (between the ankles and head)		< 3°C (5 °F)	
Effective Temperature = Humidity and Operative Temperature (Average between mean radiant and air temperature)		20°C to 23.5°C (68°F to 74°F) at 18°C (64°F) wet bulb and 20.5°C to 24.5°C (69°F to 76°F) at 2°C (36°F) dew point.	22.5°C to 26°C (73°F to 79°F) at 20°C (68°F) wet bulb 23.5°C to 27°C (74°F to 81°F) at 2°C (36°F) dew point.
Air Velocity at 40% turbulence and for low activity levels.		< 0.13 m/s (25 fpm)	<0.20 m/s (40 fpm)
Radiant Asymmetry °F (5%PPD)	Vertical	9	24
	Horizontal	41	19
Surface Temp, °F	Floor	84	65
	Wall	90	55
	Ceilings	100	55
Radiant Transfer at Surface Temperature,Btu/sf	Floor	14	13
	Wall	20	20
	Ceilings	30	20
Convective Transfer at Surface Temperature,Btu/sf	Floor	12	2
	Wall	14	14
	Ceilings	2	15
Combined Transfer at Surface Temperature,Btu/sf	Floor	26	15
	Wall	34	34
	Ceilings	32	35
Heat Transfer Coeffcient,Btu/sf/°F	Floor	1.9	1.1
	Wall	1.7	1.4
	Ceilings	1.1	1.5

Floor Surface Temperatures



Perimeter Area Calculation



Heat Transfer Coefficient

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Floor Heating Output Calculation

Formula for Output Calculation for Radiant Fl

$$\text{Btuh/ft}^2 = \text{H} \times (\text{Floor Surface Temp }^0\text{F} - \text{Room Temp }^0\text{F})$$

Heat Transfer Coefficient for "H" = 2.0 Btuh/ft^2 ^{0}F (quick calc)

Room temperature desired for comfort (Typically 65 ^{0}F)

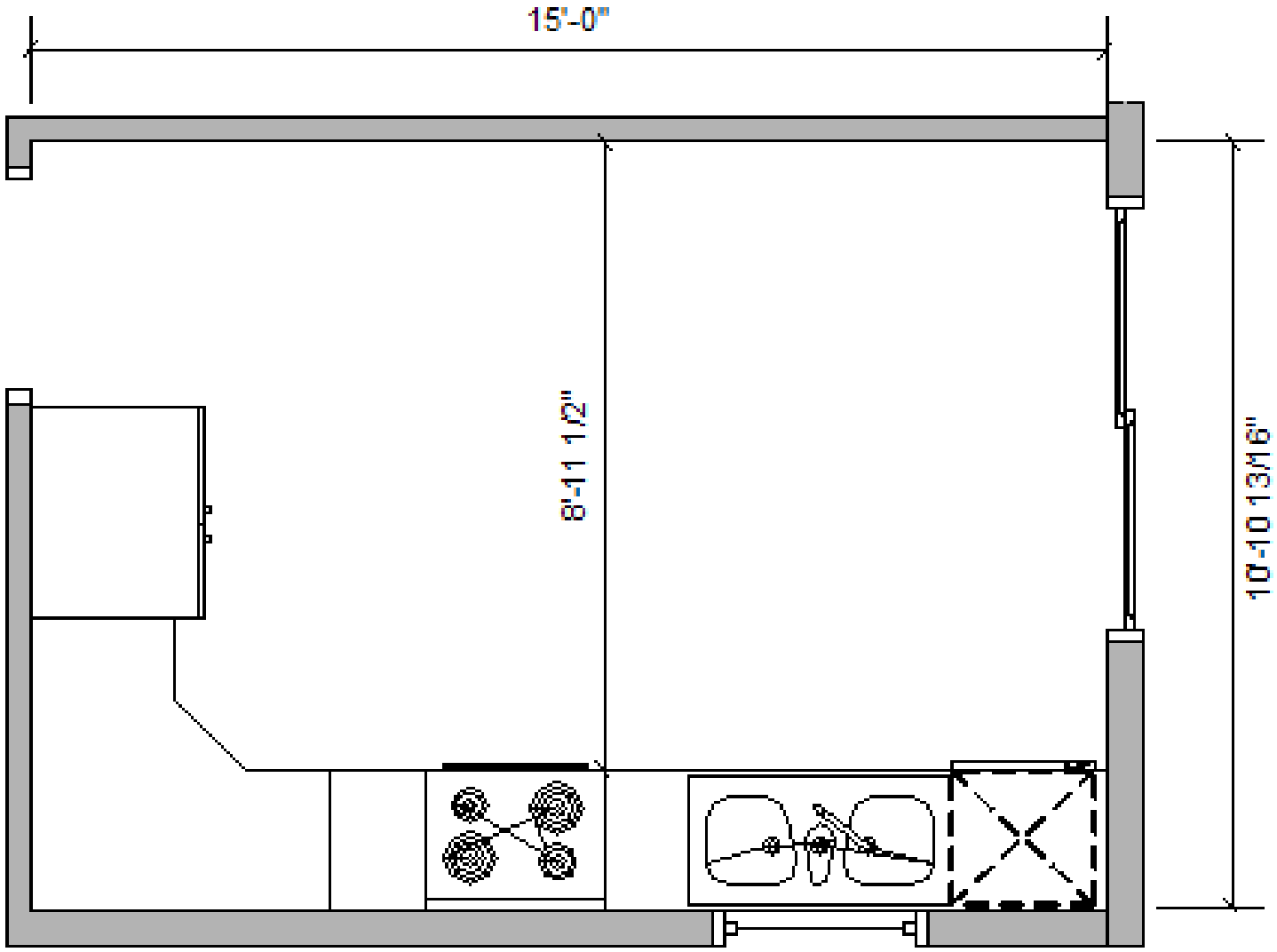
Sample Calculation Results

Floor Surface Temperature °F	Room Temperature °F	Output Btuh/ft^2
85	70	29.4
90	70	39.2
95	70	49

RFH Design Requirements

- Heat loss for Space
- Heat Production from Floor
  - Installation / Floor Coverings
- Hydraulics – Tubing and Circulators (Pumps)
- Heating Source
  - Boiler
  - Geothermal
  - Solar
  - Electric

Heat Loss for Planned Space



Heat Loss Numbers

Component	Length	Width/Height	Area ft^2	ΔT ^oF	R-value $ft^2 \cdot {}^oF$/ Btuh	Total Heat Loss Btuh
Window	3	4	12	48	1.5	384
Wall 1	15	10	138	48	19	349
Glass Door	6	7	42	48	1.5	1344
Wall 2	10’ 10”	10	66	48	19	168
Floor	15	10’10”	162	28 *	19	240
Ceiling	15	10’10”	162	48	38	205
					Total Btuh	**2,690**

Heat loss Basics

* Crawl Space Temperature equals 40°F.
Btuh = (Surface Area) * (ΔT) / R-value
ΔT = Room Temperature - Outdoor Temperature
Remember to subtract window and door area from outside wall area when calculating wall areas.

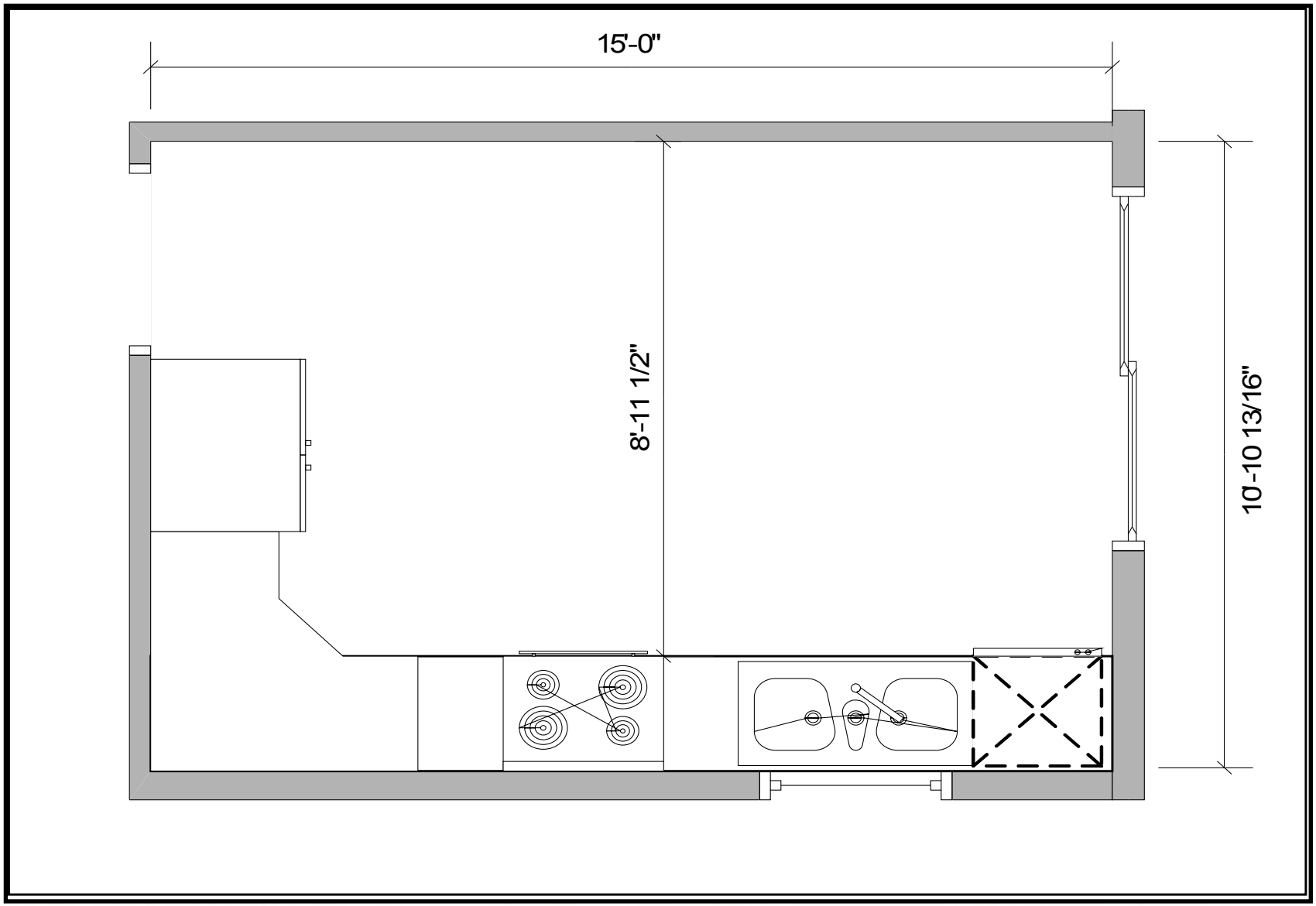
Air Infiltration of 1.5 x 2,690 = Total Heat Loss

Total Heat Loss = 4,059 Btuh

Basic Heat Loss Calculation Method

1) Determine the air temperature difference between outdoor and indoor temperatures (ΔT). Usually the desired indoor temperature is 68°F. Subtract the outdoor temperature expected on the coldest day of the year.
2) Multiply the total outdoor wall area, less the window and door area, by the ΔT. Divide this value by the R-value for the wall. Typical walls have a value of 19.
3) Multiply the total window area by the ΔT. Divide this value by the R-value for the window. The average value for a window is 1.5.
4) Do the same for the ceiling and the floor. Typical R-values are 38 for ceilings and 19 for floors.
5) Add up the heat loss for each component to determine the total heat loss for the room.
6) Multiply the heat loss by 1.5 to accommodate for air infiltration loss.
7) Determine the heat load per floor heated area requirement by dividing the total heat loss by the area to be heated. Remember that the floor area that is covered with cabinets or other fixtures will not be heated.

Available Floor Surface Area



Mean Heating Water Temperature

Mean Heating Water Temperature = MHWT
(Supply Water Temperature + Return Water Temperature) / 2 = MHWT

Example:

Supply Water Temperature = 110 oF
Return Water Temperature = 90 oF
MHWT = (110 + 90) / 2 = 100 ^{o}F

Circuit Lengths for RFH

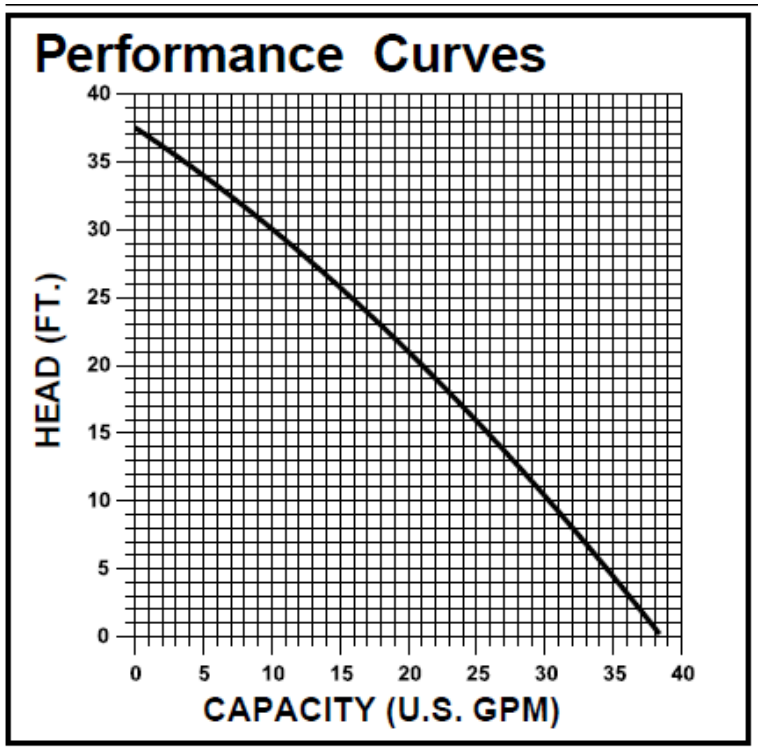
Circuit Lengths for ½” and 5/8” Nominal PEX ASTM F876/F877

1/2” PEX – 300 ft. Recommended 350 ft. Maximum

5/8” PEX – 400 ft. Recommended 500 ft. Maximum

Reference: RPA Guidelines 2004 Edition – Section 18.1.1

Pump and Pipe Tables



Pressure Drop Table
Expressed as PSI/FT Pressure Drop

GPM	SIZE					GPM	SIZE		
	3/8"	1/2"	5/8"	3/4"	1"		1 1/4"	1 1/2"	2"
1	.070	.016				10	.023		
1.5	.149	.034				11	.028		
2	.254	.058	.023			12	.033		
2.5	*.385	.087	.035			13	.038		
3	.539	.122	.048	.023		14	.044		
3.5	.717	.162	.065	.030		16	.056	.025	
4		*.208	.083	.039		18	.069	.031	
5		.314	.125	.059		20	.084	.038	
6		.440	.175	.082	.024	22	.101	.045	
7		.586	*.233	.109	.032	24	*.118	.053	
8			.298	.140	.041	26	.137	.061	
9			.371	*.174	.051	28	.157	.070	
10			.451	.211	.062	30	.179	*.080	.021
11				.252	.074	32	.202	.090	.024
12				.296	.087	34		.101	.027
13				.343	.101	36		.112	.030
14					.116	38		.124	.033
16					*.148	40		.136	.036
18					.184	45			.045
20					.224	50			.055
22					.267	55			*.066
24						60			.077
26						65			.089
28						70			.103
30						75			.116

* Indicates 8 fps maximum velocity required by some plumbing codes.

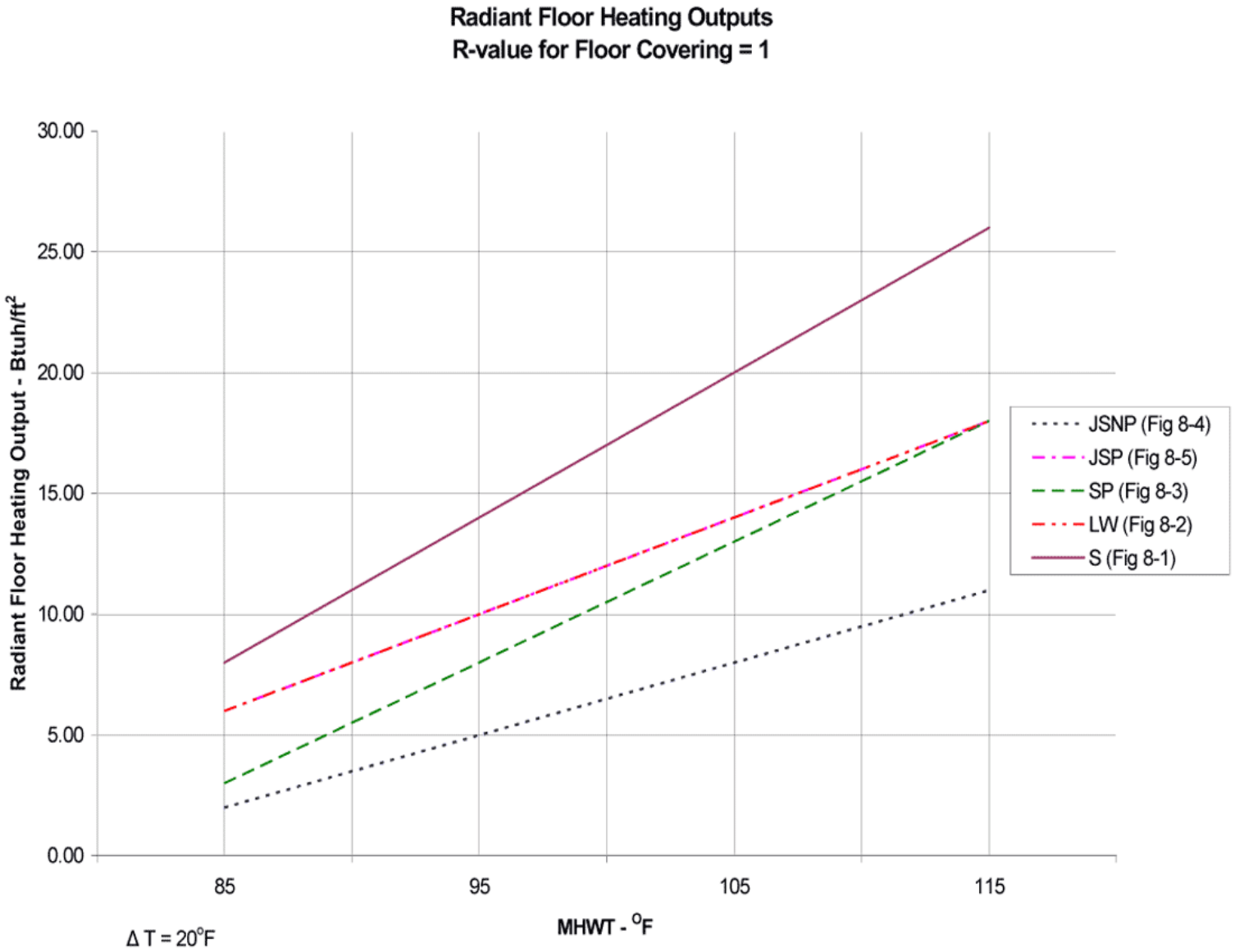
NOTE: Maximum flow for each size based on 12 FPS velocity.
PSI x 2.307 = head loss.

EXAMPLE: To calculate the pressure drop of a 1/2" line, 40 ft. long, with a 3 gpm flow rate, calculate .122 psi x 40 ft. = 4.9 psi pressure drop. Most plumbing codes require 8 psi residual pressure at the fixture. Refer to your local code requirements.

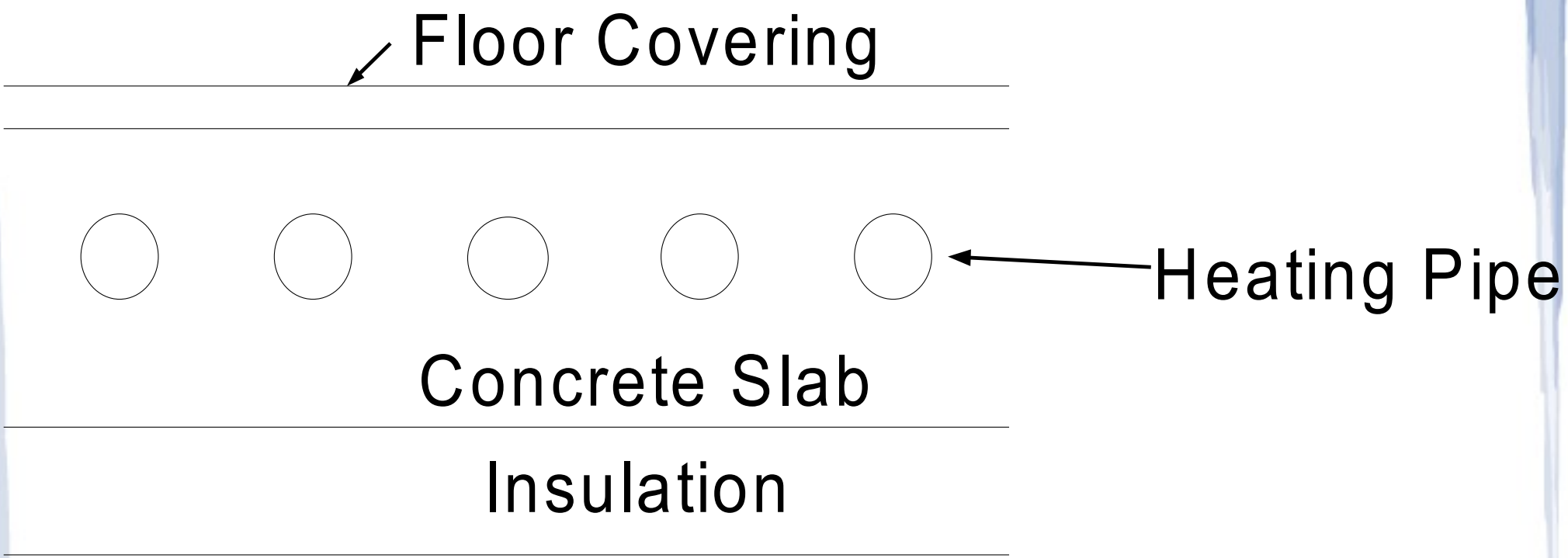
RFH Installation Methods

- Slab on Grade
- Joist Space
- Sub-Floor Installation

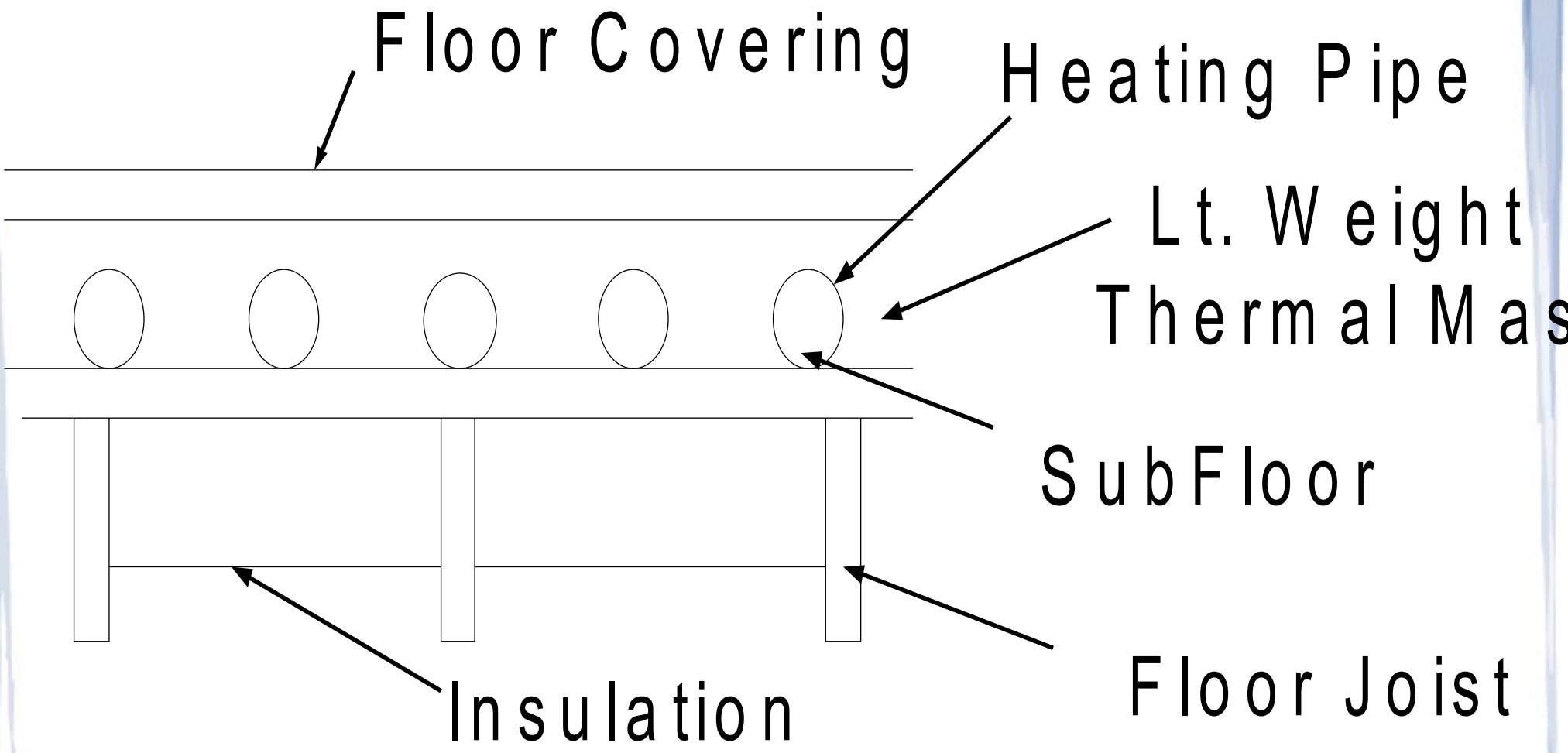
RFH Outputs by Type



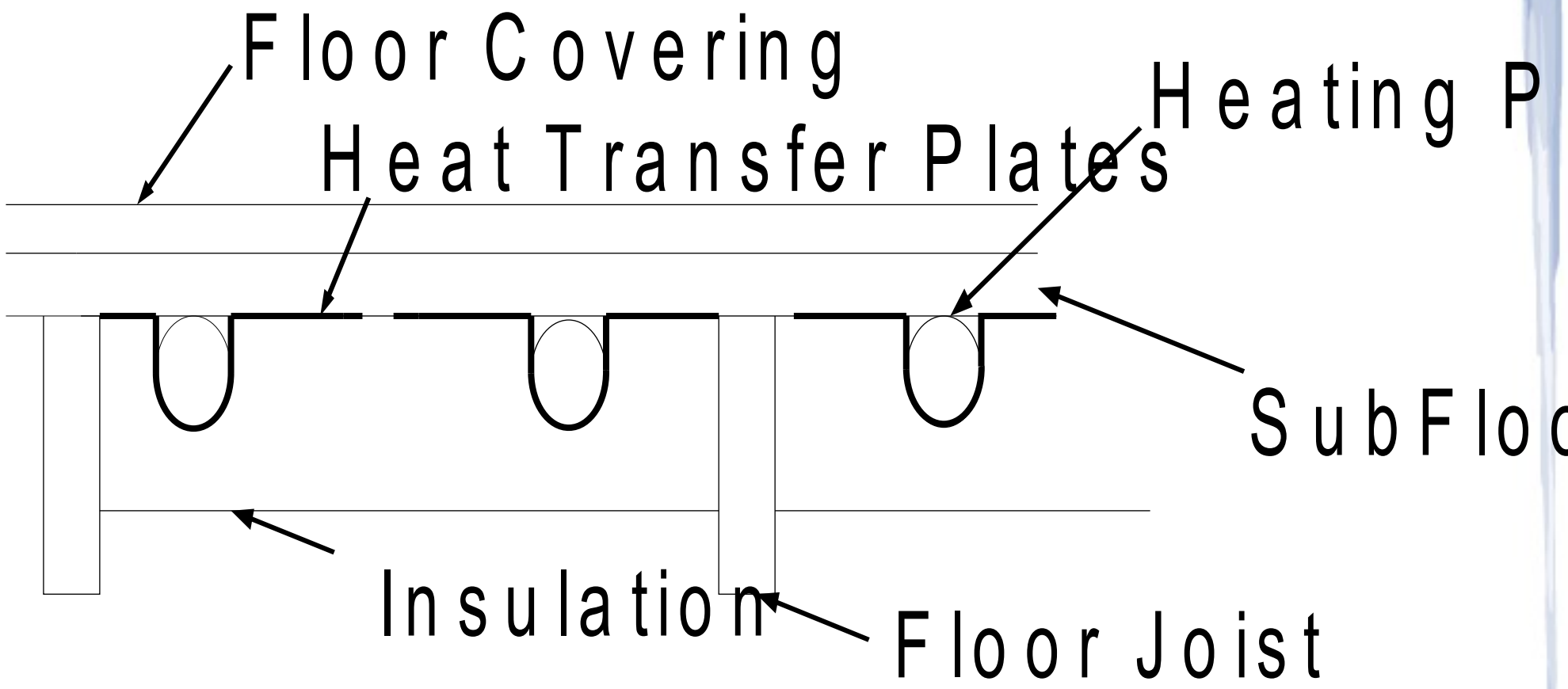
Slab on Grade



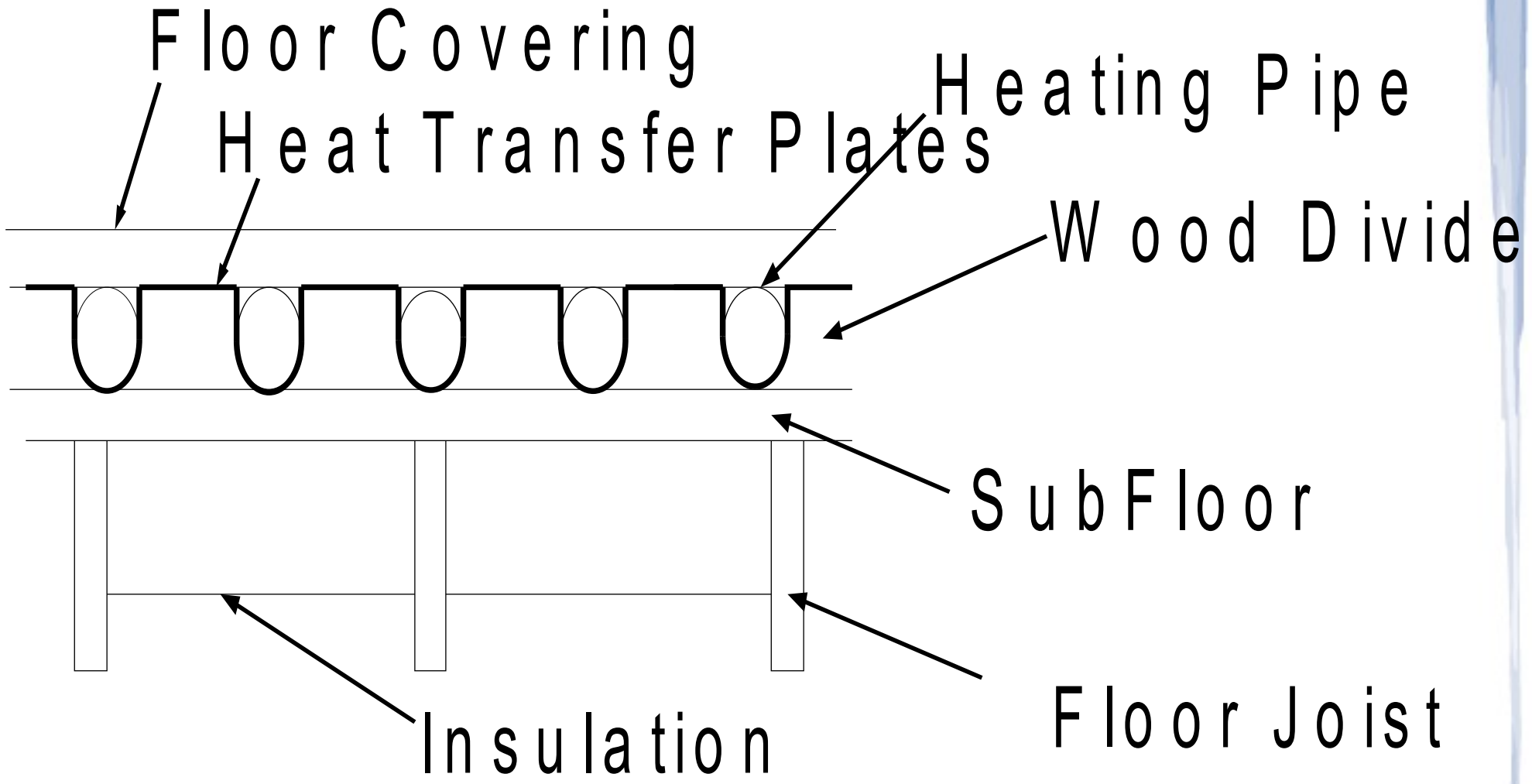
Sub-Floor Installation



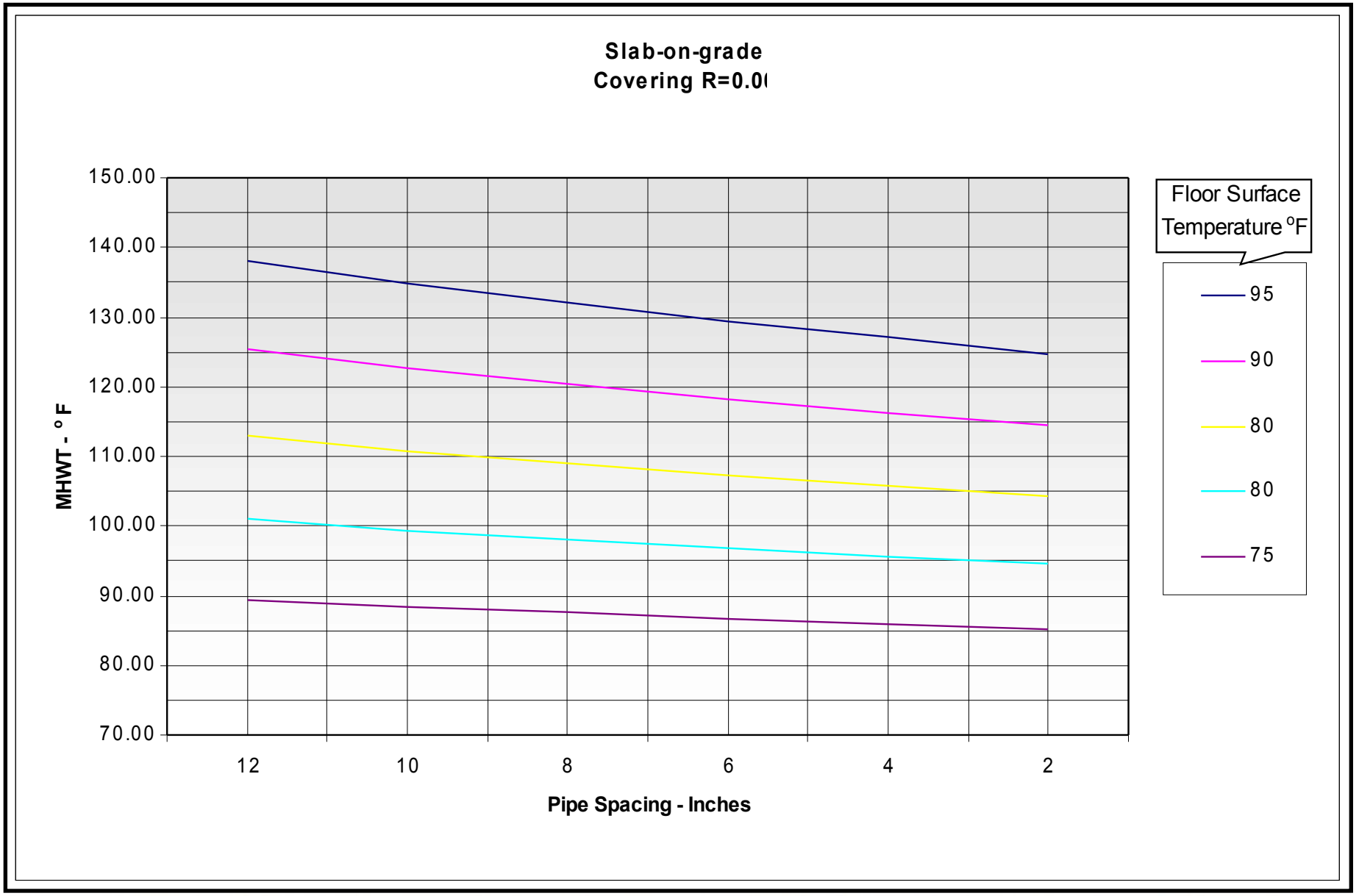
Joist Space


Floor Covering
Heat Transfer Plates
Heating P
SubFloo
Insulation
Floor Joist

Embedded Floor Installation



Heating Element Spacing

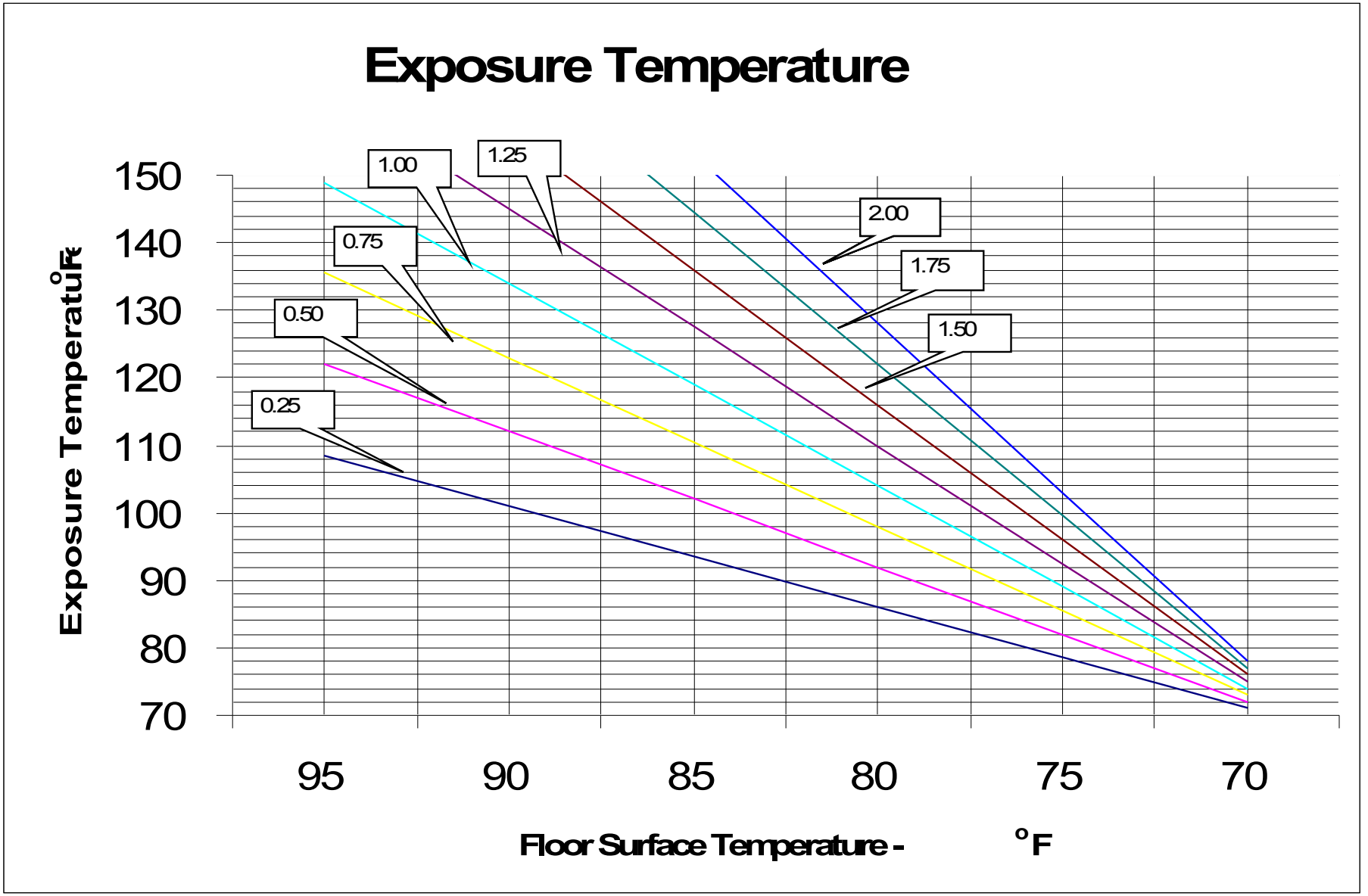


Floor Coverings

Type of Floor Covering	Thickness of Floor Covering (inches)	R-value (Btu/ft^2-^oF)	* Max Exposure Temperature (^oF)
Carpet Pad Slab Rubber	.25	.32	95
Oak Flooring	.75	.638	80
Ceramic Tile	.25	.25	125
Marble	.5	.4	100
Laminate Flooring	.16	.3	95
Carpet	.5	1.4	100
Plywood	.75	.825	140
Linoleum	.2	.125	100
Cork	.375	1.125	100

**** Table Data is generic and should be verified by specified flooring manufacturer for each installation and design case.***

Exposure Temperature



RFH System Components

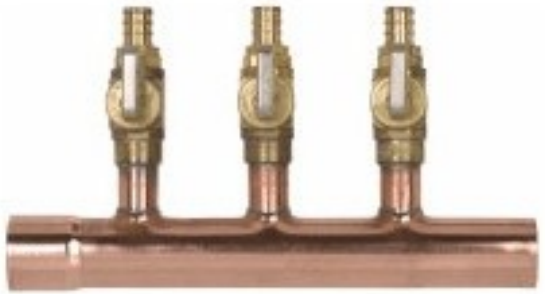
- Pipe
- Manifolds
- Fittings
- Accessories
- Controls
- Tools

Pipe

- ASTM F876/F877 - PEX c
- NSF-rfh
- ICBO ES ER 5421
- PPI Listed
- DIN 4726 Oxygen Barrier

Manifolds

- Brass
- Copper
- Easy Assembly
- Proven Components
- Many Different Sizes

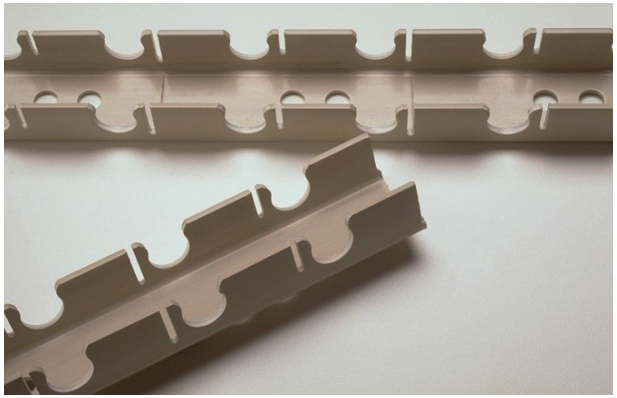


Fittings

- All Brass Construction
- Fully Tested and Certified
- NSF-rfh
- ICBO ES ER 5421
- No Special Tools Required
- ASTM F877
- Crimp Fittings
- Special Tools

Installation Accessories

- Labor Saving
- Back Saving
- Professional Installation
- Prevents Pipe Damage



Modern Controls

- Labor Saving
- Decreases Trouble Shooting Time
- Proven Service Record
- Improves System Performance
- Professional Installation

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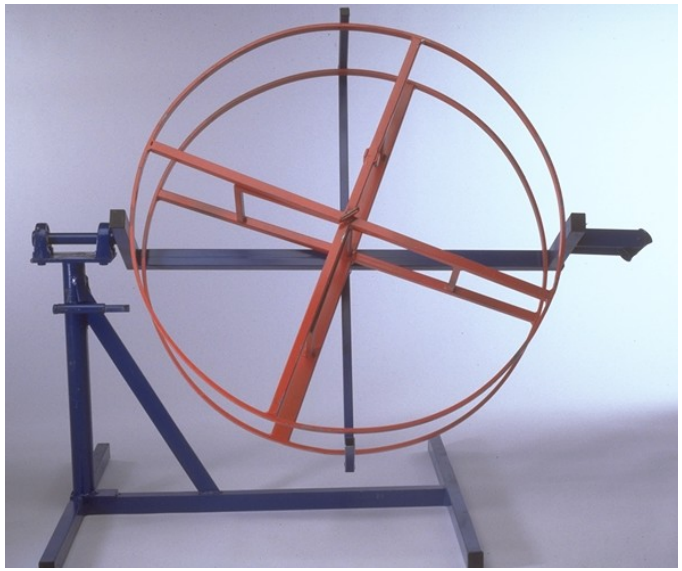
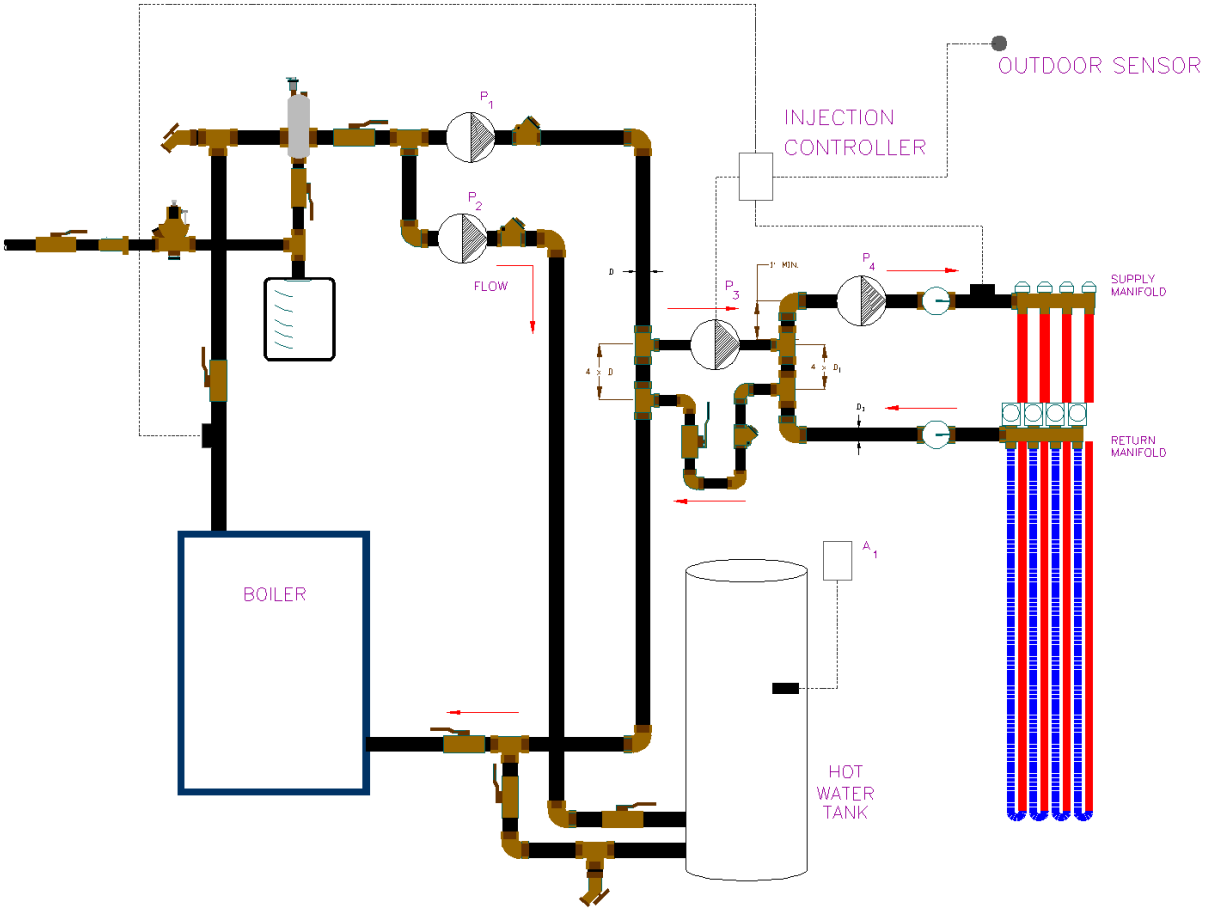
Tools

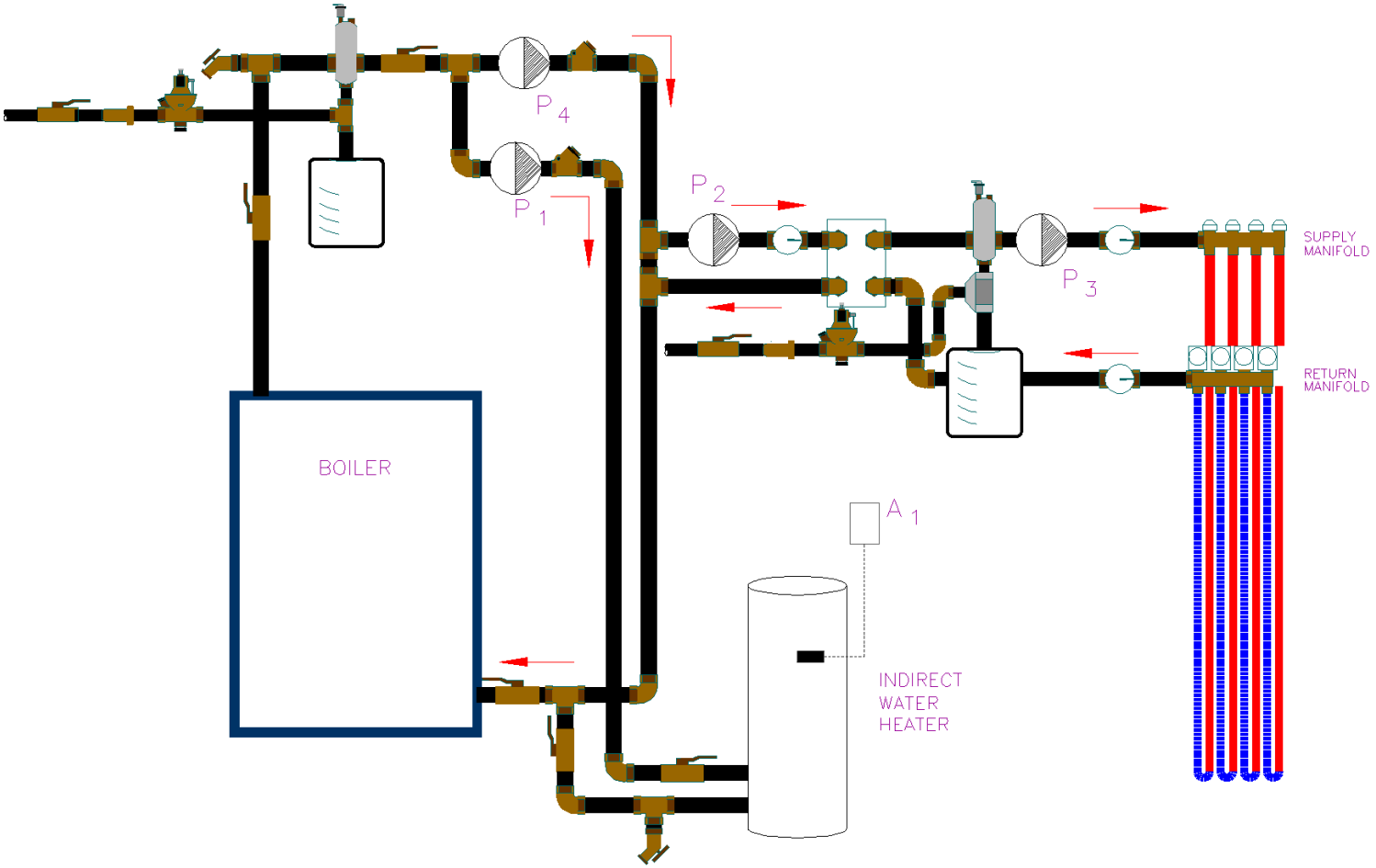
- Decreases Installation Time
- Back Saving
- Professional Quality
- Eases Installation



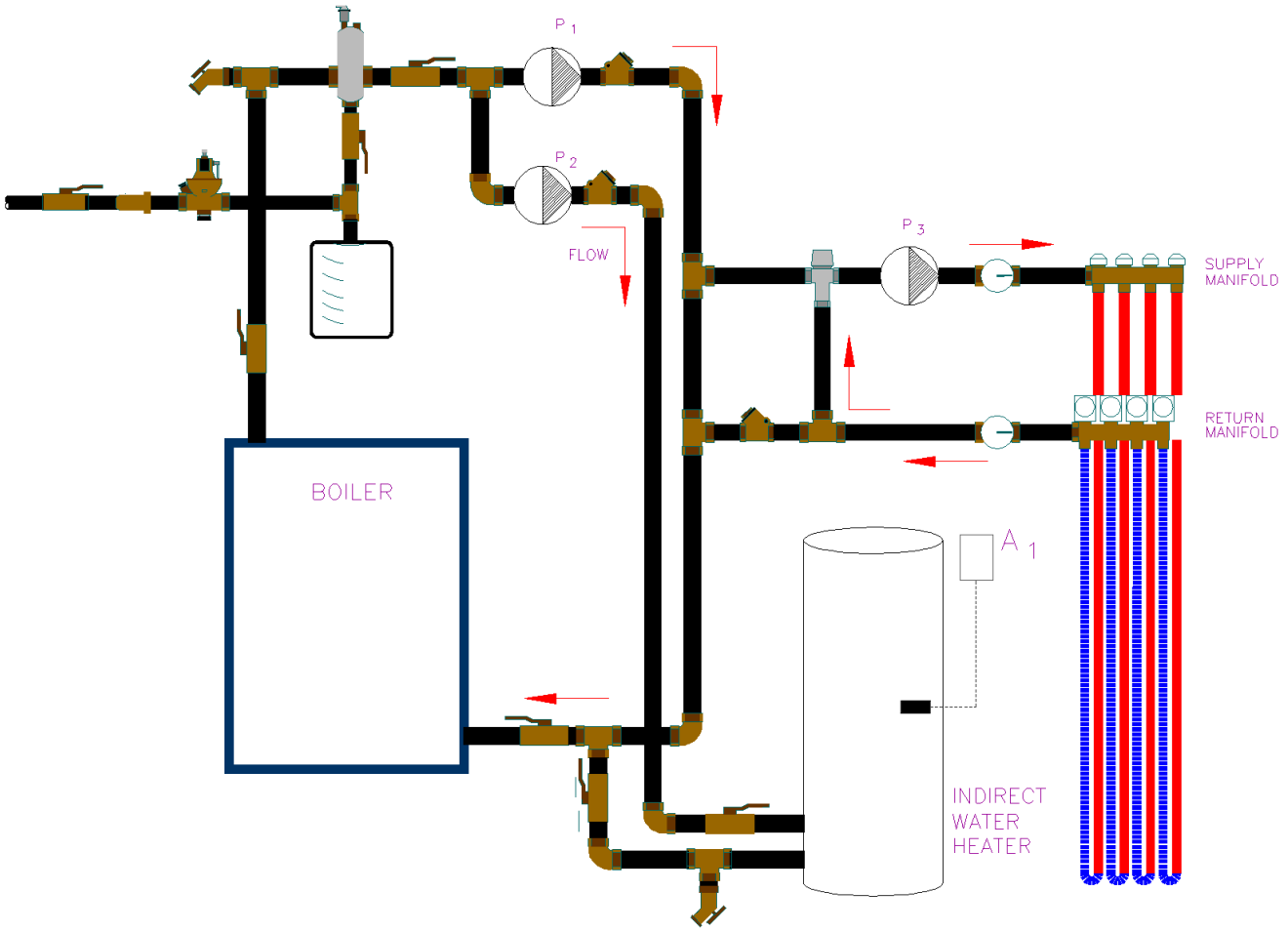
Pump Injection



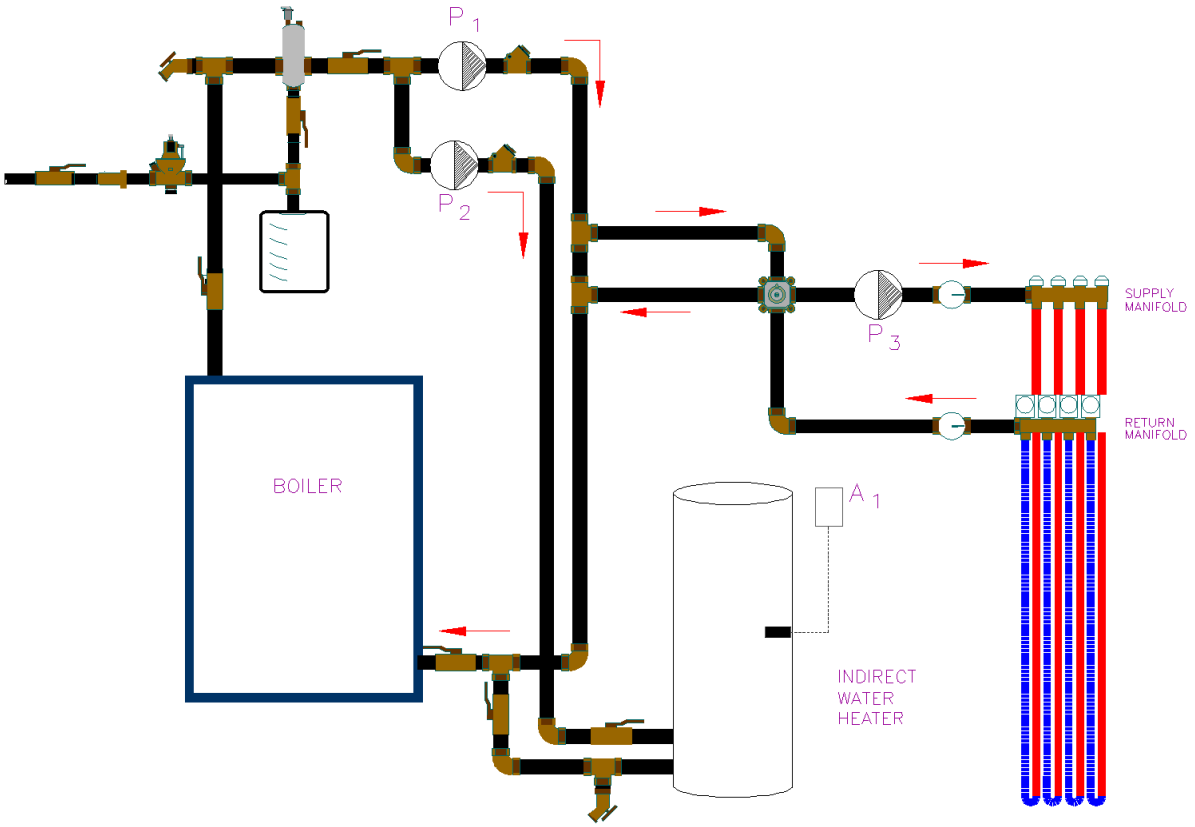
Pump Injection with HX



Thermostatic Mixing Valve



4 Way Mixing Valve



Resources for Design

- ASHRAE Handbooks
- Radiant Panel Association
- Manufacturer's Guides / Manuals

Questions