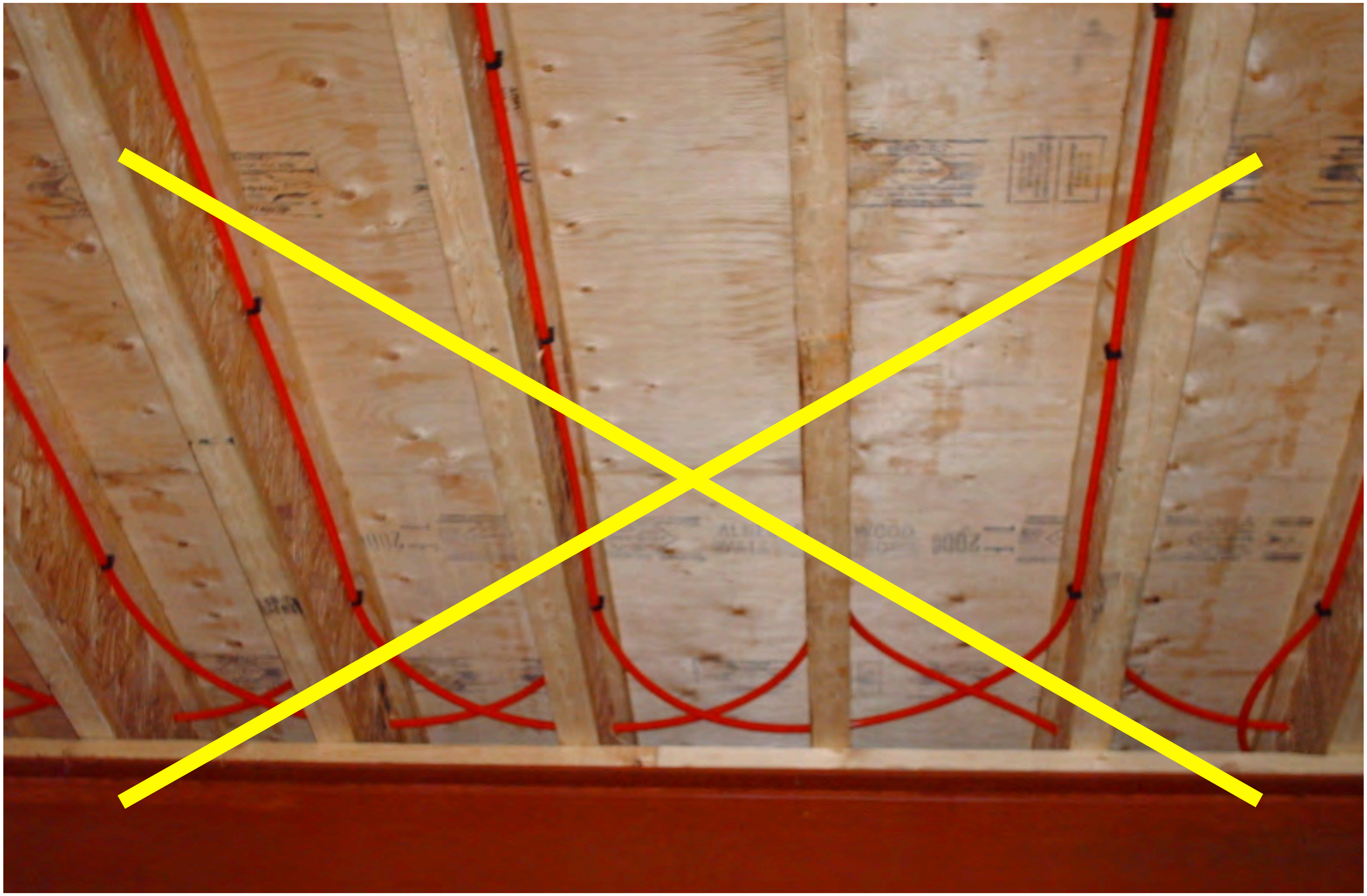
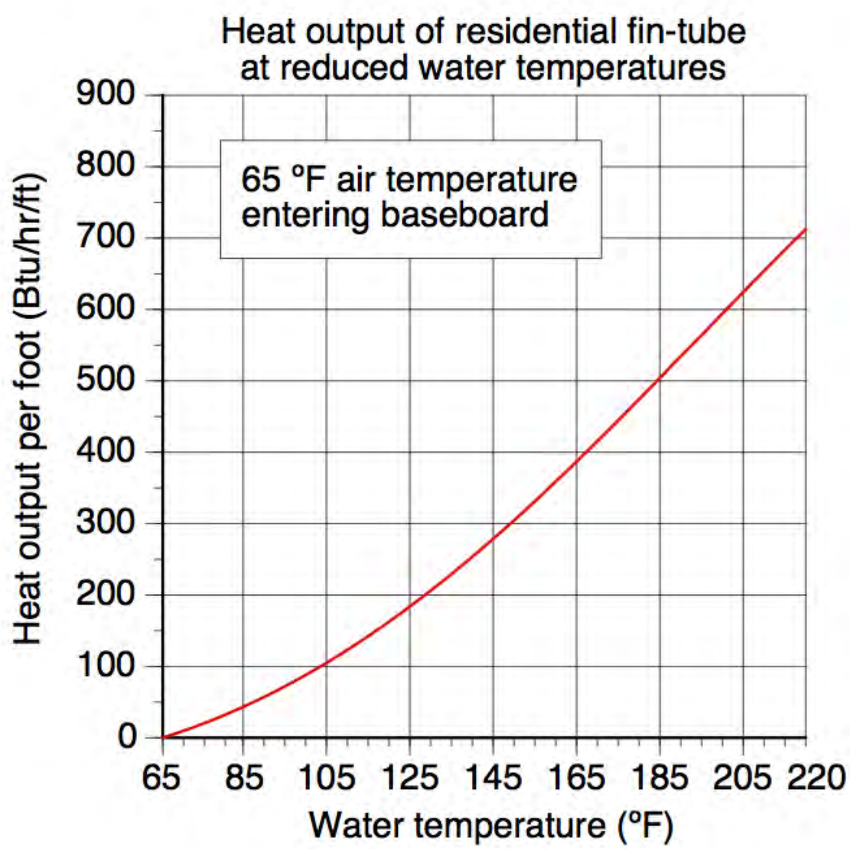
Don’t do this with ANY hydronic heat source!



Heat transfer between the water and the upper floor surface is severely restricted!

Hydronic heat emitters options for low energy use houses

Most CONVENTIONAL fin-tube baseboard has been sized around boiler temperatures of 160 to 200 °F. Much too high for good thermal performance of low temperature hydronic heat sources.

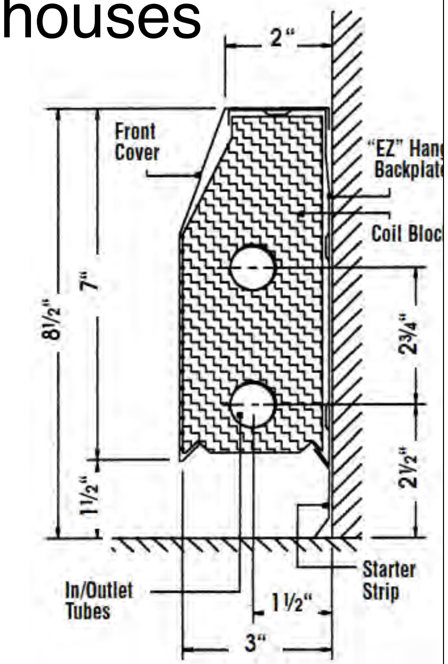


Could add fin-tube length based on lower water temperatures. BUT...

Fin-tube output at 120 °F is only about 30% of its output at 200°F

Hydronic heat emitters options for low energy use houses

Some low- temperature baseboard is now available



Heating Edge™
Hot Water Performance Ratings

Configuration	Flow Rate GPM	PD in ft of H_2O	90°F	100°F	110°F	120°F	130°F	140°F	150°F	160°F	170°F	180°F	190°F	200°F	210°F
			Average Water Temperature (BTU/hr/ft @AWT in °F)												
TWO SUPPLIES PARALLEL	1	0.0044	130	205	290	385	460	546	637	718	813	911	1009	1113	1215
	4	0.0481	155	248	345	448	550	651	755	850	950	1040	1143	1249	1352
TOP SUPPLY BOTTOM RETURN	1	0.0088	105	169	235	305	370	423	498	570	655	745	836	924	1016
	4	0.0962	147	206	295	386	470	552	640	736	810	883	957	1034	1110
BOTTOM SUPPLY TOP RETURN	1	0.0088	103	166	230	299	363	415	488	559	642	730	819	906	996
	4	0.0962	140	212	283	350	435	524	623	722	792	865	937	1013	1093
BOTTOM SUPPLY NO RETURN	1	0.0044	75	127	169	208	260	311	362	408	470	524	576	629	685
	4	0.0481	85	140	203	265	334	410	472	536	599	662	723	788	850

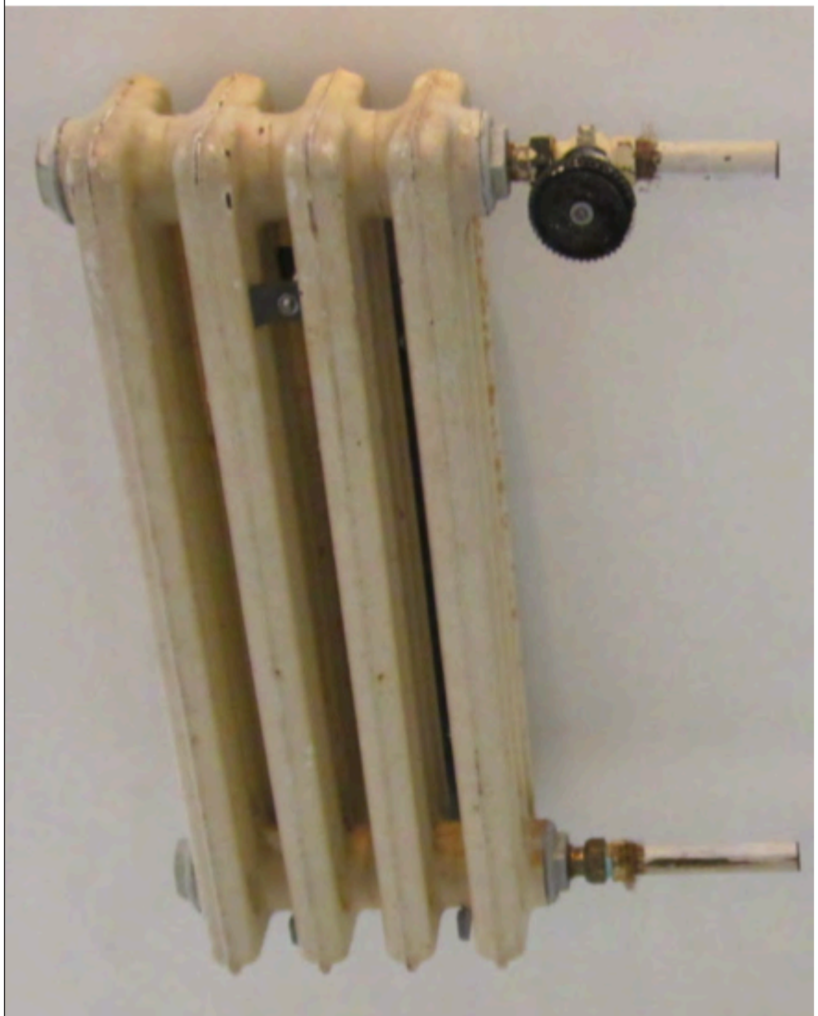
Performance Notes: • All ratings include a 15% heating effect factor • Materials of construction include all aluminum "patented" fins at 47.3 per LF, mechanically bonded to two 3/4' (075) type L copper tubes ("Coil Block") covered by a 20 gauge perforated, painted cover all mounted to a backplate. Please see dimensional drawing for fin shape and dimensions • EAT=65°F • Pressure drop in feet of H_2O per LF.

Heating Edge (HE2) has been performance tested in a BSRIA standards laboratory. The test chamber was set up according to IBR testing protocol. The above chart is shown in Average Water Temperatures (AWT) per market request.

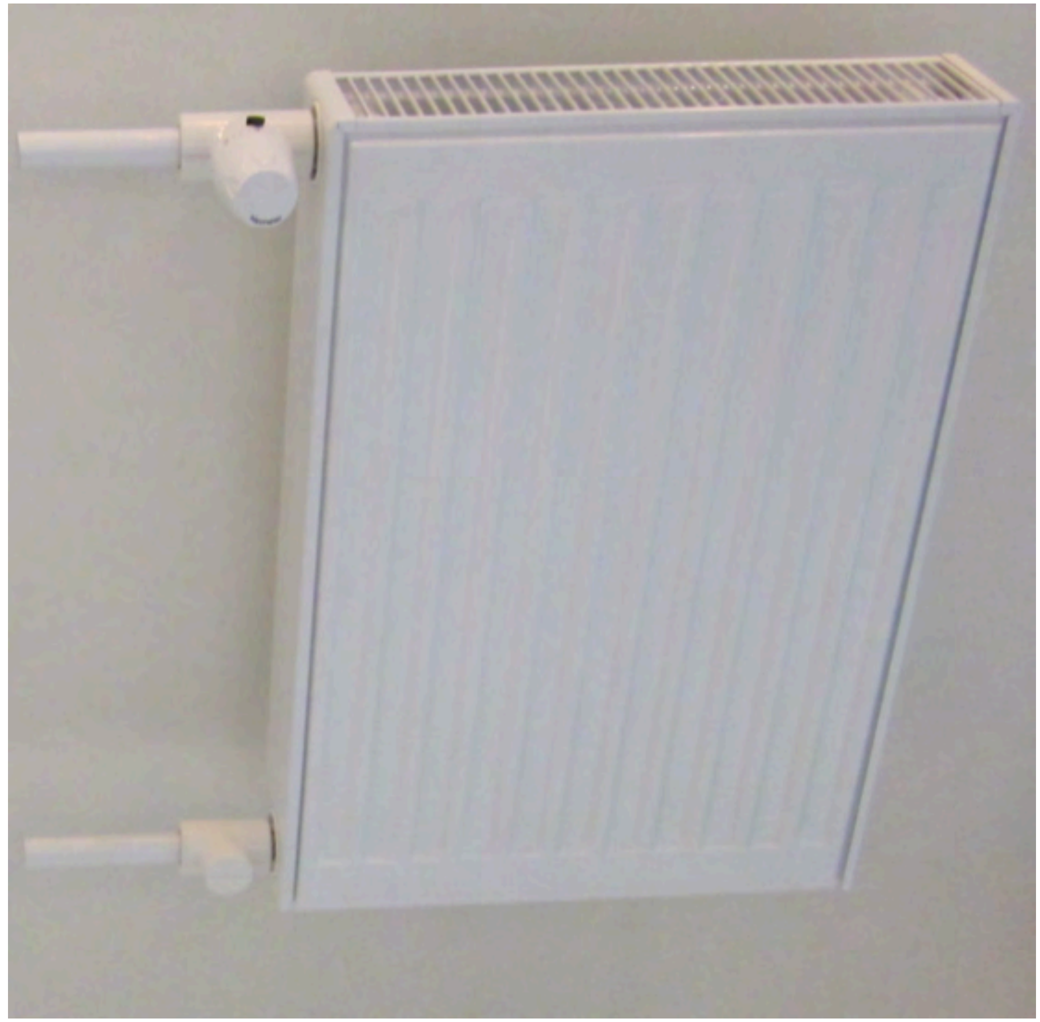
Smith's ENVIRONMENTAL PRODUCTS®
300 Pond Street, Randolph, MA 02368 • (781) 986-2525 • www.smithsenvironmental.com

Panel Radiators

Traditional cast-iron radiator



Modern panel radiator

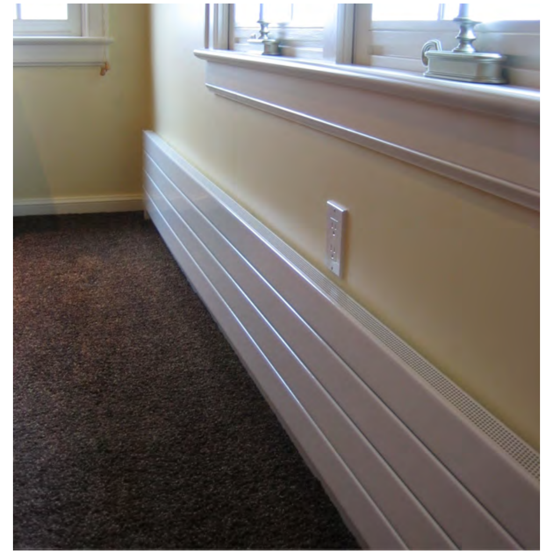


Panel Radiators

- Low water content and relatively light - fast responding

- Some can be fitted with thermostatic radiator valves for room-by-room zoning (WITHOUT ELECTRICAL CONTROLS)

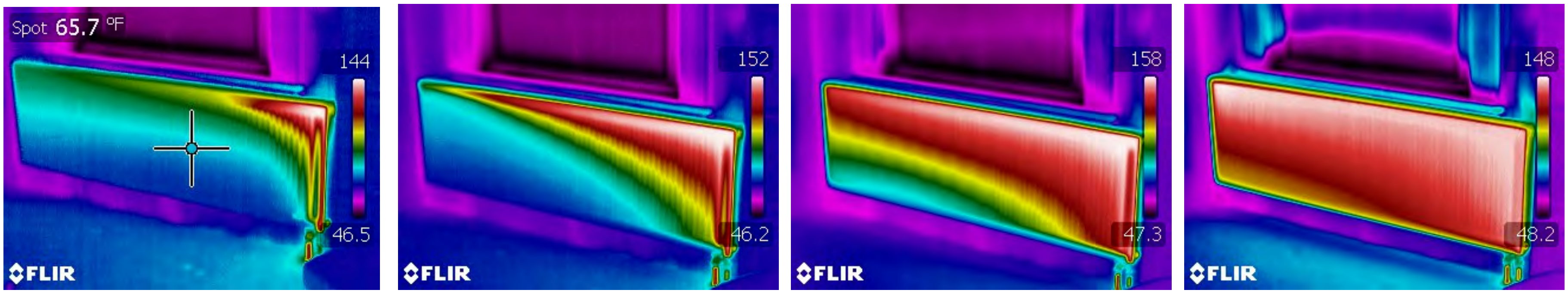
- Some are “thermal art” - but bring your VISA card...



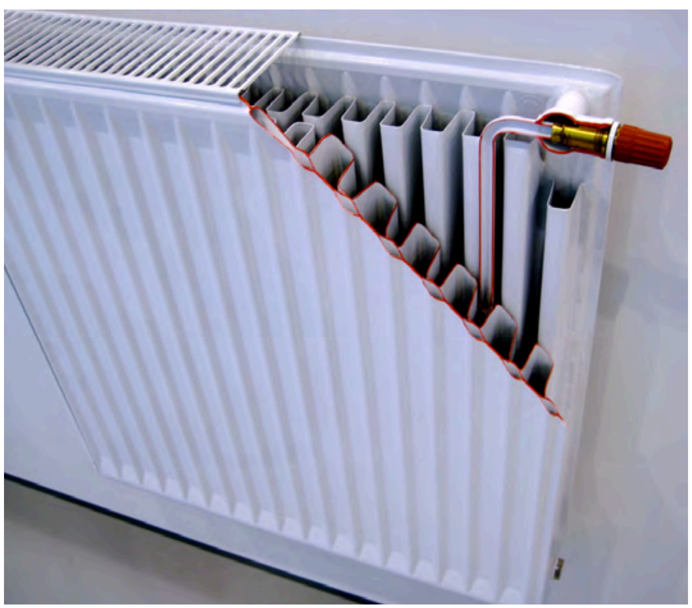
Hydronic heat emitters options for low energy use houses

Panel Radiators

One of the fastest responding hydronic heat emitters



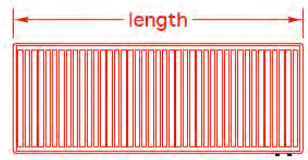
From setback to almost steady state in <u>4 minutes</u>...



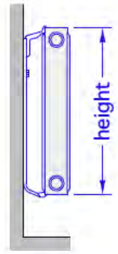
Hydronic heat emitters options for low energy use houses

Panel Radiators

- Adjust heat output for operation at lower water temperatures.

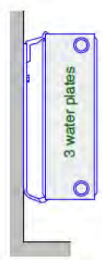


Heat output ratings (Btu/hr)
at reference conditions:
Average water temperature in panel = 180°F
Room temperature = 68°F
temperature drop across panel = 20°F

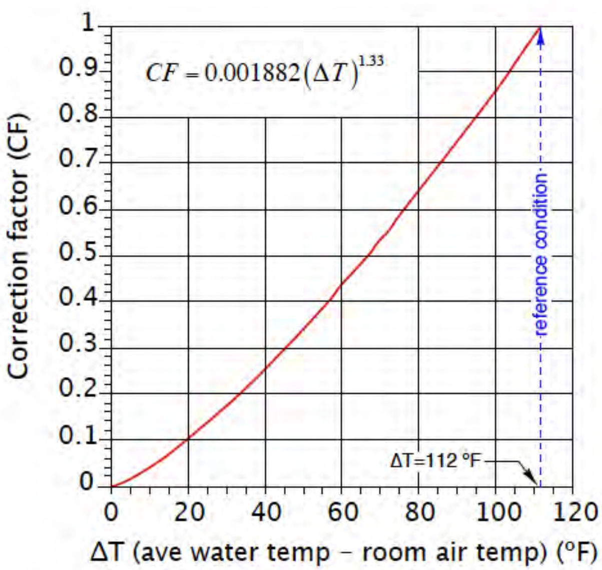


1 water plate panel thickness	16" long	24" long	36" long	48" long	64" long	72" long
24" high	1870	2817	4222	5630	7509	8447
20" high	1607	2421	3632	4842	6455	7260
16" high	1352	2032	3046	4060	5415	6091

2 water plate panel thickness	16" long	24" long	36" long	48" long	64" long	72" long
24" high	3153	4750	7127	9500	12668	14254
20" high	2733	4123	6186	8245	10994	12368
16" high	2301	3455	5180	6907	9212	10363
10" high	1491	2247	3373	4498	5995	6745



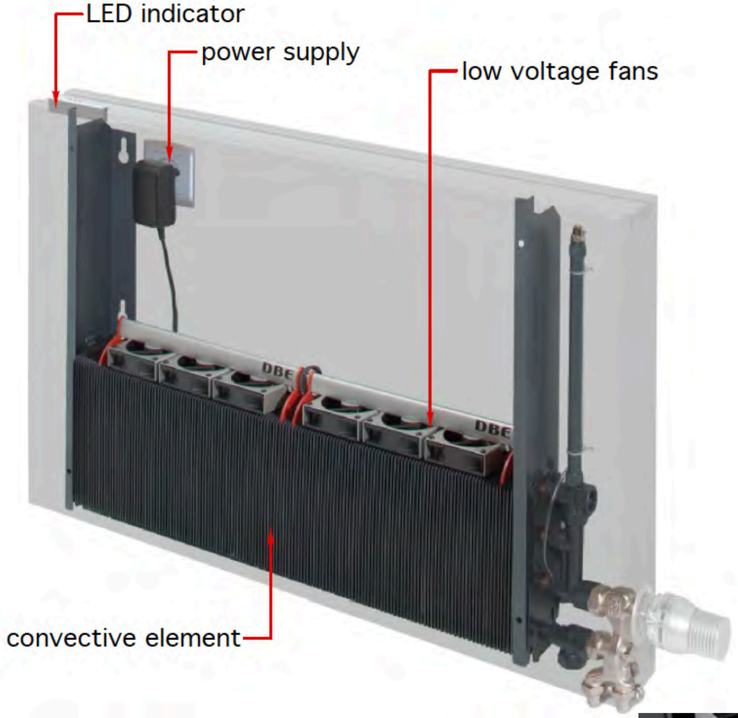
3 water plate panel thickness	16" long	24" long	36" long	48" long	64" long	72" long
24" high	4531	6830	10247	13664	18216	20494
20" high	3934	5937	9586	11870	15829	17807
16" high	3320	4978	7469	9957	13277	14938
10" high	2191	3304	4958	6609	8811	9913



Reference condition:
Ave water temp. in panel = 180°F
Room air temperature = 68°F

As an approximation, a panel radiator operating with an average water temperature of 110 °F in a room room maintained at 68 °F, provides approximately 27 percent of the heat output it yields at an average water temperature of 180 °F.

Adding low wattage fans to a low water content panel can boost heat output 50% during normal comfort mode, and over 200% during recovery from setback conditions



- At full speed these fans require about 1.5 watts each
- 30dB (virtually undetectable sound level)
- Allow supply temperatures as low as 95 °F

Styles of panel radiators

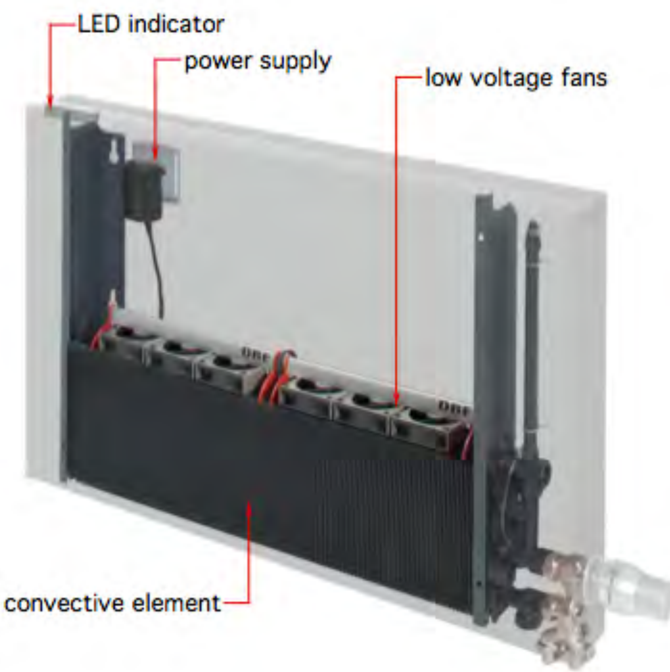
Ultra Low-Mass Panel Radiators

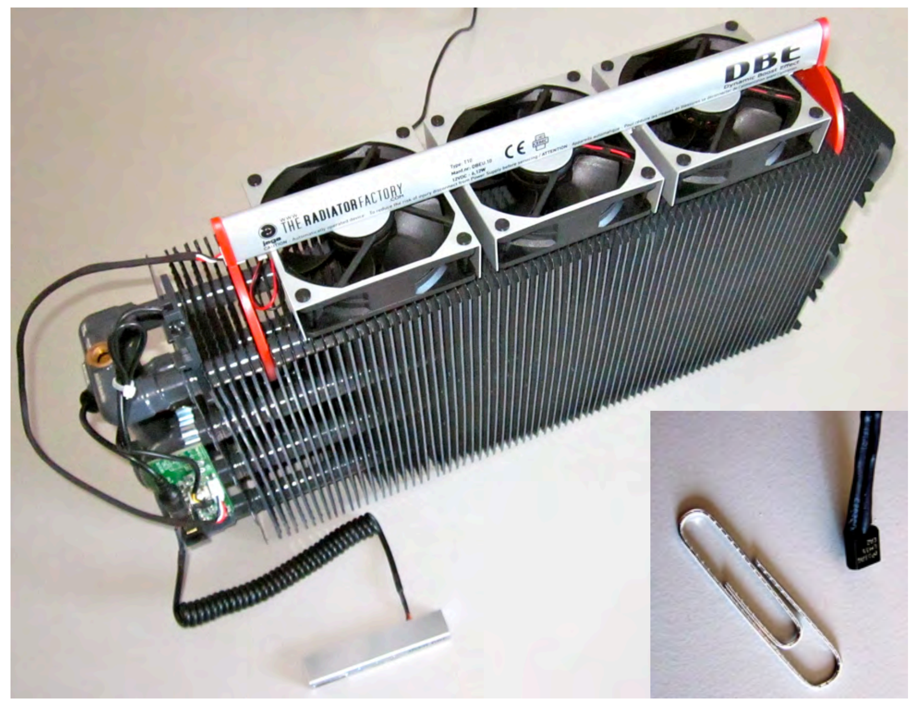

Image courtesy of JAGA North America

Microfan power consumption:

(3 fans in group)

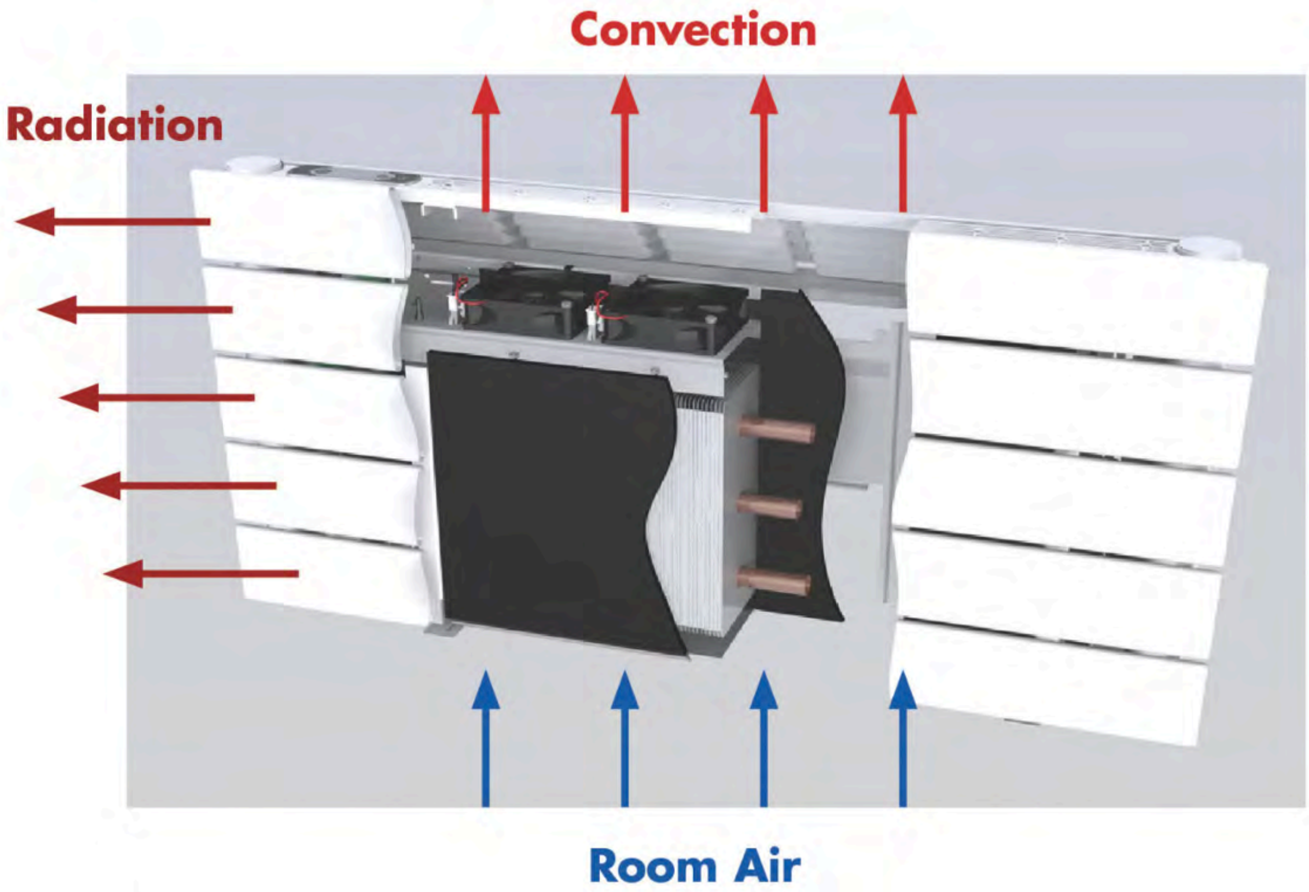
1. OFF: **1 watt** (power supply)
2. Fans at normal "comfort" setting: **4 watts**
3. Fans in "boost" mode: **5 watts**





Fan-assisted Panel Radiators

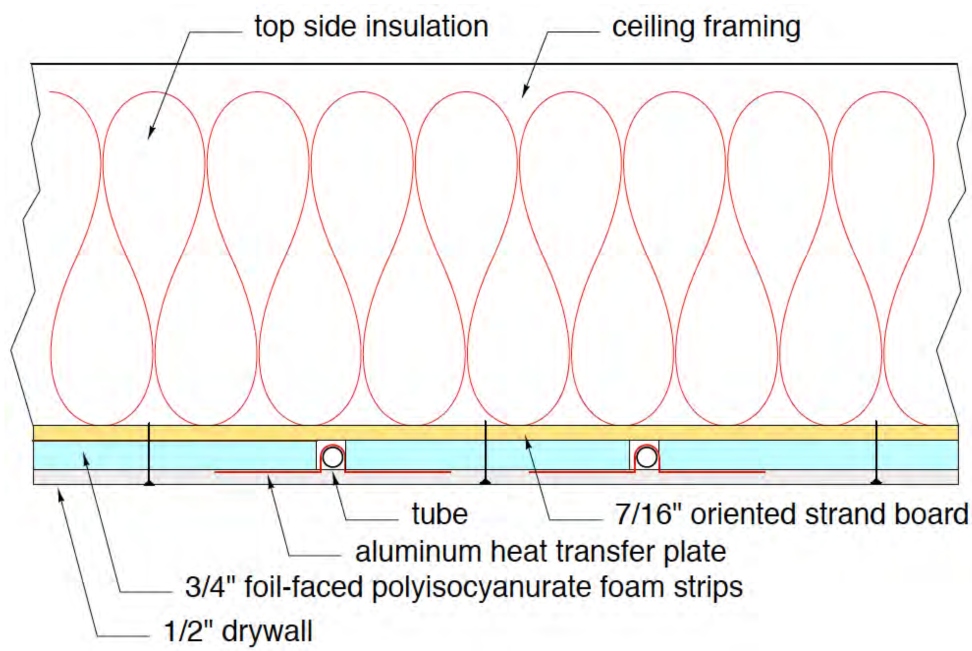
The “NEO”, just released from Runtal North America



8 tube high x 31.5” wide produces 2095 Btu/hr at average water temperature of 104 ºF in 68ºF room

8 tube high x 59” wide produces 5732 Btu/hr at average water temperature of 104 ºF in 68ºF room

Site built radiant CEILINGS...

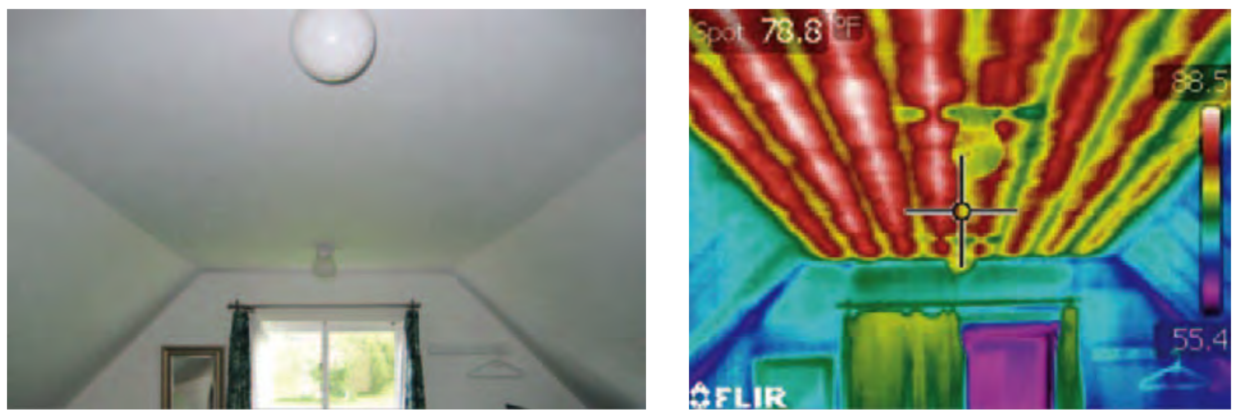


Heat output formula:

$$q = 0.71 \times (T_{water} - T_{room})$$

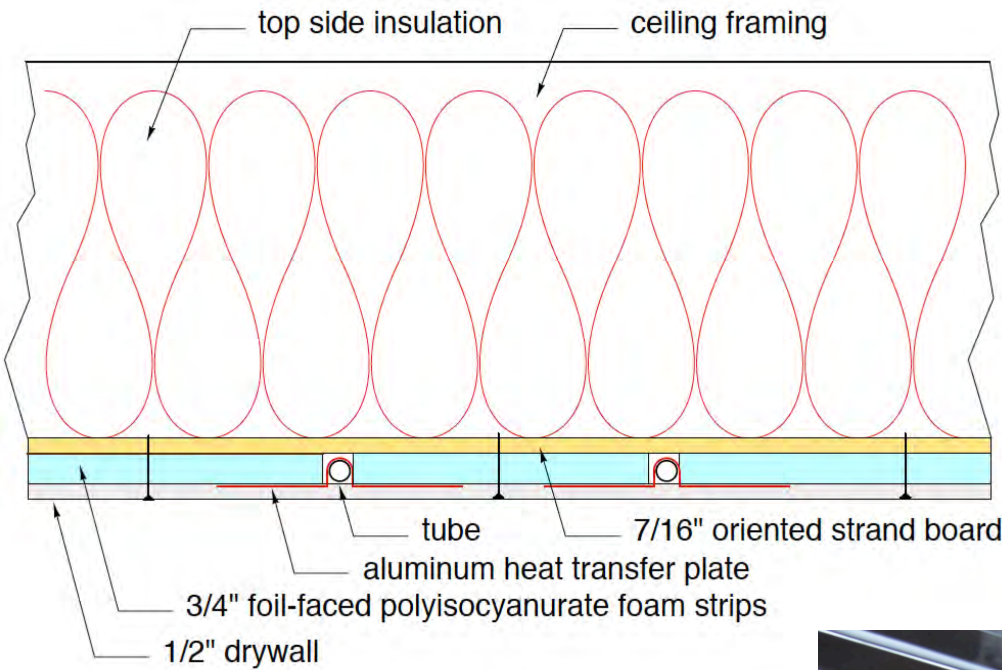
Where:

Q = heat output of ceiling (Btu/hr/ft²)
T_{water} = average water temperature in panel (°F)
T_{room} = room air temperature (°F)



Thermal image of radiant ceiling in operation

Site built radiant CEILINGS…



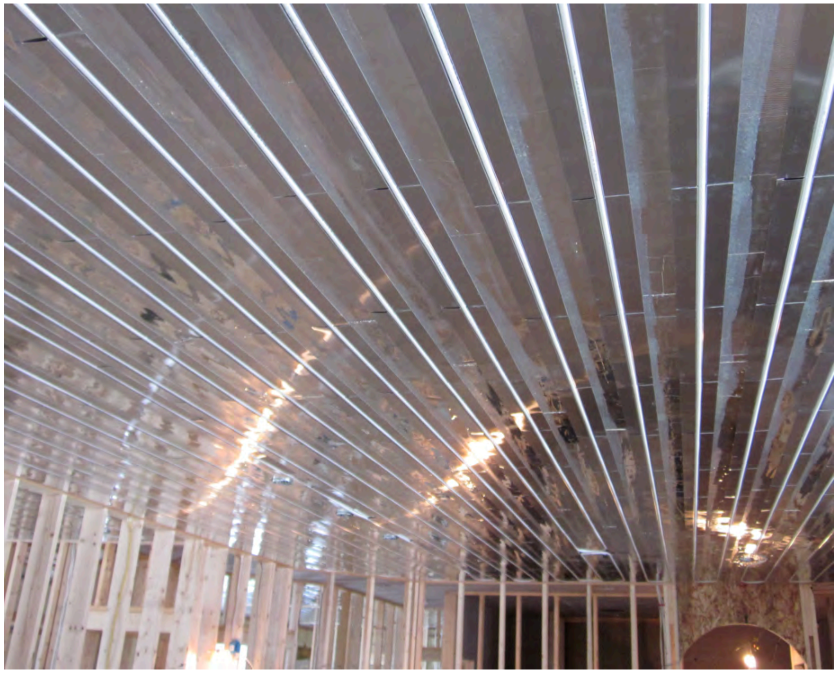
Same construction as radiant wall, just flipped 90°

Site built radiant CEILINGS...

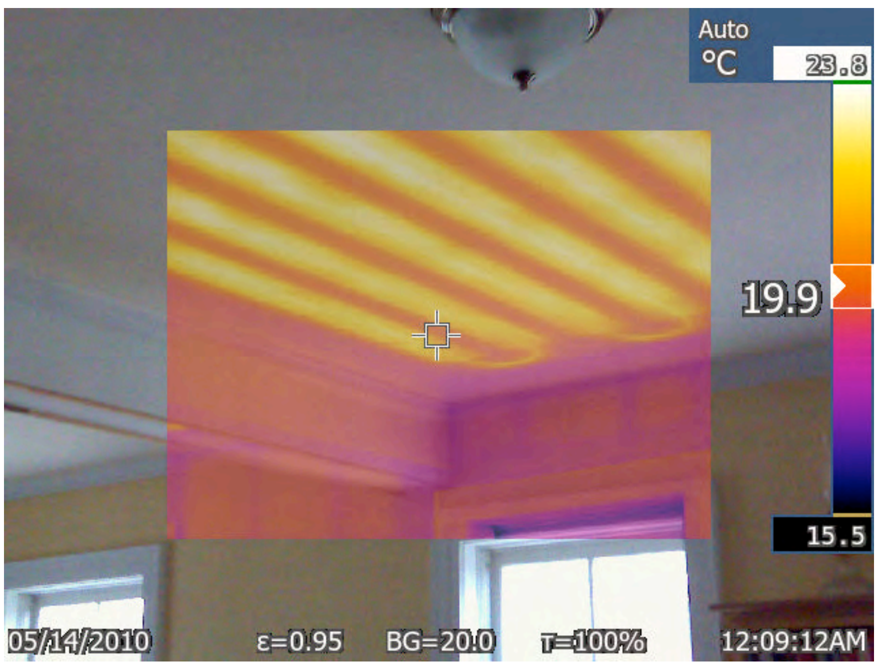


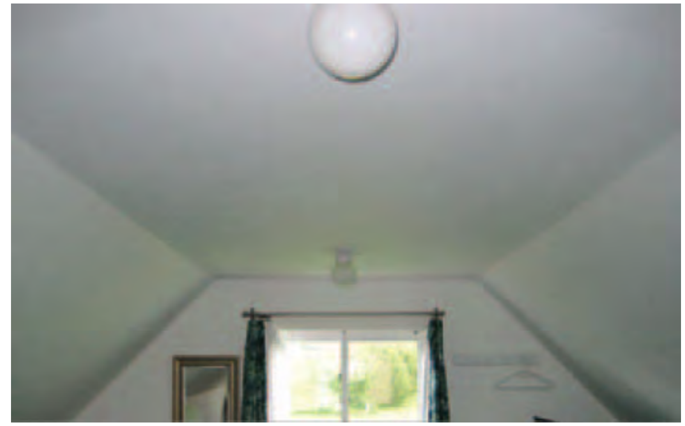

Site built radiant CEILINGS...

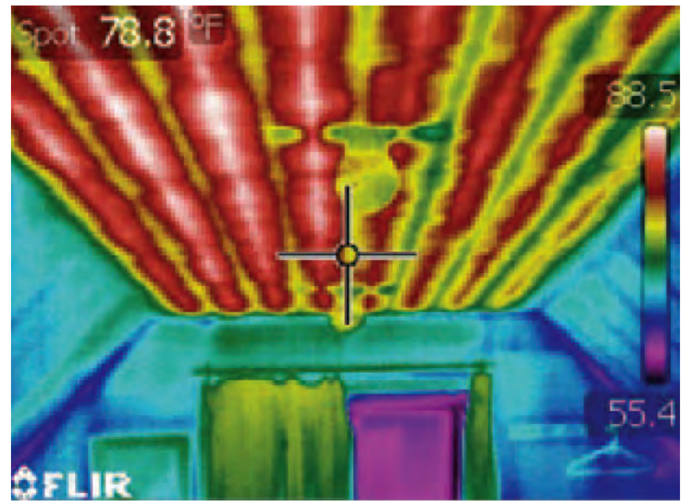


Site built radiant CEILINGS...







Thermal image of radiant ceiling in operation

Heat output formula:

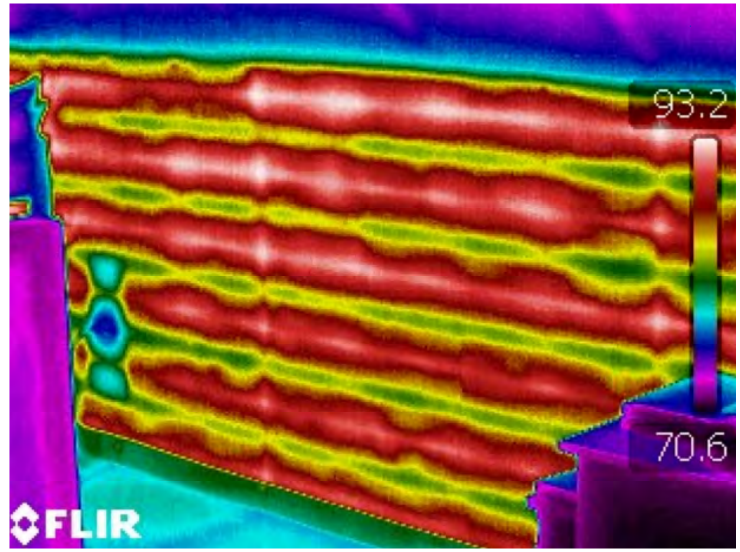
$$q = 0.71 \times (T_{water} - T_{room})$$

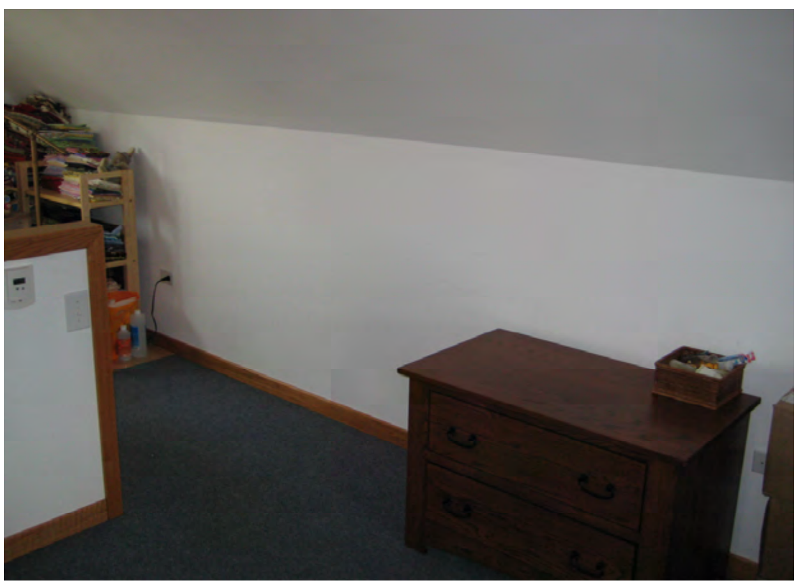
Where:

Q = heat output of ceiling (Btu/hr/ft^2)
T_{water} = average water temperature in panel (ºF)
T_{room} = room air temperature (ºF)

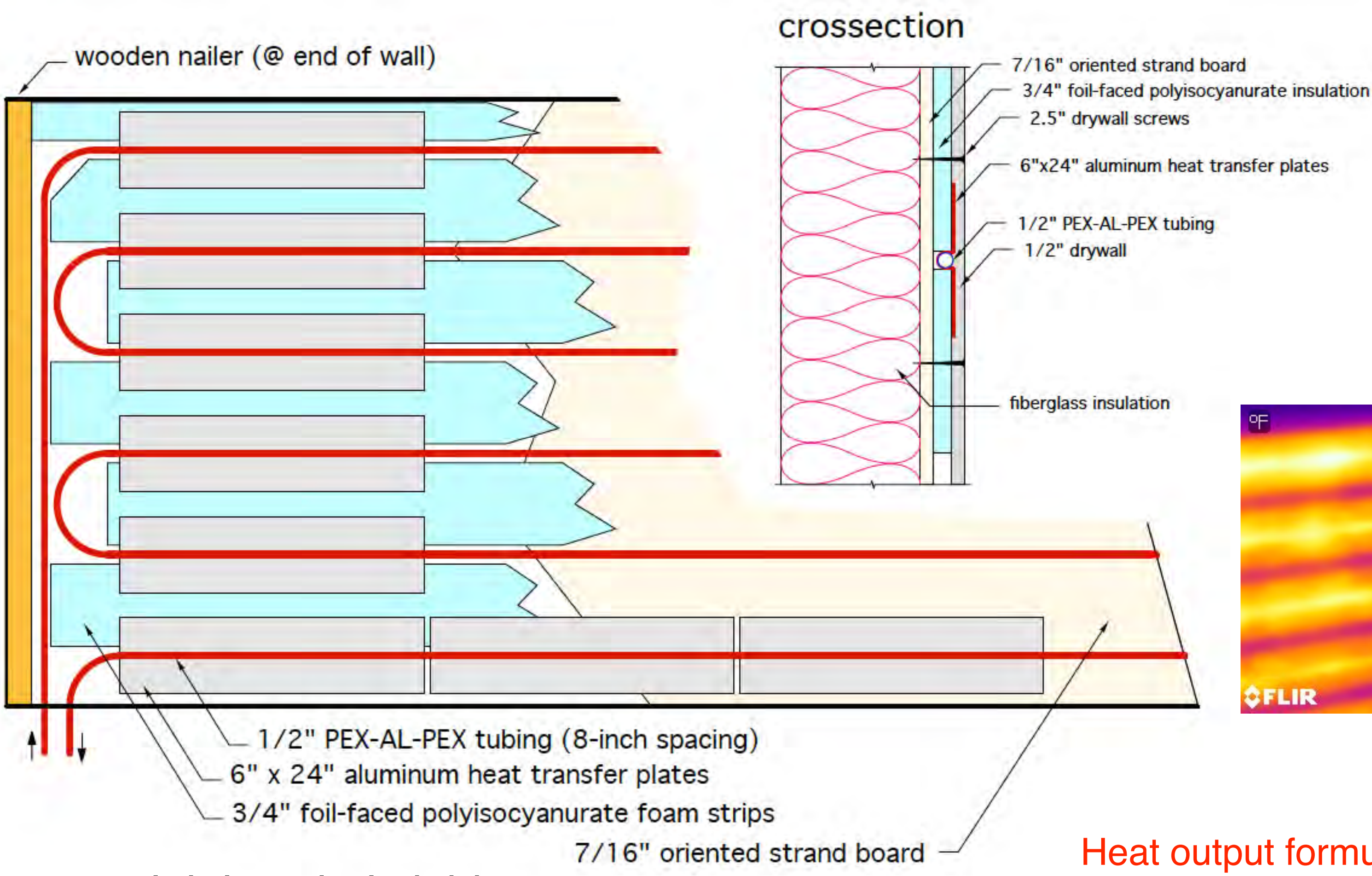
Site built radiant CEILINGS...

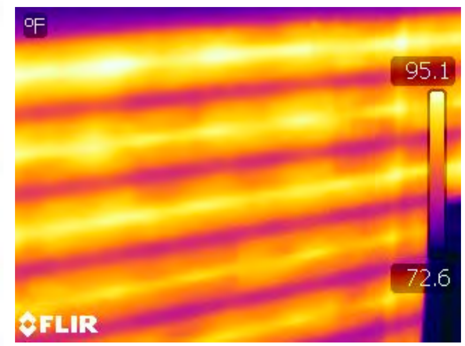
Site built radiant WALLS...





Site built radiant WALLS...





- completely out of sight
- low mass -fast response
- reasonable output at low water temperatures
- stronger than conventional drywall over studs
- don't block with furniture

Heat output formula:

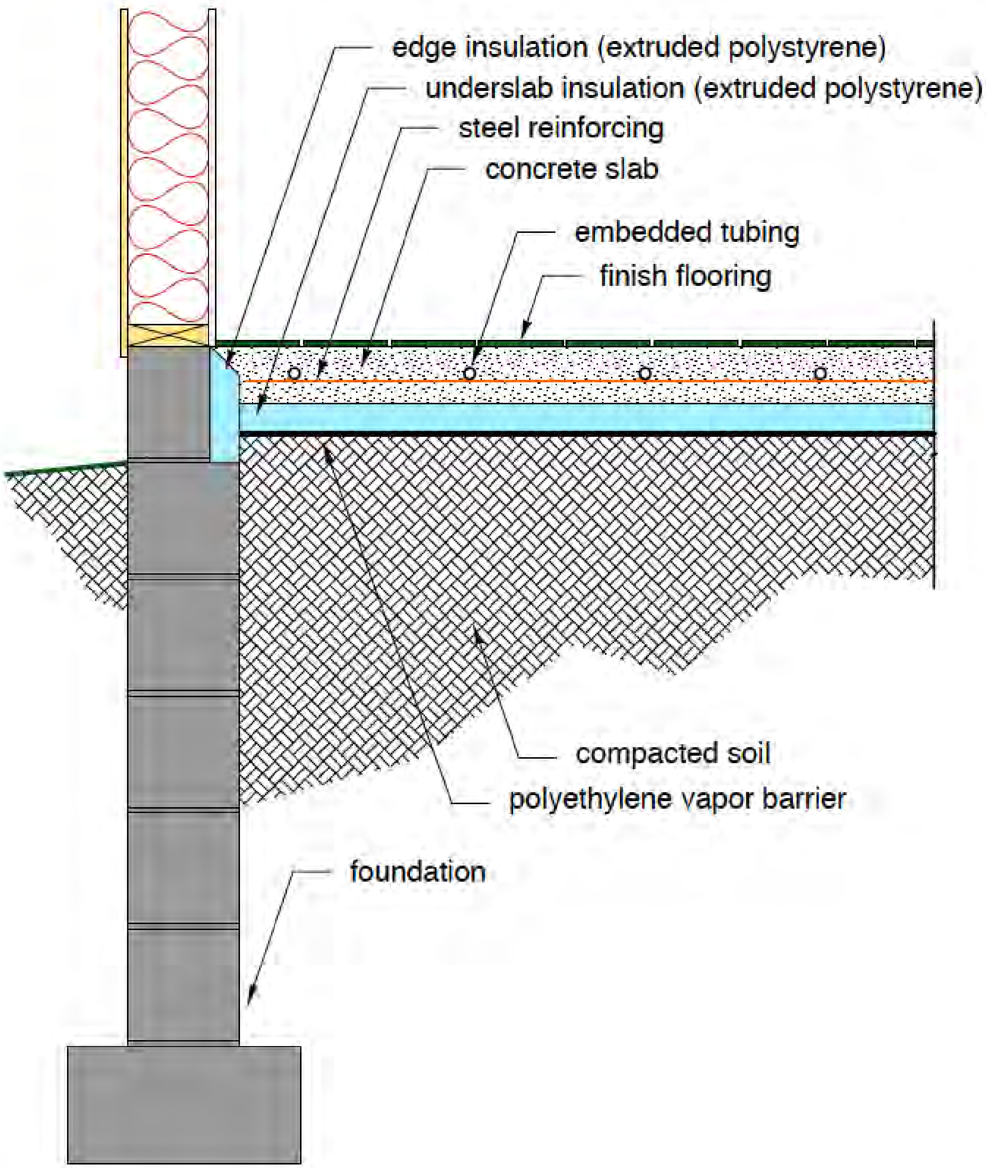
$$q = 0.8 \times (T_{water} - T_{room})$$

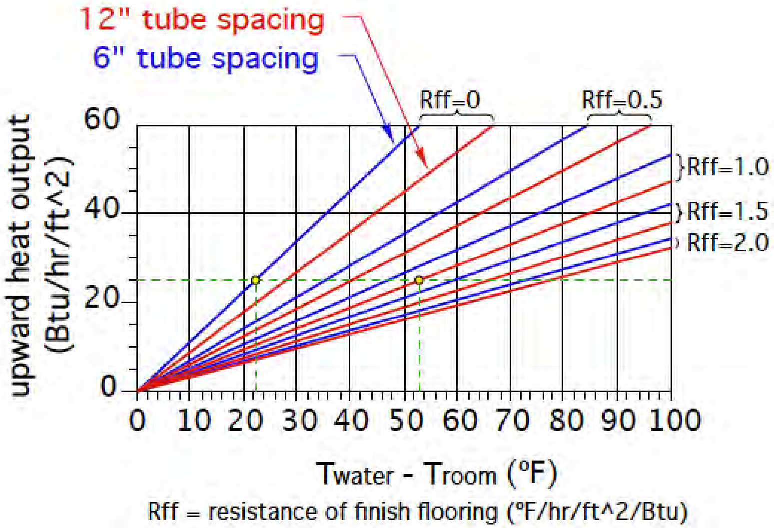
Where:

Q = heat output of wall (Btu/hr/ft^2)
T_{water} = average water temperature in panel (°F)
T_{room} = room air temperature (°F)

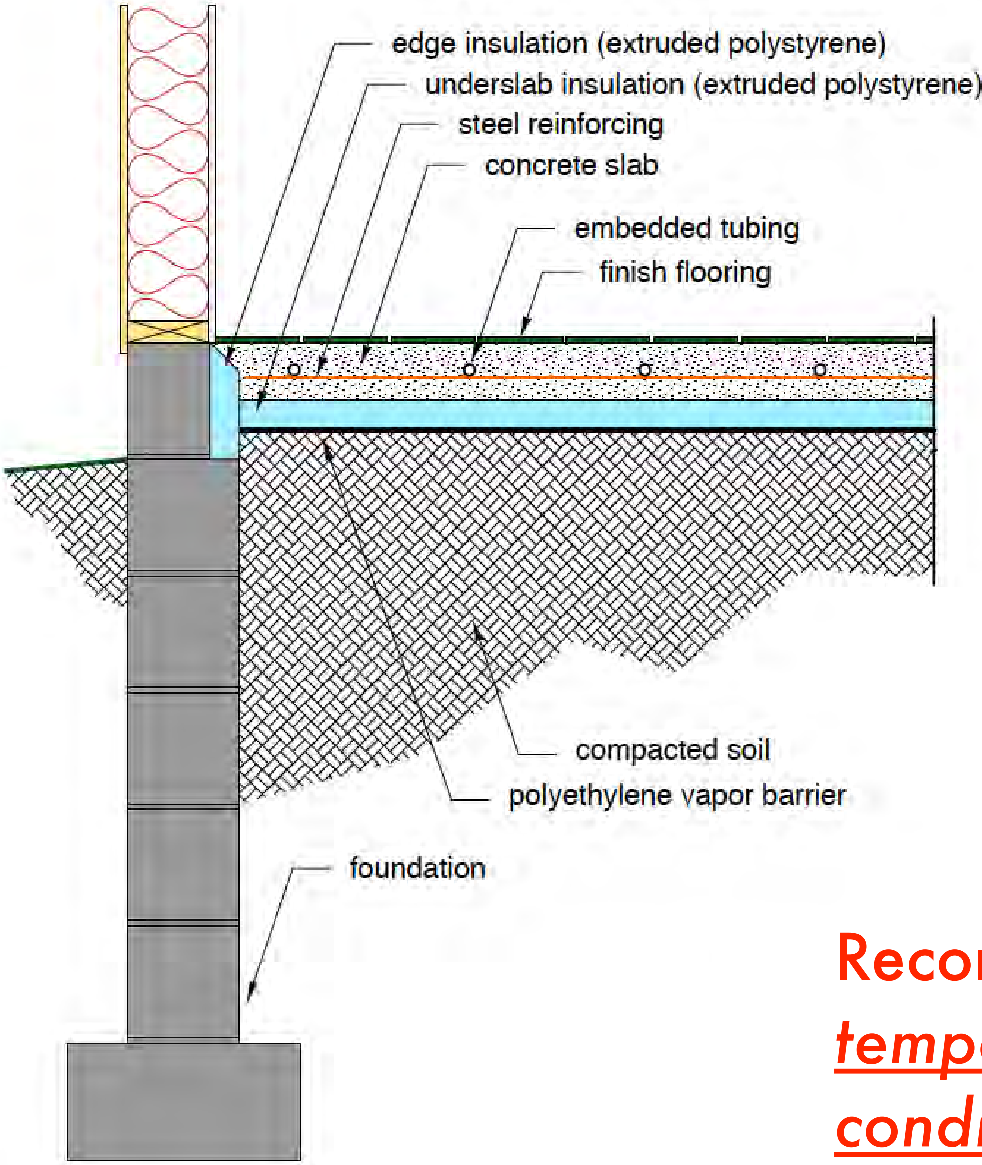
Higher mass, low & medium temperature hydronic heat emitters

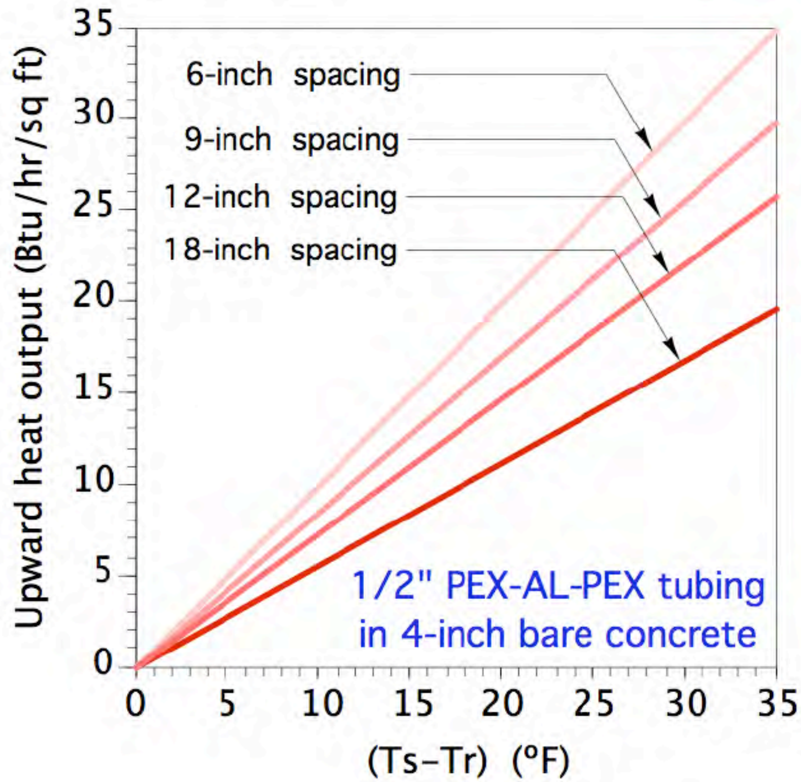
Slab-on-grade floor heating





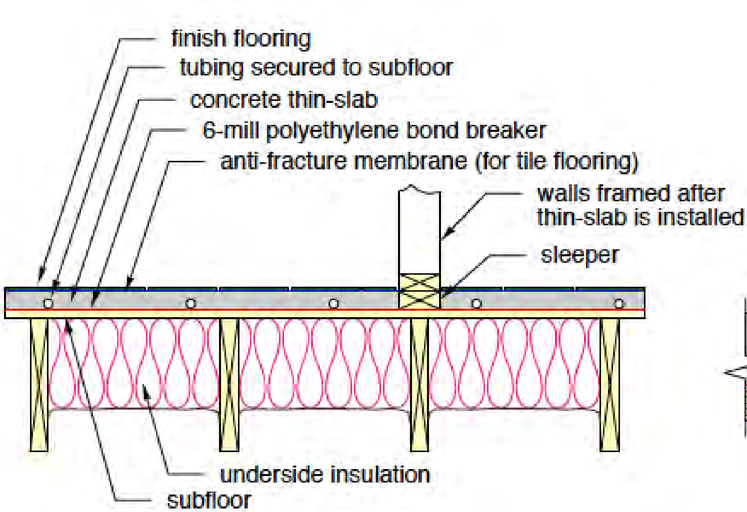
- Slab-on-grade floor heating

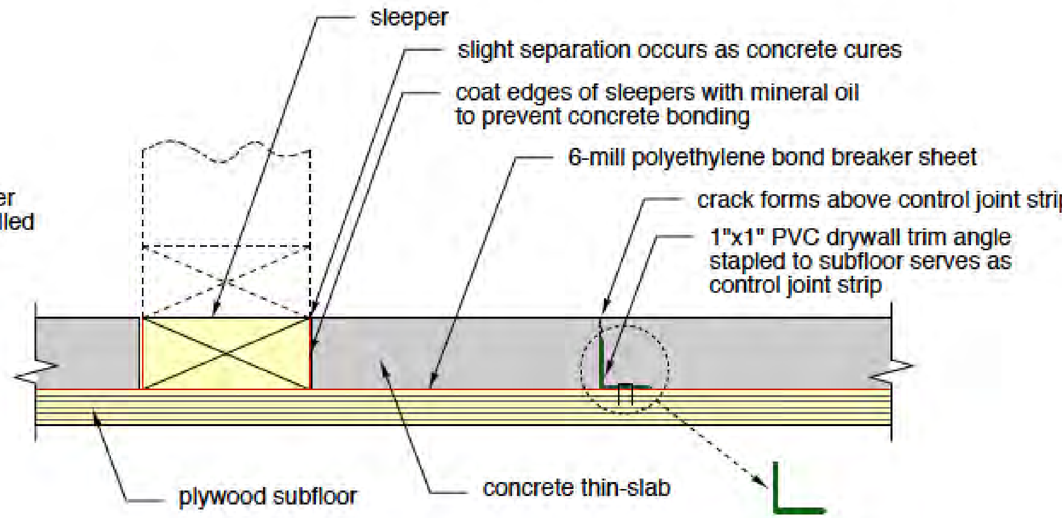




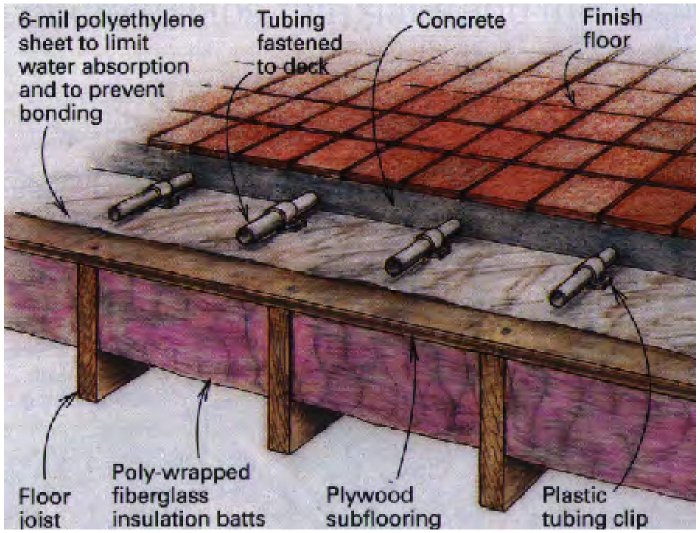
Recommendation: *Supply water temperature at design load conditions no higher than 120°F*

Thin-slab floor heating (using concrete)





Thin-slab floor heating (using concrete)



Strengths:

- Usually lower installed cost relative to poured gypsum thin-slab
- Operate on low water temperatures (good match to GSHP)
- Very durable, waterproof
- Medium thermal storage tends to smooth heat delivery

Limitations:

- Slower thermal response (best when loads are slow to change)
- Adds about 18 pounds/square foot to floor loading @ 1.5” thickness

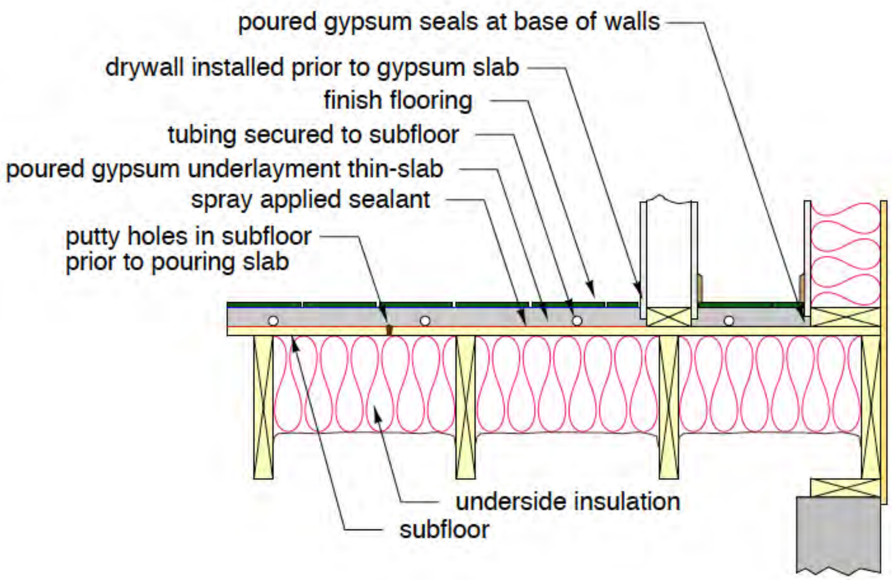
Always...

- Verify load carrying ability of floor framing
- Account for added 1.5 inches in floor height
- Install control joints and release oil on adjacent framing
- Install polyethylene bond breaker layer between subfloor and slab
- Pressure-test circuits prior to placing concrete
- Make tubing layout drawing prior to placing tubing
- Install R-11 to R-30 underside insulation

Never...

- Allow concrete to freeze prior to curing
- Pressure-test with water
- Place tubing closer than 9 inches to toilet flanges
- Cover with flooring having total R-value over 2.0°F hr/ft^2/Btu
- Use asphalt-saturated roofing felt for bond breaker layer
- Exceed 12” tube spacing

Thin-slab floor heating (using poured gypsum underlayment)



Thin-slab floor heating (using poured gypsum underlayment)

Strengths:

- Faster installation than concrete thin-slab
- Operates on low water temperatures (good match to GSHP)
- Excellent air sealing at wall/floor intersection
- Medium thermal storage tends to smooth heat delivery
- No control joints required

Limitations:

- Slower thermal response (best when loads are slow to change)
- Adds about 14.5 pounds/square foot to floor loading @ 1.5” thickness
- Not waterproof

Always…

- Verify load-carrying ability of floor framing
- Account for added 1.5 inches in floor height
- Pressure-test circuits prior to placing gypsum underlayment
- Make tubing layout drawing prior to placing tubing
- Install R-11 to R-30 underside insulation
- Use proper surface preparations prior to finish flooring

Never…

- Allow gypsum to freeze prior to curing
- Pressure-test with water
- Place tubing closer than 9 inches to toilet flanges
- Cover with flooring having total R-value over 2.0°F hr/ft^2/Btu
- Exceed 12” tube spacing
- Install in locations that could be flooded

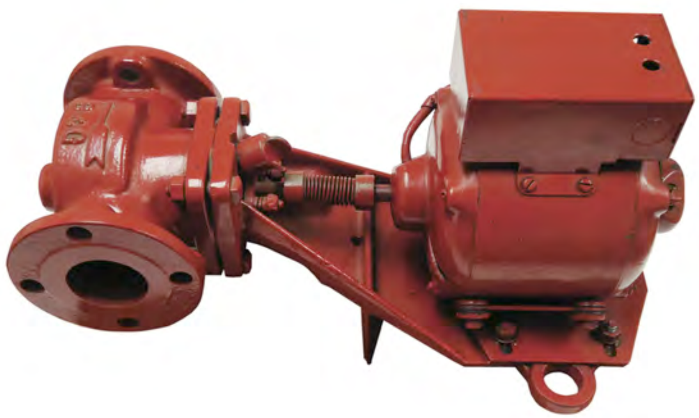
Circulators
(best practices)

Circulators

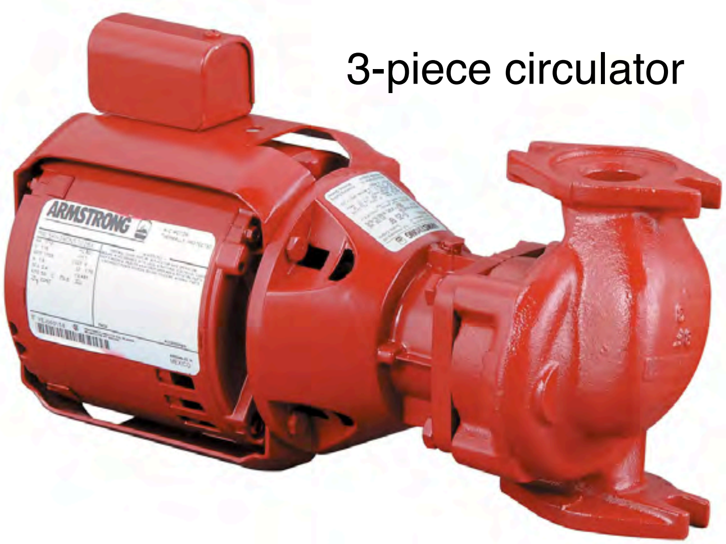
Types of circulators

“Standard” circulators with PSC (Permanent Split Capacitor), or shaded pole motors.

first electrical circulator 1930



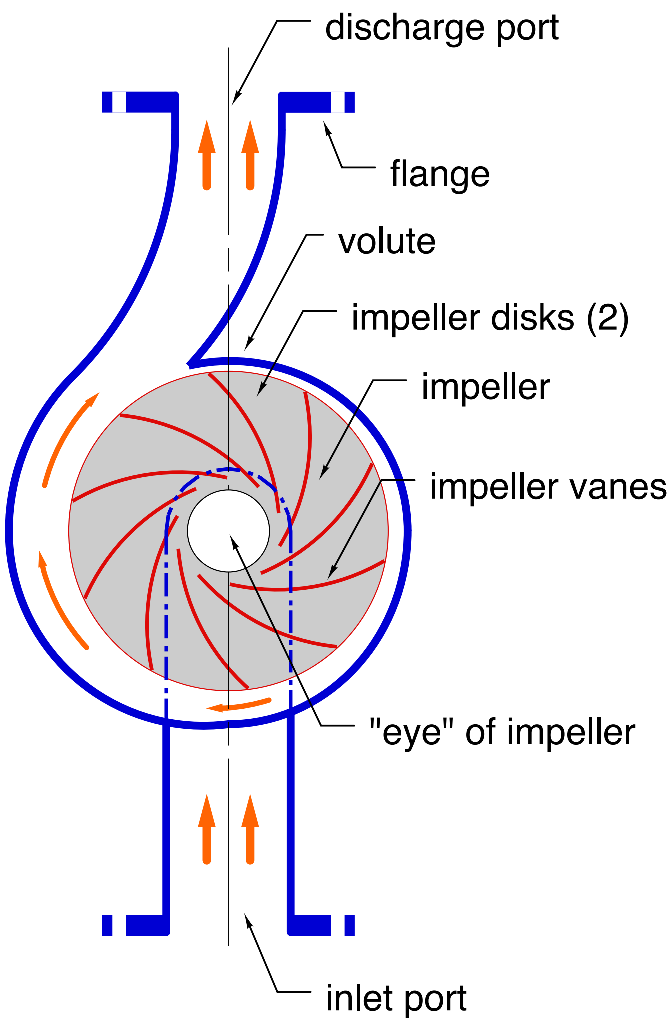
3-piece circulator

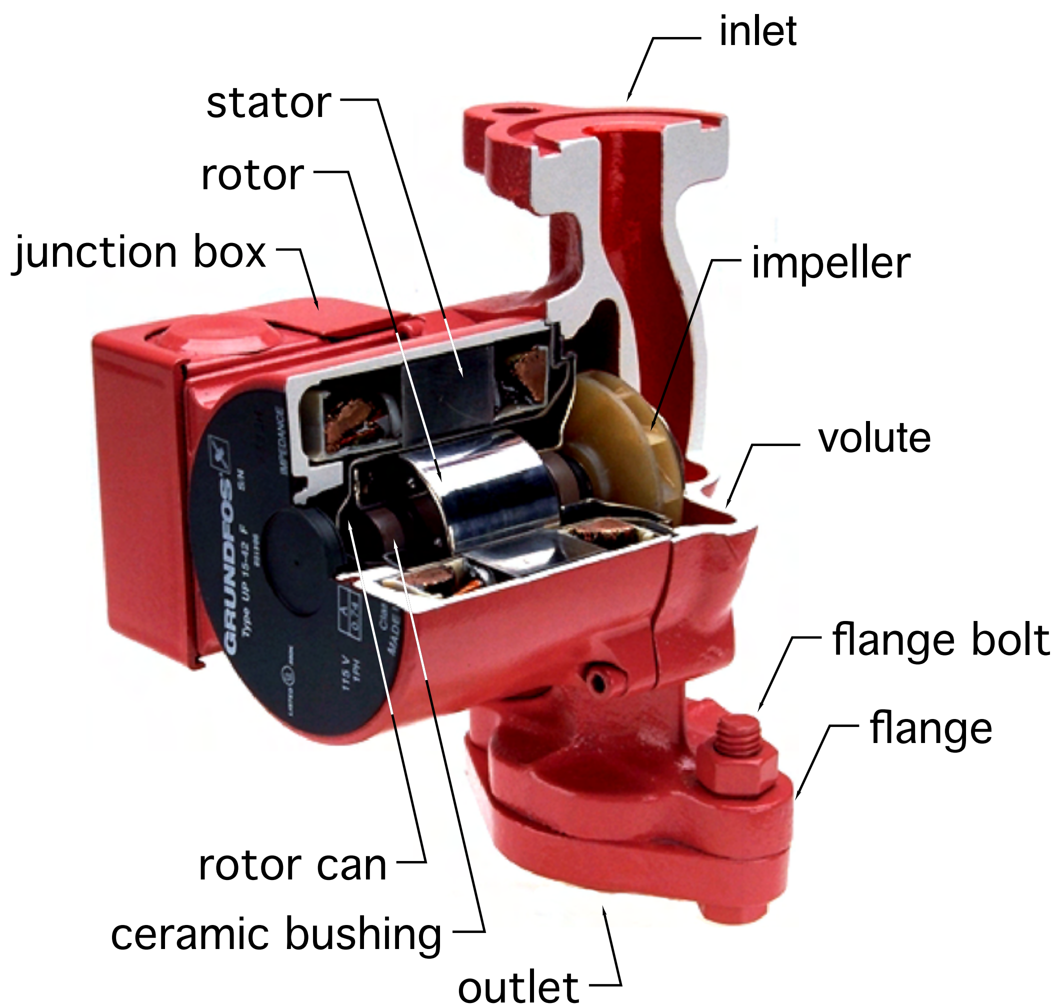


wet
rotor
circulators

Circulators

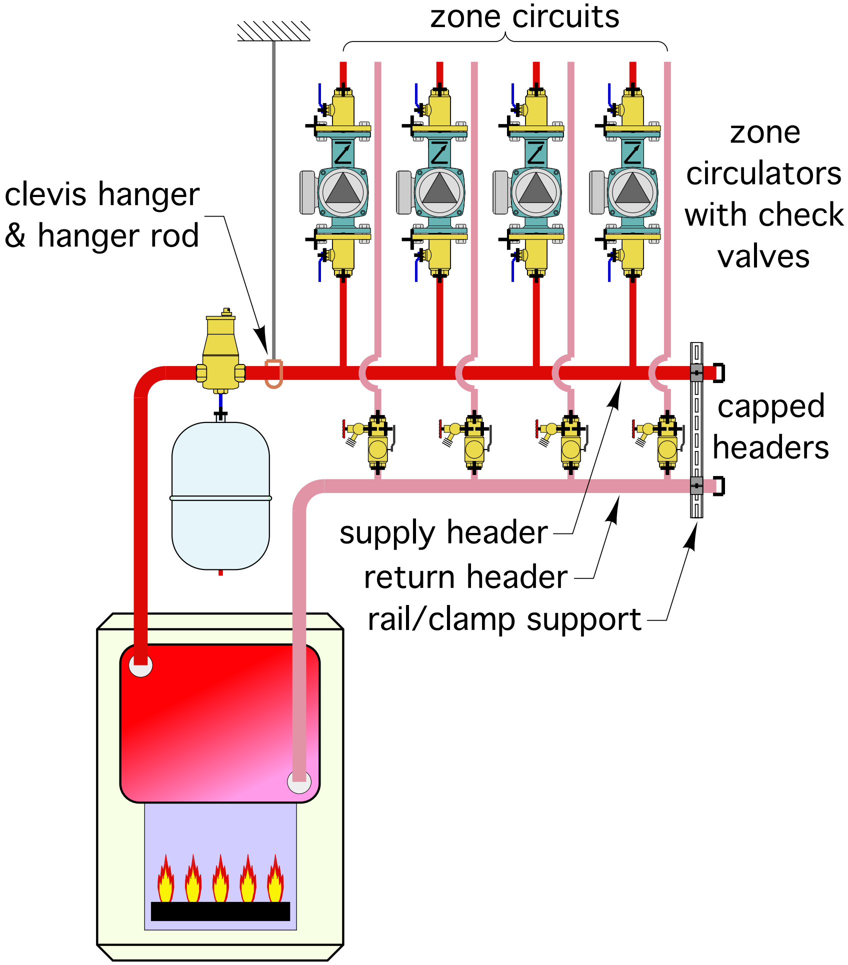
Wet rotor circulators





Circulators

Properly support circulators

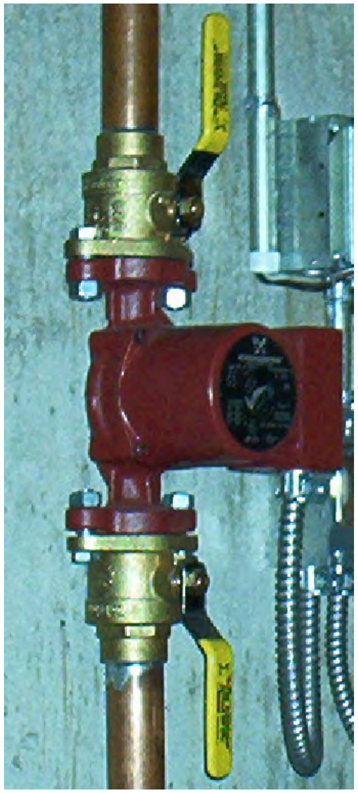


Design tip: Piping should be supported on at least one side of circulator, and within 1 foot of circulator.

Design tip: Always specify minimum of 12 diameters of straight piping on the inlet side of every circulator. This reduces noise.

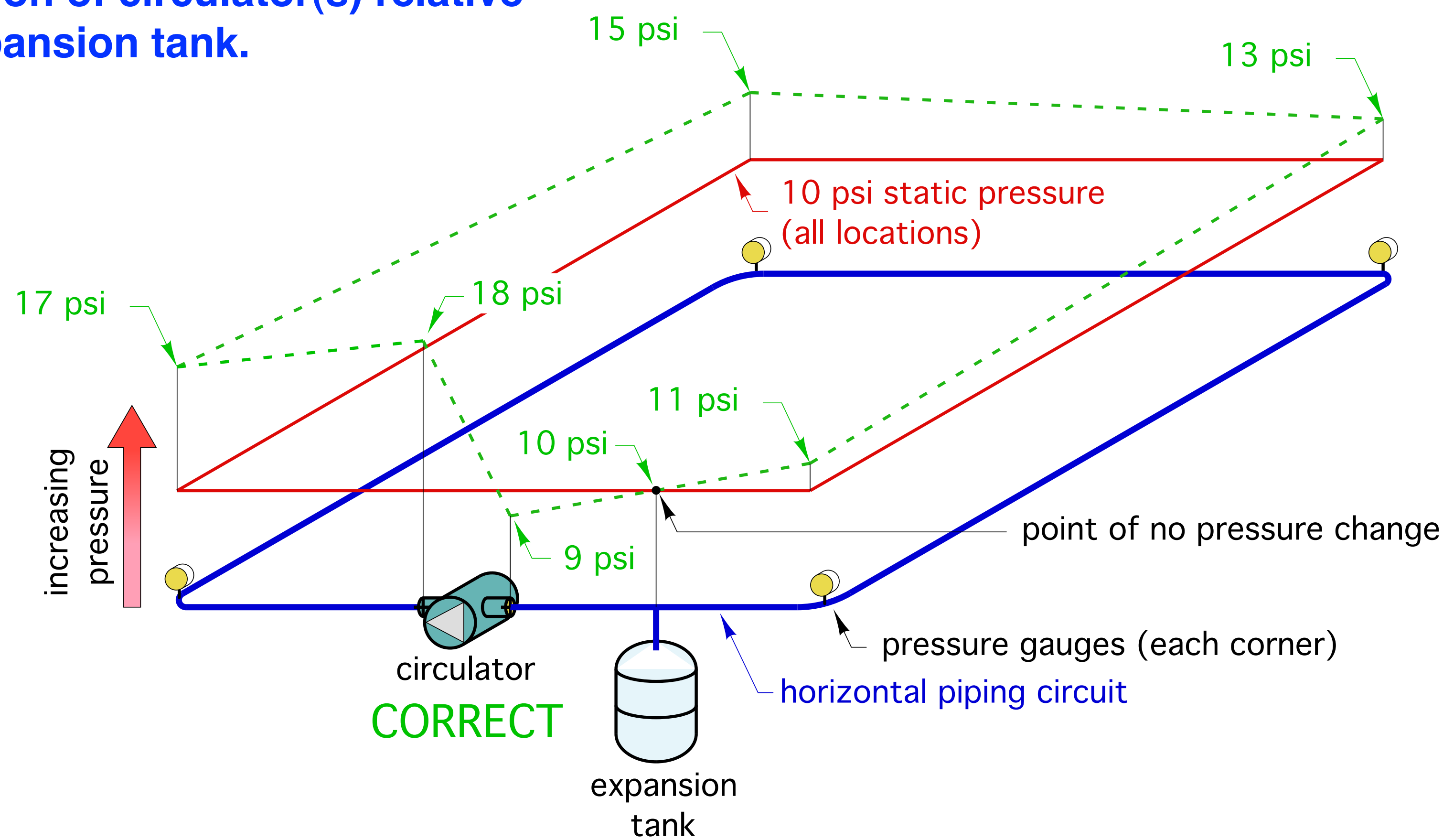
Design tip: Always mount circulator with shaft in horizontal orientation

Design tip: Preferred orientation of electrical connection to circulator is down with "drip whip" wiring to prevent possible water entry.



Circulators

Location of circulator(s) relative to expansion tank.



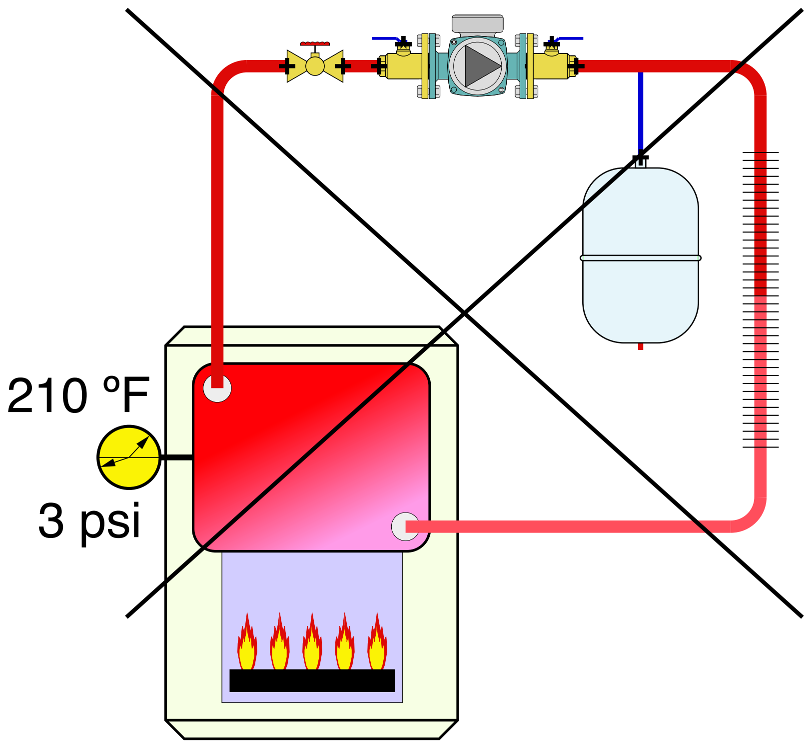
Design tip: Always "pump away" from the point where expansion tank connects to system.

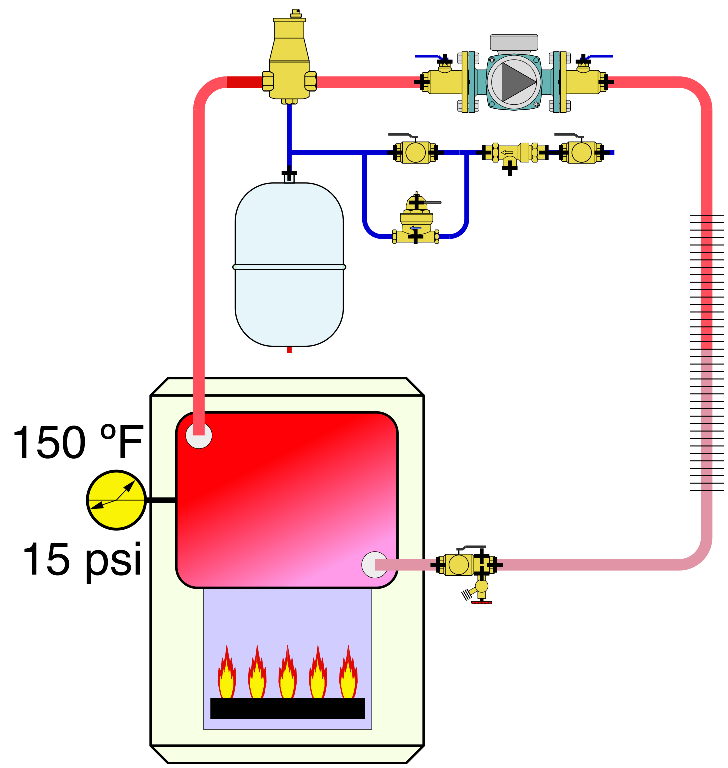
Design tip: It's not "pump away" from the boiler, it's "pump away" from expansion tank.

Circulators

Cavitation:

Design tip: Follow these *qualitative* do's and don'ts to avoid cavitation.





Design "inviting" cavitation
(what's wrong)

1. Low system pressure
2. Thottling valve near circulator inlet
3. Expansion tank near circulator outlet
4. High system operating temperature
5. lack of air separator and make up water
6. Turbulent conditions upstream of circulator

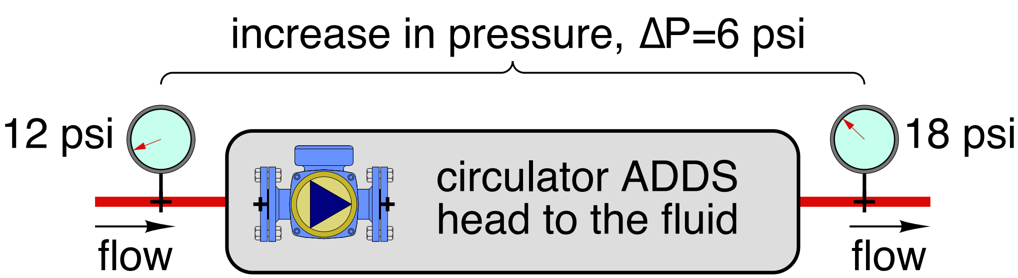
Design "discouraging" cavitation
(what's right)

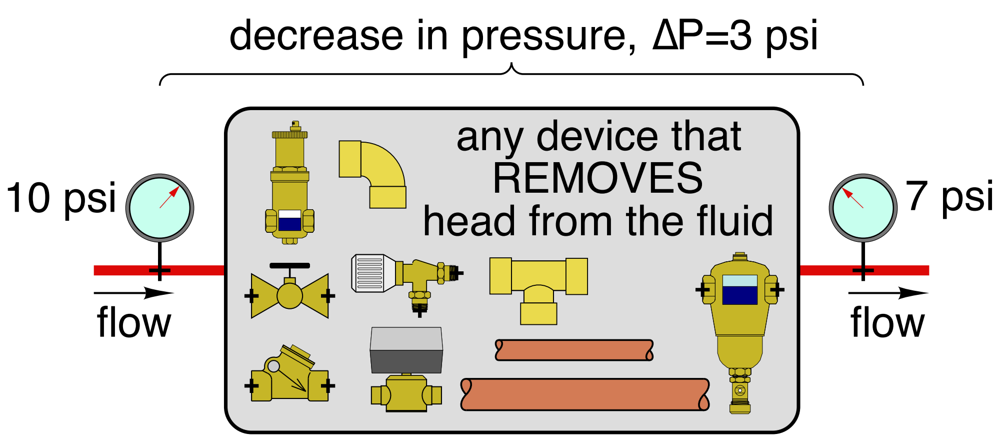
1. Higher system pressure
2. Proper air purging at start up
3. Expansion tank near circulator inlet
4. Lower system operating temperature
5. Use of quality air separator
6. Straight pipe upstream of circulator

Circulators

Head: The term "head" refers to the ***mechanical energy*** contained in a fluid.

Circulators add head energy to a fluid.





E*very other device through which flow passes* causes a LOSS of head energy.

The units for head energy are (ft•lb/lb)

$$\frac{ft \cdot lb}{lb} \qquad \frac{ft \cdot \cancel{lb}}{\cancel{lb}} = ft$$

Equation 6.6

$$\Delta P = H\left(\frac{D}{144}\right)$$

where:

ΔP = pressure change corresponding to the head added or lost (psi)
H = head added or lost from the liquid (feet of head)
D = density of the fluid at its corresponding temperature (lb/ft^3)

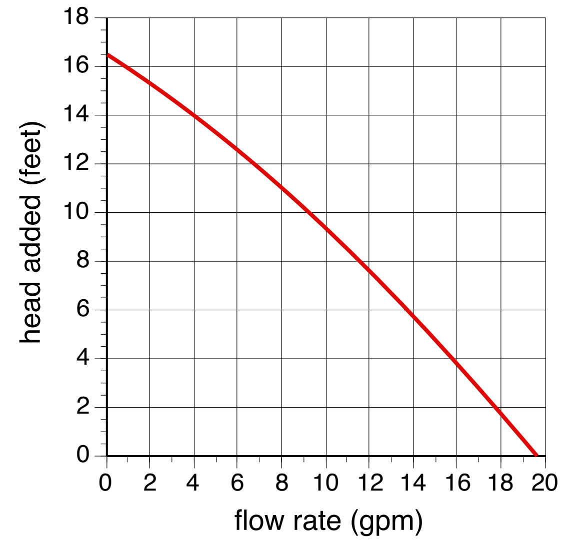
Circulators

Pump curves:

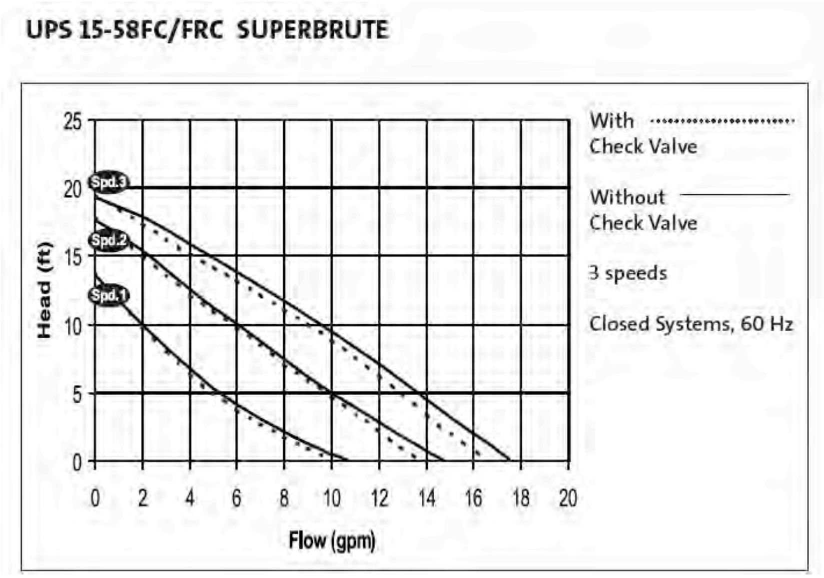
Pump curves show the mechanical energy (e.g., head) in ft·lb, added to each lb of fluid passing through the circulator.

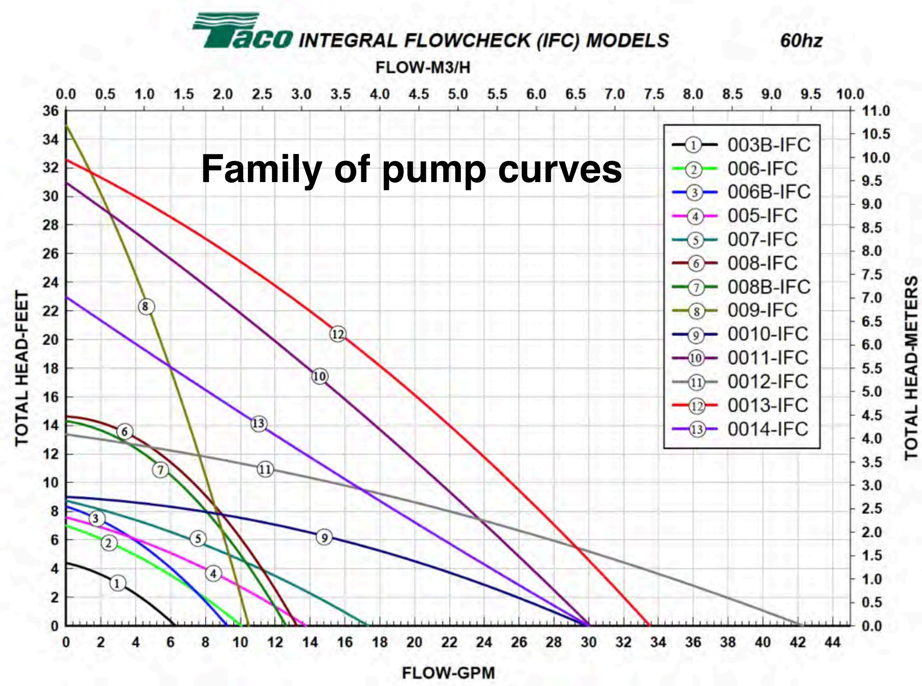
$$\frac{ft \cdot lb}{lb} \qquad \frac{ft \cdot \cancel{lb}}{\cancel{lb}} = ft$$

single speed pump curve



3 speed pump curves
(w/ and w/o internal check valve)





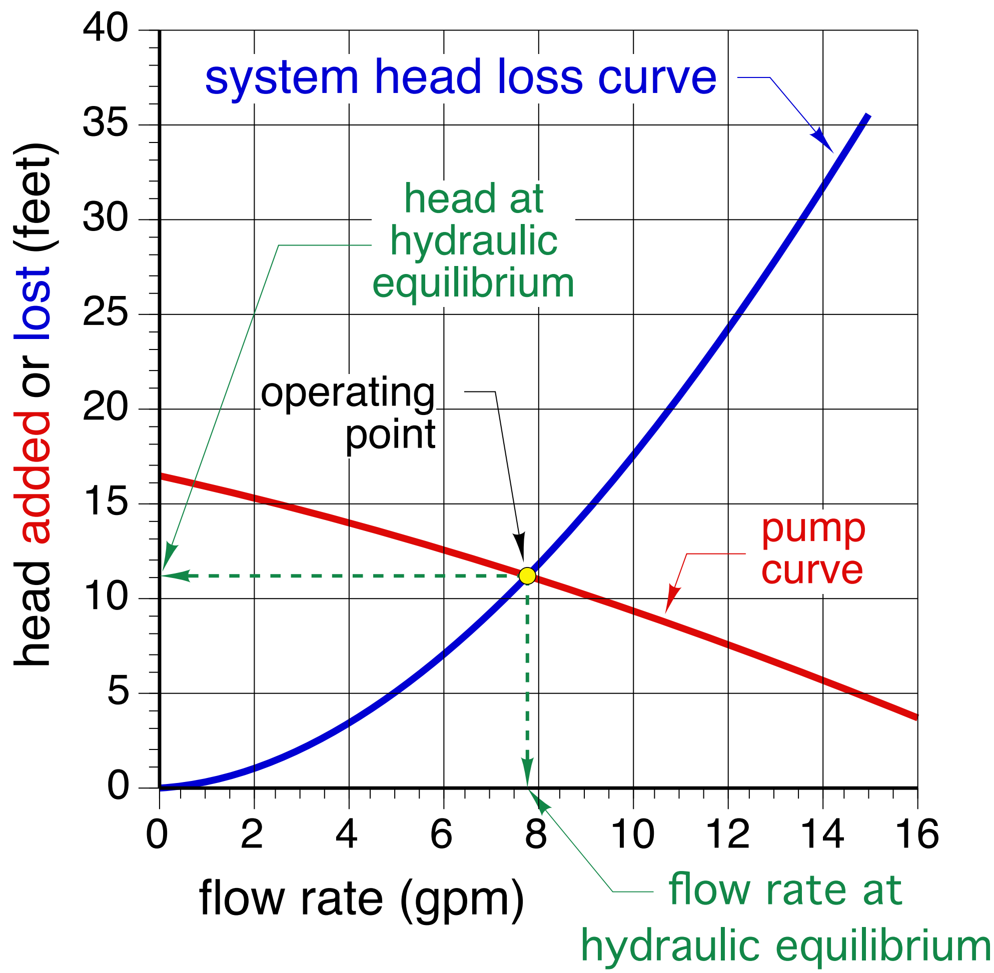
Circulators

Hydraulic equilibrium:

That condition in which the head energy added to the fluid by the circulator exactly balances the head loss (due to friction) of the fluid flowing through the circuit.

EVERY HYDRONIC SYSTEM will automatically establish hydraulic equilibrium within seconds of turning on the circulator.

Design tip: Just because hydraulic equilibrium is established, there is no guarantee that it will deliver the required amount of heat, or allow efficient operation of the circulator.



Circulators

Hydraulic equilibrium:

The *Hydronic Circuit Simulator* can instantly determine where hydraulic equilibrium occurs in a wide variety of piping systems, and with many specific circulators.