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Tubing size is decreasing in residential floor systems

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IN 1980 WHEN I installed a European floor heating system in my new home, the standard for European tubing diameter was 18mm OD (5/8-in. nominal-U.S.) for residential systems. So, that was the tubing to put in.

The system has been working for 17 years now and my family is still enjoying it everyday of the heating season. We still feel as we did after the first heating season — that it was the best investment we've ever made in our home.

Building construction standards, however, have changed dramatically over the past 20 years, both here and overseas. Twenty years ago 4-in. outside walls with R-ll insulation were standard here and the insulated glass industry was still in its infancy.

R-values have doubled and infiltration has been cut in half since then.

This has dramatically affected the way we design hydronic floor heating systems. Now 5/8-in. nominal tubing is the standard for commercial floor heating and snow melting; no one would consider using it for residential.

With Btuh-loads per sq.ft. of living space dropping dramatically year after year, tubing diameters in Europe have dropped as well, from 19mm (5/8-in. nominal) to 16mm (1/2-in. nominal) to 14mm (7/16-in. nominal) to 12mm (3/8-in. nominal) to 10mm (1/4-in. nominal). What's next? Heating your living room with a 100-watt light bulb?

Maybe not in our lifetime. We still need fresh air to breathe, which has to be heated. The standard in Europe is now 50 watts per square meter (17 Btuh/sq. ft.), a design heat loss we are approaching in most heating areas in this country as well.

Tubing diameter is irrelevant when it comes to heat transfer from the tubing to the surrounding floor sandwich, wet or dry.

The fact is, large-diameter tubing for residential floor heating is becoming a thing of the past. The real question, however, is what role do tubing diameters play when looking at Btuh-output per linear ft. of tubing in a given floor radiator sandwich?

The accompanying tables show the relationship of various tubing diameters between flow rates, circuit length, pressure drop, temperature drop and flow velocities.

Tubing diameter is completely irrelevant when it comes to heat transfer from the tubing to the surrounding floor sandwich, wet or dry. The amount of Btuh which can be carried by a circuit to satisfy its given floor space is determined by the following criteria:

A) Tubing spacing, which is important for even floor surface temperatures;
B) Water temperature drop (Delta T°F) across the circuit, which is directly related to the capability of the floor sandwich material to absorb the largest possible amount of Btuh from the tubing walls (remember, PEX tubing is a poor heat conductor) and distribute it evenly across the floor surface;
C) The mean water temperature going through the circuit (supply water temperature plus return water temperature divided by 2) must be kept as low as possible throughout the whole heat loss range; and
D) The flow rate (GPM) that's necessary to circulate through that circuit of tubing for proper Btuh delivery.

The last criterion is the fly in the ointment because of pressure drops and flow velocities. The question is how far can you reduce tubing diameters and still stay within reasonable pressure drops and flow velocities without having to use a circulator that costs more than the boiler and makes it tip over when installed. This becomes a balancing act between circuit length, pump sizing and temperature drop across the circuit.

coverings together with individual distribution stations and individual water temperature controls (a multi-temperature system).

For temperature drop (criterion B),

EXAMPLE	**1**	**2**
heat loss in Btuh	2625	4375
area in sq.ft.	175	175
Output in Btuh/sq.ft.	15	25
temp. drop in F (delta T)	25	30
flow rate per circuit in gpm	0.21	0.29
tubing spacing in inch	7	7
circuit length in ft.	300	300

inner diameter of tubing	flow velocity in ft/s		pressure drop for 300 ft. circuits	
EXAMPLE	1	2	1	2
$\frac{1}{4}$" Nom (7 mm)	1.13	1.57	9.6	17.06
$\frac{3}{8}$" Nom (10 mm)	0.55	0.77	1.76	3.12
$\frac{1}{2}$" Nom (13 mm)	0.33	0.45	0.5	0.9
$\frac{5}{8}$" Nom (16 mm)	0.22	0.3	0.19	0.33
1 capacity of low head circulator at 2.1 gpm on ft. of head				15.5
2 capacity of high head circulator at 3.5 gpm on ft. of head				22

These factors depend greatly on the system's tubing-to-floor heat transfer capability, i.e. what surrounds the tubing — concrete, aluminum on top of the subfloor or aluminum below the subfloor, and what the heat conductivity values are for these materials. All the above criteria are closely interrelated and affect each other in positive and negative ways. What's important is to adjust the maximum circuit length for each tubing diameter to keep pressure drops below 18 ft. of head and flow velocities below 3 ft. per second. This keeps circulator costs within reason.

Circuit temperature drops should be kept high — 25°F-40°F is ideal. This can be accomplished by grouping similar heat loss areas and floor using metal plates in dry systems and plasticizer in concrete systems are the traditional and best means to accomplish large temperature drops. Aluminum will always give you the most bang for the buck. Metal shavings in concrete mix have also been used successfully here and in Europe.

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