SZÉKELY ENGINEERING
EXPLANATIONS & EXAMPLES

The 60-Second Shower, *or*, Anyone Who Owns His Own Home Deserves It

The second clause above is the title of a 1962 book written by the (not recently) late Alan King, a comedian of some note back then. The first clause refers to a recent morning ritual brought on as proof of the truth of the book title.

Having become (along with my local lending institution) a first-time homeowner only 3½ years ago, I had until recently been insulated from concerns regarding the maintenance and upkeep of those systems which contribute to the relative comfort of living in the current age, among which, is on-demand hot water.

So, on the Tuesday after Memorial Day weekend as I trudged down to my cellar office, I spied water on the floor around my boiler and water heater. Having filled five 3-gallon pails with what I'd mopped up and discovered no evidence that the pressure relief on either my boiler or indirect-fired domestic hot water (DHW) heater had let go, I was left the depressing conclusion there was a leak in my DHW tank, confirmed when I re-opened its isolation valves when the plumber I'd called arrived to take a look.

While I noted the first time I saw a commercial for *Flex-Seal*, that the tape was always slapped on to a leak only about a foot below the water level in the transparent demonstration tank, hinting that it wasn't likely to do very much good against a leak in system pressurized to 40 or 50 psi, it was all I had after discovering:

- Most local plumbers were booked about a week ahead
- A replacement tank was not in stock anywhere nearby.

I was right – it doesn't do much against a supply system leak. The contractor who came for the replacement estimate remarked they keep the stuff on their trucks and have about as much luck with it as I had. It's also a bear to work with, sticking to the scissor or knife blades when trying to cut it. Forget about relocating or adjusting it after it touches what you're trying to seal.

So, as I write this, we remain engaged in a morning ritual where I open the DHW heater isolation valves and those between the boiler and the heater, run back upstairs to shower, and the run back downstairs to re-close the valves and drain the pan under, and wring out the towels around, the DHW heater, of the pint or so of water that was lost in the process. Should everything go as planned, by the time you read this, things should be back to normal, but all this got me to thinking:

What is Pressure Anyway and Did I Really Understand What Was Going on When my Elementary School Teacher Overturned a Drinking Glass Full of Water with a Card on the Top and It Didn't Spill?

So, if your Elementary School Teacher didn't perform the experiment, here it is.

Yeah, we all know pressure is force per unit area, usually given in terms of pounds per square inch psi in the English system of units. That is, pounds per square inch *atmospheric*. Zero on a gage reading (psig, pounds per square inch gage) is actually at 14.7 pounds per square inch absolute, i.e.; referred to a vacuum.

When we blow up a balloon, we are shown that property of pressure that it acts in all directions; one portion of the balloon's surface is not saggy or wrinkled while another portion is taut. Add to that the fact that in a tug of war the line goes in the direction of the team that exerted the stronger force, and it becomes obvious why the experiment works,

Doesn't it?

When we say atmospheric pressure is approximately 14.7 pounds per square inch, we're saying that force per unit area exerts itself in all directions, including under an overturned drinking glass full of water with a card covering its mouth.

So, if the drinking glass contains about a pint of water, which weighs about a pound, and its mouth is 3 inches in diameter, the area that pound of water is resting on comprises about 7 square inches, which, times the 14.7 psi of atmospheric pressure, has about 104 pounds of pressure keeping the card pressed to the glass against the pound of water trying to push the card away.

The card ultimately falls for the same reason that suction cups ultimately detach themselves – a gas can sneak into the tiniest space between solids. And when that happens the 14.7 psi begins to exert itself on the other side of the card too.

A pressure differential infinitely more subtle than 14.7 psi air pressure against the 0.14 psi of the water against the card, is, as I believe I've stated in earlier issues of this newsletter, why airplanes can fly.

To go through it again, the 174 square foot wing area of a Cessna 172 such as the ones I occasionally fly has to lift into the air 2550 pounds of (late model) airplane; a *wing loading* of 14.66 pounds of airplane weight for every square foot of wing, which, at 144 square inches in each square foot is about 0.1 pounds per square inch, so all the wing has to do is to get the atmospheric pressure at the top of the wing down to 14.6 psi so the 14.7 psi on the bottom of the wing can lift the plane into the air. Even stretch jetliners need a pressure differential of only 1 psi or so, or about 13.7 psi above the wing.

Continuing this explication after a 7-month layoff between the time I started writing this issue and now, it's been about a week since a fuselage door plug blew off a 737 Max 9 at 16,300 feet six minutes after takeoff from Portland International Airport. While it's too soon to offer theories as to what exactly happened, the pressure differential between the approximately 11 psi cabin altitude pressure of 8000 feet maintained by the pressurization system and the 7¼ psi or so standard atmospheric pressure at 16,300 feet exerted a force of nearly 8000 pounds on the plug or about a ton of *static* force against each of the four bolts holding the door plug in place, assuming the load equally distributed among them. If loose or missing bolts, allow the plug to shift from or fracture its guides, 8000 pounds will pop an approximately 80-pound plug as easily as a champagne bottle pops its cork.

Hydronic Radiant Floor Engineering Data

Building peak heat loss calculations are pretty straightforward, as are the required outputs and preferred locations of the heat sources to counteract those losses when dealing with, for want of a better term, point or linear source heating elements such as baseboard, cabinet, or unit heaters, and the like.

Radiant floors are somewhat more complicated as well as different. That is, while baseboard is run at the exterior walls*, preferably at the locations with the greatest heat loss, i.e., the windows and doors, and no one's going to be touching a heating element which is at, near, or greater, than the temperature of boiling water (which is a driver behind enclosing cast iron steam radiators), radiant systems cover the entire floor where there's little or no heat loss from core areas, and people have been known to walk on floors in bare feet.

This last thing dictates a floor surface temperature of between 70 and 80 degrees Fahrenheit with water temperatures of about 100-110 degrees Fahrenheit or so, depending upon floor construction, where the low water temperature requires a condensing boiler or primary-secondary pumping to decouple the low-temperature floor loop from the high-temperature boiler loop.

When one looks for tubing heat outputs and friction losses to size a hydronic radiant floor system and its pumps, things begin to get even more murky. Radiant floor outputs, when one can find them, are listed in BTUH per square foot of floor, where tubing spacing is usually 12", going down to 9" at exterior walls and 6" at windows, where possible – this seems like it's easier said than done, and whole-floor coverage can lead to overheating core areas.

All that said, the current consensus sits at about (again, depending not only the heating load, but also the type of floor construction) 2 BTUH per square foot per degree temperature drop between supply and return water temperatures or 20 BTUH per square foot at a 10 degree drop where flow rates are usually no more than 1 gpm through ½" PEX to 3 gpm in 1" PEX.

With a British Thermal Unit being the amount of heat to change the temperature of 1 pound of water by 1 degree Fahrenheit, the above numbers are built around the fact that 1 gallon per minute of flow amounts to approximately 500 pounds of water going by in an hour (the *H* in BTUH is BTU's *per hour*) where the flow rates are so low because there's so much water in a radiant floor system.

*Well, it should be, but in my home the system was apparently designed by a contractor who was most concerned with circuit piping lengths with the result that I have baseboard against partitions between rooms in some cases.