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ADVENTURES IN
HYDRONICS HEATING

With Dave Yates ▶ **VOLUME 3**

A SPECIAL MESSAGE FROM DAVID YATES



ADVENTURES IN HYDRONIC HEATING WITH
DAVE YATES

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EDITORIAL COLUMNS

Murder in the boiler room

Forensic investigations into mechanical mayhem.

It's been said that dead men tell no tales, but the gang of murderers I was investigating just might not be dead — yet!

View to a kill

I was invited to investigate the murder scene and determine the cause of death. She'd obviously been mistreated and neglected during her short life. It was plain to see that gluttony had been one of her vices. Her guts were strewn across the basement floor. With a normal life expectancy of 50 to 100 years, 14 was much too young to die.

It would be far too easy to have history repeat itself and subject the next victim to the same abusive forces of nature — after all, that's what others had already proposed to do. No one would be the wiser, except for me, and life would go on as the new gal would silently suffer until at death's door.

The owner of the property and I stared at the disemboweled body parts, and she wanted to know: "Can she be saved?"

"No, and I'm not sure you'd want to save her," I replied. "She's cost you an arm and a leg to keep alive?"

"You have no idea! She practically ate us out of house and home. Why'd she have to die so young?"

The investigation

The answers required we visit the three apartments above. I'd already eyeballed enough mechanical mayhem in the basement to determine things done with murderous intent: Failure to read the manufacturer's instructions by not following the drawing for near boiler piping; steam pressure set way too high; bellies in the one-pipe steam branches from



main to risers; and a Btu input that appeared to be twice what I'd expect for this three-story, three-apartment row home.

I needed to survey the connected load, and I explained what that meant as we moved from basement to foyer. On the first floor, the little old lady who greeted us with a deep pneumonia-like cough was alarmed I'd think her apartment a mess.

"I've been in hospital Mr. Plumber," she said with a thick accent. "My son and his wife took all my money, my house and left me with nothing. I do the best I can, but I've been too sick to clean."

Funny how in the blink of an eye, you're suddenly involved in someone's life and how much they appreciate a kind word or two. If she'd known a murder took place in the basement — while she slept — she'd have come unglued!

As we talked, I measured each radiator for its style, height and number of sections. My Burnham Heating Helper Booklet would later reveal each radiator's square footage of equivalent direct radiation.

“It would be far too easy to have history repeat itself and subject the next victim to the same abusive forces of nature — after all, that’s what others had already proposed to do. No one would be the wiser, except for me, and life would go on as the new gal would silently suffer until at death’s door.”

On this floor, unwitting accomplices to murder lurked in almost every room: Air vents missing their adjustable caps; one-pipe radiators pitched the wrong direction; and more than one valve partially closed in a failed attempt to regulate heat.

The second floor was vacant with the system’s thermostat located in a room where the radiator was covered by a thick curtain, and my instincts told me it was too small for such a large room. Huge single-pane windows, with drafty hollow wood sashes that house counterweights, rattled in the light fall breeze. Things you can’t know unless you get out of the boiler room and visit all of the crime scenes. Antique non-adjustable air vents were the norm on this floor.

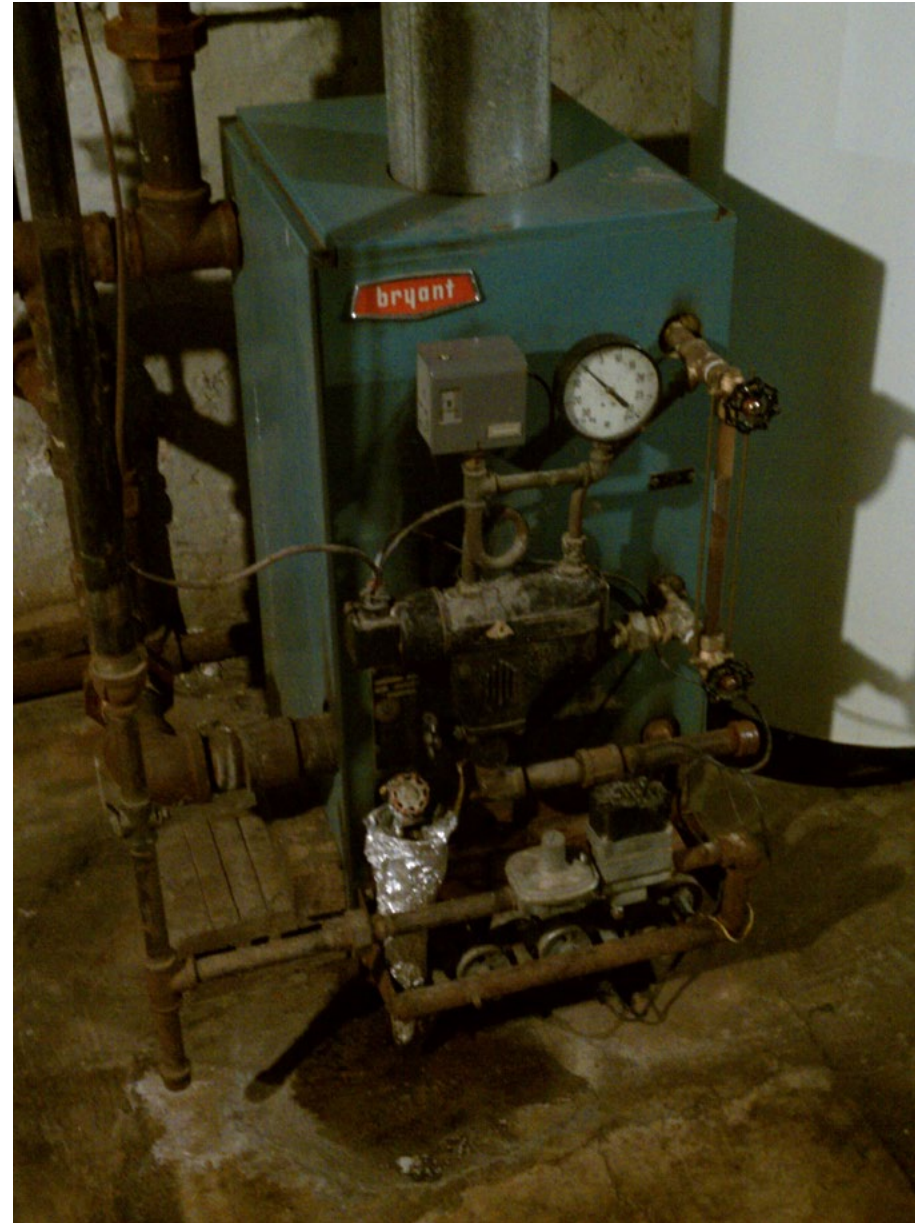
“Having a tough time balancing the heat between floors?” I asked the owner.

“Oh my, it’s been a real nightmare. No one ever seems happy, and the tenant on this floor ended up using the windows to regulate the heating!”

The third floor radiators had vents with missing caps, with one turned upside-down and more radiators tilting away from their single feed/return.

“Does it sound like a coffee pot percolating when the heat’s on?” I asked.

“Exactly, but how’d you know that?” The owner replied.



A neglected steam boiler.

The verdict

As we returned to the basement to gather final measurements, I explained was now ready to determine how she died and why those fuel bills had been so outrageous in past years. I also explained we'd be replacing the near boiler piping to allow the new boiler to live and breathe properly with dry steam being sent in ounces, instead of pounds, to the outlying radiators that would be balanced and silenced.

“No one else bothered to go upstairs to measure radiators for what you called the connected load or ask me so many questions about problem areas. How soon can you let me know how much this will cost to fix?”

Did that take longer than simply repeating the murderous history the previous installer(s) inflicted on a beautiful cast iron beauty? It did: I won't deny it takes more time to get the facts straight, but it's a forensic journey that offers challenges and opportunities that are rewarding in many ways.

The connected load and corresponding pick-up factor (to bring all the steel piping up to temperature) was less than half of the deceased boiler's net I=B=R rating. The deceased had overeaten and never exercised properly. Sustained flue gas condensation, caused by short-cycling, rotted out her belly and she bled to death. The new gal will be fit and trim with excellent prospects for a very long life.

Doing your homework separates you from the knuckle-dragging, low-ball bidders who compete on price alone — you can be the highest bidder and still get the work.

Not worth the lie

On another cracked boiler from a run-away dry fired destruction, we piled up the cracked sections in the bed of my pickup truck to take pictures for the owner's insurance company. The low-water cut-off was fouled with sludge. Once filled with sludge, its internal cigar-shaped copper float was unable to drop down, along with the



Cracked cast iron sections of a neglected steam boiler.

“Doing your homework separates you from the knuckle-dragging, low-ball bidders who compete on price alone — you can be the highest bidder and still get the work.”

receding water level, to break the voltage circuit, which would have disabled the burner.

Had the owners been doing regular blow-down, as required, to keep the float chamber free of sludge and debris? Of course not. I was pretty sure the claims adjuster was going to ask — given this likely wasn't likely his first rodeo — what caused the boiler to crack so dramatically. I told the homeowner I was not about to expose myself and/or my firm to an insurance fraud charge. He was furious and demanded I lie.

As you might expect, the claims adjuster did ask if the boiler was properly maintained. The homeowner wanted me to state we had performed regular maintenance, when, in fact, this was the first time we had ever been called to their home! I responded with the truth: This was our first ever visit; and the low water cut-off was inoperable due to buildup of sludge. The homeowner fired us — on the spot — but we maintained our integrity, which is a precious commodity that once lost is virtually impossible to recover.

Over my 48-year career in the trades, numerous “customers” have asked me to lie or shade the truth so they could collect from their insurance company. The old saying: “Why lie when the truth will do” comes to mind.

Long story short, insurance companies came to realize we were honest and have, on multiple occasions, hired me to do forensic investigations to ascertain the truth where mechanical mayhem and murders in the boiler rooms have happened.



Cracked cast iron sections of a neglected steam boiler.

Perfect Together

Brute FT® Wall Hung + PowerStor Series® Indirect Water Heater.

The Brute FT®'s modulating technology automatically adjusts fuel usage to match heat demand – saving up to 20% on heating utility bills compared to standard “on-off” boilers! It's available as a combi boiler/water heater or heat-only boiler, which you can pair with a PowerStor Series® indirect water heater for a perfect hydronic solution.

Find out more at our website
dedicated to the professional:
bwforthepro.com



Hydronics 101

How I became an adjunct professor at Thaddeus Stevens College.

“Hey, buddy, can you spare a buck?”

“Get a job, like the rest of us,” you think to yourself.

But what if it was, “Hey, buddy, can you spare a few hours to share some of your knowledge so I can get a job and become productive member of society?”

What would your response be to that question?

In 2004, I received the following e-mail from **Steve Phyllaier** a freshman HVAC instructor at Thaddeus Stevens College of Technology:

“Dave, would you consider giving us an hour or two of your time? I realize this is very short notice. We are devoting the rest of this semester to radiant heating, and I would like to invite you to address the subject with my students. I know I have a lot to learn about this and feel it is one of the more important heating topics I could cover in our program. Would you have time to come some afternoon next week?”

Are you kidding? Hydronics, especially radiant heating, is a passion that has challenged me with a career-long learning curve, which shows no signs of having an end. An opportunity to share that passion was a siren’s song not to be ignored.

The hydronics elephant

Although I’d heard about [Thaddeus Stevens College of Technology](#) (TSCT), I was not at all prepared for what I’d discover. Nestled among residential and commercial properties and just a few blocks from the square in downtown Lancaster, Pennsylvania, I came upon the TSCT campus. In my mind’s eye, I thought I’d be seeing something like an old high school building. Instead, I found myself driving across a sprawling



TSCT students learn about hydronics.

college campus that was impressive in its scope and architecture. I located the HVAC lab and quietly entered from the adjacent parking lot. Inside, I encountered students actively involved in hands-on HVAC work — trouble-shooting various pieces of equipment.

The parable about blind men being presented with an elephant came to mind. Each was positioned at various parts, and each, as you’d expect, came away with a different opinion regarding what an elephant was. Each was so adamant his perspective was correct that they came to blows over the issue! If only they’d had someone to give them an overall view of that elephant before the physical encounter. Fortunately, no one here was fighting. Instead they were keen on learning.

In two hours' time, I tried to give an overview of hydronic radiant heating. Almost as soon as I began, I realized I couldn't do the subject justice in such a short time-span. Although it went well and the students were attentive, they weren't in a position for a blind encounter with the elephant that is hydronics. More time, much more time, would be required on Professor Steve's part to fill in the blanks and give them sight.

Church lesson

Fast forward two years and another e-mail from Professor Steve:

"Will you be available to share your knowledge and experience in hydronics/radiant floor heat again with our class? I am scheduled to go to the ARI HVACR & Plumbing Instructor workshop April 5 & 6. It would be nice to know I would have someone to substitute that has so much to offer our students."

With two days to share and more time to prepare, I felt compelled to say, "Yes, I'd be delighted."

The following day, while performing an estimate in a church complex, it occurred to me I was looking at, and walking through, a perfect teaching opportunity.

The owners had two major concerns: A carbon monoxide incident and high fuel bills. The mechanical equipment included a steam boiler with a very old one-pipe steam system; a steam-powered, hydro-air unit; a multi-zone, hot-water boiler; and a forlorn, road-wear, copper-tank water heater just one year younger than I am!

During the connected-load and heat-loss survey, it was apparent there were imbalance issues. For instance, the pastor's office and study were both hotter than the hinges of... well, you get the picture. Other areas suffered too. More than once, I was asked why I was measuring rooms and radiators and, more than once, I was told other firms had not bothered to check these issues, much less ask any questions. History repeaters!

In military jargon, this tangled heating mess would be termed a target-rich environment! A return trip with camera in hand would allow me to use this for a classroom digital fieldtrip and give the students practical lessons based entirely in reality. It would also give me an opportunity to address issues regarding social interaction with the customers they'll face one day and, just maybe, give them insight into why all employees are in sales, no matter their position in a company.

Sales are built on trust and the previous outfit had lost this customer's trust. It would be worthwhile to examine why and what could have been done by the last mechanic that would have salvaged, solidified and bonded that trust. Doubts had been building, but that CO incident and the half-fast repair had sent this group of church administrators looking for salvation.

I began thinking about all the ways to present this to a classroom filled with students who hadn't yet defined what this elephant called hydronics encompassed. Striving to turn back the hands of time some 36 years, so I could remember what I would have appreciated having someone teach me, was more of a challenge than I first thought.

How could I strip away all the things you and I take for granted when viewing the elephants we've come to know so well and begin anew? My plan began to become a nightmare filled with challenge after challenge!

Teaching looks much easier than it is if you're going to be well prepared for dispensing information in a structured and logical manner. So much of what we do is built upon foundations long forgotten and taken for granted. I had to root around in the cellar of my mind to find those support mechanisms and then transfer them onto paper.

Hydronic helpers

One of those foundations was staring back at me from my desk — the Burnham Heating Helper booklet. Chock full of useful information,

a copy has been my constant companion for longer than I can remember, and a resource I rely on almost daily. In it, I saw lesson plans beginning to take shape.

Copies would be needed and time was growing short — I needed help! **Glenn Stanton**, one of this industry’s best resources and a trainer for Burnham, has a well-deserved reputation for service above and beyond the call of duty. I emailed Glenn to request a dozen copies of the HH booklet, and he responded he’d be delighted to help.

The following day, Glenn contacted me to say he only had a few copies, and that company-wide, none was to be found. The new printing wouldn’t arrive until the week following my class. He promised to see if he could find some additional copies.

True to his word, a package arrived two days ahead of class with the promised Burnham Heating Helper booklets. When I dispatched hearty thanks by e-mail, Glenn simply said he was just doing his job. Today it’s available online at www.usboiler.net/heating-helper-your-fingertips.html.

Dan Holohan, no stranger to helping those in need, read a post I’d put up on The Wall, the active and educational bulletin-board maintained on his www.heatinghelp.com website, and volunteered to donate anything needed for the students. I asked for copies of his “Pumping Away” book, which is a great introduction to the world of hydronics. They too arrived just in time for class.

The students arrived on time and settled in for what must have been a bit of a surprise. Instead of launching into the mechanical lessons, we spoke about customer relationships, how to build trust and how trust leads to sales.

We spent the first hour discussing how your looks, mannerisms of speech, smell, breath and overall listening skills can make or break a customer relationship.

Following an overview of the digital fieldtrip they’d be taking, I laid out the basics of the boiler room and they saw each of the components — just as I did on my first visit. We started with the steam boiler.

“A return trip with camera in hand would allow me to use this for a classroom digital fieldtrip and ... give me an opportunity to address issues regarding social interaction with the customers they’ll face one day ...”

Real-world scenario

First lesson: A timed dial-test of the gas meter, conversion calculations and a comparison to the boiler’s rating plate, which revealed it was being force-fed gas at twice its rated input! Digital pictures revealed the telltale soot streaks where pressurized combustion gases sought escape.

“Can you say CO?” as Mr. Rogers might have intoned.

We talked about digital combustion analyzers and why testing would have revealed the CO issue before it could kill a customer or the trust they had built. The pressure controls were set to deliver steam at 6 to 9 pounds in a system originally designed to operate with ounces of pressure.

Boyle’s Law tells us volume is halved as pressure is doubled: The higher the pressure, the greater the volume of steam required to fill the same space. More steam equals higher fuel bills. The connected-load survey required to properly size a steam boiler was accomplished with a combination of digital pictures, a scale drawing of the church and equivalent direct radiation calculations using Burnham’s Heating Helper booklet.

Bare steel piping output (utilized to heat the basement youth hall) was included in the lesson plan and added to the accumulative sheet for connected-load totals along with the system pickup factor. That gave them the ability to “see” the total system and that it was grossly oversized.



These TSCT students were bright and energetic as they became aware of their potential in real-world scenarios.

By getting out of the boiler room, they also “discovered” a long-neglected and forgotten condensate receiver/pump unit that was buried under a pile of junk. By all appearances, the last time it was checked might have been around 1920! They were beginning to see that it pays to get out of the boiler room and be observant if they’re going to be better-than-average technicians.

But they weren’t finished with this steamer — not yet. Back in the boiler room, they next checked the feed-water tank and observed it puking heated condensate to the floor drain — for minutes during every heating cycle. Given the gallons lost and fluid temperature, their next worksheet required them to calculate how many wasted Btu were disappearing down the drain.

“After all the surprises discovered in the steam system, they seemed to anticipate the litany of issues “seen” during the digital odyssey from boiler to pump manifold to heat emitters and back again.”

A hot-water boiler in this mechanical room had many issues too. Before they could “look” at it, however, they needed to consider one remaining item connected to the steam system: The hydro-air unit serving the basement recreation hall, a 40-foot by 65-foot space.

The two steam zones utilize proportional zone valves — a very expensive repair item should either of them require service. Switching to hot-water thinking mode, they were given a worksheet to calculate the heat loss, rather than connected load. It was a real delight to observe these bright and energetic students as they became aware of their potential in real-world scenarios.

They next performed additional heat-loss calculations and some oddities in system performance by virtue of questions asked during my initial survey/interview with the occupants. You can’t know if you don’t ask! After all the surprises discovered in the steam system, they seemed to anticipate the litany of issues “seen” during the digital odyssey from boiler to pump manifold to heat emitters and back again. Holohan’s “Pumping Away” book helped them understand why the pumps should be relocated and that the water-feeder was connected at the wrong spot.

So much to learn, so little time! My two days flew by in the blink of an eye, or so it seemed to me. You wouldn’t think you’d get to see the measure of a man in such a short time, but I did and I was very impressed by these young men. They’re beginning a journey filled



Dave Yates (far left) with the TSCT class showing their copies of Dan Holohan's "Pumping Away," and Burnham Heating Helper booklets.

with adventure, never-ending challenges, life-long learning and opportunities none of them can imagine.

I know their potential, and you do too because we've walked along the same path they're just beginning. Years from now, I hope, they too will take some time to give a group of young men and women a glimpse into their potential future, challenge them and give back to the industry.

Dan Holohan understands that well. The week following my teaching experience, a case of "The Lost Art of Steam Heating" books

arrived — unannounced! They were given to the students a few days later and will serve to drive home the lessons learned in class as well as challenge them with much more than we covered in class.

You too can have a positive influence in the lives of those who want to learn about and have a career in the trades. You know how to do the work; they need you to share that knowledge. Straightforward practical lessons based on actual jobs you've performed can (with a little thought and work) be turned into classroom lessons. Live, learn, teach.



CASE HISTORIES

Turning routine estimates into opportunities

Sales 101: How to separate yourself from the competition and get the customers' attention.

“Thank you for the opportunity to provide pricing for your new heating systems. While we could simply provide you with quotes for new boilers, that wouldn't resolve the current concerns. It would, in fact, repeat the history that created the problems. In the following pages, you'll find a number of issues revealing the tangled mess which has greatly contributed to your existing issues, including high fuel bills and carbon monoxide. If you have any questions or wish to have me meet with your committee or members of the congregation to go over the details, I will do my best to accommodate your schedule.”

While my proposal wasn't quite what they'd asked for, it was the only way I was willing to approach the job. In order to fully explain why I felt that way, I'd like to invite you along on an investigative tour — a bit of forensic hydronics work — and let you decide the best course. So, if you're up for a wee bit of fun, let's roll!

A non-routine call

One thing commercial and residential heating/cooling applications have in common today is the advent of ultra-high-efficiency products that incorporate smart-logic to squeeze energy dollars and reduce parasitic energy losses to a bare minimum.

While we've enjoyed that opportunity on the furnace-side of the aisle; boilers, water heaters, A/C and heat pumps are no longer a slouch where efficiency ratings are concerned. Sales opportunities for upgrading to high-efficiency equipment make perfect sense —



Pictured here is the steam hydro-air on the left; steam condensate receiver/pump and freed-water tank at the bottom right; and hot water distribution piping and circulators at the top right.

if presented to the customer(s) as a sound investment, rather than focusing on a payback period of time (typically years).

The call from the York County Council of Churches (YCCoC) was not exactly routine. The first concern expressed centered on a CO incident, which had required a building-wide evacuation. CO is something we take seriously; that's the main reason why we switched from our old dumbbell chemical combustion analyzers to precise electronic combustion analyzers.

I first met with Rita Hewitt, the director of YCCoC, and she left no doubt the CO incident was the driving force in their request for bids. Hewitt expressed the issues in this order: CO incident — need to know what happened and why; high fuel bills; need a firm quote; small budget, so sharpen your pencil; getting other bids; and if you get the nod, how soon could you start?

The investigation

Before I visited the mechanical room in this sprawling church complex — which included a sanctuary with a high vaulted ceiling and very



The old, tired water heater.

large single-pane, leaded stained-glass windows; a Youth Hall and large office under the sanctuary; multiple double-door entryways; a classroom building; and an office complex — I wanted to get a feel for how the occupants felt about overall comfort. As it turned out, there were numerous issues: Rita's office was a sauna-like sweat-box; several areas were cooler than staff liked; and the Pastor's office complex was hotter than h-e-double-hockey-sticks!

Convectors were the primary source for heat emitters, but there was a heat-pump serving several offices, too, and Rita's just happened to



Pictured is the steam boiler on left with the hot water boiler on right.

have a wall-to-wall convector and a ceiling supply register — a double-dose of heat! No wonder the tropical plants were flourishing while Rita wilted.

Smedley Craig, a YCCoC board member, led me into the bowels of the church building for an introduction to the mechanical room. He opened the door to reveal the most horrendous mechanical nightmare I'd laid eyes on for many years! Immediately to the right, there was a water-boiler with its supply riser run to the ceiling where it wrapped around the mechanical room and dropped into a rat's nest of circulators and what appeared to be a failed attempt at outdoor reset via a modulating three-way mix valve — its wires were disconnected and hanging askew while its shaft had been locked in one set position. A quick glance back at the water-boiler revealed it had no circulator of its own.

A hydro-air unit stood sentry to the left with its piping running back to a very large steam boiler. A modulating zone valve regulating flow was perched in its supply line.

Next to the hydro-air unit sat a forlorn-looking condensate feed-water tank with a twisted piping arrangement that incorporated



The York County Council of Churches.



The old steam hydro-air unit.

a condensate pump-tank (missing its pump). On the floor sat a centrifugal pump, no doubt wired to the steam boiler's low-water-cut-off. The overflow pipe terminated adjacent to a floor drain, and there was a large wet spot surrounding the area. The feed-water tank was riddled with cancer, and was actively weeping condensate in more than a few spots.

Continuing my visual tour, there was a vintage 1953 gas-fired water heater with its burner door lying on the floor and chrome skirt-ring tilted as if sadly hanging on by its fingernails.

The steam boiler was last, and from the numerous soot streaks at every opening in its jacket, this no doubt was the source of the CO leak. The technician who responded to the distress call had slathered refractory cement around the burner and chamber doors in an attempt to halt any CO from escaping. A gas boiler plus soot streaks equals bad combustion, and there was no evidence of anyone having utilized a combustion analyzer on this unit. A Burnham dual-fuel commercial burner was attached to the Peerless steam boiler!

Parts were strewn about and looked like they'd been dropped right where the technicians had disconnected them. Each of the mechanical systems could reveal its own tale of misery by the pile of discarded parts beside, on and under them.

I had carved out a 90-minute spot in my schedule for surveying this job, and it was abundantly clear I needed more time — much more time — if I was going to adequately assess what was really needed. I asked Mr. Craig if I could return to spend a full day. He was a bit surprised by my request, so I pointed out a few of the oddities I'd observed and explained the need to get out of the boiler-room to survey the buildings heat emitters and manner in which they were installed.

The steam system

Here's what I discovered during my return visit:

Steam systems must be sized to produce enough steam to completely fill the inside void of all radiators and piping connected to



The sanctuary welcome window.



Pipe corrosion from acidic condensate dripping down from open pipe connected to chimney base.

the boiler, which is referred to as the “connected load.” I measured each individual section of radiation (convectors, radiators and bare steel piping utilized as a heat source in the basement youth center) and that information was then used to determine the volume in square feet for each heat emitting device.

Then I added a 30% pick-up factor, which represents the energy required to bring the interconnecting distribution piping up to full temperature. Together, the connected load and pick-up factor equaled 196,248 Btu.



A close up view of acidic condensate damage on a pipe exterior.

Two major concerns were expressed during my first visit: A CO incident and high fuel bills. I found the following related conditions:

- Refractory cement smeared around the access door to the boiler’s combustion chamber and soot streaks at various openings in the boiler’s exterior jacket, which indicated combustion gases had been escaping the combustion chamber at any point they could find. This is a tell-tale sign that other problems exist.
- The boiler’s rating plate indicated a maximum firing rate of 470,000 Btu. When I timed the gas meter (with only the steam boiler operating), I discovered it was being fed in excess of 1,200,000 Btu! That explained the CO production issue and overstuffing any heating appliance with excess fuel reduces its operating efficiency. (Here’s the formula for timing a gas meter: $3,600 \times \text{the test dial size} \times \text{Btu content for 1-cubic foot of gas} \div \text{the number of seconds per revolution}$). In our area, natural gas is rated at 1,050 Btu per cubic foot, and the five-foot dial completed its revolution in just 15-seconds.
- The connected load survey revealed that this steam boiler is grossly over-sized. Over-sized heating systems suffer a parasitic loss of efficiency. The farther apart the size required versus the size in place, the worse the overall efficiency becomes.



Pipe corrosion from acidic condensate dripping down from open pipe connected to chimney base.



Where's Waldo? A remote antique condensate pump at the far end of the storage room, adjacent to an abandoned oil tank.

- This was originally a one-pipe vapor system and designed to operate on ounces, not pounds, of pressure. The pressure controls governing this steam boiler's operation were set to maintain 9- to 12-psi. Boyle's Law tells us if you double the pressure, you will halve the volume of a gas, which is steam in this instance. When you reduce the volume of steam produced, you still need to fill the radiators and connected load, which means the boiler is required to produce more steam. The higher the pressure, the more steam required to fill the same volume.
- I discovered an antique condensate return pump at the far reaches of the steam system. Judging by its looks and the debris that was concealing it from plain sight, it hadn't been serviced for decades.
- The feed-water tank in the boiler room was riddled with pin-hole leaks. Its purpose is to act as a reservoir for returning condensate (steam that has changed from a vapor back to a liquid) until the

boiler's low-water-cut-off senses a need for water, closes its end switch and energizes the centrifugal pump connected to the feed-water tank.

While surveying this system on my second trip, I witnessed this cycle and saw the pump couldn't overcome the high pressure in the boiler. This, in turn, caused the pump's impeller to cavitate and the heated condensate to overflow from the feed-water tank. This heated water is rejected to the adjacent floor drain where the energy disappears down the sewer line. While the roaches are no doubt delighted to have a spa-like environment within the city's sewage system, energy dollars were literally running down the drain.

Lost condensate must be replaced with fresh water, which contains free oxygen and that contributes to accelerated corrosion of all ferrous components, which encompasses just about everything in the steam system. Corrosion leads to sludge. Sludge blankets the boiler's interior surfaces, robbing its efficiency. Eventually, a sludge build-up will cause a premature failure of the boiler.

- There was a small gas leak at the gas regulator. Not a huge issue as it was not explosive or one that would support combustion. Since



The church sanctuary.

we weren't in heating season, it could be disabled until the YCCoC decided what to do — repair or replace.

- To the rear of the boiler and at the floor level, I noticed a return pipe that was severely corroded on its exterior. Looking directly above this spot, there was an open pipe connected into the chimney. Very old steam systems often saw their relief valves connected into the base of the chimney. It was not uncommon for those old system relief valves (not nearly as reliable as today's relief valves) to leak steam and letting them off-gas to the chimney was an accepted practice.

Evidently, the hot flue gases (remember — the boiler was being overstuffed with raw natural gas) are, to a limited degree, escaping from the chimney through this steel pipe. For every 100,000 Btu of energy burned in combustion, one gallon of moisture is generated if the temperature falls below 350° F. No doubt condensate from flue gases, which is corrosive, had been dripping onto this return line.

- The hydro-air unit connected to the steam boiler serves a 40-foot by 65-foot recreation hall (the adjoining kitchen is served by the hot water boiler via a Modine heater mounted at the ceiling).

In order to operate the church sanctuary and recreation hall separately, modulating steam zone valves were installed. Should either of these zone valves require service, repairs or replacement, they are very expensive, as are their various components. The hydro-air system and its connected load represent a tiny fractional load for the grossly oversized steam boiler. Even with a new and properly sized steam boiler (for the sanctuary's connected load), the basement recreation hall would be a fractional load.

Why this unit was added to the steam boiler is a mystery that baffled me — it should have been added to the hot water boiler instead! Given the 12 psi steam pressure its coil had been seeing, it was already up to snuff for pressures seen in hot water systems — but was its coil adequately sized to accommodate the heating-load at a reduced Btu outlet?

Good Grief — no wonder their fuel bills were driving them to distraction. Let's move on to look at the hot water side of this nightmare.

Hot water heating system

Unlike the connected load required to properly size steam boilers, hot water systems are properly sized by calculating the actual heat loss of the structure. While heat emitters such as baseboard, convectors or radiators need to be large enough to adequately meet or exceed the heat loss on a design day (0° outdoor for my designs), they no longer dictate the boiler's sizing.

- I found the following issues to exist during my survey and subsequent Manual-J heat loss/gain calculations:
- Here again, there was an issue when I timed the gas meter for the hot water boiler. However, the issue was exactly the opposite seen with



A convector in a classroom hallway.



An overheated “tropical” office.

the steam system — the hot water boiler was grossly under-fired!

Under-firing a boiler (or any heating appliance) can lead to what’s called sustained flue gas condensation within the boiler, metal flue piping and in the masonry chimney. As noted previously (see steam notes), flue gas condensation is corrosive and will lead to accelerated deterioration of system components. Excessive CO production is likely and loss of efficiency can occur under these conditions.

- If my Manual-J calculations were correct, this boiler was also oversized and over-sizing kills operating efficiency. The fact it had adequately heated the areas served, while being under-fired, supported this position. A significant reduction in fuel usage would be seen if the new boiler were properly sized and installed. And yes, the hydro-air coil was more than adequate to meet the calculated heat-load.
- The distribution piping within the boiler room was not installed for optimal performance. The weather-responsive controls, which failed miserably, had been eviscerated and left for dead.
- A circulator was missing from one zone with its flanges now joined with a pipe-nipple. As a result, this zone would see circulation

- whenever any other zone pump was activated.
- The automatic water-feed valve was not connected at the PONPC (Point of No Pressure Change), and consequently, had the potential to overflow the system.
- The boiler had no circulator of its own. One is needed to move the proper gpm flow-rate required for matching the boiler’s net output rating and may be one reason why this boiler’s firing rate was reduced.

The burner’s operation was governed by a flow-switch, which acted as the on/off switch whenever one of the zone circulators was activated. Given there were three circulators active, the potential existed for varying flow rates through this boiler, which was potentially detrimental. It was maintaining temperature, which wastes fuel and a steam pressure switch had been added to act as a low-water-cut-off.

- There were a number of imbalance issues reported within the occupied spaces: Overheating occupied spaces results in wasted energy and contributes to higher fuel bills.

Good grief — again!



The new steam boiler in place.

Hot water heater

One item we haven't yet discussed is the antique gas-fired water heater. It was manufactured in 1953 and, as you would expect for a product of that vintage, it is very inefficient.

A 1953-vintage tank-style water heater is, let's face reality, not exactly a spring chicken! I kind of felt sorry for recommending its demise, as it was just one year younger than I am, but such is life, my friend! With an overall efficiency that likely is less than 50%, it was long overdue for the recycle heap.

Resolutions

The YCCoC board took me at my word and offered me an opportunity to present our proposal in person. Bear in mind the board is comprised of preachers, pastors, rabbis, ministers and a father or two along with astute members of the community, so I was in the



The Watts Hydronex distribution control panel.

no-BS zone where any fabrications would be added to my personal good/bad sheet for review one day by a higher authority! It was an intimidating group and as they said the invocation prayer, I was asking the same higher authority to keep me from tripping over my tongue — something I'm very capable of doing without the added pressure of public speaking!

As you can see in the accompanying pictures, the YCCoC board picked from our good/better/best options for installation of the following:

- Install a new Burnham steam boiler properly sized to match the connected load;
- Eliminate the steam zone valves and move the hydro-air unit's energy input from the steam boiler to the hot water boiler;
- Reduce system operating pressure;
- Test combustion utilizing a digital certified analyzer and print-out the results to establish a bench-mark and verify operating efficiency;

- Replace the feed-water tank and verify the remote condensate pump's operation;
- Clean up and remove all items, pieces and parts that have been casually discarded over many years by those who previously serviced this equipment. Unless otherwise requested, all components replaced by our service technicians are removed, rather than tossed aside to accumulate;
- Install a Laars Mascot high-efficiency modulating condensing boiler with outdoor reset to automatically adjust its output to match the building's heat loss;
- Install a Watts Hydronex pump panel; and
- Install a Bradford White Indirect water heater.

I can hear a few of you wondering “why a condensing modulation boiler?” A standard issue chimney-vented boiler might, at first glance, seem like a better choice for what's typically run as a high-temperature system. I'd have argued that same point a few years ago, but who says we have to run convectors at higher-than-condensing temperatures? The fact is they work quite well when matched to outdoor reset temperatures, and we utilize a modified reset curve so the lowest temperature will be able to produce enough convection to offset the heat loss on those milder days and nights.

We've seen the lowered fuel consumption granted by mod-con boilers in exactly this type of application, and the fuel savings have been nothing short of remarkable. Given the fact that on any given year, we only see true design conditions for about 10% of the heating season, which means we'll be in a condensing mode for more than 70% of the run-time, this is an option you may want to add to your sales arsenal.

A job like the YCCoC is rare in that it had so many opportunities to pick “low-hanging fruit” from the options tree, but we often visit opportunities where we can offer our customers extremely good options for conserving energy, fossil-fuel resources and the ability to lower their global-warming carbon foot-print. And — don't forget to get the ongoing service contract!



The Laars modcon boiler and Bradford White indirect water heater.

Heat pump to hydronics conversion

Pennsylvania homeowners wrest control from old man winter.

There's one thing many professionals in the HVAC industry usually agree on: In the northern regions of the country, older model standard heat pumps are outmatched by cruel winter temperatures. Once temperatures fall below 40° F, the heat pump performance falls off the Btu/h cliff, and secondary heating is required — more often than not, that's made up of electric resistance heat coils. But the Hammer family of Manheim, Pennsylvania, fought back and, this time, old man winter took a beating.

Many winters ago (before the hydronic cure), Brian and Crystal Hammer and their two children began wearing sweatshirts in the house to stay warm inside. With outside temperatures hovering around 20° F for weeks on end, their heat pump couldn't push inside temperatures above 55°.

"If it got colder outside — down to 5° or so, which it did for several days — we got colder, and the only thing we could do was to add more clothes during the day, and more blankets at night," Brian Hammer says.

The problem was their backup electric duct-mounted heat source was short on kW. One option here would have been to add a new duct-mounted backup with more kW horsepower, but aside from being uncomfortable, heating costs were also an issue.

It's one thing to deal with some discomfort. But it's another, even tougher source of discomfort, to deal with a high electricity bill. The Hammer's monthly electric bills during the winter of 2002-2003 ranged between \$200 and \$300. By Thanksgiving and Christmas of 2003, indoor home temperatures were cooling holiday warmth considerably.



Dave Yates threads Onix tubing through the joist bay. Photo by John Herr.



Dave Yates checks installed Onix tube staple-up. Photo by John Herr.

“We felt like we were literally throwing lots of money away. The house wasn’t warm, we were uncomfortable, and the utility bills kept getting higher and higher,” Brian Hammer says. “We decided to fight back.”

Following a friend’s referral, the Hammers called F. W. Behler. I tested the seven-year-old heat pump system (installed when the home was built), studied the “envelope” — doors, windows and level of insulation — and asked lots of questions. I scrutinized the system’s air handler and electric water heater, too.

I felt like a doctor delivering great news when I’d completed the system check-up. Although they needed ‘major surgery,’ the problem could be cured. But like any good physician, I gave them some options, explaining we could beef-up the “toaster” in the heat pump air handler; this would be the cheapest fix, but the most expensive to operate. We could install an oil or gas furnace, saving the heat pump for its air-



The final clamp connection Onix to Watts manifold. Photo by John Herr.

conditioning function in the summer. Or, we could provide them with a system that would give them the best comfort and operating economy.

Though the Hammers admitted to a fairly tight budget, they also spoke of their interest in radiant heat. I responded by offering a



Dave Yates completes wiring for Laars boiler. Photo by John Herr.

solution the homeowners readily chose to go with. They settled on a plan to install a small, high-efficiency boiler, retain the heat pump for summer duty, and add a hydronic coil that would provide warmth for the second floor. We would also install a two-zone, eight-loop staple-up radiant system heat for the entire first floor.



Dave Yates solders hydronic piping. Photo by John Herr.

Two temperature zones were required because of the dissimilarity of the floor coverings on the first floor, which included hardwood, vinyl and wall-to-wall carpet. By using RadiantWorks, Watts Radiant's system design software, the varying floor supply water temperatures were quickly matched with manifolds, loop lengths and flow rates.

A "simpler is better" control panel

The system we designed would call for multiple-temperatures from a single temperature source. But rather than putting many hours into building a control panel, we turned to Watts Radiant, specifying the components and function of a HydroControl panel they would build, timed for arrival with the other ordered materials.

The Hammers had set a fairly tight budget for the project, so I settled on a simple mixing strategy. A simpler-is-better approach saves money on the front end by reducing installation and material costs,



The Hammer home. Photo by John Herr.

and electrical spending is minimized, too. This is often ignored when systems are designed.

The panel is elegant in its simplicity. A primary loop drives the heated water past two detours on the Btu highway. If a heating cycle is activated, Btu are diverted to a three-way mixing, which then tempers the water as needed.

Tiny sabers hanging down

About 1,200 linear feet of Watts Radiant EPDM “Onix” tubing was ordered for the home’s staple-up radiant system, chosen because of the several advantages it offered. We like the material because of its excellent heat transfer when stapled-up. The tubing, by design, is slightly flattened against the underfloor when stapled into position. This greatly increases the surface area for contact with subfloor, moving heat out of the tubing and into the floor — without metal plates. Its rope-like flexibility gives it two other key advantages for



Dave Yates checks over the Watts control panel. Photo by John Herr.

a job like this. It's easy to install, so we spend a lot less time on the installation — unlike PEX which has a mind of its own. And — most important for this job — Onix was the only tubing we could use to weave between the thousands of protruding metal nails driven through the subfloor when the home's hardwood flooring was applied.

Had we used a less flexible radiant tubing, most of the flooring nails would have been removed — a very time-consuming and costly process. We've tried snipping them off in the past, but that still leaves behind a sharp little stub, which is still a threat to the tubing and clearly prevents good contact between the tubing, or metal plates, if they're used. This puts a stop to good thermal transfer, defeating the whole purpose.

We learned about removing flooring nails the hard way. A few years ago, we undertook a PEX retrofit job under a large great room with hardwood flooring where extruded aluminum plates would be utilized to enhance heat transfer, increase comfort, and lower heating costs by taking advantage of ultra-low water temperatures. We knew we were in for a rough time! The joist bays looked like long, narrow minefields with oodles of sharp staple-nails hanging down like tiny sabers.

Using PEX tubing with plates meant that most of the nails has to be cut off. To remove the nails, we used dremmel tools with a cutting blade. Each nail was cut individually. Every installer on the job was burned by the falling pieces — although safety glasses protected their eyes, burning projectiles fell onto hair, burned spots on the uniforms and found their way into shirt openings. We were dancin' around like jackrabbits.

At the Hammer's home, about one-half of the home's first floor — for a total of about 500 square feet — the threat of the tiny sabers was defused. The Onix tubing saved us a ton of time because we could easily route the tubing around any nails, and there were a ton of them.

The boiler the Hammers chose (we always provide options) was a fully-modulating, sealed combustion, 85% AFUE LP gas endurance boiler/water heater made by Laars. Its internal bypass, pump, heat



Dave Yates checks water temperatures. Photo by John Herr.

exchanger and 20-gallon stainless steel storage tank matched nicely to the Hammer's needs. They wanted to get the domestic water capability because their builder-grade electric water heater wasn't saving them any money, either. The all-in-one package really appealed to the homeowners and we were glad to disconnect the old one as part of the overall energy cost conservation effort.

The new system automatically adjusts to the home's varied needs and heat demand — from 57% draw to full-fire (or, from 61,800 Btu/h to 108,200). The Endurance's built-in microprocessor monitors boiler, tank and flow temperatures and has a diagnostic display to simplify servicing. The hot surface ignition system also has built-in freeze protection, a pump exerciser to keep the pump corrosion-free, an overheat thermostat and came with a 20-year warranty. The Hammers

were also pleased that the Endurance’s low NOx emissions — less than 25 ppm — are good for the environment.

Gas is supplied by a 500-gallon LP tank installed by the local supplier. Brian Hammer decided to place the tank next to a new garden shed 40 feet from the house, then trenched a line to a point of entry at the far end of the basement. Some of our customers like providing sweat equity on projects to keep costs down.

“We’re now free to invite guests over during the winter months,” said Crystal Hammer. “That’s something we simply weren’t comfortable with before. Another thing we like is the unlimited hot water for showers. Before the new system was installed, we were limited to just two short showers, with a long wait in-between for the water heater to heat up again. Then, two more. We don’t ‘take numbers’ any more.”

“After several winters in our home where we just endured the cold, it’s hard to describe the comfort we have today,” said Brian Hammer. “We used to scan the newspaper anxiously for winter temperatures. When cold temperatures were predicted, that meant we’d be cold inside — sometimes really cold. Then we worried about the utility bill. It was like a cycle of worry — it was awful. Today, we have such a sense of peace about the home and being in it. The weather page is the last page we turn to, not the first. And we enjoy warmth in the home, not discomfort.”

In January 2004, the Hammers saved more than \$100 when paying their first utility bill with the new system in place. And that was just for the last 18 days of the month. For February 2004, the savings were more than \$200. Additionally, the electric utility audited electric use at their house. The Hammers — who pay electric on a budget plan that averages monthly costs to ease the sting of high-use months — were pleasantly surprised to see their monthly budget amount drop from \$161/month to \$78/month. “Substantial savings with no compromise to comfort,” said Brian Hammer. “We can live with that.”

The Hammer project was submitted to the annual RPA System Showcase contest and was awarded Best of Show. Almost two decades later, the system continues to perform flawlessly.

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An unusual application for hydronic radiant heating

Stretching hydronic wings to tackle difficult jobs.

Most hydronic/radiant contractors have plenty of experience doing the usual radiant floor/wall/ceiling applications. Some of us even have extensive experience in performing snowmelt systems.

My membership in the RPA (Radiant Professionals Alliance) provided me with multiple mentors, extremely useful classes, certifications and awards for a number of our installations. Eventually, it was my turn to be a mentor and instructor to repay my knowledge debts and pay it forward. I have always been drawn to challenges and the PHVAC trades have provided that — in spades — throughout my career and beyond.

A solid reputation

This most unusual opportunity came by way of performing one of the largest snow/ice melt systems ever installed in the state of Pennsylvania at the York Hospital. We worked with one of the largest mechanical contracting firms in the state, James Craft & Son. The company was responsible for providing physical plant and big bore distribution piping. Our crews were responsible for setting the manifolds, and installing the 14 miles of 3/4-inch Watts PEX tubing on 9-inch centers to serve the 55,440 square feet of snowmelt for the new hospital work.

Both companies are the same age, having been established in 1900, so that too was a draw-card for me. Craft's interest in my firm was the direct result of my work with the RPA because my name and our firm's name were ever present when they searched for a knowledgeable firm for installing hydronic radiant snowmelt systems.



Installing a test manifold while working atop the three foot thick rebar assembly.

While that got our foot in the door, we were certainly under intense scrutiny and pressure due to the initial short timeframe for the new hospital helipad. We had a large audience of hospital personnel, general contractor representatives, engineers and Craft supervisors. We completed the helipad in less time than had been allotted and gained everyone's confidence.

The project

When Craft was approached for the aggregate conditioning facility, they thought of us, and our expertise in this area immediately, and brought me in for consultation and bids. In this project, just as with the hospital, they wanted to be responsible for the heat source and



Bitter cold weather was an ongoing challenge on this project.

distribution piping, but would prefer to use the resources and talents of a company like ours that has years of experience and miles of tubing in place to back up our expertise.

The firm, Northeast Prestressed Products, who had contracted with the general contractor and his mechanical contracting team, builds concrete pre-stress beams and panels for use in building and bridge construction. It seems there are some very specific standards by which the concrete that is used in pouring these beams must be in compliance with in order to get government work.

The cement is poured into the molds for the beams at around 110° F. If cold aggregate is used, it robs heat from the cement, reducing the temperature of the pour and causing problems with compliance. This requires the aggregate (sand, pea and larger components) to be heated prior to being introduced into the cement mixing process. Their old coal-fired method, which was less than energy efficient, was to pile the aggregate on top of perforated steel pipes, and then run steam through the perforated pipes. Although it does provide for warmed aggregate, it is very inconsistent in aggregate delivery temperatures.

This was to be a radiant bunker built with pre-stressed concrete radiantly heated beams. Its second level would consist of silos preloaded with aggregate preheated radiantly. Electronically controlled gates will open to drop the preheated aggregate into the lower radiant bunker onto a conveyor track in precise portions for whatever mix is required.

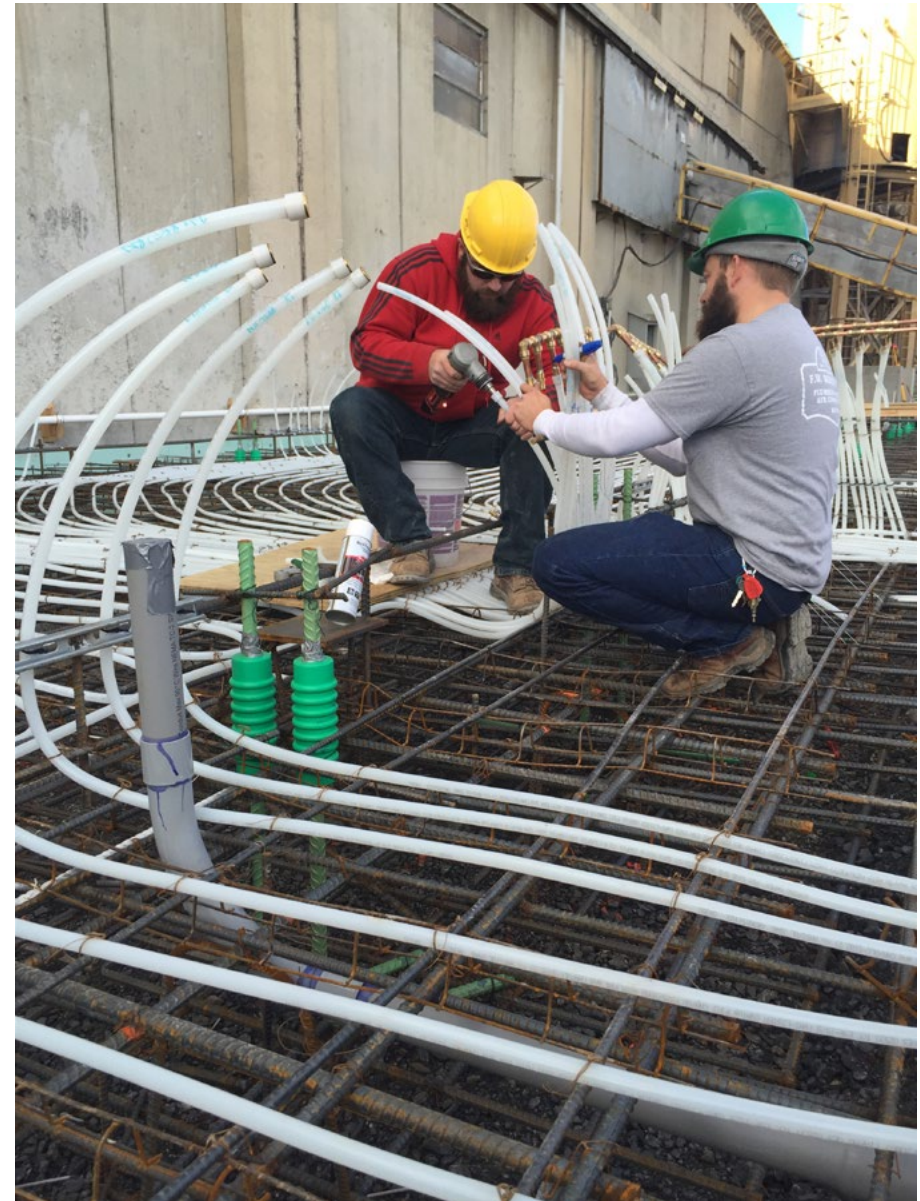
Our team of tubesters began assembling the tubing in the shop on five-foot by five-foot welded wire mesh grids. After these were built, they were transported to the NPP yard where they were incorporated into the cement forms that were being built on site for the aggregate handling facilities. The bottom floor was approximately three feet thick, and was filled with major steel reinforcement. Our guys had to work with the steel tiers, and when the elevation was right, they had to jump in, and custom-install the Uponor tubing, which was wire-tied to the

rebar using a lightening-fast cordless tie-tool. It required extremely accurate setting because the floor grids had to be tied into active pre-stressed wall panels as well.

When the wall forms were set up, we had to make darned sure there was no deviation in the centers of our tubing, because we had to tie them together with only six-inch gaps between the floor and those first 20-ton wall panels, and then between each of the individual vertical wall panels. After making these interconnects and performing pressure tests, the voids where the connections were made were filled with concrete. We used Uponor ProPEX connections, which were a life saver, but working at temperatures near 0° F is brutal, regardless of the connecting methods. Uponor's ProPEX connection method is approved for direct burial in concrete.

The overall dimensions of the bunker is 20 feet by 52 feet by 30 feet high. There are four different compartments to hold the four different grades of aggregate being heated. Depending upon the strength of the pour, the "gates" at the bottoms of the silos will open and drop heated aggregate onto a conveyor belt. From there, the aggregate is expedited to the mixing tower where it is combined with additional products prior to being mixed with water, and then transported to the pour.

The beams these folks make are massive and long. Most of them are so long that it requires special trucks and crews to transport the beams from the production facilities to the final installation location. The truck dollies carrying the front and back of the beams are remotely controlled and articulated to get the beams around the many curves on the road to get from the plant. I watched as they brought one of them out of the plant. The road curved in such a way that the beam actually ended up hanging over some peoples' back yards while the truck was making the curve. It was amazing to watch those professionals do their job. Probably almost as amazing for them while watching our crew and seeing the hundreds of precise PEX fit together like a glove.



Using a PEX expander tool to connect test manifold port.



The lower floor of the radiant bunker.

There really is nothing as satisfying as watching a plan come together, especially when there are so many details, parts and pieces that all have to fit together. Poor planning has cost more than its share of profits for people who didn't take the time to lay things out in a professional manner. That pretty much applies to any job a person is going to do, but when you have six inches of vertical space between two massive pieces of concrete, tubes on six-inch centers and a very limited recessed void to make final connections, there is zero tolerance for mistakes.



The radiant bunker completed.

The guys also had to deal with making certain that our tubing grids were kept free and clear of the pre-stress tension cables that were threaded through the rebar and PEX jungle. These cables get tons of tension applied to them before the concrete is poured into the wall forms. Once these forms have been filled and the concrete has cured for a specified time, the exterior forms are broken loose, and the wall panels are then lifted into position. It would have been nice if the contractor would have allowed us the ability to be there with tubing and fittings in hand as the panels were being placed to make the final connections easier, but safety protocol wouldn't allow any non-essential employees to be near these massive walls when they are being set, so our crew had to go back in after the wall panels were set to make the final ProPex connections. It was tough, but we got 'er done.

AN UNUSUAL APPLICATION FOR HYDRONIC RADIANT HEATING



The tubing was placed at six inches on center using 5/8-inch ID oxygen barrier Uponor PEX and fittings. Tube circuit lengths were calculated by the factory, and our crew made certain that the installations matched the specifications. The tubing for the floors was kept within six inches of the final emitting surfaces to avoid too much downward loss. Due to the weight of the floors, walls and aggregate, it was impossible to place insulation below the slab to avoid downward loss. The walls will eventually be insulated to avoid unnecessary heat loss to the outside.

When asked if I had any consternation going into this project, I said: “Now that the question has been asked, I’m happy to state as fact, and without reservation, that without my Radiant Professionals Alliance training, I would not have been at all comfortable stretching my hydronic wings to tackle either of these jobs. Having gone through **John Siegenthaler’s** teachings of “Radiant Basics,” “Advanced Radiant Design” and “Radiant Architecture” classes, as well as taking tests to become certified as installer, designer, and instructor laid a rock-solid foundation that has served as the cornerstone for all things hydronic in my career. Had **Gary Hayden** not goaded me into joining the RPA, I would have remained blissfully ignorant while thinking I knew which way the hydronic parade was marching. My very first class was Siegenthaler’s class on hydronics at an RPA conference. About three minutes in, I realized I knew very little about hydronics and became a sponge.”

You are never too old to learn, and if you don’t learn something new every day, you simply aren’t paying attention.



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The gift horse

Installing a low-temp radiant system in a large-scale custom home.

On rare occasions, work will come your way with no strings attached! A local business owner asked me to meet him in his office. He was an existing customer both for his home and for all things PHVAC at his large building supply company. When I arrived, the new house plans were rolled out on a drafting table.

The blueprints were first rate and included tons of finite details. As we bore down on the details, I made several suggestions; changes that would permit easier, more sensible plumbing and mechanical solutions, and each one was immediately approved. It was obvious, to me, that this expansive home cried out for radiant heating, which would now be built into the designs.

At this point, I asked how long I had until the bid for the PHVAC was due? The customer turned to me, offered his hand, and said, “I’m confident you and your crews will do terrific work on our new home; you’ve got the job.”

As they say, “Never look a gift horse in the mouth.” Billing would need to be exceptionally transparent, as it should be on any job when the owner has such trust in your operation.

We’d dealt with him on a few jobs in the past, and recently had completed a mainframe computer room cooling system at his building supply warehouse and office center. This was the hub of his operation, and the mainframe computers had been overheating. Overheating greatly slowed down the computers’ ability to process information; they were shutting themselves off on safety overload due to excess heat.

The original office complex HVAC ducted system had been installed long before this storage room had been converted to the heart



The basement level Watts HEPEX tubing ready to receive concrete overpour.

of their operations, which was utilized by their numerous branches to check inventory, submit orders and process payments. They were in crisis mode and our redundant ceiling-suspended inverter mini-splits offered a fast solution. End of crisis — building confidence which is what we all do in this business. We are problem solvers and comfort specialists. Even computer mainframes need comfort-conditioning!

I think that helped to tip things in our favor when he began his plans to build a large home not far from York.

Built around mechanical systems

It was apparent to me that our customer was indeed very concerned about the quality of mechanical and comfort systems for the home. Essentially, he built the home around his desire for the best work we could do.

Blueprints revealed plans for a home that would be 8,500 square feet, with an additional 4,000 square feet of living space below ground. There, the mechanical room would be nestled among a fully equipped exercise room, a wet sauna, a 1950s-style snack bar with soda and beer jerks and a movie theater.

Up above, the home's focal point would be an interior entryway with a curved rock wall, as though built around an old German fortress, a great room with exposed beams 30 feet off the ground and surrounded by a galley, plus a grand fireplace and, opposite that, a wall of windows — all fit for a king. Across from their expansive kitchen, there was to be an Irish Pub. Next to the large garage, there will be a full-sized indoor basketball court, to be radiantly heated, of course.

When excavation for the home was complete, preparations were made for the basement's concrete slab. This included two inches of rigid insulation under the entire home and its perimeter. It looked like a giant, pink swimming pool, but enabled us to radiantly heat the lower level with low temperature gently heated water.

We installed more than 12,000 linear feet of Watts HEPEx oxygen-barrier tubing in the concrete slab at nine-inch and 12-inch centers.



Dave Yates installs metal plates over Onix tubing in SubRay panels.

The day after we were done tying it down, trucks arrived with concrete. Whenever a concrete pour is being placed atop one of our radiant installations, hydronic or electric, we have someone on site to supervise the pour and be ready with replacement materials just in case any damage occurs. The construction schedule at that point was going like clockwork.

As the house progressed, plans changed from time-to-time. At certain stages, there were changes on top of changes, but that's the nature of large-scale custom homes; being able to adapt to changes on-the-fly is essential for all trades involved. On this job site, sweet harmony prevailed, which made working on this 16-month-long project a joy.

Each of our crews were assigned responsibility from start to completion of various aspects, which gave everyone an opportunity to work on such a magnificent project. It was like a large commercial job, only more detailed and prone to change. That meant a task completed three weeks earlier might need to be un-done and re-done at a later point.

Low-temp radiant

A few months later, one of the most interesting facets of the job took place. Our crews installed 14,000 square feet of Watts Radiant SubRay above-subfloor panels. This task took more than a week and made way for the installation of many more miles of Onix tubing, easily laid in SubRay channels.

This radiant heat solution puts Btu close to the finished floor surface, so we were able to reduce system delivery temperatures dramatically.

Because of the SubRay, and with an extremely well insulated home, even with ambient temperatures at 0° F, they were warming the entire home with first- and second-floor water delivery temperatures of 88° F, and basement slab temps of just 78° F during the 0°F Polar Vortex days and nights.



A Behler technician installs Watts SubRay panels.

We also installed three Watts home-run domestic water manifolds and miles of WaterPEX tubing to feed them, a 95 AFUE wall-hung Viessmann high-efficiency modulating condensing boiler with an input range of 55-172 MBH and two Viessmann 80-gallon indirect water heaters. The two indirect water heaters were at opposite ends of the home so the wait for hot water was dramatically minimized; eliminating the need for any hot water recirculation loops.

The home's cooling solution required the use of two main central HVAC systems, with the addition of multiple Fujitsu high-efficiency inverter-driven mini-splits.

When I studied the home's room-by-room designs, it was clear that there was a need to comfort-condition rooms, like the movie theater, separately from the central-system A/C. One of the many advantages provided by the Fujitsu mini-splits is the ability to use air conditioning during extremely cold weather. So if the owner hosted a group to watch a movie or for a 1950s sock-hop, the mini-splits would quietly do the job of removing body-generated Btu, even at a time of year when that would not be feasible using conventional unitary equipment.

"The Behler crews did an incredible job for us," said the homeowner, shortly after experiencing his first winter in the home. "I'm sure, the job was a challenge at times. But through all the changes, they lived up to their promise to do the best possible job. It was an adventure for all of us."



The Behler crew installs Watts SubRay panels, Onix tubing and heat transfer plates.



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Connected in quality.

Aspiring radiant

Analyzing and troubleshooting a radiant system.

When we built our home in 1993, I made sure it would be 100% radiantly heated. At that time, the builder and his employees had never constructed a home with a radiant heating system, so their curiosity was naturally piqued.

In 2003, I got a call from one of the carpenters who now worked for a different general contractor. “Hey Dave, I recalled you installed radiant heating in your home and we’re finishing a home where radiant heating was installed, but is not working very well. Can we hire you to analyze the system and provide a report with outlined resolutions?”

As it turned out, the owners had lopped off half of an existing home to construct a new, much larger addition. They had read about radiant heating and how comfortable they would be once enveloped in a luxurious radiant environment. The only problem was the master bedroom barely rose above 58° F during cold weather and the master bath stubbornly hovered around 50° F. The new hardwood flooring in the long hallway was warped and the hardwood installer was, of course, blaming the radiant heat. The homeowners, builder, flooring installers and the mechanical contractor were all in attendance. After some generalized conversation, we got down to brass tacks and worked out a schedule. The mechanical contractor stated: “Whatever recommendations Dave comes up with we will take care of.”

The following contains the report:

Conditions found during initial on-site inspection

- Two Quietside gas fired boilers twinned for heating and potable hot water generation;
- The Quietside communicating thermostat sits on a shelf adjacent to



The original vent terminations.

- the boiler;
- Multiple manifolds for zoning;
- Standard 24V thermostats utilized to activate zone pumps and boilers;
- Erratic delivery temperature for potable hot water with ASSE 1066 pressure balancing valves installed on the home run potable lines serving bathing modules. All other hot water use fixtures remain



The mechanical nook created very tight quarters.

- unprotected;
- Erratic heating throughout the home reported by the homeowners;
- Temperature limiting for all zones, except for areas using standing radiators, is achieved using 3-way mixing valves;
- Excessively high delivery temperatures for hardwood flooring,



PEX spaghetti held up with plastic strapping that broke.

- yet extremely wide ΔT (difference between supply and return temperatures). Either loop lengths are excessively long (in excess of 300 feet for this size PEX tubing) or flow rates are being adjusted on the manifolds to retard flow in order to reduce return temperatures;
- All manifolds are located adjacent to the boilers;
- Boiler vent terminations are directly under a window inside a basement window well. Carbon monoxide issue during the summer months due to potable hot water generation;
- Boiler's exhaust terminations within three feet of gas meter and its regulator;
- No insulation between the suspended PEX hydronics tubing and the ceiling of the first floor;
- Carpeting with foam padding in two dressing rooms and the master bedroom on second floor level;
- No heat in whirlpool deck in master bathroom;



PEX installed in contact with sharp screw threads.

- Cold in water closet alcove;
- Extremely hot in first floor half bath;
- Suspended tube under kitchen floor with no insulation and installed against several long screws with very sharp threads. Tubing was installed after screws were in place;
- Kitchen has sleepers, which explains why tubing disappears to an above floor cavity;
- Backloss of heating from second floor was very noticeable and caused the ceilings to be warmer than the floor in all areas under the second floor radiant areas. Indicates no insulation was installed between ceiling and radiant tubing; and
- Slab is uninsulated below living room, bar, pantry and mud room.



Nightmare on PEX Street!

Problems caused by design and installation methods

An almost total lack of communication from the mechanical contractor to the builder and flooring people was evident regarding information about what is required for radiant systems to operate properly. There was a lack of insulation between floors and the type of carpet used was the worst pick for installing radiant heat. With adequate communication and a change from suspended tube to higher performance methods of installing radiant heating, this system could have utilized low water temperatures and operated much more economically.

The suspended tube installation method employed delivers the worst radiant performance of methods available and requires temperatures too high for hardwood flooring, under most circumstances, because the resulting floor surface temperature will rise above 84° F. Floors above 84° F result in the human body feeling uncomfortable, which is why we strive to keep the surface temperature below 84°.



Installing QuikTrack in the master bedroom.

This conclusion was supported during my input of room-by-room details into the Wirsbo heat loss program, which differentiates Btu losses between various installation methods. The program flagged me for the hallway floor surface temperature, requiring I add supplemental heating before I could continue. Several areas of this home could not be properly heated with the existing suspended tube application due to potential hardwood damage, exceeding the tubing's limitation for hot water temperatures or excessive backloss of heating to the floor below.

The Quieside QVM-9 boiler is designed to utilize its communicating thermostat in order to adapt to room conditions and mode of heating. Ideally, it can react to radiant, baseboard or other types of room conditions. In order for the Quieside thermostat to be effective, it must be in the space being heated. In this installation, the thermostat was placed on a shelf beside the boilers. It is set to run at maximum settings for heat output. An Argo relay controller was installed to utilize standard 24V thermostats within the upper floors for zoning. It also relays



Master bathroom combi-towel warmer and radiant flat panel radiator to supplement heating.

a signal to the boiler via its isolated end switch. When a room thermostat calls for heating, the Argo relay then turns on the corresponding circulator and energizes the boiler. The boiler then looks to the communicating thermostat for instructions on how to respond. All it ever sees is a demand for full high temperature operation — like flooring the gas pedal in your car whenever you move forward! Bang it's on, or bang it's off.

The Quieside boilers have gained a reputation for being a problem product. APR Supply Co., a local supplier in York, has stopped selling the Quieside due to having too many warranty breakdown issues. They informed me that the Quieside's Korean-based manufacturer had sent a crew to the area in an attempt to resolve the high failure rate. You have already had one replaced (1/29/03)!



The flat panel radiator to offset chill from adjacent window and supplement heating.

The venting is not in compliance with the Quietside requirements regarding maximum number of ells and that the ells are short instead of long sweep turns. They are also venting under a window and next to the gas meter's regulator — both are safety violations and must be corrected. Unless these boilers are physically moved, they cannot be re-vented due to the boiler's limitations on vent lengths.

Additionally, too much cast iron Burnham BaseRay baseboard in the first floor half bath causes it to overheat; the concrete slabs are not insulated below or at their perimeter; and the Quietside boiler potable hot water generation diverts 100% of the boiler's capacity for as long as hot water is being drawn at faucets. There is no "time

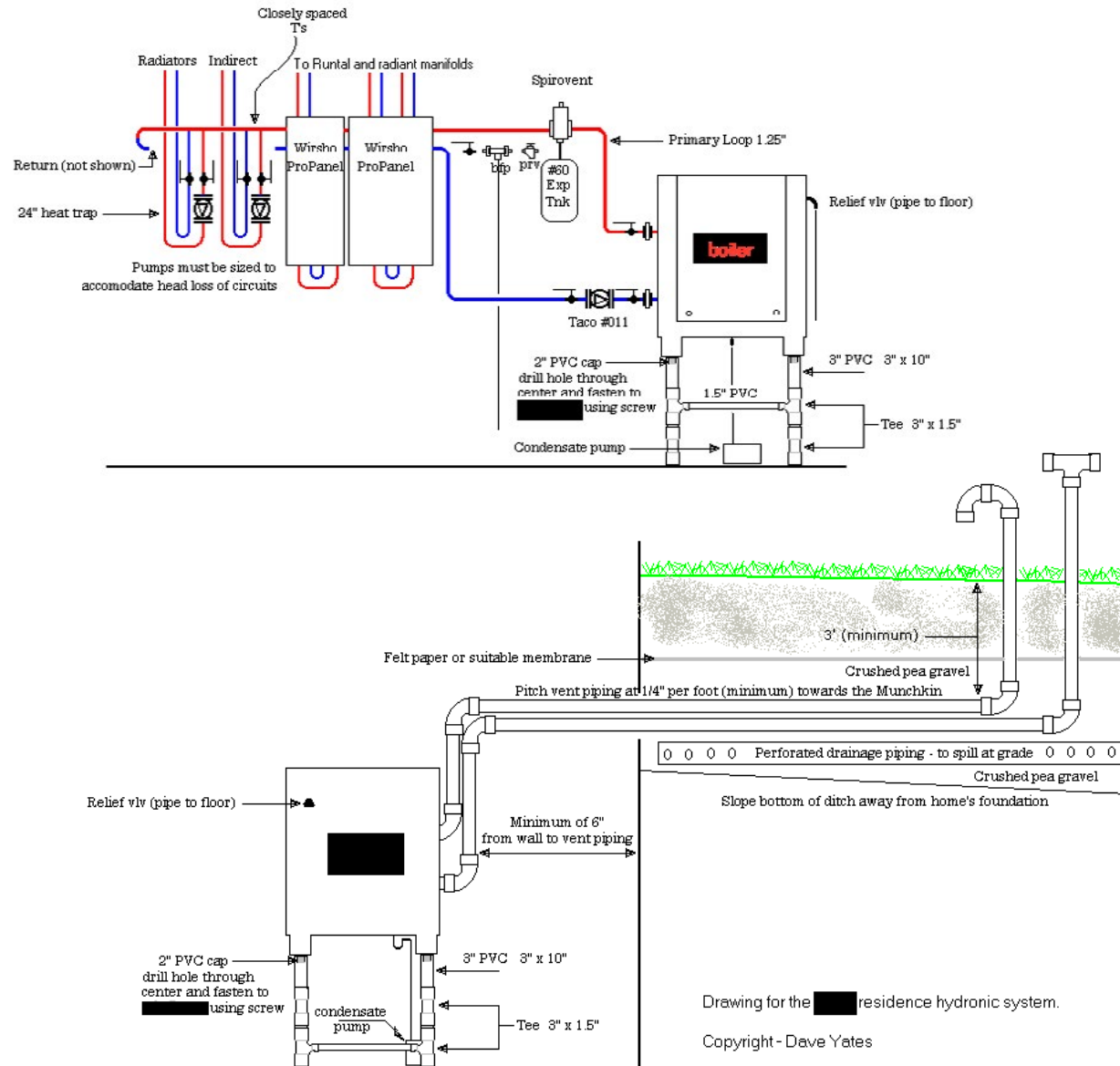


The final combined combustion exhaust/intake, located away from the home.

out" limit to redirect the boiler's power for heating if potable hot water use continues.

Potable hot water delivery temperatures are erratic. They're also limited by flow rates and incoming water temperatures. During the winter months, production can be as low as two gpm per boiler. That would require proper piping via reverse return to balance flow equally between these two boilers, instead of the existing piping installation. Although four gpm sounds like a lot of domestic potable hot water generation, it is inadequate under many circumstances when supplying such a diverse collection of showers, whirlpool, kitchen and laundry needs.

Scalding is a very real and potentially deadly scenario. The 140° water being delivered from these boilers can produce third-degree burns within a few seconds.



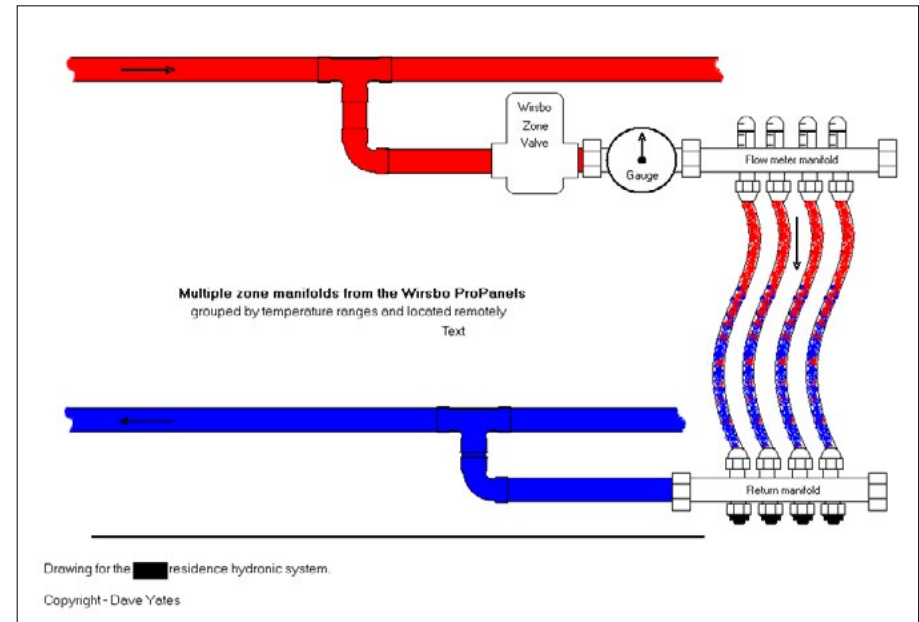
Proposed mechanical space configuration.

The hot water delivery is unprotected in all areas — some more so than others. Although your bathing modules have an ASSE 1066 “anti-scald” device installed in the basement beside or below the home run potable PEX systems, these are pressure balancing valves only. As the temperatures fluctuate within the system, so will the delivery temperature in the bathing area. They are blind as far as temperature fluctuations are concerned. There are three types of scald guard ASSE 1016-certified devices: Pressure balancing — reacting well to changes in pressure once you’ve adjusted the faucet; thermostatic, which are blind to changes in pressure; and those incorporating both pressure balancing and thermostatic protection. All three types are available in ASSE 1016-certified shower faucets. The T&P style are not much more expensive than the T or P valves. In cases utilizing scald guard devices like the 1066, it is best to install the scald guard protection device as close to the faucet as possible. Many manufacturers make scald guard devices that can be utilized for other types of faucets, such as lavatory or kitchen sinks.

The existing room loads and suspended tubing application resulted in the following conditions when providing 70° F indoor temperatures with 0° F outdoor temperature and 22-mph winds:

- Mud room — Loop Supply Temp (LST) needs to be 288.6° F, which can't be done. Floor Surface Temp (FST) = 96.1. Backloss (BL) to earth below = 7,333 Btu;
- Kitchen – LST = 140; FST = 76; and BL = 3136. Not too bad until you take into consideration the 6,454 Btu being emitted from the ceiling above! It was interesting to find that the kitchen radiant floor needs some of that added backloss from the second floor areas;
- Pantry – FLT = 90; FST = 75; and BL = 11,744. 6,006 Btu from the ceiling above.
- Bar – FLT = 196.6 — can't be done; FST = 81.8, which is higher than permitted for hardwood; and BL = 1,093 Btu. There was also close to 4,800 Btu from the ceiling;
- Living room – LST = 137; FST = 76; BL = 45,025 Btu; and 18,593 Btu's from ceiling;
- Hall, office, dressing/media room and two baths off of the hallway will remain as is for now, which renders the large backloss seen by the kitchen;
- Heather's dressing room – LST = 170; FST = 76; and BL = 6,006 Btu, which is too high;
- Master bedroom – LST = 165; FST = 78; and BL = 12,149 Btu, which is too high;
- Master bathroom – main area – LST = 162; FST = 79; and BL = 5,441 Btu, which is too high; and
- Master bath alcove for water closet – LST = 190; FST = 82; and BL = 1,003 Btu, which is also too high for the square footage.

Backlosses can effectively be cut down by utilizing proper amounts of insulation and other piping installation methods. Both will dramatically reduce the needed water temperatures. Backlosses create a difficult scenario when attempting to control the upper and lower



Remote injection manifolds to eliminate the PEX spaghetti.

areas via separate thermostats. For the master bath, master bedroom and Heather's dressing room, supplemental heating must be added to greatly reduce this backloss.

In addition, the wide T currently being seen between the existing manifold supply and return temperatures needs to disappear if we are to accurately control delivery of comfort while protecting the flooring.

(All of the original temperatures outlined above change when the necessary design changes are included).

Solutions

- Get rid of the two Quietside boilers and install a better, more reliable product. Relocate boiler(s) to the rear of the home's basement and provide exhaust terminations away from the home by running them below grade until turning vertical for above grade termination.

- Install an indirect potable hot water storage vessel. Precise storage temperatures can be achieved and higher flow rates can be utilized without sacrificing comfort or compromising safety. Installation of scald guard devices at all faucets is recommended, but not included in this current pricing scenario.
- Replace the piping arrangement in the hydronic radiant manifold area to provide primary/secondary/injection piping control. This will enable remote location of any manifold, eliminate the spaghetti-like tangle of piping now leaving the manifold area and provide precise control of radiant temperatures. Delivered water temperatures are determined by controls, which look at outdoor air temperature, indoor air temperature, supply water temperature and injection mix temperature to determine pump speed and final loop temperatures. The ΔT is typically less than 10° within the injected loop. Injection pumping is by far and away the best method for controlling a radiant system.
- Install radiant flat panel radiators in several second floor areas to provide the benefits of radiant heating while limiting the backloss of heating into the living spaces below. Each has been sized to accomplish two things: Delivery of radiant comfort, while reducing needed water temperatures; and greatly diminishing backloss of the existing radiant heating zones that are to become a floor warming/tempering system. Although there remains some backloss to the lower floor rooms, those have been taken into consideration for adjusting those lower floor loop water temperatures.
- Install Wirsbo Quik Trak for the master bedroom area, which will be covered with hardwood instead of carpet. In lieu of Quik Trak, a radiant flat panel radiator can be utilized or a combination of the two for low water temperature operation. If Quik Trak is utilized, you will need to have the floor cavity blown full of insulation. In this pricing scenario, both have been included in order to keep fluid temperatures low for efficient operation.
- All flat panel radiators included are manufactured by Runtal and include the following: Master bathroom main area — Runtal baseboard along the whirlpool’s exterior wall and a towel warmer on either of the two vanity walls; a Runtal flat panel radiator in the water closet alcove; Runtal flat panel radiator under the window in Heather’s dressing room; and the installation of both Quik Trak and a Runtal flat panel wall radiator. The existing floor suspended tubing circuits will be utilized as floor warming only and reduced substantially in water temperature.
- All of the home’s radiant zones will vary delivered loop water temperatures based upon Btu losses. There will remain one extra injection zone (unused on the control) that can be utilized to manage water temperatures for the standing cast iron radiators. Imagine them changing their temperatures as outdoor conditions warrant! That’s like adding cruise control to the radiators’ outputs.

At the final meeting, we all gathered in a conference room at the general contractor’s offices. After reviewing my report, there was a lengthy conversation and all seemed to be drawing to a friendly conclusion. Suddenly, the mechanical contractor jumped up and said: “Screw it, I’ve already been paid and I’m outta here.” You could have heard a pin drop after he stormed out. I looked up from my files to find all eyes were on me. “Can your firm do the work?” the owners asked.

We could and we did; comfort was delivered exactly as promised. So why were the hardwood boards warped in that long hallway? The flooring installer had used staples, long staples, to fasten down the planks. The steel staples, which had rusted, had punctured the PEX tubing and water was weeping at such a low rate, it never leaked sufficiently to stain the 1st floor ceiling, but provided enough moisture to warp the flooring.

Designing electric snow melt systems

The devil is in the details.

There are a great many similarities between hydronic and electric snow melt systems. The concept is simple: Input heat-energy; melt snow and ice; and provide safe passage for people. As the old saying goes — the devil is in the details! In addition to the primary reason — people safety and avoiding liability — the secondary reason for this snow melt system was the damage to concrete, bricks and landscaping caused by snow melt chemicals and mechanical snow removal.

Designing snow melt systems requires an accurate assessment of the intended construction of the area to be treated, the area geographically, physical property layout, runoff of melted snow/ice and it certainly helps to have programs like the [Watts RadiantWorks Pro](#). The training provided by the RPA (Radiant Professionals Alliance) long ago gave me a rock-solid foundation of essential knowledge for radiant hydronic and electric heating and snow melt systems. Ongoing educational opportunities are available for beginners and professionals alike at www.radiantprofessionalsalliance.org.

The project

This corporate grand entrance snow melt system encompassed several distinct, but joined together areas, including a lower sidewalk adjoining the driveway; a tapering stairway; an expansive upper landing-pad with a multi-story all-glass entrance; and to either side, ADA sloped sidewalks that meet up with the lower sidewalk. In total this would be 2,465-square-feet of snow melt. There was an ideal spot for converting a portion of unused storage



ProMelt cables are installed on the lower sidewalk.



A view of the underside wire grid supported by chairs.



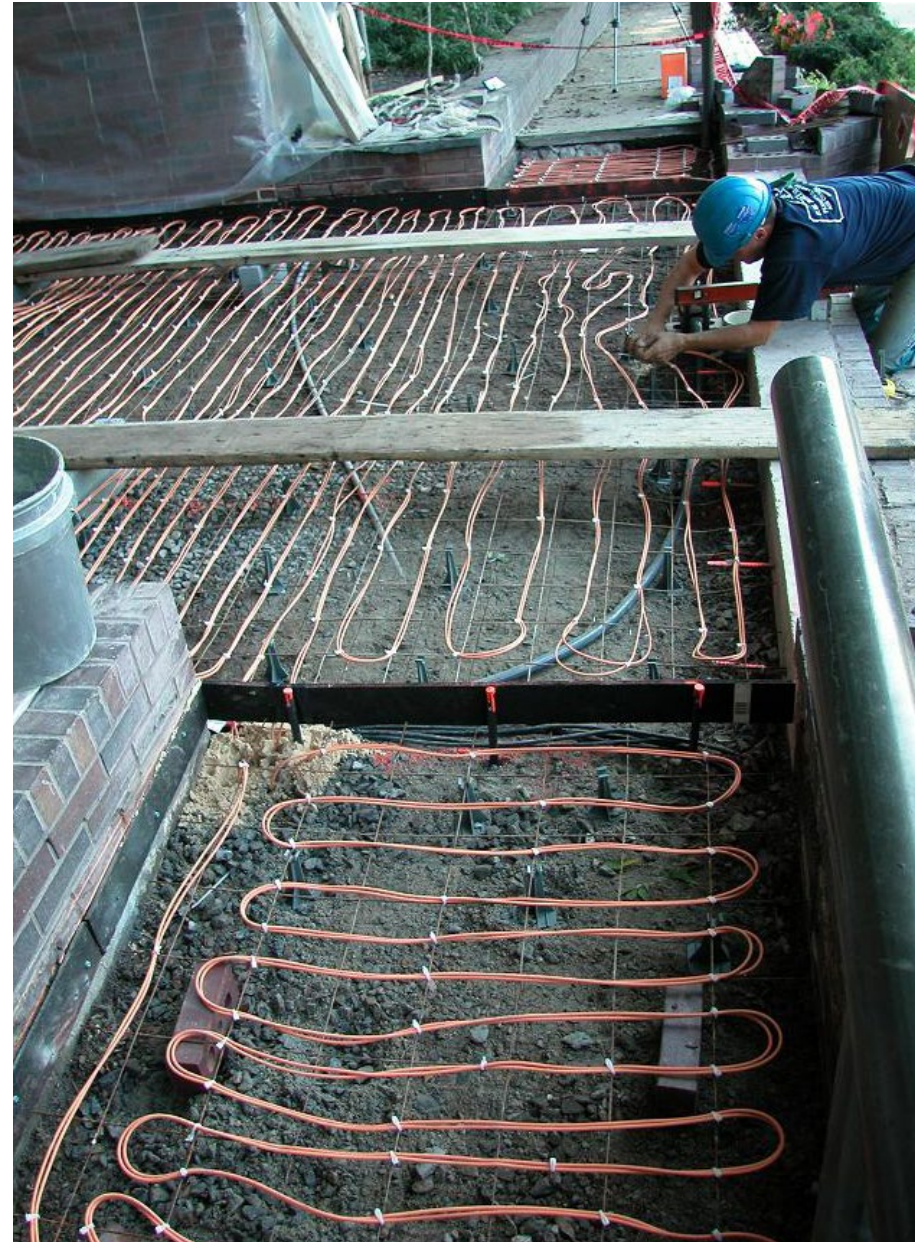
ProMelt cables are installed on the upper landing.

area adjacent to an exterior wall where natural gas entered the office building. Initial plans included redundant high-efficiency modulating condensing boilers; exterior vaults for manifolds; and the location coincided with the jump-off starting point for desired future expansion.

Early on during the design phase, the owners of the corporate center decided their snow melt system was to be electric. I encouraged them to rethink that idea, and wrote them a detailed letter with projected operating costs based upon a fixed number of run hours and existing fuel costs. The indicated future plans would incorporate a rooftop array of PV-panels to generate electricity and more than offset



A Watts snow melt sensor body is installed.



The upper landing, ready for concrete.



The concrete pour getting underway.



Concrete finishing in progress.

the watts utilized to melt snow. No problem! Watts ProMelt electric snow melt cables to the rescue!

Communication is an essential part of any successful snow melt project and **Lucas Hann** at Watts became an integral part of my team. Little did Lucas or I know, in the beginning, how crucial his role was to become! The GC needed to know how to properly slope the concrete pads for runoff of melted snow/ice to areas where no foot traffic would take place and directed to area drains. The construction crew needed to be educated about their responsibilities for protecting the installed snow melt products, and I needed to know exactly where the saw-cut joints would be so our crew knew where to dive down with the Watts ProMelt cables to keep them out of harm's way. Exact

specifications were reviewed on concrete thickness, the 2-inch thick layer of brick pavers and how the pavers would be installed. The pavers were to be bonded to the concrete with high-density mortar for transferring heat energy effectively to the surface. Location for our vault where the ProMelt cable leads would tie onto the circuits and precise location of our sidewalk snow melt sensor were hashed out early on in the project so I could lay out the grid-pattern for the seven loops of 277V cables.

In order to enhance the snow melt system's capabilities by providing 50-watts (170 Btu/h) per square foot, all ProMelt cables were installed on 3-inch centers and gently attached to the 6 by 6 steel grid with plastic zip-ties. The 6 by 6 grid was elevated by using



The stairway cables are installed.

plastic chairs to keep the ProMelt cables just 2 inches below the surface of the concrete pads, and the snow melt sensor's housing was braced in place with layers of brick with an electrical conduit run from the sensor's well to the electric vault. The Watts 200-amp 277V control panel was installed within the centrally located main electrical room on an upper floor with conduits run from it to the outdoor below-grade vault. The electrical conduits were run above the first floor's suspended ceiling, and drywall encased structural



The stairway cables installation.

support beams provided a convenient chase for the final drop before drilling through the exterior below-grade wall.

At the exterior vault, we had seven 277V lines joined as follows (amps): $19 + 19 = 38 \times 1.25$ (multiplier to provide required excess circuit ampacity per code) = 47.5; $19 + 19 = 38 \times 1.25 = 47.5$; $14.4 + 14.4 + 14.4 = 43.2 \times 1.25 = 54$. We provided three circuits: 50; 50; &



60 amps 277V. The snow melt sensor has three wires required for its separate conduit.

Expect the unexpected

While on vacation with my family, I received a panicked email from the owner of the construction firm. The electrical inspector had been on site to inspect the lower sidewalk installation of our

Surface temperatures immediately following a snow event.

Watts ProMelt cables, and several of the corporate center executives overseeing the project were on hand to hear the inspector state, as fact, that our snow melt system would never work! As you might expect, this threw everyone into a tizzy and I was out of town. I lost a day of vacation while dealing with the issue. The first step was finding out why the electrical inspector would shoot off his mouth while throwing us under the bus. As it turned out, he had incorrectly assumed the bricks would be laid over a bed of sand, which would have seriously degraded this, or any other, snow melt system's performance. Lucas Hann at Watts and I were on the hot-seat, and Lucas really came through for us during this artificial crisis. Had the inspector bothered to ask the general contractor, who was on site, he could have easily ascertained the construction details and learned the bricks were to be bonded to the concrete with mortar and only 2-inches thick.

But he didn't stop there! He went on to say we should have installed a three-phase, instead of a single-phase, snow melt system, and a three-phase system would not cost as much to operate! Lucas at Watts responded: "We do not offer 3-phase components for our electric systems. Keep in mind with an electric system based upon watts per square feet, the energy consumption will be the same whether it be 120VAC, 208VAC, 240VAC or 277VAC. Your energy bill is based upon Kilowatt hours, so the only advantage is that higher voltage systems require a lower amp load to deliver the same amount of energy.

Those inspector loose lips darn near scuttled the project.

The opera ain't over till the fat lady sings! Once a seed of doubt is placed in an owner's head, you never really get off the hot seat. That stupid statement by the electrical inspector was a poltergeist that wouldn't be exorcised until everyone within the corporation witnessed the snow melt system operation result in snow/ice-free sidewalks and stairs. Mother Nature cooperated early in the season with several dustings of snow — but no blizzard — and they let me know in no

uncertain terms that I was on the hook until the system was tested by a more severe snow-storm. A heavy wet snow settled in on Jan. 20, and I recorded surface temperatures over the entire area. On average, our snow melt areas were 65° F. Outdoor air temperature was 35° F at 3:30 p.m., and the untreated sidewalk adjacent to our snow melt was 32° F. During the blizzard, no snow had been able to accumulate — we were officially off the hook!

Off the hook, that is, until the energy audit firm monitoring their building called up to ask: "What in the world are you folks doing over there? Your power consumption is abnormally high compared to prior years."

I was summoned to a corporate meeting, and the project manager let me know in advance I was in hot water. He wouldn't tell me why, but I put two and two together and ran off a dozen copies of the letter I had submitted regarding operating costs. Good thing I did, because that was exactly the issue. Talk about entering into a Lion's Den! If looks could kill, I'd have been on my way to the morgue. I took my seat and listened carefully while they began haranguing me over the energy audit. My response was to pass out copies of that earlier letter, which took most, if not all, of them by surprise. They thanked me for being there and apologized for putting me on the hot seat. I don't know who in the hierarchy had made the decision to go with electric instead of hydronic, but he was either in the room, or would be shortly!

Hydronic or electric, you need to include time in your bid to be on site during the concrete pour to ensure no one does anything that has the potential to damage your snow melt products. The GC was a pleasure to work with and for the upper landing area, they constructed bridges to span the area for workers to handle the pumped-in concrete and work the concrete floats. It's also a good, no make that a great, idea to incorporate costs to have on hand extra product just as a CYA (cover your ass-sets) in the event your tubing or cable is damaged during the pour.

Flat panel radiators provide home with radiant comfort

Radiant panels can overcome a lot of comfort problems caused by large sliding glass doors and bare concrete floors.

“My wife and I would like you to visit our home to see if there’s anything that can be done to provide us with some comfort. We’ve been told the issues can’t be resolved.”

Like a moth to a flame!

“This is our wrap-around porch where we like to sit reading and enjoy the panoramic view of our farmland.”

The porch had been enclosed a number of years earlier with two walls of sliding glass doors: Three on the longer wall and two more on the short wall — that’s 175 square feet of ice-cold glass!

“It’s impossible to stay out here during cold weather as we feel like we’re in an icebox and our feet feel like they’re frozen. Crazy thermostat says it’s 70° F in here, too.”

At a glance, I knew why.

The problem and solution

Baseboard hot water heating had been installed along the common walls to the house. Baseboard heating relies upon convection currents to carry Btu, and this creates a rotating air-pattern for the flow of warmed air traveling up the home’s wall, across the ceiling and down across the almost solid walls of glass to be chilled by the time it reached the high-mass concrete floor of the enclosed porch. That now chilled air-mass was then pulled across their feet, and the process repeated. To compound the issue, the thermostat was mounted on the wall above the baseboard! No wonder it registered 70°.



Oversized flat panel radiators are keeping a family toasty warm even in their drafty old farmhouse.

The human body is a perfect radiator! It gives off heat in four basic ways: Radiation when wearing light clothing (about 50%); evaporation of moisture from your skin (20%); convection to surrounding air currents (30%); and conduction if you are in contact with a cooler surface, like a cold high-mass concrete floor covered only by a thin throw-rug. Whenever you are near a colder object, your body’s radiant and evaporation loss-rates are accelerated, which equals an increase in discomfort. In this case, you can toss in conduction too.

Eyeballing the room, there was a small space above each of those sliding glass doors and an 18-inch drywall space between them. I spy comfort potential! But first, a heat loss calculation was required. That provided the required Btu necessary on a design-day (the coldest day anticipated) and guidelines in my radiant design program default to 13° F for our area. One complication: The owners had a wood boiler with an oil back-up boiler they can turn on.

“Oh, we don’t use that at all, and I turned off the power to it years ago.”

“OK then, what temperature range do you allow the wood boiler to roam?”

Important knowledge to have when designing for radiant flat-panel radiators because it determines the operating design-conditions and you must design for the lowest water temperature the radiators will see and that their combined total output will meet, or beat, the room’s total heating load.

After installing the 7-foot tall vertical radiant panel radiators and the supply/return lines we wrapped around the ceiling’s perimeter, it was time for a rapid changeover from the old baseboard heaters. Their human-thermal-comfort went into perfect balance.

Then, less than a month later... “Can you return to go over some more issues?”

A return visit

Moth to flame again!

“My wife’s feet are cold whenever she stands by the kitchen countertop. We have an electric radiant panel heater in the wall by our whirlpool tub, and our daughter’s bedroom — converted from being the attic — is far too cold, especially on windy nights.”

A 3-inch tall flat panel radiator tucked nicely into the long toe-kick area of the kitchen cabinets provided for warm toes, while the electric heater — which could easily be touched while sitting in water and was not on a ground-fault circuit — was replaced by a rectangular flat-panel radiator that included two towel hooks, so they’d have toasty-warm towels waiting to wrap up in when naked and wet.

The daughter’s bedroom was turned into a radiantly comfortable space by removing the undersized baseboard heating and installing a horizontal radiant flat-panel radiator. With the exception of the toe-warming kick-space radiator, all of the radiant radiators were customized to their individual room’s heat loss.

While the porch vertical flat panel radiators are on a separate zone, the bathroom and bedroom radiators are integrated into the home’s

primary zone and deliberately over-sized to handle heat-robbing-drafts from high winds. The original hydronic piping was installed as parallel instead of series, which allowed me to over-size the new radiators and incorporate a TRV (thermostatic radiator valve), so they can better regulate the room’s thermal comfort in their drafty old farm house by nimbly reacting to whatever challenges Mother Nature can conjure up.

Time flies

That job was completed almost 30-years ago. It wasn’t the first time we were able to resolve thermal comfort issues utilizing advanced hydronic heating training and there have literally been hundreds of opportunities to apply the lessons learned over many decades.

There’s a replica Civil War era steam engine with passenger cars from the same time period, and my family was enjoying the train ride through southern York County when a roving band hired to entertain came through the rail car. Imagine my surprise to find its banjo player was none other than our customer. When he spied me, he stopped the band and asked for everyone’s attention. Praying he was a happy customer! He announced that if anyone ever had a plumbing, heating or cooling issue no one else could resolve to call me and then gave out our company information.

In the span of time over all those decades, the only issue encountered was an air vent that had to be replaced. No more cold feet as they luxuriate on their closed-in porch while reading books or gazing out upon their farmland. No more cold toes in the kitchen. Safety and warmth restored for times where they enjoy a soak in their whirlpool tub. And complete comfort for their daughter’s bedroom turned guest room on that somewhat drafty top floor.

Proper sizing for the flat panel radiators was easily accomplished once I had the Manual-J heat loss information and knew the range of wood boiler water delivery temperatures. All that remained was matching the customized size of each flat panel radiator to provide the Btu/h required on design day conditions. Adding TRVs to each one was like installing cruise control.

Failure to communicate

Contractors are responsible for communicating with all parties involved regarding requirements and responsibilities for radiant applications.

“What we’ve got here, is a failure to communicate”

That is a quote from the 1967 film, “Cool Hand Luke,” where the Captain (played by Strother Martin) responds to Luke (played by Paul Newman) after Luke once again replied sarcastically to the Captain and is subsequently beaten, but not into submission. www.youtube.com/watch?v=WUyZXhLHMk

Let’s see how that quote applied to the following forensic investigation for a failed radiant heating application.

A homeowner, who found me on the internet, called me and said: “I see, from your website, you have some experience with radiant heating. We have a new addition with radiant heating and no one involved can figure out why it’s not working. Can you help?”

You never know what you’ll find when checking out a problem job, and I have always loved the challenge of figuring out why PHVAC systems are not living up to their potential and then coming up with resolutions.

The Diagnosis

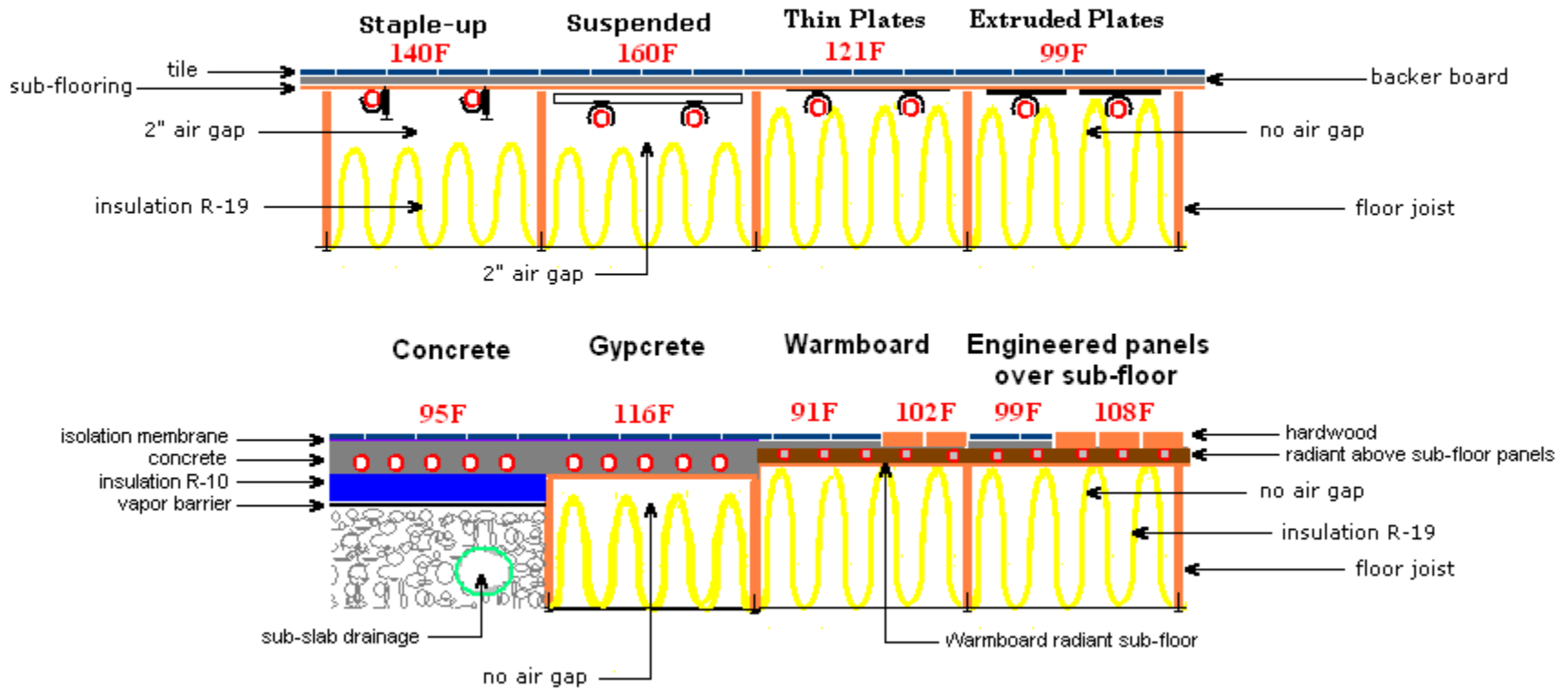
The new addition was beautiful with its expansive granite countertops in the wide open kitchen, dining and living room addition. Pristine white ceramic tile and a few throw rugs were present. There were windows, but not walls of glass, along with 9-foot ceilings and an insulated fiberglass exterior door. No red flags there, so I asked about



This mechanical room shows lots of room here for dramatic improvement!

FIGURE 1

Water temperatures required to meet the required 80F floor surface temperature.



Drawing by Dave Yates



Hydronic mayhem, layer upon layer.

insulation, which was R19 in the walls; R40 in the attic joist bays; and R19 under the floor. There was a concrete deck crawl space under the entire addition to accommodate the radiant tubing installation and air conditioning ductwork. It was time to visit the basement.

The first thing you spy is bundled PEX tubing haphazardly supported from the boiler on your left to entry of the crawl space on your right. Even the homeowner remarked: "That bothered us too, but the installer said there wasn't anything else he could do."

Gazing upon the manner in which the installer piped the radiant zone takes a few minutes to untangle in your mind's eye! 160° F



Workmanship lacking: PEX leader lengths are too long, poorly supported and not insulated.

supply and 80° F return water temperature gives us an 80° F ΔT . If we assume a 2-gpm flow rate, that means we can multiply 500×2 (gpm) $\times 80$ (ΔT) to obtain the delivered Btu/h, which was 80,000-Btu/h, in theory, being delivered to the underside of the plywood subfloor for the 800-square-foot new addition. The loops were not air-bound, given they were all hot to the touch. That also indicated the Taco 007 circulator was moving water.

Back to the truck to retrieve an infrared thermometer, which revealed striping and kicking off my work boots for a barefoot walk

concluded something had to be amiss within the crawl space. The first thing I spy in the crawl space is R30, not R19 labeling on the paper cover that is stapled to the wooden joists. What we've got here, is a failure to communicate! After obtaining permission, I peeled back one of the batts of insulation, which revealed a staple-up application. Well, that revealed why they were supplying 160° water — staple-up is a poor delivery method (see Figure 1) that often requires hotter water. But peeling back the itchy, scratchy, fiberglass insulation revealed it had been packed tightly up against the plywood subflooring. Staple-up requires leaving an air gap for warming the void space in order to transfer heat energy more evenly up through the plywood to the occupied space. This also explained the striping issue of hot/cold/hot/cold we saw in the infrared gun's temperature reading and felt through our feet on the ceramic tiled floor.

When I asked the homeowner and builder about this issue, they both said the hydronic contractor had never said a word about a gap, just that insulation was needed. They assured me they were going to have the R30 removed; R19 installed, and ensure there would be a 2-inch gap. A follow up call from the homeowner: "Dave, we're back in business and the radiant system is working well."

During my site visit, we did discuss several improvements that could be implemented, but the owner indicated his budget was already busted. If changing the insulation and providing the air gap worked, then any improvements would have to wait.

Additional improvements

Here are the things we discussed:

- Clean up the PEX spaghetti mess by eliminating those eight excessively long leader lengths of PEX by moving the supply/return manifold to the crawl space. One circulator near the manifold

and reuse the existing circulator at the boiler. Eliminating the approximately 160 feet of unnecessary PEX would reduce costs for PEX and by eliminating one of the loops, that could have been a 3-port supply/return manifold assembly once relocated to the crawl space;

- Use one of several methods to supply reduced temperature thermal energy from the single temperature boiler: 2-way mix; 3-way mix; 4-way mix; injection; and straight transfer using primary/secondary piping;
- While the insulation is down, install extruded aluminum plates to enhance heat transfer, which would allow for reusing the R30 insulation because no air gap would be required (see drawing). This would also enhance occupant comfort because of the lower supply water temperature; and
- Given they now have natural gas for the kitchen addition, go for the full Monte and install a new modulating/condensing boiler and revise that rat's nest of hydronic piping to pumping-away and slash the fuel bills. An indirect water heater could be incorporated to replace the electric water heater.

All in all, the immediate resolution was simply communicating with the owner and builder. If you are the hydronic installer, and this is critical for radiant applications, you are responsible for communicating with all parties involved regarding requirements and responsibilities. As for the less than stellar hydronics installation, there's no substitute of proper training. There are multiple resources abound today on the internet. Learn at your own pace from the comfort of home, or during shop meetings if those resources are encouraged where you work. Education in our PHVAC trades is an ongoing, never-ending process, for those who want to become superior craftsmen. The more you learn, the more you can earn.

THANK YOU



STAY TUNED FOR OUR NEXT EDITION

- Coming for Volume #4 this December – last in this series:
 - ✓ Tankless Applications and handling objections
 - ✓ Combi-Boiler applications to hydronic/radiant systems
 - ✓ Snow Melting projects – big ones!
 - ✓ Coverage of boilers and steam systems (for residential & commercial systems)
 - ✓ More Columns, Features, and advice from Dave's "lifetime" of experience!
 - ✓ PLUS – more fresh original content from Dave

Don't miss it – you will learn and be entertained!