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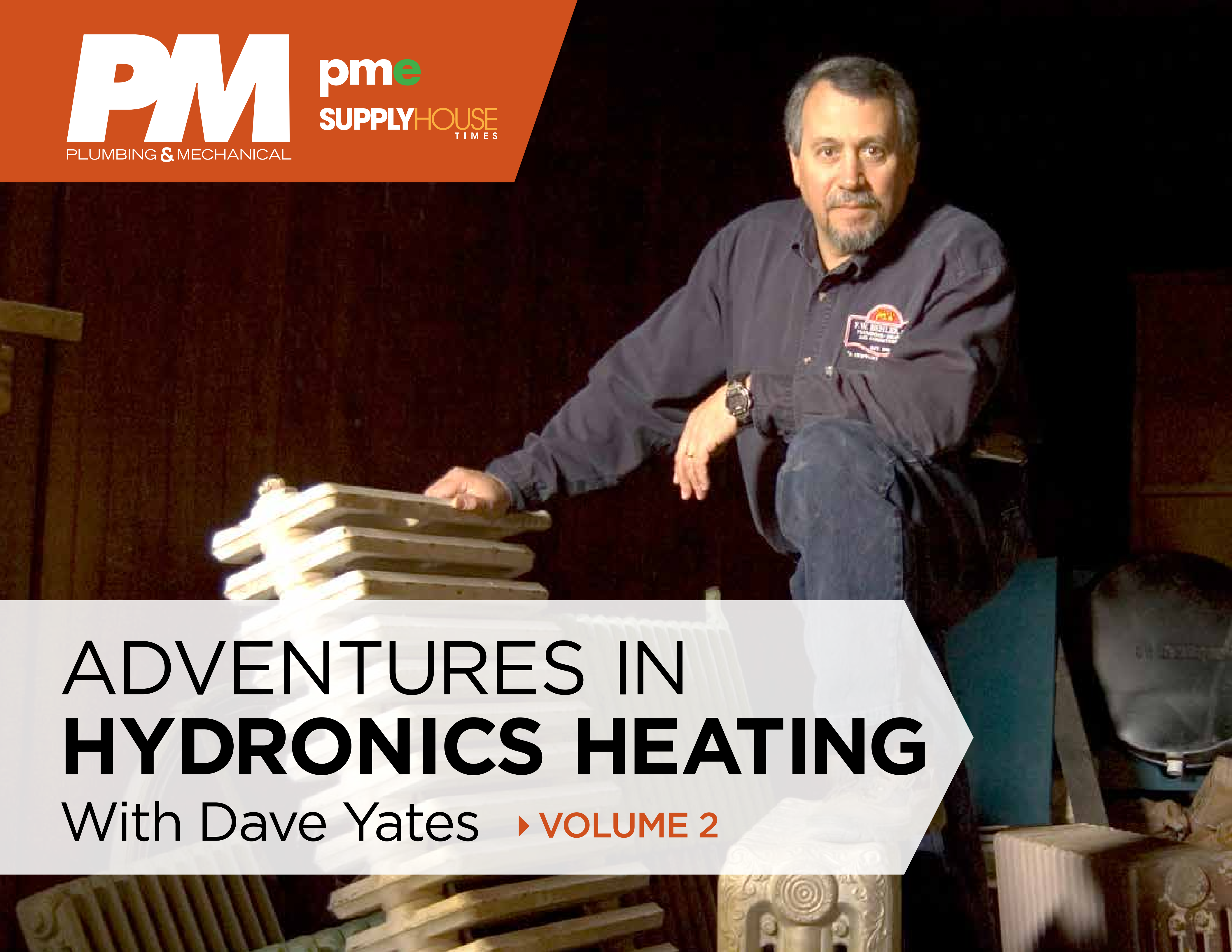
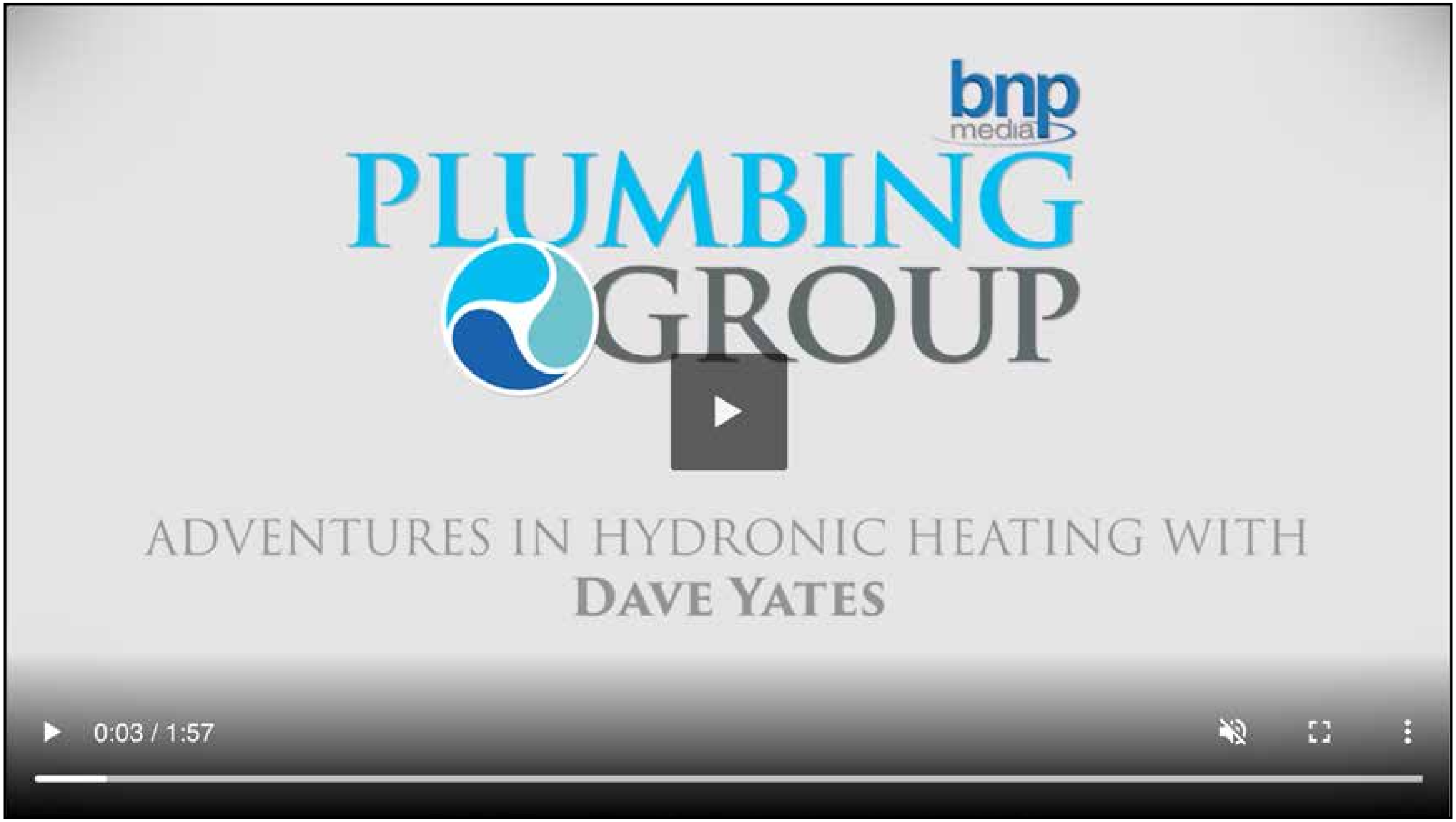


ADVENTURES IN HYDRONICS HEATING

With Dave Yates ▸ VOLUME 2

A SPECIAL MESSAGE **FROM DAVID YATES**



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CONTENTS

2020 VOLUME 2

EDITORIAL COLUMNS

CASE HISTORIES

Dave Yates began his career in the PHCP-PVF trades in 1972 with F. W. Behler, a third-generation plumbing/ HVAC firm he purchased in 1985. Yates also is an experienced teacher in the hydronics industry, serving as an adjunct professor and on the Technical Advisory Board for the Thaddeus Stevens College of Technology. He is is also very active in writing articles for industry trade publications including BNP Media's Plumbing Group, attending trade shows and speaking at events. He can be reached at dyates@fwbehler.com.

EDITORIAL COLUMNS

Steam to hot water conversion

Secrets and tips for ensuring success.

Customers with steam heating systems often ask about the possibility of converting to hot water, and it's been my experience this is driven by three basic needs: No. 1 is reducing the annual operating costs; No. 2 is uneven distribution of heating; and No. 3 is safety due to small children or elderly being burned (1-psi steam delivers 215° F radiator surface temperature). Over the past 40 years, I have performed dozens of these conversions. I'll share some of my secrets and tips in this article that have ensured success.

Oversizing

Steam boilers are sized to the connected load. The connected load calculation consists of measuring each radiator (column, tube or baseboard) to determine its EDR (Equivalent Direct Radiation), which is expressed in square feet and converted to Btu using a chart like the ones found in the Burnham Heating Helper booklet (usboiler.net — see Chapter 5).

The Spanish flu outbreak in 1918 that killed an estimated 500,000 to 850,000 Americans (17 to 50 million worldwide) caused a fundamental shift in how steam and hot water radiators were sized. Conventional wisdom, at the time, was that the stale indoor air was the underlying cause for illnesses during the heating season, and the remedy, therefore, was to keep windows slightly opened! In order for a steam boiler to heat the home evenly, it is necessary for it to be able to completely fill all connected radiators plus the distribution


Tapping threads in a radiator to receive a loose key air vent.

Heat Emissions for Cast Iron Radiators			
Design or Average Water Temperature	Heat Emission Rates Btuh per Sq. Ft.	Design or Average Water Temperature	Heat Emission Rates Btuh per Sq. Ft.
110°	30	180°	170
120°	50	185°	180
130°	70	190°	190
140°	90	195°	200
150°	110	200°	210
160°	130	205°	220
170°	150	210°	230
175°	160	215°	240

From page 71 of my Burnham Heating Helper book.

Steam-only radiators may touch, or not, across the tops of sections and cannot be converted, although others have attempted and failed (see photo). Radiators designed for use with hot water or steam will have threaded plugs, or a blank flat spot that can be drilled/tapped for a loose-key vent located on an end section — midway for a steam vent and near the top for the water air vent.

Fears that somehow steam systems will leak profusely if you attempt to convert to water are largely unfounded, and the increase in pressure is minimal compared to the normal pressure limits of the system's components. If that's a real concern, you can alter the steam pressure control setting and ramp up the pressure while checking on piping and radiation for hissing and leaks. I do recommend incorporating a bit of CYA (cover your ass-sets) in your proposal to cover the potential, which allows the homeowners to assume the risks and expense for repairs, if required. We have had just two cases where leaks developed: Cast iron baseboard with hairline cracks hidden on the back at the oval openings; and one radiator that wept between two of its sections. The baseboard was replaced and the radiator section removed, reassembled (it was oversized) and piping offset in its riser.

Hot water radiator valve with weep hole.

Proper sizing

In order to determine the proper sizing for hot water, the building's heat loss, not the connected load, is the rock-solid foundation required and where energy conservation is like striking gold, which will add value to your designs. Done on a room-by-room basis, you can now go back to compare each room's radiator EDR to the heat loss, and, from that, determine what actual water temperature is required inside that radiator to offset the design-day heat-loss. The tool of choice is ACCA's Manual-J.

Here's an example from an actual 1-pipe steam to 2-pipe hot water conversion:

- Manual-J calculation = 3,520-Btu on a design-day for the room;
- The radiator's EDR = 32 square feet;
- Required water delivery temperature = ? (see Burnham Heating Helper chart);
- 3,520 / 32 = 110 Btu/h per square foot = 150° F on a design day, and there's gold to be harvested using low water temperatures (read on for more on why this is golden); and
- Had the steam been allowed to remain on at 1 psi until the 32-square-foot radiator had heated end-to-end, that room would have been receiving 7,680 Btu!

This process is repeated for every room, and the worst performing radiator in the comparison determines the hottest water required on a design day for the system, or zone because zoning almost always goes hand-in-hand with a conversion as a nice up-sell feature to enhance both comfort and energy conservation.

Converting each radiator requires you drill out the upper vent-plug and chase the threads, remove the steam vent (if one is present) and plug the opening. You also need to remove the steam trap and install a union-ell in its place or remove the guts of the trap to permit water to freely pass through and replace the radiator valve. Old vapor-system steam radiator valves (no packing gland/nut) will leak if not replaced and steam radiator valves with packing glands should also be replaced. Hot water radiator valves incorporate a small weep-hole that allows a trickle of heated water to move through the radiator so that a closed room door isn't likely to allow the radiator to freeze and split. Thermostatic radiator valves (TRV) in parallel or home-run piped systems are another great up-sell feature for seldom-used rooms and rooms that overheat. No-go for a TRV on the room radiator(s) where the thermostat is located!

If you're dealing with a 1-pipe system, chances are the steam supply pipe will be large enough, in most cases, that its removal will allow you to run two hot water pipes in its place. Cross-linked PEX tubing with an O2 barrier or copper tubing can be connected to a twin-pipe valve with or without a thermostatic non-electric operator. The cast iron radiators in the Heidelberg Church Sanctuary were much longer than the extension tube in the Danfoss RA2000 valve, but easily customized by brazing on an extension tube to properly fit each converted radiator. Check out the valve here: https://bit.ly/3fgWIEl.

A 2-pipe steam system offers an opportunity to reuse the majority of piping. However, balancing flow for equal distribution of Btu to each room can be an issue. I always recommend either reverse-return piping or home runs to a manifold. Picture a ladder with the side rails representing the supply and return while each rung represents a radiator. Water is lazy and takes the path of least resistance — always. Connect the supply and return at the base of that ladder and the first rung (radiator) will see the greatest flow (Btu) while each successive rung will see lower flows and the last few rungs might not see any flow (no heat). Simply move the return to the opposite end of the ladder and balanced flow will naturally occur.

Zoning

I used to be a circulator guy. A circulator for every zone — I hated zone valves due to decades-old history of leaks and weak motor failures. Over the past two decades, zone valves became very reliable and leak-free. Today, we have ECM (electrically commutated motor) circulators that use 80% to 90% less power than induction motor circulators and zone valves available using a miserly 1-3 watts each. Ignoring the power-consumption side is no longer wise and up-selling jobs based on power conservation has become a key component of my sales pitches.

Sludge, rust and mud — oh my! All piping that was under water in the steam system — wet returns — must be replaced because they

Attempted steam to hot water conversion on a steam-only radiator.

Church radiator converted from steam to gently warmed water.

are partially full of junk that's blacker than the blackest ink. Spill this sludge and you'll stain whatever it touches — permanently! And, because the steam system operated for decades with steel, oxygen and water present, a strainer and magnetic filter like Adey's MagnaClean (www.adey.com/us/product/magnaclean-professional2) needs to be installed in the system return piping just before the modcon. Here's a video link to see the MagnaClean in action: www.youtube.com/watch?v=epKFRejVUMc&t=354s

The boiler choice

The boiler is the heart of your new system. There's really only one best way to go for your conversion and that's incorporating a modcon (modulating condensing) gently warmed water boiler. You have already determined the hottest water temperature required for a design day. Let's deal with the real-world efficiency potential versus the stated efficiency ratings. Let's agree the manufacturers' ratings are 82% for the steam boiler and 95% for the modcon. At face value, they would appear to be just 13% apart, yet historical data collected from our customers reveals actual reductions in energy consumption averaging 30% to 50%, and well above 50% in some cases. How can this be true? Here's a few reasons:

1. Every time the boiler runs, the modcon burns at a much lower rate than its steam counterpart would have.
2. The golden reward (your design work) for your customers lies here: The modcon adjusts its firing rate as outdoor weather temperatures moderate and couples that with a sliding scale of upper water temperature limits. If we need 150° F at 10° F outdoor air temps, we certainly have no need to make the water that hot if it's 50° outdoors.

Example of a steam only radiator - no connection between sections near the top.

For every 3° we lower the boiler's upper limit, we will enhance the system's energy consumption efficiency by roughly 1%. We carved out a significant chunk just by dropping from 215° steam to 150° water, and more will be gained as your finely-tuned outdoor reset curve steps in to lower the upper limit over time. Most modcons today incorporate a feature called "boost" that will automatically begin raising outgoing water temperature a little at a time until the zone thermostat is satisfied, which allows you to utilize a more aggressive outdoor reset curve.

Pricing process

Pricing a conversion is a fairly straight forward process:

- Each radiator takes us an average of 1 1/2 hours to convert. Add on the new materials and multiply by the total number of radiators to be converted;
- 1-pipe systems will require a second line to each radiator;
- 2-pipe systems can reuse the main distribution piping; although, I always recommend reverse-return piping to ensure good thermal balanced flow to each room for even heating, or else a home run piping strategy if the steam piping is to be eliminated;
- Develop a cost per add-on zone for your personal preferences; and
- Treat the new boiler and its near boiler piping as a module so you can develop a drop-in list of materials and labor costs for any hot water conversion. This can also be used for conventional chimney-vented 80-plus to 90-plus modcon hot water to hot water estimating.

I am conservative with customers regarding projections of lowered energy consumption, and, for a steam to hot water conversion, I'd be hesitant to suggest (note, I do not promise) more than 30% — under project and over deliver! In reality, we have seen 50% or higher reductions in energy consumption. Go forth and prosper my friends.

Taking control of a radiant heating system

8 steps to hydronic heaven.

Behind every successful radiant heating installation, there is a properly designed control panel. In fact, the control panel will make the difference between a radiant installation being just another heating system or performing as a true comfort system. A properly designed control panel becomes the central processing unit that manages all components connected throughout the home. Before panel control strategies and construction can begin, there are several steps necessary to ensure success. Here is my list of the eight steps to hydronic heaven.

1. Meeting between the owners and hydronics system designer

Communication between the owners and the radiant comfort system designer is arguably one of the most critical factors leading to successful radiant systems. Their wishes and expectations can easily be explored, along with lifestyles that may well dictate how heating strategies must be customized. Floor finishes are of particular importance, and this is the time to discuss unwelcome surprises such as large area throw rugs over a hardwood area.

Zoning by room, wing or floor-to-floor options are relatively easy to accomplish with radiant systems. Desired temperature setback control can realistically be explored with the addition of two stage thermostats for governing radiant panels in conjunction with inverter mini-splits, hydro-air or a combination utilizing zoned flat panel radiators with TRVs (thermostatic radiator valves). The wide array of floor, wall

Time saved by constructing shop-built manifolds with pre-wired controls.

and ceiling radiant panels, numerous flat panel radiators, delightful towel warmers and a seemingly unending array of options from which to choose, allow the designer to tailor virtually any system to suit a potential customer's taste and budget.

Pets are in this mix of questions, too. Dogs need a cool place to rest and your showing concern for man's best friend by planning a radiant-free spot for Spot will separate you from the pack. This face-to-face meeting to ascertain construction anomalies and apply the practical application knowledge of the experienced radiant designer is a must. There is no substitute for this step, although there are those who say otherwise and beguile consumers with claims that radiant systems need no expertise, oxygen barrier tubing or precise controls.

2. Coordination with the builder

Communicating with the builder or site supervisor to coordinate construction schedules avoids conflicts that can make mountains out of molehills. Odds are the builder needs as much education, or more, than the homeowners regarding issues with radiant comfort system construction. Details such as moisture content in hardwood, padding under carpeting, acclimation of building materials and policies regarding responsibility for tubing damage should be discussed and agreed to in advance. Then put that in writing for all parties to sign!

3. Establish a budget

It doesn't make sense to devote large chunks of your time designing a Maserati if the budget will only allow a 4-cylinder compact car approach. In some cases, the entire project must be revamped to obtain desired results, the customer pitches in with sweat equity to offset costs, or in the worst case, be terminated. If the budget reflects unrealistic expectations of delivered costs, only the initial meeting time invested exploring options is lost. This meeting can also demonstrate your depth of knowledge and establish you as the customer's trusted hydronics advisor.

4. Perform a thorough heat loss analysis

Given the numerous heat loss and design programs available through a host of manufacturers, there can be no excuse for not performing this very critical step. Loop lengths, tube spacing and water temperatures will be determined during this process. Floor coverings, glass and insulation values will drive the needed water temperatures. The nicely designed computer report printouts give the designer an opportunity to begin looking at zone loop water temperatures, fluid flow rates, head losses and opportunities to smooth out any unusual peaks or valleys between room loop temperatures. These reports, when finalized, also demonstrate to the homeowners that you've done your homework.

Following individual zone redesign, it is now time to review all the zones within the system to arrive at final control options and set the parameters for the panel design. Once this stage has been reached, it is time to review your design plans and arrange another meeting with the homeowners to explain what the system will deliver, and perhaps more importantly, why you have included the components planned for their radiant comfort system. Final costs are much easier to determine at this time and modifications can be made before any monies are invested in the actual control panel construction. This portion of the entire process is the one that requires the highest level of knowledge and offers the greatest challenge to the radiant comfort system designer.

5. Designing the panel(s)

Before a control and pump panel ever sees its first fitting, pump or control, a design sketch or schematic must be drawn. This can encompass anything from a penciled sketch on a napkin to a CAD drawing. It's less of a headache to change a pump configuration or control strategy with an eraser, and infinitely cheaper than building a panel by the seat of your pants. Building from the heat loss analysis step determines how simple or complex the control and pumping


Shop-built injection manifold.


Remote manifolds: one direct and one injection.

array will be in order to meet the design criteria you've established with the homeowners. I like to think of this as the point in a symphony where the musicians are tuning their instruments and setting the stage for a rousing concert.

6. Panel construction

There are three basic options available for choosing panel construction: Pre- or custom-built by a manufacturer; site-built; or shop-built control, piping and pump panels.

Manufacturer-built panels can sometimes be the best option if your system design fits into their patterns. They're attractively packaged, install quickly and reduce the need for highly skilled craftsmen with thorough knowledge of integrating all of the panel components. Allow extra lead time for delivery. On the other hand, it may well be less expensive to construct your own panels for those custom jobs that entail multiple mixing strategies or numerous remote injection panels.

Building a large multiple use control panel can be a daunting task when the work is performed on the job site. This usually involves robbing the shop of most, if not all, the copper fittings and can lead to disappearing inventory if the job site sees unwanted visitors during vacant hours. Weather can create adverse hardships and slow down productivity. Quality control can suffer if the designer is not on site to ensure compliance with details that may have remained in his or her head and not been transferred to the diagrams.

Shop-built panels offer the best of both worlds. The shop's entire inventory of fittings, piping, supports, controls and wiring remain at the mechanics fingertips. Supply houses are typically much closer if a run for materials becomes necessary. Weather is no longer an issue, productivity increases and labor savings are greater. Material costs are typically lower due to less waste and scrap being tossed during cleanup. Supervision and communication between field and office are vastly improved; vehicle wear and tear is reduced. Your lead mechanics can be freed up to pursue more work while those needing to improve their skills can be taught on these in-house panel construction projects. If the panels are finished in the shop, pre-testing of electrical and water-filled components can be completed and corrections made, if necessary, before ever leaving the shop. During slower periods, panel component construction can be utilized to become future productive billable time. We tend to build partial panels for large projects due to their weight and handling difficulties between shop and site. In-house shop construction is utilized to complete remote injection, snow melting or smaller panels before they are delivered to the job site.

7. Maestro, strike up the band

Connecting the various components to your "central processing unit" begins once the panel(s) has been set in place. The real music begins once the piping has been connected to the numerous components: Boiler; indirect potable hot water storage coil; glycol-isolated snow melt via a flat plate heat exchanger; high temperature baseboard; low temperature in-floor tubing; and/or any number of radiant zones which may or may not incorporate sensors for feedback control. Tuning of individual controls to match each of the zone operations to your design is a highly skilled job that requires attention to minute details. Matching pump performance curves to desired flow and injection mixing strategies while maintaining return water temperatures needed to protect non-condensing boilers can be a daunting task. For good measure, toss in some varying outdoor reset curves based upon the heat emitter's characteristics and the system begins to take on a persona unique to the home's design.

8. Communication revisited

Taking the time needed to create a schematic of the comfort system is warranted. Three copies should be made at a minimum, with one for the homeowner's records, one for your files and one kept on the control panel. That way, no matter who returns to service the system, there is an accurate record of wiring, controls and hydronic zoning. Installing a folder storage bin on the main panel to house schematics and a logbook for recording observations during visits is a great way to maintain these records. Real-world circumstances will cause some slight deviations from the system's design due to construction discrepancies, solar gain and wind infiltration. Include the time needed in your base bids to accommodate several return trips for fine-tuning the controls. Once the system is "run-in" and controls have been tweaked to peak performance for delivery of the ultimate comfort that only radiant heating can offer, annual visits to check up on the system will be all that's needed to ensure continued consistent performance.

The art of detecting leaks in radiant heating systems

Stop, look and listen.

Writing columns occasionally leads to interesting trips afield, whether that be in the form of research brought about by feedback from readers, or actual field trips. This particular column led to one such field trip, working with an old friend and making many new old friends in the process.

My introduction into the art of leak detection in slab-based hydronic radiant heating systems was in our town's version of Levittown, New York, in an area called Fireside. **Roy Sanders**, a local competitor who became a dear friend, was part of a team of engineers from York, Pennsylvania, who helped in the designs for the radiant heating systems in Levittown, and they traveled there often during its construction. After one of the trips, the team said why not build a Levittown here, and that led to the Fireside development. Slab-on-grade homes with 1/2-inch copper tubing embedded in concrete. Back then in 1972, homes in Fireside that had radiant heating systems were springing holes like a metal street sign sprayed with buckshot!

The first one I tagged along on, as an apprentice, was easy to find because it could be plainly heard below the thin concrete. It had begun at a soldered coupling, and thermal stress had driven the tubing into the coupling, breaking the solder joint. As the leak worsened, it had eroded a sink hole in the earth — almost large enough for me to crawl into!

Fireside's boilers were shoe-horned into the space below the stairs to the second floor or, for single-story homes, the boiler was out in the open and looked like a stove without any burners. The first time I encountered one of those stove-like boilers on a no-heat call, I walked through the kitchen right past it to look for one hidden in a closet. I returned to the kitchen to ask if she knew its location. Mrs.

The tubing splice repair fitting is relatively easy to insert.

Homeowner eyeballed me with a look that needed no words: "You're standing right beside the boiler (dummy)!" Fortunately, it was just the thermocouple and I had one on the truck.

Leak detecting

At the time, we used several methods for finding leaks. The first was to stop, look and listen. Appliances were unplugged or turned off, and the boiler disabled to keep the home library quiet. While walking through the home's rooms, you kept on the lookout for damp spots or windows that were dripping wet. If that yielded no clues, a return to the boiler was in order to feel the outgoing 1/2-inch tubes between the manifold and floor. The idea was to find out which lines

Foley Mechanical decathlon team advisor assists in searching for leak in radiant tubing.


UoM student team members work on assembly of radiant manifold.

were blistering hot to the touch. The boilers held domestic coils and maintained temperature, so a hydronic system at rest would quickly reveal which circuits were affected. If you were lucky, the individual copper loops were valved, so isolating the leaking loop(s) was easy.

In areas where ceramic tile or floor surface materials impervious to water damage were installed, we would turn off the radiant heating system and close its manifold valves for a few hours or days (if the weather wasn't too cold) and return to wet-mop the area while turning on the radiant system. Most Fireside homes did not include outdoor reset or mixing strategies, as we would today, and the sudden influx of hot water would create what looked like an X-ray as the tubing would dry out the flooring directly over its pathway. Leaks often appeared as a splotch of dried concrete, screaming out "dig here!"

We also used an old stethoscope-like stereo device with twin metal discs. A door slammed or hard shoes stepping on concrete sounded like gunshots, while the whine of a circulator or refrigerator motor could be heard clearly. For those of us with young knees, there was also an old-style hand-crank-like earphone device with a contact-pin sticking out its opposite end for direct contact with piping or the floor to listen for leaks.

Locate, repair, patch or abandon. Basically, those were the choices, and many opted to cap off lone circuits. If multiple circuits were involved, many chose to abandon the radiant heating and install hot water baseboard. Almost all of the copper tubing Fireside radiant systems have long been abandoned — victims of thermal stress.

But, that was then, this is now! Here's a six-step leak-detection process:

1. **Is there a leak:** A hydrostatic pressure test will reveal if there is a leak and how quickly the system is losing water. Long-term leak detection can be monitored by installing a water meter, but not all water meters are equal — make sure to purchase/install one that will detect low leakage rates.

2. **Isolation:** If loops/manifolds are valved on both the supply and return, you can begin the process of elimination.
3. **As-built records:** If the owners have an accurate as-built record for embedded tubing, you can narrow your search area considerably. **Jack Spots**, a local architect, utilized welded or threaded black iron piping for his radiant homes, and the drawings are a work of art. Given that black iron has virtually the same coefficient of thermal expansion as concrete, and that he incorporated weather-responsive mixing controls, virtually all of the radiantly heated homes Spots designed in the 1940s are still in use today, and many were installed by F. W. Behler and continue to be serviced by our firm. His drawings are like a GPS for the buried-in-concrete pipes, and of the rare few we have had to repair, they are exactly where depicted on the drawings.

   In one case, where other methods did not reveal where the leak was located, we turned off the radiant heating for several days and observed the floors with a Flir thermal camera. It was as if Spots' drawing came to life and the thermal image gave us the opportunity to have X-ray vision. We checked the kitchen, laundry room, pantry closet and finally, the bathroom, but it wasn't until we leaned over the toilet where, in the Flir image, it looked like someone had spilled a bucket of blood! It turned out the closet gasket had been leaking, probably for years, and the gap in the concrete under the closet flange allowed the water to seep into the earth, penetrate the concrete, and rot the black iron piping from the outside-inward. It was excavated and patched many years ago and is still in operation today.
4. **Detection methods:** Stop, look and listen for windows dripping with condensation; pets seeking out a single specific warm spot; wet, moldy areas; damp carpeting and noises — like a roiling boil as small stones are rattled against the underside of concrete or a hissing spray-like sound. You could try old-style listening devices. Lay plastic over concrete or tiled floors to see if a spot of wet appears on the underside, indicating a leak location.

Repair of punctured pex loop.

A hand-held, point-and-shoot, inexpensive infrared heat detector and bare feet (ask permission first) can make for a great investigative combination — after the heat has been off long enough for the floor to cool to room temperature. Turn the system on. While the detector can "see" tubing heat lines and larger areas where leaks may be present, your feet will often notice broader warmth zones. This is also a great way to find air-bound loops that aren't circulating.

If you've ever purged a hydronic system by using a garden hose, you've probably learned to double-over the hose to regulate pressure during the process. Water escaping through the partially pinched-off hose crackles as air bubbles pass from high to low pressure and expand. Ultrasonic leak detectors listen for noises generated by air or gas you've introduced in the system as it escapes through a crack or pinhole leak and expands. Expect to spend $500 to $1,500 for a high-quality detector.

A few decades ago, you needed about $30,000 to buy an infrared thermal imaging camera. A high-quality infrared camera can still cost several thousand dollars, but there are relatively inexpensive smartphone infrared cameras that provide a decent-quality image. (www.flir.com/news-center/professional-tools/how-to-find-leaks-in-concrete-using-a-flir-thermal-imaging-camera/)

Helium and hydrogen detectors can be used if they're sensitive enough to measure at or below 50 parts per million. Higher than 50-ppm devices can work too, but they're said to be less precise. Evacuate the affected loop by forcibly ejecting the hydronic fluid with compressed nitrogen or air instead of simply using an air compressor to move the fluid. When filling with helium or hydrogen, be careful not to flood the area with gas or you'll contaminate the site. Start with a single low-pressure charge and do not continue to feed gas into the system. It takes time for the tiny molecules to seep up through concrete but, if you're patient, the results can be spot-on and location of minute leaks can be pinpointed.

5. **Repairs:** There are some piping oddities awaiting your repair attention and some unwanted and unpleasant surprises. What looks like copper at the manifold can turn out to be copper-coated steel tubing below the floor. The age and type of piping materials should be considered. Demolition and removal of floor coverings, concrete and potential for interference from utilities and plumbing may all contribute to the go/no-go repair decision.
6. **Restoration:** Communication and a full understanding of the work-site responsibilities will ultimately determine how satisfied a client will or won't be at completion. Has the exterminator been there to treat for termites? With an uncanny knack for finding the exact location of the outermost loop, it's a safe bet the bug person drilled holes inside the home around its perimeter and has turned that outer run of tubing into Swiss cheese. Exterminators are better at finding radiant tubing-in-concrete than any leak detector ever invented!

University field trip

So there I was, years after this column was published, relaxing peacefully at home. Not a care in the world, when this email arrived:

Hello Dave,

I recently read your article titled "The art of hydronic radiant leak detection." I am writing you in hopes you may have some advice for my particular situation. I am a mechanical engineering student at the University of Maryland working a project for the 2007 Solar Decathlon in which university teams around the world are challenged to build a fully functional 800-square-foot home that is solely powered by solar energy. To heat the house, we're using a radiant floor composed of aluminum-PEX tubes embedded in a Warmboard subfloor. Our finish floor is a solid hardwood (Tigerwood to be exact). Unfortunately, when the flooring subcontractor installed the floor, we believe he may have punctured one of the tubes. The system was air-pressurized during the

UoM Solar Decathlon home under construction.

UoM student team member solders adaptor.

flooring installation, but the puncture was not immediately noticed (most likely due to the speed that the crew was working added to the noise of its own air compressors that would have dulled the sound of an air-leak in the floor). Long story short, we have a leak in one of our radiant loops and are curious as to what the best way to find the leak is and who would be the best person to contact to help find the leak, or if it is possible to pinpoint the leak ourselves with the help of some specialized equipment that we would be able to rent somewhere. One other factor that we have going against us is time — we need to be ready for the competition by the end of September, which would have to include the repair of the flooring. Any advice you may have on this situation would be greatly appreciated.

Thank you,

Tyler Sines, Mechanical Team Leader, LEAFHouse at the University of Maryland

My reply was this:

…………………………………………………………………………………………..

Tyler,

Saturday will work best for my schedule. Looks like it's a 1 1/2-hour drive for me to get to your college. I'll need cellphone contact info and directions to your project's location once I get to the campus. Will I be able to park at the work site? I'll need access to my truck for tools.

Which brand of PAP (PEX-AL-PEX) did you use? Do you have a splice kit? If not, you'll need at least one and you should probably ask for six with the understanding you'll return what you don't need. Do you have extra tubing?

From your previous e-mail, I gather you have a compressor and the ability to pressurize the system? How much of the flooring was installed? Your email indicates the flooring folks have more to do. Will anyone from the flooring group be available to remove flooring as needed? If not, do you have circular saws and tools to cut away any flooring we may need to remove?

Assuming we can find the leak via ultrasonic, you and your team will need to decide how much flooring you'll need to remove. I'll help with advice, but the decision-making process should be a LEAFhouse team consensus. Although the splice kit is relatively easy to insert, it's necessary to have enough tubing exposed to lift it and bend it to accommodate inserting the fitting, unless it's a compression type — and some PAP brands use compression. You'll need to gouge out some of the Warmboard to accommodate the fitting.

The other alternative is to remove enough flooring to completely replace the loop. You should have three or four loops in 800 square feet of floor space. Have you isolated the loops to identify which one is punctured? And, do you have a map of where the tubing runs are located? Did Warmboard provide you with a CAD drawing? Have you asked the flooring installers where they think the problem might be? Return bends are more likely to get nailed since that's normally the only time the flooring installers can't see the tubing, providing they ran the flooring across the straight runs.

Thanks,

Dave Yates

When I asked Tyler, who was the mechanical contractor advisor for the radiant heating system, he told me it was none other than **Dan Foley** (www.foleymechanical.com), a great friend I had come to know well via the Radiant Professionals Alliance. I contacted Foley to ask if he'd join in on the Saturday meeting to help get team LEAFhouse back on track. He and several employees of Foley Mechanical and I arrived at virtually the same time.

How did we finally locate the leaks? After exhausting every "normal" means of locating the leak, which turned out to be inaccessible and concealed under the kitchen cabinets with its concrete countertop (meaning those cabinets were not about to be removed to access and repair the tubing), we decided to try an out-of-the-box method. A mix of R-22 Freon and nitrogen was injected into the loop while utilizing an ultra-sensitive electronic refrigerant leak detector. Six in/out loops under the sink cabinets were leaking and the gods were smiling down on the decathlon student team because they were short in/out portions of the loops' run, meaning only a few feet of the radiant panel would be affected. Being under the kitchen cabinets meant they weren't needed anyway. Students must do the work for Solar Decathlon projects, but are permitted to seek out advice from pros, and it was now time for them to cut up the hardwood in the affected area, cut the tubing, groove the Warmboard to accept the splice, and once pressure tested, install new hardwood to patch the floor.

Professor Amy Gardner, the faculty advisor for this Solar Decathlon project, told us the flooring contractor who had punctured the tubing during the hardwood installation had refused to return and help the LEAFhouse team.

Sadly, I had learned this was not entirely uncommon for professional contractors, who start out with the best of intentions, to leave Solar Decathlon teams in the lurch when they are needed the most. I've enjoyed being an advisor for several SD teams and was on The Mall in Washington, D.C., assisting Penn State's SD team with installation of their mini-split inverter heat pumps when its team leader had a call from another university competitor wanting to know if I would be willing to help them.

The pro mechanical contractor who had promised to assist them with their mini-splits installation was a no-show. Lois was with me and we had hoped to have a nice romantic dinner following our work with Penn State. Instead, we ended up finishing late in the evening after guiding the University of Wisconsin's SD team to completion for their mini-split installation. Crackers and water for us, but feeling great for having helped the SD teams meet their deadlines.

Dear Amy,
I was impressed by your team's winning attitude and their willingness to "tear into" the problems you all are facing — the true mark of winners. It easy to slide through competition when things go smoothly — it's tough to persevere when things go south. You're about to come out from under that storm cloud and you all will be the stronger for having faced adversity and overcoming the challenges.

It was also interesting to observe how each individual reacted to the day's events. John's patience and dogged determination will serve him well in his life's journey.

The flooring company left you hanging and that's not just a shame, it's the kind of attitude that eventually sinks the company ship. Had they, instead, stepped up and accepted responsibility and helped you all to remove whatever flooring was needed, you'd be singing their praises instead of cursing the shadow they've cast. They've missed an opportunity to shine. Don't waste time and energy looking over your collective shoulders at their deeds, or lack therof. Concentrate on the finish instead and remain focused on the prize.

I very much enjoyed the day's challenges and working with LEAFhouse Team Maryland. See you all in D.C. next month!

Thanks,
Dave Yates

Dear Dave,
Thank you so very very much for coming. It was great to meet you, and meet another kindred spirit with excellence in mind. I (and probably we) learned a ton from you today.

And thanks for the supportive words about the project and the team. It's funny — I just had my interview with Scott for the Discovery piece, and I just was saying the same thing about the team. They don't want to make do with a second-rate effort. When they read your article, and realized we had another shot at finding a solution, there was no turning back for anyone.

UoM student team member removing Tiger hardwood flooring to expose pex tubing.

And, yeah, the flooring company will never get my biz again. Eventually, I'll contemplate how to deal with their final invoice. For now, I only have focus on getting to the competition with an intact team and the best project we can produce.

Best,
aeg

All's well that ends well! An opportunity to work with Dan Foley and his guys, help out the University of Maryland SD LEAFhouse team, and find/repair the radiant leak. Outstanding!

The University of Maryland won second place in 2007 with LEAFHouse and first place in 2011 with Watershed. Team Maryland was ranked as the top U.S. university team for the third time in a row with its 2017 reACT, winning first place in the nation and second in the world.

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Welcome, you've got radiant

Internet and email smooth the way toward home heating comfort.

The Internet has been a boon for radiant heating contractors who maintain a website that provides information regarding their services. As a result, I wasn't surprised by the initial phone call from Eric Hanson regarding his having visited our website and wanting to meet for a discussion about his new home. The phone call was simple enough — his general contractor's heating contractor had just walked off of the job.

The Hanson family wanted radiant heating — four zones of radiant heating to be exact — with a hardwood covering and not one single hardwood flooring contractor would so much as give them the time of day, much less any warranty on the products if they insisted on having radiant heating. Their call to the Hardwood Flooring Council found even that organization steering them away from radiant heating!

Too stubborn to give up so easily, this engineer who earns his living mixing hot water for pulpwood to paper processing brought construction of their dream home to a screeching halt while they searched for a radiant heating contractor who had experience with hardwood flooring. He found us via our website, www.fwbehler.com.

Talking with him over the phone indicated this was one well-educated homeowner regarding radiant heating. A jobsite visit and (joint) interview revealed he knew more than the average homeowner, and established that I knew the correct answers regarding floor temperatures and methodology of installing radiant under hardwood along with proper control strategies.

Hanson proved to be an excellent installer of Uponor QuikTrak.

Email icon

What began next was pretty standard fare for radiant heating contractors. We'd had a face-to-face meeting with an opportunity to view the jobsite and any construction anomalies that could create difficulties. The remaining tasks were heat loss/gain calculations; establish design characteristics and control strategies; select the myriad of components necessary for a reliable system; determine the construction schedule; and establish the budget. We agreed that email was the best method of communication and thus began the most intense and extensive communication I've ever had over the internet.

The only problem? The GC's heating contractor had bid just $18,000 to complete 2,800 square feet of hydronic radiant heating, installation of an oil tank, boiler, indirect water heater and two separate air conditioning systems! His bid did not even come close to covering the wholesale cost of materials and he'd vanished into thin air, leaving the homeowners holding the bag. Our estimate for completed HVAC systems was substantially higher and far beyond the budget that had been used to obtain construction financing.

Via e-mail: Thanks for your time yesterday. I really feel bad that you spent a lot of time on my project. When I signed my contract, the cost of heating/air conditioning was based on two quotes I had received. I had expected that the one quote was low and the second was OK. We had budgeted for some overrun in this area, as a contingency. The low bidder was the one gentleman who bailed out. The second bidder remains in play; however, I am waiting on more details from them. Based on their quotes, I had expected your price to be higher due to your expertise in radiant heat. I was right; however, I did not expect the magnitude. I do believe your package is the top of the line and absolutely the right way to go. The control scheme you employ is precisely what is needed for a hardwood floor application. As an engineer I can appreciate your designs and applications. The process and control is exactly what appeals most to me as an engineer.

So, the Hanson family set out to interview other heating contractors — lots of them! During this time, the house sat idle and their builder put pressure on them to proceed. They held out, knowing this was their one chance at comfort in the dream home they' d scrimped and saved for all of their lives. They kept coming back and asking more questions — our emails alone could fill several books! No matter whom they interviewed, no one else could answer their toughest questions to their satisfaction. With no one willing to grant them a warranty on the hardwood flooring, choosing the right

Hydronic piping included a boiler bypass line.

radiant heating contractor became paramount to the success of their project. A middle ground had to be found!

Sweat equity

My email icon lit up, and upon checking my inbox, I found them asking about the possibility of their doing some of the radiant installation in order to provide sweat equity. At first, I refused. After all, we had never had a homeowner take over any portion of our work, and, therefore, had no comfort level for letting anyone whose skills were not known take over installation of a segment within a radiant system that we would ultimately be responsible for. But, they persisted until I finally gave in.

Eric emailed: I have really been through the wringer with this

Hanson became adept at twists and turns created by odd wall angles.

Where the Hanson/Behler teams work became one.

HVAC. I really do thank you for being patient with us. We spent another sleepless night over the project. It is obvious we have a real dilemma. We absolutely believe in your approach, but we can't afford the price. On the other hand, I don't trust the other bidders, but I can afford their price.

Again, I greatly appreciate your time. I have been racking my brain on ways to make something work with you. The proper neurons have not fired yet in my brain; however, I do have one question. Can a system be built that provides radiant floor heat on the first floor and baseboard hot water on the second floor? In my application, this would reduce the number of zones by 2. At a later date, I could expand the system to include the upstairs. I am willing to invest sweat equity. Is this even possible or am I just hoping?

I replied: OK, break out the work gloves!

Here's the rock bottom deal: If you are willing to provide the sweat equity to install the Quik-Trak panels; fill in plywood (1/2-inch plywood sheeting to fill in places where QT doesn't get installed — typically along edges of walls); install the tubing into the QT grooves; cut holes for A/C ducts and registers; plus fill in where we can swing the work your way; this can work. For instance, cutting holes for the oil tank fill and vent. We'll help you understand the installation of the QT and tubing, which really is not too terribly complicated, and be available to work out any questions. Our equipment will be yours to use. Lost, stolen or broken = your cost. I'm more concerned about the stolen aspect, so it is wise to pack up tools overnight on jobsites when no one is living there.

We have never done this before (turning over a portion of our work), so my comfort level is not as high as I'd like, but your enthusiasm and willingness to pitch in as needed have me believing

After the Behler crew installed manifolds, Hanson connected the Uponor PEX reverse-return loops.

this might work. To that end, the final control package and potential to include at least the second floor A/C system will be dependent upon how well this works. If the second floor A/C system is completed, at least there will be some refuge from extreme weather conditions and enough bedrooms to accommodate everyone for comfortable rest.

Obviously, I don't have hard facts and previous experience with your work skills. To that end, I can't nail this experiment down to the last dollar. But, if all goes reasonably well, I believe we can remain within your new budget for the radiant and air conditioning work.

Dumbing down the radiant? Maybe. But again, your performance will dictate how low we go and I don't want to completely abandon precision control of water temperatures. I may have to resort to some combined resources for the first-floor zoning, but necessity is the mother of invention, and we're known for innovative piping/control. I have a few ideas, but need to work out the wiring and flow issues on paper first. I'll give these up as a last resort. Let me know.

Eric replied: Give me some lessons, define my goal, point me in the right direction and I can do just about anything. I excel at being a battle commander in a fluid environment. My back is against the sea with no rescue fleet in sight. My only choice is to take the fight to the foe. Failure is not an option. I am ready to go to work. I won't let you down and I greatly appreciate the risk you are willing to take. Let's get to work! Thank you!

I replied: I've got to order your Quik-Trak, tubing and manifolds, which should then arrive by Monday or Tuesday. In the interim, I need to draw up a contract and get your "John Henrys." I'm still mulling over how to word the contract since we'll have a new "apprentice" doing a lot of the work! I'll let you know what this first billing will be by tomorrow or Friday.

Once the QT is here, we'll need to arrange delivery, and then we should be on site to review the design layout plus do some practice/training. Will the end of a workday be best for your schedule? We'll loan you the screw gun, which has a long snout to help preserve the knees and back. Then you're off to the races! Midway through your installation, we hope to be on-site installing the Burnham V8 boiler, Alliance indirect water heater and main control panel. That way if you've got any questions we'll be on site to provide answers.

We found that middle ground in the bidding process and they did an excellent job of installing the radiant flooring product and tubing. We installed the major system components and "coached" them on how to connect the tubing. The job is a total comfort success and they are delighted to be settled into their radiantly heated dream home.

During the project, the Hanson family found out that child No. 3 was on the way. It's pleasing to know that (s)he will be brought into an environment surrounded by love and radiant comfort!

I'm sick of green!

All manner of products now claim to be green.

It's gone too far — this "green" issue. Green this, green that, even my clothing and my hat. But now, it's gone one step over the line too far and my green guilt-trip finds me at the check-out line blushing-red-green.

Remember Tang and how it was promoted to us by way of the 1959 Gemini NASA space program? "Tang, the breakfast drink of astronauts." And we drank ourselves silly. Today's astronauts are serious about recycling: On-board systems are collecting sweat, humidity from breathing and shower-water, along with urine to provide the ultimate in recycled water. Kind of gives new meaning to having a mixed drink! What's next, recycled poo? Advice to astronauts — pack plenty of virgin foods in your carry-on bag.

But, I'm saving trees, I explained as onlookers giggled while checking me out in the check-out line. Aren't trees renewable? Cut 'em down and grow new ones! The gathering crowd admonished. After several BSA High Adventure canoe trips in the northern woods of Maine, we saw — first hand — how well the recycling of forest acreage works. I can see their point. Why not make this product from rotating pine tree crops instead of Boreal forests?

Oh, don't get me wrong. I jumped in with both green feet long before I knew they were going to be called green. My first 'green' boiler condensed — on occasion — but did not modulate. It loved my green and drained all of it from my wallet by way of continual breakdowns. Out it went and backwards, I ventured to cast iron non-condensing technology. That lasted for two years. Like a moth to a flame: My family (drafted involuntarily) ventured even farther into green technology than we had that first time by installing a modulating condensing boiler, and that little beastie restored my faith in green by letting me keep lots of green instead of giving it to the gas company. I was, at the time,

blissfully unaware of the need to view energy conservation on the circaholic side — that epiphany would come a few years later when I would also become a reformed circaholic.

We've greened up our appliances, too, with EnergyStar rating tags on each one purchased along with utility rebates for many. The clothes washer alone reduced water consumption by 40% and spins so fast the clothes are almost dry at the end of each cycle. The laundry-queen in my home averages 312-loads-per-year: That kind of green adds up. The new ACW is at a better height too, which is much appreciated for older backs, and is whisper quiet, which is a nice side-benefit. Toilets, too, with WaterSense compliant 1.28 gpf models that work as well as 1.6 gpf water closets that had replaced the 3.5 gpf water-wasters.

And just the other week, we installed a 98% efficiency tankless modulating condensing water heater. Looking back over the past five years, we've installed 99% efficiency tank-style water heaters, indirect water heaters connected to 95% efficiency modulating condensing boilers, heat-pump water heaters, and, of course, the ultimate in green — solar thermal water heaters. Good solid green technologies with one just right for most budgets — especially back when there were nice fat Federal tax credits.

HVAC hasn't dodged the green-bullet. We're installing air source mini-split inverter heat pumps with 33-SEER and 14.2-HSPF, geothermal with slightly higher efficiency ratings and mod-con gas furnaces that top out at 99% efficiency. Oil too can be green (check out "The Fix is In" on Page XX of this eBook).

Delving deeper into green, our industry has finally taken notice to the passrasitic (passive ignorance of parasitic energy losses) consumption gobbled up by motors while transferring comfort-energy from source to occupants — an energy bridge under which energy-flow-over-the-dam was previously ignored. Going green to save green — that's about as good as green can be. ECM blowers and circulators with adaptive intelligence driving their speed to sip only the energy required to meet demand!

"We've greened up our appliances, too, with EnergyStar rating tags on each one purchased along with utility rebates for many."

My own hydronic radiant system could have served as a poster-child for being an energy hog with its thermal bridge from our 95% efficiency mod-con to the radiant floors: 13-circulators at 87- to 130-watts each, pumping for 3,000-hours each year added up to $359.04. My new variable speed ECM circulators coupled with 10 low-wattage zone valves has reduced that to just $24.83! Next year, our rates are predicted to go from 11 cents per kWh to 16.5 cents. Here's the reality check: Starting at 11 cents per kWh year one, then 16.5 cents per kWh year two, and projecting 20-years with 5% per year annual increase in electricity added in, my previous 13-circulator rig would have cost me $16,806.13. Over that same 20-year span, my redesigned system will, instead, have saved me $15,643.72. That's hard-earned green I get to pocket! Do the math and sales of these ECM circulators will be a snap once you educate your customers.

When it was time for a new floor, we chose bamboo because of its renewable green classification, and besides, it looks great. All manner of products now claim to be green and green-washing has become advertising sport that's expanding faster than the universe; each claim exceeding the next in its outrageous zest to go-for-the-green! That's the green that makes me sick because it's diluting true green for purely selfish reasons.

All of which I can certainly handle. However, I'm standing in the check-out line with a (12-pack) recycled tissue issue that folks feel compelled to squeeze and comment about. Help me Mr. Whipple! Toilet tissue that is, all kidding aside, as green (for now) as green

I'M SICK OF GREEN!

"If every American were to purchase just one roll of recycled toilet paper, 400,000 trees would be spared the axe! Gives a whole new meaning to being called a tree hugger."

gets. If every American were to purchase just one roll of recycled toilet paper, 400,000 trees would be spared the axe! Gives a whole new meaning to being called a tree hugger.

Recycled toilet paper guide: www.greenpeace.org/usa/research/tissueguide.

Of course today, given the panic buying and hoarding of toilet paper, you'd be lucky to get out of the store alive with any type at all! At the beginning of our COVID-19 quarantine, some folks were taking entire shopping carts of nothing but toilet paper through checkout lines. A few even tried selling individual rolls online for inflated pricing! That was a flop, and when attempting to return their cache of TP, they were told to go stuff it by stores refusing returns.

One of the executives at Walmart was on TV the other day saying that in five days, they sold enough rolls of toilet paper for every man, woman and child in the USA to have one roll! Lois did manage to get one 12-roll pack, and the store had an employee posted there to ensure only one pack per customer. For the two of us, that's eighteen days to go before I have to install the bidet toilet seat I got her for Christmas! Tick tock. If she manages to score some more TP, I can continue saving the world from COVID-19-spread by being a couch potato!

The calculations I've seen indicate a standard roll of TP should last each person three days. Unless, of course, you're prepping for a colonoscopy, in which case that's more like three rolls per hour! So, to the idiots who loaded up with thirty 48-pack rolls of TP that would take one individual 11.8-years to use — here's your sign.

The fix is in

Guide consumers toward the products that best fit their needs

Wayne and Jean are like most of our retired customers: They are concerned about rising fuel costs, are on a fixed income and they want some ideas about how to cut costs. They've already buttoned up their house by installing insulation, and now they're giving serious consideration to replacing the boiler.

The couple lives in a rural area and burn #2 fuel oil. Their existing boiler is approximately 20 years old, looks like it's 80 and incorporates a domestic coil. The deteriorated single-wall flue piping travels 20 feet horizontally through an unheated crawlspace to a masonry chimney and includes a very noisy draft fan to paddlewheel the exhaust gases into the chimney.

I pointed out that if we did any work on the boiler or installed a new boiler with a domestic coil, we would require an ASSE listed 1017 scald-guard mixing valve to regulate the potable water delivery temperature. They noted the water is scalding hot — especially when they first use any hot water. Actual first-draw DHW temperature matched that of the boiler and was 180° F! Noise has been an irritating issue, and that too can be virtually eliminated with newer model oil-fired boilers.

It turned out they already were familiar with indirect water heaters, but were not quite clear on how they worked. After explaining the benefits, which included lower fuel usage, they wanted pricing with options upon options.

Alternatives

Here's the deal: They'll save fuel by lowering the boiler's firing rate by .30 gph. They'll also save fuel because a new Peerless Pinnacle boiler's efficiency rating is 10% better (if they decide to go with this option)

Installation of the Peerless dual intake/exhaust flue pipe.

Behler crew installing the Peerless Pinnacle boiler and indirect water heater.


Old boiler's noisy exhaust fan.

than would be a standard chimney-vented model. And, if they go for the Peerless indirect water heater tank instead of a coil, they'll save even more fuel via lower standby heat losses.

They'll also be eliminating the additional overdraft created by the in-line paddlewheel fan (it pegs the barometric draft damper wide open), which will save Btu from already heated room-air being prematurely sucked away. Last but not least, by bringing in combustion air from outside the building envelope and eliminating the combustion draft fan, they'll save fuel by lowering the home's infiltration rate.

If they choose the pricing option that includes an indirect water heater, we can eliminate the chimney and flue through the crawlspace, too, with an upgrade option for a direct-vent boiler. Upfront costs will be higher, but with projected fuel savings, this installation has the potential to pay for itself in less than three years when compared to installing a lower efficiency chimney-vented boiler with DHW coil and auxiliary booster exhaust fan.

They will also need a new Granby Ecoguard double-wall containment oil tank to replace their 40-plus year old single-wall tank. They were firm about their desire to transfer the existing oil to the new tank in spite of our warning that sludge and water might very well be transferred in the process.

Balancing act

There's just one hitch: With the home's added insulation, the new boiler's Btu output will be substantially below the minimum input required to meet the indirect water heater's recovery rating.

Our salesman was quick to point out that the two don't meet — on paper — for determining domestic hot water recovery rates. But, if you read the fine print for the indirect water heater's recovery ratings, they never really meet — in the real world — right from the beginning!

The indirect manufacturer's assumed working conditions are based on three things: 58° incoming cold water; 135° domestic storage; and 180° from the boiler. I can only "assume" the last two are accurate because we all see 40° municipally delivered water (55° for well water) during the coldest weeks of the year. That's the domestic water design condition needed for accurately projecting hourly ratings. The manufacturer lists a required minimum net boiler output of 99,000 Btu in its calculations, and I'll have just 79,000 Btu to play with in this application.

This has become an all-too-frequent challenge, as the required Btu for domestic hot water often loom much larger than do the Btu required to meet design-day heating (baseboard hot water in this case) conditions. Should you size for the domestic or for the heating load? Should you add Btu to the heating load for domestic hot water production and upsize the boiler?

If you size to meet the domestic load, then the heating efficiency suffers, and if you follow the listed indirect ratings without doing a

Installing the Peerless pipe-in-pipe I take/exhaust flue piping.

In poor condition, it was time to also replace the oil tank. Sadly, Jean's oil tank art work would be leaving too.

A Granby Greenshield oil tank with double wall safety containment was installed and piping upgraded for code compliance.

little bit of homework, you're going to catch a liability bullet and end up giving away work to satisfy an angry customer. You're the one who stepped up to stand squarely in front of the bull's-eye. Everyone else has literature to present that clearly shows it's your fault — you didn't apply your conditions to properly size the water heater!

In this case, Wayne and Jean use well-water, so no need to upsize the indirect tank volume to make up for longer recovery time as we would if this was a municipal water application.

Flow rate is key

If those issues don't give you second thoughts, there's one more condition you need to meet that's typically ignored — choosing the right circulator to meet the flow rates required to transfer energy from boiler-to-indirect so that the recovery rates don't suffer. Any given indirect water heater has a required gpm flow rate and pressure drop (resistance to flow) to overcome.

Combined, the two will dictate where a circulator's performance will fall — if you utilize the manufacturer's performance chart. Here again, ignorance is not bliss — it's another bullet loaded in a hair-triggered liability gun. Domestic hot water production represents 15% to 30% of a home's overall energy consumption, so choosing the lowest wattage circulator that meets flow rate and pressure drop ratings can have a significant impact on yearly savings.

OK, let's review the issues and concerns I picked up by listening to Jean and Wayne. They included the skyrocketing cost for fuel; on a fixed income, but willing to invest in energy saving options — already have by adding insulation and new windows/doors; scalding hot water; poor combustion draft with odor and CO issues expressed; moderately efficient boiler; and objectionable burner and draft-fan noise.

Have you ever wondered why boilers aren't nearly as well insulated as water heaters? Boilers are rated differently than water heaters when it comes to standby and operating heat losses. Heat loss from boilers is not considered to be lost — it's given up to the interior of the home and, therefore, not deducted. Water heaters are well insulated to minimize heat losses because that energy loss counts against their performance. So, if I'm going to weigh the domestic coil option against the indirect water heater option, I can use this information for a bit of added sales sizzle.

The noise issues go away with many of today's oil-fired boilers. A direct-vent model will remove the venting issue. Here again, it's also easy to address a hidden problem and directly address a stated concern — such as fuel usage — by reducing the infiltration otherwise needed for combustion air that would have been drawn in, heated and used to support combustion. Up-selling is fun and easy if it fits within the four corners of the customers' concerns.

So, now that we've convinced the customers that these options are a good investment, it's time to determine how to make the components perform to their best efficiency and ability. Indirect water heaters come in a wide variety of shapes, sizes and models. The literature stating their recovery rates is based on information that often doesn't mirror the real-world conditions where you live.

Sizing the tank

I use design conditions of 40° incoming and 140° storage at a 100° rise. Next, I determine the boiler's net hourly output in Btu. Divide the net output by 833 to determine the hourly gallons of hot water that can be produced and divide that by 60 (minutes) to obtain the gpm rating. During winter's coldest weather, when I'll be seeing 40° incoming cold water (55° for well-water systems), I can safely assume 85% of the adjusted bathing temperature will be coming from the indirect hot water tank. Just two things remain to accurately pinpoint the required tank sizing — gpm flow rate from the bathing module(s) and duration of use. It's just that easy!

Sizing the circulator

Properly moving the boiler's energy to the indirect water heater

“Given that domestic hot water is required daily, choosing a circulator with a lower wattage rating will save your customer some additional money.”

will keep you out of hot water. Match a circulator to meet or exceed the head loss so that you will deliver the required gpm. Don’t reduce the installation instruction’s boiler-to-indirect-to-boiler pipe size! Screw up this step and you’ll have an under-performing indirect, send circulators to an early grave or generate noisy flow. You need to locate the indirect water heater’s head loss and the head loss through the boiler at the targeted gpm flow rate. The larger of the two will be the number you use. Today’s modulating condensing boilers often have a higher head loss (resistance to flow) than the indirect water heater. Circulator manufacturers’ flow charts list head along one side and gpm flow rates along the adjoining side. Drawing lines at 90-degree angles from both points to where they intersect gives you the border you can’t fall below or performance will suffer. Given that domestic hot water is required daily, choosing a circulator with a lower wattage rating will save your customer some additional money.

Efficiency matters

Indirect water heaters have very little standby heat loss. A boiler maintaining 180° (or higher) temperature so that its domestic coil stands ready to deliver hot water, by comparison, wastes great gobs of energy. Add in the dangers related to scalding and limited gpm flow rate and you begin swaying your customers’ choice. Price no longer governs the sale. Safety and comfort along with lowered fuel consumption now move to the top of their list.

Although the combined boiler-indirect provides safer hot water temperature regulation, thermal stacking likely will occur. ANSI Z21.10 regulations governing water heaters recognize this phenomenon and permit the stored water temperature to be up to 30° hotter than the control’s setting. So, 140° can become 170° and still be in compliance. While scalding can rapidly occur at 140°, it’s obvious that 170° presents a far greater danger. Adding an ASSE 1017-listed scald-guard mixing valve set for 120° will lower the risk (scalding can still occur, but takes longer). Customers will appreciate your taking the time to educate them about this much-needed safety device.

Place yourself in the customers’ shoes and imagine you’re listening to the feedback you’d give after hearing the customers’ concerns. Can’t you feel your comfort level rising and the trust developing that will induce you-as-the-customer to invest more wisely — in spite of the added costs? And that, my friends, is exactly how you can up-sell every job, no matter the product. It’s our job to provide comfort and protect health. We also must guide consumers toward the products that best fit their needs while (today more than ever before) providing products that conserve energy and last, but certainly not least, price the work properly so that our businesses remain profitable.

CASE HISTORIES

Rx radiant

Radiant heating offers unequaled comfort for homeowners.

Imagine a life devoid of such simple pleasures as walking barefoot on your floors, peaceful night's sleep and awakening refreshed, recharged and ready to face the new day's challenges free from debilitating pain. Fibromyalgia, often mistaken for arthritis, does just that.

Pat Ketrick has lived with the discomfort and pain of Fibromyalgia for many years. Cold and damp weather have been dreaded because of the extreme discomfort brought on after a fitful night's sleep in a room that has always felt cold, no matter the type heating system. Bruce and Pat have lived in twelve homes over the years and have experienced every type of heating system available, from electric to hot air to heat pump and even hot water baseboard. In every case, they found it necessary to elevate the thermostat setting well above 70° to combat Pat's pain, with limited success. Going barefoot on cold floors always resulted in severe pain, no matter how high the thermostat setting. She described the pain of Fibromyalgia as what you and I would experience after an "extremely strenuous workout." Aching muscles that require a long stretching period before you can begin the day's routines and constant pain without relief.

Several years ago, Bruce and Pat were visiting their son in Scranton, Pennsylvania, for a football weekend gathering. The crowd was larger than the home could accommodate overnight and the Ketrick's slept in the home of **Steve Camasta**, a friend of their son's. As it turned out, this night's lodging would change their lives forever.

With winter's bitter cold raging outside, Pat knew she would awake in agony following a restless night's sleep. The feeling of warmth pleasantly surprised the Ketricks as they entered Steve's home, and even more so when snuggling down for a winter's nap in a warm bed.

Radiantly heated home from top to bottom provides real comfort.

The following morning found old man winter hard at work and Pat was amazed to find she was virtually pain-free. For you see, Steve Camasta is a plumber and this portion of his home was radiantly heated. Bruce and Pat Ketrick began planning a new home, one that would be radiantly heated from top to bottom.

There was only one problem: York was far enough away from Scranton to make it impractical for Steve to do the work. The Ketricks set out to find a local contractor and wanted to deal with one that was not only well versed in radiant heating, but also a customer of theirs. Bruce and Pat own Guardian Chemical Co. in York, Pennsylvania, and have supplied F.W. Behler with boiler treatment products for many years. Their architect visited our office and interviewed me at length. He asked many pertinent questions related to radiant heating and about


Bracing for PEX transition out of concrete slab.


Yates checks manifold performance.

products that were available. Visiting our website with its information and pictures of previous radiant heating installations convinced the Ketricks that we were the right choice for installing their radiant heating. I was, at this point, completely unaware of Pat's Fibromyalgia.

The project

With a large home and bathrooms spread out on all sides, this was a perfect set-up for a boiler with indirect potable hot water storage tank. A gravity hot water circulation loop along with priority controls would ensure an almost endless supply of hot water for the master bathroom whirlpool tub, large walk-in shower with two dual faucets, laundry, dishwashing and guest bathrooms.

The home is split into four distinctly separate hydronic zones (living areas, master bedroom suite, children's wing and basement recreation/bar/bedrooms/sewing) that each required varying temperatures due to combinations of carpeting, composite free floating hardwood flooring, tile and 3/4s-inch oak hardwood flooring. Glass and cold wall exposure added to the challenges for detailed heat loss calculations. Fortunately, hydronic heating and hydronic radiant heating in particular, allow for an unending variety of comfort levels and zoning is quite easy to accomplish.

We designed the control package to monitor the outdoor air temperature, look at the indoor air temperature and then determine how much heated water to send to the various injection panels.

Mike Keefer fastens extruded aluminum heat transfer plated to subfloor.

Radiant comfort for the living room.

Injection piping is best described as being like adding hot water to a bath you've been luxuriating in to bring it back up to the desired comfort levels; very gentle and satisfying. Injection piping very easily enabled us to locate several remote circulation panels directly under or adjacent to the areas they were to serve, thereby avoiding long leader lengths between the radiant floor panel loops and manifolds, and run small 1/2-inch PEX injection loops from the main panel to these remote sites. This is possible due to the relatively large Btu carrying capacity of water, up to 10,000 Btu per gallon of flow. This eliminated dozens of long insulated runs had we used a more traditional piping method and saved several thousand feet of PEX tubing. This particular piping method also results in substantial time and material savings.

Radiant heating offers unequaled performance and comfort. Injection piping ensures whisper quiet applications. Our upper floor installation uses high quality extruded aluminum plates, stapled directly to the underside of the plywood sub flooring. The use of aluminum plates helps to spread out the warmth very quickly and enhances the heat transfer rate so that we can lower the overall water temperatures required to satisfactorily heat the home. Lower water temperatures save costs since less fuel is used, which makes for happy customers. It is not uncommon for a radiant system to use up to 40% less energy than a conventional forced hot air furnace. This is especially true in homes with vaulted ceilings since hot air tends to rise and pack against the ceiling, accelerating heat losses whereas homes with radiant systems will find the temperature virtually the same at the ceiling as they are just above the floor.

Bruce is familiar with preparing comprehensive energy audits for his customers in order to justify the substantial savings proper boiler water treatment can achieve, and had already done an exhaustive study showing the savings radiant heating would have over other methods.

"But it didn't matter," Bruce says, "Pat's comfort was the determining factor."

Mike Keefer fastens extruded aluminum heat transfer plated to subfloor.

PEX Tubing coiler allows the Viega radiant tubing to be easily installed on the Viega Climate (floor) Panels.

During construction, I repeatedly reminded the building contractor that no nails were to be driven into the floor for supporting the concrete block walls. We had carefully marked out the locations for walls and doorways so we could route our tubing runs where doorways were located in order to protect our tubing from nails. The builder agreed he would run center planks to bridge the gap between the bracing for the exterior block walls.

Fast forward to the day of commissioning our new hydronic radiant system. The carpenters were directly above us having lunch. While the water-feeder was running on bypass to speed up the process, I walked through the adjacent room where I spied a puddle on the floor. Thinking one of the carpenters above had spilled his drink, I ignored the puddle. Returning from my truck, I was surprised to find we were not building pressure. Taking a quick tour of the basement rooms, I was stunned to find mini-gueysers in every room corresponding with nail holes in the concrete! Ignoring my instructions, the builder had nailed the block wall supports to the floor and hit all but one loop. Crisis mode!

"Climate Panels to the rescue"

The Ketricks were hosting a wedding in two weeks and this was mid-March with cold weather setting in. The basement walls, trim and door frames had all been installed and tearing up the new concrete floor was not an option. Viega Climate Panels to the rescue. Losing only 1/2-inch of floor space to the Climate Panels enabled construction to move forward without interruption. Three days later, the radiant system was complete, comfort was delivered and the wedding went off without a delay.

For the first time in many years, Pat Ketrick could now stand barefoot on her kitchen ceramic tiled floor and gaze peacefully at the falling snow, free from pain. Old man winter no longer holds a grip on her comfort. When I talked with Bruce and Pat, after they had been settled in for a few weeks, they remarked with amazement that they were quite comfortable with the thermostat set between 62°and 64°. They have been discovering the additional fringe benefits of radiant heating, such as the pleasant surprise of finding their bed warm and inviting.

"I feel as if I'm bathed in warmth," Pat remarked.

Having a customer who is so tuned into the comfort having warm objects can give, such as chairs, floors and beds, has confirmed everything I've read and been taught regarding the outstanding benefits radiant heating offers.

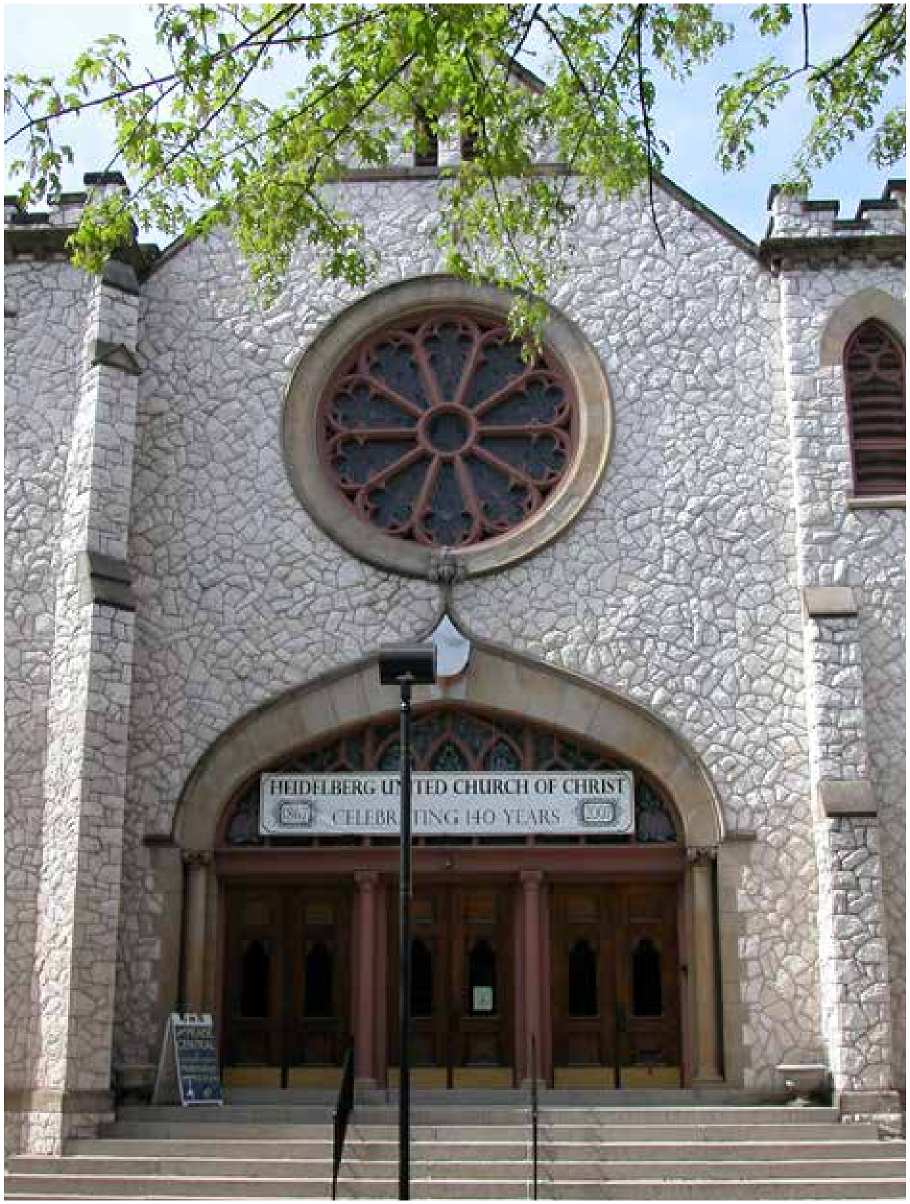
Divine intervention

Hybrid system provides energy savings for Pennsylvania church.

Heidelberg United Church of Christ in York, Pennsylvania, needed a mechanical fix in a bad way. According to one church member, heating equipment at the church needed "salvation," and, more importantly, summer services were hotter than Hades. They were praying for a Divine Intervention.

The answer to their prayers were delivered in a hybrid design we created after thoroughly studying the church building envelope, location and times when people congregated, offices and when they are occupied, and interviewing the pastor and church secretary to better understand the existing comfort issues. For example, the secretary's office was the most utilized, yet least comfortable. In order to obtain any heating, it was necessary to turn on the steam boiler utilized for heating the entire church complex; like swatting gnats with an energy sledgehammer! The hybrid system we proposed, when compared to the nearest competitor's bid, would be more than twice as efficient and cost $200,000 less. I love being the last bidder on jobs. While I don't want to see the competitors' prices, I do like to see what type of system is being proposed. The others were bidding a four pipe chiller/hydronic system that would have completely eliminated their rear parking lot in center city York, where parking was already scarce.

In addition to the energy and installation savings, our plan for the 20,000-plus square foot church was far less invasive, requiring minimal disruption to the building and the congregation. It also left the rear parking area untouched. It's no surprise that we were the contracting firm chosen to give the church its long-awaited mechanical makeover.



Heidelberg Church in center-city York, PA.

Steam radiator in Sanctuary converted to use gently warmed water.

Ancient hydronic convector.

Challenges and solutions

The oldest part of the building dates back to 1800; it has seen numerous additions and remodels since. The entire building was heated by a sinfully oversized steam boiler, which came as no shock. The 1918 Spanish Flu Pandemic brought awareness to the importance of fresh air in high-occupancy areas. The trend toward over-sizing systems allowed for windows to be cracked for fresh air circulation, even in the dead of winter. This, in a sense, marked the beginning of IAQ consciousness.

Many systems installed during the "fresh air" era were oversized by at least 20%, often more, and sometimes, much more than was needed. Of course, this also meant that the church's boiler knew bang-bang short cycling as a way of life.

"We often thought demons were knocking on the cellar door when that system started," quips congregants.

The old system had some pretty big problems. With a thermal efficiency of around 30%, the old steam boiler at Heidelberg Church was connected to a maze of crudely-patched piping. Our design plans included converting the sanctuary's steam radiators to hot water, requiring several new and compact modulating-condensing hot water boilers. The modcons would, in turn, be cascaded and staged to provide equal run time to each boiler. Remaining portions of the church would be served by a new, properly-sized steam boiler. And, to save them from summertime's inferno, our design included air conditioning to the entire non-ducted building complex with ductless Fujitsu mini-split systems. The offices could now be individually controlled for both heating and AC without the need to fire up any other equipment. The secretary's office would be comfort conditioned as desired.

The 5,000 square-foot sanctuary presented quite a few challenges for the steam-to-gently-warmed water conversion, and with the pews full, the AC


Cascade application of three modulating condensing boilers.

load had to be precise. While calculating the heat load, we compensated for lower radiator temperatures (tied to outdoor reset). No longer would radiator surface temperature be 215° F (one pound steam), but rather, a glide between 85° and 160° with gently warmed water.

Wall-hung and/or racked condensing units tied to wall-hung, ceiling suspended and floor console evaporator heads enabled a far less invasive solution for bringing Heidelberg Church an energy efficient solution for heating (either as stand-alone or working with existing hydronic heat emitters, or as stand-by backup heat) and cooling their building.

While investigating the main sanctuary heat gain/loss characteristics (a necessary first step to determine if hot water running through the current radiators would be sufficient), I discovered a generous layer of insulation had been added across the entire crawlspace above the sanctuary ceiling. The subsequent Manual-J heat loss calculation, when compared to the radiators EDR, revealed it would be a marriage made in heaven!

The steam radiators were single-tube piped, requiring some work to convert them to hot water, along with the use of twin-piped supply-side valves. The installation crew had to drill and tap each one to change all the valves and fittings. To preserve the 100-year-old ceramic tile on the sanctuary floor, return lines were run back down with the supply lines through the pre-existing, one-pipe steam floor-holes.

Ductless Fujitsu mini-split systems meet the church's air conditioning needs without cutting into very limited space.

Heating the whole sanctuary with one traditional hydronic loop would not be possible. To remedy this, we installed reverse-return piping, ensuring all the radiators reached the same temperature simultaneously.

With prolonged periods of record cold and snowfalls, the new heating systems' inaugural winter was brutal. But the congregation was delighted with the quiet warmth it delivered. And, according to the church's treasurer, they also saved $6,000 in fuel during that first winter.

Adding air conditioning

With the heating problems licked, we began implementing our AC designs. Cooling the big interior spaces of the church would have its challenges, too.

The system proposed by other contractors called for the installation of a 150-ton chiller that would have required special permitting and also eliminated the church's very-limited parking spaces. To solve the problem, we specified single- and multi-zone ductless Fujitsu mini-split systems to meet the church's air conditioning needs.

Without a prior air conditioning system of any kind, the building had no ductwork. One of the many benefits of the mini-splits is we were able to outfit the church with an a/c system that didn't require tearing down the ceiling to run ducts.

Before the overhaul, much of the building was unbearable, such as the secretary's office. The temperature was usually around 85° in the office on hot summer's day. The humidity was extreme too, resulting in poor comfort and frequent paper jams in the printer.

A 12,000 Btu evaporator unit was installed; one of three that are connected to a 2.5-ton, triple-zone condensing unit outside. The other two evaporators, at 9,000 Btu each, were installed in the nearby restrooms.

The secretary's office, the pastor's office and the auditorium together required 12 tons of cooling, all easily met with the installation of a few Fujitsu multi-zones. The sanctuary received a total of 26.5 tons of cooling from 10 evaporators.

Instead of having an on/off system, sure to gobble large chunks of the operating budget, our installed system can quietly glide from 8,500-Btu to the full 26.5-tons as needed and will react via on-board sensors wherever the congregation crowd is seated — all the while sipping only the energy required to meet demands for congregant comfort.

The church's 6,220 square foot social hall, located downstairs, is on the opposite end of the building from the sanctuary. Unlike the sanctuary, where the heat and air conditioning load is greatly dictated by the giant stained-glass windows, the social hall had a different need for heating/cooling. The area is often used for activities, where people create nearly twice as many Btu as they would quietly sitting in a sanctuary pew. There is also a large kitchen, raising the cooling needs when in use.

The social hall is one large room that is often separated into four smaller areas by divider curtains. Each of these areas, and an adjacent classroom, were zoned separately. This way, if a group of people needs only half the hall, no energy is wasted by cooling/heating the unused areas. The social hall is conditioned with 25.5 tons of cooling, delivered by nine separate air handlers; the social hall and classrooms can work together, or separately, anywhere between 8,500 Btu and full capacity.

New properly sized Burnham steam boiler.

DIVINE INTERVENTION

View of Sanctuary from choir loft.

There are 26 air handlers throughout the church connected to 23 condensing units outside, all but five of which are in a gated alley between the church and an adjacent building. To minimize their footprint, the units are racked and stacked on top of each other, two high.

On the other side of the church, the remaining five units were hung 15 feet off the ground from the exterior wall of the church to protect them from being stolen for scrap value. Fujitsu's condensing units are front discharge, so mounting them close to the brick wall was no problem. As long as the back of the unit has at least four inches of clearance, efficiency is not affected.

The new properly-sized steam boiler was equipped with a vapor-stat, because the original system was set up as a vapor operation utilizing ounces rather than pounds of steam, which is more economical to operate.

With limited outdoor space, we knew we were going to have to get creative. Fujitsu makes that a little easier. F.W. Behler installs a lot of mini-splits, not only because of the tremendous efficiency, but also because of how quiet they are. The Fujitsu evaporators run as low as 22 decibels; as quiet as the proverbial church mouse.

Before installation of the system, I was asked to appear before the congregation to present our hybrid plan for the new systems.

"Yates was very helpful in designing the system custom to our needs, and he did a great job explaining it to the congregation," says church member **Steve Green**. "His company did an excellent job installing the systems. Their work is superb, and the systems are quiet and comfortable beyond our expectations. Because of the new comfort we now have, we've also had more summer weddings and events here, and they help to pay the bills."

Addressing the congregation one Sunday morning after completion of the job, I turned to the pastor and say:

"You know, pastor, you're in control of this environment. If the congregation gets too comfortable in the sanctuary and forgets what a blessing it is to have air conditioning after so many years without it, you can always call upon a higher power to remind them. The remote control will be right in your hand. It's small and easily concealed. Maybe, with the wave of a hand, you could wield mystical powers, and that'd make 'em more attentive to the sermon!"

As with nearly every church where I have had an opportunity to thoroughly study the existing systems and perform energy audits, Heidelberg too was an ideal site for carving out massive energy conservation while, at the same time, greatly increasing human comfort. It's a win-win for everyone involved. There is a spiritual uplift for me when working on a divine intervention like the Heidelberg Church project. It is satisfying and deeply fulfilling.

Radiant for macropods

Radiant heating system provides comfort, flexibility for animal rehabilitation center.

Sales calls for radiant heating have proven to be anything but routine fare. For the most part, radiant customers are well-educated folks who have done considerable homework and have gained a grasp of basic heating issues.

Many particulars must be blended together to weave the fabric of a successful sales adventure, not the least of which includes an accurate assessment of the end-users' needs, desires and wants. More often than not, listening to their subtle undertones can provide the clues needed.

But what if the customers can't talk or speak for themselves?

I envisioned a visit to a Rehabitat center as one where wounded raptors such as hawks and owls are safely housed and fed until they have healed sufficiently for re-release to the wilderness. I pictured a place where human contact remained limited to prevent the wild inhabitants from adopting too casual an attitude regarding a healthy fear of mankind.

After winding my way through the rural countryside of Dillsburg, Pennsylvania, I found myself traveling along a gravel road into a dense thicket of woodland. Rehabitat is secluded and isolated from civilization, which is no doubt beneficial for beast and mankind alike!

Enter Owen

My arrival was greeted with a cacophony of noise from several runways housing unusual-looking dogs. No question about when strangers arrive here! To the right there was a home, and my destination for an appointment with Wendy Looker, the director of this Rehabitat facility.

Dave Yates with Davey the wallaby named for his favorite radiant heating contractor.

RADIANT FOR MACROPODS


Dave Yates testing voltages with son Mike Yates.

Wendy invited me to take a seat at her home's kitchen table so that we could lay out the plans for a new building. She had heard that radiant heating would offer the greatest comfort for her charges while saving operation costs. But installation costs were a real concern, too, and would need to fit within her very tight budget.

During our talks, Wendy excused herself to get a bottle warmed for a feeding. I assumed a fledgling hawk or owl would be joining us for a mid-morning snack and didn't give it a second thought, due to my being absorbed in thinking about what would be the most economic approach to satisfying the radiant design. The sack she carried back into the room was gently placed on the floor and out hopped Owen, a baby kangaroo — crikey!

Standing almost 2 feet tall, Owen immediately expressed his joy of being out of his "pouch" by hopping about the kitchen. I'd never been sniffed by a kangaroo before, and Owen immediately stopped to check out the stranger in his environment. Once satisfied I was OK, he continued his journey until he spied his own image in the glossy surface of the dishwasher and, startled, jumped up and back.

My curiosity piqued, I wanted to know more about this species from Down Under that I had long longed to see first-hand. I couldn't get over the fact that here I was, having a casual encounter with a kangaroo in a home's kitchen while on one of the most unusual radiant sales calls of my career!

"Macropods" (meaning large feet) was the term Wendy used in her description of Owen, and I was surprised to see his feet were almost as long as he was tall. But macropods' large feet also serve as defensive weapons when they use their muscular tails for balance while delivering a crippling blow when kicking their perceived attacker. Wendy explained that as Owen and his kangaroo siblings grew to a height of 6-plus feet, they were going to need a large enclosure to facilitate a more natural environment. To creatures with feet this big, a warm floor would feel like nirvana!

As I would soon discover, kangaroos were not the only ones in need of warm feet: Wallabies, bearcats, a two-toed sloth, various species of owls and hawks, plus Australian heeler dogs make up a part of the menagerie of exotic species whose native lands offer warm terra firma for their feet. A comfortable environment would greatly enhance their comfort and speed up recovery times.

When I mentioned that we needed to carve out an unheated space for the dogs to reside due to their needing to lose unwanted body heat via panting, Wendy began to trust my design skills. Her comfort level was rising too!

A tour of the numerous outbuildings and fly-ways introduced me to two kinkajous with prehensile tails, several skunks including an albino baby, two foxes, multiple species of owls and hawks and a parrot who,

RADIANT FOR MACROPODS

I swear, carried on an ongoing conversation with Wendy the entire time we were in "his" building.

Volunteers pitch in

In order to remain within our budget constraints, I had to find ways in which to cut labor and material costs. Wendy and I quickly settled upon a plan to utilize as much of the Rehabitat volunteer work force as possible without compromising safety or system designs. This also meant the bulk of work would be performed on weekends and weeknights when the volunteers were available.

I confess I was a bit apprehensive about the tight timeframe we had established for installing the tubing prior to the concrete flooring installation, but those concerns rapidly evaporated once everyone arrived and the first two loops had been installed. By then, everyone had grasped the concept and settled into a routine.

Utilizing Watts Onix rubber tubing turned out to be a good judgment call as it remained in place while awaiting the ministrations of the zip-tie gang. This also allowed the person running the tubing to follow my design without having the tubing recoil on its own prior to being fastened.

Teamwork prevailed, and smiles quickly replaced any concerns. Good-natured bantering between these volunteer veterans quickly revealed their deep-rooted friendships. Each one had become enamored with Wendy's Rehabitat operation during one of her many educational talks and were captivated by the majestic appearance of hawks, owls or other exotic species.

Wendy's husband, Joe, a postal carrier, has long worked additional hours in order to help support his wife's passion, and their daughter, Stephanie, chipped in making this a full-fledged family effort. Gary, a plumber by trade, was delighted to work on a radiant system and become a Wet Head — I was delighted to provide his first foray into this arena. Jamie works in the tax collection division for the state of Pennsylvania; Duane works for Purina by day.

Yates connects a loop of Watts Onyx barrier tubing.

Many of the Rehabitat tenants have appeared on national television shows including Late Night with Conan O'Brien. Endangered species are bred in captivity here by utilizing animals whose injuries preclude their release. Screech owls, barn owls and kestrels are raised and released to the wild.

In the evenings, dozens of turkey vultures settle in to visit with the raptors housed in one of the largest enclosed fly-ways in the Northeast. If given an opportunity, the mischievous and opportunistic birds will contrive a way to steal the many bits of food (dead mice and rats) placed in as natural a manner as possible for the raptors being housed.

Yates with Owen the kangaroo.

Rehabitat volunteer zip ties Watts Onyx radiant tubing to wire mesh grid.

In addition, although just as ugly as I'd always imagined, these surprisingly intelligent rascals like to play with floating toys in the Lookers' pool and tease the wire-haired dachshund dogs by walking around on the wire screening covering their runways. It quickly becomes apparent that they enjoy teasing the dogs and have made quite a game out of it. After a play period, they settle in for a night's roost and disappear by the next morning. They somehow know they're in no danger of harm here and allow one to approach to within just a few feet — each eyeing the other with rapt curiosity.

Design simplicity

With the new building divided into three distinct areas — for office and dogs, raptors and macropods — it was necessary to incorporate design simplicity friendly to a volunteer crew and that minimized materials while operating at peak efficiencies for delivering both comfort and economy. Continuing along the theme of quick-as-lightning installation to reduce labor costs, we settled on using a direct-vent, propane-fired, compact wall-mounted Laars Mini-Therm JVi boiler and a Watts pre-manufactured injection panel. Utilizing injection piping granted us the opportunity to minimize piping while, at the same time, maximizing the ability for utilizing remotely mounted manifolds.

Given the very low flow rates needed to transfer Btu with injection pumping, 1/2-inch, Watts E-PEX B lines were added for each of the two remotely mounted manifolds. The manifolds were kept close to the floor level so their distribution loops could disappear into the concrete directly below, and the injection tubing rises up from the concrete to supply the needed supply temperatures.

RADIANT FOR MACROPODS

Wendy Looker and volunteer crew hard at work.

By installing them in this manner, it is feasible to provide a protective cover for shielding the radiant products from inquisitive gnawing or aerial bombs and keep the inhabitants from inadvertently injuring themselves. Precise control of these three individual areas, with a cool spot for the dogs, will now be possible with an infinite ability to alter each area's temperatures as needed for an ever-changing menagerie of inhabitants.

Mid-term during the installation, a newborn wallaby entered this wildlife Rehabitat family and was named for his favorite radiant heating contractor: Davey!

Warm macropods, raptors and dog runways for speedier recovery and return to the wild makes for warm hearts and pleasure of newfound friends! I'll be the one humming a few bars from that oldie but goodie by Rolf Harris:

Watch me wallabies feed, mate,
Watch me wallabies feed,
They're a dangerous breed, mate,
So watch me wallabies feed
Altogether now!
Tie me kangaroo down, sport,
Tie me kangaroo down
Tie me kangaroo down, sport,
Tie me kangaroo down.

Footnote: Like a moth to a flame, I have always been drawn to unusual and challenging hydronic installations. Rehabitat was one of the most interesting radiant heating installations and a real treat to be entrusted with designing and providing a healing space with distinct zones where space temperatures could be varied to best suit whatever temporary occupants needed healing. The education and training I received from the RPA (Radiant Panel Association then, now Radiant Professionals Alliance), and many mentors/friends within the industry who have freely and generously shared knowledge enabled me to tackle many unusual hydronic design/install applications. I am forever grateful.

Heavenly radiant

A new heating system helps to convert a barn into a church.

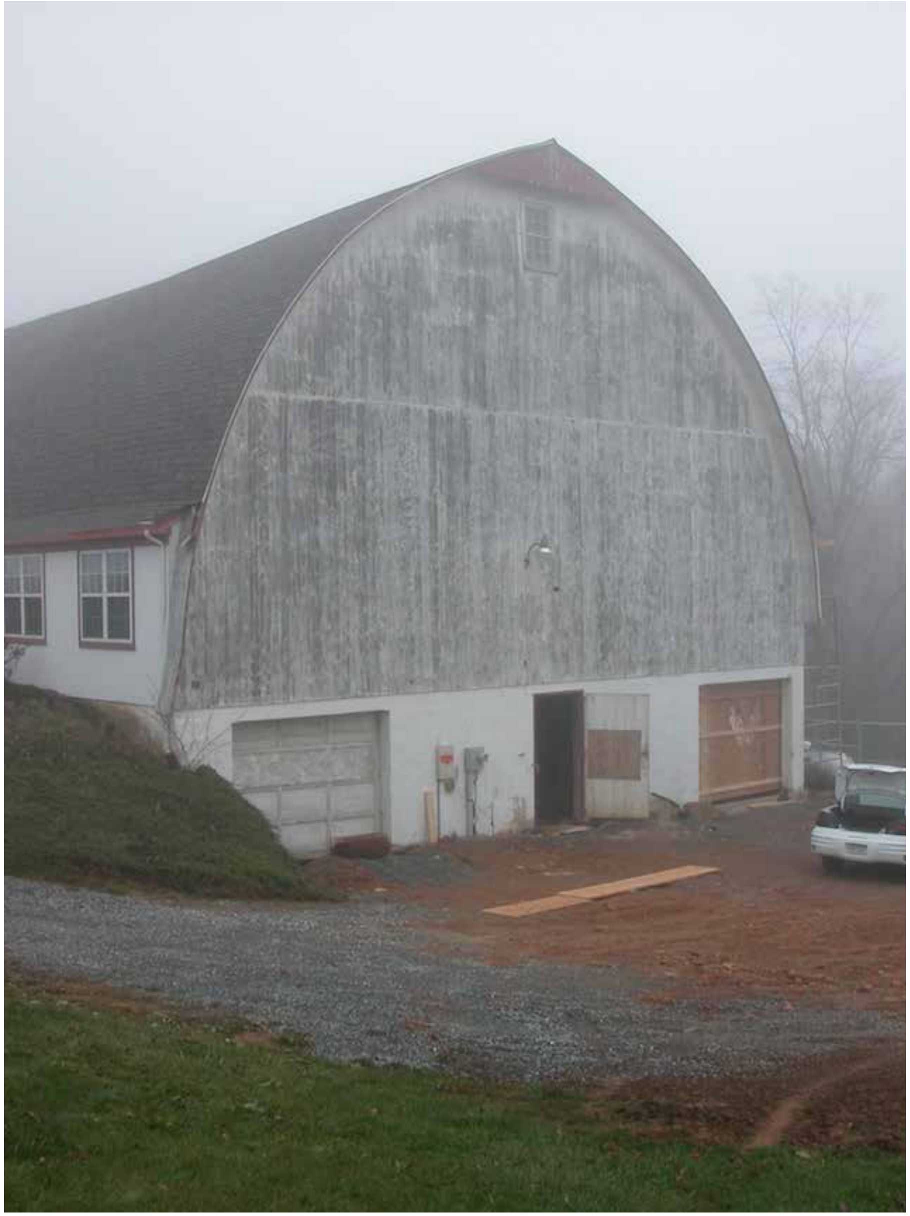
Two years ago, Pastor **Brandon Testerman** and members of his congregation began the search for a building in which they could establish a youth center. The original church was too small for their growing flock to carve out enough space, and their existing real estate precluded expansion.

Pastor Testerman and his immediate family live in a new development, which was nearing completion. With more than 300 homes constructed, the builder was rapidly winding down his operation and moving his equipment to another development under construction. The construction offices and materials storage had been housed in an old two-story timber-framed barn. No longer needing the building and its surrounding ground, the builder placed it on the auction block.

Unique fixer-upper

To say that the structure was a real fixer-upper would have been kind. The roof was sagging from where a side door had been carved from a bearing wall; the upper floor had gaping holes, and its surface undulated from years of neglect and water damage; the lower floor was dirt with more than a few groundhogs having taken up residence.

But, Pastor Testerman and several deacons of the church were visionaries who saw past the cobwebs and deteriorated condition — they instead saw a youth center within this massive 10,000-square-foot structure. Armed with little more than their faith and what cash they could collectively gather, they attended the auction. Their prayers were



New home for the expanding Cornerstone Community Church.

Popane-fired modcon boiler with indirect water heater.

Yates fastens Uponor barrier PEX tubing to wire mesh grid.

answered when the gavel struck down, and the property was in their name. Faith was being tested, too, as they ventured into this purchase knowing they would be relying on tithing for the mortgage and construction costs.

"That's when the real challenge became apparent and reality set in," Pastor Testerman recalls. "We knew this would, by necessity, be a mostly volunteer construction project, and with most of our congregation having day jobs, our free time would literally become 'free,' as in free labor."

HEAVENLY RADIANT

That's when the first revelation occurred. Almost immediately, it became clear that this dilapidated barn held the potential to become not just a youth center, but the beginning of an expanded church with space for lots of parking — the answer to their prayers! God truly does work in mysterious ways.

"Virtually every spare minute of our free time was consumed with building a temporary Sanctuary on the upper floor," Pastor Testerman says. "A furnace and bathrooms were installed, but the heating was not providing the kind of comfort we needed."

Design-build contractor

As pastor of the Cornerstone Community Church, Testerman provides comfort for souls in need of spiritual guidance. He also has a second job at the local True Value hardware store, where he provides guidance of another sort by serving customers in need of advice. Over the years, he became aware of radiant heating through sales of bubblefoil-bubble insulation to a local building contractor. The comfort that radiant heat can provide, when properly installed, appealed to Testerman, and his quest led him to our door via the internet and our website, www.fwbehler.com.

By way of confession, I'll freely admit I'm drawn to radiant heating and the challenges of designing systems that deliver the promise of heavenly comfort. Our initial meeting involved lots of questions regarding the interior use and layout of rooms, all of which help during the design process. I've always held fast to the notion that the heat-loss calculations and ultimate design of the radiant system should be done by the installation contractor. After all, if anything in the system doesn't perform as it should, I will be the guy hung out to dry.

Almost every manufacturer of radiant products has programs available to mechanical contractors that are designed to be user-friendly. While it takes time to input the necessary information, the

Uponor manifolds piped in reverse-return for balanced flow.

benefits are twofold: The designer becomes intimately acquainted with every aspect of the heat loss, and the information accumulated during this process formulates the basis for what comes next — the overall system component selection.

Unlike our counterparts in Europe, who single source their systems and purchase them direct from manufacturers who have all of the components in neat packages, we pick and choose products from a wide array of manufacturers in order to assemble a completed system. Training through organizations such as the Radiant Panel Association offer mechanical contractors an opportunity to hone their hydronic skills and grants them exposure to new products during RPA's national convention.

The RPA also provides testing to certify varying levels of skills as designers, installers and instructors of radiant heating systems. Consumers can access RPA' s website for locating contractors or obtaining useful information. Once trained, these same contractors have an opportunity to gather together individual components for recipes that have the potential to make them the Julia Child of the hydronics industry — preparing sumptuous feasts of radiant comfort.

Simplified system

Pastor Testerman impressed me with his grasp of radiant heating, and the excitement of being involved in the birth of his new church was contagious. We concentrated on things the congregation members could do in order to conserve resources and quickly settled on their getting the job site "radiant ready."

The excavation and bed of gravel to be leveled were detailed, and the bubble-foil-bubble insulation would double as a vapor barrier. Plumbing lines were to be roughed in first, and over the entire surface, a 6-inch by 6-inch grid of wire would be laid. Once accomplished, we would be called in to attach PEX tubing to this grid with nylon zip ties.

Yates data logging modcon performance.

The radiant heat loss and design program indicated this lower level slab-on-grade would need just 95° water on a 0° day in order to maintain a 68° F indoor comfort level! As the weather moderated, so should the water temperature, and a suitable control strategy would be chosen for this task.

With several restrooms and a large kitchen, domestic hot water demands loomed large. Direct venting of combustion products was needed, and the location of the mechanical room dictated longer-than normal runs to the exterior. Space was also at a premium, and this being a public building dictated our boiler had to be rated to American Society of Mechanical Engineers standards in order to pass the Pennsylvania State Labor and Industry inspection. The challenge was to keep the system as simple as possible while offering the greatest flexibility and lowest operating costs.

A small condensing boiler was the obvious choice, and given that no room existed for a buffer tank to minimize the short-cycling on-off boilers would experience, a modulating input boiler was chosen. The controls package that comes with the boiler monitors the outdoor air temperature along with both the supply and return water temperatures. On a call for heating, the boiler begins transferring Btu at its lowest setting while observing the three temperatures and gradually ramps up its speed until finding the balance point where it matches the building's heat loss at that moment in time. As a result, the burner enjoys extended run times with exhaust temperatures only slightly elevated above the supply water temperatures — in this case, only 90° on average.

An indirect water heater sits adjacent to the boiler, and although seen as just another hydronic zone by the boiler, the control module recognizes this as a distinctly different need and immediately does two things: It ramps up to full speed/Btu production, and it disables the heating zone(s) for full-bore production of potable hot water. The internal coil in the water heater ensures we will protect the potability of the drinking water by maintaining separation of the hydronic fluid.

This past winter has been brutal and tested both contractors and heating systems beyond their endurance.

"What we discovered during the construction phase of the new Sanctuary on this lower floor — with only loosely fitting plywood serving as a barrier over door and window openings — was that we were working in T shirts while the thermostat was set to only 55°!" Pastor Testerman says. "We often took breaks to observe this tiny boiler working its magic, and on more than one occasion, found it necessary to listen closely to tell if it was running — it's been as quiet as a mouse!"

"A small condensing boiler was the obvious choice"

One thing you see a lot of when observing the Cornerstone Community Church all-volunteer work force is smiles. A tightly knit sense of spirit here overflows to envelop anyone who stands in their presence. This dedicated group is building more than a church; they're building their collective spirit through selfless devotion to their ideals, and they're building a sanctuary within this new development that will offer a refuge from life's daily grind. All the while offering comfort for the soul — both spiritually and physically.

The target date for finishing the lower Sanctuary was set for Easter, which fits nicely with the resurrection of this barn. Pastor Testerman's parting comment was that once this lower floor is completed, they will begin work on the upper floor with several levels of classrooms planned on one half, while the other half will remain open to the vaulted ceiling. With what they've experienced in comfort on the lower floor, their plans now include radiant heating for the remaining construction phases. This church radiates comfort for mind, body and soul, and a warm welcome for all who enter.

Radiant retrofit worthy of a trophy room

Mini-tube answers design challenge.

As a mechanical contractor, I find that the Radiant Panel Association is a constant source of learning and an ongoing opportunity to meet fellow radiant enthusiasts, all the while sharing tips and exploring innovative ways to provide the ultimate in comfort and fuel economy to consumers. That my company, F. W. Behler, won the "Best of Show" award in May 2002 in the System Showcase contest for our Keller radiant retrofit job is a testimony to the selfless devotion of many who are involved with the RPA.

I've always been fond of hydronic heat, be it steam or hot water. Having cut my teeth as an apprentice at the 102-years-young firm I recently sold, I was fortunate to work in an old established business, which specialized in all things hydronic. As a result of this company having been an installer of many 1940s-era radiant systems, I gained exposure to the 16 benefits and comfort achieved by these systems long before PEX tubing and the current radiant revolution came along.

When my wife, Lois, and I built our new home in 1993, we never had a doubt it would be 100% radiantly heated. However, I never envisioned the changes that would take place in the ensuing years to improve these comfort delivery systems one thousand -fold in less than a decade!

This mini drives change

One of those innovations has been remote mini-tube direct injection utilizing variable-speed wet rotor circulators and outdoor reset. Not only does this technology add cruise control to any comfort driven hydronic system, it also comes with a chauffer.

When I first visited the Keller residence, it was a cool day. I could feel the radiant warmth enveloping me in soft comfort the moment I

Insulated PEX inside corrugated drainage tube.

Injection zone added to existing Burnham boiler.

Finished radiant addition on right.

entered the home. No need to tell me this was a tube-in-floor radiant system; I'm attuned to sensing radiant heating and the direction from which it emanates.

I noticed a short stretch of copper aluminum finned hot water baseboard just inside the front en- trance. The baseboard didn't make much sense given its location and the open feeling created by the lack of walls between the foyer, kitchen and large dining room.

"A very small root cellar is the only basement we've got," replies Mr. Keller upon my inquiry. His answer caused me to believe the original installer must not have been aware of any number of installation techniques that would have permitted eliminating this single baseboard-heating element.

We started with Keller's trophy room, as he is an avid big-game hunter and this was where our design challenges would begin. The plan called for doubling the room size, adding new radiant flooring that would abut an existing radiantly heated floor and bumping out an end wall that had lots of glass. Still, the Kellers wanted their addition to be treated as a separate zone.

No doubt in my mind that a trip to the boiler room was in order to assess the existing control strategies. At this point in the design phase, we faced a clean slate upon which potential solutions had yet to be explored. Too many questions remained unanswered.

Once in the tiny mechanical/laundry room, I quickly realized that this job would present unique challenges worthy of Merlin! There was absolutely no spare space in the room itself or the supply/return piping. The control strategy consisted of three-way mixing valves without the benefit of primary/secondary piping, and the existing three-zone connections were so closely spaced that they precluded any possibility of adding anything modern in the way of control strategies. This tiny room was situated quite some distance from the proposed addition, and I could see no readily apparent way to route supply and return piping for a fourth zone. My slate remained blank.


Sub-slab radiant loops of Uponor PEX.


Shop-built injection panel.

That's when I spied the 4-inch PVC conduit behind the water heater. It had only a few 14/2 wires trailing out the termination and a telltale knot of yellow nylon pump rope for pulling future wiring bundles through the conduit.

"Oh that's just an electrical conduit that runs under the slab to the root cellar," says Mr. Keller.

This obviously leads somewhere, I told myself. Time to go spelunking!

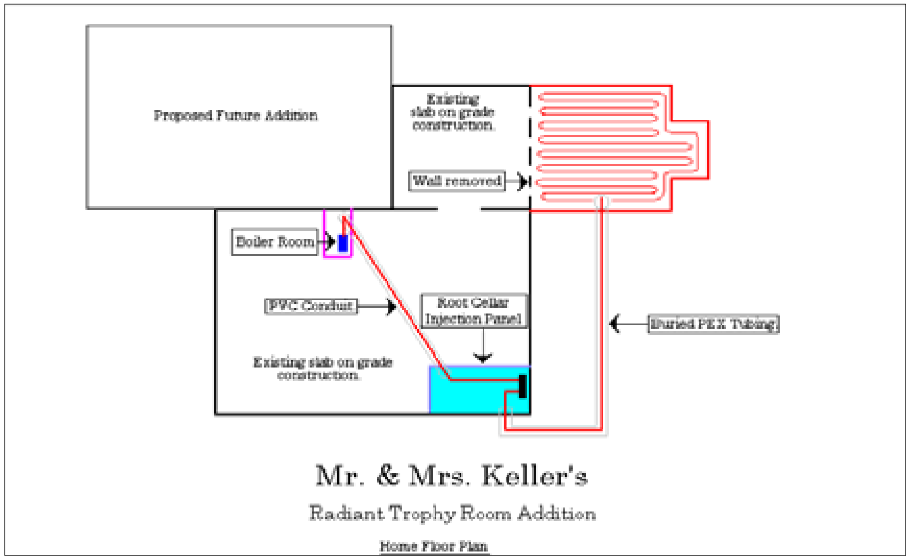
High Delta T

He wasn't kidding about the root cellar being small in width and length; it was also low in height, even for a short person like me. But, it was as close as we were going to get to the new addition at some 30-plus feet as the crow flies. My slate began to fill out nicely with a plan. That's the beauty of design challenges, they almost always dictate what will or will not work well.

With a 20-foot long under-slab 4-inch tube of PVC creating a conduit between the root cellar and the boiler room, and our being within striking distance of the new addition, a remote mini-tube direct injection, variable-speed pump tweaked by outdoor reset would be the perfect solution!

The preliminary design was now clearly drawn on my mental slate. All that remained were the technical design considerations: Heat loss, tube circuits and lengths, leader lengths to and from the circuits, Delta T (representing the difference between supply and return temperatures) from the boiler, head loss in the injection loop (resistance to flow), a circulator suitable for this use, and the control that would act as the "central processing unit" determining injection flow rates based upon outdoor ambient air and boiler supply temperatures to accurately mix the floor loop water temperatures needed to offset the Btu heat loss of the structure.

Injection piping — in particular, remote mini-tube injection piping — has been a godsend. Here's how this works in a nutshell. Imagine you're the driver for a mass transit bus. On that bus, you can transport, let's say, 100,000 passengers with ease, all the while staying under the speed limit for the highway (maximum flow rates for piping size). If on each pass from your central terminal (boiler), you drop off



Schematic for the Keller job.

tons of passengers to be distributed to multiple secondary bus lines (loops), you will return with far fewer riders and increase efficiency while enhancing gas mileage (reducing energy consumption).

That's what the high Delta T does in remote mini-tube injection systems. The greater the Delta T, the greater the number of passengers (Btu) get off at the station (remote injection panel).

By utilizing one of the many heat loss/design programs available from various manufacturers, we deter- mined the heat loss for this addition to be slightly in excess of 50,000 Btu. With a total below grade leader length of 80 feet (40-foot supply plus 40-foot return) per loop, floor space of 288 square feet and wanting to maintain close spacing between the tubing, we needed four loops of 1/2- inch PEX that would each be 256 feet long. The maximum floor water supply temperature needed on a 0° day would be 124° F, which would result in an 85.3° surface temperature. With a head loss of 1.99 and flow rate of 1.71 gpm, a small, low-energy consumption circulator and four-loop manifold were needed to make up the injection panel.

One final design detail was escaping my thoughts. In order to provide remote mini-tube injection, I have traditionally enjoyed the ease of piping from scratch at the boiler with tees spaced closely together. Closely spaced tees have little or no pressure differential (Delta P) across their span, resulting in no ghost flow — also known as overheating the new zone.

In this case, I was stymied. If I included the costs to completely re-pipe the existing three zones to a pumping away configuration with primary/ secondary piping, I knew I would price myself out of consideration. I needed to find a zone of no pressure differential.

One thing about cast-iron boilers that I remembered from experience — there were likely to be additional boiler block tappings. A light bulb went off in my head! Surely there wouldn't be a Delta P within the boiler itself, which is essentially nothing more than a larger bore piece of the piping within the heating system.

All that remained were the design considerations of the mini-tube direct injection loop. What size? Which pump? Utilizing the RPA design guidelines outlined in "Radiant Precision" by John Siegenthaler, it was a snap to determine that the flow rate needed would be 1.34 gpm. The formula works like this: Subtract floor return water temperature from boiler supply (180-104 = 76) multiply by a constant of 490 for 100% water solutions (76 x 490 = 37,240). Divide the room's heat loss of 50,000 Btu by 37,240 for the needed flow rate, which equals 1.34 gpm. .5-inch PEX can easily handle this flow rate, and we utilized a low-flow, low-energy consumption pump. We added a valve to restrict flow rates and build head so the variable-speed pump could operate at higher revolutions per minute under design conditions while maintaining that low flow rate.

The end result virtually ensures constant circulation within the floor circuit, consistently delivering com- fort, precise floor temperatures and conserving energy resources. Unlike the three way mixing valves, this system provides protection from flue gas condensation within the cast iron boiler.

Pennsylvania home gets an energy overhaul

Mini-tube answers design challenge.

In the spring of 2010, federal tax credits for first-time homebuyers fueled the sale of low and mid-range homes. Houses sold in record time. In some cases, it was a race to get offers in ahead of the next potential buyer. It was a seller's market, for sure.

I clearly recall one potential homebuyer scheduling an appointment for me to meet her to give my opinion on the home's mechanical systems. Another couple was standing in the driveway with their realtor when we entered the home. Within minutes, I could plainly see lots of issues with the ancient, dilapidated boiler, a water heater older than dirt,and an AC system in dire need to be replaced. However, it was the water damages along the interior walls both below and above grade that posed red flags in my mind.

Meanwhile, our customer was simply "in love" with the home and told her realtor she wanted to make an offer. Then, her realtor's cell phone rang and a brief conversation followed. Hanging up, she said we were to immediately leave the home because the couple standing in the driveway had made an offer 20% higher than the asking price, which was immediately accepted! I left several of my business cards on the boiler.

In the case of one Pennsylvania couple, haste to move on a move-in condition bi-level turned into a costly mistake. After dismissing the idea of a home inspection, the buyers quickly found themselves throwing money into a bonfire.

They provided their tale of woe to me during my first visit: "It all began with a puddle in the mechanical room." Two weeks later, the home had a new roof. Water that found its way inside had destroyed part of an exterior wall and 100 square feet of second story subfloor.

Before the overhaul.

Apparently, a queen bee also took a shine to the little hole where the rain got in. The pest control pro said the nest had been active for a year or two, and was quite large. In the process of replacing carpeting that smelled really awful, it became obvious pets had utilized the carpeting for their bathroom! Bathroom fixtures in harvest gold color were replaced with neutral colors, along with new flooring.

Throughout the remodeling process, the homeowners wanted to boost the home's energy efficiency. The attic, newly free of angry bees, had only four inches of fiberglass insulation. An additional 30 inches of blown-in AttiCat fiberglass made an immediate improvement. The block walls of the basement were covered in foam insulation, then pine tongue and groove boards. Most of the single-pane windows were upgraded to low-e, and doors were also replaced with insulated models.

"At every turn, we heard cha-ching, cha-ching. Money was moving into the home at a clip I'd never imagined, even though my friends and I did some of the work ourselves."

The last remaining project — a job they knew would require a team of professionals to handle — was to replace the home's mechanical system. Although in good condition, the system was designed for a much larger home. And it was grossly oversized before they had upgraded the envelope! Natural gas was not available where they lived and propane was ruled out. They wanted to continue using fuel oil as the energy source.

Leviathan boiler

The home's original mechanical equipment had been replaced in 2006. A 180 MBH, oil-fired New Yorker boiler with an internal DHW coil provided all the heating needs, and then some.

A Manual-J heat load calculation for the 2,200 square-foot home resulted in a 48,000 Btu/h heat loss, with an outdoor temp of 10° and an indoor temp of 70°. I ran my Manual-J calculations both before and after to see how oversized the New Yorker had been, and just as I suspected, it was more than twice the capacity needed. To some degree, having an internal DHW coil and a need for higher gpm flow rate to avoid tepid water while bathing may have driven the oversizing. Then again, the installer may have used the curb, doorway or gimme the biggest boiler you have in stock method! Short-cycling an oil boiler, or any heating appliance, reduces operating efficiency, and that no doubt helped explain high fuel usage the owners now wanted reduced.

The big boiler and the bees weren't the only things evicted — the mechanical room was also purged. An old water softener and whole-house UV light — both of which were well past their prime — were removed. Groundwater in southeast Pennsylvania near farms or woodlands often contains coliform bacteria, high nitrate levels and moderate amounts of scale, so the equipment was ready for replacement, too.

Good things, small package

The system I proposed included a 64,000 Btu/h Burnham MPO-IQ boiler and 75-gallon Bradford White indirect water heater. Although the new boiler is slightly narrower than the previous one, it doesn't include a DHW coil.

To size the tank, I used design conditions of 40° incoming and 140° storage at a 100° rise. Next, I determined the boiler's net hourly output in Btu. Divide the net output by 833 to determine the hourly gallons of hot water that can be produced under design conditions (coldest incoming water temperature), then divide that by 60 (minutes) to obtain the gpm rating. During winter's coldest weather, when I'll be seeing 40° incoming cold water (55° for well-water systems), I can safely assume 85% of the adjusted bathing temperature will be coming from the indirect hot water tank. Just two things remain to accurately pinpoint the required tank sizing: gpm flow rate from the bathing module(s) and duration of use. It's just that easy! After consulting with the owners and measuring the gpm flow rate of their shower, the obvious need, with a bit extra for CYA (cover your ass-sets), the 75-gallon model fit the needs.

The addition of the water heater certainly made things tight in the small mechanical room.

I carefully laid out all the mechanical components on graph paper before lighting a torch. The seven-by-eight-foot area wouldn't leave room for error. We had to conserve space on this job where even an inch meant success or failure.

One of the first, new-generation ECM circulators from Taco — the yellow and black, variable speed BumbleBee — was ordered. The owners had removed a bunch of bees from the home months ago, but they were eager for us to find a permanent place for this one once I detailed the long-term energy reduction the low-watt ECM circulator would provide. For the two separate upstairs/downstairs baseboard hot water zones, I utilized two Taco 1-Watt Zone Sentry zone valves. A Taco hydraulic separator, mounted directly above the boiler, helps the home's two heat zones and the Bradford White indirect play well together. A 007 circulator is used as the main boiler pump, providing steady circulation within the short primary loop. Also included were a half-inch Watts RBFF (residential boiler fill fitting) to ensure the system stays full, and a Taco 4900 air and dirt separator to keep the fluid clean.

The BumbleBee was a Δ-T circulator, so it ramps up to full speed momentarily until it finds the difference in supply and return temperature, then backs down to the perfect flow rate for one or both of the zones. A digital readout on the face of the circulator alternates between readouts for gpm and electric consumption. Today, Taco's full line of 00e ECM circulators is an ideal match for any hydronic system.

After the initial installation and commissioning, the Bumblebee usually coasts along at 6 1/2 gpm, consuming only 9 watts, which is 1/10 of the energy that a comparable standard induction powered circulator would use.

Devil's in the details

Access to the inside of a Burnham MPO for annual cleaning/tune up is convenient, because the front doubles as a door, which smoothly swings open for access. To help overcome tight space constraints, the Bradford White indirect was placed to the left of the boiler, so the

Yates arrives for hydronic overhaul.

Larry Lawrence in demolition mode.

service door could swing in front of the tank. To the right of the boiler, the original Well-X-Trol tank was relocated several inches from its previous position.

The replaced water softener was a single tank system and didn't take up much room in the corner. The homeowner didn't want to expose all-new water fixtures to any scale, even if it meant using a dual tank system. A twin tank Watts water treatment system was installed, so while one tank is recharging, the other can condition incoming water. There's no possibility of the bypass valve opening while one tank recharges. Although larger, the new Watts system is metered, and will use less salt than the previous timer-operated tank.

A new 12 gpm Watts whole-house UV disinfection system accompanies a media filter on the wall above the water softener. If power is lost to the house, a solenoid valve closes and no contaminated water can slip by the UV light to re-seed freshly sterilized potable water system. The old UV light was a 7.5 gpm model, but I prefer a little more flow capacity to accommodate quick bursts and very real possibility of numerous fixtures running simultaneously.

A good fit

Aside from its inherent efficiency (89.6% at the flue using an electronic calibrated combustion analyzer), the MPO boiler — with large, three-pass cast iron heat exchanger — includes the optional IQ panel that allows the addition of features like outdoor reset, low water cutoff and auxiliary high-limit for additional protection and efficiency.

The indirect tank helped keep the boiler capacity down. Though a 64,000 Btu/h MPO is a bit light to provide rapid recovery with an indirect, the 75-gallon tank provides plenty of hot water and the cushion for longer recovery time. I wanted a circulator with an internal flow check on the water heater, so we installed a Taco 00R to tap the boiler. The three-speed circulator remains on low, letting supply water take it's time through the big coil inside the tank. Bradford White tanks can be ordered with a tempering valve on top of

Yates programming the Taco ECM circulator.

Dave Yates and Larry Lawrence dismantling the old boiler.

Yates with finished Burnham, Taco, & Bradford White overhaul project.

the tank so water exits at safe temperatures. We can store 140° water to eliminate the possibility of bacterial amplification while setting the outgoing supply temp to 120°. Given that both bathrooms were in very close proximity to the mechanical room, no DHW recirculation was needed.

The removed New Yorker boiler had a 6-inch flue, while the MPO only required a 4-inch flue pipe. After sealing up the new flue, we covered the oversized terracotta chimney liner with a polished diamond plate ring as a finishing touch.

The ultimate in recycling

It would've been a shame to discard an operable, six-year-old heat plant. Prior to my initial site visit, the owners were visiting the neighbors who lamented the fast approach of winter, voicing concerns about whether or not their old boiler would make it through another season. Would I be willing to check the neighbor's home to see if the relatively new New Yorker boiler was a good fit for their home? The neighbors' enormous coal-to-oil conversion averaged 240 gallons a month at the height of the heating season. The old farmhouse needed an energy retrofit of its own, but at least they'd replaced all the old doors and windows. A second Manual-J confirmed two things: Their decrepit, antique oil-fired beast was oversized; and the New Yorker boiler was a perfect fit. Along with it, the neighbor received the expansion tank, isolation valves and some perfectly fine Taco 007s.

The best part for me? Learning that the new Burnham MPO reduced oil consumption by almost 70% and the relocated New Yorker boiler shaved about 30% off the neighbor's oil consumption too.

Here's a link to a video of the installation: https://www.youtube.com/watch?v=Yz5yiFwPh1k.

Radiant retrofit

Historic log home presents design challenges.

Sure, there were more than a few hydronic challenges at this little job in rural Mount Joy, Pennsylvania, but I am drawn to a challenge. What I found upon arrival were tasks that would be tied to an extensive remodeling project — there was an ancient, fuel oil-guzzling cast iron boiler, uninsulated walls and plans for a new kitchen to be perched above a “rock quarry.” The challenges certainly gave the job some personality and required some innovative out-of-the-box design-work.

The Martins, a family of four, live in a 2,400 square-foot log home that dates back to the time of the Revolutionary War. It’s been in the Martin family for six generations, and they were planning the first-ever major renovation.

Interesting details also included stone foundation walls and massive, hand-hewn logs that defied pipe and tubing runs. The old, cold, hydronic system needed some serious therapy.

The homeowners — Bruce and Heike Martin — had hired a remodeling contractor, **Duane Niesley**, who wasn’t an obstacle to radiant heat. In fact, he helped to champion the cause for a mechanical system overhaul that, ultimately, would entail extensive use of radiant. Though, with clearly strong German heritage on both sides and an appreciation for finely-tuned European hydronics, the homeowners were predisposed to radiant heat.

Bruce Martin met fraulein Heike Quiring, a German native, when she came to the states in 1986 and 1987 during a Mennonite international visitor exchange program. Before she left Pennsylvania, they were engaged, and, within a few months, Bruce moved to Germany where they were married. Five years later, the family of four moved to Pennsylvania and quickly established residence at the Martin family homestead.

Bruce & Heike Martin residence.

Doing their homework

Though they wanted radiant heat, the Martins also looked into other, less familiar facets of the project. After lengthy research, they specified a compact, high-efficiency boiler to replace the old monster downstairs, favored replacement of a crusty old fuel oil tank and had a pretty good feel for other mechanical system upgrades.

Hydronics is a passion for me, and these folks were talking my language. They even referred to remodeling the house around the mechanical system. It's not often that I encounter customers so well-versed in hydronics; much less the more advanced radiant aspects that define best practices, but these folks clearly had done their homework.

Roughly, one-half of the home would be involved in the renovation. Fortunately, the basement had a large room for the mechanicals — once necessary for the big, old boiler previously housed there — without it, they had plenty of room for the new equipment, and, soon, a work area for Bruce. In another area that serves as a cool spot to place the family's potato, onion and apple harvest, we would locate one of the radiant manifolds and have access for a small staple-up zone underneath the downstairs bathroom, whose floor the Martins wanted preserved.

The home's centrally-located first-floor kitchen would be the focal point of the renovation.

"We all enjoy cooking and food preparation," says Heike Martin. "So we added some cabinets and counter space and found a better spot for the refrigerator. We'd endured the cold floors long enough."

In fact, the kitchen floor was ice cold during the winter months. The foundation below it "breathed" because of the generously-ventilated rock foundation.

"This was not by intent," adds Bruce Martin. "The old foundation moved here and there over the years, and so the winter winds had relatively free access to the space below, something we'd definitely do something about during the renovation."

The only source of heat in the kitchen was a standing radiator, which was evicted in favor of a dishwasher, an appliance Heike had waited 16 years for.

The 100 square-foot laundry room is connected to the kitchen. Its floor would also be heated. Next to it was the downstairs bathroom, soon to be radiantly heated by staple-up from below. They wanted to pull out a large standing radiator in the bathroom, and the challenge would be to get enough Btu into the tile floor through a heavy pine subfloor.

Yates tacks down aluminum heat transfer sheet over Watts Subray panels.

Watts Radiant RadiantWorks program was utilized to determine each room's need for tubing and water temperature based on the design-day temperature of 0° while plugging-in building specs and construction materials information. The supplier's heat loss and radiant panel program enabled me to accurately design all facets for retrofitting radiant heating into this project. I find it difficult to understand why any contractor would allow someone else to do this aspect of the job — one of the most critical steps in the process. After all, if the system fails to perform, I'm the guy hanging out to dry.

This pointed to the importance of directly interviewing the homeowners to avoid confusion and wrong assumptions. That's not always easy when a GC is involved, but Niesley encouraged it. They decided to salvage as much of the existing mechanical system as possible. That meant marrying-up the new radiant system with the tangle of iron piping that joined other hydronic lines within the home. A snip here and a tuck there eliminated many of the old lines, soon streamlined into a neat and orderly secondary loop.

This also presented a slight design challenge because of the heating curve for the several remaining radiators, and the typical need to reset system temps based on outdoor ambient temperatures. The older untouched standing cast iron radiators required much higher water temperatures and would be zoned separately.

Mouse condo

While making the heat load calculations, the kitchen became an interesting challenge. The room was a bit troublesome because of its location above the "rock quarry," Bruce Martin's favorite description of the centuries-old pit, filled with rocks, rubble, old timbers, glass and pottery shards, a thoroughly worked-over cache of walnuts and corn cobs, and — Heike was certain — one of the oldest, continuously-inhabited 'mouse condos' in all of Lancaster County.

The floor of the kitchen would be suspended above the pit. Its underfloor was inaccessible. Even if we did have access to it, it was too rough for crawl space work. So we immediately set our sights on SubRay, a product made by Watts Radiant.

SubRay delivers a lot of heat at very low operating temperatures. Connecting panels are simply attached to the top of the subfloor and the tubing weaves between them; it delivers up to 40 Btu per square foot. We've used SubRay for many different jobs, even a multi-tiered, octagonal timber-framed home, so we're familiar with its versatility and performance.

The remodeling contractor sealed the stone foundation and cleverly devised a way to heavily insulate the underfloor of the kitchen (with R23!) — cold toes would be a thing of the past. Since the laundry

Yates connects Watts Onyx tubing to the zone-to-zone manifold.

room needed heat, too, and would become an extension of the diagonally-laid ceramic tile surface that the Martins had chosen for the kitchen, it was decided to extend the SubRay into that area as well, all on the same thermostatic zone.

The bathroom staple-up offered a new challenge. Unevenly spaced floor-joists were running in one direction above a very narrow access area, and the drain and water lines were going in another. Watts Radiant's uber-flexible EPDM radiant tubing, Onix, was the ideal solution. In a space where PEX would have been virtually impossible to install, the Onix tubing was easily woven around all the obstacles,

Yates checks water temperature on the Watts-built controller panel.


Yates installing Watts Onyx barrier tubing.

including a number of protruding nails that had been used to hold down the concrete board under the finished ceramic tile floor above.

The right equipment

The homeowners had selected an oil-fired Laars "Max" boiler and its partner, a 40-gallon DuraFlow indirect-fired hot water heater, chosen to easily meet the family's domestic water needs. The boiler is a low-mass, direct-vent unit, with a two-pass cylindrical heat exchanger that delivers about 87% efficiency. According to my calculations, the new boiler would use up to 60% less fuel than the old one while retaining 40% of the heat previously lost to the chimney. It would also occupy only 1/4 of the space needed for the old one.

Balanced flue for the sidewall venting is Laars' term for direct venting of the Max boiler. It's a quick and easy connection with stainless steel lines between the boiler's exhaust and outdoor air and the termination box where the incoming air passes over the outgoing inner stainless steel piping — this pre-warms the incoming air. No flue draft regulator is needed when using this kit.

The Laars DuraFlow indirect-fired water heater would replace a free-standing electric unit that began duty 15 years ago. With exposed element wiring and clumped-up insulation, it was ready for the plumber's morgue.

With multiple zones, the indirect's load was not factored into the total load for sizing the boiler. Setting up an indirect on a priority zone in a radiantly heated home works well because of the minimal loss of heat to comfort zones while the system idles and allows the full power from the boiler to quickly regenerate the domestic tank. There are two schools of thought here: Size the boiler to the indirect or the home's heat loss. I prefer sizing the boiler to the home's heat loss and then size the indirect to the occupants' actual usage patterns.

The control panel itself was another task. Rather than building one, we chose to provide the design specs to Watts Radiant. This job was ideally suited to fabrication of a small, simple HydroControl panel, made by their experts and shipped to the jobsite with the SubRay, tubing, manifolds and other materials.

The panel is the heart of any radiant system, and it sets the tone for how all of its parts will operate. We needed to provide a multiple-temperature system from a single high temperature source. We had two higher temperature zones — the indirect hot water tank and the remaining cast iron radiators — and two lower-temperature zones for the staple-up lower bath and kitchen, both with SubRay. We also needed to ensure that this system would be as quiet as a church mouse.

Budget realities

We sure had some fun playing with the panel's design. Budget was a real concern, so simple mixing strategies were needed. We reduced pumps and mixing valves by running higher-temperature water through the staple-up floors first and using that two-loop manifold's return flow to feed the lower temps required by the SubRay in the kitchen and laundry room. It returned to the boiler from there, essentially as an extended, single loop. The flow rates were low enough to support the strategy. Hey, eliminating one pump and a mixing valve — that's money saved.

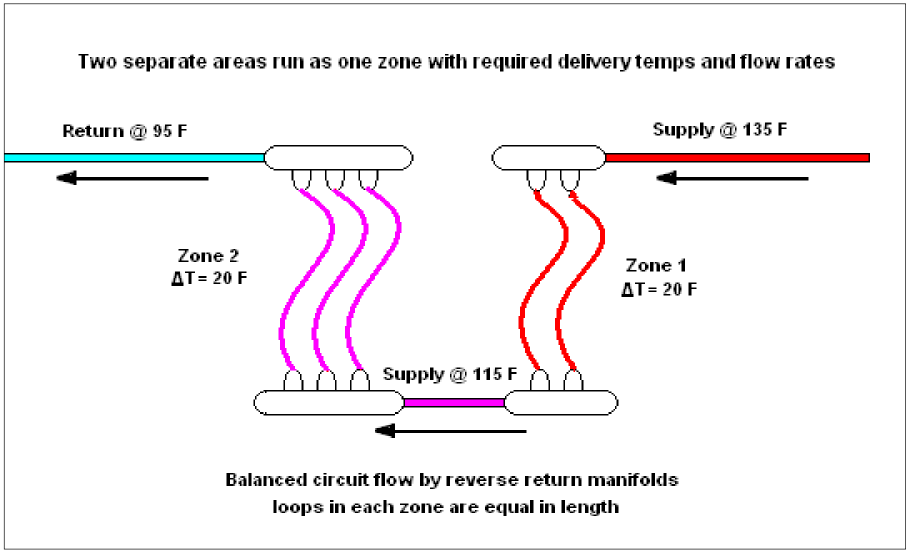
As with any system we install, we try to keep it simple and cost-effective. The fewer bells and whistles, the fewer long-term maintenance issues. I like my sleep to be uninterrupted, so designing things right at this stage is a critical issue!

To save some bucks, the owner chipped in too with some sweat equity. After we cut off the boiler piping, Bruce went to town breaking down that old cast iron beastie into its smallest pieces. By noon, he'd completely dismantled it and removed every trace of it. Well worth the effort as that reduced our labor-hours, which saved them a fair amount of their hard-earned money.

Yates placing Watts Onyx barrier tubing in Subray tracks.

As the job neared completion, two new 275-gallon oil tanks were delivered by Highland Tank from the manufacturing plant just 10 miles away. The new 12 gauge "ToughTanks" by Highland are available in 137-, 275- and 330-gallon capacities and are UL-80 labeled for oil use (a UL-142 label is available) and are available with double-wall construction.

The twinned oil tanks, with fuel lines joined at their bottom outlet, were piped to the exterior with full-sized fill and vent lines. There's a fair amount of concern lately about high pressure pumping (permitting faster delivery of fuel) and tanks having crossover lines becoming over-pressurized. Considering this, I felt the extra time and



Schematic for Watts zone-to-zone manifolds.

Dave Yates meets with owners Bruce and Heike Martin to finalize plans.

materials were warranted. With each tank having its own vent-alarm to signal when to stop pumping oil, there's now minimal chance of a spill or rupture.

A quick look at my notes about the mechanical system:

• The indirect hot water storage tank is first with an aquastat governing the relay that energizes the boiler.

• A separate manifold served the SubRay. This zone's operating temperature was set for a range of 137° F to 85° F, with a 20° drop during the initial run through the staple-up zone. The 20° drop in temperature provides the proper reset temperature ratio for the SubRay zones, which follow in series. A triple cascade with just the right temperature delivered to each successive zone.

• All components received isolation valves. A bit more costly up-front, but valuable in years to come if the mechanical components require service.

"We made it through our first winter in the newly-remodeled house," says Bruce Martin. "There's really no way to describe the feeling of comfort when it's so raw outside, the snow's piled up, and we wake up to warm home with warm floors. It's pretty remarkable."

Add to that the satisfaction they had when the two fuel oil tanks were topped-off after four months.

"The tanks were filled with less than 250 gallons," the Martins said. "It provided super-efficient heat for the entire house during a severe winter, all of our hot water for showers, baths and laundry, and with way less oil than we've consumed before."

Yates update: Before submitting this article for eBook No. 2, we checked in with the Martins asking how their system has been performing. I am happy to report that almost 20-years have passed without a single issue arising, and they indicated that exceptional comfort – even during several Polar Vortexes – has reigned supreme!

Stone cold radiant

Radiant upgrades provide energy savings for centuries-old stone farmhouse.

It's said that things come in threes, and that was certainly the case for estimates to retrofit hydronic radiant systems into centuries-old residences. The first step, as always, is a site visit to see first-hand just what kind of oddities exists in these old homes. After crunching the heat-loss numbers and determining required water-delivery temperatures, the first two homes were no-go-for-radiant-floors due to temperatures well above 180° F required to offset the heat-losses, and the owners did not want to utilize walls, ceilings, or incorporate exposed radiant panels.

"Can't we just attach the tubing to the underside of the old floor-planks? That's what we were told by an internet-based company."

Sure can — we'll just need to utilize 287° water! From the look they gave me, it was obvious they thought I was trying to pull a fast one, and, if I were a betting man, I'd wager they go forward with Mr. Staple-up.

Via e-mail, the owners for home No. 3 remarked: "We'd like an estimate for hydronic radiant heating. We're restoring a centuries-old stone farmhouse. We want to be sure we have the best for our 'forever' home."

I agreed to visit the site, but I wasn't exactly optimistic that the end result would incorporate a low-temperature radiant heating system. It's been well established that lower water temperatures result in improved energy conservation. It's simply common sense that continually reheating water to higher temperatures in repeated cycles requires more energy-use over time. A side benefit that goes along for the ride in low-temperature-systems is, as my own family discovered, increased comfort. Modcon (modulating condensing) boilers operate at peak efficiencies when lower water temperatures can be utilized by virtue of increased condensate production and the extraction of latent heat Btu

Restored stone farm house where extruded aluminum heat transfer plates were used extensively.

Purchase Costs for the Typical THREE-Zone System: Old Style vs. New Style			
Old Style System Material Cost		**New Style System Material Cost**	
4 – Fixed Speed IFC Circulators	$367.00	3 – Six-watt Zone Valves	$316.00
		1 – ECM circulator	$315.00
Total	**$367.00**	**Total**	**$631.00**

from the condensate. In order for any high-efficiency, low-temperature modcon-to-radiant system to fulfill the "green" mantra today, the picture is not complete unless the delivery side's power consumption is included. Aside from ECM (electrically commutated motor) circulator technology that cuts parasitic energy consumption on the delivery side, there is one other bump in the hydronic highway — the head loss through the boiler's heat exchanger, which often requires the addition of a high-head, high-wattage power-hungry circulator to force-feed the proper gpm for energy-production.

On site, on target

A picturesque setting greets visitors as they emerge from the woods following a steep descent through the surrounding farm-fields. Their restoration contractor met me at the door and provided a walk-through time while describing how the massive stones and carpentry were integrated more than a century before power-tools existed.

I was mentally prepared to encounter resistance against incorporating insulation (as had been the case when visiting Frank Lloyd Wright's Falling Water when it was being renovated and its floors had been temporarily removed. The suggestion to add insulation and radiant heating was flat-out rejected because that would not have been "historically accurate."

Inside, I was greeted by a 1-inch layer of Dow Tuff-R being carefully

Triangle Tube modcon boiler with Smart 40 indirect water heater.

Operating Costs for the Typical THREE-Zone System: Old Style vs. New Style				
Electrical Cost kWh	4-circ System	1-ECM, 3-ZV System	Annual Savings	ROI
11 cents	$109.10	$12.14	$96.95	**37%**
16.5 cents	$163.65	$18.22	$145.43	**55%**

concealed with its edges sealed inside new framed-walls that would be covered in plaster. Combined with a 3/4-inch air space, the Tuff-R with its incorporated foil radiant coating would provide an R-10 barrier. Couple that with the R-1.5 the thick stone walls provide plus R-.5 for the drywall/plaster for a combined total of R-12. Hope springs eternal, and my level of radiant-potential optimism was improving.

There would be three layers of radiant:

- Slab-below-grade for the basement;
- Wide-plank flooring supported by hand-hewn logs for the first floor; and
- Wide-plank flooring supported by somewhat more traditional framing and an obstacle for tubing — a central support beam! The codes inspector would take a dim view of any holes drilled through this massive timber and that limited us to just one existing opening — adding a twist that required extra loops to accommodate the extended developed-length of each PEX loop.

Challenges equal opportunities, and it was clear — crystal-clear — that installation of a radiant system in this home was not going to be run-of-the-mill. We discussed the importance of insulating the underside of the radiant floors, and the homeowners' desire to utilize and keep the old wide-plank floors as well as the underside of the wood joists and that there would be a need to use thick extruded aluminum heat-transfer plates. These were more costly, but they greatly enhance thermal-transfer with library-quiet performance, and they are the only opportunity for utilizing low water-delivery temperatures.

PEX tubing on its way to the basement zone.

Crunching the numbers

After carefully measuring each room floor-by-floor, it was time to input the information into the radiant design program. With the flexibility to quickly alter installation methods — from embedded to staple-up to thin-plates to thick extruded plates to gyp-crete — you

Projected Electrical Rates - Year	4-circ System	1-ECM + 3- ZV System	Annual Savings
2010: 11 cents per kWh	$109.10	$12.14	$96.95
2011: 16.5 cents per kWh	$163.65	$18.22	$145.43
2012: 5% yearly increase	$171.83	$19.13	$152.70
2015	$198.91	$22.14	$176.77
2020	$253.87	$28.26	$225.61
2025	$324.01	$36.07	$287.94
2030	$413.53	$46.03	$367.50
Total	**$5,520.24**	**$614.47**	**$4,905.77**

can determine water-delivery-temperatures required on a design-day (coldest anticipated weather). Maintaining a floor-surface-temperature below the threshold of 80° ensured protection of the wide-plank hardwood floors. Water delivery temperatures required on a design day of 13° with 22 mph winds were as follows:

- Basement slab-below-grade — 87.9°;
- First floor log and plank — 99°; and
- Second floor framed and plank — 98.6°.

Much better results than expected — so much so that I re-ran the numbers several more times to ensure accuracy. This ensured that the boiler would always be in full condensing mode and operating at its peak efficiency. For a DHW production target-temp of 120°, we can program the boiler to produce 140° with the hydronic return-water low enough to promote condensing. With the cornerstone of the radiant system's low-temperature-foundation securely in place, it was time to assemble the BOS (balance of system) components.

Energy consumption has been primarily focused on conservation of the Btu fuel-source. While that's an important primary first-focus, an emerging understanding regarding the amount of energy consumed to transfer thermal comfort from source-to-emitter (radiant floors in this case) has begun to vie for attention. In order to take full advantage of ECM low-wattage circulator technology, it would be necessary to utilize a low-head-loss boiler. A Triangle Tube Solo-60 Prestige boiler and Smart-40 indirect water heater were a perfect match.

One issue we've witnessed first-hand is the accumulation of crud inside modcon heat exchangers when burning propane. Triangle Tube utilizes a fire-tube down-fire wash-down (only if the boiler is condensing) stainless steel heat exchanger with a large reservoir at its base for condensate and any impurities to collect. The semi-

Basement sub-slab PEX loops.

self-cleaning action where condensate washes away impurities requires far less maintenance time during annual servicing, which saves customers money and helps to promote annual check-ups. The Smart-40 indirect water heater is ideally suited for well water where deposits created by hard water would tend to accumulate and adversely affect thermal heat transfer because its inner corrugated stainless steel tank is suspended in a bath of hydronic water, which allows it to grow/shrink as temperatures fluctuate. The tank flexing its shape causes any hard-water deposits to shed and be flushed away as hot water is drawn at domestic points of use. Having the potable-water-tank fully surrounded by the hydronic-water provides rapid heat-transfer. At the time we installed the system, Triangle Tube was the only boiler manufacturer with the fire-tube heat exchanger. Today, almost all boiler manufacturers have fire-tube heat exchangers and/or lower head loss helical heat exchangers.

Watts up Doc?

With the radiant floor and the energy production designs finalized, it was time to dial in the energy transfer conservation resolution to complete the picture. Would it be more prudent to install four induction motor circulators at 87-Watts each or one ECM 5- to 45-Watt circulator with three low-Wattage zone valves? Bear in mind that this system will be operating with a well-adjusted outdoor-reset-curve, which translates into longer run hours for circulators. Instead of seeing an average of 2,250 run hours (average for old-style on/off systems in Southeast Pennsylvania), I can expect approximately 3,000 run hours for the primary circulator due to zones overlapping their calls for heating and 2,800 run hours for each zone-valve due to the use of outdoor reset and lower/changing water-delivery-temperatures. We're also about to have deregulation of electricity in our area with a projected increase of 10% to 37%. I don't trust the utility company to be generous, so I'm using 37% in my cost projections.

The cost difference is $264 for the materials (using selling prices). Next we need to gauge the merits based on annual savings and the ROI (return on investment). No additional labor will be required, so no cost adjustment is required.

In terms of simple payback, we're looking at passing that goal early in the third year of operation. But let's take a longer look off into the future and compare the two after 20-years of operating with a 5% per year increase in costs for electricity after deregulation.

As you can see from this example, investing in ECM circulator technology can nicely enhance the energy conservation measures that are incorporated into modern hydronic system designs. When coupled with a 95% thermal-efficiency modcon boiler and the comfort of low-temperature hydronic radiant heating, it's a natural fit to complete the chain-of-efficiency from source to delivery.

Footnote: This system was commissioned in September 2010 and performed exactly as we promised the homeowners it would. The advantage of doing the necessary homework ensured my radiant

STONE COLD RADIANT

Basement PEX loops after the concrete pour.

Finished room showing the deep window wells.

design was spot-on. Although we did not have the low bid, we included the owners in the design process and educating them regarding why we were incorporating the higher-quality extruded thick aluminum plates, premium boiler and indirect water heater, and asking a ton of questions about their wants, needs and desires. By taking the extra time to sell myself and then educate them on the radiant design for their "forever" home, we were no longer viewed as a commodity and added value so that cost was no longer the No. 1 concern. An educated customer will almost always choose the best products in spite of the added cost.

The owners had this to say: "Overall, we are extremely pleased with the system and glad you guys put it in. The heat is amazingly even in the entire house, with no hot spots on the floor, cold areas, etc. The basement with the brick floor is simply amazing with it. Coupled with the insulation, I think it will be amazingly efficient and cheap to heat."

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✓ Avoiding Cold Water Sandwiches
✓ More Tankless applications
✓ More Columns, Features, and excellent advice from Dave's lifetime of experience
✓ PLUS more fresh new original content from Dave!

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