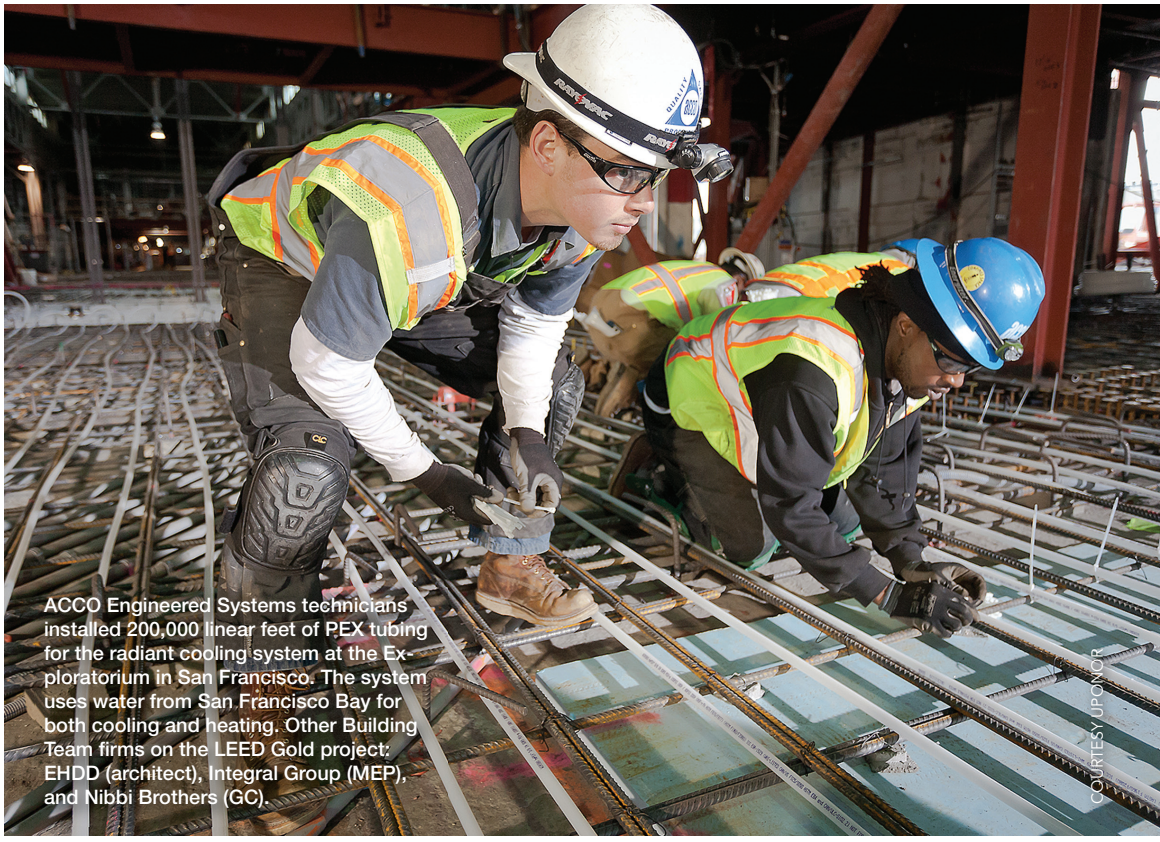
21 TIPS FROM TOP EXPERTS FOR EXECUTING radiant cooling systems

BY ROBERT CASSIDY, EXECUTIVE EDITOR

Radiant cooling can save up to 50% on electricity costs for cooling a typical office building versus an all-air system. Radiant cooling has been used successfully in Walmart stores, research labs at Lawrence Berkeley (Calif.) National Laboratory, housing for the Olympic Village in Vancouver, and the main library at the University of Minnesota.

Several LEED Platinum projects use radiant cooling: Manitoba Hydro Place, Winnipeg; the David Brower Center, Berkeley, Calif.; Cooper Union, New York City; and the net-zero energy National Renewable Energy Lab, Golden, Colo.

Today's radiant cooling systems are nothing like the metal pipe systems of the '50s and '60s, says Joseph Wenisch, PE, LEED AP, a Mechanical Engineer with Integral Group. He says building owners have an unfortunate "institutional memory" of leaking pipes, condensation (from using water that was too cold), and mold and mildew problems.



ACCO Engineered Systems technicians installed 200,000 linear feet of PEX tubing for the radiant cooling system at the Exploratorium in San Francisco. The system uses water from San Francisco Bay for both cooling and heating. Other Building Team firms on the LEED Gold project: EHDD (architect), Integral Group (MEP), and Nibbi Brothers (GC).

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Modern radiant systems use flexible PEX tubing made from cross-linked high-density polyethylene to carry cool water through a slab, ceiling, or wall. "The plastic pipe will last longer than the building," says Wenisch, who has used radiant cooling in 10 projects.

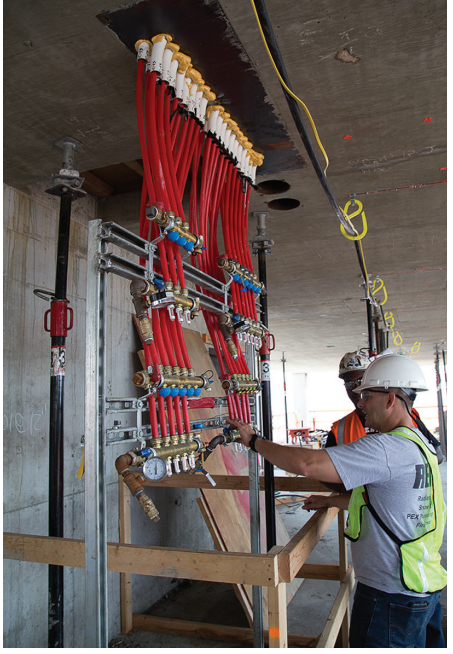
Building Design+Construction consulted technical experts on what to look for in radiant cooling. Here's what they advised:

1) **Understand the proper role of radiant cooling.** Radiant cooling addresses "sensible cooling"—the energy used to lower the temperature of a space without changing the moisture level—not "latent cooling"—the energy needed to remove moisture for humidity control (typically by condensation at a cooling coil), says Fred Bauman, PE,

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ DESCRIBE the three major types of radiant cooling and heating systems.
+ DISCUSS the proper role of radiant cooling and its energy-saving capabilities.
+ LIST three significant building projects that have successfully employed radiant cooling.
+ EVALUATE when ceiling or wall radiant cooling would be preferable to a slab system.



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Mechanical technical staff review the mockup of the manifolds for air pressure testing to confirm all PEX circuits are ready to be filled with fluid. Next steps: connect the distribution piping to the manifolds' supply and return headers, then fill and purge the system.

Project Scientist at UC Berkeley's Center for the Built Environment. Radiant cooling must be combined with a secondary air system, such as a dedicated outdoor air system (DOAS), that will provide ventilation, latent cooling, and supplemental sensible cooling. Radiant cooling can provide about 12–14 Btu/h•sf of sensible cooling, but you still need a secondary means of ventilation.

Radiant cooling systems use a large active surface area, so the surface temperature of the slabs need not be overly cold to be effective—and to avoid occupant discomfort. Rule of thumb: ≥68°F for floors, ≥63°F for ceilings, depending on humidity levels, says Bauman.

2) Don't be afraid to use radiant cooling in humid climates. Outdoor humidity should not be an obstacle to employing radiant cooling. "We have installations in humid places like Bangkok," says Devin A. Abellon, PE, Business Development Manager with PEX manufacturer Uponor. The LEED Platinum Infosys building, in Hyderabad, India, uses radiant cooling and saved 34% in electrical costs versus a variable air volume system. Tulane University's LEED Gold Lavin-Bernick Center for University Life, in steamy New Orleans, uses radiant cooling.

"Surface condensation can be avoided in a properly designed system," says Abellon. "You should only be concerned with the indoor relative humidity." Indoor RH should be kept at 60% or less.

3) Hire a mechanical contractor with experience in radiant systems. Installing PEX tubing is labor intensive. In the past, this led to mechanical contractors jacking up their estimates to cover unexpected costs. Today, reputable mechanical contractors are getting more proficient with radiant cooling, resulting in faster installation, better quality, and more reasonable costs. "As these systems become more popular, mechanical contractors are becoming more expert, and their estimates are more accurate," says Abellon, an ASHRAE Distinguished Lecturer. "There's not the wide overpricing that we saw 10 years ago."

The technology is getting better, too. Prefabricated, pre-pressurized radiant cooling rollout mats can be installed seven to eight times faster than conventional PEX tubing systems. "On a big project, we can get costs down to $5 a square foot," says Wenisch. "The mats cost more, but the overall cost with labor is much better."

4) Ask your PEX supplier for advice. The major manufacturers want your systems to work properly. "They'll help you with design and shop drawings," says Wenisch. "Depending on where your project is located, they'll even come to the job site."

5) Get your sensors and controls systems right. Our experts agree that designing the controls for a radiant cooling system should not be overly complex. Just keep the indoor relative humidity at 30–60% and the temperature of the water coolant at two or three degrees above the dew point. For an installation where the indoor RH is 50%, the dew point going to the manifold cabinet (usually mounted on a wall) will be 55°F, so the entering water should be 57–58°F. That will provide enough differential to prevent condensation from forming.

6) Build a mockup. Work closely with the structural engineer to coordinate the PEX installation with rebar and other structural elements, says Wenisch. When you get into construction, build a mockup, so that the mechanical subcontractor and trades can phase in the PEX tubing correctly. Building the mockup (or at least a small section of the radiant system) on the job site works best, but an offsite mockup can still be helpful. "The subs will often come up with ideas on how to do the installation even better," says Wenisch.

7) Downsize the mechanical air system. If you're using radiant cooling, you should be able to reduce the size of your air system quite dramatically, especially if you use a DOAS system. "Radiant cooling and DOAS go together really well," says Wenisch. You should be able to take 60-70% of the air ducts out of the system and cut air system capacity significantly. For a 60,000-sf library, Wenisch says his team was able to cut the air system volume from 80,000 cfm to 25,000.

8) Look into ways to hold down peak cooling loads. Pre-cooling radiant slab systems can significantly reduce peak cooling loads, says Bauman, Principal Investigator for a four-year, $3.2 million research

THREE TYPES OF radiant systems

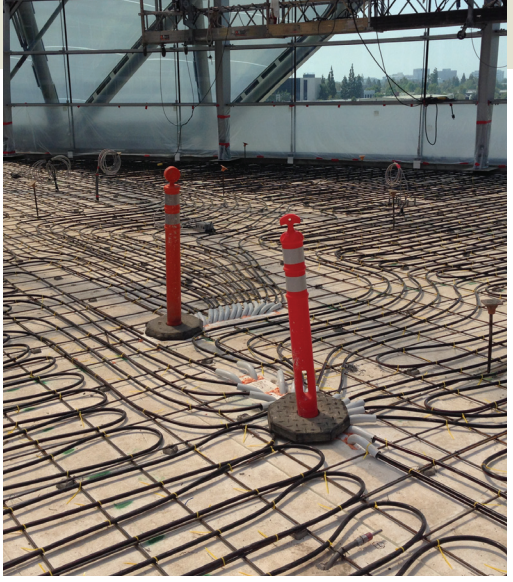
Radiant systems are used to cool and heat interior building surfaces by circulating water through piping embedded in the floor, ceiling, or walls. According to Fred S. Bauman, PE, Project Scientist at the Center for the Built Environment at UC Berkeley, there are three primary types:

Thermally activated building systems (TABS) embed plastic tubing (usually PEX) in the structural slabs. Used primarily in new construction.

Embedded surface systems (ESS) are prefabricated or installed-in-place systems consisting of embedded tubing (PEX, or small, closely spaced plastic tubing "mats") in thinner layers (e.g., topping slab, gypsum board, or plaster) that are isolated (insulated) from the building structure.

Suspended metal ceiling panels with copper tubing attached to the top surface (the radiant ceiling panel). ESS and suspended metal ceiling panels can be used in retrofits or new construction.

TABS and ESS utilize thermal mass (usually concrete) in the layer or slab. While slower to respond to control changes than all-air systems, TABS and ESS can achieve significant energy savings, peak demand reduction, and load shifting.



California Comfort Systems installed 44,000 feet of in-slab cooling/heating pipe, 18 manifolds, and 12 pumps in the LEED Platinum Anaheim (Calif.) Regional Transportation Intermodal Center. The radiant thermal system provides an energy savings of 34% over ASHRAE 90.1-2007.

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project on radiant slab cooling systems. Peak demand reduction and load shifting thanks to thermal mass can let you further downsize your air system equipment. The thermal mass allows heat gain to be removed over a longer period of time and at night, when it's cooler outside and electricity is cheaper.

9) Use only five-eighths-inch pipe, six inches on center. "No half-inch pipe! No 12-inch spacing!" That's the cry from Ryan H. Westlund, LEED GA, Commercial Projects Manager, REHAU Construction LLC. Follow that simple rule, he says, and "you'll be doing yourself a huge favor."

10) Pressure test the piping before you pour concrete. Leaks are rare, says Abellon, but you still must perform the test. While you're at it, make sure your water treatment system is up to par. "In a closed system you shouldn't have any problems, but the last thing you want is stuff building up inside the pipe and fouling your system," says Cynthia Callaway, PE, LEED AP BD+C, P2S Engineering.

11) Take advantage of "free cooling" whenever you can. If chilled water is available, use it: you'll save energy. Ground source heat pumps are another option. "Anywhere you can use geothermal, you should be thinking about it for radiant cooling," says Westlund. The David Brower Center uses chilled water from its cooing towers in its radiant system. The installation at the San Francisco Exploratorium uses water from the Bay, saving 94% on electricity use for cooling.

12) Evaluate the impact of any floor coverings you use. "A bamboo floor over the slab will reduce the capacity of the cooling system," says Westlund. You're not limited to bare concrete, but you do have to calculate the potential loss in energy efficiency from floor coverings.

13) Don't forget about wind at the edge of your slab. "It's amazing how much wind you can get," says Callaway. That's why "designers have to think about edge insulation in their slabs." *Her advice:* Detail for insulation at the edges, using a good board-type material.

14) Make sure the long-term use of the space is conducive to radiant cooling. If you've got office space that's going to be churned every few years, with walls and office spaces being moved around, you may run into trouble with thermal zoning. "You're kind of stuck with it," says Callaway. In such a case, it might be better to use radiant cooling via the ceiling rather than via the floor slab.

15) You really must commission the system. "Commissioning is a check to make sure the mechanical contractor has installed the system properly," says Abellon. If you skip the commissioning, he says, "The building owner will never know if the system is performing to the specifications."

16) Develop a schedule to periodically recalibrate the sensors. Humidity sensors will drift over time, so advise the owner and facility director to have them recalibrated every few years, advises Westlund. *A tip from CBE's Bauman:* Install duplicate humidity sensors at key control points to provide improved reliability.

17) Brace yourself for an unexpected complaint. Callaway says staff at a childcare center where she had designed a radiant cooling system complained that it was too quiet. *Her advice:* Make sure to account for acoustical factors, especially in healthcare settings where HIPAA patient privacy rules may come into play.

18) Check out "predictive control." Building Teams are linking building management systems with online weather forecasts and data on known occupancy and internal load schedules to start cooling the slab earlier than usual in anticipation of unusually hot or busy days. "It takes an average of four hours, and sometimes 8-12 hours, to reach the optimal indoor temperature," says CBE's Bauman. Integral Group's Wenisch says, "We're finding we can get more control out of the slab on abnormally hot days using predictive control."

RADIANT COOLING, BEYOND THE FLOOR SLAB

Radiant cooling systems can be installed in ceilings and walls, too. Ceiling systems can provide 25-30 Btu/h•sf of sensible capacity, about twice that of floor systems. That's because ceiling surfaces can be cooler than floor slabs without causing discomfort to occupants, and the convective heat transfer is higher. You can even have a TABS ceiling system that cools the room below and the one above. But before you rush off to install such systems, consider these points:

19) For ceiling systems, coordinate the radiant cooling with other components of the mechanical system. Lighting, fire protection, plumbing, electrical, paging, and other MEP systems have to share the space with the PEX pipes. Make sure your tubing layout also accommodates punch holes for pendant lights. "It can be done, but it's a little more complicated," says Callaway.

20) Ceiling systems have to be largely exposed to work properly. Recent research shows you can cover up to 60% of the piped area and still provide 85% of the cooling rate, says CBE's Paul Raftery, PhD. You can paint surface systems in ceilings and walls, says Callaway, and ESS walls can be angled for aesthetic effect.

21) For open-plan office spaces, the preferred radiant cooling system will usually be a TABS system in an exposed concrete ceiling. CBE's Bauman adds that it is important to consider the acoustic quality of such an open-plan space in light of the great amount of exposed concrete surface in the ceiling.

> EDITOR'S NOTE

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