# Installing Hardwood Floors over Radiant Slabs

## It can be done successfully if your floor isn't too hot, and the wood is put down dry on a dry slab and subfloor

by Don Bollinger

As a hardwood-flooring specialist, I meet lots of builders and architects who ask me the same question: What do I think about installing a wood floor over a radiant-heated slab? I tell them there's no reason not to do it—as long as you understand how wood reacts to moisture and install the floor system to minimize the effects of moisture on wood.

The best hardwood-floor installations over radiant heat have three things in common—the radiant system is designed, installed and operated with the flooring in mind, the radiant slab and the wood on it are acclimated properly, and the flooring has adequate underlayment. I'll explain more about these three keys to a good wood floor later, but first it's important to take a look at wood's hygroscopic nature.

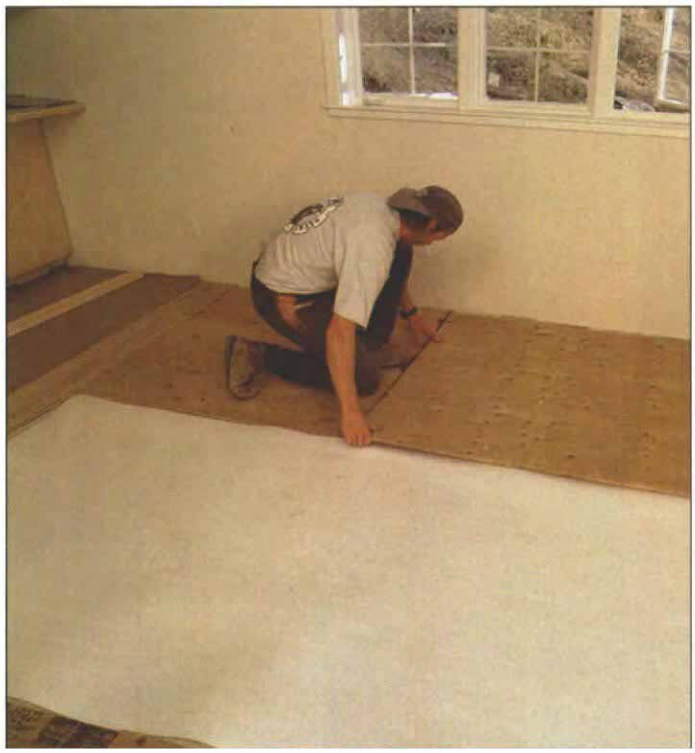
**Wood and water**—Those involved in the installation of a wood floor must understand that wood is hygroscopic, meaning that when wood is drier than its surroundings, it absorbs moisture, and when wood is wetter than its surroundings, it releases moisture. As wood absorbs moisture, it expands; as wood releases moisture, it contracts.

Heat quickens moisture movement into and out of wood and intensifies the effects of moisture moving through the wood's cell walls. Radiant heat comes through the floor, so minor humidity shifts equate to significant changes in the size and the appearance of the wood flooring installed over it. Therefore, with radiant heat, expect exaggerated movement of the flooring.

If you live in an area where summers are humid, the radiant slab will expel this moisture during the first month or two of the heating season. The flooring will absorb this moisture, and some cupping or crowning will occur. To mitigate such problems, gradually heat the slab prior to the onset of the heating season by 2° to 3° per week (see sidebar facing page). Regardless of where you live, air conditioning or dehumidification systems will prevent a home from becoming excessively humid.

Conversely, you should expect some gaps in the flooring toward the middle or end of the heating season when the heat has dried out the radiant mass and the wood floor.

Sometimes radiant heat can dry out the air in your house. If you elect to use a humidification system, keep it well-maintained and use it sparingly when the radiant system is off.



***Floating the first layer.*** **The first layer of ½-in. plywood floats over a radiant slab that's covered with a 6-mil polyethylene vapor barrier and white, 1/16-in. foam sheeting. The foam sheeting protects the vapor barrier from the abrasive surfaces of the concrete and the plywood.**

***Setting the second layer.*** **The second layer of ½-in. plywood is placed in construction adhesive with joints staggered over the bottom layer. To allow for expansion, ⅛-in. wide gaps are left between sheets. At left, kraft paper will act as slip sheet between finish flooring and subfloor.**

As for the flooring itself, you should choose the type that performs best over a radiant slab. So if your budget permits, put down a laminated flooring product or pick a species that is known for its stability, such as teak, cherry or walnut. And use quartersawn or rift-sawn flooring because it changes less in width than flatsawn flooring does. You don't have to purchase a specially milled product to get a more stable floor. Most suppliers of hardwood flooring offer lots of presorted quartersawn or rift-sawn flooring. In fact, a combination of all the different cuts is quite attractive. And use strip flooring rather than plank flooring because narrow boards expand and contract less than wide boards do. Plus, using narrow boards (less than 4 in. wide) means there are more seams in a floor to take up movement. If the flooring has eased edges, rather than square, cupping will be less obvious. Finally, keep in mind that light-colored woods show gaps more readily than darker woods. Maple, for example, is a light-colored wood that is also quite subject to shrinking and swelling. So if you choose to install a maple floor, be prepared to see some seasonal gaps between the boards.

**Flooring systems that work**—Don't even think of installing a hardwood floor over a radiant slab unless you've got a moisture meter that evaluates both wood and concrete, such as a Lignomat Mini-Ligno S/C & E/S (Lignomat USA, P. O. Box 30145, Portland, Ore. 97230; 800-227-2105).

I install hardwood floors over radiant slabs by nailing the flooring to plywood underlayment. Underlayment provides support and nailing for hardwood flooring. There are two variations on

## *The radiant-floor heating system*

**When shopping for a radiant heating system, specify one with three thermostats: one to control the tubing temperature, one for room temperature and one outside the house. A three-thermostat system is not only the most efficient, but it's also kinder to wood flooring because it moderates floor temperature. People tend to crank up the heat when they're cold, but with three thermostats, the system adapts itself to conditions both inside and out. The outside thermostat gears up the system for the arrival of colder weather, and a thermostat on the tubing will tell you when the floor is too hot.**

**The best defense against hardwood-floor movement is to decrease the amount of heat flowing through the system. In years past, many radiant-floor systems exceeded 140° F. Parquet (a wood floor with a repeating pattern) glued directly to the radiant slab was the typical choice for wood flooring. When these high temperatures were coupled with elevated moisture contents within the parquet flooring, the wood fibers were repeatedly traumatized, causing stress fractures, gaps and twisting. Repeated heating and cooling also broke down the adhesive that bonded the parquet to the slab.**

**These days, radiant systems are designed to run cooler, but you can decrease the water temperature further by running shorter loops and keeping the tubes closer together. And use tubing with an oxygen diffusion barrier because it won't cause rust. A rusty heating system is less efficient and makes you compensate with higher temperatures.**

**When the radiant tubing is installed, make sure the tubes are secured to the subfloor. Tubes that protrude will become expensive targets for nails and screws from above during construction.**

**The heat should not be turned off as soon as it gets warm outside, then cranked way up when cold weather hits. Moisture will usually collect in the floor if the system's turned off in a sudden spell of hot, humid weather. At the first cold snap, cranking up the heat could cause the flooring to check, split, twist and loosen. Instead, turn up the heat gradually. Boost the temperature no more than a few degrees per week.**

**Always keep water that's warmer than ground temperature circulating in the tubing. An active system will not only help stabilize the moisture content in the floor and the radiant slab, but it can also help stave off atrophy in your heating system. —*D. B.***

***Fastening layers together.*** **The two layers of ¾-in. plywood subfloor are screwed together 1 ft. o. c. with ¾-in. wood screws, which don't go through the bottom layer of plywood. The plywood is screwed together while the adhesive is wet to draw the sheets together.**

***Nailing into the subfloor.*** **Once the subfloor has 6% to 8% moisture content, 4-in. T&G maple flooring is blind-nailed with 1½-in. staples that don't penetrate the slab. Maple is light-colored and moves a lot, so it will show more seasonal gaps between boards than other species.**

this type of installation: the single-layer nail-down system and the dual-layer floating system. Although I like the dual-layer system better, the single-layer system has the advantage of being thinner and is preferable in small rooms where a floating system won't have the weight to stay flat on the floor. The most important thing to keep in mind with any installation is that the moisture contents of all floor components—the radiant mass, the underlayment and the wood flooring—must be stable and in balance with each other.

The single-layer nail-down underlayment system involves nailing the flooring to a layer of ¾-in. plywood underlayment over dry 2x4 sleepers (drawing below). The sleepers go in before the radiant tubing is installed and the radiant slab poured. Sleepers are usually 12 in. o. c. (sometimes 16 in. o. c.), and they're broken or notched to allow the tubing to run from bay to bay. Often, notched 2x4 sleepers are spray painted to alert the flooring installer to where the tubes pass under the sleepers. The radiant slab—usually 1½-in. deep Gypcrete—is then placed between the sleepers. In radiant floors over wood framing, the sleepers run perpendicular to joists, and the flooring runs parallel to the joists. If you want the flooring to run perpendicular to the joists, I recommend you use the dual-layer floating system, which I'll describe later.

When the slab has cured, turn the heat on—summer or winter—and leave it on for at least 30 days. (Provide fans for construction crews working inside in warm weather.) Your goal is to dry the slab to about 8% to 12% moisture content. Artificially drying with fans and dehumidifiers can help, but remember, just because the surface is dry, don't assume the whole slab is.

When the radiant slab has dried to an acceptable moisture level, plywood underlayment is nailed or screwed to the sleepers (some builders use glue and screws). The underlayment should be ¾-in. ACX plywood or better and can be either T&G or square-edged. Leave ¼-in. gaps around the edges of the underlayment and at walls, and install the plywood with the A side up. Allow the underlayment to acclimate—with the heating system on—for at least two weeks or until the plywood's moisture content stabilizes at 6% to 10% (more or less in extremely wet or dry climates—see sidebar facing page).

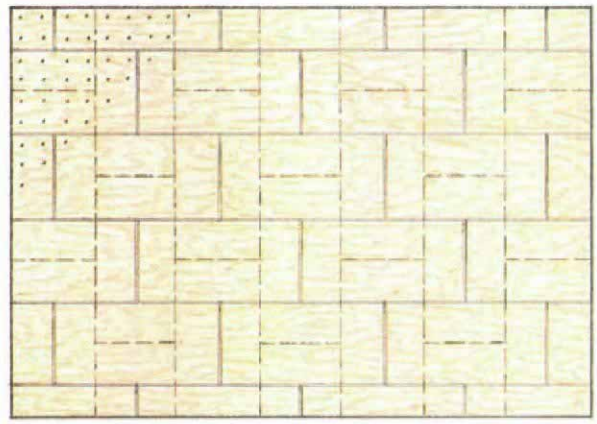
Solid wood flooring can be installed over sleepers without the use of underlayment, but the inevitable shrinkage of the radiant slab between the sleepers often results in gaps between the flooring and the slab, causing movement between floorboards and excessive floor noise. Sanding the sleepers flush to the radiant slab works only marginally well and is far more expensive than simply adding a layer of ¾-in. plywood underlayment.

The wood flooring should be brought into the structure as soon as the plywood underlayment is installed and dry (usually 6% to 8% moisture content). Stack and sticker the flooring—preferably right on the plywood-covered slab—and provide lots of ventilation until the moisture content of the flooring and the plywood are within 2% of each other. Do not expose the flooring to excessively moist conditions from painting, spackling or stone and tile work.

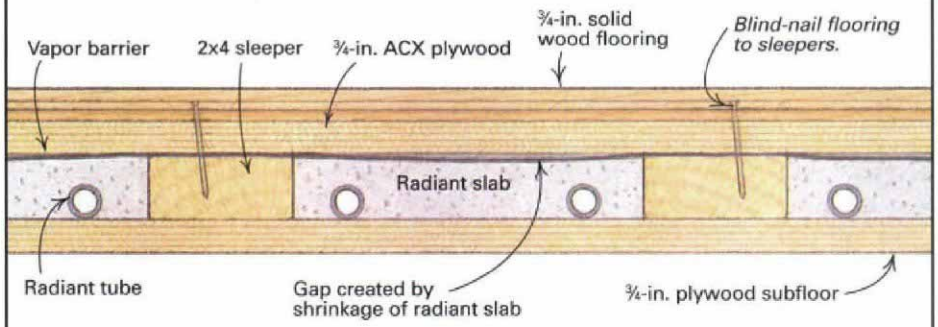
When the moisture content of the flooring, the plywood and the radiant slab are stable, install the wood flooring by blind-nailing it into the 2x4 sleepers through the underlayment.

Before sanding and finishing, allow the newly installed wood flooring to acclimate with the heat on for a minimum of two weeks—30 days is better. Waiting a little extra time pays off in a floor that retains its flat surface after sanding.

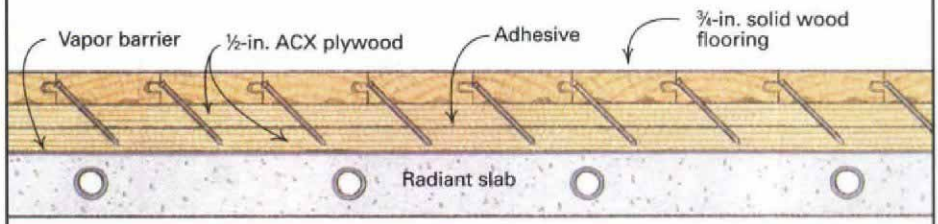
**Staggering seams** *When using the dual-layer underlayment system, float the first layer of ½-in. (min.) ACX plywood (dotted lines), spread a thin layer of adhesive and screw the top layer perpendicular to the bottom layer. Leave 1/16-in. to ⅛-in. gaps between all sheets and put the A side down on the bottom layer and up on the top layer.*



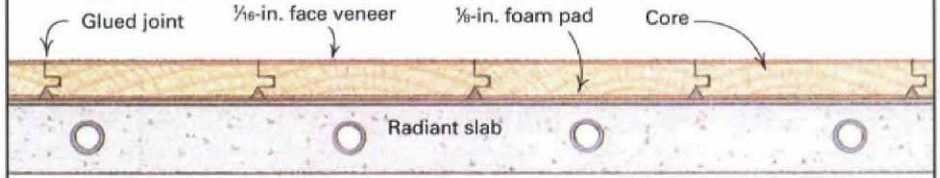

**Single-layer nail-down underlayment system.** *Sleepers and radiant tubes are secured to the subfloor; the radiant slab is placed between sleepers. When the slab's moisture content is between 6% and 8%, put down a vapor barrier and fasten plywood underlayment to the sleepers. The flooring goes down after its moisture content is within 2% of the underlayment's.*




**Dual-layer floating underlayment system.** *After the radiant slab is acceptably dry, a vapor barrier and two layers of plywood are floated, not fastened, over the mass. The top layer is glued and screwed to the bottom layer with staggered seams. Wood flooring is nailed to the underlayment once its moisture content has stabilized.*




**European-style floating floor system.** *Pieces of laminated flooring are glued edge-to-edge and floated on a ⅛-in. foam pad. Because the flooring is laminated, it's stabler than solid wood. The European-style floating floor system is also thinner than the plywood-underlayment systems, so if headroom is an issue, a European-style floor is the best choice.*




**Using two layers of plywood**—The dual-layer floating underlayment system (drawing left) uses two layers of plywood and eliminates the need for 2x4 sleepers. The two layers of underlayment "float" over the radiant slab: They aren't fastened



Drawings: Vince Babak

to it. The dual-layer floating system compensates for most of the minor variations in the level of the radiant slab by spanning any depressions and allows the wood flooring to be fastened wherever you want. With the dual-layer floating system, there's less danger of nails piercing a tube and creating a flood. And because there are no sleepers, the floor heats up more evenly, and there's more radiant slab to absorb and retain heat.

The plywood should be at least ½-in. thick, square-edged ACX. Stagger the plywood seams (right photo, p. 42) by covering all the seams of the bottom layer with a top layer of plywood that is perpendicular to the bottom layer (drawing facing page).

You should put down a 6-mil polyethylene vapor barrier before floating the underlayment (left photo, p. 42). Tape all the seams to be sure the barrier is tight. Then, to protect the barrier from rips, some flooring specialists lay 1/16-in. thick foam sheeting over the vapor barrier. Just keep in mind that this sheeting adds a layer of insulation between the radiant slab and the wood flooring.

Follow all the acclimating procedures I described for the single-layer nail-down system. Install the first layer of plywood A side down (to protect the vapor barrier), and leave ⅛-in. gaps between sheets to allow for expansion. Use a 3/16-in. notched trowel to spread a waterborne-urethane or epoxy adhesive between layers. Don't use too much adhesive because the excess could ooze up between the seams of the top layer of plywood.

As the second layer of plywood is placed A side up over the first, draw the sheets together with ¾-in. wood screws (left photo, p. 43). I find 1-ft. o. c. spacing works well. A ⅛-in. gap is left between sheets in the top layer as well.

Once the two layers have been glued and screwed, you must allow time for the moisture from the adhesive to leave the plywood and for the glue to cure fully. Check moisture contents until stability is reached—a process that can take up to several weeks. Then install the finish flooring with nails that won't penetrate the radiant slab (right photo, p. 43).

If the dual-layer floating system has a downfall—other than slightly higher cost—it's the insulating value of the added layer of plywood. It requires more energy to heat the floor initially, but once the floor is heated, the additional energy necessary to keep the system going is negligible-far less than that used by a European-style floating floor system over a foam pad.

**European-style floating floor system**—With this system, a ⅛-in. foam pad (which acts as a vapor barrier and allows the flooring to expand and contract) is placed on the radiant slab and topped with a laminated T&G floor (drawing facing page). The flooring pieces are usually glued together, with the edges held under baseboard. Because the flooring floats on the slab, this floor system moves more freely than conventional wood-flooring installations. And because most European-style flooring is prefinished, sanding and finishing are eliminated. European-style floating floors also lessen the height gain off the radiant slab. (The dual-layer system, for instance, takes away at least 1¾ in. of headroom, but a European-style floor subtracts about ¾ in.)

It's generally true that laminated floors are more stable than solid wood. But their veneers can be pretty fragile, and if a laminated floor gets soaked, the veneer can pull away from the core.

Often the surface laminate is rotary-cut veneer (skinned from the log the same way plywood veneers are cut). Laminated flooring with rotary-cut veneers won't last as long as those with sliced veneers, especially in areas with heavy traffic, such as hallways and foyers. However, sliced veneers are typically laminated to a pine core, which is softer and can expand and contract differently from the surface laminate.

Fortunately, at least one European manufacturer, Junckers Hardwood, Inc. (4920 East Landon Dr., Anaheim, Calif. 92807; 800-878-9663), offers a floating-style floor of solid wood. It's a T&G product that's held together with metal clips. It's easy to install and works quite well over a radiant slab. Because the Junckers flooring is solid, it can be sanded and refinished, and it projects less of a floating or cushiony feel underfoot.

The product does have its disadvantages, however: It's more expensive than laminated flooring, it's difficult to join mitered pieces because it's a clip system, and transitions between this flooring and adjacent floors require the use of a saddle or a threshold. Still, the Junckers flooring is a good choice if you don't want a laminated floor and have height-gain problems, or if you're looking to reduce the total buildup of wood over the radiant slab. □

*Don Bollinger is a hardwood-flooring specialist and the author of* Installing Hardwood Floors, *a book and video series published by the Taunton Press. Photos by Charles Miller.*

## *The southwestern view*

***by Paul Page***

**In the southwestern United States the air is dry, but houses under construction are wet. That's because most houses here have cement-based ulterior finishes—plastered adobe, stone floors set in mortar, brick floors set in damp sand, river-rock fireplaces. Add in the load of water in vigas and solid timbers, and you have conditions ripe for wood-floor failure, especially when a radiant slab soaks up this moisture and then releases it into the flooring. How does a southwestern flooring contractor thrive in this difficult environment?**

**I try to get top scheduling priority. That means the wood floor goes down once all the wet stuff is finished and dry—period; no exceptions. At this point the indoor humidity has settled to where it will stay-between 25% and 45%. If I can't get top scheduling priority, everyone involved must understand how a compromise will affect the flooring.**

**Conventional wisdom dictates that subflooring and wood flooring be delivered to the job site to acclimate. But on a southwestern job site, lots of water is added during the final phases of plaster, stone and brick work, and the humidity inside the house soars to levels it will never experience again. Acclimating the plywood subfloor and wood flooring to this high humidity is a big mistake.**

**A much better alternative is to store the subfloor and the finish floor off site, at the installer's shop or warehouse, for example, or at a warm (at least 15° above ambient temperature), dry, on-site location such as an enclosed garage, where someone can make sure the flooring stays dry while the job site itself dries out. The storage facility must be dry-heated. Nonvented heaters dump lots of humidity into the air, a by-product of the fuel they burn.**

**The subfloor and the flooring should be brought to the job site when the humidity in the house falls between 25% and 45%. The radiant-heating system should be on constantly during this drying-out period.**

**I measure the moisture contents of materials with a moisture meter, and I measure indoor humidity with a hygrometer (A. M. Leonard, Box 816, Piqua, Ohio 45356; 800-543-8955). Available at houseware stores for about $10, a hygrometer placed in a house under construction and monitored daily tells when the house has exhaled construction moisture.**

**When the hygrometer needle sinks to between 25% and 45% and stays there with the radiant-heating system on for at least two weeks, and the moisture-meter readings of the flooring and the subflooring are stable in the 5% to 7% range, I begin installing a floor.**

**As a part of my installations, I always use a 6-mil polyethylene vapor barrier on the concrete before the subfloor goes down.**

**I also apply urethane to the subfloor and the finish flooring. I brush the urethane onto the subfloor plywood before installing the wood flooring, and I back-coat the wood flooring with urethane. Flooring laid out, or racked, upside down over the subfloor can be coated just before installation. I'm careful to use a moderate amount of urethane to avoid drips over the edges. Back-coating is particularly helpful when installing solid plank flooring, which is wider and moves more than strip flooring.**

**It's safe to sand and finish when the hygrometer readings stabilize.**

***—Paul Fuge is a flooring contractor in Santa Fe, N. M.***