

INSTALLING

Hardwood Strip Flooring

Dry out the
job site, prep
the subfloor, and
don't skimp on nails

by Howard Brickman

Even after 20 years in the wood flooring industry, I still get immense satisfaction when my tools are packed up in the van and I can admire the natural beauty of a newly completed job. For that wood floor to perform flawlessly throughout its projected 50- to 80-year life span, however, there are many crucial steps I have to carefully perform.

Moisture Control Is Critical

Accounting for moisture is the single most important factor when laying a hardwood floor. Understanding how moisture affects wood is not a mystical art taught only in the inner sanctum of the Temple of Wood Flooring, it's common sense. Simply put, wood reaches a state of equilibrium with the relative humidity (RH) of the surrounding materials and environment. When RH is low, wood loses water molecules and shrinks. When RH is high, wood gains water molecules and swells.

Wood scientists and lumber manufacturers long ago figured out the relationship between the amount of water in wood and

the surrounding RH levels (see Figure 1). We call the amount of water contained in a wood sample its *moisture content* (MC), which is calculated for each type of wood as a percentage of its weight when oven dry (OD). A sample is deemed oven dry when it has been baked in a 200°F oven for 24 to 48 hours and all of the water molecules have been removed.

A wood sample shrinks to its minimum dimensions at 0% RH and 0% MC. Maximum swelling occurs at 100% RH and 28% MC, at which point wood reaches its fiber saturation point (FSP). The FSP is the total amount of water molecules that can be absorbed within the microstructure of wood.

At the Mill

Because of the shrinking and swelling that accompanies changes in RH, it makes no sense to manufacture any wood product to its final dimensions and shape until it has been

dried. The first step in lumber processing is to remove the excess moisture from the green wood. After the lumber is rough-cut, it's dried to an MC falling in the range of RH levels to which the wood will be exposed as a finished product.

During the 1930s, a nationwide survey of interior RH and MC by the USDA found regional variations based on local climatic conditions (Figure 2). Today most manufacturers kiln-dry wood building materials to an MC of 7.5% at a corresponding RH of 40% — roughly the national average.

Job-Site Moisture

Excessive moisture at the job site is the leading cause of problems with wood floors. All of the expense and effort to properly kiln-dry and precisely manufacture wood strip flooring are for naught if it is later exposed to excessive moisture and swells before, during, or after it is installed.

Much of the wood flooring industry literature is misleading because it emphasizes acclimating wood flooring to job sites. In reality, the reverse is true: A job site needs to be dried out before any wood flooring arrives. There is nearly always excessive moisture on new construction sites and major remodeling job sites.

Wood flooring should *never* be delivered to the job until all excessive moisture has been eliminated. The quickest and most effective method for removing job-site moisture is to run the heating system and increase fresh air ventilation.

Wood flooring should be installed only after the interior MC level of a structure has been reduced to within the range that will prevail during the life of that structure *after it is occupied*. This prevents the excessive moisture present during any major renovation or new construction project from being absorbed into a kiln-dried wood floor. If the wood subfloor over which the wood floor is to be installed contains excessive moisture, then the wood flooring will absorb the moisture and swell.

Three of the biggest lies I've been told in my 20 years as a flooring contractor are, "We're from the government and we're here to help you;" "The check is in the mail;" and "This job is as dry as a bone — you can start laying the floor next Monday."

Even if there is no intent to deceive, you need to confirm that a job site is dry by measuring the moisture content of the subfloor. If you're acting as the flooring sub, don't rely on the contractor to control site moisture. In the end, it's the installer who needs to take responsibility for checking MC levels.

Water vapor is colorless and odorless, so it can only be reliably measured with moisture meters (Figure 3). Electrical resistance meters are the simplest type to use and provide the only practical non-destructive way to determine moisture content in wood frame construction. Two pins are driven into a wood surface parallel to the grain and the meter gives an MC reading. Small

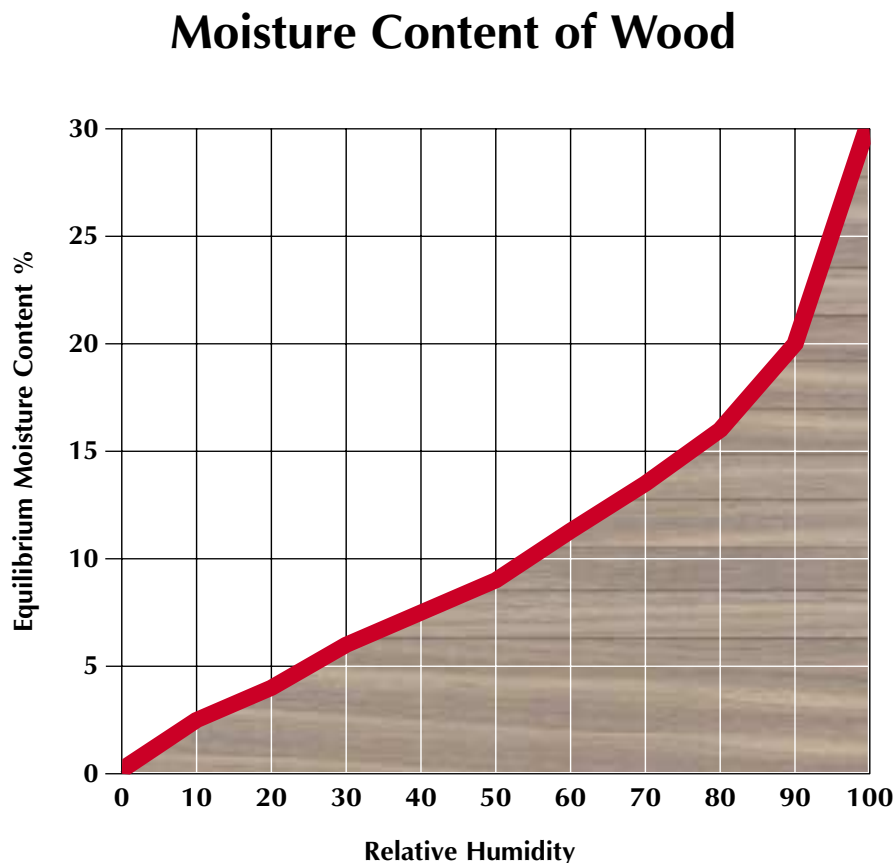


Figure 1. As relative humidity (RH) in the air rises, so does wood's moisture content (MC). Wood swells in size until it reaches its fiber saturation point, at an MC level of 28%.

pocket versions are available from several manufacturers for less than \$200.

Wood Subfloors

Standard 3/4-inch-thick solid strip flooring must be nailed into a wood subfloor. This includes plywood, OSB, or plank subflooring — as long as certain conditions are met. My preference is 3/4-inch plywood; OSB can swell if it gets wet. Old plank subfloors are usually okay as long as there's not a moisture problem in the building. (As an aside, I do not recommend the use of fire-retardant-treated plywood as subflooring. The water used in the process is not always properly removed before delivery, and the salts used in the treatment process may cause fasteners to corrode and work loose over time.)

Beyond acceptable dryness, a few other qualities are important for a nailing substrate to function properly. First, the subfloor needs to be thick enough to allow the use of standard length nails. There must be enough substrate area for plenty of nails throughout the floor, which is why two-by sleepers by themselves do not make an adequate nail base. Last, to prevent movement during seasonal changes in RH, a subfloor needs adequate strength and stiffness.

The key to prepping conventional subfloors is taking the time to get rid of any potential squeaks and uneven areas before the wood flooring goes down. In new construction, properly glue and nail T&G plywood to floor joists to provide a uniform, squeak-free surface. On an existing subfloor, check for and nail off any loose spots and repair any unevenness at joints.

Wood Floors Over Concrete

Concrete under a wood floor must be dry. If it's not dry, use heat and ventilation to dry it. Also, concrete should be level to 1/4 inch over 10 feet and should be clean and free of surface contamination before a flooring installation begins. Concrete in contact with the ground should be placed over at least 6 inches of crushed stone or gravel with a 6-mil polyethylene vapor barrier under

Ideal Flooring MC Levels

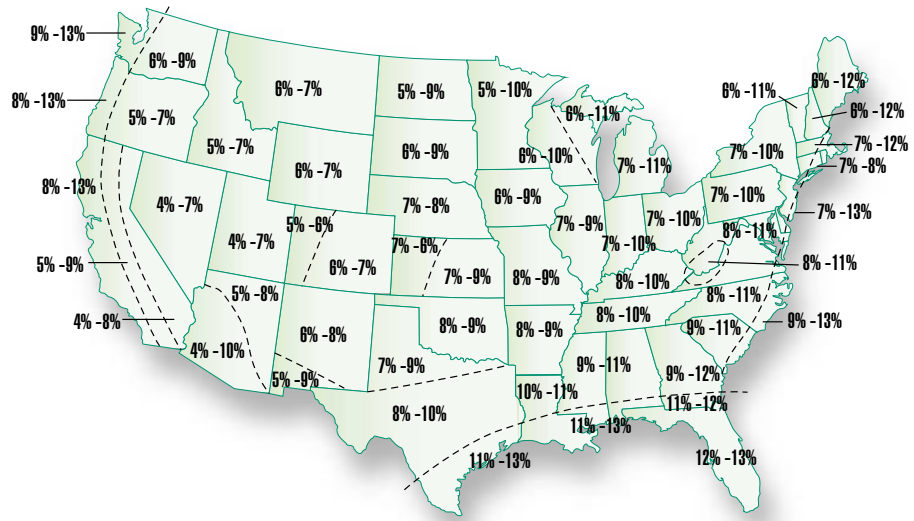


Figure 2. Seasonal ranges in RH vary across the U.S. Optimally, both the subfloor and the strip flooring should be at mid-range MC levels shown on this map during installation. This means drying out new construction sites before delivering materials, and acclimating materials only if you are in extremely dry or moist areas of the country.



Figure 3. Using a moisture meter is the only accurate way to check for excessive moisture in subfloors and finish flooring strips. A pocket-size meter costs less than \$200 and is an essential tool for good wood flooring installations.

the concrete (for a more complete discussion, see "Laying Wood Floors Over Concrete Slabs," 10/94).

A vapor barrier is vital because concrete is *not* waterproof, but somewhat porous. Looked at under a microscope, concrete has tiny spaces throughout. If you doubt this, pour a cup of water on any unsealed concrete surface and

watch the concrete absorb the water. The tiny voids in concrete allow water and especially water vapor to move through the concrete in a manner similar to capillary action.

Before delivering flooring to a wood-over-concrete job, check moisture levels. If there is excessive moisture present, it will continue to evaporate up



Figure 4. The author screeds dry mason's sand to level a low spot on a slab before installing a plywood nailing substrate. The trick with this technique is to avoid stepping in the sand after you've screeded it level and covered it with a poly vapor barrier.



Figure 5. When installing flooring over a single sheet of plywood on a slab, a shim beneath the nailer shoe will angle the nail to prevent its striking the concrete.

through the surface of the concrete. There are basically three ways to test for moisture in concrete: electronic moisture meters, calcium chloride crystals, and the rubber mat/polyethylene test, which I use because it's easy and dependable. I simply place several solid, smooth-backed rubber or vinyl mats on the surface of the concrete. A variation of this test is to tape 2 x 2-foot squares of clear polyethylene to the surface of the concrete with duct tape. After 24 hours, any dampness or even slight darkness beneath the mat or polyethylene indicates excessive moisture. Many times you can observe the presence of excessive moisture in a slab by looking under boxes, plywood, or other items that may have been stacked on the surface overnight.

It is vital that you document the results of this test somewhere in your field notes or job file. Many times the customer wants work completed as quickly as possible and will try to push you to "Just do it!" If you fail to point out potential problems to the customer and make them understand the risks, you may assume the liability.

When my company encounters this problem, I write a letter explaining the situation and include an unconditional release of liability with signature blocks for the customers. I also request a meeting where I present the facts calmly and professionally. I then present the letter for their signature and explain that I am unwilling to assume the increased risk of proceeding with the delivery of materials until the excessive moisture conditions are eliminated. If a customer won't accept the risk, I believe it's more cost-effective to find some other work rather than to do a job twice but get paid only once.

Plywood Substrate Over Concrete

I don't install wood flooring over 2x4 sleepers and I don't recommend it under any circumstance. Instead, I provide a nailing substrate using fastened or floating plywood systems laid over a poly vapor barrier right on top of the concrete. The reason often stated to justify sleeper systems is to provide space

for the floor to breathe. If we agree that breathing is unnecessary because no moisture is present and that the use of sleepers without a plywood subfloor doesn't provide an adequate nailing substrate, then the extra cost and hassle of installing sleepers under plywood is unjustified.

Leveling the slab. Check to see that the slab is flat and does not vary more than a gradual $\frac{1}{4}$ inch over 10 feet when checked with a straightedge. Fill any low spots with a leveling product — I usually just use clean dry sanitary mason's sand (Figure 4). Just be careful not to walk in the sand before you cover it with rigid foam insulation or plywood.

Plywood fastened to slab. After placing a poly vapor barrier over the slab, lay down sheets of $\frac{3}{4}$ -inch-thick plywood, leaving $\frac{1}{4}$ -inch spaces between panels and at least a $\frac{1}{2}$ -inch space around the room perimeter. Then fasten the plywood directly to the concrete with power-driven concrete nails. The poly vapor barrier is still 99% intact, with small punctures every square foot or so. Under normal conditions these punctures should not dramatically decrease moisture resistance.

Next, proceed with the normal installation by using 15-lb. asphalt-saturated building paper or felt between the plywood and the finish flooring. It will be necessary either to use shorter $1\frac{3}{4}$ -inch flooring fasteners or to slightly tilt the nailing machine so that nails don't strike the concrete and damage the tool (Figure 5).

Floating plywood on slab. Whenever I'm worried about future moisture intrusion through the slab, I use the floating plywood method. First, place 6-mil poly over the concrete. To protect against anticipated moisture problems, take the extra steps of taping the overlaps with duct tape and extending the poly up the walls several inches. You may want to put down a layer of compression-rated rigid foam insulation (no gluing necessary) to limit heat loss through the floor (Figure 6). Then, place a layer of $\frac{1}{2}$ -inch plywood oriented with the long direction of the room. Space the panels $\frac{1}{4}$ to



Figure 6. To insulate a floor installed over concrete, the author installs compression-rated rigid foam insulation under the floating plywood nailing substrate.

Recommended Nailing for Strip Flooring



Flooring Width (inches)	Interval (inches)
$1\frac{1}{2}$	10 to 11
$2\frac{1}{4}$	6 to 8
3	5 to 6
$3\frac{1}{4}$	5
4	4
5	3 to 4
6	3
7	2 to 3
8	2

Figure 7. You need to drive lots of nails into wood flooring to hold it firmly in place during regular seasonal climate swings. The wider the flooring, the more nails that need to be driven along the nailing edge of each board.

Checklist

Prep Work

Make sure the moisture content (MC) of the subfloor is within a normal range (no more than 2% beyond the maximum MC for the region). Be sure to eliminate all excessive moisture before you even deliver the flooring to the site.

Check the wood subfloor for looseness and proper nailing. Remove squeaks now! Repair any damaged areas in the subfloor. Point out any major uneven spots to the customer and find out if they want you to repair them.



Figure A. Snapping a chalk line to start the layout in a new room ensures the flooring runs parallel to the walls.

Lay down 15-lb. asphalt-saturated felt underlayment. This is the cheapest insurance policy you can buy.

Mark floor joist locations for the first and last courses of flooring.

Installation

Pick out straight pieces of flooring to start and finish the floor. Nothing is quite as frustrating as trying to rip a warped and twisted piece of flooring to fit against the wall.

Use a string, chalk line, or straightedge to start the floor. Start straight to stay straight (Figure A). This, in conjunction with the straight boards, makes nailing a walk in the park.

Stagger the end joints at least 6 to 8 inches as you lay out the floor.

Nail every 6 to 8 inches for 2¹/₄-inch strip flooring and even closer as width increases (see Figure 7, previous page).

Use splines whenever you have to reverse direction — in other words, run the flooring groove to groove (Figure B). Be sure to nail down the groove edge so that it doesn't rise up from the pressure applied during installation.



Figure B. The author makes splines to use whenever he has to run the flooring groove side to groove side.

1/2 inch apart and leave at least 1/2 inch along the perimeter. Do *not* fasten this layer to the concrete.

Then lay a second layer of 1/2-inch plywood over the first, orienting these panels 45 degrees to the first layer with the same spacing at the edges and perimeter. The 45-degree orientation of the second layer keeps the joints of the two layers from lining up and helps to form a rigid monolithic system when the installation of the flooring is complete. Staple the two layers together with a pneumatic stapler, making sure that the staples don't go completely through the bottom layer. You may substitute screws for staples, but be careful not to puncture the polyethylene vapor barrier. Then proceed with normal installation, using 15-lb. asphalt-saturated felt between the plywood and finish flooring.

Flooring Installation Basics

The checklist at left gives the proper steps and sequence for installing a tongue-and-groove wood-strip floor. Four issues always seem to generate the most interest and discussion: acclimation of the flooring, use of 15-lb. asphalt-saturated felt paper, frequency of nailing, and whether to leave an expansion space.

To acclimate or not? Ideally, the proper moisture content for the installation of any wood floor is midway between the seasonal high humidity, which occurs during the summer, and the seasonal low humidity, which occurs near the end of the first winter heating season after construction is completed. In my 20 years of consulting in the wood flooring industry, I have often seen damage done to wood flooring from "acclimating" the flooring to the job before installation. Because the quality of kiln-drying within the wood flooring industry is high, acclimation is only appropriate in extreme climates where interior relative humidity levels are substantially above or below the 7.5% MC/40% RH manufacturing specifications. This includes the arid regions of the western U.S. and the humid southeastern U.S. Acclimating wood

flooring in other regions actually risks exposing it to the high levels of relative humidity and moisture present during summer or on a new construction site. This will cause the wood flooring to swell before and during installation. Then, during the first heating season, it will shrink and permanent spaces will be left between the flooring strips. Instead, dry out the building before bringing the flooring on site.

Felt paper. I've often heard doubters ask, "Why should I use 15-lb. felt, and what does it really do?" It performs four functions:

1. Felt slows the flow of water vapor.

It gradually absorbs moisture in the subflooring, allowing it to pass through the flooring slowly, instead of flooding the underside of the flooring and causing it to swell and possibly cup.

2. Felt increases the friction between the flooring and the subfloor, which in turn helps to resist lateral movement in the event that swelling occurs.

3. Felt adheres to the subfloor and wood flooring and will help to eliminate any vertical looseness or movement that might occur.

4. Finally, felt will help safeguard a manufacturer's warranty in the event that you encounter a problem like cupping or large spaces between the boards. The majority of the wood flooring manufacturers consider the use of 15-lb. felt to be mandatory and will deem your installation to be negligent if you don't use it.

The cost for materials and labor to include 15-lb. asphalt-saturated felt underlayment is approximately 5¢ per square foot. That's cheap insurance even if its only function is to avoid warranty issues in the event of a problem.

Nailing. I go nuts when I hear a person say that you should not use too many nails because then the flooring can't move — the argument of many hackers and trunk slammers in the construction business. There is no such thing as too many nails unless they start splitting the flooring strips into little pieces. Nails are what hold the flooring in place and keep it from moving.

I prefer to think in terms of nails per



Figure 8. Because he uses plenty of nails to keep the flooring from moving, the author doesn't leave perimeter expansion spaces on typical residential strip flooring installations. Countersunk face nails hold the perimeter strips snug; the last strip is scribed tight to the wall. To prevent splitting when nailing these last courses, the author uses a nail spinner from Vermont American (inset), which chucks into a drill, to drive the finish nails.

square foot to determine the proper fastening for flooring of different widths. If the optimal nailing interval for 2 $\frac{1}{4}$ -inch-wide strip flooring is 6 to 8 inches, this is equal to 9 or more nails per square foot. The schedule in Figure 7 gives the average nailing interval necessary for 9 nails per square foot for other flooring widths.

Expansion gap. Since wood shrinks and swells very little in length (with the grain direction), there is no need to allow any space at the ends of the flooring. In fact, I generally don't worry about leaving expansion spaces anywhere — sides or ends — when installing a traditional nail-down T&G floor (Figure 8). This is because, as mentioned above, I use enough nails to firmly hold the individual pieces of flooring in place.

As long as the moisture cycle stays within the normal range for the region where the floor is installed, movement isn't usually a problem when the flooring shrinks and swells. Wood is somewhat elastic and can be slightly compressed without becoming permanently deformed. The exception is when there's an unexpected source of excessive moisture, such as a plumbing leak or an abnormally long period of extremely high humidity. In that case,

the swelling of the floor can exert such pressure that the wood actually compresses permanently. Then, when the moisture subsides and the flooring shrinks, large gaps will result and the floor will creak and pop when it is walked on. In the case of excessive moisture, leaving a perimeter expansion gap will do nothing to prevent damage.

Expansion is typically less of a problem than shrinkage. In the Boston area, for example, most nail-down solid tongue-and-groove flooring is fit tight against pre-installed baseboards and other moldings. Later, during the first heating season, the flooring shrinks, leaving gaps between the perimeter flooring and the baseboards. To remedy at least part of this problem, it's wise to install baseboards over the already installed wood floor.

Remember, this discussion applies only to nail-down floors over attached subfloors. When installing floating or glue-down wood floors, however, you must be certain to leave adequate expansion spaces. Those are entirely different installations, and a subject for a different article.



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