SUBSTRATES: Wood Subfloors

Wood flooring by design is not to be used to strengthen/stiffen a subfloor and will not do so. The subfloor is the foundation for the wood floor. The final wood floor installation is only as good as the subfloor it is installed over.

With new construction, it is the responsibility of the builder to ensure the facility is designed and capable of sustaining an environment conducive to the building materials being used in it. The wood flooring contractor shall not be responsible for the design or installation of the subfloor system, inadequate deflection limits, improper joist/floor truss spans, and spacing/panel thickness combinations, or any subsequent flooring problems resulting from prior jobsite damage, unless otherwise contracted to do so.

If it is the opinion of the wood flooring contractor that the subfloor is not in suitable condition for hardwood flooring, it is the responsibility of the wood flooring contractor to either remedy the subfloor and/or to notify the builder/owner prior to installation to allow them to make it suitable for the flooring being installed.

PART I
Floor Joists and Trusses

Floor joists and trusses are the structural components in a floor framing system that transfer floor loading above to the wall or foundation-bearing supports below. They run between foundations, walls, or beams, and typically are laid out in repetitive patterns. They can be made of solid wood, engineered wood, or steel. You can work with the architect, the builder, and the designer to ensure the facility is designed and capable of maintaining the minimum requirements necessary for the flooring products being used in it.

A. Traditional lumber joists are usually 2″x or 3″x dimensional material and are sized according to the these factors:
   1. Species and grade of the wood.
   2. Spacing and span of the joists.
   3. The design load requirements.

B. I-joists have a higher strength-to-weight ratio than lumber joists and often are used for longer spans. They use top and bottom flanges that typically are solid lumber, structural composite lumber, or laminated veneer lumber (also called LVL). They also use web material that typically is made of oriented strand board (OSB).

C. Floor trusses usually are made up of 2″x4″ or 2″x3″ lumber on top and bottom chords with an open-web configuration with metal plates. The lumber in the floor truss flanges usually is oriented flat-wise providing for up to 3½″ wide bearing surfaces. These trusses are often used for longer spans than lumber joists.

D. Maximum subfloor deflection limits are set by building codes. They are expressed as a fraction: clear span in inches (L) over a given number. Building code allows for the maximum allowable floor member live load and concentrated load deflection for wood framed floor systems to not exceed L/360, where "L" is the clear span length of the supporting members.
   1. A subfloor system built to this minimum specification is sufficient for most wood floor installations.
   2. Some thinner-profile (solid and engineered) wood flooring products may benefit from a stiffer subfloor system.
   3. Subflooring systems that lack adequate stiffness can contribute to performance problems in wood floors such as fasteners pulling out of the subfloor, excessive noise, and potential damage to the surface finish. Where subfloor deflection is a concern, a qualified professional can help the end-user determine the best method to stiffen the subfloor system. Some common options for stiffening a subfloor system include:
      a. Increasing the subfloor panel thickness.
      b. Adding a second layer of wood panel subflooring to the existing subfloor.
      c. Selecting a high-performance subfloor product that has a higher design stiffness than commodity panel options.
      d. Increasing the depth of the floor joists/trusses.
      e. Selecting a wood grade for the floor joists/trusses with a higher modulus of elasticity.
      f. Reducing the floor joist/truss spacing.
      g. Reducing the span of the floor joists/trusses

PART II
Wood Panel Subflooring

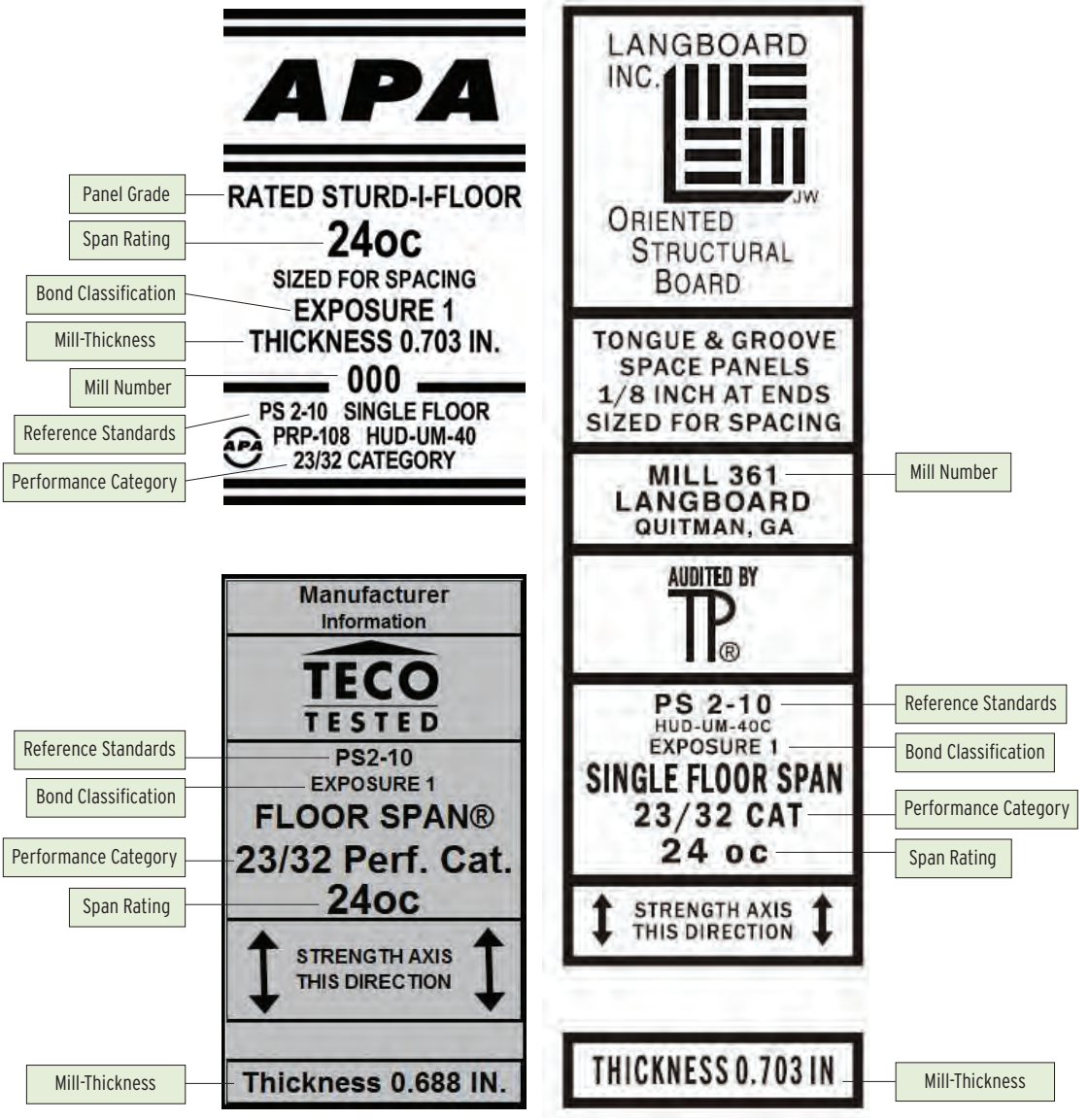
A. Wood Panel Subfloor Standards:

1. **Plywood subfloor panels** should conform to the most-current U.S. Voluntary Product Standard PS 1 performance standard, for Construction and Industrial Plywood and/or Canadian standards CSA 0153 or CSA 0121, and/or Canadian performance standard CAN 0325. It should also comply with the requirements of the International Residential Code (IRC) and International Building Code (IBC) at the date it was manufactured.

2. **Oriented strand board (OSB) subfloor panels** should conform to the governing version U.S. Voluntary PS 2 and/or Canadian performance standard CAN/CSA 0325 or CSA 0437. It should also comply with the requirements of the IRC and the IBC at the date it was manufactured.
3. Some manufacturers have chosen to produce wood structural panels that have higher strength, stiffness and fastener holding properties than commodity OSB and plywood subflooring. To be recognized as "**high-performance**" subflooring, panels must have an accompanying evaluation report from an approved testing agency substantiating any claims to elevated performance properties. Enhanced performance properties shall be listed in the evaluation report. Proprietary reports typically list these properties as "design values" to be used by specifiers.
4. These standards apply to wood structural panels suitable for use as subflooring material, which should be plywood or oriented strand board with a bond classification of Exposure 1 or Exterior. Alternative wood-based structural panels are permitted if recognized in a current Evaluation Report from an approved testing source as satisfying the requirements for subflooring in the governing building code.

B. Wood Panel Subfloor Identification:

1. When possible, check the back of the subfloor panel for identifying information about the panel such as span rating, thickness, and exposure rating. This information is listed within the third party certifying agency stamp. Flooring assemblies (joist/floor truss spacing and panel thickness) must be designed and constructed to accommodate design loads and the floor covering being installed over it.
2. When evaluating the wood panel subfloor, the underside of the installed panel should contain a product grade stamp from an accredited testing agency indicating that is complies with the governing product standard (PS 1 or PS 2) at the time it was manufactured. Common accredited testing agencies for OSB and plywood subfloors are APA (The Engineered Wood Association), PFS TECO (PFS Corporation and Timberco Inc.), and TPI (Timber Products Inspection). The information included in each of these stamps is detailed here:



Panel grade: identifies the intended use of the panel.

Span rating: maximum for roof spans/maximum for floor joist span.

Bond classification: indicates how much weather and moisture the panel is designed to withstand.

Mill-thickness: thickness of the material.

Mill number: Identifies the Mill ID #.

Reference standards: industry standard designations.

Performance category: nominal thickness of product.

Wood Panel Performance Category for Plywood or OSB	
PERFORMANCE CATEGORY (NOMINAL THICKNESS)	MILL THICKNESS LABEL
1/4	0.225 in. (5.715 mm)
11/32	0.322 in. (8.179 mm)
3/8	0.354 in. (8.992 mm)
7/16	0.418 in. (10.617 mm)
15/32	0.451 in. (11.455 mm)
1/2	0.483 in. (12.268 mm)
19/32	0.578 in. (14.681 mm)
5/8	0.609 in. (15.469 mm)
23/32	0.703 in. (17.856 mm)
3/4	0.734 in. (18.644 mm)
13/16	0.788 in. (20.015 mm)
7/8	0.849 in. (21.565 mm)
1	0.970 in. (24.638 mm)
1-1/8	1.091 in. (27.711 mm)
1-1/4	1.213 in. (30.810 mm)

PART III

Wood Panel Subfloor Installation Requirements

A. Single floor subfloor panels should be installed continuous over two or more spans, with the long panel dimension (strength axis) perpendicular to floor trusses or joists. All panel edges not supported continuously with framing shall be tongue and groove.

B. To minimize the potential for floor squeaks, most wood panel subfloor manufacturers recommend that the subfloor panels be glued and nailed to the floor framing using recommended fasteners and subfloor adhesives conforming to ASTM D3498 or APA Specification AFG-01. Joist spacing greater than 16" on center (O.C.) must be glued and fastened. A thin bead of glue inside the groove profile is also sometimes recommended.

C. The ends of the panels should land at the center of the floor joist/truss, with a minimum bearing of ½".

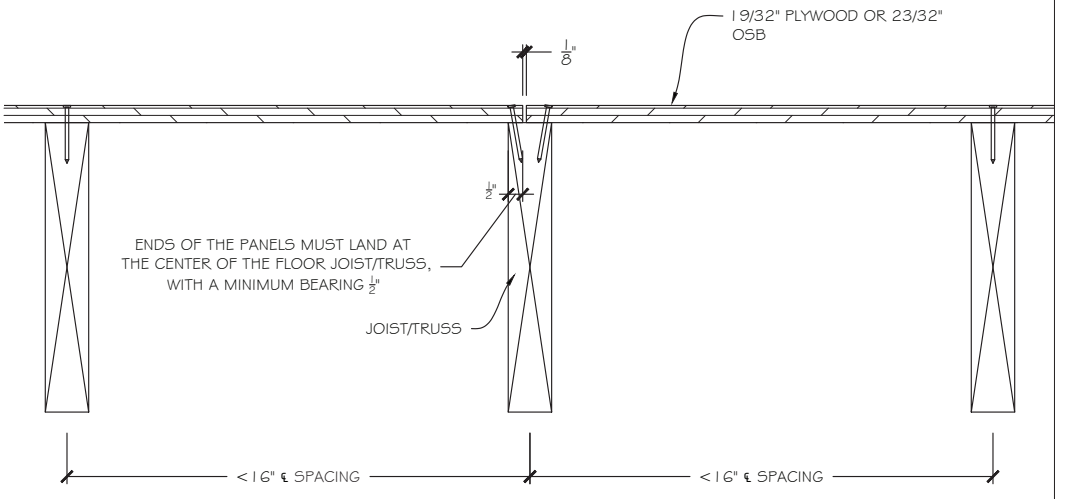
D. Glue-nailed subfloor panels up to 23/32" thick should be fastened with 6d ring- or screw-shank nails, 8d common nails, or proprietary screws spaced 12" O.C. along panel edges and 12" O.C. along intermediate supports. Some subfloor panel manufacturers may have more-restrictive fastener requirements.

E. Typical panel edge spacing requirements for floor joist/truss systems call for 1/16" - 1/8" gap around the perimeter (all four sides) of each panel. Some panel manufacturers mill their tongue and groove edges to gap themselves.

NOTICE: For additional information on the installation of Wood Panel Subflooring, see APA's *Engineered Wood Construction Guide* (Form E30) at www.apawood.org or refer to the panel manufacturer's recommendations.

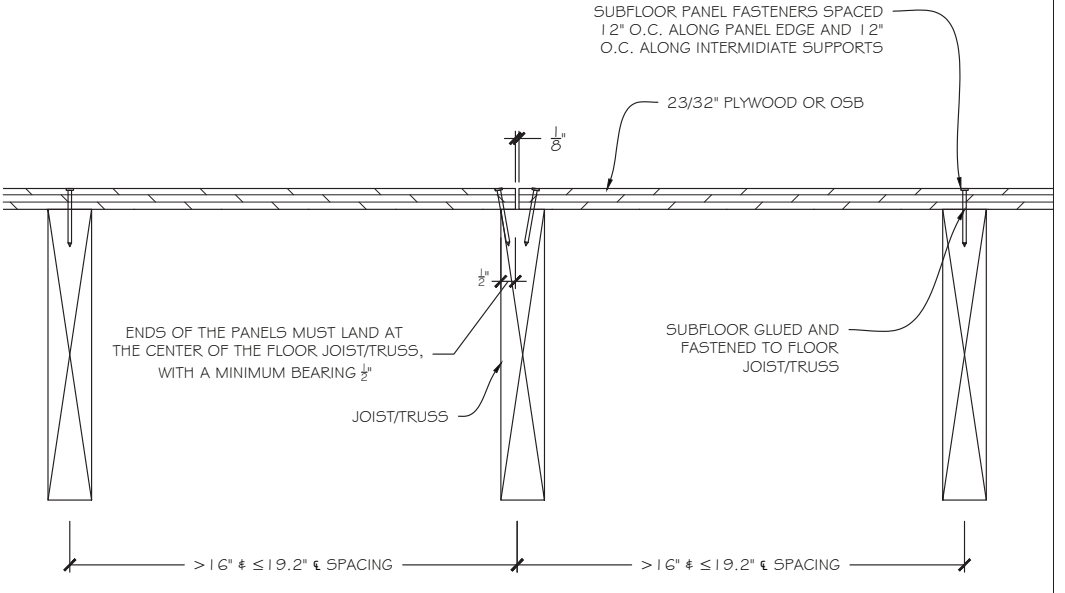
Joist/Floor Truss Spacing & Panel Thickness Requirements for Wood Flooring Installation

WOOD SUBFLOORS ≤16" JOIST SPACING



JOIST SPACING	MINIMUM SUBFLOOR PANEL PERFORMANCE CATEGORY
≤16" (406 mm)	19/32 plywood or 23/32 OSB

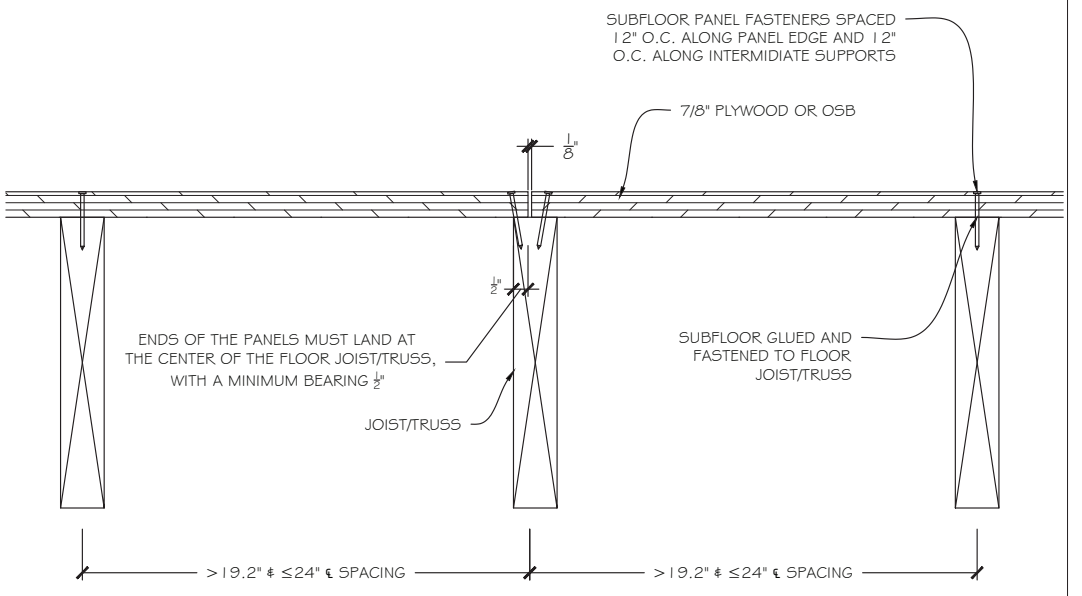
WOOD SUBFLOOR >16" & ≤19.2" JOIST SPACING



JOIST SPACING	MINIMUM SUBFLOOR PANEL PERFORMANCE CATEGORY
>16" and ≤19.2" (488 mm)	23/32 plywood or OSB

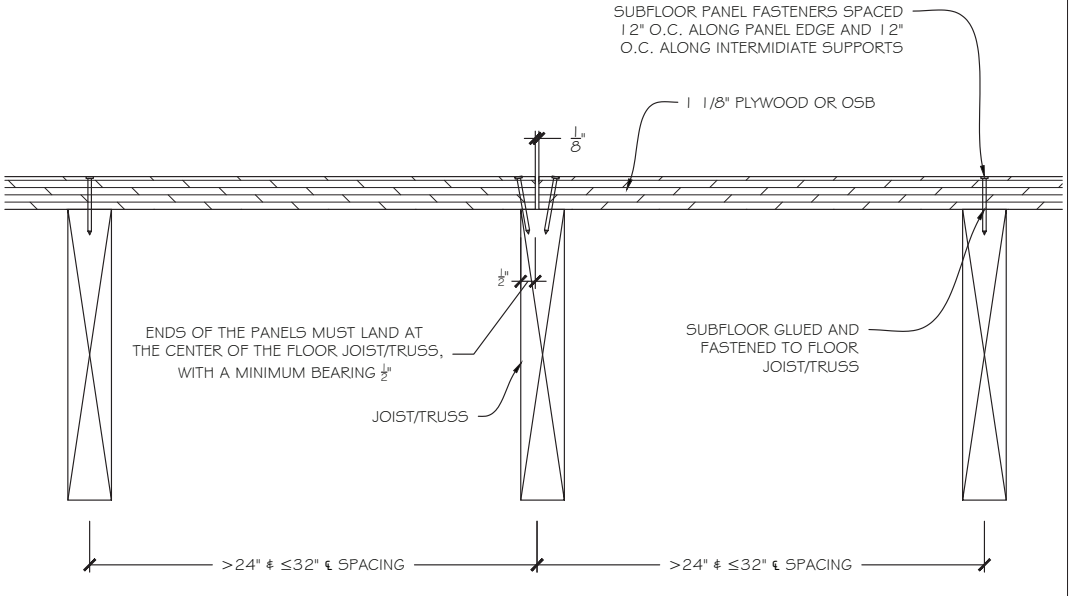
NOTE: Where minimum building code is less-restrictive than NWFA recommendations, the existing subfloor will require installation of a double-layer subfloor system.

WOOD SUBFLOOR >19.2" & ≤24" JOIST SPACING



JOIST SPACING	MINIMUM SUBFLOOR PANEL PERFORMANCE CATEGORY
>19.2" and ≤24" (610 mm)	7/8 plywood or OSB

WOOD SUBFLOOR >24" & ≤32" JOIST SPACING



JOIST SPACING	MINIMUM SUBFLOOR PANEL PERFORMANCE CATEGORY
>24" and ≤32" (812 mm)	1-1/8 plywood or OSB

NOTE: Where minimum building code is less-restrictive than NWFA recommendations, the existing subfloor will require installation of a double-layer subfloor system.

PART IV

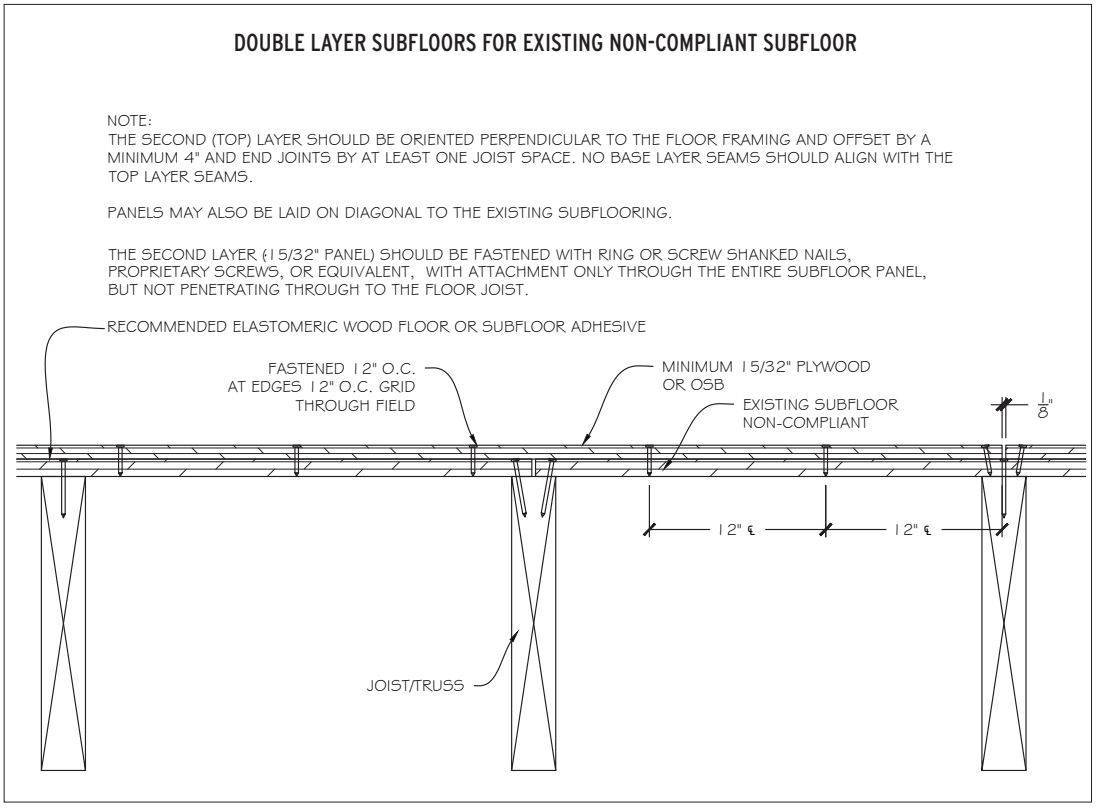
Double-Layer Subfloor Systems

A. For double-layer floors (one subfloor layer and a second (top) layer of underlayment), panels should be plywood or oriented strand board (OSB), Exposure 1, manufactured according to U.S. Product Standard PS 1 or PS 2, or Canadian standard CSA O121, O151, O325, or O437.

B. Before installing a second layer, allow the panels to acclimate in the area where they will be installed. The lower layer of subfloor panels should also be dry as noted in the Subfloor Moisture section of this chapter.

C. Where the existing base layer panel thickness and joist spacing combination do not meet NWFA or manufacturer minimum guidelines, install a second layer over the subfloor:

1. The second (top) layer should be a minimum 15/32 (.451 in.) subfloor panel.
2. The 15/32 panels should be oriented perpendicular to the floor framing and the long (strength axis) edge, offset by minimum 4" and end joints by at least one joist space. Panels may also be laid on diagonal to the existing subflooring. No base layer seams should align with the top layer seams.
3. 1/16" - 1/8" gap must be maintained around the perimeter (all four sides) of each panel, as well as ¾" gap at all vertical obstructions.
4. The second layer of panels should be fastened at a minimum of 12" O.C. along all panel edges and 12" O.C. grid pattern through the field. Use only ring- or screw-shanked nails, proprietary screws, or equivalent fasteners with attachment only through the entire subfloor panel, but not penetrating through to the floor joists. Application of an elastomeric wood floor or subfloor adhesive can assist in joining the two panels together.



NOTE: Where minimum building code is less-restrictive than NWFA recommendations, or where thinner-profile (solid and engineered) wood flooring products require a stiffer subfloor system, the existing subfloor will require installation of a double-layer subfloor system, or additional structural supports designed and installed by a qualified professional, or replacement of the subfloor to conform to NWFA Guidelines.

D. Where the existing base layer is particleboard or solid board subfloor, where removal is not an option, and it does not meet NWFA or manufacturer minimum guidelines for the flooring being installed:
   1. The second (top) layer should be overlaid with a minimum 19/32 subfloor panels.
   2. The 19/32 panels should be oriented perpendicular to the floor framing and offset by a minimum of 4", and end joints by at least one joist space. Panels may also be laid on a diagonal to the existing subflooring. No base layer seams should align with the top layer seams.
   3. 1/16" - 1/8" gap must be maintained around the perimeter (all four sides) of each panel, as well as ¾" gap at all vertical obstructions.
   4. The second layer of panels should be fastened at a minimum of 12" O.C. along all panel edges and 12" O.C. grid pattern through the field. Use only ring- or screw-shanked nails, proprietary screws, or equivalent fasteners with attachment only through the entire subfloor panel, but not penetrating through to the floor joists. Application of an elastomeric wood floor or subfloor adhesive is often necessary in joining the two panels together.

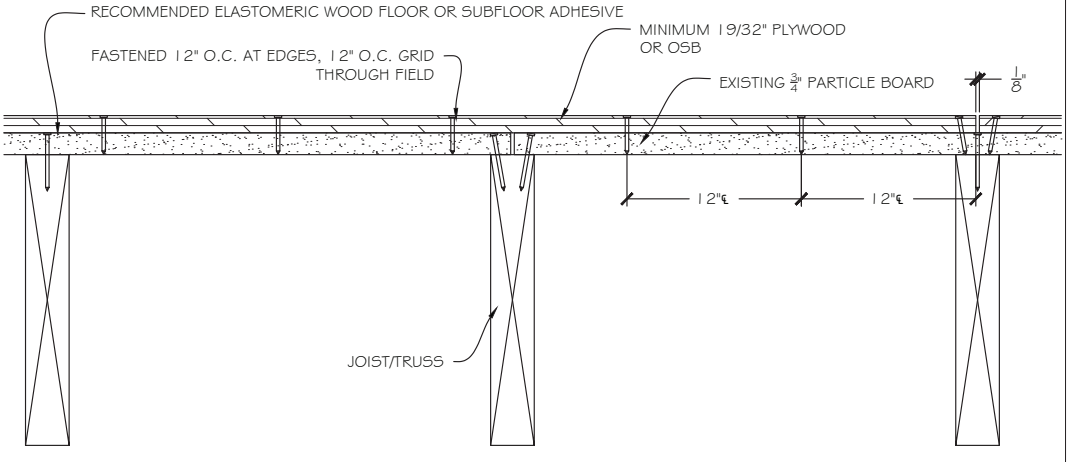
NOTICE: For additional information on the installation of underlayment grade panels, see APA publication L335 at www.apawood.org or refer to the panel manufacturer's recommendations.

DOUBLE LAYER SUBFLOORS FOR EXISTING 3/4" PARTICLE BOARD SUBFLOOR

NOTE:
THE SECOND TOP LAYER SHOULD BE ORIENTED PERPENDICULAR TO THE FLOOR FRAMING AND OFFSET BY A MINIMUM 4" AND END JOINTS BY AT LEAST ONE JOIST SPACE. NO BASE LAYER SEAMS SHOULD ALIGN WITH THE TOP LAYER SEAMS.

PANELS MAY ALSO BE LAID ON DIAGONAL TO THE EXISTING SUBFLOORING.

THE SECOND LAYER (19/32" PANEL) SHOULD BE FASTENED WITH RING OR SCREW SHANKED NAILS, PROPRIETARY SCREWS, OR EQUIVALENT, WITH ATTACHMENT ONLY THROUGH THE ENTIRE SUBFLOOR PANEL, BUT NOT PENETRATING THROUGH TO THE FLOOR JOIST.

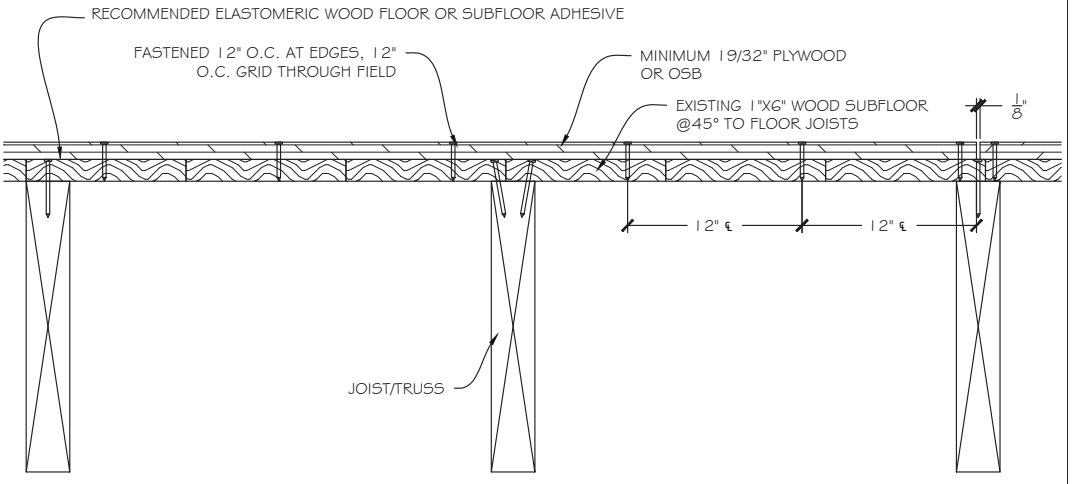


DOUBLE LAYER SUBFLOORS FOR EXISTING 1 X 6 SOLID BOARDS REQUIRING AN OVERLAY

NOTE:
THE SECOND TOP LAYER SHOULD BE ORIENTED PERPENDICULAR TO THE FLOOR FRAMING AND OFFSET BY A MINIMUM 4" AND END JOINTS BY AT LEAST ONE JOIST SPACE.

PANELS MAY ALSO BE LAID ON DIAGONAL TO THE EXISTING SUBFLOORING.

THE SECOND LAYER (19/32" PANEL) SHOULD BE FASTENED WITH RING OR SCREW SHANKED NAILS, PROPRIETARY SCREWS, OR EQUIVALENT, WITH ATTACHMENT ONLY THROUGH THE ENTIRE SUBFLOOR PANEL, BUT NOT PENETRATING THROUGH TO THE FLOOR JOIST.



PART V
Solid-Board Subflooring

A. Solid board subflooring should be ¾" x 5½" (1" x 6" nominal), Group 1 dense softwood, No. 2 Common, kiln-dried and at a moisture content that coincides with the expected "in-use" conditions of the space and the wood flooring being installed. (Reference R503.1 of the most-current IRC.)

B. Solid-board subflooring should consist of boards no wider than 6", installed on a 45° angle to the joists, with all board ends full bearing on the joists and fastened with minimum 8d rosin-coated or ring-shanked nails, or equivalent.

C. Installation of any of the following wood floors over a solid board subfloor will require replacement of the subfloor to conform to NWFA Guidelines, or installation of a double-layer subfloor system (see Part IV).
   1. Engineered flooring less than ¾" thick.
   2. Thin-classification (less than ¾" thick) solid wood flooring.
   3. Parquet wood flooring.
   4. End-grain blocks.

PART VI
Particleboard

A. Particleboard is a wood composite material (also known as waferboard, chipboard, or pressboard) manufactured from wood particles including wood shavings, chips, or dust, and synthetic resins or other suitable binders, then pressed into panel products.
   1. Particleboard must be a minimum 40-lb. density, stamped underlayment grade.

B. Nail-down installations:
   1. Particleboard is not an acceptable underlayment for nailing down any wood floor, due to the inability of these products to hold fasteners or retain their integrity when fasteners are driven through.
   2. For nail-down installations where particleboard exists, replacement of the subfloor to conform to NWFA Guidelines, or installation of a double-layer subfloor system (see Part IV) is required.

C. Glue-down installations:
   1. Due to the inherent instability of particleboard, glue-down is normally not recommended installation method. Check with the adhesive manufacturer before proceeding with any glue-down installation over particleboard subflooring.
   2. For glue-down installations where particleboard exists, and the adhesive is not recommended or compatible, replacement of the subfloor to conform to NWFA Guidelines, or installation of a double-layer subfloor system (see Part IV) is required.

D. Particleboard is an acceptable subfloor for floating floor installations.

PART VII
Wood Subfloor Integrity

A. The subfloor should be sound. Evaluate the subfloor carefully prior to installation of the wood floor. If there is movement, objectionable noises, water damage, delamination or damaged areas of the subflooring material, damage within the subfloor system, or if the subfloor simply doesn't meet minimum standards for the wood floor being installed, it should be appropriately addressed by a qualified professional before installation of the wood floor.

B. Do not install flooring over any observed issues without first addressing with the builder, general contractor, architect, homeowner, or any other responsible party prior to installation of new flooring.

C. Floor squeaks or other objectionable noises may be addressed according to panel manufacturer requirements or APA Technical Note C468 (Floor Squeaks: Causes, Solutions and Prevention). Use of screws to address noisy floors is a common practice. Be mindful of what lies beneath the subfloor before driving screws into it.

D. Protruding or loose fasteners should be remedied by either removing them or driving them deeper into the subfloor.

E. Document your findings by taking photographs and notes in the Jobsite Checklist.

PART VIII
Wood Subfloor Flatness

A. Subfloor flatness is one of the many considerations that should be addressed before installation of any wood floor. With new construction, use caution addressing subfloor repairs yourself. Outside of sanding seams, the builder should address any substrate issues before any wood floor is delivered to the jobsite.

B. Subfloor flatness should be measured across the span of each room receiving wood flooring to get an overall perspective of the topography of the subfloor. The floor does not need to be level in most situations, but should be flat.

C. Where one room meets another, the subfloor flatness should remain in tolerance. Where adjoining rooms are not within tolerance, are on a separate plane, or abutting a ramp, a specialty or customized transition separating each floor, will be necessary.

D. Assessing Wood Subfloor Flatness: Measure subfloor flatness using a laser-level, string-line, or straight-edge by taking measurements across the plane of the line to determine tolerances.

1. **Laser-level**: Place the laser level on the floor in the room receiving wood (ideally at the highest point of the subfloor). Lasers featuring a 360° static or rotating beam allow you to take measurements from the subfloor to the plane of the laser at any given point within the room. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, calipers, or the target provided by the laser manufacturer.
2. **String-line**: Place two blocks of wood (of the same thickness) at each end of the room, and then run a taught string-line across them. Take multiple measurements across the string-line between the blocks from the line to the subfloor. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, or calipers. Move the blocks to multiple locations down each wall to cover the entire floor space.
3. **Straight-edge**: Place the straight edge across the substrate. Take multiple measurements across the straight-edge between the edge and the subfloor. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, or calipers. Move the straight-edge to multiple locations, and rotate it 180° at each location to cover the entire floor space.

E. Mark out any discrepancies on the subfloor itself, giving a good indication of what alterations will be necessary. Document and photograph the results.

F. For installations using mechanical fasteners of 1½" and longer, the subfloor should be flat to within minimum tolerance of 3/16" in 6', or ¼" in 10', unless otherwise specified by the wood flooring manufacturer. For glue down installations, floating installations, and installations using mechanical fasteners of less than 1½", the subfloor should be flat to within minimum tolerance of 1/8" in 6', or 3/16" in 10', unless otherwise specified by the wood flooring manufacturer.

G. Addressing Wood Subfloor Flatness:

1. High Spots
   a. Use caution when sanding wood subfloors, as breathing wood particles may cause allergic respiratory symptoms, mucosal and non-allergic respiratory symptoms, or even cancer. Proper use of a respirator minimizes the effects of these airborne particulates.
   b. Sand all of the abutting subfloor seams throughout the entire layout. Sanding seams is necessary on most jobs due to the tendency of wood panels to swell at the edges (known as edge-swell) when exposed to rain, snow, or construction-related moisture introduced during the construction process. Some manufacturers produce higher performing grades of OSB that are less prone to edge swell than typical commodity-grade panels.
   c. Sand the seams flat with either an edger or a buffer with coarse grit sandpaper.
2. Low Spots
   a. **Overlays**: A common method to flatten wood subfloors to the required tolerance in remodel situations. (Note: Minor overlay repairs used to build up low spots in the subfloor may, depending on how much build-up is necessary, decrease the fastener penetration into the wood subfloor, and may increase the potential for squeaks, crackles, pops, or overall disengagement from the subfloor. Use of longer fasteners and adhesive may assist in minimizing these risks.)
      i. Underlayment material may be used to build slight elevation gains. In general, vapor retarding membranes such as 15# felt or asphalt-saturated kraft paper are normally just shy of 1/64" thick.

ii. Plywood allows for better build-up with lower undulations in the subfloor. Plywood is available in many thicknesses that can allow for drastic build-up where necessary.
- Build up from the lowest elevation, using the products that allow for enough incremental elevation gain to get to within flatness tolerance.
- Using an elastomeric wood flooring adhesive along with screws will help minimize any potential for inadvertent noises such as squeaks or pops.
- Any ridges at the panel edges should be sanded flat using an edger with coarse grit sandpaper. (Note: Proper use of a disposable particulate respirator minimizes the effects of these airborne particulates. See Safety Chapter for more detail.)

iii. Sheet vinyl products, such as linoleum, may range up to 1/8" in thickness. Many tear-outs include removal of linoleum to be replaced with wood floors. This can be a way to repurpose old material. (NOTE: Some of these types of floor coverings installed in homes built prior to 1986 could contain asbestos. Refer to the Safety chapter for more detail).

iv. Cedar shims can give elevation gain from 0 to 3/8" within a short 15" span. When elevation gain requires more, customized screeds planed to the necessary thickness may be necessary. Install the shims in a bed of elastomeric wood flooring adhesive to ensure a sound base for the wood flooring installation.

v. Self-levelers are not normally approved or recommended for use over non-dimensionally stable subfloors such as OSB or plywood. More importantly, you cannot nail through them. Check with your manufacturer for use and compatibility of these types of products over wood floors if you're considering a glue-down or floating installation.

vi. A combination of multiple methods may be necessary to get the floor flat to within tolerance.

b. **Removals**: Prior to removal of any subflooring, determine whether the sagging/low areas are in any way structural. In some cases, a structural engineer or qualified builder may need to assess the situation to make this determination. Also note that in many jurisdictions, if you "cut" or "alter" the structure in any way, a building permit will be required. Altering the structure would include removal of the subflooring to access the joists in order to make necessary corrections.

i. The following are common methods for addressing the joists before reinstalling the subflooring material:
- **Planing**: the existing floor joists, which includes removal of material to bring the elevations to within tolerance after the subfloor is replaced.
- **Sistering**: material to get the elevations within tolerance, which is the reinforcement of a joist by nailing, or attaching alongside the existing joist, another joist, or reinforcing member.
- **Replacement**: the joists altogether, which requires removal and replacement of entire joists. Keep in mind, plumbing lines and electrical wiring/conduit are often run through/or alongside the joists, and will add to the difficulty of the replacement.

ii. Be mindful that doing any of these repairs also opens the flooring contractor up to potential liabilities due to the completion of work outside of the wood flooring profession. This work may also require alternative/upgraded insurance policies, state licensing requirements, building permits, as well as further training or qualification of this skillset.

PART IX
Wood Subfloor Moisture

A. With new construction, it is the responsibility of the builder to control moisture during the building process by protecting moisture-sensitive and porous materials (such as wood panel subflooring) during transport and on-site storage, and by drying wet materials before they are enclosed inside building assemblies or covered by finish materials.

B. Check with your moisture meter manufacturer for the proper species correction setting for the subfloor material being tested. If you are unable to determine the proper species correction for your moisture meter, find other wood materials within the structure that are at equilibrium moisture content, and use this value as your "base" for testing the subfloor. (See Moisture Testing chapter for more-detailed information on moisture testing wood subfloors.)

C. In hot and humid climates, and during the humid season, the subflooring should not exceed 13% moisture content (MC). In regions where equilibrium moisture content (EMC) within the facility can sustain these higher MC levels, additional precautions should be implemented through the flooring product selection and the acclimation/conditioning process. (See Acclimation/Conditioning chapter for more information.)

D. When subjected to water from leaks, flooding, rain, or snow (during construction), wood panels have the potential to absorb moisture, which may result in swelling and expansion in panel length, width, and thickness.
   1. **Plywood**: swelling, distortion, linear expansion, and delamination can occur when exposed to high levels of moisture. Moisture tests should be conducted using insulated pin, hammer probe type meters on the surface, on the backing, and within the core of the material in several areas of the damaged material to properly assess the extent of moisture intrusion. Replace the plywood when the damage is evident. Ensure replacement material is within acceptable MC ranges prior to reinstallation of wood flooring.
   2. **Oriented Strand Board (OSB)**: swelling and linear expansion can occur with OSB when exposed to water. Swelling, and subsequent drying in OSB can result in a decrease in density and a reduction in within-board strength due to the release of compaction stress created during the pressing process of manufacturing. This will directly affect how existing fasteners hold the wood flooring to the subflooring material. Replace when damage is evident. Ensure replacement material is within acceptable MC ranges prior to reinstallation of wood flooring.

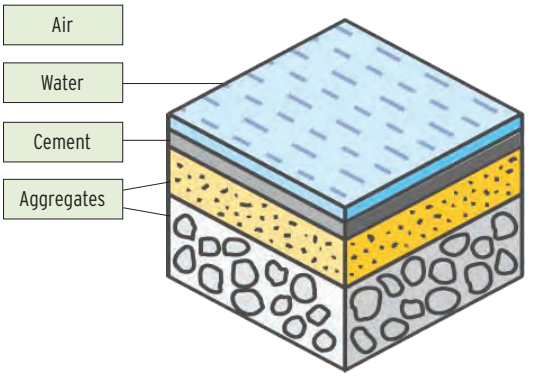
E. Subsequent drying of previously wetted panels may result in shrinkage of the wood. Wood panels typically can tolerate short-term wetting, but they must be dry to an adequate MC level before flooring is installed over them.
   1. If wood flooring is installed prior to adequate subfloor drying, the eventual shrinkage in the subfloor can result in gaps along wood flooring joints, gaps between the flooring and subflooring, and noisy floors from a reduction in fastener holding capacity.
   2. Installing wood flooring prior to adequate drying can also result in expansion of finished flooring as strips or planks absorb moisture from the subfloor.

SUBSTRATES: Concrete Subfloors

Understanding the basics of concrete can help ensure successful wood flooring installations. The subfloor is the foundation for the wood floor. The final wood floor installation is only as good as the subfloor it is installed over. In the event of subfloor failure, the wood flooring contractor shall not be responsible for the performance of the subflooring material, or any subsequent flooring damage resulting from prior jobsite damage, unless otherwise contracted to do so.

PART I
Components of Concrete

A. Concrete is comprised of four main materials: Portland cement, coarse aggregate (stone), fine aggregate (sand), and water. When water is introduced to the dry materials, a chemical reaction occurs that is known as hydration.



1. Water comprises about 14 to 21 percent of concrete.
2. Cement comprises about 7 to 15 percent of concrete.
3. Aggregates, which can include materials like sand and gravel, comprise about 60 to 75 percent of concrete.
4. Air can comprise up to 8 percent of concrete.

B. The more water that is added to the cement mixture, the more permeable the cement paste will become. The ratio of the amount of water to the amount of concrete in a mixture is referred to as the water-to-cement ratio (w/c).

1. The w/c is determined from the following equation: w/c equals the weight of the water divided by the weight of the cement.

$$W/C = \frac{\text{weight of water}}{\text{weight of cement}}$$

2. A concrete mixture with a high w/c will produce concrete that is weaker and more permeable than a concrete mixture with a low w/c.
3. The amount of water that is necessary strictly for the hydration of the cementitious materials in a concrete slab mixture falls between 0.25 and 0.28. However, at that low of a w/c, the concrete is not workable. It is for the purpose of creating a workable concrete mixture that additional water is added.
4. Concrete mixtures designed and used for slab construction typically fall between a w/c of 0.42 and 0.50. The excess water that is added to create workable concrete is referred to as "free water," or "water of convenience." This excess "free water" is not consumed in the hydration reaction and is the first source of rising moisture that can adversely affect a wood flooring installation.

C. Under "ideal" conditions that include concrete with a w/c of 0.50 or lower, a non-burnished concrete finish where a membrane-forming curing compound was not used, and favorable drying conditions surrounding the slab, it may take 30-45 days after placement before you can begin evaluating it for flooring. (This does not indicate that any slab that is 30 days old is ready to receive flooring.)

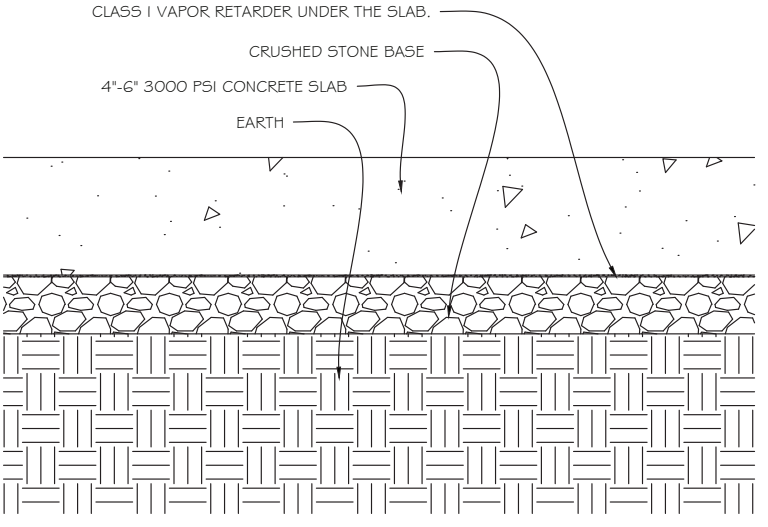
PART II
Types of Concrete Subfloors

As a flooring installer, you should be able to identify the different types of concrete subfloors over which you will be installing wood flooring. The type of concrete subfloor affects how you will conduct moisture tests, how you will prepare the slab, the type of installation method, and potentially what type of flooring you will be able to use. Follow the adhesive manufacturer's instructions for appropriate subflooring.

A. **Slab-on-Grade** (also called a slab on-ground) is a concrete slab poured on the ground that is typically 4"-6" in thickness.

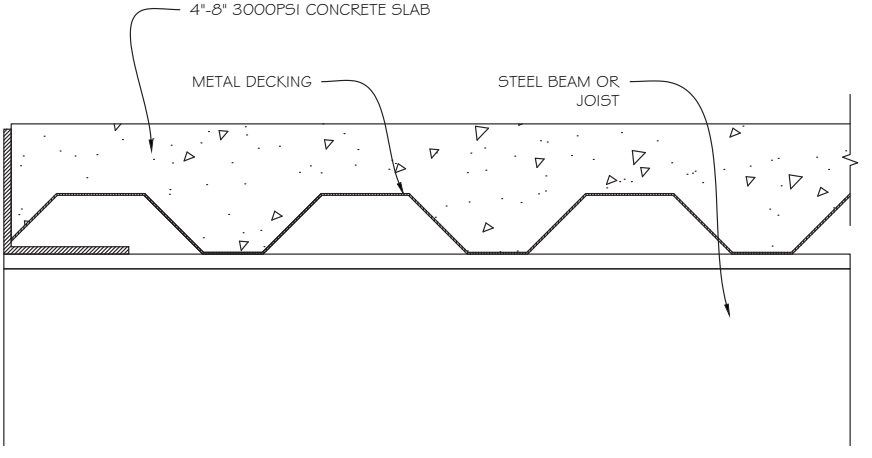
1. The concrete slab is required to be protected from ground moisture with an effective and intact Class I vapor retarder that conforms to the requirements of ASTM E1745 (Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs), or specification ASTM E1993 (Standard Specification for Bituminous Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs) installed in accordance with the recommendations of ACI 302.2R (Guide to Concrete Slabs that Receive Moisture-Sensitive Flooring Materials).
2. The vapor retarder must be installed directly below the slab.

CONCRETE SUBFLOOR: 4"- 6" CONCRETE SLAB ON-GRADE



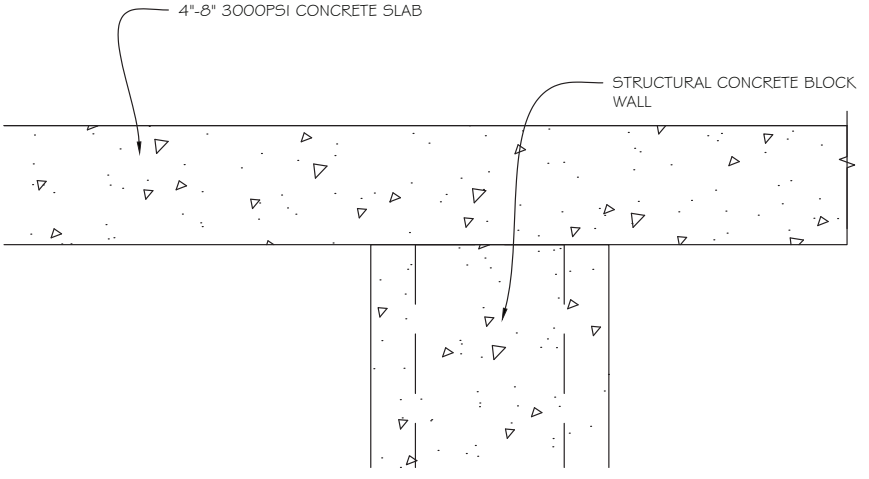
B. An **elevated concrete slab** may be one of the following designs:
   1. Normal or lightweight concrete on metal decking.
      a. Concrete slabs on metal decking experience the greatest measure of deflection.
      b. Because drying is only possible from the top surface, such construction usually requires additional drying time.

CONCRETE SUBFLOOR: ELEVATED SLAB ON METAL DECKING



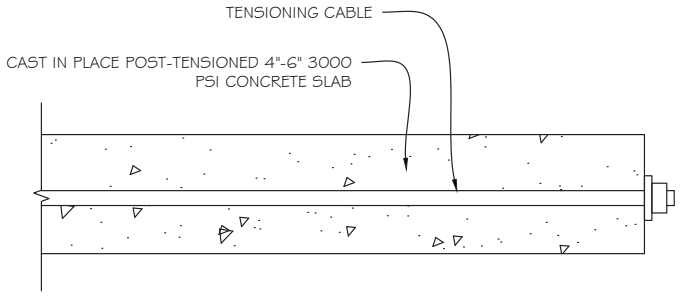
2. Cast-in-place structural concrete. Cast-in-place structural concrete is a technology in the construction of buildings where walls and slabs of the buildings are cast at the site using formwork.

ELEVATED CONCRETE SLAB CAST-IN-PLACE-STRUCTURAL



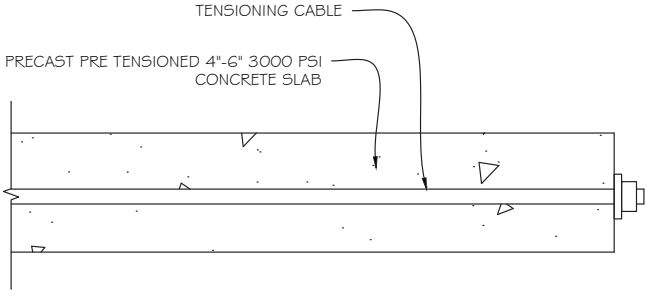
3. Cast-in-place post-tensioned concrete. Post-tensioning is accomplished where the tendons are stressed and each end is anchored to the concrete section after the concrete has hardened.

ELEVATED CONCRETE SLAB CAST-IN-PLACE POST-STRESSED/TENSIONED



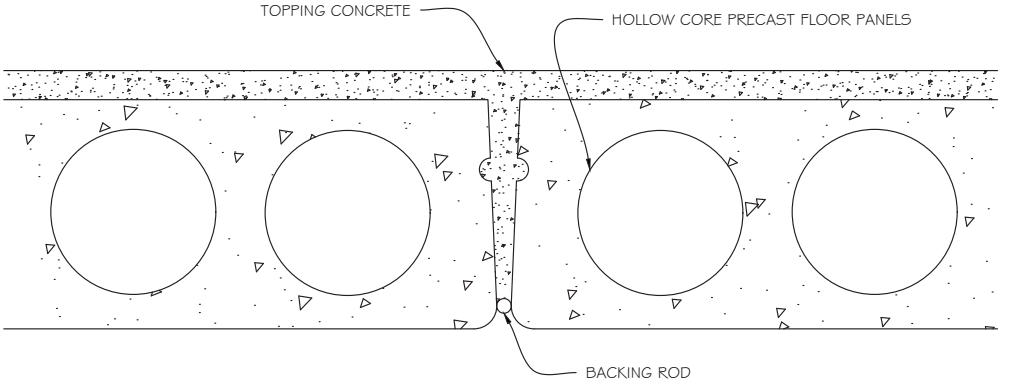
4. Prestressed concrete members.
   a. Prestressed concrete is a method for overcoming concrete's natural weakness in tension.
   b. Pre-tensioning is accomplished by stressing wires or tendons, to a predetermined amount, by stretching them between two anchors prior to pouring concrete.

ELEVATED CONCRETE SLAB CAST-IN-PLACE PRE-STRESSED/TENSIONED



5. Precast concrete is a construction product produced by casting concrete in a reusable mold or "form" that is then cured in a controlled environment, transported to the construction site, and lifted into place. In contrast, standard concrete is poured into site-specific forms and cured on site.

CONCRETE SUBFLOOR: HOLLOW CORE PRECAST PANEL



6. When testing moisture in an elevated concrete slab, it is important to know which design is present.
    a. For concrete slabs on fluted metal decking, concrete internal relative humidity tests (ASTM F2170) are to be taken at 40% of the slab thickness in the deepest part of the flute.
    b. For structural slabs, where the concrete is free to lose moisture from both the top and bottom, concrete internal relative humidity tests are to be taken at 20% of the slab thickness.
    c. For any post-tensioned or pre-tensioned slabs, you must identify where the wires or tendons are located within the slab prior to drilling any holes for relative humidity tests.

PART III
Concrete Subfloor Joints

There are three types of joints typically found in residential and commercial concrete floor slabs.

CONSTRUCTION JOINTS

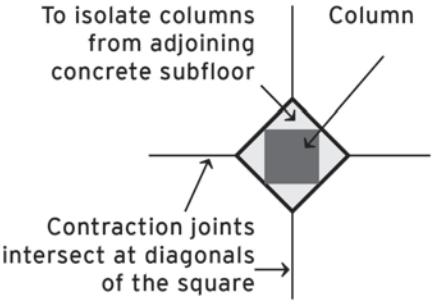
Keyed Doweled

A. **Construction/cold joints:** Construction/cold joints are those points within a concrete placement that either by design, or necessity, the placement of one slab of concrete meets another slab of concrete. Construction/cold joints are weakened joints that, upon movement, will shift, and will affect the flooring installed over them.

CONTRACTION JOINTS
Sawcut or Tooled

B. **Control/contraction joints:** Control/contraction joints are planes of weakness purposely introduced into a concrete floor slab that encourage the cracking that develops due to drying shrinkage to occur in an orderly, predetermined pattern rather than randomly. Control/contraction joints are most commonly created by forming, tooling, or by making saw cuts in the new slab to a prescribed depth, most often 1/4 of the slab thickness.

ISOLATION JOINTS



C. **Isolation joints:** Isolation joints are those joints where the slab abuts a fixed object such as a wall, column, or foundation base, and bond is not desired.

D. Other classes of joints are acoustical joints and expansion joints.
    1. **Acoustical joints** form a non-hardened, rubber-like seal at the perimeter and at all penetrations and retaining surfaces of a floor installation assembly in which a bonded sound reduction membrane has been installed for sound reduction. The primary function of an acoustical joint is to minimize the transmission of sound through joints, penetrations, or structural components within the assembly.
    2. **Expansion joints** allow movement where expansion is likely to exceed contraction. Expansion joints are normally filled with compressible filler material allowing for independent movement between adjoining slabs.

E. Joints in a concrete slab typically are specified by the architect or engineer and noted on the architectural and/or structural drawings.

F. Moving joints must be honored and not be filled with underlayment products or other materials.

G. Wood flooring secured to the substrate should not bridge moving joints without allowing for a breaking point. When concrete decides to move, it is going to move.

H. Transitions and/or expansion space should be built into the wood flooring system to avoid potential wood floor damage at these locations in case of future movement.

I. Identify joints within the slab and address them with the flooring installation appropriately. The end-user should be made aware of the additional installation necessities and costs for any specialized installation methods required when addressing these joints.

PART IV
Compressive Strength

A. The builder or architect should be able to let you know what type of concrete is present in order for you to determine proper preparation of the slab prior to a wood floor installation. If the information is not available, run a nail forcefully across the surface. If it leaves an indentation, it will be necessary to apply a sealer or a densifier that is compatible with the adhesive being used. Check with the adhesive manufacturer for what to use in this situation.

B. Normal weight concrete subfloors are designed and constructed with concrete mixtures with compressive strengths between 3,000 psi and 4,000 psi. A 3,000 psi compressive strength is the minimum requirement for most standard wood floor installations, including glue-down wood floors, or glued/mechanically anchored subfloors.
   1. The compressive strength of concrete can be tested according to ASTM C39.
   2. The compressive strength of hydraulic cement mortars can be tested according to ASTM C109/C109M.
   3. The compressive strength of gypsum can be tested in accordance with ASTM C472.
   4. In all cases, a downward force is applied to the cast, or cored specimen, until it breaks.

C. Lightweight concrete is a lower-density concrete comprised of lightweight aggregate (such as pumice, clay, shale, foamed slag, and sintered pulverized), or has been aerated producing a lightweight cellular material. It is less dense than normal weight concrete. Lightweight concrete is most often used as a subflooring material where a lighter weight on a building's structural load is necessary, as a part of a larger sound-control subflooring system, where higher insulating is required, and/or in conjunction with many radiant heating systems.
   1. For glue-down applications, check with the adhesive manufacturer for applicable installation methods over lightweight concrete subfloors.
   2. Lightweight concrete must be prepared differently than normal weight concrete, and requires additional preparation, such as application of surface densifiers or hardeners properly applied prior to installation of wood flooring.
   3. The aggregate used in lightweight concrete is pre-saturated with water, which is not included in the w/c. Because of this, lightweight concrete can take longer than normal weight concrete to dry.
   4. ASTM F2170 is an approved and recognized testing method for lightweight concrete. Electronic moisture meters, used in accordance with ASTM F2659, can be used to quickly assess the surface moisture of a concrete subfloor, but are not to be used for a go-no-go determination. ASTM has specifically disallowed ASTM F1869 for testing lightweight concrete.

PART V
Subfloor Toppings

There are several types of materials used to level or smooth a concrete subfloor. They include proprietary blends of compounds based on Portland cement, gypsum, and calcium aluminates.

A. Follow the adhesive manufacturer requirements for compatibility and use of subfloor toppings.

B. These subfloor toppings are commonly used for these purposes:
   1. Fire rating requirements.
   2. Where the existing substrate will not provide adequate performance standards.
   3. Floor flattening or leveling.
   4. Where a lighter weight on a building's structural load is necessary and normal weight concrete is not an option.
   5. As a part of a larger sound control subflooring system.
   6. Where higher insulating is required.
   7. In conjunction with many radiant heating systems.

C. Properly mixed subfloor toppings should have a minimum compressive strength of 3,000 psi when tested in accordance with ASTM test method C109/C109M, C472, or C349, whichever is appropriate, for most standard wood floor installations, including glue down wood floors, or glued/mechanically anchored subfloors.

D. Identify existing subfloor toppings that may not be suitable for wood floor installation. Typical characteristics of a subfloor topping that may be inadequate include: surface softness, chalkiness, cracks, surface deformation or irregularities, and loose gypsum that is no longer secured to the plywood or OSB subfloor. Repair options include any or all of the following:
   1. Remove damaged/loose subfloor topping and any loose debris.
   2. Replace damaged areas with manufacturer-recommended patches.
   3. Allow ample dry-time.
   4. Apply a manufacturer-recommended primer or densifier (multiple coats if necessary).

E. Prior to any wood floor installation over gypsum-based underlayment material, the substrate must be completely dry. Once dried, it is often necessary to apply a sealer and/or a densifier/hardener that is compatible with the adhesive being used, in order to provide moisture protection and reduce cracking and degradation caused by natural movement.

F. Dry-times of subfloor toppings vary from product to product, and manufacturer to manufacturer. Check with the manufacturer for dry times and moisture testing requirements.

G. There is no recognized moisture testing method for gypsum-based underlayments. Most manufacturers recommend using either a specifically designated pinless meter, a pin-type meter, or following ASTM F2170. Follow the gypsum-based underlayment manufacturer's moisture testing instructions to determine when it has adequately dried.

H. It is important to know when a gypsum-based topping is being used over concrete. The concrete subfloor must be at an acceptable level of dryness for the wood flooring and the surface of the concrete must be properly prepared and primed with the gypsum manufacturer's specified primer.

I. Fiber-reinforced gypsum underlayments, fiber cement board, and cementitious backerboard are not suitable materials to be used below a wood flooring installation.

PART VI
Integrity

There are several types of materials used to level or smooth a concrete subfloor. They include proprietary blends of compounds based on Portland cement, gypsum, and calcium aluminates.

A. All substrates must be sound. Check for hollow spots, voids, loose or crumbling areas, and stress cracks.

B. Do not install flooring over any issues without first addressing them with the builder, concrete contractor, architect, homeowner, or any other responsible party, prior to preparing the subfloor for new flooring. Many stress cracks, hollow spots, or crumbling areas may be an indication of structural issues, geographic soil conditions, or poor quality concrete that should be addressed by a professional.

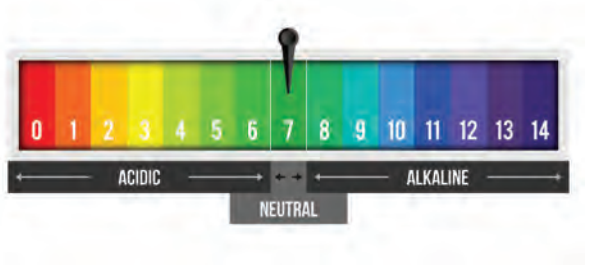
C. Stress cracks in concrete slabs should be addressed with crack isolation membranes, or in conjunction with the adhesive manufacturer's suggested system. Any crack isolation membrane must be compatible with the sealers and adhesives being used. Some adhesives and underlayment materials are designed to have crack-isolating properties.

D. Follow the adhesive and underlayment manufacturers' recommendations to address stress cracks.

E. Document the integrity of the slab by taking photographs and notes in the Jobsite Checklist.

PART VII
Concrete pH

A. pH is a measure of hydrogen ion concentration, a measure of acidity or alkalinity in a solution. The pH scale runs from 0 to 14; where 7 is neutral. Below 7 is considered acidic and above 7 is alkaline.



B. The pH of a new concrete slab typically measures between 12 and 13. However, over time, as the surface of the slab reacts with carbon dioxide in the air, the pH of the surface

is gradually reduced to about 8.5. The process is referred to as carbonation.

C. Follow the adhesive manufacturer's instructions on pH testing and acceptable results.

D. When sufficient moisture is present in a slab to create a solution, the high pH solution that develops is capable of breaking down some types of wood flooring adhesives, and can lead to a flooring failure.

E. The current method for measuring the pH level of a concrete slab surface is described in ASTM F710 (Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring). Note: This procedure introduces an external source of liquid water that may not exist in the concrete, which can be misleading. It is far more important for the moisture levels in the subfloor to be at a level where solution chemistry will not develop, than it is to conduct a pre-installation pH test where liquid water from an external source has been introduced.

F. Rinsing and vacuuming the surface of a concrete slab with potable water can lower the surface pH level. Doing so, however, cannot prevent the future development of a high pH condition at the surface of the slab if there is enough moisture in the slab to create a solution. Do not use acid rinses to "neutralize" a high-pH concrete surface. The acid will deposit unwanted salts and can attack interior building finishes and be detrimental to the final installation.

PART VIII
Contaminates

A. The slab must be free from any non-compatible contaminants or foreign materials such as sealers, curing compounds, waxes, oils, paint, dust, or drywall compounds, that might prevent adhesive bond as described in ASTM F710.

B. Test for sealers, waxes, and contaminates by placing a drop of water on the concrete. If it beads-up, the concrete may contain a sealer or waxy substance.

C. All contaminates must be properly removed from the surface. These contaminates can often be removed by using a concrete vacuum grinder, or by using a buffer/rotary sanding machine, equipped with special stripping discs or wire brushes. (Refer to the Health and Safety chapter for silica precautions.)

D. Curing compounds are sometimes applied to the surface of a freshly finished concrete slab to retard the escape of moisture during the initial curing process. Curing compounds that remain on the slab surface may interfere with adhesion of the wood flooring adhesives and should be removed.

E. Cutback adhesive: Some previously manufactured asphaltic cutback adhesives contain asbestos. This material must be tested and properly removed by an asbestos remediation company. It is best to presume all cutback adhesive contains asbestos, until testing proves otherwise. (Refer to the Health and Safety chapter for more information.)

PART IX
Porosity

A. The ability of a concrete subfloor surface to readily absorb water is a key indicator in determining which types of adhesives, moisture control systems, primers, and self-leveling underlayments can be used in the installation process.

B. Follow the adhesive manufacturer recommendations for porosity criteria.

C. ASTM F3191 describes the procedure for assessing the substrate water absorption (often referred to as substrate porosity) of horizontal substrate surfaces prior to the installation of resilient floor coverings. The procedure involves applying a single drop of water to the surface of properly prepared substrate, and then determining whether that drop of water is absorbed within a given time period. Although this test method is specific to resilient floor coverings, many of the procedures included in this practice may be useful for assessing the substrate water absorption for substrates to receive wood flooring as well.

D. Nonporous substrates such as densely machine-troweled concrete, mature and well-hydrated concrete, existing resilient flooring, terrazzo, and others, may require adjustments to the surface preparation method or product selection to ensure a successful installation. (See Concrete Surface Profile section.)

E. Porous substrates, surfaces that are chalky or dusty, or have varying degrees of absorption may require a densifier/hardener that is compatible with the adhesive being used prior to wood floor installation.

PART X

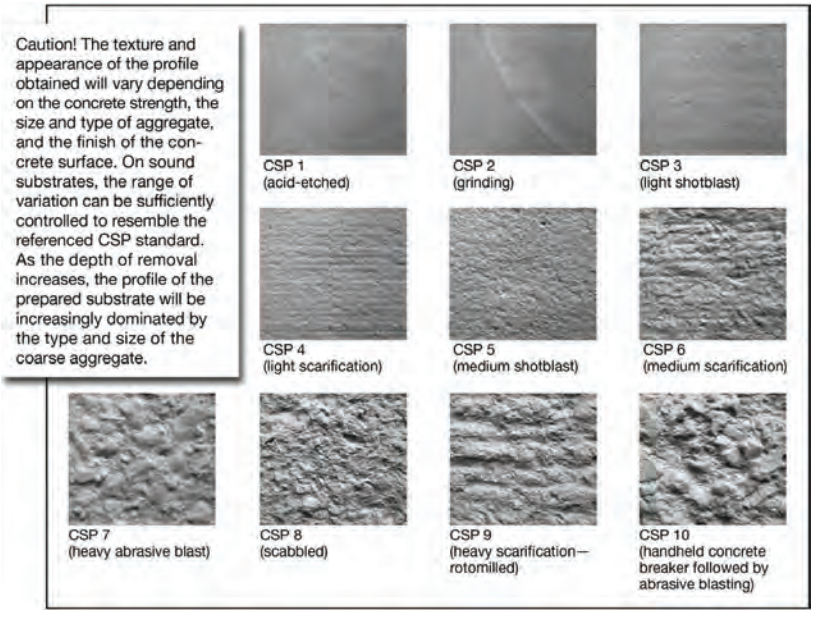
Concrete Surface Profile (CSP)

CSP is a standardized measure for the 'roughness' of a surface that is defined by the International Concrete Repair Institute (ICRI).

A. CSP is the measure, under a cross-sectional view of the concrete surface, of the average distance from the peaks of the surface to the valleys. A very rough surface will have a high CSP number, such as CSP 10. A very smooth surface will be a CSP 1.

B. The slab must meet minimum CSP requirements set forth by the adhesive manufacturer. Most manufacturers recommend a CSP of somewhere between CSP 1 and CSP 4. This typically can be found on the adhesive product technical data sheets (TDS).

C. Adequate CSP can be achieved through a variety of methods including grinding, acid etching, needle scaling, abrasive blasting, shot-blasting, high and ultra-high pressure wet-jetting, and scarifying/shaving.



Surface preparation method	Concrete Surface Profile									
	CSP 1	CSP 2	CSP 3	CSP 4	CSP 5	CSP 6	CSP 7	CSP 8	CSP 9	CSP 10
Detergent scrubbing	■									
Low-pressure water cleaning	■									
Grinding	■	■								
Acid etching	■	■	■							
Needle scaling		■	■	■						
Abrasive blasting		■	■	■	■	■	■			
Shotblasting		■	■	■	■	■	■	■	■	
High- and ultra-high-pressure water jetting			■	■	■	■	■	■	■	■
Scarifying				■	■	■	■			
Surface retarder (1)					■	■	■	■	■	■
Rotomilling						■	■	■	■	
Scabbling							■	■	■	
Handheld concrete breaker							■	■	■	■

(1) Only suitable for freshly placed cementitious materials

PART XI

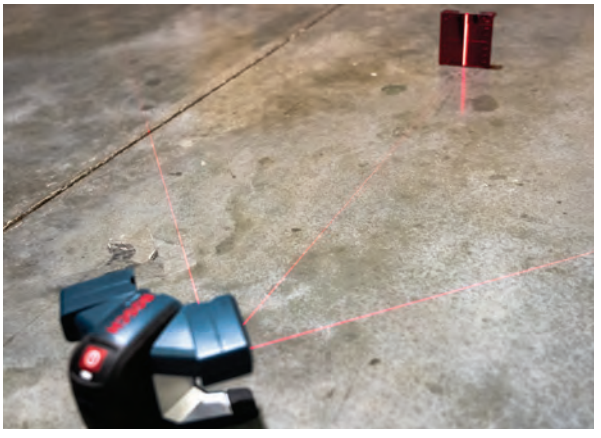
Concrete Subfloor Flatness

A. Subfloor flatness should be measured across the span of each individual room receiving wood flooring to get an overall perspective of the topography of the subfloor.

B. Where one room meets another, the subfloor flatness should remain in tolerance. Where adjoining rooms are not within tolerance, are on a separate plane, or are abutting a ramp, a specialty or customized transition will be necessary.

C. Measure subfloor flatness using a laser-level, string-line, or straight-edge by taking measurements across the plane of the line to determine tolerances.

1. **Laser-level**: Place the laser level on the floor in the room receiving wood (ideally at the highest point of the subfloor). Lasers featuring a 360° static or rotating beam that allows you to take measurements from the subfloor to the plane of the laser at any given point within the room should be employed. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, calipers, or the target provided by the laser manufacturer.



2. **String-line**: Place two blocks of wood (of the same thickness) at each end of the room, and then run a taught string-line across them. Take multiple measurements across the string-line between the blocks from the line to the subfloor. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, or calipers. Move the blocks to multiple locations down each wall to cover the entire floor space.

3. **Straight-edge**: Place the straight edge across the substrate. Take multiple measurements across the straight-edge between the edge and the subfloor. Measure the deviations in the subfloor by using a tape measure, taper gauge, feeler gauge, depth finder, or calipers. Move the straight-edge to multiple locations, and rotate it 180° at each location to cover the entire floor space.

D. From here, you should be able to mark out any discrepancies on the subfloor itself, giving a good indication of what alterations will be necessary. Document and photograph results.

E. The floor does not need to be level in most situations, but should be flat. The slab should be flat to within minimum tolerance of 1/8" in 6', or 3/16" in 10', unless otherwise specified by the wood flooring manufacturer.

F. If the slab is out of specification, it will need to be flattened. Flattening a concrete subfloor requires grinding high areas, filling low areas, or a combination of both. (Refer to the Health and Safety chapter for silica precautions.)

G. Grinding high areas:

1. Isolated high spots in concrete can be ground flat by using handheld angle grinders with a dust containment shroud attached to the tool when in use. A diamond cup wheel, or tungsten carbide or diamond disc wheel attachment normally works best for concrete removal.
2. Larger areas of concrete subfloors that need to be flattened may require larger equipment such as walk-behind or riding grinders.

H. Filling low areas:
   1. Prior to applying any patching compounds or self-levelers, the moisture conditions of the slab must be assessed through applicable moisture testing methods.
   2. Use of approved patching compounds or self-levelers is normally recommended by the adhesive manufacturers to fill low areas in concrete subfloors.
   3. Patching compounds and self-levelers containing polymer-based cement normally are recommended and must be compatible with the moisture control and adhesive systems.
   4. Most patching compounds and self-levelers require a primer to be applied to the underlying substrate (dependent on the substrate) prior to application. Follow the manufacturer's instructions.
   5. Each patching compound and self-leveler must be mixed and applied per the manufacturer's specific instructions. Thickness limitations, mixing instructions, application methods, dry times, and spread rates vary from product to product and from manufacturer to manufacturer. Follow the manufacturer's instructions.
   6. Self-levelers and patches are normally applied by use of a gauge rake, a flat edge stainless steel trowel, smoothing trowels/spreaders, and other specialty tools as designated by the manufacturers of these products.

NOTICE: Disparity between concrete floor flatness tolerances and subfloor flatness tolerances designated for wood flooring at the time of installation. The following disparity has been adopted as detailed in the American Society of Concrete Contractors (ASCC) as published in "Concrete International, a publication of the American Concrete Institute (ACI)":

A. Division 3 specifications for concrete floor flatness typically include floor flatness requirements. The specifications also require that floor tolerance measurements be taken in accordance with ASTM E 1155, "Standard Test Method for Determining Floor Flatness (FF) and Floor Levelness (FL) Numbers." Thus, the F-number measurements for meeting Division 3 requirements incorporate the following:
   1. Point elevations measured at regular 12" (300 mm) intervals along each line.
   2. Measurement lines distributed uniformly across the test section.
   3. Minimum # of readings required for statistical approach.
   4. Measurement lines not within 2' (.6 m) of any slab boundary, construction joint, isolation joint, block-out, penetration, or other similar discontinuity.
   5. Flatness measured within 72 hours of concrete placement.

B. Division 9 specifications for concrete floors to receive a wood floor provide floor flatness requirements in terms of an allowable gap (1/8" in 6' or 3/16" in 10') under an unleveled straightedge. There is no ASTM procedure for this measurement. Straightedge measurements for Division 9 incorporate the following:
   1. Continuous measurement at any gap under the straightedge.
   2. Indefinite number of straightedge locations on the floor.
   3. No minimum or maximum number of readings.
   4. Measurements typically taken with the straightedge crossing construction joints, or column blockouts, and near penetrations.
   5. Measurements made just prior to the installation of the floor, which can be between 4-18 months after concrete placement.

C. These two tolerances are obviously not compatible, nor measured with the same specifications. And floor flatness changes with time (due to curling of the slab) which makes it impossible to predict flatness when flooring is ready to be installed. To further complicate the issue, concrete contractors seldom receive Division 9 specification requirements when bidding the job, nor are floor coverings normally selected at this time. Concrete contractors are responsible for meeting the requirements of Division 3.

D. It is recommended by NWFA, American Society of Concrete Contractors (ASCC), National Tile Contractors Association (NTCA), The Flooring Contractors Association (FCICA), Tile Contractors Association of America (TCAA), International Masonry Institute (IMI), and International Union of Bricklayers and Allied Craftworkers (BAC), that the owner of the project provide a bid allowance, established by the architect/engineer and based on the flooring requirements, for any necessary grinding and patching to close the gap between Division 3 and Division 9 tolerances. Providing an allowance enables the owner to compare floor covering bids on an equal basis.

PART XII
Moisture and Concrete

Concrete, whether used as a subfloor or as a building material, can introduce moisture to a structure. Excess moisture can pose problems for wood floors. An otherwise perfect flooring installation can fail if moisture is not addressed.

A. The age of the slab does not coincide with the moisture levels present in the slab. A 50-year-old slab needs to be assessed the same as a newer slab.

B. The point at which a wood floor can be installed over a concrete slab is dictated by the adhesive and flooring manufacturer requirements, and moisture testing results aligning with those requirements.

C. The slab must be dry and meet the moisture condition requirements of the flooring and the adhesive manufacturers. Be certain to follow specific moisture testing protocol as defined in the applicable ASTM testing method. Document and photograph dates, jobsite conditions, and moisture readings. (Refer to the Moisture Testing chapter for details about moisture testing concrete subfloors.)

D. There are three main sources of concrete moisture. They include water originating from the mix, water originating from above the slab, and water originating from below the slab.

1. **Water originating from the mix**

a. Most slabs poured with the intention of being used for a residential or commercial interior substrate, are poured directly over a vapor retarding membrane. Assuming this membrane was installed properly, and remains completely intact, the moisture within the slab is the primary moisture that needs to be addressed.

b. Under "ideal" conditions, that include concrete with a w/c of 0.50 or lower, a non-burnished concrete finish where a membrane-forming curing compound was not used, and favorable drying conditions surrounding the slab, it may take 30-45 days after placement before you can begin evaluating it for flooring (this does not indicate that any slab that is 30 days old is ready to receive flooring).

c. Curing compounds inhibit the evaporation of moisture and will also extend the drying time dramatically.

2. **Water from above the slab**

a. Concrete is a porous material. Once a dried concrete slab becomes wet, it takes time for this water to evaporate from the pores in the slab. The most common external source of moisture during new construction is precipitation, where the building is open to the elements.

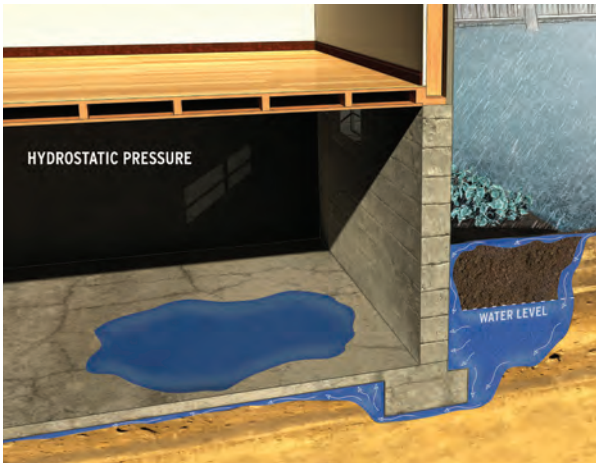
b. If the slab gets rewetted after starting to dry, the "drying clock" must be reset. Rewetting may include exposure to rainwater, power washing, leaks, or floods. The drying clock doesn't start until the slab has been protected from rewetting and the ambient conditions are conducive to drying. Studies have shown that due to the porous nature of all types of concrete, rewetting can greatly affect the dry time of the concrete slab.

c. Conditions in the space

i. High RH conditions within the structure can affect the moisture levels within the slab.

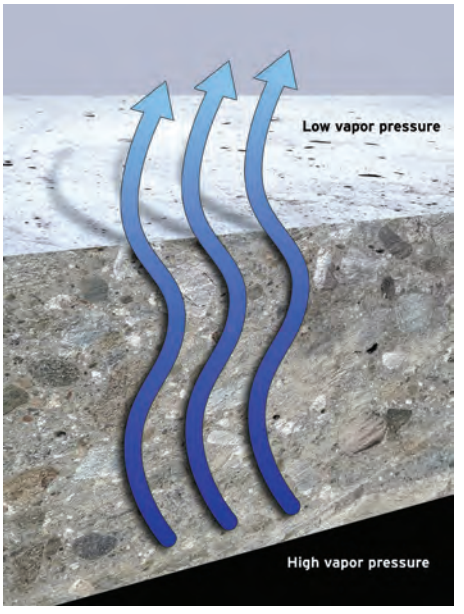
ii. Condensation on a slab occurs when the temperature of the slab allows the dew point to be reached, turning moisture from a vapor to a liquid.

3. **Water from below the slab**: There are three main ways moisture can find its way through a concrete slab. They include hydrostatic pressure, capillary action, and vapor diffusion. Other sub-slab sources may include broken pipe leaks from below or embedded within the slab, landscape irrigation, and breached or degraded vapor retarders.



a. **Hydrostatic pressure**: Fluid pressure that develops when the elevation of groundwater rises above the bottom elevation of the slab. Except in flood conditions, hydrostatic pressure only develops in "below-grade" applications. Moisture issues related to hydrostatic pressure can be avoided by using adequate drainage systems and/or waterproofing membranes around the foundation of the structure. This situation rarely occurs in the field.

b. **Capillary action**: The ability of liquid water to rise above the water table when the soil structure beneath the building is conducive to such rise. Through the forces of adhesion and cohesion liquid water has the ability to climb upward, against gravity, through soil structures where the gap between the soil particles is extremely small. An example of capillary action is the "wicking" up of water into a paper towel. To protect against the rise of liquid water by capillary action, the design team will specify removal of the finer soil beneath the slab to a specified depth and require replacement of that material with a very coarse fill material or crushed stone where the gap between particles is widened and capillary rise is broken.



c. **Vapor diffusion**: The movement of water vapor through a vapor-permeable material from an area of higher concentration to an area of lower concentration. When the moisture level in one area is higher in concentration than another, moisture will diffuse to the area of lower concentration until a state of equilibrium is reached. The relative humidity below a slab-on-ground, regardless of the depth of the water table, will typically be 100 percent. The higher vapor pressure below the slab will naturally find its way to the area above the concrete, which will have a lower vapor pressure. This natural movement of water in vapor form can create an environment that can lead to a flooring failure. An intact Class I vapor retarder that conforms to the requirements of ASTM E1745 installed directly below the slab can minimize or alleviate these issues.

SUBSTRATES: Wood Subfloor Systems Over Concrete

In many situations, the installation method calls for an installation of a wood subfloor over a concrete subfloor. Different methods may be necessary depending on the subfloor system, the region you're in, and/or the flooring being installed. Always follow the flooring manufacturer's recommendations for adequate and recommended subfloor requirements below their flooring.

PART I
Concrete Substrate Requirements

A. The concrete slab should be flat, prior to installation of any wood panel system, to within 1/8" in 6' or 3/16" in 10', as detailed in the Concrete Subfloors chapter.

B. The concrete slab should meet all moisture requirements as defined in the Moisture in Concrete chapter, and tested as detailed in the Moisture Testing chapter.

C. For glue-down or mechanically anchored panels over concrete, the compressive strength of the slab should be a minimum of 3,000 psi.

D. The concrete slab should meet all other requirements as detailed in the Concrete Subfloors chapter.

PART II
Wood Panel Requirements

A. Before installing any wood panel materials over concrete, the panels must be properly acclimated to a moisture content that coincides with the wood flooring and the facility in which they are being installed. (Refer to the Acclimation/Conditioning chapter for more detail.)

B. The wood subfloor panels used in these installation methods should be suitable for use as subflooring material for the wood flooring being installed over them as detailed in the Wood Subfloor chapter.

C. Do not use pressure-treated plywood unless it has been kiln-dried after treatment (KDAT), and has been acclimated to a moisture content that coincides with the wood flooring and the facility in which it is being installed.

D. The wood panels installed over a concrete slab must meet all other requirements as detailed in the Wood Subfloors chapter.

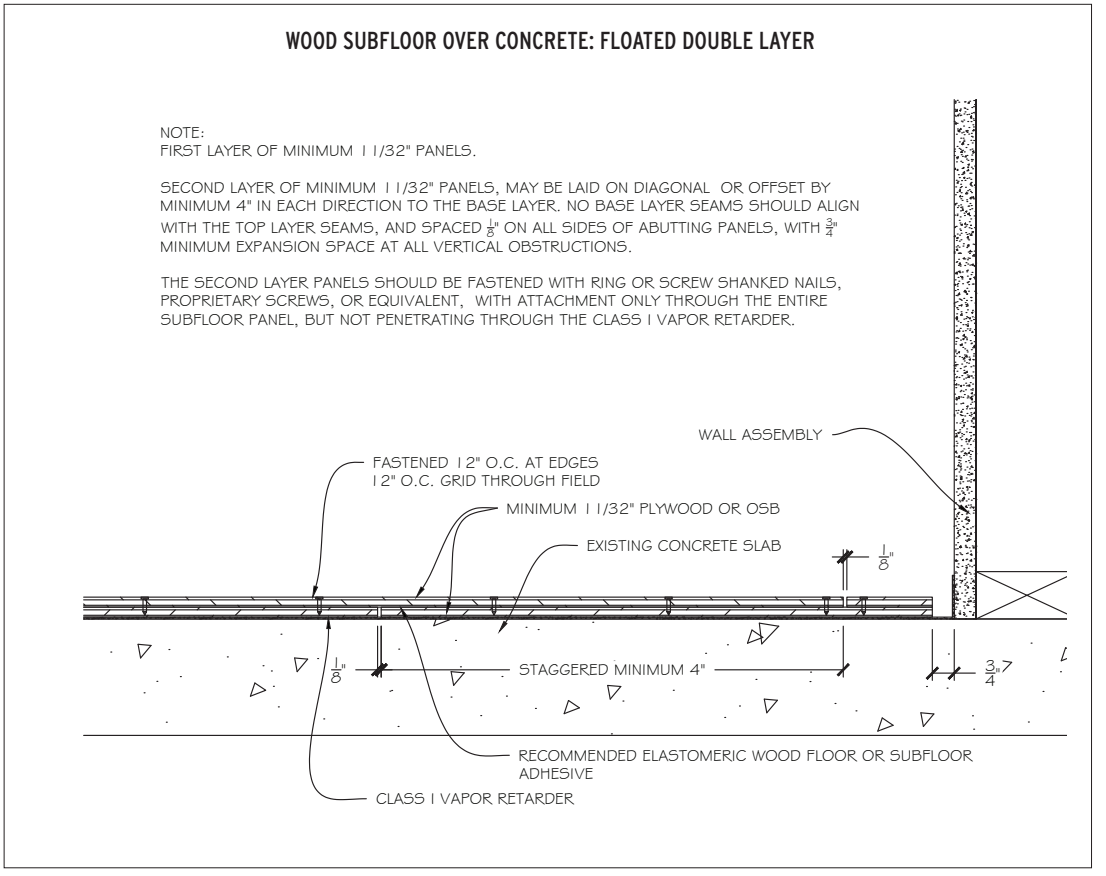
PART III
Wood Subfloor Systems

A. **Floated Subfloor**

1. Install a Class 1 impermeable vapor retarder over the slab when calcium chloride readings are greater than 3 pounds, relative humidity readings are greater than 80%, or calcium carbide readings are greater than 2.5%. In on- and below-grade applications, due to the ever-changing moisture variability with a concrete slab, and the likelihood of sub-slab moisture barrier degradation over time, a Class I impermeable vapor retarder is always recommended.

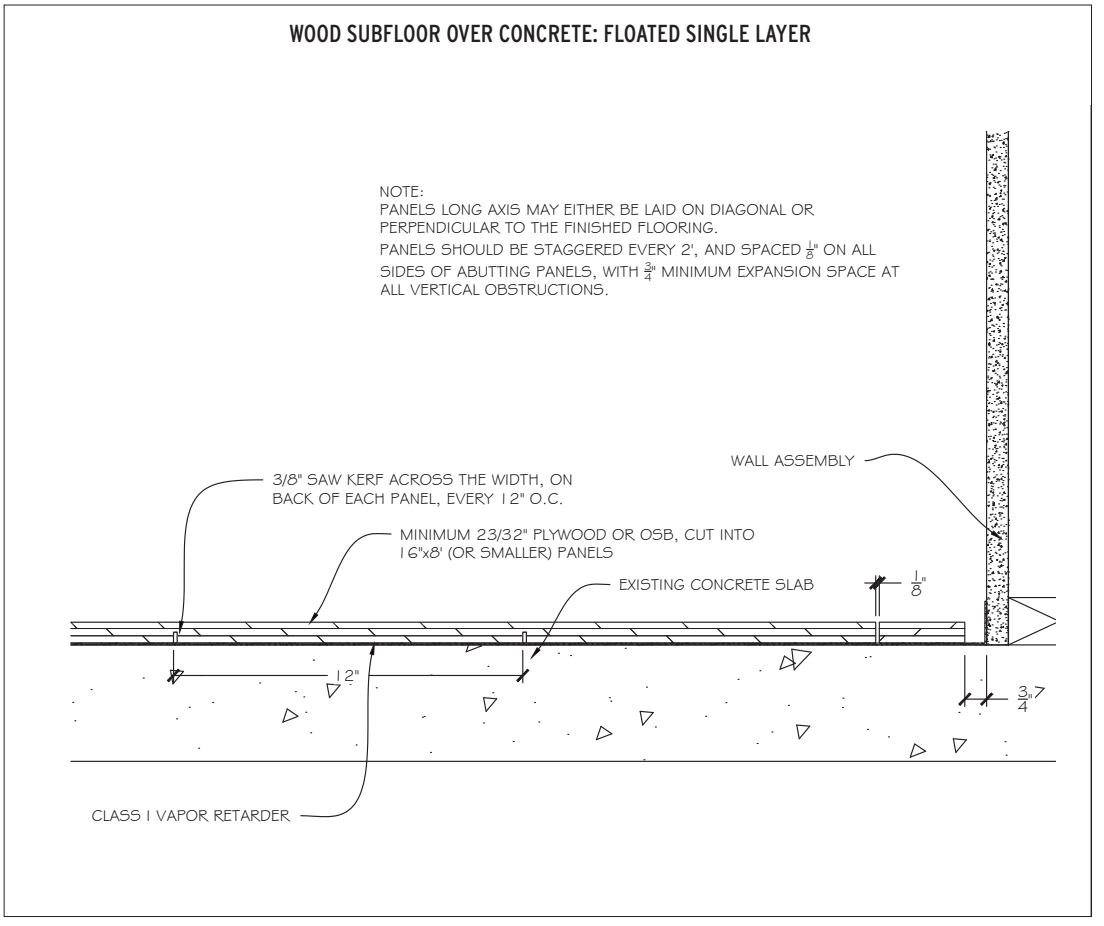
2. **Double-Layer Subfloor**
   a. For double-layer floors (one subfloor layer and a second (top) layer of underlayment), panels should be plywood or oriented strand board (OSB), Exposure 1, manufactured according to U.S. Product Standard PS 1 or PS 2, or Canadian standard CSA O121, O151, O325, or O437.
   b. Use minimum 11/32 (9.5mm) subfloor panels in 4'x8' sheets for both layers.
   c. Both layers of subfloor panels should be properly acclimated in the area where they will be installed as noted in the Subfloor Moisture section of the Wood Subfloors chapter.
   d. Place the first subfloor panel layer with edges parallel to the wall, without fastening.
   e. The second layer should be laid on a diagonal or offset by a minimum 4" in each direction to the base layer. No base layer seams should align with the top layer seams.
   f. Both layers of the subfloor panels should be placed with 1/16"-1/8" gaps between abutting panels on all four sides and ¾" minimum expansion space at all vertical obstructions.
   g. The second layer of panels should be fastened at a minimum of 12" O.C. along all panel edges and 12" O.C. grid pattern through the field. Use only ring- or screw-shanked nails, proprietary screws, or equivalent fasteners. Application of an elastomeric wood floor or subfloor adhesive can assist in joining the two panels together.
   h. When nailing down a wood floor, consider the overall subfloor thickness when selecting flooring fastener length to avoid penetrating through the subfloor system and the vapor retarding membrane below.

WOOD SUBFLOOR OVER CONCRETE: FLOATED DOUBLE LAYER



3. **Single-Layer Subfloor**
   a. Use minimum 23/32 (19mm) subfloor panels, cut into approximately 16"x8' or smaller panels.
   b. Kerf the subfloor panels on the back 3/8" deep, at a minimum of every 12" across the width of the panels.
   c. 16" panel's long-axis should be oriented perpendicular to, or diagonally to, the direction of the flooring installation.
   d. Panels should be staggered every 2', and spaced 1/8" on all four sides of abutting panels, with ¾" minimum expansion space at all vertical obstructions.
   e. When nailing down a wood floor, consider the overall subfloor thickness when selecting flooring fastener length to avoid penetrating through the subfloor system and the vapor retarding membrane below.

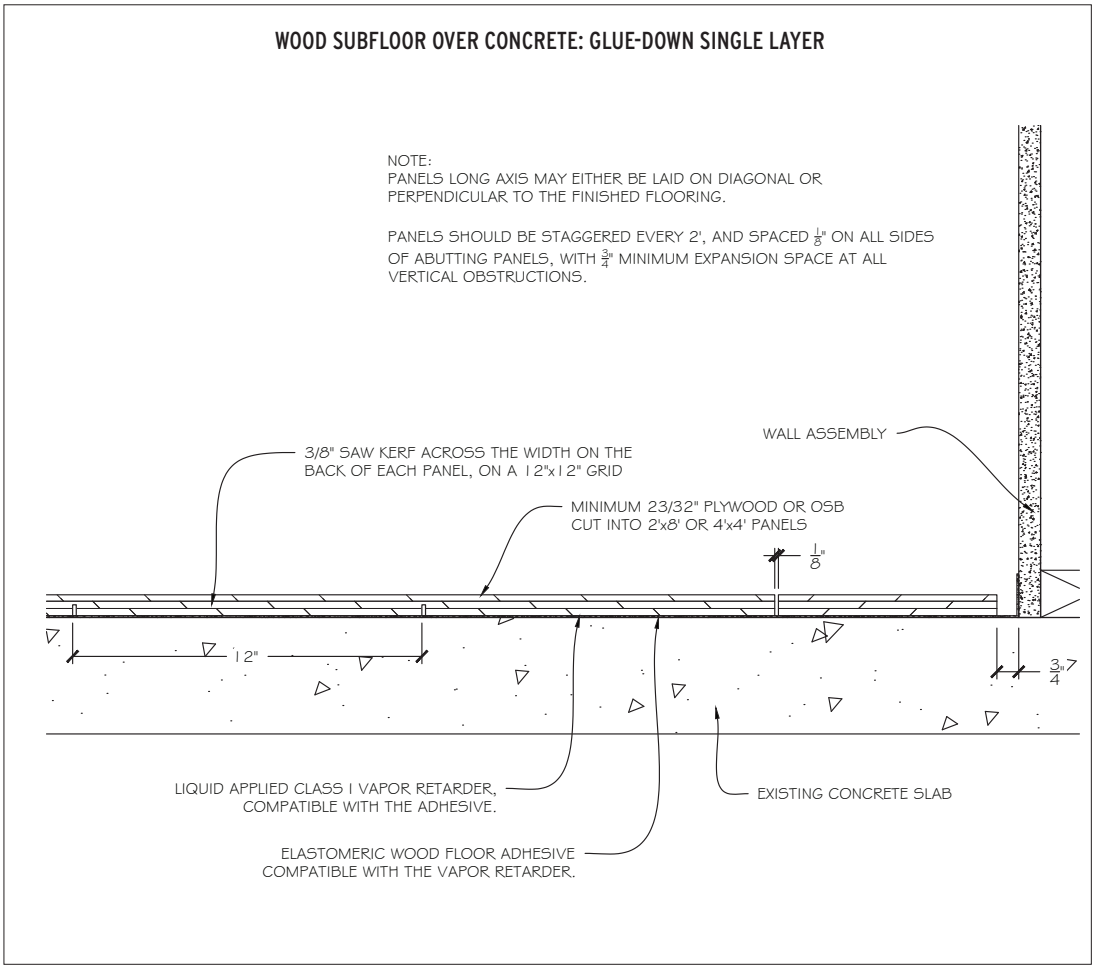
WOOD SUBFLOOR OVER CONCRETE: FLOATED SINGLE LAYER



B. **Glue-Down Subfloor**

1. Always follow the adhesive manufacturer's recommendation for moisture requirements and limitations, compatible moisture control systems, application method, trowel notch type, and spread rates.
2. Install a Class 1 impermeable vapor retarder over the slab when calcium chloride readings are greater than 3 pounds, relative humidity readings are greater than 80%, or calcium carbide readings are greater than 2.5%. In on- and below-grade applications, due to the ever-changing moisture variability with a concrete slab, and the likelihood of sub-slab moisture barrier degradation over time, a Class I impermeable vapor retarder is always recommended.
3. Use minimum 23/32 (18.3mm) subfloor panels, cut into 2'x8' or 4'x4' sections.
4. Kerf the subfloor panels on the back 3/8" deep, on a 12"x12" grid.
5. With 2'x8' panels, the panel's long-axis should be oriented perpendicular to, or diagonally to, the direction of the flooring installation.
6. Panels should be staggered every 2' in the adhesive, and spaced 1/8" on all four sides of abutting panels, and ¾" minimum expansion space at all vertical obstructions.
7. When nailing down a wood floor, consider the overall subfloor thickness when selecting flooring fastener length to avoid penetrating through the subfloor system and the vapor retarding membrane below.

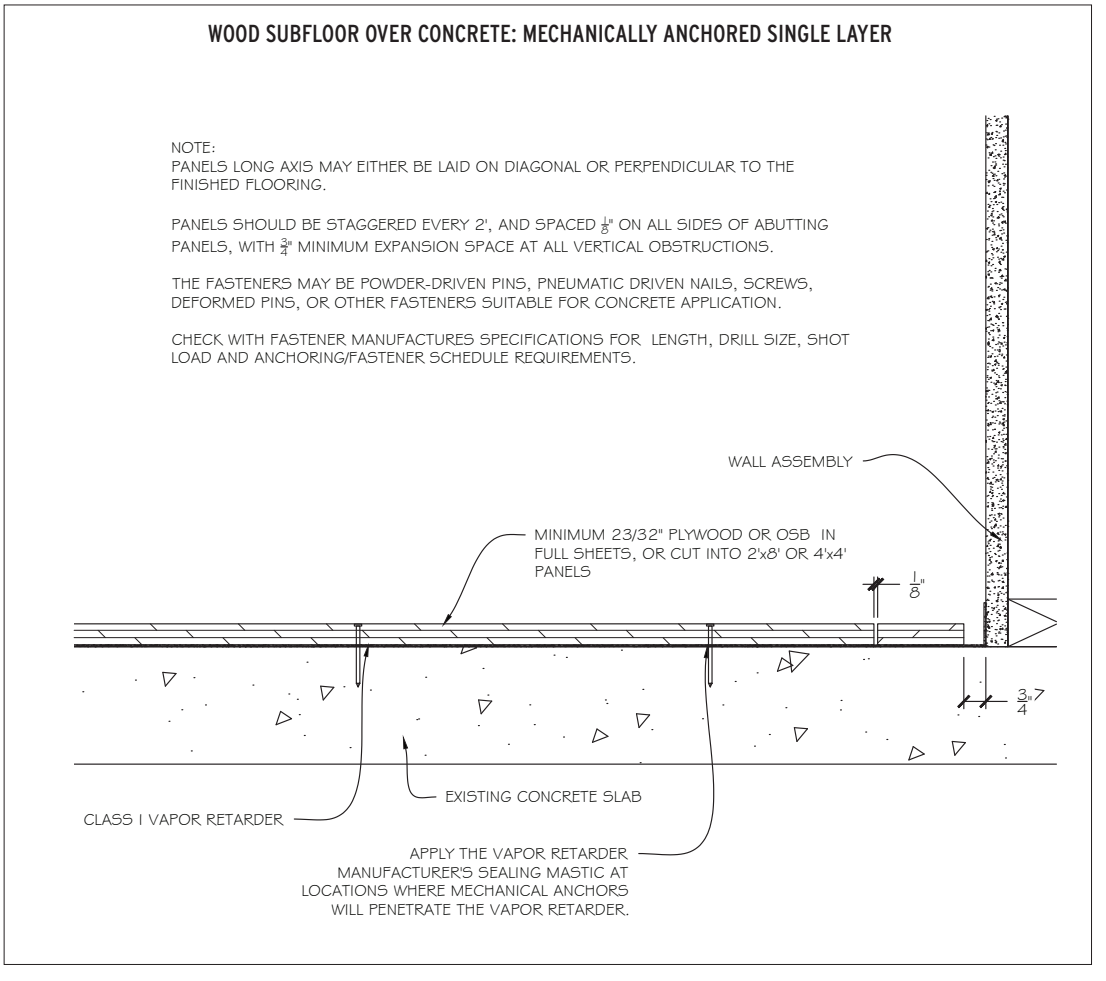
WOOD SUBFLOOR OVER CONCRETE: GLUE-DOWN SINGLE LAYER



C. **Mechanically Anchored Subfloor**

1. A Class I impermeable vapor retarder is always recommended below the wood subfloor.
2. In on-grade and below-grade slabs, where subsurface may be a concern, the use of mechanical anchors that penetrate the vapor retarder can allow moisture a path into the wood subfloor system. Always use the vapor retarder manufacturer's sealing mastic at locations where mechanical anchors will penetrate the vapor retarder.
3. Use minimum 23/32 (18.3mm) subfloor panels in full 4'x8' sheets, or cut into 2'x8' or 4'x4' sections.
4. The panel's long-axis should be oriented perpendicular to, or diagonally to, the direction of the flooring installation.
5. Place panels in a staggered joint pattern, with 1/8" spacing between sheets, and ¾" minimum expansion space at walls and all vertical obstructions.
6. Panels should be mechanically anchored. The anchors may be powder-driven pins, pneumatic driven nails, screws, deformed pins, or other fasteners suitable for concrete application. Check with the fastener manufacturer for specification such as length, drill size, shot load, and anchoring/fastener schedule requirements where applicable.
7. When nailing down a wood floor, consider the overall subfloor thickness when selecting flooring fastener length to avoid penetrating through the subfloor system and the vapor retarder below.

WOOD SUBFLOOR OVER CONCRETE: MECHANICALLY ANCHORED SINGLE LAYER



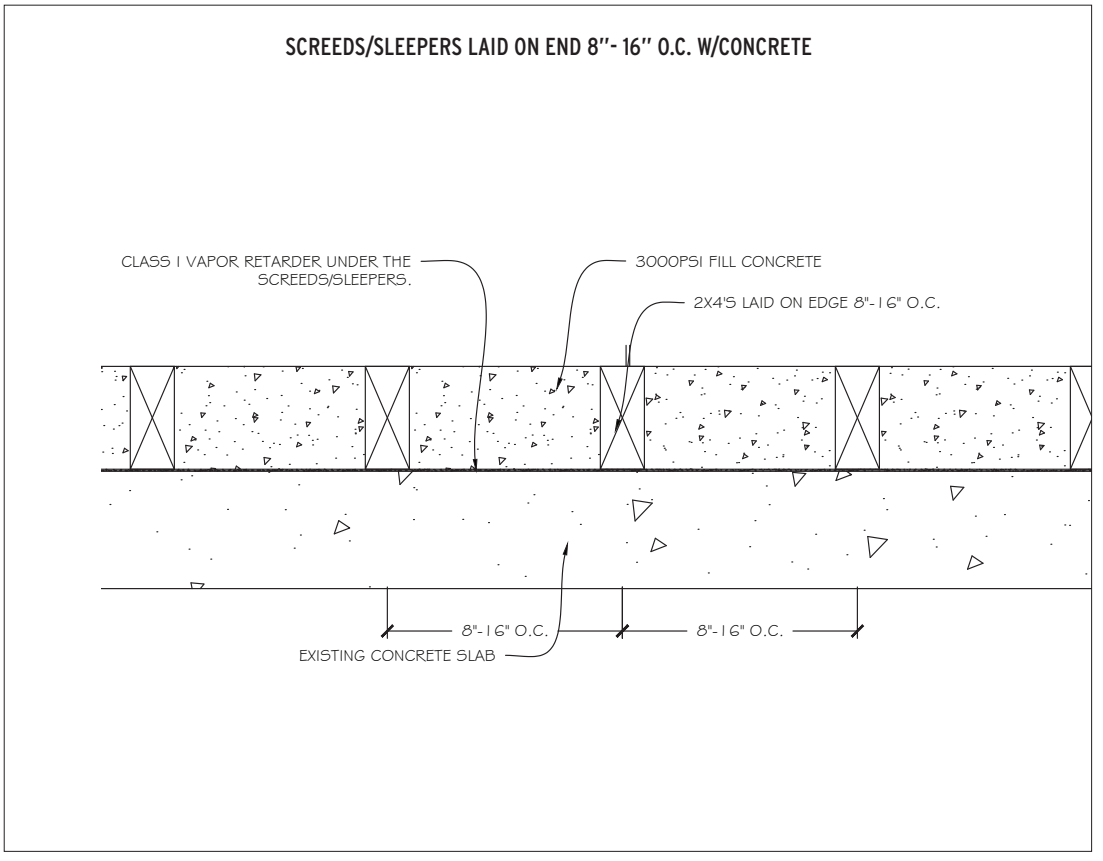
SUBSTRATES: Screeds/Sleepers

Screeds (also known as sleepers) are dimensional lumber boards that are laid over, or embedded in, a substrate. They are laid perpendicular to the finished floor, either laid on-end or laid flat-side-down, providing a nailing surface for the wood flooring.

PART I
Screeds/Sleepers (laid on-end)

A. Materials
   1. Screed/sleeper material laid on-end is typically 2"x4" (50mm x 100mm) lumber made of pine, Douglas fir, or other framing lumber.
   2. Screed/sleeper material must be kiln-dried. If using pressure-treated material, only use KDAT (kiln-dried after treatment) material.
   3. Screed/sleeper material should be conditioned to the expected in-use conditions and the moisture content should coincide with the temperature and humidity (EMC) requirements of the flooring being installed over them.

B. Screed/sleeper Installation Requirements:
   1. Moisture test and prepare the substrate according to the type of substrate the screeds/sleepers are being installed over, per the applicable chapter in these guidelines.
   2. Installation of an appropriate vapor retarder is necessary over the substrate and below the screeds/sleepers. Refer to the Underlayments-Moisture Control chapter for detail related to the appropriate substrate.
   3. Screeds/sleepers should be laid perpendicular to the direction of the flooring, and parallel to one another.
   4. For nail-down installation, screeds/sleeper spacing should be laid out no more than 8" O.C., to accommodate most ¾" flooring installation fastener schedule requirements. When embedded screeds/sleepers are spaced wider than 8", the wood floor installation must be installed in full-spread adhesive, nail-assisted glue-down, floating, or with a wood panel subfloor system installed over the screeds/sleepers.
   5. The channels between the screeds/sleepers should be filled with concrete, a lightweight concrete mix, or a gypsum-based topping compound that meet the minimum requirements as detailed in the Concrete Subfloors chapter.
   6. The compound should be poured even with the top of the screeds/sleepers. The introduction of water from the mix will introduce moisture to the screeds/sleepers, and may cause them to become distorted and swell.



7. Moisture:
   a. Dry-times of subfloor toppings vary from product to product, and manufacturer to manufacturer. The retention of moisture with most lightweight concrete aggregate mixtures adds significant time to the drying process. Check with the manufacturer for dry times and moisture testing requirements.
   b. A minimum of 20 areas per 1,000 square feet of subflooring should be moisture tested. Testing locations should be representative of the entire project and include a minimum of three tests per room. Elevated readings should be addressed prior to delivery and installation of any wood flooring.
   c. The moisture content of any screed/sleeper material should be no more than 2% MC difference from plank flooring (≥3" widths) and no more than 4% difference from strip flooring (<3" widths). Check and record the moisture of the screeds/sleepers using a wood moisture meter set to the appropriate species setting for the wood being tested. Take readings at multiple depths to ensure all moisture has dissipated.

PART II
Screeds/Sleepers (laid flat)

A. Materials:
   1. Screed/sleeper material laid flat is typically 2"x4" or 1"x4" lumber made of pine, Douglas fir, or high-performance 23/32 OSB or plywood ripped to 3½" widths.
   2. Screed/sleeper material must be kiln-dried. If using pressure-treated material, only use material that has been kiln-dried after treatment (KDAT).

3. Screed/sleeper material should be conditioned to the expected in-use conditions and should coincide with the temperature and humidity (EMC) requirements of the flooring being installed over them.
4. When screeds/sleepers are laid flat, they should be cut to approximately 24" lengths.

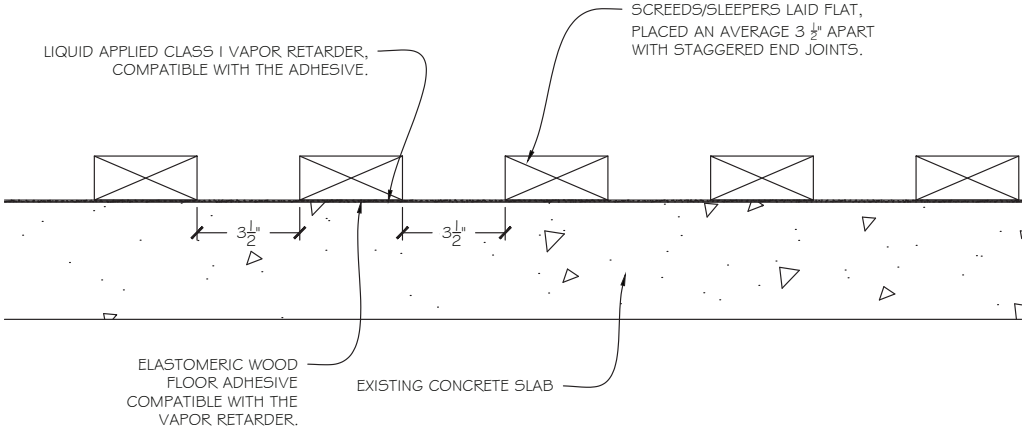
B. Installation Requirements:

1. Moisture test and prepare the substrate according to the type of substrate the screeds/sleepers are being installed over, per the applicable chapter in these guidelines.
2. Screeds/sleepers should be adhered to the concrete subfloor perpendicular to the direction of the flooring, and parallel to one another.
3. Adhere the screeds/sleepers to the concrete subfloor. Use an elastomeric wood floor adhesive or hot-tar specifically formulated for wood flooring installations, both of which allow for movement within the flooring system. Follow the adhesive manufacturer's recommendation for moisture requirements, and moisture limitations, compatible moisture control systems, application method, and spread rates.
4. For ¾" flooring up to 3¼" widths, screeds/sleepers should be placed an average of 3½" apart, to provide approximately 50% coverage of the subfloor.
5. For ¾" flooring >3¼" up to 5" in width, screeds/sleepers should be placed an average of 1" apart, to provide approximately 90% coverage of the subfloor.
6. Do not install wide plank wood flooring (>5") directly over screeds/sleepers laid flat. Wide plank flooring will require a minimum 23/32 wood panel subfloor to be installed over the screeds/sleepers.
7. Screed/sleepers joints should be staggered, which is easily accomplished by alternating full and half pieces on the starter wall.
8. Leave a minimum of ¾" expansion space at all vertical obstructions.
9. The moisture content of any screed/sleeper material should be no more than 2% MC difference from plank flooring (≥3" widths) and no more than 4% difference from strip flooring (<3" widths). Check the moisture of the screeds/sleepers using a wood moisture meter set to the appropriate species setting for the wood being tested. Take readings at multiple depths to ensure all moisture has dissipated.

SCREEDS/SLEEPERS LAID FLAT FOR STRIP FLOORING

NOTES:
¾" THICK WOOD FLOORING UP TO 3 ¼" WIDTHS, LAID PERPENDICULAR TO SCREEDS/SLEEPERS.

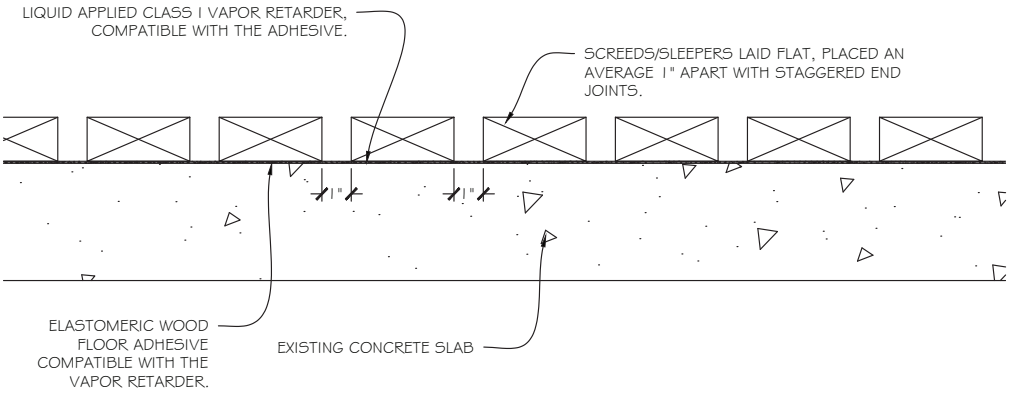
SCREEDS/SLEEPERS ARE TYPICALLY LUMBER MADE OF PINE, DOUGLAS FIR, OR HIGH PERFORMANCE 23/32" OSB OR PLYWOOD, RIPPED TO 3 ½" WIDTHS, CUT TO APPROXIMATELY 24" LENGTHS.



SCREEDS/SLEEPERS LAID FLAT FOR PLANK FLOORING

NOTES:
$\frac{3}{4}$" WOOD FLOORING FROM >3 $\frac{1}{4}$" UP TO 5" WIDTHS, LAID PERPENDICULAR TO SCREEDS/SLEEPERS.

SCREEDS/SLEEPERS ARE TYPICALLY LUMBER MADE OF PINE, DOUGLAS FIR, OR HIGH PERFORMANCE $\frac{23}{32}$" OSB OR PLYWOOD, RIPPED TO 3 $\frac{1}{2}$" WIDTHS, CUT TO APPROXIMATELY 24" LENGTHS.



PART III
Installation Methods over Screeds/Sleepers

A. Screed/Sleeper Flatness Requirements:
   1. Check screeds for flatness with an 8-10' straight edge. All screeds should come into full contact with the straight edge.
   2. Sand or plane the high areas of the screeds to achieve a flatness tolerance where the straight edge comes in to full contact with all screeds. Replace low screeds or shim the low areas of the screeds with a shimming material that will not affect the penetration of the flooring fastener into the screed.

B. Only ¾" solid or engineered tongue-and-groove wood flooring may be installed directly to screeds/sleepers.

C. Only use floor board lengths that span two or more screeds/sleepers.

D. If radiant heating tubes or elements are embedded within the concrete, the radiant heating system should be fully operational, turned on, and maintained at the normal and expected operating temperature, regardless of season, for a minimum of 5 days prior to delivery of wood flooring. Keeping the system on helps force out moisture from the concrete or compound mix. (Refer to the Radiant Heat chapter for more detailed information.)

E. Nail-Down Installations over Screeds/Sleepers:
   1. When screeds/sleepers are spaced 8" O.C. or less, the nail-down installation method may be employed, as long as fastener placement coincides with fastener schedule requirements. (Refer to the Nail-Down Installation Methods chapter for more-detailed information.)
   2. Blind-nail wood flooring to the screeds. Fastener length should not be less than 1½".
   3. Fastener schedule over the screed/sleeper systems will be dictated by screed/sleeper placement and may not allow for adequate fastener schedules. The use of an elastomeric adhesive in conjunction with the mechanical fasteners is recommended any time the flooring fastener schedule will be compromised.
   4. When nailing down a wood floor, consider the screed/sleeper placement in comparison to the angle of the fastener driving into it to avoid penetrating into any radiant heating tubes or elements.

F. Nail-Assisted Glue-Down Installation Methods over Screeds/Sleepers (laid on-end):
   1. When screeds/sleepers are spaced greater than 8" O.C., and space between is filled with concrete, lightweight concrete mix or a gypsum-based topping, the nail-assisted glue-down installation method is required.
   2. When using a flooring adhesive over a lightweight concrete mix or a gypsum-based topping compound, a sealer and/or densifier may be necessary. Follow the adhesive manufacturer's installation instructions based on the type of substrate being installed over.
   3. The full-spread adhesive application should remain the same as normal installation for the flooring being installed. The addition of mechanical fasteners is not intended as a replacement fastening mechanism, rather a supplemental fastening method to the adhesive. It is best to blind-nail the flooring into the screeds/sleepers to hold the flooring in place while the adhesive sets-up.
   4. This method may be appropriate where flooring needs to be driven tight during the installation.

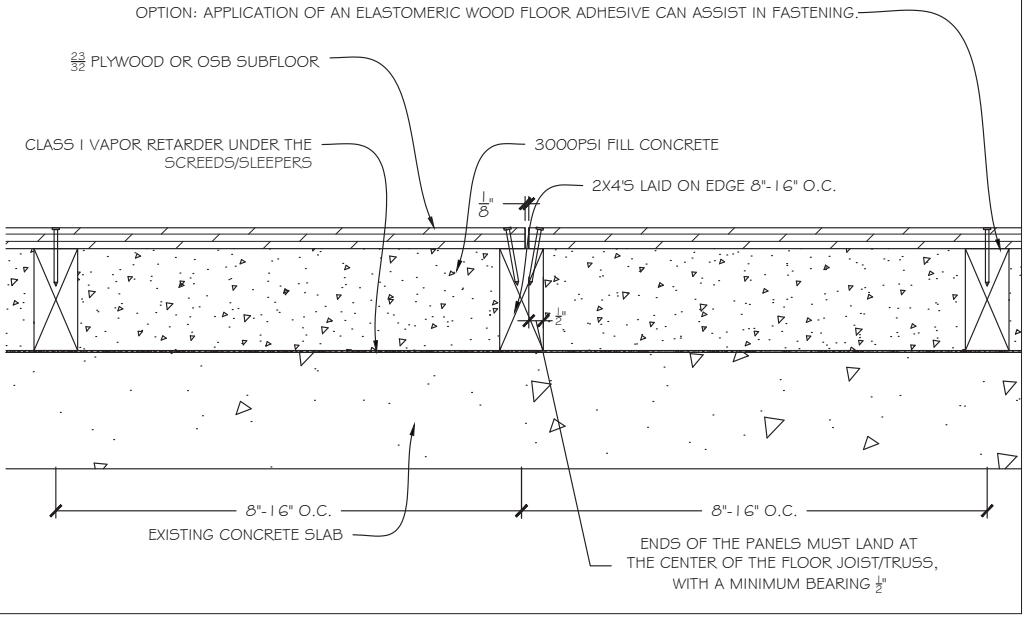
G. Additional information about screed/sleeper systems used in gym floor applications can be found at www.maplefloor.org.

H. Engineered wood flooring less than ¾" thick, any solid or engineered wide plank floor (>5" widths), and solid thin-classification strip flooring (including ½") should not be installed directly to screeds/sleepers. These floors may be installed following the below method:
   1. Overlay the screed/sleeper system with a minimum single layer of 23/32 plywood or high-performance OSB subfloor panels, acclimated to the expected live-in conditions of the facility (refer to the Wood Subfloors chapter for more detail).
   2. Subfloor panels should be installed with the long panel dimension (strength axis) perpendicular to the screeds/sleepers and offset by minimum 4" from adjacent panels. Panels may also be laid on diagonal to the screeds/sleepers.
   3. The ends of the panels should land near the center of the screeds/sleepers, with a minimum bearing of ½".
   4. The panels should be fastened at a minimum of 12" O.C. along all panel edges and 12" O.C. along each screed/sleeper. Use only ring- or screw-shanked nails, proprietary screws, or equivalent fasteners. Fastener lengths should account for the total thickness of the wood paneling and screeds/sleepers, as to not puncture through the vapor retarder below. Application of an elastomeric wood floor adhesive can assist in fastening them in place.
   5. Typical panel edge spacing requirements for floor joist/truss systems call for a 1/16" - 1/8" gap around the perimeter (all four sides) of each panel, as well as ¾" gap at all vertical obstructions.

SCREEDS/SLEEPERS LAID ON END W/CONCRETE W/WOOD PANEL OVERLAY

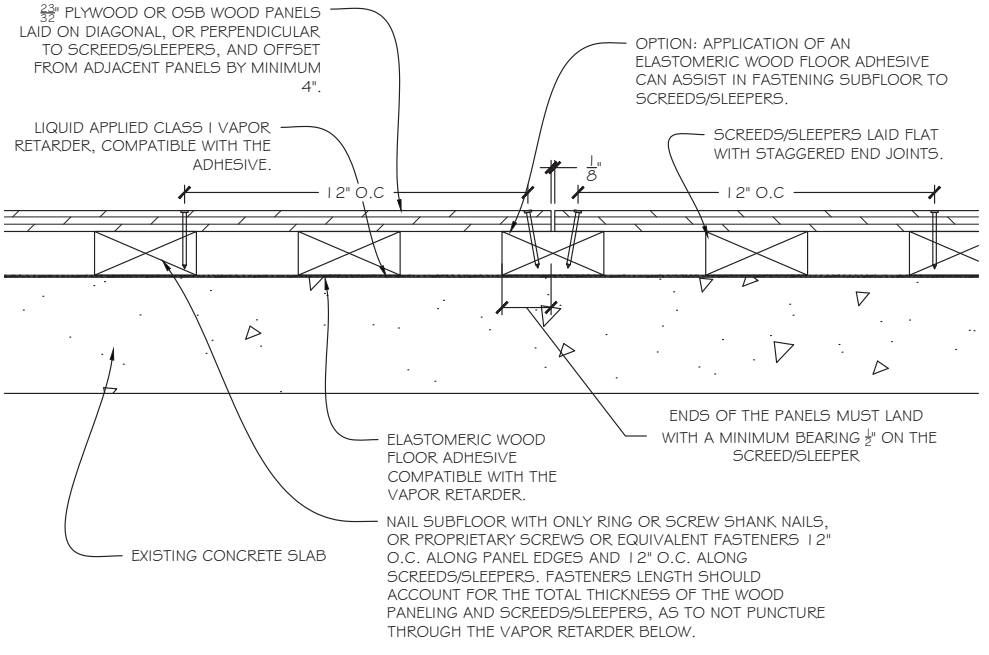
NOTES:
FASTENED ALONG ALL PANEL EDGES AND 12" O.C. ALONG EACH SCREED/SLEEPER THROUGH FIELD.

THE PANELS SHOULD BE FASTENED USING ONLY RING OR SCREW-SHANKED NAILS, PROPRIETARY SCREWS, OR EQUIVALENT FASTENERS.



SCREEDS/SLEEPERS LAID FLAT FOR WOOD PANEL OVERLAY

NOTES:
SCREEDS/SLEEPERS ARE TYPICALLY LUMBER MADE OF PINE, DOUGLAS FIR, OR HIGH PERFORMANCE 23/32" OSB OR PLYWOOD, RIPPED TO 3 1/2" WIDTHS CUT TO APPROXIMATELY 24" LENGTHS.



SUBSTRATES: Radiant Heat

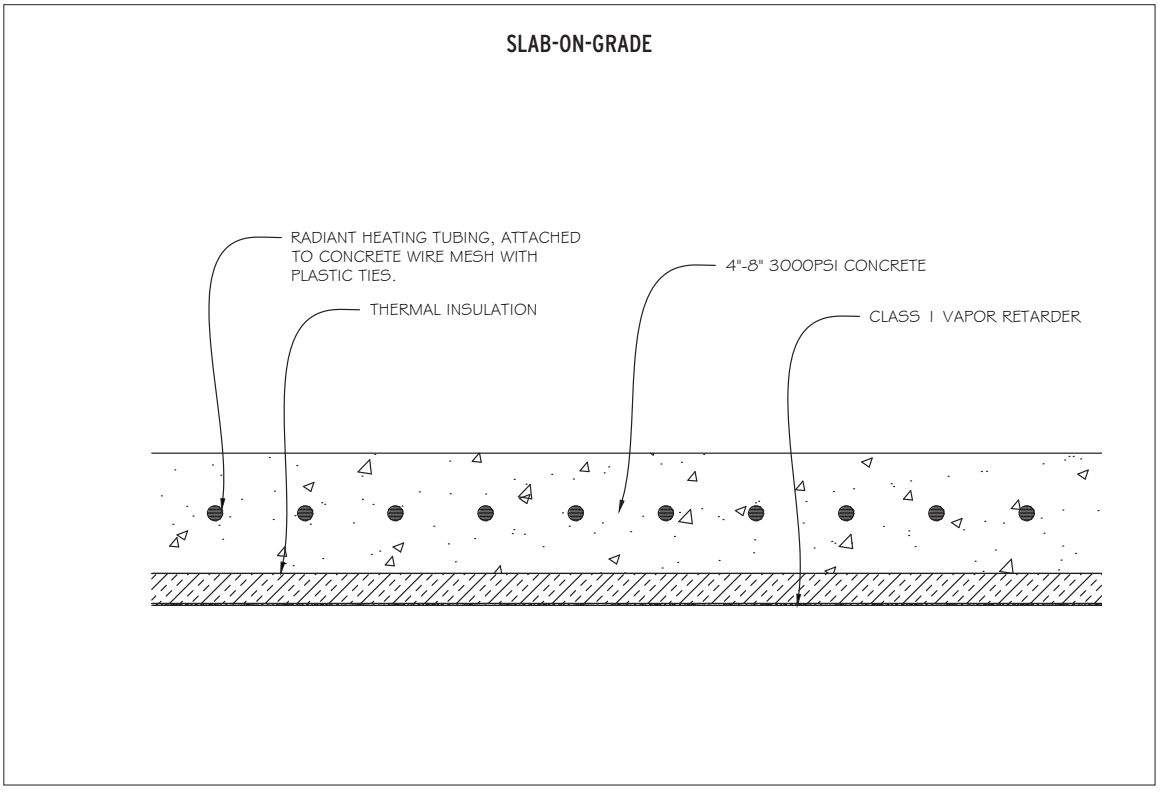
Radiant (underfloor) heating is a type of heating system that is placed below the floor. Radiant heating as a technology is the method of intentionally using the principles of radiant heat to transfer radiant energy from an emitting heat source to an object. Radiant heating may be either hydronic (water/fluid flowing through pipes) or electric (electric resistance heating elements).

PART I
Types of Radiant Heating Systems

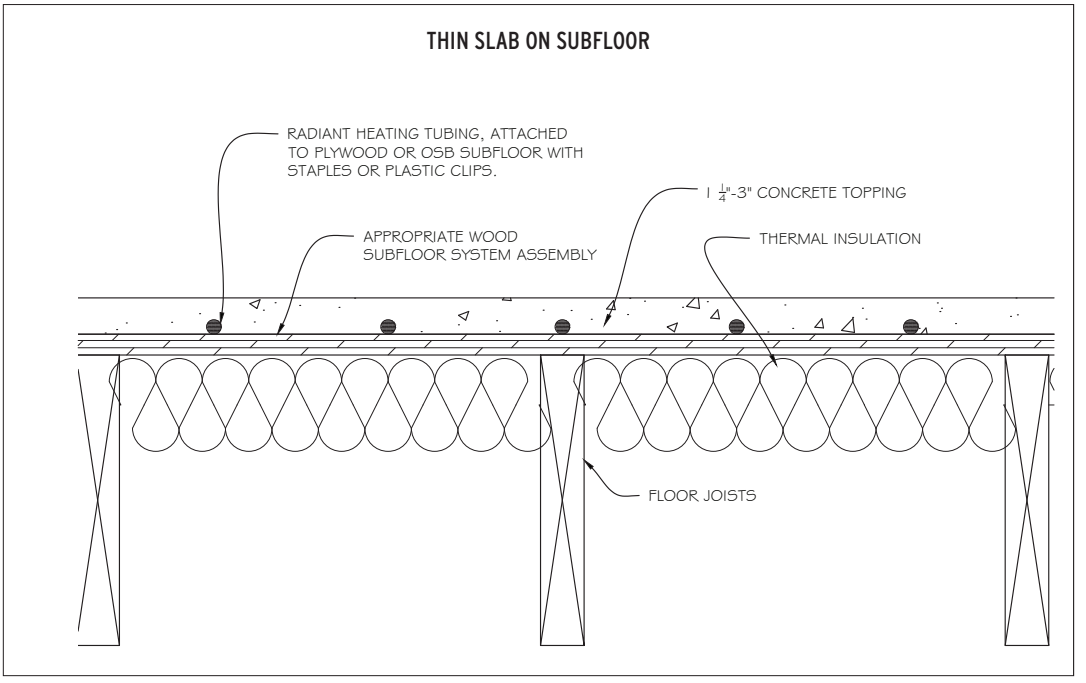
There are many types of radiant heating systems available. The heating system must be approved and properly set up for each specific zone, and for each flooring type being installed over it. Check with the flooring manufacturer for approval, and the recommended installation method over the specific system that is in place. For more-detailed information on any of these systems, visit the Radiant Professionals Alliance (RPA) at www.radiantprofessionalsalliance.org.

A. **Hydronic Radiant Heating:** An underfloor heating or warming system that involves transfer of heat by circulating a fluid (such as water) in a closed system of pipes. Insulation is required below the heat source for most of these systems. Types of hydronic radiant heating systems include:

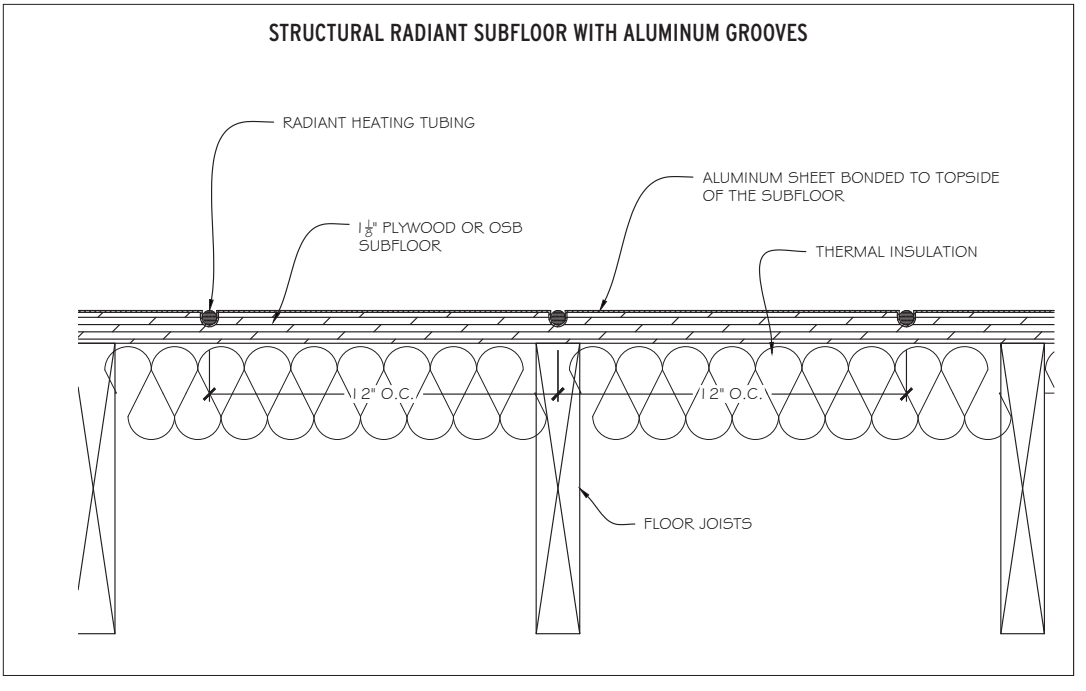
   1. **Slab-on-Grade:** Radiant tubing is embedded in concrete. The tubing typically is attached to metal mesh with plastic ties. A 4" slab is most typical. The tubing is normally placed in the middle of the slab. Full under-slab insulation and moisture control is required for most residential applications. Slabs have a large thermal mass, which stabilizes temperature swings, but slows response.



2. **Thin Slab on Subfloor:** Radiant tubing is attached on top of the wood subfloor with approved staples or plastic clips. A thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete is poured over the tubing. Typical slabs are a minimum of 1 ½" thick (when using ½" tubing), but may be as thin as 1 ¼" thick (when using 3/8" tubing). The maximum thin slab thickness is 3". Gypsum concrete is lighter than cement, but a little less conductive.

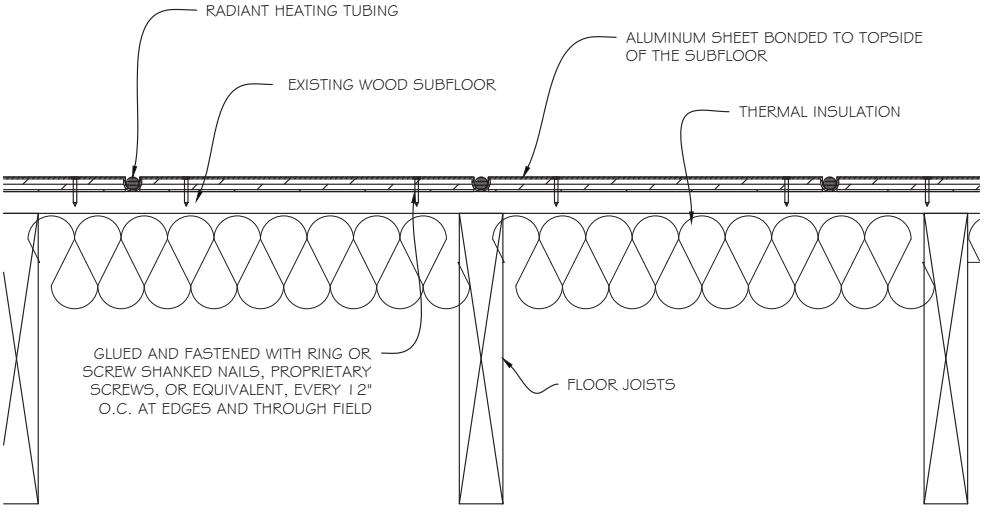


3. **Structural Radiant Subfloor with Aluminum Grooves:** Premanufactured 1 1/8" thick wood subfloor panels that have grooves for tubing and an aluminum sheet bonded to the panel. In this case, the premanufactured panels serve both as the structural subfloor and as the channel into which the tubing is installed. The aluminum sheet makes the system accelerate rapidly and spreads out the heat. Tubing normally is installed 12" on center in the grooves.



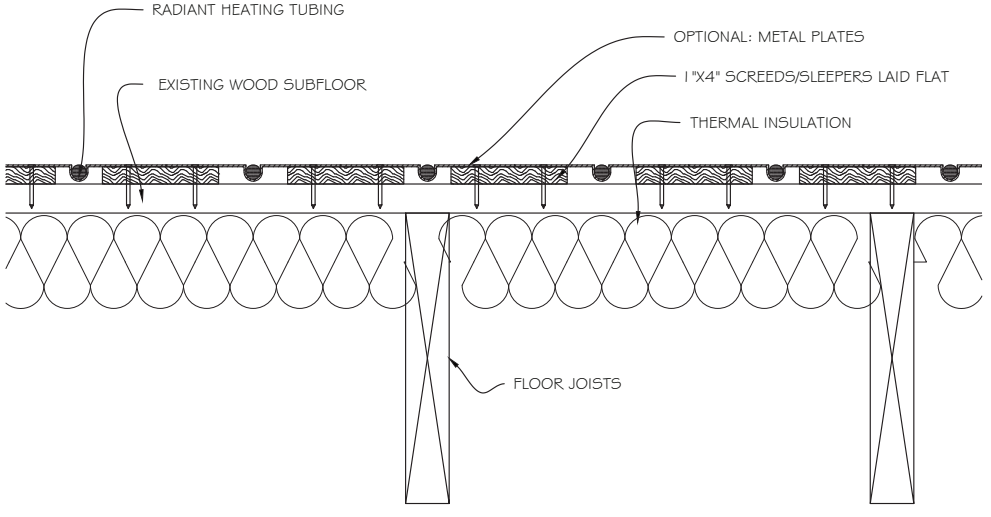
4. **Boards with Grooves and Metal, Attached to Top of Subfloor:** Several varieties currently exist. One board has metal on the bottom and another on the top. Both serve to spread the heat laterally. Normally, they are glued and screwed, or stapled, to the top of a wood subfloor panel. Under some conditions, they may be attached on top of existing slabs. Different products use different pipe sizes.

BOARDS WITH GROOVES AND METAL, ATTACHED TO TOP OF SUBFLOOR

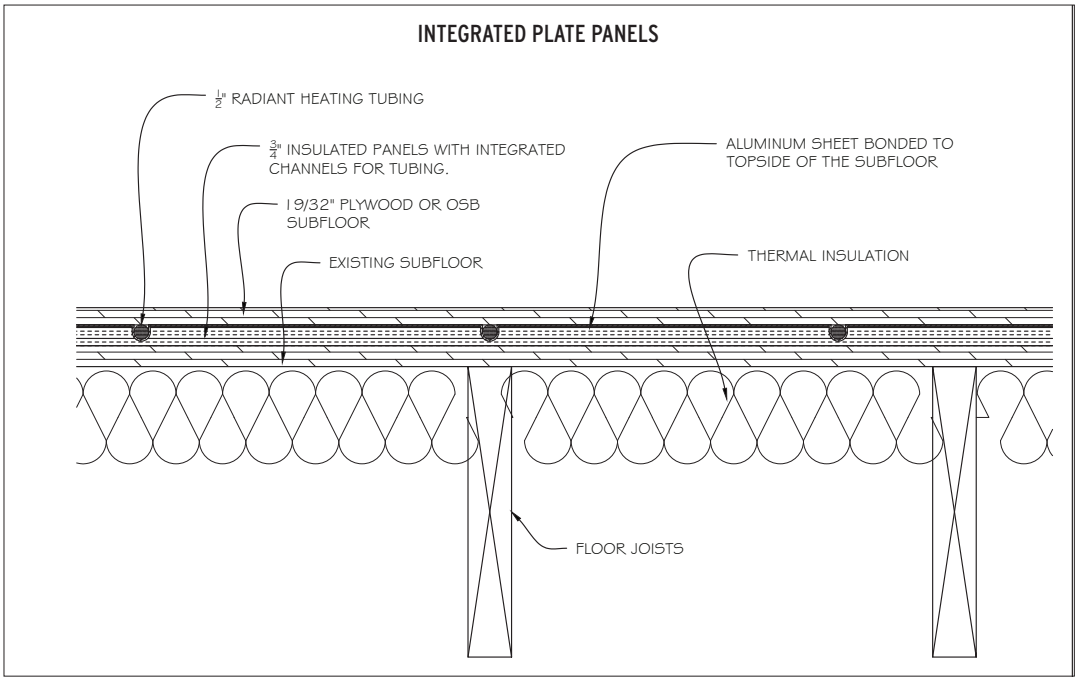


5. **Sandwich Method with or without Plates on Top of Subfloor:** Typically, 1"x4" screeds/sleepers are attached to the top of the subfloor, and pipe is laid between the screeds/sleepers with or without the addition of the metal plates. Metal plates typically cover about 80% of the outside diameter of the pipe, adding significantly to the even dispersion of heat.

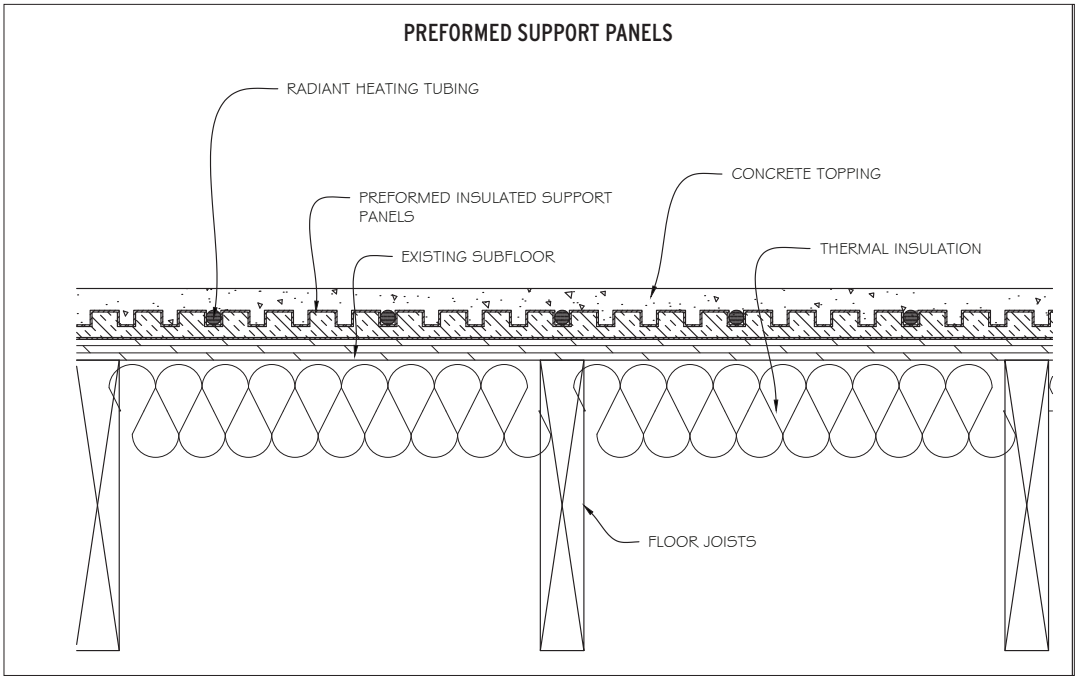
SANDWICH METHOD WITH OR WITHOUT PLATES ON TOP OF SUBFLOOR



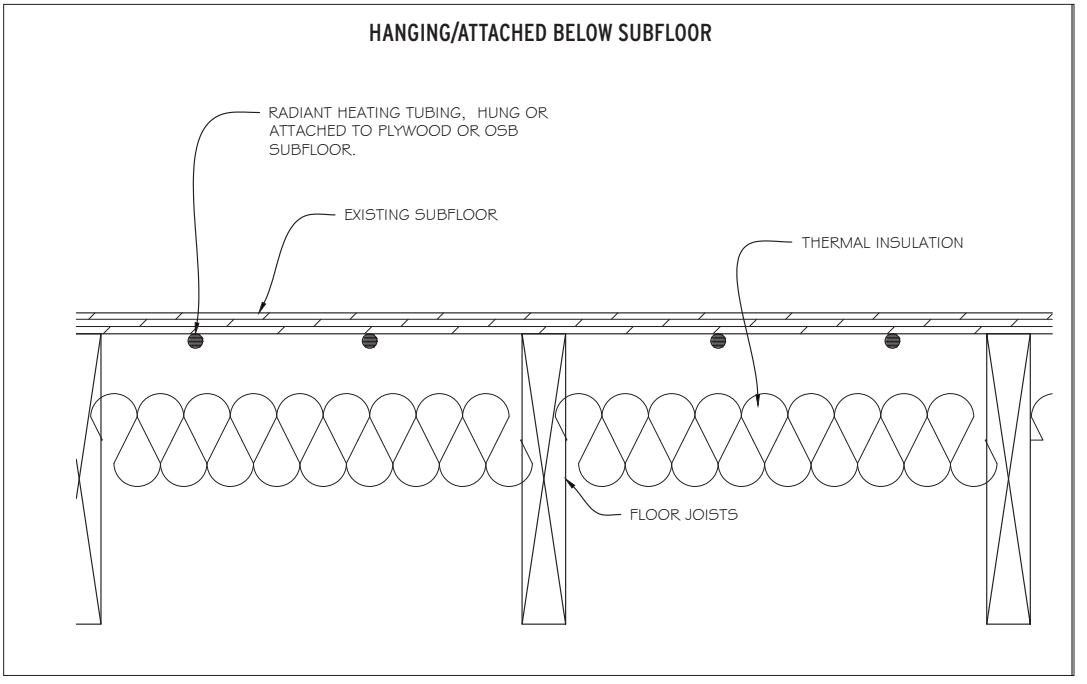
6. **Integrated Plate Panels:** The integrated plate panel system is designed to install over an existing subfloor. The ¾" panels are pre-insulated and water-resistant. The use of ½" pipe allows for greater circuit lengths and is 100% covered by metal. The integrated plate panels are sandwiched between the wood subfloor and wood nailing surface for hardwood flooring.



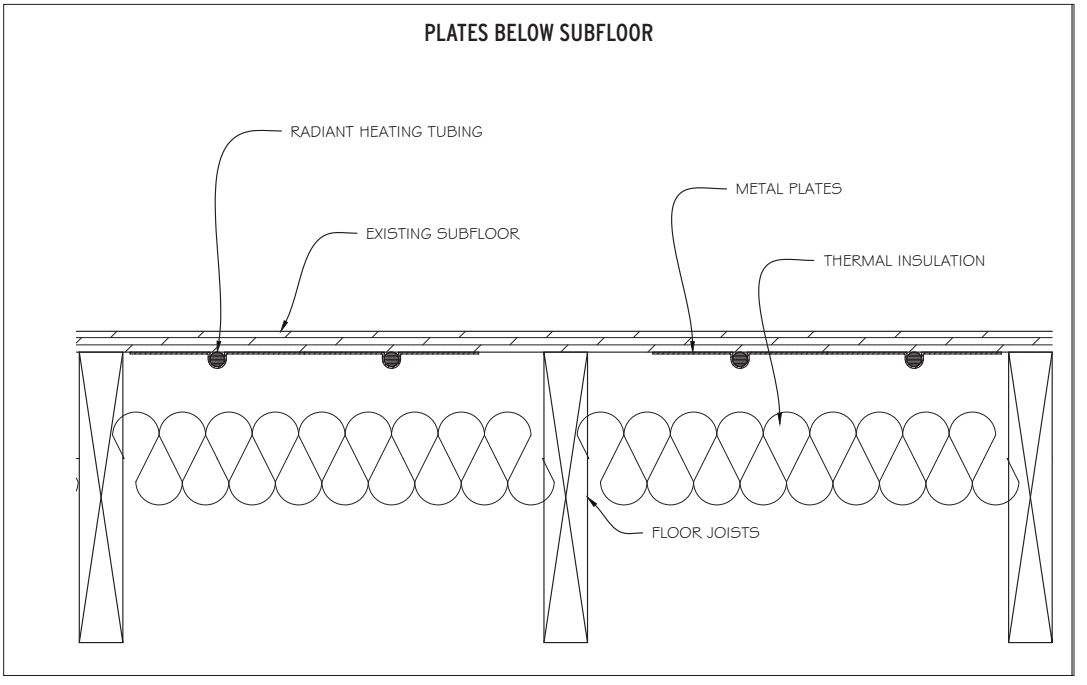
7. **Preformed Support Panels:** Molded panels designed to hold the radiant tubing cover the entire subfloor surface. This system may incorporate insulation molded as part of the panel. Some systems are designed to be embedded in cement, while others have dense, stone-like tiles that are supported by the molded pedestals. They may also include metal heat transfer plates to help disperse the heat evenly.



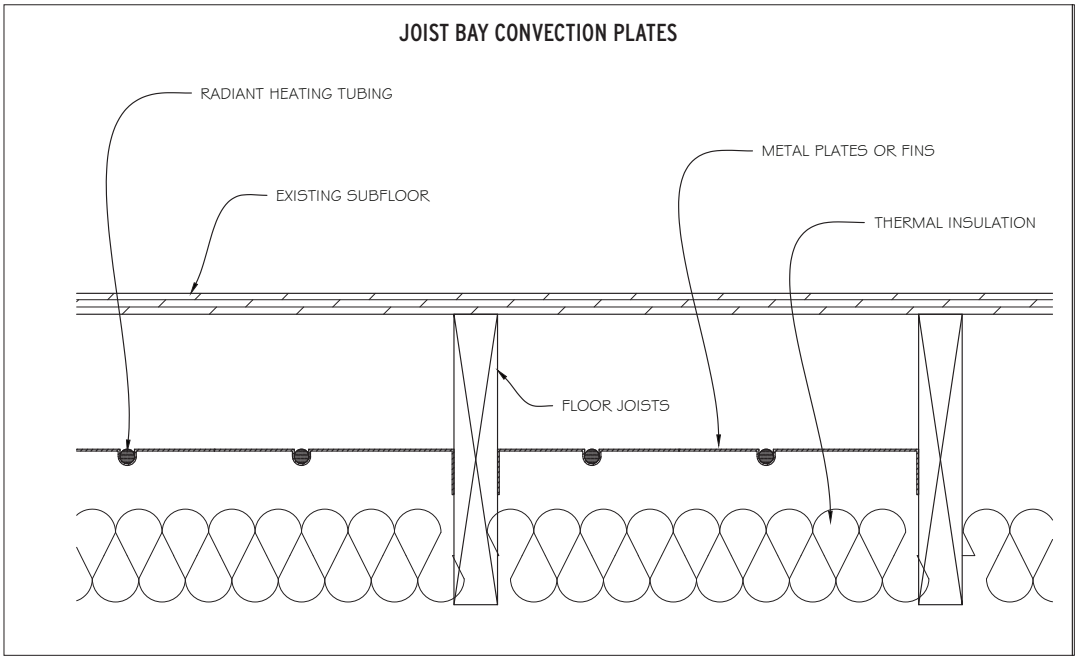
8. **Hanging/Attached Below Subfloor:** Radiant tubing is hung or attached to the underside of the subflooring in an airspace with insulation below. This requires higher water temperatures and has more-limited heat output than other systems. It is often used for retrofitting when access from below is possible. Suspended systems have more-even joist cavity temperatures than when the pipe is attached in direct contact with the subfloor joists.



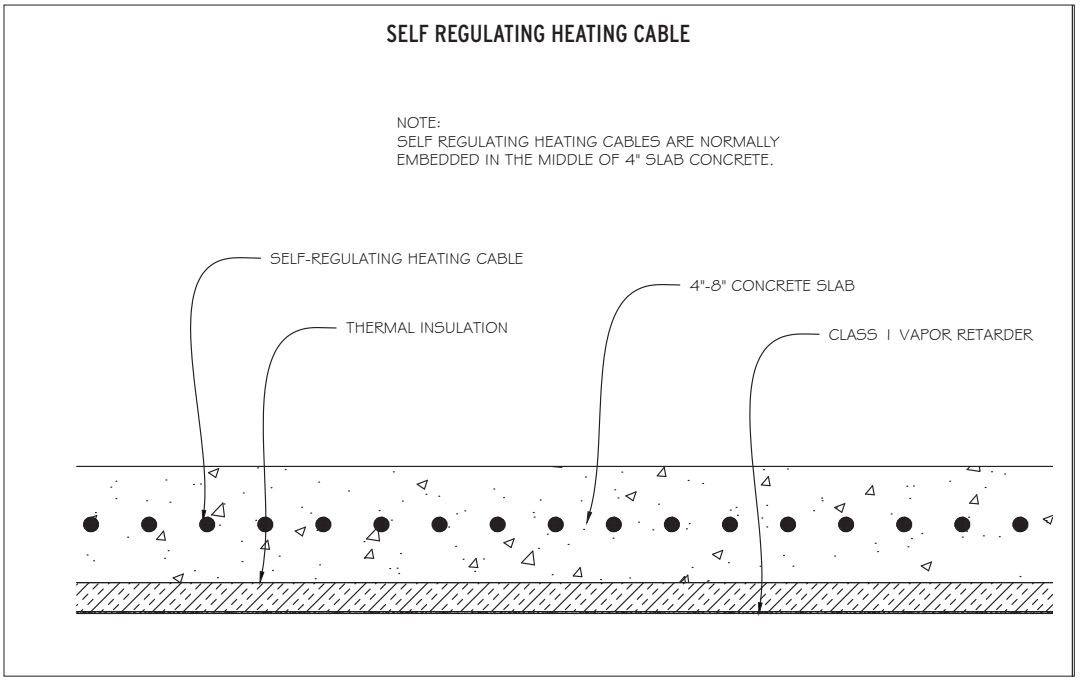
9. **Plates Below Subfloor:** Radiant tubing is attached to the underside of the subfloor with metal plates to diffuse the heat. This type of system has higher water temperatures and more limited heat output than above subfloor systems, but plates make it more effective than suspended pipes under the joists. It is often used for retrofitting when access to joist space is available.



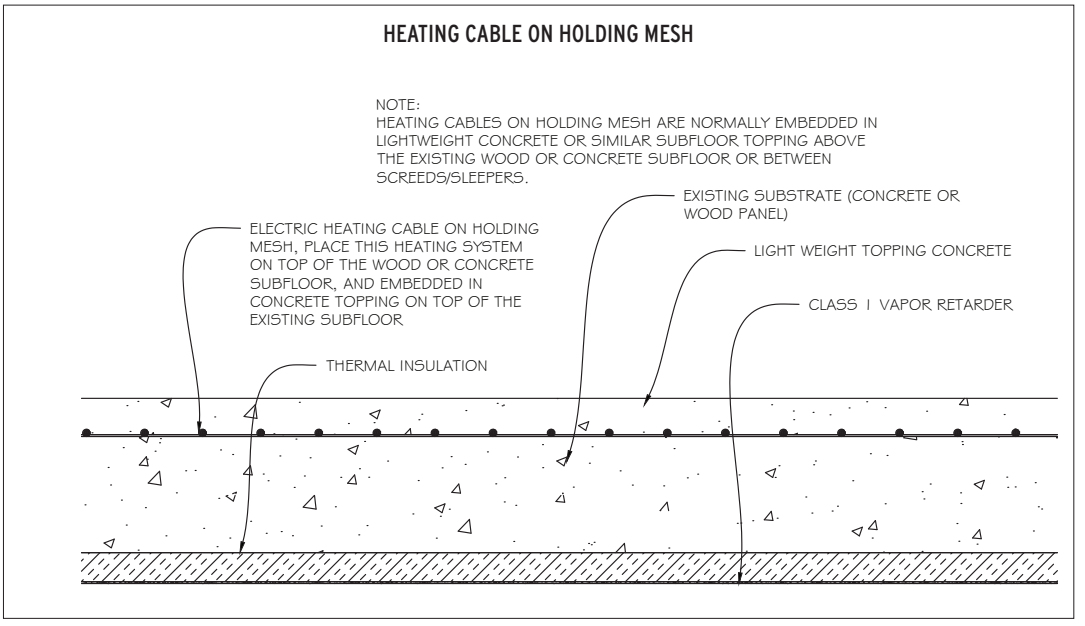
10. **Joist Bay Convection Plates:** The radiant tubing is suspended in a clear airspace beneath the subfloor and between the joists with metal plates or fins attached to the tubing. The tubing and metal fins heat the air within the joist space, which in turn, heats the subfloor. Higher water temperatures are also required than in systems with the plates in direct contact with the floor. Tubing is normally run parallel to the joists or perpendicular when holes are drilled to accommodate the tubing.



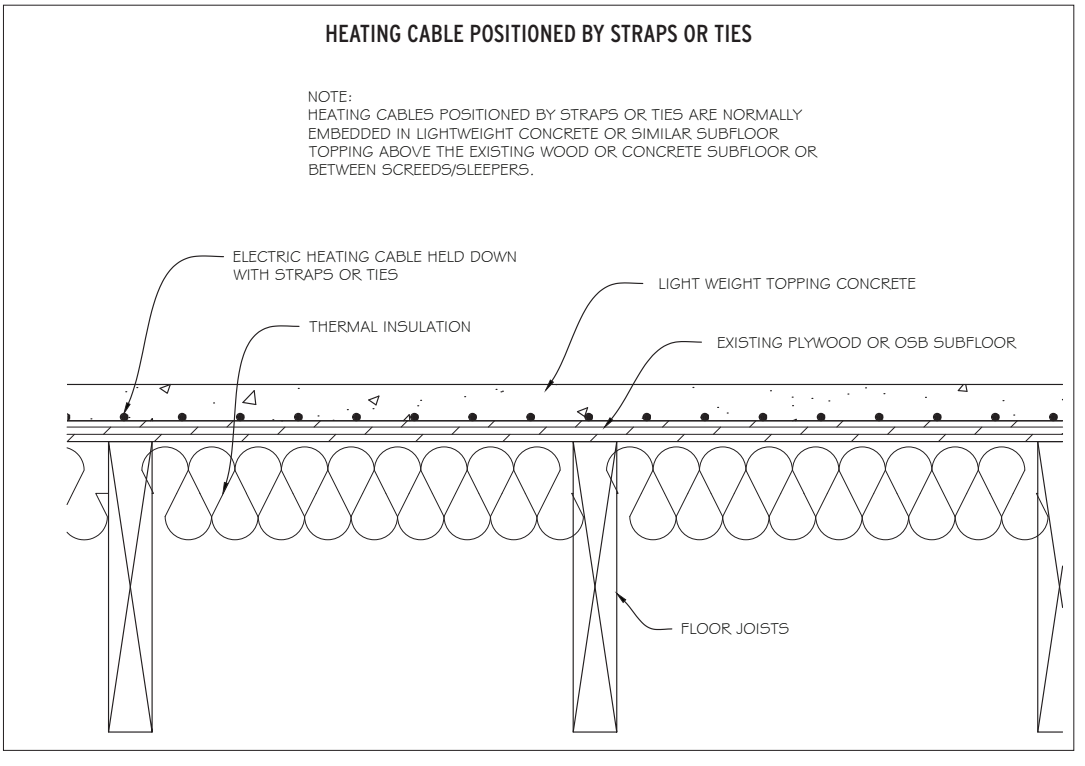
B. **Electric Radiant Heating:** An underfloor heating or warming system that involves the conversion of electrical energy to heat. Types of electric radiant heating systems include:
   1. **Self-Regulating Heating Cable:** This cable is made of a semi-conductive polymer and is self-regulating. It is to be embedded in a concrete slab. This product comes in a variety of voltages including low-voltage, 120V, 208V, and 240V versions.



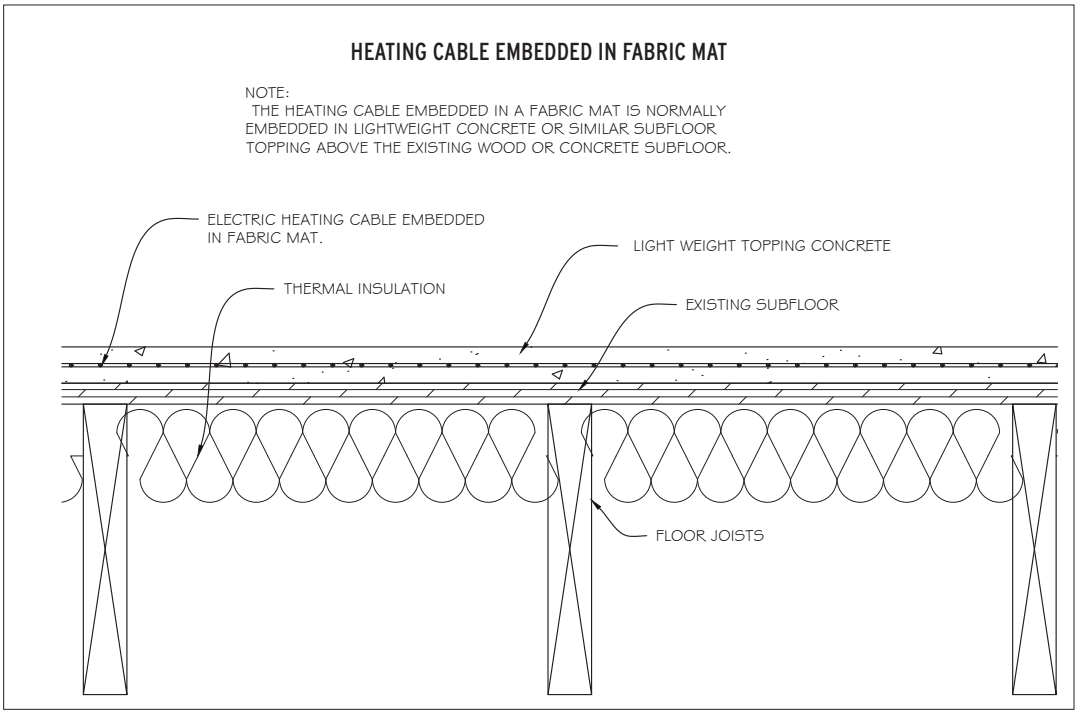
2. **Heating Cable on Holding Mesh:** The constant-wattage heating mat normally is embedded in the slab or in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete set above the subfloor or between screeds/sleepers. These heating mats are available in a variety of voltages including low voltage, 120V, 208V, and 240V versions.



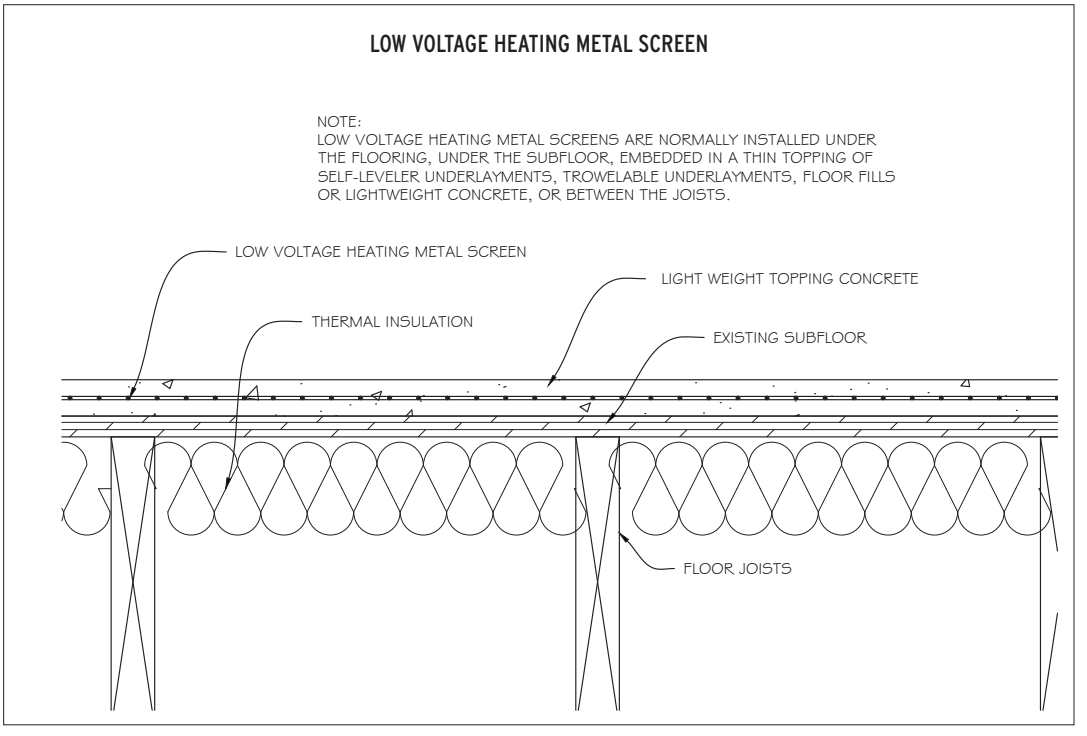
3. **Heating Cable Positioned by Straps or Ties:** The constant-wattage heating cable is held in place by straps, ties, or fixing strips, and embedded in the slab or in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete set above the subfloor or between screeds/sleepers. The heating cable is available in a variety of voltages including low-voltage, 120V, 208V, and 240V versions.



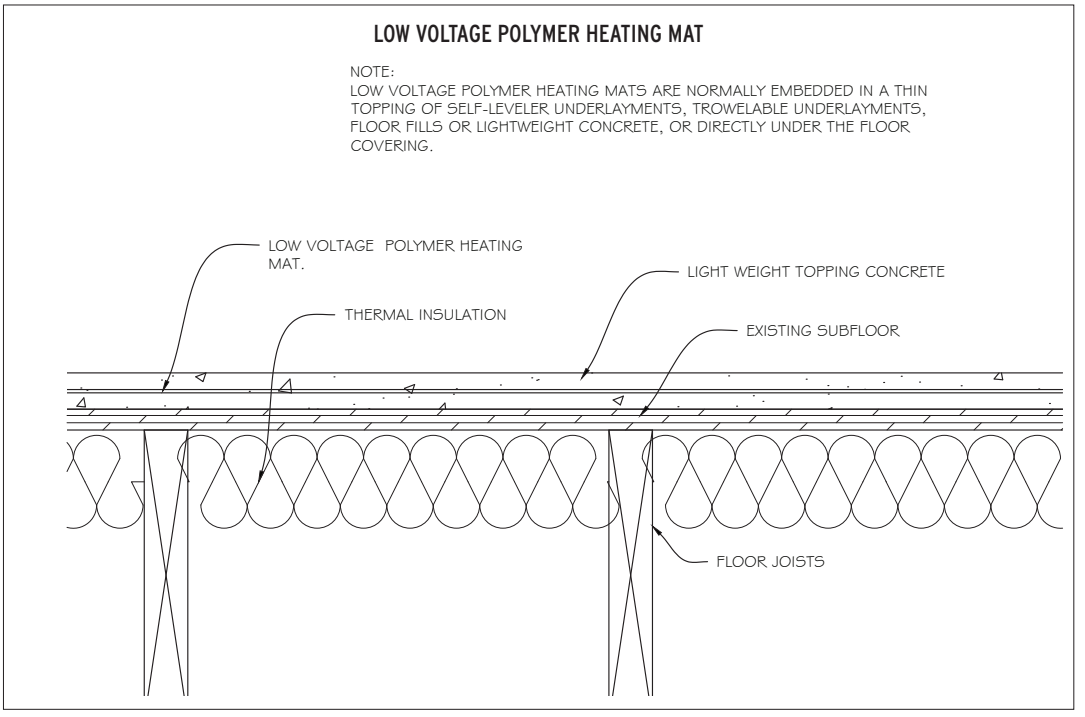
4. **Heating Cable Embedded in Fabric Mat:** Heating cables encased in a fabric carrier mat. The heating mat is embedded in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete set above the subfloor. This product comes in a variety of standard and custom sizes, as well as a variety of voltages including 120V, 208V, and 240V versions.



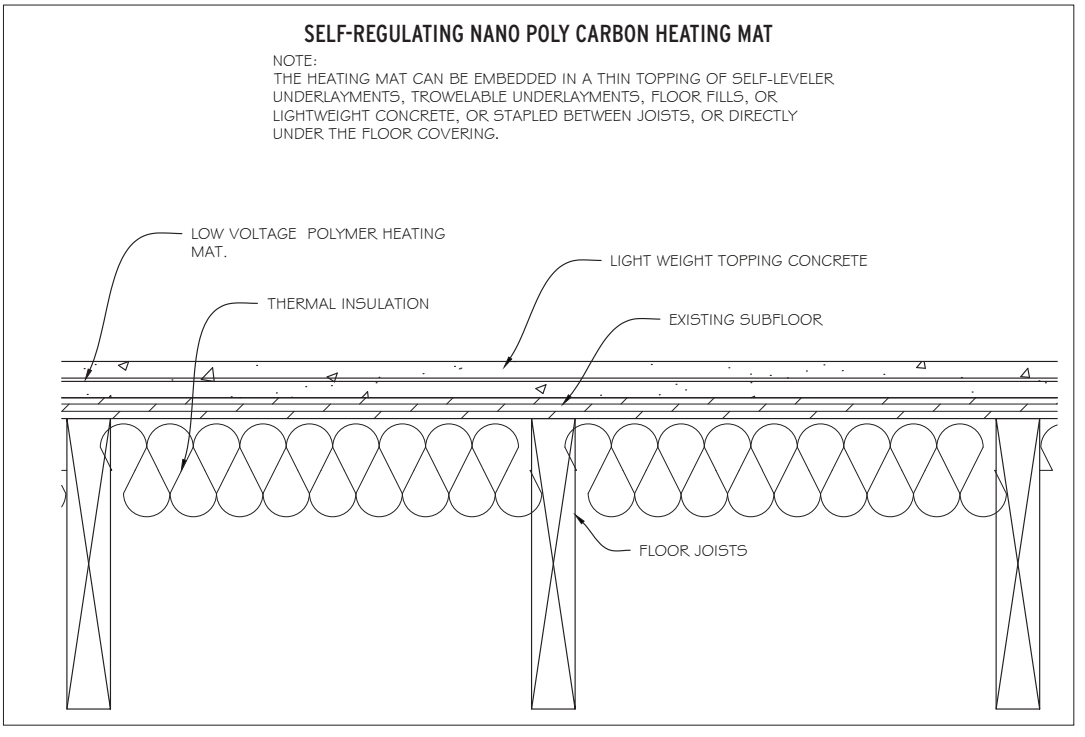
5. **Low-Voltage Heating Metal Screen:**
This mesh heating product is designed to be installed under the flooring, under the subfloor, embedded in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete, or between the joists. The heating mesh can be used in direct nail-down situations (when recommended by the flooring manufacturer). This product comes in low-voltage only.



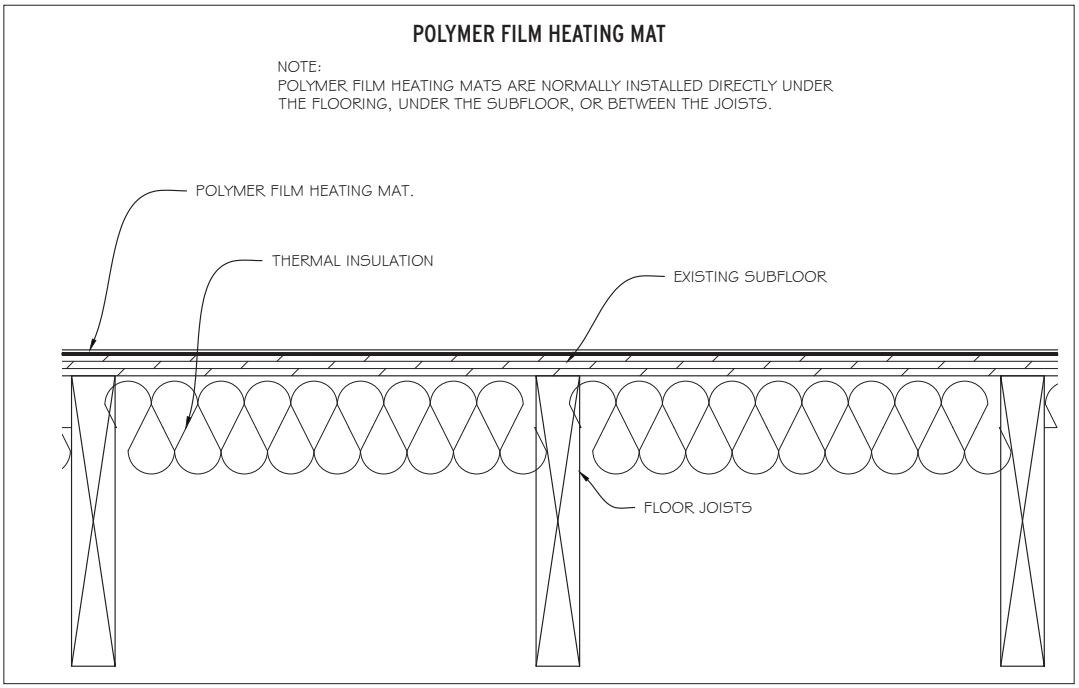
6. **Low-Voltage Polymer Heating Mat:** This mat is made of a semi-conductive polymer and is self-regulating. The heating mat can be embedded in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete, or directly under the floor covering. This product comes in low-voltage only.



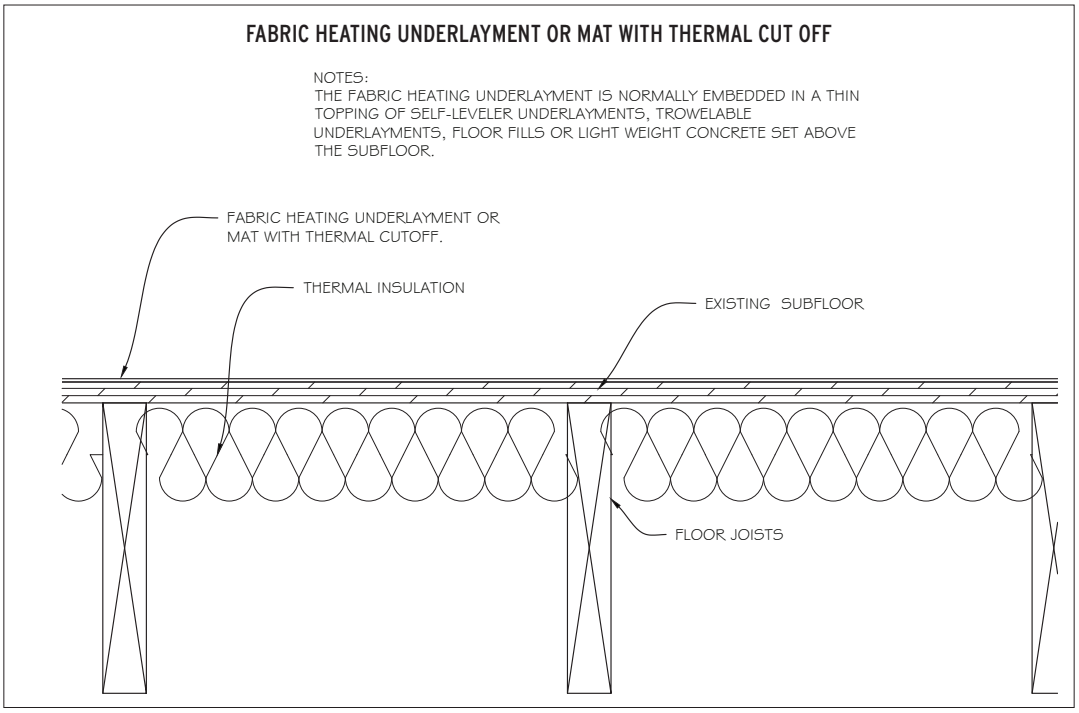
7. **Self-Regulating Nano Poly Carbon Heating Mat:** This mat is made of extruded homogeneous semi-conductive polymer and can be cut to size. Normally low-voltage or powered by solar panels. The heating mat can be embedded in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete, or stapled between joists, or directly under the floor covering.



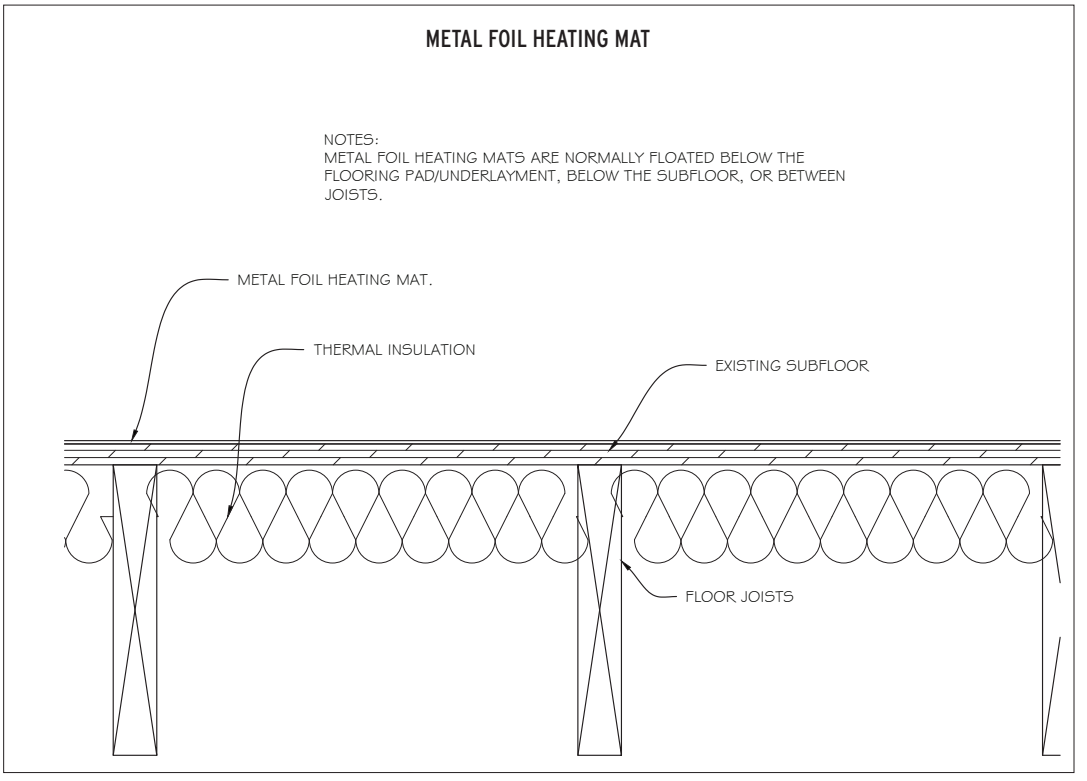
8. **Polymer Film Heating Mat:** These mats consist of a thin and flat printed heater encased between layers of polymer film. The mat is designed for installation directly under the flooring, under the subfloor, or between the joists. The polymer film heating mat comes in a variety of voltages including low-voltage, 120V, 208V, and 240V versions.



9. **Fabric-Heating Underlayment or Mat with Thermal Cut Off:** Thin constant wattage heating element, having thermal-cut-off (TCO) overheat protection is encased between two layers of fabric and/or a breathable underlayment. These systems provide heating, thermal insulation, and noise reduction. These systems are designed to be in direct contact with the wood floor covering. These systems may also be embedded in a thin topping of self-leveler underlayments, trowelable underlayments, floor fills, or lightweight concrete set above the subfloor. This fabric-heating underlayment or mat is offered in a variety of voltages including 120V, 208V, and 240V versions.



10. **Metal Foil Heating Mat:** These products are designed for floating floor installations only. These floor heating products are not embedded, glued down, or glued to. These products are designed to float below the flooring pad/underlayment, below the subfloor, or between joists. This product comes in a variety of voltages including 120V, 208V, and 240V versions.



PART II
Radiant Heating System Requirements

A. Radiant heating systems are designed to either be the sole heating source (floor heating), or a part of a larger heating system (floor warming). Regardless of their intended use, when placed under a wood floor, they must do so without damaging the floor.

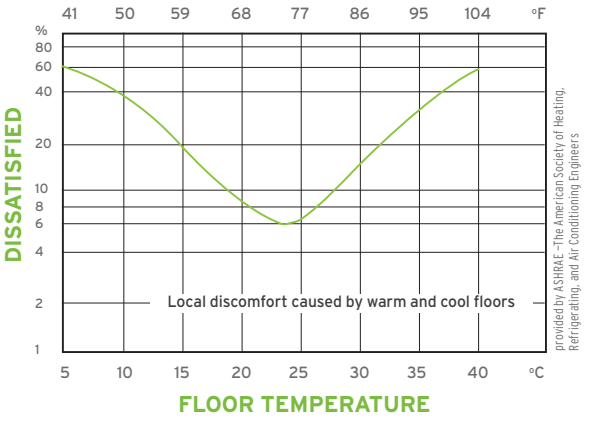
B. To provide an adequate thermal environment for the end-user, many factors must be taken into account, including the size of the room, the construction of the home, R-value of the windows, HVAC systems, the number and age of the occupants, and the interior finishes that may be directly affected by these requirements.

C. The builder, the radiant heating system design engineer, and the radiant heating system installer should be made aware of the type of floor covering being installed over the radiant heating system in order to adequately pair the system with the flooring requirements, based on the facility in which they are being installed. This design coordination should consider whether the heating system is expected to be the sole heating source, or a part of a larger heating system.

D. Radiant cooling systems are never recommended under wood flooring.

E. The radiant heat system design engineer and radiant heating system installer should make available a room-by-room heat-loss calculation based on all of the factors that will affect the heat output of the radiant system. This analysis must establish a maximum operating temperature of the heating system dependent on the floor covering being installed over it.

F. According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), a floor surface temperature that creates optimal human comfort for most people lies somewhere between 70-80°F.



G. Unless otherwise specified by the wood flooring manufacturer, the heat-loss calculations designed for wood flooring installations should restrict the operating temperature of the radiant heat system to never allow the surface of the installed wood floor to exceed 80°F. The entire wood flooring system, including the wood product, the installation method, and the underlayment systems must be taken into account.
   1. Where radiant hydronic heating systems are installed, this heat-loss calculation analysis should establish a maximum heat gain of 20 BTU/hr/sf from the floor heating system, for each room receiving wood flooring. If the ambient conditions of the airspace cannot sufficiently be maintained at 70°F with the radiant heating system operating at a maximum 20 BTU/hr/sf floor load, a supplemental heating system will be necessary.
   2. Where electric radiant heat systems are installed as the sole heating source, the heat-loss calculation analysis should establish a maximum heat gain of 20 BTU/hr/sf from the floor heating system using a maximum 6 watts per sf/hr for each room receiving wood flooring. If the ambient conditions of the airspace cannot sufficiently be maintained at 70°F with the radiant heating system operating at a maximum 20 BTU/hr/sf floor load, a supplemental heating system will be necessary.

H. Separation of heating zones and thermostats, based on flooring type and temperature limitations, is required when multiple floor coverings are being installed over any radiant heating system.

I. The radiant heating system should provide an even distribution of heat to the wood flooring surface. The wood floor surface temperature should vary no more than 3°F at any point within the installed wood floor.

J. In locations where the radiant heating tubing layout becomes bunched together (through hallways or where it emanates to or from the manifold), it will be necessary for the heating system installer to insulate the tubes in these areas of high-density to avoid creating high-density heat situations, which can impact the wood flooring performance.

K. Wood flooring performs best with subtle changes in temperature. The floor should not fluctuate by more than 5°F per day.
   1. For hydronic radiant heating systems, an outdoor reset control (zone reset controls) with high/low temperature settings (to minimize the boiler temperature), along with an in-floor sensor, should be installed with the system to minimize the effects of rapid changes in temperature. These sensors and thermostats allow the heating process to be gradual and based on small incremental increases in relation to the exterior temperature. "Set back" or programmable thermostats could vary room temperature greater than 5°F per day, and should not be used.
   2. For electric radiant heating systems, a thermostat along with an in-floor sensor must be installed with the electric floor heating system to minimize the effects of rapid changes in temperature. It is also recommended to use a thermostat that would limit floor temperature changes to 5°F per day.

L. Items such as area rugs, mattresses, exercise mats, pet beds, bean bags, or other highly insulating products that cover the floor will trap heat and increase the temperature of the floor it is covering, which can result in irreversible damage to any type of floor. When the floor is expected to be covered, the radiant heating design engineer, and the radiant heating installer should calculate and factor-in the R-value of the specific insulating item that will be covering the floor, and make adjustments to the heating output as necessary. The end-user should consider the effects of heat build-up and subsequent flooring damage.

M. All radiant heating systems should be fully operational, regardless of season, for a minimum of 5 days prior to delivery of wood flooring. Keeping the system on helps force out moisture and ensures the system is operational prior to flooring install.
   1. Water-heated (hydronic) radiant-heat systems should be pressure tested, all system controls should be fully operational, and functional operating results should be made available by the system installer.
   2. Electric underfloor systems should be tested for proper operation, and functional operating results documented and made available to the wood flooring installer by the heating system installer.

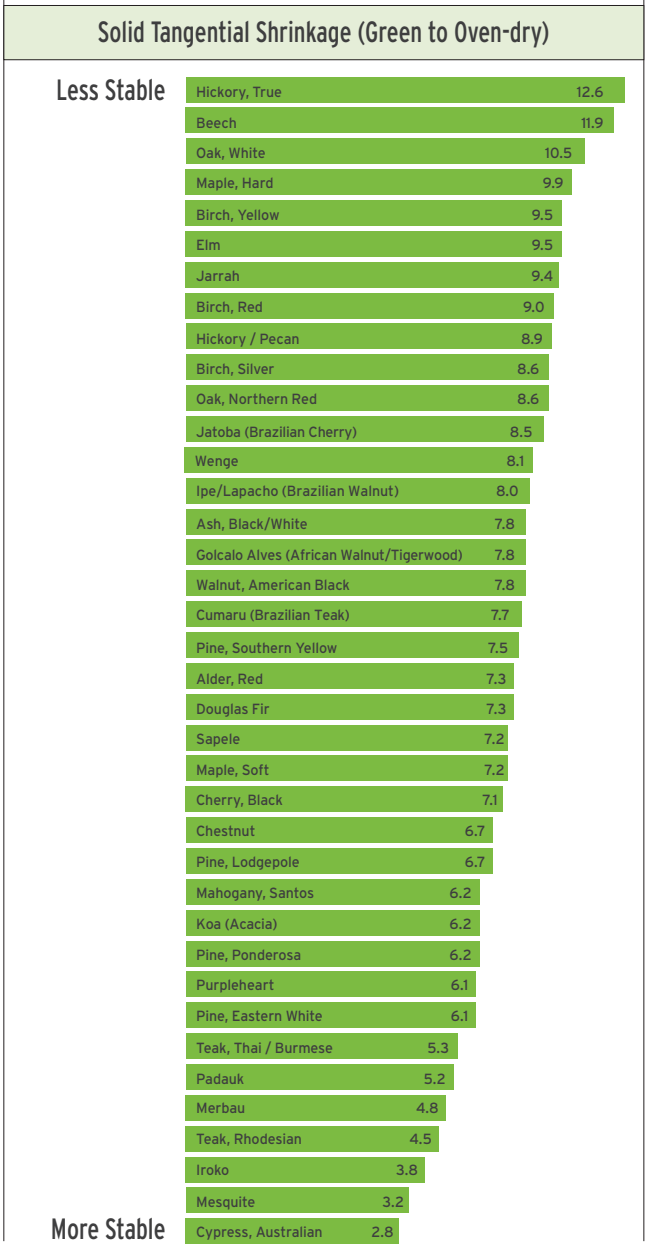
N. The end-user should be made aware of the importance of proper usage of the entire radiant heating system by the radiant heating system design engineer and the radiant heating

system installer as it directly relates to the floor covering installed over it. The wood floor installer should provide maintenance instructions related to the heating and relative humidity requirements of the wood floor to the end-user.

PART III
Wood Flooring Selection over Radiant Heat

A. Most wood flooring can be installed over radiant heat, providing all of the necessary conditions are met.
   1. Successful wood floor installations occur when the radiant heat system design engineer, the radiant heating system installer, the wood flooring installer, and the end-user all communicate and fully understand what is required for the entire flooring system being installed.
   2. This communication should include which type of wood flooring to use, what installation method to use, understanding how this heat source may impact the wood flooring, what precautions to take before-, during- and after-installation, and consistent communication between all parties when any changes take place to any part of the system.

B. The types of wood flooring best suited for under-floor radiant heat systems should be accounted for to ensure long-term performance. The flooring categories directly affecting the dimensional stability of the wood flooring often include:
   1. **Flooring cut:** Wood is a hygroscopic and an anisotropic material, meaning it takes-on and throws-off moisture, and it shrinks and swells differently in each direction, dependent on changes in moisture. How the wood changes dimension is largely influenced by the species characteristics and the way in which the wood is cut from the tree. The way in which it is cut from the tree for solid or sawn flooring is classified as plainsawn, quartersawn, riftsawn, livesawn, or end-grain. Quartersawn and riftsawn wood flooring is more dimensionally stable in width than plainsawn or end-grain wood flooring.
   2. **Flooring width:** Wood changes dimension proportional to the width of the plank. Narrow boards expand and contract less than wider width boards of the same species and cut.
   3. **Flooring type:** Engineered wood flooring is, in general, more dimensionally stable than solid wood flooring. However, not all engineered wood flooring is recommended or appropriate for use over radiant heating systems. Engineered flooring with less-stable wear layer species such as hickory, beech, and maple are not normally best-suited over radiant heat, unless otherwise suggested by the flooring manufacturer. The cut of the wear layer lamina (peeled, sliced, or sawn) can also affect how the floor performs over radiant heat. Follow the flooring manufacturer recommendations as to whether or not each specific product is intended to be used over radiant heat.
   4. Wood flooring manufactured and expected to perform at MC levels higher than 9% or in conditions above 50% RH, should not be used with radiant heating systems unless otherwise recommended by the flooring manufacturer.
   5. **Species**: Both in solid and engineered flooring options, certain species are known for their inherent dimensional stability such as American chestnut, black cherry, black walnut, and others. Less-stable species such as hickory, beech, and maple are less-suitable for use over radiant heat.



C. A supplemental humidity control system is often necessary, and should be specified into any radiant heat wood flooring project, in order to properly support ambient airspace conditions between 30% - 50% RH, or as otherwise required by the wood flooring manufacturer. Supplemental humidification should be present and operational prior to delivery, during and post-installation of the wood flooring.

D. Wood flooring selection should be aligned with the conditions in which it is expected to perform. With the heating source placed directly below the installed wood flooring, the moisture content will forcibly be reduced during the heating season if supplemental humidification is not added.

E. In-floor, or under-floor temperature and humidity data-logging devices are recommended to be installed by the radiant system installer or the flooring contractor, to monitor the conditions in the space after the floor has been placed into service. Placement of these sensors should be determined with the assistance of the radiant heating system installer in order to gain the most-accurate floor temperature readings.

F. The end-user should have a clear understanding of the flooring product, maintenance requirements, humidification systems, data loggers, and the radiant heating system features, limitations, and abilities, to ensure adequate conditions are maintained year-round.

PART IV
Installation Methods over Radiant Heat

Radiant heating systems may be installed within, above, or below any substrate. Substrates may include concrete, wood, screeds/sleepers or a combination of any of these. The type of flooring specified, the flooring manufacturer requirements, and the subflooring system will dictate the flooring installation method.

A. Nail-Down over Wood Panel Subfloor
   1. Refer to the Nail-Down Installation chapter for details on proper installation methods, unless otherwise directed by the flooring manufacturer.
   2. Subfloor surface temperature should not exceed 80ºF at the time of installation.
   3. A class II vapor retarder should be placed over a wood subfloor and below the wood flooring when being installed over an unconditioned space (refer to the Underlayments: Moisture Control chapter). Do not use asphalt- or bitumen-type vapor retarders over radiant heat systems.
   4. Where a wood panel subfloor has been installed over a concrete slab, install a Class 1 impermeable vapor retarder over the slab, and under the wood panel subfloor in all on- and below-grade applications, and when calcium chloride readings are greater than 3 pounds, relative humidity readings are greater than 80%, or calcium carbide readings are greater than 2.5%.
   5. Fastener length should be taken into account to avoid penetration of the vapor retarder.
   6. Avoid penetration of the heating tubes/elements with wood flooring fasteners. Length and placement of fasteners must be assessed and addressed prior to and during the install.
   7. When the required fastener schedule cannot be followed due to the type of radiant heating system being used, an alternative installation method may be necessary. This may include any of the following:
      a. Nail-assisted glue-down (the use of an elastomeric adhesive in conjunction with the mechanical fasteners is recommended any time fastener length, fastener schedule, or any portion of the installation would benefit from additional hold-power).
      b. Full spread glue-down.
      c. Floating installation methods.

B. Direct Nail to Screeds/Sleepers
   1. Refer to the Screeds/Sleepers chapter for proper nail-down installation methods over screeds/sleepers, unless otherwise directed by the flooring manufacturer.
   2. The subfloor surface temperature should never exceed 80ºF at the time of installation.
   3. A vapor retarder should be installed below the screeds/sleepers. Do not use asphalt- or bitumen-type vapor retarders over radiant heat systems.

4. Hydronic tubing and electric elements typically are installed into the channels between the screeds/sleepers, and then embedded in a gypsum or lightweight concrete mix, which is poured even with the top of the screed/sleeper. This should present a flat surface that minimizes any air space between the subfloor and the flooring. The heating tubes/elements should be submerged enough below the surface of the screeds/sleepers that the wood flooring does not come into direct contact with the heating tubes/elements.
5. When nailing down a wood floor, consider the screed/sleeper placement in comparison to the angle of the fastener to avoid penetrating into any radiant heating tubes or elements.
6. When the required fastener schedule cannot be followed due to the placement of the screeds/sleepers, an alternative installation method may be necessary. This may include any of the following:
    a. Nail-assisted glue-down (the use of an elastomeric adhesive in conjunction with the mechanical fasteners is recommended any time fastener length, fastener schedule, or any portion of the installation would benefit from additional hold-power).
    b. Full spread glue-down.
    c. Floating installation methods.

C. Glue-Down
1. Refer to the Glue-Down Installation chapter for details on proper installation methods, unless otherwise directed by the flooring manufacturer.
2. The heat will need to be reduced or even turned off during installation of the flooring to avoid premature drying and skinning-over of the adhesive. Check with the adhesive manufacturer for minimum/maximum subfloor temperature limitations during the installation.
3. The subfloor surface temperature should never exceed 80°F at the time of installation.
4. Do not fill the channels containing radiant tubing with adhesive.
5. Install a Class 1 impermeable vapor retarder over the slab in all on- and below-grade applications, and when calcium chloride readings are greater than 3 pounds, relative humidity readings are greater than 80%, or calcium carbide readings are greater than 2.5%. Use an adhesive and moisture control system suitable for the flooring being installed and for the radiant heating system it is being installed over. Do not use asphalt- or bitumen-type vapor retarders over radiant heat systems.
6. Note: When using the in-situ relative humidity tests (ASTM F2170), be extremely cautious when drilling into the slab where hydronic tubing or electric heating elements have been embedded, so as to not damage or puncture the heating system. Use of infrared cameras or heat-detecting devices may assist in identifying a safe location for testing.

D. Floating Engineered
1. Refer to the Floating Installation chapter for details on proper installation methods, unless otherwise directed by the flooring manufacturer.
2. Subfloor surface temperature should never exceed 80°F at the time of installation.
3. The insulating properties (R-values) of flooring underlayment pads vary, and may compromise the radiant heat efficiency. The pad R-value should be taken into account during the design and specification of the heating system. Do not use asphalt- or bitumen-type vapor retarders over radiant heat systems.
4. For edge-glued floors, ensure the glue recommended by the flooring manufacturer is approved for use with radiant heat.

E. Direct-Nail through Low-Voltage Radiant Systems
1. Refer to the radiant heating manufacturer installation instructions prior to nailing through any electric radiant heating system.
2. Refer to the flooring manufacturer for proper installation methods over these types of heating systems.

SUBSTRATES: Existing Flooring

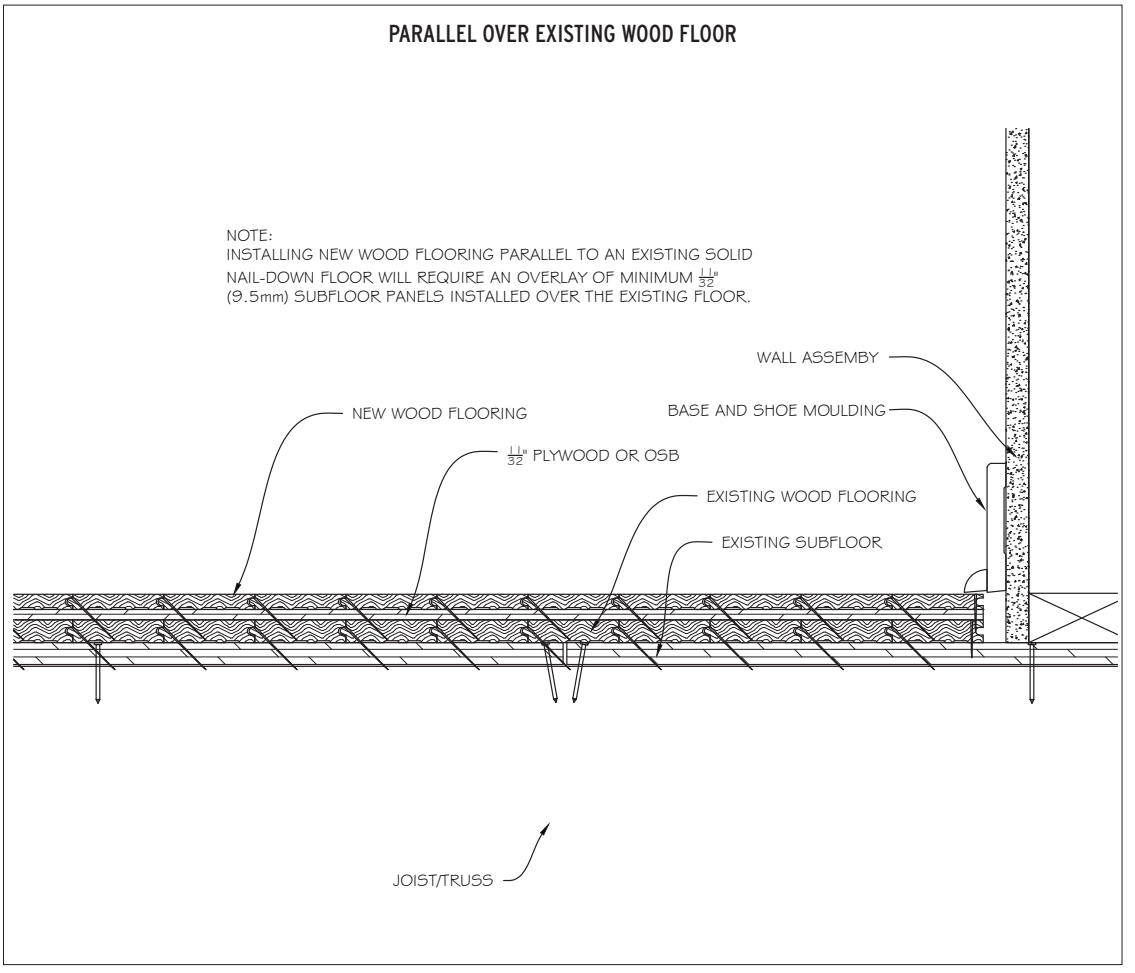
Installation over existing floorcoverings is not uncommon, and is often necessary. In situations where asbestos or lead are present in the home, disturbing the existing floorcovering may not always be the best option. Wood subflooring may be installed over an existing floor covering as an alternative (refer to the Wood Subfloors over Concrete chapter for direction).

PART I
Existing Wood Floors

A. For glue-down, nail-down, or floating installation methods, follow the installation method as detailed in the applicable chapter.

B. Follow all involved manufacturer's instructions for proper installation methods over existing flooring.

C. Installing new wood flooring parallel to an existing solid nail-down wood floor will require an overlay of minimum 11/32" (9.5mm) subfloor panels installed over the existing floor. Refer to the Double-Layer Subfloor Systems section in the Wood Subfloors chapter for installation processes.

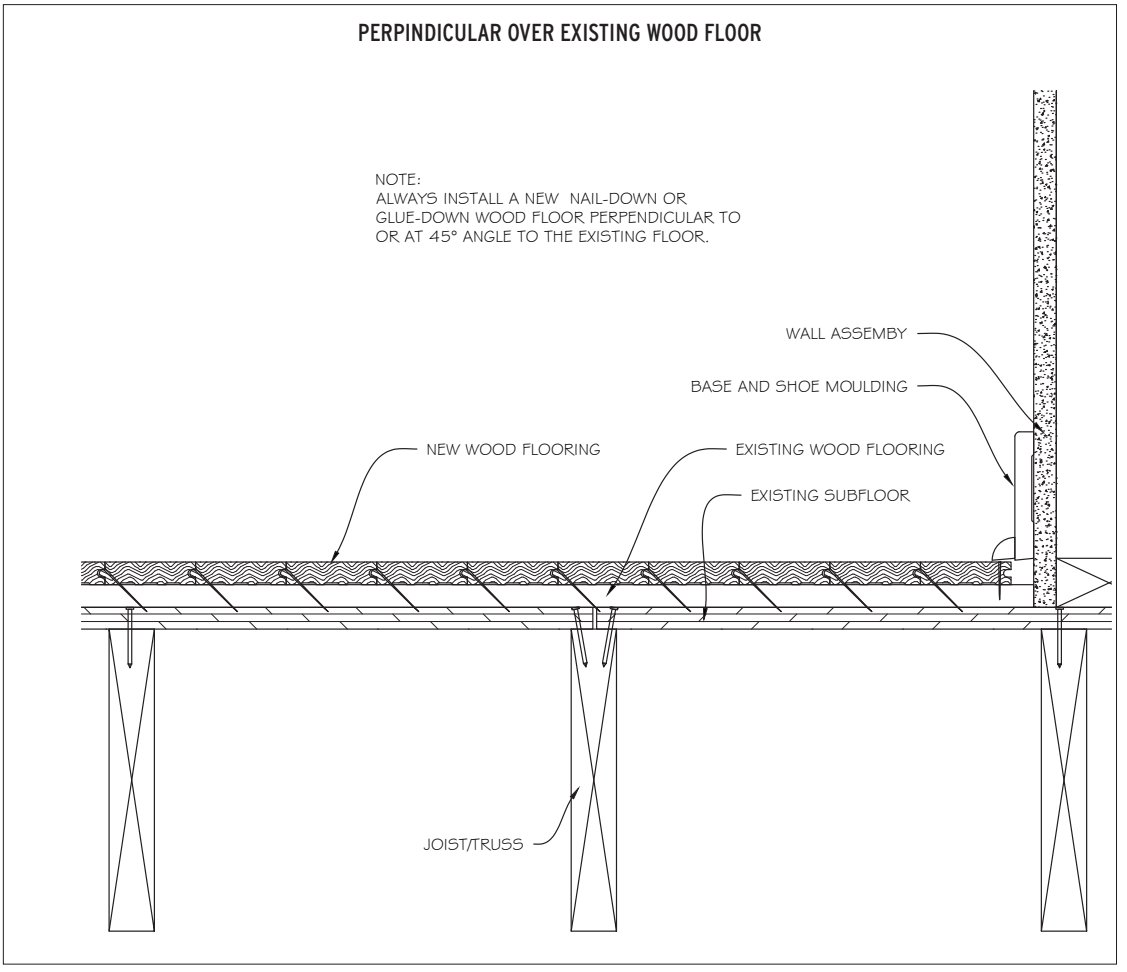


D. The existing floor should be flat to within 1/4″ in 10′ or 3/16″ in 6′.
   1. Sand off old finish and high spots in the existing floor. Repair, replace, or refasten loose flooring as necessary. Caution: Do not sand any surfaces containing lead finishes or paints, or containing asbestos. Check applicable local and federal EPA and OSHA regulations. (Refer to the Safety chapter for more information.)

E. The existing wood floor and the new wood floor should be within 2% MC for plank (≥3″ width) flooring, and within 4% MC for strip (<3″ width) flooring, of each other.

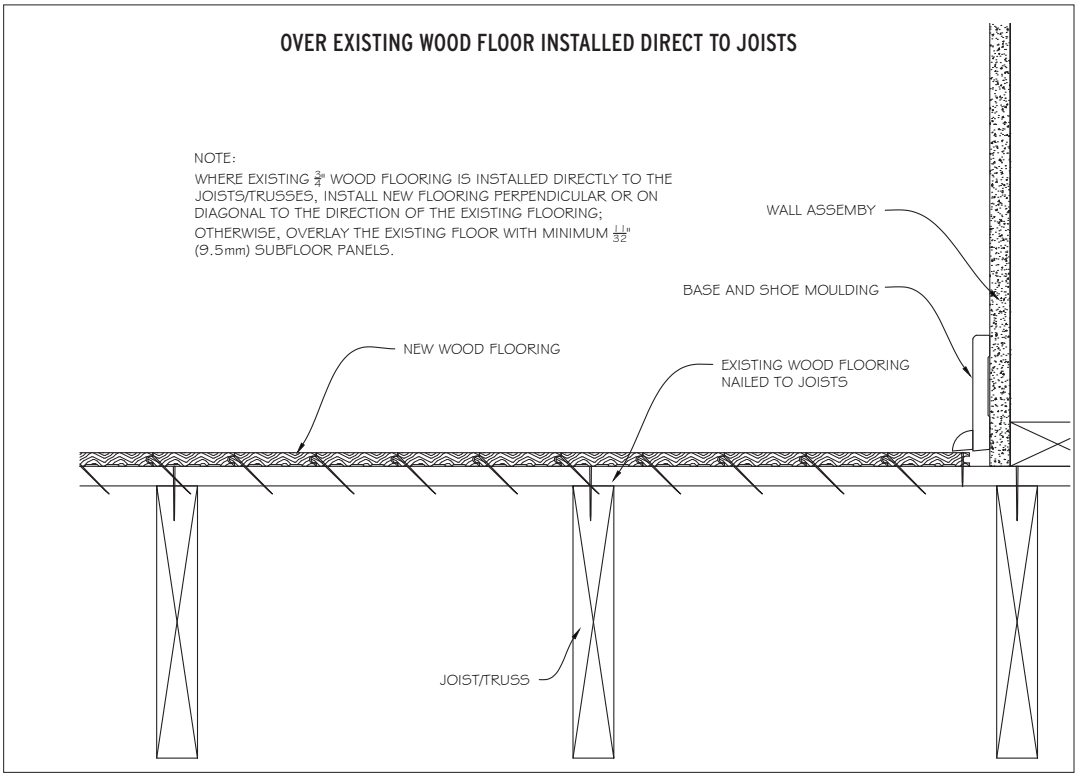
F. Always install a new nail-down or glue-down wood floor perpendicular to or on diagonal to the existing floor.

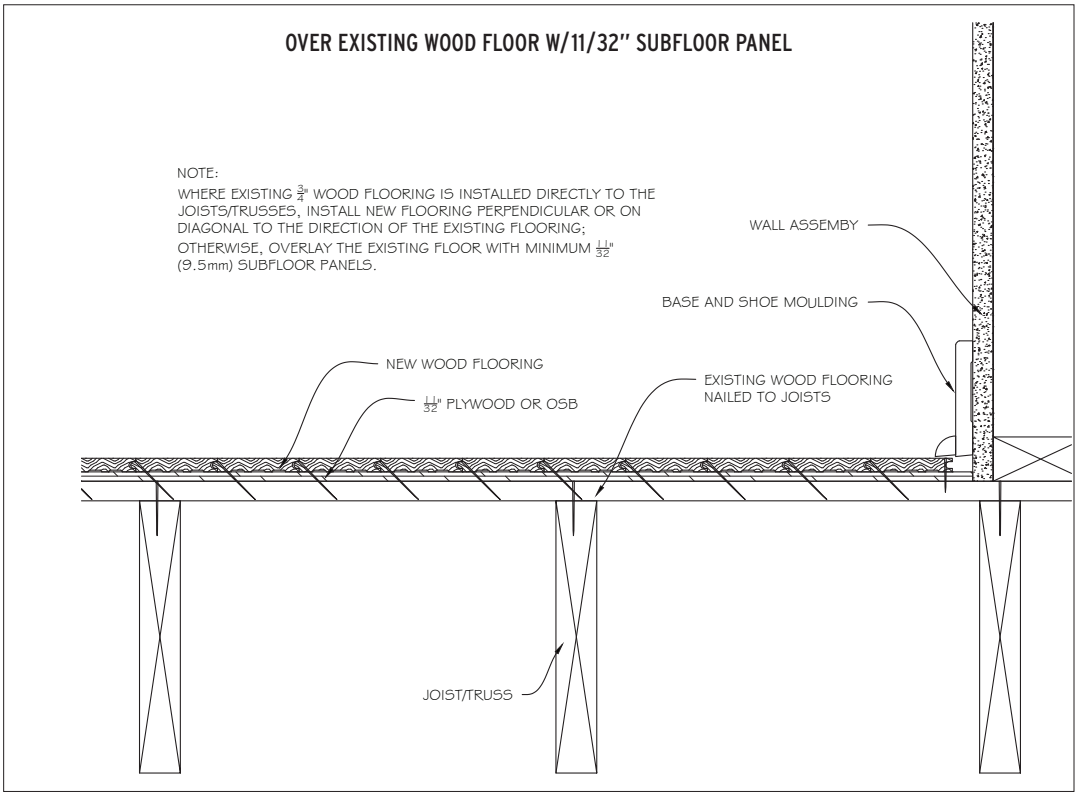
PERPINDICULAR OVER EXISTING WOOD FLOOR



G. When floating a new wood floor over an existing wood floor, the direction of the new floor does not matter.

H. Where the existing ¾" wood flooring is installed directly to the joists/trusses, install new flooring perpendicular or on diagonal to the direction of the existing flooring; otherwise, overlay the existing floor with minimum 11/32" (9.5mm) subfloor panels.





I. When installing a new floor over an existing glue-down floor, glue the new wood floor directly to the existing wood floor. If the thickness of the floor will allow, you can nail the new floor to the existing floor.

J. Never install a new wood floor over an existing floating wood floor.

PART II
Existing Vinyl, Resilient Tile, Cork Flooring and Linoleum

A. For glue-down, nail-down, or floating installations, follow the installation method as detailed in the applicable chapter.

B. Follow all involved manufacturer's instructions for proper installation methods over existing flooring.

C. The existing floor should be flat to within 3/16" in 10' or 1/8" in 6'.

D. Make sure the floor covering materials are well-bonded to the subfloor/underlayment with full-spread adhesive and are no more than two layers thick, not to exceed 3/16 (5 mm). Remove any loose areas.

E. The flooring fastener must penetrate the underlying wood subfloor by a minimum of 5/8".

F. With approved wood/wood composite subfloors, if vinyl or tiles are loose, broken, or in poor condition, overlay the floor with a minimum 11/32" (9.5 mm) underlayment directly over the flooring materials.

G. For glue-down installations, clean the flooring materials as necessary to create a good adhesive bond. Test for adequate adhesive bond and compatibility prior to installation.

H. PVA adhesives are not recommended over vinyl, resilient tile, cork, or linoleum flooring.

I. Other types of adhesives may require the use of a primer or vinyl blocker when installing over sheet vinyl, or vinyl and cork flooring. Follow the adhesive manufacturer's instructions.

J. Test for adequate adhesive bond prior to the installation.

K. If a maintenance material is present on the floor covering or a gloss is present, follow the adhesive manufacturer's instructions on compatibility and removal of the maintenance product. (NOTE: Do not sand any resilient products. They may contain asbestos fibers, which may be harmful.)

L. Cork floors must be well-bonded to the substrate and have all sealers and surface treatments removed before installation begins. Always check for adequate adhesive bond.

M. Never install a new wood floor over an existing floating floor.

PART III
Existing Ceramic, Terrazzo, Slate and Marble

A. Use only glue-down or floating installations methods over these types of substrates.

B. Follow the instructions in the Concrete Subfloors chapter for more-detail on subfloor requirements.

C. Follow the adhesive manufacturer's instructions for proper installation methods over existing ceramic, terrazzo, slate, or marble.

D. The existing floor should be flat to within 3/16" in 10' or 1/8" in 6'.

E. Remove any loose grout or tile.

F. All grout joints and broken corners that exceed 3/16 (5 mm) must be filled with a cementitious leveling compound in conjunction with an appropriate primer for adhesion.

G. All compounds used must have adequate dry time prior to new floor installation.

H. The surface should be thoroughly cleaned, and all exiting sealers and surface treatments removed.

I. Follow the Glue-Down Installation Methods chapter for installation instructions.

J. The surface will likely require abrasion or scarification to create a good bonding surface for the wood flooring adhesive. Caution: Do not sand any surfaces containing lead finishes or paints, or containing asbestos. Check applicable local and federal EPA and OSHA regulations. (Refer to the Safety chapter for more information.)

K. Test for adequate adhesive bond and compatibility prior to the installation.

L. Wood subflooring may be installed over an existing floor covering as an alternative (refer to the Wood Subfloors over Concrete chapter for more information).

PART IV
Existing Carpet

A. Never install a wood floor over any type of carpet or carpet pad.