

Glue-Down and Floating Installation Instructions

Prefinished Engineered 5/16" x 3" or 5/16" x 6 1/4" (Length – 48" with occasional 24" pieces)

Thank you for choosing BR-111™ Exotic Hardwood Flooring. Protect your investment; thoroughly review and adhere to the following installation instructions.

Please note that these are instructions for the experienced hardwood flooring installer. For more detailed information on the basics of installing hardwood flooring, please contact the National Wood Flooring Association (NWFA) at 1-800-422-4556 or visit www.nwfa.org

Installer/Owner Responsibility

Hardwood flooring is a natural product; therefore defects in the flooring can occur in the manufacturing process or naturally as a characteristic of the wood. BR-111™ 5/16" Engineered hardwood floors are manufactured within accepted industry standards, allowing for up to 5% defective product (may be natural or manufacturing related) based on the original hardwood flooring purchase order. Order 5% additional flooring product above actual square footage requirements to allow for cutting and grading of material.

Prior to installation, the installer and owner assumes all responsibility for final inspection and quality of the product.

Flooring should be carefully examined for finish and quality. Do not install hardwood flooring that is unacceptable; contact seller immediately. Final grade, manufacturing, finish quality checks and final approval of the product is the sole responsibility of the owner and installer. The installer must exercise good judgment and common sense before and during installation. Flooring with obvious defects or imperfections should be trimmed and used in hidden places or discarded. Once installed, the floor is considered as having been accepted by the owner and installer. If any floor is installed with obvious defects or imperfections at time of installation, BR-111™ will NOT in any case be liable for installer's lack of judgment, quality of installation, labor, installation, and associated costs.

The installer must determine that the job-site environment and sub-floor surfaces meet applicable construction and material industry standards. BR-111™ declines any responsibility for job failure resulting from deficiencies associated with sub-floor or job-site environment.

The installer must hold out or cut off defective flooring material during installation. Filler or putty stick may be used to correct minor flooring defects during installation and is considered a normal procedure.

The installer is commissioned and contracted by the owner. Owners should choose their installer carefully by checking references and previous job experience, etc. The cheapest is not always the best. Installing hardwood flooring is a highly skilled operation. The contract to install is between the owner and the installer. BR-111™ is in no way responsible for the owner's choice of installer or any failure by the installer to satisfy the owner.

Basic Tools and Accessories

- Rubber mallet
- 3-M Blue Tape
- Broom
- Chalk line
- Pencil
- Tape measure
- Table saw or band saw
- Jamb saw or hand saw
- Hammer
- Calcium Chloride Test (may be needed)
- Leading brand of hardwood flooring cleaner
- Quality moisture meter with manufacturer's relevant exotic species calibration figures

Do not nail or staple this product.

Additional Tools for Glue-Down Installation

- **Warranted Moisture Sealer Products**
The following are sealer and glue systems that offer a warranty from their manufacturers for sub-floor moisture intrusion. BR-111 highly recommends the use of these products when gluing down the 5/16" Engineered hardwood flooring to concrete slabs where moisture tests (see step 5 Testing for Moisture) indicate moisture contents and emissions beyond recommended levels.
- **Sealers** (Sub-floor moisture intrusion warranty provided by their manufacturer)
 - **Franklin Titebond 531 Epoxy Moisture Control System** used to seal the sub-floor along with the use of a Franklin Moisture Cured Urethane Adhesive. See website www.franklinflooring.com for details.
 - **Bostik MVP (Moisture Vapor Protection)** used to seal the sub-floor along with the use of a Bostik Moisture Cured Urethane Adhesive. See website

www.bostik-us.com for details.

- **Sika Primer** used to seal the sub-floor along with the use of Sika T55 Adhesive. See website www.sikausa.com for details.
- **Dri Tac - MCS 7000 Concrete Moisture Control** used to seal the sub-floor along with the use of a Dri Tac 7600 Moisture Cured Urethane Adhesive. See website www.dritac.com for details.

There are many leading brand concrete sealer and glue systems that offer moisture vapor protection and warranties. Always check with the manufacturer of the sealer system to investigate what protection and warranties are offered. Remember your moisture protection warranty comes from the sealer manufacturer. **ALL BR-111 PRODUCTS REQUIRE THE USE OF A MOISTURE CURED URETHANE ADHESIVE. DO NOT USE WATER BASED ADHESIVES WITH BR-111 GLUE-DOWN PRODUCTS.**

Other Approved Urethane-Based Adhesives that provide a BOND WARRANTY ONLY

(This bond warranty is supplied by their manufacturer. No moisture protection warranties are offered by any of the adhesive products listed below.)

- BR-111's StrateStuff Urethane Adhesive
- Franklin 811 or Franklin 811 Plus Urethane Adhesive
- Bostik's Best, Bostik Fast Tack, Bostik's BST Urethane
- DriTac 7600
- Parabond 4002
- Sika Bond T55

Other Tools Required for Glue-Down

- **Trowel**
Correct trowel as requested by glue manufacturer for 5/16" Engineered hardwood flooring product. BR-111 StrateStuff requires a 1/4" x 1/8" x 1/4" square notch trowel. Always confirm with adhesive manufacturers recommendations.
- **Urethane Adhesive Cleaner**
Many of the leading glue manufacturers offer their own adhesive cleaner. Please use them. If none is available, a light application of mineral spirits to a terry cloth will help.
- **3-M Blue Tape**

DO NOT USE WATER-BASED ADHESIVES WITH THIS PRODUCT.

Additional tools for floating installation

- Pull Tool or Crowbar

- Floating floor pad with built in moisture barrier foam with moisture barrier 2 in 1 or 3 in 1
- Tapping Block (used with care)
- 3-M Blue Tape
- Glue — Franklin Titebond II or Equivalent PVA-2 floating floor (poly vinyl acetate) adhesive

Step 1: Pre-Installation

Site Inspection

Prior to installing hardwood floors, the building must be structurally complete and enclosed, including installation of exterior doors and windows. Concrete, masonry, drywall, and paint must also be complete, allowing adequate drying time as to not raise moisture content within the building.

HVAC systems must be fully operational at least 14 days prior to flooring installation, maintaining a consistent room temperature between 60-75 degrees Fahrenheit and relative humidity between 35-55%. This not only stabilizes the building's interior environment, but also is essential when acclimating hardwood flooring to the job-site.

Exterior grading, directing drainage away from the structure, as well as gutters and down-spouts should also be completed. Floors may be installed on, above, or below grade level and are not recommended in full bathrooms.

It is essential that basements and crawl spaces are dry. Crawl spaces must be a minimum of 24" from the ground to underside of joists. A vapor barrier must be established in crawl spaces using 6 mil polyethylene (poly) film with joints overlapped and taped.

During the final pre-installation inspection, sub-floors must be checked for moisture content using the appropriate metering device for wood and/or concrete.

Step 2: Equalizing Hardwood Flooring

Wood is a porous material with a natural cellular structure that expands and contracts depending on the amount of relative humidity present in the surrounding atmosphere. Equalizing moisture content to the job-site equilibrium point before installation is paramount to stabilizing movement after installation.

Handle and unload hardwood flooring with care and stored within the environmentally controlled site in which it is expected to perform. Flooring stored upon "on-grade" concrete floors

should be elevated at least four inches to allow air circulation under cartons. Hardwood flooring must acclimate for as long as necessary to meet minimum installation requirements for moisture content. Using the equilibrium moisture content chart below, determine the proper moisture content for the installation. Always use a moisture meter to determine where the flooring and present job-site conditions are in relation to the projected final equilibrium point taking into account seasonal changes.

Monitor the flooring and job-site conditions as they acclimate. If the wood is neither gaining nor losing moisture, an equilibrium condition has been reached.

NOTE: Equilibrium points vary dramatically throughout the country, from the dry desert areas of the Southwest to moist areas along the Gulf of Mexico. In addition, a wide range of relative humidity can be experienced between individual job-sites within the same basic locale. Different heating/air conditioning systems can also dramatically alter on-site relative humidity. As a result, no one fixed moisture content is right for all situations, and it is up to the individual installer to establish the proper moisture content for each installation.

Additional information regarding equalizing exotic hardwood flooring to specific geographic regions is available upon request, or may be obtained from our reference manual posted on-line at www.br111.com.

Step 3: Recommended Sub-Flooring

Preferred

3/4" (19mm) CDX Grade Plywood or 3/4" (23/32") OSB PS2
Rated Underlayment with a minimum 40 lbs. density

Minimum

5/8" (15mm) CDX Grade Plywood, existing wood flooring, 3/4" Chip, Waferboard, or Particleboard with a minimum 40 lbs. density underlayment grade.

- Concrete Slabs
- Cork (Acoustic)
- Acoustic Concrete
- Ceramic, Terrazzo, Slate, Marble
- Resilient Tile or Vinyl

THIS PRODUCT IS DESIGNED FOR GLUE-DOWN OR FLOATING INSTALLATIONS ONLY.

Step 4: Sub-Floor Preparation

All Sub-floors Must Be:

- Dry and free of wax, paint, oil, and debris. Replace any water-damaged or delaminated sub-flooring or underlayments. Scrape smooth and sweep prior to installation.
- Level/flat within 3/16" over 10' and/or 1/8" over 6'. If sub-floor is concrete and a leveling compound is needed, use Portland based leveling compounds such as Parabond or Ardex. Follow the manufacturer's recommendation for applying the leveling compound. Any area containing the leveling compound must be completely dry before proceeding with the installation of the wood floor. If sub-floor is plywood or equivalent, high areas or joints can be sanded flat.

Equilibrium Moisture Content Chart

Temp. Relative Humidity, Percent

	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	98
30° F	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3	26.9
40° F	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3	26.9
50° F	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3	26.9
60° F	1.3	2.5	3.6	4.6	5.4	6.2	7.0	7.8	8.6	9.4	10.2	11.1	12.1	13.3	14.6	16.2	18.2	20.7	24.1	26.8
70° F	1.3	2.5	3.5	4.5	5.4	6.2	6.9	7.7	8.5	9.2	10.1	11.0	12.0	13.1	14.4	16.0	17.9	20.5	23.9	26.6
80° F	1.3	2.4	3.5	4.4	5.3	6.1	6.8	7.6	8.3	9.1	9.9	10.8	11.7	12.9	14.2	15.7	17.7	20.2	23.6	26.0
90° F	1.2	2.3	3.4	4.3	5.1	5.9	6.7	7.4	8.1	8.9	9.7	10.5	11.5	12.6	13.9	15.4	17.3	19.8	23.3	26.0
100° F	1.2	2.3	3.3	4.2	5.0	5.8	6.5	7.2	7.9	8.7	9.5	10.3	11.2	12.3	13.6	15.1	17.0	19.5	22.9	25.6

From the U.S. Dept. of Agriculture "Wood Handbook — Wood as an Engineering Material"

- If plywood or equivalent, sub-floor must be structurally sound prior to installation. Sub-floor must be properly secured with nails or screws every 6 inches along joists to reduce the possibility of squeaking after final installation.
- Appropriate moisture tests must be performed as outlined in the "Step 5: Testing for Moisture Content" section listed below.

Step 5: Testing For Moisture Content

For Wood and Other Sub-Floors Types

Using a quality moisture meter, measure the moisture content of both the sub-floor and the hardwood flooring. **Sub-floors must not exceed 12% moisture content and the difference between sub-floor and hardwood flooring cannot exceed 4%.** If sub-floors exceed this amount, an effort should be made to locate and eliminate the source of moisture before further installation.

For Concrete Sub-Floors

Concrete sub-floors should always be checked for moisture content prior to the installation of wood flooring. Please note that these tests do not guarantee a dry concrete slab year round. The two most common moisture tests include:

- **Calcium Chloride Test**
Moisture transfer should not exceed 3 lbs/1000 square feet with this test. One test must be performed every 250 square feet. Calcium chloride tests can be found in flooring retail stores or retail websites on the internet such as www.taylorlortools.com or www.moisturetestkit.com 1-888-216-TEST (8378).
- **Tramex Concrete Moisture Encounter Meter**
Moisture readings using a metering device should not exceed 4.5 on the upper scale (www.tramexltd.com).

Step 6: Moisture Barrier Systems

The following moisture barrier systems are recommended. They carry a warranty from their manufacturer.

- **Franklinwww.franklinflooring.com**
– Tech Services: 1-800-669-4583
- **Bostik-Findley....www.bostik-us.com**
– Tech Services: 1-800-523-6530
- **Sika Primer...www.sikausa.com**
– Tech Services: 1-800-933-SIKA
- **Dri Tac....www.dritac.com**
– Tech Services: 1-800-394-9310

Please see the above websites and product labels and literature for full details.

The above sealer systems may require some form of testing of the concrete sub-floor (i.e. Calcium Chloride Test).

PLEASE REMEMBER THAT YOUR WARRANTY AGAINST MOISTURE VAPOR TRANSMISSION COMES FROM THE MANUFACTURER OF THE SEALER. Before use of any of these sealer/adhesive systems please check with their manufacturer regarding limitations warranties and installation instructions.

Step 7: Preparation For Specific Sub-Floor Types

Sub-Floor Type: Concrete Slabs

Glue-Down Application — BR-111™ 5/16" Engineered can be glued directly to high compression strength concrete slabs or floated using the appropriate adhesive. BR-111™ recommends a moisture cured urethane adhesive.

All concrete sub-floors must be tested for moisture content, especially adjacent to exterior walls and plumbing fixtures. Visual checks are not acceptable. Please refer to the "Step 5: Testing for Moisture Content" section.

Floating Application — Make sure sub-floor is level. A moisture barrier is required along with the appropriate foam padding or 2 in 1 Pad may be used. Perform appropriate moisture tests.

Sub-Floor Type: Acoustic Concrete

Glue-Down Application — Acoustic concrete sub-floors must have a minimum compressive strength of 2500 PSI. Because acoustic concrete contains large quantities of gypsum, the surface must first be coated with a primer/surface hardener as recommended by the concrete manufacturer. Perform appropriate moisture tests.

Floating Application — Make sure sub-floor is level. A moisture barrier is required along with the appropriate foam padding or 2 in 1 Pad may be used. Perform appropriate moisture tests.

Sub-Floor Type: Plywood (or equivalent) Over Concrete

Glue-Down Application — A suitable moisture barrier must be established followed by installation of 3/4" (preferred) plywood or equivalent (see "Recommend Sub-Flooring" section).

Allow 1/2" expansion space with the plywood (or equivalent) around all vertical objects and sub-floor panels should be spaced 1/8" apart to allow for expansion. Using pneumatic or power-actuated fasteners, attach sub-flooring to concrete with a minimum of one fastener per square foot. Perform appropriate moisture tests.

Floating Application — Make sure sub-floor is level. A moisture barrier is required along with the appropriate foam padding or 2 in 1 Pad may be used. Perform appropriate moisture tests.

Sub-Floor Type: Plywood (or equivalent) Over Wood Structural Panel

Glue-Down Application — In glue-down applications, a moisture barrier is not required unless moisture readings from the sub-floor are at unacceptable levels (please refer to "Step 5: Testing for Moisture Content").

Minimum thickness sub-floor material recommendations are satisfactory for 16" on center joist spacing. Thicker sub-floor recommendations will allow up to 19.2" joist spacing. When joist spacing is greater than 19.2" on center, flooring will exhibit minimum performance. Minimum performance may result in movement, gaps, and/or noises. A second layer of sub-flooring material bringing the overall thickness to 1" – 1 1/8", will provide optimum results when joist spacing exceeds 19.2" on center. Hardwood flooring should, whenever possible, be installed perpendicular to flooring joists. Perform appropriate moisture tests.

Floating Application — Make sure sub-floor is level. A moisture barrier is required along with the appropriate foam padding or 2 in 1 Pad may be used. Perform appropriate moisture tests.

Sub-Floor Type: Resilient Tile or Resilient Sheet Vinyl

Glue-Down Application — Vinyl or tile must be in fair condition, level, and permanently bonded to the sub-floor with full spread adhesive. Do not glue-down hardwood floors on resilient floors that exceed two layers. Clean surface thoroughly with a good quality household detergent and de-gloss flooring as necessary to create a good adhesive bond using an abrasive pad. If necessary, remove wax coating when present on vinyl, using an appropriate stripper. Perform appropriate moisture tests.

Floating Application — Vinyl or tile must be in fair condition, level, and permanently bonded to the sub-floor with full spread adhesive. Perform appropriate moisture tests.

Sub-Floor Type: Cork (Acoustic)

Glue-Down Only Application — Make sure cork is level and permanently bonded to the sub-floor with full spread moisture

cured urethane adhesive. The minimum density required for cork is 11.4 lbs./cubic foot; maximum density should not exceed 13 lbs./cubic foot. The cork should be no more than 1/4" thick and constructed of pure cork with polyurethane binders, installed to the manufacturer's specifications. Cork must be rolled into adhesive. Cork is not a moisture barrier.

Floating Application — Make sure cork is level and permanently bonded to the sub-floor with full spread adhesive. Perform appropriate moisture tests.

Sub-Floor Type: Ceramic, Terrazzo, Slate, or Marble

Glue-Down Only Application — The above tile products should be level and permanently bonded to the sub-floor by the appropriate methods. Clean and abrade surfaces to remove any sealers or surface treatments to insure a good adhesive bond. Loose tiles must be re-adhered to the sub-floor, and grout joints that exceed 1/16" must be filled with a leveling compound. Follow the manufacturer's recommendation for applying the leveling compound. Any area containing the leveling compound must be completely dry before proceeding with the installation of the wood floor. Perform appropriate moisture tests. A moisture barrier may be required.

Floating Application — The above tile products should be level and permanently bonded to the sub-floor by the appropriate methods. Perform appropriate moisture tests.

Step 8: Installing The Floor

Helpful Tips

- Remove flooring from several different cartons to maximize color and shade mixture.
- Stagger the ends of boards at least 6" in adjacent rows. For floating application, use 4 foot, 3 foot, 2 foot, and 1 foot stagger pattern as specified in the "Floating Installation" section listed below.
- Installation parallel to the longest wall provides the best visual effect.

Doorway and Wall Preparation

Undercut or notch-out door casings 1/16" higher than the thickness of the flooring being installed to avoid difficult scribe cuts during installation. Also remove existing base and shoe molding as well as doorway thresholds; each can be replaced after installation is complete.

INSTALLING THE FLOOR: Glue-Down Installation

An exterior wall is usually the straightest and best reference line to start the installation. Direction of finished flooring should be

at right angles to the floor joists whenever possible. Establish a starting point by leaving a minimum 5/16" expansion gap around all vertical obstructions. Measure this distance from the starting wall (in at least two places) close to the starting wall's opposite corners. Mark these points and snap a working chalk line parallel to the starting wall allowing the required expansion space between the starting wall and the edge of the first row of flooring. To maintain the expansion gap throughout the installation, cut several boards into small pieces to use as spacers between hardwood flooring board and wall or other object.

Apply recommended urethane adhesive with manufacturers recommended trowel. Follow manufacturer's recommendations for the application of the adhesive. **DO NOT USE A WATER-BASED ADHESIVE WITH THIS HARDWOOD FLOORING PRODUCT.**

Boards should be installed left to right with the edge of the groove lined up against the chalk line, side-tongue facing out to the left. Whenever possible, the tongue along with width and length of the board should be facing out so that the tapping block or pull tool always uses the tongue of the flooring. If the groove is facing out and a tapping block or pull tool is used, the edge of the board may be damaged.

Firmly seat the first row in the adhesive, as additional rows will be pushed back to this original row. When installing boards, avoid sliding materials through adhesive when placing them in position. Engage the end joint first, as close as possible to side tongue-and-groove, and fit boards together. Check for a tight fit between all edges and ends of each board. Occasionally lift a board to check for adequate adhesive transfer. Stagger the ends of boards at least 6" in adjacent rows creating a stair-step pattern (see figure 1).

3-M Blue Tape should be used to hold planks tightly together and reduce minor shifting of floors during installation. Remove all adhesive from the surface of the flooring with urethane adhesive remover or mineral spirits as you go. **Adhesive is very difficult to remove from prefinished hardwood floors if allowed to dry and may damage finish on flooring. All adhesive must be removed from flooring surfaces prior to applying 3-M Blue Tape. Remove 3-M Blue Tape within 24 hours.**

Allow a 5/16" minimum expansion gap around all vertical obstructions. Wood expands and contracts with changes in humidity. Wood will buckle and/or cup if an adequate expansion space is not provided. Always allow for expansion when making end or side cuts around vertical objects.

Continue across the room until finished; remember to provide adequate spacing for expansion gap. Once completed install molding and trim. Thoroughly clean, sweep, and vacuum

installed floor before further use. If floor is to be covered, use a breathable material such as cardboard or rosin paper. Do not cover with plastic.

INSTALLING THE FLOOR: Floating Installation

Install leading brand pad with built in moisture barrier - 2 in 1 or 3 in 1. Follow pad manufacturers instructions.

An exterior wall is usually the straightest and best reference line to start the installation. Direction of finished flooring should be at right angles to the floor joists whenever possible. Establish a starting line by leaving a minimum 5/16" expansion gap around all vertical obstructions. Measure this distance from the starting wall (in at least two places) close to the starting wall's opposite corners. Mark these points and snap a working chalk line parallel to the starting wall allowing the required expansion space between the starting wall and the edge of the first row of flooring. To maintain the expansion gap throughout the installation, cut several boards into small pieces to use as spacers between hardwood flooring board and wall or other object.

Boards should be installed left to right with the edge of the groove lined up against the chalk line, side-tongue facing out to the left. Whenever possible, the tongue along with width and length of the board should be facing out so that the tapping block or pull tool always uses the tongue of the flooring. If the groove is facing out and a tapping block or pull tool is used, the edge of the board may be damaged.

For the best performance of your floating floor, use a 4 foot, 3 foot, 2 foot, 1 foot stair-step pattern style installation (see figure 1). By using this installation style, you will have a minimum of 12 inches between end-joints. Dry fit first row using stair-step pattern by starting with a 4 foot piece and continue row with additional 4 foot pieces. Cut last plank of every row to fit, remembering to allow for expansion gap. Dry fit second row by starting with a 3 foot piece and then continue row with additional 4 foot pieces. Dry fit third row by starting with a 2 foot piece and

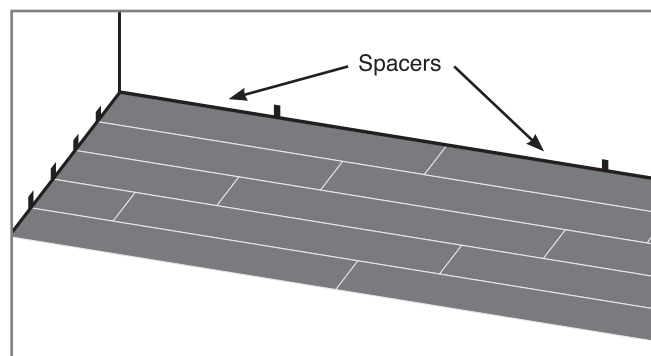


figure 1

then continue row with additional 4 foot pieces. Dry fit fourth row by starting with a 1 foot piece and then continue row with additional 4 foot pieces.

Install first two rows by applying a thin bead of glue in the groove on the side and end of each board (see figure 2). Press each board firmly together and lightly use a tapping block if necessary. Clean excess glue from between boards with a damp cloth or mineral spirits. Tape each board together at side and end seams using 3-M Blue Tape. Allow glue to set before continuing installation of subsequent rows.

After fourth row, start fifth row using a 4 foot piece and then repeat stair-step pattern throughout the rest of the installation. Always remember to allow for the expansion gap and clean excess glue from between boards. Often the last row will not end with a full plank. When this happens, place a full row of planks on top of the last row installed. Insert a 5/16" spacer against wall, and using a full width plank, trace distance from wall onto final row (see figure 3). Cut planks for final row to designated width. Apply glue and fit into place. Trim excess polyethylene film and/or padding so it will not be visible once moldings are installed. Tape may be removed within one hour. Allow 12 hours before placing furniture on floors and 24 hours before introducing heavy objects or full traffic.

Step 9: Common Sense Care

It is important to keep your hardwood floors free from dirt, water, food, grease, and other spills which can damage the floor or finish.

Periodically clean floors using a leading brand of cleaner made for prefinished hardwood floors (follow directions on bottle). Do not use ammonia or oil-based wax, polish, abrasive cleaners, or furniture cleaners. Make sure to install floor protectors under furniture, chairs or other items that may sit directly on your hardwood floor to help prevent scratches, scarring, and dents. Regularly, sweep, dust mop and/or vacuum to keep dirt and grit from dulling the shine and scratching the finish. Wipe up all spills promptly with a soft, dry cloth. Avoid walking on floors with sharp, stiletto high heel shoes or shoes with soles in need of repair.

CONGRATULATIONS on your new BR-111™ hardwood floor!
If you have any further questions or comments regarding exotic hardwood flooring, please contact our technical department toll-free at 1-800-525-BR111 (2711).

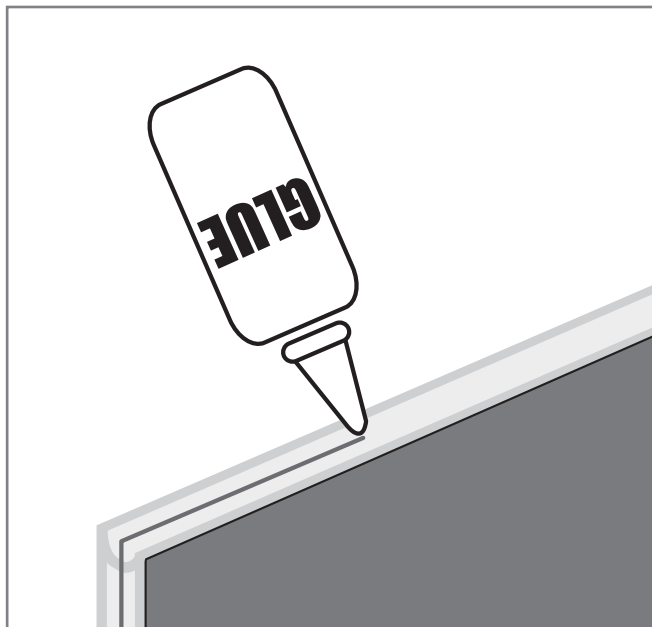


figure 2

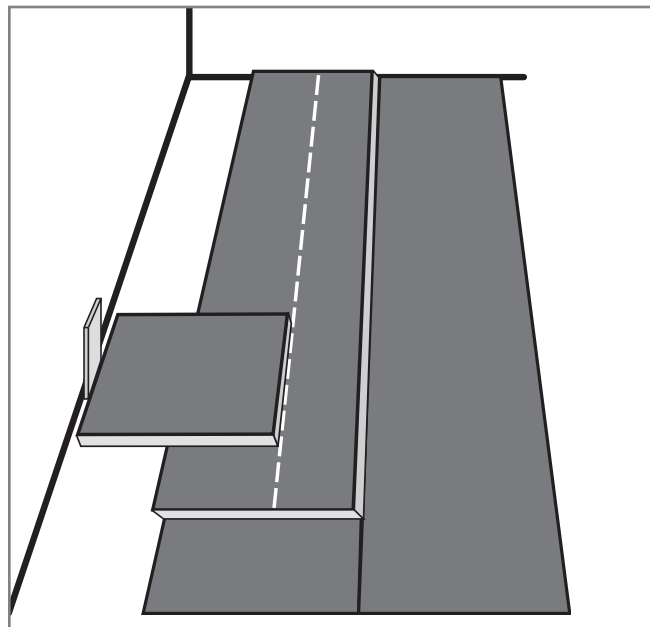


figure 3