Installation, Operation, and Maintenance Manual

SmartTrac™

Radiant Panel Solution

WATTS®

An Introduction to Radiant, the Smart Way

This manual contains information related to radiant floor installations using the SmartTrac™ Radiant Panel Solution. For design information, please consult Watts Radiant's RadiantWorks® or LoopCAD® Professional design software.

Many of the accessory items used with SmartTrac™ are mentioned in this manual. New tools and accessory items are added to the Watts Radiant product offering on a regular basis. Please refer to the Watts Radiant product catalog for current product information. Additional product information may also be found at our web site www.wattsradiant.com.

Watts Radiant offers a wide range of support options, from local wholesalers and representatives to our factory-direct toll-free number.

When you select Watts Radiant, your choice comes with an entire support team.

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⚠ WARNING

To avoid serious personal injury or property damage:

- Read Manual and all product labels BEFORE using this product and follow all safety and use information. Failure to do so could result in personal injury or property damage.
- Do not use unless you know the safe and proper operation of equipment required for installation.
- It is the installers responsibility to ensure that this product is safely installed according to all applicable codes and standards.
- Keep this Manual available for easy access by all users. Replacement Manuals are available at WattsRadiant.com

NOTICE

This manual only covers installation of Watts Radiant's SmartTrac™. This is not a design manual. For design assistance, we encourage you to contact us or our representatives for a design analysis using RadiantWorks® or LoopCAD® Professional system design software.

Before designing or installing a radiant heating or cooling system, you should always consult with local, experienced design and installation professionals to ensure compliance with local building practices, climate conditions, state and local building codes, and past customs.

Understanding Safety Information

This is a safety-alert symbol. The safety alert symbol is shown alone or used with a signal word (WARNING or CAUTION), a pictorial and/or a safety message to identify hazards.

When you see this symbol alone or with a signal word on your equipment or in this Manual, be alert to the potential for death or serious personal injury.

⚠ WARNING This symbol identifies hazards which, if not avoided, could result in death or serious injury.

⚠ CAUTION This symbol identifies hazards which, if not avoided, could result in minor or moderate injury.

NOTICE This symbol identifies practices, actions, or failure to act which could result in property damage or damage to the equipment.

Introduction

The SmartTrac™ Radiant Panel is non-structural and designed specifically for subfloor, ceiling and wall applications. It is made of high recycled content MDF. The dense board spreads the heat evenly and quickly from the hydronic tubing that snaps easily into the channel.

SmartTrac™ heats rapidly and is easy to control with setback thermostats for maximum energy efficiency. It contains just enough thermal mass to be effective, but not so much that it is difficult to control. No other product offers this combination of performance, ease of installation, cost-effectiveness and ecologically responsible construction.

SmartTrac™ Properties

Dimensions:	24" x 24" x 5/8" (610 mm x 610 mm x 16 mm)
Standard Panel Weight:	8.95 lbs (4.06 kg)
Utility Panel Weight:	8.65 lbs (3.92 kg)
Tube Spacing:	8" (203 mm) O.C.
MDF Board:	Awarded CARB ULEF Exemption. Products meet CARB ATCM 93120 Phase 2 emission requirements. Meets physical properties of ANSI A208.2-2009 Grade 130

U.S. Patent # 6,533,185 and Patents Pending

NOTICE

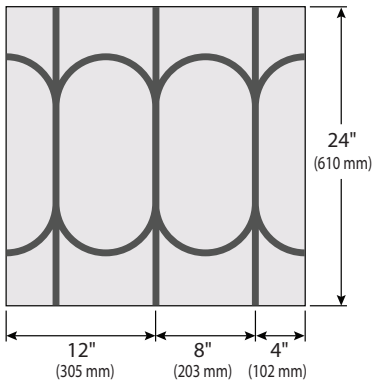
Due to the nature of MDF, it is susceptible to deformation and damage from moisture. Ensure that SmartTrac™ panels are protected from moisture at all times. Store in a dry area with a temperature range between 40 and 90°F (4 to 32°C). Avoid prolonged exposure to sunlight. Be sure to follow all instructions in this manual regarding protecting the board from prolonged moisture contact. If these instructions are not followed, expansion can create undesirable effects.

MDF Technical Data

Density:	46 lb/ft^3 (7.4 kg/mm^3)
Internal Bond:	130 lb/in^2 (896 kPa)
Screw Holding, Face:	225 lbs (102 kg)
Screw Holding, Edge:	200 lbs (91 kg)
Flame Spread Rating:	Class 3 (C)
Moisture Content:	4 - 6%
Thickness Swell:	5%
Linear Expansion:	0.3%

Average physical properties for 3/4" (19 mm) panel, based on a 5 panel average, when tested in accordance with ASTM D1037. Emissions tested in accordance with ASTM E-1333.

SmartTrac™ Panel



Features & Benefits of SmartTrac™

Hydronic radiant heating is the most comfortable and efficient way to heat your home or building, with numerous construction benefits and unsurpassed flexibility in zoning. SmartTrac™ is designed for the application of hydronic radiant tubing over a variety of construction types. It may be used in new construction and is also advantageous in the growing retrofit market. While only adding 5/8" (16 mm) to the existing floor height, SmartTrac™ provides a superior performing radiant heating or cooling system.

Installation Friendly

SmartTrac™ has all the intelligence you need built into it so that the vast majority of installations can be quickly accomplished using only the Standard panel. For more complex installations, the Utility panel can be used.

Construction Friendly

SmartTrac™ avoids joist upsizing, double plating and hardwood nailing strips associated with gypsum-based concrete radiant heating systems. Also, SmartTrac™ eliminates substantial drying costs required by moisture-laden concrete and gypsum-based cement. Time is money. SmartTrac™ eliminates scheduling and curing delays.

Cost Friendly

SmartTrac™ is installed using conventional construction practices and commonly used tools. With a layout plan, SmartTrac™ panels can be quickly and systematically arranged on the subfloor. Not only are the boards light weight - they are also easy to handle, cut and attach.

Flooring Friendly

SmartTrac™ provides a quality flat surface for floor covering assemblies. Each of these flooring assemblies are detailed later in this manual.

- Hardwood
- Engineered Wood
- Tile/Stone
- Carpet
- Laminate
- Vinyl/Resilient Flooring

Green Product

SmartTrac™ is made from certified MDF with a high recycled wood content. SmartTrac™ also meets CARB ATCM 93120 Phase 2 emission requirements.

Heat loss analysis and system design

Systematic heat loss and design for the structure to be heated should be done prior to any installation of SmartTrac™. As with all radiant heating jobs, a detailed and accurate heat loss must be calculated in order to determine proper design conditions.

R-Value of floor assemblies

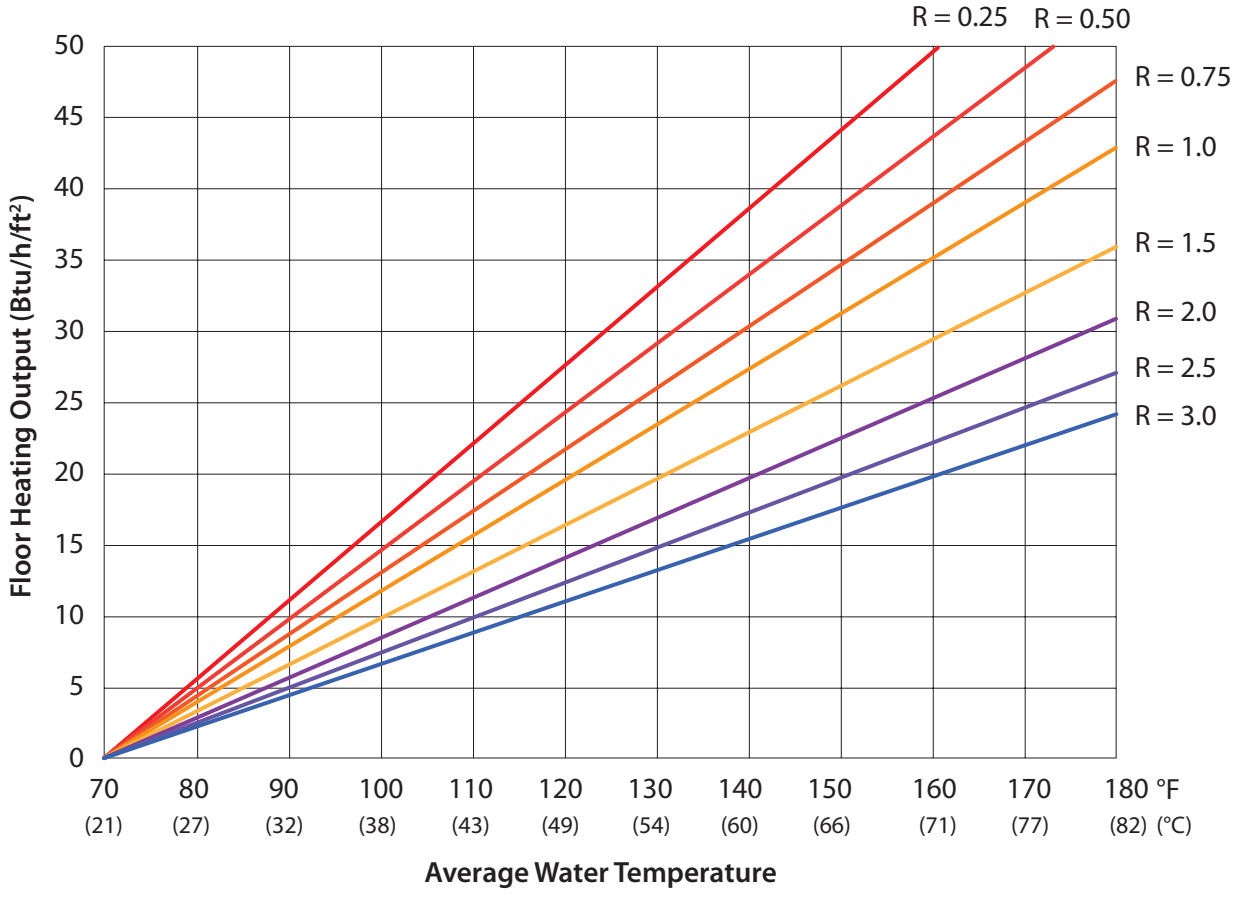
While SmartTrac™ will work with a wide variety of floor coverings , it is important to realize that all floor coverings offer a resistance to heat transfer (indicated by their R-Value). As with any radiant floor system, if the R-value of the floor coverings is excessive, performance may be compromised and require a higher average water temperature (150°F (66°C)) is the maximum supply water temperature that can be used with SmartTrac™). See Appendix A for R-values of typical floor coverings.

System Output

While an accurate heat-loss analysis is the preferred method to design a system, the performance chart below can be used to estimate system output with different floor coverings. This chart shows the steady state performance of SmartTrac™. To the left are the BTU/Sq. Ft/Hour. The diagonal lines represent the resistance of the floor coverings on top of SmartTrac™. Along the bottom is the average water temperature required to achieve the output.

The chart is read by selecting the correct BTU requirement and then moving horizontally until you find the line indicating the correct R-Value of the floor assembly on top of SmartTrac™. At that point, drop down vertically to see average water temperature.

Performance Chart for SmartTrac™

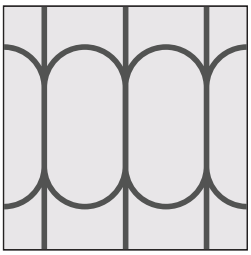


This chart shows average water temperature. In order to calculate required supply temperature, add half of expected delta-T to the average (i.e. add 10°F to the average if expected delta-T is 20°F).

The performance above is based on typical construction practices and environmental conditions (at 70°F (21°C) room temperature). Actual results may vary.

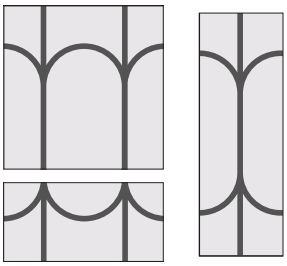
Understanding the Product

SmartTrac™ comes in 2 patterns: “Standard” and “Utility”. The boards are assembled to make a continuous channel for the pipe. Each piece measures approximately 24" x 24" x 5/8" (610 mm x 610 mm x 16 mm) thick. The grooves are centered 8" (203 mm) apart. SmartTrac™ cuts easily with a circular saw.

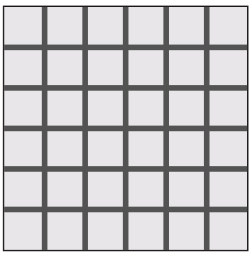


Standard Panel

Almost every job can be done with this one board shape, it may be easily cut with a circular saw or table saw into many useful additional shapes.

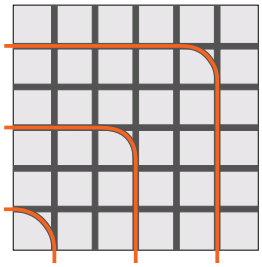


Various shapes can be cut from the Standard Panel to finish off areas of the room less than 24" (610 mm).



Utility Panel

For more complex areas such as the perimeter of rooms or down long hallways, the Utility Panel can be useful.



Custom tubing paths can be cut. See details on page 7.

Tubing & Tube Lengths

SmartTrac™ is designed for use with 3/8" (10 mm) nominal ASTM F-876 PEX (cross-linked polyethylene) or ASTM F-2623 PERT (polyethylene of raised temperature), with an average outer diameter measuring 1/2" (13 mm). Loops shall never be over 300 ft (91 m) including the leaders to the manifolds. For areas with heat loss greater than 25 BTU/sq.ft., loops shall never be over 250 ft (76.2 m). This is due to high pressure drops and water velocity. Friction losses in the chart are approximate; actual friction losses depend on fluid viscosity and temperature.

Watts Radiant does not recommend the use of PEX or PERT tubing with an exposed (outer) oxygen barrier layer, as this can lead to noise issues induced by contraction and expansion of the tubing. Both RadiantPEX+ and RadiantPERT have a protective layer outside of the oxygen barrier and offer quiet operation with SmartTrac™.

Pressure drop for 3/8" (10 mm) PEX/PERT at various flow rates/circuit lengths

The shaded areas in the charts above indicate a high pressure drop. It is recommended to use a shorter loop length in these cases.

Length (ft)	Flow (gpm)	Ft of Head	Velocity (ft/s)	Max. sq.ft
200	0.1	0.4	0.3	133
200	0.2	2.0	0.7	133
200	0.3	4.0	1.0	133
200	0.4	6.5	1.3	133
200	0.5	9.5	1.7	133
200	0.6	13.0	2.0	133
200	0.7	16.9	2.3	133
200	0.8	21.4	2.7	133
200	0.9	26.4	3.0	133
200	1	31.9	3.3	133

Length (ft)	Flow (gpm)	Ft of Head	Velocity (ft/s)	Max. sq.ft
250	0.1	0.5	0.3	166
250	0.2	2.4	0.7	166
250	0.3	5.0	1.0	166
250	0.4	8.1	1.3	166
250	0.5	11.8	1.7	166
250	0.6	16.2	2.0	166
250	0.7	21.2	2.3	166
250	0.8	26.8	2.7	166
250	0.9	33.0	3.0	166
250	1	39.9	3.3	166

Length (ft)	Flow (gpm)	Ft of Head	Velocity (ft/s)	Max. sq.ft
300	0.1	0.7	0.3	200
300	0.2	2.9	0.7	200
300	0.3	5.9	1.0	200
300	0.4	9.7	1.3	200
300	0.5	14.2	1.7	200
300	0.6	19.4	2.0	200
300	0.7	25.4	2.3	200
300	0.8	32.1	2.7	200
300	0.9	39.6	3.0	200
300	1	47.8	3.3	200

Preparing for Installation

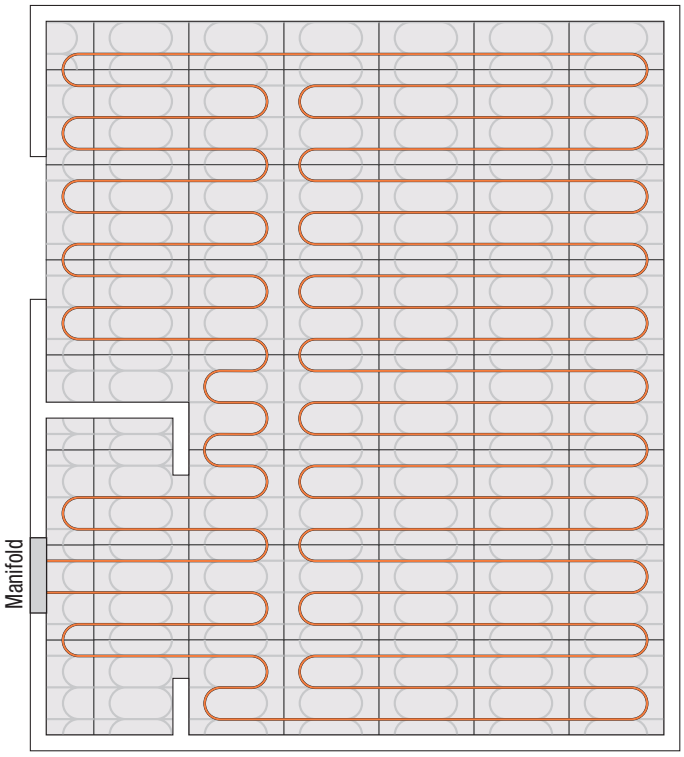
Estimating the required tubing

In order to calculate the length of pipe required, multiply the total square footage by 1.5. Then, add the lengths required to attach each loop to the manifold.

Example: For a 500 Sq.Ft. room, multiplying 500 by 1.5 gives 750 lineal feet of 3/8" (10 mm) PEX/PERT tubing required for the floor. Adding 4 feet to each loop for a connection to the manifold brings the total to 762 feet, or 3 loops of 254 feet.

Metric example: 46.5 ft^2 room multiplied by 1.5 equals 69.75 lineal meters of pipe. Add 1.2 m per loop for manifold connections to total 74.55 meters of pipe, or 3 loops of 24.85 m.

Radiant systems perform the best when the loops are of an equal length. A pipe loop layout diagram like the one shown below can help in planning your installation. Visit WattsRadiant.com/SmartTrac to see other loop layout examples.



Example Pipe Loop Layout

Estimating the required number of panels

The following calculations can be used for estimating the required number of panels. For experienced installers, use the following formula: square footage divided by four plus 2% for waste.

Example: For a 600 Sq. ft. room, dividing 600 by 4 gives 150 panels. It is always recommended that an additional 2% material excess be added to the estimation for waste. Adding a 2% waste factor would provide a total of 153 boards. Each panel is 24" x 24" or 4 square feet.

Metric example: 55.75m^2 room divided by ***0.371*** = 150 panels. To add 2% waste factor multiply by 1.02 with a result of 153.

Doing an exact layout will give the most accurate estimate of panels needed. Cutting the boards on multiples of 8" (203 mm) will make off-cuts more useful and reduce waste. Small gaps may be filled with standard 5/8" (16 mm) material.

General floor surface requirements

The surface of the subfloor must be flat. The requirement for flatness is defined as the maximum difference between two adjacent high points and the intermediate low point. The maximum acceptable difference in level is 3/16" (5 mm) across a span that is 10 feet (3 m) in diameter.

Fill excessive voids or low areas using a leveling compound. Allow the leveling compound to dry thoroughly before beginning the installation. Check with the leveling compound manufacturer to be sure it is appropriate for the application. High areas can be ground down or floated over with a self-leveling compound. The surface of the floor must be clean and dry.

Wood subfloor requirements

Wood subfloors must have a stable moisture content, between 6 to 10%. Creaking subfloors must be repaired before installation. If the subfloor sags, inspect the joists below for twists or weakness. If the subfloor is cupped or uneven at the joints, recheck the moisture content of the subfloor to be sure it is in the 6 – 10% range. Check for excessive moisture in the crawl space or basement and look for other signs of a potential water problem. High areas are sanded or planed; low areas are patched or filled with an appropriate leveling compound, or covered with a rigid underlayment. When using a leveling compound, be sure to follow the manufacturer's recommendations, and allow the compound to dry completely before starting to install the floor.

Installation

Equipment required for installation over a wood subfloor

The following is necessary for the installation of SmartTrac™

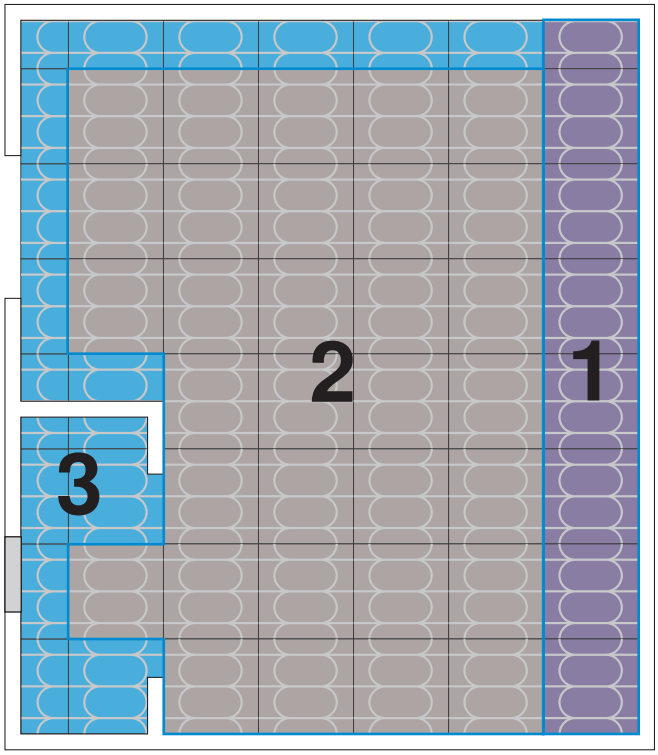
- Table or circular saw. A carbide blade is recommended.
- Drill driver
- Driver bit (if screwing down boards)
- 5/8" (16 mm) drill bit (if using supply and return bury points)
- Sheathing type pneumatic stapler (if cross stapling panels)
- Rubber or hard hide mallet, or roller for pushing tubing into groove
- Chalk line, marking pencils and square
- Vacuum cleaner to clean grooves prior to installation of the tubing
- 6" (152 mm) pieces of 3/8" (10 mm) PEX used for aligning boards
- Tubing uncoiler is recommended for installing tubing

Installation Overview

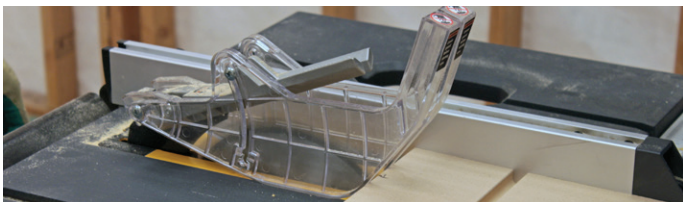
- Layout full boards
- Add cut boards as necessary
- Trace tubing layout to ensure the correct number of passes, allowing entry and exit
- Glue panels down, ensuring alignment
- Screw or cross-staple panels
- Vacuum grooves to remove debris
- Trace tubing layout to ensure entry and exit points of tubing
- Walk tubing in and attach to manifold
- Pressure test

Layout

1. Start at an exterior wall or wall furthest from the manifold and place the full boards into position. Verify that there is room for an even number of pipe passes, which allow supply and return connection.
2. Fill in the remaining full boards.
3. Add cut boards to the layout as necessary to accommodate for the room lengths and the supply and return paths to the manifold. Allow for a 1/32" (0.8 mm) gap between the cut ends similar to the natural spacing of uncut boards. This provides room for expansion and contraction of the material.



When cutting the boards, a circular or table saw with a high tooth count carbide blade will produce a smoother finish. Rough cut blades are not recommended. It is important that panels be cut squarely to keep the alignment of grooves accurate in the installation. Where possible, 8" (203 mm) cuts are recommended.



Creating Custom Paths

Both Standard and Utility panels can have custom paths added by using a router, Rotozip® or jigsaw. When cutting pipe paths, leave edges with a smooth finish to prevent damage to tubing.

1. Trace the outline of a gentle curve using a length of pipe or a curve template.
2. Clamp the panel to a workbench.
3. Using a jigsaw, Rotozip®, or router with 1/2" (13 mm) round nose bit set to the proper depth, remove material between the traced lines.
4. Test fit the path with a section of pipe before attaching the panel to the subfloor.

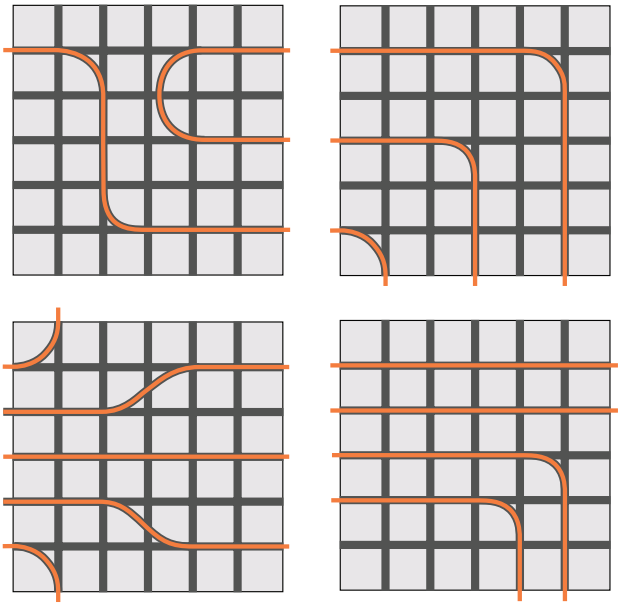
⚠ WARNING

Cutting tool operators shall wear eye protection and follow all rules and practices for safe operation of the cutting tool. Make sure the panel is safely secured during cutting. Watts Radiant specifically disclaims liability for any installer use of cutting tools.

Utility panels provide 4" (102 mm) spacing and the ability to create a custom path. This flexibility can be useful for areas where multiple circuits pass through a hallway, or converge near doorways and manifolds.

When creating custom paths using the utility panel, ensure that both the pipe and finished flooring are well supported by leaving the smallest gaps possible.

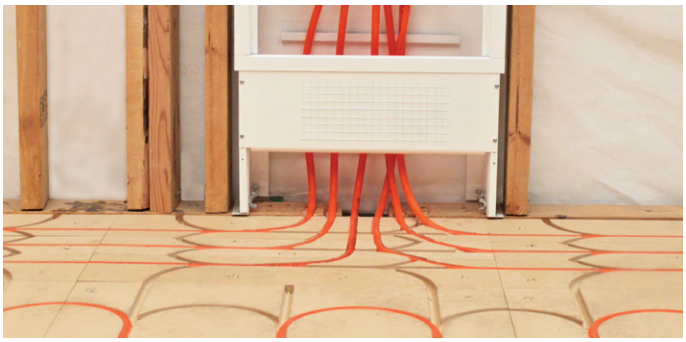
Designers should take care when using the 4" (102 mm) spacing on multiple utility panels (for example down a hallway) as overheating could occur due to the tighter pipe spacing.



Manifold detail

Manifolds are usually located in a space with an access panel, near the heating zone they serve, in places like in the back of a closet. The tubing may be routed to the manifold in four ways:

1. Use SmartTrac™ utility panels to provide a 4" (102 mm) tube spacing in front of the manifold.
2. Drill holes in the panels and subfloor to route tubing under the floor in front of the manifold. Bring tubing back up through holes that align with the manifold connections.
3. Place a 5/8" (16 mm) solid MDF, OSB or Plywood sheet next to the manifold. Use a router to custom groove supply and return lines from the manifold to the adjacent standard panels.
4. Attach tubing between the closest panel and the manifold to the subfloor with clips. A grout may then be used to cover the tubing and level it to SmartTrac™. If needed, sleepers are placed in between tubing to provide a nailing or screwing base for floor coverings. Use nailing plates as necessary to protect tubing from damage. Depending on how many circuits are on a given manifold various sizes of sheets or grouting area are required.



How to align the grooves correctly

The easiest way to assure the grooves for the pipe are correctly aligned between boards is to cut 6" (152 mm) pieces of 3/8" (10 mm) ASTM F-876 PEX/PERT and use them as alignment tools. To do this, get the boards close to the desired alignment and press a piece of tubing in each groove, lapping 3" (76 mm) into the groove of each board, as shown below. After the board is attached, these should be removed.

Attaching SmartTrac™ to a subfloor

Each SmartTrac™ panel should be glued to a wooden subfloor using construction adhesive type glue at a minimum 1/8" (3 mm) bead in the gluing pattern below. Every board should be glued.

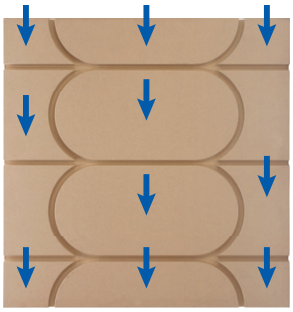
The glue may be applied to the underside of the board or to the floor.

NOTICE

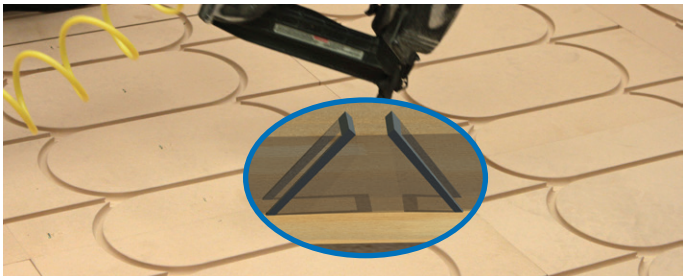
Avoid getting glue in the groove or where it may come in contact with the tubing. Many glues can damage PEX/PERT tubing.

Screw or cross staple boards to the subfloor

After you have glued SmartTrac™, the boards should be screwed or cross-stapled to the subfloor (1" (24 mm) long, #8 screws are recommended). On full size pieces (24" x 24" (610 mm x 610 mm)), 10 screws should be used, 3 on each side and 4 in the middle. This pattern is shown below (blue arrows indicate attachment points).



When using staples instead of screws it is very important that the board is glued and stapled with the same quantity of glue and staple points as shown in the pattern above. Cross stapling with a sheathing stapler is the fastest way to install SmartTrac™. 1-1/2" (38 mm) long, 16 gauge staples are recommended. Cross stapling means 2 staples are put closely together at opposing 45° angles. (45° angle to the surface)

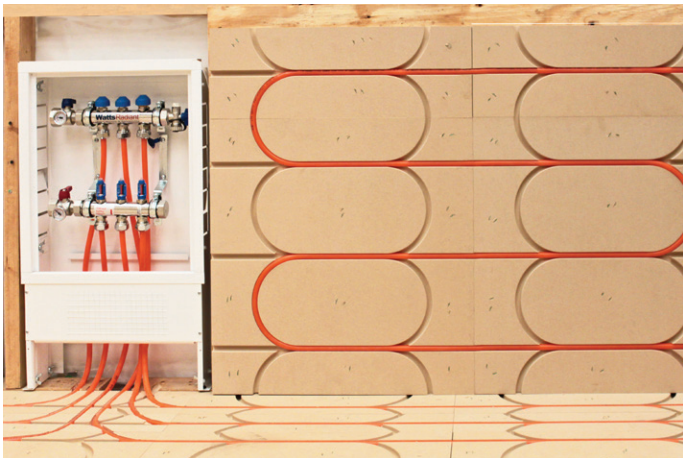


Installing SmartTrac™ on walls or ceilings

SmartTrac™ can be installed on walls and ceilings when additional capacity is required, or when it's not practical to heat through the floor. It is very important not to overheat sheetrock or discoloration or damage may occur. Supply water temperatures should not exceed 120°F (49°C).

Wood blocking or a layer of plywood can be used to provide an adequate surface for attaching the SmartTrac™ panels. The edges of all panels must be in contact with a solid surface. Wall installations are commonly limited to a lower section to reduce the chance of puncturing.

Ensure proper alignment of panels using the same method with 6" (152 mm) lengths of pex as recommended for floor installations. Once the panels are installed, clean the groove with a vacuum just prior to tubing installation. Add steel plate protectors over tubing where tubing crosses studs.



Installing SmartTrac™ over concrete

Successful installation of SmartTrac™ over concrete requires special care. When installing over concrete, moisture considerations must be carefully addressed to prevent damage to the panels.

Moisture in the concrete should be tested according to ASTM F 1869 (Calcium Chloride Moisture Test using the Quantitative Method). With a calcium chloride test, the maximum acceptable reading is 3 lbs./ 4 hours/ 1,000 Sq. ft. New concrete slabs and basements must be cured for a minimum of 60 days prior to installation.

NOTICE

It is strongly recommended that all slabs below grade and slabs on grade be sealed against moisture penetration before installing SmartTrac™ by means of vapor barriers or product such as Hydroment Ultraseal that is a sealant and an adhesive.

Slabs that are on or below grade commonly require insulation to prevent downward and perimeter heat loss. Check with local authorities for recommended guidelines on insulating radiant systems.

Details about installation of floor coverings over SmartTrac™ on a concrete floor are provided later in this brochure.

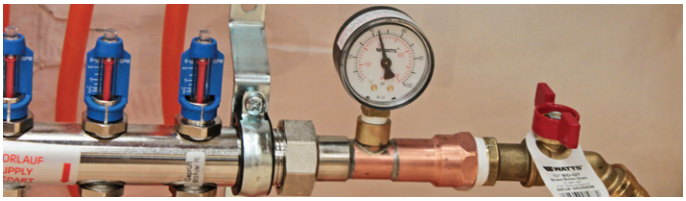
Installing tubing in the grooves

First, vacuum the grooves to remove any debris. Failure to do so may damage the tubing or keep it from going properly into the groove.

The use of a tubing uncoiler is recommended. Start at the intended manifold location and allow enough tubing as a 'leader' to attach the tubing to the manifold. You may then begin, but make sure you understand the layout and where and how you will return to the manifold. There is, intentionally, a tight tolerance between the ASTM F-876 PEX tube and the slightly undercut groove. This allows the tubing to be retained in the grooves once it is pushed in place. Usually, this only requires 'walking the tubing into the groove' as shown in the photograph below. Occasionally tubing installation may require the use of a rubber or hide mallet to force the tubing in place in the grooves. **After installing a loop of tubing, always walk the loop and make sure the tubing is fully in the groove for the entire length of the groove. This is very important!** The top of the tubing should be just below the level of the top of SmartTrac™, and fully retained in the groove.

Pressure testing

Once the tubing ends are connected to the manifold, a water or air pressure test should be performed to ensure there are no leaks before installing the finished flooring.



Flooring Installation

There are common precautions to take for any flooring type as well as specifics based on the flooring material. Make sure that the flooring installers understand how to avoid puncturing the tubing.

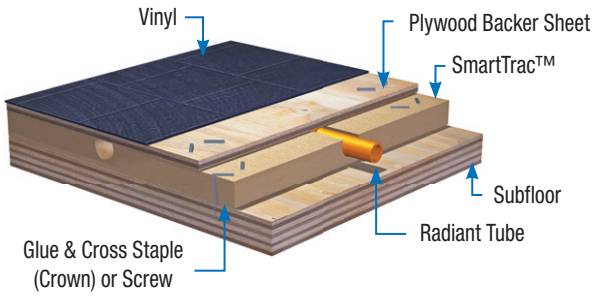
Some flooring types such as traditional hardwood require very gradual temperature changes to prevent cracking and warping. A maximum temperature is also a consideration. Thermostats that include floor temperature sensing and control features can be purchased through Watts Radiant distributors.

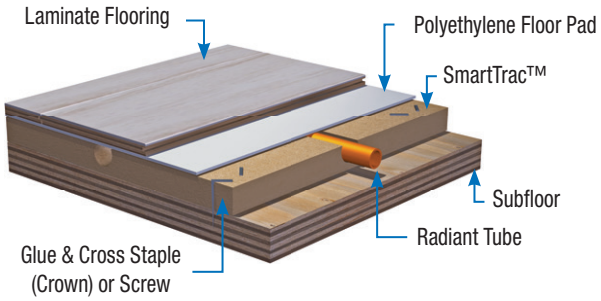
Laminate or vinyl over SmartTrac™

Laminate, vinyl and resilient flooring all require a thin underlayment to provide a smooth finish. Underlayment plywood that has a grid printed on it helps locate tubing runs to prevent puncturing the tubing when the plywood is attached to the SmartTrac™. In water exposed areas such as kitchens and bathrooms a sealant layer should be applied over the plywood. Laminate may also be installed over a polyethylene floor pad. In the case of vinyl, use underlayment, filler and glues suggested by the manufacturer for use over radiant heat. Attach required underlayment with care to not puncture tubing.

NOTICE

Most vinyl flooring is manufactured to an ASTM standard with an upper limit of floor temperatures of 85°F (29°C). This limit should be followed.

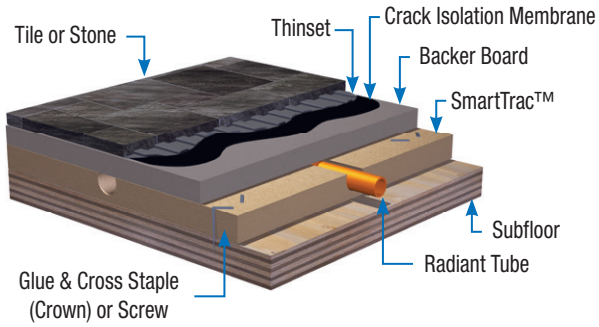


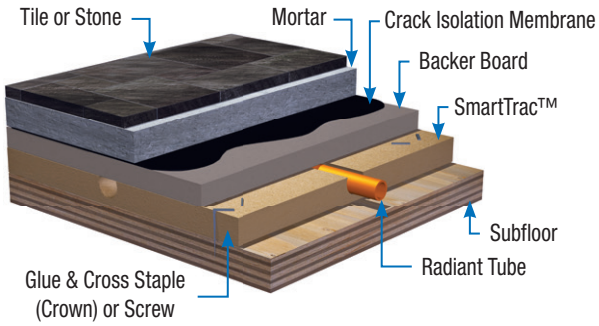


Prevent damage to laminate flooring by using controls that gradually adjust supply water temperatures with a reset curve. A floor temperature limiting sensor can be used to comply with flooring manufacturer's flooring temperature specifications.

Tile or stone over SmartTrac™

To prevent moisture damage, install water resistant backer board over SmartTrac™ panels in areas with tile or stone. Maintain a 2" (51 mm) minimum tubing clearance when screwing backer boards down. Trowel apply thinset that is compatible with Pex pipe under the backer board. In the kitchen, baths, laundry or any other area where water may be present, a water sealant layer shall be used. Where tile or stone is going to be thin-set, an antifracture membrane is recommended over the backer board to help prevent cracking.

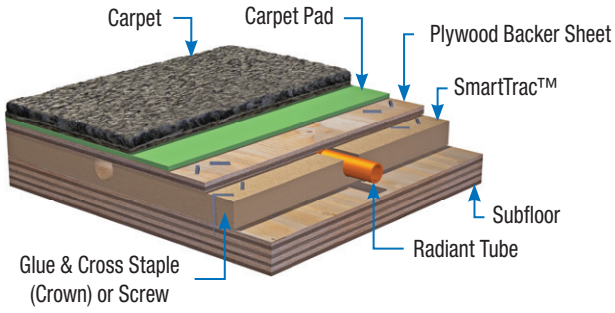




Carpet over SmartTrac™

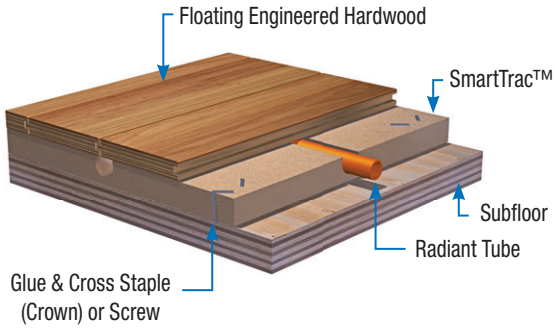
For a lower resistance to heat transfer, foam rubber pad and short high density carpet are recommended. When installing the pad, care should be taken to avoid puncturing tubing. A thin layer of plywood underlayment under the pad will protect tubing from point loads.

High temperature latex adhesive can be used to attach the pad to the plywood underlayment. Consider placement of carpet tack strips around the perimeter of the area. Ensure tack strips are at least 2 inches away from tubing.



Engineered wood over SmartTrac™

Many, but not all, engineered wood flooring products are suitable and recommended by the manufacturer for use with radiant floor heat. Check before installing. Many engineered wood flooring products have floor temperature limits that need to be observed as well. Install engineered wood flooring crosswise to SmartTrac™ whenever possible. It is recommended that engineered wood flooring installed over SmartTrac™ shall employ controls that gradually adjust water temperature going to the SmartTrac™ with a reset curve. A floor temperature limiting sensor can be used to comply with flooring manufacturer's flooring temperature specifications.



Traditional hardwood over SmartTrac™

A conventional nailed hardwood type system may be used directly over SmartTrac™, with nailing long enough to penetrate the subfloor, and with the utilization of recommended controls.

When using glue, attach hardwood to a 1/4" (6 mm) layer of plywood over the SmartTrac™ panels or use a glue that is compatible with high temperature polyethylene or PEX.

The key to installing wood floors over radiant heat is to give extra care to wood species, wood width and thickness, moisture levels, installation practices, the heat output requirements of your system, and radiant heating control.

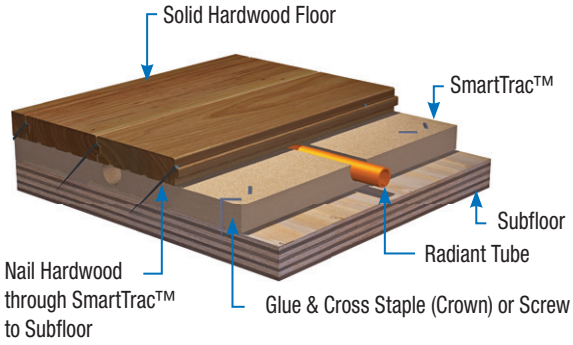
BOARD WIDTH: Install narrow board widths, preferably 3" (76 mm) or less. Avoid boards wider than 4" (102 mm) . Narrow boards provide more gaps for expansion and contraction across a floor; therefore, gaps resulting from natural movement are much less noticeable. The maximum recommended board depth is 3/4" (19 mm). Thicker boards add too much resistance to heat transfer.

DIMENSIONAL STABILITY: Use quarter sawn wood. It is significantly more dimensionally stable than wood that is plain sawn. Pick a wood that's known for its dimensional stability. American cherry, ash, most softwoods and teak fill this bill, and oak is reasonably stable. By contrast, hickory, maple, madronne and American beech are known to be less stable.

AGE & DRYING IN TROPICAL WOODS: If you are importing tropical or exotic woods, pay close attention to the source, age and how the wood has been dried. Tropical wood needs to dry slowly. Quick drying creates stresses that can affect the wood later as it expands and contracts. If your supplier has stored the wood in your region with no problems for one to two years, surprise stress-related problems are much less likely. Avoid pioneering the use of a wood where there is little information on its dimensional stability.

MOISTURE: Wood naturally expands and contracts in response to changes in moisture. With this in mind, avoid installing wood flooring during stages like sheet rocking or painting, when significant moisture may be introduced into a structure. Operate the heating system until the humidity in the structure stabilizes to the average level expected for the area in which the wood floor will be installed. Then, allow the wood to acclimatize to this humidity level by "sticking" (usually several weeks) before installation. This will minimize dimensional changes due to moisture. Make sure the wood is dry, since radiant heat itself can be drying. Experienced flooring installers recommend buying wood for radiant at around 6 to 8 percent moisture content. This figure may change somewhat regionally. Use a moisture meter during the construction process, and then use the average of many readings. Remember, the average expected humidity level of a structure is an average of seasonal conditions. So if the structure is expected to average 30 percent humidity in the winter and 50 percent in the summer, the average would be 40 percent. This equates to about a 7.5 percent moisture content in the wood. Most installers consider this average the ideal moisture level at which to install wood flooring. These numbers can vary significantly by region.

SURFACE TEMPERATURE: The maximum surface temperature of a wood floor should be limited to 85°F (29°C). Use a control strategy that ensures this will not be exceeded. Use an indoor or outdoor reset control that brings the floors to temperature gradually.



Installation requirements for hardwood floors:

1. Avoid nailing the tubing by installing wood flooring lengths in a direction perpendicular to the direction of tubing.
2. Hardwood floor joints shall not be installed directly over a SmartTrac™ panel joint.
3. Hardwood floor nails shall be long enough to penetrate both hardwood and subfloor.
4. Hardwood floors installed directly over SmartTrac™ shall employ controls with a reset curve that gradually adjusts supply water temperatures. The floor will expand and contract gradually with temperature changes. This will reduce the likelihood of warping, gapping or shrinkage problems. The use of a floor temperature limiting sensor is recommended.
5. Install strip wood flooring with mallet driven nails and nails penetrating SmartTrac™.
6. Structure humidity shall be kept within the range specified by the flooring manufacturer.
7. The wood flooring shall be installed at the relative humidity recommended by the manufacturer for the climate involved.
8. Use narrower 2" to 3-1/2" (51 to 89 mm) strips of wood flooring over radiant floors.
9. The lessons of local practice and climate shall be referenced.
10. Make sure the heating system has been running and the space has been maintained at least 65°F (18°C) long enough that temperature and humidity have stabilized to predicted future levels.
11. The flooring product shall be allowed to acclimatize before installation.
12. Use woods that are known to be dimensionally stable.

Installing SmartTrac™ Over Concrete

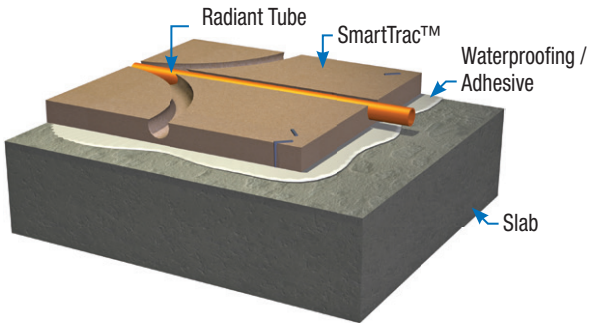
NOTICE

During the design process, consider that moisture content in slabs can vary seasonally and due to yearly climatic variations.

SmartTrac™ may be installed over concrete using the following 3 methods only when the installing parties are willing to assume full responsibility for any installation issues regarding moisture and attachment of SmartTrac™ to concrete.

Bonding to concrete using sealant and adhesive

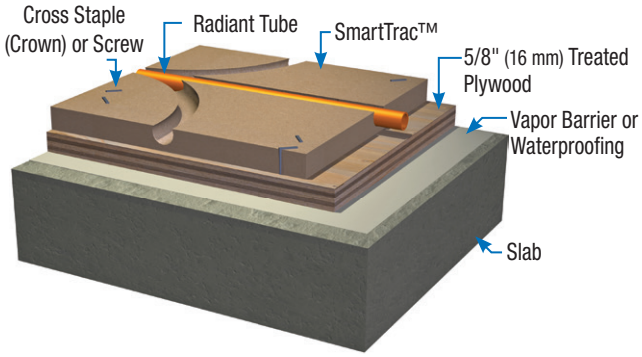
SmartTrac™ may be installed directly over concrete slabs only when the contractor has verified that moisture conditions will be adequately controlled by the use of a sealant on the slab or a vapor barrier under the slab. When using a sealant and adhesive on top of the slab, the sealant may be a combination sealant/wood adhesive such as Hydroment Ultra-Set Advanced™ or the sealant and adhesive may be two separate but compatible products.



Concrete slabs which are attached to radiant heating systems should typically have insulation between the soil and the concrete along the edge (perimeter) and beneath. Recommended R-values vary with climate. Heating non-insulated slabs may increase heat loss and energy use.

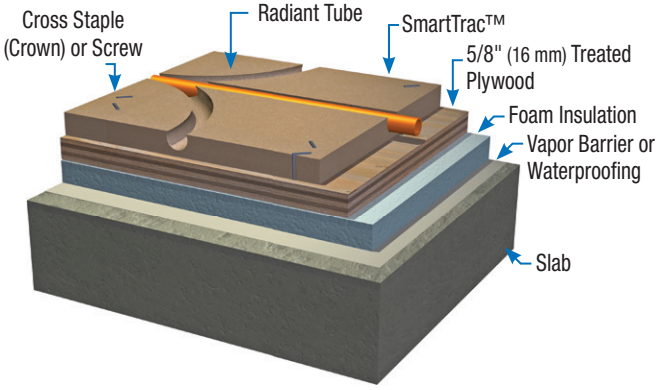
Plywood over concrete with vapor barrier or waterproofing

SmartTrac™ may be installed on 5/8" (16 mm) T&G treated plywood with a vapor barrier or waterproofing over concrete slabs only when the contractor has verified that moisture conditions will be adequately controlled by the use of a sealant on the slab or a vapor barrier over or under the slab.



Plywood over concrete with foam insulation and vapor barrier or waterproofing

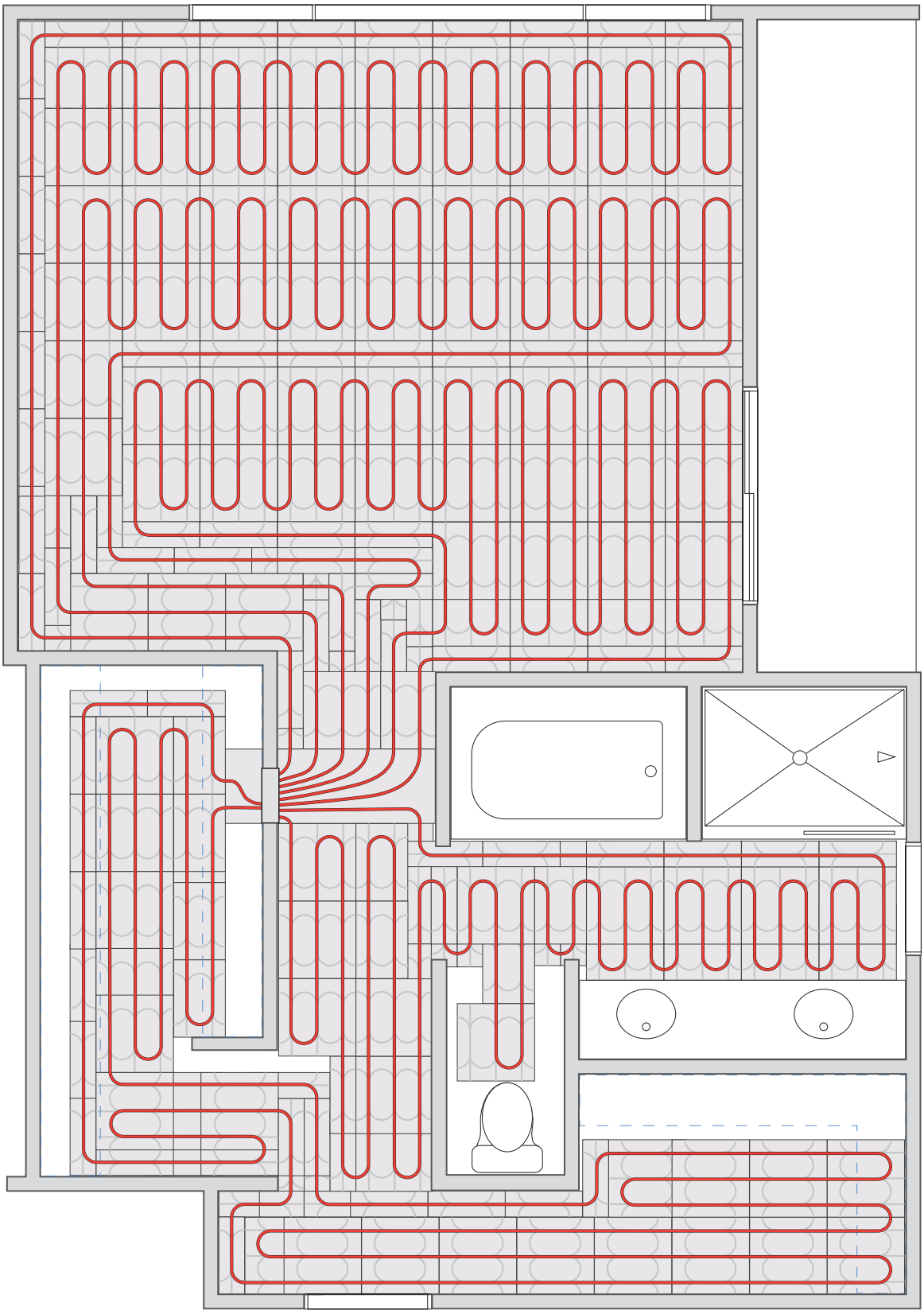
SmartTrac™ may be installed on 5/8" (16 mm) T&G treated plywood, over foam and with a vapor barrier or waterproofing over concrete slabs only when the contractor has verified that moisture conditions will be adequately controlled by the use of a sealant on the slab or a vapor barrier over or under the slab.

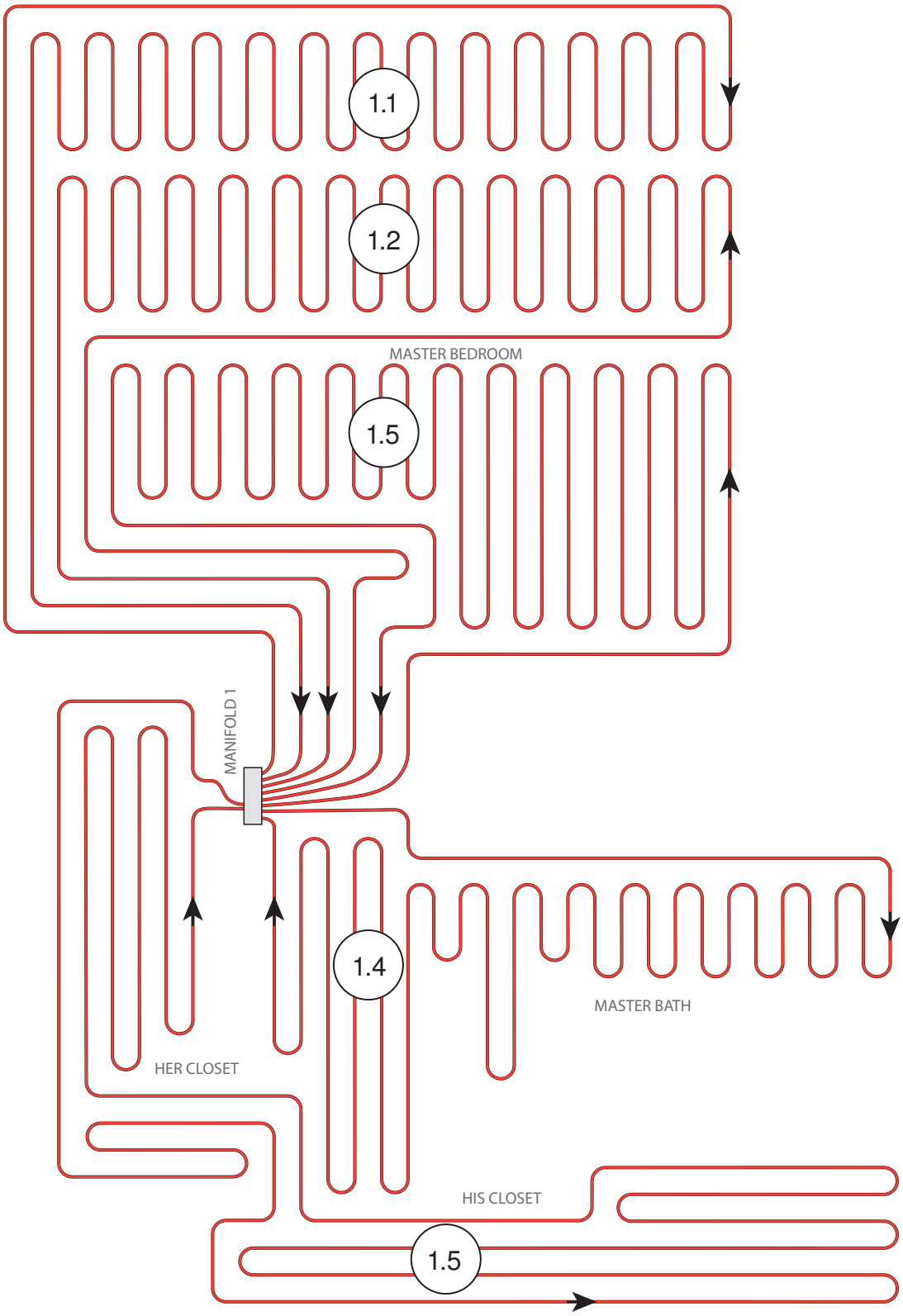


Appendix A - R-Value of Typical Flooring Materials

Material	R-Value Per Inch	Typical Thickness	Typical R-Value
Plywood	1.1	3/4” (19 mm)	0.825
OSB	1.4	3/4” (19 mm)	1.05
Softwood	1.1	3/4” (19 mm)	0.825
Sheet Vinyl	1.6	1/8” (3 mm)	0.2
Vinyl Composition Tile	1.6	1/8” (3 mm)	0.2
Linoleum	1.6	1/4” (6 mm)	0.4
Linoleum	1.6	1/8” (3 mm)	0.2
Dense Rubber Flooring	1.3	21/64” (8 mm)	0.25
Recycled Rubber Flooring	2.2	1/2” (13 mm)	1.1
Cork	3	1-1/2” (38 mm)	1.125
Cork/MDF/Laminate	2.35	1/2” (13 mm)	1.175
Brick	2.25	1-1/2” (38 mm)	3.375
Marble	0.8	1/2” (13 mm)	0.4
Ceramic Tile	1	1/4" (6 mm)	0.25
Thinset Mortar	0.4	1/8" (3 mm)	0.05
MDF/Plastic Laminate	1	1/2" (13 mm)	0.5
Laminate Floor Pad	1.92	5/32" (4 mm)	0.3
Engineered Wood	1	1/4" (6 mm)	0.25
Engineered Wood	1	3/8" (10 mm)	0.375
Engineered Wood	1	5/8" (16 mm)	0.625
Engineered Wood	1	3/4" (19 mm)	0.75
Engineered Wood Flooring Pad	1.6	1/8" (3 mm)	0.2
Engineered Bamboo	0.96	3/4" (19 mm)	0.72
Oak	0.85	3/4" (19 mm)	0.638
Ash	1	3/4" (19 mm)	0.75
Maple	1	3/4" (19 mm)	0.75
Pine	1.3	3/4" (19 mm)	0.975
Fir	1.2	3/4" (19 mm)	0.9
Carpet Pad/Slab Rubber 33lb	1.28	1/4" (6 mm)	0.32
Carpet Pad/Slab Rubber 33lb	1.28	3/8" (10 mm)	0.48
Carpet Pad/Slab Rubber 33lb	1.28	1/2" (13 mm)	0.64
Carpet Pad/Waffle Rubber 25lb	2.48	1/4" (6 mm)	0.62
Carpet Pad/Waffle Rubber 25lb	2.48	1/4" (6 mm)	1.24
Carpet Pad/Frothed Polyurethane 16lb	3.53	1/8" (3 mm)	0.53
Carpet Pad/Frothed Polyurethane 12lb	3.48	1/4" (6 mm)	0.87
Carpet Pad/Frothed Polyurethane 10lb	3.22	3/8" (10 mm)	1.2
Carpet Pad/Frothed Polyurethane 10lb	3.22	1/2" (13 mm)	1.61
Hair Jute	3.88	1/2" (13 mm)	1.94
Hair Jute	3.88	21/64" (8 mm)	1.25
Synthetic Fiber Pad 20 oz	1.8	15/64" (6 mm)	0.421
Synthetic Fiber Pad 27 oz	1.98	18/64" (7 mm)	0.545
Synthetic Fiber Pad 32 oz	2.1	19/64" (8 mm)	0.63
Synthetic Fiber Pad 40 oz	2.2	11/32" (9 mm)	0.77
Prime Urethane	4.3	21/64" (8 mm)	1.4
Prime Urethane	4.3	1/2" (13 mm)	2.15
Bonded Urethane	4.2	21/64" (8 mm)	1.35
Bonded Urethane	4.2	1/2" (13 mm)	2.1
Carpet	2.8	1/4" (6 mm)	0.7
Carpet	2.8	3/8" (10 mm)	1.05
Carpet	2.8	1/2" (13 mm)	1.4
Carpet	2.8	5/8" (16 mm)	1.75
Carpet	2.8	3/4" (19 mm)	2.1
Wool Carpet	4.2	3/8" (10 mm)	1.575
Wool Carpet	4.2	1/2" (13 mm)	2.1

Example panel layout for 5 circuit system




1.1
1.2
MASTER BEDROOM
1.5
MANIFOLD 1
1.4
MASTER BATH
HER CLOSET
HIS CLOSET
1.5

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