ComfortScrim(R)
Installation Guide

Low-Voltage Heating for Wall, Ceiling, Floor, and Anti-Mould Applications.

INSTALLATION MANUAL BY LAMINAHEAT NO.202301

Catalogue

LaminaHeat Low voltage heating film wall, ceiling, floor and anti mould heating system installation guide

1.0)Overview

LaminaHeat Has a series of carbon fiber heating films dedicated to building heating that can be installed on floors, walls and ceilings for use as primary or secondary heat sources. **LaminaHeat's** heating films are lightweight, easy to use and maintenance-free. At the same time, these heating films are very thin, and aren't susceptible to corrosion making them ideal for use in a variety of building materials. Giving a wide range of flexibility for indoor heating system design and installations. In addition, because the films themselves are lightweight and heavy a high electrical conductivity, they have an extremely rapid thermal response. These factors make **LaminaHeat's** heating film an ideal solution for the primary or secondary heating of buildings. More importantly, the **LaminaHeat** heating film, owing to it's ease of installation on walls and ceilings, heats primarily through radiant heating by reaching a surface temperature of 45-50C, creating a more Comfortable environment faster and more efficiently than non-radiant heating. The widths of the heating film are 600 and 900mm, and the length of each roll can reach up to 100 meters.

1.1)Using LaminaHeat's ComfortScrim

Before the start of the installation, an installation plan should be prepared to confirm the location of the heating film, power supply unit (transformer, switching power supply, etc.), wires, as well as the temperature controller.

In order to ensure the best installation results, it is necessary to calculate the required heat load of the space and then determine the correct distribution of heating film to make sure the proper heating effect is elicited(DIN EN 12831). In order to determine proper heating load it may be beneficial to go by the local countries building codes, use them as a base, and then conduct an on site survey to determine any possible variation. Additional care should be taken during the design stage to ensure that the area where the heating film is installed is not covered by interior objects.

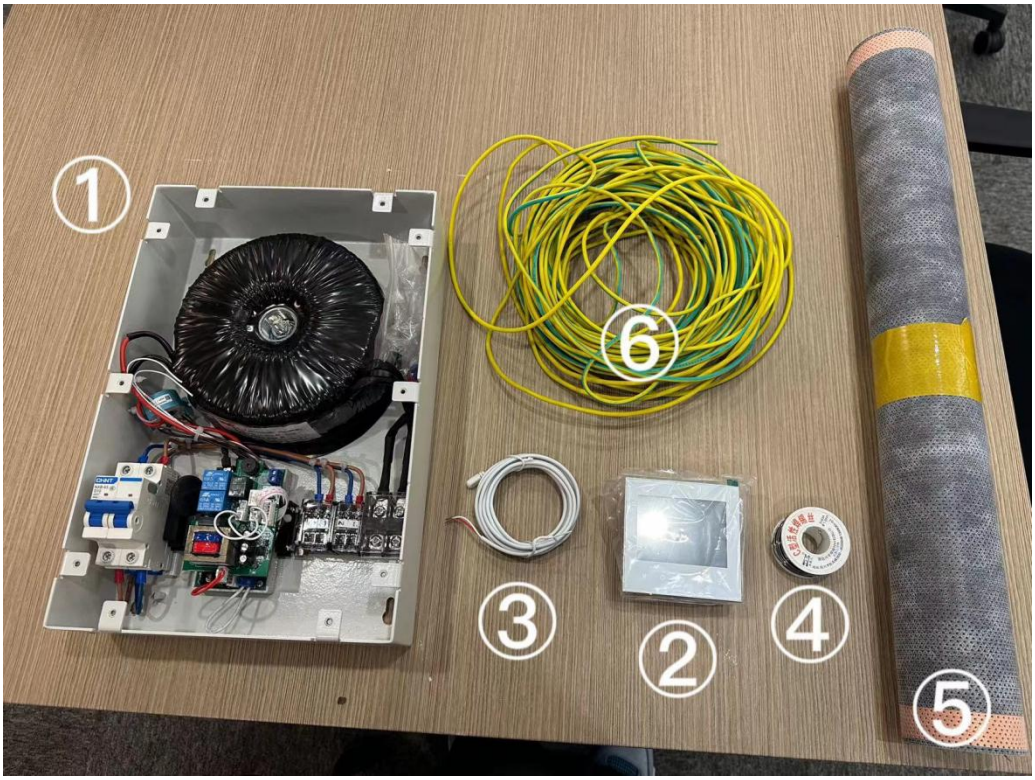
To verify if a material is appropriate to be used with the heating films, it is recommended to contact the manufacturer and obtain the following information: note the thickness, thermal conductivity λ[W/(mK)], or the resulting heat transfer resistance R[㎡ K/W], as well as the material's emissivity (.8≥ e). The maximum heat transfer resistance of the covering, including the bottom and finish of the floor, should not exceed R = 0,15 m_2K/W. Very thin wall/ceiling coverings (wallpaper, plaster systems, ceramic/marble coverings) are recommended for the best heating effect.

Reference is made for thermal conductivity of common floor finishes

Material name	Thickness (mm)	Thermal conductivityユ [W/(mK)]	Heat transfer resistanceR [m 2 K/W]
Tile	13	1.05	0.012
Natural slate	12	1.2	0.01
Carpet	-	-	0.07-0.17
Pincushion	6.5	0.54	0.12
Linoleum	2.5	0.17	0.015
PVC	2.0	0.20	0.01
Parquet floor	11-14	0.09-0.12	0.055-0.076
Laminate	9	0.17	0.05
Cork - Cork laminate	3-10	0.12-0.10	0, 027-0,102
Light gypsum	3	0.1. 2	0.01-015
Cement/sand-basedgypsum	3	0.71	0.004

Table 1 Thermal conductivity parameters for common floor finishes

2.0) LaminaHeat ComfortScrim Electric Heating System Introduction (see P1)



LaminaHeat Low Voltage Heating Film Electric Heating System Main materials/Components:

1 Toroidal transformer 36-48VDC, power depends on the project installation power, must leave a 10-15% power allowance dependent on total installed power.

2 16-20 amps // 220 VAC electronic thermostat

3 Ground and/or wall thermolimitors, the wire length of thermolimitors is generally recommended to be about 2m

4 Soldering tin

5 **LaminaHeat ComfortScrim** with widths 600/900 mm (140-350W/m2)

6 1.25mm2-6mm2 electrical wire (Base wire size on actual project design and maximal amperage

The purpose of using a thermolimitor is to regulate the actual surface temperature of the heating film/heating film exterior finish (especially in underfloor heating scenarios) to prevent the possibility of overheating of the heating surface. This step is optional for wall and ceiling but highly recommended for the floor.

For large surface areas, it is necessary to use multiple thermostats or one temperature controller with multiple temperature control probes to partition, in order to streamline usage and maintain a uniform heating effect.

LaminaHeat ComfortScrim Electric Heating System is equipped with a thermostat in each room. This allows for individual room control and heating, thus saving energy. Each thermostat generally has a load of 16-20 amps at 220 volts AC. Each zone should have its own thermostat/temperature sensor to monitor temperature in order to ensure optimal performance.

3.0) LaminaHeat ComfortScrim Technical Data

3.1) **LaminaHeat ComfortScrim** materials: polypropylene (PET) non-woven scrim, PVC non-woven scrim, with carbon/glass conductive reinforced fiber with/without fine pores heating film substrates.

Table 2- Product model data sheet

:		PG11-048-140-600RPerforated	PG11-048-140-900R Perforated	PG11-048-320-600R Perforated	PG11-048-320-900RPerforated
Mounting		Floor	Floor	Walls/Ceiling	Walls/Ceiling
Power	W/m2	140	140	320	350
Power	W/lm	77	119	176	298
Totalwidth	mm	600	900	600	900
Heatingwidth	mm	550	850	550	850
Copper strip width	mm	20	20	20	20
AC voltage	V	48	48	48	48
Current	A/lm	1.6	2.5	3.7	6.2
Maximum Current	A	16	16	16	16
Max Length	M	10	6.4	4.3	2.5
Resistance	Ω/m2	54.4 +/- 10%	22.8 +/- 10%	23.8 +/- 10%	9.1+/- 10%
weight	gsm	350	350	350	350

Table 3- Material properties Table

· Physical properties	• Material	PETG Film with PET Scrim
	• Thickness	300 µm (PETG / PET)
· Electrical properties	• Dielectric strength• Dielectric constant @ 60 Hz•	2 KV/mm 3.2
	Dissipation factor @60 Hz•	0.0096
	Volume resistivity @50%RH	5.4x10' Ω -cm
· Thermal properties	• Maximal operating temperature	60 ° C
	• Thermal expansion	11 x 10¯6m/m/°C
	• Thermal conductivity	1.6 W/m ° K
· Mechanical properties	• Heater conductor thickness	50 µm
	• Weight	375 gsm/m² (PETG / PET)
	• Max. Tensile strength	20 MPa

	• Elongation at break	2.8%
	• Tensile modulus	7 Gpa
	• Cross section Cu bus bar	20 mm x 0.05 mm

4.0) LaminaHeat ComfortScrim Usage

Ease of installation and ease of use are the main features of **LaminaHeat's ComfortScrim** low voltage electric heating system. **LaminaHeat's ComfortScrim** low voltage heating film electric heating system can be installed in indoor floors, walls and ceilings. When designing the placement of the **ComfortScrim** film, consider the placement of furniture and other objects that may block the surface first, and take care to avoid these areas. Second, the designer should consider the optimal heat distribution when determining film placement. In general it is better to allow for a bit of space between heating films to allow for a more homogeneous heating effect. The total length of each **ComfortScrim** strip depends on the project design specifications and can be cut to fit the specific project needs during application(care should be taken not to exceed the maximal lengths for one continuous strip specified in the **ComfortScrim** data sheet (Part 3).

When using the **LaminaHeat ComfortScrim** low voltage electric heating system, the thermostat should be set to the desired temperature, and the system will automatically adjust the room to the specified temperature. If the specified temperature is not reached then either inadequate wattage has been installed for the specific application or the thermostat temperature probe may be malfunctioning.

* **Note:**

The surface temperature of the area where the heating film is installed as well as how fast the room heats up are both related to the heat dissipation performance of the surface material being used with the **ComfortScrim** material as well as the type of material (insulative or not) that the **ComfortScrim** is installed on top of.

For every **ComfortScrim** installation make sure to make an installation plan diagram for the project in order to ensure proper design and record keeping in case issues arise at a later date.

4.1) System Maintenance

LaminaHeat ComfortScrim low voltage electric heating system requires almost no periodic maintenance and/or replacement of accessories. However, if an issue does arise with the system please check the following items for initial troubleshooting.

Check the thermostat for signs indicating a fault and other conditions that may cause abnormal operation.

Inspect the heating area for any damage

Check the power supply and building fuses or circuit breakers

If you still cannot identify and resolve the issue, please contact a professional electrician or your LaminaHeat dealer for further assistance

* **Note:** The system must be inspected for quality control by a LaminaHeat technician one month after installation and five years after installation. This inspection is required to maintain the warranty and ensure continued good use of the system as well as receive customer feedback.

5.0) Installation

5.1) Preparation for Installation

This section includes the installation of the **ComfortScrim** heating film as well as transformer. Installation of the electrical cables and electrical connections is described in Section 6.1.6 Electrical Requirements.

* **Note:** Installation work should be carried out when the ambient temperature is above 5 degrees Celsius.

Prepare the installation plan, material list, and ensure that the required materials are available in sufficient quantity and quality prior to installation. See Appendix 2 for the general list of materials.

Survey the project site in advance to ensure that the project information provided by the client is correct (such as dimensions, location of electrical installations, and overall condition of the site) to minimize uncertainty/any unplanned issues on the site. See Appendix 5 for a list of site survey criteria.

Unnecessary damage to the heating film, such as tearing from sharp objects or excessive bending, should be avoided before and during installation. Therefore, be sure to roll up the heating film and

maintain it in packaging before installation is required. If you need to punch holes in the heating film after installation, referto section 6.2.7

* **Note:** On surfaces such as walls/ceilings where the heating film is installed, a plastic plug with electrical insulation must be used if nails are required (see P 2). Also, no conductive material should be connected between two nails (e.g., metal picture frames, decorative metal trims, metal shelving systems).

After the site survey has been completed and all the required materials have been prepared and tested, the installation can begin.

P2

5.2) Installation Surface Preparation

LaminaHeat ComfortScrim can be applied to or embedded into any clean, flat surface made of inorganic materials (such as stone, plaster, marble, etc.) or organic materials (such as wood, cork, plastic (possibly with a finish/tile layer), etc.). The material on both the surface and back of the heating film must be able to withstand a temperature of 70 ℃. Contact the manufacturer of these materials if you have any doubts.

Irregular/uneven surfaces (e.g. visible wood/stone bricks) should be avoided. If special circumstances necessitate installation on these surfaces, the surface needs to first be smoothed out with putty or some other material beforehand. Special care must be taken to ensure that the mounting surface is free of sharp objects (such as stones, screw heads, nails,etc.).

P3 Preparing the installation surface

In a floor installation scenario, if there is no adhesive between the mortar layer and the floor finish, we recommend adding a cork layer, fiberglass mat, or alternative underlay of approximately 2mm below the heating film to guarantee the stability of the installation.

A flat/even surfaces is required when **ComfortScrim** is to be applied to walls and ceilings. In addition, the surface must allow for the application of plaster or an alternative adhesive/putty which can bond firmly to the heating film. If the wall/ceiling surface does not meet the above conditions, it must be treated, treatment can be done by covering the mounting surface with another material or sanding it to achieve the required flatness.

5.3) Insulation

It is highly recommended to install insulation in floors, walls and ceilings to reduce heat loss and improve overall heating efficiency, while reducing energy consumption. Ideally, these surfaces should be I nsulated throughout the house. At a minimum, however, ensure that **the area where the LaminaHeat ComfortScrim** film is installed is insulated. In order to reduce heat loss in any installation, the following

maximum U values (according to EN 50559:2013-12) must be followed:

Depending on the specific orientation of the room/house in the building, the U values are required as follows

Mid-floor ceiling (not building roof), above a fully heated room: Maximum U value 1.25W /(m^2*K)

Mid-floor ceilings (non-building roofs), above partially heated rooms: Maximum U value is 0.75 W(m^2*K)

Basement ceilings, walls and ceilings next to unheated rooms, and ceilings and walls adjacent to the ground: Maximum U value is 0.35W /(m2*K)

Maximum thermal transmittance values must be followed to. A standardized insulation material suitable for floor heating must be used. Insulation should not produce more than 5mm of compression under pressure. If there are multiple layers, the amount of compression from all layers combined should not compress more than 5 mm. The insulation layer below the floor must be selected according to the following table:

6.0)Installation options

6.1)Underfloor heating

The heating film is pressed into or embedded in a thin layer of adhesive, putty, or mortar; They can also be mounted on a floating floor. The **ComfortScrim** should be cut to the designed length and place it in the correct position. Special attention should be paid to cable placement when deciding on heater placement.

P4 Example Floating Floor Heating

6.1.1)Select the ComfortScrim type

A)Calculate the floor area to be heated; This depends on the overall insulation quality of the space and the corresponding heat load requirements. An example of the heat load requirements along with the corresponding insulation quality is provided below.

KfW BUILDING REQUIREMENTS

Requirements for a new building according to:	Energy Saving Ordinance 2014	KfW Energy Efficiency House 70	KfW Energy Efficiency House 55	KfW Energy Efficiency House 40
Annual primary energy demand: Qp in kWh/(m²·a)	ca. 70 kWh/(m²·a) (ca. 5 to 7- litre/house)	ca. 50 kWh/(m²·a) (ca. 4 to 5- litre/house)	ca. 40 kWh/(m²·a) (ca. 3 to 4- litre/house)	ca. 30 kWh/(m²·a) (ca. 2 to 3- litre/house)
LaminaHeat heating solution W/m² requirement	**55-65 W/m²**	**45-55 W/m²**	**35-45 w/m²**	**25-35 W/m²**
U-value in W/m²K for:				
Exterior walls	≤ 0,28	≤ 0,25	≤ 0,21	≤ 0,18
Window / outer door	≤ 1,30 / 1,80	≤ 1,10 / 1,80	≤ 1,90 / 1,50	≤ 0,90 / 1,50
Roof	≤ 0,20	≤ 0,18	≤ 0,16	≤ 0,14
Basement wall / sole	≤ 0,32 / 0,39	≤ 0,26 / 0,32	≤ 0,26 / 0,32	≤ 0,18 / 0,18
Ventilation	Tested airtightness and window ventilation	Tested airtightness and window ventilation with heat recovery	Tested airtightness and window ventilation with heat recovery	Tested airtightness and window ventilation with heat recovery
Heater Plant variation / Alternatives	Condensing boiler, heat pump, pellet heating, solar hot water	Heat pump, pellet heating block-type thermal power station, solar hot water preparation, if necessary with heating support	Heat pump, pellet heating block-type thermal power station, solar hot water preparation, if necessary with heating support	Heat pump, pellet heating block-type thermal power station, solar hot water preparation, if necessary with heating support

Table 4 KFW Building Energy Efficiency

Area (m_2) = A= length X width

The heating area shall be determined by referring to the above insulation level. For example, suppose that 80% coverage is required for a poorly insulated space, while 60% is sufficient for a better insulated space

B)Choose the membrane width which is closest to the size of the area you want to heat. (* In the following example, we will use a 900mm wide heating film, model PG11-048-140-900R) Then determine the heat load requirements. The house in this example is poorly insulated, has an area of 50 square meters, and the wattage requirement is 110 watts/square meters

C)See Table 2 for information on all heating film sizes:

D)Calculate the power and length of **ComfortScrim** required:

Table 2: Product specifications for PG11-048-140-900R Perforated
Power density = 140 W/m2 Power per linear meter = 119W Voltage = 48 VAC
Installation area = 50 square meters Power requirement: 110w/m2Total power at 48V = 50 X 110Watts= 5,500Watts Total heating film = Total power (5,500)/Heating film power per linear meter (119) = 46.21LM

E)Select transformer power: use D) to obtain the power required to select the appropriate power of 36-48 VACtransformer (the transformer total rated power should be at least 1.1x that of the installed power for installations under 4000Watts and 1.15x for installed powers exceeding 4000Watts)

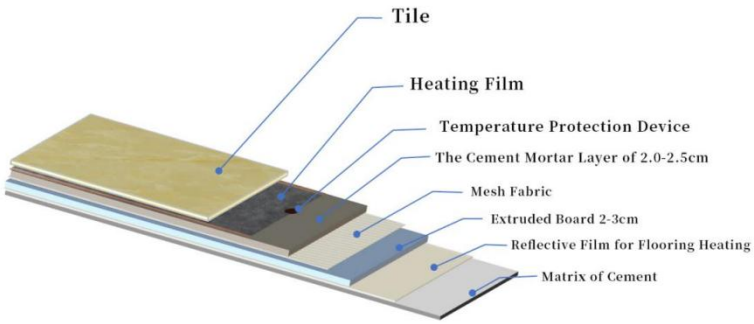
* **Note:**

The heating film must notoverlap and ideally will have at least 2cm of space between the edges.
The heating film must beconnectedin parallel
A single thermostat can control and handle loads of 16-20 amps (Care must be taken that 20amps is never exceeded in a single zone)

6.1.2) Embedded FlooHeating

Under Tile Installations:

After Initial Cement Layer has been installed install moisture barrier layer
Then install a 2-3cm thick EPS insulation board(including grooves for cables if desired).
Install a Mesh Fabric if one wants extra security on adhesion of adhesive to insulation
Add additional 2-2.5cm of Cement mortar/tile adhesive
Install Temperature Protection Device if required.
Adhere film to adhesive layer by pressing the heating film into the adhesive, pushing the adhesive through the fine holes in the film.
Make sure the wires are pressed into either the adhesive or the insulation underneath to guarantee a smooth finish.
Smooth out the surface of the heating film/adhesive using a roller.
Apply a second coat of adhesive (1-3mm) making sure the film is completely covered then proceed to lay the tile.
Smooth out the surface of the heating film/adhesive using a roller.Apply a second coat of adhesive(1-3mm), making sure the heating film completely covers the adhesive bed, and then lay the tile



P7 Floating floor

Cement Floor Installations:

Install moisture barrier

Install 2-3cm thick insulative board (EPS/PU/XPS)

Cut grooves into insulative board for temperature protection device or cables

Tape the heating film in place first to prevent sliding and moving during application of the cement mortar.

Leave at least 20mm of space between the heating films.

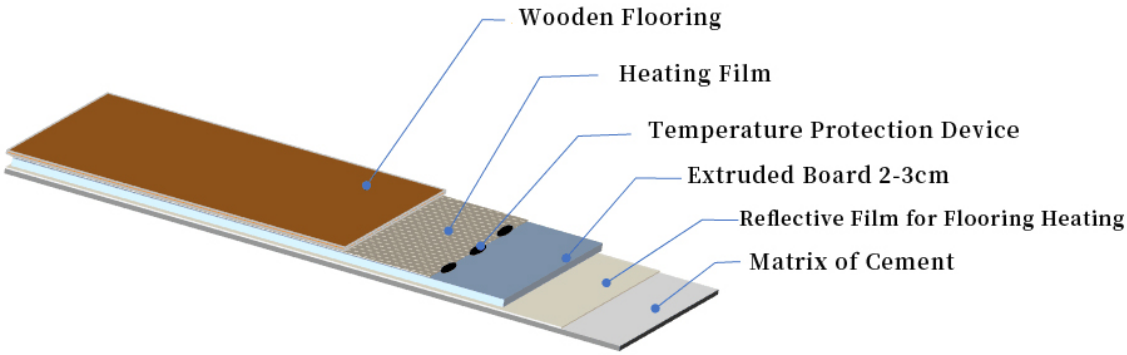
Apply cement mortar to ensure an even surface. Allow the surface to dry according to the manufacturer's instructions.

P6 Cement mortar surface installation



6.1.3)Floating floor underfloor heating

- On top of the base cement layer/ground layer install a moisture barrier layer.
- Install a 2-3cm insulative board (Highly recommended, or at the very least have a 6mm insulative underlay installed).
- Cut grooves into the insulation for the electrical wires to fit into.
- Adhere the using tape adhere the temperature protection device as well as the **ComfortScrim** to the insulative board/underlay. Alternatively an adhesive or mortar can also be used in this step.
- Lay the floating wooden floor on top.



P8: Example of Floating floor Installation

6.1.4) Laminate wood flooring

Make sure your laminate flooring is suitable for electric underfloor heating. Most wood/laminate flooring is compatible with LaminaHeat **ComfortScrim, but we do not recommend using any wood flooring that is thicker than 18mm.**

6.1.5)Thermal InsulationMaterial

Under the surface of the LaminaHeat **ComfortScrim**, an appropriate soft or semi-soft insulation or underlay must be installed, depending on the exterior finish of the floor. This layer of insulation material not only prevents heat from escaping downward, but also plays the role of sound insulation. It can also help avoid possible damage caused to the heating film by abnormal extreme weight from furniture and/or people being put upon the film.

The insulation should be at the very least be 6 mm thick and suitable for electric floor heating scenarios. The insulation capacity of the material is very important, the stronger the insulation (R-value), the less heat loss to the layer below the insulation, so the heating time is shorter and the energy savings are higher.

6.1.6) Electrical requirements

All electrical work must be performed by a certified electrician. All work must meet the current IEE wiring requirements: BS7671:2008.

- A 30 mA residual current device (RCD) must be used to protect the entire circuit.
- For systems carrying current up to 13 amps, the following units of protection are required, fuse wire or 30 mA residual current devices with contact separation at all poles to provide complete disconnection under Overvoltage conditions.
- For systems carrying currents in excess of 13 amps, a suitable protection device that meets the current wiring requirements must be used.
- Calculate the current in each circuit of the system and use the appropriate wire to ensure that the wire can withstand the current passing through the circuit in which it is located.

Name	Working Current (A)	PVC-coated Cable (mm^2)
ComfortScrim System	I≤10	1.50
	10＜I≤16	2.50
	16＜I≤22	2.50+(Customized, actual cross-section size 3.3mm^2) (or larger dependent on total Current)

The cross-sectional area of the conductor, the continuous current that can be allowed to pass through, and the strands are stranded.Maximum current (in amperes) of a single conductor at different temperature ratings of the insulation layer

Cross-sectional area mm	60°C	70°C	85 to 90°C	105°C	125°C	200°C	Maximum number of strand twists	
							Type A *	Type B *
0.75	6	10	12	16	20	25	16	
1	8	14	18	20	25	35	16	
1.5	12	18	21	25	30	40	19	26
2.5	17	25	30	35	40	45	19	41
4	22	35	40	45	50	55	19	65
6	29	45	50	60	70	75	19	105

Table 5 Cross section of wire and through current comparison table

6.1.7) Wire connection

A key component in LaminaHeat's **ComfortScrim** system is wiring and connection. Properly connecting the wires to the heating film ensures the long-term stability of the system and minimizes errors. In order to connect the cable to the heating film, solder the wire to the copper strip of the heating film. It is recommended to not soldier until close to time of installation. The welding procedure is as follows:

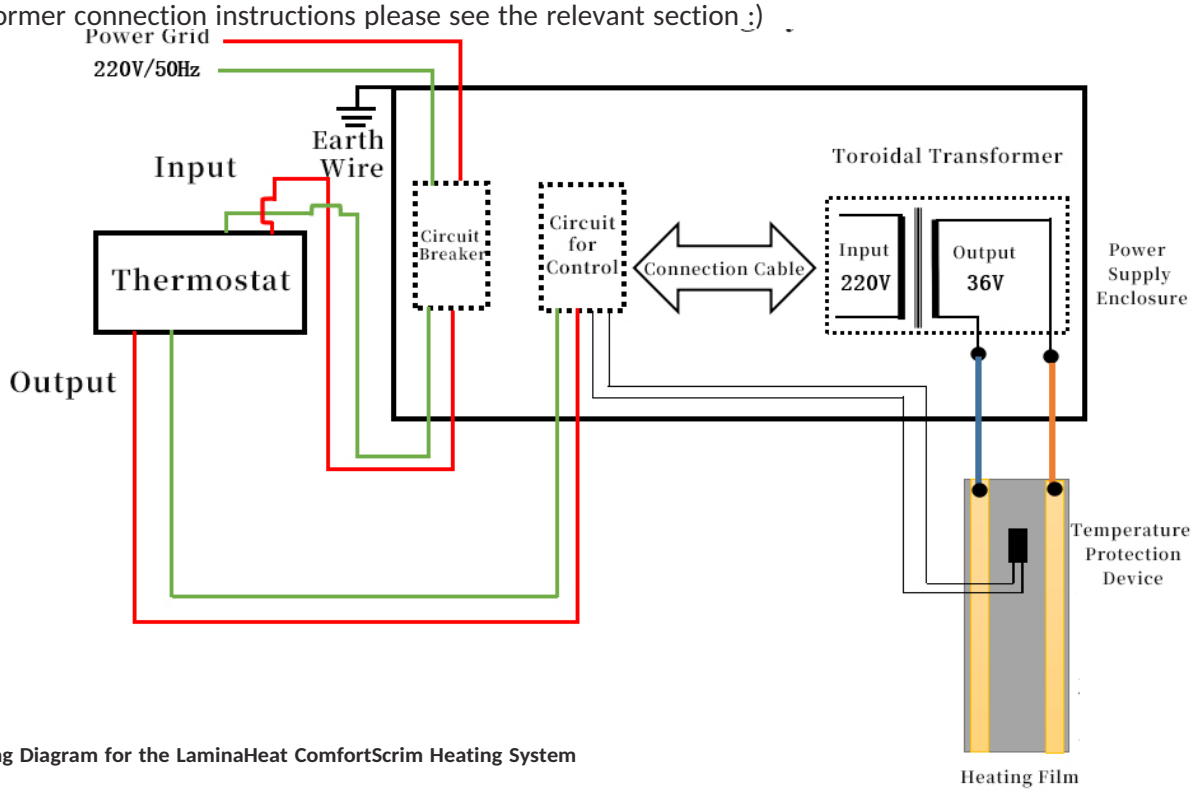
① Select the appropriate length and size of wires, and use the wire stripper to strip out both ends of the copper core.
② Using, a carpenter's knife or a soldering iron set to 350°C melt/scrape a 10x10mm square out of the outermost PETG layer to expose the copper underneath. (If done correctly, the exposed surface square should be reflective, as shown in the soldering video.)
③ Apply appropriate amount of soldering tin to the bare part of the copper strip as the welding base.
④ Apply a thin layer of solder to the exposed copper of the prepared wire.
⑤ Connect the wire with the tin to the already tinned copper strip (make sure the soldering iron is not too hot or it may burn through the copper strip and the carbon fiber layer around it. A soldering iron that reaches 350°c is sufficient. Please contact LaminaHeat technicians for any questions about the soldering iron equipment.
⑥ Wait thirty seconds after connection, then perform a pull test to ensure the connection has been firmly established.
⑦ In floor heating applications, it is recommended to apply liquid electrical insulating glue to the connection points for waterproofing purposes.

P8 Welding the wire to the heating film

6.1.8) Connecting the Thermostat

A thermostat must be installed in a heated room. In a bathroom or wet area, consult an electrician for the appropriate area to install the thermostat.The thermostat should be capable of carrying a current load of 16-20 amps. For larger installations in excess of 20 amps, more than one thermostat is required, or a thermo

-switch is used. After all connections have been made, it is recommended that the electrician fill out the relevant forms and record and display this information on the fuse board in accordance with BS7671:2008 Section 753. In addition, care should be taken not to install the thermostat above any heating equipment such as transformers or other electrical equipment to avoid inaccurate temperature readings. (For the transformer connection instructions please see the relevant section :)



P9: Wiring Diagram for the LaminaHeat ComfortScrim Heating System

6.1.9) Operational Tests of ComfortScrim

Resistance should be tested before, during and after installation of LaminaHeat's **ComfortScrim** heating system. Do not power up during the test. The test process is as follows:

① Calculate resistance according to heating film length, rated voltage and heating film technical parameters. For example, 2.7m **PG11-048-320-600R** has a resistance of 4.8 +/- 10%. Refer to Appendix 6 for the LaminaHeat **ComfortScrim** product resistance table.
② Use the ohm function of the A/C clamp or multimeter and contact the live and neutral poles to record the resistance shown (see P 9).
③ Compare the recorded results with the expected results and record the data in the project plan.

P 9 Test the heating film resistance

Contact your LaminaHeat dealer for guidance if the resistance test results do not match, or if you experience problems measuring the resistance. Additionally, the resistances should be measured when connections have been made to the transformer as well. Record the reading on the control sheet *(see Appendix 3 Resistance Control Sheet)*.

Note: Thermolimitors used under the floor should be tested before finishing floor installations. The relevant values for the Thermolimitor can be found in the thermostat instructions. When testing Thermolimitors for floor use, make sure that a clamp or multimeter can read ohms up to 20 KΩ .

6.1.10) Installation Plan

Prior to installation, fill out an installation plan documenting the location of LaminaHeat **ComfortScrim**, Floor Thermolimitor, thermostat, transformer, junction box(s) to be installed.

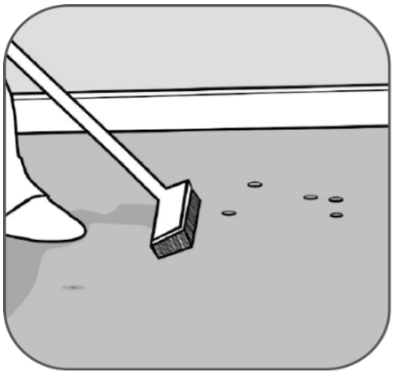
If using a floor heating system with **ComfortScrim** as the primary heat source, the film should cover at least 60-80% of the room floor area. According to the insulation situation of the room, choose the best heating film combination scheme(different widths) to meet the best design of the 60-80 % installation space. Special attention should be paid to unconventional room conditions, such as rooms with extremely heavy furniture on the floor or places like gyms where the floor is under high and frequent pressure.

*** Note:**

Depending on the insulation, ventilation and overall heat loss of the room, the installed power may need to be increased to elicit the proper heating effect

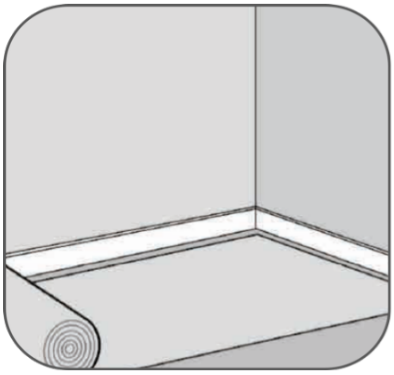
For the ease of future troubleshooting, it is highly recommended to keep records of every installation.

LaminaHeat **ComfortScrim** floating floor installation process



Check and prepare the underfloor

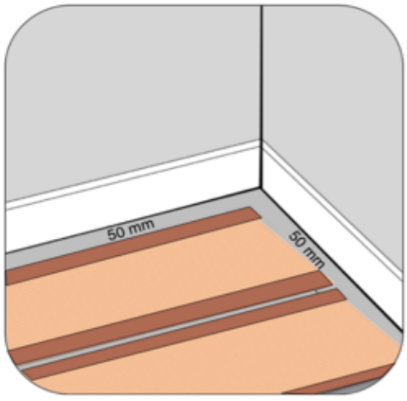
for "floating floor application scenarios," LaminaHeat ComfortScrim must be installed with a soft insulation or underlay.
Carefully inspect the condition of the floor to ensure that it is clean and free of sharp edges, protruding nails or any other object that could damage the



Lay insulation or padding

please use insulation materials in accordance with the manufacturer's instructions

Before installation, please check whether LaminaHeat's ComfortScrim is in good condition.



Prepare the heating film

Take the heating film roll out of the packaging, and check whether there is any damage to the ComfortScrim's surface.

According to the layout diagram, Cut the ComfortScrim to the required lengths and segments(cut in a 90 degree angle to the copper strip and use a scissor or stan knife).

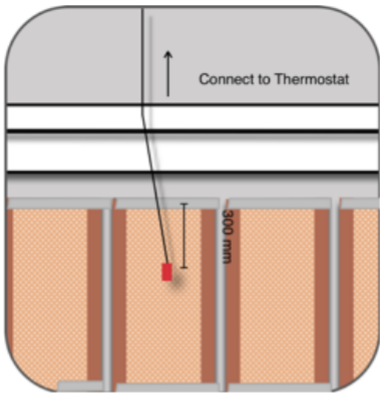
For each piece of heating film, a multimeter (set in the range of 200 ohms) is used to measure the resistance, and the recommended value on the product description and material are compared. If a large variance is detected contact the manufacturer.

Record the reading on the control card.

- Determine the location of the ComfortScrim then place the ComfortScrim on the insulation layer, .

  Make sure to keep at least 5cm of space between the wall and the heating film.

  The heating film should be laid copper strips facing down into the insulation with a groove ideally having been cut into said insulation for the wires, please make sure that there is at least a 20 mm gap between heating film.
  A tape or adhesive should be used to hold the film in place. Heaters should not overlap.



Determine The Thermolimitor location

choose an article about the heating film, in the middle of a room.

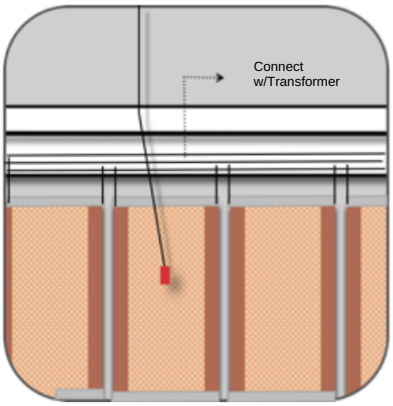
lowered the thermolimitor probe flat in between the insulation and ComfortScrim, about 300 mm from the heating film top position.

Thermolimitor sensor should be fixed in place with tape.

must be careful not to damage the Thermolimitor probe.

Connect the Thermolimitor to the thermostat per the thermostat instructions.

Use a multimeter to test the resistance of the thermolimitor (resistance/temperature value can be found in the notes of the thermostat).



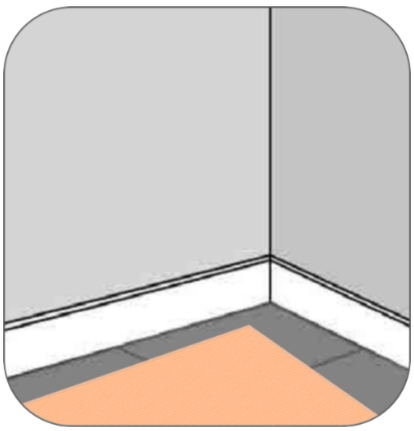
Connecting to The Transformer

Prepare each films electrical wires (2/heating segment) , the size of wire according to the length of the ComfortScrim and its power (cross section is usually between 1.25-4mm2 see table 5 for more instructions).

Follow the soldering instructions laid out in part 6)Electrical connections or in the soldering connection video.

All ComfortScrim segments should be connected in Parallel. (see P24)

. Wire into the corner according to the room design, to ensure that the floor surface is smooth. (see P10-12).



Installing the floor finish

Before installing the floor finish, check and test the resistance of the heating film to ensure that they are not damaged during installation.

Note: Do not proceed with installation if the second resistance reading differs by more than 15% from the original reading. Please contact your LaminaHeat dealer for advice

6.2)Ceiling and Wall nstallation's

For walls and ceilings, use **PG11-048-320-600R** or **PG11-048-320-900R ComfortScrim.** These films are specially designed to be embedded in plaster walls/ceilings, Enabling wall or ceiling surfaces to reach 45-50℃. This design provides comfortable radiant heating without compromising the integrity of the surface plaster. The **ComfortScrim** described above can also be drilled into, with holes not exceeding 7cm diameter being allowed in order to fit light fixtures or outlets(still recommended to install an insulative jacket within these holes). However, care should be taken not to cover the heating area with any large pieces of furniture or objects (such as closets, bookcases, etc.). If the area where the heating film is installed is blocked or is likely to be blocked by large objects, then it is recommended to install thermolimitors on the walls to reduce the risk of overheating. At the same time, it should be verified that the surface covering can tolerate temperatures of 70-80C.

6.2.1)Determining the Installation Plan

For any wall or ceiling design installation, it is essential to first determine the installation conditions before the start of the project. Depending on the overall condition of the installation site, it may be strongly recommended to first install insulation to ensure optimal performance of the heating film. If the overall thermal conductivity U value of the project is known and the thermal load requirement calculated from the U value does not exceed 80w/m_2, the insulation requirements do not need to be calculated. However, in the absence of U value or similar insulative/heating load requirement values, it is recommended to use the table below to form a basis for heating load requirements and determine if any additional insulation materials need to be installed.

<table>
<tr><td>Overall insulation score (insulation condition + insulation quality) = _____</td><td colspan="4">Without knowing the specific U value of your house's insulation, follow these scoring guidelines to rate the overall insulation of the project. For each category, choose 1 value that is closest to the actual situation. If the total is no more than 9 points, insulation must be installed or the project cannot proceed. For projects that score between 10 and 14 points, it is highly recommended to install additional insulation, and it is required to install insulation where the heating film is installed. For projects that score 15-18, additional insulation is not required, but can be installed depending on the clients requests. Additionally, this is meant to serve as a general guideline. It may be beneficial to consult local building codes to further supplement this information in order to determine accurate heating loads.</td></tr>
<tr><td rowspan="8">Insulation score ____</td><td>Scores:</td><td>Score:</td><td>Score:</td><td>Score:</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>1 - open space, there is no door</td><td>1 - single glazing</td><td>1 - no outer wall insulation</td><td>1 - No inner wall insulation</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>2 - Poorly insulated door, such as PVC door, full metal doors, etc</td><td>2 marks - double glazing or single glazing with low e finish</td><td>3 - outer wall has been installed</td><td>3 - inner wall insulation is installed</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>3 - Well insulated door , such as glass fiber reinforced plastic, plywood hollow moulded door, etc</td><td>3 -- Triple glazing or double glazing with an inert gas like argon</td><td></td><td></td></tr>
<tr><td colspan="4"></td></tr>
</table>

Insulation quality score ____	Score:	Score:	Score:	
	1 - no seal around the door	1 - The window is poorly sealed and there are air leaks in the window frame	1 mark - There is no detailed planning and data record on the insulation of the room, and the room suffers from clear thermal bridging	
	Two - Well sealed door	2 marks - The Windows are well sealed and there are no air leaks in the window frames	2 marks -- insulation measures are taken to minimize the impact of thermal bridging	

Table 6 House insulation level evaluation table

Once the insulation level has been confirmed/after the internal insulation has been installed according to the project plan, the exact amount of heating film required can be calculated.

Calculate the amount of heating film required

To calculate the amount of **ComfortScrim** you will need to use, you need to assess the overall heat load requirements. However, in the absence of specific data, please determine the heat load requirement based on the scoring results in the table above. The specific algorithm is as follows:

Projects with a score of 15-18 typically require 10-90 W/m^2 of installed power
Projects with a score of 10-14 typically require 90-110 w/m^2 of installed power
Projects with scores of 9 and below usually require 110+ w/m^2 of installed power

If a project scores below 9, which is a heat load requirement higher than 110w/m2, additional insulation will need to be installed in order to ensure a proper heating effect.

Once the heat load has been determined, you can then calculate the amount of heating film required. The known conditions required for the calculation are the total surface area used, the per linear meter power of the **ComfortScrim** being used, and the heat load requirement. An example is provided below for reference.

Area = 22m
Heat load requirement = 100w/m
Heating film used = PG11-048-320-900R
Heating film power per linear meter = 298W
Total installed power required = area X thermal load demand = 22x100 =2200 watts
Total length of heating film required = total power/Heating film power per linear meter = 2200/272= 7.38LM

Choosing The Right Supporting Transformer

After determining the total power required, select a suitable transformer. The rated power of the transformer should leave a margin of about 10% for installed wattages below 4000Watts, meaning that if the installed power is 2200 watts, a 2500 watt transformer is recommended. Or 15% for installed wattages exceeding 4000Watts. This is to account for potential fluctuations in the electrical grid. Additional consideration should be taken to the placement of the transformer (hung or embedded) as well as inside the room or in an adjacent room. Lastly, it should be determined if a single zone transformer will be required or a multi zone.

Determine the location of wiring and transformers

Before installation begins, you need to determine the location of the transformer and wires to ensure aesthetics and proper functioning of the system. Transformers can be mounted on walls, or placed in distribution boxes, or embedded in walls. Note: The transformer needs to dissipate heat. If in doubt about how to select the correct and qualified transformer, consult a LaminaHeat representative. For wiring, it will need to be determined whether the path of wire connection to the transformer will be embedded in the ceiling/wall, or placed in external PVC wire pipes. The exact wiring scheme needs to be determined on a case -by-case basis.

P10 Wall slotted wiring

P11 PVC slot wiring

P12 PVC wire slots shielded by kickers

Without Installing Insulation :

If the wall plaster is cracked, wet, peeling or exhibits other uneven conditions, please scrape it off/level it out.

Get rid of any sand bumps and unevenness to ensure a smooth surface. The surface needs to be dry, clean, and dust-free.

Clearly mark the surface where the heating film will be placed as well as the location of the wiring. It may be desired to already make the wire grooves in the wall as well.

P13 Wooden profiles for installation of insulation

With Installing Insulation:

The total amount of insulation material and the installation position of the insulation layer depends on the specific project situation.

It is recommended to use thermal insulation materials with thermal conductivity values of at least 0.021-0.025 w/m●k.

It is generally recommended to use a polyurethane insulation board with a thickness of no less than 10mm and no more than 20mm, and a density of 30-50kg/m. In addition, care needs to be taken to ensure that the insulation used can withstand temperatures up to 100℃.

After confirming the type and amount of insulation material, you need to determine if you need to

install a profile system. A profile system has the advantage of ensuring flatness throughout the insulation and providing support that ensures stability. However, the profile itself can also create a thermal bridge effect that reduces the overall effect of the insulation.

If you do decide to install a profile system, it is recommended to maintain at least 600mm spacing to adapt to the differing sizes of insulation materialon the market. First, Secure the profile in place, making sure it is level, then cut the insulation to the desired size according to the profile layout and embed it in the profile (if on the wall, a basic adhesive will suffice (such as two- component polyurethane glue), but on the ceiling, adhesive and insulation nails are recommended to ensure the insulation is secured in place.

If you do not use a profile, simply fasten the insulation to the the wall using fastening screws.

There are three ways to adhere insulation to the wall:

te PL300 around the board to fit onto the eed to make sure the

he insulation

pplied to the pplication of d be mixed according to manufacturer's specifications. The coating of crack resistant mortar should be 2-3mm and require at least 8 hours to dry (depending on the weather conditions, this may take longer)

* **Note**: The surface should be kept level throughout the process.

P1

P16 Using insulation nails to secure

ce coated withcrack resistant mortar

Once the anti-crack mortar layer is dry, you can proceed to the next step. Drill holes for placing insulation nails on the surface, then place the insulation board on the surface according to the position of the reserved holes, and finally drill in the insulation nails to fix the insulation board. It is recommended to use 7 to 9, 60 to 120mm nails on a 1200x600mm insulation board. The insulation nails should be neither too tight nor too loose. An easy way to determine good fit is to nail the insulation nails to the point where they are flush with the surface of the insulation board. In addition, you should also ensure that the insulation board is securely secured, the general practice is to ensure that the insulation nails are nailed at least 20mm as high as the mounting surface.

3. **Apply the two methods at the same time**, which is the most effective solution, but also the most time-consuming and expensive option. If adhesive is applied first, only 4-5 insulation nails are needed per board to ensure stability.Any of the above solutions can achieve the effect of fixing please decide which solution to use according to the specific situation.

6.2.3)Installing LaminaHeat's ComfortScrim

1 Perform a visual inspection of the **ComfortScrim** to ensure that it is in good condition and not damaged.

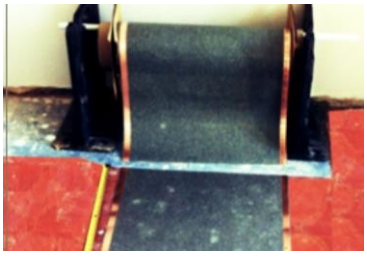
2 Cut the desired length from the **ComfortScrim** roll.

③ Make the soldering connection to **ComfortScrim** by following the wire connection instructions provided in section 6)Electrical connections.

④ Before installing, check the resistance of each piece of **ComfortScrim**, compare it to the theoretical calculated value and record the result (do not use the **ComfortScrim** and contact the manufacturer if the actual value differs from the theoretical value by +/ -15%).

⑤Start by applying a plaster coating of 1-2mm to the wall orceiling (please make sure the plaster quality/performance is sufficient to apply to the wall installation, if in doubt contact a LaminaHeat representative for product verification). Hold one side of the heating film in place, then gradually press it down from one side to the other until the entire strip of heating film is completely pressed into the plaster paste. Which side to start on will depend on the specific project requirements (the direction of the wire will vary). Care should be taken to push out any air bubbles.

⑥Use rollers to lay out the heating film and remove air bubbles. Make sure the sides of the heating film are firmly glued to the wall, otherwise the corners of the heating film will tip up when applying a second coat of plaster.



P17 Cutting the heating film (Manual cutting can be done for smaller projects)

P18 Soldering Connection

P19 Testing the heating film resistance

P20 Pressing the heating film into the plaster

P21 Pressing the heating film using a roller

⑦After the heating film is laid(or before), in some application scenarios, it may be necessary to cut out cable grooves on the wall/ceiling surface (insulation board or gypsum board) and insert wires for aesthetic effect.The trough should be deep enough to meet all wire sizes, and the surface of the trough will be paved with plaster in subsequent steps.

P 22 Treating the wiring slot

(* **LaminaHeat ComfortScrim** is light and has excellent adhesion properties, so it can be operated by one person even for ceiling applications**)**

P23 Applying Plaster Top Coat

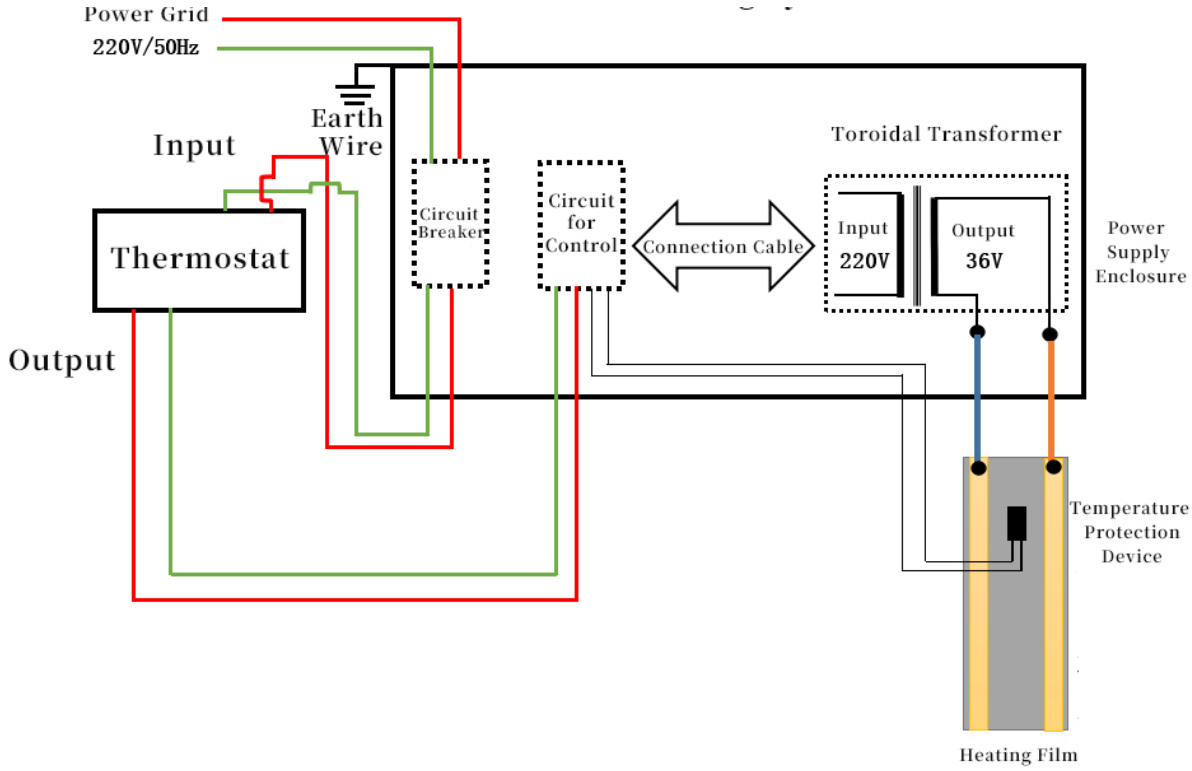
6.2.4)Covering The **ComfortScrim**

Coat LaminaHeat **ComfortScrim** with plaster or putty coating. The coat should be 2-3 mm thick.
The plaster or other coating will bind firmly to the surface through the holes in the heated film and should be evenly distributed. Make sure you use a competent plasterer for this step.
Make sure that the plaster/other coating is completely covering the surface of the heating film so that the other coatings for subsequent covers will stick well (subsequent coatings can be paint, wallpaper, etc.).

At least a day should be allowed for the plaster to dry prior to adding a paint or wallpaper top coat.

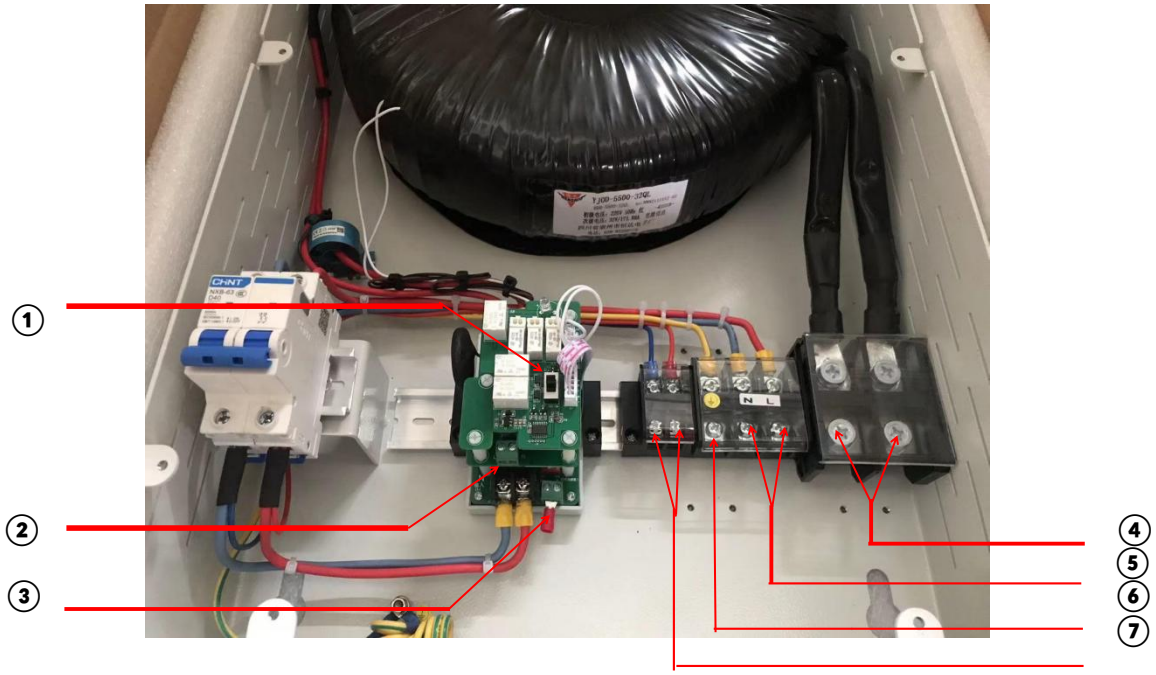
6.2.5)ElectricalConnection

The ends of the cables are connected to the **ComfortScrim** by soldering (see6.1.7)
All LaminaHeat **ComfortScrim** units are connected in parallel to the transformer supply and are uniformly controlled by a temperature controller/thermostat.



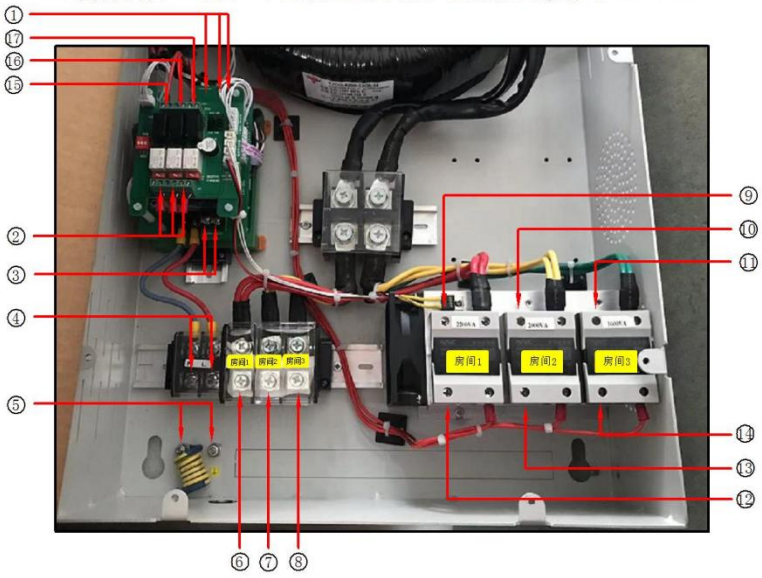
P21: Wiring Diagram for the LaminaHeat ComfortScrim Heating System

[Transformer internal connection]

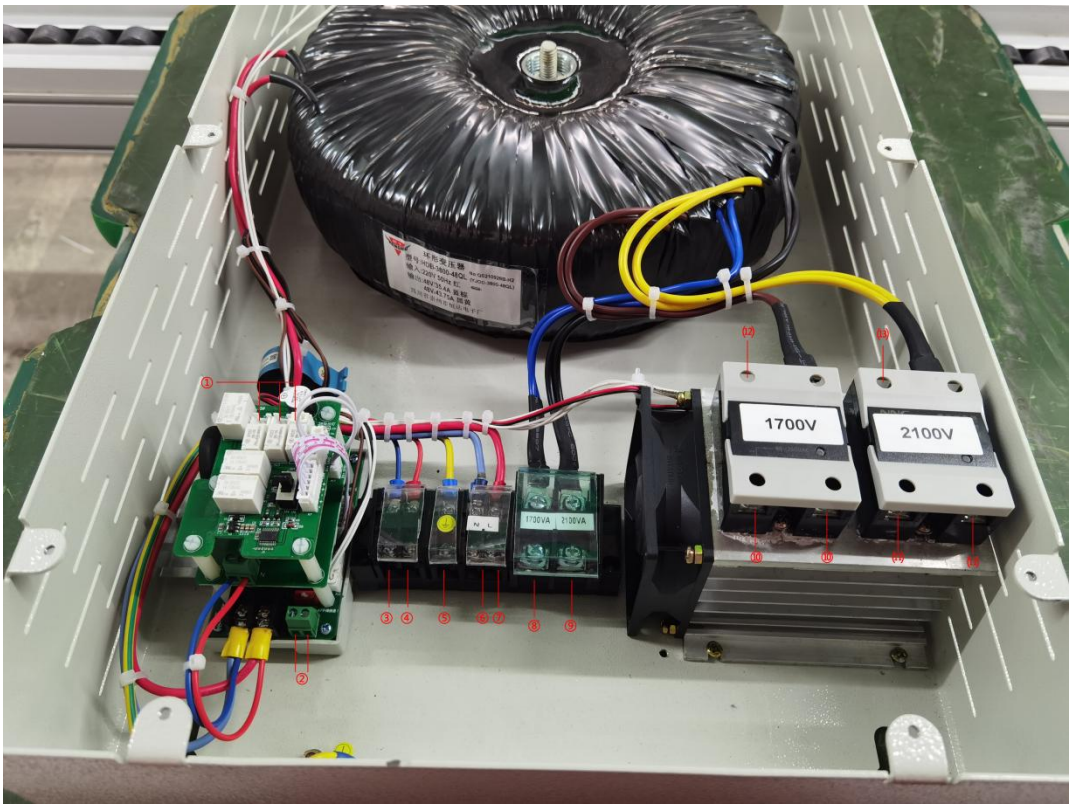


Transformer connection note:
①: secondary maintenance transfer switch (LaminaHeat Installer should operate this 100hrs post install);
②: output port of thermostat;
③: Electric heat film overheating protection connection port (if not being used, please short circuit);
(4) Electric heat film access port;

⑤: 220V input port of main power;
⑥: ground port;
⑦: temperature controller input port;



Transformer Connection Notes：
①Three Room Thermostat in/out connection port
②Three room thermolimitor connection port.
Connection
③Three room thermostat parallel wiring input port.
④:Main Power Supply Input (Left N, Right L)
⑤Grounding Connection
⑥:Room 1 ComfortScrim “+” Connection port
⑦:Room 1 ComfortScrim “-” Connection Port
⑧:Room 2 ComfortScrim “+” Connection Port
⑨:Room 2 ComfortScrim “-” Connection Port
⑩:Room 3 ComfortScrim“+” Connection Port
⑪:Room 3 ComfortScrim “-” Connection Port
⑫Room 1 Thermostat Input “+”Connection Port
⑬Room 2 Thermostat Input “+”Connection Port
⑭Room 3 Thermostat Input “+”Connection Port
⑮Room 1 Thermostat Input “-” Connection Port
⑯Room 2 Thermostat Input “-” Connection Port
⑰Room 3 Thermostat Input “-” Connection Port



Transformer connection note：

:①:Choose any of the two ports and connect to the black and red output control signal voltage of the smart thermostat.
②: Two Zone thermolimitor connection ports. If there are two, connect in series and then connect to the port. If none then short circuit this port.
③:④:Smart Thermostat L/N connection ports. Connect each zone's L/N in parallel and connect with port.(3 N, 4 L)
⑤:Grounding Port；
⑥⑦:Primary Power Connection（⑥N⑦L）；
⑧:Room 1 **ComfortScrim** L Port；⑨:Room 2 **ComfortScrim** L Port;
⑩:Room 1 Thermostat Connection Port；⑪:Room 2 Thermostat Connection Port；
⑫:Room 1 **ComfortScrim** N port；⑬:**ComfortScrim** N Port；

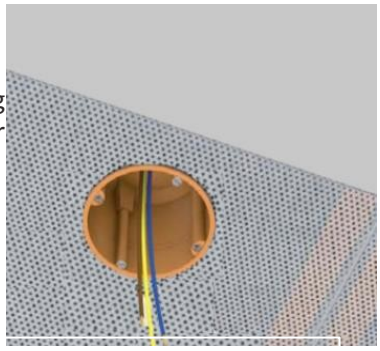
* **Note:**

Be sure to use the correct sizewire.
The electrical connection of **ComfortScrim** should be completed by a professional electrician.
Before connecting each heating film to a transformer power supply, check the resistance of each heating film and record the results.

6.2.6)Installation of fittings andother fixtures

If you need to make holes in wall and ceiling areas where LaminaHeat low voltage heating film is installed for lamps, plugs and receptacles, treat these holes according to the following instructions to ensure that the heating film works properly and efficiently (as shown)

The copper tape on the heating film must **never** be damaged when punching holes (use a standard cable detector to determine the location of the copper tape on the ceiling or wall)
The maximum diameter of the allowable holes is 75 mm (or equivalent square area).
Make sure the area around the hole is insulated to prevent short circuits.



P25. Illustration making a hole in ComfortScrim

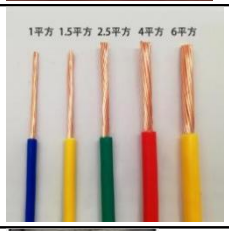
7.0) Connect the power source to start the device

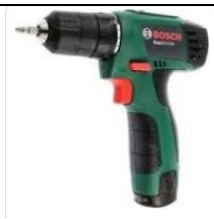
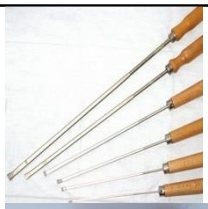
Once the floor/wall/ceiling installation is complete, connect the transformer and thermostat (see 8.0). The final connection need(s) to be done by a qualified electrician. (For any installation, be sure to allow sufficient time for the plaster/coating to dry completely before powering the unit on(2-7 Days depending on specific scenario).
Underfloor heating applications should ensure that the maximum temperature of the floor does not exceed 30℃.
The transformer may be mounted on or flush with the surface. The transformer must be at least 50 mm away from a **ComfortScrim** Segment. A Thermostat must be used to regulate the temperature.
It is best to provide separate thermostats for each room. This allows the reach area to be controlled separately, heating individual areas when needed, thus saving energy.
When turning on the heating system, use a clamp meter to record the total current passing through each wire and compare it to the calculated data in the project design.

Refer to Appendix 2 for material brand and purchase channel recommendations.

Appendix 1: 1 Thermostat Connection

Attached record 2 General list of materials

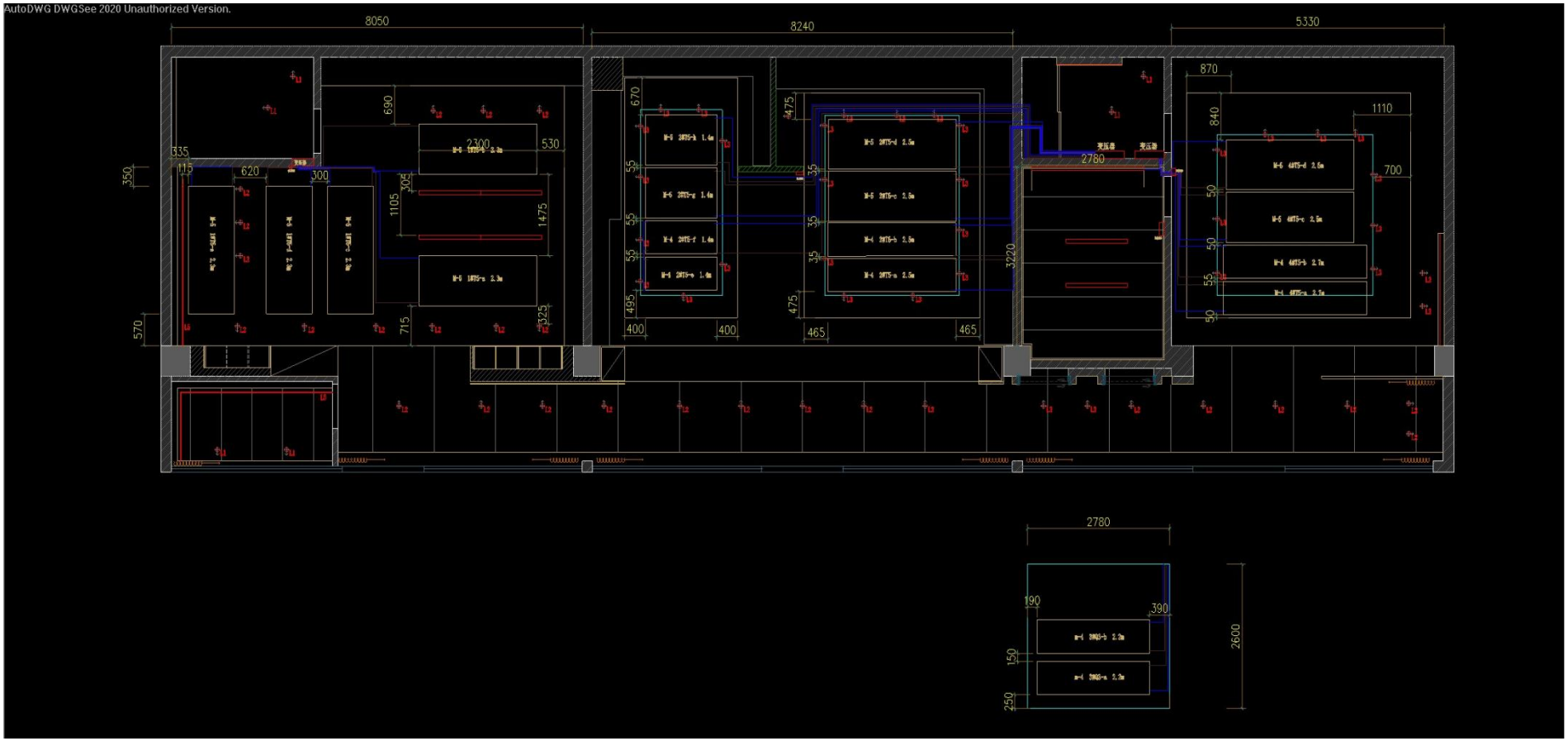
Tools			Raw materials		
1.	Electric soldering irons with temperature of up to 350°C 350C capacitive soldering iron		12.	Polyurethane insulation board 1200x600x10-20mm	
2.	Solder wire/stick Soldiering Tin		13.	Wooden Profiles	
3.	Soldering Paste		14.	Insulation Fastening Nails	
4.	Multimeter		15.	1-4mm2 square wires	
5.	Wire strippers		16.	Crack resistant mortar	
6.	Serrated trowel		17.	Plaster	

7.	Power drill		18.	1 16-20 amps Temperature controller	
8.	Electric mixer/electric drill bit for mixing plaster		19.	PVC wire slot/pipe	
9.	Scissors/box cutter		20.	LaminaHeat Low voltage heating film	
10.	Wire slot scraper or electric hammer	 	21.	Woodworking tape	
11.	Transformer 36-48V		22.	thermo-switch	

Appendix 3 Resistance Test Record Sheet

Room number		Total Power (W)		Rated network voltage (V)			
Comfort Scrim code		Install Date		Measured grid voltage (V)			
Pre-power on test			Post-power-on test				
Comfort Scrim code	Measured resistance value ()	Measured total resistance value	load voltage (v)	**Comfort Scrim** current (A)	Total current (A)	Total power (W)	
Notes:							
1. Under rated conditions, the working current of each carbon fiber heating film should not exceed 20A. If it exceeds 20A, the system should be analyzed for the cause.							
2. The error between the measured resistance value and the resistance value in the planning diagram should not exceed 5%.							
3. Under rated conditions, the error between the measured total power and the designed total power should not exceed 10%.							
Test conclusion							

Appendix 4 Sample Installation Plan drawing



Appendix 5 Project Site Survey Sheet

User name					House floor plan												
Address																	
Contact number																	
Surveyor		Franchise number															
Date of form filling		Order number															
Room number	Grid voltage (V)			Frequency (Hz)	Electrical capacity			Room size				Interior condition	Room energy coefficient survey				
	Morning |	Noon |	evening		Main line cross-sectional area (mm")	Branch cross-sectional area (mmi)	Air switch	Area (m')	Length (m')	Wide m)	Height (m)		Class I	Class II	Class III	Other	
Special notes:																	

Appendix 6 LaminaHeat low voltage heating film

Product Name	PG11-048-140-600R Perforated		PG11-048-140-900R Perforated		PG11-048-320-600R Perforated		PG11-048-320-900R Perforated	
Application	Underfloor heating		Underfloor heating		Wall heating		Ceiling warming	
Resistance +/- 10%	47.6 Ω / □		19.9 Ω / □		23.8 Ω / □		10.0 Ω / □	
Power (W/SQM)	160		160		320		320	
Voltage (vAC)	48		48		48		48	
Heating width (mm)	550		850		550		850	
Length of heating (m)	Resistance (Ω)	Current (A)	Resistance (Ω)	Current (A)	Resistance (Ω)	Current (A)	Resistance (Ω)	Current (A)
0.5	52.360	0.92	38.720	1.35	26.180	1.83	17.000	2.83
1.0	26.180	1.83	19.361	2.58	13.090	3.67	8.500	5.67
1.5	17.453	2.75	12.908	3.81	8.727	5.50	5.667	8.50
2.0	13.090	3.67	9.681	5.04	6.545	7.33	4.250	11.33
2.5	10.472	4.58	7.745	6.27	5.236	9.17	3.400	14.17
3.0	8.727	5.50	6.485	7.5	4.363	11.00		
3.5	7.480	6.42	5.532	8.73	3.740	12.83		
4.0	6.545	7.33	4.840	9.96	3.273	14.67		
4.5	5.818	8.25	4.308	11.19				
5.0	5.236	9.17	3.872	12.42				
5.5	4.760	10.08	3.520	13.65				
6.0	4.363	11.00	3.227	14.88				
6.5	4.028	11.92	2.98	16.11				
7.0	3.740	12.83						
7.5	3.491	13.75						
8.0	3.273	14.67						
8.5	3.080	15.58						
8.8	2.975							
Maximum single piece length	10 m		6.5m		4.36m		2.82m	

15 Rue Morschheimer, LaminaHeat GmbH. 67292 Kirchheimbolanden. Phone +49 -6352-7199760· Fax +49-6352-7199759. info@laminaheat.comManaging Director: Rainer Duchene Registergericht Kaiserslautern. HRB 32069· Tax Code: 44/661/10051 · USt.-ID: DE815642650Deutsche Bank AG IBAN: DE07 5407 0092 0039 9626 00. BIC/SWIFT: DEUTDESM540

China representative officeAdd: Room 1902, Building 8, Zone B, Jinling Garden, No. 12 Xianxaling Road, Laoshan District, QingdaoContact number: 18678618385Email address :sduchene@laminaheat.com