

Insulating panels for floor heating

URL di riferimento: http://www.valsir.it/ita/prodotti/risc_pavimento/tecnica/area_tecnica.htm

Why install floor insulating panels? What influence do they have on system response time and efficiency, and therefore on energy saving? These are the questions we will try to answer in this section of the manual.

Influence of insulating panels on system performance

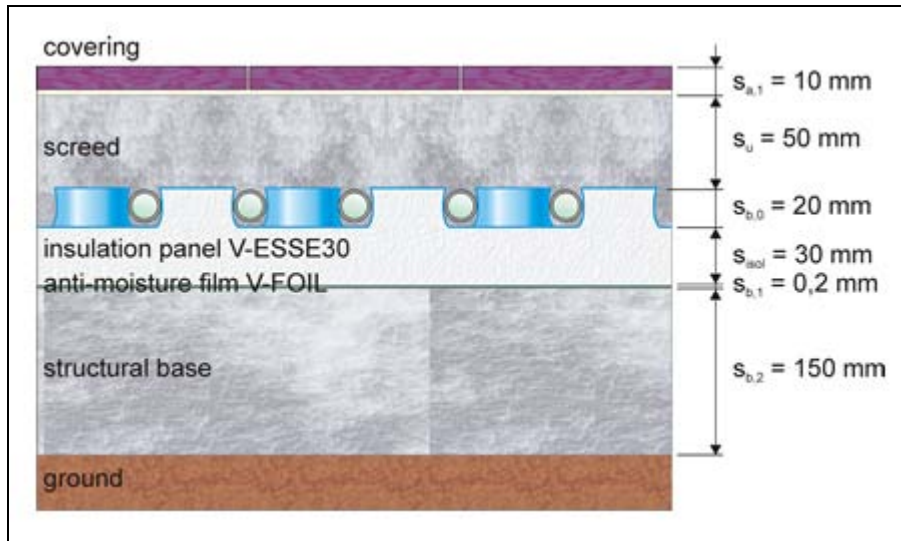
Mechanical function

One of the functions of the insulating panel in floor heating systems is to provide a support onto which the circuits are laid. The panels can be pocketed and contain slots for holding the pipe, or they can be smooth, in which case the pipe is fixed by means of appropriate anchoring clips. Due to the manner in which floor heating is conceived, insulating panels are therefore, a part of the system itself, and although their use is often neglected for economical reasons, they actually have a very important effect on the system's performance. It is, of course, possible to create radiant panels without using insulation, by using metal reinforcement grids on top of which the pipe is laid by means of suitable clips; in this case, however, there would be no barrier to downward heat dispersion and the performance of the system would consequently be compromised.

Reduction of thermal mass

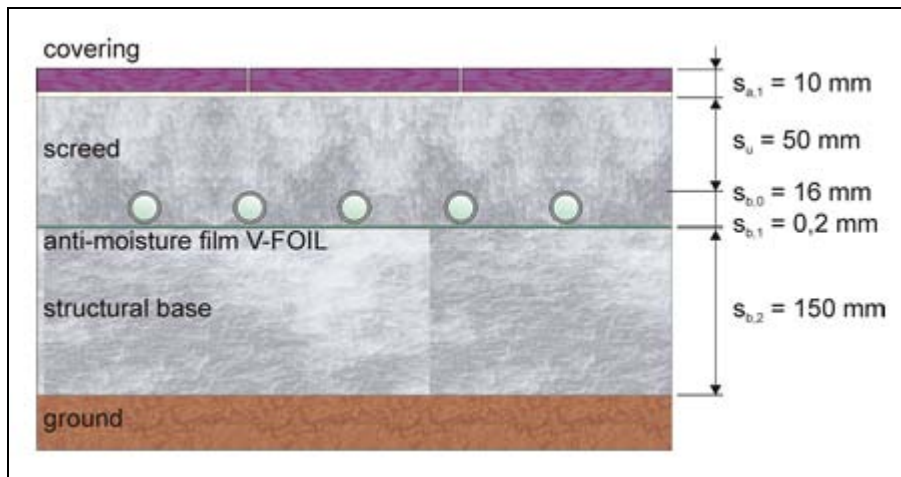
Thermal mass refers to the capacity of materials to store thermal energy (heat). A rock, for example, has a greater thermal mass than a piece of wood; it in fact retains heat for longer than a piece of wood. This is due to the fact that the rock is denser and therefore contains a greater mass at equal volume. When a heated thermal mass is subject to a stream of cold air, for example, it starts to dissipate thermal energy (heat) at a speed proportionate to the difference in temperature between the air and the thermal mass. The principle of floor heating is to maintain constant and uniform the temperature of the thermal mass in such a way as to dissipate sufficient thermal energy to heat the room.

The presence of insulating panels inside the floor structure reduces the thermal mass. The insulating panels, by separating the layer of concrete in which the heating pipes are buried from the load-bearing sub-floor, reduce the thermal mass to be heated and therefore create systems which respond quicker to the variation in room or outdoor temperatures. Let's evaluate a floor heating system in a residential building of approximately 100 m², the structure of the floor containing insulating panel is illustrated in Figure H.1.



FigureH.1. Stratification of an insulated radiant floor

In this case, the volume of the concrete in direct contact with the pipe, and which therefore influences the thermal mass effect, is approximately $0.061 \text{ m}^3/\text{m}^2$ (quantity of concrete per square meter of surface). If the same system had been created without insulating panels (see Figure), the volume of concrete in direct contact with the pipe would be $0.213 \text{ m}^3/\text{m}^2$ (given by the volume of screed above the pipe and the volume of concrete). It is easy to verify that the relationship between the volume of concrete is from **1** to **3.5** and therefore there is a significant increase in the thermal mass should insulating panels not be used. Based on what has been expressed in the introduction, it follows that the greater the thermal mass the longer it will take the system to respond to the variations in temperature.



FigureH.2. . Stratification of a radiant floor with insulation

Thermal insulation

The energy produced by the coils is directed both upwards, bringing the necessary contribution to the heating of the room, and downwards, generating a loss of energy towards the underlying ground.

The flow of downward energy depends on the temperature of the ground and the room below and on the total thermal resistance of the layers of material below the pipes.

Obviously, the better the insulation the less thermal energy that is wasted.

To reduce energy loss, the Standard UNI EN 1264, which establishes the sizing rules for floor heating systems, imposes minimum thermal resistance values for the layer of insulating material in relation to the climatic conditions. The minimum value required is $0,75 \text{ m}^2\text{K/W}$ for rooms which lie above other continuously heated rooms. A panel of expanded polystyrene which insures such a thermal resistance value must have a minimum thickness of at least 22-25 mm.

A critical analysis of the difference between a building with an insulated floor and one without will successively be made.

Numeric analysis of insulation

Calculation basis

To evaluate the positive effect of insulating panels on the output of the floor heating systems, the project results of two systems to UNI EN 1264 will be compared: one with V-ESSE30 panels and the other with no type of insulation. According to the Standard requirements, and with reference to Figure H.3, the thermal resistance to the vertical thermal flow both towards the inside of the room R_o and towards the underlying room R_u must be calculated as indicated in chapter 5. The percentage energy loss is calculated as the proportion $q_b / (q_a + q_b)$ between the downward thermal flow and the total thermal flow created by the system.

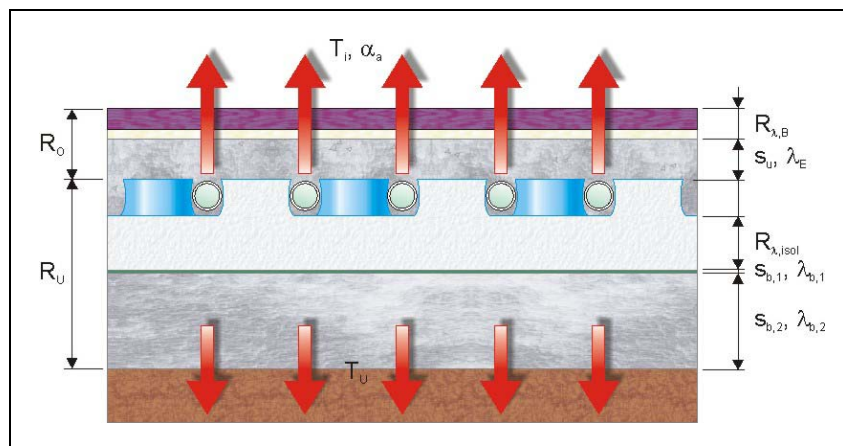


Figure H.3. Energy flow of a radiant floor

Results

To evaluate the energy loss through the floor, systems were sized with and without insulating panels, maintaining the floor structure and varying several fundamental parameters: the temperature of the underlying room T_u and the useful thermal flow q_a .

A building of a residential type of approximately 100 m^2 was considered and the system was installed with the multilayer pipe Valsir Mixal 16x2.

Variation of the external temperature at equal thermal flow

A thermal flow of 70 W/m^2 was considered and the downward energy loss in a room with floor insulation and one without insulation was calculated at varying temperatures in the underlying room.

From Table H.1 and Figure H.4 the following can be observed: going from a temperature T_u of -6°C (rooms over a terrace in cold climates) to a temperature of $+4^\circ\text{C}$ (rooms on the ground) until reaching a temperature of $+16^\circ\text{C}$ (rooms over heated rooms) there is an energy loss which varies

from 26% to 12% for systems with insulating panels and which goes from 44% to 24% for systems without insulating panels.

A building without insulation, therefore, has significantly higher energy losses and on average, they are double the losses in buildings with floor insulation. In the coldest conditions, the energy loss in a system with no floor insulation can reach values as high as 44%.

Temperature of the room below	Downward thermal flow with insulating panel	Energy loss	Downward thermal flow without insulating panel	Energy loss	Δ
T_U	q_b		q_b		
[°C]	[W/m ²]	[%]	[W/m ²]	[%]	[%]
-6	24,1	26%	56,1	44%	+19%
-4	22,8	25%	53,0	43%	+19%
-2	21,5	23%	49,9	42%	+18%
2	18,8	21%	43,7	38%	+17%
4	17,5	20%	40,6	37%	+17%
6	16,1	19%	37,5	35%	+16%
8	14,8	17%	34,5	33%	+16%
10	13,5	16%	31,4	31%	+15%
12	12,2	15%	28,3	29%	+14%
14	10,8	13%	25,2	26%	+13%
16	9,5	12%	22,1	24%	+12%

Table H.1. Downward energy loss according to the variation in temperature of the room below

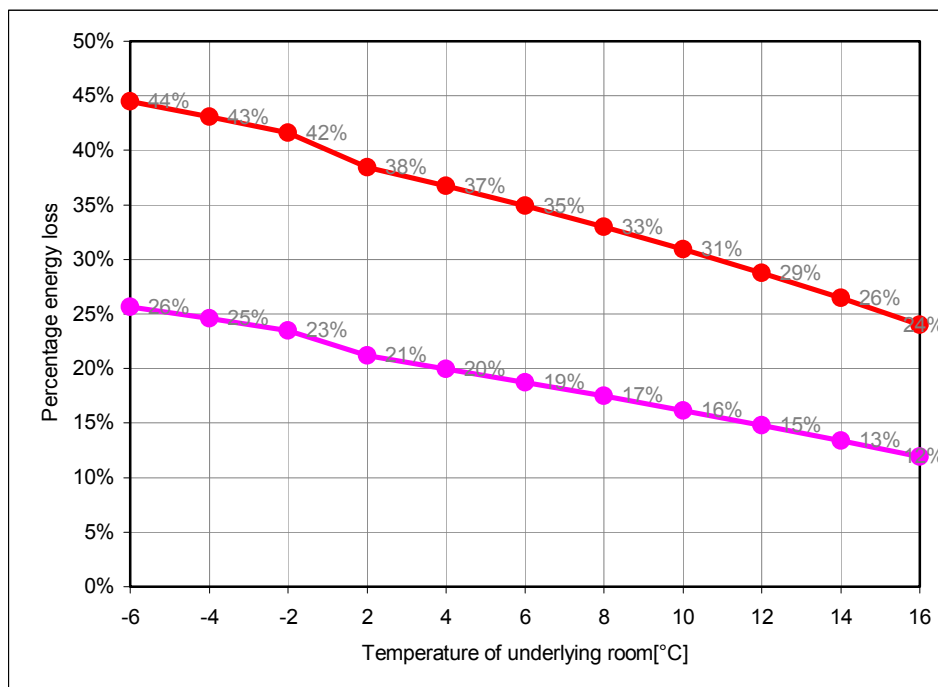


Figure H.4. Trend of downward loss in relation to the temperature variation in the underlying room

Variation of thermal flow at equal external temperature

A building situated on the ground with a temperature of +5°C was taken into consideration and, as the temperature necessary for heating the rooms varied, the downward energy loss was calculated for rooms with and without floor insulation.

From Table H.2 and Figure H.5 the following can be observed: going from a thermal flow q_a of 50 W/m^2 to 95 W/m^2 there is an energy loss which drops from 23% to 17% for systems with insulating panels and 41% to 32% for systems without insulating panels.

Again, it has been revealed that the energy loss for systems without floor insulation is double the loss in systems with floor insulation. In conditions of low thermal flow (50 W/m^2) the energy loss reaches 41%.

Upward thermal flow	Downward thermal flow with insulating panel	Energy loss	Downward thermal flow without insulating panel	Energy loss	Δ
q_a	q_b		q_b		
[W/m^2]	[W/m^2]	[%]	[W/m^2]	[%]	[%]
50	14,9	23%	34,6	41%	+18%
55	15,3	22%	35,7	39%	+18%
60	15,8	21%	36,8	38%	+17%
65	16,3	20%	38,0	37%	+17%
70	16,8	19%	39,1	36%	+16%
75	17,3	19%	40,2	35%	+16%
80	17,8	18%	41,4	34%	+16%
85	18,3	18%	42,5	33%	+16%
90	18,8	17%	43,6	33%	+15%
95	19,3	17%	44,8	32%	+15%

Table H.2. Downward energy loss in relation to the variation of useful thermal flow

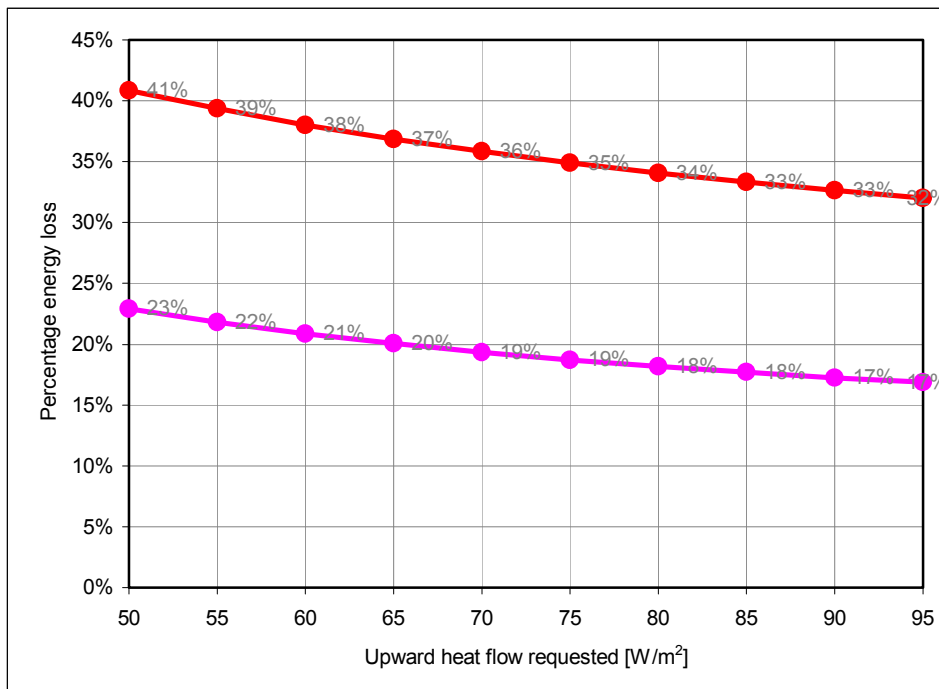


Figura H.5. Andamento delle perdite verso il basso al variare del flusso termico

Economic analysis

From a simplified economic analysis it is possible to evacuate the difference in terms of heating expense between the two the buildings, the first with floor insulation (which we will call case A), the second without floor insulation (which we will call case B). Let's suppose that the building is situated on the round ($T_U=+4^{\circ}\text{C}$) and the heating power is 7000 W (70 W/m² for a surface of 100 m²).

From the table the following is read:

- the downward energy loss in case A is 19%
- the downward energy loss in case B is 36%

therefore:

- the necessary heating power in case A is 8640 W
- the necessary heating power in case B is 10937 W

If a boiler efficiency of 90% and methane heating power of 8200 kcal/m³ (34330 kJ/m³) is considered, it is possible to determine the flow of methane necessary in both cases and the annual consumption, considering 75 days of heating per year and the cost of methane at 0,55 €/m³.

The result is therefore:

- a flow of methane in case A of 1.01 m³/h,
- a flow of methane in case B of 1.27 m³/h

and annual consumption is:

- 1810 m³/year equal to approx. 996 €/year in case A, and
- 2290 m³/year equal to approx. 1260 €/year with a difference p.a. of approx. 265 €/year in case B.

Conclusion

From the results obtained it is deduced that the absence of insulating panels has a significant negative effect on the heat output of the heating system which could entail an energy loss of as much as 40%. The use of insulating panels is therefore always strongly recommended; it allows, in fact, to achieve important reductions in annual consumption, in the example taken into consideration, a saving in methane consumption of approximately 20% was calculated. The considerations that were made for residential floor heating systems can be transferred to an industrial type floor heating system with the same results.

The use of insulating panels influences not only consumption but also the performance of the system, it has been seen how the presence of the panel reduces the thermal mass and therefore enable the system to respond quicker to changes in the temperature.