THERMAL INSULATION VALUES FOR REFLECTIVE FOILS AND CAVITIES

Pages 16 and 17 of Technical Working Paper #3 ~ Tables for Thermal Insulation.
For more information see: www.nienhuys.info (page thermal insulation).

Calculations

The calculations of the reflective foil qualities were realised by Han Kwang Nienhuys (12-1-2012) and based on materials which could be found in the market. The thermal insulation value is a combination of the emissivity of the material, the insulation value of the air layers in between the foils, and the conductivity of the moving air.

The best performance was the aluminium-coated polyester film from Tonzon®. Aluminium-coated polyester food wrapping foils which are also coated with a very thin plastic film have an r= 90%, but will not be influenced by corrosion over time. The corrosion of pure aluminium will greatly reduce the reflectivity (emissivity). This will be especially the case in humid cavities or with condensation on the foil.

Dry Air Insulates

An important factor in the insulation value of the reflective foils is the insulation value of DRY air. The reflective foil can also function as a moisture (vapour) barrier to avoid condensation inside the insulation material on the cold side of that moisture barrier. When, however, condensation takes place on the reflective foil (from the warm side), the aluminium coating can become dull and reduce part of its emissivity; this is especially the case with pure aluminium foils. In addition, condensation on the foil is only possible when the humidity level reaches 100%. This means that inside the cavity, very humid air is circulating; this very humid air will have a much lower thermal insulation value than dry air.

Breathable Reflective Foils

Perforated reflective foils are currently available in the market, allowing moisture (and oxygen or CO_2) to pass or exchange but still work as reflective foils and increase the thermal insulation value. These foils are also called "perforated breathable foils" and "perforated radiant barrier foils". Brand names are: Sisalation® facing foil, Ecofoil, Armafoil, EcoGUARD, Thermabar and Atticbar.

Ventilation[1]

The insulation performance of the perforated foils is as good as the sealing foils, but the application of breathable foils can be an advantage when applying inside walls of existing houses. In such houses, the ventilation after sealing is often inadequate to allow sufficient oxygen, vapour and CO_2 exchange. Depending on the construction type, traditional wall constructions of timber or brick masonry allow a little natural breathing of the house by which vapour, oxygen and CO_2 levels are very slowly balanced with the outside air values. When vapour sealing insulating foils are applied, the ventilation should be substantially increased to remove exhaled air and obtain fresh air from outside. The use of the breathable foils in old houses can make the construction of additional ventilation openings or mechanisms slightly less necessary.

Position of the Cavity and Direction Heat Flow

When making calculations, two positions of the cavity should be analysed, horizontal and vertical.

In a vertical air layer, movement of air will occur between the cold and the warm surface, and this movement will increase with a wider as well as higher space. The optimum width of the air layer is about 2 cm. Interrupting a 5 cm height of an air space with a building material such as a durable plastic foil will slightly increase the insulation.

With the horizontal cavity, the insulating value depends on the location of the heat source. With the heat source from above, the insulation value is substantially larger than with the heat source from below. This has to do with the air movement. Warm air rises and cooled air sinks; this air movement is large when the heat source is from below and small when the heat source is from above.

Position of Reflective Foil Side

The horizontally placed reflective foils will become dusty over time when these are not protected by durable plastic foils spaced directly above them. Dust in the air and falling through roof or floor boards which settle onto the reflective side will substantially affect the emission characteristics and thus affect the insulation value negatively. **In such cases, the reflective side should be placed downwards; this way dust cannot settle on the reflective side.** This means that reflective foils with PE backing should be placed with the PE backing upwards; for floors, ceilings and roofs.

[1] An additional technical paper will be posted on ventilation in general.

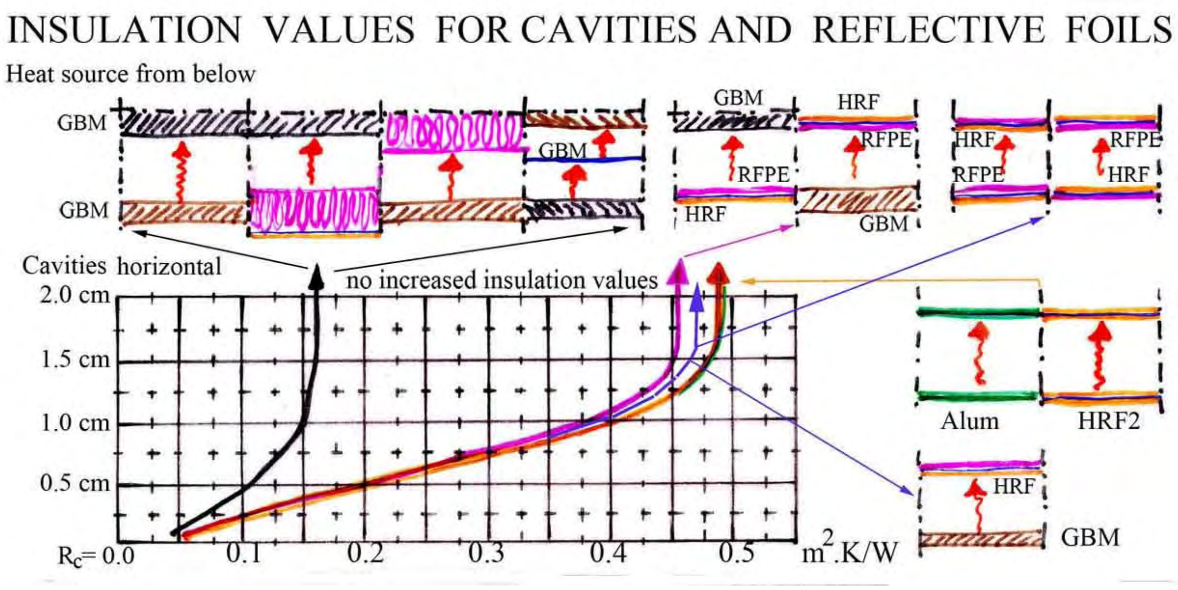
THERMAL INSULATION VALUES FOR REFLECTIVE FOILS AND CAVITIES

Insulation values for **horizontal** cavities with heat flow from below, such as **ceilings**.

The calculations are based on reflectivity (r) and emissivity (ε) of materials: $r + R_C + \varepsilon = 1$
in which the R_C is the insulation value of the foil itself (very little).

Height in cm	GBM-GBM Black Line: $R_C = m^2.K/W$	GBM-RFPE RFPE-GBM Pink Line: $R_C = m^2.K/W$	GBM-HRF, HRF-RFPE HRF-GBM Blue Line: $R_C = m^2.K/W$	HRF-HRF HRF-Alum Alum-Alum, Alum-HRF Orange and Green Lines: $R_C = m^2.K/W$
0.1	0.035	0.04	0.04	0.04
0.5	0.11	0.2	0.2	0.2
0.7	0.13	0.27	0.28	0.28
1.0	0.15	0.38	0.39	0.4
>1.5	0.16	0.45	0.47	0.48

GBM — **All General Building Materials (ε = 0.9; r = 10%)**
RFPE — **Reflective Foil with 3 mm Polyethylene foam backing (ε = 0.1, r = 90%)**
HRF or HRF2 — **Highly Reflective Foil and 2 sided HRF (ε = 0.04, r = 95%)**
Alum — **Aluminium Foil, both sides (ε = 0.04, r = 95%)**
When the reflectivity of the foil is less than 90%, an intermediate value is needed.



Observations
The above graph indicates that increasing the air space more than 2 cm does not increase the thermal insulation value. The placing of a durable (non-reflective) plastic foil, hardboard or similar material in spaces higher than 4-5 cm will increase the thermal insulation, but will be about one-third as effective as an intermediate reflective foil. Height allowances should be made for sagging.

With a closed attic area, the entire attic will function as additional thermal insulation to the house. The ceiling, air space and roof construction work together as thermal insulation.

THERMAL INSULATION VALUES FOR REFLECTIVE FOILS AND CAVITIES

Insulation values for **vertical** cavities, such as with **wall cavities**.

The calculations are based on reflectivity (r) and emissivity (ε) of materials: $r + R_C + \varepsilon = 1$
in which the R_C is the insulation value of the foil itself (very little).

Height in cm	GBM-GBM Black Line: $R_C = m^2.K/W$	GBM-RFPE RFPE-GBM Pink Line: $R_C = m^2.K/W$	GBM-HRF, HRF-RFPE HRF-GBM Blue Line: $R_C = m^2.K/W$	HRF-HRF HRF-Alum Alum-Alum, Alum-HRF Orange and Green Lines: $R_C = m^2.K/W$
0.1	0.035	0.04	0.04	0.04
0.5	0.11	0.2	0.2	0.2
0.7	0.13	0.28	0.28	0.28
1.0	0.15	0.39	0.39	0.4
1.5	0.17	0.55	0.56	0.58
2.0	0.17	0.61	0.62	0.64
2.5	0.18	0.68	0.69	0.71
>3.0	0.19	0.68	0.69	0.71

GBM — **All General Building Materials (ε = 0.9; r = 10%)**
RFPE — **Reflective Foil with 3 mm Polyethylene foam backing (ε = 0.1, r = 90%)**
HRF or HRF2 — **Highly Reflective Foil and 2 sided HRF (ε = 0.04, r = 95%)**
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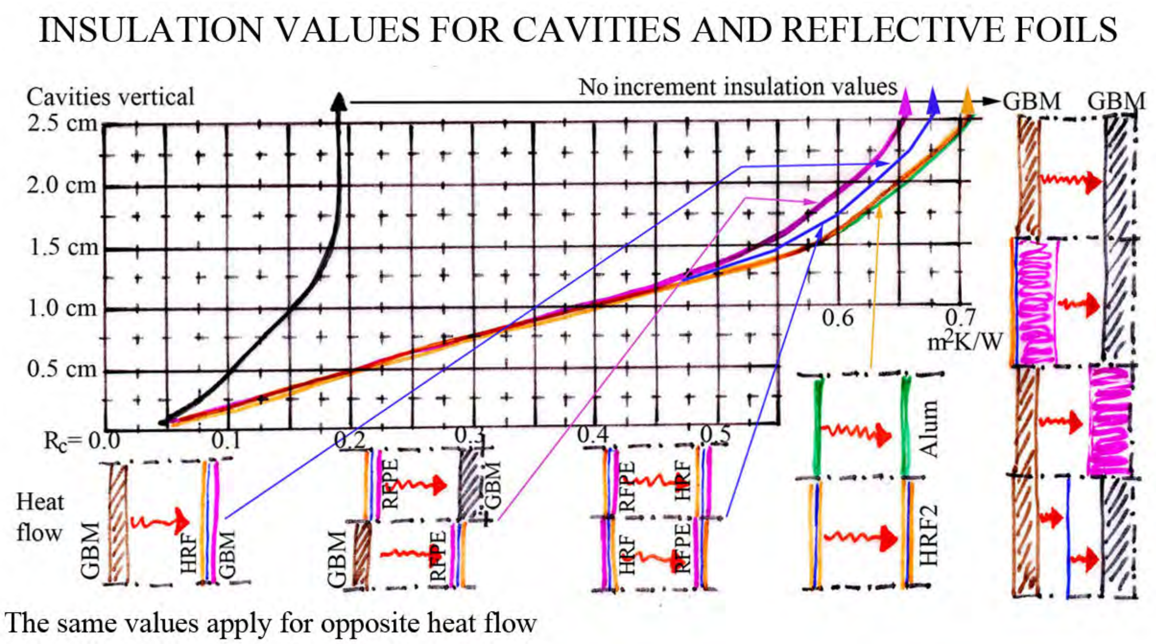
When the reflectivity of the foil is less than 90%, an intermediate value is needed.



Observations

According to the scientific calculations, there is no difference in emission or insulation value between reflective foils facing the heat source or facing the cold side.

The above graph indicates that increasing the air space more than 2 cm between common building materials or more than 2.5 cm to 3 cm with reflective foils does not increase the thermal insulation value. Placing of a durable (non-reflective) plastic foil, hardboard or similar material in vertical cavity spaces wider than 5 cm to 6 cm will increase the thermal insulation, but only be about one-third as effective as an intermediate reflective foil.

A closed non-ventilated vertical cavity area will function as thermal insulation. A ventilated cavity, however, will hardly function as thermal insulation. When the air flow inside the cavity is very low, the transmission coefficients between the two inside faces can be taken as inside transmission coefficients.

THERMAL INSULATION VALUES FOR REFLECTIVE FOILS AND CAVITIES

Insulation values for **horizontal** cavities with <u>heat flow from above</u>,
such as occurs under **floors of warm rooms or under roofs.**

Height in cm	GBM-GBM Black Line: R_C = m^2.K/W	GBM-RFPE RFPE-GBM Pink Line: R_C = m^2.K/W	GBM-HRF, HRF-RFPE HRF-GBM Blue Line: R_C = m^2.K/W	HRF-HRF HRF-Alum Alum-Alum, Alum-HRF Orange and Green Lines: R_C = m^2.K/W
0.1	0.035	0.04	0.04	0.04
0.5	0.11	0.2	0.2	0.2
0.7	0.13	0.28	0.28	0.28
1.0	0.15	0.39	0.39	0.4
1.5	0.17	0.55	0.56	0.58
2.0	0.18	0.72	0.74	0.76
2.5	0.185	0.86	0.88	0.92
3.0	0.19	0.96	1.02	1.1
4.0	0.20	1.15	1.2	1.45
5.0	0.21	1.5	1.6	1.7
10.0	0.21	2.8	3.2	3.5
>20.0	0.23	3.0	3.5	4.0

GBM All General Building Materials (ε = 0.9; r = 10%)
RFPE Reflective Foil with 3 mm Polyethylene foam backing (ε = 0.1, r = 90%)
HRF or HRF2 Highly Reflective Foil and 2 sided HRF (ε = 0.04, r = 95%)
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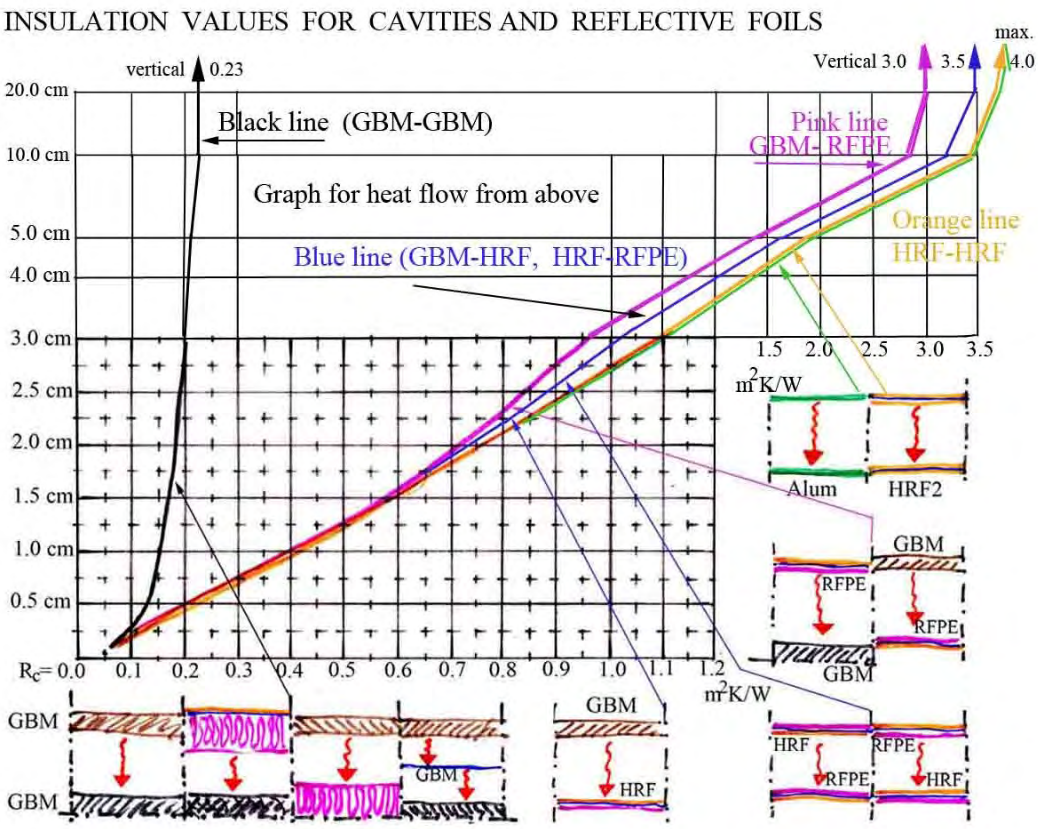

<u>Observations</u>
In the graph above, the scale on the left side is not linear to save space. Increasing the vertical distance of the cavity above the 2 cm for General Building Materials and non-reflective plastic foils, or more than 10 cm for reflective foils, hardly increases the insulation value. This means that attic air space under a roof works much better to insulate the heat radiation from a hot roof above to the (suspended) ceiling inside a house than against heat loss in the winter (first graph). This is mainly caused by the circulation properties of warm and cold air.