Energy saving methods of ThermoShield –
Results and practical experiences

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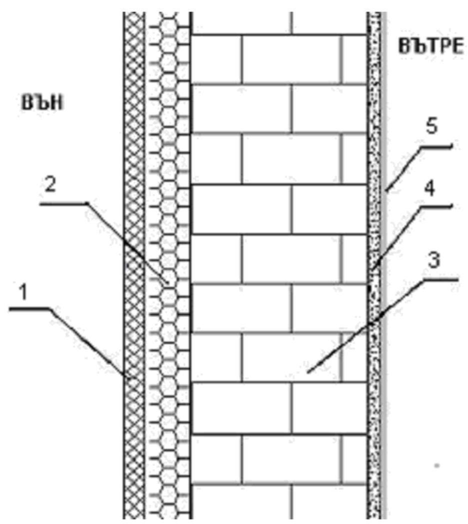
The energy saving has two aspects:

- in summer by reducing the cooling costs;
- in winter by reducing the heating costs.

In the time of the global warming both directions are equally important

A. Energy saving in summer by reducing energy for cooling.

It is pointed in actual Bulgarian norms for thermal insulation of buildings, that the standard insulation of the roof and outside walls, calculated for winter time, is enough for the summer. But the practice shows, this is not completely true. During sunny summer days the surface temperature of southern and western outside walls, and the surface temperature of the roof, are quite higher than the calculated temperature of the outside air. This problem for the new wall constructions, outside well insulated, is more serious than old massive construction without insulation. The reason is the thin protective layer (1) over the insulation – about 10 mm, which has low thermal inertness and changes its temperature very quickly.



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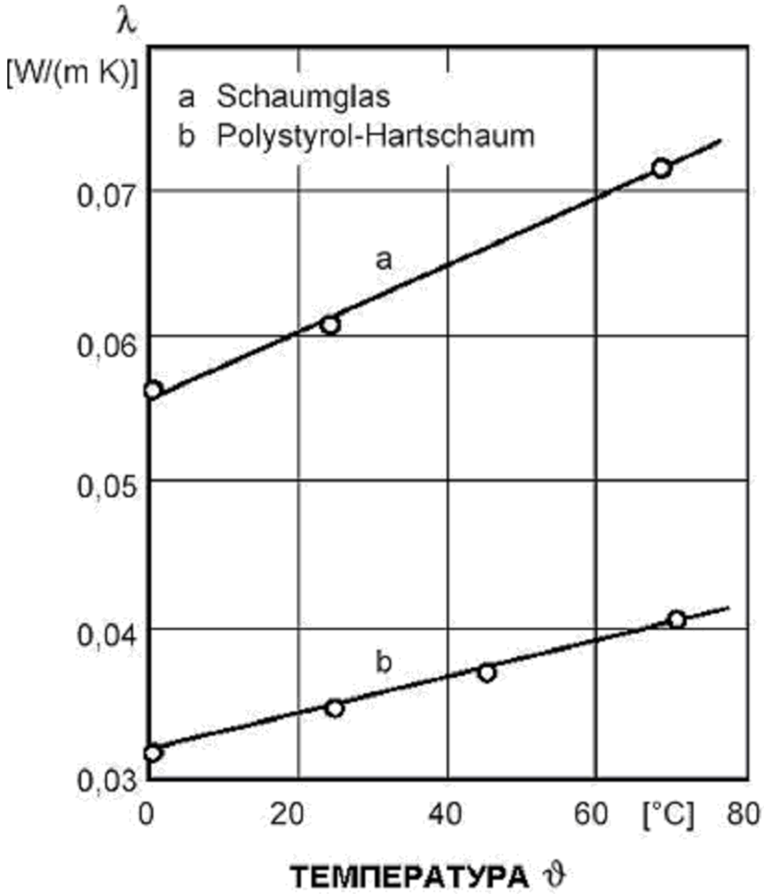
The result is very negative – high thermal stress for the insulation:

- increase of **λ** (reduce of thermal resistance of the insulation)



[1]

- high deformation of the protective layer -cracks and disintegration of the insulation).

One typical example from such negative practice in Bulgaria – full disintegration of the southern façade insulation in a building in Sofia. Because of the use of low sun reflection material with dark gray color the surface temperature reached **72 deg C** in the sunny summer days. The linear deformations are very high and the damages are clear on the photo.

In this situation XPS λ increases from 0.027 W/mK to 0.042 W/mK and **K-wert** of the wall - from 0.5 W/m2K (project calculation) to real **0.85 W/m2K**. During a sunny day the heat flow is very high – above the possibilities of air-conditioned devices. But during the night the temperature of the insulation quickly goes down and λ improves. It is the second negative result – the accumulated heat in the massive construction can't go away to the environment – now the insulation works properly!

In principle the same problem exists for roofs, but it is not typical in Bulgaria. Most of our roofs have a double construction with ventilation space between hydro insulation and heat insulation. The air temperature in the ventilation space is near to the temperature of outside air, that's why the roof heat insulation works without thermal stress during day and night and doesn't need any other protection.

The common result of high wall surface temperature, worse function of heat insulation and accumulation of heat means an about 2 times higher consumption of energy for cooling!

To solve this problem a project for creation of ENERGY SAVING METHOD for design and thermal calculation of outside walls started last year. The scientific work has 3 stages:

1. To find a physical criterion, which is corresponding to the real process and to formulate an easy method to practice.

2. To find the best material, which has the following main characteristics:
- high reflection of sun radiation – to reach lowest temperature during sun radiation;
- high heat emission – for maximum cooling during the night
- good flexibility for saving of thermal deformation in the cycles "worming-cooling"

3. To create a calculation method, which can show to the INVESTORS the profit of using sun protective coatings.

During the first stage we studied many criteria. In our mind the best practical criterion for the worming process of façade materials in sun radiation is "TEMPERATURE RISE" $t\uparrow$ [grad C] ; $t\uparrow = t_{surf} - t_{air}$. The criterion was formulated in the States like a part of the state program "white roofs", but our research results show, that it can be used for southern and western walls, too. The main point of the philosophy of our ENERGY SAVING METHOD is changing the formula of the density of heat flow q.

As standard, in the summer day (10 – 19:00) , $q = k\,(t_e - t_i)$

t_e – temperature of the outside air

t_i – temperature of the inside air

but for surfaces under sun radiation the surface temperature is higher than the outside air temperature. $t_{surf} > t_e$, and the $k_{sun} > k$, because the $\lambda_{sun} > \lambda$

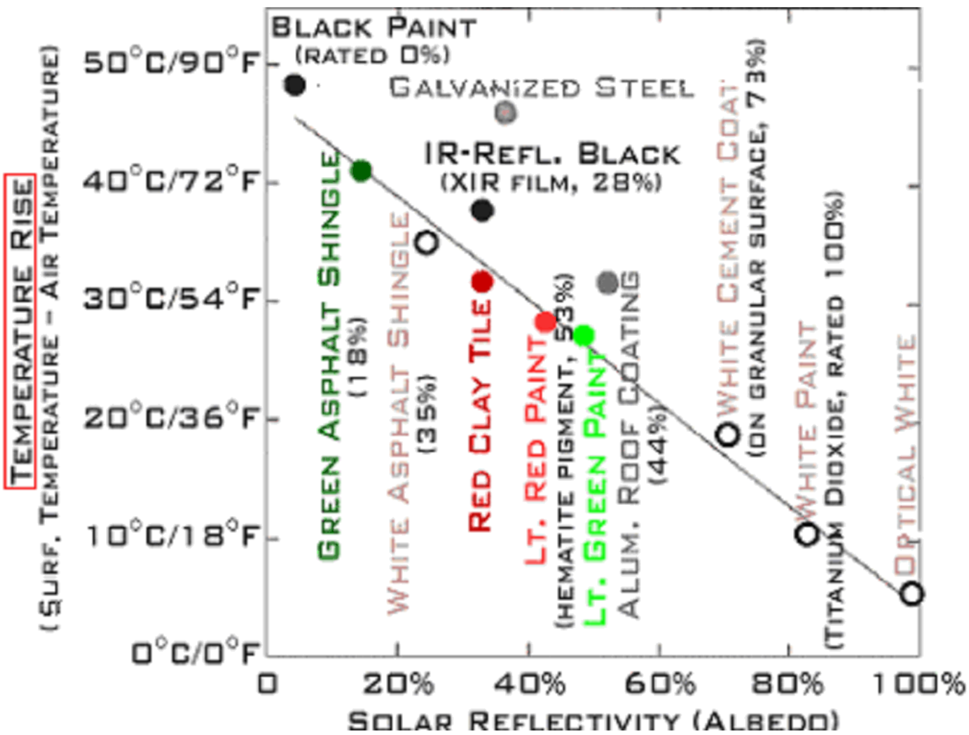
That's why the right heat flow is in accordance with:

$$q_{sun} = k_{sun} (t_{surf} - t_i), \quad t_{surf} = t_e + t\uparrow$$

To use this formula we need information like:

- increasing of λ in accordance with increasing of t for heat insulating materials in the Bulgarian practice;
- "TEMPERATURE RISE" $t\uparrow$ for the façade paints, linings, coatings in Bulgarian practice.

The information for exchanging of λ exists in the product specifications. It is quite difficult to find information for "TEMPERATURE RISE", but such information exists in the Internet. **[2]**



During the development of the project, we collected own measurements of TEMPERATURE RISE for traditional building materials in Bulgaria (July, 14:00, clear sky, no wind) as follows:

- ultra-white façade acrylic paint, import – 11 degC

- white façade acrylic paint BG production – 13 degC
- light beige façade acrylic paint – 18 degC
- yellow façade acrylic paint – 21 degC
- white cement plaster – 22 degC
- beige polymer plaster – 23 degC
- light green façade acrylic paint – 28 degC
- naturale decorative concrete – 29 degC
- decorative bricks – 29 deg C
- aluminum lining – 31 deg C
- brown terracotta tiles – 32 degC
- red polymer plaster – 32 degC
- black terracotta tiles – 45 degC
- galvanized steel lining – 47 degC

During the second stage over 30 sun reflective coatings were studied. Principally, all coatings, containing ceramic bubbles, have good characteristics. Our choice for the future development was ThermoShield Exterior. ThermoShield Exterior has shown the best characteristics for the needs of the project – highest sun reflection - 89%, very good emissivity – 94% and perfect flexibility and elasticity. The TEMPERATURE RISE of ThermoShield, white, is 5 degC (9 degF) **[3]** . The coating has stable quality and long tradition. The production started in Germany, Berlin in 2002.

In the third stage we prepared very simple examples for the INVESTORS. Normally INVESTORS receive building project, where facades are finished by standard coatings, paints or plaster. We point TEMPERATURE RISE of the standard material with $t\uparrow_{St}$. TEMPERATURE RISE of ThermoShield is $t\uparrow TS$.

The energy saving result is:

$$\Delta q = q_{sun\ St} - q_{sun\ TS} = k_{sun\ St}[(t_e + t\uparrow_{St}) - t_i)] - k_{sun\ TS}[(t_e + t\uparrow_{TS}) - t_i)]$$

$k_{sun\ St} > k_{sun\ TS}$,because ThermoShield keeps lower temperature in the insulation than standard finishing materials, and

$t\uparrow_{St} > t\uparrow_{TS}$ (see the tables above), $\Delta q = q_{sun\ St} - q_{sun\ TS}$ [W/m2]. is always positive.

In this way it is very easy to calculate the real energy saving effect of using ThermoShield Exterior like final façade coating. ThermoShield Exterior has to be on all façade surfaces, which are under direct sunlight. The area, coated by ThermoShield, is pointed by **A** [m2].

$\mathbf{Q} = \Delta\, q\, .A$ [W] is the reduction of heat flow, but not only. It is the real saving of cooling power – a real energy saving effect.

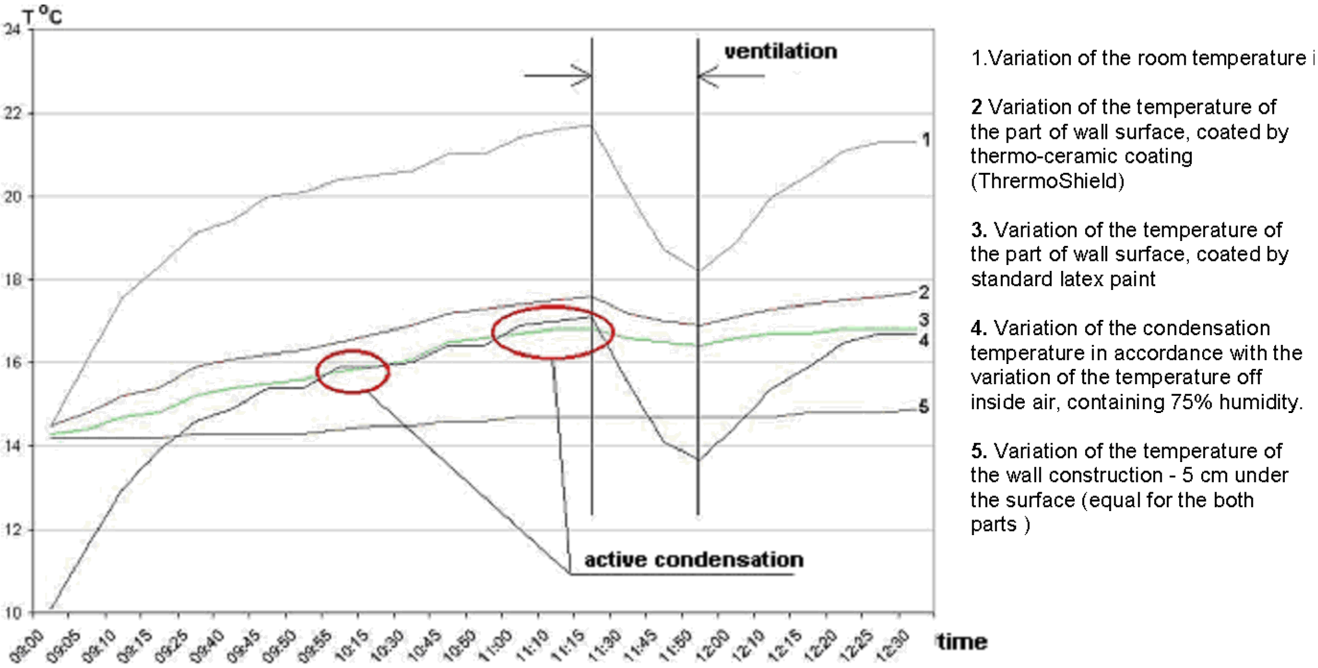
One result from the practice:

- a part of southern façade, formerly coated by white cement plaster, was coated by ThermoShield. Now the conditioners keep the same room temperature
- 22 degC, but their working power was reduced from 2000W to 1500W (one position lower. The total energy saving during the summer was over 6500 kW/h

The façade is without any cracks since 4 years after reconstruction. During the winter period the building is under very difficult situations – strong wind, horizontal rain, ice and snow, but the climate in the rooms is very good - the insulation keeps good thermal properties.

B. Energy saving in winter by ThermoShield Interior.

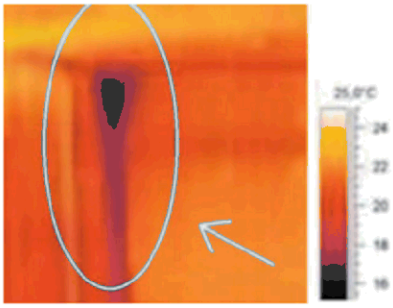
ThermoShield Interior is clasified like decorative coating of low heat permeability. **[4]** If the heat-exchange process is strongly non-stationary (variation of the heating), the low heat permeability of the coating ensures high contact temperature between indoor air and boundary wall surface (about 1 degC higher on an average). The formation of a cold zone, which would worsen the comfort of inhabitation, is avoided. Also the conditions for the emerging of condensation and mould are eliminated. The energy saving result is about 15% - reduction of heating coast. **[4]**



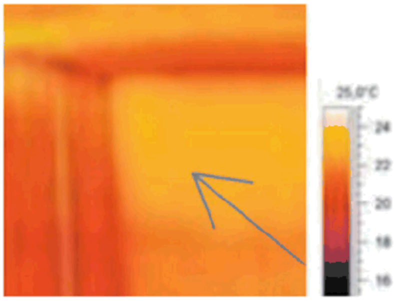
Comparative analyses of two wall surfaces, one of them painted by standard latex, and the other – by popular thermo-ceramic coating (ThermoShield) . The part of the wall, coated by the ceramic coating keeps stabile temperature (2), higher than the temperature of condensation (4), but in the latex painted part (3) the risk of condensation is greater – there is condensation in the red signed areas.

Long time ago we abstained to comment the thermal conductivity of the dry layer of ThermoShield Interior because of the different values which were published. But one thing is sure. Information about higher surface temperatures after application of ThermoShield exist practically in all publications and reports. The TEMPERATURE RISE is from 0.4 to 1.5 degC in different cases (depending on the thickness of the dry layer and the variation of heating). **[5]**

Digital photo Thermography



Before ThermoShield Interior



After ThermoShield Interior 0.5 mm

What could be the interpretation of those facts from the physical point of view?

The basic formula of surface temperature shows:

$t_{surf} = t_i - q / \alpha_i$; $q = k_{wert} (t_i - t_i)$

after a transformation $q = \alpha_i (t_i - t_{surf})$

for standard coating:

$q_{St} = \alpha_i (t_{i\,St} - t_{St\,surf})$; $t_{i\,St} - t_{St\,surf} = \Delta t_{St}$

for ThermoShield Interior:

$q_{TS} = \alpha_i (t_{i\,TS} - t_{TS\,surf})$; $t_{i\,TS} - t_{TS\,surf} = \Delta t_{TS}$

α_i is equal, because the ε (emissivity) of Thermo Shield Interior like standard coatings – ε =0.91

That's why $q_{TS} / q_{St} = \Delta t_{TS} / \Delta t_{St}$

Generally, at equal outside and inside temperatures, $\Delta t_{TS} < \Delta t_{St}$, $q_{TS} < q_{St}$, usually q_{TS} = 0,85 to 0.92 q_{St}.

Δt_{TS} – temperature difference between temperature of inside air and inside surface, coated by ThermoShield;

Δt_{St}– temperature difference between temperature of inside air and inside surface, coated by standard paint;

q_{TS} – density of heat flow trough the construction (wall, ceiling) coated by ThermoShield

q_{St} – density of heat flow trough the construction (wall, ceiling) coated by standard paint

This approximate theoretical model confirms the energy saving results of complex ThermoShield Interior using in practice – from 8 to 15 % reduction of heating energy during winter time. But we believe that the theoretical works on this problem are not completed yet.

References:

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3. http://eetd.lbl.gov/coolroof/coating.htm#tinted coatings

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