

3023

H3023

THE EFFECT OF INSTALLATION DEFECTS ON THE THERMAL
PERFORMANCE OF MINERAL FIBER INSULATION

Inge-Lise Clausen and Helge Hoyer
Rockwool International
Hovedgaden 501
DK-2640 Hedehusene, Denmark

INTRODUCTION

By calculation of heat loss in a building construction it is normally not included in the calculations that the permeability of the insulation material can affect the insulating properties of the construction, and truly this consideration is justifiable when it is a question of a construction where the insulation material has been perfectly installed.

However, perfect installation is rare, and it therefore would be interesting to know exactly how air permeability affects the heat loss of a building construction.

SCOPE

In order to reveal the effect of not only perfect workmanship but also the influence of the permeability of the insulation material the investigation described in this article was carried out.

The investigation concentrated on frequently occurring insulation defects in a ventilated roof construction insulated with Alu-Rolls.

Common defects¹ in a construction of this type may be:

- faulty joints
- application of too big/small Alu-Roll
- poor fitting of the Alu-Roll in the truss

The first type of defects - faulty joints - occur as fissures in the insulation running across the truss. These are likely to occur e.g. where two rolls meet, or where the insulation ends at the base of the rafters. This type of defect is especially critical when the pressure conditions above the insulation are causing a "short circuit" between the cold air in the ventilation gap and the air on the hot side of the construction. This is giving rise to a considerable increase of the heat loss.

Application of too small Alu-Rolls generates an air gap between roll and rafter in the longitudinal direction of the rafter. In this gap convection will occur, and this air movement tends to contribute to a substantial deterioration of the insulating capacity of the construction². A situation which is similar to the one happening when there is not installed any insulation material between the first rafter and the gable wall.

Likewise the heat loss may be increased by application of too big rolls. When an oversize Alu-Roll is installed in the construction the insulation will "arch" between the rafters. An air-filled space then occurs between the coating of the insulation and the internal wall lining. In this space convection may occur giving rise to an increased heat loss.

The last type of defects - poor fitting - occurs when an easily compressible insulation material is forced down between the rafters during the installation. The edges of the Alu-Roll are then so much compressed that triangular ducts are formed along the rafters, and the missing insulation thickness on the cold side reduces the insulating ability.

TEST SET-UP

The investigations were carried out as measurements of heat transmittance in a calibrated hot box. The object under measurement was a roof construction of the following structure.

The roof construction shown in fig. 1 was built up in the measurement frame of the hot box. The roofing tiles were omitted during the measurement. The inside dimensions of the measurement frame are 2.40 x 2.40 m.

The roof construction was designed so that there was four trusses in the measurement frame.

To prevent any increased heat loss at the edge of the measurement frame from affecting the determination of the heat loss of the construction insulation defects were only established at the two middle trusses. The distance between the rafters was 550 mm. During the measurements the outmost trusses were insulated with an insulation material similar to the one tested in the Centre trusses.

During the measurements the hot box was placed so that the measurement frame formed an angle of 40° with horizontal. This in order to obtain the same thermal conditions as in a roof construction of this type.

In excess of the air movement, caused by the thermal buoyancy in the ventilation gap between the underlay and the surface of the insulation, a mechanical ventilation was established from base of rafter to ridge.

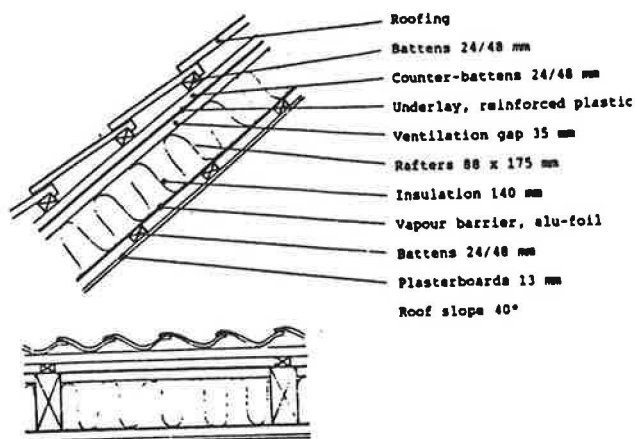


Figure 1

The heat loss of the construction was determined in each separate test situation under steady state temperature conditions. The air temperature on the hot side of the construction was 20°C, and on the cold side it was 0°C.

As it was the air to detect not only the effect of insulation defects but also the influence of the permeability of the insulation material three different types of mineral wool were used at the determination of the heat loss. Type A and type B are Alu-Rolls with different density and permeability. Type B are triangular insulation slabs of the same density and permeability as type A.

Product	Type of material	10 [W/m ² K]	Density [kg/m ³]	Permeability [m ⁴ /h N] *
Product type A	Alu-Roll 2500 x 600 x 140 mm	0.035	31.1	0.5
Product type B	Alu-Roll 5000 x 600 x 140 mm	0.037	16.4	1.2
Product type C	Triangular mineral wool slabs 1000 x 600 x 140 mm	0.036	30.1	0.5

* The permeability of the slabs was measured in the direction corresponding to parallel to the rafters.

Figure 2. Shows the specifications for each material.

Each of the three types of insulation was tested with the insulation defects mentioned above. Besides, the effect of increased air velocity in the ventilation gap was tested for each type of defect.

The air velocity in the ventilation gap between the supporting structure and the surface of the mineral wool was chosen at 0.2 m/s and 0.4 m/s. The speed 0.2 m/s represents the air speed which normally will prevail in the ventilation gap in a roof construction of the investigated type. The wind conditions around the building may increase the speed in the tap. Investigations made by Lit. 3 show that air velocities of up to 0.4 m/s may be measured under special pressure conditions.

MEASUREMENT RESULTS

The results of the test series for all three types of material are compared in fig. 3.

Fig. 3 shows the insulating value of the construction in each test situation. The U-value is, as mentioned above, determined at both high and low air velocity in the ventilation gap. The insulating value at low air speed is shown in the bar chart with hatching.

Fig. 3 also shows the influence of the insulation defects on the insulating ability of the construction expressed for each separate test situation as the ratio U_B divided by U_A .

OBSERVATIONS

From fig. 3 it appears that insulation defects may cause quite considerable deteriorations of the insulating capacity of the roof construction.

The most substantial reduction of the insulating ability occurs where insulation defects cause a 'short circuit' between the air from the hot side of the insulation material and the air from the cold side. The poorly fitted transverse joint therefore is the most serious type of defects. This increase is most pronounced for produce type B. This Alu-Roll has a lower permeability which makes the cold air in the ventilation gap penetrate deeper into the insulation material. When the transverse joint does not fit tight a 'short circuit' will arise between hot and cold air.

The application of too small Alu-Rolls also cause a considerable increase of the heat loss as not only the missing insulation but also the convection in the gap between insulation material and rafter is increasing the heat loss considerably.

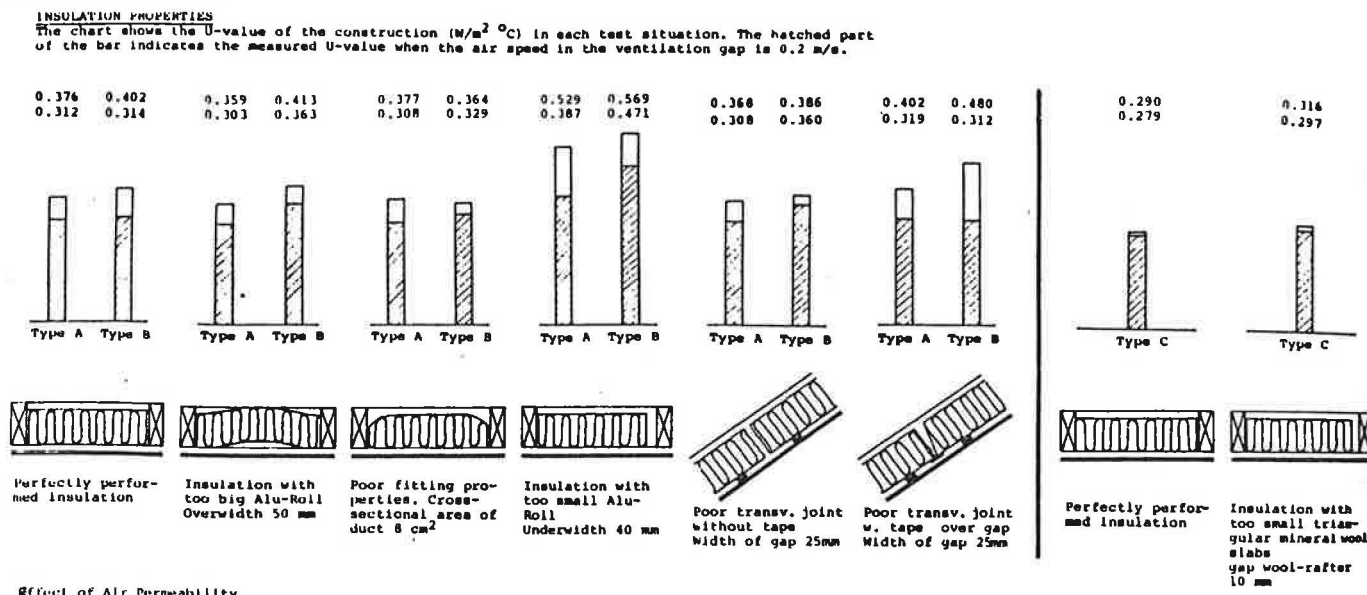


Figure 3

It also appears that product type B, due to the lower permeability, has a poorer insulating ability in almost all installation situations.

If the measured insulation properties for the three types of material are compared it appears that by using triangular mineral wool slabs an insulation is obtained which is less susceptible to infiltration of cold air from the outside than is the case where Alu-Rolls are applied.

Besides, the triangular insulation slabs present the advantage that they are not pressed in position in the construction, which is the case with the roll products. This insulation system fits the construction much better and thus the insulation ability is increased. Another advantage is that the vapor barrier is not installed until the insulation work has been completed which makes it possible to control the quality of the installation work.

REFERENCES

1. Prexis baulicher Energiesparmassnahmen Ber. 04079 - Schriftenreihe des Bundesministers für Raumordnung, Bauwesen und Städtebau.
2. Claes Bankvall, Byggnadskonstruktioners varmeisoleringsformaga Inverkan av luftrorelser och arbetsudforande.
3. Klaus W. Liersch, Stromungsmechanische Untersuchungen an einem beluftenen Steildach Bauphysik 101(1980) H. 1/2.