

## **Thermal Conditions within a Piglet Creep Area with Different Cover Constructions and Different Surface of Cover Materials**

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### **ABSTRACT**

In farrowing houses, higher temperatures are needed for the piglets than for the sow. One of the methods frequently used to achieve this is to maintain a low room air temperature and provide protection to the piglets by covering the creep area in different ways. However, only limited information is found in literature on the specific thermal consequences of different cover designs.

An experiment was conducted with a 0.6 m by 1.0 m creep area surrounded by 4 different constructions, each covered with 3 different materials. The tested model was placed in a draft free room, where the air temperature was maintained at 21 °C, and heated with 140 W electric floor panel with dimensions equal to the creep floor area. Air temperature and black-globe temperature were measured in 9 positions in the creep. Floor panel surface temperature was measured in 2 positions.

The results showed that a creep area surrounded only with walls (without roof) created better thermal conditions than 3 walls with roof and open front, what was unexpected. 50%-covered front improved thermal conditions two times, and 90 %-covered front four times in comparison to cover with open front. The obtained results indicated that the not only thermo-insulating properties of cover material, must be considerate but, above all, we must focus on the material surface. It should be smooth, monolithic and not absorb the thermal radiation but reflect it.

**KEY WORDS:** piglets, creep area, air temperature, black-globe temperature, cover material, cover construction

### **INTRODUCTION**

A farrowing pen is very specific and difficult to handle thermally because within an area of 4-6 square meters we have to create two zones: one for the sow, which prefers temperature around 18°C and a second one for the piglets which just after delivery need even 34-38°C [Connor 1993, Mount 1963, Owen 1982]. Within the farrowing pen, a small space called a creep area is supported with heating element situated inside a floor or hanged above the piglets. To keep heat in the piglet zone and to prevent the sow from too high temperature, the creep area is very often

surrounded by a cover construction. In practice very often it is only a roof made of steel or wooden plate. Sometimes the creep area is also surrounded with three walls (back and two sides), from time to time an entrance is covered with a plastic curtain. Unfortunately only very limited information is found in the literature on the thermal consequences of different cover designs and materials.

The aim of this paper is to provide specific information on the effect of cover configurations made of different materials on the thermal conditions in piglet creep area.

## MATERIALS AND METHODS

### Experimental set-up.

The experiment was conducted at the Laboratory of the Institute of Building and Landscape Architecture, Agricultural University of Wrocław. A draft free room with the constant air temperature maintained at 21°C was used for the experiment. A 100% scale model of a piglet creep area 1.0 m x 0.6 m continuously heated with 140 W floor electric panel was the control treatment. That model was surrounded with 4 different cover constructions (fig. 1):

A - 3 walls and front curtain (without roof)

B - 3 walls and roof

C - 3 walls, roof and front plate

D - 3 walls, roof and front curtain

The different constructions and cover materials, which are possible to meet in practice, were tested earlier [Houszka et al., 2000, Houszka, 2001]. The constructions tested in this experiment were chosen as the most representative.

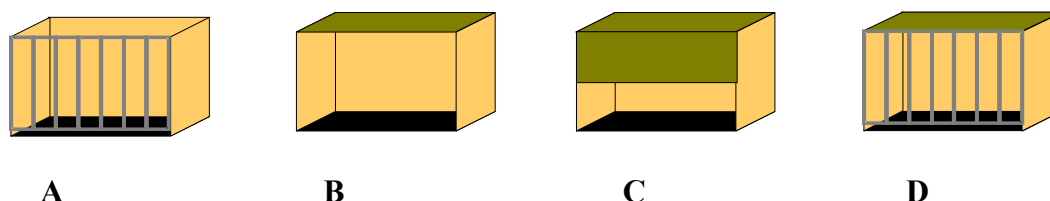


Fig.1. Different types of the nest construction: **A** - 3 walls and front curtain, **B** - 3 walls and roof, **C** - 3 walls, roof and front plate, **D** - 3 walls, roof and front curtain.

The cover construction was 0.6 m high, front plate covered 50% of the entrance, curtain covered 90% of the entrance.

Each construction was made in 3 versions using the following cover materials: foamed polystyrene plate, galvanized steel board, and both: galvanized steel + foamed polystyrene. The front curtain was made of soft transparent PVC stripes 0.55m long and 0.2 m wide.

Physical properties of the cover materials:

	Polystyrene foam	galvanized steel	PVC
Thickness	10 mm	0,5 mm	4 mm
Thermal conductivity coefficient $\lambda$	0.045 Wm <sup>-1</sup> K <sup>-1</sup>	58 Wm <sup>-1</sup> K <sup>-1</sup>	0,20 Wm <sup>-1</sup> K <sup>-1</sup>

In total 12 combinations were tested during the experiment.

## Measurements and instrumentation

The following temperatures were measured: floor surface temperature, air temperature, black-globe temperature, and room air temperature.

The air temperature under the cover was measured at 9 positions (fig. 2, 3) with type T thermocouple sensors placed 0.1 m above the floor surface. The sensor accuracy was  $0.1^{\circ}\text{C}$ .

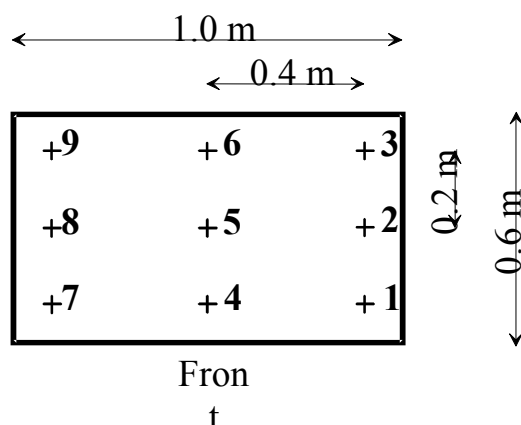


Fig.2. Dimensions of floor heating panel and horizontal positions of temperature sensors.

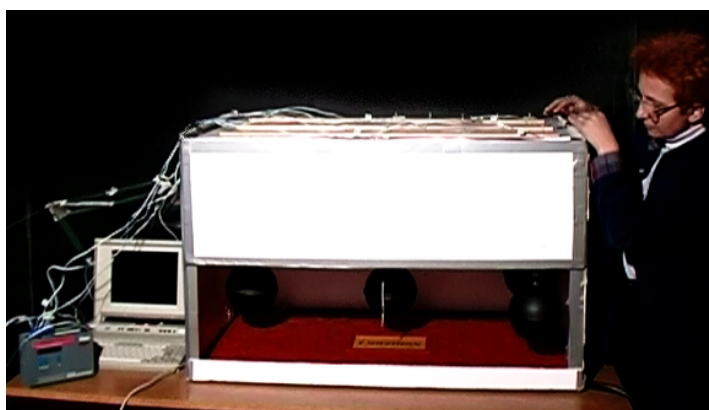


Fig.3. Test set-up.

The black-globe temperatures were measured at the same positions using 36-mm diameter plastic globes with thermocouple sensors (Grant product, type EU-T-M4).

The temperature of the floor panel was recorded at 2 points (number 4 and 9) with surface contact temperature sensors mounted on cooper base (Grant product, type AG-K-Q3).

Air temperature was also recorded in the surrounding room in order to calculate the temperature effects for the different cover configurations. It was measured with a sensor placed at a distance of 1.0 m from the tested model.

## Data collection and data analyses

For each experimental set-up the cover configuration was thermally stabilized for at least 4 hours for thermal stabilization. Temperatures were then recorded at 1-minute intervals, for 2 hours with a data logging system (Grant product, Squirrel, 1000 Series).

All notations in this paper are given as a “temperature lift”. It was calculated as a difference between the temperature recorded within the covered creep area minus the temperature recorded within an open (without any cover) creep area. Average values were determined of the measured values of all sensors and recordings. Standard deviations were calculated

## RESULTS

### Air temperature

The results are presented on the fig. 4.

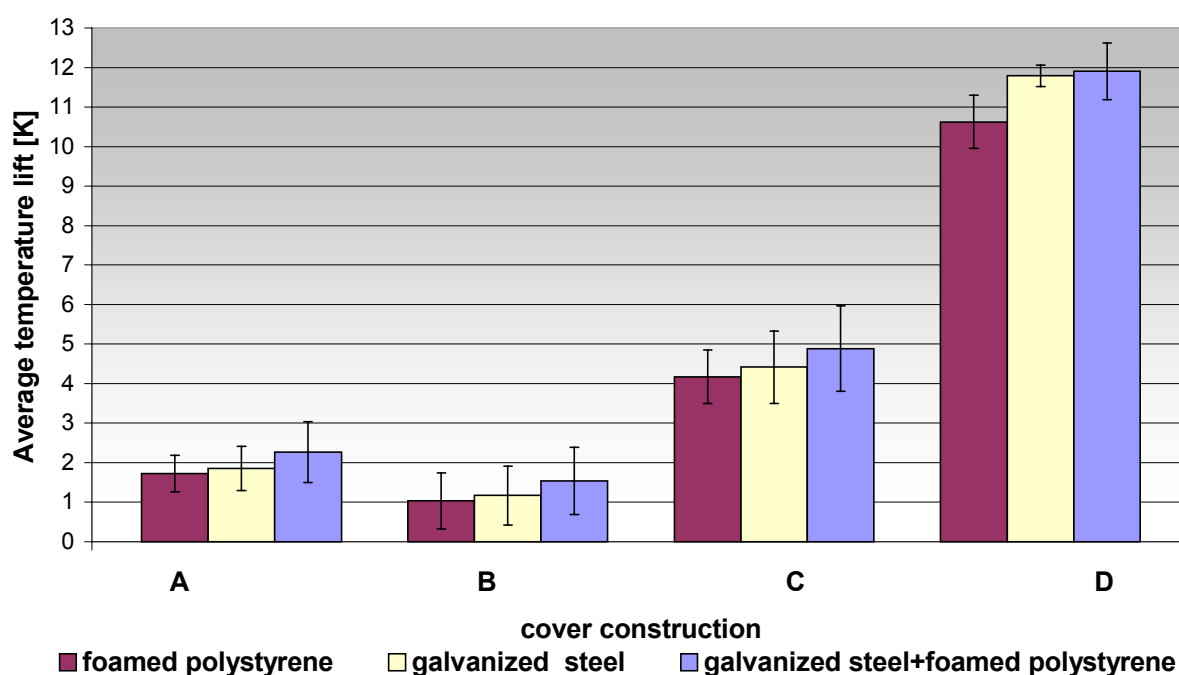


Fig.4. Average air temperature lift within piglet creep area covered in different way and with different materials.

In the creep area covered only with walls (construction A) the average air temperature lift was very similar for all 3 tested materials: 1.7 K for foamed polystyrene, 1.8 K for galvanized steel and 2.3 K for galvanized steel + foamed polystyrene. This means that foamed polystyrene and galvanized steel created nearly identically temperatures and galvanized steel + foamed polystyrene gave ca 0.5 K higher temperature.

Under the cover B (3 walls and a roof) the results for each material were 0.6 – 0.7 K lower than under the cover A, giving a deference between materials on the same level.

Within the model C (3 walls, roof and front plate) average air temperature lift was much higher and increases up to: 4.2 K for foamed polystyrene, 4.4 K for galvanized steel and 4.9 K for galvanized steel + foamed polystyrene. The differences between materials still remained on the same level.

The cover D (3 walls, roof and front curtain) created the highest temperature lift: 10.6 K, 11.8 K and 11.9 K adequate to tested materials. In this model the difference between materials changed. The result for cover made of foamed polystyrene was 1.1 – 1.2 K lower than for the two other materials.

### Black-globe temperature

The results of the experiment are given on the fig. 5.

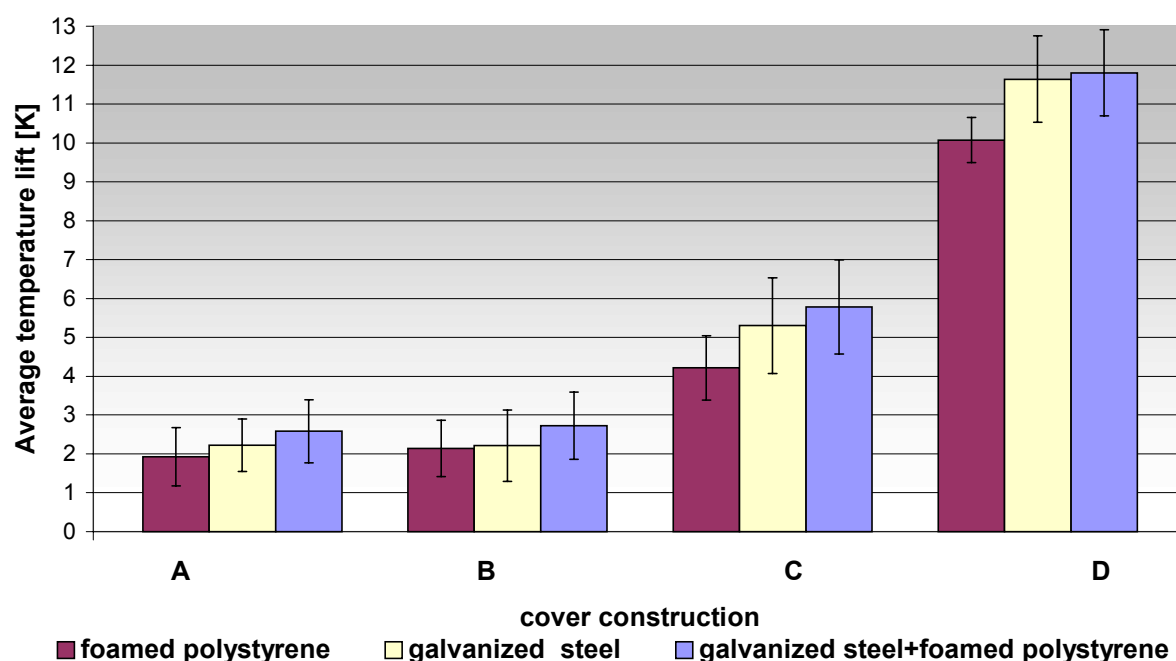


Fig.5. Average black-globe temperature lift within piglet creep area covered in different way and with different materials.

The average black-globe temperature lift, for all 3 tested materials, was nearly the same for models A (1.9 K, 2.2 K, 2.6 K) and B (2.2 K, 2.1 K, 2.7 K). The deference between a cover made of foamed polystyrene and galvanized steel was very small (from 0.1 to 0.3. K). Combination of galvanized steel and foamed polystyrene gave ca 0.5 K higher temperature than two previous materials.

Model C created a more than 2 times higher temperature lift than models A and B. It was 4.2K for foamed polystyrene, 5.3 K for galvanized steel, and 5.8 K for galvanized steel + foamed polystyrene. In that model the difference between foamed polystyrene and galvanized

steel was bigger (1.1 K) than in the models A and B; for two remaining materials the difference was 0,5 K (like in the previous models).

Model D created also more than 2 times higher temperature lift for each tested material (10.7 K, 11.6 K, and 11.8 K) than model C. Additionally, in that model, the difference between materials was not the same like for covers A, B, and C. The result for foamed polystyrene cover was 1.5 K lower than for two other tested materials.

For most cover configurations and materials the black-globe temperature recorded inside the creep area was approximately 2°K higher than the air temperature [Houszka et al., 2000] but the temperature lift (in comparison to the temperature level within an open creep area) was very similar for both used parameters. It was less than 0.5K for models A and D and close to 1.0 K for models B and C.

### Floor surface temperature

The results are given on the fig. 6.

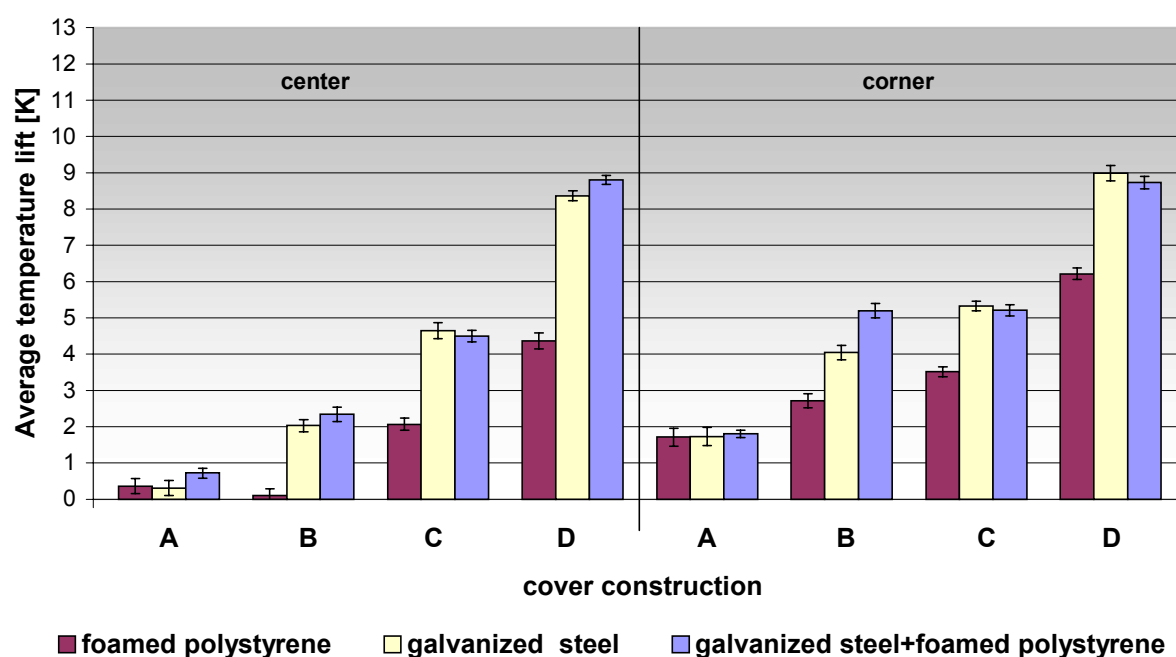


Fig.6. Average floor surface temperature lift in the center and in the corner of piglet creep area covered in different way and with different materials.

Within model A (without roof) the floor surface temperature lift was very small (ca 0.5K in the center and 1.7K in the corner) and similar for all 3 tested materials (difference 0.1-03 K).

Models B, C and D covered with the steel or steel and polystyrene (reflecting surface) always created much higher temperatures than models covered with the foamed polystyrene (non-reflecting surface). In the center of the creep area the differences were from 2.0 K to 4.4 K and in the corner from 1.3 to 2.8 K. The difference between steel cover and combination of

steel and foamed polystyrene were very small (less than 0.5 K for model) with one exception (model B difference 1.2K). It means that, for the model, the reflecting surface roof gave 1.5 - 2 times higher temperatures lift than the non-reflecting roof.

## DISCUSSION

In general the effect of the cover configuration and cover materials, especially foamed polystyrene, on the thermal conditions within creep area was smaller than expected.

With the two first models A - "only walls" and B - "roof and 3 walls", air temperature increased only 1 – 2 K and black-globe temperature 2 – 2.5 K. The results showed that walls without roof created better conditions than a roof with 3 walls and open front, what was unexpected. 50%-covered front (model C) improved thermal conditions two times, and 90 %-covered front (model D) four times in comparison to cover with open front (model B). This is in agreement with earlier findings [Houszka, H. 2000; Houszka et al., 2000]

It could be expected that thermal conditions under a cover made of foamed polystyrene should be much better than under galvanized steel because thermal conductivity coefficient for foamed polystyrene is  $\lambda = 0.045 \text{ W m}^{-1} \text{ K}^{-1}$  and for steel  $58 \text{ W m}^{-1} \text{ K}^{-1}$ . The given results were contrary to expectations: for model A and B air and black-globe temperature lift was very similar (difference up to 0.3 K), but for model C and D foamed polystyrene created lower temperatures up to 1.5 K. The cover made of the combination of galvanized steel and foamed polystyrene practically did not improve air and black-globe temperatures; they were only from 0.2 to 0.5 K higher than for galvanized steel. This means that a reflecting effect given by galvanized steel was a more important influence than very good thermo-insulating properties of foamed polystyrene.

The analysis of floor surface temperature lift confirmed these findings. In model A (without roof) temperatures were the same for foamed polystyrene and galvanized steel with foamed polystyrene. It means that "warmth" was kept inside the creep area by surrounding walls without reflecting effect. A roof made of galvanized steel, giving reflecting effects, raised the floor surface temperatures depending on model from 1.3 up to 4.4 K in comparison to a roof made of foamed polystyrene.

The results presented in this paper could be taken under consideration only when floor-heating element is used. For hanging radiators the results are not the same [Houszka 2000].

It could be predicted that covering the creep area has also a positive effect on the sow, especially in small farrowing pens with restrictions. It separated sow from heater radiation and to high temperature. Under the high temperature sows feed intake as well as milk production decrease. The result is a significantly lower body gain [Zhou & Xin 1998, Vermeer et al. 1993]. Covering piglet zone also gives a possibility of the energy savings [Houszka et al. 1996].

## CONCLUSION

The results obtained in the experiment indicated that the influence of cover materials on the thermal conditions within a creep area was almost identical for partly covered constructions (model A and B). The difference between materials was only noticeable after using nearly fully covered constructions (models C and D).

The cover made of the foamed polystyrene gave the lowest temperature lift, the galvanized steel cover created always a little bit better thermal conditions within the creep area (temperatures higher up to 1.5 K). The highest temperatures were recorded when the construction was surrounded with combination of galvanized steel and foamed polystyrene but the difference to the previous materials was meaningless- not more than 0.5 K.

It can be concluded that by choosing the cover material, not only its thermo-insulating properties must be considered but, above all, must focus on the type of the configuration and the material surface. It should be smooth, monolithic and not absorb the thermal radiation but reflect it.

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