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EXPERIMENTAL RESEARCH REPORT

No. Z - 15 - 004

IMPACT OF AERO-THERM THERMO ACTIVE COATING ON ENERGY CONSUMPTION FOR HEATING WHILE MAINTAINING THE THERMAL COMFORT IN HEATED PREMISES

Client:

THERMO INDUSTRY, a.s.

Na Spravedlnosti 1533

530 02 Pardubice

ID No.: 287 81 481

Contractor:

Výzkumný ústav pozemních staveb - Certifikační společnost, s.r.o.

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represented by Ing. Lubomír Keim, CSc., CEO

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In Prague on: August 26, 2015

Ing. Lubomír Keim, CSc.
Managing Director

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Total pages 16

CONTENTS

1. Contractor's Reference 2
2. Experimental research objective 3
3. Applied standards 3
4. Objects description 3
5. Determination of selected thermal and technical characteristics of the envelope structures 5
6. Calculation of thermal loss of the building 6
7. Measurement program, measurement preparation 6
   7.1 Measured quantities and used meters 6
   7.2 Measurement program 7
8. Measurement process 11
   8.1 Measurement program 11
   8.2 Measured values evaluation 11
   8.3 Results quantification in the area of thermal losses 16
      8.3.1 Phase I.1 – 5 day section (May 14, 0:00 – May 18, 24:00) 16
      8.3.2 Phase I.2 – 5 day section (May 14, 0:00 – May 26, 24:00) 17
9. Conclusion 18

1. CONTRACTOR'S REFERENCE

- **Authorized body 227** for the performance of state testing pursuant to Act No. 22/1997 Coll. by the Czech Office for Standards, Metrology and Testing, authorized body for certification and assessment of conformity of construction products pursuant to Government Regulation No. 163/2002 Coll., as amended by Government Regulation No. 312/2005 Coll.
- **Notified body 1516**, by the Czech Office for Standards, Metrology and Testing to requirements of Regulation No. 305/2011 and with validity from July 1, 2013 the organization notified by the European Commission in compliance with Regulation (EU) No. 305/2011 for the verification and assessment of constancy of construction products properties marking CE with the authorization for using the marking Notified Body 1516, NB 1516 / Oznámený subjekt 1516, OS 1516.
- **Accredited certification body for management systems No. 3009**. by the Český institut pro akreditaci, o.p.s., accredited body to the requirements of ČSN EN ISO/IEC 17021, "Conformity assessment - Requirements for bodies providing audit and certification of management systems".
- **Accredited certification body for products, processes, qualification, and EPD No. 3013.** by the Český institut pro akreditaci, o.p.s., accredited certification body to the requirements of ČSN EN 45011, "General requirements for bodies operating product certification systems".

- **Accredited test laboratory No. 1234**. by the Český institut pro akreditaci, o.p.s., accredited test laboratory to the requirements of ČSN EN ISO/IEC 17025, "Conformity assessment - General requirements for the competence of testing and calibration laboratories".
- **Organization appointed and registered by the Ministry of Transport of the Czech Republic** for verification and certification of the qualification of organizations for execution of road works, construction and design works pursuant to the requirements of the department's system of the MT CZ, Roads Department.
- **Organization acknowledged and registered by the Association of Building Entrepreneurs** for qualification assessment of building contractors for public contracts pursuant to the provisions of Act No. 137/2006 in the National System of Certified Building Contractors.
- **Organization accepted and declared by the** Czech Office for Standards, Metrology and Testing for the activities of the Technical Standardization Center for the field of thermal insulation materials, water-proofing of buildings and suspended ceilings and their design. http://www.vups.cz/_28.html
- **Organization registered in the list of institutes qualified for expert activities in civil engineering.**

2. EXPERIMENTAL RESEARCH OBJECTIVE

The objective of the experimental research for company THERMO INDUSTRY, a.s., which manufactures the AERO-THERM thermo active coating, is to determine the impact of material characteristics of the coating applied to an interior surface in a building structure on heating energy consumption while maintaining the thermal comfort in heated premises. The tool of the research works consists in reference measurement of the interior environment parameters and heating energy consumption in the long-term and the measured data integration. The measurement will take place on two comparison buildings built by the Client.
The report provides the measurement results describing thermal behavior of the experimental building with internal surfaces provided with AERO-THERM thermo active coating and the reference building. It also serves as the groundwork for issued certificates No. OV-15-0297 and No. OV-15-0298 within the framework of the research project pursued by the manufacturer - THERMO INDUSTRY, a.s. "Impact of AERO-THERM thermo active coating on thermal protection of buildings".

3. APPLIED STANDARDS

[1] ČSN 73 0540 - Thermal protection of buildings - Part 1-4

[2] ČSN EN ISO 7726 - Ergonomics of the thermal environment - Instruments for measuring physical quantities

[3] ČSN EN 12831 – Heating systems in buildings - Method for calculation of the design heat load

4. OBJECTS DESCRIPTION

The measurement is going to take place in two experimental buildings - see the figure below. These are two identical single-storey buildings with interior floor area of 3 x 4 m with penthouse roof, one window with fixed glazing and entrance door. Overhead clearance of each building is 2.6 m. Both buildings have identical orientation towards the cardinal points, window is fitted towards the south, the buildings are not shaded by any other object and their mutual spacing is 5.2 m. Interior surfaces of one building are provided with the AERO-THERM coating with the thickness of 1 mm, the other building is provided with standard smooth coat - in both cases applied directly on the masonry.

A mobile electric heating element is used as the heat source in both buildings. It is normally placed under the fixed window. Another heat source is the electric floor heating in the major area of the floor. Each building is equipped with Kanlux fan with the capacity of 100 cubic meters per hour with air inlet through a penetration in the external wall for air conditioning.

The external walls consist of (interior – exterior):

- AERO-THERM coating with the thickness of 1 mm in the first building / smooth coat in the other building
- HELUZ Plus masonry, thickness 380 mm
- Stelax leveling coating, th. 2 mm

Penthouse roof with inaccessible roof space, ceiling consisting of (interior – exterior):

- AERO-THERM coating with the thickness of 1 mm in the first building / smooth coat in the other building
- Gypsum plasterboards, th. 12.5 mm
- MW TI boards, th. 220 mm

The floor consists of (interior – exterior):

- wood chip boards, th. 20 mm
- floor heating foils
- EPS TI boards, th. 100 mm
- HI layer Bitagit 35 Mineral

- reinforced concrete panels on sand bed

Dimensions of the plastic window are 1.2 x 1.5 m, it has fixed glazing with triple insulating glass with aluminum spacing frame and total heat transfer coefficient of U_w = 0.9 W/(m^2.K). The windows are provided with louvres on the exterior side.

Entry doors have the dimensions of 1.01 x 2.1 m, aluminum, door swing filled with hard PUR with the total heat transfer coefficient of UD = 1.4 W/(m^2.K).

5. DETERMINATION OF SELECTED THERMAL AND TECHNICAL CHARACTERISTICS OF THE ENVELOPE STRUCTURES

In order to determine and assess the thermal stability of the room during summer period and thermal losses of the building, the heat transfer coefficient of the envelope structures has been calculated on the groundwork of the composition data provided in buildings description. Temperature damping and phase shift of the temperature oscillation of the envelope structures have been determined for the purpose of determining the duration of the monitoring for each defined operating state.

The heat transfer coefficient U [W/(m^2·K)] represents the total heat exchange in steady state between two environments mutually separated by a building structure with thermal resistance R and with adjacent boundary air layers. It comprises the influence of all thermal bridges including the influence of perforating sockets and anchors.

Thermal attenuation ν [-] represents the ability of a structure to attenuate harmonic changes of outside air temperature in winter and summer period on the interior surface of the structure.

Phase shift of the temperature oscillation ψ [h] indicates the time required for through-heating of the structure in summer period thus indicating the thermal stability in the interior.

The above-mentioned characteristics of the structures have been calculated using authorized software "Stavební fyzika verze 2011 - Teplo" (Building Physics, Version 2011 - Heat). Thermal-technical characteristics of the materials used in the structures have been taken over from relevant technical sheets and from ČSN 73 0540-3.

The following table lists the values of the above-mentioned characteristics of the envelope structures

Structure	Heat transfer coefficient U [W/(m^2.K)]	Thermal attenuation ν [-]	Phase shift of the temperature oscillation ψ [h]
External wall	0.28	1163	22.4
Ceiling	0.18	61	2.9
Floor	0.41	15	0.3
Window	0.9	-	-
Door	1.4	-	-

6. CALCULATION OF THERMAL LOSS OF THE BUILDING

Thermal loss of the building has been determined with the aim of ascertaining whether the individual heat sources in the buildings, i.e., the electric heating element and the floor heating, are capable of covering the thermal loss of the building and thus ensuring the required interior ambient temperature.

Thermal loss of the building has been determined for the interior air temperature of 20 °C, standardized air exchange corresponding to 0.5 of the volume per hour, and for 5 variants of outside air temperature using the heat transfer coefficient values of the envelope structures specified in Chapter No. 5.

The following table provides the thermal loss values of the buildings for individual outside temperatures

Design outside air temperature	Thermal loss of the building
-5°C	ϕ = 566 W
0°C	ϕ = 469 W
5°C	ϕ = 371 W
8°C	ϕ = 312 W
10°C	ϕ = 273 W

First phase of the measurement started in the half of May when the night time temperatures do not drop below 0°C. From this perspective, the heat sources in the buildings are capable of covering the thermal losses of each building (with reserve) thus ensuring the required interior air temperature during predefined operating conditions.

7. MEASUREMENT PROGRAM, MEASUREMENT PREPARATION

7.1 Measured quantities and used meters

The final temperature, i.e., the temperature which considers the influence of air temperature and the radiation of surrounding objects will be measured with ball thermometers of Vernon-Jokl type, i.e., copper sheet balls coated with black polyurethane with temperature sensor located in the middle.
The ball thermometers will be connected to L0141 recorders with universal temperature sensors of Ni1000 type installed in a cylindrical casing with the diameter of 6 mm and length of 60 mm and to S0141 recorders with universal sensors of Pt1000 type installed in the identical casing. The accuracy of the probes is approximately ± 0.3°C depending on conductor lengths.

Comet S3120 recorders will be used for interior temperature and relative humidity measurement. The measured values will not be displayed. The recorders' manufacturer declares the accuracy of ±2.5 % for relative air humidity measurement and ±0.2 °C for air temperature measurement.

Surface temperatures of the structures will be measured with Comet L0141 recorders with Ni1000 resistance sensors installed in copper casing and S0141 recorders with Pt1000 resistance sensors installed in copper casing. The accuracy of the probes is approximately ±0.3°C depending on conductor lengths.

Individual recorders shall record the data in the intervals of 10 minutes.

Electricity consumption will be measured by single-phase electronic electrometer EM12 DIN.

7.2 Measurement program

Experimental research of the influence of radiating characteristics of the AERO-THERM coating on the interior environment parameters and electricity consumption required for achieving these parameters. The buildings will be monitored in three phases.

Experimental research phases

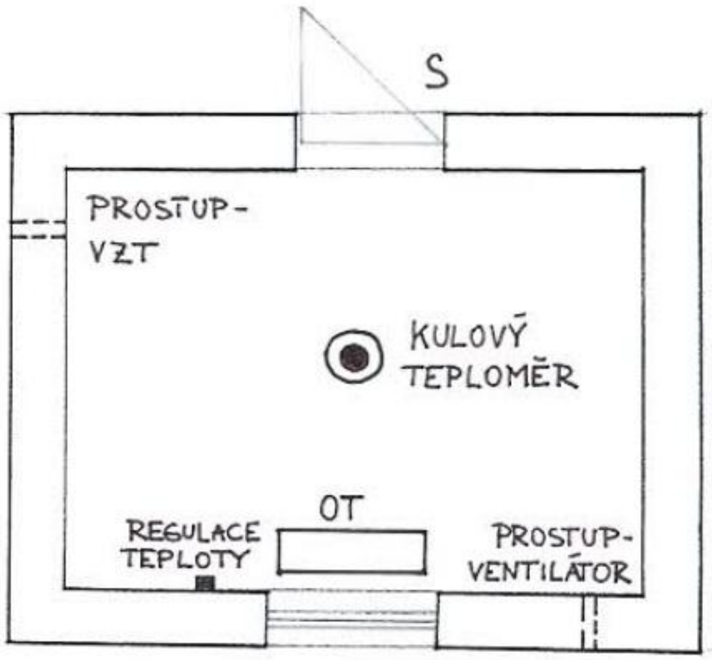
Phase I - measurement of parameters in current condition without cooling, with heating according to the test program. Output - the impact of the coating on man's thermal comfort and electricity consumption at defined operating conditions corresponding to buildings' parameters.

Several identical measurements at defined operating conditions will be carried out in each comparison building during this phase. Measurement results and differences in measured values in both comparison buildings will be used as the basic groundwork for determining the impact of AERO-THERM reflective coating on the parameters, internal environment stability, and energy demand of the buildings.

Due to high temperature attenuation and phase shift of the temperature oscillation of the envelope, it has been determined that each measurement with defined operating condition **shall take place for at least 1 week.** Measured values will be thus downloaded from the recorders for continuous evaluation every week. Next operating mode for the particular phase will be set-up after data verification (confirmation that the data loggers measured correctly).

The objective of Phase I is to determine the influence of the AERO-THERM reflective coating on achieving and maintaining the required internal environment condition without cooling, with heating according to the test program on the groundwork of interior and surface temperatures development, and the differences in electricity consumption in comparison buildings determined by power input of the technical equipment in given operating mode, i.e., heating element, floor heating foils, fan.

Technical equipment layout scheme is shown in the following figure.



Prostup VZT – Ventilation entry

Kulový teploměr – Ball thermometer

Regulace teploty – Temperature control

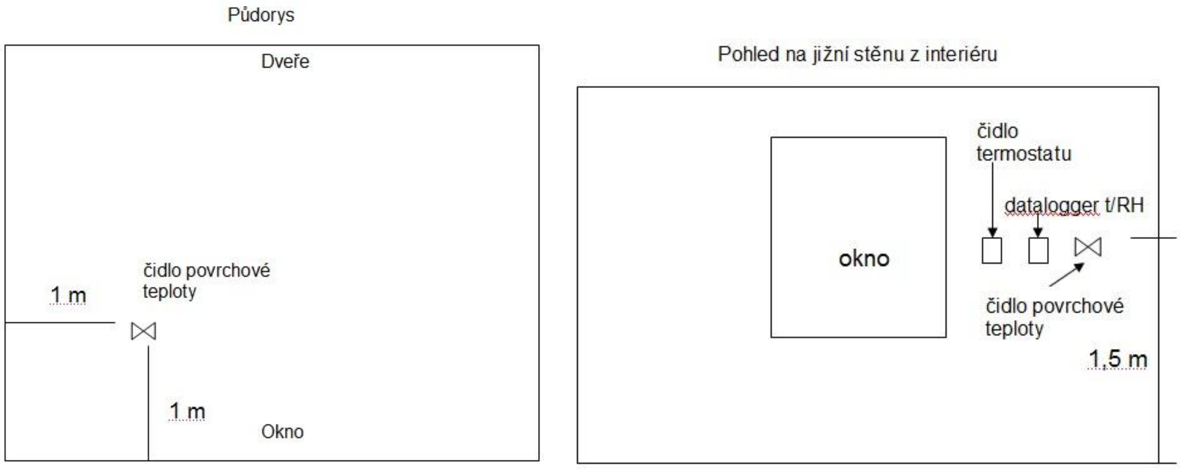
Prostup – ventilátor – Penetration – fan

OT – heating element

<u>Phase I.1:</u> Achieving and maintaining the required interior environment using the **floor heating** only. The equipment will be controlled so that the interior wall surface temperature of 21 °C is maintained. The building will be sealed, there will be no air exchange. Thermal loss of the building will only take place by heat transfer through the structures. Outdoor louvres will be completely up.

The following values will be measured in each building:

- resulting temperature of the ball thermometer with data recording in the middle of the room at the ankle level –0.15 m, abdomen level –1.1 m and head level 1.7 m above the floor.
- temperature and humidity in the room, the data logger will be located next to the thermostat sensor on the wall according to the scheme, temperature and humidity of the outside environment.
- surface temperature of structures, data logger with 4 sensors – the sensors will be located on brick/board surface, not in joints. Sensors on the floor and ceiling will be located approximately according to the scheme, 2 sensors on the external wall will be on the southern (see scheme) and western wall in the height of 1.5 m above the floor, approximately 0.5 m from the common corner.
- total consumption of energy for building heating based on the power output of the heating foils and the floor heating.



Čidlo povrchové teploty – surface temperature sensor

Okno – window

Dveře – door

Čidlo termostatu – Thermostat sensor

Pohled na jižní stranu z interiéru – View of the southern wall from the interior

<u>Phase I.2:</u> Achieving and maintaining the required interior environment using the **heating element** only. The equipment will be controlled so that the interior wall surface temperature of 21 °C is maintained. The building will remain sealed identically to Phase I.1.

The following values will be measured in each building:

- resulting temperature of the ball thermometer with data recording in the middle of the room at the ankle level – 0.15 m, abdomen level –1.1 m and head level 1.7 m above the floor.
- temperature and humidity in the room, the data logger will be located identically to Phase I.1, temperature and humidity of the outside environment.

- surface temperature of structures, data logger with 4 sensors – the sensors will be located identically as in Phase 1.1, only with the difference that the sensor from the western wall will be located on the heating element.
- total consumption of energy for building heating based on the power output of the heating element.

Phase I.3: Achieving and maintaining the required interior environment using the **floor heating** only. The equipment will be controlled on the groundwork of interior air temperature set to 21°C (wall mounted thermostat). The building will remain sealed identically to Phase I.1 and I.2.

The following values will be measured in each building:

- resulting temperature of the ball thermometer with data recording in the middle of the room at the ankle level – 0.15 m, abdomen level – 1.1 m and head level 1.7 m above the floor.
- temperature and humidity in the room, the data logger will be located next to the thermostat sensor on the wall according to the scheme, temperature and humidity of the outside environment.
- surface temperature of structures, data logger with 4 sensors – the sensors will be located on brick/board surface, not in joints. Sensors on the floor and ceiling will be located approximately according to the scheme, 2 sensors on the external wall will be on the southern (see scheme) and western wall in the height of 1.5 m above the floor, approximately 0.5 m from the common corner.
- total consumption of energy for building heating based on the power output of the heating foils and the floor heating.

Phase I.4: Achieving and maintaining the required interior environment using the **floor heating** only. The equipment will be controlled on the groundwork of interior air temperature set to 21°C (wall mounted thermostat). Using the **fan** with the capacity of 100 cubic meters per hour and with power input of 19 W, the air replacement corresponding to 0.5 of the room volume per hour will be ensured. This corresponds to 10 minutes of ventilation during each hour considering the declared fan capacity. Air will be supplied through a hole in the wall intended for air conditioning with the diameter of 150 mm.

The following values will be measured in each building:

- resulting temperature of the ball thermometer with data recording in the middle of the room at the ankle level – 0.15 m, abdomen level – 1.1 m and head level 1.7 m above the floor.
- temperature and humidity in the room, the data logger will be located next to the thermostat sensor on the wall, temperature and humidity of the outside environment.
- surface temperature of the structures, data logger with 4 sensors – the layout of the sensors will be identical to that in Phase I.1.
- total consumption of energy for the building based on the power output of the floor heating foils and the fan.

8. MEASUREMENT PROCESS

8.1 Measurement program

Measurement started on May 12, 2015. Measurement schedule for individual sections including the set-up mode are summarized in the following table. At the end of each

Time section designation	Start of measurement	End of measurement
Phase I.1	May 12, 2015	May 19, 2015
Phase I.2	May 19, 2015	May 26, 2015
No power supply*	May 26, 2015	June 9, 2015
Phase I.3	June 9, 2015	June 16, 2015
Phase I.4	June 16, 2015	June 23, 2015

* power supply into both buildings was interrupted in given time section for the purpose of individual phases evaluation.

Accuracy of temperature control sensors was compared. Both sensors were placed in a vessel eliminating the impacts of surrounding environment and the measured values differed by 0.2 - 0.3°C after stabilization. This is within the tolerance limit considering the measurement uncertainty.

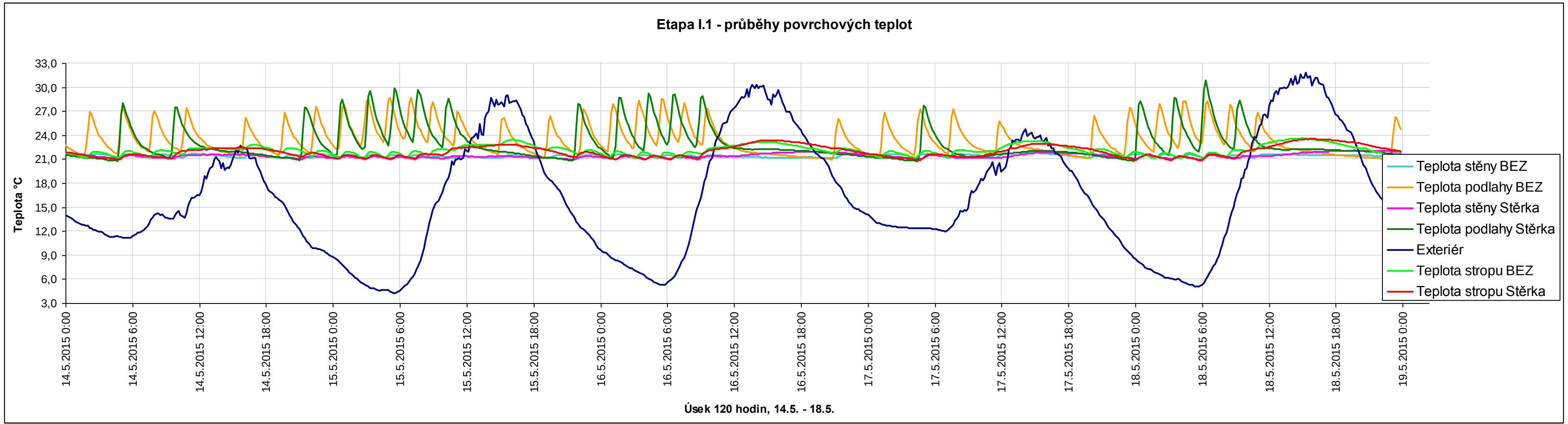
8.2 Measured values evaluation

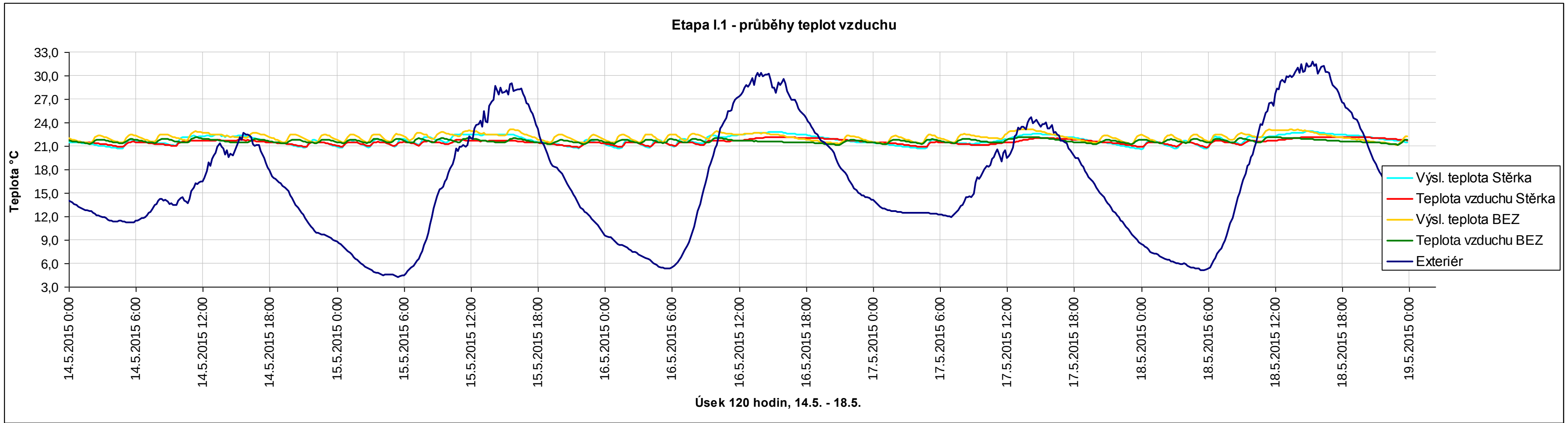
Each section was evaluated without the first measured day due to the high phase shift of the temperature oscillations of the external wall in order to avoid influencing the measured parameters.

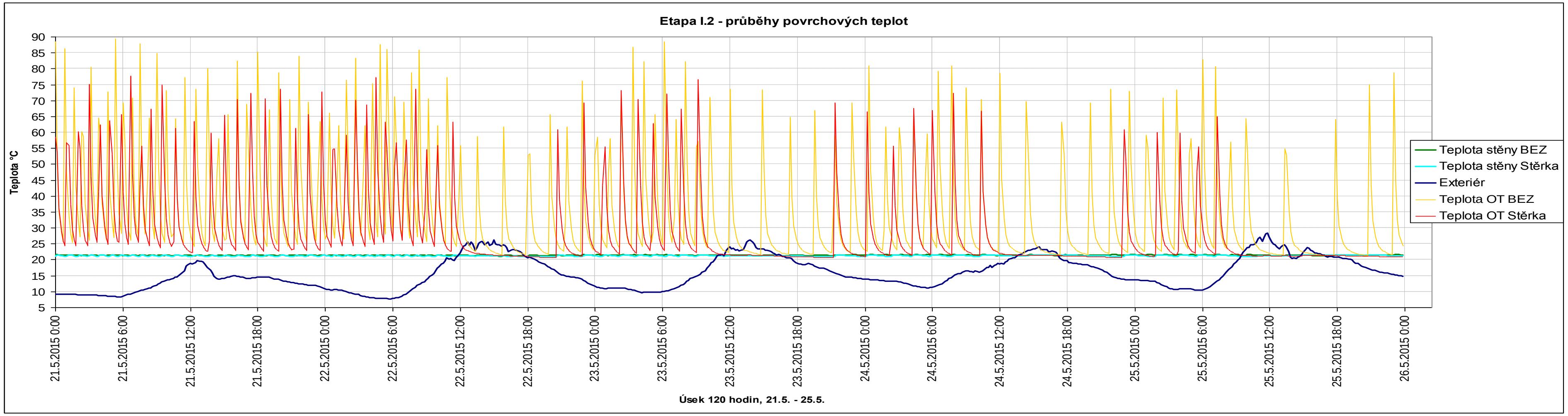
Phase I.1 with radiating heat source is the most important one for the evaluation purposes together with Phase I.2 with convection heat source. Both phases were controlled on the groundwork of interior wall surface temperature and the buildings were sealed so that the thermal losses only take place by heat transmission through the structures.

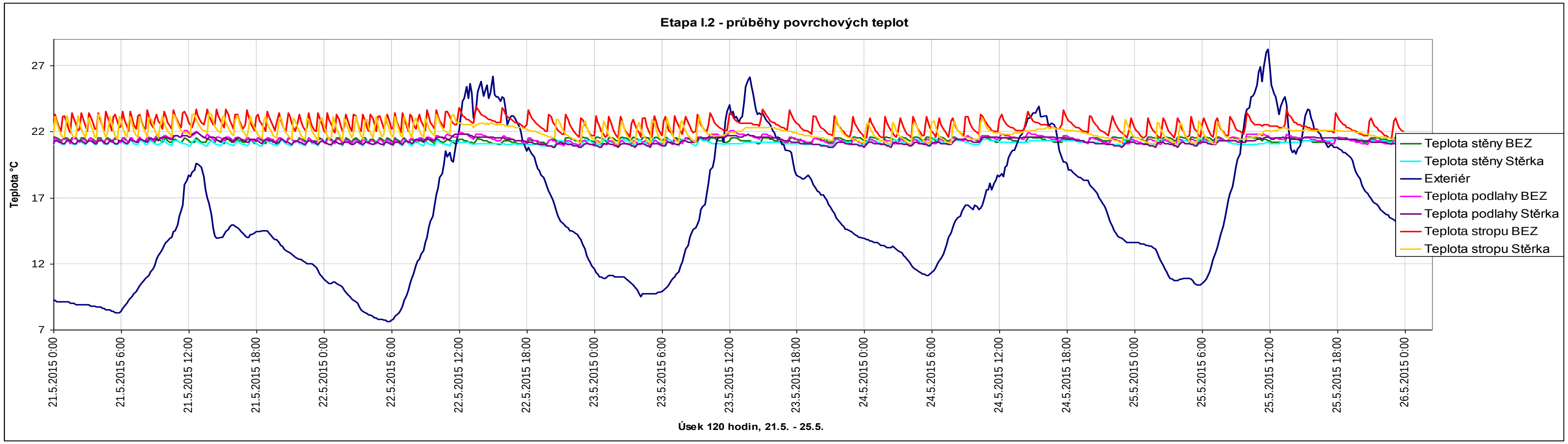
This was followed by the phase when both buildings were without power. This phase with identical development of the resulting temperature in both buildings confirms that both buildings were structurally identical.

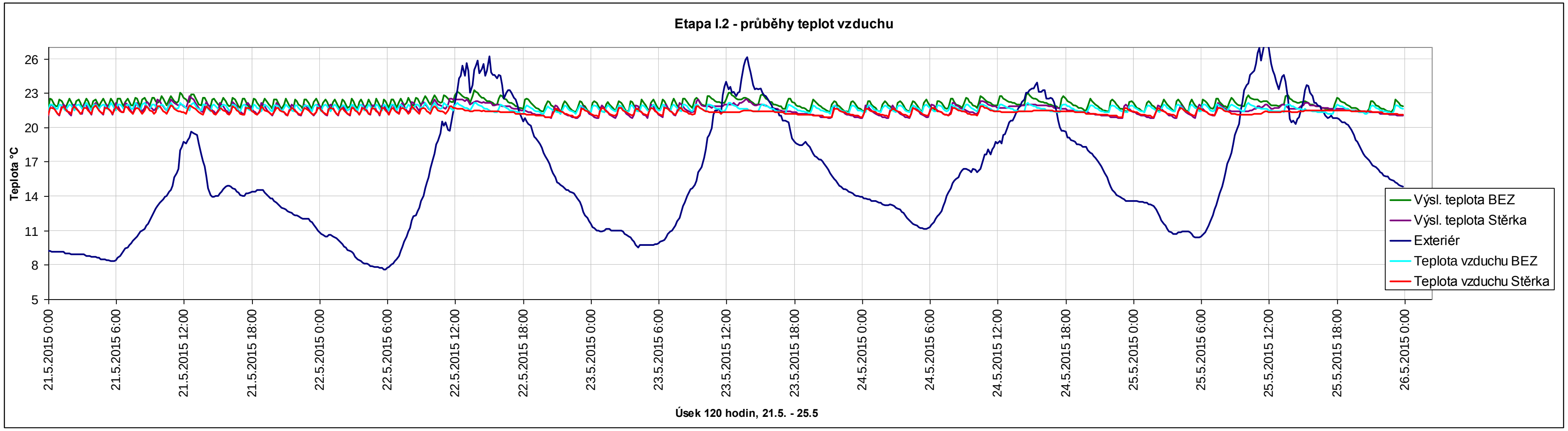
Charts with the course of measured parameters for individual sections are provided below.

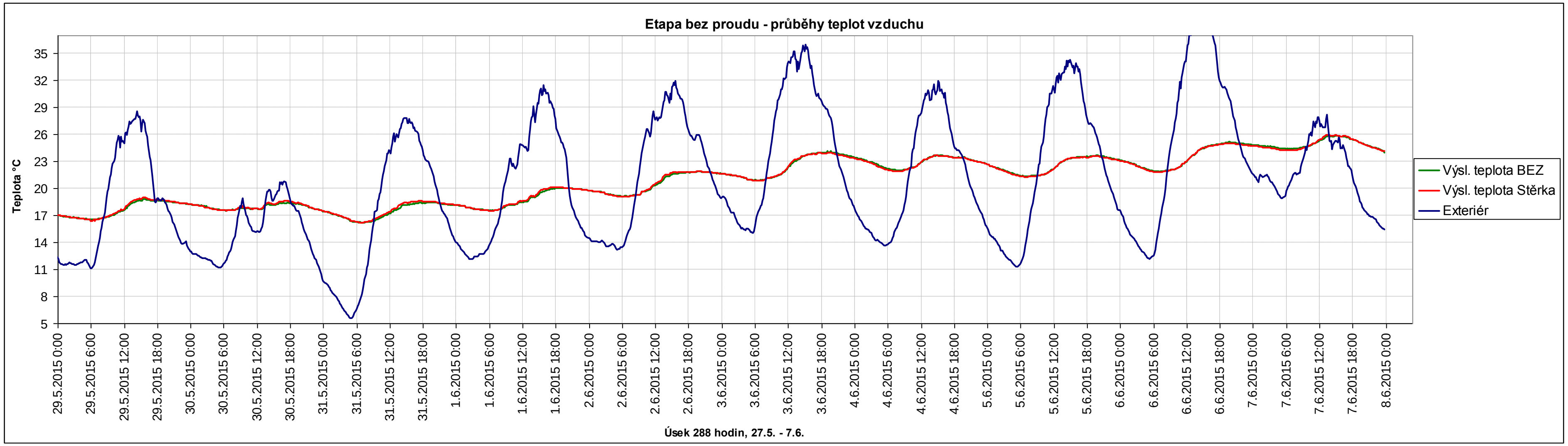

Etapa I.1 - průběhy povrchových teplot
Teplota °C
Úsek 120 hodin, 14.5. - 18.5.
Teplota stěny BEZ
Teplota podlahy BEZ
Teplota stěny Stěrka
Teplota podlahy Stěrka
Exteriér
Teplota stropu BEZ
Teplota stropu Stěrka


Etapa I.1 - průběhy teplot vzduchu
Teplota °C
Úsek 120 hodin, 14.5. - 18.5.
Výsl. teplota Stěrka
Teplota vzduchu Stěrka
Výsl. teplota BEZ
Teplota vzduchu BEZ
Exteriér


Etapa I.2 - průběhy povrchových teplot
Teplota °C
Úsek 120 hodin, 21.5. - 25.5.
Teplota stěny BEZ
Teplota stěny Stěrka
Exteriér
Teplota OT BEZ
Teplota OT Stěrka


Etapa I.2 - průběhy povrchových teplot
Teplota °C
27
22
17
12
7
21.5.2015 0:00
21.5.2015 6:00
21.5.2015 12:00
21.5.2015 18:00
22.5.2015 0:00
22.5.2015 6:00
22.5.2015 12:00
22.5.2015 18:00
23.5.2015 0:00
23.5.2015 6:00
23.5.2015 12:00
23.5.2015 18:00
24.5.2015 0:00
24.5.2015 6:00
24.5.2015 12:00
24.5.2015 18:00
25.5.2015 0:00
25.5.2015 6:00
25.5.2015 12:00
25.5.2015 18:00
26.5.2015 0:00
Úsek 120 hodin, 21.5. - 25.5.
Teplota stěny BEZ
Teplota stěny Stěrka
Exteriér
Teplota podlahy BEZ
Teplota podlahy Stěrka
Teplota stropu BEZ
Teplota stropu Stěrka


Etapa I.2 - průběhy teplot vzduchu
Teplota °C
26
23
20
17
14
11
8
5
21.5.2015 0:00
21.5.2015 6:00
21.5.2015 12:00
21.5.2015 18:00
22.5.2015 0:00
22.5.2015 6:00
22.5.2015 12:00
22.5.2015 18:00
23.5.2015 0:00
23.5.2015 6:00
23.5.2015 12:00
23.5.2015 18:00
24.5.2015 0:00
24.5.2015 6:00
24.5.2015 12:00
24.5.2015 18:00
25.5.2015 0:00
25.5.2015 6:00
25.5.2015 12:00
25.5.2015 18:00
26.5.2015 0:00
Úsek 120 hodin, 21.5. - 25.5
Výsl. teplota BEZ
Výsl. teplota Stěrka
Exteriér
Teplota vzduchu BEZ
Teplota vzduchu Stěrka


Etapa bez proudu - průběhy teplot vzduchu
Teplota °C
35
32
29
26
23
20
17
14
11
8
5
29.5.2015 0:00
29.5.2015 6:00
29.5.2015 12:00
29.5.2015 18:00
30.5.2015 0:00
30.5.2015 6:00
30.5.2015 12:00
30.5.2015 18:00
31.5.2015 0:00
31.5.2015 6:00
31.5.2015 12:00
31.5.2015 18:00
1.6.2015 0:00
1.6.2015 6:00
1.6.2015 12:00
1.6.2015 18:00
2.6.2015 0:00
2.6.2015 6:00
2.6.2015 12:00
2.6.2015 18:00
3.6.2015 0:00
3.6.2015 6:00
3.6.2015 12:00
3.6.2015 18:00
4.6.2015 0:00
4.6.2015 6:00
4.6.2015 12:00
4.6.2015 18:00
5.6.2015 0:00
5.6.2015 6:00
5.6.2015 12:00
5.6.2015 18:00
6.6.2015 0:00
6.6.2015 6:00
6.6.2015 12:00
6.6.2015 18:00
7.6.2015 0:00
7.6.2015 6:00
7.6.2015 12:00
7.6.2015 18:00
8.6.2015 0:00
Úsek 288 hodin, 27.5. - 7.6.
Výsl. teplota BEZ
Výsl. teplota Stěrka
Exteriér

8.3 Results quantification in the area of thermal losses

Five day sections (midnight to midnight) from Phases I.1 and I.2 were used for measured values quantification, for the calculation of design heat output by heat transfer and corresponding design energy pursuant to ČSN EN 12831 and its comparison with measured consumption in both buildings.

8.3.1 Phase I.1 – 5-day section (May 14, 0:00 – May 18, 24:00)

Floor foils served as the heat source (radiating heating). The building was sealed in order to prevent air exchange with the outside environment.

Boundary conditions:

Average parameters of the outside and inside environment for the assessed period:

Building with coating without special characteristics		Building with AERO-THERM coating	
resulting temperature, 1.1 m	22.1 °C	resulting temperature, 1.1 m	21.7 °C
resulting temperature, 0.15 m	22.2 °C	resulting temperature, 0.15 m	21.7 °C
resulting temperature, 1.7 m	22.0 °C	resulting temperature, 1.7 m	21.8 °C
interior air temperature	21.6 °C	interior air temperature	21.5 °C
wall surface temperature	21.4 °C	wall surface temperature	21.4 °C

Average outside air temperature 16.3 °C

Parameters of the structures:

Structure	Heat transfer coefficient U [W/(m^2.K)]
External wall	0.29 *
Ceiling	0.18
Floor	0.41
Window	0.9
Door	1.4

* as the heating is controlled with regard to the interior wall surface temperature, the heat transfer coefficient of the wall structure was reduced by the heat transfer coefficient on the interior side R_{SI}.

Building geometry is specified in Chapter 4. Objects description.

Calculation results:

Design heat output by heat transfer from the heated space was determined on the groundwork of
ČSN EN 12831 using Svoboda – Ztráty software.

design heat output by transfer 140.0 W

corresponding design energy supply for 120 hours 16.8 kWh

Measured electricity consumption:
This means only the energy required for heating of the premises, the energy entering the soil due to floor heating is not considered.

Building with coating without special characteristics	17.9 kWh
corresponding heat output	149.1 W
Building with AERO-THERM coating	9.8 kWh (value recalculated to the average temperature in the other building)
corresponding heat output	81.6 W

The above-mentioned figures indicate possible reduction of the design heat output by heat transfer through the envelope structures by 35%.

8.3.2 Phase I.2 – 5-day section (May 14, 0:00 – May 26, 24:00)

Electric heating element was used as the heat source; the nature of the heating was thus convective. The building was sealed in order to prevent air exchange with the outside environment.

Boundary conditions:

Average parameters of the outside and inside environment for the assessed period:

Building with coating without special characteristics		Building with AERO-THERM coating	
resulting temperature, 1.1 m	22.1 °C	resulting temperature, 1.1 m	21.5 °C
resulting temperature, 0.15 m	21.6 °C	resulting temperature, 0.15 m	21.3 °C
resulting temperature, 1.7 m	22.2 °C	resulting temperature, 1.7 m	21.7 °C
interior air temperature	21.7 °C	interior air temperature	21.4 °C
wall surface temperature	21.4 °C	wall surface temperature	21.2 °C

Average outside air temperature 15.7 °C

Parameters of the structures are identical to those described in Section 9.3.2.

Calculation results:

Design heat output by heat transfer from the heated space was determined on the groundwork of
ČSN EN 12831 using Svoboda – Ztráty software.

design heat output by transfer	155.0 W
corresponding design energy supply for 120 hours	18.6 kWh

Measured electricity consumption:

Building with coating without special characteristics	20.0 kWh
corresponding heat output	166.7 W
Building with AERO-THERM coating	12.3 kWh (value recalculated to the average temperature in the other building)
corresponding heat output	102.5 W

The above-mentioned figures indicate possible reduction of the design heat output by heat transfer through the envelope structures by 26%.

9. CONCLUSION

Measurement of the parameters of both interior and exterior environment and the electricity consumption of the building proved the positive influence of the AERO-THERM thermo active coating applied on the interior surface of the external wall and ceiling on the energy consumption of the building. Usage of the thermo active coating on interior surfaces of structures can reduce the design heat output by heat transfer through external structures.

This report is intended as the groundwork for issued certificates No. OV-15-0297 and No. OV-15-0298 dated August 26, 2015.

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