CTU IN PRAGUE, FACULTY OF CIVIL ENGINEERING

Technical report

Bachelor project: Heating system with renewable energy sources

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Content

1. Function and shape of the building

1.1. Basic information about the building

Name of the building:	Building of company VESKOM Slovakia
Location of the building:	Vinohrádok 2861, 901 01, Malacky, Slovakia
Type of the building:	Administrative building
Character of the construction:	reconstruction
Investor:	VESKOM Slovakia, spol s.r.o. (IČO: 35 820 331)
Area of the land:	1776 m^2
Area of the building:	183 m^2
Area of the roof:	183 m^2
Type of the roof:	pent roof
Capacity of the building:	13 people
Number of floors:	3 (1 underground floor, 2 above ground floors)
Days of operation per year:	225

1.2. Description of the building

The building is situated in Slovakia in Malacky (address: Vinohrádok 2861, 901 01, Malacky, Slovakia) . It is an administrative building that belongs to company VESKOM Slovakia, spol s.r.o. (IČO: 35 820 331). This building is the renovation of the old building that was standing in this place. It has a rectangular shape and it consists of the basement, ground floor, and the first floor. The basement is accessible from the outside by two staircases. Each of the staircases to a different room in the basement, these two rooms are not connected and between them is soil so the basement is not under the whole building. The basement is not being used. There is a storage room on the first floor which is connected with the entrance hall of the building and also it is accessible by the special entrance with a ramp. There are also a meeting room, plant room, kitchen, WC and utility room in the ground floor. The second place is a workspace with seven offices connected by a corridor, WC for men women and kitchen. The building was designed for 13 people to work in it. The operation of the building is continuous within the whole year with the exception of weekend and national holidays. A predicted number of work days per year is 225 days.

2. Documentation

The documentation provided for this building consists of the plan of each floor, situation and the description of the composition of each layer (from this information U-value of each construction was calculated). Also, the location was known which helps to determine climatic condition and also the geological conditions according to geological maps that were used to help calculate heat source.

3. Basic technical information

The building is located in Malacky, which means that the outside temperature t_e= -11°C and the annual average outside temperature t_{me}= 0,0°C. The elevation is 160m above sea level. The geological area was determined according to the geological map of Slovakia that it is mix of sand and gravel and it is soaked with water because this area has relatively high ground water level.

The temperature for the offices and meeting room is 20°C, the temperature in the entrance hall, storage room and corridor is 15°C and the temperature in the sanitary rooms is 18°C (These temperatures are set according to ČSN EN 12831). Internal exchange of air is 0,5 h^{-1}. Heat loss of the whole building is 20 161 W. (calculated in Protech – TV – norma ČSN EN 12831).

Heat loss through the constructions	16 279 W
Heat loss due to air exchange	3 881 W
Total heat loss	**20 161 W**

4. Heat source

The heat source was chosen according to the calculation of heat losses and energy needed. The heat source is geothermal heat pump IVT PremiumLine EQ E17 with the dimensions 600 x 645 x1520mm and the output 17kW.

The heat source is situated on the ground floor in the room no.1.08 – plant room with the area 17,5 m^2. The door to this room has dimensions 1800x1970 and since the dimension of the heat source is 600 x 645 x 1520mm there is no need to make any change in the construction design.

The internal parts of this heat pump are compressor Scroll Copeland, three-way valve with the possibility to connect water storage tank, electrical boiler, electrically controlled circulation pumps WILO for the primary and secondary circuit, elastic pipes to eliminate vibration of the heat pump and muffler cover of the compressor. The external parts of this heat pump are expansion vessel for primary circuit, filters for primary and secondary circuit and an external sensor for equithermal regulation.

Energetic class	-	A++
Output (0°C/35°C)	kW	17,0
Input	kW	3,64
Output (0°C/45°C)	kW	16,1
Input	kW	4,47
Max. pressure of cold water circle	bar	4
Volume of cold water inside the heat pump	l	5
Max. pressure of hot water circle	bar	3
Volume of hot water circles inside the heat pump	l	7
Weight	kg	192
Refrigerant	-	no freon refrigerant R 410A
Max. pressure on circle	bar	42
Dimensions	mm	600 x 645 x 1520
Mass of the refrigerant	kg	2,8
Max. temperature of the hot water	°C	62
COP	-	5,1

The room is not neighbouring to any room where people spend most of the time so there are no problems with the acoustic. The machine room where the heat pump is located is next to the utility room, stairs and entrance hall. There is no need of extra mechanical ventilation system in the machine room.

4.1. Horizontal collectors

The source of geothermal energy is horizontal collector situated in the garden. The calculated need of horizontal collectors is $444m^2$. The horizontal collectors are divided into the two circuits each of them with the length 230m with the spacing of pipes 1m. The pipes are 1,2 under the surface and they are lied down in the sand bedding. The layout of the

horizontal collector is classical. The circuits are drained into the reservoir PAK MINI with dimensions 715x480 mm. The orientation of the reservoir is right. It is made from polypropylene with the width of side walls 15 mm. The cover of the reservoir is standard green and the maximal allowed load acting on the cover is 200kg. The reservoir is watertight.

4.2. Water storage tank for domestic hot water

The minimum volume of domestic hot water storage tank calculated is 70l. The storage tank that chosen for this building is SMART 100 from company ACV. The total capacity is 105 l. The width is 565 mm. The height is 800 mm. It is made from stainless steel which is anti-corrosive. The water storage tank is insulated all around its surface by 50mm of polyurethane insulation. Heat losses are minimized to 0,35°C per hour. It has the ANTI-legionella feature.

4.3. Accumulation tank

The accumulation tank designed IVT BC 300/3 which is suitable to be combined with heat pumps. The volume of this tank is 300 l. The dimensions are 600x600mm with the height 1600mm. The weight without the water is 77 kg. This tank does not allow accumulating cold water for cooling. It is delivered with the insulation and sheathing.

5. Heating system

The heating distribution system consists of heat source – geothermal heat pump, heat transfer medium – water transferred through pipes and heat emitters – radiators and radiant floor heating system. The operation of the heating system depends on the work time. There is no need to heat up building for 100% during holidays and weekends. The heating system is central. It is a two-pipe system (contra flow). The maximal temperature of heat system is 45°C and the temperature different varies for radiators and radiant floor heating.
The difference of temperatures for the radiators is 10°C so the lower temperature is 35°C. The pipes are mostly located on the floor. Only vertical pipes are situated in the core in the wall.The pipes are divided in the REHAU Stainless steel manifolds. The manifold has 5 outlets in the ground floor and 11 in the first floor. The pipes used are PE-Xa REHAU Rautherm S with the external diameter 32, 25, 20, 17 and 12 mm.

The insulation of the pipes varies according to their diameter. The insulation used for the pipes is ROCKWOLL – PIPO ALS. This insulation works as a thermal and also acoustics insulation. The table below shows what the thickness of the insulation is for different diameters of pipes. The thickness of the insulation was calculated in accordance with the Regulation no. 193/2007.

Diameter of pipe	Thickness of insulation	Energy savings of insulated pipes
25 x 2,3	30 mm	77 %
20 x 2,0	25 mm	72 %
17 x 2,0	25 mm	70 %
12 x 2,0	25 mm	64 %

6. Heat emitters

There are two types of heat emitters used in this project. In the offices and the meeting room, there is radiant floor heating and the rest of rooms are heated by radiators. Different types of radiators used in this project are listed in the table below.

6.1. Types of heat emitters used-radiators

RADIK 11 VK	(400/400)
RADIK 22 VK	(900/700)
RADIK 22 VK	(900/2000)
RADIK 22 VK	(900/1600)
RADIK 22 VK	(900/500)
RADIK 22 VK	(600/1000)
RADIK 22 VK	(900/1200)
RADIK 33 VK	(600/1100)
RADIK PLAN VERTIKAL –M10	(1800/600)

The radiators are fixed to the wall, they are located either under the windows (so the maximal height of these radiators is 600mm) or they are fixed to the wall without any openings (for example in WC). In that case, the height is not limited. The radiators are connected to the heating system with VK straight to the pipes RAUTITAN stabl connection. The connection of all the radiators type RADIK VK is right down.

6.2. The radiant floor heating system

The layout of pipes is meander with 267mm distance of pipes from the walls. The pipes are PE-Xa REHAU Rautherm S with the external diameter 20 mm and the internal diameter 16 mm.

Room no.	t_i [°C]	Purpose of the room	Heat loss [W]	Spacing [mm]	Length [mm]	S $[m^2]$
1.03	20	Meeting room	1452	200	106,1	19,8
2.02	20	Office	1676	200	74,5	13,6
2.03	20	Office	1025	200	65,6	11,7
2.04	20	Office	1025	250	66	12,4
2.05-1	20	Office	1821	200	67,8	9,2
2.05-2	20	Office	1821	200	67,5	9,5
2.06-1	20	Office	1851	250	61,9	10,8
2.06-2	20	Office	1851	250	62	10,8
2.07	20	Office	1105	300	62	14,7
2.08	20	Office	1219	200	79,1	15,2

Room no.	t_{inco} [°C]	Δt [K]	t_{floor} [°C]	R*l+z [Pa]	Setting of valve	Coverage [%]
1.03	45	15	26,9	2331	2,5	102%
2.02	45	5	28,9	11966	6,0	117%
2.03	45	5,5	28,8	6807	2,85	112%
2.04	45	5,2	27,9	6828	2,85	105%
2.05-1	45	5,2	29	6727	2,83	103%
2.05-2	45	4,5	29	6718	2,83	103%
2.06-1	45	4,6	28	6486	2,83	103%
2.06-2	45	4,6	28	6490	2,83	103%
2.07	45	4,6	27	6658	2,85	101%
2.08	45	6,9	28,5	7481	2,88	118%

7. Regulation and armatures

7.1. Expansion vessel

The minimum volume of expansion vessel was calculated as 18,36l. The expansion vessel chosen for this project is REFLEX N 25, red, expansion vessel, Article-No. 7206300. Nominal volume is 25 l, the useful volume is maximum 22,5 l. System connection is R 3/4. Colour is rot and it has the durable external powder coated finish. The diameter of this expansion vessel is 308 mm, the height is 481 mm and net weight 4,3 kg. The permanent operating overpressure is 3 bar. This expansion vessel is designed according to EN 13831 and it is situated on the ground floor in the room no.1.08 – plant room.

7.2. Regulation of heat emitters

The heat emitters type Korado RADIK VK are installed with thermostatic head to regulate the heating temperature in the room individually for each room with the radiator. The radiators in the ground floor have the ventilation set during the installation as follows:

Room	Radiator	Setting
1.01	RADIK 22 VK (900/700)	1
1.02	RADIK 22 VK (600/3000)	6
1.02	RADIK 22 VK (900/2000)	8
1.02	RADIK 22 VK (600/2000)	8
1.04	RADIK 22 VK (900/500)	1
1.05	RADIK 33 VK (600/1100)	3
1.06	RADIK 11 VK (400/400)	1

7.3. Circulation Pump

There are two circulation pumps WILO Para energetic class A for primary and secondary circuit already inside the heat pump. There is additional circulation pump installed in the secondary circuit for the heating system. The additional circulation pump is GRUNDFOS ALPHA 2 XX-60 and the designed was based on the maximal calculated pressure in the pipes. The insulation class of this pump is F. It allows the heating medium to be in the temperature range from +2°C to +110°C. The temperature of surroundings is in the range 0°C to +40°C. The maximal allowed pressure in the system is 1,0 MPa (10 bar). The acoustic level of the circulation pump is lower than 43dB. The material of the circulation pump is stainless steel. This circulation pump was designed in a way that its output allows water to circulated in all parts of heating system.

7.4. Pressure relief valve

There are three safety valves situated in the machine room. The first one is on the primary circuit (cold side) from the heat pump to the heat collectors. The other one is on the secondary circuit (warm side). The third one is on the connection to the water storage tank. The safety valves designed are GIACOMINI 1/2" x 3,0 with the membrane. The requirement is to control the system once a year.

8. Control system

There is equithermal regulation REGO 1000 installed inside the heat pump. The circulation pumps WILO Para is electrically regulated which saves kWh of electricity per year. The basic function of regulation REGO 1000 is that it operates circulation of hot water and also operates the work of the electric boiler. It shows the energy that is produced by the heat pump and how much energy was produced by the electric boiler (or another type of supplementary heat source). It also shows energy consumed by the heating and domestic hot water. The heat pump cooperates with the internal room sensor with LCD screen. The heat pump can be connected to the internet at building so the user can download the application to his android or iPhone and controlled and set up the temperature of the water, holiday regime, time regimes etc.

9. Quality of water requirements

Water quality required for the heat emitter: pH 8,5 - 9,5; salinity 300 – 500 μS/cm; the hardness of water up to 1 mmol/l; the content of oxygen max. 0,1 mg/l.

Water requirement for the heat pumps: amount of oxygen 0,5-1 mg/l; amount of sulphates SO_4<100mg/l; amount of CO_2<1 mg/l; amount of chlorides Cl <100mg/l. In case that the supplied water has bigger amount of chlorides or sulphates than allowed It is necessary to install ions convertor. In case the water has higher pH then it is given by VDI 2035 it is necessary to install filer in order to soften water.

10.Conclusion

All the work done has to be tested with accordance with relevant ČSN and with the related regulations. The testing of the devices is in accordance with ČSN 06 0310. The results and the progress of the test should be written in the specific protocols and also in the construction diary.

Before the radiant floor heating system is covered by the concrete it has to be specially tested by the pressure test. The system is filled by the water under certain pressure. The test last 24 hours and if no leakage occurs and the pressure loss in the system is lower than 0,1 bar the test is successful and the system can be covered with concrete.

Norms and regulation used:

ČSN EN 12831	Calculation of heat losses
ČSN 73 0540-(1-4)	Calculation of consumption of energy
Regulation no. 120/2011 Sb.	Consumption of hot water
ČSN 06 0320	Calculation of storage tank
EN 12 828	Design of expansion vessel
ČSN EN 14511	Design of heat pump
ČSN EN 15450	Design of horizontal collectors
Regulation no. 193/2007 Sb.	Design of insulation of pipes
ČSN 06 0310	Testing of the system

Programs used:

AutoCad 2016	Drawings
Protech -TV - norma ČSN EN 12831	Calculation of heat losses
RauCAD/TechCON 7.2	Calculation and design of radiant floor heating