Alexander Kalyuzhny'y
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VERIFICATION OF THE TEMPERATURE MEASUREMENTS IN AN AIR HANDLING UNIT

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Building services engineering

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MIKKELIN AMMATTIKORKEAKOULU
Mikkeli University of Applied Sciences

DESCRIPTION

<table>
<tr><td colspan="2">MIKKELIN AMMATTIKORKEAKOULU
Mikkeli University of Applied Sciences</td><td colspan="2">Date of the bachelor's thesis

16.02.2012</td></tr>
<tr><td colspan="2">Author(s)

Alexander Kalyuzhny’y</td><td colspan="2">Degree programme and option
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Verification of the temperature measurements in an air handling unit.</td></tr>
<tr><td colspan="4">Abstract
The subject of the thesis was Air Handling Unit AHU TK 43, its working principles and principles of monitoring by a variety of electrical instruments. The aim of this thesis was to study working principles of electric devices measuring parameters of air condition and to determine the temperature efficiency of AHU TK 43. Also within thesis the importance of correct measuring equipment installation was shown in order to collect the appropriate data.

Appropriate indoor climate for educational building is very important and widely discussed. Students and teachers spend plenty time in premises there. Many countries think about it and make special standards and guidelines to determine the design parameters for indoor climate. In this thesis three commonest documents were discussed: ASHRAE, National building Code of Finland D2, Russian designing and State Russian Standard 30494-96. Also the comparison between their data was made.

The main function of ventilating and air conditioning systems and all equipment of these systems is to provide the indoor climate for educational premises. The climate should have defined parameters to be good for comfort and healthy of people and constructions there. If one of parameters or several change and became have the big deviate from design meaning, this must be shown on the data of electrical instrument. Showing on the display and collecting of the information from there it can be possible to determine conditions of indoor climate and effectiveness the working of AHU TK 43.

The diverse kind of electrical instruments were shown in this thesis. All operating principles and possible places of installation were discussed. Monitoring the AHU TK43 by these devices can make the working of ventilation specialists more comfortable and easy because of the possibility to collect all information distantly.</td></tr>
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<tr><td colspan="2">Tutor

Aki Valkeapää</td><td colspan="2">Employer of the bachelor's thesis</td></tr>
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CONTENTS

DEFINITIONS

“Accessible area of a premise – placed in a premise, limited by planes parallel to the floor and walls: on the level 0,1m and 2,0m above the floor (but not closer than 1 meter from heated ceiling), on the distance 0,5m from the inner surface of exterior and interior walls, windows and radiators.” /1, p. 2/

”Cold period (heating season) - the period of the year, characterized by the average daily outdoor temperature equal to 8 ° C and below.” /1, p. 2/

”Indoor climate - the state of the internal environment of premises, which have an impact on the person, characterized by indicators of air temperature and walling, humidity and air mobility.” /1, p. 2/

”Optimal parameters of microclimate - a combination of values of parameters of microclimate, which prolonged and systematic influence provide a normal thermal state of the organism with the minimum voltage of the mechanisms of thermoregulation and comfort no less than 80% of people in the room.” /1, p. 2/

“Optimal operative temperature – operative temperature where the maximum number of the occupant can be expected to feel the indoor temperature acceptable (Note – for mechanical cooled building it corresponds to PMV = 0).” /2, p.9/

“Occupied hours – the hours during which the majority of the buildings is in its intended use.” /2, p.9/

”Permissible parameters of microclimate - combinations of parameters of microclimate, which, if prolonged and systematic influence may cause local and general discomfort, deterioration of health and a decrease in performance and do not cause injury or ill health.” /1, p. 2/

”Room with a constant presence of people - the premise in which people are no less than 2 hours continuously or 6 hours in total during the day.” /1, p. 2/

”Velocity of air - averaged value of velocity over the volume of service area.” /1, p. 2/

“Ventilation rate – magnitude of outdoor air flow to a room or building either through the ventilation system or infiltration through building envelop.” /2, p.9/

“Warm period (cooling season) - the period of the year, characterized by the average daily outdoor temperature is above 8 ° C.” /1, p. 2/

NOMENCLATURE

t_0	operative temperature, (°C)
t_i	air temperature, (°C)
t_s	mean radiant temperature, (°C)
t_u	temperature of outdoor air , (°C)
t_t	temperature of supply air after the heater, (°C)
t_p	temperature of extract air before the heat exchanger, (°C)
t_{lto}	temperature of supply air after the heat exchanger, (°C)
t_j	temperature of extract air after the heat exchanger, (°C)
$q_{v,t}$	supply air volume flow, (m³/s)
$q_{v,p}$	exhaust air volume flow ,(m³/s)

1 INTRODUCTION

The education building is the place where people: teachers and their students; spend a lot of time for teaching, studying, researching and doing other activities. The education building should have the indoor climate which is good and healthy for people and which provide long operation period for building construction and materials. For this purpose effective ventilation and air-conditioning system should be created.

Indoor climate of educational (public) buildings have a diverse king of characterizing parameters. When these parameters correspond to the standards of design parameters the indoor climate is good. The design value of indoor climate parameters are given in different standards and guidelines. These documents are made by different countries and pay attention to the different groups of indoor climate parameters and the design value of parameters can be different from each other.

According to the recommendations of the regulations and guidelines the air-conditioning system should be possible to control and monitor by electrical instruments. It allows the determination of existing value of indoor climate parameters and their deviations from design value.

This thesis accumulates information about AHU in educational buildings and the principals of monitoring AHU with measuring sensors. The aim of this thesis was to study working principles of electric devices measuring parameters of air condition and to determine the temperature efficiency of AHU TK 43. Also within thesis the importance of correct measuring equipment installation was showed in order to collect the appropriate data.

The first part of this thesis contains information about main parameters of indoor climate of educational (public) building, about their significance, design values and consequences of the big deviations from normal parameters. Then the three common regulation documents are discussed. It’s given on which parameters they pay attention and which design meaning these parameters have. After that the comparison between these recommendations was done. After the theoretical part of the thesis the practical part is given. Electrical instruments and their operational principles are written about and then the practical test and calculation of thermal efficiency of heat exchanger of AHU TK 43 is described. Final part of thesis contains conclusion about the effectiveness of AHU TK 43 working and of operating by different electrical instruments.

2 PARAMETERS OF INDOOR AIR FOR PUBLIC BUILDINGS

In order to ensure comfortable circumstances for people and avoid the bad affect on human health good indoor environment should be achieved. For this purpose ventilation and air-conditioning systems should provide proper parameters of indoor air. There are several main parameters, which engineers take into account when designing ventilation and air-conditioning system. The definitions of these parameters are given in this chapter.

Usually heat losses of human body are in balance with the heat generated by person. But sometimes this balance is broken during some periods or little deviations from balance can occur. There are several parameters that have importance for the heat balance: environmental parameters and sensitivity of human body. The environmental parameters (physical and thermal) which can be regulated by air handling unit are following: air temperature, relative air velocity, air humidity and water vapor pressure. The parameters of human sensibility are metabolic rate of human body and thermal resistance of the clothing. /3, p.92-93/.

Metabolic rate

The metabolic rate is expressed as the heat produced by human body. This parameter is often measured in the unit “Met”. The metabolic rate of a relaxed seated person is one (1) Met, where 1 Met = 58 W/m².

The total metabolic rate for a mean body can be calculated by multiplying with the area. The mean value of human body surface is approximately 1,8 m². The total heat production from a seated relaxed person with the surface of 1,8 m² would be 58 W/m² x 1.8 m² = 104 W /3, p.93/. In the table situated below we can see values of metabolic rates for some common activities.

Table1. Levels of activity and their corresponding metabolic rates /3, p.93/

Activity	Metabolic rate	
	met	W/m^2
Seated, relaxed	1.0	58
Sedentary activity	1.2	70
Standing, light activity	1.6	93
Standing, medium activity	2.0	116
Walking 2 km/h	1.9	110
Walking 5 km/h	3.4	200

Thermal resistance of clothing

Thermal resistance of clothing has measuring unit called "clo". One "clo" is 0,154 m² K/W. In the table 2 we can see values of thermal insulation for some general clothing resistance /3, p.93/.

Table 2. Some standard values for thermal insulation of clothing ensembles /3, p.93/

Clothing ensemble	Clothing insulation	
	clo	M2 K/W
Underpants, T-shirt, shorts, light socks and sandals	0.30	0.050
Underpants, shirt with short sleeves, light trousers, light socks and shoes	0.50	0.080
Underwear with short sleeves and legs, shirt, trousers, jacket	1.00	0.154
Underwear with long sleeves and legs, thermojacket, trousers, socks and shoes	2.20	0.340

Air temperature

Indoor air temperature is one of the most important parameters which define condition of thermal comfort in the premise. Human body can generate the heat and this heat should be rejected from person to prevent overheating. The rejection of heat is carried out mainly by heat exchange with outdoor air.

As the initial information during calculation of thermal load we can use values of temperature in premises, outdoor temperatures and comfortable temperatures calculated for different types of buildings defined in standards and regulations.

The recommendations indicate the temperatures inside the premises. Comfortable temperature (operating temperature), air temperature and mean average temperature of the adjacent premises must be taken into account.

Air temperature (t_i) describes the thermal conditions of a thermally uniform space and takes into account the convective heat transfer between the body and the environment.
Mean radiant temperature (t_s) takes into account the radiation exchange with the environment. This parameter allows determine influence heat radiation on heat balance of person. It is difficult to calculate this thermal parameter. Using measuring equipment we can measure the value of mean radiant temperature, but average value can be only calculated /3, p. 96-98/.

Operative temperature (t_0) takes into account both convection and radiation. We can use this type of thermal parameters as a design temperature during designing if temperatures of large room surface differ significantly. In most of the cases described of state standards there is air flow velocity less than 0.2 m/s. Hence in order to calculate value of operative temperature the following formula can be used

$$t_0 = \frac{t_i + t_s}{2} \quad (1)$$

Where t_0 is the operative temperature, t_i is the air temperature and t_s is the mean radiant temperature.

If the amount of people dissatisfied to the thermal conditions is minimum (by certain clothing I_{cl} and metabolic rate M), then the operative temperature is optimal. In this situation PMV=0 and percent of dissatisfied persons is equal 5%.

Humidity

One more physical parameter of indoor environment, which has influence on heat exchange between human body and environment, is humidity of air. The relative humidity is the ratio of the partial pressure of water vapor to the saturated vapor pressure of water at the same temperature. Humidity describes its water vapor saturation. Changing of relative humidity in the premises is not general process of air handling, except premises with the special conditions, like swimming pool or drying room. In the most cases existing relative humidity doesn't have the big influence on thermal sensation. But if we have too high level of relative humidity it can cause some problems. For example, too high relative humidity (more than 65 %) can leads to deterioration of heat transfer during evaporation of sweat, a feeling of suffocation and growth of microbes. On the contrary, if we have relative air humidity less than 20%, it can cause drying of mucous membranes, cause cough /2, p.16/.

If we don't have definitely information about required parameters of indoor air, the design should be based on the supposition the there is no source of excessive humidity (other than human activity and water vapor of exit air). When we design air conditioning system to provide required level of relative humidity we should take into account the following things: the energy issues, thermal conditions of season, possibility of air quality controlling, risk of condensation and moisture damages /4, p. 31/.

Temperature of air and relative air humidity should be in balance with each other. In Figure 1 below we can see the parameters (they are limited with bold line) which provide comfort conditions for people.

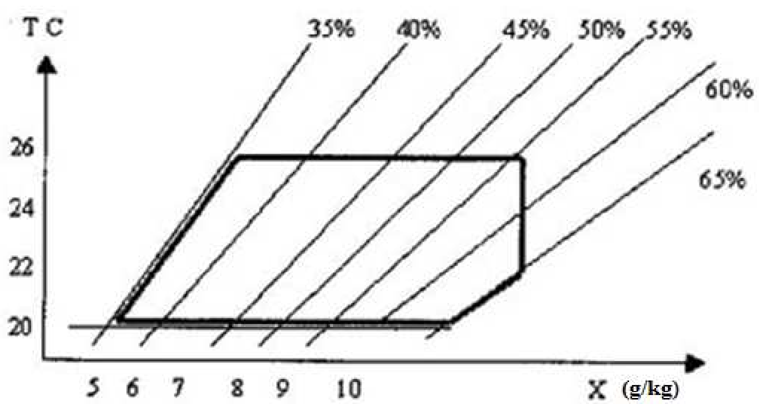

Figure1. The impact of temperature and relative humidity on satisfaction of people /5/

Air flow rate

From SFS EN 15251 we can know that in order to design the proper air handling unit we need to know needed air flow rate which specified in the design guidelines based on the existing national standards. It is possible to operate with different rates in premises with different categories of indoor air quality. The regulation documents give recommendations to choose flow rate according to the category. The values of air flow rate do not depend on the seasons. The general factors which have influence on the choosing of air flow rate are human activity, other processes occurring in the premise, amount of people and emissions from building material or structure. /2, p.15/

Optimal exchange rate provides constant temperature in premise and prevents big temperature difference which does not exceed 2-4 degrees. The appropriate air exchange rate needed is defined in each situation and depends on many factors. It’s logical that the less the amount of supply air the bigger difference between temperature of supply air and temperature into premise should provide. And vice versa if the amount of supply air is enough the temperature of supply air can have a little difference from existing temperature. In ideal case fresh air with required temperature just replaces existing air with inappropriate temperature. The air flow of ventilation system or air conditioning system should be within the minimum required amount of outdoor air needed to breath and flow. It maintains the temperature and humidity parameters in the whole volume of the room (if the room does not have an intensive source of pollutions). /5/

It is not obligatory to provide air exchange using outdoor air. To support required air temperature it is enough to use recirculation, i.e. supply air to the premise taking it from the same premise. Obviously, the energy consumption of processing the room air for recycling would be much less when air is being processed by needed parameters will be slightly different from the norm. This is most likely when the used air comer from the same areas. According to this principle most of the household air-conditioners work according to the following scheme: they take air from premise, cool or heated (and sometimes dried) and throw into the same room. The air exchange rate should not be less than 5. /5/

Pressure

Usually there is a difference between the indoor air temperature and outdoor air temperature. Due to this there are different density weight of air inside the building and its surrounding atmosphere, which leads to the gravitational pressure. This factor is actively used in natural ventilation.

In most cases, the indoor air temperature is much higher than the outdoor air temperature, and due to the gravitational pressure air from the upper part of the room tries to go out. In the lower part of the room negative pressure is created and outdoor air tends to enter the premises. This way natural exhaust ventilation is carried out.

The gravitational pressure is constant operative force and its value can change depending on the difference between indoor and outdoor temperature. It has an impact on the change of the natural ventilation efficiency, which does not provide sufficient stability and accuracy in maintaining preset parameters of the microclimate as a mechanical supply and exhaust ventilation.

In addition to the gravitational pressure such natural factors as wind pressure can participate in the functioning of natural ventilation that is the pressure exerted by wind flow on the surface of the premise. The pressure drop that occurs through the windward side of the building causes movement of air either through the air, or through leaks, cracks and openings in the building.

Both of these natural factors are used in natural ventilation. They create small amount of pressure, which allows only general exchange or local systems with a very limited extent of network air. In addition, the air pressure created by these natural forces depends on such variable parameters as wind and air temperature. So the intensity of the air exchange with natural ventilation depends on external factors. It does not provide a certain level of intake and replacement of air in the room. /6/

3 PARAMETERS OF INDOOR AIR GIVEN IN STANDARDS

Values of the parameters classifying the condition of indoor air are described in different standards and regulations. In this chapter recommendations about values of indoor air parameters (given by Finland D2, American ASHRAE and Russian guidelines) will be presented and compared between each other.

3.1 Finnish Nation Building code D2.

In this chapter it is discussed the recommendations given by Finnish Nation Building code D2 2003 “Indoor climate and ventilation of building” /7/, which contains information about designing acceptable indoor climate in the building.

Indoor air temperature in the premises according to D2 should be + 21°C during heating season; and below +23°C during cooling season. Temperature in the premises can be higher than +23°C, if the average outdoor temperature over a maximum period of five hours is higher than 20°C.

Optimal level of relative humidity applicable to air temperature + 21°C is 45 %. During heaitng season in order to avoid the harmfull affect of low relative humidity it’s necessarry to decrease the excessively high indoor temperature. Acceptable value of other parameters of indoor climate for eductional establishment, such as air flow rates, sound level and air velocity, are given in the Table 3.
/7, p. 8, 10, 33/

Table 3. Recomended parameters of indoor climate for educational establishments /7, p.33/

Space type	Outdoor air flow (dm^3/s) per person	Outdoor air flow (dm^3/s)/m^2	Extract air flow (dm^3/s)/m^2	Sound level $L_{A,eq,T}$ / $L_{A,max}$ dB	Air velocity (winter / summer) m/s	Note!
Classroom	6	3		**33 / 38 ***	0.20 / 0.30	#4, *C1 gdln
Corridors / Lobbies		4		38 / 43		#2
Gym:						#3
– use for gym purposes		2		38 / 43	0.30	
– use as assembly hall		6		33 / 38	0.25	
Lecture room	8	6		33 / 38	0.20 / 0.30	#4
Team work area	8	4		33 / 38	0.20 / 0.30	#4
Canteen	6	5		33 / 38	0.25	
Storage rooms			0.35			#S

#1 For hygiene rooms’ extract air flows, see Table 11 Hygiene rooms.
#2 Guideline values for air velocity at fixed workstations are the same as for offices.
#3 Indoor climate and ventilation shall be designed in accordance with the most demanding use, shall be able to be controlled as necessary for the purposes of different types of use.
#4 Ventilation shall be controllable according to the actual demand..
#S Transferred air can be used.

3.2 ASHRAE

In this chapter we will discuss the recommendations given by ASHRAE standard 55-2004 “Thermal environmental conditions for human occupancy” /9/ and Standard ASHRAE 62-2001 “Ventilation for acceptable indoor air quality” /8/.

ASHRAE Standard 62-2001 “Ventilation for Acceptable Indoor Air Quality” gives recommendations concerning the requirements for ventilation and quality of indoor air. But this standard doesn’t content the requirements about thermal comfort. In Table 4 the outdoor air requirements for ventilation in institutional facilities are showed. In particular the optimal air flow rate per person is given.

ASHRAE standard 55-2004 “Thermal environmental conditions for human occupancy” /9/ is specified on the recommendations about some parameters of indoor climate to provide acceptable thermal indoor environment. Several types of methods to determine the optimal operative temperature for occupied zones are given in this standard. For using of these methods we should know the required values of air velocity, relative humidity, metabolic rate, and insulation of clothes. Concerning to the required velocity of air flow these guidelines claim: “The required air speed may not be higher than 0,8 m/s..... the elevated air speed must be under the direct control of the affected occupants and adjustable in steps no greater than 0,15 m/s “/9, p.6/.

Table 4. Outdoor air requirements for ventilation in institution facilities /8, p.10/.

Application	Outdoor air requirements		Comments
	L/s per person	L/s per m2	
Education			
Classroom	8		
Laboratories	10		Special contaminant control system may be required for the processor or functions including laboratory occupancy
Training shop	10		
Music room	8		
Libraries	8		
Locker room		2.5	
Corridors		0.5	
Auditoriums	8		
Smoking lounges	30		

3.3 State Russian Standard 30494-96.

State Russian Standard 30494-96/1/ divides premises into six categories. Premises of university building belong to the second category. The second category is the premises where people spend their time studying something. Optimal and acceptable norms of microclimate in the area serviced by the premises with the second category shall conform to the values given in Table 5.

In order to ensure the needed value of parameter of microclimate in different points of range allowed:
- drop of the air temperature up to 2 ° C for optimal performance, and 3 ° C - for acceptable.
- change of the speed of air movement - no more than 0,07 m / s for optimum performance and 0,1 m / s - for admissible;
- change of relative humidity - less than 7% for optimum performance and 15% - for all admissible.

Table 5. Optimal and admissible values of temperature, relative humidity and air velocity in the area served by public buildings /1, p.4-5/

Season	Category of premise	Air temperature, °C		Relative humidity, %		Air velocity, m/s	
		optimal	admissible	optimal	admissible and higher	Optimal and higher	admisseble and higher
Heating	2 category	19 - 21	18 - 23	45 - 30	60	0,2	0,3
Cooling	Premises with permanent presence of people	23 - 25	18 - 28	60 - 30	65	0,3	0,5

In the public buildings it is allowed to reduce climate indicators, provided that the required parameters to the beginning of working time after working hours./1, p. 4-6/.

3.4 Comparison

In the previous sections the requirements for parameters of indoor climate of educational buildings were described. These requirements possess a different character: some are mandatory, others are less strict. Each standard pays attention to the definite parameters of indoor climate, which it considers the most important to ensure a healthy indoor climate of classrooms. In this section, a comparison of requirements for all three standards on the basis of the data presented earlier will be done.

In this chapter each parameter of indoor climate will be discussed separately, and will be investigated the similarity and difference of recommendations given in D2 Regulations and guidelines, State Russian Standard and Standard ASHRAE.

<u>Air velocity.</u> All of these three standards possess the indications about appropriate rate of air velocity. D2 Regulations and guidelines recommend rate of air velocity for different type of premises and also indentify them for two seasons (winter – heating season, summer – cooling season). Design rate of air velocity according to the D2 cannot exceed 0,30 m/s (in summer). Standard ASHRAE 62-2001 does not give certain parameters of the rate of air velocity for educational buildings. The ASHRAE standards only say that the air velocity should not exceed 0.8 m/sec. State Russian Standard 30494-96 only presents the parameters under which the indoor climate is optimal, and also gives framework in which the values of air velocity can deviate from the optimum.

<u>Air temperature</u>. Certain recommendations concerning to the indoor air temperature are given only by State Russian Standard 30494-96. This Standard indicates the intervals of optimal and admissiable meanings of air temperature, specifying them for two seasons: heating and cooling. In Standard ASHRAE, there are no strict requirements of design indoor air temperature. In each case, data of indoor air temperature depends on many other parameters and also the decision of the designer. It should be noted that the recommendations for measuring temperature are common to all types of premises with presence of people in them. Therefore, ASHRAE standards don’t give certain parameters of the indoor air temperature for educational buildings. In D2 Regulations and guidelines

says indoor air temperature in the premises according to D2 should be + 21°C during heating season, and below +23°C during cooling season and this recommendation is attached to the nearly all type of premises.

Outdoor air flow. Only two of standards give the recommendations about designed volume flow of outdoor air, the Russian Standard doesn't at all. Standard ASHRAE 62-2001 as well as D2 Regulations and guidelines recommend rate of outdoor air flow for different type of premises. Both standards specify design values of volume flow oriented on two various factors: people and on square of premise.

Relative humidity. D2 Regulations and guidelines indicate design value of relative humidity for all premises don't specifying it for educational building. Optimal level of relative humidity is 45 % according to D2. Russian Standard 30494-96 indicates the optimal and admissiable values of relative humidity, specifying them for two seasons: heating and cooling. Standard ASHRAE doesn't give any recommendations concerning to the design relative humidity.

Sound level. Design sound level appropriate for educational building is specified only by D2 Regulations and guidelines (table 3). Other standard don't give any information about sound level for educational building.

As a result, it can be claimed that the more strictly the parameters of indoor climate are defined, the more accurate and better air conditioning system will be designed (hence, the better climate will be in the building). In different premises where people engage in different activities and therefore produce different amounts of heat, microclimate parameters must be different. So ASHRAE standards and D2 Regulations and guidelines are more useful for the designer. At the same time at different seasons people wear different clothes and parameters of outdoor air are radically different, therefore, it should also be taken into account when the air conditioning systems are designed. From this perspective, Russian Standard is the most convenient.

4 MEASURING METHODS OF THE PARAMETERS OF INDOOR AIR.

4.1 SFS EN 12599.

This chapter is based on the guidelines of Standard SFS EN 12599.Usually the measurements of air temperature should be done in the room, in the duct and exhaust air devices. The measuring point should be in the occupied zones. If the local thermal discomfort is suggested the operative temperature must be determinate. The general equipment determining the value of air temperature is a thermometer. Thermometer should be placed in the needed point but the value of temperature should not be taken immediately. At least 1,5 times of the constant period of device should passed and after the value of temperature can be taken. /10, p.13-14/

If the necessity of humidifying or dehumidifying processes must be determined the measurements of air humidity must be carried out. The values of air humidity should be measured in the same locations as for measurements of air temperature. Only the measuring equipment with recording possibility can be used to carrying out the measurements. The period of recording should be not least then 24 hours. The equipment measuring the air humidity should be protect against the dust and impurities. Hydrometers which is the general equipment measuring value of humidity, should be adjusted, checked and cleaned. /10, p.13-14/.

Air flow rate can be calculated using values of the air velocity and of the area of cross section. Where values of the air velocity can be found using measurements by anemometers or value of pressure drop. Measurements should be done at a convenient cross-section in the duct. Value of air velocity should be measured several times in different points in the cross-section and then the mean value is taken to account. If the needed cross-section in the duct can not available, the cross-section within the air device can be used. /10, p.13-14/.

4.2 State Russian Standard 30494-96.

This chapter is based on the recommendations given by State Russian Standards. Measurement of the microclimate during the cold season should be performed when the outdoor temperature is not higher than minus 5 ° C. It is not allowed to measure at the cloudless sky during the daytime. For the warm period, the measurement of microclimate should be performed at ambient air temperatures above 15 ° C. It is not allowed to measure at the cloudless sky during the daytime. /1, p.6-7/.

Temperature, humidity and air velocity should be measured in the area at a height

- 0,1, 0,4 and 1,7 m above the floor for pre-school institutions
- 0,1, 0,6 and 1,7 m above the floor when people stay indoors mostly in a sitting position
- 0,1, 1,1 and 1,7 m above the floor in areas where people largely stand or walk
- in the center range and at a distance of 0,5 m from the inner surface of exterior walls .

Stationary heating appliances in the premises specified in Table 6.

Table 6. Places for measurements /1, p.6/

Type of building	Search of premise	Point of measurement
Hotel, motel, hospital, school	In one corner in the room on the first floor and last floor	In the center of the planes, which are separated from the inner surface of the outer wall and the radiator to 0,5 m and in the center of the room (at the intersection of diagonal lines of the premises) at altitude given before.
Other public building	In each premise	The same for premises with area of 100 m2 and more.

The temperature of the inner surface of walls, partitions, floors, ceilings should be measured in the center of the respective surface. Relative humidity in the room should be measured in the center of the room at a height of 1,1 m from the floor. For the manual recording of the climate at least three measurements should be performed at intervals of not less than 5 minutes; for automatic recording - the measurement should be for 2 hours. Comparing with normative values, the average value of measured parameters should be taken. Indicators of indoor climate should be measured by devices which is registered and have a certificate. Measuring range and allowable error of measuring instruments must correspond with the requirements of Table 7. /1, p. 6-7/.

Table 7. Requirements for the measuring equipments /1, p.7/

Parameters	Measurement range	Max deviation
Indoor air temperature, °C	from 5 to 40	0,1
Temperature of inner surfaces, °C	» 0 » 50	0,1
Temperature of heater’s surfaces, °C	» 5 » 90	0,1
Resulting room temperature, °C	» 5 » 40	0,1
Relative humidity, %	» 10 » 90	5,0
Air velocity, m/s	from 0,05 to 0,6	0,05

5 AIR HANDLING UNIT

5.1 Demand controlled ventilation system

Demand Controlled Ventilation (DCV) system is a ventilation system with feed-forward and feed-back control of the airflow rate basing on a measured demand indicator. The demand is defined by a number of the thermal comfort parameters and the air quality indicator. The room air temperature and a combination of temperature and humidity are used as thermal comfort parameters. The main indicator of air quality is the combination of contaminations such as gases, particles, etc. Carbon dioxide is the most common indicator of air quality related to human occupancy.

A DCV system supplies the ventilation air flow rate matching with the existing requirements. DCV system delivers an apparent advantage compared to Constant Air Volume flow system. In the cases when DCV system is based on temperature control it allows eliminate additional heating in premises when the cooling capacity of the supply air is more than the cooling capacity needed. This situation is illustrated in Figure 3. Moreover, it is needed less energy for fan operation and for thermal handling of supply air because data of average flow rates is reduced. A DCV system based on air quality control regulate the air volume flow according to the actual pollution load. This load is proportional to the occupancy. The feature of educational buildings is that all the room there can not be occupied at the same time. The quite a few studies show that in educational buildings the average occupancy usually is not more than 30%. And the bigger difference between the minimum and maximum loads, the more energy is saved with a DCV system based on air-quality control.

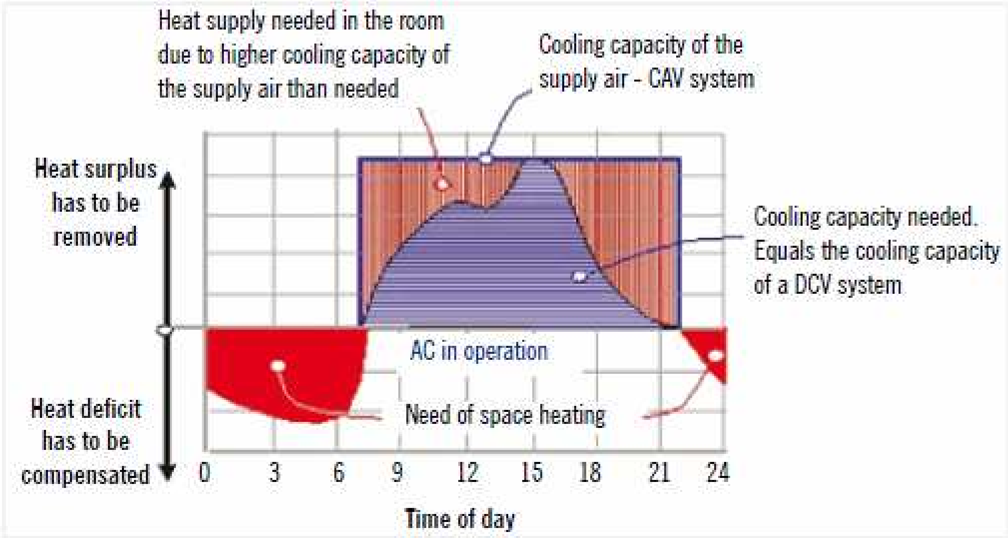

Figure3. Comparison of DCV systems based on temperature control with CAV system /11, p. 26/

Finally the obvious functional advantages can be founded with DCV systems. The performance is ensured by the right design and the comfortable installation, commissioning and maintenance. /11, p. 26-27/.

5.2 Automation principle of AHU and list of electrical instruments

Reliable working of air handling unit and effective monitoring of the system can be realized by automation controlled devices installed in some points of the system. All principles and aspects of automation monitoring of the AHU are shown on the automation scheme (Appendix 2).

All electrical instruments which are installed in diverse points of the system and carry out monitoring and maintaining of the system are specified in Table3. Later in Chapter 6 the main principles of work of these instruments, also their parameters and functions in system operating will be discussed.

Table 3. List of the electrical instruments installed in points of AHU 43

Point, where instrument is installed	Manufacture	Model of instrument	Notes
Supply line			
FG01	T.A.C.	M-AF 24	Open/close damper actuation
PDIE01	T.A.C.	SPD310/SPD360	Differential pressure measuring
TI	WIKA	-	Temperature measuring
PDE 75	T.A.C.	SPD310/SPD360	Differential pressure measuring
PDIE02	T.A.C.	SPD310/SPD360	Differential pressure measuring
TI	WIKA	-	Temperature measuring
TE02	T.A.C.	STD190	Temperature measuring
TV45	T.A.C.	M400	3-port valve control
FE10	T.A.C.	SPD310/SPD360	Differential pressure measuring
TE10	T.A.C.	STD100	Temperature measuring
PE10	T.A.C.	SPD310/SPD360	Differential pressure measuring
PE11	T.A.C.	SPD310/SPD360	Differential pressure measuring
SC01	Schneider electric	Altivar 61	Fan speed control
Return line			
FG02	T.A.C.	M-AF 24	Open/close damper actuation
fan	KOJA		
FE30	T.A.C.	SPD310/SPD360	Differential pressure measuring
TE	T.A.C.	STD100	Temperature measuring
TI	WIKA	-	Temperature measuring
PDIE 30	T.A.C.	SPD310/SPD360	Differential pressure measuring
TE30	T.A.C.	STD100	Temperature measuring
TI	WIKA	-	Temperature measuring
PE31	T.A.C.	SPD310/SPD360	Differential pressure measuring
PE30	T.A.C.	SPD310/SPD360	Differential pressure measuring
SC02	Schneider electric		

6 HVAC SENSORS

Sensors and transmitters are the units of the HVAC system of building. They are designed for measuring, alarming, adjusting, handling processes and devices. It we are talking about practical principles the target of transmitters and sensors are almost the same. But transmitter's data can be read by people, and sensor's data generally can be read automatically. Sensors convert the monitoring value (pressure, temperature, flow, concentration, frequency, etc.) in electrical signal, convenient for measuring, transmitting, converting, storage and registration of information about conditions of the object.

Sensors are connected with measuring equipment and the measuring devices, such as thermometers, flow meters, barometers, etc. A term sensor appreciated in connection with the development of automatic control systems, as part of a logical chain "sensor - control unit - the unit of executive - the object of control". In special cases sensors are used in automated systems of registration options, such as in systems research. /12, p. 135/ .

6.1 Differential pressure transmitter air SPD310/SPD360

Differential pressure transmitter air is used for monitoring of air ducts and of operation of filters, fans and other equipment of air conditioning and ventilation system. SPD transmitter (is shown in Figure 4) is produced by T.A.C. company, which is the leading provider of building automation solution. Transmitters are equipped with 2-meter tube and plastic duct connectors. Data (the differential pressure in Pa; mbar; InH20) of transmitter can be read on display. All information about technical parameters of transmitters SPD 310/SPD360 can be read in booklet T.A.C. /13, p. 1-2/

Figure 4. SPD 310/360 /13/

According to the technical drawings SPD310/360 transmitters are mounted on the supply line (filter after damper, heat exchanger, filter after exchanger, fan, in the points of air duct near exit from AHU) and on the return line (in the points of air duct near entrance in AHU, filter before heat exchanger and fan).

Differential pressure transmitters measure difference between sides of lower and upper pressures. These transmitters convert a measured pressure difference into continuous analog output signal unified current, voltage or inductor. The most sensitive element of transmitter is elastically deformable membrane with fixed measuring strain gauges. There are also the protect membranes into the transmitter on the both sides of membrane. The deformable membrane is isolated from the working medium. The pressure of working medium applies to the protect membranes and deforms it. Under the influence of applied forces the protect membranes are deformed and deforms the measuring membrane and the strain gauges deform followed by it.

Because the transmitter measures the pressure data from the both side so its framework has two connecting nipples: positive and negative. The nipples are situated paralel to each other on the same side of the transmitter. If the medium pressure applied to the positive nipple is bigger than pressure applied to the negative nipple the transmitter will show data of pressure difference with minus. If the pressure applied to the positive nipple is bigger then pressure applied to the newgative one – data will be with plus. The model of operating principle of the measuring membrane is shown in the figure 5 /14/.

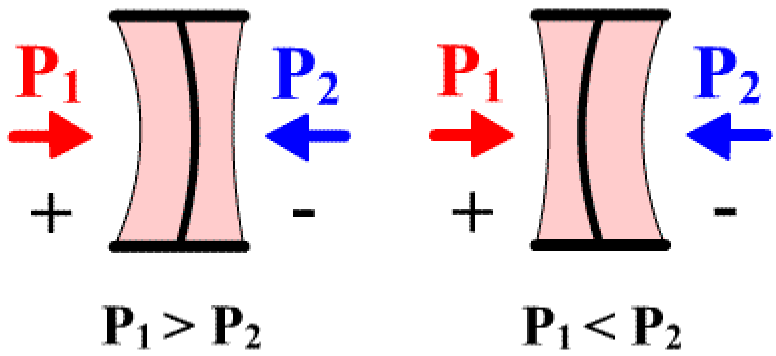

Figure 5. The model of operating principle of the measuring membrane /14/

Differential pressure difference transmitter can measure comparatively not big range of pressure of working medium. The upper limits of measuring data are situated from several tens millimeters of water column (m H2O) to several hundreds kPa.

6.2 Duct temperature sensor STD100

All information about technical parameters of transmitters STD100 can be read in booklet T.A.C. /15, p. 1-2/ According to the technical drawings STD100 sensors are mounted on the supply line (after filter mounted after exchanger, after fan) and on the return line (before filter mounted before heat exchanger and before fan).

Figure 6. Duct temperature sensor STD100 /15, p.1/

The temperature sensor is designed to maintain the temperature in the air duct or in the premise. Distinguish channel sensors and room. Duct sensors are installed in the duct through the hole. Flexible plastic bush allows to mounting sensors on both rectangular and round ducts on. Depth of sensor installation is usually from 40 to 130 mm.

The framework of duct sensors is usually made of durable stainless steel tube. As the sensitive element temperature sensor uses a standard resistance thermometer, which provides reliable and accurate measurement.

If to maintain the proper temperature the thermostat is used, the duct temperature sensor should be located at least 1.5 meters from heating installation. This will not have an impact on the heated infrared heaters on the sensor. Besides, at this distance, the air after the heating installation already has mixed, and its temperature is no more than a hundred-uniform. Sensor should be mounted as close as possible to the center of the duct.
/16/

6.3 WIKA temperature measuring instruments

Special measuring devices are installed in several points of air handling unit to monitor the temperature. These devices are manufactured by WIKA group. WIKA provides maintaining and producing of pressure and temperature measuring instruments to meet indoor climate standards.

Temperature measuring instruments are divided into three main groups: Electrical temperature measuring instruments; Mechanical temperature measuring instruments; Thermowells.

Electrical temperature measuring instruments includes thermocouples, resistance thermometers, analogue and digital temperature transmitters, digital indicators, controllers and calibrators for temperature ranges from -200 °C to +1,800 °C. An electrical thermometer consists of 3 components: the thermowell, the connection head and the measuring insert. The target of thermowell is to mount thermometers to the process and to protect the sensor from harmful conditions. The thermowell is mounted into ducts using a hygienic connection. Swivel-fitting to the connection head allows rotate components to the desired direction. The resistance thermometer can be pulled out together with the connection head. It makes possible to calibrate the entire measuring chain directly at the measuring point without disconnect the electrical connections. It minimises the risk of contamination because the process does not need to be opened.

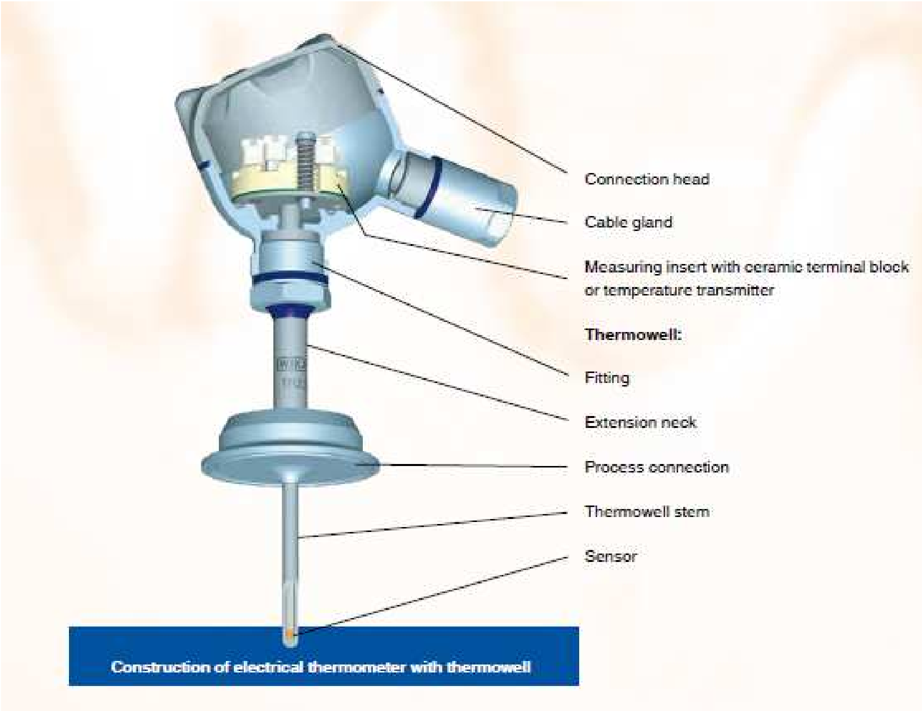

Figure 7. Construction of electrical thermometer with thermowell /17, p/18/.

The two types if resistance thermometers are used in TK 43 air handling unit: TR21 and TR2x .The main characteristics of TR21 series are compact design and fast electric connection. In the other side the advantages of TR2x series is using the proven temperature transmitters, so all usual output signals are available. Thus this reduced hygienic risk because in this case instruments can be maintenance and calibrated (or with other words – sensors are removable) without opening the system or disconnect the electrical connection.

a) b)

Figure 8. Model of WIKA temperature measuring instruments: a)TR21-B; b)TR22-A /17, p/21/.

Working range of mechanical temperature measuring instruments is from -200 °C to +700 °C. WIKA resistance thermometers have a high quality and measuring accuracy. Resistance thermometers are equipped with sensor elements which change their electrical resistance dependent on temperature.

Thermometers are employed with a variety of thermowells, it allows use thermometers even under extreme process conditions. In pipelines, the housing is orbitally welded between two pipe-ends. They also offer the possibility of a additional measuring point to integrate a pressure sensor.

WIKA group temperature transmitters are used the 4-20 mA analogue signal. Their main aim is to convert the temperature-dependent change in resistance and the same change in voltage into the load-independent current signal. This method provides a direct and reliable transmission of the temperature values measured.

The transmitters in the T19 series are provided with various ranges. These transmitters are especially suitable for applications where diversity of requirements have to be taken into account.

The temperature transmitters can be mounted either in the measuring point or in the switch cabinet. The case is designed as a head-mounted transmitter for installation into the temperature probe and can be mounted into any DIN connection head without any problem. Temperature transmitter Model T19 is shown in the Figure 9. /17, p. 18-22/.

Figure 9. Model T19 of WIKA temperature transmitter /17, p22/.

6.4 ALTIVAR 61

Altivar 61 produced by Schneider electric is used for diverse speed drives on centrifugal pump and fans. All information about technical parameters of Altivar 61 (showed in the Figure 10) can be read in booklet T.A.C. /18, p. 5/. According to the technical drawings Altivar 61 is installed on the fans on supply and return lines. Altivar 61 enables to reduce energy costs by adjusting the motor speed; reduce life cycle costs of the installation by eliminating mechanical shock to motor; improve indoor air quality by regulating flow rate. Directly for the fan operating Altivar 61 allows to adjust flow rate on the needed rate; detect broke fan belt; automatic restart after trouble; reduce noise pollution.

Figure 10. Altivar 61 /18, p5/.

Altivar 61 is easy to control and monitoring. It has the following advantages: graphic screen with adjusted screen; support six languages; navigation wheel for easy enjoyment of menu; “Simply start” menu for quick start and immediate benefit.

It’s known that HVAC systems are applied to keep proper indoor air parameters during hot or cold weather periods. With another HVAC system should be operated at full capacity only during 10-20 days annually. In the other days HVAC system can work at a reduced capacity. Therefore variable frequency drives are used to heating and cooling demands. They can reduce the motor speed when full capacity of HVAC system is not required. The biggest advantageous possibility for change of flow rate is the operation fan with variable speed. Speed control is a pretty low cost method in comparison with another variant. Because of the achieved energy cost saving for the short period – payback period for using Altivar 61 for adjustable fan by frequency controlled drive.
/18, p. 1-9/

6.5 Globe valve actuator M400

Actuator M400 is produced by T.A.C. company and used to control 2-port and 3-port valves which operated in air handling systems, domestic hot water systems and heating systems. All information about technical parameters of actuators M400 (showed in the Figure 11) can be read in booklet T.A.C. /19, p. 25/. According to the technical drawings actuator M400 is installed on the 3-port valve serviced working of heating stage of AHU.

Figure 11. Globe valve actuator M400 /19, p25/.

Connecting and mounting process of this actuator are enough easy. It can be installed straight on the 3-port valve without any equipage. Actuator M400 can be monitored by a lifting/lowering signal or by modulated control signal. The stroke of the actuator can be adjusted automatically according to the stroke of the valve.
/19, p. 25/

6.6 Spring return actuator for open/close damper actuation TAC M-AF 24

All information about technical parameters of actuators TAC M-AF24 can be read in booklet T.A.C. /20, p. 1-2/. According to the technical drawings TAC M-AF24 actuators are mounted on the supply line (entrance damper) and on the return line (exit damper).

Actuators with spring return mechanism TAC M-AF 24 are used to controlling of air dampers with 3 square meters area, providing the frost, fire and smoke protect functions. The spring return mechanism provides the pre-protection (return to the original state) if the electrician switches off. The degree of damper opening can be defined preliminary. The duration can be provided in any directions. The actuators can be operated automatically and manually.

Figure 12. Spring return actuator for open/close damper actuation M-AF 24 /20, p1/

The operational principle of actuator is the following: when the electrical power switches on the operated damper starts the opening in 90 °C. When the stop mechanism depending from the torque switches on the damper stops. In these occasions the transmission became blocked. By accident and power switch-off the transmission became unblocked damper closes. /20, p. 1-2/.

7 LABORATORY TEST ILLUSTRATING WORKING PROCESS OF AHU 43

For investigating the working process of AHU 43 the following laboratory tests was done. The most informative data characterizing the changing of condition of worked air (and as a consequence the efficiency or AHU working) is an air temperature. Also such indicators as a relative humidity, air mass flow, pressure etc. are well descriptive data about worked air condition. Whole laboratory test consists of two separate stages. First stage was done by diverse electrical instruments discussed in previous chapter and the second one was done using automation program of Schneider electric company.

In this chapter obtained information about air temperatures will be shown. Information includes five values of air temperature gotten in five different point of AHU 43 related to the various stage of handling. All points of temperature getting are schematically shown in Figure 13.

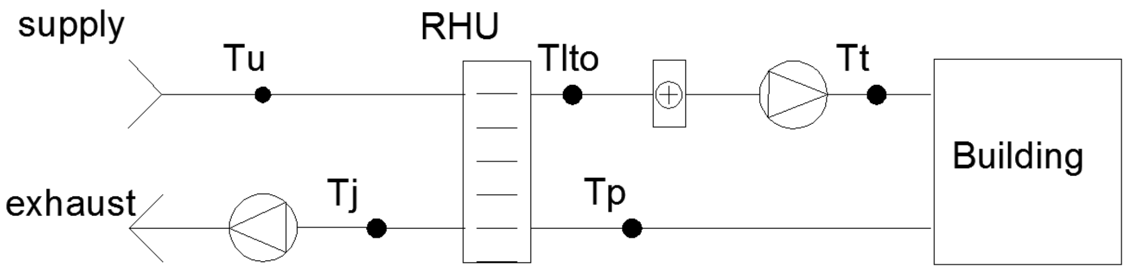

Figure 13. Working scheme of AHU TK 43

The first stage. As it was said earlier measurement s in the first stage were done by variety electrical instruments. All information about working principals and operational ways of these instruments can be found in previous chapter. In this case stage of test had to be done according to the Standard SFS 5511 using Long-Linear Method (Method of six points). But the disadvantage of AHU 43 is an absence of special holes for entrance of pitot-pipe. So the temperatures can be gotten only using temperature measurement devices installed on the equipment and air ducts. Obtained temperatures data is submitted in Table 4. As it can be claimed according to this table, air comes from outdoor with + 11,1 °C degrees temperature, then in heat exchanger it was heated by recirculating air up to 16,9 °C degrees. After this in heater supply air was heated due the fan up to 17,4 °C temperature and in this condition it flow to the education premises.

Table 4. Air temperatures from various point of AHU 43 (1-st stage)

	t (°C)
T u	11.9
T lto	16.9
T t	17.4
T p	21.5
T j	14.4

<u>The second stage</u>. The following stage of test was done by automation program of Schnieder Electric company. Values of all needed parameters of working media are indicated of computer monitor. Especially concerned to the AHU 43 it was presented as a Application 3. System meters such parameters as air temperature, pressure, volume flow, energy consumption and efficiency of equipment in the points of AHU 43 where the special probes are installed. Temperatures data obtained in November 2011 is submitted in Application 4. AHU is not operated during night time (from 20:00 to 7:00), so all the values are not presented. Sometimes the temperature of supply air after the heat exchanger exceed the temperature of extract air before the heat exchanger. This is impossible because air can't give heat more than it has. In those cases thermal efficiency of heat exchanger can't be calculated and in table of Application 4 "incorrect" efficiency is given instead of the value. In the Table 5 the particular temperature data is presented when the first stage of test (measuring by temperature devices) was done.

Table 5. Air temperatures from various point of AHU 43 (2-nd stage)

	t (°C)
T u	10.7
T lto	17.8
T p	21.6
T j	16.4

According to the temperature data it can be said that measured meanings of air temperatures by electrical instruments have deviation from meaning gotten by automation program. From tables it’s seen that the biggest deviations concern the temperature after the HRU in supply line and in exhaust line, such as in the point of incoming air from outdoor. It can talk that probes are installed in incorrect places. Also it can be claimed that statements of probes of automation program overestimate measuring temperatures so they have to be adjusted.

8 TEMPERATURE EFFICIENCY OF HEAT RECOVERY UNIT

In this eightieth chapter the determination of temperature efficiency of heat recovery unit composed of air handling unit AHU 43 will be discussed. According to Finnish National Building Code D2: “Temperature efficiency: the ratio between the temperature change that takes place in the supply air at the heat exchanger of the heat recovery equipment and the difference between the temperatures of the extract air and the outdoor air at the heat exchanger” /8/.

The temperature efficiency of a heat recovery unit can be expressed as

$$\eta_t = \frac{t_2 - t_1}{t_3 - t_1} \cdot 100\% \qquad (2)$$

Where t_1 (= t u) is a temperature of exhaust air **before** the heat exchanger (°C), t_2 (= t lto) is a temperature of supply to room air **after** the heat exchanger (°C), t_3 (= t p) is a temperature of exhaust air **before** the heat exchanger (°C).

Temperature efficiency using temperature meaning taken in 1-st stage:

t_1 = t u = 11.9 °C;

t_2 = t lto = 16.9 °C;

t_3 = t p = 21.5 °C.

$$\eta_t = \frac{16,9 - 11,9}{21,5 - 11,9} \cdot 100\% = {}^{5,0}\!/_{9,6} = 52\%$$

Temperature efficiency using temperature meaning taken in 2-nd stage:

t_1 = t u = 10.7 °C;

t_2 = t lto = 17.8 °C;

$t_3 = t\ p = 21.6$ °C.

$$\eta_t = \frac{17{,}8 - 10{,}7}{21{,}6 - 10{,}7} \cdot 100\% = 7{,}1 / 10{,}9 = 65\%$$

Temperature efficiency should be bigger 50%, which recommended in D2 regulations. In the same time the manufactures (e.g. Daikin, Systemair) give values of rotary HE efficiency about 65-75%. According to the previous calculations it was gotten that temperature efficiency of heat recovery in AHU 43 corresponds to these recommendations. So heat recovery unit allow provide all need effective working – all possible heat from exhaust air transmits to supply air.

Defined results show the big error between value of temperature efficiency obtained with data from 1-st test stage and value of temperature efficiency obtained with results from 2-nd stage. It allows consider the impropriety of measuring devices installation.

9 CONCLUSION

The target of this thesis was to familiar with the principles of monitoring and control of ventilation system AHU TK 43. Establishment of proper ventilation, ensuring a healthy and a good climate in educational facilities is a very important and responsible task. Modern ventilation systems must be easy to regulate and adjust, depending on the initial parameters of air and air parameters needed to be in maintained premises. This particularly applies to educational buildings, where all rooms are almost never occupied at the same time and the peak level of occupancy occurs most unlikely simultaneously. For convenience of controlling of air handling unit the special sensors and power probes are mounted on AHU TK 43. With these devices man can local and remotely monitor and regulate the parameters of the working air to make adjustments to the ventilation system. In addition, a variety of automation programs can also be used in monitoring of performance of AHU by a computer (such as Schneider Electric program in our test).

Accuracy of worked air characteristics reading depends on the proper operation and correct installating location of the sensors or probes. Consequently, the correct configuration of the ventilation system, and hence the final parameters of air supplied to the premises served depends on it. This problem was described in this thesis by carrying out two tests. Their results showed incorrect installation of some sensors.

The correct installation of measuring sensors obtaining parameters of the thermal state of the working air is very important for operation of the AHU. Using the information about working air conditions it's possible to estimate the correctness of the condition system working. Incorrect information may lead to not properly configure devices of conditioning system. Finally this can result in the supply air with the parameters which are not acceptable to the comfort occupancy in the premises, or even to the harmful effects on humans or the building constructions. It is therefore necessary from time to time to carry out studies similar to those that were made in the performance of this thesis. Comparing the data of the air conditions, obtained by different methods, it is possible to evaluate the performance of sensors and identify sources of incorrect information.

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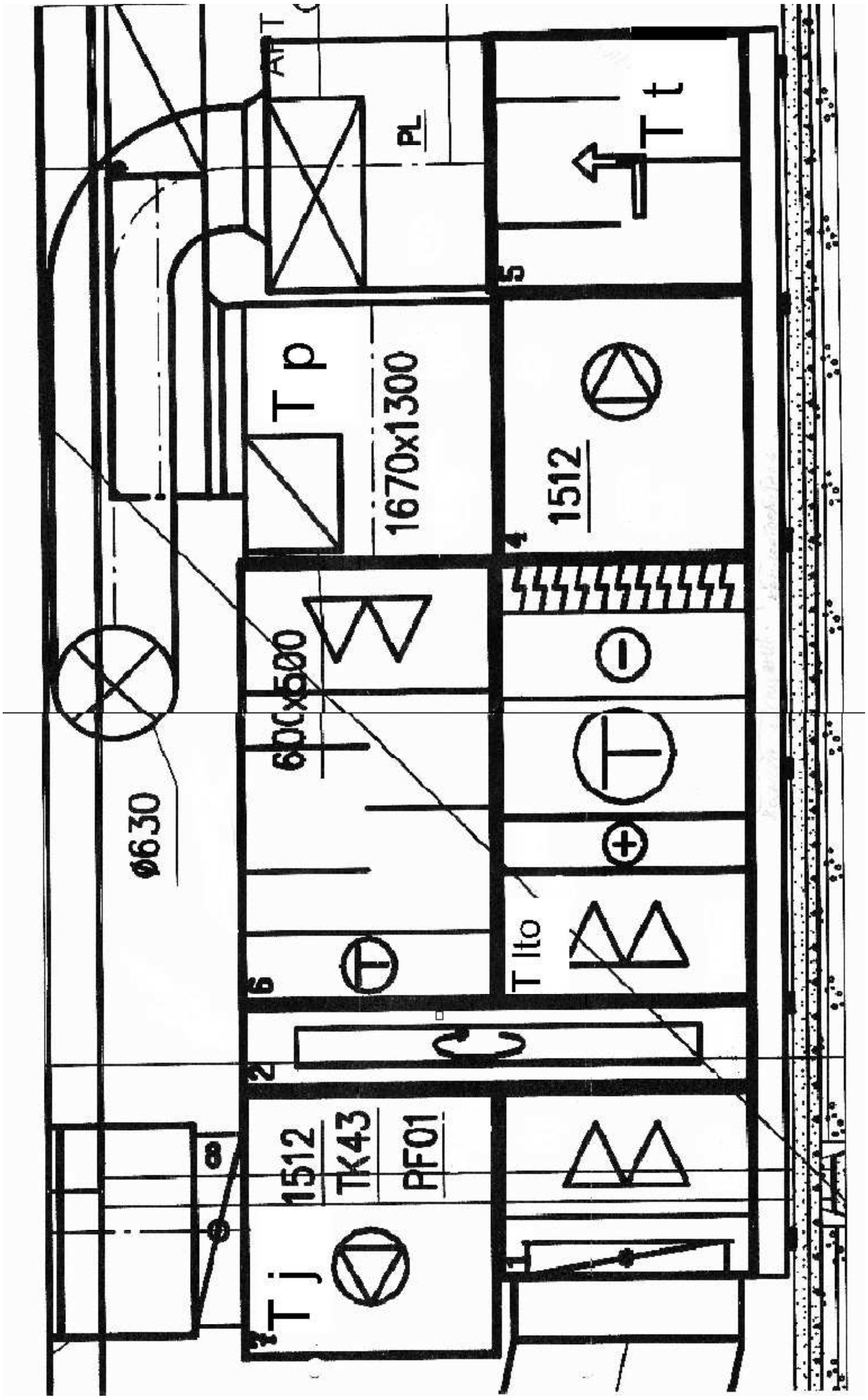
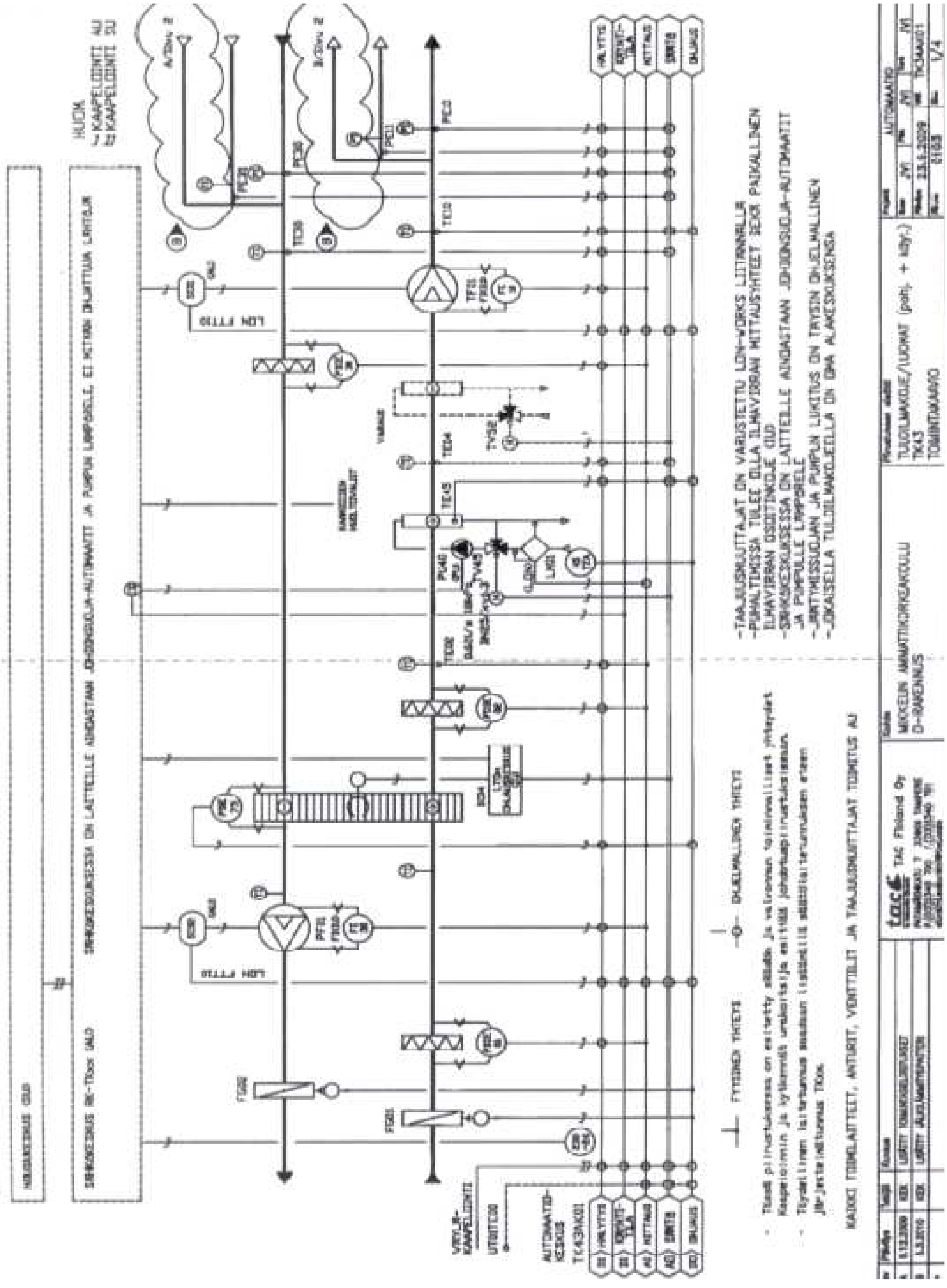
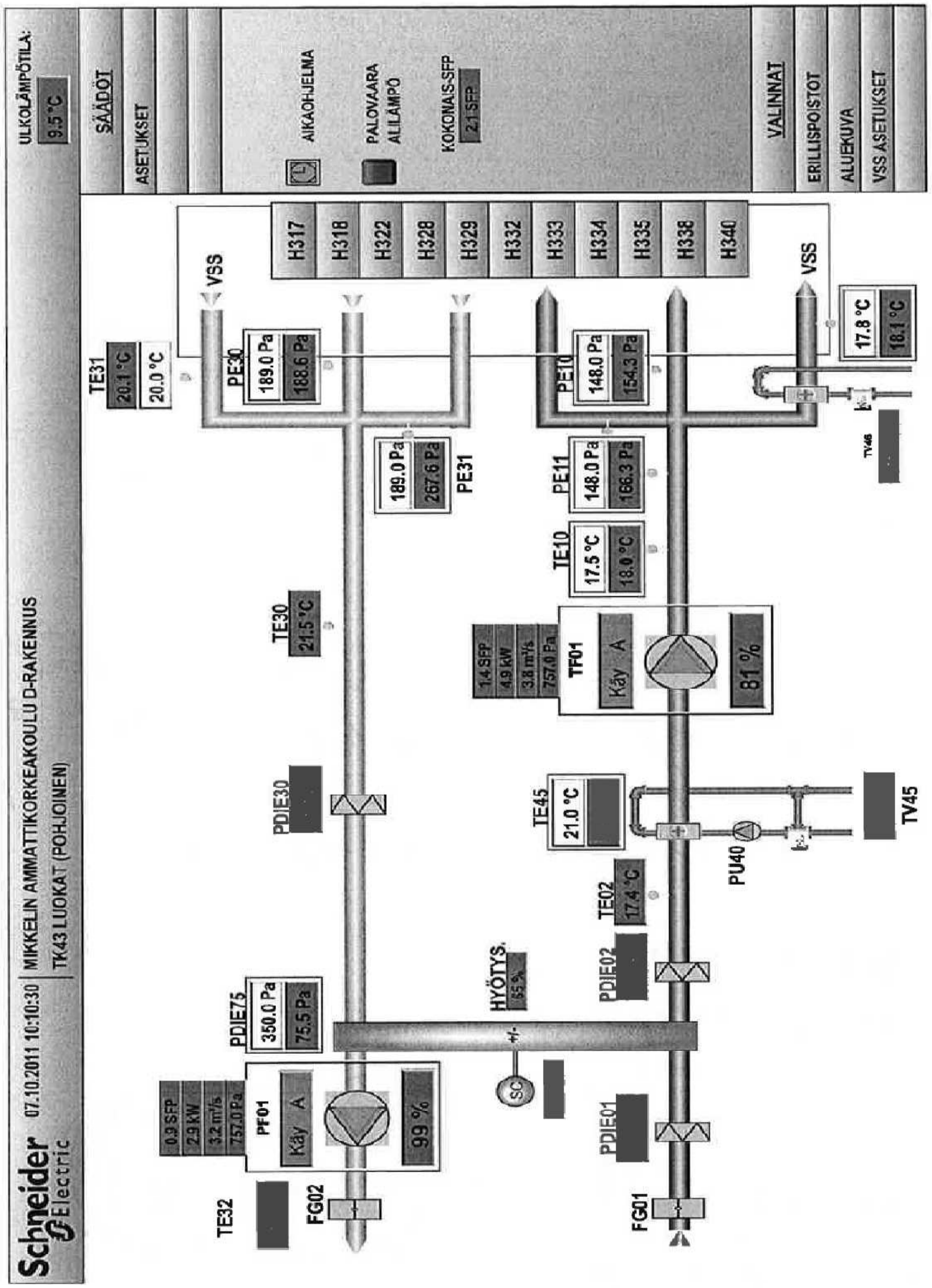


Appendix 1. Technical scheme of AHU TK43



Appendix 2. Automation scheme of AHU TK4



Appendix 3. Automation system Schneider electric Schema with data of working parameters of AHU TK 43

date	time	tu (TE00)	t lto (TE02)	tp (TE30)	tj (TE32)	qv,t (FE10)	qv,p (FE30)	$\eta_{t\,aut}$
		°C	°C	°C	°C	m³/s	m³/s	
01.11.2011	02:01:00	-	-	-	-	-	-	-
01.11.2011	03:01:00	-	-	-	-	-	-	-
01.11.2011	04:01:00	-	-	-	-	-	-	-
01.11.2011	05:01:00	-	-	-	-	-	-	-
01.11.2011	06:01:00	-	-	-	-	-	-	-
01.11.2011	07:01:00	6,77	16,57	21,35	11,32	3,35	2,74	67,22
01.11.2011	08:01:00	6,78	15,99	21,14	10,61	3,65	3	64,14
01.11.2011	09:01:00	6,51	16,05	21,5	10,42	3,65	2,98	63,64
01.11.2011	10:01:00	6,41	16,15	21,79	10,48	3,7	3,04	63,33
01.11.2011	11:01:00	6,64	16,27	21,76	10,79	3,75	3,1	63,69
01.11.2011	12:01:00	6,73	16,38	21,66	11,12	3,74	3,12	64,63
01.11.2011	13:01:00	7,51	16,79	22,03	11,68	3,76	3,17	63,91
01.11.2011	14:01:00	7,92	16,92	21,89	12,06	3,75	3,17	64,42
01.11.2011	15:01:00	7,92	16,93	21,84	12,16	3,76	3,15	64,73
01.11.2011	16:01:00	7,71	16,61	21,62	11,67	3,74	3,15	63,98
01.11.2011	17:01:00	6,81	16,28	21,53	11,03	3,76	3,16	64,33
01.11.2011	18:01:00	6,81	16,3	21,42	11,09	3,71	3,11	64,96
01.11.2011	19:01:00	7,16	16,33	21,15	11,41	3,67	3,06	65,55
01.11.2011	20:01:00	-	-	-	-	-	-	-
01.11.2011	21:01:00	-	-	-	-	-	-	-
01.11.2011	22:01:00	-	-	-	-	-	-	-
01.11.2011	23:01:00	-	-	-	-	-	-	-
02.11.2011	00:01:00	-	-	-	-	-	-	-
02.11.2011	01:01:00	-	-	-	-	-	-	-
02.11.2011	02:01:00	-	-	-	-	-	-	-
02.11.2011	03:01:00	-	-	-	-	-	-	-
02.11.2011	04:01:00	-	-	-	-	-	-	-
02.11.2011	05:01:00	-	-	-	-	-	-	-
02.11.2011	06:01:00	-	-	-	-	-	-	-
02.11.2011	07:01:00	9,86	17,98	21,49	14,51	3,3	2,75	69,82
02.11.2011	08:01:00	9,86	17,73	21,26	14,48	3,68	3,05	69,04
02.11.2011	09:01:00	10,63	17,88	21,56	15,76	3,69	3,06	66,33
02.11.2011	10:01:00	10,7	17,78	21,56	16,43	3,69	3,05	65,19
02.11.2011	11:01:00	10,7	17,82	21,68	16,6	3,77	3,14	64,85
02.11.2011	12:01:01	10,7	17,78	21,51	16,6	3,73	3,17	65,49
02.11.2011	13:01:00	10,7	17,82	21,67	16,6	3,74	3,16	64,90
02.11.2011	14:01:00	10,7	17,8	21,72	16,62	3,74	3,17	64,43
02.11.2011	15:01:00	10,7	17,7	21,72	16,6	3,72	3,17	63,52
02.11.2011	16:01:00	10,34	17,37	21,37	15,55	3,72	3,1	63,74
02.11.2011	17:01:00	10,14	17,37	21,34	15	3,69	3,04	64,55
02.11.2011	18:01:00	9,98	17,38	21,26	14,86	3,68	3,05	65,60
02.11.2011	19:01:00	9,98	17,38	21,16	14,74	3,68	3,05	66,19

02.11.2011	20:01:00	-	-	-	-	-	-	-
02.11.2011	21:01:00	-	-	-	-	-	-	-
02.11.2011	22:01:00	-	-	-	-	-	-	-
02.11.2011	23:01:00	-	-	-	-	-	-	-
03.11.2011	00:01:00	-	-	-	-	-	-	-
03.11.2011	01:01:00	-	-	-	-	-	-	-
03.11.2011	02:01:00	-	-	-	-	-	-	-
03.11.2011	03:01:00	-	-	-	-	-	-	-
03.11.2011	04:01:00	-	-	-	-	-	-	-
03.11.2011	05:01:00	-	-	-	-	-	-	-
03.11.2011	06:01:00	-	-	-	-	-	-	-
03.11.2011	07:01:00	6,51	16,81	21,44	11,9	3,38	2,81	68,99
03.11.2011	08:01:01	6,42	16,16	21,2	10,99	3,68	3,05	65,90
03.11.2011	09:01:00	6,41	16,36	21,61	11,02	3,67	3,06	65,46
03.11.2011	10:01:00	6,41	16,54	21,84	11,17	3,67	3,05	65,65
03.11.2011	11:01:00	6,98	16,66	21,91	11,42	3,66	3,06	64,84
03.11.2011	12:01:00	7,25	16,64	21,7	11,58	3,66	3,06	64,98
03.11.2011	13:01:00	7,64	17,11	22,06	12,29	3,68	3,09	65,67
03.11.2011	14:01:00	7,94	17,49	22,07	13,89	3,74	3,15	67,59
03.11.2011	15:01:00	7,97	17,36	22,02	14,13	3,72	3,07	66,83
03.11.2011	16:01:00	7,23	16,96	21,53	13,01	3,65	3,05	68,04
03.11.2011	17:01:00	5,68	16,31	21,35	11,27	3,7	3,11	67,84
03.11.2011	18:01:00	4,44	15,68	21,17	10,04	3,73	3,14	67,18
03.11.2011	19:01:00	3,65	15,21	21,07	9,03	3,76	3,12	66,36
04.11.2011	07:01:00	3,22	15,84	21,55	9,61	3,4	2,83	68,85
04.11.2011	08:01:00	3,22	15,19	21,29	8,79	3,73	3,08	66,24
04.11.2011	09:01:00	3,29	15,27	21,46	8,79	3,73	3,08	65,93
04.11.2011	10:01:00	4,26	15,47	21,59	9,09	3,7	3,08	64,69
04.11.2011	11:01:00	4,59	15,57	21,62	9,32	3,7	3,06	64,47
04.11.2011	12:01:02	5,21	15,79	21,58	9,75	3,72	3,09	64,63
04.11.2011	13:01:00	5,74	15,88	21,61	9,98	3,71	3,09	63,89
04.11.2011	14:01:00	5,92	15,89	21,46	10,18	3,7	3,09	64,16
04.11.2011	15:01:00	5,92	15,95	21,44	10,31	3,7	3,1	64,63
04.11.2011	16:01:00	5,92	15,93	21,39	10,27	3,7	3,09	64,71
04.11.2011	17:01:00	5,92	15,84	21,24	10,27	3,72	3,07	64,75
04.11.2011	18:01:00	5,92	15,69	21,06	10,11	3,7	3,03	64,53
04.11.2011	19:01:00	5,7	15,57	20,97	9,9	3,67	3,06	64,64
05.11.2011	07:01:00	5,43	20,5	21,9	17,92	0,44	0,69	91,50
05.11.2011	08:01:00	5,43	16,35	21,49	10,96	3,34	2,77	68,00
05.11.2011	09:01:00	5,43	15,63	21,06	10,07	3,69	3	65,26
05.11.2011	10:01:00	5,45	15,67	21	10,18	3,72	3,02	65,72
05.11.2011	11:01:00	5,84	15,82	20,98	10,54	3,7	3,02	65,92
05.11.2011	12:01:00	6,42	15,85	20,88	10,7	3,71	3,02	65,21
05.11.2011	13:01:00	6,41	15,77	20,85	10,57	3,7	3	64,82
05.11.2011	14:01:00	6,42	15,68	20,81	10,48	3,69	3	64,35
05.11.2011	15:01:00	6,41	15,64	20,78	10,34	3,69	3,01	64,23
05.11.2011	16:01:00	6,08	15,55	20,76	10,12	3,7	2,99	64,51

05.11.2011	17:01:00	5,91	15,39	20,74	9,86	3,71	3	63,92
05.11.2011	18:01:00	5,25	15,28	20,75	9,61	3,72	3,01	64,71
05.11.2011	19:01:00	5,2	21,48	20,83	14,82	0,71	0,9	incorrect
06.11.2011	07:01:01	3,61	22,61	22,06	18,76	0,47	0,65	incorrect
06.11.2011	08:01:00	3,61	15,85	21,42	9,64	3,4	2,76	68,73
06.11.2011	09:01:00	3,61	14,95	21,02	8,55	3,72	3	65,13
06.11.2011	10:01:00	3,61	14,9	20,95	8,55	3,72	3	65,11
06.11.2011	11:01:00	3,61	14,93	20,94	8,63	3,73	2,99	65,32
06.11.2011	12:01:00	3,61	14,95	20,91	8,67	3,7	3,01	65,55
06.11.2011	13:01:00	3,72	15,07	20,92	8,92	3,73	3	65,99
06.11.2011	14:01:00	4,15	15,34	20,97	9,46	3,72	3,02	66,53
06.11.2011	15:01:00	5,04	15,69	21,02	10,24	3,72	3,01	66,65
06.11.2011	16:01:00	5,2	15,77	20,94	10,45	3,71	3,02	67,15
06.11.2011	17:01:00	5,2	15,78	20,91	10,49	3,72	3,02	67,35
06.11.2011	18:01:00	5,3	15,79	20,93	10,53	3,7	3,01	67,11
06.11.2011	19:01:00	5,59	20,94	20,95	15,29	0,63	0,87	99,93
07.11.2011	07:01:00	5,92	16,29	21,38	10,93	3,39	2,82	67,08
07.11.2011	08:01:00	5,92	15,66	21,05	10,09	3,74	3,08	64,38
07.11.2011	09:01:00	5,92	15,76	21,23	10,16	3,72	3,09	64,27
07.11.2011	10:01:00	5,92	15,98	21,43	10,39	3,74	3,14	64,86
07.11.2011	11:01:00	5,92	16,16	21,58	10,57	3,71	3,17	65,39
07.11.2011	12:01:00	5,92	16,2	21,6	10,74	3,72	3,16	65,56
07.11.2011	13:01:00	6,31	16,43	21,87	11,03	3,76	3,14	65,04
07.11.2011	14:01:00	6,44	16,45	21,75	11,23	3,73	3,15	65,38
07.11.2011	15:01:00	6,78	16,54	21,85	11,33	3,74	3,13	64,76
07.11.2011	16:01:00	6,74	16,66	21,84	11,52	3,73	3,16	65,70
07.11.2011	17:01:00	6,73	16,48	21,6	11,46	3,75	3,13	65,57
07.11.2011	18:01:00	6,73	16,31	21,28	11,41	3,73	3,1	65,84
07.11.2011	19:01:00	6,73	16,31	21,18	11,45	3,72	3,08	66,30
08.11.2011	07:01:00	6,32	16,78	21,44	11,91	3,38	2,76	69,18
08.11.2011	08:01:00	6,31	16,39	21,25	11,5	3,7	3,07	67,47
08.11.2011	09:01:00	6,65	16,59	21,49	11,69	3,69	3,08	66,98
08.11.2011	10:01:00	7,1	16,81	21,79	11,93	3,71	3,07	66,10
08.11.2011	11:01:00	7,67	16,9	21,85	12,12	3,72	3,06	65,09
08.11.2011	12:01:00	7,82	17	21,74	12,36	3,69	3,12	65,95
08.11.2011	13:01:00	8,14	17,32	22	12,97	3,7	3,16	66,23
08.11.2011	14:01:00	8,34	17,43	21,91	13,83	3,73	3,17	66,99
08.11.2011	15:01:00	8,29	17,35	21,77	13,76	3,71	3,16	67,21
08.11.2011	16:01:00	7,66	17,01	21,55	13,18	3,72	3,15	67,31
08.11.2011	17:01:00	6,65	16,31	21,3	11,39	3,72	3,1	65,94
08.11.2011	18:01:00	5,41	15,87	21,2	10,42	3,71	3,08	66,24
08.11.2011	19:01:00	4,84	15,6	21,2	9,79	3,71	3,06	65,77
09.11.2011	07:01:00	-0,21	14,72	21,62	7,38	3,34	2,77	68,39
09.11.2011	08:01:00	-0,72	13,85	21,32	6,14	3,74	3,01	66,11
09.11.2011	09:01:01	-0,75	14,05	21,57	6,28	3,71	3,03	66,31
09.11.2011	10:01:00	-0,57	14,48	21,7	6,84	3,67	3,06	67,58
09.11.2011	11:01:00	0,47	14,83	21,74	7,55	3,66	3,07	67,51

APPENDIX 4

09.11.2011	12:01:00	0,47	15,13	21,72	8,15	3,69	3,06	68,99
09.11.2011	13:01:00	1,18	15,36	21,83	8,48	3,68	3,06	68,67
09.11.2011	14:01:00	2,11	15,43	21,87	8,69	3,65	3,07	67,41
09.11.2011	15:01:00	2,08	15,44	21,86	8,68	3,68	3,07	67,54
09.11.2011	16:01:00	1,82	15,17	21,68	8,25	3,69	3,08	67,22
09.11.2011	17:01:00	1,82	14,65	21,54	7,3	3,68	3,06	65,06
09.11.2011	18:01:00	-0,98	14,11	21,54	6,34	3,7	3,06	67,01
09.11.2011	19:01:00	-1,89	13,84	21,53	5,77	3,71	3,05	67,16
10.11.2011	07:01:00	-3,52	13,98	21,91	5,24	3,38	2,81	68,82
10.11.2011	08:01:00	-3,52	13,11	21,5	4,15	3,69	3,08	66,47
10.11.2011	09:01:00	-3,19	13,31	21,77	4,25	3,72	3,07	66,11
10.11.2011	10:01:00	-2,85	13,34	22,02	4,33	3,73	3,03	65,10
10.11.2011	11:01:00	-2,2	13,48	22,11	4,76	3,77	3,01	64,50
10.11.2011	12:01:00	-1,31	13,69	22,06	5,22	3,76	3	64,18
10.11.2011	13:01:00	-0,65	13,95	22,09	5,73	3,76	3,02	64,20
10.11.2011	14:01:00	0	14,06	22,04	5,74	3,64	2,88	63,79
10.11.2011	15:01:00	0,06	14,21	21,99	6,03	3,62	2,93	64,52
10.11.2011	16:01:00	0,02	14,43	21,94	6,36	3,61	3,03	65,74
10.11.2011	17:01:00	0,02	14,45	21,81	6,55	3,64	3	66,22
10.11.2011	18:01:00	0,27	14,42	21,69	6,62	3,61	2,98	66,06
10.11.2011	19:01:00	0,74	14,4	21,52	6,79	3,59	2,93	65,74
11.11.2011	07:01:00	4,46	16,25	21,71	10,18	3,2	2,69	68,35
11.11.2011	08:01:00	4,47	15,57	21,31	9,4	3,55	2,95	65,91
11.11.2011	09:01:00	4,42	15,53	21,31	9,3	3,57	2,94	65,78
11.11.2011	10:01:00	4,4	15,66	21,48	9,46	3,6	2,99	65,93
11.11.2011	11:01:00	4,44	15,75	21,51	9,57	3,59	3	66,26
11.11.2011	12:01:00	4,41	15,83	21,51	9,67	3,57	3,04	66,78
11.11.2011	13:01:00	4,66	15,67	21,45	9,46	3,59	3	65,57
11.11.2011	14:01:00	4,79	15,51	21,42	9,19	3,56	2,94	64,46
11.11.2011	15:01:00	4,79	15,44	21,47	8,95	3,55	2,93	63,85
11.11.2011	16:01:00	4,18	15,25	21,4	8,65	3,59	2,93	64,29
11.11.2011	17:01:00	3,78	15,14	21,38	8,32	3,55	2,93	64,55
11.11.2011	18:01:00	3,59	15,03	21,27	8,2	3,56	2,93	64,71
11.11.2011	19:01:00	3,59	15	21,18	8,19	3,57	2,94	64,87
12.11.2011	07:01:00	2,61	19,39	21,31	17,04	0,44	0,69	89,73
12.11.2011	08:01:00	2,49	15,22	21,5	8,42	3,33	2,67	66,96
12.11.2011	09:01:00	2,49	14,68	21,34	7,51	3,6	2,91	64,67
12.11.2011	10:01:00	2,49	14,87	21,52	7,74	3,61	2,91	65,06
12.11.2011	11:01:00	2,68	14,99	21,54	7,99	3,61	2,9	65,27
12.11.2011	12:01:00	2,78	15,01	21,56	8,02	3,61	2,91	65,12
12.11.2011	13:01:00	3,27	15,05	21,5	8,21	3,63	2,91	64,62
12.11.2011	14:01:00	3,61	15,23	21,52	8,57	3,63	2,92	64,88
12.11.2011	15:01:00	2,9	15,29	21,5	8,67	3,6	2,92	66,61
12.11.2011	16:01:00	2,08	14,92	21,33	8,05	3,62	2,92	66,70
12.11.2011	17:01:00	1,69	14,35	21,15	7,06	3,62	2,91	65,06
12.11.2011	18:01:00	1,69	23,28	21,06	12,73	0,77	0,91	incorrect
12.11.2011	19:01:00	1,89	21,59	21,34	15,51	0,5	0,73	incorrect

13.11.2011	07:01:00	2,7	20,9	22,21	17,81	0,49	0,72	93,29
13.11.2011	08:01:00	2,93	21,79	22,13	17,92	0,52	0,68	98,23
13.11.2011	09:01:00	3,2	22,3	21,95	18,11	0,52	0,68	incorrect
13.11.2011	10:01:00	3,2	22,41	21,86	18,31	0,48	0,66	incorrect
13.11.2011	11:01:00	4,16	22,6	21,84	18,49	0,49	0,66	incorrect
13.11.2011	12:01:00	4,44	22,67	21,8	18,64	0,51	0,65	incorrect
13.11.2011	13:01:00	4,44	22,7	21,79	18,74	0,48	0,68	incorrect
13.11.2011	14:01:00	4,44	22,71	21,78	18,85	0,49	0,69	incorrect
13.11.2011	15:01:00	4,57	22,72	21,74	18,91	0,55	0,67	incorrect
13.11.2011	16:01:00	4,75	22,69	21,76	18,96	0,5	0,68	incorrect
13.11.2011	17:01:00	4,75	22,62	21,7	18,98	0,52	0,68	incorrect
13.11.2011	18:01:00	4,75	22,69	21,69	18,95	0,54	0,7	incorrect
13.11.2011	19:01:00	5,14	21,93	21,72	18,89	0,54	0,7	incorrect
14.11.2011	07:01:00	3,56	16,08	21,6	9,74	3,14	2,62	69,40
14.11.2011	08:01:00	3,81	15,56	21,35	9,01	3,45	2,81	66,99
14.11.2011	09:01:00	3,98	15,73	21,54	9,26	3,45	2,82	66,91
14.11.2011	10:01:00	4,45	16,01	21,75	9,91	3,63	3	66,82
14.11.2011	11:01:00	4,49	16,03	21,71	9,95	3,61	3,03	67,02
14.11.2011	12:01:00	5,2	16,1	21,59	10,13	3,55	3	66,50
14.11.2011	13:01:00	5,2	16,23	21,62	10,37	3,51	2,98	67,17
14.11.2011	14:01:00	5,2	16,33	21,75	10,66	3,68	3,12	67,25
14.11.2011	15:01:00	5,01	16,22	21,97	10,36	3,71	3,17	66,10
14.11.2011	16:01:00	4,05	15,94	21,98	9,49	3,58	3,06	66,31
14.11.2011	17:01:00	2,75	15,13	21,63	8,04	3,58	2,92	65,57
14.11.2011	18:01:00	1,83	14,67	21,48	7,09	3,49	2,88	65,34
14.11.2011	19:01:00	0,74	14,32	21,44	6,42	3,48	2,85	65,60
15.11.2011	07:01:00	-3,42	14,19	21,74	5,34	3,19	2,59	69,99
15.11.2011	08:01:00	-3,5	13,29	21,5	3,92	3,48	2,84	67,16
15.11.2011	09:01:00	-3,5	13,36	21,78	3,84	3,47	2,83	66,69
15.11.2011	10:01:00	-3,5	13,57	21,93	4,11	3,48	2,84	67,13
15.11.2011	11:01:00	-2,4	13,94	21,89	5,16	3,56	2,96	67,27
15.11.2011	12:01:00	-1,48	14,02	21,76	5,52	3,56	2,92	66,70
15.11.2011	13:01:00	-0,7	14,31	22,13	5,94	3,58	3	65,75
15.11.2011	14:01:00	-0,7	14,32	21,99	6,09	3,6	3	66,20
15.11.2011	15:01:01	-0,7	14,34	21,87	6,19	3,61	3	66,64
15.11.2011	16:01:00	-1,39	14,1	21,71	5,91	3,61	2,97	67,06
15.11.2011	17:01:00	-1,84	13,98	21,64	5,56	3,52	2,87	67,38
15.11.2011	18:01:00	-1,84	13,97	21,62	5,49	3,49	2,82	67,39
15.11.2011	19:01:00	-1,84	13,94	21,59	5,41	3,49	2,84	67,35
16.11.2011	07:01:00	-0,26	15,1	21,86	7,35	3,19	2,6	69,44
16.11.2011	08:01:00	0,16	14,33	21,53	6,35	3,49	2,83	66,31
16.11.2011	09:01:00	0,3	14,59	21,67	6,72	3,48	2,84	66,87
16.11.2011	10:01:00	0,56	14,84	21,85	7,03	3,46	2,86	67,07
16.11.2011	11:01:00	1,38	14,94	21,85	7,46	3,59	2,98	66,24
16.11.2011	12:01:00	1,69	15,09	21,78	7,8	3,56	2,95	66,70
16.11.2011	13:01:00	2,16	15,44	21,96	8,28	3,56	2,96	67,07
16.11.2011	14:01:00	2,44	15,69	22,05	8,83	3,6	3,04	67,57

16.11.2011	15:01:00	3,27	15,78	21,98	9,09	3,63	3,04	66,86
16.11.2011	16:01:00	3,26	15,69	21,85	9,06	3,63	3	66,86
16.11.2011	17:01:00	3,27	15,53	21,77	8,81	3,57	2,9	66,27
16.11.2011	18:01:01	3,44	15,48	21,69	8,77	3,53	2,87	65,97
16.11.2011	19:01:00	3,61	15,38	21,44	8,72	3,51	2,83	66,01
17.11.2011	07:01:00	3,56	19,66	22,01	16,42	0,71	0,8	87,26
17.11.2011	08:01:00	3,56	15,59	21,68	8,94	3,53	2,83	66,39
17.11.2011	09:01:00	3,44	15,7	21,79	9,16	3,62	3,01	66,81
17.11.2011	10:01:00	3,42	15,85	21,97	9,3	3,62	3,04	67,01
17.11.2011	11:01:00	3,78	15,9	21,88	9,53	3,63	3,01	66,96
17.11.2011	12:01:00	4,12	15,86	21,67	9,64	3,61	2,98	66,89
17.11.2011	13:01:00	4,79	16	22,02	9,71	3,59	2,94	65,06
17.11.2011	14:01:00	4,79	16,06	22,03	9,8	3,6	2,94	65,37
17.11.2011	15:01:00	4,79	16,12	22,09	9,89	3,57	2,96	65,49
17.11.2011	16:01:00	4,72	15,95	21,73	9,86	3,63	3,01	66,02
17.11.2011	17:01:00	4,39	15,6	21,42	9,43	3,62	3,01	65,83
17.11.2011	18:01:00	4,39	15,45	21,16	9,21	3,57	2,94	65,95
17.11.2011	19:01:00	3,31	15,11	21,09	8,44	3,53	2,87	66,37
18.11.2011	07:01:00	-0,41	19,78	21,69	15,92	0,69	0,8	91,36
18.11.2011	08:01:00	-0,28	14,09	21,46	5,88	3,48	2,83	66,10
18.11.2011	09:01:00	-0,02	14,26	21,45	6,19	3,52	2,9	66,51
18.11.2011	10:01:00	0,08	14,36	21,67	6,27	3,5	2,9	66,14
18.11.2011	11:01:00	0,48	14,65	21,82	6,79	3,55	2,92	66,40
18.11.2011	12:01:00	1,4	14,81	21,72	7,25	3,52	2,89	65,99
18.11.2011	13:01:00	1,83	15,06	21,74	7,75	3,52	2,89	66,45
18.11.2011	14:01:00	2,5	15,08	21,58	8,01	3,53	2,88	65,93
18.11.2011	15:01:00	2,81	15,25	21,58	8,35	3,59	2,91	66,28
18.11.2011	16:01:00	2,81	15,28	21,45	8,49	3,53	2,88	66,90
18.11.2011	17:01:00	3,18	15,35	21,39	8,69	3,53	2,87	66,83
18.11.2011	18:01:00	3,22	15,33	21,25	8,81	3,51	2,84	67,17
18.11.2011	19:01:00	3,42	15,28	21,09	8,84	3,53	2,84	67,12
19.11.2011	07:01:00	2,45	19,89	21,23	16,71	0,44	0,7	92,86
19.11.2011	08:01:00	2,05	20,92	21,38	16,75	0,41	0,72	97,62
19.11.2011	09:01:00	2,05	16,99	21,38	10,56	2,38	2,05	77,29
19.11.2011	10:01:00	2,05	14,63	21,15	7,4	3,5	2,78	65,86
19.11.2011	11:01:00	2,56	14,71	21,1	7,67	3,49	2,79	65,53
19.11.2011	12:01:00	3,04	14,93	21,01	8,16	3,48	2,78	66,17
19.11.2011	13:01:00	3,26	15	21,01	8,27	3,47	2,8	66,14
19.11.2011	14:01:00	2,68	14,62	20,94	7,53	3,49	2,78	65,39
19.11.2011	15:01:00	1,74	18,79	20,87	9,44	2,19	1,96	89,13
19.11.2011	16:01:00	1,12	24,32	20,82	14,18	0,35	0,78	incorrect
19.11.2011	17:01:00	0,39	21,88	20,89	15,99	0,43	0,76	incorrect
19.11.2011	18:01:00	0,39	20,62	21	16,39	0,48	0,76	98,16
19.11.2011	19:01:00	0,39	20,88	21,11	16,68	0,39	0,75	98,89
20.11.2011	07:01:01	-7,17	22,48	21,97	17,22	0,54	0,73	incorrect
20.11.2011	08:01:00	-8,24	22,34	22,01	17,24	0,56	0,75	incorrect
20.11.2011	09:01:00	-8,82	22,4	22,02	17,27	0,55	0,75	incorrect

20.11.2011	10:01:00	-8,22	22,49	22,03	17,26	0,55	0,73	incorrect
20.11.2011	11:01:00	-7,63	22,34	22,05	17,32	0,55	0,74	incorrect
20.11.2011	12:01:00	-7,35	22,12	22,09	17,42	0,55	0,77	incorrect
20.11.2011	13:01:00	-6,81	21,41	22,04	17,45	0,55	0,78	97,82
20.11.2011	14:01:00	-6,7	21,24	22,09	17,41	0,57	0,77	97,05
20.11.2011	15:01:00	-6,7	21,02	22,1	17,33	0,54	0,74	96,25
20.11.2011	16:01:00	-7,45	20,98	22,03	17,19	0,55	0,72	96,44
20.11.2011	17:01:00	-7,45	20,88	22	16,99	0,56	0,71	96,20
20.11.2011	18:01:00	-9,17	20,93	21,95	16,76	0,51	0,73	96,72
20.11.2011	19:01:00	-9,5	21,82	22,11	16,68	0,53	0,73	99,08
21.11.2011	07:01:00	-7,45	22,33	22,43	16,65	0,68	0,77	99,67
21.11.2011	08:01:00	-6,63	12,62	21,45	2,4	3,5	2,79	68,55
21.11.2011	09:01:00	-5,76	13	21,46	3,18	3,46	2,81	68,92
21.11.2011	10:01:00	-4,66	13,41	21,62	4,06	3,46	2,84	68,76
21.11.2011	11:01:00	-3,38	13,64	21,6	4,65	3,45	2,83	68,13
21.11.2011	12:01:00	-2,85	13,69	21,54	4,8	3,46	2,83	67,81
21.11.2011	13:01:00	-2,48	13,76	21,58	5	3,5	2,85	67,50
21.11.2011	14:01:00	-2,16	13,91	21,65	5,36	3,52	2,88	67,49
21.11.2011	15:01:01	-1,77	14,1	21,85	5,69	3,56	2,88	67,19
21.11.2011	16:01:00	-1,03	14,1	21,85	5,69	3,56	2,88	66,13
21.11.2011	17:01:00	-0,73	14,09	21,52	6,14	3,59	2,92	66,61
21.11.2011	18:01:00	-0,47	14,03	21,29	6,2	3,54	2,9	66,64
21.11.2011	19:01:00	-0,47	14,08	21,2	6,35	3,53	2,89	67,14
22.11.2011	07:01:00	0,39	19,67	21,3	15,76	0,65	0,85	92,20
22.11.2011	08:01:00	0,39	13,93	21,37	5,77	3,49	2,82	64,54
22.11.2011	09:01:00	0,18	14,03	21,59	5,78	3,55	2,93	64,69
22.11.2011	10:01:00	0,18	14,14	21,88	5,59	3,48	2,85	64,33
22.11.2011	11:01:00	0,18	14,17	21,9	5,85	3,6	2,97	64,41
22.11.2011	12:01:00	0,18	14	21,59	5,82	3,59	2,92	64,55
22.11.2011	13:01:00	0,18	14,07	21,85	6,1	3,69	2,97	64,10
22.11.2011	14:01:00	0,18	14,23	21,75	6,15	3,58	3,01	65,14
22.11.2011	15:01:00	0,18	14,09	21,54	5,93	3,54	2,9	65,12
22.11.2011	16:01:00	0,18	14,06	21,51	5,91	3,55	2,96	65,07
22.11.2011	17:01:00	0,18	13,97	21,47	5,9	3,58	2,96	64,77
22.11.2011	18:01:00	0,18	13,87	21,24	5,76	3,57	2,94	65,00
22.11.2011	19:01:00	0,18	13,74	21,07	5,7	3,55	2,93	64,91
23.11.2011	07:01:00	0,18	21,99	21,69	17,09	0,71	0,85	incorrect
23.11.2011	08:01:00	0,19	14,23	21,29	6,35	3,48	2,83	66,54
23.11.2011	09:01:00	0,18	14,37	21,51	6,64	3,6	2,97	66,53
23.11.2011	10:01:00	0,5	14,63	21,78	6,95	3,6	3,04	66,40
23.11.2011	11:01:00	0,87	14,7	21,87	7,1	3,62	3,03	65,86
23.11.2011	12:01:00	1,22	14,62	21,43	7,24	3,58	3,01	66,30
23.11.2011	13:01:00	1,47	14,84	21,43	7,59	3,6	3,03	66,98
23.11.2011	14:01:00	1,53	14,95	21,54	7,79	3,62	3,03	67,07
23.11.2011	15:01:00	1,65	15,05	21,58	7,98	3,6	3,04	67,24
23.11.2011	16:01:00	2,27	15,35	21,56	8,53	3,59	3,03	67,81
23.11.2011	17:01:00	2,56	15,19	21,29	8,6	3,55	2,97	67,43

23.11.2011	18:01:00	2,73	15,18	21,18	8,71	3,57	2,92	67,48
23.11.2011	19:01:01	2,73	15,07	21,08	8,48	3,52	2,89	67,25
24.11.2011	07:01:00	5,22	22,15	21,64	18,09	0,67	0,85	incorrect
24.11.2011	08:01:00	5,22	15,95	21,22	10,19	3,53	2,92	67,06
24.11.2011	09:01:00	5,22	15,95	21,17	10,28	3,55	2,96	67,27
24.11.2011	10:01:00	5,45	16,36	21,46	10,92	3,59	3,06	68,14
24.11.2011	11:01:00	6	16,42	21,5	11,05	3,59	3,04	67,23
24.11.2011	12:01:00	6,44	16,29	21,34	10,93	3,58	3,04	66,11
24.11.2011	13:01:00	6,44	16,34	21,49	10,89	3,61	3,05	65,78
24.11.2011	14:01:00	6,44	16,27	21,45	10,75	3,6	3,06	65,49
24.11.2011	15:01:00	5,97	16,22	21,39	10,73	3,61	3,08	66,47
24.11.2011	16:01:00	5,73	15,95	21,14	10,32	3,6	2,99	66,32
24.11.2011	17:01:00	4,2	15,55	21,03	9,48	3,56	2,93	67,44
24.11.2011	18:01:00	3,98	15,5	20,94	9,42	3,56	2,91	67,92
24.11.2011	19:01:00	3,98	15,31	20,85	9,17	3,5	2,9	67,16
25.11.2011	07:01:00	-1,42	21,46	21,66	16,67	0,78	0,82	99,13
25.11.2011	08:01:00	-0,5	14,05	21,2	6,19	3,52	2,88	67,05
25.11.2011	09:01:00	0,05	14,18	21,12	6,48	3,53	2,91	67,06
25.11.2011	10:01:00	0,34	14,51	21,45	6,91	3,55	2,89	67,12
25.11.2011	11:01:00	1,29	14,9	21,42	7,67	3,54	2,92	67,61
25.11.2011	12:01:00	2,06	15,17	21,4	8,18	3,53	2,92	67,79
25.11.2011	13:01:00	2,69	15,28	21,35	8,55	3,55	2,92	67,47
25.11.2011	14:01:00	3,46	15,7	21,33	9,48	3,53	2,94	68,49
25.11.2011	15:01:00	4,9	16,11	21,38	10,48	3,58	2,97	68,02
25.11.2011	16:01:00	5,86	16,42	21,43	11,12	3,6	2,96	67,82
25.11.2011	17:01:00	6,34	16,47	21,21	11,45	3,55	2,92	68,12
25.11.2011	18:01:00	6,34	16,36	20,98	11,42	3,54	2,92	68,44
25.11.2011	19:01:00	6,65	16,22	20,81	11,29	3,58	2,94	67,58
26.11.2011	07:01:00	3,75	22,6	21,41	18,46	0,51	0,69	incorrect
26.11.2011	08:01:00	2,67	22,78	21,42	18,47	0,52	0,67	incorrect
26.11.2011	09:01:00	2,17	17,6	21,3	11,58	2,53	2,06	80,66
26.11.2011	10:01:00	2,51	14,8	20,93	8,01	3,55	2,83	66,72
26.11.2011	11:01:00	2,97	14,96	20,89	8,36	3,54	2,84	66,91
26.11.2011	12:01:00	3,84	15,17	20,88	8,78	3,53	2,84	66,49
26.11.2011	13:01:01	3,41	15,04	20,86	8,58	3,54	2,84	66,65
26.11.2011	14:01:00	3,02	14,98	20,81	8,43	3,53	2,84	67,23
26.11.2011	15:01:00	2,75	18,85	20,79	10,73	2,29	1,97	89,25
26.11.2011	16:01:00	2,56	23,85	20,77	15,32	0,53	0,74	incorrect
26.11.2011	17:01:00	2,32	22,42	20,87	16,76	0,53	0,73	incorrect
26.11.2011	18:01:00	2,08	22,27	21	17,31	0,46	0,72	incorrect
26.11.2011	19:01:00	1,86	22,39	21,12	17,66	0,52	0,69	incorrect
27.11.2011	07:01:00	0,42	22,74	21,61	18,31	0,56	0,71	incorrect
27.11.2011	08:01:00	0,42	22,77	21,67	18,33	0,56	0,71	incorrect
27.11.2011	09:01:00	0,42	22,66	21,69	18,35	0,58	0,74	incorrect
27.11.2011	10:01:00	0,43	22,58	21,71	18,35	0,53	0,73	incorrect
27.11.2011	11:01:00	0,75	22,65	21,72	18,35	0,5	0,73	incorrect
27.11.2011	12:01:00	0,91	22,71	21,71	18,38	0,5	0,69	incorrect

27.11.2011	13:01:00	0,91	22,72	21,69	18,37	0,49	0,67	incorrect
27.11.2011	14:01:00	1,12	22,65	21,69	18,39	0,38	0,67	incorrect
27.11.2011	15:01:00	1,22	22,75	21,72	18,41	0,42	0,68	incorrect
27.11.2011	16:01:00	1,22	22,82	21,72	18,42	0,49	0,7	incorrect
27.11.2011	17:01:00	1,22	22,84	21,72	18,43	0,45	0,69	incorrect
27.11.2011	18:01:00	1,29	22,91	21,63	18,4	0,51	0,69	incorrect
27.11.2011	19:01:00	2,02	22,99	21,62	18,35	0,58	0,68	incorrect
28.11.2011	07:01:00	0,13	21,98	21,5	16,96	0,7	0,82	incorrect
28.11.2011	08:01:00	0,13	13,93	21,05	5,64	3,44	2,8	65,97
28.11.2011	09:01:00	0,13	13,93	21,1	5,52	3,43	2,84	65,81
28.11.2011	10:01:00	0,13	14,02	21,3	5,68	3,5	2,88	65,61
28.11.2011	11:01:00	0,13	14,18	21,4	6,32	3,68	3,14	66,06
28.11.2011	12:01:00	0,13	14,19	21,26	6,42	3,64	3,04	66,54
28.11.2011	13:01:00	0,13	14,45	21,41	6,8	3,61	3,06	67,29
28.11.2011	14:01:00	0,22	14,47	21,39	6,79	3,56	2,99	67,31
28.11.2011	15:01:00	0,42	14,44	21,53	6,59	3,54	2,91	66,41
28.11.2011	16:01:00	0,42	14,39	21,55	6,51	3,6	2,96	66,11
28.11.2011	17:01:00	0,17	14,2	21,38	6,36	3,63	3,04	66,15
28.11.2011	18:01:00	0,05	14,09	21,18	6,44	3,67	3,06	66,45
28.11.2011	19:01:00	0,33	14,08	20,98	6,66	3,65	3,01	66,59
29.11.2011	07:01:00	-0,34	20,97	21,38	16,18	0,72	0,82	98,11
29.11.2011	08:01:00	-0,34	13,8	21,1	5,46	3,49	2,88	65,95
29.11.2011	09:01:00	-0,6	13,82	21,33	5,42	3,56	3,01	65,75
29.11.2011	10:01:00	-0,78	13,79	21,52	5,33	3,61	3	65,34
29.11.2011	11:01:00	-0,79	13,79	21,5	5,37	3,6	3,04	65,41
29.11.2011	12:01:00	-0,75	13,84	21,43	5,54	3,61	3,06	65,78
29.11.2011	13:01:00	-0,34	13,96	21,66	5,55	3,61	3,06	65,00
29.11.2011	14:01:00	-0,34	13,7	21,29	5,31	3,58	3,02	64,91

Appendix 4. Data of working parameters of AHU TK 43 taken with Automation system Schneider electric