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CONSTRUCŢII. ARHITECTURĂ

ANALYSIS AND CHOICE OF OPTIMAL HEATING VENTILATION AIR CONDITIONING SYSTEM FOR A TEACHING UNIT

BY

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Under the conditions of present society in which providing an optimum interior comfort is confronted with the necessity of the energy consumption reduction, solving this problem depends on the factors which contribute to the achievements of this comfort.

Modern buildings – implicitly teaching unit – may be equipped with installations which have low energy consumption, respective a heating, cooling and ventilating integrated system with heat pumps system which can assure all the required comfort conditions.

This paper underlines the necessity to use the heat pump in heating system for a teaching unit, energetic and economic guides and the possibility to increase them when using cooling and heating mixed. The solution of heat pumps for heating of the teaching unit and the energetic and economic advantages of the system is made in study.

1. Introduction

To increase the energy efficiency of indoor heating installations for a teaching unit the following goals are taken into account:

a) to obtain energy economies at the level of the whole building, by reducing consumption with the heating systems;

b) to comply with comfort parameters imposed by the present technical requirements;

c) to reduce fuel consumption;

d) to organize a new heating – ventilation system;

e) to increase the energy efficiency with direct effects in environment protection and the students' health state by reduction of gas pollution generated by the process of energy production, transformation and transport.

2. Solutions Regarding Energetic Heating Ventilation Air Conditioning Systems Efficiency Increase at a Teaching Unit

For Heating Ventilation Air Conditioning systems efficiency increase of a school we recommended the following solutions:

T y p e I. Low-temperature – pressure-hot water heating system (LTHW) and natural ventilation (Fig. 1):

a) The preparation of thermal agent will be performed in a centralized local system:

– the standard gas boiler with a capacity of 100 kW;

– the boiler functions with an authorized circuit determined by the exterior temperature, with a linear controlled check system of the water's temperature in the boiler;

– thermal efficiency (at a temperature of 80°/60°C) – 88%;

– the rooms will be equipped with static heating systems – pig-iron radiators.

b) Natural ventilation: the fresh air flow necessary for the dilution of CO_2 is taken from the exterior through windows.

Type I has the following advantages:

a) a relatively reduced investment;

b) partially assured comfort parameters;

c) a lower CO_2 emission;

and disadvantages:

a) the radiators take some space from classrooms;

b) a irregular temperature distribution in vertical and horizontal plane.

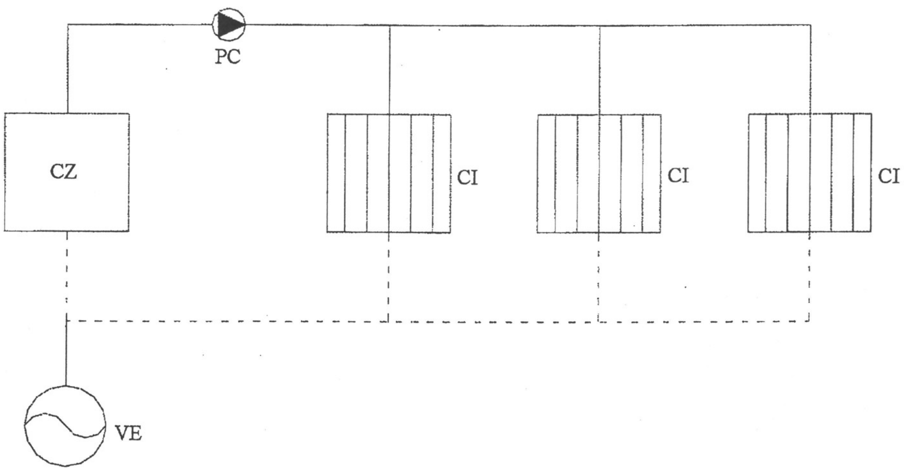

Fig. 1.– Type I - heating assured with radiators and natural ventilation: CZ – gas boiler; CI – heat emitters; PC – circulating pump; VE – expansion vessel.

T y p e II. Air conditioning – centralized system (Fig. 2):

a) The preparation of thermal agent will be realized in a centralized local system:

– the condensing gas boiler with a capacity of 100 kW;

– the boiler functions with an authorized circuit determined by the exterior temperature, with a linear controlled check system of the water's temperature in the boiler.

b) In the classrooms, ventilation and air heating will be achieved – primary air system; the entrance halls and the toilets will be equipped with static heating systems – pig-iron radiators:

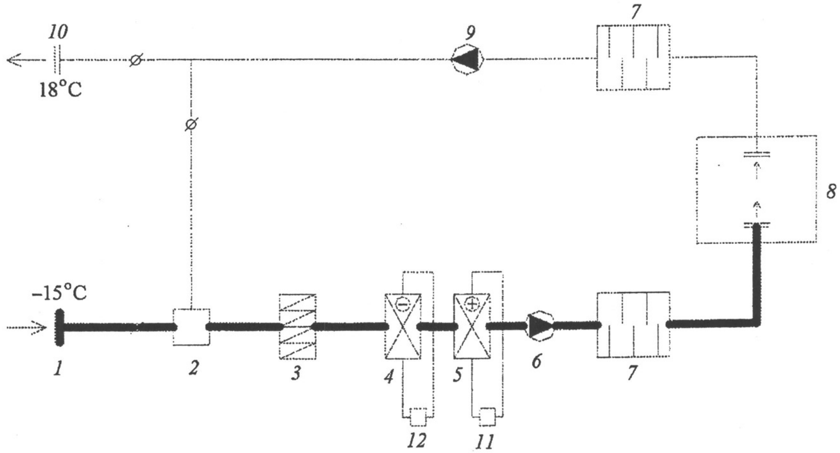

Fig. 2.– Type II – air conditioning and ventilation with a central system: *1* – fresh air intake; *2* – mixing box for fresh air with recirculation air; *3* – dust filter; *4* – cooler battery with cold water 7°/12°C; *5* – heater battery with warm water 90°/70°C; *6* – intake fan for treated battery; *7* – sound attenuator; *8* – classroom; *9* – exhaust fan for vicious air; *10* – air outlet vicious air; *11* – condensing gas boiler with capacity of 100 kW for water 90°/70°C; *12* – chiller for cold water 7°/12°C, cooled with air.

– the fresh-air flow necessary for the dilution of CO_2 is taken from the exterior, filtrated, heated and cooled up to a temperature equal to that of the interior-air temperature;

– after treatment, the air is sent to the classrooms by the blended air diffuser situated in the upper part of the rooms;

– the air treatment unit and distribution pipes will be placed in the building's attic and thermal isolation measures will be taken;

– thermal agent distribution to the treatment unit (boiler) and blended air diffuser will be achieved by a hot water system (80°/60°C) also located in the attic;

– fresh (primary) unit of air treatment has an air flow of 3,600 m^3/h, available pressure of 50 Pa and a heating thermal requirement of 40,000 W;

– the supplied airflow is constant, with an input temperature of –15°C and the output constant temperature of 18°C;

– for the protection of the heat-barrier against freeze a safety-system with closing flaps is designed and they will be checked by a thermostat set on the evacuated air side maintaining a constant out-air temperature, three-way-mixing valve is designed, run by an engine controlled by the thermostat; after mixing, the air is filtered and heated during winter and cooled during the summer;

– the air evacuation temperature is adjusted by modifying the thermal agent temperature which fuels the heating battery through the three-way electro-valve operated by the ambience thermostat in the classroom.

Type II has the following advantages:

a) a relatively reduced investment;

b) thermal efficiency (at a temperature of 80°/60°C) – 98%;

c) increased efficiency leads to decreased polluting substance emissions;

d) silent functioning; noise level is very low –35 dB;

e) small dimensions and reduced weight;

f) the assurance of both heating and cooling of classrooms;

g) the energy transfer is assured by a single agent;

h) easy maintenance thanks to equipment centralization;

i) thermal comfort of the occupants will increase productivity, improve health of the students and reduce the absenteeism;

and disadvantages:

a) the sizes of air channels are big, a lot of space is so used and the investment cost is high;

b) the parameter adjusting can not be done for each classroom individually;

c) the minimal temperature must be assured.

T y p e III. Air conditioning - primary air and local substation with fan-coil (Fig. 3):

a) The preparation of thermal agent will be realized in a centralized local system:

– the condensing gas boiler with a capacity of 100 kW;

– the boiler functions with an authorized circuit determined by the exterior temperature, with a linear controlled check system of the water's temperature in the boiler;

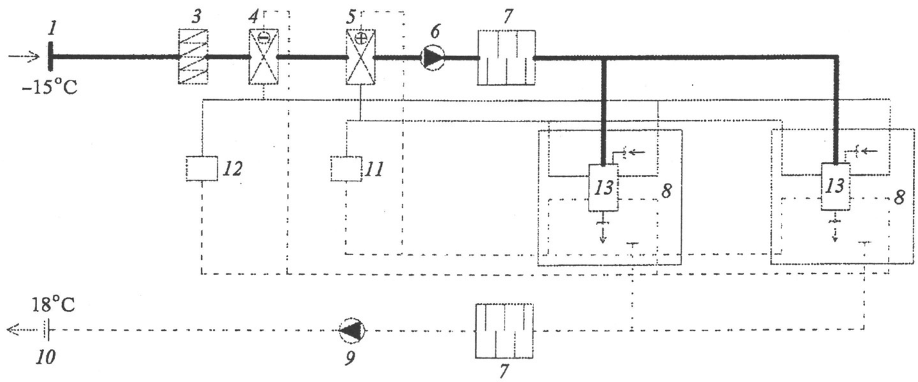

Fig. 3.– Type III – air conditioning – primary air and local substation with fan-coil: *1* – fresh air intake; *3* – dust filter; *4* – cooler battery with cold water 7°/12°C; *5* – heater battery with warm water 90°/70°C; *6* – intake fan for treated battery; *7* – sound attenuator; *8* – classroom; *9* – exhaust fan for vicious air; *10* – air outlet vicious air; *11* – condensing gas boiler with capacity of 100 kW for water 90°/70°C; *12* – chiller for cold water 7°/12°C cooled with air; *13* – fan coil.

b) In the classrooms ventilation and air heating will be achieved – primary air system and area substations with fan-coil will be placed with a fresh-air in-take; the entrance halls and the toilets will be equipped with static heating systems – pig-iron radiators:

– the fresh-air flow necessary for the dilution of CO_2 is taken from the exterior, filtrated and heated up to a temperature equal to that of the interior-air temperature, then it is sent through the piping to each classroom;

– for each classroom, local substations with fan-coil are designed; they do the final air mixture between the fresh and the recycled air, the filtration, and heating and cooling until the final stage determined by the imposed parameters of the heated rooms is achieved; after treatment, the air is sent to the classrooms by the fan-coil situated in the upper part of the rooms;

– the fresh-air treatment unit, the air-distribution pipes and the fan-coil will be placed in the building's attic and thermal isolation measures will be taken;

– thermal agent distribution to the treatment unit (boiler) and blended air diffuser will be achieved by a hot water system (80°/60°C) also located in the attic;

– the supplied air flow is constant, with an input temperature of –15°C and the output constant temperature of 18°C;

– for the protection of the heat-barrier against freeze a safety-system with closing flaps is designed and they will be checked by a thermostat set on the evacuated air side maintaining a constant out-air temperature; three-way-mixing valve is designed, run by an engine controlled by the thermostat;

– fan-coil will be equipped with mixing chambers in which fresh-air gets in (from the fresh-air central and the recycled air taken through an air-intake situated on the classrooms ceiling); after mixing, the air is filtered and heated during winter and cooled during the summer;

– the air evacuation temperature is adjusted by modifying the thermal agent temperature which fuels the heating battery through the three way electro-valve operated by the ambience thermostat in the classroom.

Type III has the following advantages:

a) the advantages from Type 2 plus

b) the air channels dimensions are reduced;

c) the parameter adjusting can be done for each classroom individually;

d) the minimal temperature is not to be assured;

and disadvantages:

a) the energy transport is done with two agents (water–air);

b) higher cost.

T y p e IV. Reversible alternative bivalent system (condensing boiler and heat pump air–water R-407C) and air conditioning-primary air and local substation with fan-coil (Fig. 4):

a) the preparation of thermal agent will be realized in a centralized local system:

– the condensing gas boiler with a capacity of 100 kW;

– the boiler functions with an authorized circuit determined by the exterior temperature, with a linear controlled check system of the water's temperature in the boiler;

– heat pump air–water – 40 kW heating capacity; 28 kW cooling capacity:

- coefficient of performance of heat pump (COP) – 2,177;
- mass flow of refrigerant – 0,176 kg/s;
- evaporating temperature – 13°C;
- condensing temperature – 47°C;
- power consumption 12,99 kW.

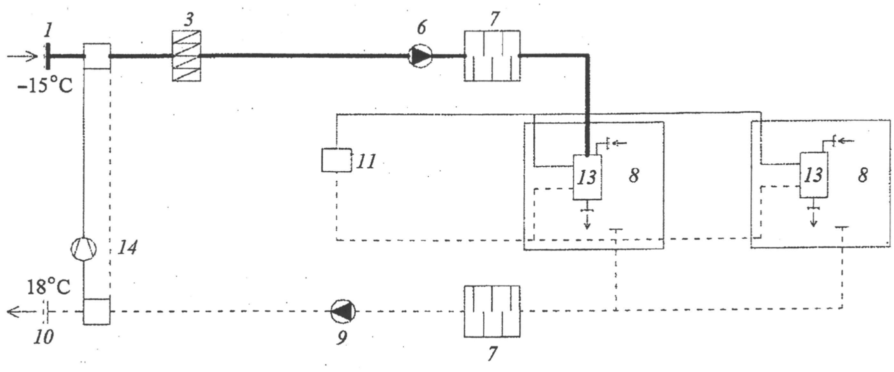

Fig. 4.– Reversible alternative bivalent system (condensing boiler and heat pump air–water R-407C) and air conditioning – primary air and local substation with fan-coil: *1* – fresh air intake; *3* – dust filter; *6* – intake fan for treated battery; *7* – sound attenuator; *8* – classroom; *9* – exhaust fan for vicious air; *10* – air outlet vicious air; *11* – condensing boiler for water 90°/70°C; *13* – fan coil; *14* – heat pump air–water – 40 kW heating capacity; 28 kW cooling capacity.

b) In the classrooms, ventilation and air heating will be achieved – primary air system and area substations with fan-coil will be placed with a fresh-air in-take; the entrance halls and the toilets will be equipped with static heating systems – pig-iron radiators. The other characteristics of equipment are the same like for Type III.

Type IV has the following advantages:

– the advantages from Type III plus

– the introduction of the heating pump causes an increase installation efficiency in addition with direct results on the energetic consumptions;

– ODP (R-407C) = 0;

and disadvantages:

– the energy transport is realized with two agents (water–air);

– higher initial investment;

– GWP_{100} $(CO_2) = 1{,}525$.

T y p e V. Reversible alternative bivalent system (condensing boiler and heat pump air–water R 717–NH_3) and air conditioning – primary air and local substation with fan-coil (Fig. 5):

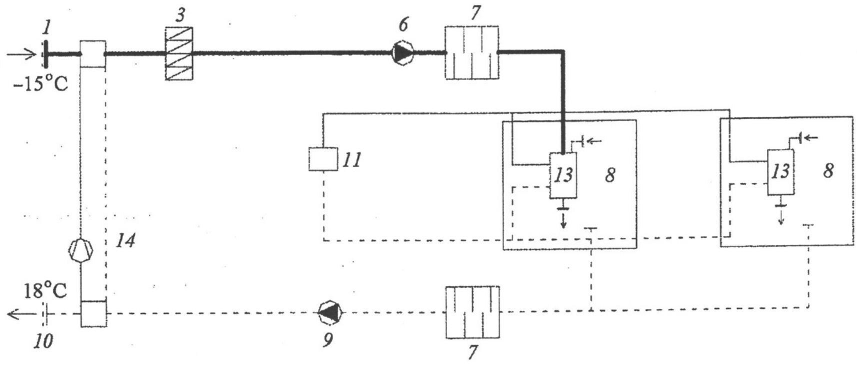

Fig. 5.– Reversible alternative bivalent system (condensing boiler and heat pump air–water R 717–NH_3) and air conditioning – primary air and local substation with fan-coil: *1* – fresh air intake; *3* – dust filter; *6* – intake fan for treated battery; *7* – sound attenuator; *8* – classroom; *9* – exhaust fan for vicious air; *10* – air outlet vicious air; *11* – condensing boiler for water 90°/70°C; *13* – fan coil; *14* – heat pump air–water – 40 kW heating capacity; 28 kW cooling capacity.

a) The preparation of thermal agent will be realized in a centralized local system:

– the condensing gas boiler with a capacity of 100 kW.

b) The boiler functions with an authorized circuit determined by the exterior temperature, with a linear controlled check system of the water's temperature in the boiler.

c) Heat pump air–water – 40 kW heating capacity; 28 kW cooling capacity:

– coefficient of performance of heat pump (COP) – 2,32;

– mass flow of refrigerant – 0,11 kg/s;

– evaporating temperature – 13°C;

– condensing temperature – 47°C;

– power consumption – 12,82 kW;

The Type V has the following advantages:

a) the advantages from Type 4 plus

b) GWP_{100} $(CO_2) = 0$;

c) NH_3 is a cheap refrigerating agent.

The diagrams from Figs. 6,...10 illustrate the results of our study.

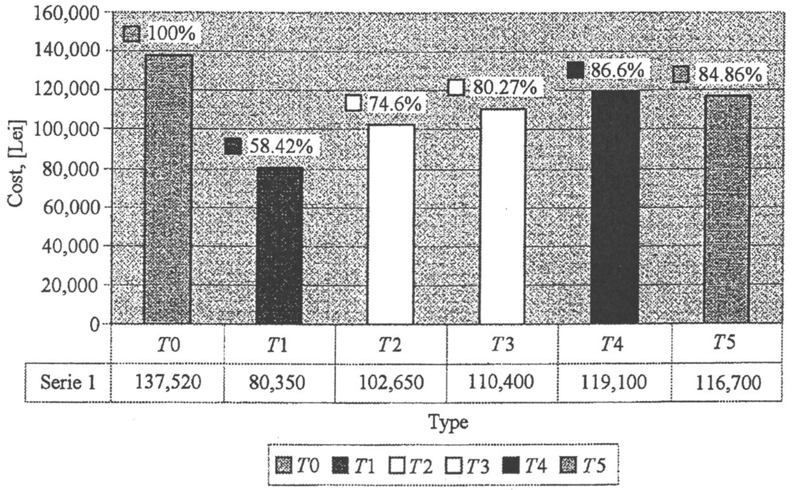

Fig. 6.– Investment analyse.

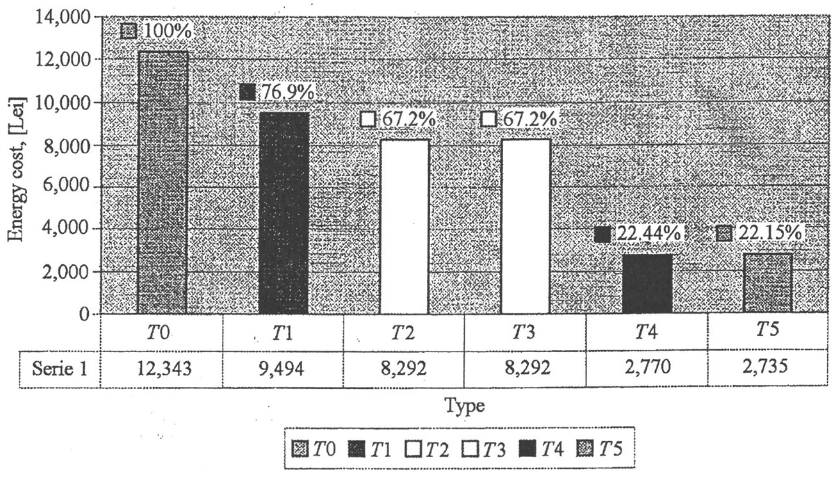

Fig. 7.– Energy cost.

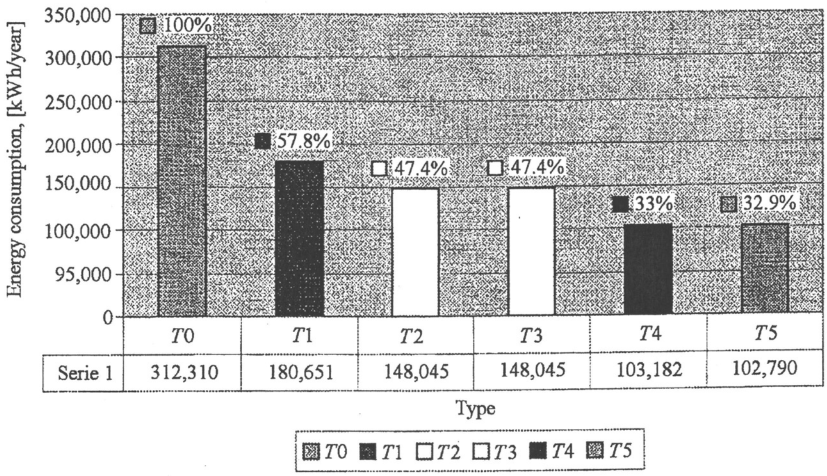

Fig. 8.– Energy consumption.

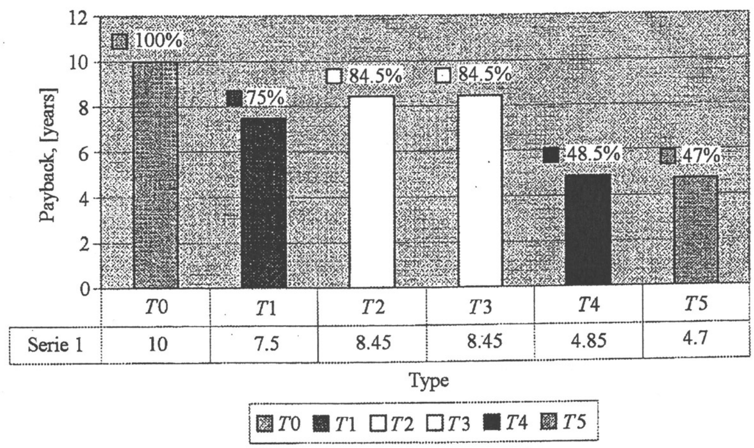

Fig. 9.– Payback.

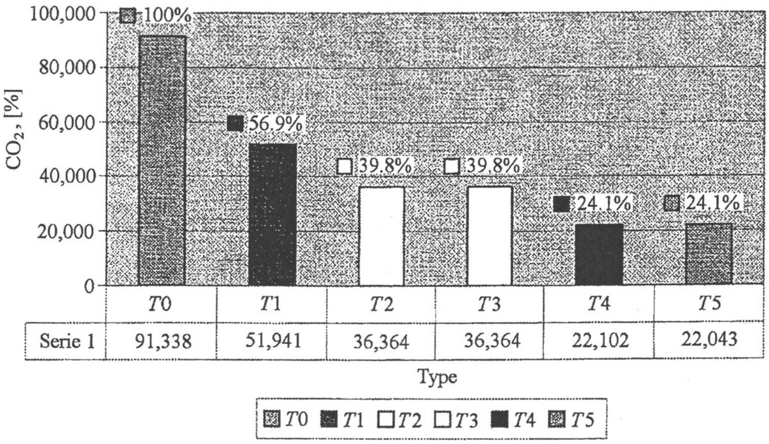

Fig. 10.– CO_2 emission.

3. Conclusions

1. Recommendations for optimal system selection concern Type V.
2. System bivalent alternative reversible (condensing boiler heat pomp air–water).
3. The heat pumps utilize refrigerant type R717 (NH_3).
4. Offers superior IAQ by decupling space latent and sensible loads.
5. Avoid cross-contamination involved with circulation of air.
6. Guarantees compliance with ventilation requirements.
7. Reduces energy consumption and plant size.
8. The system has low operation and maintenance cost.
9. The system meets the requirements of the Montreal and Kyoto Protocols.
10. Minimizes energy consumption for cooling and heating while fulfilling all comfort criteria.

4. Final Conclusions

1. Indoor ventilation is a complex problem influenced by a great number of factors, especially in civil buildings an excessive isolation concerning indoor air quality. Therefore the air ratio or the minimum air changes per hour must assure both the physical and chemical indoor air condition, not to affect human health comfort through humidity, dust, bacteria or toxic gases.
2. The heat pump has alternative heating installation, more energy efficiency and unless pollutant if we make a comparison with classic plants (liquid or gas fuel thermal kettle).

3. Ammonia has a big potential in the future in refrigerant plants because of thermodynamics properties, heat transfer and protection of the environment. So, is important to take account by designer and users the advantages of the ammonia. In concordance standards above presented, ammonia is rated in second group as regards the security; it has a medium dangerous risk.

4. Although, is necessary to know the risk factors and security measures must be taken when using ammonia like working fluid in refrigerant plant and special associate installations (supply with electrical energy, ventilation, detection of the leakage ammonia and alarm).

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ANALIZA ŞI SELECTAREA SOLUŢIEI OPTIME DE INSTALAŢII (ÎNCĂLZIRE, RĂCIRE, AER CONDIŢIONAT) PENTRU O UNITATE DE ÎNVĂŢĂMÂNT

(Rezumat)

În condiţiile societăţii de astăzi, în care obţinerea unui confort interior în clădiri este confruntată cu necesitatea reducerii consumului de energie, rezolvarea acestei probleme depinde de factorii care participă la asigurarea acestui confort.

Clădirile moderne – implicit spaţiile destinate activităţilor didactice – trebuie echipate cu instalaţii care au consumuri energetice scăzute, respectiv sisteme integrate de încalzire, răcire şi ventilare şi pompe de căldură care pot asigura toate cerinţele de confort solicitate.

Se subliniază necesitatea utilizării pompelor de căldură în sistemul de încălzire al unei şcoli şi se studiază indicatorii economici şi energetici precum şi posibilităţile de creştere a acestora prin utilizarea combinată a frigului şi a căldurii.