TRENDS FOR RETROFIT OF VAC SYSTEMS IN HOSPITALS - POLISH CASE STUDY

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Introduction

Political and economical changes that have been started in Poland since 1989 strongly influenced the building construction market. New owners or managers of institutional buildings have began the process of retrofitting, focusing on:

- reconstruction of building cover joined with exchange of windows and insulation of external barriers,
- modernization of technical equipment of building - introducing new low energy HVAC systems.

The main goal that has to be reached is to prevent the conditions of climate comfort (proper Indoor Air Quality) and to optimize total energy consumption of building.
The paper presents the problems that can appear during realization of retrofitting process of VAC (Ventilation & Air Conditioning) systems in Polish hospitals.

National laws and standards

The process of retrofitting a building has to fulfill the national standards. In Poland the main standards regulating the process of building construction or modernization are:

- Building Law - National Act N° 89/94, established in July 1994 [1],
- The Decree of Ministry of Urban Planning and Building Construction - National Act N° 10/95, established in December 1994 [2].

Additionally modernization of hospital building has to correspond with The Decree of Ministry of Health and Social Care - National Act N° 74/92, established in September 1992 [3].

Building Law [1] is general decree that regulates the investment process of building construction e.g.:

- the rights and obligations of investors, designers and contractors,
- the rules of application for construction permit,
- the rules of leading the construction and starting the exploitation process of building,
- the rules of exploitation of building.

National Act N° 10/95 [2] describes the technical conditions that have to be considered in the process of building location and construction e.g.:

- functional composition of building,
- construction of technical equipment of building (HVAC, natural gas, domestic water and sewage systems),
- construction of fire protection systems,
- maximum annual energy consumption (only for residential buildings[1]).

National Act N° 74/92 concerns the technical and hygienic demands for hospital building e.g.:

- functional composition of building (rules of location aseptic and septic zones),
- minimum areas of specific zones (operating rooms, sterilization rooms)
- construction of technical equipment of building (HVAC, natural gas, technical gases, domestic water and sewage systems).

Starting the process of retrofitting VAC systems in hospital building in Poland one has to take national acts mentioned above into consideration.

Retrofitting of VAC system of operating block

The key function of introducing the VAC system to hospital building is to prevent the conditions of:

- thermal comfort,
- indoor air quality,
- fire safety.

[1] The maximum values of annual energy consumption for residential buildings are set for 120 kWh/m^{2}a for multifamily buildings (more than 5 apartments) and 140 kWh/m^{2}a for singel family buildings

Retrofitting of operating blocks is one of the most difficult process in existing hospitals. It is because of:

- limited space for location of air ducts and ceiling diffusers,
- limited thermal capacity of energy sources (boilers, heat exchangers, steam generators),
- limited capacity of electrical stations (supplying of fans and cooling systems).

According to National Act N° 74/92 the minimum area of operating room has to be at least 35 m^2 and the minimum height 3,30 m [3]. Average amount of air flow through operating room has to be set between 20 to 25 air volume changes per hour, depending on the type of diffuser employed. Taking into account figures mentioned above volumetric flow of conditioned air has to be kept in the range of:

$$\dot{V}_{min} = 2310 \div 2890 \ m^3 / h$$

Air flow through operating room implicates two designing parameters of VAC system:

- the size of the supply and exhaust air ducts,
- the capacity of technological parts of air handling unit (ventilators, heater, cooler, humidifier ..).

The size of air supply and exhaust ducts is determined by the maximum value of air velocity (set usually on 4 to 5 m/s). Significant size of the ducts may cause several problems joined with collision with building construction elements. It may also make problems with fulfilling the minimum height condition (h_{min}= 3,30 m), especially for laminar flow diffusers, mounted in the false ceiling of operating room.

The capacity of technological parts of air handling unit is strongly dependent on the air flow in the system. Considering the optimization of total energy consumption by VAC system it is important to reduce:

- electrical energy consumption of fans,
- energy consumption of air heaters,
- energy consumption of air cooler.

Electrical energy consumption of fans is dependent on the air flow and pressure drop in duct system. Main cause of pressure drop is the triple stage filter system, usually consisted of:

- EU-3 class filter mounted as the first section of air handling unit,
- EU-7 class filter mounted as the last section of air handling unit,
- EU-13 class filter mounted close to the operating room very often as the part of air diffuser.

In operating rooms the air flow through the operating zone has to be constant. The reduction of energy consumption is possible only by introducing multiple stage fans allowing for the reduction of air flow through the operating room during "stand by period" (no operation time).

The total energy demand for heat exchangers (air heaters and cooler) depends on the efficiency of heat recovery unit utilized. There are usually four types of heat recovery systems utilized in air handling units:

- recirculation of exhaust air - recovery efficiency depends on the mixing ratio of fresh and exhaust air,
- rotary heat exchangers - recovery efficiency up to 80%,
- plate heat exchangers - recovery efficiency up to 50%,
- heat recovery system operating with circulating agent (usually glycol) - recovery efficiency up to 45%.

According to the N.A. 10/95 and 74/92 [2,3] no recirculation of exhaust air is permitted in the operating blocks. It implicates that last two of mentioned above solutions are taken into consideration in polish practice.

Polish case study

As the polish case study the process of modernization the operating block at Ophthalmology Clinics National University Hospital N° 1 in Poznań has been chosen. The building of Ophthalmology Clinics, shown in the Figure 1 had been established in 1820. Since 1990 the activities of complete modernization of building and its technical equipment have started.

Fig. 1. The building of Ophthalmology Clinics in Poznań

At the end of 1996 the retrofitting of operating block has been completed. The technical layout of VAC system of operating room has been shown in the figure 2 and technical data of the system has been listed in the Table 1.

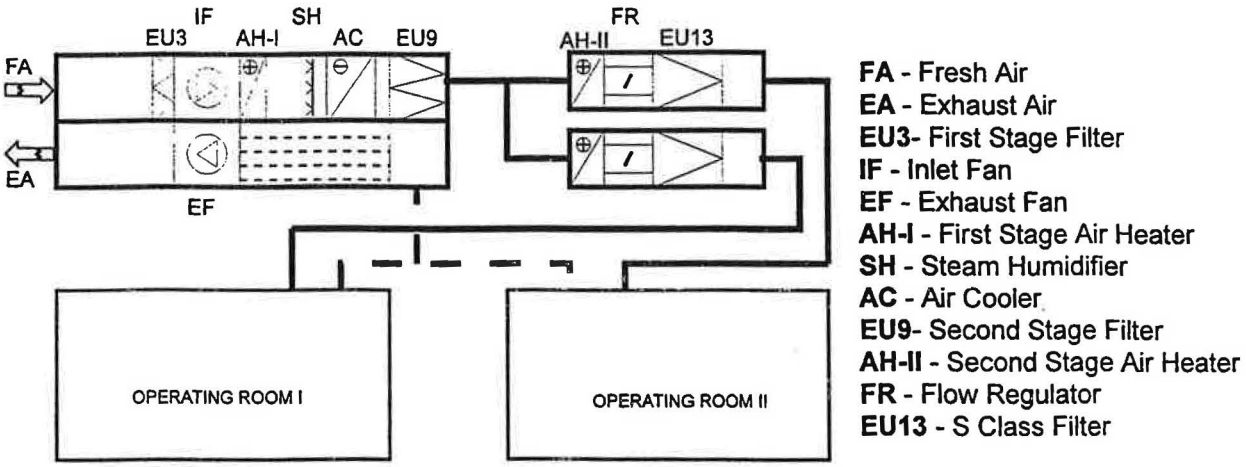

Fig. 2. Technical layout of operating block VAC system

Table 1. *Technical data of operating room VAC system*

Air handling unit	**GEA Happel**
Air flow	6000 m^3/h
Heat recovery	not employed
Cooling system	district glycol ethylene system 6/12 °C
Heating system	district hot water 95/70 °C
Humidifier	water vapor 0,4 bar
Air exchange system	**Laminar flow**
Air inlet	laminar flow ceiling diffuser
Air exhaust	wall exhaust grills: 80% lower part of the room 20% upper part of the room

The picture of operating room has been shown in the figure 3.

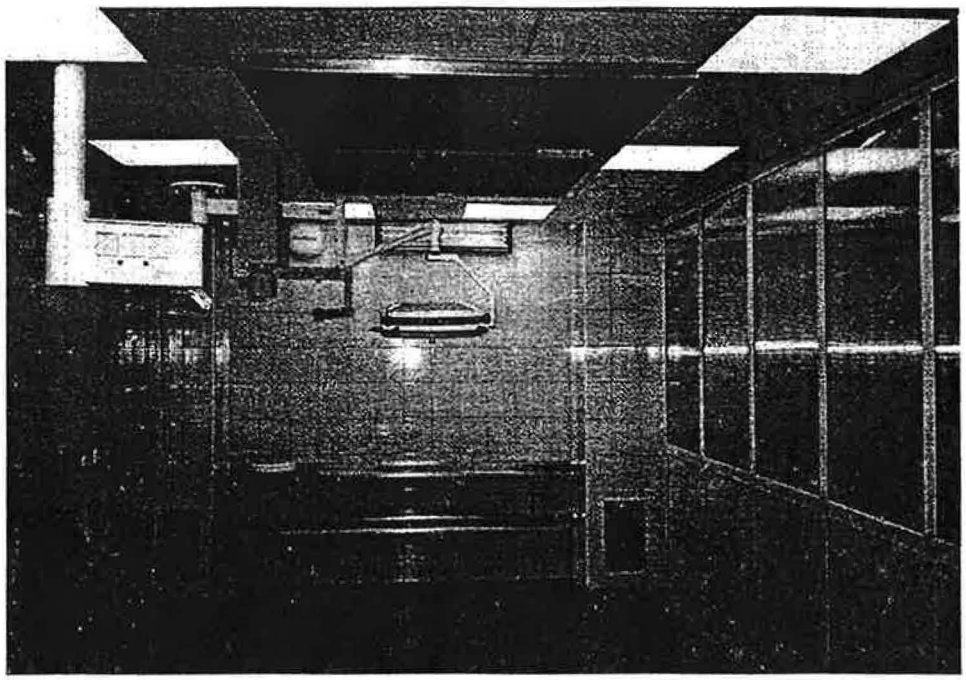

Fig. 3. *Operating room at Ophthalmology Clinics in Poznań*

The main problems that had occurred during modernization of operating block were:

- limited height of false ceiling joined with the need of keeping the height of the operating room on the level of 3,30 m,

- high energy requirements joined with lack of heat recovery unit (caused by the lack of space in the VAC mechanical room),
- need of modernization of existing district heating and cooling system,
- collisions with construction elements of the building, e.g.: beams, construction walls (joined with long distance between operating room and VAC technical room).

Conclusions

Retrofitting of VAC systems of operating blocks in polish hospitals may cause several problems joined with:

- limited space for VAC elements in the construction of the building,
- limited capacities of existing district heating and cooling systems.

It is mainly due to the existing standards [2,3] prohibiting recirculation of exhaust air. It implicates the need of operating VAC systems with 100% of fresh air. The size of the fresh and exhaust air ducts and the total energy consumption is higher comparing with the systems with air recirculation.

References

1. Building Law; Polish National Act No 89/94, July 1994;
2. Decree of Ministry of Urban Planning and Building Construction - Polish National Act N° 10/95, December 1994 [2];
3. Decree of Ministry of Health and Social Care - Polish National Act N° 74/92, September 1992.