Case Study: A Controlled Ventilation Solution for Laboratories at The Department of Natural Science of Tallinn University of Technology

Teet Tark¹, Albert Rodin¹ and Kaido Hääl²

¹Hevac Ltd, Estonia
²Tallinn University of Technology, Estonia

Corresponding email: teet.tark@hevac.ee

SUMMARY

This case study deals with the renovation project of ventilation system in the Natural Science Building of Tallinn University of Technology, covering the established aims and principles of technical solutions, in general, and results of monitoring. The reconstruction project involved the task of creating a new ventilation system for required indoor climate of laboratories, avoiding dissemination of harmful materials to rooms. In addition, it was required to keep the operations costs approximately at an acceptable level.

There are two separate central supply-exhaust air ventilation systems for general air exchange and for local ventilation systems. To assess the operating systems and to achieve the established aims, special testing of joint work between fume cupboards and main ventilation was conducted, using airflow smoke to emphasize the effect.

Results of monitoring demonstrate that investments for these ventilation systems were justified and the installed ventilation systems corresponded to our technical and sanitary-hygienic expectations.

INTRODUCTION

The main target of the ventilation systems for a laboratory is to guarantee a healthy working environment, avoiding dissemination of harmful materials from fume cupboards to rooms and between the rooms.

At the same time, an optimum energy consumption of the ventilation systems is required.

This case study deals with the renovation project of ventilation in the Natural Science Building of Tallinn University of Technology, covering the established aims and principles of technical solutions, in general, and results of monitoring. In this building there are mainly educational and scientific laboratories. Additionally there are some office and maintenance rooms. The present study only deals with subjects pertaining to the laboratories.

The reconstructed building has 4 floors with 7900 m² of total area. The laboratories hold 97 fume cupboards, 18 local exhaust - ventilation systems for specific purposes and 45 cupboards for chemical reagents, all situated dispersed in 50 different rooms.
TECHNICAL SOLUTION

Target Requirements

The following target requirements were adhered to while working out the technical solution:

- The constant air speed 0,5 m/s in fume cupboard holes will be restored after a couple of seconds;
- The air pressure balance in the rooms;
- The maximum inside temperature 25 °C; The maximum CO2 900 ppm;
- The optimum energy consumption

Energy Consumption and Fume Cupboard’s Door Opening Time

Several earlier studies have shown that it’s necessary to guarantee constant air speed 0,5 m/s in fume cupboard holes for the fume cupboards to work effectively. The dimensioning of the fume cupboards in the present study is based on assumption that the design air flow of one equipment is 150 l/s while the door is opened and 30 l/s in stand-by. The longer fume cupboard door is opened, the larger is the consumption of heat and electric energy. The figures below illustrate estimated consumption of heat and electric energy per fume cupboard in a year, depending on the length of time the door is open during astronomical day in Estonian climate conditions.

![Graph](image1)

Figure 1 Annual heat (left) and electricity (right) energy consumption per fume cupboards (FC) depending of FC’s door opening time.

The usage of heat recovery allows for significant savings in heat energy. The supply and exhaust air may not mix in the heat recovery system.

Design Solution

Two separate supply-exhaust air ventilation systems are designed for the laboratories: for general air exchange and for local ventilation systems. Both systems have recuperative indirect heat recovery units with a circulating fluid medium. To extract dangerous and abrasive materials, additional separate local exhaust ventilation systems are provided.

Air handling units (AHU) are situated in the maintenance room of the last floor. The AHU-s are equipped with heating and cooling coil and heat recovery. The main ducts of the ventilation are situated in the technical room of the last floor where the vertical risers are going down from. The risers are branching off horizontally on every floor, in the start of
branches there are constant pressure dumpers. Generally one horizontal branch services 1 to 4 rooms (laboratories). Figure 2 illustrates the global ventilation solution.

**Figure 2. General scheme of ventilation ducts**

There is a local automation system in every laboratory room. Automation of ventilation systems is characterized by a short-time response – 1…3 seconds. Indoor conditions of the rooms during some changes (e.g. after regulation of the size of fume hoods opening), the required air pressure balance in the rooms and constant air speed in fume cupboard holes will be restored after some seconds. The system of automation has several additional functions, such as to ensure the minimum main air exchange rate in the rooms (so-called standby conditions), signalisation about system disturbances and non-economical operation in part of the rooms to guarantee the required level of CO₂ concentration or indoor air temperature. Figure 3 illustrates the ventilation control system of a typical laboratory room.

**Figure 3. The ventilation control principle of a typical laboratory room**
RESULTS

To assess the operating systems and to achieve the established aims, there was conducted a special test of collaboration between fume cupboards and main ventilation, using air flow smoke to emphasize the effect. During this monitoring, CO₂ concentration and air temperature in the rooms and the air speed values in the fume cupboard openings were scrutinised.

In the educational laboratories the concentration of CO₂ stayed below the target value of 900 ppm during mass attendance of students (Fig. 4).

![Figure 4. The concentration of CO₂ in the room air of educational laboratories during a typical school day.](image)

The temperatures of indoor air stayed generally in between 21 ... 25 °C (Fig. 5).

![Figure 5. The temperatures of indoor air in different rooms.](image)

Smoke tests proved that necessary over/underpressure in between different rooms was predominantly assured. During significant changes of air amount in the ventilation system (the opening of numerous fume cupboard doors at the same time), necessary pressure balance stabilised after up to 10 seconds.

In the course of monitoring air movement speed in fume cupboard holes was measured during different usage regimens. Necessary speed (0,5 m/s) stabilised in the work holes after 1…5 seconds. Changing the positions of the fume cupboard doors in neighbouring rooms
connected to the ventilation system practically did not influence air speed in other fume cupboard holes connected to the same system.

The total heat energy consumption in 2006 of the building was 1 752 MWh and specific consumption was 222 kWh/m² (55 kWh/m³). There is no official statistics in Estonia on energy consumption of laboratory buildings. The specific consumption is in the same order of magnitude as the indices of Estonian dwelling fond. Considering the air exchange in laboratories is significantly larger than in dwellings, the achieved energy expenditure is satisfactory.

Results of monitoring demonstrate that investments into these ventilation systems were justified and the installed ventilation systems corresponds to our technical and sanitary-hygienic expectations.

CONCLUSIONS

From the viewpoint of both investments and operation, it’s expedient to prefer central ventilation systems. A great number of fume cupboards and other local exhaust devices can be connected into a global ventilation system – in case of the case study there were 60-70. Separate local exhaust ventilation systems have to be provided to extract dangerous and abrasive materials. With the help of special short-time response regulation valves and respective room-specific automatics system, necessary indoor air quality requirements can be guaranteed in the laboratories with reasonable investment- and operation costs. While designing such ventilation systems, long ventilation stub networks should be avoided.

REFERENCES