Inspection of ventilation systems

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Well-functioning ventilation is a prerequisite both for good indoor climate and for efficient use of energy in buildings, which both represent substantial economical values. Anyone who realizes the value of quality assured ventilation also realizes the importance of adequate ventilation inspections. Still there seems to be a need to promote inspection of ventilation systems by law enforcement.

Keywords: Ventilation function, air handling unit, air distribution, airflow rate, indoor climate, energy efficiency, measurement

A Swedish example of ventilation inspections

Since 1991 there is a legislative requirement for recurring ventilation inspections in Sweden. The inspections, denoted *Mandatory Ventilation Inspection* or *Obligatory Ventilation Control – OVK* (Boverket, 2021), have been extensively used as one of the tools for assuring a good built environment, which is one of the Swedish national environmental goals. The first inspection shall be carried out before any new ventilation system is taken into operation for the first time. Then, inspections shall be carried out on a regular basis. The building owner has a legislative responsibility that the inspections really are carried out according to the rules. One of the rules is that the inspections shall be carried out by personnel certified for the task.

The regular inspections shall be carried out either every 3 or 6 years, depending on the building type. Pre-schools, schools and health-care buildings shall be inspected with the shorter interval, 3 years. Multifamily buildings and office buildings with mechanical exhaust and supply ventilation shall also be inspected with the shorter interval. Buildings with natural ventilation, or mechanical exhaust ventilation only, shall be inspected every 6 years, except buildings with only one or two dwellings. Such small residential buildings shall be inspected when new, but there is no requirement for any recurring inspections.

At each inspection it shall be verified that:

- the ventilation system does not contain any pollution that may spread in the building,
- instructions and manuals are easily accessible, and
- the ventilation system works according to the intended function.

At the very first inspection it shall also be verified that the function and the properties of the ventilation system are in accordance with all relevant requirements from the authorities.

The recurring inspections shall comprise:

- verification that the function and properties mainly are in agreement with the requirements that were in effect when the system was taken into operation for the first time, and
- identification of measures that may be implemented in order to improve energy conservation without deteriorating the indoor climate.

The OVK as described above has been effective for 30 years now, and during recent years there is an ongoing debate regarding the effectiveness of the system. Recent review of the system shows that complete OVK-inspections in schools have been carried out in due time in only 30–40% of the municipalities. In every fourth municipality 25% of the schools have failed the inspection due to faults and deficiencies identified at the latest ventilation inspection. One problem in this context is claimed to be associated with lacking routines and resources at the municipal supervisory authorities.

To conclude, the system of OVK-inspections is definitely a valuable tool for the many building owners that have realized its value and, thus, are prepared to use it for quality assurance of the ventilation system function. Others appear to consider the system a burden, and when the supervisory authorities lack the strength to enforce the law, the system loses its potential. The ongoing debate can be expected to initiate reformation of the OVK-system.

Inspections to be founded already in the design-phase

Many building owners have realized that quality assured ventilation systems are a key both to good indoor climate and to efficient use of energy; conditions that represent high economical values. In this context the efforts by the Swedish National Network of Non-Residential Building Owners – BELOK are worth a closer look. Among many publications related to property management, the network has issued guidelines for both planning and conducting inspections (BELOK, 2015). Some main features of these voluntary guidelines are summarized briefly below.

A preliminary testing and inspections program should preferably be developed already in the early design-phase. The advantage is that the program will be developed with the ideas behind the selected ventilation system solution fresh in mind, which reduces the risk of misinterpretations and increases the chance that the inspections will comprise testing of all important functions. It is also a recommended practice for the design engineer to develop a check-list comprising any items that are of importance for the indoor climate control and for the energy efficiency. The intention is to provide the operating personnel with a tool that confirms correct ventilation operation, or reveals erroneous functions.

The check-list should be part of the instructions for operation, service and maintenance of the ventilation system. This documentation can be considered being a manual for the ventilation system, describing not only the overall principle, but all-important details about the intended operation. In addition to being a tool for the operation of the system, the manual will preserve information of importance when the building and/or ventilation system becomes subject to re-construction in the future. The manual would typically be developed by the ventilation design engineer, possibly assisted by the automation engineer, in case they are not one and the same. As a minimum, the manual should comprise:

- Function descriptions; of the system as a whole and of all sub-system (how the systems are intended to work).
- Instructions for operation and control of all sub-systems (how the systems shall be operated I practice).
- Principal diagrams and flow-charts (to facilitate the understanding of the two previous items in this list).
- A summary of set-points, times of operation etc.
- A list of sensors for control and for surveillance.
- Recommended procedures for calibration of sensors.

If a ventilation inspection is carried out without understanding of the information covered by the items in the list above, there is an imminent risk that the inspection will not really verify whether the ventilation system works without faults and deficiencies. This becomes increasingly important as ventilation control technology may move towards a higher degree of complexity.

The ventilation function shows the way

The basic cornerstones of ventilation inspection can be identified by considering the basic functions the ventilation is intended to provide, i.e. sufficient capacity to

remove both heat surplus and airborne pollution. To ensure these functions, it is necessary that the ventilation provides:

- Appropriate airflow rates
- Proper air distribution in the occupied zones
- Adequate supply air temperature
- Clean supply air
- Ventilation operation with respect to the times of occupancy

In addition, the ventilation system must be able to function without creating disturbances like noise and draft, which both may occur if the air velocity in some parts of the system becomes too high. This may be the case if the air flow rate is unnecessarily high or if the supply air devices are of inappropriate type or size.

Given the functions indicated above, it is clear that inspection of ventilation should comprise at least measurements of airflow rates and temperature levels. Indeed, also the remaining items in the list, i.e. air distribution, supply air quality together with the time of operation, must be checked. Parts of these checks can be made as visual inspections; others may require measurements.

A systematic approach

In order to establish a systematic approach to ventilation inspection it is suitable to divide a mechanical ventilation system into the three parts illustrated in **Figure 1–3**; The air handling unit, the air distribution ductwork and the air distribution in the room. Each of these parts are built up by the sub-systems and components indicated in **Table 1**. The table gives examples of important items that should be subject to inspection.

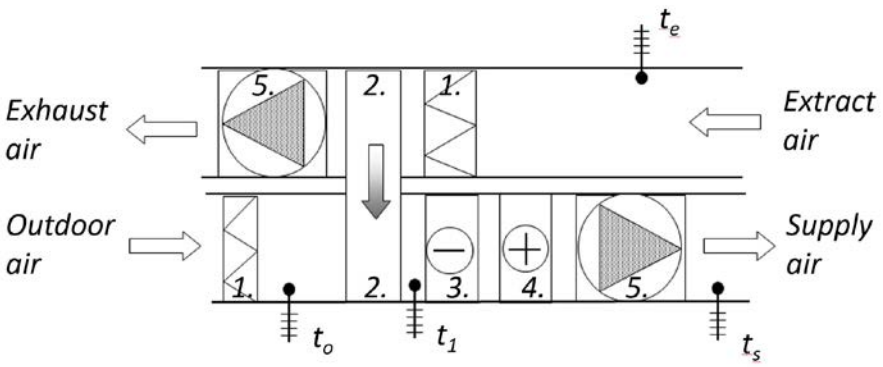

Figure 1. Sketch of an air handling unit for mechanical supply and exhaust ventilation. Components indicated: 1) air filter, 2) heat recovery unit, 3) cooling coil, 4) heating coil and 5) fan. Examples of items subject to inspection are given in Table 1.

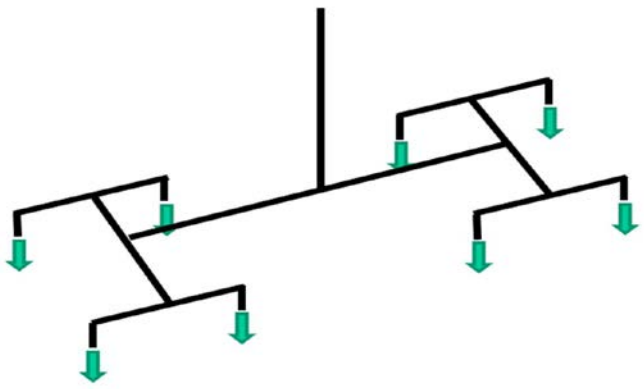

Figure 2. Sketch of supply air distribution ductwork. Components not shown: fire dampers, balancing dampers, airflow control dampers, airflow rate measurement devices, inspection hatches. Examples of items subject to inspection are given in Table 1.

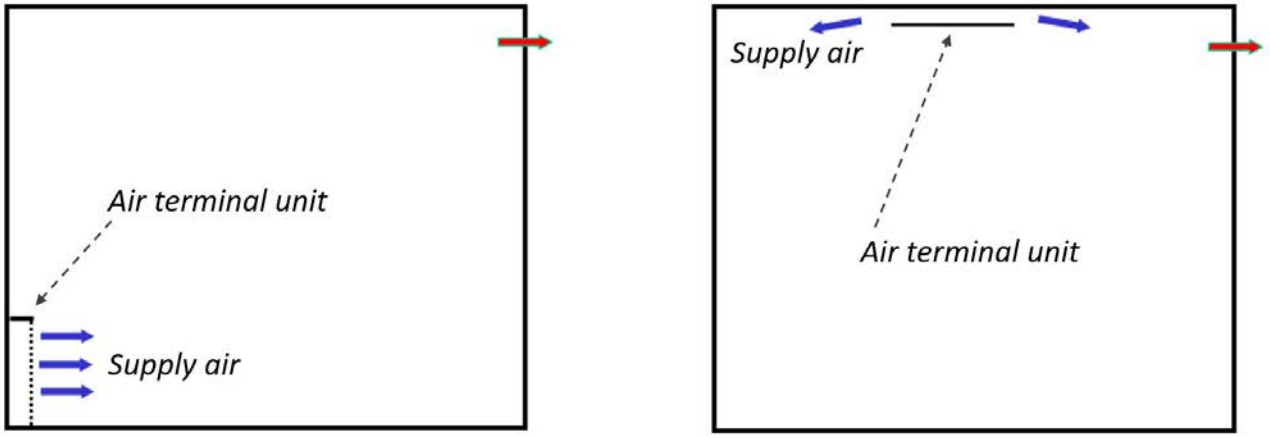

Figure 3. Sketch illustrating two different principles of room air distribution; displacement ventilation to the left and mixing ventilation to the right. Examples of items subject to inspection are given in Table 1.

Table 1. *The primary parts, sub-systems and components of mechanical ventilation systems requiring inspection.*

Primary part	Sub-system/component	Items subject to inspection
Air Handling Unit	Outdoor air intake	Cleanness, free opening, face velocity
	Air filter	Filter quality, status, pressure drop, age
	Heat recovery units	Capacity, efficiency, control functions
	Cooling and heating coils	Capacity, control-valve size and function
	Fans	Capacity, pressure vs. airflow rate, efficiency, control function
	Dampers	Air tightness, intended function (shut-off, flow control, fire-protection), control principle
Air distribution ductwork	Fire dampers	Air tightness class, automatic function
	Balancing dampers	Proper location and size
	Airflow control dampers	Proper location, size and control function
	Airflow rate measurement devices	Correctly located devices/dampers with suitable measurement range
	Possibilities for inspection of the interior surfaces	Inspection hatches, location, accessibility
	Interior cleanliness	Dust accumulation
Room air distribution	Type of air terminal units	Air-jet throw and drop (reaching across the room) Supply air velocity Low risk of draft sensation
	Locations of air terminal units	
	Supply air	Temperature according to design specification Airflow rate according to design specification and possible demand control function

Guidance regarding the practical inspection methods

The trade of carrying out ventilation inspections in practice requires thorough preparations by professionals with the right competence and experience, in order to ensure that sufficient accuracy of the results is obtained with a reasonable effort. For example, a seemingly simple task as carrying out airflow rate measurements in a ventilation system may comprise a massive amount of work if the system is big.

Obviously, the inspections must be carried out by personnel with sufficient qualifications and the assignment must be given an appropriate time-budget. Thus, the procurement of the inspection service is of great importance. The tender documents, including a clear requirement specification, must be developed by someone with good understanding of ventilation in general and the system subject to inspection in particular. Typically, a good suggestion is to give this responsibility to the ventilation design engineer.

Any inspection should preferably start by visual judgement of the status of the system and careful consideration of the required extent of any measurements. Guidance in this respect is provided by the Swedish chapter of ISIAQ, SWESIAQ (2017). Furthermore, detailed guidance for various measurement methods is provided by European and international standards, such as EN 16211:2015, EN 12599:2012 and ISO 12569:2017. Valuable method descriptions within the field of ventilation have also been published by Nordtest over the years. They are still available for download at http://www.nordtest.info. Take a look, just as an example, at Nordtest (1997) which specifies the method for measurement of indoor carbon dioxide and determination of the so-called local ventilation index.

Concluding remarks

The experience shared above indicates that enforcement of the law may not be the primary key to adequate ventilation inspections. Instead, it appears far more efficient to increase the awareness among the stake holders - in this context primarily building owners - that well-functioning ventilation is a prerequisite for good indoor climate and efficient use of energy, which both represent substantial economical values. Anyone who realizes the value of quality assured ventilation also realizes the importance of adequate ventilation inspections. ■

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