The Prevention of the Snow Entrance to the HVAC-systems

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SUMMARY

Entrance of snow into the HVAC-systems is common problem in the arctic- and sub-arctic climates and may cause moistening or wetting of filters and outdoor air chambers which promotes microbe growth. Blocking the filters also increases pressure drop or even damages the filters. The design features and velocity of air in the outdoor air intake play key role when the problems occurs. To eliminate the snow entrance into the HVAC-systems the face velocity of the outdoor air shall be below 1 m/s at the intake louvre. The pressure caused by wind is one of the external conditions that influence the snow penetration through the intake louvre and some solutions for elimination of this problem are presented. If the snow, however, is entranced to the HVAC-system good design and hygiene control of the intake section of the HVAC-system is important which is discussed more detailed in this paper.

INTRODUCTION

Supply air filters are designed for collection particles such as pollen and other bioaerosols from the outdoor air. The better the filtration is more efficiency the concentration of particles in the supply air decreased. Besides decreased particle concentration in the air, the dust accumulation on the duct surfaces is minimized with proper filtration. Microbes of the outdoor air accumulate to the filters and especially during the warm seasons the concentrations of microbes increased. In normal operation conditions when the HVAC-system is running the filter is dry and air velocity through the filter is high enough that microbes will loose their viability. The life times of the microbes on the filter vary from few hours to few days. Non-viable spores of fungi and bacteria stayed on filter are comparable to the other particles which are not considered to cause adverse health effects. However, spores of the microbes are able to activate when conditions on the filter turns favourable for the microbial growth. These conditions could be possible it the air humidity is high or the filters get wet by the rain water or the melted snow and the supply air fan is shut down. If massive microbial growth occurs on the filters some of the spores will be released to down stream of the filter. The microbial growth is also possible on other parts of the HVAC-system if the moisture is present.

Control of humidity or water entrance to HVAC-system is important because excess moisture will be a risk for microbial contamination of the system [1]. When outdoor air intakes of the HVAC-systems were dry the microbial contamination of the HVAC-systems were not observed. The transportation of microbes via supply air ducts from the outdoor air intake to the supply and indoor air has been reported [2]. Hansen [3] has concluded that dry and clean outdoor air intakes

are less likely to be microbiologically contaminated, and thus a good design and maintenance of the air intakes is a key factor for minimizing the risks from potential problems.

When the snow accumulates to the outdoor air chamber of the HVAC-system the surface of the snow can be at the same level than the outdoor air damper, ductwork and filter. In worst case the snow even totally blocks the outdoor air dampers and filters (picture 1). When the filter is blocked the supply air flow will decrease remarkably and the pressure difference in the building may be changed dramatically. This may cause serious indoor air quality problems in buildings like laboratories and hospitals. In some cases the pressure drop over the filter blocked with snow has increased so high that the filter has broken. The broken filter may release dust accumulated to the filter and this dust may spread to the supply and indoor air.

Picture 1. The filter blocked up with snow.

The humidity penetration to the HVAC-system is difficult predict because it is accidental and depends on weather conditions. In Norway 31 HVAC-systems were studied and in 15 of them supply air fans had humidity problems [4]. In our study we revealed a questionaire for the service people of about 270 HVAC-systems in Finland. Serious snow entrance problems existed annually on the average of 10 % (range 7-42%) of the studied HVAC-systems.

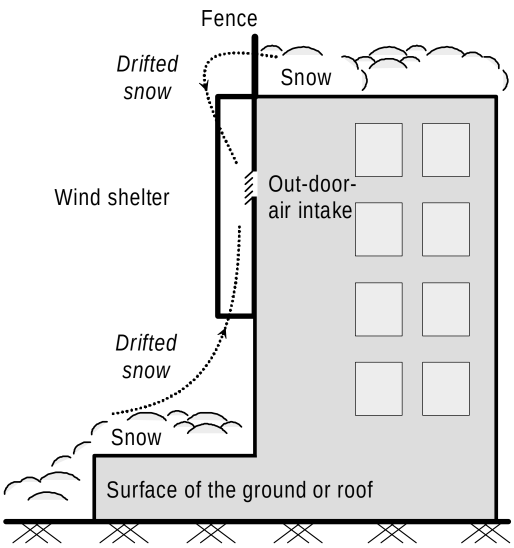
The penetration of the snow or rain water into the HVAC-system's outdoor air chamber is most probable in those where the face velocity of the air is too high and air intake is located incorrectly. The most serious problems in HVAC-systems are focused on the systems where the moisture penetrate through the air intake louvre and due to too high air velocity, too small outdoor air chamber or incorrectly located outdoor air duct the humidity drift to the filter.
The most serious snow entrance problems are detected in the HVAC-systems equipped with an alarm system which alarms when the pressure drop over the filter increases if outdoor air damper or the filter is fully or partial blocked up with the snow. In these cases, the alarms for pressure-drop indicate air flow limitation and malfunction of ventilation system. In the HVAC-systems which had not been equipped with the alarm system the snow entrance was difficult detect. These systems need checks of the outdoor air intake section after every snowfall.

DESIGN OF AIR INTAKE AGAINST THE SNOW ENTRANCE

Outdoor air intakes shall be located so that the outdoor air is as clean as possible. Instructions for location of the intakes have been given for example in Finish building code [5]. Also the maximum face velocity of the outdoor air on the intake shall not exceed 2 m/s.

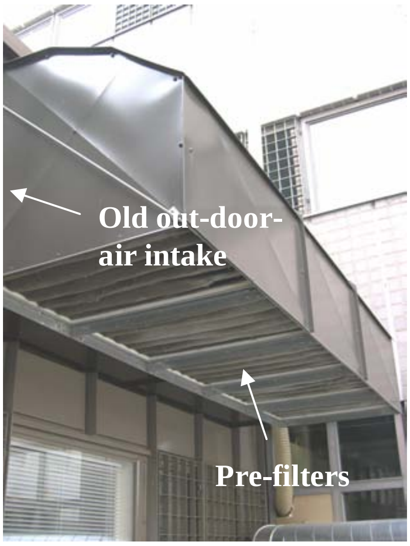
On the snowfall the falling speed of the snow flake is slow 0.2-1.0 m/s [6] and that's why the snow flakes drifts easily to the HVAC-system if the face velocity is too high in the air intake. Because of the slow falling speed the prevention of the snow penetration is more difficult than the rain water penetration and it is recommended that the face velocity of the outdoor air shall be below 1 m/s. If intake is located just above roof or ground, the snow will be driven to the system more easily (Picture 2). A proper location higher from the roof or ground levels prevents snow entrance. Also the wind shelters and fences could be used against the drifted snow (pictures 2 and 3).

The effect of the wind pressure on the penetration of the snow into the HVAC-system has not been studied, but effect might be remarkable because typical annually mean wind speed for example in Finland is 2.0-6.7 m/s and during stormy raining wind speed will be much faster. The pressure caused by wind may at times even exceed the pressure caused the supply air fan and that's why the air intake shall be located so that the wind pressure is low as possible. Good placements for air intakes are in inner yards of the building because the wind speed is typical lower than on outer facades. Also other buildings and plants especially conifers decrease the wind speed. The effect of the wind pressure could be reduced also with the wind shelters (Picture 2 and 3). The wind shelters shall be dimensioned wide enough or they shall be open only from bottom so that wind could not directly blow to the air intake. When the wind shelter is used it's important that the opening of the outdoor air intake is wide enough so that the air velocity and pressure at the opening is not too high.




Pictures 2 and 3. The wind shelters and the fence against the drifted snow and wind pressure.

There are many commercial prevention solutions for the snow and rain water penetration which are based on the mechanical separation or/and melting of the snow. The function of **mechanical louvres** based on the separation of the water and snow particles to the air flow with the labyrinth construction of the louvre. In some mechanical louvres **electric heating devices** are also used which melt the snow and increases louvre's prevention efficiency for snow. The function of the **needle heat exchanger** is also based on the melting of the snow and separation of the snow and melted water to the air flow. On the needle heat exchangers the needed energy is transferred from the exhaust air. **Pre-filters** are also applied for of snow penetration and for example the method in picture 4 is used for prevention of the snow entrance. With this solution one of very difficult snow penetration problem has solved. During the snow fall snow is collected to the pre-filter and after the snow fall snow will drip from the filter.



Picture 4. The pre-filter used for prevention of the snow entrance.

THE MINIMIZING OF THE PROBLEMS CAUSED BY THE MOISTURE AND SNOW PENETRATION

The outdoor air chamber shall be large enough to prevent the snow entrance to the supply air filter and into the HVAC-system which allows to snow settle down to the bottom of the chamber. For dimensions of the outdoor air chamber are not given in any instructions but size of the chamber shall be in relation to the air flow rate. The outdoor airduct and damper shall be located to the upper part of the chamber which increases the efficiency of snow capture in the chamber. The melt water shall be sewed from the chamber and the bottom of the chamber shall slope to the drain. However the enlargement of the outdoor air chamber is often difficult and expensive renovation solution because the chamber shall re-located. The hygiene of the outdoor air chamber shall taken account and all unnecessary material and debris shall be removed from the chamber. The coating material of the chamber's ceiling, walls and especially floor shall be hygiene, easily cleanable and moisture-resistant because on the dirty and moist materials are increases the risk of the microbial growth. For the same reason porous sound attenuation material in the outdoor air chamber is not recommended if there is the risk of the moisture penetration.

The snow entrance to the filters located too near of the outdoor air intake and chamber is more probable because the snow has no time to settle down before the filter. However if there is long outdoor air duct between the outdoor air chamber and filter care shall be taken for drainage of the melted water from duct. To ensure proper drying of the filter it shall install so there is no contact with the bottom of the filter chamber even when supply air fan is turned off. The operation time of the HVAC-system has effect to the moisture and the microbial contamination of the filters and it is concluded that the continuously operated HVAC-system creates less favourable conditions for microbial growth in filters than does the periodically operated system [7].

THE INSTRUCTIONS IF SNOW OR MOISTURE IS PENETRATED TO THE HVAC-SYSTEM

If the snow or moisture entrance to the HVAC-system and filters are filled up with the snow:

1. Supply air fan shall turn off
2. Wet or snowy filters shall remove as soon as possible
3. Filter shall be changed
4. Outdoor air chamber, -damper and other components of the HVAC-system shall check and snow and moisture shall remove
5. Supply air fan shall turn on

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