IN-SITU TESTING OF VENTILATION AIR INTAKE LOUVERS SUBJECTED TO SNOW

O Kristiansen[1*], S O Hanssen[2] and J Stang[3]

[1] Lars Myhre AS, Oslo, Norway
[2] Norwegian University of Science and Technology, Trondheim, Norway
[3] SINTEF Energy Research, Trondheim, Norway

ABSTRACT
The ventilation air intake is the first line of defence against an unfavourable outdoor climate. Previous studies have shown that it often is a neglected component which can result in unwanted intrusion of rain and snow. In Norway and other areas with similar climatic conditions, snow is a major problem. In order to study the performance of louvers available on the market with respect to snow penetration, we have tested 10 louvers of 4 types in an in-situ test rig. Each louver was fitted into an opening of 0,6m x 0,6m, and the air speed through the gross area was 1,7m/s. The penetrated snow was collected in bag type air filters downstream of each louver. Increase in pressure drop between the front of the louver and downstream of the snow collection filter was used as a measure on snow penetration in order to rank the louvers. A louver with a complex flow profile and an electric heating cable performed significantly better than ordinary louvers.

INDEX TERMS
Ventilation, Outdoor air intake, Louvers, Snow penetration, In-situ testing

INTRODUCTION
The ventilation air intake is the first line of defence against an unfavourable outdoor climate. Unfortunately, the component is often a neglected part of many heating, ventilation and air conditioning (HVAC) systems. Underestimating the importance of the air intake may cause intrusion of rain and snow into the system. Furthermore, this can imply risk of corrosion of components and surfaces in the system, water leaks in the building as well as unwanted growth of microorganisms in sedimented dust and debris. Corrosion of HVAC systems and water leaks deteriorate the technical installations and the building structure while unwanted microbial growth can cause indoor environmental problems and possible adverse health effects.

Previous studies (Armstrong 1993, Lysne, Ahlén, Stang et al. 1999 and Kristiansen, Hanssen, Stang et al. 1999) have shown that snow penetration through ventilation air intake louvers is a major problem in Norway and other areas with similar climatic conditions. In order to test ordinary louvers available on the market with respect to snow penetration, we have selected 10 louvers of 4 types and tested them in an in-situ test rig during the winter 1999/2000.

METHODS
Description of the test rig
In order to study the performance of air intake louvers subjected to snow, we have modified and used a test rig originally made for exposure tests of ventilation air filters. The test rig was

* Contact author email: ornulfk@larsmyhre.no

made as a roof mounted ventilation unit (2,8m x 2,9m x 7,5m) and placed on the roof of a building on the university campus in Trondheim. The unit was 0,9m above the flat roof, which was 10m above the ground. There was no obstructions between the inlet of the unit and the edge of the roof which could disrupt the air flow.

Previously, when the test rig was used for air filter testing there was two louvered doors in the front (2,8m x 2,9m). When testing air intake louvers, the doors were opened so they work as a louvered wall (1,4m x 2,9m) on each side of the rig. It was possible to test 10 different louvers which were made to fit into an opening of 0,6m x 0,6m simultaneously. A sketch of the front of the rig is shown in figure 1.

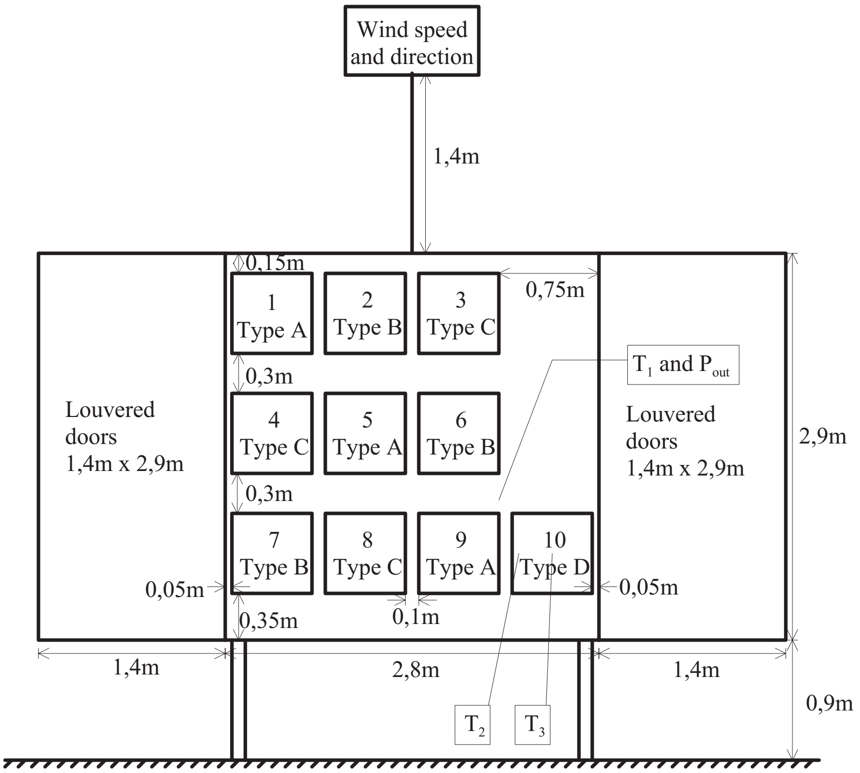

Figure 1. Sketch of the front of the test rig with the air intake louvers (0,6m x 0,6m) numbered from 1 to 10. Measuring points for temperature (T_1, T_2 and T_3), air pressure (P_{out}), wind speed and wind direction is also indicated.

Snow that passed through each of the test louvers was collected in separate bagfilters made of synthetic organic material (class F7 according to CEN EN 779 from Camfil). Each filter had a surface area of 7,8m^2 which was sewn into 10 pockets or bags. The filters were placed 0,6m behind each louver. The increase in pressure drop between the front of the louvers (atmospheric pressure) and downstream of each filter was used to measure how snow was collected in the filters. The pressure differences were measured with a Rosemount differential pressure cell, type 1DR2F22 with measuring range 0-700Pa. A PC and a connected Fluke Hydra data logger (type 2625) controlled 10 magnetic valves that switched between the different pressure measurements in a continuos sequence. Measurements were made every minute, which means that each pressure was measured every 10th minute.

This set-up did not give absolute values with respect to how much snow that was passing through each louver, but it was possible to rank and compare the louvers. The collected snow sublimated or melted between larger snowfalls so the measurements could run continuously.

The wall with the 10 louvers was directed towards south-southwest. Individual flow controllers were placed downstream of each set of louver and filter in order to maintain equal air flows when the pressure difference varied due to snow accumulation. The flow controllers were of the type Trox RN 31.

Downstream of the flow controllers, the air went though a plenum and a sound attenuator to the fan. After the fan there was another sound attenuator and an exhaust louver. A principle sketch of the test rig is shown in figure 2.

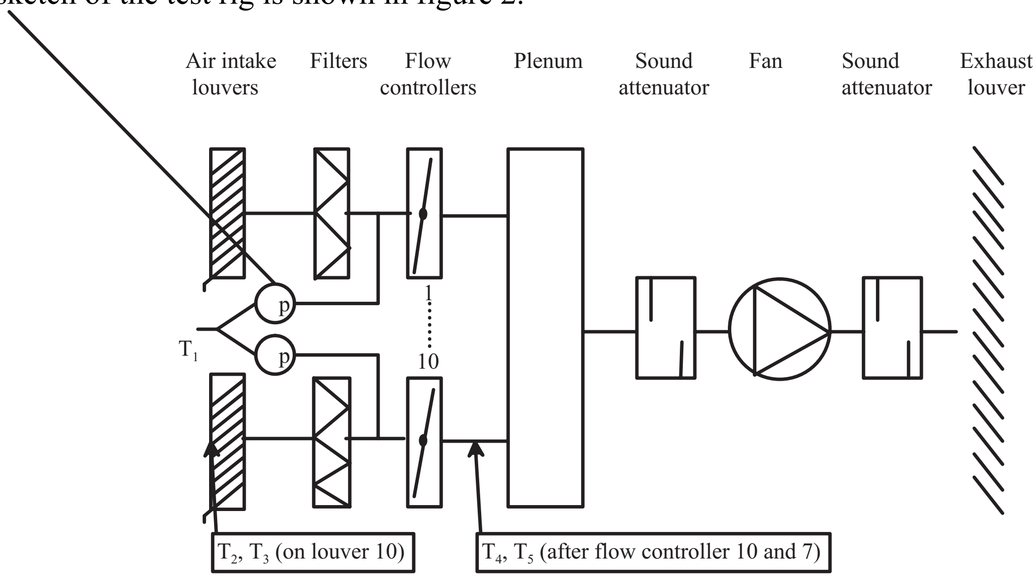

Figure 2. Principle sketch of the components in the test rig. The location of the measuring points for temperature and static pressure is indicated.

Equipment for measurement of wind speed and wind direction was placed 1,4m above the centre of the rig in order to determine whether the local wind conditions had any effect on the intrusion on snow in the rig or not. The wind speed was measured with a Theodor Friedrichs & Co. type 4201 and the wind direction was measured with a type 4121. The horizontal distance between them was 0,7m.

The temperature was measured in five different places with thermocouples type T. Their locations are indicated in figure 1 and 2. A short description of each of them is below. Louver 10 is the only one with heating cable.

T_1: Air temperature at the inlet of the test rig.
T_2 and T_3: Temperatures on the heating cable of louver 10 as an indicator of snowfall.
T_4 and T_5: Air temperatures after the flow controllers of louver 10 and 7 in order to see any increase in the air temperature due to the heating cable.

Test objects
10 louvers of four different types (3 of A, 3 of B, 3 of C and 1 of D) were tested. A, B and C had, according to leading HVAC consultants in Trondheim, been recently used in their projects. Type D is marketed against snow problems. The louvers were made to fit into an

opening of 0,6m x 0,6m. Their location in the rig is indicated in figure 1, and a short description of them is made below.

Type A: 10 vertical louver blades with a depth of 22cm
Type B: 11 horizontal louver blades with a depth of 8cm
Type C: 14 horizontal louver blades with a depth of 5cm
Type D: 2 layers of vertical louver blades with a depth of 13cm. Integrated electric heating cable, 780W.

RESULTS

We logged pressure drop, temperatures and wind data in the test rig from 12 Nov 1999 to 28 Nov 2000. The flow controllers were checked before and after the test, and the mean air speed through the gross area (0,6m x 0,6m) of each louver had been 1,7 m/s.

The results from 11 Feb 2000 to 24 Feb 2000 are presented as a representative example of the performance of the louvers. Figure 3 and 4 shows the increase in pressure drop over a set of louver and filter on the upper curve (with the average pressure drop on 15 Feb 2000 as the 100%-level) and the temperature on the heating cable (T_2) on the lower curve. The drops in temperature indicate periods with snowfall. The accumulated snow in the filters melted or sublimated between each major snowfall. The louver in figure 3 is a representative example of one of the "ordinary" louvers (type A, B and C which performed almost similar). The louver in figure 4 is type D with heating cable and a complex air flow profile.

The increase in air temperature due to the heating cable of louver 10 (780W) is 0,8°C compared to louver 7. The temperatures were measured at the inlet of the rig and near the outlet from the flow controllers (see figure 2 for details).

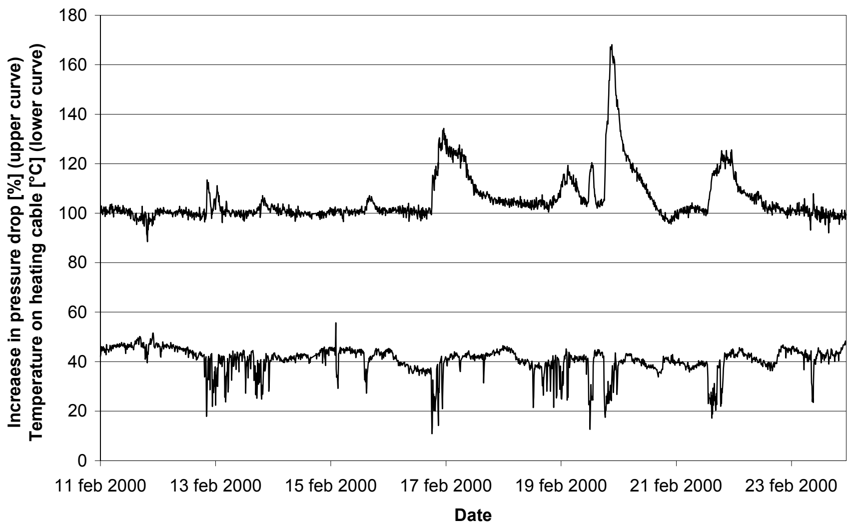

Figure 3. Increase in pressure drop over an ordinary louver and filter on the upper curve (with the average pressure drop on 15 Feb 2000 as the 100%-level) and the temperature on the heating cable (T_2) on the lower curve in order to indicate periods with snowfall.

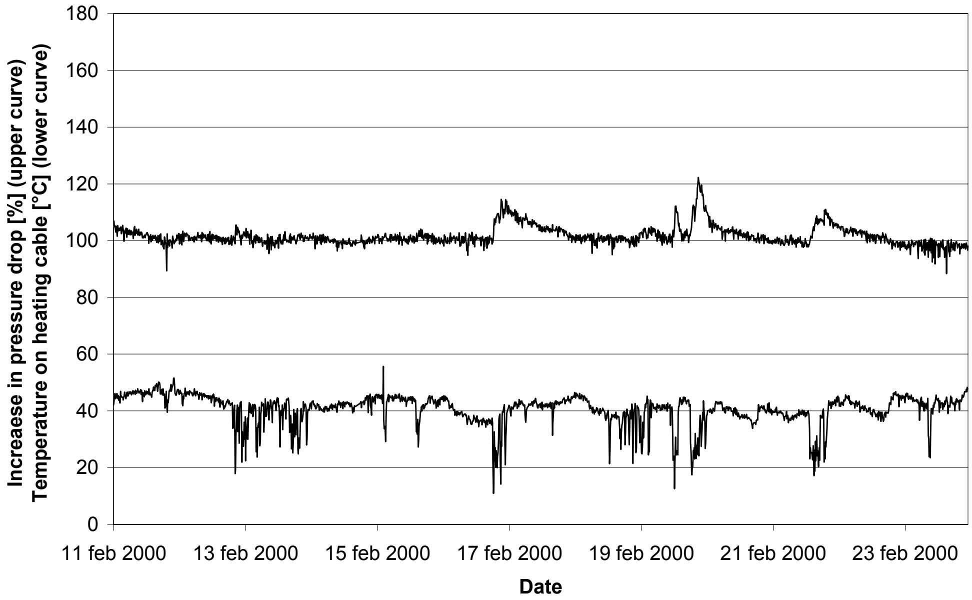

Figure 4. Increase in pressure drop over the louver with heating cable and its filter on the upper curve (with the average pressure drop on 15 Feb 2000 as the 100%-level) and the temperature on the heating cable (T_2) on the lower curve in order to indicate periods with snowfall.

DISCUSSION AND CONCLUSION

The results indicate that the louver with heating cable and a complex flow profile performed much better than the other louvers at an air speed through the gross area (0,6m x 0,6m) of 1,7m/s. The result seems to be a combination of the louver design and the use of heating cable to melt snow. There were no effects of location in the rig (e.g. high/centre/low or left/centre/right) on the results. Due to little wind during the snowfalls, it was not possible to conclude whether the wind effects increased the snow penetration or not.

In the test, the heating cable has been on continuously regardless of snowfall. When used in HVAC systems it is important to control the cable in order to save energy. One can use a snow sensor or simply turn it off when the outdoor air temperature rises above a certain limit (e.g. 0°C or +2°C) depending on local climatic conditions.

ACKNOWLEDGEMENTS

ABB Miljø and the Research Council of Norway are highly acknowledged for their financial support in the beginning of the project.

REFERENCES

Armstrong R S. 1993. HVAC design considerations for cold climates. *ASHRAE Journal*. Vol 35, No 9, pp 22-28.

Kristiansen O, Hanssen S O, Stang J et al. 1999. Ventilation air intake – first line of defence against an unfavourable outdoor climate, *Proceedings of the 8th International conference on Indoor Air Quality and Climate – Indoor Air '99*. Vol 5, pp 61-62. Edinburgh: Indoor Air '99.

Lysne H N, Ahlén C, Stang J et al. 1999. Hygienic conditions in ventilation systems and the possible impact on indoor air microbial flora, *Proceedings of the 8th International conference on Indoor Air Quality and Climate – Indoor Air '99*. Vol 2, pp 220-224. Edinburgh: Indoor Air '99.