# Implementation of a ventilation system with clean installation method

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**ABSTRACT**
It is showed that side grinder produce significantly metal sheet dust onto the inner surfaces of ventilation ducts. New, cleaner installation method was developed in which shears are used as installation tools. The aim of this study was to carry out ventilation system installations at three building sites with clean installation method and to collect information about operating characteristics of the shears by interviewing assembly workers.

The results of dust measurements showed that the average amount of dust on the inner surfaces of supply air ducts was very low in all three buildings. Assembly workers considered that shears were applicable tools for installations and they were willing to use seam metal shear also in the future. By changing the working habits and tools, cleaner ventilation systems can be implemented and safer working environment provided. As a result of this study installation manual for clean ventilation system was published. The installation manual gives instructions how to implement clean ventilation systems in practice.

**INDEX TERMS**
Ventilation system, Duct, Installation, Dust, Sampling

**INTRODUCTION**
Cleanliness of ventilation system ducts and accessories during building process was studied at three office building site during 1998-1999. The study showed that highest dust loads were accumulated during the storage and installation of the ventilation ducts at the building site and the most important impurity in the ducts was the metal sheet dust produced while side grinder was used for cutting the ducts (Luoma, 2000). During 2000-2001 clean installation method for ventilation ducts was developed (Luoma and Kolari, 2002) by the use of which the new national ventilation cleanliness class can be achieved (FiSIAQ, 2001). The laboratory tests and field experiments showed that the side grinder widely used nowadays in Finland can be replaced with shears. Shears do not produce metal sheet dust, do not sparkle and are not as noisy as the side grinder. Also, the speed of work and work safety is good with the shears. The operating characteristics of the shears were appraised well and the assembly workers were satisfied with the new method.

The aim of this study was to carry out ventilation system installations at three different building site with previously developed clean installation method and to collect information about operating characteristics of the new installation tools by interviewing assembly worker's. As a result of this study installation manual for clean ventilation system was published. The installation manual gives instructions how to implement clean ventilation systems in practice.

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## METHODS

### Buildings under construction

Three buildings under construction were chosen to this study. Building 1 was a rehabilitation centre's renovation site, which cleanliness class demand was P1. Building 2 was a new office building, which cleanliness class was P2, but instead of that ventilation system installations were carried out following demands in P1 class. Building 3 was school's renovation site, which cleanliness class was P1. Office building was the largest building and the length of ventilation system ductwork was about 6 km. The length of ductwork in rehabilitation centre was about 450 m and at school 1,5 km.

### Installation tools and the installation guide

For all three building sites two new installation tools were given, one of each shear type (seam metal shear and gauge shear). Shears were the same, which were showed to be the most suitable tools for ventilation installation in the previous study (Luoma and Kolari, 2002).

During the construction time at building site 1 mainly two assembly workers were doing the ventilation system installation. Assembly workers were showed how to use properly the shears. They were also given the installation guide, where instructions for handling, storing and protecting the ventilation system ducts were given. Side grinder as an installation tool was prohibited to use in building sites 2 and 3. In building site 1, side grinder was allowed, but it was not used. In building site 2, side grinder was used to cut the biggest ducts in the building, because the sheet in those ducts was too thick for shears. Cutting the biggest ducts were done outside the building.

### Interviews, checklist and dust accumulation measurements

Information about the aims of this study and demands of cleanliness class P1 were given to building developer, contractor's of ventilation installation and procedure control people at meetings arranged at each building site. The checklist concerning supervising of implementation of clean ventilation system with clean installation method were given to procedure control people (Alén and Kolari, 2002). The checklist included instructions about storing ventilation ducts and accessories, installation work, protecting ventilation ducts and accessories during installation work and instructions about general cleanliness of building site. After the ventilation systems installation work were done, building developer, contractors of ventilation installation work and procedure control people were interviewed. They were asked questions about ventilation duct installation work, installation tools, general cleanliness of building site, cleaning of ventilation ducts and using the checklist. According to information received in those interviews, installation guide for clean ventilation practise was prepared (Alén and Kolari, 2002). Assembly workers were asked to estimate the operating characteristics of the shears. The workers estimated the following characteristics: work safety, noisiness, handling, effectiveness, and work speed. Assembly worker's interviews gave new information about operating characteristics and using comfort of installation tools.

Dust accumulation rates on the inner surfaces of supply air ducts were also measured. Measurements were made before functional test of ventilation system. In building 3, dust accumulation rates were measured three times during construction work. The first measurements were carried out immediately after ventilation ducts and accessories were delivered to building site from factory. The second measurements were made before functional test and the third measurements were made during building commissioning. Dust accumulation rates were measured by using vacuum test method (Pasanen *et al*. 2001).

## RESULTS

### Interviews of assembly workers

Assembly workers had been used shears to cut the ventilation ducts and to make access doors. Knife, spike or drill was used to make the opening holes in to the ducts. Assembly workers estimated that the shears were more quiet and more safety than side grinder. Handiness and weightiness of the shears were the best characteristics according to assembly workers. They also noticed that tools did not spark.

Assembly workers experiences of seam metal shear were quite similar. They thought that seam metal shear is suitable tool for installation work for ducts which diameter is smaller than 500 mm. In building 2, seam metal shear's blade had gone broken during the installation work. Some of assembly workers thought that seam metal shear is suitable tool for installation work for ducts which diameter is smaller than 315 mm. Assembly workers had also noticed that shears were not suitable tools for cutting grease ducts, which are commonly being used as exhaust ducts in kitchen.

Gauge shear shared assembly workers opinions more than seam metal shear. Some of assembly workers thought that gauge shear was more ineffective and more difficult to handle than seam metal shear. They also thought that gauge shears were suitable for cutting ducts but not making access doors. Gauge shears seemed to be suitable for cutting ducts smaller than 315 mm by diameter. Some of assembly workers thought that gauge shear is not suitable tool for installation work for any kind of ducts, because it's blades strands easily into the joints. All assembly workers had used much more often seam metal shear than gauge shear. They all were more willing to use seam metal shear in the future as an installation tool than side grinder.

### Characteristics of the tools and their suitability for ventilation installations

Assembly workers were asked to estimate the operating characteristics and using comfort of the shears. Using side grinder was not allowed in building site, but all assembly workers had used it before. Figure 1 shows average estimations of operating characteristic and using comfort reported by assembly workers. Operating characteristics were estimated by scale 1-5. Number 1 means that tool was "bad" by the asked character. Number 5 means that tool was "good" by the asked character. Six assembly workers estimated characteristics of seam metal shear. Four assembly workers estimated characteristic of gauge shear and five characteristics of side grinder, respectively.

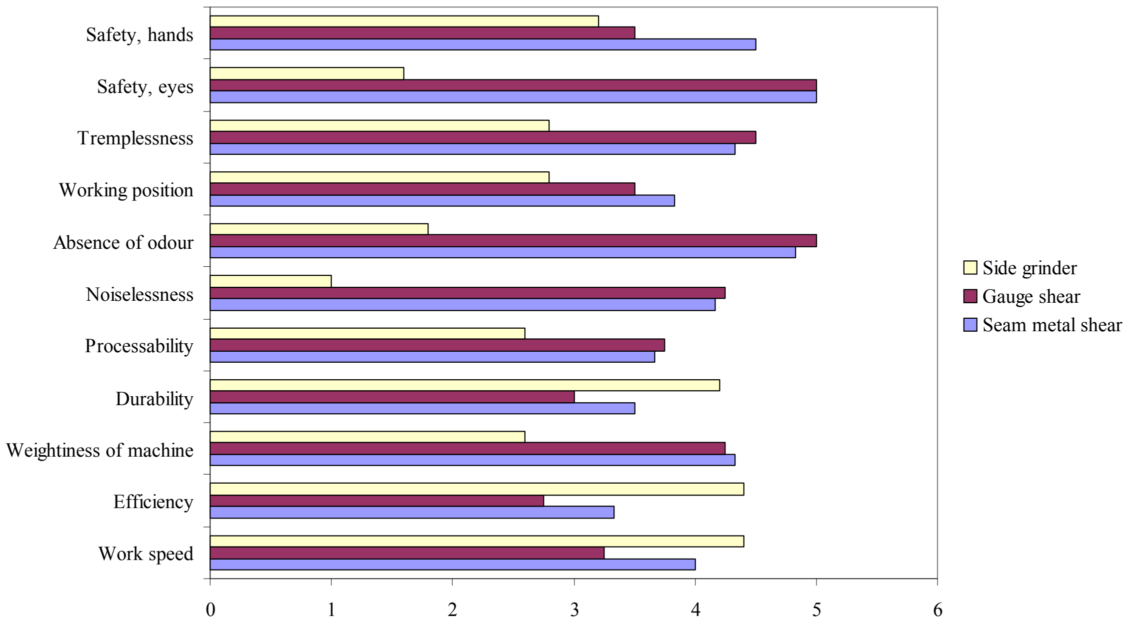


Figure 1. Operating characteristic and using comfort estimated by assembly workers. Scale 1-5, in which 1=bad, 3=neutral and 5=good.

**Dust accumulation rates**

Dust accumulation rates on the inner surfaces of ventilation ducts was also measured. Table 1 summarise averages and ranges of dust accumulation rates.

Table 1. Dust accumulation rates ($g/m^2$) measured at three building sites.

| Building | Cleanliness class | Measuring time | Dust accumulation rate ($g/m^2$) |
|---|---|---|---|
| 1 | P1 | Before functional test | 0,2 (<0,1-1,7) |
| 2 | P2 | Before functional test | 0,4 (<0,1-5,5) |
| 3 | P1 | After factory delivery | <0,1 (<0,1-0,1) |
| 3 | P1 | Before functional test | <0,1 (<0,1-0,5) |
| 3 | P1 | Building commissioning | 0,1 (<0,1-0,3) |

**DISCUSSION**

In this study installation tools did not differ from each other much by operating characteristics or using comfort (Figure 1). Both shears were experienced more safety and comfortable to use than side grinder. Working comfort with shears were also experienced better than working with side grinder. On the other hand, side grinder was held more durable and more efficient than shears. Working speed with side grinder was also experienced better than with shears. Although there was no major differences in operating characteristics and using comfort within the shears (Figure 1), assembly workers expressed very clearly that seam metal shear was a better tool and they used it more often than gauge shear. All assembly workers in this study wanted to use seam metal shear in the future as an installation tool much rather than side grinder. Still side grinder will be used to cut bigger than 500 mm by diameter ducts. In that case, it must be ensured that inner surfaces of ducts are clean before installation.

According to the Finnish Classification of Indoor Climate (FiSIAQ, 2001), the dust accumulation on the inner duct surfaces of a new ventilation system may not on average exceed 1.0 $g/m^2$ in class P1 measured using a pre-weighted filter cassette (Pasanen *et al.* 1992). On the contrary, in class P2, the dust accumulation on inner duct surfaces of a new ventilation system may not exceed 2.5 $g/m^2$ (FiSIAQ, 2001). In all building sites ventilation ducts dust accumulation rates were under the demand of cleanliness class P1 (Table 1). In buildings 1 and 2 measured values varied more than in building 3. Variation of measured values was related to single samples. Eleven samples were taken from building 1 and 39 samples from building 2, respectively. One sample in building 1 contained a little piece of metal, which raised up the mass of sample and thereby the average dust accumulation rate. Four samples in building 2 crossed the demand of cleanliness class P1. The biggest value was measured on the inner surface of rectangular duct. That sample contained sand and wool. The three others, which values were bigger than 1,0 $g/m^2$ contained white grains and brown fibrous powder. It was noticed that protection of ducts was not succeeded properly in building 2. At the same time with installation work of ventilation ducts grinding of walls and floors were made at building site. The interviews made in building 2 turned out that if all people in the building site do not understand the meaning of protection of the ventilation ducts and work for cleaner ventilation system, the clean ventilation system without cleaning may not be reached.

The building 1 was a very good example of building site where all people were internalised the meaning of protection the ventilation ducts. In building 3 dust accumulation rates were measured three times during construction work. Dust accumulation rate was <0,1 $g/m^2$ after factory delivery (Table 1). The dust accumulation rate on the inner surfaces of new ventilation ducts and accessories may not exceed 0,5 $g/m^2$ in factory (FiSIAQ, 2001). In this building average dust accumulation rates did not really change during the construction work.

## CONCLUSION AND IMPLICATIONS

It can be concluded that a clean ventilation system can be reached by using the clean installation method. Assembly workers, contractor's of ventilation installations, building developers and even users of the building benefit from this method. Assembly workers occupational safety and working comfort amends. Contractor's of ventilation installations and building developers benefits of lower expenses. Expenses get lower when ventilation ducts do not have to be cleaned before taking the building to use.

Reaching the clean ventilation system requires that all people working in building site be committed to work for clean ventilation system. The installation guide, which was developed in this study, was planed to help for implementation of clean ventilation system.

## ACKNOWLEDGEMENTS

This study was carried out as a part of the Clean Ventilation Systems project, which was funded by National Technology Agency (Tekes), Finnish industry and participating research organisations. The Clean Ventilation Systems project has been a part of the Healthy Building Technology Programme.

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