DEVELOPMENT OF A CLEAN INSTALLATION METHOD FOR VENTILATION SYSTEMS

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ABSTRACT
Ventilation ducts and accessories have been shown to get dirty during the storage and installation at the building site. Most important factor that makes the inner duct surfaces dirty is the metal dust that is accumulated while side grinder is used to cut the ducts. The aim of the study was to develop a clean installation method for ventilation ducts, by the use of which the new national ventilation cleanliness class can be achieved. 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 are good with the shears. The operating characteristics of the shears were appraised good and the assembly workers were satisfied with the new method.

INDEX TERMS
Ventilation system, Duct, Installation, Office building, Clean, Dust, Supply air

BACKGROUND
The Finnish Classification of Indoor Climate (FiSIAQ 2001) is aimed to be used as a help for designing, contracting and building healthy and comfortable buildings. The guidelines consist of two cleanliness classes for ventilation systems, P1 and P2. The purpose of the cleanliness classification for ventilation systems is to make sure that the supply air is clean and does not contain substances harmful to health, unpleasant odors or particles.

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).

Many factors contribute to the dust accumulation rate of a newly constructed ventilation system, such as manufacturing, transportation, and storage of ventilation ducts and accessories, quality of assembly workmanship, general tidiness of the building site and whether the open ends of ducts are shielded after the assembly. It has been noticed that dust accumulation on the ventilation components coming from the factory line is low (<0.1 g/m^2, Luoma 2000). The highest dust loads accumulate during the storage and installation of the ventilation ducts at the building site (Luoma 2000). The most important impurity in the ducts is the metal sheet dust produced while side grinder is used for cutting the ducts. At certain sites, considerable amounts of metal sheet dust can be found in the ducts and usually it is not removed from the duct after assembly work.

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The aim of this study was to develop an installation method for ventilation system that fulfills the requirements for the cleanliness class P1 (FiSIAQ 2001). Furthermore, the purpose of the study was to promote the implementation of the new method in the assembly work of ventilation systems.

METHODS

Testing the tools in laboratory settings

The aim of the laboratory tests was to investigate, whether such tools exist, that do not produce metal sheet dust and thus could be used in clean ventilation assembly. A portion of the tools tested were typically used in assembly work in Finland and a portion were such that they would fit to the ventilation assembly. Tools tested were: side grinder, seam metal shear, two nibblers (1 and 2), gauge shear and sheet metal scissors.

Metal sheet ducts of three diameters (125 mm, 315 mm, 500 mm) were used in the tests. The ducts were shielded before the tests. The duct was cut three times with each tool and three assembly doors were made. A professional assembly worker was doing the work.

The amount of metal sheet dust generated during cutting of the duct and making the hole for the access door was measured using a pre-weighted filter cassette (Pasanen et al. 1992). The samples were collected from an area of 250 cm^2 by sucking the sample with a pump to a filter cassette. Samples were collected from the duct diameter 315 mm. Three samples were collected from a duct that was not cut.

The time period for cutting and making the assembly hole was measured and the amount and quality of the metal sheet dust generated were assessed by naked eye. The professional assembly worker was asked to estimate whether the tools were suitable for the work.

Testing the tools at a building site

The laboratory tests showed that the most suitable tools for the assembly work were the seam metal shear and gauge shear and these tools were tested at a building site of a university hospital. This building site was categorized to cleanliness class P1.

At the basement floor of the university hospital, the side grinder was used in assembly work, and the holes to the ducts were made mainly by using sheet metal scissors. In the first floor, the cutting of ducts and making holes to the duct walls were done by using shears. Just a few holes were made by sheet metal scissors.

The cleanliness of the ventilation system was estimated by naked eye and measurements of dust accumulated. Dust samples were collected from an area of 120-200 cm^2. Samples were collected from both floors (totally 20 samples). Samples were collected from supply and exhaust ducts through terminal device openings and access doors.

Two assembly workers were working at the building site, and they were asked to estimate the operating characteristics of the shears. The workers estimated the following characteristics: work safety, noisiness, handling, effectiveness, and work speed.

RESULTS

Dust accumulation rates and visual estimates in laboratory tests

The average dust accumulation rates by using seam metal shear, gauge shear and sheet metal scissors were less than 0.1 g/m^2 (Table 1). Also estimated by naked eye, the inner duct surface was clean after the cutting. Nibbler 2 and side grinder generated equal amounts of metal sheet dust, but the type of metal sheet dust was different. The side grinder generated fine dust, which spread far away in the duct. Nibbler's dust consisted of small moon-like pieces, which could be removed from the duct by lifting it. Nibbler 1 produced high dust accumulation (237.7 g/m^2), which contained rough metal burr. The dust accumulation of clean duct was low (<0.1 g/m^2).

The dust loads accumulated during making the assembly hole were <0.1 g/m^2 with seam metal shear, nibbler 2 and sheet metal scissors. By nibbler 2 the low accumulation rate was due to the fact that the dust was settled outside the duct.

Table 1. The amount of dust produced in the cutting of duct (diameter 315 mm) and making assembly hole with different tools.

	Dust accumulation rate (g/m^2)*	
Sheet metal tools	Cutting of a duct	Making assembly hole to the duct wall
Side grinder	18,2	–
Seam metal shear	< 0,1	< 0,1
Nibbler 1	237,7	26,1
Nibbler 2	23,4	< 0,1
Gauge shear	< 0,1	< 0,1
Manual sheet metal scissors	< 0,1	< 0,1

* Average of three measurements.

Suitability of the tools to ventilation installations

The assembly worker estimated the suitability of the tools for cutting a duct and making assembly hole to the duct wall (Table 2).

Table 2. The suitability of different tools to cutting a ventilation duct and making an assembly hole to the duct wall based on assembly worker's estimation.

Tool	Cutting a ventilation duct			Making an assembly hole to the duct wall		
	Duct diameter			Duct diameter		
	125 mm	315 mm	500 mm	125 mm	315 mm	500 mm
Side grinder	+	+	+	–	–	–
Seam metal shear	+	+	+	+	+	+
Nibbler 1	+	+	+	+	+	+
Nibbler 2	+	+	–	+	+	–
Gauge shear	+	+	–	+	+	–
Manual sheet metal scissors	+	+	–	+	+	–

+ = Suitable, - = Not suitable.

In cutting the duct, side grinder, seam metal shear and nibbler 1 were suitable for the work in all three duct diameters. Nibbler 2, gauge shear and manual sheet metal scissors were suitable for diameters 125 mm and 315 mm, but the duct diameter 500 mm was too heavy for these tools.

In making the access doors to the duct wall, seam metal shears and nibbler 1 were suitable for the work in all three diameters. Nibbler 2, gauge shear and sheet metal scissors were suitable to making assembly holes in the same duct diameter as in cutting. Side grinder was not suitable to making holes for access doors.

Work speed
The work speed with different tools was estimated with the time spend to cutting the duct and making the assembly hole to the duct wall. The time included the time needed for making a small circular starting hole and for removing burrs or finishing the cutting edge.

Seam metal shear and gauge shear were the fastest tools in both cutting and making the hole. The working speed with the shears was a surprise, because the assumption was that the shears might be slow because a starting hole is needed to be made before cutting. For the duct diameter of 500 mm the assembly hole could be made only by nibbler 1 and seam metal shear.

Dust accumulation rate at the building site
The dust accumulation rates in both floors of the university hospital were low (the average dust accumulation rate was 0.2 g/m^2). The average dust accumulation rate was 0.3 g/m^2 (0.0.-1.29 g/m^2) in the floor that was assembled by using the side grinder, and it was <0.1 g/m2 (0.00-0.20 g/m^2) in the floor where shears were used.

Seen by naked eye, the inner duct surfaces looked cleaner in the floor where shears were used for assembly work. At the basement floor, amounts of metal sheet dust were seen in the ductwork, as well as a fine layer of building dust. According to the assembly worker, some dusty work took place such as grinding and brickwork at the same time with the ventilation duct assembly.

Opinions of the assembly workers at the building site
The assembly workers estimated the shears to be better than the side grinder as evaluated by the different characteristics asked. The biggest differences were noticed with noise and work safety. The evaluations at the building site were in accordance with the evaluations made in laboratory as regards to the suitability to cutting of a duct and making a hole to the duct wall. Making sharp turns and working with ducts the diameter of which is less than 100 mm is difficult with shears.

When the assembly workers were asked whether they would take the shears into use they were positive. They argued that the work is faster, the shears are quiet and they do not sparkle. They thought that the shears were handy to use and light weighted. The workers said however, that the seam metal shear was more suitable to the work than the gauge shear.

The shears affected the work safety of the other workers at the building site, too. The other workers had also noticed that the shears were quiet and did not sparkle. The complaints of the other assembly workers were less than normal while shears were used.

DISCUSSION

It is a pertinent question to be asked, whether ventilation system assembly should be done in a clean manner or whether the ventilation ductwork should be cleaned by a professional duct cleaning company after the building has been taken into use. In Finland, it is common that the ventilation systems have been assembled by using side grinders and that the assembly workers do not pay attention to the cleanliness of the inner duct surfaces. Thus, it is not uncommon that large buildings with new ventilation systems have been cleaned because the inner duct surfaces are not visibly clean. The cost of duct cleaning is high and the building owner and ventilation contractor would be willing to avoid that cost, if possible.

This study showed that there are tools available that do not generate metal sheet dust to the ductwork. The study showed also that the assembly workers fairly quickly were willing to change their working habits and tools towards cleaner and safer working habits and working environment.

CONCLUSIONS AND IMPLICATIONS

It can be concluded that assembly workers are playing an important role as regards the cleanliness of ventilation systems. By changing the working habits and tools, the assembly workers can make cleaner ventilation systems. The new national guideline of a clean ventilation system (dust load does not exceed 1.0 g/m^2 in a newly assembled ventilation system) can be reached.

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