MEASURING METHODS FOR DETERMINING THE LEVEL OF DUST IN THE AIR DUCT

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ABSTRACT

The aim of this experiment was to compare three measuring methods to determine the level of dust in air ducts. Compared methods were a vacuum test, a tape method and an optical method. The dust samples were taken from the supply air ducts of new buildings. The paper presents and compares the results of the tests.

The samples were taken from three day-care centers in the Helsinki area. The ducts were not cleaned after the manufacturing process or protected during the construction. Duct surfaces had also oil residues from the manufacturing process. The samples for each method were taken from same location. All the methods gave different results. The best correlation between the methods were found between the vacuum test and the tape method. The quality of the dust seemed to have the strongest effect on the results from the optical test method.

INTRODUCTION

Dust that has accumulated in the air duct can be quantified either by weighing or by an optical method. Typical sampling devices for vacuum test are an air pump, a suction hose, a pre-weighted filter and scales [3, 4]. The sample is taken with a vacuum pump, which collects dust from a standardized surface area on a pre-weighted filter. With this method the composition of the dust and the microbe concentration can be determined from the collected sample. As the weight of the sample is only a few milligrams, the sample has to be weighed with high resolution laboratory scales (resolution of 0.1 mg or better). Dust sampling can also be done with a tape [2]. In this method, the sample is taken by pressing a pre-weighted tape against a test surface under examination. Tape method is easy to use in field. The result emerges as a weight of dust per surface area.

The optical measuring device (*BM-Dustdetector*) which was originally developed to evaluate quality of space cleaning, is also used to define the amount of dust in the air duct [5]. The operating principle is based on the transmission of a laser beam through a sampling tape. A clean sampling tape transmits light better than a contaminated tape. The dust detector consists of a measuring device, adhesive tapes and a roller. The design of the roller ensures that the force with which the roller is pressed against the surface remains constant (10 N). The dust detector gives the result in percentage of reduction of the light transmission through the contaminated tape from the light transmission of a clean tape. This number serves as a measure of the surface cleanliness.

The cleanliness of the air duct and of the whole air handling system can also be estimated visually. This is an important method because dust may be accumulated unevenly in various locations of the system, and dirty spots may not be found with sampling methods. Visual

inspection should always be the primary method in inspection. In some cases it may be the only one available to verify the cleanliness of the system. Instruments such as mirrors, borescopes, fiberoscopes and video can be used in visual inspection. With a remote controlled video camera it is possible to inspect places that would be impossible to see otherwise.

Even though the accumulated dust on the duct surfaces is an important criterion of the cleanliness, it is not the only one. The inner surface of the duct may contain residual oil from the manufacturing process. Measuring it requires collection of an oil sample from the surface with a solvent, which is then analyzed [1]. The quality of the air flowing through a duct might also be used as a criterion of cleanliness. Tests have shown that olfactory panel can be used to detect the differences in perceived air quality before and after the tested duct. Both the amount of residual oil and the difference of perceived odor can also be used as criteria of cleanliness.

SUBJECTS AND METHODS

Buildings

The selected buildings for the investigation were three new day-care centers in Helsinki. The buildings were completed between 1 and 3 months before the study. The dust samples were taken from the supply air duct. Most of the samples were taken from a round air duct, which had also some residual oil on the inner surfaces. The number of sampling locations were 4–8, depending on the size of the air handling system in the building. The composition of the dust was also estimated visually.

Dust Vacuum Sampling test

The sampling device of the vacuum test consisted of a suction hose, a pre-weighed filter, and an air pump. The air flow of the air pump was 10 dm^3/min. The sample was collected from a standardized surface area (see Figure 1) on a pre-weighed filter (0.22 micron pore size). Dust sample was taken carefully from the duct surface with the suction hose. During sampling the air conditioning system was not running. Samples were taken from each predetermined location in the duct system. Additionally, a field blank (a pre-filter which did not collect dust) was taken from each buildings. The sample was weighed with laboratory scales (METTLER AE 240 Dual Range Balance) with resolution of 0.01 mg.

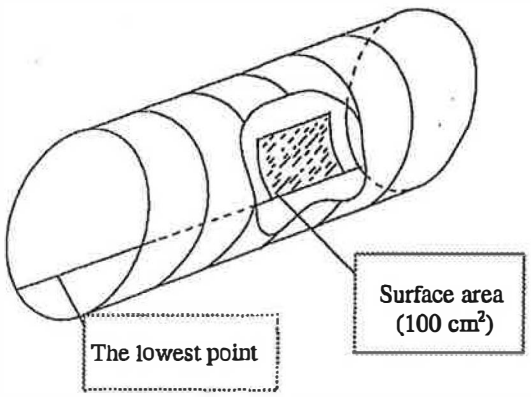

Figure 1. The standardized surface area and location of dust sample in vacuum sampling method.

Tape Method

The second sampling method was the tape method. The sampling apparatus has a two-sided tape between transparent sheets. The size of the tape was 42 cm^2. During sampling the other transparent sheet was removed from the other side of the sampling tape. The sample was taken with a roller, which pressed the pre-weighted tape against the examined surface, pressing force remained constant (10 N). Three samples were taken from each sampling location. Sampling tapes were weighed before and after sampling with laboratory scales (METTLER AE 240 Dual Range Balance) with a resolution of 0.01 mg.

BM-Dustdetector

The third method was an optical measuring device. The operating principle is based on transmission of a laser beam through the sampling tape. A clean sampling tape transmits light differently than a contaminated tape does. The *BM-Dustdetector* displays reduction of light transmittance in percentage compared to a clean tape.

The measuring procedure was the following: the light transmission was measured first with an unused tape. Then the adhesive tape was placed on the duct surface and pressed with a roller on duct. The roller was run over the tape three times in a transverse direction (Figure 2). After the tape was contaminated its light transmission was measured again. The amount of the collected dust reduced the light transmission of the tape. From each sampling points four dust samples were taken. The result are presented as average of the measurements.

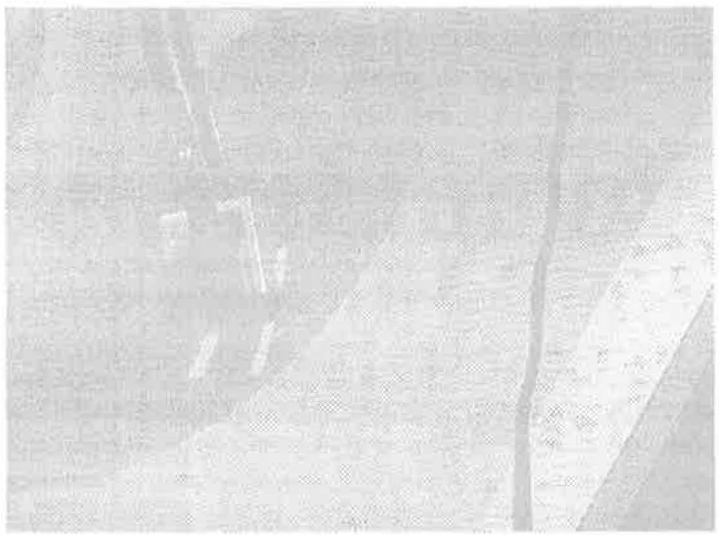

Figure 2. Dust sampling with *BM-Dustdetector*

RESULTS

The results are shown in Figures 3, 4 and 5. The level of accumulated dust in supply air duct was between 0.04–8.4 g/m^2 using the vacuum test, and 0.08–3.9 g/m^2 by using the tape

method. Cleanliness of the supply air ducts was 5.1–40.2% by using *BM-Dustdetector*. All the methods gave different results. The best correlation between the methods were found between the vacuum test and the tape method. The highest amount of dust was 8.4 g/m^2 measured with the vacuum method. This corresponded to 12% with the optical method.

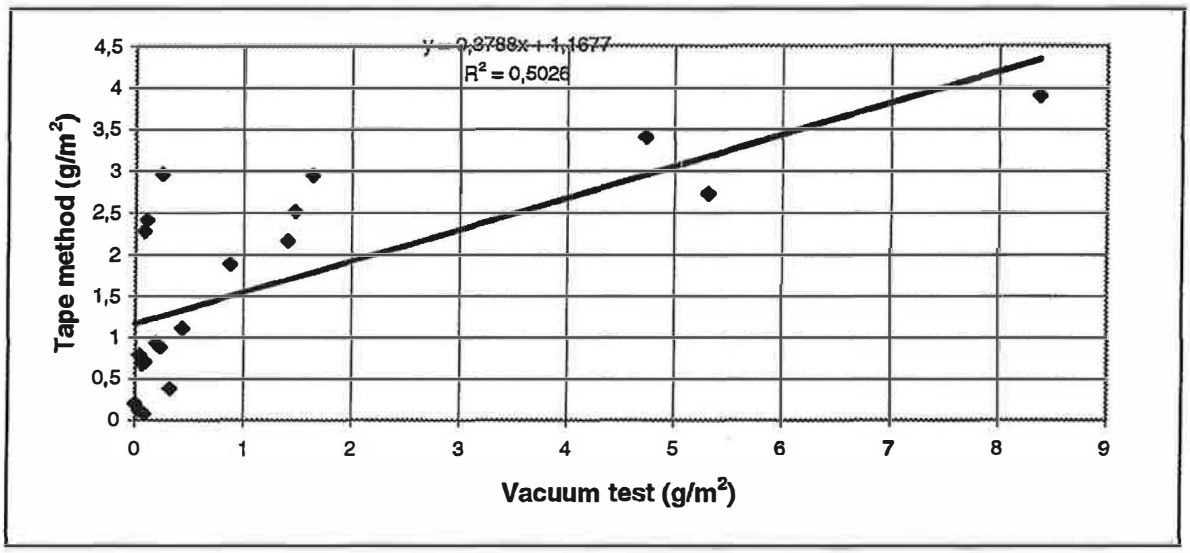

Figure 3. The results from the tape method and vacuum test. Each data point represents results from one sampling location. The results of the tape method are averages of three samples and a sample of the vacuum test.

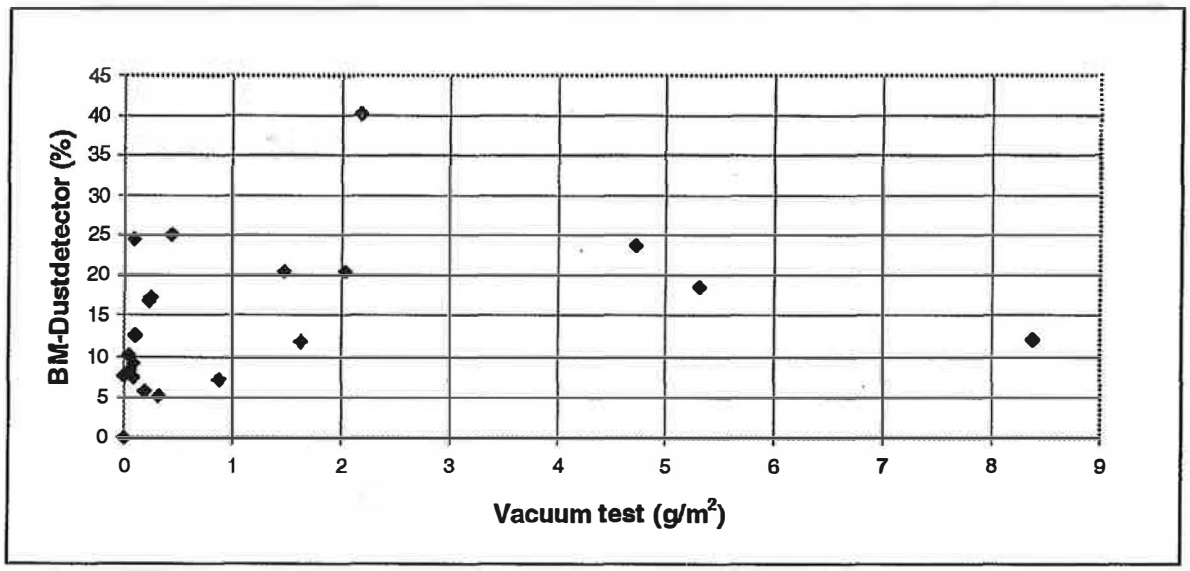

Figure 4. The results from the optical test and vacuum test. Each data point represents results from one sampling location. Results of the optical method are averages of four samples and a sample of the vacuum test.

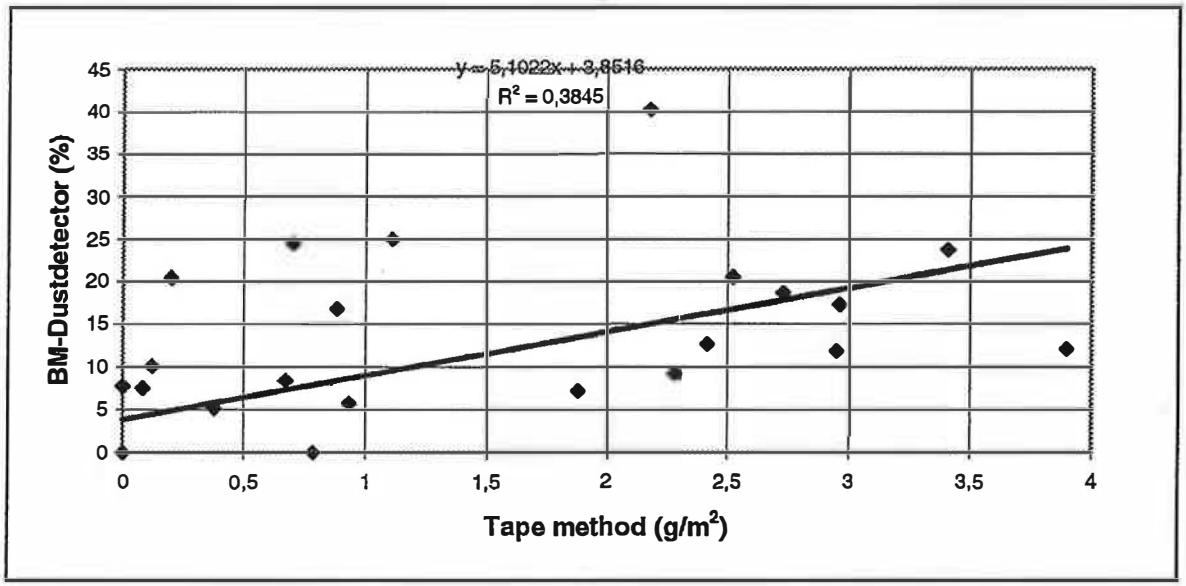

Figure 5. The results from the optical test and tape method. Each data point represents results from one sampling location. The results of the tape method are averages of three samples and average of four samples of the optical test.

DISCUSSION

Most of the samples had more dust than 1 mg/100 cm^2, which is the limit value for dust in a cleaned air handling systems according to North American Standards (NADCA 1992). The correlation between the vacuum test and the tape method was best when the level of accumulated dust was between 2–8 g/m^2 on the examined surface measured with the vacuum test. Highest loads of accumulated dust were found on the bottom surfaces of the air ducts and on places where air speed was low, such as close to terminal units. Composition of dust was different in sampling locations by visual inspection, but was not further analyzed. This may have had an effect on the results, particularly with optical method.

The vacuum test is the most important method to determine the amount of dust in the air duct. As the weight of the sample is only a few milligrams, the sample has to be weighed with high resolution laboratory scales, which makes the method awkward to use in field applications.

With the tape method, it is important to press the sampling tape with a constant force against all the examined surfaces. In this study, the tape was made of a transparent sheet and the two-sided tape which of was not a hygroscopic material (plastic). Some plastic materials are hygroscopic, and the amount of water adsorbed by the tape may cause a significant error. Thus, the tape material shall not absorb water. The tape method is useful for field application, and the result emerges as a weight of dust per surface area. A limitation of the tape method is also the possible saturation of sampling tape. From a very dusty surface the tape may collect only the top layer of dust, and leave the bottom part on the surface.

The optical method was included in the study because the method is simple and designed for field applications. The reading of *BM-Dustdetector* is the reduction of light transmittance of sample in percentage from a clean sampling tape. This reading is used as an indicator of the cleanliness of the surface. The readings were between 5.1–40.2%. The operating range of the optical instruments was 0–52% (the maximum value of 52% corresponding black tape used as reference). The results indicate that the composition of dust have a significant influence on the reading of optical instrument. The highest dust accumulation on the duct surface was 8.4 g/m^2 measured with the vacuum test, and the optical device gave only 12% reduction of light for that sampling point. This makes the optical method unreliable. Further studies are needed to quantify this effect.

The results of this study shown how poorly the results from the tested method correlate, and only the results with the same method are comparable. The results of the study may be biased due to different sampling points; even though the location of the sampling was the same, the exact sampled areas were different.

ACKNOWLEDGEMENTS

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