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Needs and methods for ductwork cleaning in France

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1 Introduction

Air supplied by ventilation plants and air conditioning systems carries small particles whose size depends on filtration device efficiency.

Mineral, vegetal or biological particles may deposit on the inner surface of air ducts and other air conditioning equipment creating a thin layer of dust. Such dust deposit may deteriorate the quality of the air flow blown into the rooms through the booths and consequently the global indoor air quality in the building.

Elsewhere dust deposits may reduce performances of the ventilation plant. Air duct cleaning is therefore an essential need to maintain the ventilation system in a good healthy.

In France only a few building owners are aware that HVAC installations cleaning is a real need and there is no clear regulation in force to compel them to do it. However HVAC plants cleaning is a growing activity since the beginning of the second millennium.
Basic professional rules have been developed by COSTIC and the French Association of ductwork cleaners (GHR). COSTIC is a research and training centre for HVAC – construction technology and equipment.

This paper presents the main principles and methodologies on which these rules are based.

2 Deposit evolution

A HVAC system (Heating, Ventilation and Air Conditioning System) allows reducing effectively the indoor air pollution. But, this system can carry particles, gaseous or microbiological pollution.

A HVAC system consists of various components designed to transport, treat and filter the air.

The main components are:
- Air ducts,
- Filters,
- Heating and cooling heat exchangers,
- Fans,
- Humidifier,
- Dampers,
- Air diffusers.

Indoor air pollution results from various sources which can be classified into four categories:
- Outside sources,
- Sources related to occupants
- Sources related to the building components (walls…) and furniture
- Sources related to technical equipment in the building.

French regulation requires only a low level of filtration of the fresh air.

In fact, local Health regulation (RSDT) and Code of Labour only recommend a Class G4 air filter of according to standard NF EN 779.

Due to poor air filtration numerous particles accumulate on the inner surface of air ducts, creating a dust deposit.

In addition moisture and air temperature may facilitate the growth of mould on duct surfaces when dust deposit contains biological particles (bacteria, mushrooms…). Elsewhere dust deposits will increase the duct roughness and thus facilitate the sticking of other particles, creating a phenomenon of fouling.

Microbial development on the duct surface is usually followed by a production of substances leading to the making of an organic matrix more or less viscous composed of water, proteins, nucleic acids (BRIANDET et al., 2003). The combination of the matrix and microbial cells form what is called biofilm. The biofilm is characterized by a strong resistance to disinfectants.

Other factors directly related to the HVAC components implementation may contribute to the process of dust accumulation in ventilation ductworks.

For example air ducts will foul up even faster when they are carried to the building site without protection and presence of oil on the surface of duct may favour deposit of dust.

Filters are another significant source of pollution. Despite a significant efficiency of the filter on the reduction of fungal spores and bacteria (reduction between upstream and downstream of the order of 70 % to 80%), it was highlighted a possible release of microorganisms from the filter especially in the case of high relative humidity (MORITZ M. et al. quoted by PARAT S., 2002).

3 Effect of dust deposit

Accumulation of dust on the ventilation system (fan, heat exchangers, filters) will increase their pressure drop and thereby reduce the design performances.

Dust accumulation can influence indoor air quality. Supply and extract airflows are reduced and the air blown into the indoor spaces can be contaminated by particles, micro-organisms or Volatile Organic Compounds (VOC).

For example, a dust deposit 6 mm thick leads to a reduction of 10% of the air flow rate (for a duct circular diameter of 254 mm). A dust deposit of 12 mm thick leads to a reduction of about 19 % of the air flow rate (An, 2000).

Conflicting results about the impact of dust deposits on indoor air quality can be found in literature. For example different studies shown microbiological contamination of duct surfaces impact on the indoor air (SIQUEIRA and al., 1999; BUTTNER and al., 1999 quoted by PARAT S., 2002) while another study shows there is no link between the number and nature of the micro-organisms present in the flow network and the indoor air (NEUMEISTER-Kemp and al., 1999 quoted by PARAT S., 2002).

Lastly, biofilm may bring out problems among building occupants. It is considered that 65% of nosocomial infections are due to the presence of biofilm in air ducts (LINCKING, 1999, quoted by BRIANDET et al., 2003).

4 Different steps of HVAC systems cleaning

Four steps are essential to carry out an air duct cleaning operation. These different phases are diagnosis, cleaning, disinfection process and monitoring.

4.1 French regulation

In France only few special ventilation systems are subject to a detailed regulation concerning maintenance operations. This is the case of VMC-GAZ system (Combined mechanical ventilation and fumes extraction) and large professional kitchens. For residential buildings the decree of 31 January 86 (dealing with fire safety) stipulates that "the owner is required to make at least a yearly inspection of the ventilation system".

Some other decrees require that ventilation plants must be checked at least one time a year and duck network kept in a good cleanliness and working order. Apart from these few texts there is no requirement for diagnosis and cleaning of ventilation plants in the French regulation.

4.2 HVAC system inspection

The diagnosis is carried out to assess the general state of the duct system and to look for local and deposits of dust. Depending on the results, the diagnosis can justify or not a complete and deep air duct cleaning. Ductwork diagnosis requires three main phases: visual inspection, dust accumulation measurements and microbiological analysis.

Visual inspection allows evaluating dust accumulation along the ductwork. In addition, this diagnosis can highlight defaults of the installation: bad connection between ducts elements, corrosion and internal moisture. Depending on the network shape different tools may be used. A simple camera is used for vertical ducts. A four wheel mobile camera is particularly suitable for horizontal ducts.

But this type of diagnosis is quite limited because when the deposit duct looks like a thin layer it is very difficult to judge on its importance and therefore to assess the effect on comfort and health in the indoor spaces.

Other methods may be used to assess objectively the dust accumulation level. The method mostly used in France to make dust accumulation measurement is the weighing method, known as the Vacuum Test (IBARCQ P and FELDMANN C., 2003). This method consists in vacuuming dust on the inner surface of an air duct through a template delimiting the sampling area (100 cm²). Dust vacuumed is collected on a filter which will be weighed by an accurate laboratory weighting machine. The vacuum test method can only be applied for:

- strong and non porous ducts,
- horizontal and plane parts of ductworks (ideal shape of ducts is the rectangular one but samplings can be made on circular ducts which diameter upper than 300 mm),
- dry environment, dry deposit and dry inner surface of duct.

Figure 1 : Camera (photo COSTIC)

Figure 2 : Four wheel mobile camera unit (extract of BARBAT M. and FELDMANN C., 2006 – Cleaning Professional SIV VEISTA)

However additional studies have still to be carried out in order to define the limits and the accuracy of this method.

Microbiological analysis aims to characterise the degree of contamination of the system. Three different sampling points are required.

A reference sampling point must be located near the outdoor air intake. A second sampling has to be carried out in the insufflation air part of the ductwork right after the Air Handle Unit. The third sampling point must be located

in the extract air duct. In order to obtain reliable results air sampling must be made with an iso- kinetic probe in which air velocity is equal to air flow velocity in the duct.

4.3 Mechanical cleaning methodology

Cleaning procedure consists of two complementary tasks:

- unstick dust particles from the duct surface
- collect dust in suspension in the air flow

To achieve a good cleaning of the ductwork, air velocity must be much higher than the velocity design values.

The two most popular duct cleaning techniques in France are mechanical brushing and compressed air blowing.

Mechanical brushing is based on the rotary motion of a brush. Rotation speed and direction of the brush may generally be controlled. Depending on the type of deposit brush material may be more or less stiff.

Compressed air blowing is mainly used for fragile duct wall materials (i.e glass wool). It can be also used for the total completion of the cleaning process.

Glass wool wall ducts require special care when cleaning. The cleaning process used depends on internal protection of the insulation material of the duct. The following table gives the recommended means of cleaning in regard to protection of the insulation material (COSTIC and GHR, 2001).

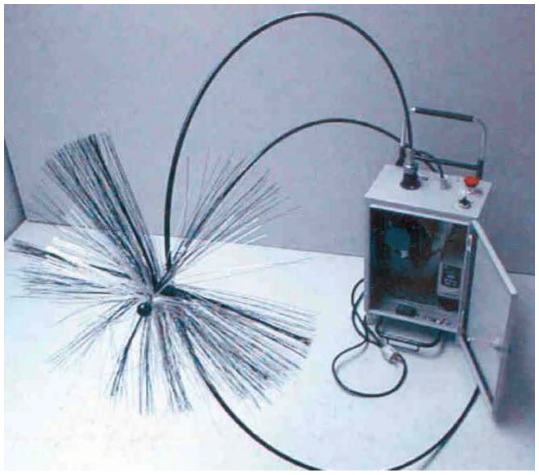

Figure 3 : Mechanical brushing

Figure 4 : Compressed air with a channel (extract of COSTIC and GHR, 2003)

Table 1: Cleaning methodology vs insulation of mother the duct

Year	Insulating	Mechanical cleaning methodology
Before 1980	Insulation material without protection	No techniques
Since 1986	Insulation material with a light protection	Compressed air
Since 1993	Insulation material with an aluminium protection	Mechanical brushing
Since 1996	Insulating material with a thick protection	Mechanical brushing and compressed air

4.4 Disinfection methods

The disinfection process is carried out after the cleaning of the air duct network. The aim of the disinfection process is to remove or kill micro-organisms. Micro-diffusion is the most common way of doing this.

The method consist of producing a non-wetting fog (particles below 1 mm) having a wide anti-bacteria activity spectrum into the ductwork.

Another method is based on the combustion of active substances. Fumes emitted by combustion provide an anti-bacteria effect. Due to deposit of small particles on the duct surface a re-cleaning of ducts is needed when using this process.

4.5 Cleanliness checking

Visual inspection, microbiological sampling and analysis and dust accumulation measurement must be carried out before and after the cleaning operation.

5 Conclusion

Except few texts there is no requirement for diagnosis and cleaning of ventilation plants in the French regulation. Nevertheless, air duct cleaning is a growing activity in France because ventilation plays an essential role in securing indoor air quality.

This activity is supported by a Professional Association (GHR) which have been strongly involved with COSTIC in the writing of basic professional rules for air ducts cleaning.

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The Air Infiltration and Ventilation Centre provides technical support in air infiltration and ventilation research and application. The aim is to promote the understanding of the complex behaviour of the air flow in buildings and to advance the effective application of associated energy saving measures in the design of new buildings and the improvement of the existing building stock.