

# AIRLESS, A EUROPEAN PROJECT ON HVAC SYSTEMS: MAINTENANCE OF HVAC-SYSTEMS TASK TWO

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## ABSTRACT

In the beginning of 1998 the European project, AIRLESS, was started to develop strategies, principles and protocols to improve and control the performance of HVAC-systems and its components for the incorporation in codes and guidelines. The project is divided in 6 tasks. The Hermann-Rietschel-Institute deals with the second task of the project, the maintenance of HVAC-systems. People stay approximately 90% of their lifetime in enclosed rooms. These rooms are often served by HVAC systems. In recent years poor indoor climate has caused health problems in buildings. One reason for these problems can be wrong maintenance of the HVAC-systems. The objective of this task is to develop a new maintenance guideline for better indoor air quality. This paper deals with the first two sub-tasks of the task two of the project. In the first part existing maintenance guidelines will be compared. In the second part investigations for defining cleanliness are described. The third and last sub-task, the definition of a new guideline, is not part of that report. The literature review shows, that the existing guidelines do not address the full spectrum of critical factors. Some of them lack precise specifications about cleanliness and precise working procedures. Thus, the new maintenance guideline should be a mixture of existing guidelines and results from the investigations about cleanliness and related working procedures. First investigations for definition of cleanliness show that it is not easy to give only some values for cleanliness. The first results are presented in the following chapters.

## INTRODUCTION

Maintenance of air-conditioning systems is acknowledged as an important means to run HVAC-systems properly. Although several maintenance programs and standards exist, not many systems are maintained in a proper way. Most standards and programs are not concerned with the indoor environment, they are only concerned with repair and failure response of system components. Therefore additional maintenance efforts are necessary. In this task of the project, current maintenance strategies will be reviewed and occurred problems are pointed out. Furthermore, different cleaning methods for all components will be investigated to define cleanliness and criteria for cleanliness with respect to HVAC-systems and their components.

Table 1. Time schedule task 2

<u>Action:</u>	<u>Time:</u>
2.1 Literature review	01.01.1998 – 03.31.1998 (Is done)
2.2 Definition of cleanliness	04.01.1998 – 06.31.1999
2.3 New maintenance protocol	04.01.1999 – 12.31.1999

A "new" maintenance protocol, including also methods to check ventilation and energy performance will be developed. In table 1 the timetable for the task two is shown.

## THE LITERATURE REVIEW

### Methods [1]

This literature review contains a review of international maintenance guidelines. The analysis of these guidelines was made according to the following points of view:

1. Maintenance cycles
2. Definition of cleanliness
3. Maintenance tasks and description
4. How is the work described?
5. Spatial needs, requirements and accessibility
6. Training of maintenance personnel

For this project "maintenance" was defined according to the German guideline DIN 31 051 [2] (Table 2). The goal of Task 2 "maintenance" is to develop a new maintenance guideline for better indoor air quality.

**Table 2: Definition of Maintenance according to DIN 31 051 [2, 3]**

Maintenance		
Grouping of measures		
Servicing	Inspection	Repair
Aims of measures = definition according to DIN 31 051		
Maintaining the prescribed condition	Identification and assessment of the actual condition	Restoration of the prescribed condition
Individual measures		
Testing Readjustment Replacement Supplementation Lubrication Preservation Cleaning	Testing Measurement Assessment	Repair Replacement
Carried out by		
Skilled mechanic Technician	Technician Engineer	Skilled mechanic Technician

### Results [1]

Because it is not possible to show the whole investigated standards, a single example will be used as an illustration - VDMA 24186 [3] - Part 1: Maintenance program for HVAC systems

Under this standard, a maintenance program is set up for each equipment component. According to this standard, duct cleaning is not a maintenance activity.

1. The maintenance cycles are divided in "periodic" and "as required" activities. The time interval must be defined for each system.
2. No definition available. Contamination must be checked.
3. No concrete definition for hygienic aspects.
4. Activities are well described for each component, could be still completed, a. No definition for spatial needs.
5. Maintenance is only to be executed by trained technical personnel (DIN 31051).

## Discussion

The review shows that it is important to define a new maintenance guideline for HVAC systems. The existing guidelines do not address the full spectrum of critical factors. Some of them lack precise specifications about cleanliness and precise working procedures. Thus, the new maintenance guideline should be a mixture of existing guidelines and results from the investigations about cleanliness and related working procedures.

## DEFINITION OF CLEANLINESS FOR DUCTS

### Methods [6]

First investigations are started for defining cleanliness. Questions like: "How clean is clean?", has to be answered. The definitions for cleanliness for ducts and humidifiers are done. For this report only ducts will be pointed out. In the presentation it is possible to give more information about the investigations. For the definition of cleanliness in ducts we made field studies and literature researches. The field studies are done in cooperation with the FU Berlin, Institute for Hygiene. The main task was the comparison of the different methods for defining the dust load in ducts. Parallel the existing levels for dust loads in ducts were compared (Table 3).

### Results [4,5]

In Table 5 a summary of dust surface concentration levels from various studies is shown. Different methods for measuring the dust load on the surface are shown. Also the different guidelines or standards are figured out. Some of the methods are listed in the following tables 3 and 4. These are only two of more than 5 lists. The difference between the compared methods is the ways how to get the dust from the duct surface. The so called "new method" in table 6 is not yet patented, so it is not possible to explain more about it until now. The existing current target values on the dust load of air ducts and room air are shown in table 5.

Table 3. Visual methods to define the dust loads in ducts

Description	Land	Working method	Test medium	Measuring device and equipment
JADCA	Japan	Measurements of the light transmission through transparent adhesive tape	adhesive tape	Light transmission Meter
BM- method	USA	Measurements of the light transmission through transparent adhesive tape	adhesive tape	Diode Laser (high costs)

Table 4. Exhaust methods with mechanic methods to release the particles

Description	Land	Working method	Test Medium	Measuring device and equipment
EPA-MVDS	USA	After the particles will be released with brushes they will be exhausted. Afterwards the filters will be weighed.	Filter	Vacuum pump; Filter cassette; Pattern; Nozzles with brushes
SP	Sweden	The same! Only Spatula instead of brushes.	Filter	Vacuum pump; Filter cassette; Pattern; Spatula

Table 5: Summary of dust surface concentration levels from various studies

Type of building	n	Age [Years]	Filter class range [EU]	Mean [g/m <sup>2</sup> ]	range [g/m <sup>2</sup> ]	Annual deposition rate [g/(m <sup>2</sup> ·a)]	Method	Efficiency(3) of detection [%]	Source
School, office	13	3 to 29	n.r.	6,8	1,1 to 50,9	0,7(2)	Vacuum, razor blade	100	Nielsen et. al. (1990)
School, office	6	5 to 11	2 to 7	18,2	3,6 to 140	2,3	Vacuum, plastic blade	n.r.	Laatikainen et. al. (1991)
publ. Buildings	6	7 to 51	5 to 7	10,6	1,2 to 58,3	3,5	Vacuum, plastic blade	n.r.	Pasanen et. al. (1992)
Residential	33	0 to 45	n.r.	0,2	<DL to 2,7	<0,1	Vacuum (NADCA)	< 1 (47 bis 92)	Auger (1994)
Office	14	3 to 34	2 to 7	13,2	1,2 to 158	1,0	Vacuum, plastic blade	n.r.	Pasanen (1995)
Residential	23	2 to 16	3 to 5	1,2(1)	0,2 to 3,9	n.r.	Vacuum, brush	n.r.	Kallikoski et. al. (1995)
n.r.	5	19 to 37	2 to 6	2,6	1,9 to 3,0	0,2 bis 0,3	Tape	38	Fransson et. al. (1995)
n.r.	4	22 to 32	n.r.	7,5	n.r.	n.r.	Wiping with cloth (JADCA)	90	Ito et. al. (1996)
Residential	9	9 to 35	n.r.	6,4	1,5 to 26,0	n.r.	Vacuum (MVDS)	(94)	Fortmann et. al. (1997)
Day-care centers	3	< 1	n.r.	n.r.	0,04 to 8,4	n.a.	Vacuum	n.r.	Holopainen et. al. (1999)
publ. Buildings	13	3 to 30	3 to 9	18,8	4,0 to 131	1,1	New method with solvent	100	Küchen (1998)
publ. Buildings	17	3 to 30	3 to 9	7,0	0,2 to 82	0,5	Wiping (JADCA)	41	Küchen (1998)
publ. Buildings	12	3 to 30	3 to 9	1,9	<DL to 21	0,2	Vacuum	12	Küchen (1998)

Notes:

(1) dust concentration calculated based on whole duct area

(2) refers to a operation time of one year

(3) Values in parenthesis for loose (soft) dust layer (Fortmann et al., 1997)

Values without parenthesis reported by Fransson et al. (1995)

Values for JADCA-wiping method reported by Yoshizawa et al. (1997)

n.r. not reported

DL Detection Limit

JADCA Japanese Air Duct Cleaners Association method (Ito et al., 1996)

NADCA National Air Duct Cleaners Association method (NADCA, 1992)

MVDS Medium Volume Dust Sampler by US EPA (Fortmann et al. 1997)

Table 6: Current target values on the hygiene of air ducts and room air.

Surface Dust					
Country	Duct used for	Dust-Values		Method	Remarks (Source-No.)
		after Cleaning	prior to Cleaning		
USA	(1)	0.1 g/m <sup>2</sup>		Vacuum Method NADCA	Guideline (1)
Great Britain	Supply Air	0.1 g/m <sup>2</sup>	1 g/m <sup>2</sup> 60 µm	Vacuum Method HVCA(3)	Guideline (2)
	Recirculating Air		1 g/m <sup>2</sup> 60 µm	Vacuum Method HVCA(3)	
	Exhaust Air		6 g/m <sup>2</sup> 180 µm	Vacuum Method HVCA(3)	
Sweden	Supply Air		1 g/m <sup>2</sup>	not mentioned	Ordinance (4)
Japan	Supply Air	1 g/m <sup>2</sup>		Wiping Method JADCA	Guideline (5)
Finland	Supply Air		2 g/m <sup>2</sup> 5 g/m <sup>2</sup>	plastic blade / vacuum,	Guideline (6)
Germany	general	broom-clean		plastic blade / vacuum	Guideline (7)

References:

- (1) National Air Duct Cleaners Association (NADCA, 1992)
- (2) Heating and Ventilation Contractors Association (HVCA, 1998)
- (3) Mikrometer-Values refer to measurement of dust thickness
- (4) The Swedish National Board of Housing, Building and Planning (BFS, 1992)
- (5) Yoshizawa et al. (1997)
- (6) 2 g/m<sup>2</sup> = "excellent maintenance", 5 g/m<sup>2</sup> = "good maintenance", Finnish Society of Indoor Air Quality and Climate, (FiSIAQ, 1995)
- (7) Verein Deutscher Ingenieure, Guideline VDI 6022 (VDI, 1998)

Comparison of different methods to define the dust load in ducts

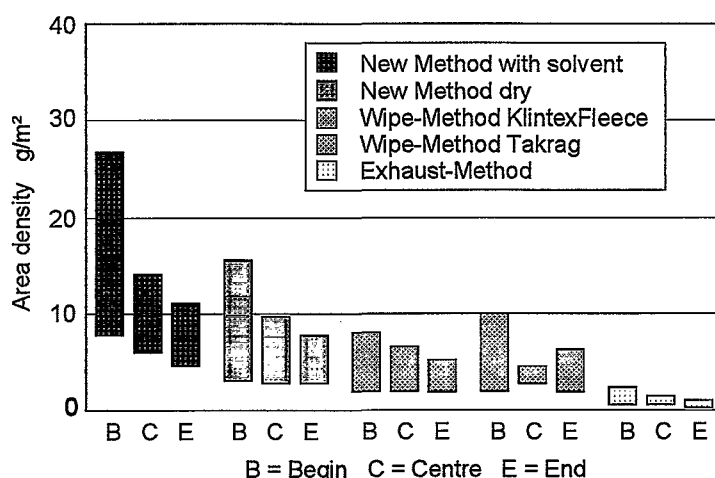


Figure 1. Comparison of different methods to define the dust load in ducts [6]

In the field studies the different methods for defining dust load on a surface are compared. Figure 1 shows the measured dust load in one duct with different methods. The measurements were made at the beginning, at the middle and at the end of a duct. It is possible to see that the dust load decreases to the end of a duct. But the important result is that different methods will

give different loads at the same place. The conclusion of that results is that it is not possible to define only limits for cleanliness. It is important to define also the method for measuring that limits.

## DISCUSSION OF THE DEFINITION OF CLEANLINESS

Table 7 includes the first definition of cleanliness made by TU Berlin for ducts. The limits are made for the various existing dust measurement methods

**Table 7: Approximate corresponding target values for duct cleanliness referring to various existing dust measurement methods [5]**

Method	description	Detection efficiency (Faktor)	Dust surface concentration [g/m <sup>2</sup> ]		
			low standard	medium standard	high standard
Total dust	solvent	1	20.0	10.0	5.0
Vacuum	with blade	0.9	18.0	9.0	4.5
Wiping	JADCA	0.5	10.0	5.0	2.5
Tape	gravimetric	0.35	7.0	3.5	1.8
Vacuum	with brush	0.15	3.0	1.5	0.8
Vacuum	Wintest	0.1	2.0	1.0	0.5
Vacuum	NADCA/HVCA	0.02	0.4	0.2	0.1

It is important to define limits which are essential for a good indoor air quality, and also easy to apply for maintenance companies. A guideline with limits which are not realizable is not useful. The defined limits has to be checked for that.

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