VHExCo 99

The International Ventilation Hygiene Conference and Exhibition

March 24-25 1999

National Motorcycle Museum,
Solihull, Birmingham, UK

Delegate information pack

VHExCo99 International Ventilation Hygiene Conference

March 1999, Solihull, Birmingham, UK

Air Filtration Issues Related to Ventilation Hygiene

Wander ter Kuile - Product Manager - Air Filtration
BTR Environmental Ltd - Vokes
Henley Park Guildford Surrey GU3 2AF

Introduction

Air filtration provides the primary means of controlling the ingress and emission of contaminants into and out of any ventilated space. With air filtration we are therefore concerned with the control of particulate matter and gases which influence our health and comfort, the spaces we occupy, the products we manufacture, the equipment we use and by no means least, the environment.

Air filtration in a ventilation system therefore provides the means for healthier and more comfortable working conditions and to prevent build up of contaminants on the components and surfaces within the ventilation system.

The correct design, selection, installation and maintenance of the air filtration system is critically important in ensuring that the ventilation system provides the necessary quality of air.

While the actual cause or causes of poor system hygiene may be poorly understood, the effectiveness of the air filtration system is undoubtedly a contributory factor. It is often difficult to convince people that filtration is an important and necessary process within any air conditioning system. This is largely because normal airborne contaminants are difficult to see or comprehend unless they are in their concentrated state.

Contaminants

In a HVAC system, very large quantities of air are passed through components such as heat exchangers and are fed through an extensive duct work system to various parts of the building. This air carries with it measurable quantities of pollutants, which without air filtration will deposit everywhere within the system and the building. If fouling of the air conditioning system is allowed to occur, maintenance and energy consumption would increase.

System components and ductwork can be cleaned which can be a very complex and costly exercise depending on the design, layout and accessibility. The result of deposition in the building environment would also be quickly noticeable, with air discharge grills becoming fouled and unsightly, and dark stains appearing on decoration in their immediate vicinity.

Flat surfaces such as desks and floors would rapidly accumulate a layer of dust, resulting in excessive cleaning costs and the expense of redecoration when cleaning becomes impossible. Complaints are also likely from the occupants of the building as nobody likes working in visibly dirty conditions.

The increase in contamination will affect soft furnishings such as blinds, curtains, upholstery and carpets. The grit often contained in dust can be abrasive and will accelerate wear. The building may contain delicate equipment, all of which can suffer irreparable damage from exposure to excessive quantities of airborne contaminants.

The 'fresh' outdoor air contains a diverse population of particles, micro-organisms and fibres. The relative proportion of these materials and their total concentration varies widely according to geographical location and the time of year.

Typically, the total quantity of particulate suspended in clean outside air varies between 0.01 and 0.1 mg/m^3 as an annual average. The influence of industry or traffic can easily result in a one to two order of magnitude increase.
To see how such concentrations effect deposition rates in HVAC systems and building interiors, it simply requires the application of airflow and running hours. For example, a 6000 m^3/hr fresh air system operating for 10 hours per day throughout the year with an average inlet concentration of 0.1 mg/m^3 would ingest 2.2 Kg of dust. A dust concentration of 0.1 mg/m^3 can represent a population of $10^6 - 10^7$ particles/m^3.

This population ranges in size from 0.01 to 30 microns, with the vast majority being below 10 microns.

The larger particles (> 10 microns) settle rapidly, and are mostly only in suspension close to the point of origin or in high velocity streams. Particles in the range 1 to 10 microns tend to stay suspended in the air currents or settle slowly. Particles in the range 0.01 to 1 micron have negligible settling velocities.

It is wholly unrealistic to consider operating any form of HVAC system in a building without the provision of air filtration. A properly designed and operated system will offer significant improvement in the quality of the working environment and have a dramatic impact on the energy, maintenance and cleaning costs.

To keep energy costs to a minimum it is normal to recirculate up to 90% of the throughput depending on the time of year.

Both fresh and recirculated air should be passed through a filtration system .This ensures that the airborne pollutants from outside and the contamination generated within the building itself are eliminated from the air in circulation.

The generation of particles within a building is far more significant than most people realise. For example, a typical room at rest contains a particle concentration of 5 x $10^5/m^3$. With people undergoing normal activities in such a room they emit particles at the rate of 5 x 10^6/minute. The human body sheds a complete layer of skin every day. This combined with hair, cosmetics and particles exhaled are the major contributors.

Included in the particles shed are the large numbers of bacteria liberated with the skin and respired aerosols. At rest a human can liberate up to 10^4 bacteria per minute. Most of these bacteria are harmless, but some are infectious and the ventilation system is therefore a highly effective vehicle for dispersing infections.

Odours are often described as a nuisance rather than a contaminant. Most odours are carried by particles, and heavy dust loading within HVAC systems can be a considerable source of such nuisance odours.

Microbial growth within HVAC systems has been a topic of concern over recent years and much valuable work has been done to identify cause and effect. It has been shown that the appropriate conditions of humidity and temperature are needed before microbial growth takes place on system components, including filters.

Filtration

A properly specified and designed filter system is quite capable of removing all of the contaminants mentioned, including many bacteria and viruses. However the cost of achieving such high levels of cleanliness is only necessary and justifiable in highly critical applications.

In conventional HVAC applications an economic compromise is reached between cleanliness specification, filtration performance and cost. General ventilation filters have been classified in Europe to EN 779 since 1993. These range in performance from coarse pre-filter pads and panels, (classes G1 to G4), which have only a limited ability to remove respirable particles from the air. There are also Fine grade filters such as glass and synthetic bag filters and semi-absolute inserts, (classes F5 to F9), which can be used alone or in conjunction with pre-filters to provide a relatively good level of cleanliness for ventilation air. For hygienic requirements consideration should be taken of the removal of biological particles such as pollen, fungi and bacteria during the design process.

Filter life is generally expressed by filter manufacturers as the combination of dust retention and the corresponding pressure drop. These parameters are generated under ideal laboratory conditions using a standardised test dust as a challenge. The results are compared to a classification as indicated by whatever standard is being used. Rarely does the performance in actual conditions replicate the laboratory results. This is why the industry is in the process of producing more realistic standards which use particle size efficiency as the comparator, which in turn can be validated in situ.

The dust accumulation rate on filters is dependent on many factors, the most obvious being the ambient dust concentration, the filter rating and the media flux density. It is typical that efficiency increases through the loading cycle. This is particularly the case with high efficiency filters. Coarse filters and the lower grades of fine filters follow the same characteristic during the initial stages but can suffer from unloading and shedding if rated pressure loss limits are exceeded. It is therefore essential to inspect and monitor filter condition regularly.

Coarse pre-filters are typically changed 4 to 6 times per year on timed interval, rate of pressure loss increase or even discoloration. Fine filters when used in conjunction with pre-filters typically last twice as long before replacement is required. For fine filters the only reliable measure for change is pressure loss. There is however no such thing as a guaranteed life for an installed filter, and hence many operators prefer the time based change interval.

The selection of the appropriate grades of filter is largely application dependent and the standards of cleanliness required. It is an important consideration because one type of filter may be preferable to another.

Filters with anti microbial additives have been used by some operators as contributors to maintaining hygiene of the HVAC system. Filters provide a very small percentage of the potential surface area available for fungal growth, and the need for such filters is not necessary if moisture or high humidity conditions can be avoided by appropriate system design.

If the installed filters prove unsatisfactory, retrofitting the installation should also be accompanied by cleaning the remainder of the HVAC system. Frequently the levels of residual contamination of the ductwork mask the filter effectiveness. This can equally be a problem from initial build if the ductwork is contaminated with residues from the construction and building phases. Rarely is the ductwork cleansed before start up.

Maintenance Problems

Unfortunately changing filters is a dirty and often uncomfortable job, and is very often delegated as far down the line as possible and as a result is often carried out by improperly trained personnel, and errors are frequently made.

It is essential that the correct grade of filter is used, because the consulting engineer, installation contractor and equipment manufacturer have gone to a lot of trouble to ensure that the system was initially constructed and installed to the right specification in order to provide the right air cleanliness standards within the building. It so often happens that due to budgetary pressure, the maintenance engineer fits a lower grade filter than had originally been specified.

The invariable result is increased energy consumption, higher cleaning costs and an increase in the amount of contaminants being circulated within the building. It is essential that maintenance is done by properly trained, conscientious personnel, and if it cannot be done by maintenance staff attached to the facility, then a reputable contractor should be employed.

With filter installations, the particular areas that cause concern are the sealing of the filters in their frames. Frequently, incorrect sizes are installed or are even left out altogether, sometimes by accident, sometimes deliberately. Gaskets are often not replaced on frames or access doors. Poorly maintained instrumentation is a common problem. There a numerous examples on record, where the filters have been blocked or have burst because nobody bothered to look at manometers or maintain them. Sometimes instrumentation is removed and not replaced.

It is essential to fit appropriate instrumentation to monitor the true condition of the filters.

Conclusion

Air filters are not a fit and forget component of a ventilation system, and if they are to do the job for which they are designed, all the air must pass through them. Damaged, ill-fitting, or missing filters allow the bypass of unfiltered air and contaminants, which entirely defeats the object of their installation. Such situations result in the necessity for subsequent cleaning and maintenance of other system components.

The installation of a properly designed filter system that receives regular and comprehensive maintenance will do much to improve the environmental conditions within a building,. It will minimise operating costs and will help avoid poor HVAC system and building hygiene.

BTR Environmental

Air Filtration Issues Related to Ventilation Hygiene

VOKES DCE DELTA NEU NEOTECHNIK NAFCO REFILCO HOFFMAN

VHExCo99 - Solihull, Birmingham. March 1999

Wander ter Kuile

What is a Filter?

- A filter is a device that removes particulate from an air stream as the particulate laden air passes through it.

Air Filtration in HVAC - Where?

- Atmospheric inlet air to a system,process or occupied space
- Recirculated air
- Exhaust air to atmosphere

BTR Environmental

VOKES

Ventilation

- The object of introducing fresh air into a room is to dilute the level of contamination to one that is safe and acceptable
- Fresh air is defined as outdoor air, that is, sourced from outside of buildings. However the quality of this air maybe of uncertain purity.

BTR Environmental

VOKES

Fresh Air?

- Sources of Contamination
  - Construction residues, Demolition debris
  - Hydrocarbons - Oils, Exhaust Fumes, Fly Ash
  - Elemental Erosion
  - Dusts, Salts
  - Pollen, Moulds, Bacteria, Fungi
  - Skin
  - Fibres
  - Odorous substances
  - Chemicals

BTR Environmental VOKES

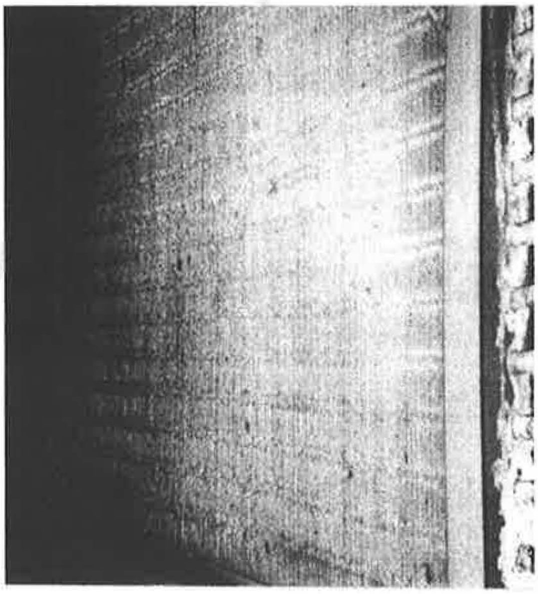
System Contamination

- Large quantities of air
- High particle populations
- 0.01 to 0.1 mg/cu.m in good conditions
- 1 to 10 mg/cu.m in severe conditions
- Equates to many kilograms of dust accumulation if unfiltered
- Even with a G3/F7 combination expect to accumulate 1gm per sq.m duct per year

BTR Environmental VOKES

Effect of Contamination

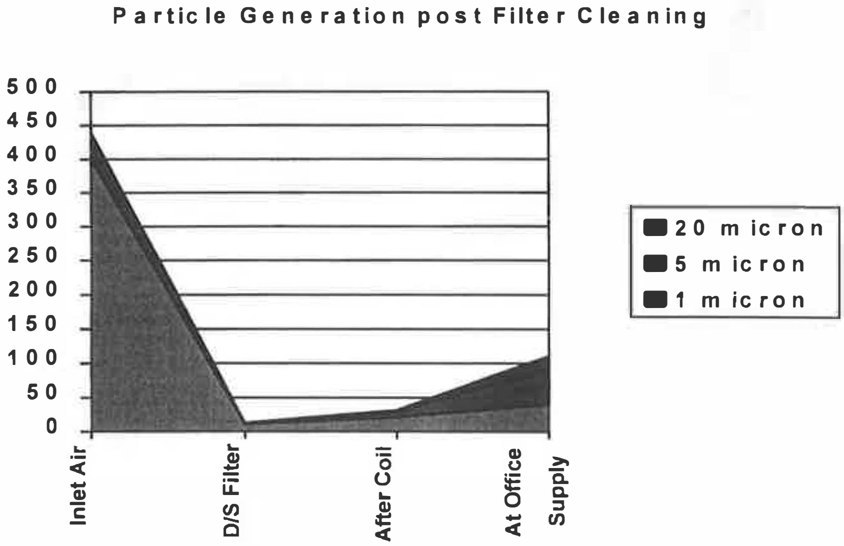
- Poor performance of system components
- Increased energy costs
- Increased maintenance costs
- Cleaning costs of system and building
- Occupant dissatisfaction
- Sources of odours
- Sources of micro organisms



BTR Environmental

VOKES

Result of Filter Exchange in a poorly Maintained System



BTR Environmental

VOKES

Filter System

- A properly specified and designed filter system is quite capable of removing all of the likely contaminants including many bacteria and viruses.
- Commercial HVAC is normally a compromise between cost and perceived benefit.
- Is it really worth saving pennies on filters when the impact of using a poorly designed or maintained system is so great?

BTR Environmental

VOKES

New Filter Classification

New Filter Classification to EN 779 Rev 3 : 1998

Grade	Em @ 0.4 μm Am= Average Arrestance
G1	Am < 65
G2	65 Am < 80
G3	80 Am < 90
G4	90 Am
F5	40 Em < 60
F6	60 Em < 80
F7	80 Em < 90
F8	90 Em < 95
F9	95 Em

Based on particle size efficiency for fine filters F5-9. Grades are equivalent to current version of EN779 based on ASHRAE 52-92 and Eurovent 4/5

BTR Environmental

VOKES

Common Maintenance Problems

- Poor filter installation
- Missing filters
- Wrong filter grades installed
- Improper sealing of filters and access doors
- Missing or inoperable Instrumentation

BTR Environmental

VOKES

The Importance of Air Filtration in HVAC

- Air Filtration Provides the Means:

- To provide healthier and more comfortable living and working conditions
- To reduce the risk of infection in hospitals and other related environments
- To prevent contamination of foods, drugs and other delicate manufactured goods
- To prevent build up of contminants in HVAC systems
- To protect expensive or delicate equipment
- To prevent ingress or emission of hazardous substances

BTR Environmental

VOKES

Summary

- The most important criteria within an air filter system installed to control air quality, and to stop the ingestion of contaminants, is the installation of the correct grade and quality of filters.
- These filters will require scheduled maintenance & replacement.
- Poor quality, ill fitting, damaged, or missing, filters will allow the bypass of unfiltered air which will defeat the object of their installation

BTR Environmental

VOKES

BTR Environmental

Air Filtration Issues Related to Ventilation Hygiene

VOKES DCE DELTA NEU NEOTECHNIK NAFCO REFILCO HOFFMAN

VHExCo99 - Solihull, Birmingham. March 1999

Wander ter Kuile

Table 2. Fungal growth on HVAC materials at various contamination levels at various relative humidities of air.

Material	Type of contamination	T °C	Tested humidity range and manifestation of growth — Relative humidity of air (%) 75 80 85 90 95 100
unused GF insulation/ duct board	Clean	21	6 weeks / 6 w
unused GF insulation/ duct board	5-10 g/m² soiling	21	
unused GF insulation/ duct board	100-200 g/m² soiling	21	4-5 w / 1-2 w
used GF insulation	contaminated in field conditions for 5-10 years, relatively clean	21	
Galvanised steel	no soiling	21	6 w
Galvanised steel	7 g/m² soiling	21	6 w
Galvanised steel	90-180 g/m² soiling	21	
used GF filter	used for 4 months at 40% and 80 % of RH	Amb	18 w
used GF filter	used for 12 months	Amb	ambient RH for 52 w
used GF filter	used for 12 months, no air flow in test conditions	21	2 w; 4 w upstream side only; growth on both sides; 52 w
(used) GF filter	one year recirculation filter relatively clean	21	
(used) GF filter	artificial nutrients with water spray	21	<1 w
used GF filter	used 6 months no air flow in test conditions	20	3 w
		5	3 w
		20	5 w

Manifestation of the fungal growth: no growth | slight growth | growth

Amb = ambient temperature   w = week or weeks

References: Pasanen et al. 1991c, Kemp et al. 1995a-b, Chang et al. 1996, Foarde et al. 1996b.

VHExCo 99

The International Ventilation Hygiene Conference and Exhibition

March 24-25 1999
National Motorcycle Museum,
Solihull, Birmingham, UK

Welcome to VHExCo 99

VHExCo 99 - the International Ventilation Hygiene Conference & Exhibition - is the first event of its kind in Europe for the ventilation hygiene industry and we welcome all delegates from many differing sectors of the market, from many different parts of the world.

Inside this delegate information pack you will find everything you need to make your time at the conference as enjoyable and interesting as possible. There is a full programme, copies of speakers' presentations and details of exhibitors at the accompanying trade show. Please also ensure you present your lunch vouchers at lunchtime.

The exhibition is open at designated times shown on the programme. Please make the most of this time to view the stands and talk to as many of the participating companies as possible.

If you require photocopy, fax or telephone services, please go the main reception where there is a business centre.

If you have any other queries during the conference do not hesitate to contact Michelle Marshall or Chris Godman from *European Cleaning Journal*, or Stephen Loyd of BSRIA.

We trust you will find your time at VHExCo 99 both profitable and enjoyable.

european CLEANING journal

Criterion Publishing Ltd, 2 Darsham Walk, Lums Yard, 32 High Street, Chesham, Bucks HP5 1EP, UK.
Tel: +44 (0)1494 791222. Fax: +44 (0)1494 792223.
E-mail: michelle@criterion.demon.co.uk

BSRIA

The Building Services Research and Information Association, Old Bracknell Lane West, Bracknell, Berkshire RG12 7AH, UK. Tel: +44 (0)1344 426511.
Fax: +44 (0)1344 487575. E-mail: StephenL@bsria.co.uk

VHExCo 99

The International Ventilation Hygiene Conference and Exhibition

Final programme

Wednesday March 24

8.30am - 9.15am	**Registration and coffee**
9.15am	Welcome
9.20am -	**'Risk Management'** by **Tony Clarke** (James R Knowles) Keynote speaker
9.45am	**'The Story of Ductwork'** by **Brian Roberts & Mike Barber** (CIBSE Heritage Group)
10.15am	**'System Cleaning'** by **Inger Dahl** (The Norwegian Building Research Institute)
10.45am	**Coffee and exhibition**
11.30am	**'Air Quality Monitoring'** by **Duncan Brown** (Environmental Montoring Services)
12pm	**'Inspection Techniques'** by **Einar Yri** (Montana Corporation)
12.30pm	**'The Role of the Consulting Engineer'** by **Bob Brown** (Zisman Bowyer Partnership
1pm	**Lunch and exhibition**
2.15pm	**'A Client's Experience'** by **John Armstrong** (Arup Facilities Management)
2.40pm	**'Hospital Ventilation & Infection Control'** by **Peter Hoffman** (Central Public Health Laboratory)
3.15pm	**Tea and exhibition**
4pm	**'Biocides & Disinfectants'** by **Philip Clarke** (Health & Safety Executive)
4.30pm	**'Filtration'** by **Wander ter Kuile** (BTR Environmental)
5pm	Questions and discussion
5.15pm	**Close**

Thursday March 25

9.00am	**Exhibition and coffee**
9.30am	**'Duct Cleaning Methods'** by **Richard Trebilco** (HVCA/EDCA)
10.00am -	**'Verification of Cleanliness'** by **Pertti Pasanen** (University of Kuopio, Finland)
10.30am	**Coffee and exhibition**
11.15am	**'Insurance & Kitchens'** by **Mark Newton** (Royal & Sun Alliance)
11.45am	**'Protection of Kitchen Extracts'** by **David Stoneman** (Techniair)
12.10pm	**'The Importance of Training'** by **Brian Loader** (Aquazur)
12.40pm	**'After a Clean - What Next'** by Charles Gray (CGA Healthcare Engineering Services)
1pm	Questions and discussion
1.15pm	**Lunch and exhibition**
2.30pm	**'Ventilation Hygiene Standards - an Overview'** by **Richard Trebilco** (HVCA/EDCA)
2.50pm	**'Clean Classified HVAC Components - a Finnish Approach'** by **Pertti Pasanen** (University of Kuopio, Finland)
3.10pm	**'The Air Conditioning Market'** by **Anette Holley** (BSRIA)
3.30pm	**'Marketing Ventilation Hygiene Services'** by **Olle Berglund** (RSVR, Sweden)
4pm	Questions and discussion
4.15pm	**Close**

WEDNESDAY
MARCH 24

Keynote speaker

Tony Clarke MSc, FCIOB, MCIPS, MaPS, FFB

Tony Clarke is a Chartered Builder and Project Manager with experience of a wide range of building and civil engineering projects in the UK. For the first 10 years of his career he worked on a series of infrastructure projects in the north west of England. In 1976 he moved with his family to Cambridge and was project manager on the A45 Cambridge Northern Bypass and a section of the M11 motorway. Upon completion he was promoted to the board of his employer, assuming responsibility for about £40m per annum of large-scale civil and engineering projects throughout East Anglia.

From 1982-84 he owned and operated his own building and project management company, which undertook about £60m worth of work throughout East Anglia in that time. Clients included Regional and Local Government, large private sector manufacturing organisations, and occasionally Cambridge University and Colleges.

In 1994, post Latham, he joined James R Knowles to establish and manage a new division offering a range of best practice construction procurement services to major public and private sector clients. He is executive director of James R Knowles Ltd and Managing Director of Procurement and Partnering Services Ltd, and works closely with Sir Michael Latham in his capacity as Chairman of PPSL

JM (Mike) Barber

A graduate of the Building Department of UMIST in 1965. On graduation he joined GN Haden & Sons Ltd and worked with them until 1971 when he joined Oscar Faber of St Albans as a project engineer. In 1973 he joined Liverpool University as a lecturer in Building Engineering, subsequently becoming a lecturer in the School of Arthitecture and Building Engineering. His specialist subject is Building Services Hardware and Energy.

As a Chartered Engineer, Barber is a member of both the CIBSE and the IMech E. He is particularly interested in the history of building services, and is Secretary of the CIBSE Heritage Group.

The Story of Ductwork

by Michael Barber & Brian Roberts, CIBSE Heritage Group

Early systems of air shafts can be traced back to the ancient civilisations in Egypt and on Crete. The first great heating engineers were the Romans who developed the underfloor warm air heating system, the hypocaust, as they built their public baths and extended their civilisation northwards into colder climates.

The 11th century saw the development of the chimney which continued for several centuries, reaching a peak in Victorian times with the multiple flue systems employed in large houses. The soot from coal fires had to be cleaned from inside the chimneys by sweeping boys - an unpleasant and dangerous job.

The mid-Victorian era also saw the introduction of ventilation shafts in large public and institutional buildings - seats of government (such as the Houses of Parliament and the Capitol), museums, universities, hospitals and theatres. Many early systems used natural ventilation techniques or the ventilation was fire-assisted or aided by gas-burners used for lighting. Shafts were large and cleaning was not usually a problem. But the latter part of the 19th century saw the development of the fan and gradually as techniques developed, higher air duct velocities were used and ducts started to become smaller.

With the introduction of air conditioning, mainly for industrial applications, at the turn of the century and the growth of comfort air conditioning in the USA from the 1920s and 30s, duct systems were often both extensive and complicated. However, the need for duct cleaning only seems to have started to be recognised during the 1940s.

But the late 1950s saw the introduction of high velocity air systems with small ducts, mixing boxes and room terminals units, all posing serious obstacles to duct cleaning.

In recent years, environmental concerns has led to the recognition of potential health problems in duct-work systems and air conditioning equipment - legionella, humidifier fever and sick building syndrome. As a result a new and important branch of our industry has emerged, covering air quality monitoring, inspection and cleaning of systems, hygiene training and establishment of standards.

J Michael Barber & Brian M Roberts

THE STORY OF DUCTWORK

1. TITLE: CLEAN YOUR DUCTS
"Clean Your Ducts for Better Results" might well be the present-day message of this Conference. However, air shafts and air ducts can be traced back to some of the very early civilisations, and how, or if, these ducts were cleaned is open to doubt.

2. 2000 BC: CRETE
The Minoan civilisation on Crete flourished some 4000 years ago. The Queen's Chamber in the Royal Palace was naturally ventilated and daylighted by vertical air shafts, shown in the background. Such air shafts were a feature of Minoan architecture.
You are concentrating on the air shafts, aren't you?

3. 1400 BC: EGYPT
The earliest drawing of air ducts may be that in a house of a notable of Thebes in ancient Egypt around 1400 BC. His 3-storey town house has a ground floor kitchen, private apartments on the 1st floor and offices on the 2nd. Sacks of grain are stored on the roof -top left. Ducts were built into the ceilings so that air could circulate and cool the building. Whether the ducts had to be cleaned after a sandstorm is not recorded.

4. 100 AD: ROMAN HYPOCAUST
The first great heating engineers were the Romans. They developed the underfloor system of warm air heating, known as the hypocaust, for their great public baths and for their villas, as they expanded their Empire northwards into the colder parts of Europe.

The hypocaust used a raised floor, supported on a series of pillars. Warm air, heated in a furnace or stokehold, was circulated through this hypocaust, heating the floor and rooms above.

5. 100 AD: ROMAN BATHS AT BATH
In this plan of the Roman Baths at Bath, the multiple small squares are the remains of the hypocaust pillars.

6. 1834: VICTORIAN CHIMNEYS
After the fall of the Roman Empire, the heating industry went into decline, only to re-emerge just before the reign of Queen Victoria. These Dark Ages saw a return to open fires and the hearth, the introduction of the stove and the development of the chimney. This drawing shows a complex of individual Victorian domestic chimneys serving coal-burning grates. The soot, which accumulated on the inside walls of the chimneys, was cleaned away, by small boys, who in this drawing of 1834, can be seen wedged inside these flues.

99. 1800 SWEEP'S BOY
The work of cleaning the chimneys was carried out by small boys. It was hot, dirty and dangerous.

THE STORY OF DUCTWORK

7. 1806. DERBY INFIRMARY
Around 1806 a warm air stove, or cockle as it was called, was installed in Derby Infirmary. It was devised by William Strutt and developed by Charles Sylvester who started the heating company that was later to become Rosser & Russell. In winter, fresh air heated by the cockle was distributed through a large underground passage.

8. 1834. HOUSES OF PARLIAMENT
The Houses of Parliament was destroyed by fire in 1834. The architect, Charles Barry, prepared a number of designs for the new building. Dr Boswell Reid was appointed to design the ventilating scheme for the Commons, while Barry would see to that for the Lords.

Reids scheme involved the use of large chimneys or towers with the ventilation system assisted by the heat of fires. The painting shows one of Barry's designs, which incorporated a large central tower. This scheme was not adopted.

9. REIDS VENT HOUSE OF COMMONS
Reids ventilation scheme for the Commons made extensive use of large ducts, chambers and a tall chimney. His scheme is shown here in plan -top left, and in section.

Air is drawn in at the left through basement chambers, filtered, and then supplied to the Chamber of the Commons through a perforated floor. Next it is extracted at high level, drawn into the fire at the bottom of the chimney and then discharged. Probably, plenty of space for cleaning, but the system was unsuccessful. The chimney failed to generate sufficient draught.

10. REID ST GEORGES HALL
Earlier Reid had designed a huge ventilation scheme for the massive St Georges Hall in Liverpool.

98. ST GEORGES HALL -VENT
Completed in 1854, this installation was more successful. It used four 10 feet diameter fans with large basement air passages.

97. 1850 GUYS HOSPITAL.
Another notable installation of this period was the fresh air intake tower and upcast heated exhaust air tower used at Guys Hospital around 1850. These ventilating towers and associated ducts were extremely large compared with the ventilated space and, presumably, access and cleaning were fairly easy -if in fact cleaning was carried out.

THE STORY OF DUCTWORK

11. 1857. CAPITOL WASHINGTON
During the 1850s, the United States Capitol in Washington was rebuilt and enlarged.

12. CAPITOL DUCTS -PLAN
General Montgomery Meigs was responsible for co-ordinating the design of the heating and ventilation. This later drawing of 1881 shows the main fans, marked A and B, with the basement ducts and chambers which were described as "generously proportioned". The 16 feet and 12 feet diameter fans were driven by steam engines, the larger capable of discharging air at the rate of one hundred thousand cubic feet per minute.

13. CAPITOL DUCTS -SECT
This section through the Capitol system shows the large heating chamber and walk-through basement shafts which connect to vertical supply air shafts feeding floor outlets.

14. 1858 EARTH COOLING SYSTEM
Something completely different was the scheme proposed by a Dr Jeffreys in 1858 to use underground tunnels to ventilate soldiers' barracks in India. The theory was that the cold earth, well below the surface and shielded from the summer heat above, would chill the entering fresh air. But the tunnels were not deep enough.

15. VIENNA OPERA HOUSE
Later in the 19th century, Vienna built a new opera. house

16. VIENNA -VENT
This plan & section of 1881 shows the opera house ventilation system. The scheme used basement fresh air chambers with a fan, marked S, and large heating chambers. Foul air was exhasted up through a roof tower by a large ventilating gas light and a fan, marked U.

17. 1885 JOHN HOPKINS HOSPITAL, BALTIMORE
An early example of a naturally ventilated hospital was the John Hopkins of 1885 in Baltimore. Note the low level fresh air inlets, the window louvres and shades, and the extensive system of exhaust air stacks rising above the roof line.

18. HOPKINS -DUCTS
The complex of air ducts and exhaust shafts at the John Hopkins hospital can be seen in this cross-section.

THE STORY OF DUCTWORK

19. 1883 METROPOLITAN OPERA HOUSE NEW YORK
Another famous opera house was the original Metropolitan, built in New York in 1883.

20. METRO -VENT
This plan of 1883 shows the huge main air ducts and giant plenum which completely filled the void under the main auditorium. How different to the ducted systems of today.

21. 1891 CARNEGIE HALL NEW YORK
Another famous New York building of 1891 was Carnegie Hall.

22. CARNEGIE HALL -VENT
This drawing shows builders work plant chambers but also increasing use of sheet metal distribution ducts. Incidentally, the building was initially called "The New York Music Hall" and, in summer, ice blocks were placed in the chambers to cool the air.

23. 1904 LARKIN BLDG
In 1904, the Larkin Building in Buffalo was opened. Built on a site suffering from severe atmospheric pollution, the building designed by architect Frank Lloyd Wright was basically a sealed box, with an atrium core, daylit from above, and with a vertical service tower at each corner.

24. LARKIN VENT
This plan show the basement distribution ducts for the four mechanical heating and ventilation systems, having a plant in each tower. Refrigeration was added in 1909 making this one of the first air conditioned office buildings. The Larkin Building has since been demolished.

25. ELECTRIC FAN
And it was around the turn of the century that the electric motor driven fan began to supplant the steam engine driven fan.

26. 1895 HOTCHKISS
The turn of the century also saw the start of companies specialising in the manufacture of sheet metal ducts and other apparatus. This is the firm of Hotchkiss in 1895.

27. 1900 US METAL SHOP
Here are the workers of an American sheet metal shop of around 1900.

28. 1907 SAN FRANCISCO SHOP
Another American sheet metal shop is this one of 1907 in San Francisco.

THE STORY OF DUCTWORK

29. MATTHEWS & YATES FANS
As a matter of interest, this is how Matthews & Yates fans were delivered around the turn of the century.

But the UK ductwork industry continued to develop

30. 1920s HARGREAVES
This is the workshop of Henry Hargreaves in the 1920s.

31. 1938 GARDNERS
Here are two lorry-loads of ducts from J Gardner in 1938.

32. 1944 TUPHOLMES
This is a 1944 advert for Tupholmes.

33. 1944 AIRDUCTS
Also from 1944 is this Airducts advert.

34. 1946 TUPHOLMES
And Tupholmes again, from 1946.

35. SKYSCRAPERS
The 1920s and 1930s saw the rise of the skyscraper office in the United States. Relatively few were air conditioned, but mechanical heating and ventilation became widespread.

36. 1945 US DUCT FABRICATION
This is an American duct fabrication shop of 1945.

37. US METAL SHOP
And here a painting of another American sheet metal shop.

38. US FURNACE
Here a painting of multiple small warm air ducts being connected to a basement furnace.

39. 1950s US OFFICE BLOCK
By the 1950s, the duct systems in the American office block were becoming quite complicated.

40. 1950s US OFFICE BLOCK
Another 1950s example of ducts above a suspended ceiling.

41. 1960s LABORATORY DUCTS
Here we have ducts and fans in a 1960s laboratory block.

42. 1960s HOSPITAL DUCTS
Also 1960s, a maze of ducts in a hospital corridor. No doubt due to be hidden above a false ceiling.

THE STORY OF DUCTWORK

43. 1960s HIGH VELOCITY DUCTS
But now access and cleaning of ducts gets even more difficult with the introduction of high velocity systems, mixing boxes and small ducts.

44. FACTORY A/C
Fortunately, these exposed air conditioning ducts in a tobacco fctory can be readily cleaned, both inside and outside.

45. 1947 DUCT CLEANING
There has been an unofficial competition between BSRIA and the CIBSE Heritage Group to find the earliest picture of duct cleaners in action. This BSRIA entry is from 1947.

46. 1947 DUCT CLEANING
Another BSRIA duct cleaning picture from about the same time.

47. 1840s BREATHING APPARATUS
However, the Heritage Group has come up with this picture of a man in full protective clothing with inspection light and breathing apparatus. It dates from the 1840s. Unfortunately, it turns out to be of an early fire-fighter.

48. US OFFICE BLOCK
Another example of ductwork being installed.

49. ACCESS DOOR
An access door into the ductwork is always considered helpful.

50. BARBICAN
Some sheet metal ducts are large enough to walk inside. This example from the 1970s is in the Barbican Centre.

51. POMPIDOU
However, the 1976 Pompidou Centre in Paris put much of its ducting outside the building. Maybe this makes cleaning easier?

52. LLOYDS LONDON
The 1985 Lloyds Building in London also has its share of external ducts. And to the untrained eye, cleaning looks like it could be quite hazardous.

These are but a few assorted duct systems over the ages.

53. GAS MASKS
We leave you with a picture from the first duct cleaners convention.

54. CLEAN YOUR DUCTS
Remember Clean Your Ducts for Better Results.

Inger Dahl, BEng

Inger Dahl worked at the University of Oslo and other research institutions for 16 yers before moving to the cleaning industry. She worked for ISS (International Service System) for 14 years as a Technical Manager in the Technical Division. ISS is a leading international company within the field of industrial cleaning and one of the most important jobs of the Technical Division is to look at cleaning methods in relation to the indoor climate and ventilation systems.

Since leaving ISS a year ago, Dahl has worked for the Building Technology Department of the Norwegian Building Research Institute and is now a senior specialist consultant of the Department of Building and Environment at the National Institute of Technology.

Why Ventilation Systems Should be Clean

Inger Dahl, National Institute of Technology, Norway

Why Ventilation Systems Should be Clean

Inger Dahl, National Institute of Technology, Norway

Dust and Indoor Environment

One of the main reasons for cleaning is to lower the pollution level by removing dust and other contaminants from the indoor environment. In addition to cleaning, the pollution level is affected by the choice of building materials, activities, dirt-inhibiting measures and ventilation. Dirt sources are many: even while performing sedentary activities, humans give off about 500.000 particles per minute, due to natural skin exfoliation (the outer skin layer is completely replaced over a period of two to three days). In addition, textile fibers are released from clothing and further pollution is produced by work activities.

Neither cleaning, nor ventilation can individually remove all dust. While 50% of particles greater than 3-4ìm are removed at 1 complete air-change per hour, 10 air-changes per hour are necessary to remove 50% of the particles of size 10ìm. Thus a large part of the pollutants in a building are extracted through the ventilation channels that can often collect a lot of dirt.

Dirty exhaust ducts are an extra fire hazard. Fire can spread through the ducts at a faster rate than that in which it is possible to shut down the fire prevention valves. In 1997, the reason given for a school in Oslo burning to the ground was dirty exhaust ducts.

In recycling air there is a risk that the incoming air is polluted in the tube network before arrival.

The Danish "Town Hall Study" (1) is the first large research project on indoor environments confirming the effect of cleaning. The project took place during 1984 and 1985, and included twenty-eight local administration buildings in Copenhagen. The risk of developing "sick building"-symptoms was shown to increase with rising dust levels. The risk was particularly high if the dust contained large amounts of macromolecular material, that is organic material in the form of food remains, skin, hair, etc.

"Dust an the sick building syndrom." (2) is a follow up of "The Town Hall Study". It analyzed dust from the same buildings to find relations between the components of the dust and the presence of "sick building"-symptoms. It found the following statistically significant relations:

- Dominance of gram-negative bacteria and the presence of:
  - General fuzzy symptoms (headaches, tiredness, etc)
  - Irritation of the mucus membrane in the lower part of the upper respiratory tract.

- Dominance of inorganic dust particles (over fiber and skin fragments) and
  - General irritation of mucus membranes.

- Content levels of volatile organic compounds (TVOC) and
  - The symptom "heavy headed".

Some types of dust irritate the skin and mucus membranes even without such "passengers". Examples are dust from cement or concrete and mineral-wool fibers. Mineral-wool fibers are often accidentally left in the ventilation channels of new buildings, to be blown out when the ventilation system is first started.

The purpose of ventilation systems is to provide clean, fresh air to the work areas. This is however not always the case. Research has shown that the air provided is often contributing more pollution than both the building materials and the humans in the area (4).

"The Town Hall Study"(1) also showed that modern ventilation systems can have a negative effect on the indoor environment. In buildings with balanced ventilation, risks of mucus membrane irritation and general fuzzy symptoms were respectively 1.4 and 1.85 times greater than in buildings with exhaust ventilation systems. This is probably due to insufficient attention to and maintenance of the systems.

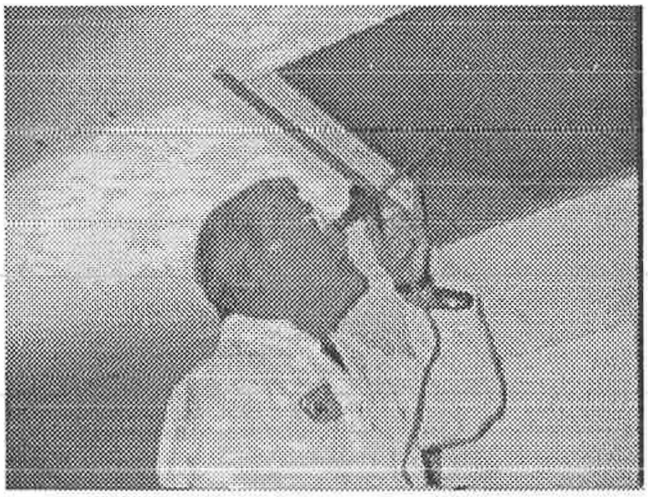
Studies using Ole Fanger's trained panels found that ventilation systems are often the source of sensory pollution in buildings.

On inspection of ventilation systems we often find large amounts of pollution. Ducts and aggregates can gather dust, soot, fat or grease, and waste may remain from the time of building or installation. Rust and other products of corrosion have also been found, in addition to dead and living animals, including insects. These extraneous elements can nurture fungal and bacterial microorganisms that further contribute to a deterioration of the indoor environment. Ventilation systems should therefore be inspected on a regular basis so that they may be cleaned and disinfected as necessary. It also needs to be ensured that the system has effective filters (min. EU 7) and that all the air passes through them. In Sweden, cleaning of ventilation systems has been made compulsory in an effort to reduce indoor environment problems. However, recent studies (6) indicate that cleaning can be avoided if filtering is effective (dayworking, 3000 h/year, EU 7).

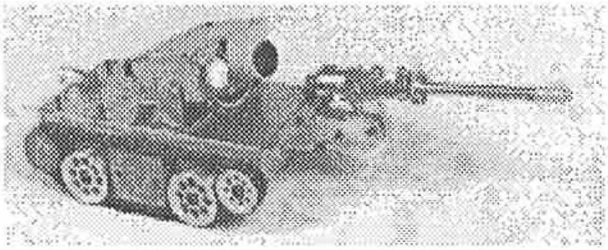
Pre Study

Before cleaning of ventilation system is undertaken, the state of the system is evaluated by way of visual inspection and analysis of collected dirt samples (particles and microorganisms). For the inspection, video cameras, fiberoptics and a periscope are used, see pictures.

Inspection with fiberoptics



Video camera

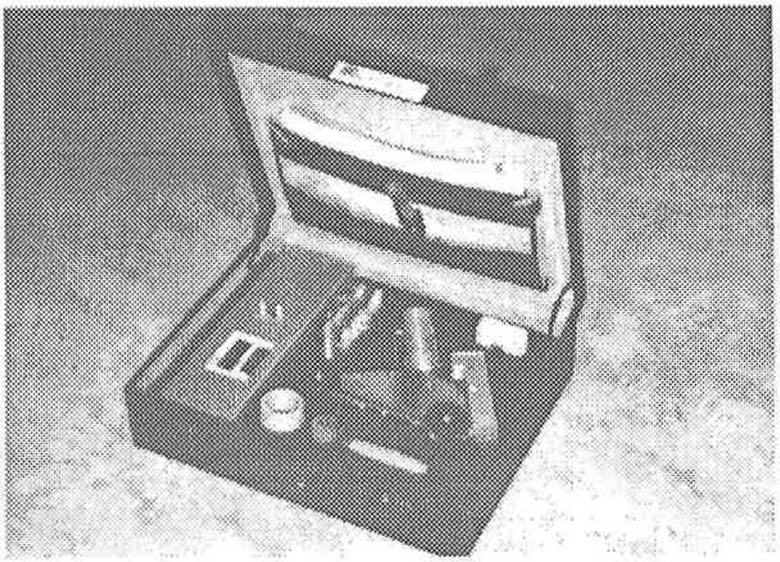


Dust measurements can be taken from dirt deposits with gel-tape-tests, and by air particle counts. Particle counts are normally taken before and after filters and at the in-air valve to control filter efficiency and possible emissions from duct surface. A workgroup has made a suggestion for limitations on dust deposits in different types of ventilation systems (5). Tests of microorganisms are collected by means of contact plates or similar that are incubated and interpreted. Air samples may also be used. (RCS-sampler)

In 1985 at the Institute for Work Environment in Copenhagen, Thomas Schnieder developed a method of examining dirt deposits (primarily aimed at mineral-wool fibers) on flat, hard surfaces using gel-tape as a sampling medium, and microscope analysis (6). The method also proved appropriate for analysis of general contamination of all hard surfaces. The tape can also be used for sticky dirt types. As a result, gel-tape is particularly suitable for analysis of the quality of cleaning. Schneider's method has since been developed and adjusted for this purpose (7). In later years a simple field method has been developed for the analysis of cleaning quality using gel-tape as the sampling medium (8).

The measuring instrument BM-Dustdetector has been commercially available since Spring 1991, and has proved to be a useful tool in the control of cleaning quality. After the cleaning is complete, inspection and measurements are undertaken as previously described.

The BM-Dustdetector



Cleaning Quality at Time of Handover

In Norway, industrial standards have been developed for regulation of the cleanliness of different surfaces, se the table below.

Objective limits on cleaning quality should firstly be used as a contractual demand at the time of handover of a building.

SURFACE	Cleaning classes					
	A: HIGH		B: NORMAL		C:LOW	
	Norm	Max	Norm	Max	Norm	Max
Furniture (settled building cleanliness)	0,7 %	1,0 %	1,5 %	2,0 %	2,5 %	4,0 %
Walls, ceiling, floor	1,0 %	1,5 %	2,0 %	3,0 %	3,0 %	5,0 %
Carpetfloor Dust index*)	2,0 %	3,0 %	3,0 %	5,0 %	5,0 %	7,0 %
Surfaces of the furniture High surfaces, Shelves	1,0 %	1,5 %	3,0 %	4,5 %	4,0 %	6,0 %
Cavity before closed	2,0 %	3,0 %	3,0 %	5,0 %	4,0 %	6,0 %
Inside surfaces in the ventilation ducts	3,0 %	5,0 %	5,0 %	7,0 %	7,0 %	10,0 %

*) The measurements are reported as dust-index according to the industrial standards.

The dust cover percentage is measured shortly after cleaning has been completed. The measurements are taken using the BM-Dustdetector.

The regulations on cleaning quality of internal surfaces in ventilation systems are based on measurements taken in the CLEAN BUILDING-project.

References

1. Peder Skov, Ole Valbjørn, Finn Gytelberg og DISG; "The Town Hall Study – Indoor environment in offices", Arbejdsmiljøfondet, København 1989.

2. Finn Gyntelberg & al.; «Dust and the Sick Building Syndrome», Indoor Air1994, no. 4, s. 223-238.

3. Birgitta Bruzelius; "Hidden olfs, the cause of unhealthy buildings" fra "How do we get healthy buildings", Swedish Council for Buildings Research 1988.

4. Leif Bejner, S. Lindgren, O. Tommisto; "Luftrenare, kunskapsoversikt och riktlinjer för val av luftrenare i förvaltningsbyggnader m.m.", 1990.

5. Jørgen Waage m.fl.: «Arbeidsrapport - Normer for renhold av ventilasjonssystemer», Teknologisk Institutt, Overflatedager'94

6. Thomas Schneider; "Kvantifisering af overfladers kontaminering med partikler", Arbejdsmiljøinstituttet 1985.

7. Thomas Schneider & al., "Måling af rengøring", AMI-rapport Nr.27/1988, Arbejdstilsynet København.

8. Ole Holm Petersen & al; "Udvikling af instrument og metoder til måling af støv på overflader", Arbejdstilsynet og Bygge- og Miljøteknik A/S 1991.

Duncan Brown, BSC

Duncan Brown has a BSC (Hons) in microbiology, and is a Fellow of the Institute of Biomedical Sciences. He joined Environmental Monitoring Services in 1989 as Environmental Consultant with a background in public health and environmental microbiology. After three years he became an Operations Manager responsible for a team of environmental consultants and key account management. In addition he was involved in product and technical development, and training seminars on legionella management and control. He is EMS's Health & Safety Office and Chairman of its Health & Safety Committee.

Air Quality Monitoring

by Duncan Brown, Environmental Monitoring Services

We first need to consider several definitions which highlight the difference between Indoor AirœQuality monitoring and assessing Ventilation Ductwork Hygiene. The first, Indoor Air Quality monitoring, is concerned solely with meeting your obligations to provide air qualityœwithin your workplace of at least equal to that of the external air to your premises. I loathe to call it fresh air because in some instances it may be far from it! Whereas, under the second definition, you are trying to assess whether or not there are significant levels of contamination within your ventilation systems to warrant, what can be costly, cleaning processes.

However, there is an overlap where due to poor standards of maintenance over prolonged periods, Indoor Air Quality is affected by Ventilation Hygiene. There is also anœoverlap where Energy Management is a cause for concern because dirty systems may proveœto be less effective in maintaining ventilation rates to the occupied space and more energyœmay be required to maintain comfort conditions due to heat transfer processes becoming impaired if heat exchange batteries become covered with dust contamination.

An early issue to any manager responsible for premises considering the need for ventilation cleaning would be in determining if it is applicable in his circumstances or not. Obviously, with the Health and Safety implications, it is important that the competency of the contractor or consultant providing the inspection and monitoring service is an early criteria to be established.

So how can the Facilities Manager or the Manager of premises assess the potential competency of such contractors or consultants? The first thing to look for is obviously the right experience.

Can the supplier, demonstrate that the staff to be employed have theœnecessary experience in heating, ventilation and air conditioning systems and can they show you that they understand how your ventilation system works? Can they provide you with clear references from satisfied customers and a proven track record? Can they provide youœwith a clear demonstration that the staff they are employing in this process of assessing yourœductwork systems have the necessary experience in the relevant laboratory sciences, including microbiology? Can they show you that they follow a clear rationale in the testing and sampling that they will perform and show you the standards they will employ in interpreting the results before any of the monitoring process starts? Otherwise what is the point of assessing the system and how can the contractor know that they will meet the customer expectations?

The second aspect in establishing the potential competency of an assessor is the need for you to consider are their specific qualifications. Does the potential supplier or their staff have a recognised qualification in heating, ventilation or air conditioning design, maintenance or installation. Does the same supplier have staff with recognised qualifications in laboratory science, including microbiology? Can they demonstrate to you that they have quality assurance programmes with quality systems to nationally recognised standards so that the data they produce for you is recognised as reliable, accurate and re-producible? So for instance, do they have ISO 9002 or UKAS accreditation for the sampling, laboratory and inspection work?

A key aspect maybe to consider the resources such potential suppliers have to monitor and assess your system, taking into account both manpower and equipment requirements for them to effectively carry out the work that you delegate to them. Can they show in this process that everybody they employ meets a necessary minimum standard? And of course can they show you that all aspects of health and safety pertaining to the actions they will be carrying out have been fully considered by their risk assessment which they should provide to you before starting the monitoring/assessment process. Can they show you all their staff are suitably trained to be fully aware of their health and safety procedure that should beœcarried out when dealing with air conditioning or ventilation plant? After all, the last thing you need when having your ventilation systems checked for condition, is for your chosen supplier to injure themselves or your employees.

When it comes to determining from the Facility Manager's perspective what should be included in terms of inspection, sampling and testing of supply ventilation systems, certain key elements will need to be considered. Firstly, although indoor air quality is linked in the extreme cases to ventilation hygiene, that is not always the case. So whoever you use it is important that they incorporate visual inspections of all air handing plant, ductwork supply systems and terminal units. This should assess the conditions of the plant from fresh air intakes all the way through to point of delivery. Key aspects within this survey will be noting the conditions within the main air handling plant, looking for evidence of filter bypass or loading, the condition of heat exchange batteries, humidifiers, and all air handling unit chambers.

Essentially, this aspect of the inspection is looking for indicators that these important areas of systems have been poorly maintained, because if this the case, there will most certainly be the potential for a ong term detrimental effect on the ductwork supply system with possible cleaning implications. In terms of assessing the quality of supplied air, three key elements need to be considered. Airborne particles across a range of sizes which can be utilised to firstly assess the effectiveness of installed filters in removing external contaminants, and determine by taking measurements at set points within the duct-work supply system and comparing to results post-filtration as to whether significant levels of impaction, or increased levels of contamination, are occurring as the air passes through supply ductwork systems. The first indicates potential future problems and the latter that significant problems already exist.

The next aspect to consider are the types of dust particles present. This can include gravimetric analysis of the airborne particles present to determine load it will also be appropriate to types and sizes of any specific dust found to be present, which can aid in determining if there are any recognisable health risks being presented to your staff by the air supplied from the ductwork system.

And the third element to assess is to sample and analyse the supplied air for presence of bacteria and fungi. Since it would be easy to inadvertently contaminate the sample, an accredited rationale and detailed sampling/analysis procedure is required to ensure that re-producible and accurate results as to the supplied air quality and the ductwork distribution systems contribution toœthat quality is determined. This is especially important if you were to follow the advice given by the World Health Organisation which concludes that treatment with biocides for ventilation systems should be strongly discouraged or limited because of the toxic risks to the occupants. This would also take into account that our general population is becoming far more susceptible to a wide range of chemicals that can be irritant to specific individuals, and taking into account the requirements of the Control of Substances Hazardous to Health Regulations. So, unless you have a very good reason for disinfecting ventilation ductwork systems, this should only be a path of last resort. The exceptions perhaps being hospital theatres or where microbiological contamination is categorically established by an accredited sampling and analysis procedure.

Should your contractor/consultant who provides the assessment services also carry out the remedial measures? That is only a question of course you can answer yourself, but, in my opinion, it would be sensible to ensure that whoever carries out the monitoring and testing, clearly defines to you the standards they expect to use to determine whether or not cleaning of theœwhole system or parts of the system are warranted. From your perspective, you may well feel more comfortable, and indeed as our society becomes more litigacous, the contractors themselves may feel more comfortable if you employ independent assessors who patently have no vested interest in the results. These should work for the client only and at the start it should be made clear that they will not benefit from whatever results they obtain (ie. They themselves or any linked company). Any other pattern of work may actually damage the long term health of the cleaning industry as users may become sceptical of the value of any form of ductwork cleaning in any circumstance.

Essentially, the Facility Manager should ensure that their M&E contractor is installing all filters within air handling units correctly, that they are the right size and quality to do the job, that these air handling unit systems are independently inspected on a frequent basis and that indoor air quality monitoring and system inspections are regularly performed in order to limit wherever possible the need to perform ful hygiene cleans with the considerable cost implications.

In my opinion, only as a matter of last recourse would you wish to use disinfecting agents within your ductwork supply systems because of the potential impact it may have upon your staff and the fact that the only reasons that micro-organisms would grow within the system would be if moisture is present. This is rarely the case, and if it is found, the requisite remedial measure would be to remove that moisture whether it be condensate failing to drain away, blow through from syphon pack, spinning disc or spray coil humidifiers or condensate accumulations.

As for the inspection techniques available, this will be dealt with elsewhere so I will be just looking at the air sampling side. There are three recognised methodologies. The first is where you either spot or grab samples whereby small quantities of air are captured in a container and then various analytical instrumentation used to detect levels of pollutants present. The second technique is where time integrated sampling occurs where the levels of pollutants may be below the detection limits of the analytical instruments in use (examples being where particulates are collected on membranes or filters and measured as a time weighted average, usually over 24 hours or longer). And the final approach would be real time continuous monitoring analysis which allows you to plot the variations in concentration against time and location as well as providing average concentration levels over set periods. All have their uses in providing assessment data.

However, provided suitable and sufficient levels of maintenance are performed on the systems and provided that these systems produce indoor air quality at least the equal to outside air quality with nothing detected that is injurious to health, the motivation to carry out deep cleans of the fresh ventilation systems must by necessity rely heavily upon the subjective. So unless in the monitoring you are demonstrating a deterioration in indoor airœquality or something potentially hazardous to health or energy wastage. You must seriouslyœconsider the cost implications. The contractor providing assessment must also consider theœpossible litigation problems that may ensue of not clearly defining the standards, issues, procedures and actions from the interpretation of the results prior to starting any monitoringœprogramme that leads to cleaning.

So, hopefully the key criteria you will take from this session is that:

- Your system assessor monitor is; (i) competent, and (ii) accredited to nationally recognised standards.
- You employ him directly and independently so his results cannot be regarded as ofbenefit to him.
- You agree clear standards or levels where actions are required and where they will be.

Einar Yri

Einar Yri is a director of Montana Corporation, London-based ventilation hygiene consultants. His experience includes ventilation hygiene surveys and monitoring in most types of buildings; manufacture and marketing of specialist equipment for remote control inspection and mechanical cleaning of ventilation systems. He also has experience of running training courses and several hundred delegates have passed through Montana Corporation's Ventilation Hygiene seminars which are held regularly at BSRIA in Bracknell and in Manchester.

Yri also served on BSRIA's drafting panel which produced the 'Standard Specification for Ventilation Hygiene'.

Inspection Techniques

by Einar Yri, Montana Corporation

Inspection of ventilation systems is always a precursor to decisions on system cleaning and often used to verify the quality of system cleaning once cleaning has been carried out. Accordingly, findings of system inspections play an important role in the management of ventilation hygiene. Together with records of air monitoring, maintenance, plant efficiency measurements and plant inventory, system inspection findings provide key information needed to demonstrate management control of indoor air quality and system condition.

With legislation, general public awareness and insurance companies placing ever stricter demands on building owners to exercise management control, system inspection is becoming increasingly important. In particular inspection of air ducts; normally out of sight and often difficult to access. To reach parts of air duct systems, which are difficult to access, purpose built remote control cameras have been developed, which will record the internal conditions of most air ducts, irrespective of type, size and layout. The focus of this paper is on air duct inspection.

Some reasons for system inspection

- System malfunction/performance reduction.
- Air quality complaints.
- Risk assessment.
- Legislation compliance.
- Assessment/verification of works carried out.
- Part of maintenance programme.
- To establish system integrity.
- To re-establish and retrace ductruns where drawings are missing.

Main inspection methods

- Visual inspection in the form of a walkthrough.
- Visual inspection using remote control cameras.

Many air handling units will be readily accessible and can thus be inspected with no other tools than a handheld camera, should recording of findings be required. Air duct systems, however, tend to be inaccessible, at least in part, and so can only be thoroughly inspected with the help of remote control cameras or borescopes.

Air duct inspection

Air duct inspections come in different sizes and complexities; from a quick spot check taking a couple of hours to a relatively comprehensive inspection running into weeks or months. Depending on the nature and extent of the inspection, it may be very straightforward or require considerable planning and consideration.

Scope: Provided no special problems are known to exist within the ductwork, a representative amount of the ductwork should be examined. Where inspection forms part of an ongoing monitoring programme, it is important that methodology and equipment remain constant throughout the programme, so as to assure detection of changes in conditions between inspections.

Whatever the complexity of the inspection, it is recommended that the inspection Contractor present the Client with a set of Inspection Protocol or Method Statement and Terms of Operation with his Quotation. Some of the details of these documents may well have to be discussed and perhaps adjusted before an agreement is reached, but the purpose should be to leave both parties with a clear understanding of what is expected from the inspection and how it will be managed and carried out.

The above mentioned documentation should as a minimum set out the following:

- Purpose of the inspection.
- Extent of the inspection.
- How the inspection will be carried out.
- Input expected from the Client.
- Health and Safety implications.
- Time schedule.
- How and when the Inspection Contractor will report his findings.
- Inspection fees.

During the course of the inspection the inspection Contractor will keep a log giving information on venue, date, inspection area, system reference, access point reference, duct size and length inspected; together with inspection findings. Observations on structural integrity and general maintenance and hygiene issues which may have a bearing on ventilation hygiene, will also be noted. Inspection access points will be entered onto drawings.

Air duct inspection methods and equipment

The simplest way to inspect a ventilation duct is to put one's head in through an access door and have a good look around, perhaps with the help of a torch. This presupposes that reasonable access is available and is not going to be much help in ducting without access openings, very small diameter ducting, ducting behind walls, in floors or in ceilings. The majority of older systems may have few, if any, access doors installed. Where access doors are in place, they may be too few and far between to enable proper inspection. Sadly, this is being found to be the case even in new installations.

in choosing inspection methods and equipment, information on the following may be of help:

- Access to the point of inspection.
- Size and lengths of ductwork to be inspected.
- Size and type of access into the duct.
- Location in duct of specific item to be inspected; if known.
- Obstacles / internal features to be negotiated in duct.
- Whether or not documentation of internal condition is required.
- Availability of electrical power.

Where proper access is poor or non-existent and video or still photographic documentation of internal condition is required, remote control cameras or borescopes may be applied. Here are some examples of equipment used in remote inspection of ductwork:

Ventcam - remote control duct inspection robot: Long operational distance - colour camera - works off 110 V and 240 V - camera / lighting unclip

Minicam - system for inspection of ducts and pipes 50 mm and over: Small size - access through grilles - works off battery - truly portable

Microcam - system for inspection of ducts and pipes 22 mm and over: Small size - watertight - works off battery - truly portable

Top-Optic Borescope - for inspection entry of 12 mm and over: Small size - lightsource works off battery - truly portable

See Annex for further details.

Inspection report

The resulting inspection report accompanied by video tape or photographs should as a minimum include comments on the following points:

- Client, venue, date of inspection, contact person, reference / order no.
- Purpose of inspection.
- Extent of inspection.
- General observations.
- Main findings.
- Conclusions.
- Recommendations.

After inspection

Inspections will lead to actions based on the findings and recommendations of the inspection report. Here are some possible actions:

- Cleaning / decontamination.
- Amendments to drawings and records.
- Amendments to maintenance schedules.
- Carry out repairs.
- Air testing and monitoring.
- Setting date(s) for future inspections.

Frequency of inspections will normally be determined by conditions recorded at the first inspection.

Remote control air duct inspection equipment

Ventcam - remote control duct inspection robot: Long operational distance - colour camera - works off 110 V and 240 V - camera / lighting unclip

The Ventcam has been designed specifically with the inspection of ventilation ducts in mind. The operational distance of the Ventcam is normally 50 m from one access opening and in most cases this will be more than sufficient. The range can be extended to 100 m if needed. The Ventcam requires an access opening of 200 x 200 mm for entry into the ductwork. Joystick controlled, it will work in horizontal ducts on tank track chassis, and in vertical ducts separated from its chassis. A further option is to attach the camera / lighting unit to an extendable pole to reach inaccessible places e.g. grilles under high ceilings. Findings are video taped.

Minicam - system for inspection of ducts and pipes 50 mm and over: Small size - access through grilles - works off battery - truly portable

The Minicam inspects up to 20 m of ducts and pipes up to 500 x 500 mm. Attached to a semi rigid push pull cable which houses camera and power connections, the Minicam will find its way in horizontal and vertical ducts. Findings can be video taped.

Microcam - system for inspection of ducts and pipes 22 mm and over: Small size - watertight - works off battery - truly portable

The Microcam inspects up to 20 m of ducts and pipes up to 300 x 300 mm. The camera with its integrated semi rigid push pull cable is watertight and, like the Minicam, it can find it's way into ducts through grilles or diffusers. Uses the same control unit as the Minicam. Findings can be taped to video tape.

Top-Optic Borescope - for inspection entry of 12 mm and over: Small size - lightsource works off battery - truly portable

Borescopes can enter through openings a few millimetre larger than their size and are intended to give a picture of what can be seen at that point. In the case of the 12 mm Top-Optic borescope with lightsource a good view may be gained of the inside of a duct 300 x 300 mm. May be used with a camera.

Bob Brown, MCIBSE, FIHEEM, FRSH

Bob Brown is a Senior Associate with Zisman Bowyer and Partners, Richmond. His professional career started in 1963 as a student apprenticeship with G N Haden Ltd and later as a design engineer with Haden Young, working on a range of public and commercial buildings. He joined Zisman Bowyer and Partners in 1973, becoming a Senior Associate in 1982. Recent experience has included healthcare PFI projects, nucleus hospital design, research facilities for microbiological work, high specification ventilation systems and legionella risk assessment surveys.

He has participated in BSRIA research projects on Displacement Air Flow Systems, and Legionnaires' Disease. He is a member of the CIBSE Natural Ventilation Group.

The Role of the Consulting Engineer

Bob Brown, Zisman Bowyer & Partners

The Consulting Engineer's role is to advise what is a sensible cleaning regime to meet the Client's needs. Certain Clients may well have set their own standard from experience or as a particular requirement of their business, others will need guidance.

There are three main categories of building for consideration:

i) Existing building.
ii) Refurbishments/upgrades.
iii) New building.

Consulting Engineers have a role in all of these three building categories whether it be:

i) Advising a Client on carrying out surveys, setting up better maintenance regimes or carrying out a cleaning contract on existing ductwork systems.
ii) Understanding and advising on a change of use and works in a refurbishment contract, again with any survey works, preclean or disinfection of existing systems or parts of systems that may be re-used.
iii) Understanding and assisting a Client with a brief to produce a new design that can be maintained and cleaned to a standard that is comparable with the hygiene standard or process that the Client requires, be it for an industrial storage or factory unit right through the range up to an operating theatre, or a microbiological research laboratory.

In each case the Consulting Engineer would carry out an initial risk assessment with the Client and consider any relevant legislation. There is a clear need to understand the building function and the process that goes on inside the building particularly with respect to IAQ and any specific hygiene requirements.

Existing/Refurbishments

On an existing building or refurbished building a condition survey may need to be carried out by a specialist company to ascertain conditions in the existing plant and ductwork systems.

The Consulting Engineer would then review the Survey report with the Client and recommend a course of action that was relevant to the building function. If this involved a cleaning contract then a specification and drawing package would need to be prepared.

The Contract Specification could for example be based around BSRIA Facilities Management Specification FMS1/97 and its Guidance document "Specification for Ventilation Hygiene". These documents provide the basis for a ventilation hygiene contract between a Client and a Contractor for all types of mechanical ventilation systems, except for local exhaust ventilation (LEV) as these are covered by COSHH and HSE guidance notes.

Drawing information will depend on the availability and quality of existing record drawings and any drawings produced from the survey.

It may be in many cases that detailed site survey visits will be needed before cleaning quotations can be given. There will almost certainly will be a need to cut in additional access doors within the ductwork system and possibly create new accesses to the ductwork e.g. through plastered ceilings, riser ducts etc.

Before any work commences the setting of all regulating devices need to be recorded and the location of all duct mounted sensors identified and agreement reached whether each sensor is protected or removed from the ductwork.

There must also be agreement on the verification process, be it visual, by vacuum test or by microbiological surface sampling.

The Client must also confirm the system is safe, from any hazard or contaminants.

New Buildings

On all new projects there are now standard documents that can be referred to when writing the specification for a new ductwork installation..

a) HVCA DW/TM2 "Guide to Good Practice" Internal Cleanliness of New Ductwork Installations – 1991

   This has been produced for all buildings and covers, delivery, installation and protection. Three levels of clean, i.e. Basic (for say industrial buildings), Intermediate and Advanced (for say hospitals). None of these levels involve specialist cleaning.

   When all the standards referred to in this document are achieved at handover the systems will generally be much cleaner than previously has been the case.

   However, statements like "clean, dry and dust free" for site storage and working area are generally impractical to achieve on the most building sites.

b) HVCA DW 144 is the new trade standard for ductwork installations published in 1998 (the previous standard was DW142) and Appendix M is the Guideline note for inspection, servicing and cleaning access openings.

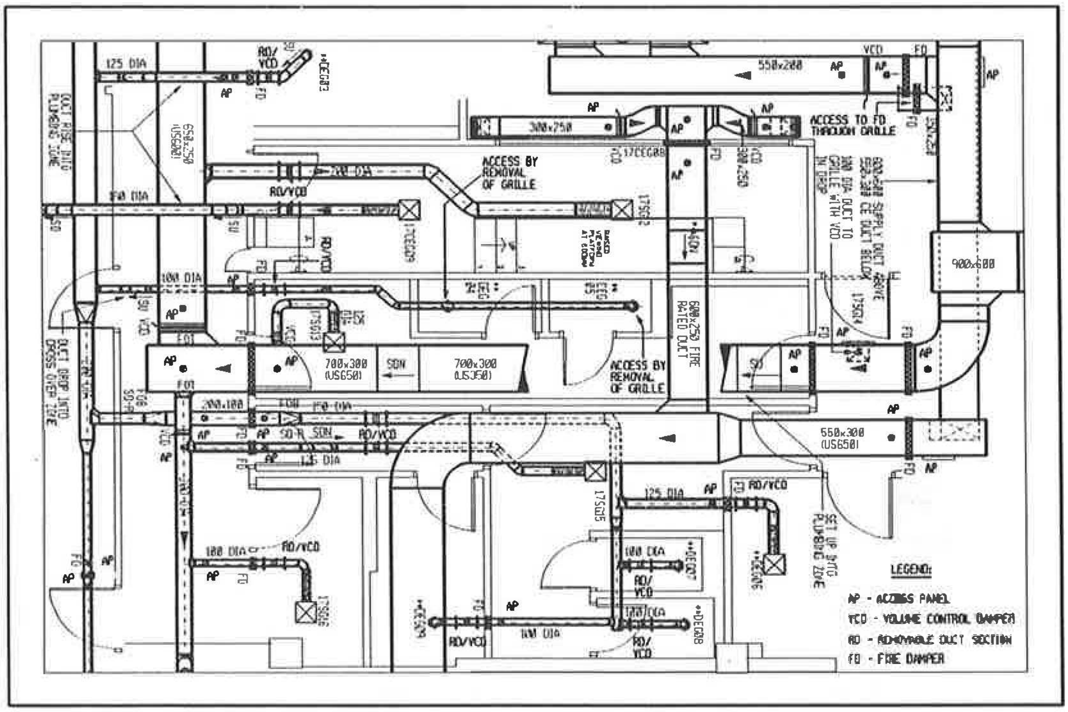
This sets out the requirements for the designer to specify:-

a) The extent of cleaning in accordance with HVCA Publication TR17.
b) The access requirements to achieve this.

TR17 "Guide to Good Practice - Cleanliness of Ventilation Systems" was also published in 1998. This covers new buildings, refurbishments and maintenance of existing systems.

We show on the following diagram a section from a design layout drawing for a current scheme where we, as the designer, after consultation and agreement with the Client, are showing the level of access and cleaning provision within the ductwork system.

In this particular instance the Client's own requirements are actually more onerous than those set out in TR/17.



The Pre-Contract Process

Risk Assessment

In carrying out a risk assessment the following questions need to be addressed.

What are the risks to the occupants or process that is taking place in the building with an existing or new ductwork scheme if it is dirty, contaminated or has microbiological growth?

What are the risks to the same occupants or processes or even components in the ductwork system if different forms of cleaning take place i.e. water, steam cleaning, chemicals, biocides etc?

What is the disruption to the Client's business from the survey, cleaning and any re-commissioning?

Legislation

1.0 **Health and Safety at Work Act 1974**

Employer has "Common duty of care to both employees and visitors to a building.

2.0 **BS 5720 – 1979 Code of Practice for Mechanical Ventilation and Air Conditioning in Buildings**

Early BS (formally CP352) on design of ductwork systems, but had no section on ductwork cleaning.

3.0 **The Occupiers Liability Act 1984**

Duty of care on occupier of premises to prevent (within reason) risks to other.

4.0 **The Workplace (Health, Safety and Welfare) Regulations 1992 & Approved Code of Practice (ACOP)**

This requires an enclosed workplace to have adequate ventilation and where this is by mechanical means, it should be maintained and cleaned in an efficient state.

The ACOP was issued with the 1992 Regulations and gives guidance on how compliance can be achieved.

5.0 **HSG (70) Health & Safety Executive Guidance Note 1993**
This gives guidance on the control of Legionellosis including Legionnaires Disease and particularly covers wet areas in air handling plants.

6.0 **COSHH Regulations 1994**

Require an employer to prevent exposure of employees to substances hazardous to health or ensure exposure is adequately controlled.

Also to carry out risk assessment from hazardous substances (including substantial quantities of dust in the air).

7.0 **HS(G) 132 Health & Safety Executive Guidance Note 1995**

This gives Guidance on Sick Building Syndrome and contains a section on cleaning operations.

8.0 **Construction (Design & Management) Regulations 1995**

9.0 **Draft for Development from BSI – DDENV 12097 : 1997**

Ventilation for buildings – Ductwork – Requirements for ductwork components to facilitate maintenance of ductwork systems.
This draft BS, not yet issued formally, is very prescriptive in terms of access provision for cleaning ductwork systems and also covers levels of cleanliness for delivery, installation and protection of ductwork.

Client Needs & Function

Obviously all mechanical ventilation systems need to be clean, as we all breathe the air that has travelled through the supply or recirculation ductwork.

However, there are different standards of cleanliness needed, be it for an office, museum with precious artefacts, aseptic suite in a hospital pharmacy or a microchip clean room.

Many Clients are knowledgeable and know exactly what they require in terms of cleanliness or microbiological levels, particularly in specialist buildings. However, other Clients do not have this knowledge and need guidance, both in setting up a cleaning enquiry and understanding the implications of the cleaning process on their building, employees and business.

Particular IAQ/Hygiene Requirements

Certain buildings or business as within a building will require more particular air quality than for general comfort conditions. Usually in these instances the Client will be able to be specific about the quality of the air supplied, be it for food processing, pharmaceutical production, orthopaedic surgery etc.

Condition Survey

This will need to be carried out prior to any cleaning contract to ascertain the existing cleanliness of the ventilation systems.

This can be done by visual inspection, by remote CCTV camera and/or by microbiological sampling.

The condition survey will also need to evaluate the amount of existing access provision and what additional provisions will need to be made for a cleaning contract.

Interpretation & Recommendations

Following a condition survey and report, the results need to be properly analysed and judgements made on whether the existing systems are acceptable, or parts or even the total system needs cleaning. If cleaning is required to what standard and what method.

All the discussions held previously on risk assessment, Client needs, legislation etc will have a bearing on the final judgement and recommendations.

The Cleaning Contract

Drawings & Specification

In producing documentation for a cleaning contract tender, the Specification could usefully be based around BSRIA's "Standard Specification for Ventilation Hygiene".

Schedules enumerating the different systems to be cleaned, and to what standard, and by which method should need to be prepared.

All available record drawings, plant schedules and records of hazardous materials should form part of the tender package for information and to meet the obligations of the CDM regulations. Clearly another reason of why building owners should keep record drawings and plant schedules up to date, particularly when local upgrades or changes have taken place.

Access Provision

As part of the documentation, all general access provisions around the building, including special or secure rooms and times of availability need to be listed as well as access to plantrooms, risers and suspended ceilings. (Specific access into ductwork should be on the record drawings!)

Scope of Works

The alternative methods of cleaning and guidance as to which method may be appropriate for the different components within the air handling system, are well documented in BSRIA's Guidance to the Standard for Ventilation Hygiene (1997) and more recently in HVCA TR17.

If it is decided to do more than a dry cleaning process, other factors have to be considered:

a) for wet cleaning, all the components in the system need to be thoroughly dried afterwards as moisture can aid the growth of micro-organisms.

b) steam cleaning or high pressure water can find slight cracks/joints that were not a problem before and again need a thorough drying out afterwards.

c) chemical or biocidal cleaners need to have been fully assessed under COSHH regulations for safe use and would need approved method statements agreed prior to their use.

d) full fumigation (e.g. formaldehyde) needs very careful control. There must be no risk of exposure to humans and all the component materials in the system checked for its use – Formalin is very aggressive to many surfaces including metals.

Standards

The standard of cleanliness can be defined from TR17 or by the Client's own specific requirements. Due to the very subjective nature of visual inspection and to avoid disputes afterwards, the standard of cleaned ductwork must be very clearly agreed before the work takes place.

Post Clean Checks

This should entail the Consultant in reading the Contractors Post Clean report and ascertaining that all work has been done and to a satisfactory condition. Also that the report clearly describes the extent of cleaning carried out, the type of cleaning and cleanliness achieved.

Confirmation will be needed that all regulating devices and in-duct sensors have been replaced and re-set to their original setpoints.

It also needs to be established if any problems were encountered, if there were areas not cleaned and why and any shortcomings in the system that need correction before any future clean.

The Consultant will then ascertain if any re-commissioning of automatic controls or the ventilation plant is needed for the building to function correctly.

All certificates and confirming documentation should be in place together with recommendations as to when future inspections should be carried out, be it 6 monthly or every so many years depending on the system.

There has to be a pragmatic approach to life here, as the majority of existing ventilation system have never been cleaned properly. For many of the basic building types described previously, provided filter maintenance is properly carried out, the systems once cleaned should give many years of operation.

Other final actions for the Client are to have the record drawings updated to reflect amendments made, during the cleaning exercise (including any additional access provisions) and to amend the PPM records to reflect the cleaning procedures.

Client/Consultant/Contract Relationship

Contractors Performance

During the tendering period, the Contractor would be expected /encouraged to visit the site and inspect the installation to satisfy himself that the tender information reflects the scope of work involved.

The returned tender should provide sufficient outline information to clarify the Contractor's proposal to allow proper evaluations of both quality and cost issues by the Consultant/Client

The Contractor once appointed will prepare detailed method statements describing the cleaning operation area by area or system by system and indicating likely disruption to the Clients daily operations. The method statement should be accompanied by a full programme for the work showing intended sequence of works, any out of hours working and periods of time plant or systems will be out of operation.

The Client should also be advised (under CDM/COSHH regulations) of any chemicals used in the cleaning process.

Dispute Resolution

Obviously with an activity like ductwork cleaning the Client is going to be disrupted, may actually never see the improved ductwork (it's not quite like repainting or re-carpeting his office!) and may question the time spent, the costs and the finished product.

It is here that if a Consultant has been employed by the Client that advice can be given with regard to the details of the Contract to assist both the Client and Contractor to resolve these difficulties without one or the other feeling aggrieved. As stated previously, getting all the standards agreed and requirements well defined before the work is carried out is the positive way forward.

The Changing Situation

Past

Until a few years ago there were no national standards for ductwork cleanliness. Ductwork was a hidden service, building owners or occupiers did not generally concern themselves with its internal condition provided that the air was getting into and out of the space.

Building owners or occupiers may or may not have known there was dust in the systems until they saw pattern staining around supply grilles and diffusers. Once this was acknowledged the only action usually taken was that the grilles and ceiling were cleaned and the air filters changed in the air handling plant.

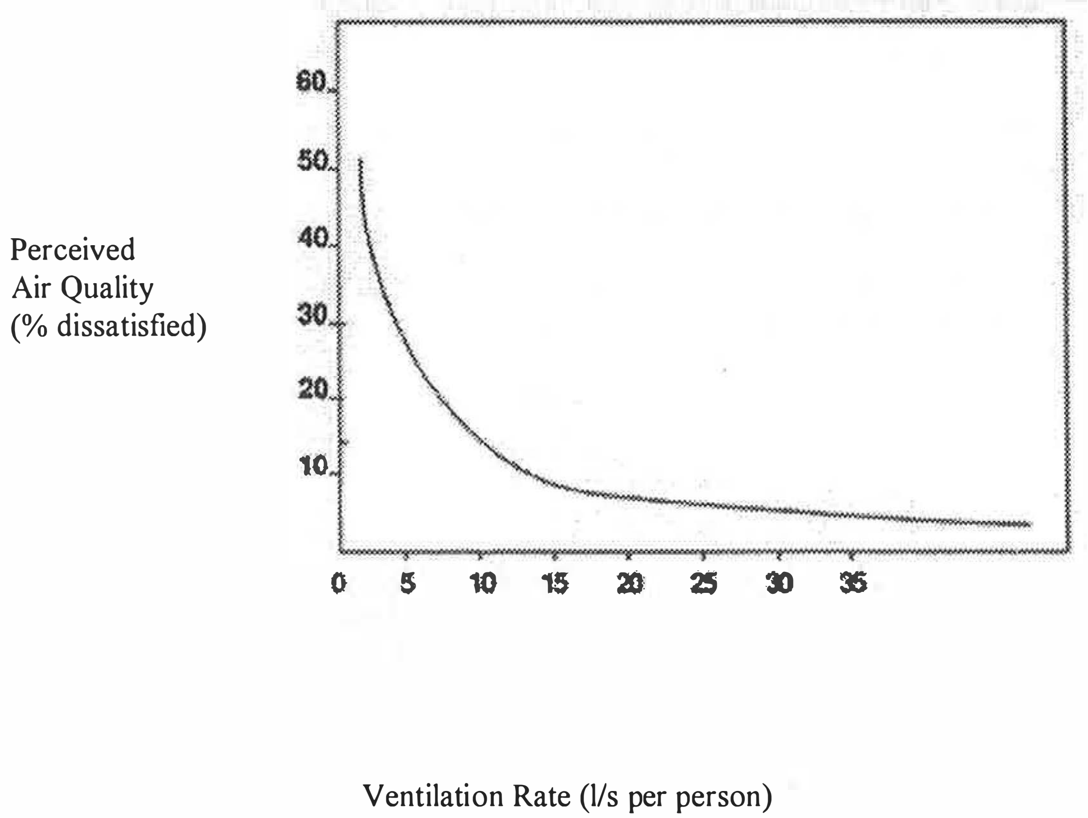
The systems that were usually regularly cleaned were kitchen extract systems and that was for fire precautions due to the build-up of fat deposits.

Present

In the last few years people have become much more conscious of dust in buildings, the problem of allergies, lack of fresh air in internal spaces and the whole concept of Sick Building Syndrome.

Work by BSRIA and HVCA have resulted in standard documents that can now be used to assess, measure and rectify to a common standard, dirty ventilation systems. It is a recognised fact that peoples dissatisfaction rises sharply as the ventilation rate decreases. This relationship is now being used as part of a draft European Standard on indoor air quality.

Here is a typical graph illustrating this fact.



Future

In the future with legislation tightening up and working conditions improving all the time, ventilation systems will be under scrutiny much more and standards will need to rise. It will do little good just improving the quantity of fresh air for people in sealed buildings if the filtration standards and ductwork cleanliness standards are not raised as well.

The current work by HVCA in TR/17 gives specific surface deposit limits for existing supply/recirculation or extract ductwork systems based on two methods (deposit thickness or vacuumed dust weight). It also gives a post clean standard based on vacuumed dust weight.

This is a "first" and a positive step forward but needs to be taken further and graded for building types.

For example, there is little point in having very clean ductwork in a factory or shopping mall where large doorways are continuously open and outside dust is blown into the building and people continually bring dirt in on their shoes and outdoor clothes.

However people working all day in a sealed office environment certainly want a higher standard of air cleanliness (matched by a general cleaning regime for carpets, chairs etc!).

Other buildings such as laboratories or hospitals will need even higher cleanliness standards due to the medical needs of patients and the use of increasingly delicate diagnostic equipment.

Perhaps at this stage it could be suggested as a starting point that the current single standard in TR17 table 5 is split into three categories (similar to the three standards of ductwork protection in TM2) as illustrated on the following diagram.

Actual values have not been shown as this would clearly need some further research and agreement by a panel of experts such as the contributors to TR17.

Surface Deposit Limits			
Building Type	**System Type**	**Surface Contaminant Limit**	**Test Method**
Basic	Supply/Recirc	g/m^2	Vacuum
		µm	Deposit Thickness
	Extract	g/m^2	Vacuum
		µm	Deposit Thickness
Standard	Supply/Recirc	g/m^2	Vacuum
		µm	Deposit Thickness
	Extract	g/m^2	Vacuum
		µm	Deposit Thickness
Specialist	Supply/Recirc	g/m^2	Vacuum
		µm	Deposit Thickness
	Extract	g/m^2	Vacuum
		µm	Deposit Thickness

Building Types:

Basic - Industrial, Shopping Malls, Workshops, Cinemas Theatres, Public Spaces in Hotels, Hospitals etc.

Standard - Offices, Colleges, Lecture/Seminar Rooms, Libraries etc.

Specialist - Hospital Clinical Areas, Clean Rooms, Research Laboratories, Special Archives etc.

Conclusion

To finish on a positive note ventilation standards including ductwork cleanliness are improving all the time and are now a much higher profile subject than before. The work by BSRIA and HVCA, plus conferences like this will really help to provide us all with a better internal environment in our work and leisure time.

John Armstrong MPhil, CEng, MIMechE, MCIBSE

John Armstrong MPhil, CEng, MIMechE, MCIBSE is a Senior Engineer at Ove Arup and Partners, Facilities Management Group, working on the care and maintenance of building services including contract documentation, maintenance standards, business strategy and assessing contractor performance. Previously he was employed in the Property Department of Barclays Bank, BSRIA and the Health Service. Armstrong is currently Chairman of the CIBSE Maintenance Task Group and has produced a number of publications dealing with aspects of maintenance.

A Client's Experience

by John Armstrong, Arup Facilities Management

Rhino Bank and the Bank of Hippo are two High Street financial organisations. Their identities are not significant for this presentation. Both Banks have similar purpose built Cash Centres at a town centre location. The buildings function independently and are secure from each other, but share a party wall and a common first floor plant room. For convenience both use the same maintenance contractor, Repairs Ltd. The buildings are about 15 years old. No ductwork cleaning had previously been carried out.

Bank of Hippo is the site landlord, Rhino Bank the tenant.

Cash Centres

By their nature, Cash Centres are high security buildings with effectively no windows. Access is strictly controlled through two close fitting doors with an air lock between. Mechanical ventilation is the only means of providing supply and extract air.

The function of Cash Centres is to sort cash in the form of both coin and notes. In recent years, the demand has been increasingly for note sorting, which is likely to generate considerable paper dust.

Reasons for cleaning ductwork

Repairs Ltd were appointed by Bank of Hippo, the landlord, to clean their ventilation ductwork. Repairs Ltd. used their initiative and approached Rhino Bank, suggesting that their ductwork could be cleaned at the same time. The client department of Rhino Bank (the Cash Centre) approached their Property Services Dept. (PSD) to find out whether the work was required.

PSD were conscious that ductwork cleaning was not a routine process and the cost throughout the entire property estate would be considerable, potentially several million pounds. They were also aware that the client had very limited financial resources for such work.

Inspection and cost

PSD carried out a visual inspection of the ductwork and found dust levels up to an eighth of an inch thick at the worst locations. Dust staining was noticeable on the inlet and extract grilles, indicating internal dust build up. Wiping the internal surface of the ducts produced a visible dirty deposit.

A cost for the work was obtained from Repairs Ltd, this being £36,500. The work covered cleaning the central supply and extract air handling unit, six separate zones, and seven van bay exhaust ventilation systems. All the work needed to be done at weekends when the Centre was not in use. There would be additional costs to the client for providing security attendance whilst the work was carried out.

Recommendation

PSD recommended that the work should be undertaken because:

- Visual inspection had confirmed the ductwork and fan impellors were dirty and needed cleaning.
- Mechanical ventilation was the only means of introducing fresh air into the building and following the visual inspection, both PSD and the client were now aware of the dirt.
- The work process at the Cash Centre was inherently dust producing.
- There was regular interchange of staff between the two Centres so the duct cleaning in Bank of Hippo could lead to staff relations issues if not also undertaken in Rhino Bank.

Action

The client agreed the work should go ahead and issued an order to the maintenance contractor. A method statement for the work was received and dates agreed for the work to commence. PSD monitored the work by site visits to ensure progress was being made and to act as liaison between the contractor and the client.

When the work was completed, the client sought confirmation from PSD that it was satisfactory. PSD attended site with the contractor.

Lessons learned

The cleaning work was carried out by a specialist duct cleaning contractor working for the maintenance contractor. The process adopted was compressed air with rotary brushes and high velocity vacuum extraction. The specialist contractor determined this during their site inspection. No drawings were provided showing the ductwork layout.

The specialist was shown the site by Repairs Ltd, including the means of electrical isolation. Isolation during the work was carried out by the specialist.

The specialist contractor provided the Method Statement which identified all the work to be done including the marking of damper and control positions and returning them to their original positions. It stated the plant items would be electrically isolated. It also stated that the ductwork would be disinfected after the cleaning. The Method Statement indicated that the dust had been identified as non-greasy, so a compressed air lance and high volume vacuum extraction system would be used.

Access to the ductwork for entry by the cleaning operatives was assessed by the specialist and found to be good. The specialist provided a limited number of additional access points, the cost of these was allowed for in their price. The initial ductwork from the AHU was large enough to be cleaned by crawling through and manually brushing, following a visual inspection that it would support the weight of the operative.

The ductwork was sterilised after the clean, using a proprietary disinfectant introduced by aerosol. This was included in the Method Statement and original price.

New filters were provided by the maintenance contractor and installed by the specialist cleaner.

The specialist cleaner marked all the damper positions and ensured they were returned to these at the end of the cleaning work. It was subsequently agreed that there was imbalance in the ventilation system causing warm and cool areas, with some zones having minimal ventilation. This was not due to the cleaning work and needed to be addressed by a full system rebalance.

Flexible ducting, terminal boxes and grilles were all cleaned. Subsequent questioning about how this was done discovered the flexible ducting was disconnected from connection points and cleaned with compressed air, manual brushing was used where the ducting could not be removed. The contractor removed dirty finger marks at a subsequent visit.

The dust was principally collected in the high velocity vacuum cleaner and removed from site in plastic bags to the local authority waste disposal point.

A certificate of the work was issued to the client detailing what was done.

The work cost - £36,500 as indicated in the original quotation. No comparison was made with alternative specialists or market indices to assess whether value for money was achieved.

HVCA Guide

HVCA Guide to Good Practice for Cleanliness of Ventilation Systems records some points for consideration. It lists relevant legislation and regulations. Chief amongst these is the Health and Safety at Work Regulations, which identifies the need for a common duty of care.

The Workplace Regulations require the workplace to be ventilated with sufficient quantities of fresh air and mechanical ventilation systems to be in an efficient state. PSD opted not to raise these with the client.

HVCA also lists criteria for contractor selection, these being experience, affiliation, QA, health and safety, insurance and financial.

At the time, with the appointment being through the site maintenance contractor, these were not fully investigated. A subsequent assessment found:

- **Experience** - 2.5 years in the business.
- **Affiliation** - Member of National Air Duct Cleaners Association (USA based).
- **QA** - seeking accreditation to ISO 9000.
- **Health and Safety** - have general Health and Safety policy, all work preceded by particular method statement.
- **Insurance** - covered for contracted work, Public liability and Employer liability.
- **Financial** - published accounts available.

The need for duct cleaning

The debate about the need for duct cleaning still continues. This particular project was driven by the decision of the adjacent occupier (and landlord) to carry out duct cleaning.

It has not become a standard maintenance requirement of Rhino Bank. However there is greater responsibility being placed on maintenance contractors to report the results of visual inspections of the ductwork to allow provision to be made in future annual maintenance budgets. Quantitative testing as set out in the HVCA Good Practice Guide is not routinely carried out.

Peter Hoffman

Peter Hoffman is a clinical scientist in the Laboratory of Hospital Infection at the Central Public Health Laboratory, London. He has responsibilities for the wider aspects of infection control, investigation following outbreaks of infection and assessment of control measures. Such measures include sterilisation, disinfection, environmental hygiene and assessment of ventilation systems.

Hoffman is on the organising committee of, and teaches on, the Hospital Infection Society/Public Health Laboratory Service Diploma of Hospital Infection which includes modules on hospital ventilation.

Hospital Ventilation & Infection Control

by Peter Hoffman, Central Public Health Laboratory

Airborne microbes can result from deliberate natural release (e.g. fungal spores), evaporation of water droplets (e.g. legionella from spray cooling towers), dispersion of skin fragments 'skin scales', mechanical action (operating theatre tools, vacuum cleaners) or biological action (coughing & sneezing).

The larger the particle, the faster it will fall to the ground. At 20 m (0.02mm), particles will fall at about a metre a minute, at around 1 m (0.001mm), they will take about 1,000 minutes to descend one metre. At this rate of settling, thermals and air currents can keep them in the air far longer than this.

The larger the particle, the less chance it has of entering deep into the lungs. Particles over about 20 m will probably impact on the surfaces of the nose or mouth. Particles less than 5 m can descend into the alveolar sacks deep in the lungs which allows them long-term escape from the cilliary-based cleansing mechanisms of the respiratory tract.

Various grades of air filters exist; only those designated 'HEPA' (high efficiency particulate air) filters are tested at particles sizes relevant to microbiology.

Air hygiene in hospitals can be divided into three categories: Operating theatres; protective isolation; source isolation.

The main source of contamination in operating theatres is the dispersal of contaminated skin scales by the surgical staff. These will settle-out in the wound and onto 'sterile' instruments laid out ready to be used in surgery. Air hygiene in operating theatres is by supplying clean air to the cleanest areas in theatre suites (the operating room and the 'lay up' room where sterile instruments are unpacked and laid out). From these, it is encouraged to flow to sequentially less clean areas.

For operations where airborne infection poses a high risk (particularly where foreign material is implanted e.g. hip prostheses), an ultra-clean ventilation system can be used: filtered air cascades down over the patient in laminar flow (non-turbulent flow that will prevent entrainment of contamination from outside this field of flow).

In protective isolation, individuals whose immunity has been grossly compromised (e.g. solid organ or bone marrow transplant patients) can, when profoundly immunosupressed, be inside rooms to which highly filtered air is supplied. One of the infectious complications this group suffers from is aspergillosis (mainly by Aspergillus fumigatus) of the lung. An excess of air is supplied to these rooms (over the volume that is extracted) so the room is under positive pressure to all its surroundings, so that all gaps (doors, pipe and electric cable entry points, false ceilings etc.) leak safely outwards rather than bringing unfiltered contamination into the room).

In source isolation, the opposite principles apply: Patients dispersing microbes that may be highly hazardous to other patients as well as to staff and visitors can be housed in rooms from which air is safely exhausted by mechanical extract systems such that no air escapes into surrounding ward areas, i.e. the room is at negative pressure to its surroundings. This can be applied where airborne transmission is likely and has serious consequences. The most notable of these conditions are the viral haemorrhagic fevers (VHFs) such as Lassa, Ebola etc., but there have recently been two U.K. hospital outbreaks of multiply drug-resistant tuberculosis to patients rendered highly susceptible by prior HIV-infection.

It is generally accepted that there is no need to filter the air extracted from rooms housing TB patients (dilution factors are so large) but it is still expected from rooms housing VHF patients. Air discharge points must be away from air intake points.

Philip Clarke

Philip Clarke is a civil servant working for the UK Health & Safety Executive (HSE) and is part of a small team responsible for implementing the Biocidal Products Directive. Prior to this he worked in other HSE policy sections dealing with occupational exposure to workplace chemicals and global harmonisation of the classification of chemicals. Before joining HSE he performed a variety of policy jobs for the government's Department of Employment.

Biocides & Disinfectants

by Philip Clarke, Health & Safety Executive

Good afternoon ladies and gentlemen. I work for the Health and Safety Executive, who will be the competent authority for the Biocidal Products Regulations. I am part of a small team working on the implementation of the Biocidal Products Directive. Today may be the first time many of you have heard about this Directive, but there may equally be some of you who have a vague notion of what the Directive is all about and may have heard some scare stories. My aim therefore this afternoon is to dispel any myths and to:

• Give you a brief history of the Directive - why it was proposed in the first place and how we reached the text of the Directive that we now have.
• Describe the aims of the Directive; its scope and the type of products that it covers - including those of most relevance to the ventilation industry.
• Tell you how the HSE is going about implementing the Directive and industry's involvement in that process.
• Give you an idea of how we believe the Directive, and implementing Regulations will affect your industry.

I plan to talk for about 20 - 25 minutes and would be pleased to take questions at the end.

Why a Directive at all?

So why have a Biocidal Products Directive in the first place, and how did we end up with a Directive that is said to be the second most complex Directive ever to have come out of the European Commission.

To start we need to go all the way back to the Marketing and Use Directive - Directive 76/769. That Directive placed a number of restrictions on certain active substances - mainly wood preservatives. It had very laudable objectives, but it soon became apparent as the Directive was in operation that it was a very complicated way of trying to regulate the placing on the market of a very wide range of active substances. Agricultural pesticides were taken out and the Plant Protection Products Directive - 91/414/EC - to control agricultural pesticides came into being. This left a gap for non-agricultural pesticides - or biocidal products as they came to be known. The European Commission proposed the Biocidal Products Directive to fill the gap in chemical legislation and had two central aims:

• To harmonise the European market for biocidal products.
• To provide a high level of protection for humans and the environment.

The Directive was extensively negotiated over the next 5 years until the final agreed text was published in the Official Journal of the European Communities in May 1998 and given the number 98/8.

This marked the end of the European stages of the Directive and Member States could start on the implementation process. Member States have 24 months in which to implement the Directive - that is by 14 May 2000. The UK is committed to meeting this deadline and we plan to have the implementing Regulations in place by that date.

What is a biocidal product?

So what exactly is a biocidal product. The Directive gives the formal definition as: *active substances and preparations containing one or more active substances, put up in the form in which they are supplied to the user, intended to destroy, deter, render harmless, prevent the action of or otherwise exert a controlling effect on any harmful organism by chemical or biological means.'*

That rather wordy - typically Eurospeak - definition can be simplified. Basically it means that any product that is to control unwanted organisms, but that is not a food additive, a plant protection product (i.e. an agricultural pesticide), a medicine, a veterinary medicine or a cosmetic is classed as a biocide. This makes the scope of the Directive very wide.

So how many product types does the Directive cover?. In all the Directive covers 23 product types, and these are divided into 4 main groups:

- **Disinfectants and general biocidal products.**
- **Preservatives** - such as those used in paints and for wood.
- **Pest control** - such as rodenticides and insecticides.
- **Other biocidal products** - such as preservatives for food and feedstocks; antifouling products; and embalming and taxidermist products.

Therefore we have products from those that are designed to prevent micro-organisms contaminating water to disinfectants that help prevent disease in hospitals, public places or the home; they can be added to products to prevent deterioration, such as in-can preservatives in paints or products that prevent contamination of processed food and drinks. They include non-agricultural pesticides and a number of very specialist products such as embalming and taxidermist fluids. Many industrial processes rely on biocides either during processing or to extend their performance whilst in use. Examples include metal working fluids for engineering, adhesives, plastics, leather and paper. Biocidal products also protect wood and prevent fouling of ships' hulls and marine structures, such as oil rigs. It is important to remember however that adding a biocide to something else does not make the resulting product a biocide as well. For example, if a biocide to water in a cooling tower it does not make the water a biocidal product.

Many products that are used in the home contain biocides or are biocidal products. They feature as household cleaners and detergents, or in paints and adhesives such as glues and wallpaper pastes.

The vast majority of biocidal products have beneficial effects and can be used without causing harm to users or the environment in which they are used. However, given their purpose, if their use is not properly controlled, biocidal products can have unintended harmful effects on people - workers, consumers or others just going about their daily lives - animals or the environment.

So where does the ventilation industry fit into all of this?. Biocidal products that will commonly be used in the ventilation industry are:

- **Product type 2:** private area and public health area disinfectants and other biocidal products.
- **Product type 11:** preservatives for liquid-cooling and processing systems.

Let's look at each of these product types in a little more detail.

Product type 2 - private area and public health area disinfectants. These are products that are used for the disinfection of air, surfaces, materials, equipment and furniture which are not used for direct food or feed contact in private, public and industrial areas, including hospitals, as well as products used as algaecides.

Usage areas include, amongst other things, air-conditioning systems to prevent legionnaires' disease; swimming pools, aquariums, bathing and other waters; walls and floors in health and other institutions; and chemical toilets, waste water and hospital waste. Such products will be used to disinfect ventilation ducts.

Product type 11 - preservatives for liquid-cooling and processing systems. These are products that are used for the preservation of water or other liquids used in cooling and processing systems by the control of harmful organisms such as microbes, algae and mussels.

So what will be different about these products to what we have now? As I said earlier one of the primary aims of the Directive is to ensure that humans and the environment are protected against any potential harmful effects of these products. The Directive will do this in the following way.

How will the Directive work?

The overriding rule is that ultimately only those biocidal products which contain an active substance that is listed on Annex I of the Directive will be allowed to be put on the market, and approval of active substances and biocidal products is a two step process.

The first step involves active substances. All existing and new active substances will be evaluated by Member States to ascertain whether or not they can be included in the Annex I list. Both processes will require industry to submit a package of data to be evaluated. The Directive lists what data needs to be submitted. It is a very comprehensive package and asks for data to cover all potential risks.

When data has been evaluated in one Member State the recommendation over Annex I listing will be discussed and decided upon at the European level committee - the Standing Committee on Biocides. This committee is made up of representatives of all Member States and chaired by the European Commission.

Existing active substances will be reviewed over a 10 year period after the Directive has been implemented and will be controlled by a Review Regulation - although this has yet to come out of the European Commission. Work has however started on compiling the list of existing active substances. Whilst existing active substances are being reviewed nothing will be done to the products that contain them until a decision is taken over the active. Current national controls will apply.

All data will be protected by a system of data protection, although HSE would encourage industry to share data, perhaps by forming task forces, This will help to reduce the costs of supplying data and very importantly reduce the need for duplicate, unnecessary animal testing.

The second step concerns biocidal products themselves. Once an active substance is listed on Annex I, products that contain it can be authorised for marketing in individual Member States by national competent authorities.

Again industry will have to provide data on the biocidal products they wish to have authorised - although we would hope to read most of the data across from the active substance. This data will be evaluated to ensure that the product does not pose any unacceptable effects on humans, animals or the environment and then providing any conditions put on the Annex I entry are met, the product will be authorised.

Once a product has been authorised in one Member State it will be possible for it to be mutually recognised and therefore authorised by other Member States without having to go through a full authorisation process in each country. This means that the same authorised biocidal products will be able to sold and used throughout the European Union.

The Directive also allows for simplified procedures for certain types of biocidal products. These are low-risk products - that is products that are considered to pose a low-risk to humans, and the environment, and the system ensures that the level of control is commensurate with the risk. Something that the UK was instrumental in getting written into the Directive. Low-risk biocidal products can also be mutually recognised throughout the European Union. There will also be simplified procedures for basic substances - substances whose major use in non-pesticidal but that have some biocidal use - carbon dioxide is a good example; and frame formulations - where the only difference between products is their colour or fragrance - these will be authorised as one product.

So that explains how the Directive works - now I would like to move onto how HSE is going about implementing it and how it may affect you.

Implementation

As I said earlier, as from May 1998, Member States had 24 months in which to implement the Directive. At the time that seemed quite a long time - but here we are in March 1999 and there are only 14 months left. But we aim to get there.

HSE is responsible for implementing this Directive, but because its scope is so wide we can' t do it on our own. We are therefore working very closely with the many other Government Departments who have an interest in biocides, and of course with all the sectors of industry on whom the Directive will impact.

Strategy

In order to implement the Directive, HSE developed a strategy that had three central themes. These were agreed with the Health and Safety Commission and Ministers. It was agreed that the new Regulations and biocides regime had to be:

- Efficient and effective.
- Transparent and accountable.
- In accordance with Article 25 of the Directive - something that perhaps you will not be so keen on.
- Self-financing.

I would like to describe how we are putting each of these themes into practice.

Efficient and effective

From the outset we believed that HSE should be the sole competent authority dealing with all active substances and biocidal products in the UK. This will make it easier for the biocides industry to know who they have to deal with - there are currently 5 Government Departments involved in the control of pesticides - potential for much confusion; it promotes the 'one-stop' shop idea; and is also more cost effective. Ministers have agreed to this proposal.

We are aware that we need to make sure that the transition from current legislation - in particular Control of Pesticides Regulations - to the new Regulations, is as smooth as possible. To ensure this we will be producing a comprehensive set of guidance to explain the new regime. There will a guidance document for suppliers and importers of active substances and biocidal products; a guidance documents for all users of biocidal products; guidance on the transitional arrangements of moving from current legislation to the new regime; a guide for applicants on how to get active substances onto Annex I or biocidal products authorised; and, perhaps most difficult of all, a simple free guide to the new regime. All these will produced in consultation with industry and other interested parties to make sure they meet the needs of the target audiences.

Guidance will also extend to the products themselves - users of biocidal products will receive more information about the products they use than now. The Regulations will set down strict rules on what information should be put on the product's label or accompanying leaflet, and safety data sheets will continue to be provided for professional and industrial users of biocidal products that are classified as dangerous.

Transparent and accountable

The second part of the implementation strategy is to make sure that the biocides regime is transparent and accountable. A key element of this will be an independent Biocides Committee which will look at the work that HSE does as the competent authority to make sure we are applying the new Regulations properly and not authorising products that could harm to people, animals or the environment.

The Biocides Committee will be made up of independent experts in their scientific field and will be appointed by Ministers. Appointments will be advertised and made in accordance with the strict guidelines set out by Lord Nolan. Government Departments with an interest in biocides will also have an input into the decision making process.

We plan to ensure that the workings of the Committee are as open as possible - through perhaps an annual report and regular news releases - although of course with regard to the commercially confidential nature of much of the business of the Committee.

The proposals for the Committee will be included in the extensive public consultation exercise planned for July this year. It is this public consultation exercise which is perhaps the most important part of ensuring that the biocides regime is open and transparent. In line with HSE' s normal practice we will be consulting fully on the draft biocides Regulations, the associated guidance and explaining the new regime - more about that in a moment.

Self-financing

As I said earlier - Article 25 of the Directive includes a requirement for Member States to recover from industry the cost of work done by compete in relation to the biocides regime. This is in line with Government policy - HSE already charges for such things as asbestos licensing and controlling of major hazards. Government policy is also to ensure that costs are kept at the lowest level possible but still produce the necessary outputs consistent with the requirements of the Regulations. A transparent regime that can be examined is a means of ensuring this does occur. We set up a group made up of industry
representatives to discuss the charging regime. This is a subgroup of the main industry group that we consult on all matters relating to biocides. Mr Asprey from the Heating and Ventilation Contractors Association sits on the main ad-hoc group.

At present, in line with industry's wishes, we a proposing two types of charges. There will be a fee charged where there is a clearly identifiable customer - for example for authorising or registering a biocidal product; and a general industry charge for work that needs to done where there is no clearly identifiable customer. An example of such work would be monitoring both the effectiveness of biocides - such as reducing the number of outbreaks of legionnaires' disease, and any adverse effects of biocides - ill health caused by biocides.

Proposals for both forms of charges will be included in the public consultation exercise.

Progress to date

So where have we got to so far? We are making good progress with drafting the Regulations and much of the guidance. These have been seen by other Government Departments and those members of industry who sit on our ad-hoc working group I mentioned earlier. This group was established up when the Directive was first proposed and was invaluable during negotiations of the Directive. It is now proving equally valuable during implementation to give us practical advice,

As I mentioned earlier - we plan to start public consultation on the draft Regulations and guidance early in July 1999. This consultation period will last at least 3 months and during that time we plan to attend a number of meetings organised by industry to explain the new regime.

All responses that we receive from the consultation exercise will be made public - unless we are specifically asked not to do so. All responses will be acknowledged and we will send substantive replies where appropriate. After the consultation exercise there will be a summary report available of the comments we receive.

After the consultation exercise has finished we will make any necessary amendments to the Regulations and guidance before they are put to the Health and Safety Commission and then to Ministers for final approval. The aim is for the Regulations to be laid before Parliament in time for them to come into force in May 2000. The May 2000 deadline is a legal requirement set down by Brussels.

May 2000 sounds a long way off - but there is still a great deal to do between now and then.

Effect on the ventilation industry

I hope what I have just been saying hasn't scared you too much. There will be some changes for the ventilation industry - although you probably will not notice any for a very long time. The move to the new regulatory regime will be a slow one. But what changes will there eventually be:

- All biocidal products that you use will be authorised or registered for use and carry an HSE identification number.
- All biocidal products that you use will have been fully tested in line with the requirements of the Directive to ensure that they are safe for you to use, and safe for the environment and animals.
- That any controls put on products are commensurate with risks.
- All biocidal products will be fully labelled to explain how you should use them safely and how to dispose of the product safely; labels will carry much more information than they do now.
- If you own a company where contractors use biocides you will know that the products they use have been properly tested to ensure they are safe to be used on your premises.
- If you are part of a company that manufacture biocidal products - once they have been authorised in one Member State you can apply to have that authorisation recognised throughout the European Union. This will open up the market for your products.

The final message I would leave you with is not to worry too much at this stage. Yes - the Biocidal Products Directive is very complex and there are some wild rumours flying around about it - but HSE, with industry's help, is working hard to unravel it and make it as simple as possible. Yes - the Biocidal Products Directive will bring about changes - but these changes will be gradual. Yes - there will be a new set of Regulations that you will need to comply with - but the Regulations are being developed in consultation with interested parties and will be supported by a very comprehensive set of guidance. Finally - we are here to help and as they say "only a 'phone call away".

Wander ter Kuile, CEng, MIMechE

Wander ter Kuile is the Air Filter Product Manager at Vokes Ltd, Guildford, and has global responsibility for all air filter products manufactured under the Vokes brand. Graduating in 1983 with a degree in Aeronautical Engineering, he joined Altair Filters International in 1984 as a Development Engineer before becoming Development Manager in 1989. He joined Vokes Air Filtration in 1994 as a Technical and Business Development Manager. He is also actively involved in the development of technical standards covering a wide range of air filtration applications for BSI, CEN, ISO and ASME.

Air Filtration Issues Related to Ventilation Hygiene

Wander ter Kuile, BTRE Vokes Ltd, UK

Synopsis

Air filtration provides the primary means of controlling the ingress and emission of contaminants into and out of any ventilated space. With air filtration we are therefore concerned with the control of particulate matter and gases which influence our health and comfort, the spaces we occupy, the products we manufacture, the equipment we use and by no means least, the environment.

Air filtration in a ventilation system therefore provides the means for healthier and more comfortable working conditions and to prevent build up of contaminants on the components and surfaces within the ventilation system.

The correct design, selection, installation and maintenance of the air filtration system is critically important in ensuring that the ventilation system provides the necessary quality of air.

Air filters are not a fit and forget component of a ventilation system, and if they are to do the job for which they are designed, all the air must pass through them. Damaged, ill-fitting, or missing filters allow the bypass of unfiltered air and contaminants, which entirely defeats the object of their installation. Such situations result in the necessity for subsequent cleaning and maintenance of other system components.

This paper will discuss the importance of air filtration with respect to sustainable ventilation hygiene, focusing on air filter design, selection, installation and maintenance.

VHExCo 99

THURSDAY
MARCH 25

Richard Trebilco

Richard Trebilco has had a long career in all aspects of mechanical services. He was trained within a small company in the design of heating, ventilation and air conditioning systems and was responsible for a variety of successful projects in industrial/commercial premises. He then became the mechanical services maintenance engineer for a major retail chain store. Responsible for the ongoing maintenance in over 100 stores, he became aware of the necessity for the cleaning of ventilation systems, particularly kitchen extract systems.

In 1990 Trebilco set up his own ventilation and water hygiene company - Excalibur Services - which specialises in all aspects of ventilation system hygiene. He has lectured on ventilation system cleaning techniques to building operators, owners and other duct cleaning companies. He was a co-author of the HVCA's guide to good practice TR17 *Cleanliness of Ventilation Systems* and is currently Chairman of the Ventilation Hygiene Group. He is also Chairman of the committee involved in the creation of European Duct Cleaners Association (EDCA) which is being formed to promote good practice across the European Community. He is an active member of the American-based National Air Duct Cleaners Association (NADCA) where he is keen to promote worldwide links.

Duct Cleaning Methods

by Richard Trebilco , HVCA, EDCA,
Excalibur Services

Duct cleaning falls into a variety of different methods.

These can be defined as;-

- Manual Duct Cleaning
- Mechanical powered brush cleaning
- Compressed air cleaning
- Robotic cleaning
- Chemical washing
- Others

Often a combination of these methods will be used.

Manual duct cleaning

Manual duct cleaning is normally used in situations where the other methods are either not efficient enough, not quick enough or not possible.

Most air handling units are cleaned manually as their physical layout makes other techniques impossible. Larger ducting is also cleaned in this manner.

Manual techniques

Manual duct cleaning includes the following

Hand wipe
Wiping of the surface using a medium appropriate to the purpose-ie tack rag, damp or dry cloth. Usually only effective on light deposits or as a 'polish' after other cleaning.

Hand scrape
Removing heavy deposits by hand scraping using a scraper or (in heavily contaminated ducting) a shovel. Used where there is a deep deposit or where the deposit is of a sticky nature.

Hand brushing
Brushing the surface of the ductwork using a brush appropriate to the surface. This can vary from the traditional 'chimney sweep' type brushing to small hand brushes used with a dustpan to collect the deposit. Usually used on dry, non-sticky deposits.

The chimney sweep type brushing is often used in smaller diameter round ducting and may be used in conjunction with the extract fan to remove the disturbed dirt. Also useful when cleaning components in an air handling unit

Hand vacuum
Using a vacuum nozzle connected to some form of vacuum cleaner to suck the deposit from the duct surface.

Mechanical powered brush cleaning

• Mechanical powered brush cleaning utilises a rotating brush usually on a long rotating shaft to mechanically agitate the duct surface to loosen the deposit.

• Rotary brushes will typically be connected to their power source by either a twisted wire cable running within a shaft or by a semi-rigid rod.

• Power sources range from a small electric hand drill system for use on smaller ducting to larger floor mounted units with reversing capabilities to enable the brushes to be run in either direction.

• Brushes can be selected from hard or soft bristle or a combination of both dependant on application or even wire brushes.

• This method is usually used in conjunction with a mobile high volume filtered extraction unit. This will be connected to a suitable spigot or access port downstream from the brushing, permitting some bypass of replacement air to ensure a transport velocity which is sufficient to capture the particular matter raised by the brushing in the filter section of the mobile fan unit. In order to ensure a sufficiently high air flow rate it is common to use sectional blocking to isolate small areas of ducting.

Compressed air cleaning

Compressed air cleaning uses the power of air movement to either directly agitate the deposit in the duct or to provide motive power for flailing tubes or balls etc. There are two distinct types- low volume and high volume.

Low volume
Typically using an air pressure below 3 bar the air is supplied to a cleaning head via a tube. The cleaning head may be an air whip or skipper ball. Needs to be used in conjunction with a vacuum collection device.
i) An air whip has a number of flailing rubber or plastic tubes that the air passes through. These 'whip about in the duct and mechanically agitate the duct walls. The rush of air helps to transport the removed deposit

ii) The skipper ball is usually of plastic construction and again the action of the air causes the ball to strike the duct surface and physically agitate the deposit.

iii) Air lance -Occasionally an 'air lance' or 'air gun' will be used to direct low volume compressed air at the duct wall to blow the duct off

High volume
i) High volume compressed air uses a much larger compressed air source and will work at higher pressure (up to 9bar). The air is supplied via a semi-rigid hose a specially shaped nozzle head. This head may be fitted with rear facing outlet nozzles, a rotating nozzle head or (with a more rigid tube) forward facing nozzles.

In each case the speed and volume of the air is used to directly agitate the duct wall and lifts the deposit off and transports it to a vacuum collection vessel

Robotic cleaning

Robotic cleaning methods have been developed over the last few years. The layout of most duct cleaning robots are similar and consist of the following elements:-

• A tracked or wheeled buggy that transports the cleaning tools into the duct. This will be connected to an umbilical cable to supply power and control.
• A vision system consisting of forward facing and /or rear facing cameras feeding back to a video monitor and/or video recording unit. The cameras may be fixed or capable of being moved to look in any direction.
• A cleaning head - usually a rotating brush, but may be a compressed air cleaner or a scraper. Often capable of adjustment in height and brush size to suit different size ducting.
• A spray nozzle to carry out sanitising sprays or duct wall painting.
• Other options include sampling heads for surface sampling within the duct, or pure vision systems for duct inspection.

Chemical washing

Chemical washing is a relatively little used technique but may be carried out after the main source removal cleaning has been carried out to provide a final deep clean or sanitisation. Most commonly used in kitchen grease extract duct to provide a final surface clean.

Other methods

Other techniques for duct cleaning that are found in use less often include:-

• High pressure (hot) water jetting. Used in kitchen extract system that are designed with water proof ducting. Lack of water integrity in other systems make it a likely that water leakage / damage would occur.

• Solid carbon dioxide (dry ice) sand blasting. A relatively new technique that uses solid carbon dioxide particles as the 'grit' in a specially designed sand blasting type unit to remove grease deposits from the duct surface. This system is reported to be highly effective for this purpose.

• Proprietary system (name unknown) that uses a large extract air handling unit to move large volumes of air through the system to be cleaned. Plastic balls are poured into the other end of the duct and bounce and rebound their way towards the extractor agitating the duct walls and removing dirt as they go.

Pertti Pasanen, Ph.D

Pertti Pasanen is a lecturer in Environmental Engineering at the Department of Environmental Sciences of the University of Kuopio, Finland. He started indoor air research in 1988 on a project dealing with odour emissions and performance of supply air filters in Finnish office buildings. He has been involved in many projects dealing with duct cleaning and its impact on system performance. While writing a doctoral thesis on ventilation hygiene in Finnish offices he had to develop methods for verification of the dust load on HVAC surfaces.

During the last two years Pasanen has initiated a research and development programme to improve cleanliness and design criteria for HVAC systems in co-operation with Helsinki University of Technology, the Technical Research Centre of Finland, and major Finnish HVAC companies. As a member of the Finnish Society of Indoor Air Quality and Climate he has participated in a working group which has produced the first draft of the Classification of HVAC Systems.