PROTECTION AGAINST ALLERGIES IN OFFICES

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INTRODUCTION

Allergies and over-sensitivities should be taken into account as soon a building is being designed. In fact, all building should be done with the potentially most sensitive group of users in mind, namely those suffering from respiratory ailments. Since that group constitutes 25 % of the Dutch population, the above point of departure would seem quite reasonable. Dust deterrence will be the theme of the present artic1e. Hyper sensitivity to emissions from materials will not be discussed.

Ailments of allergic origin such as asthma and hay fever are increasing strongly in the Western world. In some countries an increase of roughly 50% has been recorded during the last five years.

Many allergic or sensitivity reactions are caused by breathing in allergens clinging to dust particles in the air. At home one of the things sensitive persons can protect themselves to a certain extent is to keep their homes as clean as possible. But that possibility is not available at work in an office. Moreover, office buildings are often extra hazardous owing to insufficient cleaning and ill conceived, poorly functioning and/or dirty air-conditioning systems .

Also dust that has settled on surfaces can cause complaints when it sticks to fingers, the skin or rubbed into the eyes. Micro-biological contamination is another problem of objects or materials to which dust is likely to cling or of a construction that is prone to dust accumulation. Such contamination is not limited to air-conditioning plants with poor humidifying systems, or places where humidity can accumulate. Human beings themselves are a great source of micro-organisms, proliferating on the skin flakes shed at the rate of 2 gr/24 hours[2]. Such flakes and their organisms make up a substantial part of dust. Some of these organisms may cause irritations. Neither should allergy to the common dust mite be overlooked.

That is why risk reduction for allergic and oversensitive people is important in designing or exploiting of office buildings. Matters to be considered are:

-**The Building**: construction to exclude dust and facilitate cleaning: no out of reach horizontal surfaces on which dust may collect.

- **The Interior**: no frills, easy to clean thoroughly, including carpeting and light fixtures.

- **Cleaning**: central vacuuming system, regular schedule including the air conditioning system.

- **Heating, Ventilation And Air-Conditioning**: hygienic design, e.g. free of dust, spores and fungus, easily cleaned and maintained; up-flow ventilation with high ventilation effectiveness; no recirculation; ceiling heating and cooling system: no false ceilings.

INDOOR CLIMATE AND MUCOUS MEMBRANES

During investigations, conducted in 2 laboratory and 2 office buildings, into complaints about the indoor atmosphere conducted in two university buildings, the relationship between the kind of work carried out and physical discomfort was analyzed. That analysis showed that people

working in laboratories, and particularly those working with chemicals, plants and micro-organisms had far more complaints about irritation of the mucous membranes and the skin, than those doing other work in the same building. In other words, a higher level of irritants in the air increases the number of complaints. The same holds true for dust, fibres. gasses emitted by building materials and dust with its related micro-organisms.

Conversely, it may be concluded that optimum indoor climate conditions are required where the irritant level in the atmosphere is high as a result of the work done, the construction of the building and/or mediocre cleaning. Prevention of high temperatures is important: Sensations of dryness and many other Sick Building Syndrome symptoms have been found to increase substantially with small increase in air temperature[12]. Above 23°C the mucous membranes start swelling and become extra sensitive. Their sensitivity also depends on the humidity. If the relative humidity drops below 30 %. the dirt expelling capacity of the membranes is reduced. A relative humidity of over 60% or under 40% causes increased growth of certain micro-organisms[13] .

THE BUILDING AND FURNISHINGS

Examples Of Building And Furnishing That Are Detrimental To Health:

- **Rough Cement Wall Covering And Synthetic Fibre Carpet**: As regards the use of building materials, one of the notable findings in the above investigations was the high percentage of complaints in one of the office buildings about eye irritations and dust in the air (31 % and 21 % versus 17% and 5%). Work done and cleaning schedules were similar in both buildings, but there are some important differences: in the building with the lower percentage of complaints are less rough cement walls and 25 % of the floor is smooth.

- **Open Ceilings In A Laboratory:** For reasons of heat accumulation no false ceilings were installed in a laboratory building. Unfortunately the cleaning of pipes and ducts directly under the ceiling turned out to be more difficult and costlier than expected. A number of the staff suffer allergic reactions to the possible allergens and chemicals that accumulate in the dust on the pipes and ducts. Installation of a closed, false ceiling is being considered.

- **Pipes And Ledges Along The Ceiling**: In a high library, where many pipes and ledges run along the ceilil1g, dust eddies appear to occur about every five minutes. The dust concentration of 0.9 mg/m^3 in the puffs is about 10 x higher than the basic concentration of 0.09 mg/m^3. In comparison, a reasonably clean office for one person has a dust concentration of 0.04 mg/m^3. These measurements were taken with a real time aerosol monitor and the readings are not absolute values. In the library concerned. the staff complained about irritated eyes and contact lenses, even with a relative humidity of 50 %.

-**Dust As Breeding Ground For Microbe Contamination**: In a large air-conditioned administrative space belonging to the library, microbiological examination revealed a too great a concentration of skin bacteria in addition to an excessive concentration of fungi from a spray humidifier. Compared to open air values the findings were: Staphylococci 910 CFU versus 100 CFU and Aspergillus fumigatus 80 CFU versus 10 CFU. The staff complained about skin and eye irritation as well as frequent colds. The humidifier was obsolete and had a hard to adjust drip-tray. The furnishing made the room difficult to clean and both the long sides were covered with gauze curtains while the floor covering was of synthetic material.

- **Uncoated Cement**: For the sake of economy smooth cement walls and ceilings were not coated. A full year after the building was handed over, the walls continue emitting dust, causing slippery floors and a stuffiness. They will, finally, be given a layer of coating.
- **Unwrapped Glass Fibre**: An old building was renovated. For sound attenuation, unwrapped glass fibre slabs were placed on the ceiling tiles. Months after the handover of the building, staff still suffered from skin and throat irritation.

Recommendations For Construction And Interior Finishing

Building in such a way as to prevent such problems as referred to above, is not more expensive and saves the user much sickness pay and cleaning expenses later. To be avoided are:
. woolly or ribbed wall coverings, which collects dust,
. uncoated cement and concrete,
. ledges or ridges on which dust can settle,
. open or false ceilings,
. fixtures or cable leads that are not fixed to the ceiling,
. sound insulation with an open structure,
. unwrapped glass fibre slabs, even on ceiling tiles,
. heating elements, under or behind which much dust can collect,
. textile covered surfaces.

CLEANING

Achieving a visual absence of dirt is most certainly not the only purpose of cleaning. Promoting health is the chief aim. In a clean environment pathogens have less chance, while work is safer and more efficient[2]. The perception of cleanliness is very variable. It may be defined as the "absence of annoying dirt[3]".

In offices much emphasis is laid on visual dirt and methods to assess the quality of cleaning are usually based on quantifying the amount of visual din. That this is insufficient bas been demonstrated in numerous investigations. It has been shown that with insufficient cleaning the amount of dirt in soft floor covering can rise to several hundred grams per m^2, so that under unfavourable conditions, such as excessive humidity, micro-organisms can multiply very rapidly[4]. The results of cleaning floors and the interior of offices depends heavily on the equipment, the detergents and the methods. Dusting should never be done dry, but preferably with a damp, dust absorbing cloth. Normal dust cloths and feather dusters should not be used.

A smooth floor can be well cleaned visually by means of a vacuum cleaner, but small dust particles are most effectively removed by wiping[5]. For wall to wall carpeting the best cleaning results are obtained by daily vacuum cleaning, although considerable quantities of dust are not removed even then[4]. The amount of dirt retained depends also on the material of the carpeting and the way it is woven: a woollen carpet is more suitable for vacuum cleaning than one of synthetic fibres. boucle carpeting is better for cleaning than velour. and a used carpet can be more effectively cleaned than a new one[4].

Ideally, vacuum cleaning of carpeting should, from the hygiene point of view, be done with a central vacuuming system for the following reasons:
- the dust filters of most vacuum cleaners let through a part of the smaller particles. so that the space is filled with micro-dust, while a central system collects all the dust centrally and the space remains cleaner.

- The suction power of a central system is more constant and greater than that of conventional vacuum cleaners. making the cleaning more effective.

Calculations have shown that the extra investment for a central vacuuming system pays itself back. More research into the necessary intensity and frequency of vacuum cleaning in relation to the ventilation system, dust sources. carpeting and suction power is still needed. One thing is clear however, deeply ingrained dust -the habitat of mites- cannot be removed from carpets by normal vacuum cleaners, so that periodic dry or humid in-depth cleaning is required. e.g. with steam heated to 70°C to kill the dust miles.

HEATING, VENTILATING AND AIR-CONDITIONING

In the development of HVAC systems, the thermal comfort of human beings has always been strongly in the foreground. Not until about ten years ago did health aspects start receiving more attention. The consensus now is that a good indoor climate is vital and than it rests on two principles : health and comfort. Hygienic assembly and running of the air conditioning plant is every bit as important as achieving the right climatic conditions.

This chapter will serve to explain why displacement ventilation combined with ceiling heating and cooling is the safest combination.

Filtration Of Outside Air: Particles smaller that 2 µm are not expelled from the bronchi, so these constitute the greatest risk because they can enter the lungs. At the same time such particles are the main cause of indoor pollution[6,7].That is why air filters must trap these particles efficiently. The filtration yield as measured by means of the Ashrae standard 52-76, must be at least 85%, which corresponds to Eurovent class EU 7. For optimum results a 95 % yield is recommended, which corresponds to class EU 9.

Proper functioning of the air filters must be carefully monitored. Moisture penetration. freezing and overloading must be avoided. The most effective measure is to ensure that the filter remains dry under all conditions. The necessary knowledge is available, but is not, unfortunately often applied in office buildings.

Air Handling Units:

- double walled construction with properly treated surfaces.
- proper observation ports and interior lighting.
- easy cleaning of heating and cooling units: e.g. widely spaced fins,
- prevention of moisture penetration in the cooling units by low air velocity,
- good drainage of condensation from the cooling units.

Some German manufacturers have set up quality standards for air handling units. Hygiene aspects have been included in those norms[9]. Some of the norms specifically apply to hospitals, but applying them to offices deserves consideration.

Humidifiers: Humidifying by means of steam is preferable from the hygiene point of view but overhumidification and subsequent condensation in the air ducts must be avoided. A good second choice is evaporation of water from a large surface that is constantly drenched. Since the relative humidity need not be much higher than 30 %, drenching with 100% pure water without circulation is usually justifiable. The last option is spray humidification. where hygiene is complicated and costly. A droplet separator is always required and aerosols and their microbological load, if any, must be trapped in a high grade end filter. When not in use, all types of

humidifiers must be completely dried and extra protection by means of ultraviolet radiation is recommended.

Air Ducts: Round ducts are preferable because their inner surface is less, so that less dust can settle than in rectangular ducts. Moreover, round ducts are easier to clean with rotating brushes. Upon delivery air ducts must be entirely degreased and cleaned before being installed. They must be kept clean during installation. During work interruptions open ends should be c1osed. In designing the duct system, the later cleaning strategy should be taken into account, e.g. the location of inspection and cleaning ports, *etc.*

System Components: Induction and fan-coil units are very susceptible to internal pollution by recycled air. Easily dismountable and exchangeable air filters are obligatory.

End Filters: Some manufacturers propagate placing end filters, immediately behind the air inlets in the rooms. Such filters can be very useful in removing noxious gases (NO_x, SO_2 and Ozone), micro-biological contamination, allergens, odours and dust, However. if the plant was built and is managed on hygienic principles, end filters are usually not required. Such filters are clearly useful where the air-conditioning installation is contaminated or difficult to clean, particularly in spaces where allergic people work. The filters can also prevent contamination of the air ducts when the system is closed down. In microbiological contaminated workspaces the front part of the air inlet ducts can be contaminated (own research) .

Air-Distribution Systems: Air distribution can be accomplished in two entirely different ways: the mixing system and the displacement system: In the former system, the air is blown into the top of the space at fairly high speed and extracted from the top as well. The maximum effectiveness is 1. The, what are called all-air systems often cause high air velocities, particularly at floor level, so that small dust particles are not a1lowed to settle, while dust in the carpeting is dislodged.

With displacement ventilation the slightly cooler air is blown softly into the space at floor level and extracted as high up as possible. The air rising from local heat sources, such as people and personal computers is continuously replaced by clean air from below, so that the ventilation effectiveness can reach 1.5. Measurements have shown that the dust concentration in the habitable zone is far less than with the mixing system[10]. This makes displacement ventilation the favourite from the dust prevention point of view, but it cannot be combined with either floor or air heating systems.

Radiators And Convectors: The greater the share of convection heat in the total heat production, the greater will be the air currants in the heated space. This causes dust to remain in circulation. Convectors and convection fins are usually not easy to clean. Unhygienic dust whorls may occur.

The following guidelines and recommendations are important:

- ban the use of convectors,
- use smooth radiators with the greatest possible radiation effect,
- ensure easy cleaning of the radiators and all around them. Do not place them in alcoves or pits.
- floors under and walls behind the radiators should be easily accessible for cleaning.

Air Heating: Air heating usually requires a greater air flow rate than ventilation. A great proportion of the air is recirculated. A part of the dust in that air will also be recirculated, because the filters trap only a part of it. Hot air heating is not a good choice from the dust prevention point of view.

Floor Heating: Floor heating works with low temperatures and a large radiation element, so that convection currants remain limited. It also counteracts the breeding of dust mites in carpeting. Because they die in winter, the development of mite colonies in the humid summer is reduced.

Ceiling Heating: Ceiling heating is pure radiant heating and so it is ideal from the dust prevention point of view. Owing to the high costs and the difficult accessibility of ceiling spaces, this system is not often applied in offices, but in combination with cooled ceilings referred to below, it is an excellent system, provided a certain conditions are met.

All-Air Cooling Systems: As with the heating systems, greater air volumes are required than for ventilation only. The disadvantages of recirculated air have already been described.

Air/Water Coding Systems: The primary air can be supplied through induction or fan-coil units, which provide cooling by recirculation of the air. Both systems are very susceptible to contamination by the circulating air, while fairly strong draughts occur in the cooled space and dust partic1es remain in the air. They cannot be recommended for anti allergic work spaces.

Conc1usion: The safest system is ceiling cooling which is ideal in combination with displacement ventilation. The ceiling can also provide heating.

REFERENCES

1 Gösta Ewert (1965) *"On the mucus flow rate* in *the human nose"* Acta Olalazyngologica suppl. 200 – Stockholm

2 Dr. Johanna E.M.H. van Bronswijk (1991) *"Carpeting, air conditioning and Sick buildings"* Eindhoven University of technology

3 P.M.J. Terpstra *(1993)"Bepaling van de kwaliteit van reinigingsprocessen en middelen"* Huishoudstudies 3 (:993) nr. 3, p 20-29.

4 P.M.J. Terpstra, LW. Geesing (1990) *"Onderzoek naar de effectiviteit van stofzuigen bij verschillende stofzuigfrequenties"* Instituut voor Reinigingstechnieken TNO. VSR rapport SM 19

5 P.M.J. Terpstra, C.M. Görtz en J.W. Geesing (1992) *"Onderzoek naar effectiviteit van stofzuigen, wissen, rolvegen en zwabberen op vijf verschillende harde vloeroppervlakten"* Instituut voor Reinigingstechnieken TNO. VSR rapport SM 30.

6 *"1989 ASHRAE Handbook - Fundamentals"* American Society of Heating, Refrigerating and Air Conditioning Engineers Inc.

7 *"1988 ASHRAE Handbook - Equipment"* American Society of Heating, Refrigerating and Air Conditioning Engineers Inc.

8 DIN Deutsches Instiut für Normerung e.V. (1994) *DIN* 1946 - *Teil* 2 - *Raumlufttechniek . Gesundheitstechnisch Anforderungen"* Beuth Verlag G.m.b.H. Berlin

9 Gütegemeinschaft Raumlufttechnische Geräte e. V. (1995) *"Gütesichering RAL - GZ652"* Ral Deutsches Institut für Gütesicherung und Kennzeichnung e.V.

10 Schmidt - Reuter (1990) *"Partikelmessungen in klimatisierten Gebäuden"* BMFT - Forschungsauftrag nr. FB - ET 5094A

11 Dr. J.H. Elixman (1989) *"Milben und Schimmelpilze in Teppichböden von Wohnungen mit und ohne Fussbodenheizung"*

12 David P. Wyon *"Thermal gradients, individual differences and air quality"* (1994) Proceedings of the 3rd International Conference on Healthy Buildings

13 E.M. Sterling, A. Arundel, T.D. Sterling (1984) *"Criteria for human exposure to humidity in occupied buildings"* research report for Environmental Health Directorate, Simon Fraser University, Burnaby, BC, Canada.