Indoor air Vol 5

H1656

#1656

INDOOR AIR QUALITY AS A PART OF TOTAL BUILDING PERFORMANCE

Michael Clarkson
Public Works Canada, Ottawa, Canada

Abstract

An indoor air quality investigation of a 60,000 m^2 8 storey government office building was carried out as a part of an in-depth study of the Total Building Performance of the building. The trans-disciplinary study included the following areas of building performance: lighting, acoustics, thermal comfort, ventilation, energy use, air circulation, air quality, occupant comfort, building envelope thermography, functional use and enclosure integrity. The air quality conclusions generic to large offices are presented.

Overview of Air Quality in Large Offices

The field of indoor air quality has a rapidly growing literature. Many review articles and conference proceedings are in the published literature (3-5), but most of the work contained in these reviews is in the residential setting. There are major differences between the environment of office buildings and houses in the type of exposure, the sources of pollutants, and the interrelationship that air quality has with other office environmental stressors such as acoustics, lighting, thermal comfort and job satisfaction.

In comparison with the work in residential settings, the volume of literature available regarding air quality in office buildings is sparse. Although there is no lack of "sick building syndrome" buildings being studied, in many cases the specific cause or aetiology of the complaint is never fully traced, or the results are not fully published in the open literature. At the present, several features of the air quality field are making themselves clear:

The number of air quality complaints in office buildings is rising rapidly. From mid-1980 to mid-1981 13% of the requests to the National Institute for Occupational Safety and Health were to investigate complaints of workers in office settings (1), an increase from only 5% three years before. In the majority of these buildings no cause was found other than inadequate ventilation and humidity control. Over 70% of the buildings investigated were for hermetically sealed buildings.

In the studies where a wide range of individual pollutant levels were measured, the levels rarely exceed the occupational health and safety exposure limits that are thought to be levels at which no health effects are to be expected.

Most studies are carried out at a level that is too incomplete to draw causal conclusions. It is virtually impossible to measure all aspects of air quality including micro-environment air change rates, gaseous pollutant levels of ozone, formaldehyde, carbon monoxide, carbon dioxide, nitrogen oxides, trace organic contaminants of 200 to 300 compounds including polycyclic aromatic hydrocarbons, pollens, fungi and bacteria, and carry out health interviews, a questionnaire survey and follow-up. As many office buildings are now reaching the population of a small town such a level of detailed investigation is almost impossible.

The synergistic effect of exposure to low levels of pollutants are largely unknown. Although this is an important aspect of current medical research, particularly in the area of carcinogenisis, the results may not be complete for decades in the range of exposures that we face in building situations. It must also be kept in mind that the average office building's occupants represent a very wide and uncharacterized range of human susceptibilities.

We see that any attempt to establish a causal link between objective measurements of air quality and specific health effects is a very arduous undertaking. As a corollary it is equally perilous to suppose that if all pollutant levels are below permissible levels then no health effects should be expected. This is especially true if we begin to examine the interrelationships between air quality and other environmental conditions in the office environment. Poor air circulation in the interior space can lead to the impression of poor air quality even in the absence of high pollutant levels, as can high temperature or too high or too low humidity. Poor lighting, the lack of acoustical privacy, or even the functionality of the interior layout all play a role.

Total Building Performance

It is clear that related stressors in the office environment must have some impact on the occupants' health and well-being particularly with regard to fatigue, eye-strain, headaches and increased susceptability to routine infectious diseases such as colds or the flu, but the exact causal links would be exceedingly difficult to establish. In many instances, these interelated stressors may play a more important role in adversely affecting the occupants' health than the exposure to individual pollutants or toxins.

Rather than trying to correlate health aspects of the occupants with measurements of pollutant levels, the approach adopted in this study has been to adopt a transdisciplinary process of measuring air quality in relationship to other environmental stressors. Air Quality then becomes an aspect of **Total Building Performance,** where Total Building Performance is a critical approach which suggests that testing procedures should not be subdivided by disciplinary expertise but by performance mandates and their interrelationships (2).

In this approach air quality measurements are made in control and problem areas in order to establish sources and compliance with prevailing standards. These results are then integrated with knowledge of the building mechanical systems, and responses to distributed questionnaires and interviews. Tentative hypotheses are then explored by all members of an transdisciplinary team and are examined for synergistic or conflicting interrelationships with other aspects of the interior environment. Then recommendations are formed within this framework and examined for possible deleterious side effects on any aspect of the building's performance be it environmental, building integrity, functionality or energy use.

The advantage of this approach is that the recommendations for ameliorating the problem are examined by all disciplines for possible conflicts, and are likely to benefit from the practical experience of each of the individual disciplines involved. Although the exact causal relationships between air quality and health effects may not be established, by treating the building environment in a holistic fashion we move closer to our ultimate goal of providing occupant satisfaction, instead of simply trying to attain "good" air quality. The recommendations formed from such a study can be implemented by the building owner or manager with some degree of assurance that the possible side effects of each recommendation have been examined in detail. Furthermore, the recommendations can be considered from a generic transdisciplinary point of view that allows them to be readily incorporated into the process of building design so that problems are solved rather than perpetuated.

In the particular building that was studied sampling was carried out for Radon, formaldehyde, carbon monoxide, carbon dioxide, and trace organics by GC/MS. Even though there were a number of air quality complaint areas in the building, all pollutant levels were below ASHRAE or ACGIH standards, and the building-wide fresh air ventilation rates varied between 14 and 200 L/s/person. Rather than presenting the specific sampling results for the remainder of this paper we wish to present a summary of the generic air quality conclusions that should be applicable to most large office buildings.

Summary of Air Quality Conclusions

Specific Pollutant Sources

Copiers and print machines can generate large amounts of a wide variety of toxic chemicals. The thermal load from these copiers may not be high enough to demand adequate fresh air to clear the room of pollutants, or the original room may have been designed as a single person office. In either case a special air supply and exhaust system must be installed. Unless this effluent is ducted to the exterior of the building, or a return air shaft, these pollutants will adversely affect the air quality in the surrounding areas. If the exhaust is merely ducted to the return air plenum, there is not likely to be sufficient return air flow to prevent the settling of particulates and the contamination of areas along the return air path. Ducting of copier effluent would be more readily incorporated into original designs rather than retrofit.

Solvents for cleaning copiers or print machines are usually stored near copier machines and may contribute to the pollutant load during both the cleaning operation and storage.

Blueprint machines generate ammonia and should have the effluent ducted to the building exterior or return air shafts. The finished prints themselves also continue to emit ammonia partly due to their large surface area. Scavengers are recommended to reduce the amount of ammonia fumes that are created when blueprints are made. However, they do not obviate the need for special ventilation for the room itself.

Ventilation Problem Areas

Final fit-up of the air supply systems must take place after all usage of spaces has been defined. Although the air supply trunks can be specified in advance, the location of thermostats, number of VAV boxes, and diffuser layout cannot take place until after all walls have been decided upon and space population densities and usages are known. **Thermostats** must be located central to the area whose air supply they control, and control only one type of micro-enviroment.

Depending on the supply air temperature adding more supply air to a problem area may not be a panacea for air quality complaints, for it can give rise of thermal comfort problems. Installation of supplemental air conditioning units to handle the extra heat load from computers or word processors can have an adverse effect the thermal comfort in surrounding areas if the heated exhaust is not properly ducted to the building exterior or the return air shaft.

Storage areas have potentially poor air quality as the materials stored often outgas chemical pollutants. Rather than being viewed as areas of low air supply need or low thermal load, they should be viewed as areas of high pollutant load and handled accordingly.

Waiting rooms have a high density transient load that requires a dedicated air supply for the area, and it appears that in many cases these needs have not been allowed for in the original design specification. The terminal air supply ducting is often specified before the final determination of the use of the spaces was known.

Air supply from diffusers located in the ceiling combined with a ceiling air return plenum can lead to a short-circuiting of the air circulation if the room is small. Although there may be adequate air supply, our tracer gas tests have shown that the supply air may not be descending or mixing more than 50 to 80 cm below the plenum.

Technological change can alter dramatically the use of space and the amount of thermal load in a given space. As the increased usage often exceeds the load that the space was designed for, dramatic deterioration of air quality can be expected unless the necessary changes for the ventilation system are carried out concurrently.

Open office partitions can impede air circulation particularly if they extend all the way to the floor. In our experience, lifting the partitions 15 to 20 cm off the floor will greatly improve the air circulation without too great an adverse effect on acoustical privacy.

Mechanical Systems

Mechanical systems with a full economizer cycle use 100% fresh air during most of the year except for mid-summer and mid-winter. This is optimal regarding air quality. For new buildings, economiser systems also offer the possibility of using 100% fresh air for the first six to twelve months until all off-gassing of newly installed textiles is finished.

Intake air can be contaminated by building exhaust, toilet exhaust or kitchen exhaust, or by industrial pollution from nearby factories. Air intakes located on street level have the potential for drawing in air contaminated by automobile exhaust from urban traffic.

Humidifier systems play on important role in the overall air quality in the building. Poor cleaning of humidifier trough can lead to either foul smells, odours and the possibility of bacterial infection, or the distribution of fine calcium and magnesium carbonate dust. Humidifier operation should be governed by return air humidity, and sensors should be checked and recalibrated on a regular basis.

Delamping a building as an energy saving measure can adversely affect the air quality by reducing the thermal load on interior spaces thereby reducing the demand for cooling fresh air. If no other changes in the air supply systems are made concurrently such as raising the supply air temperature, the delamping operation may lead to a reduction in the air supplied per person.

Facets of Architectural Design

Mechanical shafts can act as chimneys within the building, and carry pollutants from the basement or ground floor levels to the top floors of the building. Such shafts should be sealed.

Service elevators located adjacent to loading docks can conduct vehicle exhaust from the dock area to the top floors of the building. Improved sealing of the elevator doors, automatic double doors between the service elevator and loading dock, and depressurization of the elevator shaft may be required to stop this pollutant migration.

Parking garage ventilation that relies on CO monitors should have the monitors checked and recalibrated on a regular basis.

Concluding Remarks

Rather than attempt to link specific pollutant levels with related health effects, we have carried out the air quality study as a part of Total Building Performance. We feel that this approach helps overcome the interdisciplinary conflicts with other aspects of the interior environment, and presents the building owner, operator and designer with a pragnatic solution to air quality problems in large office buildings.

References

(1) R.A. Keenlyside, Recent NIOSH Indoor Air Quality Investigations NIOSH conference on Occupational Health Issues Affecting Clerical/Secretarial Personnel, Cinncinnati, July 1981.

(2) P. Mill, Transdisciplinary Building Diagnostics/Total Building Performance, Public Works Canada, Ottawa 1983.

(3) National Research Council, Indoor Pollutants, National Academy Press, Washington, 1981.

(4) Proceedings, International Symposium on Indoor Air Pollution, Health and Energy Conservation, Amherst, 1981.

(5) B.M. Small, Indoor Air Pollution and Housing Technology, Canada Mortgage and Housing Corporation, Ottawa, 1983.