#7096

GUIDELINES FOR REDUCTION OF EXPOSURE TO VOLATILE ORGANIC COMPOUNDS (VOC) IN NEWLY CONSTRUCTED OR REMODELED OFFICE BUILDINGS

Steven B. Hayward and Jerome J. Wesolowski

California Indoor Air Quality Program, Air and Industrial Hygiene Laboratory, California Department of Health Services, Berkeley, CA, USA

ABSTRACT

In 1990 the California legislature mandated that the California Indoor Air Quality Program develop nonbinding guidelines for the reduction of exposure to volatile organic compounds (VOC) from newly constructed or remodeled office buildings. This legislation was the result of concern about increasing complaints of sick building syndrome (SBS). The resulting guidelines cover all aspects of the design, construction, and operation of new or renovated buildings. They primarily apply to projects that utilize mechanical heating, ventilating, and air-conditioning (HVAC) systems, although elements of the guidelines can be applied to buildings that use natural ventilation. This paper gives an overview of the contents of the guidelines.

INTRODUCTION

Sick building syndrome (SBS) refers to the situation in which building occupants report relatively non-specific symptoms, such as mucous membrane irritation, headaches, stuffiness, lethargy, and drowsiness, and which the occupants associate with occupancy of the building. The California Occupational Safety and Health Administration has estimated that approximately 1000 buildings are associated with SBS in California each year (1). Since most of these buildings have many occupants, SBS is a problem that can affect the health and productivity of many of California's workers.

It has been postulated that VOC play a role in many of the SBS complaints. This is because such problems often occur in new or newly-renovated office buildings, often with sealed windows and substantial amounts of new building and furnishing materials. It is well known that such materials emit VOC, and that their emissions decrease with time. Because of concerns about increasing complaints of SBS, the California legislature mandated in 1990 that the California Indoor Air Quality Program develop nonbinding guidelines for the reduction of exposure to VOC from newly constructed or remodeled office buildings (2).

The 30 page guidelines primarily apply to projects that utilize mechanical heating, ventilating, and air-conditioning (HVAC) systems, but portions can also be applied to buildings that use natural ventilation. They cover various aspects of the design, construction, commissioning, and operation after occupancy of new or renovated buildings that are likely to influence exposure to VOC. Recommendations are based on the four basic methods of reduction of indoor exposures: source control (including material

selection, construction and renovation procedures), ventilation system design and commissioning, occupancy control, and air cleaning. A section is included which discusses the information available to date on the usefulness of building bake-outs, and an appendix is included which provides suggestions on bake-out procedures. Finally, the circumstances under which regulations rather than nonbinding guidelines might be appropriate is discussed.

DESIGN RECOMMENDATIONS

The major design recommendations were as follows.

* Select building and furnishing materials to avoid using unnecessarily strong emitters of VOC, and especially of other known irritants or toxic chemicals. Designers should put pressure on manufacturers to provide data on product content.

* Design the ventilation system using the current California non-residential energy standard (3), as well as ASHRAE Standard 62-1989, "Ventilation for Acceptable Air Quality"(4).

* Anticipate policies on smoking. If smoking will be allowed in certain areas, exhaust-only ventilation should be provided. Such ventilation is also needed for any area in which other significant sources will be in use.

* During the design phase, anticipate both a pre-occupancy ventilation (and possibly bake-out) period and likely renovations throughout the life of the building.

* Design ventilation systems to prevent the buildup of contamination within the system, and to allow easy access to system components for inspection and maintenance.

* Consider including VOC sorption capability in the design of any new ventilation system. However, whenever possible, it is better to eliminate the source than to rely on dilution to reduce exposure. This is a particularly relevant consideration for environmental tobacco smoke (ETS) since the U.S. EPA has declared ETS to be a Class A carcinogen, and has provided evidence for many other adverse health effects (5).

CONSTRUCTION AND RENOVATION RECOMMENDATIONS

The major recommendations were as follows.

* During construction or renovation, fully isolate construction zones in partially or fully occupied buildings. Keep these areas under negative pressure relative to the adjacent spaces. Once an area is occupied, limit the use of materials that emit VOC in the building.

* When installing "wet" products, maximize outside air ventilation - preferably at least 5 air changes per hour of outside air.

* Schedule construction or installation of furnishings to minimize the build-up of high levels of contaminants that cannot be removed before occupants enter or return to the space.

* Whenever possible, install adsorptive surfaces such as textiles, insulations, and carpets after applying "wet" products such as caulks, adhesives, paints, sealants, etc.

* Maximize ventilation during installation of materials. Seal return-air ducts and use direct exhaust to the outdoors either through operable windows or through temporary openings - possibly with fan-powered assistance.

COMMISSIONING

The major recommendations were as follows.

* Commission any new building, and recommission it any time a major renovation is completed. In renovating an older building, follow as many of the commissioning guidelines as are appropriate for the renovated portions of the building. Follow ASHRAE guidelines (6), and refer to ASHRAE's update on those guidelines (7, 8, 9, 10, 11, and 12) for more detailed information on commissioning.

* Carefully consider "baking out" a new building or a renovated space prior to occupancy. "Bake-Out" is discussed in more detail below.

* Plan adequate time between the interior finish work and the move-in process.

* Ventilate a construction area with 100% outside air and no recirculation before occupancy.

OPERATION DURING INITIAL OCCUPANCY

The major recommendations were as follows.

* Operate the ventilation system during the initial occupancy period with maximum achievable outdoor air consistent with necessary temperature and humidity control.

* Require that building maintenance and housekeeping staff use low-emitting materials.

* Establish a clear smoking policy.

* Monitor subjective occupant responses during the initial occupancy period to determine if additional steps are needed to reduce VOC, or to determine when the ventilation system can be operated in the normal mode.

"BAKE-OUT"

"Bake-Out" is the process of overheating a building or space to artificially age the materials that are sources of VOC. Much of the research on the effectiveness of baking out buildings has been conducted by DHS, and consists of field trials in actual buildings. Based on this limited experience, it appears that baking out is likely to be effective only if:

1) the entire building is baked out, or the portion that is baked can be effectively isolated, both physically and with respect to air flows, from the rest of the building, 2) temperatures can be increased to greater than 95°F, and maintained for at least 24 hours, while moderate amounts of outside air are provided to remove emitted pollutants, and 3) all building materials, furnishings, and finish work are complete and in place (13, 14, and 15). Experience by other researchers has been less encouraging (16). The likelihood that a bake-out will be successful may depend on what specific materials are the primary emitters in the building.

DHS does not at this time recommend conducting building bake-outs, since there is disagreement in this field, and since no field studies have been conducted with adequate control buildings. That is, no studies have been conducted in which one building has been baked out, while a corresponding, identical building has been allowed to age at normal temperatures, with measurements being made in both buildings of the time course of VOC levels. Also, no systematic chamber studies have been conducted to evaluate the effects of extreme temperature on emissions of building and furnishing materials, or on adsorption and re-emission by sinks. More extensive studies are essential before it can be stated with certainty just how effective bake-outs are likely to be, and if so, the desired conditions, time period, and ventilation rates needed to effectively reduce VOC concentrations well below those that would result from normal aging and ventilation. Therefore, this procedure must be considered experimental. However, DHS has no reason to discourage experimentation with this procedure, as long as the builder and/or building owner is aware that some material damage may result from it. The guidelines give preliminary guidance for conducting a "bake-out" based on the limited experience of DHS researchers.

NON-BINDING GUIDELINES OR MANDATORY REGULATIONS

These guidelines stress finding cooperative solutions to problems whenever possible, and recommend consideration of establishing regulations only when it is apparent that other solutions have failed. Whether or not the guidelines should be codified in the future depends on the success of a non-binding approach, and whether there are cost-effective ways available to enforce such regulations.

One area of particular concern is the recommendation that architects, builders, and building furnishers request manufacturers of building materials and furnishings for VOC emission data. This "hit or miss" approach is difficult to implement. A more systematic approach would result from an environmental labeling process. This is a process by which a label, often referred to as a "green label," is affixed to a product indicating the degree of "environmental friendliness". The purpose of such labels is to make it easy for consumers to identify products which have environmental traits of interest to the consumer. The world's first green labels were developed in West Germany in 1978. Since then many other countries have developed environmental labeling programs, and the Organization for Economic Development and Cooperation (OECD) predicts that as many as 22 of its member countries will have some type of labeling system by the end of 1992 (17). Because of the need for an efficient process for selecting products that will minimize indoor air quality problems and the fact that labelling programs have met with consumer approval in countries with such programs, it is recommended that consideration be given to the possible development of such a program in California, at least for those building materials and furnishings that can affect indoor air quality.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge numerous reviewers for their timely comments on an early draft of the guidelines. We especially thank Hal Levin, upon whose article in *Indoor Air Bulletin* the first draft was partially based.

REFERENCES

1. Nicas, M. (1985), Appendix to the Final Statement of Reasons for Section 5142. of the General Industry Safety Orders, Title 8, Chapter 4, Subchapter 7, Article 107, "Mechanically Driven Heating, Ventilating, and Air Conditioning (HVAC) Systems to Provide Minimum Building Ventilation".
2. Speier, J., 1990, California Legislature Assembly Bill 3588 - Chapter 1229 of California Health and Safety Code.
3. California Energy Commission (1992) Energy Efficiency Standards for Non-residential Buildings, California Code of Regulations, Section 2-5320 *et seq.*
4. ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.), (1989) Standard 62-1989, "Ventilation for acceptable indoor air quality".
5. U.S. Environmental Protection Agency (1992) Respiratory Health Effects of Passive Smoking: Lung Cancer and Other Disorders (EPA/600/6-90/006F).
6. ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.), (1989) Guideline 1-1989, "Guideline for commissioning of HVAC systems".
7. Brickman, H. (1989) "Commissioning: Why we need it - what are the benefits?," in transactions of the 1989 Winter meeting of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Chicago *(ASHRAE Transactions, Vol. 95)*, p. 881.
8. Gill, K. E. (1989) "Specifying HVAC Systems Commissioning," in transactions of the 1989 Winter meeting of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Chicago *(ASHRAE Transactions, Vol. 95)*, p. 883.
9. Lawson, C. N. (1989) "Commissioning-the construction phase," in transactions of the 1989 Winter meeting of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Chicago *(ASHRAE Transactions, Vol. 95)*, p. 885.
10. Sterling, E. M. (1989) "Designing healthy buildings: The architect's role in the commissioning process," in transactions of the 1989 Winter meeting of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Chicago *(ASHRAE Transactions, Vol. 95)*, p. 893.
11. Stone, D. T. (1989) "The HVAC commissioning plan," in transactions of the 1989 Winter meeting of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Chicago *(ASHRAE Transactions, Vol. 95)*, p. 885.
12. Trueman, C. S. (1989) "Commissioning: An owner's approach for effective operations," in transactions of the 1989 Winter meeting of the American Society of Heating, Refrigerating, and Air-conditioning Engineers, Chicago *(ASHRAE Transactions, Vol. 95)*, p. 895.
13. Girman, J. R., Alevantis, L. E., Petreas, M. X., and Webber, L. M. (1990) "Building bake-out studies," in Proceedings of the 5th International Conference on Indoor Air, Toronto, *Vol. 3*, p. 349.

14. Girman, J. R., Alevantis, L. E., Kulasingam, G. C., Petreas, M. X., and Webber, L. M. (1989) "The bake-out of an office building: A case study," *Environment International, vol. 15,* pp. 449-453.
15. Girman, J. R. (1989) "Volatile organic compounds and building bake-out," *Occupational Medicine: State of the Art Reviews, Vol. 4:4*, pp. 695-712.
16. Hicks, J., Worl, K., and Hall, K. (1990) "Building bake-out during commissioning: Effects on VOC concentrations," in Proceedings of the 5th International Conference on Indoor Air Quality and Comfort, Toronto, *Vol. 3*, p. 413.
17. Salzman, J. (1991) *Environmental Labelling in OECD Countries*, Organization for Economic Co-operation and Development, 2 rue Andre-Pascal, 75775 PARIS CEDEX 16, France.