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The State of Washington's Experimental Approach to Controlling IAQ in New Construction

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ABSTRACT

The state of Washington's Department of General Administration, East Campus Plus Program, requires that its new office buildings, currently in the design/build and construction process, offer a productive as well as a safe and comfortable environment for its occupants. Realizing the need to achieve this goal, an assessment and implementation program for indoor air quality has been designed.

The program incorporates various building design and operational controls as well as specifications for those materials that will be used in the construction and furnishing of the buildings. Control parameters, including ventilation, occupancy, and space use factors, are considered, in addition to potential chemical emissions from materials and internal activities.

Specifications have been made to control the pollutant loads from building activities and internal materials by minimizing pollutant contributions and implementing a building "flush-out" period prior to occupancy. Pollutant contributions have been limited per product or activity to maximum values of 500 $\mu g/m^3$ of TVOC; 50 $\mu g/m^3$ of respirable particles; and 60 μ/m^3 of formaldehyde. Using the latest environmental chamber technology and computer exposure models, prediction of resultant chemical emissions from materials such as office furniture, adhesives, flooring systems, wall-covering systems, office machines, and other sources are being computed based on the actual building design and operational requirements.

INTRODUCTION

New and recently remodeled buildings appear to be particularly vulnerable to problems of indoor air quality (IAQ). This may be the result of a myriad of problems including inadequate and inefficient ventilation, chemical and/or biological pollutants emitted from indoor activities and materials, and pollutants from outdoor sources being re-entrained into the air supply. Other indirect contributors may include the actual use of the building in ways unforeseen by the designer.

The state of Washington progressively designed and implemented a comprehensive indoor air quality program to avoid IAQ problems as they began the design and construction of four new office buildings (Brown 1991). This program focuses on those issues important in achieving good IAQ, such as building location and outdoor air quality, building design features, space occupancy, space use, ventilation design, selection of construction materials and interior furnishings, design implementation and building commissioning, and training of building occupants and support personnel as HVAC technicians. This program began in the design phase and is continuing through construction, occupancy, and operation of the building.

One area of particular concern was a mechanism to control IAQ pollutant loads within the buildings. In addition to effecting ventilation controls over certain activities and ensuring adequate and efficient ventilation (complying with the design criteria of ASHRAE *Standard 62-1989*), manufacturers of interior furnishings and materials are being required to submit pollutant emissions data with their bid indicating their compliance with actual specifications established by the IAQ program. A 90-day "flush-out" period with 100% outside air is also planned to help abate pollutant emissions.

The first product evaluated under this program was office furniture, and others are following, such as carpet, adhesives, wall coverings, and paint. The office furniture evaluations have been completed and have indicated that the four bidding manufacturers met the required specification. The adhesive data indicate that part of the building "flush-out" period needs to be conducted prior to the furniture installation to prevent potential sink effects.

POLLUTANT SPECIFICATIONS

In the absence of regulated indoor air pollutant standards, criteria have been established to control pollutant emissions from interior materials, manufactured products, and other pollutant generators. These emissions standards are defined as those

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"emission rates" of pollutants emanating from the product of concern that will not produce building air concentrations greater than:

60 $\mu g/m^3$ of formaldehyde (CHOH);

500 $\mu g/m^3$ of total volatile organic compounds (TVOC);

50 $\mu g/m^3$ of total particles; and

6.5 $\mu g/m^3$ 4-phenylcyclohexen (4-PC) (for carpet only).

Compliance data are required from the manufacturer indicating that the product can achieve these levels under defined state of Washington building conditions. The data must be supported by submission of actual product descriptions, detailed testing protocols, and test data and documentation, including emission changes over time indicating the change in concentration with product age and exposure time in the building.

In addition to the TVOC requirement, which is considered a "generalized" VOC control mechanism, data are also required on specific individual volatile organic compounds. Those individual compounds identified in the product emissions that meet the following requirements must be individually reported along with their predicted building concentrations:

1. Those contained on the list of chemical carcinogens established by the International Agency for Research;

2. Those contained on the carcinogen list of the National Toxicology Program;

3. Those contained on the Reproductive Toxin list as included in the *Catalogue of Teratogenic Agents*;

4. Those more than 1/10th the TLV (threshold limit value according to the American Conference of Governmental and Industrial Hygienists); and

5. Those on the National Ambient Air Quality Standard Lists of primary and secondary air pollutants.

Although little is known about the health effects related to indoor air pollutant exposures, these criteria provide a safety margin over current occupational chemical exposure standards and those currently referenced for indoor air (WHO 1987; Molhave 1985; Tucker 1986; and Otto 1989).

ANALYTICAL EVALUATION OF PRODUCTS

Pollutant emission testing of the products requires analytical evaluations using environmental chamber technology coupled with mathematical modeling of the predicted air concentrations.

Testing specifications were designed following the basic theory, analytical procedures, and quality assurance as presented by EPA (Tichenor 1989) and most recently by ASTM (1991). A large-chamber testing requirement and protocol was established for the evaluation of office furniture as developed specifically for modular office furniture and associated products (AQS 1989) and adopted by the state of Washington. This testing protocol incorporated many factors, including chamber design and operation, supply air specifications, environmental control, ventilation control, pollutant measurement specifications, product exposure requirements, product handling, and quality control measures.

A modified IAQ model (Sparks 1989) was used to predict indoor air concentrations of the pollutants of concern. The model parameters were determined from the actual building design, ventilation system design, space use, occupancy rate, and any other related factors.

The pollutant air concentrations determined from the model predictions were used to determine compliance or noncompliance with the pollutant emissions criteria.

OFFICE FURNITURE EVALUATIONS

The first product to be evaluated under this program was office furniture. Most of the office space within the new buildings is planned to be open, designed with freestanding modular workstations as generically presented in Figure 1. The workstations, as an aggregate, correspond to the single interior furnishing providing the most exposed surface area in the occupied spaces. From an IAQ point of view, this product is a very significant component of the interior space and presents an offgassing potential. In addition, the procurement price for this product is approximately $10 million, a figure that demands a good product in all aspects.

The furniture was tested according to the established large-chamber protocol. A state of Washington representative was actually on site at each manufacturing facility during the test product selection and observed it packaged and loaded onto a truck for shipment to the testing laboratory. Testing began immediately within 24 hours following manufacturing and packaging. Emission data were acquired from a one-hour exposure point through a six-week period.

Product comparison data for the maximum values of formaldehyde, TVOCs, and particles are shown in Figures 2, 3, and 4. Individual VOCs identified included low levels of branched benzenes, normal and branched hydrocarbons, chlorinated solvents, aldehydes, and alcohols. Those compounds that required special listing status are shown in Figure 5. Formaldehyde was

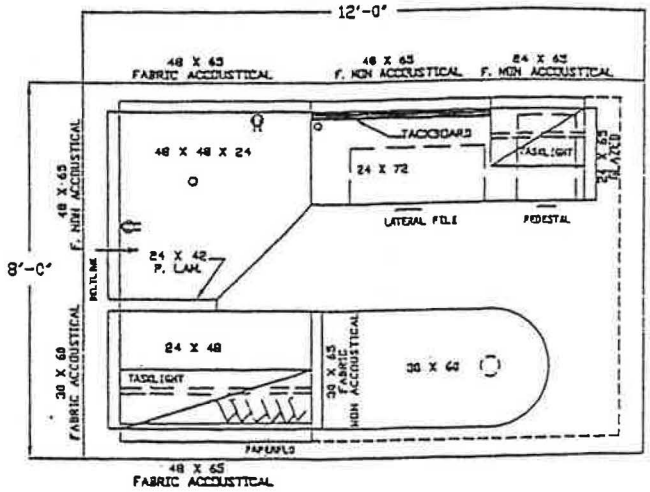

Figure 1 Chamber test layout

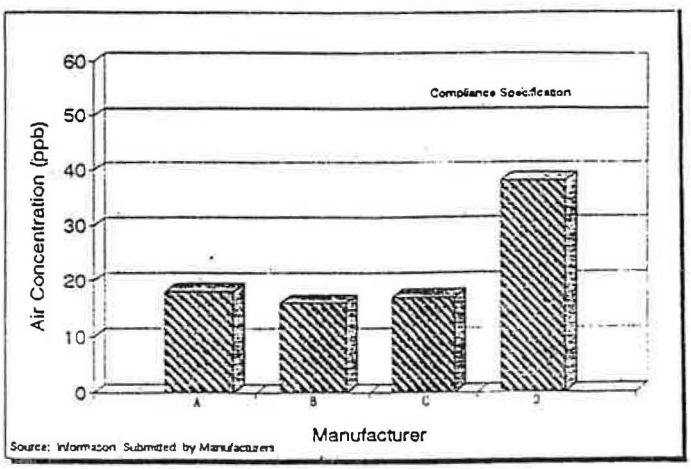

Figure 2 State of Washington compliance—formaldehyde air concentration

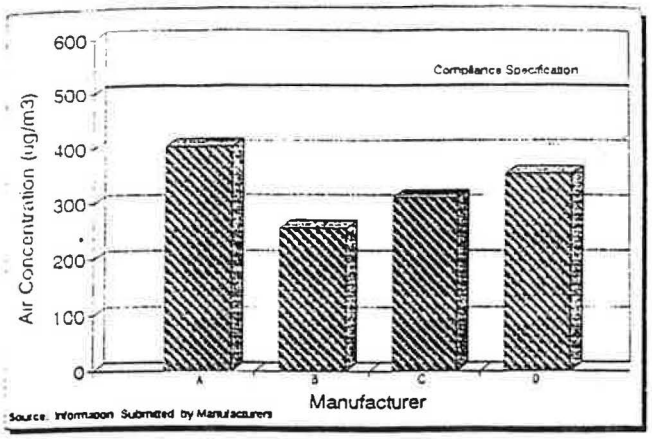

Figure 3 State of Washington compliance—total VOC air concentration

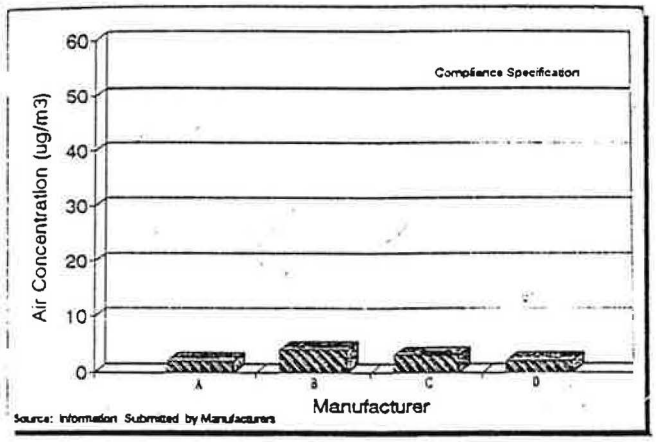

Figure 4 State of Washington compliance—total particles air concentration

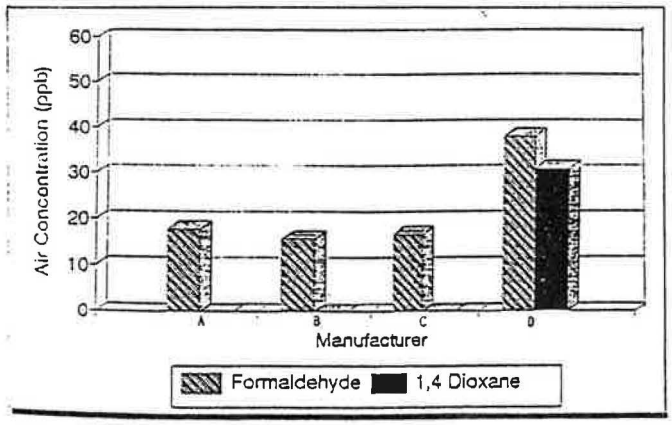

Figure 5 State of Washington compliance—carcinogen air concentrations

present in the emissions of all the products, and 1,4-dioxane was present in one furniture system at a maximum concentration of 170 $\mu g/m^3$.

The TVOCs decayed rapidly with exposure time, but formaldehyde emissions were more steady and even increased in time for one manufacturer (Figures 6 and 7). All four manufacturers complied with the pollutant emission criteria or simply "everyone passed." The selected manufacturer will be required to supply quality control data on those products that are ultimately delivered to the buildings, illustrating a continuing compliance.

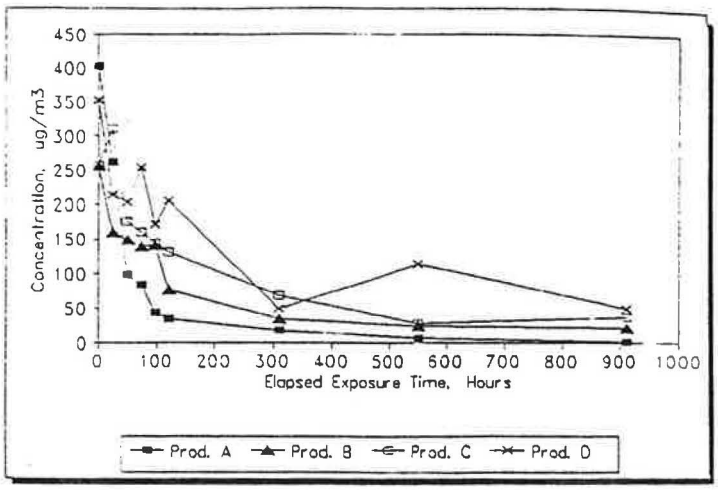

Figure 6 TVOC predicted concentration with time (excluding formaldehyde)

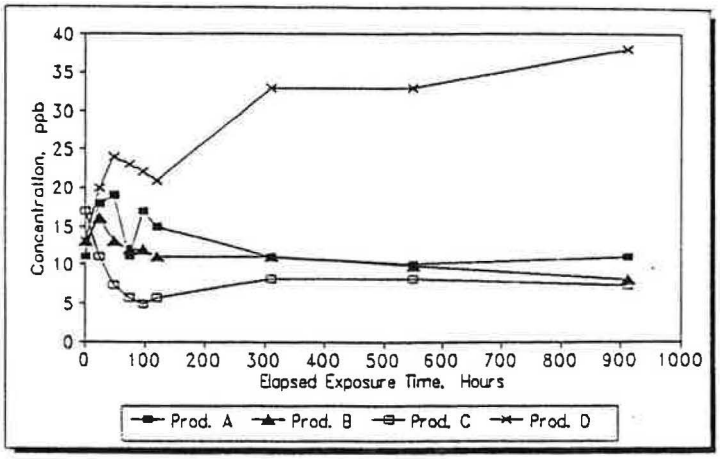

Figure 7 HCOH predicted concentration with time (formaldehyde only)

In addition to complying with the state of Washington's requirement, each of the four manufacturers obtained emissions data on a specific product line that may be used again. If similar data are required of the same product, each manufacturer may use the emissions data in conjunction with other building-specific data to predict potential air concentrations resulting from their product. The building-specific information is critical in final evaluation of the product's actual IAQ performance.

OTHER PRODUCT EVALUATIONS

Additional product evaluations are currently underway for this project. Other systems, such as carpet, adhesive, and fireproofing, are currently being evaluated. Preliminary "wet-source" (e.g., adhesive) emissions testing indicated an exposure time requirement prior to complying with the TVOC criteria. Based on these data, as shown in Figure 8, the IAQ program has been modified to allow a 30-day "flush-out" period with 100% outside air prior to initiating furniture installation. This decision was made to prevent VOC contamination of the furniture by the adhesive and other "wet" pollutant emitters through potential sink effects.

CONCLUSION

Product source testing and exposure modeling of materials and furnishings are being used effectively in a comprehensively

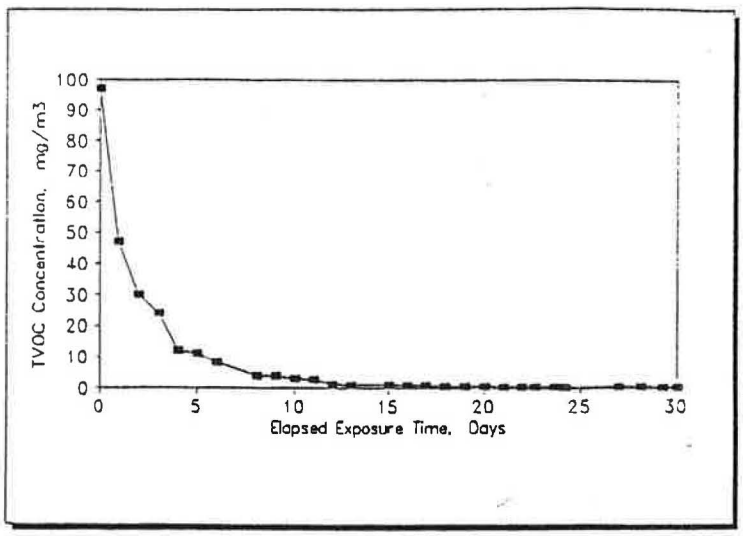

Figure 8 TVOC predicted concentration with time (general adhesive)

designed IAQ program to help control pollutant loads within office buildings. This is just one step in addition to many other controls—such as proper design and implementation of a good ventilation system—in a master plan to prevent IAQ problems within new buildings. Although there is still much to learn about "sick building" health complaints and the relationship of pollutant exposures, this pollution control step is expected to help achieve acceptable indoor air quality within the state of Washington's new office buildings.

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