SPECIAL ENVIRONMENTAL REQUIREMENTS FOR A CALIFORNIA STATE OFFICE BUILDING

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ABSTRACT

A Special Environmental Requirements specification was developed for screening building materials based on modeling maximum chemical concentrations attributable to emissions from their potential sources for use in a State of California office building. In addition, minimum requirements for recycled contents of these materials were specified. Small environmental chamber emission test protocols were developed and maximum allowable concentrations for chemicals of concern were adopted. Contractors were required to submit emission test reports. The architect reviewed these reports for conformance with the specification requirements. Materials were accepted, rejected, or in some cases were chemically re-formulated and re-tested. While there were difficulties in obtaining emission test reports from some manufacturers, most required test reports were received. This specification will be applied to other building projects with some modifications including standardization and clarification.

INDEX TERMS

Offices; Building materials; VOC emission guidelines; Improved IAQ practices; Sustainable building specifications

INTRODUCTION

A high performance 44,500 m^2 (479,000 ft^2) office building with 6 stories and 1 below-grade parking level is being built in Sacramento, California, for the Department of General Services (DGS). The DGS project environmental performance goals included the following: (a) that the project should be at least 30% more energy efficient than required by the 1998 California Title 24 energy code, (b) that the project have enhanced indoor environmental quality, (c) that the project use a significant quantity of recycled-content materials, and (d) that the project be completed on budget and within the time constraints of an aggressive construction schedule.

This paper describes the method used to achieve enhanced indoor air quality (IAQ) by screening of major interior building materials while using some resource efficient and many high recycled content materials. The material selection methodology builds on prior work done in the field for building projects such as the San Francisco Main Library (Bernheim, 1993, Bernheim and Levin, 1997), and prior work by members of the project team (Levin and Hodgson, 1996); including, the State of California's environmental specifications for office furniture systems (Levin et al, 2000).

The challenge for the design team was to develop and implement an effective material source control strategy that could be seamlessly integrated into the overall project schedule. This

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strategy needed to be understandable and usable by the project team (general contractor, sub-contractors, material manufacturers and suppliers), and by the architects as a basis for acceptance or rejection of a project material. The significance of this work is that IAQ emissions test protocols and maximum acceptable concentrations for volatile organic compounds (VOCs) were developed based on existing publicly available literature and were incorporated into the project specifications together with other "green" building requirements. This specification has been re-written and is now available on the web for use by design professionals on other building projects (Bernheim and Levin, 2001).

METHOD

Based on an environmental specification initially developed by the State of California for inclusion in its 3 year, $\$60x10^6$ contract for office systems furniture for this building, members of our team developed a specification for interior building materials. This specification section, titled "Special Environmental Requirements" was integrated into the project specifications and included the following requirements:

- IAQ:
  - Identification of specific materials for individual, adhesive, and assembly (similar to final installation and including the material, adhesive and substrate) emission testing.
  - Submission of environmental chamber test data, based on ASTM Standard D5116-97, Guide for Small Scale Environmental Chamber Determination of Organic Emissions from Indoor Materials/Products.
  - Preparation of test specimens as follows: The specimens for wet-applied products were pre-conditioned for 5 days in clean air ventilated at 1 air change per hour (ACH). Then samples were collected and results reported for total volatile organic compounds (TVOC) at 6, 24, and 48 hours, and for individual VOCs and formaldehyde at 48 hours. The specimens for dry products were pre-conditioned for 10 days in clean air ventilated at 1 ACH. Then samples were collected and results reported for sum VOCs and formaldehyde at 6, 24, and 96 hours, and for individual VOCs at 96 hours.
  - Establishment of project criteria for material acceptance or rejection. Manufacturers were required to identify the following information regarding chemicals of concern in the test results:
    A. Chemicals listed as probable or known human carcinogens in the latest published editions of the California Environmental Protection Agency (Cal EPA.), the Air Resources Board (ARB) List of Toxic Air Contaminants, and the Office of Environmental Health Hazard Assessment (OEHHA) Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65).
    B. Chemicals with Chronic Reference Exposure Levels (RELs) as listed by Cal EPA's OEHHA on their latest published list (Cal-EPA, 2000). The maximum modeled indoor chemical concentration permitted for any single chemical emitted at 48 hours and 96 hours for the wet-applied products and dry products respectively could not exceed 1/2 the OEHHA REL with the exception of formaldehyde. In the case of formaldehyde, no single material could contribute more than 1/2 the OEHHA staff recommended indoor air limit for formaldehyde in office environments of 27 ppb (33 $\mu g/m^3$).
    C. Adhesive special requirements: No component present in any adhesive at more than 1% of the total mass of the adhesive could be a carcinogen or reproductive toxicant as listed in the Cal-EPA ARB List of Toxic Air Contaminants and Proposition 65.
- Resource Efficient Materials:
  - Minimum post-industrial (PI) and post-consumer (PC) recycled contents.

- Material recyclabiltiy for specific products such as carpeting.

Project specifications were provided to the general contractor who requested the required emissions test data from the subcontractors and materials manufacturers. For specific indoor materials, the manufacturers provided these data to the contractor and the Architect for review and a determination of compliance with the specifications.

Table 1. Material Tests for Various Building Materials

Material	*Individual Test*	*Adhesive Test*	*Assembly Test*	*Modeled Formaldehyde Concentration* $(\mu g/m^3)$	*Recycled Content*
MDF + Plastic Laminate			X	6.4	25% PI + 75% PC (MDF)
MDF + Wood Veneer			X	<0.1	
Fiberglass Insulation Batts	X			10	4% PI +29% PC
Acoustical Ceiling Panels	X			Table 2	82% PI
Joint Sealers			X	<0.1	
Stone Floor Sealers	X			<0.1	
Linoleum	X	X	X	<0.2, <0.2, <0.2	54% PI
Resilient Flooring	X	X	X *	<0.5, <0.6	0%
Carpet Tile	X	X	X *	2.4,1.8,0.4	42.7% PI +10% PC
Interior Paint Primer	X			<2.0	0%
Interior Flat Paint	X			<2.0	0%
Interior Eggshell Paint	X			<2.0	0%
Interior Semi-gloss Paint	X			<0.1	0%
Access Floor Pedestal Adhesive	X *			<0.09	
Fabric Wall Cover	X			<0.05	
Acoustical Wall Panels			X	0.17	

* Adhesive Special Requirement, N/A = Not Available, PC = Post-Consumer, PI = Post-Industrial

RESULTS

Table 1 indicates the materials tested for emissions. The test results and the modeled chemical indoor air concentrations varied by material type and indicated relatively low modeled formaldehyde concentrations. Each material required special review to confirm acceptance with the project specifications.

- Medium density fiberboard (MDF) with plastic laminate, MDF with wood veneer, resilient flooring, and the access floor pedestal adhesive: Emissions test reports including the modeled indoor air concentrations confirmed compliance with the project specifications.
- Fiberglass insulation batts: The project specifications for the thermal insulation required formaldehyde-free batts. Since only one manufacturer was found to comply with this requirement, and it was desirable to be able to select from more than one manufacturer, the contractor was given the option to provide either a formaldehyde-free product or another thermal insulation product that was tested for formaldehyde and other chemical emissions. Manufacturers of such other material would have to indicate compliance with the project IAQ requirements. Modeled chemical indoor air concentrations were provided for R-19 fiberglass batts with a formaldehyde binder that met the specification requirements, other than the formaldehyde-free requirement, and the contractor was given the option to use either of the 2 products.
- Acoustical ceiling panels: The project specifications required formaldehyde-free acoustical ceiling panels. Modeled chemical indoor air concentrations for formaldehyde

for the four acoustical ceiling products considered for the project, are given in Table 2. One manufacturer tested their synthetic vitreous fiber acoustical panels three times attempting to understand the reason for the high formaldehyde concentrations while adjusting the material contents before each subsequent test. The material did not comply with the zero-formaldehyde requirement, and the manufacturer could not make adjustments in time for the construction schedule. The test reports for the synthetic vitreous fiber acoustical panels of another manufacturer indicated a much lower modeled formaldehyde concentration, and in order to comply with the construction schedule, the panel with the lowest modeled formaldehyde concentration was selected for the project.

Table 2. Modeled Formaldehyde Concentrations for Various Acoustical Ceiling Panels

Product No.	*Test No.*	*Certified Recycled Content*	*Modeled Formaldehyde Concentration* ($\mu g/m^3$)
1	1	73% PI + 6% PC, Synthetic Vitreous Fiber: Slag wool, Perlite, Cornstarch, Clay (73% PI); Newsprint (6% PC)	29.6
1	2		22.9
1	3		21.9
2	1	68% PI, Synthetic Vitreous Fiber: Slag wool, Starch, Minerals	7.1
3*	1	82% PI, Synthetic Vitreous Fiber: Slag wool, Starch, Minerals	<1
4	1	77% PI, Synthetic Vitreous Fiber: Slag wool, Starch	5.6
5	1	40% (with up to 8% PC), Synthetic Vitreous Fiber: Slag wool, Perlite, Starch, Paper Fiber, Clay	9

*Selected Product, PC = Post-Consumer, PI = Post-Industrial

- Joint sealers and stone floor sealers: Numerous joint sealers and a small quantity of floor sealer were specified. The contractor (not the product manufacturer) provided the test data for these sealers indicating compliance with the IAQ requirements. Product manufacturers were unwilling to provide the required test data because of the small material quantities used on this project.
- Linoleum: The first linoleum product tested produced higher than allowable modeled concentrations of acetaldehyde. A second product tested using a smaller quantity of the material produced sufficiently low concentrations thus meeting the project requirements.
- Carpet tile: Test reports of the carpet tile and the carpet tile tested as an installed assembly indicated that the material met the requirements of all chemical compounds including formaldehyde. The first adhesive on a cement backerboard test indicated higher than allowable concentration of naphthalene based on 1/2 the OEHHA REL of 9 $\mu g/m^3$. Subsequent testing of the adhesive on another backer board (previously used successfully for other materials) suggested that the high naphthalene concentrations may have emanated from the backerboard rather than from the adhesive.
- Interior paint: Paint with PC recycled content was not permitted for interior use and was not submitted for testing. Two manufacturers tested their paint products and both product systems met the project requirement. Each manufacturer used a different laboratory and raised questions separately about the preparation of paint test specimens. During the initial phase of the testing, we realized that the specification provided insufficient guidance for paint test specimen preparation. Therefore, an amendment to the original specification was issued to include specific requirements for paint test specimen preparation and handling.
- Fabric wall cover and acoustical wall panels: A relatively small quantity (1,092 m^2, 11,754 ft^2) of fabric wall covering and acoustic wall panels had been specified for this project. However, the test data were not easily forthcoming. The wall cover material manufacturer did not initially want to have the material test performed because of the small quantity, and the panel fabricator did not want to test the composite panel because of concerns about the responsibility for potential emissions from the individual panel

components. In the end, the material and the panel assembly were tested and both met the project requirements.

DISCUSSION

Obtaining emissions data for the major materials on this project was relatively easy. Manufacturers of large quantity materials, realized that this is a highly visible major public project, and provided test reports generally within the allotted time period. Client support from DGS and the California State Green Team under the auspices of the Sustainable Building Task Force lent authority to requests for test reports. However, there were substantial barriers to obtaining the required data from some manufacturers such as for the stone floor sealer, the sealants, the wall fabric covering and acoustic wall panels. There was a lack of understanding on the part of some contractors and material manufacturers about the need for and use of the test data. Where the cost of the emissions tests exceeded the costs of the quantity of the material used on the project, some manufacturers were unwilling to perform the required tests.

In order to meet the emissions requirements for some materials, alternative materials had to be specified with less PC recycled contents than those specified. For example, the selected acoustical ceiling panel has 0% PC recycled content compared to 6% originally specified. The manufacturer of ceiling panel originally specified is investigating the potential source of the high formaldehyde emissions, which may be attributable to the PC recycled content or to the scrim adhesive.

The "Special Environmental Requirements" specification required the manufacturers to provide the modeled air concentrations based on the emission test results, the building volume and weekly average design ventilation rate, and the material area as part of the test report. Receiving this information in the report simplified the architect's role in reviewing the test data for compliance with the specifications. This inevitably made it clear whether or not the product was in compliance and avoided unnecessary discussions and debates. It is important to note that the modeled air concentrations are specific to this project. In addition to the review of materials test data and the modeled chemical concentrations, a detailed IAQ commissioning plan has been developed. This plan includes: (a) building flush out prior to occupancy; (b) air sampling after construction completion and prior to furniture installation, after the furniture installation and prior to occupancy, and after full occupancy; and (c) evaluation of the results of the IAQ testing to determine the source of any unexpectedly elevated concentrations and recommendation of mitigation measures, if necessary.

CONCLUSION AND IMPLICATIONS

The procedures used on this project to achieve good IAQ can be applied to other building projects. For example, the State of California has already incorporated aspects of the specifications in DGS's Standard Agreement for all professional architectural and engineering services (State of California, 2001). In addition, manufacturers can use the test data to change their products to reduce VOC and formaldehyde emissions. Emissions test data collected for this project can be used on future projects provided that the material content formulation of the materials under consideration is identical to the formulation of the tested materials. Based on this information, modeled chemical concentrations can be calculated using the building project specific parameters (amounts of material used, building or space volumes, and average ventilation rates). Under contract with the State of California, the "Special Environmental Requirements" specification section has been modified for use by design professionals on other building projects and is now available on the web (Bernheim and Levin, 2001). The specifications will need to be standardized with the inclusion of agreed upon standard testing protocols for the multitude of building material types used in construction. As material types are tested and lessons are learned, these specifications and list of target chemicals will need to be updated.

As design professionals specify materials with higher recycled contents, there is even a greater need for emission testing. There will need to be a correlation between the desires for "green" building materials and those with low chemical emissions. To address this need, the State of California is currently investigating emissions from building materials with high recycled contents and comparing these to emissions from comparable materials with low or no recycled contents (State of California, 2002). The benefits of such material selection and testing will need to be better understood by building owners, operators, maintenance personnel, architects, contractors and the occupants, in order to better protect the health and safety of the building occupants.

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