A PROCEDURE USED TO EVALUATE BUILDING MATERIALS AND FURNISHINGS FOR A LARGE OFFICE BUILDING

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Abstract

A building products and materials evaluation program was completed for a large California office building as part of a program to control indoor pollutant levels. Results from tests in an environmental chamber, bulk testing, and headspace sampling are consistent with each other and comparable to tests conducted elsewhere. The age of test materials appears significantly to affect emission rates and material chemical content. The work demonstrates useful procedures for building design, materials selections, construction, move-in procedures and mechanical ventilation system operations. Further work is needed to reduce costs and increase undestanding of the interactions among materials in test chambers and buildings.

Introduction

New building materials, products and furnishings are known to emit a large number of chemicals into indoor air (1,4,5,9). Building occupants' sickness, irritation and discomfort are often blamed on the presence of such chemicals in indoor air (2,9). The health effects of these chemical emissions are not well understood, but substantial numbers of known or suspected human irritants and carcinogens are among the chemicals emitted by building products, materials and furnishings into indoor air (4).

Building designers, owners, operators and occupants are increasingly concerned about indoor air quality problems. The results of building products and materials emissions testing are now being used for design and for establishing ventilation system operational protocols to improve indoor air quality. Procedures are available to prevent or remedy problems resulting from materials' emissions. Many office buildings now operate under special ventilation protocols prior to initial occupancy to "bake off" chemicals from materials, products and furnishing. Product manufacturers and building designers (architects, engineers, interior designers) are increasingly concerned about products specified for use. This paper reports an application of materials evaluation for building design, construction planning, and building operation (3).

A program of materials and indoor air quality testing was conducted during design and construction of a large new office building in Califonia. The project's purpose was to minimize indoor air quality problems. A major element of the work was to identify products which might release sinificant quantities of toxins or irritants and to recommend methods to reduce their airborne concentrations. The recommended methods have included careful product selection by architects; modifications of selected products by manufacturers; packing, shipping, installation and handling procedures for building materials and furnishings; "bake-off" procedures prior to occupancy; and ventilation protocols during the initial occupancy period.

Screening of major components of the building fabric and furnishings was done by determining their quantity and distribution in the building, their chemical composition, and the stability and toxicity of their major chemical constituents. Materials Safety Data Sheets (MSDSs) listing all hazardous substances were obtained for each product of interest based on lists of all components of each product prepared by potential vendors. Chemical contents were reviewed by referring to published data on vapor pressure, toxicity, and irritation (6,7,10).

The results of the screening process led to the determination that the products most likely to emit significant quantities of irritating or toxic substances were the carpet, the work station components (office furnishings), and the fiberglass ceiling tiles. These materials were evaluated during the emissions testing phase described below.

Experimental work

Test methods included bulk testing, environmental chamber and headspace air sampling. Air sampling was also done in the first completed portion of the building. Temperature comparisons were done in some chamber and headspace tests. Temperatures of approximately 23 C. and 37 C. were used. Chamber tests were conducted in a 1.7 m^3 sheet metal box with controlled air flow and temperature, and with excellent mixing within the chamber. The chamber size allowed testing of full-sized (uncut) samples of furnishings and large sheet material samples with maximal surface-to-edge ratios, thus reducing or eliminating problems associated with edges of cut samples. Material samples were generally conditioned in the chamber for $\geq$16 hours prior to testing.

The purpose of the testing dictated that material handling resemble that employed in actual installations in buildings. Products were stored in factory containers until testing. Once opened, the were kept in a normally-ventilated room containing typical, but slightly aged office furnishings.

Sample collection for bulk samples was by appropriate solvents. Air samples were collected using personal monitoring pumps or grab samplers following standard methods for the substances of interest. Headspace samples were collected from stainless steel laboratory containers. The cannister was placed in a water bath to control temperature for tests where elevated temperature protocols were indicated. Air was supplied to headspace cannisters by personal monitoring pumps through appropriate media at rates equal to the sample collection rate. Analysis was performed by a certified laboratory using appropriate ASTM, EPA or NIOSH methods.

Discussion

Results for materials testing are given in Figure 1. Results from various test methods were generally consistent with each other and comparable to tests conducted elsewhere for similar products (8). The age of materials being tested was generally known. Testing results show a relation between some materials' ages and their chemical content suggesting an effect of material age on emission rates. Limited chamber and headspace tests suggest support for this hypothesis.

There was an approximately tenfold decrease in carpet and ceiling tile formaldehyde content during the first three to six weeks of exposure to room air. Fiberglass ceiling tile showed a decline in formaldehyde content through the twentieth week of exposure to room air. It is clear from our bulk testing that both the carpet and ceiling tile samples tested released substantial quantities of formaldehyde after initial exposure to room air. Also significant was the apparent reduction in the formaldehyde emission rate from work surface components (plastic-laminated, medium-density particle board) when 1 cm pre-drilled holes in the bottom were plugged during chamber testing. The freshly unwrapped work station vertical panel (fabric covered, free-standing partition) produced a total hydrocarbon (THC) air level of 45.4 ppm in the chamber. The THC found was consisted primarily of an unidentified low molecular weight compound.

The nature of the work did not permit replicate testing necessary for statistical validation of results. Nevertheless, results were reasonably consistent among sampling methods and in comparison to results reported by other investigators. Further work is necessary to increase the reliability of the fi·dings.

An important outcome of the work was discussions with manufacturers and suppliers of some products which resulted in several product modifications to reduce unstable chemical content or emissions. Test results were helpful in forecasting indoor pollutant concentrations in the completed building. Ventilation protocols were recommended to contol certain air pollutants. The recommendations included operating the building at minimum acceptable temperatures and maximum acceptable ventilation rates during the initial occupancy period. It was also suggested that panels of occupants subjectively evaluate indoor air quality to assist building engineers determine acceptable reductions in the hours of operation, the amount of outside air to be introduced, and the acceptable temperature range.

Conclusions

1. It is clear that significant contributions to improved indoor air quality can be made by material evaluation during building design and material selection. Screening materials based on available data on content can reduce the number of materials requiring actual emissions testing. Test results can be used to improve plans for mechanical system operations.

2. Further work is needed to identify organic compounds and validate temperature effect testing. Effects of different chamber surface materials on concentrations of diverse compounds (especially those of low volatility) need to be determined. And tests using multiple products containing compounds known or expected to interact or impact air concentrations need to be conducted to determine source-sink dynamics.

3. Inclusion of consumer and office products and appliances should be considered in future testing projects. The results from such testing will

broaden the scope of the contributions emissions testing can make in the prediction or modelling of indoor air quality during building design.

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Test Method	# of Samples	Description of Material(s)	Sample Age (mo)	Results (ppm) Formaldehdye Range	Formaldehdye Ave.	Total Hydrocarbons Range	Total Hydrocarbons Average
		-----Carpet Test Results-----					
Bulk	15	5 mfrs.	1.3-4.5	<0.4-2.3	0.83		
	1	Mfr. X	0.7		17.99		
	1	"	1.5		1.95		
	1	"	2.3		0.71		
	3	3 mfrs.	2.3-5.5			19.5-23.6%	22.15%
	1	Mfr. X	2.0				9.93%
HdSp	1	"	2.0		<0.003		
	3	3 mfrs.	2.3-5.5			0.45-0.73	0.58 (1)
	1	Mfr X	0.8			0.68-0.90	0.80 (2)
	1	Mfr. X	2.1				0.62
Chbr	3	Mfr. X	1.3		>0.067		>0.03
		------Fiber Glass Ceiling Board Test Results------					
Bulk	1		~16-18		5.7		
	1		~1.5		48.23		
	1		~3.0		8.04		
	1	Cut sample	Unknown				2.1
HdSp	1	Composite bd	~3.0		<0.003		
		Fiberglass only			0.10		
		Acoust mtl only			0.11		
	2	@ T = 24.5 C.	21-23				<0.03
	2	@ T = 38 C	21-23				0.06
	1	Composite	~3.0				0.75
		Fiberglass only					0.07
		Acoust mtl only					0.60
Chbr	1		~2.0		0.03		
	1		~2.0		>0.03		
	1		~2.0				0.7
		-----Vertical Panel Test Results-----					
Bulk	1	3 full panels	2.0	0.03-0.06	0.043		
HdSp	1	Cut sample	Unknown				0.41
	2	" "	"			0.25-0.82	0.43
Chbr	1	3 full panels	~2.0				45.4
		-----Work Surface Test Results-----					
Bulk	1	Cut sample	Unknown		346.7		
Chbr	1	Full sample	Unknown		0.030 (1)		
	1	Full sample	2.0		>0.034		
	1	Full sample	3.0				
		w/ screws			0.030		
		w/o screws			0.080		
		Full sample	3.3				
		w/ screws			0.007		
		w/o screws			0.037		
		Full sample	3.4		0.075		1.048

Notes: (1) GC/MS identified as >95% Dioctyl Phthalate.
(2) C_8-C_{10} Aliphatic HC.

Figure 1. Formaldehyde and Total Hydrocarbon Emissions Testing Results