

VOC Source strengths in pre- and post-occupancy periods of a new California state office building

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Introduction: Volatile organic compound (VOC) source strength data are valuable for identifying and addressing important sources of potential VOC exposure in buildings. Concentration measurement data alone are insufficient for reliable assessment of occupant exposures outside of the sample collection period itself. Few published data exist with calculation of VOC source strengths in new buildings during construction and after completion. Such calculations require indoor and outdoor VOC concentrations and air change rates to be measured contemporaneously. VOC source strengths based on VOC and ventilation rate measurements made as part of the “IAQ commissioning” process in a new “green” State of California office building are reported.

Methods: VOCs were collected on multisorbent tubes and analyzed by thermal desorption-GC/MS. More than 50 individual VOCs were quantified. TVOC was determined by GC/MS total ion current response. Formaldehyde and acetaldehyde were collected using DNPH impregnated cartridges and analyzed by HPLC with a UV detector.

Ventilation rates were determined by the tracer gas decay method using SF₆ as the tracer gas with analysis by portable gas chromatograph using electron capture detector for quantification.

Source strengths were calculated by dividing the concentration indoors minus the concentration outdoors by the product of the air change rate and the ceiling height. These are sometimes referred to as emission factors or area specific emission rates. Although samples were collected on five of the sixth floors during the project, only the 6th floor concentrations were measured immediately before and after furniture installation and only 6th floor source strengths are reported here..

Figure 1. 6th floor TVOC source strengths (µg/m² h)

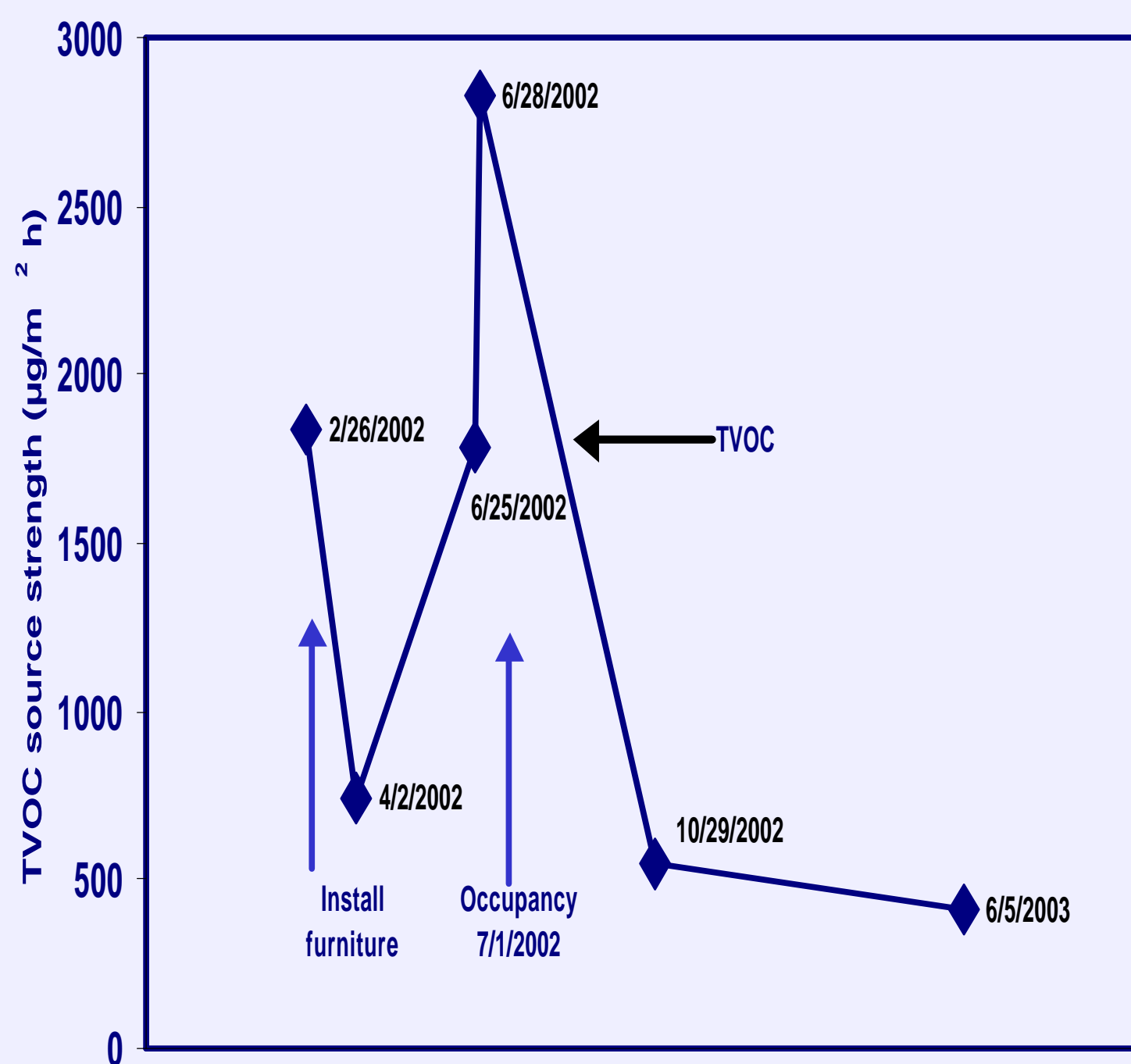


Figure 2. 6th floor VOC source strengths (µg/m² h)

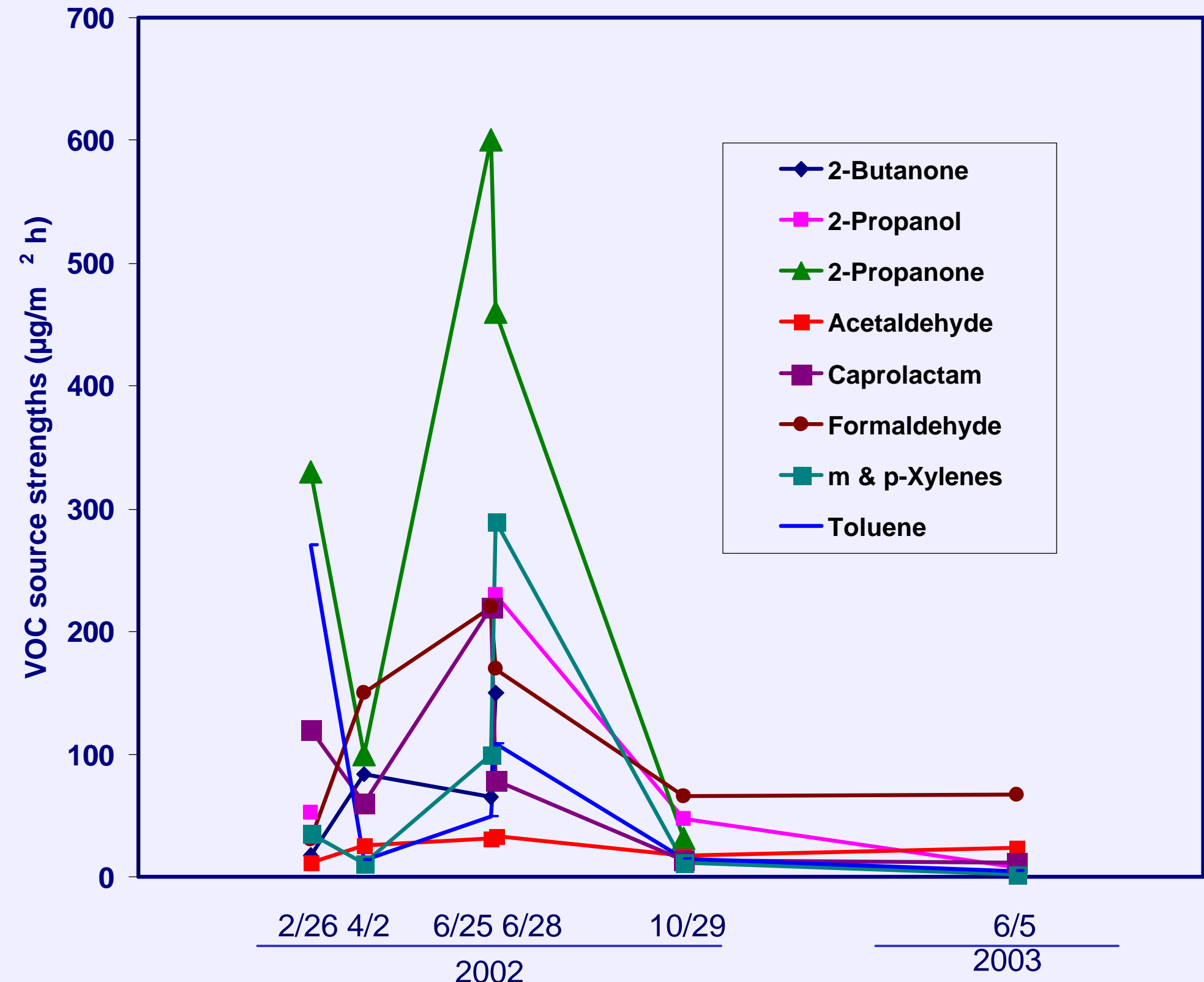


Table 1. 6th floor VOC source strengths (µg/m² h) of 18 relatively abundant compounds.*

	2/26/'02	4/2/'02	6/25/'02	6/28/'02	10/29/'02	6/5/'03
air change rate (h-1)	4.3	3.6	4.9	1.3	0.9	0.8
Acetaldehyde	12	25	31	33	18	23
1-Butanol	40	23	20	41	12	11
2-Butanone	18	84	65	150		1
Caprolactam	120	60	220	79	13	12
n-Decane	77	11	10	53	5	2
2-Ethyl-1-hexanol	36	21	22	26	5	6
Ethyl acetate	33				4	4
Ethylene glycol				210		
Formaldehyde	31	150	220	170	66	67
Hexanal		90	59	160	41	25
d-Limonene				12	17	35
n-Nonane	27	3	10	33	1	
Nonanal	74	56	100	39		10
Phenol	49	39	69	47	6	11
2-Propanol	52			230	47	8
2-Propanone	330	100	600	460	32	
Texanol 1 & 3	42		22	41		12
Toluene	270	13	49	110	14	5
n-Undecane	36	9	16	34	5	3
m & p-Xylenes	36	11	100	290	12	2
TVOC	1840	740	1780	2830	550	420

* Note: Where outdoor concentrations or the detection limits for them were larger than the indoor concentrations, no emission factor is reported.

Discussion: Table 1 shows source strengths of 20 relatively abundant VOCs and TVOC from the first day of testing (before office furniture was installed) through the next 15 months. Apart from the normal decay in source strengths from new materials, source strengths generally were higher as expected at higher ventilation rates. Introduction of new sources of 2-propanone, 2-propanol, and xylenes immediately preceding initial occupancy (July 1, '02) is apparent and help explain elevated TVOC source strengths in late June '02. Sources not tested but used to prepare the building for initial occupancy resulted in significant temporary elevation of VOC concentrations in the final days before occupancy when touch-up work, cleaning, and polishing activities occurred. Concentrations of VOCs associated with materials and furnishings decayed significantly in the following 4 months. Low source strengths were achieved by June '03. Caprolactam is emitted largely from one source (carpet fiber). Furnishings likely were the main source of formaldehyde. Acetaldehyde had relatively constant emissions. Source strengths based on major building materials and office work station emissions test results were comparable to actual building measurements.

Conclusion: Source strengths of most VOCs had diminished considerably 11 months after initial occupancy. Further work is needed to characterize source strengths attributable to building occupants and their activities including especially cleaning and maintenance products.

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