THE INFLUENCE OF SPECIFIC VENTILATION RATE ON THE EMISSIONS FROM CONSTRUCTION PRODUCTS

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ABSTRACT

Very little experimental data exist validating the influence of temperature, ventilation rate, air velocity, humidity and adsorbed pollutants from other sources on emission rates from construction products. Experiments were performed using small scale climate chambers including the new CLIMPAQ quantifying emissions from test specimens of linoleum, acrylic paint, nylon carpet, and sealant. A trained sensory panel voted on the decipol scale and chemical analysis identified and quantified the major pollutants after the specimens had been conditioned in the chambers for six days. When specific ventilation rate (l/s m^2) is low, the rate has a significant influence on emission rates. In both sensory and chemical terms emission rates increase when ventilation is increased. For low ventilation rates the emission rates may be proportional to the specific ventilation rate and for higher ventilation rates the emission rates stabilize independent of ventilation.

INTRODUCTION

The emissions from building materials depend on many use and indoor climate related parameters: Temperature, time after manufacture (1), air velocity, moisture content in air and material, surface treatments and pollution from other activities (tobacco smoking) adsorbed on materials (2,3). For some wood finishing products a few hours after application Tichenor and Guo (4) have demonstrated an important influence of concentration of pollution in the air expressed as specific ventilation rate. Indoor air often contains a complex mixture of pollutants influenced differently by these parameters. A better understanding of the basic processes controlling emission rates may give a better basis for controlling air pollution sources in buildings.

When and how is ventilation most efficient? How are construction products conditioned best before buildings are taken into use? Which sources are important when buildings are new and which are after some years? We need more information on the influence of the interactions between environmental and use related parameters and emission rates.

In a typical building the air exchange rate is between 0.5 h^{-1} and 5 h^{-1} comparable to 0.35 - 3.5 l/s m^2 floor. Emission testing of construction products should relate to these rates to have relevance for buildings. Tests are often performed at extreme ventilation rates in order to meet detection limits of quantifying equipment or geometrical limitations.

It has been the purpose to investigate the influence of air concentration of pollution expressed as ventilation rate per surface area on emission rates from typical construction products.

MATERIALS AND METHODS

The following products also used in (5) were tested: Carpet (Polyamide fibers on a latex foam backing. Tested and preconditioned while stabled back to back), Linoleum (Oxidized mixture of linseed oil, wood flours and pine resins on a jute backing. Tested and preconditioned while stabled back to back), Paint (Water borne acrylic paint on both sides of 0.7 mm aluminum plates. Applied with roll twice using 0.1 l/m² per time) and Sealant (Silicone based sealant for indoor use. Tested in aluminum profiles, inner width and depth of profiles 10 mm and 12 mm). All products were new. A few days after they were received from the manufactories they were cut into size or applied to test frames. The carpet and linoleum were wrapped in aluminum foil. The sealant and paint were left in a well ventilated room for one week to harden and thereafter wrapped. After two to four weeks in wrapping they were hung up in a well ventilated room for 7 days and thereafter placed in the chambers one product at a time.

Table 1. Test facilities used in the experiment.

	Volume l	Air supply rate l/s	Mean air velocity m/s	Specimen area m²
CLIMPAQ 1 CLIMPAQ 2 CLIMPAQ 3 and CLIMPAQ 4 CLIMPAQ 5	50.9	0.0069 0.5 0.86 1.6	0.15	Floor: 0.61 Wall: 1.82 Seal: 0.018
FLEC 1 FLEC 2 FLEC 3	0.035	0.00167 0.00333 0.00667	0.0035 0.007 0.014	Floor: 0.018 Wall: 0.018 Seal: 0.00072
3-l-C 1	3.0	0.86	0.43 (Uncertain value)	Floor: Linoleum: 0.18 Carpet: 0.12 Wall: 0.28 Seal: 0.018
3-l C 2	3.0	0.86	0.43 (Uncertain value)	Floor: Linoleum: 0.061 Carpet: 0.031

Five test chambers of the new type CLIMPAQ (5) were used together with three field and laboratory emission cells, FLECs (6) and two jar like 3 l glass chambers, 3-l-C (7). Main parameters during tests are summarized in table 1. All chambers were kept at a temperature of 22 +/-1 °C. Supply air also had the same temperature. The FLEC and the one CLIMPAQ with low air supply got the air via an activated carbon filter. The other chambers were taking their air supply from the surrounding chamber. A high ventilation rate in the surrounding chamber with temperated and particle filtered outdoor air assured a sufficiently clean air supply.

The chambers were cleaned with acetone and flushed with distilled water between tests. Thereafter temperatures in the empty chambers were raised to 40 °C for 12 h. The twin chamber was only cleaned by raising temperatures, and the FLEC was cleaned according to its protocol. Each material was placed in the different chambers simultaneously. After six days chemical samples were taken and the sensory panel assessed the air quality. The tests were performed at ventilation rates comparable to typical buildings and at some extreme values. The building realistic ventilation rates caused many of the chemical measurements to be below detection limits of typically 2 µg/m³, but the sensory evaluations had a sufficient signal at most test conditions. Sensory assessments were not made on air flows below 0.5 l/s in order to expose panelists to concentrations independent of sniffing behavior.

A panel of 15 trained persons assessed the perceived air quality in decipol (8). Each panel member assessed each test condition twice. Minor corrections were made according to known concentrations of acetone also assessed in the randomized blind test. The three compounds emitted at highest rates were quantified by a flame ionization detector after thermal desorption and chromatographical separation of samples taken on Tenax TA.

RESULTS

Concentration measurements were transformed to emission rates based on specimen area and air change measurements with tracer gas at each test. Background concentrations were subtracted. The emission rates in each chamber are presented in sensory terms in figure 1 and in chemical terms in figure 2. Only the compound measured in highest concentration in CLIMPAQ 3 has been selected for presentation. Some measurements of other compounds in the FLEC did not fit the model in figure 4.

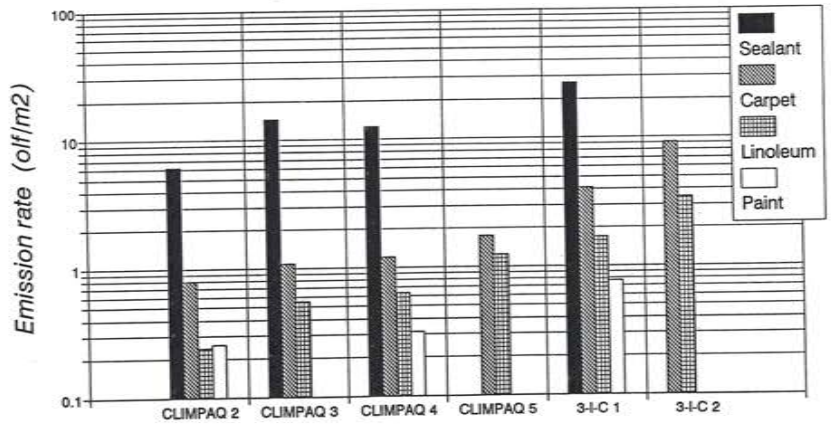

Figure 1. The calculated emission rates per specimen area (olf/m²) in the chambers based on the initially perceived air quality assessed by the sensory panel after six days in the chambers.

In a room of 28.5 m³ with a height of 2.5 m and a square floor, the area ratio between floor, wall and sealant may be 1 : 3.0 : 0.030 respectively. Based on these relations the emission rates per floor area in a typical room may be calculated. Figures 3 and 4 were made by also converting air supply to ventilation rate per floor area in a typical room by these relations. Emission rates are seen to depend significantly on the ventilation rate at lower ventilation rates.

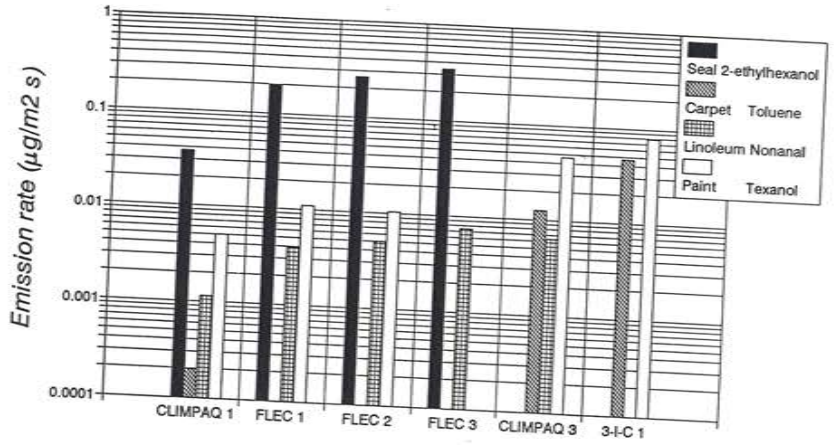

Figure 2. The calculated emission rates of selected compounds per specimen area (µg/m² s) in the chambers based on chemical measurements after six days in the chambers.

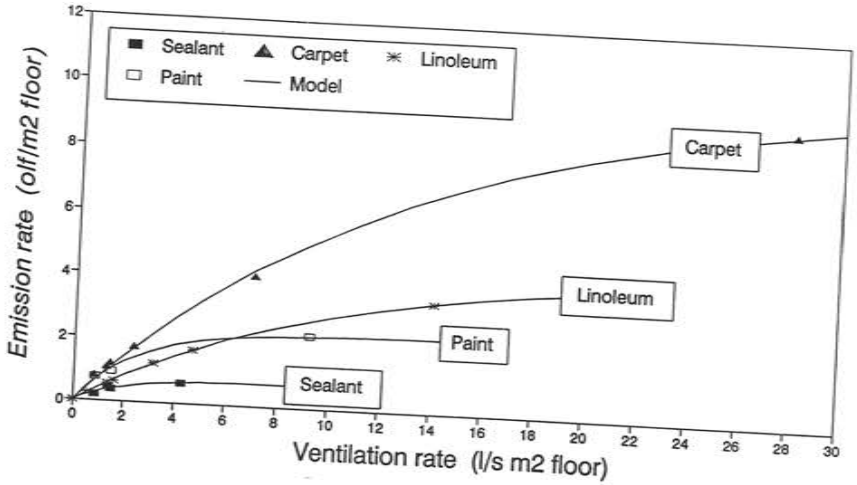

Figure 3. The emission rates per floor area in a typical room based on perceived air quality in relation to ventilation per floor area rate after six days in the chambers.

An empirical model has been fitted to the observed data of the form:

$$E = K_1 (1 - e^{-k_2 V})$$

E: Specific emission rate (µg/s m² floor), V: Specific ventilation rate (l/s m² floor), K_1 and K_2: Constants. A prerequisite for this model is that the remaining emitable mass does not vary significantly between test conditions.

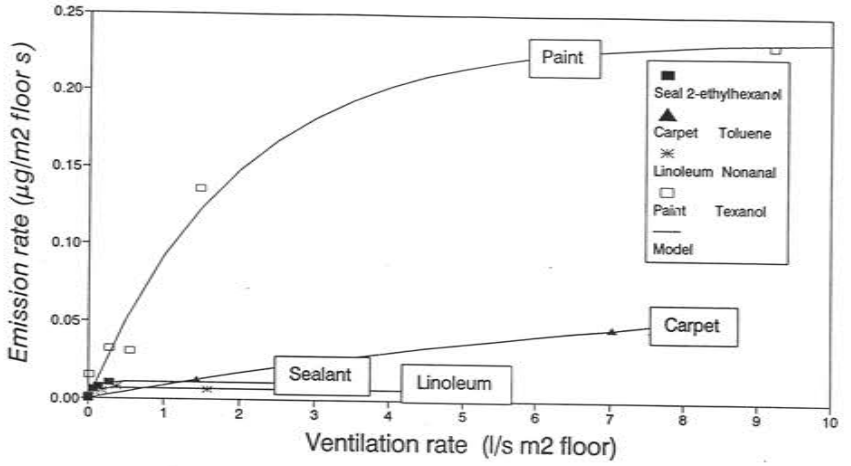

Figure 4. The emission rates per floor area in a typical room based on chemical measurements in relation to ventilation rate per floor area after six days in the chambers.

DISCUSSION

Results are in good agreement with previous findings (4) on thin layers of wood finishing products a few hours after their application. From no ventilation up to some stabilizing level the emission rates depend on ventilation rate. As ventilation is increased from low rates where evaporation controls emission diffusion in the materials becomes more and more important and emission rates become les influenced by ventilation at the high rates. Apparently both emission and evaporation control are seen depending on ventilation rate for all the tested materials. The emission rates may be considered proportional to ventilation rates at the low ventilation rates. At these low rates the concentration of air pollution is changed very little when ventilation rates are changed for short periods.

The different ventilation rates may have caused differences in remaining emitable mass between chambers. Considering the previous conditioning period outside the chambers these differences are expected to be small. Also the effect of reduced emitable mass in an emission favoring environment would be the opposite of the found influence of ventilation rate. Building installations are often operated on a diurnal basis with mechanical ventilation halted during unoccupied periods at nights. At these shorter temporal changes of ventilation rates, the effect of increased ventilation may be small. The main effect of

reased ventilation may for many sources be a faster reduction of emission rates during first months after installation caused by a faster decay of emitable mass.

iny air pollution sources indoor are ventilated at very high specific ventilation rates npared to the primary surface materials as paint, sealant, linoleum and carpet. Pro-cts introduced at minor renovation works, furniture and office machinery are examples air pollution sources which may be highly ventilated per surface area. Consequently y may be considered to be diffusion controlled pollution sources and emitting at rates lependent of ventilation.

NCLUSION

both sensory and chemical terms the emission rates from large area sources often rease when ventilation is increased for some days. For low ventilation rates the influ-e of ventilaton rate on emission rates may important. For higher ventilation rates the ission rates becomes independent of ventilation.

r low ventilation rates and short term changes of ventilation rates the resulting con-ıtration of air pollution from some primary surface materials are independent of air ınge rates.

he influence of ventilation rate on emission rate is unknown it is recommended to test ıstruction products at ventilation rates comparable to the relevant rates in buildings.

KNOWLEDGEMENTS

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