Advanced Technology for Indoor Air Quality

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Reduction of Formaldehyde, Ammonia, SO_2 and CO_2 Concentrations in Room Air

ABSTRACT

Analyses by the writer indicated that complex electrical fields could modify perceived odor and particulate distribution. In subsequent experimentation, this was found to be the case. A complementary experiment was undertaken to gather information on the influence of in-duct complex electrical fields on the concentration of several gases: formaldehyde, ammonia, sulphur dioxide, and carbon dioxide. İt was found that the complex electrical field reduced each, as compared to controls. The reductions, depending on the gas, ranged up to 49 percent. The strong effect on formaldehye is of potential practical significance due its possible human carcinogenicity.

INTRODUCTION

The complex electrical fields that exıst in all spaces interact with airborne charges, particulates, water droplets, and adsorbed gases. These interactions, in large part, determine the deposition of contaminants in and on people, objects, and walls in a room.

The complex electrical fields that can be created in ducts also affect and influence the deposition of contaminants. For example, in one experiment, passing animal room air through a complex electrical field in the supply duct reduced the perceived room odor intensty by half. In another experiment, using particle mass and laser light scattlering measures, it was found that passing air through an in-duct complex electrical field substantially decreased the respirable aerosol concentration in the supplied room. An additional experiment, using an in-duct electrical field, showed a substantial field effect in that the field reduced the mass of small particulates in the air and slightly increased the mass of large particulates. The fields reduced small particle mass in the room air to 61 percent of what it was with the field off. At the same time, the field increased the mass of the large particles in the air to 367 percent of what it was in the condition. The loss of small particle mass was not balanced by the gain in large particle mass, for the gain of 367 percent in large particle mass in the field-on condition accounted for only 6 percent of the mass lost in small particles. The other 94 percent of the decrement in small particle mass may have gone into the filter. It was established in the above experiments that the effects were not due to ionization or ozone. They appear to be due to an acceleration of natural processes involving cougulation.

In view of these findings on particulates and odorants, a complementary experiment was undertaken to gather information on the influence of complex electrical fields on several gases, since many gases adsorb on particulates.

METHOD

The gases used were formaldehyde, ammonia, sulphur dioxide, and carbon dioxide. There were two series of experiments using these gases. In the first series, the initial gas concentrations were set at levels at which the effects on people are just noticeable. In the second series, the intial gas concentrations were set levels that would be hazardous to people with short exposure.

The testing was carried out in a room 2.75x5.80x2.45 m (9x19x8 ft) with a floor of vinyl tile and panelled walls and ceiling. The panelling was coated with polyurethane varnish and the joints were sealed with duct tape. The room had its own circuit air handing system. Air entered the room through supply diffusers at one side, as shown in Figure 1, passed across the room, and exited into a duct through return grills at an air change rate of 21 per hour. In the duct, the air passed sequentially through a 55-percent filter, two electrial field screens, the blower and then re-entered the room through the supply diffusers. The air in the room was outside between test runs and replaced by building air.

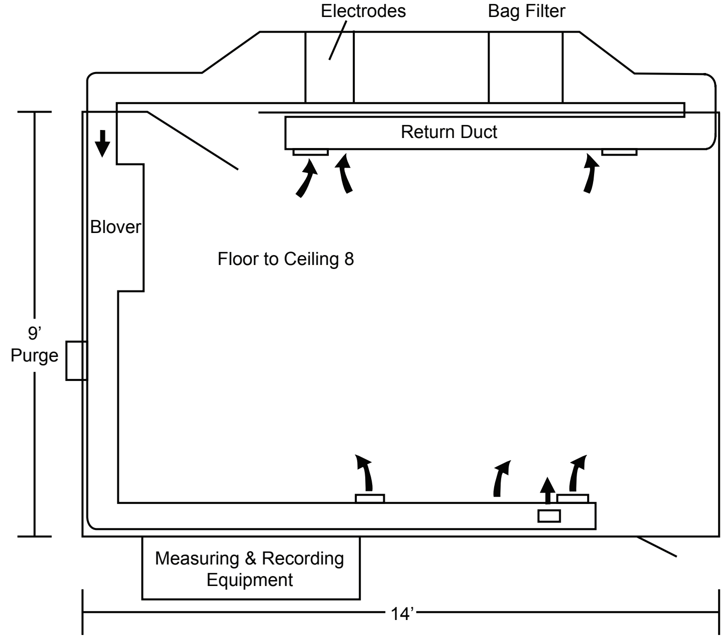

Figure 1. Test Facility Showing Air Handling System

Keywords: electrical field, contamination, formaldehyde, ammonia, sulphur dioxide, carbon dioxide

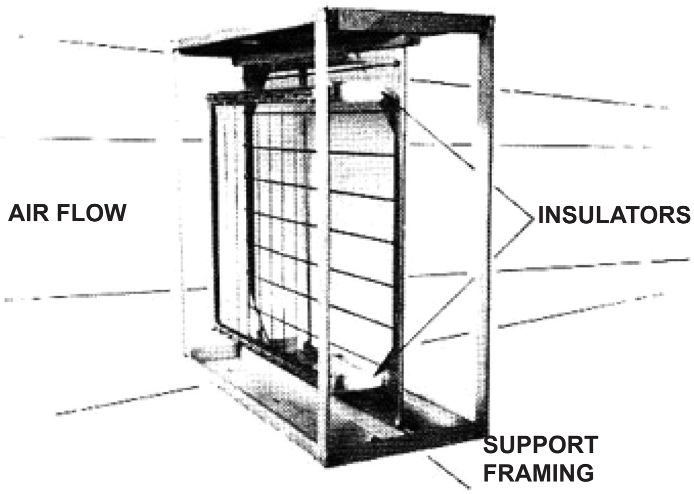

Figure 2. Configuration of electrical field screens

Table 1

Gas	End of 30 minutes		End of 60 minutes	
	Mean Percent Reduction	Significance	Mean Percent Reduction	Significance
CH_2O	26	.001	39	.01
NH_3	27	.01	29	.001
SO_2		ns	22	.05
CO_2		ns	11	.01

The initial gas concentrations in Table 1 were set at the level of first noticeable effects in people. The in-duct complex electrical fields reduced, as compared to controls, the concentrations as shown. The significance levels were determined with use of the analysis of variance.
The mean concentration at the 5, 30, and 60-minute point were formaldehyde (CH_2O): 2.8, 2.5, 1.5 ppm; ammonia (NH_3): 24.7, 14.4, 7.5 ppm; sulphur dioxide (SO_2): 25.3, 18.7, 14.3 ppm; carbon dioxide (CO_2): 2.4, 1.9, 1.5 percent

Table 2

Gas	End of 30 minutes		End of 60 minutes	
	Mean Percent Reduction	Significance	Mean Percent Reduction	Significance
CH_2O	39	.001	49	.01
NH_3	13	ns	25	.001
SO_2	10	.01	14	.001
CO_2		.01	13	.001

The initial gas concentrations in Table 2 were set at the level hazardous to people when exposed for a short period. The in-duct complex electrical fields reduced, as compared to controls, the concentrations as shown. The significance levels were determined with use of the analysis of variance.
The mean concentration at the 5, 30, and 60-minute point were formaldehyde (CH_2O): 4.3, 2.0, 1.3 ppm; ammonia (NH_3): 39.6, 24.6, 14.1 ppm; sulphur dioxide (SO_2): 49.8, 40.5, 32.9 ppm; carbon dioxide (CO_2): 4.8, 4.0, 3.4 percent

The upstream electrical field screen installed in the duct was 60x60 cm (24 x 24 in) and the downstream one was 50 x 50 cm (20 x 20 in). They were spaced 7.6 cm (3 in) apart, as shown in Fiqure 2. The screens consisted of .33 cm wide tinned copper braid. Electric field generators supplied a 25-KV DC signal that was applied to the upstream screen and a 700-V peak-to-peak 177 –KHz signal that was applied to the downstream screen. The current was less than 3 milliamp. No ozone is produced by this system.

A Gastec gas detector tube system was used as the measuring instrument. The detector tubes contain colorimetric reagents adsorbed on fine grain silica gel, activated alumina or other adsorbing media. The reagents are sensitive to particular gases or vapors and react quantitatively to provide a length –of stain indication. Each detector tube contains a precise amount af detecting reagent in a constant inner diameter glass tube that is hermetically sealed at both ends. When a measurement was to be taken, the tip was broken off a tube, which was placed in the center of the room and connected to the sampling pump via a hose. The chemical reagent in the detector tube reacted with the sample gas and a color stain devoloped starting at the inlet of the detector tube. The gas concentration was measured as the location of the interface of the stained –to-unstained reagent when staining stopped. The calibration curve on most Gastec detector tubes is a straight line, and points on the scale are equal intervals. The calibration scales are printed on the basis of individual production lots.

Therefore, possible confounding factors such as the variation of inner tube diameters, precision of tube packing, and the quality and reactivity of each reagent are eliminated. Two evaluators independently read each tube in the first series. One evaluator had no knowledge of the test conditions, so the experiment was double-blind for him. Because of the reliability of the evaluators, as noted in the results, there was only one evaluation in the second series.

The procedure was that the air handing system was turned on and the air in the test room purged to the outside for 30 minutes. This reduced the concentration of the gas of interest down to normal ambient as verified by a detector tube measurement at the end of each purge. A gas, such as sulphur dioxide, was then injected into the test room. Sufficient gas was injected to bring the concentration up to approximately the predetermined standard concentration used in the test. At this point, the gas was turned off and the 60-minute run was started. The gas concentration was measured with detector tubes 5 minutes after injection stopped, 30 minutes into the run, and at the end of the 60-minute run. At the end of each run, the room was purged to baseline concentration and the next run in the test then begun. There were twelve runs for each gas in each of the two series, six with the fields on and six with them off. The runs were done in an ordered, counterbalanced sequnence.

The sulphur dioxide and carbon dioxide were injected into the center of the room via a hose connected to a cylinder of gas located outside the room. The ammonia and formaldehye were injected into the room with a Paasche model H airbrush spraying a 10-percent formaldehyde solution or an ammonium hydroxide solution.

RESULTS

The first question addressed was the reliability of the readings of the detector tubes. Pearson product-moment correlations were computed between the data provided by evaluators 1 and 2. There was near perfect correlation in each set of their readings ($r > .95$). This indicates that they were reliably reading the defector tubes and were doing so without bias.

There was natural decay in gas concentrations over time without the electrical field on. Thus, for clarity of presentation, the data is presented as the percent reduction in the field-on condition compared to the control (field-off) condition. For testing the significance of the differences between conditions, an analysis of variance was done on the data. The results of the statistical analyses for each of the gases for the first series are shown in Table 1. The results of the second series are shown in Table 2.

CONCLUSIONS

This data on gases extend the finding that passing room air through in-duct complex electrical fields has a significant effect on contaminants. The extent and rate of the effect varies as a function of which gas is used. The amount of adsorption on particulates or molecular composition are the factors most likely to be involved in this. But it is premature to hypothesize on the relationship between molecular composition and effect.

Taken with previous findings on odorants and particulates, it is clear that study of the effects of complex in-duct electrical fields on contaminants may well advance our knowledge of contamination control. The strong effect on formaldehyde has particular implications. Formaldehyde is a ubiquitous environmental pollutant for it is found in many non-occupational as well as occupational settings. It is even found in tobacco smoke and the exhaust from gasoline and diesel combustion. İt has been shown to cause single-strand breaks in DNA and DNA –protein crosslinks; it is mutagenic in Drosophila larvae, bacteria, and fungl:it damages DNA and inhibts DNA repair in human cells: it is a respiratory carcinogen in small mammals; and ıt has been judged to be a carcinogenic risk to humans. As Bernstein et al. note “In...1980, the Centers for Disease Control, National institute for Occupational Safety and Health…and the Occupational Safety and Health Administration...issued a joint bulletin alerting employers, employees and health officials to the laboratory evidence for formaldehyde’s...potential human carcinogenicity. The bulletin recommended that it would be prudent to reduce occupational HCHO exposures to the lowest feasible level by the use of engineering controls and stringent work practices...” Thus, a means of reducing the concentration of formaldehyde in room air is of interest.

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