Remediation of Smoke Particles in Fairbanks Homes June-August 2004

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INTRODUCTION - The Alaska forest fires in the summer 2004 produced airborne particulates in the vicinity of Fairbanks that were categorized as hazardous by the EPA. These fine particles are known to exacerbate asthma and allergies. A previous study by William Reynolds of *Solutions to Healthy Breathing* and Dr. Catherine Cahill of the Geophysical Institute of the University of Alaska Fairbanks showed that different ventilation and filtration strategies resulted in significantly different levels of particulate infiltration. In this study we evaluated the ability of HEPA air filtration units made by Fantech to reduce the level of fine particulates in the indoor air.

The particle size range measured in this study is referred to as PM 2.5, which means particles that are 2.5 microns in diameter or less. Although there is no established indoor air quality standard, the EPA has set an allowable outdoor standard for PM 2.5 of 65 micrograms per meter cubed (65 $\mu g/m^3$) for a 24-hour average. Outdoor PM 2.5 levels in Fairbanks exceeded 1000$\mu g/m^3$ during the summer of 2004. The objective of this study was the reduction of interior PM 2.5 and a comparison of this reduction in pressurized versus non-pressurized homes.

METHODS - *Solutions to Healthy Breathing* purchased 20 Fantech 300 HEPA Filter Systems and made them available to the public at cost with the provision that CCHRC could monitor the indoor particulates. Homes were selected on first come, first served basis, without consideration of size, age, tightness of construction, location, or ventilation presently installed. All respondents reported some form of respiratory distress.

The Fantech Filter System used in this study has a pre-filter to remove larger particles, a carbon filter to reduce VOCs (volatile organic compounds) and a true HEPA filter (99.97% removal of all particles down to 0.3 microns). The unit is designed to work with an existing forced air system, an HRV system or to be stand-alone ventilation. It came with a single speed fan that delivers air at a maximum rate of 240 cfm. *Solutions* added an electronic fan speed control for more flexibility in air movement. Fantech supported the research effort with technical information and free filter element replacements.

The Fantech Filter systems were placed in 19 homes during the time period of July 10 through July 20. The test homes were divided into two groups with systems installed in a pressurized and non-pressurized configuration. In the first group of 9 homes filtration was a supply-only system to pressurize the house to prevent ingress of particulates via natural infiltration. The pressurized configuration of this group was achieved by blocking an open door or window with a sheet of rigid insulation. A hole was cut in the insulation and a collar was installed and connected to the intake of the Fantech Filter System with a flexible duct. In the second group of 10 homes, filtration of interior air was achieved through recirculation of indoor air only. In both groups, doors and windows were closed during sampling periods. Due to constraints of time and resources, blower door testing was not conducted in any of the homes.

Sampling was conducted from mid July through the end of August during times of elevated outdoor particulates. Due to occupant traffic, construction of the dwelling and varied existing ventilation penetrations, the initial outside to inside particulate ratio varied greatly house to house. Any active or passive ventilation installed was turned off during testing. All systems had been in operation in excess of 24 hours prior to sampling. At each home the indoor and outdoor air was sampled at least once. Sampling time varied between a minimum of one hour and a maximum of eight hours. Two homes, one re-circulation only and one pressurized, were resampled at 1-hour intervals for 7 hours with PM 2.5 particulate levels commencing at natural infiltration levels for each dwelling.

RESULTS - The improvement of indoor air quality that resulted from filtering the air was remarkable. In the first group of 9 homes with a supply of filtered outdoor air to pressurize the house the net reduction of PM 2.5 inside the home was 87-92% compared to outside (Table 1). In the pressurized homes, the hourly rates of air exchange varied between 2 and 4 air changes per hour (ACH) depending on the size and integrity of the dwelling. Interior pressures during fan operation measured 0.7-1.4 Pa above outside atmospheric pressure. In the second group of 10 homes with recirculation of indoor air only the net reduction of PM 2.5 inside the home was 76-87% compared to outside (Table 2). In follow-up interviews, all recipients of the Fantech HEPA Filter Systems reported beneficial health improvements as a result of this study. Improvements were rated from “better to “very substantial”.

Table 1 – Filtration of outdoor pressurized air

Sample #	Outside PM 2.5	PM 2.5 Exiting Filter	Percent of Outside PM 2.5	Diluted Room PM 2.5	Net room Reduction
			Exiting Filter System		Compared to Outside
	µg/m³	µg/m³		µg/m³	
1	285.14	8.78	3%	25.18	91%
2	204.72	14.24	7%	27.21	87%
3	93.88	4.71	5%	11.71	88%
4	368.18	12.43	3%	34.35	91%
5	168.89	12.78	8%	18.57	89%
6	251.14	11.33	5%	18.87	92%
7	134.38	6.87	5%	12.98	90%
8	188.63	8.04	4%	19.23	90%
9	93.87	5.24	6%	10.41	89%

Table 2 – Filtration of interior recirculation of air

Sample #	Outside PM 2.5	PM 2.5 Exiting Filter	Percent of Outside PM 2.5 Exiting Filter System	Diluted Room PM 2.5	Net Room Reduction Compared to Outside
	µg/m³	µg/m³		µg/m³	
10	52.80	7.08	13%	11.71	78%
11	97.38	8.05	8%	17.04	82%
12	122.31	12.07	10%	17.05	86%
13	280.04	12.92	5%	36.14	87%
14	284.04	17.02	6%	42.67	85%
15	340.45	16.13	5%	61.03	82%
16	168.77	5.56	3%	29.39	83%
17	175.55	5.80	3%	27.37	84%
18	10.93	0.01	0%	2.63	76%
19	94.57	9.75	10%	14.23	85%

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DISCUSSION - A low cost HEPA filtration system can substantially reduce particulates in the home. Pressurizing the house will prevent ingress of particulates by natural infiltration and also bring in fresh air. A recirculation system will also reduce particulates but not to PM 2.5 levels as low as those achieved by the pressurization. Additionally, during smoke episodes, air temperatures in Fairbanks are generally quite high – often 80-90^{o} F. The result is that indoor temperatures rise proportionally. Temperatures cool at night, thus an added benefit of the pressurized system is the reduction of indoor temperatures, while with the recirculation-only system, indoor air temperatures will most probably increase to uncomfortable levels.