Notice to the Reader: Health Consultation - Formaldehyde Sampling of FEMA Temporary-Housing Trailers issued February, 2007

Since releasing this health consultation on February 1, 2007, ATSDR has determined there was insufficient discussion of the health implications of formaldehyde exposure and some language may have been unclear, potentially leading readers to draw incorrect or inappropriate conclusions. Additionally, analyses of formaldehyde levels by trailer type and by daily temperature were not conducted. As a result, this health consultation has been replaced by a new version, dated October 4, 2007.

Health Consultation

Formaldehyde Sampling at FEMA Temporary Housing Units

Baton Rouge, Louisiana

February 1, 2007

Agency for Toxic Substances and Disease Registry

Executive Summary:

The ATSDR Emergency Response program was requested by the Federal Emergency Management Agency (FEMA), Office of Chief Counsel to review and provide an evaluation of analytical data related to a project involving formaldehyde sampling at FEMA temporary housing units/trailers located in Baton Rouge, Louisiana.

The objectives of the sampling project included the establishment of general baseline concentrations of formaldehyde and other VOCs in the 96 trailers involved in the study, in addition to the evaluation of the effectiveness of two separate and distinct ventilation practices used on these particular trailers to reduce the concentrations below levels of health concern. In Group A, ventilation was provided by running the air conditioning system with the bathroom static vents open; in Group B, ventilation was provided by opening windows and vents. The study involved a 14 day sampling period and was not intended to evaluate longer term formaldehyde levels or potential exposures for trailer residents.

The purpose of the ATSDR consultation is to provide FEMA a clearer understanding of the issues associated with formaldehyde in temporary housing units. The consultation is not intended to establish FEMA's future policy concerning temporary housing units. The conclusions derived from the sampling of the 96 trailers are for those trailers only, and are not necessarily applicable to all other trailers due to numerous variables for which appropriate data and information are not available.

In the 96 trailers sampled, the method of ventilation used in trailer group B, of opening all windows, static vents, and exhaust fan vents, was more effective at lowering the concentration of formaldehyde during the period of this sampling project than the method of ventilation used in trailer Group A of running the air conditioning system with the bathroom static vents open. The method of ventilation which allowed for the greatest number of air exchanges was the most effective in lowering the concentration of formaldehyde.

The average concentration of formaldehyde per day in Group B trailers, after the fourth day of sampling and for the remainder of the study, was below the level of concern for sensitive individuals of 369 ug/m3 (0.3 ppm). The average concentration of formaldehyde per day in Group A trailers was above the level of concern for sensitive individuals in all but two days of the study. Individuals previously sensitized to formaldehyde may experience symptoms above 369 ug/m3 (0.3 ppm). A combination of ventilation methods, in addition to Method A, may be necessary to reduce formaldehyde concentrations below levels of health concern for sensitive individuals.

The concentrations of the other VOCs detected during the sampling project were below levels expected to produce adverse health effects.

FEMA has not requested ATSDR to evaluate longer-term formaldehyde concentrations in trailers or health concerns related to potential exposures. ATSDR will be available to provide assistance if such data becomes available in the future.

Formaldehyde Sampling at FEMA Temporary Housing Units
Baton Rouge, Louisiana

I. Background and Statement of Issues:

The ATSDR Emergency Response program was requested by the Federal Emergency Management Agency (FEMA), Office of Chief Counsel to review and provide an evaluation of analytical data related to a project involving formaldehyde sampling at FEMA temporary housing units located in Baton Rouge, Louisiana. The examples of temporary housing units used in the study are similar to those utilized by Hurricane Katrina displaced persons. The sampling project was being conducted by the U.S. Environmental Protection Agency (EPA), as requested by FEMA. ATSDR was requested to provide an evaluation of the data once the sampling project was completed by EPA. The initial request for ATSDR assistance with the data evaluation occurred on a conference call held on July 13, 2006. The sampling was completed by EPA on October 10, 2006. On December 6, 2006, the ATSDR Emergency Response program received a DVD from FEMA, OGC containing the analytical data for review.

FEMA had requested EPA to conduct a sampling and analytical program to evaluate formaldehyde and other volatile organic compounds (VOCs) in indoor air, inside FEMA selected and supplied temporary housing units or trailers. Air samples were collected and analyzed from new, unused trailers with and without the heating, ventilation and air conditioning (HVAC) systems operating. The indoor air samples were collected from a total of 96 new, unused trailers that were produced by eight separate manufacturers. A target of twelve trailers per manufacturer was identified by FEMA for analysis. The sampling was conducted September 19 through October 7, 2006, at a trailer staging area located in Baton Rouge, Louisiana [4].

The objectives of the sampling project included the establishment of general baseline concentrations of formaldehyde and other VOCs in the 96 trailers involved in the study, in addition to the evaluation of the general effect of two separate and distinct ventilation practices used on these particular trailers. In Group A, ventilation was provided by running the air conditioning system; in Group B, ventilation was provided by opening windows and vents. The study involved a 14 day sampling period and was not intended to evaluate longer term formaldehyde levels or potential exposures for trailer residents.

The purpose of the ATSDR consultation is to provide FEMA a clearer understanding of the issues associated with formaldehyde in temporary housing units. The consultation is not intended to establish FEMA's future policy concerning temporary housing units. The conclusions derived from the sampling of the 96 trailers are for those trailers only, and are not necessarily applicable to all other trailers due to numerous variables for which appropriate data and information are not available.

II. Discussion:

Formaldehyde Background:

Formaldehyde (HCHO) is one of the 25 most abundantly produced chemicals in the world [1]. It is pervasive throughout our society and is found in numerous construction materials, home furnishings, and products used in the home. At room temperature, formaldehyde is a colorless, flammable gas. It may have a noticeable irritating odor to some people at very low concentrations, with an odor threshold of approximately 0.5 to 1.0 part per million (ppm) in air, which is equivalent to 615 to 1230 micrograms per cubic meter (ug/m3) in air [2,3].

Formaldehyde may be released into the air from many products used in the home. It is present in the adhesives used to make plywood and particle board. Cabinets and furniture used in the home are often made from these materials. Formaldehyde is also found in new permanent press fabrics, new carpets, latex paint, decorative laminates, and fiberglass products. Many products used everyday around the house also contain formaldehyde such as fingernail polish and hardeners, antiseptics, medicines, cosmetics, dish-washing liquids, fabric softeners, shoe-care agents, carpet cleaners, glues and adhesives, lacquers, and plastics. Some paper products such as grocery bags and paper towels also give off small amounts of formaldehyde. Some food products such as certain types of Italian cheeses, dried foods, and fish, contain formaldehyde as a preservative. In addition, formaldehyde is produced by cigarettes and other tobacco products, gas cookers, and open fireplaces [2].

The concentration of formaldehyde detected outdoors, in general, is usually less than that detected in indoor air. Background levels of formaldehyde detected in outdoor air from urban areas are dependent on local conditions and can vary widely. Concentrations generally range from 1 to 20 ug/m3 (0.0008 - 0.016 ppm) . The incomplete combustion of hydrocarbon fuels can contribute to the level of formaldehyde in outdoor air. Urban air concentrations during heavy traffic or severe inversions can range up to 100 ug/m3 (0.08 ppm) (IARC 1995) [3].

Factors which effect the concentration of formaldehyde in indoor air include the type and quantity of source materials, the age of the source materials, ventilation, temperature, and humidity. Some of the major sources of formaldehyde indoors have been the off-gassing of urea-formaldehyde foam insulation (UFFI) and particle board. The release of formaldehyde is expected to decrease from wood-based building materials as they age. (EPA 1996; Zinn et al. 1990) [2]. The concentration of formaldehyde in mobile homes would be expected to be higher than that found in conventional homes due to their lower rate of air exchange (Wolff 1991) [2]. The levels of formaldehyde appear to decrease as the mobile home and its formaldehyde-based resins age, with a half-life of 4 to 5 years (IARC, 1995) [3].

Several monitoring studies were conducted in the US during the 1980s to measure formaldehyde concentrations in indoor environments. Much of the data was collected in either older homes, in homes that had urea formaldehyde foam insulation (UFFI), or in homes in which occupants had filed complaints of formaldehyde irritant symptoms. Mobile homes with a complaint had formaldehyde concentrations ranging from 0.00 to 4.2 ppm (5166 ug/m3), (Gammage and Hawthorne 1985). Randomly selected mobile homes without a complaint had formaldehyde concentrations ranging from less than 0.01 to 2.9 ppm (12.3 – 3567 ug/m3), (EPA 1987). Conventional homes overall had a concentration of formaldehyde ranging from less than 0.02 to 0.4 ppm (24.6 – 492 ug/m3), (Hawthorne et al. 1985, 1986). Since the mid 1980s, plywood and particle board manufacturing methods have changed to reduce formaldehyde emissions. Home construction methods have also changed to reduce the use of UFFI. A study conducted on a newly constructed and unoccupied house, found average indoor concentrations of formaldehyde to be 0.035 to 0.45 ppm (43 – 553 ug/m3), approximately 30 days after formaldehyde releasing materials were installed (Hare et al. 1996) [2].

In a 1993 study, the ranges of formaldehyde concentrations in complaint homes, mobile homes, and homes containing large quantities of particle board or UFFI were 0.02 to 0.8 ppm (24.6 – 984 ug/m3), with levels as high as 4 ppm (4920 ug/m3), sufficient to cause irritating symptoms, observed in some instances. Formaldehyde concentrations in conventional homes less than one year old were within the range of 0.05 to 0.2 ppm (61.5 – 246 ug/m3), with few measurements exceeding 0.3 ppm (369 ug/m3). Older conventional homes had the lowest indoor concentrations of formaldehyde with values typically less than 0.05 ppm (61.5 ug/m3), (Gold et al. 1993) [2].

Formaldehyde Toxicity:

Exposure to formaldehyde can occur through several routes of exposure including inhalation, dermal contact, and ingestion. Most formaldehyde exposures occur by inhalation or by skin/eye contact. Most cases of acute exposure to formaldehyde will likely be detected by the sense of smell. At very low concentrations, formaldehyde may have a noticeable irritating odor with an odor threshold of approximately 0.5 to 1.0 ppm (615 – 1230 ug/m3), [2,3].

Formaldehyde can be irritating to many tissues when it comes into direct contact with them. The most common symptoms of formaldehyde exposure include the irritation of the eyes, nose, and throat; along with increased tearing, which occurs in air concentrations of about 0.4 to 3.0 ppm (492 – 3690 ug/m3), [2]. Other symptoms at low concentrations may include headache, runny nose, and difficulty breathing [1]. At higher concentrations, formaldehyde has a pungent, distinct odor and may cause a burning sensation to the eyes, nose, and lungs [2].

Some people are more sensitive to the effects of formaldehyde than others. In persons who have been previously sensitized, inhalation and skin contact may cause various skin disorders, asthma-like symptoms, anaphylactic reactions, and

rarely hemolysis. In persons who are not sensitized, prolonged inhalation of formaldehyde at low levels is unlikely to result in chronic pulmonary injury [1]. Formaldehyde liquid is considered to be a dermal sensitizer, but not the gaseous phase, nor formalin (aqueous solution usually 37% formaldehyde), (Hilton et al.1996) [2].

Persons who are sensitized to formaldehyde may experience headaches, and minor eye and airway irritation at levels below the odor threshold of 0.5 to 1.0 ppm (615 – 1230 ug/m3). Some sensitive individuals may experience asthma-like symptoms, and dermatitis, even at very low doses [1]. Previously sensitized individuals can develop severe narrowing of the bronchi at very low concentrations such as 0.3 ppm (369 ug/m3). Bronchial narrowing may begin immediately, or can be delayed for 3 to 4 hours. Effects may worsen for up to 20 hours after exposure and can persist for several days [1]. The Threshold Limit Value (TLV), Short–term Exposure Limit (STEL) recommended by the American Conference of Government Industrial Hygienists (ACGIH) is also 0.3 ppm (369 ug/m3) [6].

Populations of humans that have received considerable attention in the literature as being particularly sensitive to formaldehyde exposure following inhalation and/or dermal contact include asthmatics and persons with dermal sensitization. The concerns involving asthmatics focuses on the potential changes in lung function parameters that formaldehyde may produce. Studies involving asthmatics have been somewhat conflicting, but generally indicate that formaldehyde does not induce airway hyper-reactivity at concentrations less than 3 ppm (3690 ug/m3) [2]. Symptoms of increased itching, sneezing, mucosal congestion, and transient burning sensation of the eyes and the nasal passages, were observed in a group of potentially sensitive individuals, some with dermal hypersensitivity, exposed to formaldehyde at a concentration of 0.4 ppm (492 ug/m3) for a period of 2 hours (Pazdrak et al. 1993) [2].

Dermal allergic reactions have been reported in doctors and nurses exposed to formaldehyde (Rudzki et al. 1989) as well as in fiberglass worker (Kilburn et al. 1985). Anaphylactic reactions have been reported in the literature (Maurice et al. 1986), in a description of a case in which anaphylaxis occurred in a patient due to skin contact with adhesives sterilized with formaldehyde prior to hemodialysis therapy. Other persons with dermal sensitization to formaldehyde are not likely to develop signs of respiratory insufficiency [2].

Although formaldehyde is readily absorbed into the body, it is also very quickly broken down. It is not stored in fat. Formaldehyde is also naturally produced in small amounts in the human body as a part of normal, everyday metabolism. The normal blood level of formaldehyde in humans is approximately 2.5 ppm (2500 micrograms per liter (ug/L)). Formaldehyde has a half-life in blood of approximately 1.5 minutes (Sullivan, 1999) [3]. Almost every tissues of the body has the ability to break down formaldehyde. It is usually converted to a non-toxic

chemical called formate, which is excreted in the urine. In addition, formaldehyde can also be converted to carbon dioxide and breathed out of the body [2].

A level of concern for formaldehyde in trailers used for temporary housing would be 0.3 ppm (369 ug/m3), which is an effect level associated with the narrowing of the bronchi in sensitive individuals [1].

FEMA/EPA Sampling Plan:

During the FEMA/EPA temporary housing units sampling project an initial sampling event was conducted to establish baseline conditions for formaldehyde and VOC concentrations in indoor air. The initial sampling event was conducted in all trailers with doors and windows closed without ventilation. One 24-hour VOC sample and one 1-hour formaldehyde sample was collected in each trailer [4].

Upon completion of the initial sampling, the trailers were divided into two subsets: In one subset (Group A), the air conditioning system was set to cool (thermostat set at 72 degrees Fahrenheit and without targeted humidity control) and the bathroom static vents left open. No other ventilation was provided for the Group A trailers. In the second subset (Group B), ventilation was provided by opening all windows, static vents, and exhaust fan vents. Exhaust fans were not operated (turned on) [4].

Sampling for formaldehyde was conducted twice daily over a 14-day period while the Group A and Group B ventilation conditions were maintained. A total of 2284 formaldehyde samples were collected during the project. In addition, a final 24-hour sampling event for VOCs was conducted at the end of the 14-day period while the Group A and Group B ventilation conditions were maintained [4].

Sampling Results:

The outdoor background concentration of formaldehyde detected at the trailer staging area during the sampling project ranged from 1 to 87 ug/m3 with an average of approximately 6 ug/m3 [5]. The background level of formaldehyde detected was consistent with the levels detected in urban areas in other studies as previously stated.

From the data provided by FEMA, queries were conducted to determine the minimum, maximum, and average concentrations of formaldehyde detected each day for the two different ventilation methods (see attached data table). Ventilation in Group A trailers was provided by running the air conditioning system; while ventilation in Group B trailers was provided by opening the windows and vents. The average formaldehyde concentration per day for each method was plotted on a graph for comparison (see attached graph).

In Group A trailers, a total of 1090 samples were collected for formaldehyde throughout the entire sampling project. The concentrations of formaldehyde detected in all of the Group A trailers included a minimum of 3.4 ug/m3, a maximum of 3000 ug/m3, and an average of 490 ug/m3. In Group B trailers, a total of 1117 samples were also collected for formaldehyde. Formaldehyde concentrations in all of the Group B trailers included a minimum concentration of 3 ug/m3, a maximum of 4500 ug/m3, and an average of 172 ug/m3.

Several general trends can be observed from the attached graph, concerning the 96 trailers involved in the sampling project. The graph indicates the average formaldehyde concentration per day for each of the two ventilation methods plotted side by side for comparison. After the fourth day of sampling, the two methods showed a general decline in formaldehyde concentration in all trailers for the remainder of the 14-day study. The trailers in Group B, overall and in general, had a lower average concentrations of formaldehyde than the trailers in Group A. The average concentration of formaldehyde per day in all of Group B was below the level of concern of 369 ug/m3, after the fourth day of sampling and for the remainder of the study. In the trailers in Group A, the average concentration of formaldehyde per day was lower than the level of concern of 369 ug/m3 only on two days, 9/29 and 10/7.

In addition to formaldehyde, other volatile organic compounds (VOCs) were also analyzed. Most of the other (VOCs) detected were in the low ug/m3 range. VOCs in the higher ug/m3 range included styrene and tetrachloroethene at a maximum concentration of 790 ug/m3 and 490 ug/m3, respectively. The concentrations of these VOCs were at levels not expected to produce adverse health effects.

III. Conclusions:

In the 96 trailers sampled, the method of ventilation used in trailer group B, of opening all windows, static vents, and exhaust fan vents, was more effective at lowering the concentration of formaldehyde during the period of this sampling project than the method of ventilation used in trailer Group A of running the air conditioning system with the bathroom static vents open. The method of ventilation which allowed for the greatest number of air exchanges was the most effective in lowering the concentration of formaldehyde.

The average concentration of formaldehyde per day in Group B trailers, after the fourth day of sampling and for the remainder of the study, was below the level of concern for sensitive individuals of 369 ug/m3 (0.3 ppm). The average concentration of formaldehyde per day in Group A trailers was above the level of concern for sensitive individuals in all but two days of the study. Individuals previously sensitized to formaldehyde may experience symptoms above 369 ug/m3 (0.3 ppm). A combination of ventilation methods, in addition to Method A, may be necessary to reduce formaldehyde concentrations below levels of health concern for sensitive individuals.

The concentrations of the other VOCs detected during the sampling project were below levels expected to produce adverse health effects.

FEMA has not requested ATSDR to evaluate longer-term formaldehyde concentrations in trailers or health concerns related to potential exposures. ATSDR will be available to provide assistance if such data becomes available in the future.

IV. Recommendations:

Formaldehyde is given off as a gas from the manufactured wood products, including plywood and particle board, used in new mobile homes. The amount of formaldehyde released from these products decreases slowly over time. Formaldehyde levels in indoor air are usually higher than the levels outdoors. The amount of formaldehyde in mobile homes is usually higher than it is in conventional homes because of the lower air turnover. Opening windows or using a fan to bring in fresh air is the easiest way to lower formaldehyde levels in the home and reduce the risk of exposure [2].

Formaldehyde is found in small amounts in many consumer products including household cleaners, antiseptics, medicines, dish-washing liquids, fabric softeners, shoe-care agents, carpet cleaners, glues, adhesives, and lacquers. When using these products, providing fresh outdoor air will reduce exposure to formaldehyde. Some cosmetics, such as nail hardeners, have very high levels of formaldehyde. Not using these products in a small room, or providing plenty of ventilation when they are used will reduce the level of exposure to formaldehyde [2]

Removing formaldehyde sources from the house will also reduce the risk of exposure. Since formaldehyde is found in tobacco smoke, not smoking or smoking outside will reduce exposure to formaldehyde. Unvented heaters, such as portable kerosene heaters, also produce formaldehyde. Not using these heaters in a home will help to prevent the buildup of formaldehyde indoors [2].

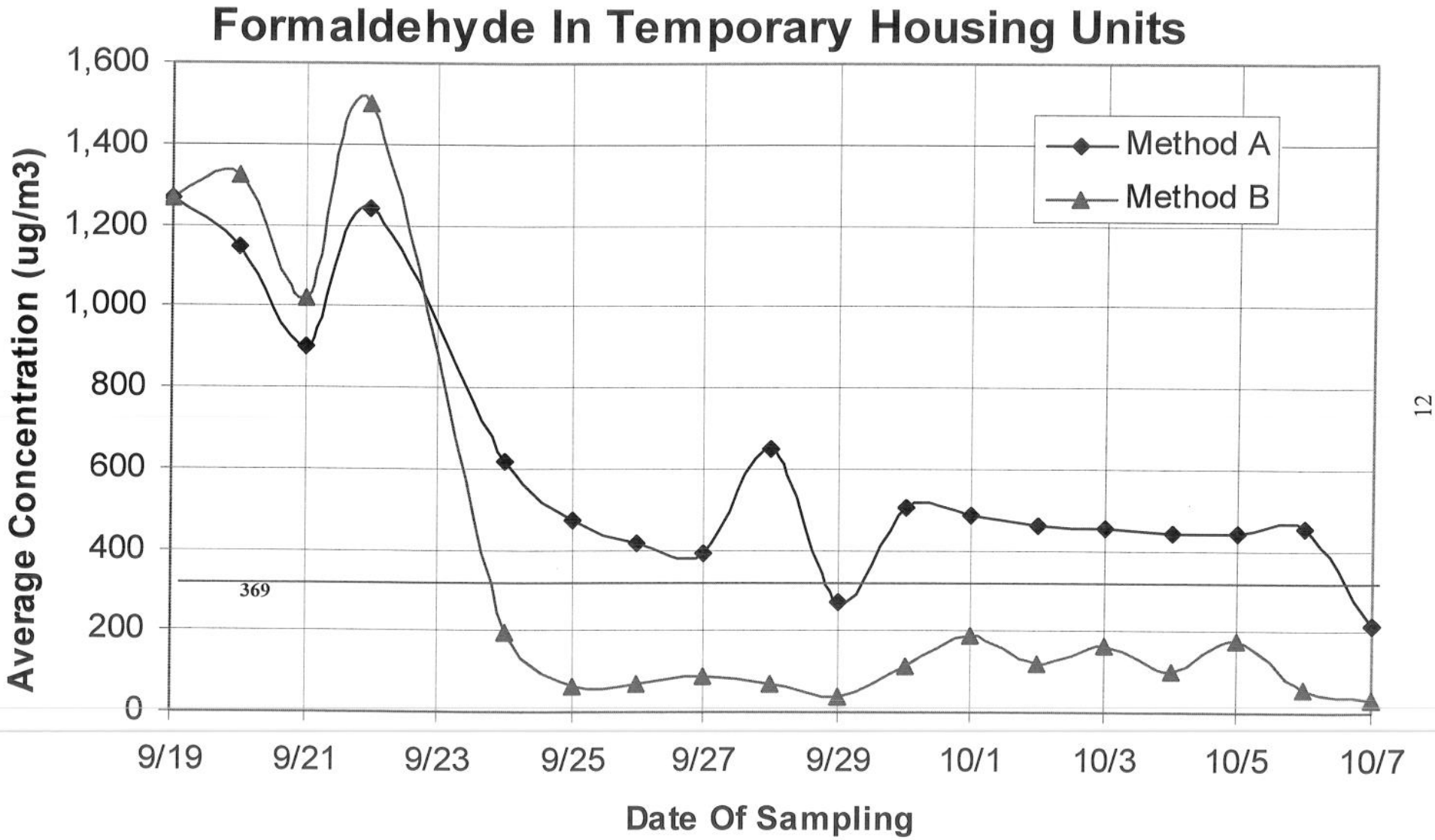
Some new permanent press fabrics also emit formaldehyde. Washing these new clothes before they are used will usually lower the amount of formaldehyde [2].

Increasing the ventilation to provide for the greatest number of air exchanges will be the most effective action in lowering the potential exposure to formaldehyde.

Prepared by:

Joseph D. Little, MSPH
CDR U.S. Public Health Service
Emergency Response Coordinator
Prevention Response and Medical Support Branch
Division of Toxicology and Environmental Medicine

Scott V. Wright, MS
Emergency Response Coordinator
Prevention Response and Medical Support Branch
Division of Toxicology and Environmental Medicine


Formaldehyde In Temporary Housing Units
Average Concentration (ug/m3)
1,600
1,400
1,200
1,000
800
600
400
200
0
369
Method A
Method B
9/19
9/21
9/23
9/25
9/27
9/29
10/1
10/3
10/5
10/7
Date Of Sampling

Formaldehyde in Temporary Housing Units

Analyte	Method	Date	Min	Ave	SDs	GM	GSD	Max	N
Formaldehyde	A	9/19/2006	5.3	1,264.98	842.62	629.2	6.41	2500	17
Formaldehyde	A	9/20/2006	6.6	1,145.12	680.63	740.82	4.5	2100	13
Formaldehyde	A	9/21/2006	5.2	901.69	808.84	352.25	7.56	2200	14
Formaldehyde	A	9/22/2006	4.6	1,240.08	913.94	530.62	8.23	3000	15
Formaldehyde	A	9/24/2006	3.4	619.28	442.71	339.85	4.8	2000	116
Formaldehyde	A	9/25/2006	3.9	473.75	348.04	295.34	3.63	1700	103
Formaldehyde	A	9/26/2006	4.6	418.41	314.28	258.26	3.62	1500	118
Formaldehyde	A	9/27/2006	3.4	390.05	301.96	239.74	3.53	1400	118
Formaldehyde	A	9/28/2006	4.3	649.4	440.62	426.74	3.44	1700	56
Formaldehyde	A	9/29/2006	3.6	268.04	187.82	172.03	3.44	800	56
Formaldehyde	A	9/30/2006	3.5	502.38	340.1	300.86	4.11	1400	57
Formaldehyde	A	10/1/2006	4.6	484.59	305.55	323.51	3.51	1200	53
Formaldehyde	A	10/2/2006	4.3	460.32	308.35	290.9	3.69	1200	61
Formaldehyde	A	10/3/2006	4.7	455.03	303.04	305.85	3.19	1200	60
Formaldehyde	A	10/4/2006	3.8	439.4	298.68	273.49	3.82	1300	55
Formaldehyde	A	10/5/2006	4	442.35	302.55	287	3.39	1200	59
Formaldehyde	A	10/6/2006	3.4	453.12	292.51	282.13	3.95	1300	60
Formaldehyde	A	10/7/2006	4.8	216.39	137.36	151.29	2.91	590	59
Formaldehyde	B	9/19/2006	5.9	1,263.29	758.39	845.02	4.07	2800	17
Formaldehyde	B	9/20/2006	4.3	1,322.25	969.85	509.78	9.39	2800	17
Formaldehyde	B	9/21/2006	190	1,018.57	644.38	784.36	2.26	1900	14
Formaldehyde	B	9/22/2006	4.6	1,496.07	1,353.82	585.53	8.16	4500	15
Formaldehyde	B	9/24/2006	3	196.6	138.31	138.92	2.8	600	117
Formaldehyde	B	9/25/2006	3.9	61.1	41.37	47.36	2.2	190	112
Formaldehyde	B	9/26/2006	3.4	66.45	40.35	52.24	2.24	180	114
Formaldehyde	B	9/27/2006	3.4	90.56	56.44	69.68	2.36	240	112
Formaldehyde	B	9/28/2006	4	72.34	42.96	57.34	2.2	180	59
Formaldehyde	B	9/29/2006	3.5	40.49	25.95	32.54	2.04	130	60
Formaldehyde	B	9/30/2006	4.9	115.49	72.12	88.75	2.37	300	60
Formaldehyde	B	10/1/2006	3.8	185.87	124.93	130.36	2.93	560	65
Formaldehyde	B	10/2/2006	3.9	120	77.48	90.09	2.51	340	56
Formaldehyde	B	10/3/2006	4.4	162.19	105.31	116.45	2.75	450	57
Formaldehyde	B	10/4/2006	4.1	102.76	77.13	72.14	2.58	330	62
Formaldehyde	B	10/5/2006	3.5	178.46	118.41	125.5	2.9	470	61
Formaldehyde	B	10/6/2006	3.4	53.62	39.54	37.69	2.61	180	60
Formaldehyde	B	10/7/2006	3.6	29.06	16.9	24.29	1.92	95	59

References:

1. Agency for Toxic Substances and Disease Registry, Managing Hazardous Materials Incidents, Medical Management Guidelines for Acute Chemical Exposures, Formaldehyde. Atlanta, ATSDR, 2001.

2. Agency for Toxic Substances and Disease Registry, Toxicological Profile for Formaldehyde. Atlanta, ATSDR, July 1999.

3. National Library of Medicine, Hazardous Substances Data Bank (HSDB), Formaldehyde, 2006. http://toxnet.nlm.nih.gov.

4. U.S. Environmental Protection Agency, Formaldehyde Sampling at FEMA Temporary Housing Units, Task Specific Addendum to: Contingency Air Monitoring and Sampling Plan for C&D Burning or Grinding Sites, USEPA, September 23, 2006.

5. Federal Emergency Management Agency, Formaldehyde in FEMA Family Units Sampling Program, Baton Rouge, LA, Field Documentation, Data Files, and Analytical Data DVD. FEMA, November 13, 2006.

6. American Conference of Government Industrial Hygienists, Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, ACGIH, 2006.