Formaldehyde Exposure in Homes: A Reference for State Officials to Use in Decision-making

Background

The issue of formaldehyde exposure in homes is long-standing and has been studied over time. Formaldehyde is frequently used in plywood, fiberboard, resins, glues, and several other construction components. In the past, formaldehyde was also used in insulation of many homes. In March of 1982, the U.S. Consumer Product Safety Commission (CPSC) called for a ban on urea foam formaldehyde insulation (UFFI). (US Consumer Product Safety Commission, March 1982, Release # 82-005) While this ban was challenged by several commercial groups citing that formaldehyde exposure was greater from carpets and other building materials, UFFI use had dropped precipitously by the mid 1980's. However, homes built before or around the time of the ban of UFFI still had this insulation in their homes.

Changes in formaldehyde use in home construction

The 1982 ban on UFFI is one factor contributing to decreased levels of formaldehyde that are found in more recent studies. Another factor is a change in the type of pressed wood products containing formaldehyde resins or glues. In the past, pressed wood products often contained urea-formaldehyde resins. These resins are not as widely used today. Instead, many pressed wood products are constructed with phenol-formaldehyde products (commonly known as exterior grade products). Phenol-formaldehyde products emit much less formaldehyde.

Temperature, humidity, ventilation, and age of the house also contribute to differences in formaldehyde levels measured. Studies demonstrated that formaldehyde emission rates were constant over the first eight months after construction but then began to decline, suggesting formaldehyde off-gassing continues for extended periods of time but decreases as the age of the home increases. Other studies show that older homes have lower formaldehyde levels than newer homes (Hodgson et al., 2000; Gordon et al., 1999).

Awareness about the health risks of formaldehyde is increasing, and exposure exists for all housing types across America. An early U.S. study conducted in 1985 investigated formaldehyde levels in different types of housing. That study demonstrated that formaldehyde levels in 38 conventional U.S. homes averaged 40 parts per billion (ppb) with highs of 140 ppb. Nineteen apartments and 11 condominiums were also studied and had formaldehyde levels averaging 80 ppb and 90 ppb, respectively, with highs of 290 ppb (Stock & Mendez, 1985). A more recent study of new homes found the geometric mean formaldehyde level was 34 ppb in manufactured homes and 36 ppb in

site-built homes (Hodgson et al., 2000). This study also suggested that formaldehyde concentrations in conventional homes have decreased greatly since the 1980s due to decreased use of plywood paneling and reduced emissions from the composite wood products used.

In another study conducted by the US Environmental Protection Agency (EPA), the National Human Exposure Assessment Survey found 189 Arizona homes had a median formaldehyde level of 17 ppb with a high of 332 ppb. (Gordon et al., 1999) The most recent study of 184 single family homes in different several cities (RIOPA, 2005) found a mean concentration of formaldehyde in outdoor ambient air of 3 ppb and in housing of 17 ppb. That same study found a mean level of formaldehyde for mobile homes or trailers ranging from 15.5 to 24.7 ppb.

These studies show a trend: while all homes have some level of formaldehyde, formaldehyde levels in general seem to have been decreasing since the early 1980's. Another trend is that traditional stand-alone homes tend to have lower levels than do manufactured homes. Lower ventilation rates in manufactured homes, due to construction differences, may play a role in this trend.

Major health effects of formaldehyde exposure

Acute and chronic health effects of formaldehyde vary depending on the individual. The typical threshold for development of acute symptoms due to inhaled formaldehyde is 800 ppb; however, sensitive individuals have reported symptoms at formaldehyde levels around 100 ppb (Main et al, 1983; Bender et al., 1983).

Additional studies also have supported that health effects can occur in sensitized individuals at 100 ppb when they are exposed chronically to formaldehyde. (Ritchie IM, et al 1987) These sensitized individuals can have exacerbations of symptoms without the appreciation of odor, giving the individual little or no warning of exposure. Typically, olfactory recognition occurs around 500 ppb, leaving the average exposure from a home below the olfactory detection limit (Kulle et al., 1987; RIOPA, 2005).

The common symptoms from acute exposure to formaldehyde manifest as irritation of the throat, nose, eyes, and skin. This upper respiratory tract irritation can potentially exacerbate asthma symptoms and other respiratory illnesses (Main et al., 1983; Bracken et al., 1985; Kilburn et al., 1985; Imbus et al., 1985; Anderson et al., 1979).

In addition to acute health effects of formaldehyde, chronic exposures in occupational settings also have been extensively studied. Respiratory symptoms of chronic runny nose, chronic bronchitis, and obstructive lung disease all have been suggested (Malaka et al., 1990; Alexandersson et al., 1982; Holness, 1989).

Studies that have attempted to quantify pulmonary symptoms with formal pulmonary function testing have demonstrated conflicting results (Alexandersson et al., 1982). One study demonstrated a small decrease in forced expiratory volume (FEV-1) and forced vital capacity (FVC) but noted the changes to be reversible (Alexandersson et al., 1989). However, several additional studies that also utilized formal pulmonary function testing have demonstrated no statistical difference in pulmonary parameters (Horvath,1988; Holness et al., 1989).

The carcinogenicity of formaldehyde has been extensively studied over the last 30 years. In June 2004, The International Agency for Research on Cancer (IARC) reclassified formaldehyde from “probably carcinogenic to humans” to “carcinogenic to humans”. (http://www.iarc.fr/ENG/Press_Releases/archives/pr153a.html). IARC asserts that “there is now sufficient evidence that formaldehyde causes nasopharyngeal cancer in humans, a rare cancer in developed countries.” The National Toxicology Program (NTP) continues to classify formaldehyde as, “reasonably anticipated to be a carcinogen in humans” for nasopharyngeal cancer (http://ntp.niehs.nih.gov/ntp/roc/eleventh/profiles/s089form.pdf).

A discussion of the current status of quantitative cancer risk estimation for formaldehyde involves several complexities beyond the scope of this fact sheet. Uncertainty remains as to how to quantitatively relate measured air concentrations of formaldehyde to cancer risk. Since many other factors play a role in the development of cancer and since we are all exposed to formaldehyde every day in our environment, no definitive level can be drawn that places individuals in a “high risk” category. The safest way to reduce an individual’s risk of cancer is to limit exposure. Clinically useful biologic markers, such as blood or urine tests, are also lacking, which further complicates the ability to tie exposure to outcome. In general, the lower the level and shorter the duration of exposure, the less risk of cancer and other health effects.

Government standards in occupational settings

The information in this section is provided as a reference only. Occupational levels are not appropriate for application to residential settings for a variety of reasons. For example, the population in residential settings is more diverse (e.g., children, elderly) and may have greater susceptibility as a result of pre-existing health conditions (e.g., age, infirmity, chronic illness). Exposure times in homes can vary substantially from those in occupational settings as can the circumstances of exposure. Most occupational settings have ongoing monitoring programs in place and may have safety requirements related to reduction of exposure.

At present, there is no generally agreed upon standard for formaldehyde concentrations in residential settings. Several different governmental agencies and other organizations have established occupational definitions and levels for formaldehyde. Regulatory levels differ significantly among agencies.

The Occupational Safety and Health Administration (OSHA), has set legal permissible exposure limits (PELs) to regulate worker exposure to formaldehyde in occupational settings. A PEL is usually given as a time-weighted average (TWA) over an 8-hour period, although can be given as a short term exposure limit (STEL). OSHA defines the PEL/TWA as 750 ppb in air for formaldehyde. The PEL/TWA may not capture high exposures during brief periods of time so OSHA also has established PEL/STELs. PEL/STELs regulate the concentration to which workers can be exposed continuously for a short period of time (15 minutes) without suffering health effects. OSHA has set the PEL/STEL at 2000 ppb in air for formaldehyde.

The National Institute of Occupational Safety and Health (NIOSH) uses the same definition for TWA, but its levels differ. NIOSH defines the TWA as 16 ppb. Since the IARC reclassified formaldehyde as a carcinogen, NIOSH recommends limiting exposures to levels below the limit of detection.

The American Conference of Governmental Industrial Hygienists (ACGIH), a non-governmental organization, uses different definitions from either OSHA or NIOSH. ACGIH defines acceptable occupational exposures by using a term threshold limit value. This value is defined as the reasonable level to which a worker can be exposed without adverse health effects. ACGIH has set this level at 300 ppb.

In addition to the occupational definitions, the US Department of Housing and Urban Development (HUD), has regulated formaldehyde emissions from wood products. HUD uses the regulatory term “maximum allowable concentration,” which is the maximum concentration of formaldehyde emissions allowed from a wood product. HUD has set this level at 300 ppb. It should be emphasized that this standard is based upon emission rates which relate to a chamber test.

The World Health Organization (WHO) has developed a guideline for formaldehyde in non-occupational settings at 100 ppb (0.1 mg/m3) for 30 minutes. This guideline was developed to protect against sensory irritation in the general population, but WHO states that it also represents an exposure level at which there is negligible risk of upper respiratory tract cancer in humans (WHO, 1989).

The State of California Office of Health Hazard Assessment (OHHEA) established guideline indoor concentration values, called Chronic Reference Exposure Levels (CRELs), for 80 chemicals. The OEHHA CREL list addresses health effects of volatile organic compounds (VOCs) with known chronic health effects and provides concentrations below which chronic health effects have not been observed in studies. Due to the fact that OEHHA determined that the CREL for formaldehyde is less than typical ambient levels, they recommended an office concentration level of 23 ppb, based upon the concept of “as low as reasonably achievable.” The OHHEA reference materials can be found at: www.oehha.ca.gov/air/chronic_rels/AllChrels.html.

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Resources for Evaluating Formaldehyde Concentrations in Indoor Environments

1. US Environmental Protection Agency

http://www.epa.gov/iaq/formalde.html
Basic Information: Formaldehyde.
Brief discussion with emphasis on the indoor environment. This site includes information about sources of formaldehyde, health effects, levels in homes, steps to reduce exposure, as well as a link to other resources.

http://www.epa.gov/iaq/base/index.html
Building Assessment and Evaluation Study (BASE)

http://www.epa.gov/iaq/base/summarized_data.html#Volatile%20Organic%20Compounds
Summarized data of formaldehyde concentrations in 100 randomly selected U.S. office buildings.

http://www.epa.gov/iris/subst/0419.htm
Integrated Risk Information System (IRIS)
A compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects. IRIS initially was developed for EPA staff in response to a growing demand for consistent information about substances for use in risk assessments, decision-making, and regulatory activities. The information in IRIS is intended for those without extensive training in toxicology but with some knowledge of health sciences.

2. US Consumer Products Safety Commission.

http://www.cpsc.gov/cpscpub/pubs/725.html
An Update on Formaldehyde (1997)

3. US Department of Energy, Lawrence Berkeley National Laboratory

http://eetd.lbl.gov/ied/pdf/LBNL-51715.pdf
Volatile Organic Compounds in Indoor Air: A Review of Concentrations Measured in North America since 1990: Contains central tendency and upper limit concentrations of VOCs including formaldehyde in residential and office buildings.