

Indoor Air Quality Guideline

No. 1

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California Environmental Protection Agency

 **Air Resources Board**

Formaldehyde in the Home

About This Guideline

This indoor air quality guideline summarizes the health effects of formaldehyde and tells about sources of formaldehyde in your home. The guideline also explains how you and your family can reduce your exposure to formaldehyde. The California Air Resources Board (ARB) has classified formaldehyde as a Toxic Air Contaminant, based on its potential to cause cancer and other adverse health effects.

What is formaldehyde?

Formaldehyde is a colorless gas. At elevated concentrations it has a strong, pungent odor and can be irritating to the eyes, nose, and lungs. Formaldehyde is released into the home from a variety of indoor sources. Some resins, or glues, used to bind wood chips or fibers into plywood, particleboard, and other pressed wood products, contain formaldehyde. Cabinetry and some floor and wall materials are often made from such products. Formaldehyde is also used in fabrics to impart wrinkle resistance or to fix color, and in some consumer products it is used as a hardening agent or preservative. Also, formaldehyde is a by-product of



**Cabinetry & gas appliances
are common sources**

combustion processes, such as wood burning, gas appliance use, and cigarette smoking. Formaldehyde is usually present at lower (but not necessarily healthful) levels in outdoor air; it is emitted in car exhaust and from some industrial sources, and is also created from chemical reactions in the air among combustion pollutants, such as those in automobile exhaust.

SOME COMMON SOURCES OF FORMALDEHYDE INDOORS

Pressed wood products: particleboard, plywood, medium-density fiberboard (MDF); often used in cabinetry, and wall and floor materials

Consumer Products: fingernail hardeners, nail polish, wallpaper, some other paper goods, paint, coatings; often a preservative in these and other products

Coatings for Some Cabinet and Furniture Products: acid-catalyzed urea-formaldehyde type finishes

Permanent Press Fabrics: clothing, linens, draperies

Combustion Appliances: wood stoves, gas appliances, kerosene stoves

Tobacco products: cigarettes, cigars

Do I have formaldehyde in my home?

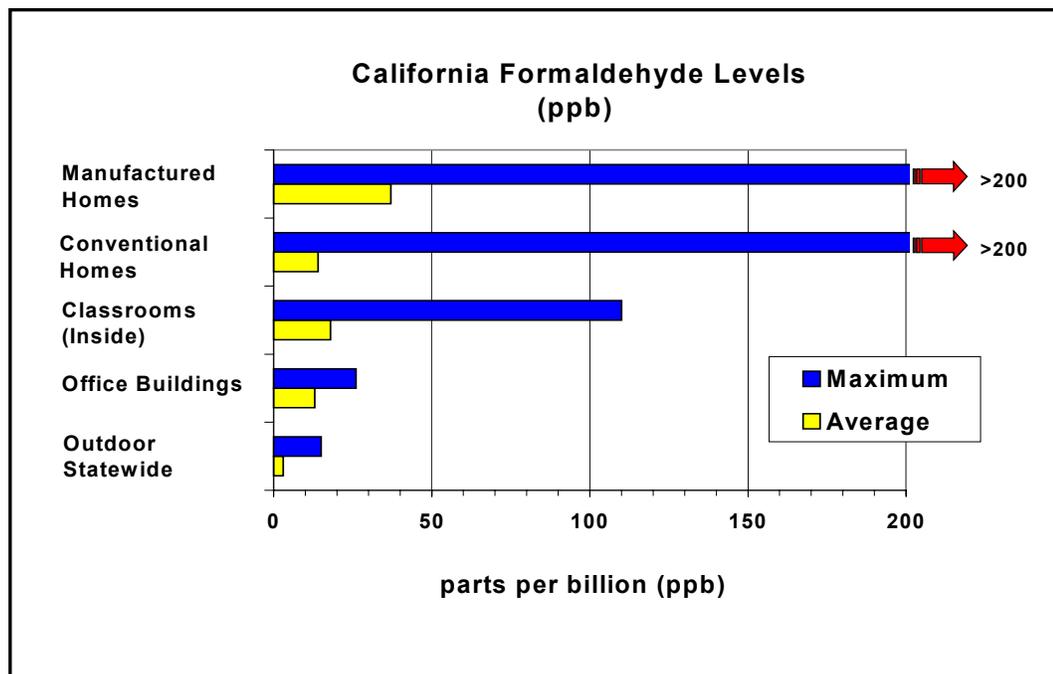
Formaldehyde is a very common indoor air pollutant. Because there are many sources, formaldehyde is found in virtually all homes and buildings. Mobile homes, manufactured homes, new homes, and recently remodeled homes are more likely to contain high levels of formaldehyde. Higher formaldehyde in these homes may be caused by the presence of a large quantity of pressed wood products, such as particleboard and plywood. Older homes typically have less formaldehyde in the air because pressed wood products emit less formaldehyde over time.

FORMALDEHYDE INDOORS COMPARED TO OUTDOORS

Concentrations of formaldehyde are typically several times greater indoors than outdoors because a large amount of formaldehyde-emitting material is contained within a confined space. During the 1980s, formaldehyde concentrations in California averaged about 50 parts per billion (ppb¹) in conventional homes, and 70 ppb in mobile homes, about 13 to 18 times

¹ A part per billion can be thought of as one grain of sand in a sandbox containing a billion grains of sand.

higher than average outdoor concentrations at that time. Since then, manufacturers have voluntarily reduced formaldehyde emissions from pressed wood products, and some common product formulations have changed. Limited measurements show that concentrations indoors are generally lower than in the past. The bar chart below shows the relative indoor concentrations in several indoor environments, based on the most recently available information. The average outdoor formaldehyde level today is approximately 3 ppb. The majority of Californians' exposure to formaldehyde results from indoor sources, due to elevated indoor concentrations and the fact that people spend most of their time indoors.



How can formaldehyde affect my health?

Inhaling formaldehyde in the air can cause both short-term irritant effects and long-term health effects, such as cancer. The potential effect formaldehyde can have on your health depends on the amount you are exposed to, the length of time you are exposed, and your individual sensitivity. Certain people may react differently to the same formaldehyde exposure. People with eye, skin, respiratory, or allergic conditions, and those with asthma, are potentially more susceptible to the irritant effects of formaldehyde. Children and the elderly may be more sensitive as well.

ODOR

The level at which people can first detect formaldehyde by odor varies widely among individuals, from 50 to 500 ppb. Some health effects, such as eye or nose irritation, can occur at formaldehyde concentrations that some people cannot smell.

HEALTH EFFECTS FROM EXPOSURE TO FORMALDEHYDE	
<u>EFFECT</u>	<u>CONCENTRATION *</u>
Odor	50-500 ppb
Eye & nose irritation, nasal stuffiness, lung discomfort (coughing, wheezing, bronchitis symptoms)	40-500 ppb
Allergic reactions, worsening of asthma symptoms	Variable
Cancer	No known level with zero risk

**Approx. range of concentrations where effect first observed, in parts per billion (ppb)*

EYE, NOSE, THROAT, AND LUNG IRRITATION

Exposure to moderate levels of formaldehyde can cause a number of irritant symptoms, including temporary burning or itching of the eyes or nose, stuffy nose, and sore throat. At higher concentrations, formaldehyde exposure can also cause irritation of the lung's passageways. At very high formaldehyde concentrations, chest tightness, coughing, and wheezing can occur. Some people have reported headache, nausea, and fatigue after exposure to formaldehyde.

ALLERGIC REACTIONS

Formaldehyde is a strong sensitizer, meaning that exposure to formaldehyde can induce an allergic reaction. Skin rashes are the most common form of formaldehyde allergy, especially when the skin is exposed to liquid formaldehyde. Allergic skin reactions can also result from exposure to formaldehyde present in dry products, such as new permanent press clothing,

when moistened with sweat. Airborne formaldehyde may cause allergic reactions in occupationally exposed persons, and also may result in a worsening of asthma symptoms in people with asthma.

Allergens, other volatile chemicals, and a variety of medical conditions can cause some of the same symptoms as formaldehyde does. As with any medical condition, persons with symptoms should have a thorough medical exam to identify the cause.

CANCER

The International Agency for Research on Cancer (IARC) recently concluded, based on human exposures in the workplace, that formaldehyde can cause nasopharyngeal cancer (cancer of the nose and throat). IARC also found limited evidence that formaldehyde may cause other respiratory tract cancers, and a possible link with leukemia. Previously, the U.S. Environmental Protection Agency had classified formaldehyde as a “probable” human carcinogen, based on studies of laboratory animals repeatedly exposed to high levels of formaldehyde.

When assessing formaldehyde for identification as a California Toxic Air Contaminant, the ARB’s Scientific Review Panel concluded that, like other carcinogens, there is no level of exposure below which the risk of developing cancer is zero. Estimating Californians’ risk from current indoor levels of formaldehyde is complex. As an approximation, if the California population were exposed to current, average indoor levels of formaldehyde over a lifetime, ARB staff estimate that about 4000 excess cases of cancer would be expected to develop, or about 115 excess cases of cancer per million people exposed. Reducing your exposure to formaldehyde will help reduce your individual risk.

What can I do to reduce formaldehyde in my home?

There are practical steps you can take to reduce your exposure to formaldehyde in your home. Levels can be reduced whether you are building a new home, remodeling an older home, or seeking to reduce exposure from sources you may have in your home. **The most effective way to reduce formaldehyde in indoor air is to remove or reduce sources of formaldehyde in the home and avoid adding new sources.** Formaldehyde from sources such as pressed wood products can take years to off-gas. Additionally, porous materials and furnishings can absorb

formaldehyde and re-emit it later. Thus, avoidance of sources and prevention of emissions from the start is best.

Make Smart Choices... **When Building a Home or Remodeling**

Whether you are doing the work yourself, or working with a contractor, there are some practical steps you can take to reduce your exposure to formaldehyde.

- ◆ **Avoid the use of bare, uncoated urea-formaldehyde (UF) pressed wood products.** UF products, such as particleboard, are often used to cover large areas, and therefore can emit relatively high amounts of formaldehyde.

PRESSED WOOD PRODUCTS TYPICALLY MADE WITH UF RESIN

Hardwood plywood - Used for paneling, furniture, and other products.

Particleboard - Used for shelving, countertops, cabinets, floor underlayment, some laminate flooring, furniture, and other products; used also as center layer of some exterior-grade softwood plywood products.

Medium Density Fiberboard (MDF) - Used for cabinets, furniture, doors, some laminate flooring, and other products.

Hardboard - Occasionally, a type of UF particleboard is sold as “hardboard” (it is not true hardboard).

- ◆ **Use formaldehyde-free building materials.** It is often possible to substitute other materials for pressed-wood products. Examples of formaldehyde-free materials include lumber, gypsum board, some hardboard products, stainless steel and other metals, adobe, bricks, tile, and other masonry, and plastic. Use insulation materials that emit little or no formaldehyde, too; request emission test results to document low emissions. Formaldehyde emitted from insulation materials installed in the ceiling or walls can enter living spaces in the home.²

² Prior to 1982, urea-formaldehyde foam insulation (UFFI) was blown into attics and wall spaces in many homes. Since then, the sale and installation of UFFI in California has been essentially prohibited. Because emissions decrease over time, formaldehyde concentrations inside California homes with UFFI are now generally comparable to levels inside newer homes.

- ◆ **Use low-emitting building materials.** If you still prefer or need a pressed wood product, there are products available that emit very low amounts of formaldehyde. Pressed wood products glued together with phenol formaldehyde (PF) resin or methylene diisocyanate (MDI) resin emit much less formaldehyde than UF products when new. These products also emit less formaldehyde over time because they are more resistant to water vapor. PF and MDI products are often labeled as “exterior grade” or “moisture resistant” by the construction industry.

Pressed wood products made with PF or MDI resin can include: softwood plywood, oriented strand board, hardboard siding, and other weather resistant pressed wood products. You can request PF or MDI products at the lumberyard or from a local distributor.



- ◆ **Avoid products with urea-formaldehyde-based coatings.** Cabinets, solid and laminate wood floors, and furniture are sometimes sealed with a coating that emits very high amounts of formaldehyde when new. This finish is known as an acid-catalyzed urea-formaldehyde coating. Typically this product is either factory-applied or applied by a commercial floor contractor in a two-part process; it generally is not available to consumers. You should contact the product’s distributor or manufacturer to ask if the product or floor finish considered for use in your home is of this product type, and avoid being in the home when the product is applied.

Make Smart Choices...

When using urea-formaldehyde pressed wood products

Currently available, domestically produced UF pressed wood products emit less formaldehyde than similar products produced prior to and during the 1980s. Yet, installing large amounts of certain pressed wood products can elevate formaldehyde levels indoors for a significant period of time. In general, it is best to avoid using UF pressed wood products in your home. However, there can be times when the use of such products is unavoidable.

Here are some steps you can take to reduce formaldehyde emissions when you need to use UF particleboard or hardwood plywood:

- ◆ **Buy particleboard or hardwood plywood stamped with the Composite Panel Association (CPA) or Hardwood Plywood and Veneer Association (HPVA) stamp.** Particleboard and hardwood plywood bearing these stamps are certified to meet certain formaldehyde emission standards, and may be lower in formaldehyde emissions than products that are not certified.

Products made with PF or MDI resins emit significantly less formaldehyde, and are not required to be stamped. Various other low-emitting products are also available, but are not stamped. Ask the manufacturer or salesperson to assist you in distinguishing among the different kinds of pressed wood products.

Examples of CPA and HPVA formaldehyde emission certification stamps

HARDWOOD PLYWOOD & VENEER ASSOCIATION		
FORMALDEHYDE EMISSION 0.20 PPM CONFORMS TO HUD REQUIREMENTS	SIMULATED DECORATIVE FINISH ON PLYWOOD 	FLAME SPREAD 200 OR LESS ASTM E84
LAY UP 14 1/4 INCH THICK HP-SG-96	MILL XXX SPECIALTY GRADE	BOND LINE TYPE II ANSI/HPVA HP-1-2000

Sample Industrial Board Bundle Tag For Particleboard
Certified to HUD (0.30 PPM) Standard. Tag Size 4"x5"

**CONFORMS TO PARTICLEBOARD
FORMALDEHYDE EMISSION REQUIREMENTS
OF BOTH ANSI A208.1-1999, TABLE A
AND HUD 24 CFR 3280**

 **MILL 000**

**COMPANY
LOCATION
PRODUCTION DATE/SHIFT**

- ◆ **Buy UF products that are sealed with certain factory finishes.** A number of factory finishes are useful for reducing formaldehyde emissions (see box below). UF products are often coated with these finishes on only one side: consumers may wish to apply appropriate sealants to the edges and backs of these products. Also, the consumer can specify that all surfaces be sealed when buying made-to-order products. Avoid urea-formaldehyde acid-catalyzed coatings.

SOME FACTORY FINISHES THAT CAN REDUCE FORMALDEHYDE EMISSIONS
Acrylic Coating
Vinyl Coating
Melamine Laminate
Heat-curable 2-component Polyurethane
UV-curable Acrylate*
UV-curable Multifunctional Acrylate*
<i>*These finishes emit relatively low amounts of Volatile Organic Compounds (VOCs).</i>

- ◆ **Seal bare UF pressed wood products with multiple layers of water resistant sealants.** If alternative products are not available, sealing exposed surfaces of UF-containing products will reduce formaldehyde emissions for months to years after application. Research indicates that polyurethane, vinyl laminate, dinitrocellulose and other lacquers, and alkyd paint and other water-resistant coatings can reduce formaldehyde emissions. The effectiveness of these sealants varies greatly depending on the formulation of the individual product, the thickness of the layer and the thoroughness of its application. Some manufacturers provide sealants that are specially designed to reduce formaldehyde emissions; these are sold under various trade labels. To seal in formaldehyde fumes, it is advisable to seal all surfaces, including the back and edges of the board, and use multiple layers of coatings. **Caution:** Sealants may release other VOCs for a time when newly applied.

Choose coatings or barrier materials that are water resistant, bond well to the wood products, and can withstand the natural swelling and shrinkage of wood over time. Coatings will remain effective only as long as the integrity of the coating layer remains intact. Any sanding, drilling, or cutting

of sealed pressed wood products will also result in increased emissions of formaldehyde.

Use Plenty of Ventilation During and After Applying Liquid Sealants.

Liquid coatings, including paints, lacquers, stains, and other sealants, release volatile organic chemicals (VOCs) when freshly applied. It is important to use plenty of ventilation during application and for several days after application. Consider wearing a respirator during application.

Make Smart Choices...

When decorating and furnishing your home

A number of consumer products used in home decorating emit formaldehyde, especially when new. These products include some paints and other liquid coatings, wallpaper, furniture made from pressed wood products, and permanent press draperies and other textile products. Here are some simple steps you can use to reduce your formaldehyde exposure from these products.

- ◆ **Ventilate well during and after applying paint and other liquid coatings.** Increasing ventilation rates, such as by using an exhaust fan, is recommended during paint application, and for at least several days afterwards, to protect both painters and occupants. Sensitive persons should avoid areas where coatings are being applied.

**INITIAL EMISSION RATES FROM FRESHLY APPLIED COATINGS
– Typical Conditions –
($\mu\text{g}/\text{m}^2/\text{h}$: micrograms per square meter per hour)**

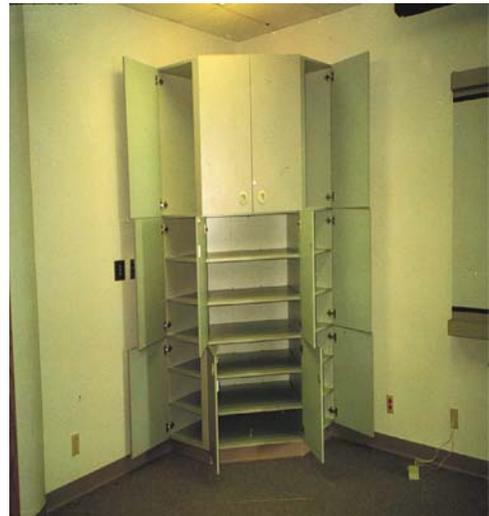
Latex paint	600
Latex paint (higher quality)	300
Wallpaper	700
Acid-catalyzed commercial floor finish, base coat	1,000,000
Acid-catalyzed commercial floor finish, top coat	400,000

Source: Kelly, TJ; Smith, DL; Satola, J, In *Environ. Sci. Technol.* 1999, 33, 81-88.

Formaldehyde and other aldehydes are used in small quantities as a preservative in many paint products. Because of the relatively large

amount of surface area usually painted, formaldehyde concentrations can be elevated for a time, particularly when the paint is still wet. People sensitive to formaldehyde may wish to avoid areas that are being painted. Even paint products marketed as “low-emission” or “low VOCs” may still contain small amounts of formaldehyde.

- ◆ **Ventilate well during and after wallpaper application.** Research shows that formaldehyde is released in significant quantities during wallpaper application and curing.
- ◆ **Buy used or antique furniture.** Most formaldehyde in used and antique furniture will have been released over the years of prior ownership. Beware of furniture that has been repaired or refurbished using UF pressed wood.
- ◆ **When buying furniture made from UF pressed wood products, look for furniture with the maximum amount of surface covered by veneer, vinyl, or other water-resistant coating.** Although veneer itself is attached with UF glue, tests show that it suppresses formaldehyde emissions from particleboard surfaces. Note that some furniture finishes contain UF resin, and emit formaldehyde, especially when new. Unfortunately, it is sometimes difficult to identify such furniture pieces, so it is best to try to obtain emission or content information from the manufacturer before making a purchase.
- ◆ **Air out new furniture made from pressed wood products,** preferably away from the home in a well-ventilated warehouse or other building, before placing it in your home. The area must have fresh air passing through the building or formaldehyde will not be removed. This process will not remove all of the formaldehyde, but it can accelerate the off-gassing of formaldehyde and other noxious or odorous gases.



- ◆ **Air out permanent press draperies and other textiles away from the home.** Ask the distributor to do this before installing them in your home. The airing process should involve fully opening the material and allowing fresh air to circulate across its surface for several days. Caution: When airing out furniture or draperies,

avoid using buildings that are used for storing paints, solvents, pesticides, and other chemicals. Fumes from these chemicals can be absorbed by fabrics and other porous materials.

Make Smart Choices...

When using consumer products

Formaldehyde is used as an ingredient in a variety of consumer products. Products emitting high levels of formaldehyde include permanent press fabrics, fingernail hardeners, and fingernail polish. Other consumer products such as household cleaning agents, dishwashing liquids, fabric softeners, shoe-care agents, carpet cleaning agents, adhesives, shampoos, antiperspirants, and other personal care products may also contain formaldehyde.

- ◆ **Wash permanent press clothing, sheets, and other fabrics before using.** Laundering can reduce formaldehyde emissions from these fabrics by about 60 percent. This also will help minimize skin irritation from formaldehyde.
- ◆ **Ventilate thoroughly when using fingernail hardeners, nail polish, and other consumer products that may contain formaldehyde.** Some fingernail hardeners and nail polish emit especially high amounts of formaldehyde during application and drying. Formaldehyde exposure can be significant to the person applying either of these products.

Make Smart Choices...

When using combustion sources

Smoking tobacco products and burning gas, liquid, or solid fuel in heaters, ranges and ovens, wood stoves, and other combustion appliances can increase formaldehyde concentrations indoors, in addition to releasing a number of other, harmful pollutants. Some steps you can take to reduce formaldehyde exposure from these sources in the home include:

- ◆ **Restrict tobacco smoking to the outdoors.** Tobacco smoking produces formaldehyde and other toxic chemicals.

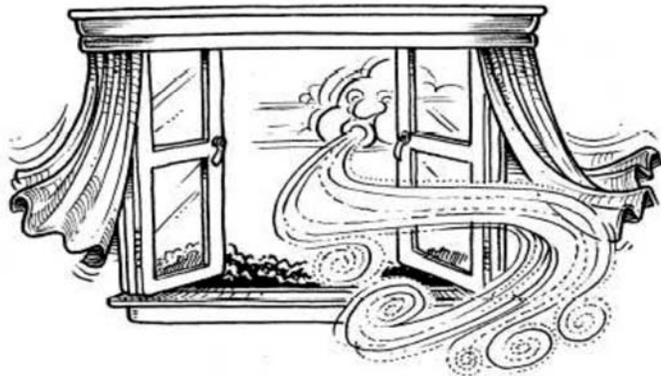
- ◆ **Exhaust all combustion appliances directly to the outdoors.** This includes gas heaters, ranges and ovens, and propane and wood burning appliances.
- ◆ **Have combustion appliances and fireplaces checked annually by a professional.** Malfunctioning wood stoves, gas appliances, and other combustion appliances produce more formaldehyde and other combustion pollutants (such as carbon monoxide) than appliances that are properly maintained. Local utility companies often will check combustion appliances at no charge.



- ◆ **Request ARB's guideline, *Combustion Pollutants in Your Home*, and the supplement to the guideline, for more information on reducing your exposure to combustion pollutants indoors.**

More Steps for Reducing Exposure to Formaldehyde

- ◆ **Increase ventilation in your home.** You can reduce your exposure to formaldehyde and other indoor pollutants by bringing more outdoor air into your home. Open windows and doors whenever possible. Extra ventilation during warm weather will remove greater amounts of formaldehyde than ventilation when temperatures are cool. Consider installing a whole house fan or a fresh-air ventilation system in your home. This can be helpful for newer homes that are tightly insulated.



- ◆ **Keep indoor temperatures moderate.** Formaldehyde concentrations in buildings are especially sensitive to increases in temperature. A temperature increase of 40 degrees Fahrenheit (such as an increase from 50 to 90 degrees F) can result in a doubling of formaldehyde concentrations. You can use the air conditioner to keep summer

temperatures relatively low. However, use swamp cooler-type air conditioners cautiously during periods of high ozone; they tend to bring ozone directly indoors, where it reacts and can cause increased levels of fine aerosols and formaldehyde.

- ◆ **Lower your home's humidity.** High humidity, especially during warm periods, increases the rate at which formaldehyde is released from pressed wood and other products. Humidity should be maintained at about 40% to 50% relative humidity in the home.

SOME WAYS TO REDUCE HUMIDITY IN THE HOME

Install and use exhaust fans in areas where moisture is generated (kitchen, bathroom, laundry room). Fans must vent all the way to the outdoors, not to the attic. Use fans during bathing, showering, and cooking.

Install a dehumidifier in humid climates. Follow the manufacturer's directions for cleaning and maintaining this device.

Avoid the use of humidifiers, swamp coolers, or other devices that purposely add moisture to the air. However, these devices may be necessary in extremely dry desert climates, or during dry periods.

Reduce moisture in the crawl space or basement. Wet or moist basements or crawl spaces can create excess humidity indoors.

Recommended Exposure Limits for Formaldehyde

Because formaldehyde can contribute to the risk of getting cancer, and, like other carcinogens, has no level that is known to be risk free, the ARB recommends that you reduce indoor formaldehyde concentrations as much as possible. This also will reduce the likelihood of irritant effects that can develop from long-term exposures to low levels of formaldehyde. Current outdoor levels average about 3 ppb in California and can range to about 10-12 ppb in some locales. It is desirable to reduce indoor levels to as near to outdoor levels as possible; however, it is generally not possible to reduce indoor levels below nearby outdoor levels.

As mentioned earlier, formaldehyde also can cause short-term irritant effects. For short-term exposure, the California Office of Environmental Health

Hazard Assessment (OEHHA) has calculated an Acute Reference Exposure Level (acute REL) of 76 ppb for a one-hour exposure. This acute REL is the concentration at which scientists are reasonably confident that no adverse effects would be experienced by sensitive individuals exposed for one hour. Individuals can be exposed to this level without immediate health effects, such as eye or throat irritation. For an eight-hour exposure time, no short-term adverse effects would be expected to occur if average levels do not exceed 27 ppb (OEHHA's interim 8-hour REL).

However, people often spend more than eight hours a day in their homes; infants, young children and the infirm sometimes spend virtually the entire day inside their home. Thus, it is highly desirable that residential levels remain well below 27 ppb to avoid acute effects in such individuals. To avoid irritant effects, air concentrations in new homes, including manufactured homes, also should not exceed 27 ppb. Because materials off-gas formaldehyde over time, levels in new homes should decrease well below this level over time, unless new sources are brought into the home.



Can I measure the formaldehyde inside my home?

It is generally not necessary to measure the formaldehyde in your home; taking the actions recommended in this guideline will usually lower your levels to acceptable levels. However, if you have large or numerous formaldehyde sources in your home, you may want to measure the formaldehyde level inside your home.

Home test kits are available that can provide a measure of the average indoor level during the test period, usually five to ten days. These kits cost about \$90. For more information on home formaldehyde testing, contact us as indicated below. For more comprehensive testing, you will need to hire an indoor air quality test service.

Formaldehyde levels typically fluctuate over time: they increase with higher temperatures and humidity. Simple factors such as the location of the sampler (upstairs or downstairs) or number of times doors and windows are opened

during the day can also significantly affect test results. You may want to test in both summer and winter.

A few final words

Remember that the most important action you can take to prevent excessive formaldehyde exposure is to **reduce the formaldehyde sources in your home**. Building materials and certain coatings are often the major sources in homes. If you have large amounts of pressed wood products and other formaldehyde sources already in your home that cannot easily be removed, the best way to reduce your exposure to formaldehyde is to ventilate your home with outdoor air, maintain moderate temperatures, prevent excessive humidity, and do not bring additional sources into your home.

For More Information...

For more information on formaldehyde and other indoor air quality topics, check our web site at <http://www.arb.ca.gov/research/indoor/indoor.htm>.

For more information on home test kits or information not available on our website, please contact us at:

California Air Resources Board
Indoor Exposure Assessment Section
Research Division
P.O. Box 2815
Sacramento, CA 95812
(916) 322-8282 (Indoor Air Quality Message Line)
(916) 445-0753
General air quality information: (916) 322-2990 (Public Information Office)

You may also wish to check the following websites:

California Department of Health Services
Indoor Air Quality Program
<http://www.dhs.ca.gov/IAQ> or <http://www.cal-iaq.org/>
(includes list of California indoor air quality consultants)

California Office of Environmental Health Hazard Assessment
<http://www.oehha.ca.gov/air.html>

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