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ASBP The Alliance for Sustainable Building Products

FORMALDEHYDE

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What is Formaldehyde?

Formaldehyde is a simple chemical made of carbon, hydrogen and oxygen. It is naturally occurring and present all around us. Formaldehyde is made by the human body and occurs naturally in the air we breathe.

Industrially, formaldehyde is an important chemical used to make other chemicals. It is a raw material in as many as 85 industries and is used to make hundreds of different types of products, ranging from home furnishing, household cleaners, paints, resins and pesticides through to medicinal and personal care products. Worldwide, approximately 21 million tonnes of formaldehyde are produced annually, half of which are used to make resins, including those for the manufacture of wood-based panels.

At room temperature, formaldehyde is a colourless gas, which can be detected by smell, depending on concentration and sensitivity. Formaldehyde is just one chemical in a large family of chemical compounds commonly referred to as volatile organic compounds (VOCs), which means that they vaporise or become a gas at room temperature. Whilst known commonly as VOCs the World Health Organisations (WHO) actually has three classifications based on boiling point.

Very Volatile Organic Compounds (VVOCs)
Permanent gases (e.g. methane, **formaldehyde**)
Boiling point range <50-100°C

Volatile Organic Compounds (VOCs)
Exist in both gas and liquid/solid state
Boiling point range <50-100°C to 240-260°C

Semi-Volatile Organic Compounds (SVOCs)
Exist primarily in semi-solid/solid state
Boiling point range 240-260°C to 380-400°C

Background levels of formaldehyde in the environment

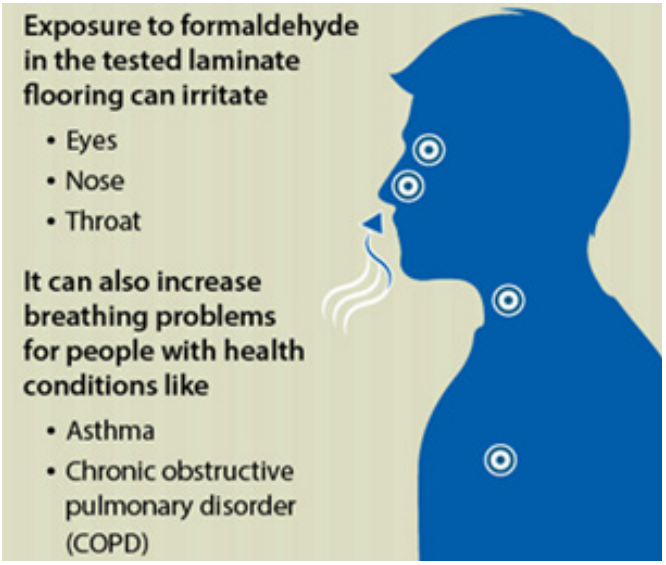
Formaldehyde is normally present in the environment at low levels approximately 0.03 ppm (parts per million). It does not accumulate in the environment, because it is broken down within a few hours by sunlight or bacteria in the soil. Outdoor areas in rural environments generally have lower concentrations than outdoor areas in the urban environments. In outdoor urban areas, levels of formaldehyde are more variable and depend on local conditions such as traffic flow, weather conditions and pollution levels.

Levels of formaldehyde indoors are often higher than those outdoors due principally to the off-gassing of products, a problem which came to prominence in the 1980s.

Why should we be concerned about formaldehyde?

Formaldehyde exposure may potentially cause a number of symptoms and adverse health effects such as eye, nose, throat and skin irritation, respiratory problems – coughing and wheezing as well as allergic reactions. Long term exposure at high level has been associated with cancer and in 2006 the International Agency for Research on Cancer (IARC) published its recommendations on formaldehyde stating that, *"there is sufficient evidence in humans and in experimental animals for the carcinogenicity of formaldehyde"* and that, *"formaldehyde is carcinogenic to humans (Group 1)"*.

Formaldehyde exposure impacts people differently. Some people are very sensitive to formaldehyde at certain levels while others may not have any noticeable reactions at the same level of exposure. Sensitivity to formaldehyde may change over time. Children, older adults, and people with asthma or other breathing problems are most at risk.



Who should be concerned about formaldehyde?

We should all be concerned about the quality of the air we breathe at home, work, indoors and outdoors. Since formaldehyde emission was identified as a potential contributor to poor indoor air quality, efforts have been made by both government and industry to reduce it, including the establishment of occupational and residential exposure limits.

Employers

Under the law, employers are responsible for health and safety management (see www.hse.gov.uk). As an employer it is your duty to protect the health, safety and welfare of your employees and other people who may be affected by your business, effectively controlling any risks to injury or health that could arise in the workplace. You should control levels of formaldehyde in your workplace and ensure that you comply with the occupational exposure limits (see Table 2 below).

Employees

As an employee, your employer must give you information about the risks in your workplace and how you are protected. They should instruct and train you on how to deal with risks. You have a duty to take care of your own health and safety and that of others who may be affected by your actions, and you must co-operate with your employers and co-workers to help everyone meet their legal requirements.

Public

As a member of the public you may unknowingly come into contact with products that contain formaldehyde on a daily basis. For most people, low level exposure to formaldehyde will not produce any adverse effects, for sensitive people however, the effects may be different. If you are sensitive to formaldehyde you will need to avoid many of these everyday items to reduce the possibility of suffering from symptoms.

Formaldehyde in the wood based industries

Most of the focus within the wood industry in relation to issues around formaldehyde has been focused around products that use formaldehyde based glues (such as particleboard, MDF and plywood). Tests to measure emissions have been agreed and categories of emissions levels have been approved in different countries. Over the last 30 years, emissions from wood based panels have fallen from approximately 3 ppm to 0.1ppm (see Table 3 below). Legislation covering levels of formaldehyde emissions from wood-based products are now in place and there is increased focus and controls on products known to release formaldehyde.

Wood – the raw material

All species of wood contain and emit small amounts of naturally occurring formaldehyde. Formaldehyde can be formed from the main components of wood, cellulose, hemicelluloses and lignin as well as from extractives. Formaldehyde emissions from wood depend on a number of variables including species, temperature and humidity. Emissions of formaldehyde from wood, which do not contain adhesive resin have been explained by the thermal degradation of polysaccharides in the wood and have been shown to rapidly decrease to levels below those set by EN717-1 and EN717-2 (the test methods used to classify formaldehyde emissions for wood-based panels). Table 1 below shows formaldehyde emission values for some softwoods and hardwoods using test methods employed in the panels industry.

Table 1: Formaldehyde emission values measured with EN717-1 (ppm) and EN 717 (mg/m2h) for some solid wood samples.

	Formaldehyde emission values	
Wood species	*ppm*	*mg/m2h*
Beech	0.0068	0.084
Poplar	0.0042	0.014
Birch	0.0036	0.049
Oak	0.0042	0.014
Pine	0.0053	0.016
Spruce	0.0055	0.069

Panel product manufacture

Within the panel product industries there are two main areas of concern when it comes to formaldehyde emissions arising from the binder used; firstly its presence in the work environment where panels are being manufactured and secondly within the products themselves and how those products are subsequently used. In the wood-based panels industry wood particles are bonded with urea formaldehyde, melamine formaldehyde, melamine-urea-formaldehyde and/or phenol-formaldehyde. The mattress formed from the wood and resin is compacted into the required density and thickness and hot pressed to cure the resin and bind the particles together. After the hot press, the boards are cooled before being cut and finished.

The work environment

Highest exposure within the manufacturing process is likely to be in the areas of the factory where resin is being applied, boards are being hot pressed and where panels are cooling after pressing. Within the work environment employers will need to follow HSE guidelines and comply with occupational exposure limits (OELs) for formaldehyde, which vary from country to country, illustrated in Table 2.

Table 2: Occupational exposure limits (OELs) and maximum exposure limits (MEL) for formaldehyde

	Occupational Exposure Limits (OELs) for formaldehyde (IARC 2006. FormaCare 2007. Q&A on formaldehyde)		Formaldehyde maximum exposure limits (MEL) in the living space in various countries (as in 1999)
Country	*Concen-tration (ppm)*	*Type*	*HCHO MEL, living space (ppm)*
Austria	0.3	TWA	0.1
Belgium	0.3	Ceiling	-
Denmark	0.3	TWA & STEL	0.12
France	0.5	TWA	-
Germany	0.3	TWA	0.1
Greece	0.3	TWA	-
Ireland	2.0	TWA	-
Italy	0.3	Ceiling	-
Nether-lands	1.0	TWA	-
Norway	0.5	TWA	0.1
Spain	0.5	STEL	-
Sweden	0.5	TWA	0.2
Switzerland	0.3	TWA	0.1
UK	2.0	TWA	-

TWA (Time weighted average) - This is the average concentration calculated using the duration of exposure to different concentrations of the chemical in air during a specific time period, usually a normal 8-hour working day and 40 hour week, to which nearly all workers may be exposed day after day without harmful effects. With the TWA higher and lower exposures are averaged over the day or week.

STEL (Short-Term Exposure Limit) - is the average concentration to which workers can be exposed for a short period of time (usually 15 minutes) without experiencing irritation, long-term or irreversible tissue damage, or reduced alertness. The aim of STEL is to prevent adverse health effects and other unwanted effects due to peak exposure that may not be controlled by the application of an 8 hour TWA limit. The number of times the concentration reaches the STEL and the amount of time between these occurrences can also

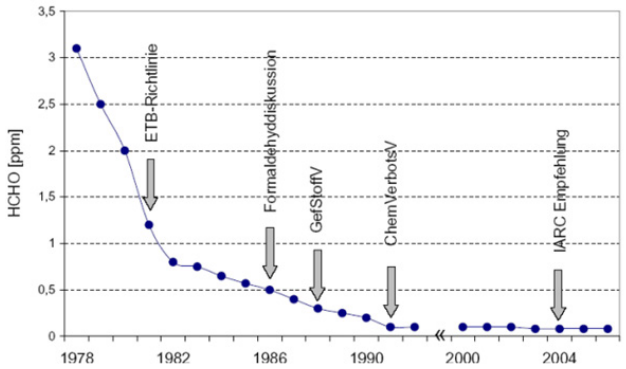
be restricted.

Ceiling (C) - exposure limit is the concentration which should not be exceeded at any time.

Wood-based panel products and applications

Wood-based panels are widely used to manufacture furniture, particularly particleboard and MDF, and in home constructions (for wall partitioning, ceilings, flooring and finishing). Particleboard is one of the most important panels within the EU wood-based panels industry, followed by MDF and plywood. Particleboard and MDF are mostly used in the furniture sector and a large and increasing amount of MDF goes into laminate flooring, very little MDF is used in the building industry.

The figure below (Marutzky,R; 2008) shows how the wood based panel industry has responded to changes in standards over time and significantly reduced formaldehyde emissions from panels. E1 panels currently have a level of 0.1 ppm. Other, lower limits are also set in different countries, regions and by various organisations. For example to apply the voluntary Blue Angel label to a panel would require levels of below 0.05 ppm, while the eco-label Natureplus would be 0.036 ppm (equivalent) which is in line with the standards set by members of the German Association of Prefabricated Houses (BDF) requiring members to uses panels with 0.03ppm emissions.



Marutzky.R (2008) Opening and Thematic Introduction, Proceedings of the Technical Formaldehyde Conference. WKI 13-14 March 2008, Hannover, Germany

European formaldehyde limits for wood based panels are summarised in the harmonised standard EN12986 which includes the emission classes E1 and E2. In addition to these standards, some countries and companies have set their own limits:

- Germany, Austria, Denmark and Sweden require compliance with emission limits of 6.5 mg/100g dry board.
- The European Panel Federation (EPF7) decided to draw up its own standard (eg for particleboard 4mg/100g and for MDF 5mg/100g (thickness > 8mm)
- The EPF agreed in 2011 on a reduction in formaldehyde emission for CE labelling, uncoated wood panels for construction that should not exceed 0.065ppm
- IKEA has set its own emission limits of half E1- so called E0.5 (0.05 ppm, IOS-MAT-003) although not yet recognised officially by CEN

Table 3: Formaldehyde limits from wood based panels according to European Standards

Emission type / board class	European standard / test method	Limit value for formaldehyde release
E1 Particleboard, MDF, OSB, Plywood (coated and uncoated)	EN 13986 / EN 717-1 Chamber EN 120 Perforator EN 717-2 Gas analysis	≤ 0.124 mg/m3 air (0.099ppm) ≤ 8.0 mg/100g oven dry board ≤ 3.5 mg/m2h
E2 Particleboard, MDF, OSB, Plywood	EN 13986 / EN 717-1 Chamber EN 120 Perforator EN 717-2 Gas analysis	> 0.124 mg/m3 air (0.099ppm) > 8.0 mg/100g oven dry board > 3.5 mg/m2h

Exposure to formaldehyde in the woodworking industries

In industries such as furniture making, sources of formaldehyde emission come primarily from the type of coatings used and from formaldehyde-based resins used to join different elements of the furniture components together. This is also the case for laminate and parquet flooring. Formaldehyde can be released during the preparation of paints and varnishes, their

application and drying. In a factory situation, paint application can be made inside well ventilated spray booths, so that the formaldehyde is exhausted and does not contaminate the work environment and exceed OELs. In an onsite situation where say fixtures are being fitted, laminate flooring being laid or paints and varnishes being applied control of exposure to formaldehyde and other VOCs may be harder to control. Good health and safety practices should be followed and consideration made to use alternative materials, which emit lower levels of formaldehyde and VOCs.

What is a safe level of exposure?

Opinions and data varies as to what is a safe level of exposure, as more research is carried out and more studies into the effects, not just of formaldehyde but other chemicals, are undertaken. Improved data sets will help to inform decision-making. Already we know acceptable levels have been reduced significantly over the years, but as yet there is no consensus on absolute values. It could be considered best practice to follow the highest standards and regulations set rather minimum levels. The bullet points below shows the levels recommended in various situations:

- **100 µg/m^3** is recommended to prevent sensory irritation in the general population. Perception of odour starts at around 120 µg/m3 although some people will detect at lower concentrations.
- **210 µg/m^3** is recommended for protection of long term effects including cancer. [1]
- **2500 µg/m^3** (2ppm) is the HSE Workplace Exposure Limit (10 minutes) [2]

[1] WHO Guldelines for Indoor Air Quality, 2010 - chapter 3 "guidelines" section in page 140/141

[2] HSE EH40/2005 Workplace Exposure Limits

Table 4 shows comparatively how exposure mean and maximum exposure levels for formaldehyde have been set in different countries and at different times. The table shows levels reducing significantly over time.

Table 4: Mean and Maximum Exposure levels

Country/ Organisation/ Year	Mean (95th percentile) (µg/ m3)	Max (µg/m3)
BRE UK 1999	61.2	171
GER ES IV Germany 2003-2006	47.7	68.9
EPOLIS Finland	41.4	77.8
French Observatory 2003 - 2005	46.7	86.3
Canada 2005	29.5	-
Japan 1996	78	600
Japan 2005	31	300

Symptoms and potentially adverse health effects

The health risks from exposure to formaldehyde (like any chemical) depends on how much is in the air and how long and how often a person is exposed to it. People respond differently to formaldehyde and a level that cause symptoms in one person (see table below) may cause no apparent effects in another. Peoples responses may change over time so although someone may not have reacted to low levels of exposure in the past that may not be true in the future and sensitisation may take place which could lead to an allergic reaction.

Table 5: Body areas affected and the potential health effects

Areas/ systems affected	Potential adverse health effects
Eyes	• Stinging, burning, itching • Excessive tear production
Nose and throat	• Stinging, burning, itching • Sore throat, Runny nose • Blocked sinuses • Sneezing • Cancer (human and laboratory animals)
Respiratory	• Chest tightness • Wheezing • Asthma

Skin	• Allergic contact dermatitis • Rashes, blisters and flaky dry skin
Neurological	• Headaches • Mood changes (depression, irritability) • Insomnia • Attention deficit • Nausea • Impairments in dexterity, memory and equilibrium

Indoor sources of formaldehyde

Within the indoor environment (homes, offices, schools, hospitals etc.) formaldehyde emissions may arise from a variety of products and activities (See below). Whist the wood-based industries have made great progress in reducing emission levels over the last 10 – 20 years further progress can still be made in this and other sectors. More comprehensive studies monitoring indoor environments will in the future hopefully lead to more focused advice on key products, activities and building practices leading to improved indoor air quality. Improving indoor air quality and reducing emission levels of formaldehyde and other VOCs is important because of the amount of time people spend indoors, estimated to be about 90%.

Indoor sources of formaldehyde include:

Building related materials
- Paints and varnishes
- Adhesives
- Carpet and vinyl flooring
- Composite wood products

Home based products
- Air fresheners
- Cleaning products
- Cosmetics
- Upholstery and foams

Activities
- Smoking
- Dry cleaning
- Photocopiers
- Cooking
- Burning fuels

Factors influencing formaldehyde levels indoors

Formaldehyde levels in indoor environments can vary depending on a number of variables. Indoors formaldehyde levels may change day-to-day, season, day-to-night etc. Understanding these factors is important especially if considering measuring formaldehyde levels.

Formaldehyde source - Type of product: paint, floor covering, furniture, woodbased panel, solid wood, household cleaners etc.

Age of product – Generally emissions decrease with age; products with sealed surfaces and edges emit less; products with a large surface area or that have been treated with certain finishes have potentially increased emissions

Temperature - increased emissions with increased temperature

Humidity - increased emissions with increased humidity

Air exchange rates - increased build up with a decrease in air exchange rate

Ambient outdoor or indoor ozone concentration - In presence of ozone formaldehyde levels increase, e.g. where there are high levels of pollution

Reducing existing formaldehyde levels

The method used to reduce indoor air formaldehyde levels is unique to each situation. Common methods of reduction include:

- Remove formaldehyde emitting products
- Increase ventilation to bring fresh air in, open doors and windows or use exhaust fans
- Seal the surface of formaldehyde emitting products that are not already laminated or coated (NB seal completely using a product that does not contain formaldehyde)
- Install ultra-low or no-add formaldehyde products (eg wood based panels, laminate flooring) – look for and ask for products labelled “No VOC/low VOC”
- For new products it is recommended to wash some

clothing and furnishings (eg curtains) before use or to let new products release formaldehyde/ VOCs outside of your living space before installing them.

Still concerned about formaldehyde? What to do next

If you are concerned that you have formaldehyde related symptoms that lessen when you are away from the home or office but re-occur upon your return, you should take action and you may want to contact your doctor or local health department for further assistance.

Look at your environment and try to determine if your symptoms are related to formaldehyde exposure.

- Do you or others smoke indoors?
- Have there been any changes in your environment such as refinishing/fitting of flooring or cabinets?
- Has new furniture / curtains been installed?
- Has a wood-burning stove or other combustion source been used?
- Has your house been tightly insulated / made air tight recently for energy efficiency?

You may want to test for formaldehyde in the indoor environment, in your home, work place or school to check the levels and see if you can identify a source or reason if levels are high so that mitigating action can then be taken. There are a number of professional laboratories that will do this testing for you, indoor air quality related issues can be complex and are often related to design and function so good sampling methods are required. Consumer sampling kits are available which consist of a badge or vile that is opened and placed in a representative area for a defined period of time, the sampler is then sealed and returned to the supplier/laboratory for analysis.

Sources of further information and advice

- **Allergy UK** - www.allergyuk.org; Helpline 01322 619898
- **Alliance for Sustainable Building Products** - www.asbp.org.uk
- **HSE** - www.hse.gov.uk
- **Waverton Analytics** - www.waverton-iaq.com