

Formaldehyde and Engineered Wood Products



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Formaldehyde is a naturally occurring organic airborne chemical that can be synthesized for certain industrial uses such as adhesives used for wood products and in the manufacture of many other household goods such as medical products, carpets and cosmetics. Because elevated levels of formaldehyde may lead to health concerns, regulations exist to limit exposure. These include limits on formaldehyde emissions from some types of wood products. In addition, some green building specifications create preference for low emitting products. This *Technical Note* provides facts on formaldehyde and regulations applicable to engineered wood products.

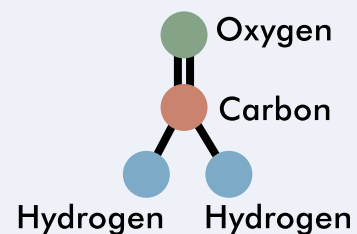
FORMALDEHYDE

At room temperature, formaldehyde is a colorless gas which has a pungent smell at higher concentrations. Small amounts of formaldehyde are naturally produced by humans, animals and plants and may be emitted by fruits, vegetables, trees and raw wood. Formaldehyde is naturally present in outdoor air. Compared to rural air, urban outdoor air concentrations of formaldehyde are typically higher due to human activities such as traffic and other combustion sources. Indoor air may contain formaldehyde from products that emit formaldehyde as well as from combustion sources such as cigarette smoking, cooking or heating fuels. Table 1 shows levels of formaldehyde exposure measured from some typical household activities.

When formaldehyde is emitted into air, it is broken down into carbon dioxide, usually within hours. Formaldehyde is naturally attracted to water, where it is readily absorbed and breaks down. Formaldehyde does not build up in humans or plants. Further information on formaldehyde is cited in the reference section of this publication.

WHAT IS FORMALDEHYDE?

Formaldehyde is a simple chemical made of hydrogen, oxygen, and carbon. It occurs naturally, and is the product of many natural processes. It is made by human bodies and is in the air. Plants and animals also produce formaldehyde. It is in many fruits and vegetables, and is a byproduct of cooking certain vegetables, such as brussel sprouts and cabbage. This chemical breaks down quickly and is metabolized to simple carbon dioxide. Our bodies readily break down the low levels to which people are exposed everyday.



Formaldehyde is also a product from combustion associated with the burning of kerosene and natural gas; automobile emissions; and cigarettes. It is an important industrial chemical used in the manufacture of numerous consumer products, including permanent press fabrics and even toothpaste.

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TABLE 1

VARIOUS FORMALDEHYDE EXPOSURE LEVELS

Source/Description	Expected Exposure, parts per billion (ppb)	Footnote (see below)
Painting a 12 ft x 12 ft x 9 ft room	968	(a)
Wallpapering a 12 ft x 12 ft x 9 ft room	2051	(a)
Broil fish using a gas or electric range	105	(b)
Gas range in self-clean mode	337	(b)
Electric range in self-clean mode	183	(b)
One cigarette in small room	49	(c)
Human breath	Around 2	(d)
Typical indoor air	10-30	(e)
Urban air	5-100	—
Rural air	0.8-5	—
Raw wood (emission chamber)	20	—

(a) Calculated from data taken from the Batelle report for the California Air Resources Board, *Determination of Formaldehyde & Diisocyanate Emission from Residential Indoor Sources*, Contract No. 93-9315, Final Report 1996.

(b) *Indoor Air Quality Residential Cooking Exposures Final Report*, prepared for the California Air Resources Board, CARB Contract Number 97-330, prepared by Ray Fortmann, Peter Kariher, and Russ Clayton, ARCADIS, Geraghty & Miller, Inc, November 30, 2001.

(c) Reference taken from the *International Programme on Chemical Safety, Environmental Health Criteria 89* published under the joint sponsorship of The United Nations Environment Programme, The International Labour Organization, The World Health Organization, Geneva, 1989.

(d) *Mass Spectrometric Profile of Exhaled Breath* – field study by PTR-MS, Berthold Moser, Florian Bodrogi, Guenther Eibl, Matthias Lechner, Josef Rieder, Philipp Lirk, 2004.

(e) *Interim Findings on Formaldehyde Levels in FEMA-Supplied Travel Trailers, Park Models and Mobile Homes* from the Centers for Disease Control and Prevention, February 29, 2008.

FORMALDEHYDE STANDARDS AND REGULATIONS OF WOOD PRODUCTS

Because some adhesives used to produce composite wood products contain formaldehyde, limits on emissions from pressed wood products have been developed in product standards and state and national regulations. In the U.S., formaldehyde regulations of composite wood products began in the early 1980s for particleboard and decorative plywood panels used in manufactured homes (HUD CFR 3280.308). Data indicated that emission levels from moisture resistant phenol formaldehyde adhesives used for structural plywood were very low; therefore the HUD regulations explicitly excluded plywood made with phenol formaldehyde adhesives.

This *Technical Note* provides information on formaldehyde regulations that apply to U.S. and Canadian structural engineered wood products. For purposes of this *Technical Note*, “engineered wood products” are defined as wood products recognized in the U.S. and Canadian building codes for structural applications. Because the vast majority of North American construction involves site-built conditions where exposure to weather is expected, the standards for engineered wood products require moisture-resistant adhesive systems. The inherent structural and moisture durability of these adhesive systems naturally results in very low formaldehyde emissions. Table 2 provides definitions of the standards, adhesive systems and applications for engineered wood products.

TABLE 2

DESCRIPTION OF U.S. AND CANADIAN ENGINEERED WOOD PRODUCTS**U.S. and Canadian Engineered Wood Products**

Product	Applicable Standard(s)^(a)	Adhesives	Uses
Structural Plywood	<i>U.S. Voluntary Product Standard PS 1-09 Structural Plywood, U.S. Voluntary Product Standard PS 2-10 Performance Standard for Wood-Based Structural-Use Panels, CSA O121 Canadian Douglas-fir Plywood and CSA O151 Canadian Softwood Plywood</i>	Phenol formaldehyde	Sheathing for walls, floors, roof and other industrial and construction uses
Oriented Strand Board (OSB)	<i>U.S. Voluntary Product Standard PS 2-10 Performance Standard for Wood-Based Structural-Use Panels, and CSA O325, Construction Sheathing</i>	Phenol formaldehyde, pMDI ^(b)	Sheathing for walls, floors, roof and industrial uses
Structural Glued Laminated Timber	<i>ANSI A190.1 Structural Glued Laminated Timber, CSA O122 Structural Glued-Laminated Timber and CSA O177 Qualification Code for Manufacturers of Structural Glued Laminated Timber</i>	Phenol resorcinol formaldehyde (PRF), melamine, polymer isocyanate ^(c)	Beams, headers, columns, trusses
Prefabricated Wood I-joists	<i>ASTM D5055 Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists</i>	Phenol formaldehyde, melamine, polymer isocyanate ^(d)	Floor joists, roof rafters
Structural Composite Lumber (SCL) ^(e)	<i>ASTM D5456 Standard Specification for Evaluation of Structural Composite Lumber Products</i>	Phenol formaldehyde, pMDI ^(f)	Beams, headers, studs, flanges of I-joists
Specialty Products – Cross Laminated Timber (CLT), Rim Board, Engineered Wood Siding	<i>ANSI/APA PRG 320 Standard for Performance-Rated Cross-Laminated Timber, ANSI/APA PRR 410 Standard for Performance-Rated Engineered Wood Rim Boards, ANSI/APA PRP 201 Standard for Performance-Rated Engineered Wood Siding, and ICC ES AC 321</i>	Phenol formaldehyde, pMDI	Specialty construction uses

(a) Complete citation of standards is provided in the reference section at the end of this publication

(b) pMDI = Polymeric Methylene Diphenyl Diisocyanate

(c) ANSI A190.1 adhesives must also meet ANSI 405 and ASTM D2559

(d) Adhesives used to adhere components must meet ASTM D2559 and D7247 in the U.S., and CSA O112.7, O112.9 or O112.10 in Canada

(e) SCL includes laminated veneer lumber (LVL), parallel strand lumber (PSL), oriented strand lumber (OSL) and laminated strand lumber (LSL)

(f) Adhesives must meet ASTM D2559, D5456, and D7247 in the U.S. and CSA O112.6, O112.9 or O112.10 in Canada

U.S. AND CANADIAN FORMALDEHYDE REGULATIONS APPLICABLE TO OTHER WOOD PRODUCTS

1. U.S. HUD Manufactured Home Construction and Safety Standard (CFR 3280.308)

This standard specifies a 0.20 ppm emission limit for plywood and a 0.30 ppm limit for particleboard when tested with the ASTM E1333 Large Chamber Method. The intent was to regulate the specific nonstructural panel types. Testing during development of the regulation confirmed PS 1 structural plywood readily meets the plywood emission limit; therefore the regulation explicitly exempts phenolic bonded plywood from ongoing testing and certification. Therefore, **the engineered wood products in Table 2 are either not covered by, or are explicitly exempt from, the HUD regulation.**

2. California Air Resources Board (CARB) Air Toxic Control Measure (ATCM) for Composite Wood Products

This regulation was developed by a division of the California EPA and took effect in 2009. The scope of the standard covers particleboard, MDF and hardwood plywood. The demonstrated low emission levels of the engineered wood products listed in Table 2, led the CARB regulation to **explicitly exempt structural plywood specified to PS 1, structural panels specified to PS 2, OSB specified to PS 2, structural composite lumber specified to ASTM D5456, structural glued-laminated timber specified to ANSI A190.1 and prefabricated wood I-joists specified to ASTM D5055.**

3. U.S. Formaldehyde Standards for Composite Wood Products Act

This Federal Act was signed into law July 2010 and instructed the EPA to publish implementation rules by January 2013. The act mirrors the standard established by the California Air Resources Board and it **explicitly exempts structural plywood specified to PS 1, structural panels specified to PS 2, OSB specified to PS 2, structural composite lumber specified to ASTM D5456, structural glued-laminated timber specified to ANSI A190.1 and prefabricated wood I-joists specified to ASTM D5055.**

4. Health Canada Guidelines

Wood products manufactured in Canada are not regulated for formaldehyde emissions. Health Canada provides guidelines for residential indoor air quality and the recommended formaldehyde exposure levels (<http://www.hc-sc.gc.ca/ewh-semt/pubs/air/formaldehyde-eng.php>). The engineered wood products in Canada and the U.S. are manufactured under similar product standards and adhesives, and have similar product performance and formaldehyde emission characteristics, which have been proven to meet the most stringent formaldehyde regulations around the world (see the following sections).

INTERNATIONAL REGULATIONS FOR ENGINEERED WOOD PRODUCTS

Wood product standards in other countries often group structural and nonstructural panel types into a common standard, whereby the moisture resistance and formaldehyde emission characteristics are evaluated to specific criteria. Some North American engineered wood products have been evaluated to these international formaldehyde emission standards. Following are summary conclusions:

1. The Japanese Agricultural Standards (JAS) use the JIS A1460 test method that measures the emissions for wood products when enclosed in a desiccator. The most stringent formaldehyde limit is the F**** designation whereby the product must have average emission level below 0.30 mg/l. U.S. and Canadian structural plywood (PS 1, PS 2, CSA O121, or CSA O151), OSB (PS 2 or CSA O325), structural glued-laminated timber (ANSI A190.1, CSA O177, or CSA O122) and Structural Composite Lumber (ASTM D5456) easily and consistently meet the F**** requirements when evaluated to the respective JAS standard. This formaldehyde regulation is considered one of the most stringent limits in the world.
2. U.S. and Canadian OSB and plywood panels sold in Europe for construction uses must meet the specific product standard for the panel type (such as EN 300 for OSB and EN 636 for plywood) and the general panel standard EN 13986 used for construction applications throughout the European Union. The European standard for formaldehyde emissions is EN 717-1 which uses a one cubic meter chamber to measure emission levels. U.S. and Canadian structural plywood (PS 1, PS 2, CSA O121, or CSA O151) and OSB (PS 2 or CSA O325) easily meet the 0.124 mg/m³ limit of the E1 class, the most stringent formaldehyde class based on EN 717-1.
3. Laminated Veneer Lumber (LVL) is regulated in Australia by evaluation of formaldehyde emissions using the AS/NZS 4357.4 test method. This method is very similar to the JIS A1460 test method used in the JAS standards. U.S. and Canadian LVL made to ASTM D5456 has easily and consistently met the 0.5 mg/l limit which qualifies it for the E₀ rating, the most stringent rating in AS/NZS LVL standards.
4. The Korean Standard KS M 1998:2009 for determination of formaldehyde in building interior products is a method very similar to the JIS A1460 desiccator method. The most stringent formaldehyde limit for timber building products in Korea is the SE₀, with an average below 0.3 mg/l. U.S. and Canadian structural plywood (PS 1, PS 2, CSA O121, or CSA O151), OSB (PS 2 or CSA O325), structural glued laminated timber (ANSI A190.1, CSA O177 or CSA O122) and Structural Composite Lumber (ASTM D5456) easily and consistently meet the SE₀ requirements when evaluated to methods similar to the Korean standard.

In summary, when tested to international formaldehyde emission limits, North American engineered wood products have consistently met the most stringent emission regulations.

GREEN BUILDING SPECIFICATIONS

Green building rating systems often include criteria to address indoor air quality goals, including mitigation of formaldehyde concentrations or formaldehyde-emitting products. Some of these specifications are relevant to engineered wood products as follows:

1. LEED v4

This popular rating system uses a point rating system for green buildings. The indoor Environmental Quality Credit includes “Low-Emitting Materials—Composite Wood.” The section criteria specifies products that meet the California Air Resources Board Air Toxics Control Measure for Formaldehyde Requirements for Ultra Low-Emitting Formaldehyde (ULEF) Resins or “no added formaldehyde resin.” All of the products within Table 2 automatically meet the criteria for this section, and thereby are eligible for the point. As with other green building rating systems, final approval is subject to verification by the designer or approved professional that assesses LEED compliance.

2. 2012 National Green Building Standard ICC 700-2012

This national green rating program was developed as a consensus standard and adopted by the International Code Council as a reference standard for adoption by member code groups for residential construction. The criteria for formaldehyde emissions from composite wood products are similar to the LEED 2009 and CARB. **The engineered wood products listed in Table 2 are eligible for the points in Section 901.4(5) which require that a minimum of 85 percent of material within the product group is manufactured from composite wood products that contain no added urea-formaldehyde or are in accordance with the CARB regulations.**

3. CALGreen

This standard has been adopted into California State building law as a method to verify structures meet state environmental goals for buildings. The third edition of CALGreen (effective July 1, 2012) requires all new buildings (residential and nonresidential) as well as all remodels and additions to existing nonresidential buildings exceeding 2,000 square feet or \$500,000 must meet the mandatory requirements of CALGreen. CALGreen specifies that composite wood products used in the interior or the exterior of a building meet the CARB regulations. Similar to the CARB regulation, all structural engineered wood products are explicitly exempt from the requirement. **The engineered wood products in Table 2 are not within the scope of the CALGreen formaldehyde limits and are therefore permitted—(see also the previous section on CARB).**

REFERENCES

Engineered Wood Product Standards

U.S. Voluntary Product Standard PS 1-09 Structural Plywood

U.S. Voluntary Product Standard PS 2-10 Performance Standard for Wood-Based Structural-Use Panels

ANSI A190.1 Structural Glued Laminated Timber

ANSI 405 Standard for Adhesives for Use in Structural Glued Laminated Timbers

ANSI/APA PRG 320 Standard for Performance-Rated Cross-Laminated Timber

ANSI/APA PRR 410 Standard for Performance-Rated Engineered Wood Rim Boards

ASTM D2559 Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions

ASTM D5456 Standard Specification for Evaluation of Structural Composite Lumber Products

CSA O121 Canadian Douglas-fir Plywood

CSA O122 Structural Glued-Laminated Timber

CSA O151 Canadian Softwood Plywood

CSA O177 Qualification Code for Manufacturers of Structural Glued Laminated Timber

CSA O325 Construction Sheathing

Formaldehyde Emission Standards (for Wood Products)

JAS/JIS A 1460 Building Boards, Determination of Formaldehyde Emission—Desiccator Method

EN 717-1 Wood-Based Panels, Determination of Formaldehyde Release, Formaldehyde Emission by the Chamber Method

AS/NZS 4357.4 Structural Laminated Veneer Lumber, Part 4: Determination of Formaldehyde Emissions

KS M 1998:2009 Determination of the Emission Rate of Formaldehyde and Volatile Organic Compounds in Building Interior Products

Formaldehyde Regulations

HUD: standard is available at www.gpo.gov/fdsys/pkg/CFR-2010-title24-vol1/content-detail.html (search for cfr 3280, Manufactured Housing Construction Safety Standard)

CARB: www.arb.ca.gov/toxics/compwood/compwood.htm

EPA Federal Act: www.epa.gov/oppt/chemtest/formaldehyde/

CALGreen: www.documents.dgs.ca.gov/bsc/CALGreen/2010_CA_Green_Bldg.pdf

Formaldehyde Guidance

EPA Integrated Risk Information System: www.epa.gov/iris/subst/0419.htm

U.S. EPA: www.epa.gov/iaq/formaldehyde.html

U.S. Consumer Product Safety Commission: www.cpsc.gov/CPSCPUB/PUBS/725.html

ACC website: www.formaldehydefacts.org

U.S. Green Building Council website: www.usgbc.org/node/2614095?view=forum

Formaldehyde and Engineered Wood Products

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