

## TECHNICAL NOTE

# 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 a 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 that 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 brussels 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 every day. 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.

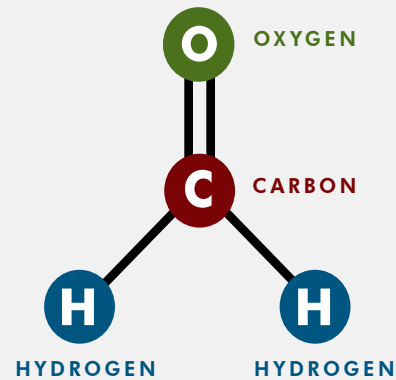


TABLE 1

### 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	—

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

Product	Applicable Standard(s) <sup>a</sup>	Adhesives	Uses
Structural Plywood	<i>U.S. Voluntary Product Standard PS 1 Structural Plywood, U.S. Voluntary Product Standard PS 2 Performance Standard for Wood Structural Panels, CSA O121 Canadian Douglas-fir Plywood and CSA O151 Canadian Softwood Plywood</i>	Phenol formaldehyde	Sheathing for walls, floors, roofs and other industrial and construction uses
Oriented Strand Board (OSB)	<i>U.S. Voluntary Product Standard PS 2 Performance Standard for Wood Structural Panels and CSA O325, Construction Sheathing</i>	Phenol formaldehyde, pMDI <sup>b</sup>	Sheathing for walls, floors, roofs and industrial uses
Structural Glued Laminated Timber (Glulam)	<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, polyurethane <sup>c</sup>	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 <sup>d</sup>	Floor joists, roof rafters
Structural Composite Lumber (SCL) <sup>e</sup>	<i>ASTM D5456 Standard Specification for Evaluation of Structural Composite Lumber Products</i>	Phenol formaldehyde, pMDI <sup>f</sup>	Beams, headers, studs, flanges of I-joists
Specialty Products – Cross Laminated Timber (CLT), <sup>g</sup> 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 210 Standard for Performance Rated Engineered Wood Siding and ICC ES AC 321</i>	Phenol formaldehyde, pMDI, melamine, polymer isocyanate, polyurethane <sup>g</sup>	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. 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 strand lumber (LSL), laminated veneer lumber (LVL), parallel strand lumber (PSL) and oriented strand lumber (OSL).  
f. Adhesives must meet ASTM D2559, D5456 and D7247 in the U.S. and CSA O112.6, O112.9 or O112.10 in Canada.  
g. Adhesives must meet ANSI/APA PRG 320.

Table 3 provides formaldehyde emission results from a limited APA test program, where engineered wood products were tested using the ASTM E1333 large chamber test method.

TABLE 3

**TEST RESULTS OF FORMALDEHYDE EMISSIONS FROM ENGINEERED WOOD PRODUCTS.<sup>a</sup>**

Product	Test Chamber Loading Ratio (ft <sup>2</sup> /ft <sup>3</sup> ) <sup>b</sup>	Range of Test Results (ppm)
Structural Plywood	0.130	0.01-0.04
OSB	0.130	0.02-0.03
LVL	0.016	0.00-0.01
I-joists	0.210	0.01-0.08

a. APA Report T2018L-18, Benchmarking Formaldehyde Emissions From Structural Plywood, OSB, LVL and I-joists.

b. Test chamber loading ratio in ASTM E1333 is defined as the surface divided by the chamber volume. The test method specifies loading ratios for some wood products, but does not specify loading ratios for structural engineered wood products. Loading ratios for structural engineered wood products were based on technical analysis of the surface area to air volume ratio of the products used in construction applications.

## U.S. and Canadian Formaldehyde Regulations Applicable to Engineered 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 regulations confirmed PS 1 structural plywood readily meets the plywood emission limit; therefore the regulations explicitly exempt 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 regulations.**

### 2. California Air Resources Board (CARB) Airborne Toxic Control Measure (ATCM) for Composite Wood Products (also known as Title 17, California Code of Regulation 93120)

These regulations were 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 regulations 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.** These exemptions apply to the product trademarked or audited by APA under the APA quality assurance program, regardless of whether the product is used in a construction application or in an industrial (manufacturing) application. Note that although CLT is not listed as an exempted product, CLT certified to ANSI/APA PRG 320 is made with moisture-resistant adhesives and has a low formaldehyde emission.

### 3. U.S. Formaldehyde Standards for Composite Wood Products Act (also known as EPA TSCA Title VI)

This Federal Act was signed into law in July 2010. The EPA published draft implementation rules in July 2016 for implementation of the law in 2018. The emission standard 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, as trademarked or audited by APA under the APA quality assurance program.** Note that although CLT is not listed as an exempted product, CLT certified to ANSI/APA PRG 320 is made with moisture-resistant adhesives and has a low formaldehyde emission.

### 4. Canadian Formaldehyde Emissions from Composite Wood Products Regulations

The Canadian government published the *Formaldehyde Emissions from Composite Wood Products Regulations* on June 17, 2021. The regulation comes into force 18 months afterward, and the requirements for laminated products will apply five years after the regulations come into force.

The regulations were developed following CARB and EPA TSCA Title VI to allow for uniform requirements for both the U.S. and Canada. **Therefore, the Canadian regulations also do not apply to structural plywood specified to PS 1, CSA O121 or CSA O151; OSB specified to CSA O325 or PS 2; structural glued laminated timber specified to CAN/CSA O122 or ANSI A190.1; prefabricated wood I-joists specified to ASTM D5055; structural composite lumber, including laminated strand lumber (LSL), laminated veneer lumber (LVL), parallel strand lumber (PSL) and oriented strand lumber (OSL) specified to ASTM D5456; and cross-laminated timber (CLT) specified to ANSI/APA PRG 320.** CSA O160, *Formaldehyde Emission Standard for Composite Wood Products*, is a voluntary standard providing the requirements for product sampling, emissions testing, marking and labeling for composite wood products in compliance with formaldehyde regulations in Canada.



## 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 level 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/m<sup>3</sup> 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 SE<sub>0</sub>, 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 SE<sub>0</sub> 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. U.S. Green Building Council (USGBC) 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 criteria specifies products that meet the California Air Resources Board (CARB) Airborne Toxic Control Measure for Formaldehyde Requirements for Ultra Low-Emitting Formaldehyde (ULEF) Resins or “no added formaldehyde resin” (NAF). LEED Interpretation (LI) 10466 was issued to clarify the applicability of structural engineered wood products in the LEED v4 low-emitting materials credit. It also clarifies that the scope of California Department of Public Health (CDPHH) Standard v1.1 does not apply to structural products. **Products specifically considered compliant as LEED low emitting materials include the referenced standards in Table 2 for structural plywood, oriented strand board, structural glued laminated timber, prefabricated wood I-joists, structural composite lumber and cross-laminated timber.**

### 2. National Green Building Standard ICC 700-2020

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 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 2019 edition of CALGreen requires all new buildings (residential and nonresidential) as well as all remodels and additions to existing nonresidential buildings exceeding 1,000 square feet or \$200,000 (Section 301.3 of CALGreen) 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 regulations, 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.**



#### 4. The EPA Indoor airPLUS Program

The EPA Indoor airPLUS program is a voluntary partnership and labeling system that helps new home builders improve the quality of indoor air by requiring construction practices and product specifications that minimize exposure to airborne pollutants and contaminants. EPA created the Indoor airPLUS program to help builders meet the growing consumer preference for homes with improved indoor air quality. Indoor airPLUS builds on the foundation of EPA's ENERGY STAR® requirements for new homes and provides additional construction specifications to provide comprehensive indoor air quality protections in new homes. Section 6.1 of the Indoor airPLUS program provides information for composite wood. For structural plywood and OSB, the program prescriptively recognizes that PS 1 and PS 2 panels meet the requirements of the program.

## References

### Engineered Wood Product Standards

*U.S. Voluntary Product Standard PS 1 Structural Plywood*

*U.S. Voluntary Product Standard PS 2 Performance Standard for Wood Structural Panels*

*ANSI A190.1 Structural Glued Laminated Timber*

*ANSI/APA PRP 210, Standard for Performance-Rated Engineered Wood Siding*

*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 Standard Specification for Adhesives for Bonded Structural Wood Products for Use Under Exterior Exposure Conditions*

*ASTM D5055 Standard Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists*

*ASTM D5456 Standard Specification for Evaluation of Structural Composite Lumber Products*

*ASTM D7247 Standard Test Method for Evaluating the Shear Strength of Adhesive Bonds in Laminated Wood Products at Elevated Temperatures*

*ASTM E1333 Standard Test Method for Determining Formaldehyde Concentrations in Air and Emission Rates from Wood Products Using a Large Chamber*

*CSA O112 Standards for Wood Adhesives*

*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)**

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

CSA O160 *Formaldehyde Emission Standards for Composite Wood Products*

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

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

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

### **U.S. Formaldehyde Regulations**

CALGreen: <https://www.dgs.ca.gov/BSC/CALGreen>

CARB: <https://ww2.arb.ca.gov/our-work/programs/composite-wood-products-program>

EPA Federal Act: <https://www.regulations.gov/document/EPA-HQ-OPPT-2016-0461-0001>

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

### **Canadian Formaldehyde Regulations**

Health Canada: <https://canadagazette.gc.ca/rp-pr/p2/2021/2021-07-07/html/sor-dors148-eng.html>

### **Formaldehyde Guidance**

ACC website: [www.formaldehydefacts.org](http://www.formaldehydefacts.org)

U.S. Consumer Product Safety Commission: <https://www.cpsc.gov/Regulations-Laws--Standards>

U.S. EPA: [www.epa.gov/iaq/formaldehyde.html](http://www.epa.gov/iaq/formaldehyde.html)

U.S. EPA Integrated Risk Information System: <https://www.epa.gov/iris>

U.S. Green Building Council LEED Interpretation website: <https://www.usgbc.org/leed-interpretations>

U.S. Green Building Council website: <https://www.usgbc.org/>

# Formaldehyde and Engineered Wood Products

We have field representatives in many major U.S. cities and in Canada who can help answer questions involving APA trademarked products. For additional assistance in specifying engineered wood products, contact us:

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