**Manufactured Housing Consensus Committee**
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January 28, 2005

Regulations Division
Office of General Counsel
Room 10276
U.S. Department of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410-0500

Re: Docket No. FR-4886-P-01
RIN 2502-AI12
**Manufactured Housing Construction and Safety Standards**

The following comments are submitted on behalf of the Manufactured Housing Consensus Committee (MHCC) and reflect the actions taken by the MHCC in the meeting on January 27, 2005 regarding these proposed rules.

The MHCC wants the public record to contain our appreciation of the Department of Housing and Urban Development (HUD)'s efforts to assist and work with the MHCC to develop this first set of changes to the Manufactured Housing Construction and Safety Standards (Standards) under the requirements of the Manufactured Housing Improvement Act of 2000 (2000 Act).

HUD's cooperation and efforts to expedite getting these proposed rules out for public comment in light of all the requirements on HUD in the 2000 Act deserves recognition.

The MHCC supports HUD's publishing these proposed changes to the Standards as final rules along with the few modifications / revisions / and additions recommended below.

- **3280.309 Formaldehyde Health Notice.**

  HUD is seeking comments on their rejection of the MHCC recommendation to not prominently display the Health Notice in each manufactured home. The reason for the rejection was "the MHCC did not provide or reference any data or studies supporting its recommendation to remove the requirement".

  The MHCC discussed this issue with HUD at the MHCC meetings in June and August of 2004. This discussion included a review of the data in the proposed rule in 1983 and the final rule in 1984 that led to the adoption of the formaldehyde standards in 3280.308 and the Notice requirements in 3280.309. Further, the MHCC reviewed several documents including: current data from NFPA supporting the MHCC recommendation to amend the standards to not "prominently display the Health Notice"; a Study by the Manufactured Housing Research Alliance dated July 2004; and current Environmental Protection Agency documents concerning

Formaldehyde that are on their Environmental, Health and Safety Online system (See attached documentation). It is important to note that the MHCC **is not recommending any change to the current standards regarding the formaldehyde emission controls;** we are only talking about the notice.

All of this information was considered by the MHCC in its August 2004 meeting in developing a recommendation that rather than totally eliminating 3280.309 (Notice), the MHCC would be in favor of revising 3280.309 and require the Notice to be provided in the homeowner's packet instead of having the Notice prominently displayed in the home. The MHCC at its January 27, 2005 meeting approved adoption of MHCC modified recommendation to include the health notice in the home owner's packet only and consider the attached documentation as data sufficient to support adding this recommendation to the final rule.

- **3280.206 Fire blocking.**

HUD modified the MHCC recommendation for fire blocking by removing the alternatives that would permit the use of mineral wool, cellulose insulation and other loose fill materials as acceptable material for fire blocking. HUD stated the removal was due to: "These types of insulation have not been adequately evaluated for transportation effects that could cause settling or shifting when installed around pipes or vents in furnace and water heater compartments".

The MHCC reviewed HUD's concerns and believe the original MHCC recommendation addressed those concerns with the wording: "Where it has been specifically tested in the form and manner intended for use to demonstrate its ability to remain in place and to retard the spread or fire and hot gasses". The MHCC at its January 27, 2005 meeting reaffirmed its initial recommendation and recommends allowing the use of these alternatives when they can demonstrate they will **remain in place** in the final rule.

- **Testing Protocols 3280.303 (g).**

HUD is seeking comments on whether the final approval of alternate test methods should be solely delegated to DAPIAS. The MHCC unanimously approved delegating the approval to the DAPIAS in its recommendation to HUD and continues to believe this is appropriate.

HUD currently relies on the DAPIAS to review and accept or reject all drawings, calculations, tests, and other justifications supplied by the manufacturer for the design of the home. As far as testing is concerned 3282.203(b)(11) requires the home manufacturer to submit "reports of all tests that were run to validate the conformance of the design to the standards." 3282.361(b) (2) states that DAPIAS "...shall require the submission of all drawings, specifications, calculations, and test records....of each manufactured home design or variation." Further, 3280.203(c) provide the necessary regulation to carry out the quality assurance manual approvals that include a review and approval of the designs, work flow, testing, quality control systems and calculations used by manufacturers to build to the Standards.

The MHCC noted this delegation is in line with current DAPIA authority and that HUD has sufficient remedies under the regulations to deal with a DAPIAS poor performance in any area of responsibility. The MHCC again reviewed its recommendation at the January 27, 2005 meeting and continues to recommend that HUD adopt this change as proposed by the MHCC in the final rule.

- **3280.305(c) (1) (ii) (B) Footnote 9 on One –Piece Metal Roofing.**

HUD has modified the note as proposed by the MHCC and in so doing destroyed the original intent of the MHCC recommendation. HUD states they are modifying the MHCC proposal to make it "consistent with the provisions of the Interpretative Bulletin I-2-98".

The intent of the MHCC proposal was to eliminate said IB by rendering it null and void, not to conform to it. (The record shows that IB I-2-98 when issued for public comment received 12 comments, all of which were negative, however, HUD ignored all 12 comments and issued the IB as proposed). HUD states they have modified the footnote "to indicate that test methods must be approved by HUD and comply with the requirements of 24 CFR 3280.303(c) and (g) and 3280.401 of the MHCSS".

The portion of HUD's argument dealing with 3280. 303 and 3280.401 is confusing since ALL test methods are already required to comply with 3280.303(c) and (g) and 3280.401. Therefore, the addition of this language to the note serves no purpose.

Notwithstanding, the MHCC's main objection is that HUD is trying to re-impose the very pre-approval of test methods by HUD staff that have been eliminated in the 3280.303(g) proposal contained in these proposed rules. [See discussion above on 3280.303(g)] As discussed above, there is no valid reason for such pre-approval by HUD. It is noted that HUD's proposal lacks any justification as to why it believes pre-approval by its staff for this one product/design is necessary when they are agreeing to eliminate pre-approval for all other current/future products anddesigns by changing 3280.303(g). The one-piece metal roof catenary design is much stronger than the prescriptive roof sheathing option currently permitted by footnote 7 to the table for resisting uplift loads.

The MHCC at the January 27, 2005 meeting recommended that HUD adopt MHCC'S recommendation in the final rule by using the wording as proposed by the MHCC.

- **Metric Units, page 70033**

"HUD has requested comments on the use of metric units of measurement in the Construction and Safety Standards. Comment is specifically requested on whether English and metric units should be used concurrently or whether only one or the other should be used. HUD is interested in any information on whether there are circumstances in which the use of one of these measurement systems would be more appropriate than the use of the other."

HUD should definitely concentrate on a single system of units and that system should be English. Most aspects of the construction industry have been, and will continue to be, slow to convert to metric. So a dual system would only confuse and take up additional space. One only has to look at the current model building codes to see how little is gained by the constant use of metrics in parentheses and in footnotes to tables.

There may be some isolated cases where the reference to metric in addition to English could prove helpful. In the case of small pressures, where Pounds per Square Inch (psi) or inches of water or inches of mercury have traditionally been used, Pascals is becoming the unit of choice. Some dial gauges, in fact, may only have Pascal increments. Having Pascal alternate numbers in parenthesis in these isolated cases could prove helpful.

- **Additional Testing 3280 305 (e) (2):**

HUD is requesting comments on whether these changes for critical connections in high wind regions should be implemented unless also supported by suitable load tests.

The MHCC did not believe "suitable load testing" is necessary when engineering calculations and analysis supports use of these materials and connections in the proposed rules presented to HUD. HUD has always allowed calculations and analysis to be used instead of testing. Testing, while more specific than calculations, is generally less conservative.

In fact it is generally understood that HUD will not allow testing of simple assemblies which can be easily calculated. Some of the connections used in high wind regions would fall into this situation and need to be calculated anyway. This change is also consistent with the preference to use "performance requirements" set forth in 3280.1.

The MHCC again reviewed our recommendation at the January 27, 2005 meeting and continues to recommend that the final rule does not need to require "suitable load testing".

- **Ventilated Walls 3280.504 (b).**

HUD is requesting comments on whether the final rule should also include provisions to restrict exterior wall cavities from being ventilated to the outdoors as required by the Waiver. The rule as published already has such a restriction on exterior wall cavities being vented to the outside when the alternate specified in 3280.504 (b) (4) is used. Note that the vapor retarder location specified in 3280.504 (b) (4) is an alternate to that called out in 3280.504 (b) (1) and therefore could not be used with a vented wall cavity specified in 3280.504 (b) (3).

From a practical – useable standpoint, in order for the alternate vapor retarder location to be of any use at all, it is absolutely necessary to provide some minor exception to the requirement that the interior finish have a combined permeance of not less than 5.0 perms. The MHCC has already discussed with HUD the need to

include these exceptions which are part of further changes to the Standards approved by the MHCC but not yet in proposed rule form.

The MHCC at the January 27, 2005 meeting recommended that HUD include these exceptions in the final rule so the alternate vapor retarder location can be a useable option.

- **Proposed changes to 3280.209 Roof Truss Testing.**

The MHCC recommended accepting more stringent initial qualification testing of truss designs that have been talked about and supported by the industry, code development work groups and task forces over the last ten plus years.

Based on this history and the MHCC recommendation, HUD included these changes in these proposed rules. However, as part of the public review process concerns have been expressed by, and to members of the MHCC. These concerns include issues either not previously considered or not believed to have been a problem by the MHCC in developing its recommendations to HUD.

Several areas especially lacking in the MHCC consensus development process were adequate consideration of the true costs associated with the adoption of this proposal; the impact these changes may have on the testing procedures and the industry; and the proposal's impact on roof truss home design and future innovation.

Based on the MHCC consideration of these concerns at the January 27, 2005 meeting, the MHCC is asking that HUD extract this proposal from the proposed rules and return the proposal to the MHCC for further consideration and development.

The Manufactured Housing Consensus Committee asks that you consider these comments which reflect our actions at the January 27, 2005 meeting as the Department of Housing and Urban Development proceeds with final rule adoption.

Sincerely,

Robert E. Solomon, PE
Project Manager
Manufactured Housing Consensus Committee

C: MHCC Members

ENCL: Supporting Materials for 3280.309

ENCLOSURE

SUPPORTING DOCUMENT FOR 3280.309 FORMALDEHYDE HEALTH NOTICE

duced or finished or where the plywood is finished. The quality control plan shall be designed to ensure that all panels comply with 4-8.1. The plan shall establish ongoing procedures to identify increases in the formaldehyde emission characteristics of the finished product resulting from the following changes in production:

(1) In the case of plywood

a. The facility where the unfinished panels are produced is changed.

b. The thickness of the panels is changed so that the panels are thinner.

c. The grooving pattern in the panels is changed so that the grooves are deeper or closer together.

(2) In the case of particleboard

a. The resin formulation is changed so that the formaldehyde-to-urea ratio is increased.

b. The amount of formaldehyde resin used is increased.

c. The press time is decreased.

(3) In the case of plywood or particleboard

a. The finishing or top coat is changed and the new finishing or top coat has a greater formaldehyde content.

b. The amount of finishing or top coat used on the panels is increased, provided that such finishing or top coat contains formaldehyde.

**4-8.2.4** The testing laboratory shall periodically visit the plant to monitor quality control procedures to ensure that all certified panels meet the standard.

**4-8.2.5** To maintain its certification, plywood or particleboard shall be tested by the air chamber test specified in Section 5-6 whenever one of the following events occurs:

(1) In the case of particleboard, the resin formulation is changed so that the formaldehyde-to-urea ratio is increased.

(2) In the case of particleboard or plywood, the finishing or top coat is changed, and the new finishing or top coat contains formaldehyde.

(3) In the case of particleboard or plywood, the testing laboratory determines that an air chamber test is necessary to ensure that panels comply with 4-8.1.

**4-8.2.6** In the event that an air chamber test measures levels of formaldehyde from plywood or particleboard in excess of those permitted under 4-8.1, the tested product's certification shall immediately lapse as of the date of production of the tested panels. No panel produced on the same date as the tested panels, or on any day thereafter, shall be used or certified for use in manufactured homes, unless in accordance with 4-8.2.6.1 and 4-8.2.6.2.

**4-8.2.6.1** A new product certification shall be permitted to be obtained by testing randomly selected panels that were produced on any day following the date of production of the tested panels. If such panels pass the air chamber test specified in Section 5-6, the plywood or particleboard produced on that day and subsequent days shall be permitted to be used and certified for use in manufactured homes.

**4-8.2.6.2** Plywood or particleboard produced on the same day as the tested panels, and panels produced on subsequent days, if not certified pursuant to 4-8.2, shall be permitted to be used in manufactured homes only under the following circumstances:

(1) Each panel is treated with a scavenger, sealant, or other means of reducing formaldehyde emissions that does not adversely affect the structural quality of the product.

(2) Panels randomly selected from the treated panels are tested by and pass the air chamber test specified in Section 5-6.

**4-8.3 Panel Identification.** Each plywood and particleboard panel bonded or coated with a resin system containing formaldehyde, other than an exclusively phenol-formaldehyde resin system, that is installed in manufactured homes shall be stamped or labeled so as to identify the product manufacturer, date of production and/or lot number, and the testing laboratory certifying compliance with this section.

**4-8.4 Treatment after Certification.** If certified plywood or particleboard subsequently is treated with paint, varnish, or any other substance containing formaldehyde, the certification shall no longer be valid. In such a case, each stamp or label placed on the panels pursuant to 4-8.3 shall be obliterated. The treated panels shall be permitted to be recertified and reidentified in accordance with 4-8.2 and 4-8.3.

**4-9 Health Notice on Formaldehyde Emissions.**

**4-9.1** Each manufactured home shall have a health notice on formaldehyde emissions prominently displayed in a temporary manner in the kitchen (e.g., countertop or exposed cabinet face). The notice shall read as shown in Figure 4-9.1.

**4-9.2** The notice shall be legible and typed using letters at least $^1/_4$ in. (6 mm) in size. The title shall be typed using letters at least $^3/_4$ in. (19 mm) in size.

**4-9.3** The notice shall not be removed by any party prior to delivery of the home to the first purchaser of the home for purposes other than resale.

**4-9.4** A copy of the notice shall be included in the consumer manual required by Section 1-3.

**Figure 4-9.1 Health notice on formaldehyde emissions.**

**Important Health Notice**

Some of the building materials used in this home emit formaldehyde. Eye, nose, and throat irritation, headache, nausea, and a variety of asthma-like symptoms, including shortness of breath, have been reported as a result of formaldehyde exposure. Elderly persons and young children, as well as anyone with a history of asthma, allergies,or lung problems, may be at greater risk. Research is continuing on the possible long-term effects of exposure to formaldehyde.

Reduced ventilation resulting from energy efficiency standards may allow formaldehyde and other contaminants to accumulate in the indoor air. Additional ventilation to dilute the indoor air may be obtained from a passive or mechanical ventilation system offered by the manufacturer. Consult your dealer for information about the ventilation options offered with this home.

High indoor temperatures and humidity raise formaldehyde levels. When a home is to be located in areas subject to extreme summer temperatures, an air-conditioning system can be used to control indoor temperature levels. Check the comfort cooling certificate to determine if this home has been equipped or designed for the installation of an air-conditioning system.

If you have any questions regarding the health effects of formaldehyde, consult your doctor or local health department.

VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 13

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(Log #50)
Committee: MAN-STR

501- 71 - (4-9 [3280.309]): Accept
SUBMITTER: Frank Walter, Manufactured Housing Inst. (MHI)
RECOMMENDATION: Delete Section 4-9 in its entirety:
~~4-9 Health Notice on Formaldehyde Emissions.~~
~~4-9.1 Each manufactured home shall have a health notice on formaldehyde emissions prominently displayed in a temporary manner in the kitchen (e.g., countertop or exposed cabinet face). The notice shall read as follows:~~
~~IMPORTANT HEALTH NOTICE~~
~~Some of the building materials used in this home emit formaldehyde. Eyes, nose, and throat irritation, headache, nausea, and a variety of Asthma like symptoms, including shortness of breath, have been reported as a result of formaldehyde exposure. Elderly persons and young children, as well as anyone with a history of asthma, allergies, or lung problems, may be at great risk. Research is continuing on the possible long-term effects of exposure to formaldehyde.~~
~~Reduced ventilation resulting from energy efficiency standards may allow formaldehyde and other contaminants to accumulate in the indoor air. Additional ventilation to dilute the indoor air may be obtained from a passive or mechanical ventilation system offered by the manufacturer. Consult your dealer for information about the ventilation options offered with this home.~~
~~High indoor temperatures and humidity raise formaldehyde levels. When a home is to be located in areas subject to extreme summer temperatures, an air conditioning system can be used to control indoor temperature levels. Check the comfort cooling certificate to determine if this home has been equipped or designed for the installation of an air conditioning system.~~
~~If you have any questions regarding the health effects of formaldehyde, consult your doctor or local health department.~~
~~4-9.2 The notice shall be legible and typed using letters at least 1/4 in. (6 mm) in size. The title shall be typed using letters at least 3/4 in. (19 mm) in size.~~
~~4-9.3 The notice shall not be removed by any party prior to delivery of the home to the first purchaser of the home for purposes other than resale.~~
~~4-9.4 A copy of the notice shall be included in the customer manual required by Section 1-3.~~
SUBSTANTIATION: This recommended change was originally submitted to HUD by the MHCSS Consensus Committee on 12-29-92, but no action has been taken. There is no difference in the materials used in manufactured homes versus site-built homes or modular homes, which require no health notices.
There is no evidence that this Health Notice is instrumental in protecting the public or in preventing litigation.
Since 1985 when the formaldehyde product standards for plywood and particleboard became effective, there has been a lot of progress in lowering formaldehyde levels in homes. Other high emitters, such as cigarette smoke, are not regulated by the Standard.
The Health Notice is only a sales deterrent and should be eliminated. It only complicates an issue that is already misunderstood by the public in general.
COMMITTEE ACTION: Accept.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 13
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 12
NEGATIVE: 1
EXPLANATION OF NEGATIVE:
JONES: This warning was enacted due to prior public health concerns and litigation. The reason to remove the warning is not substantiated.

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(Log #108)
Committee: MAN-STR

501- 72 - (5-1.1 [3280.401(a)]): Accept in Principle
SUBMITTER: Michael L. Zieman, RADCO
RECOMMENDATION: Add the following text after the sentence in the middle of the paragraph which ends "...rupture, fracture, or excessive yielding."
(Note: Design live load deflection criteria does not apply when the structural assembly being evaluated does not include structural framing members. For example: exterior metal siding tests where the metal siding and its fastening are evaluated but the framing system, necessary to test the metal siding, is not being evaluated.)
SUBSTANTIATION: This is common sense but the clarification is needed to correct actual and potential misinterpretations. In the example above for exterior metal siding tests the framing system used in the actual home would be separately substantiated by calculations or other tests which would include an evaluation for conformance to deflection criteria in 4-5.4 [3280-305(d)].
COMMITTEE ACTION: Accept in Principle.
Revise 5-1.1 and add a new appendix note to read as follows:
5-1.1* Proof Load Tests. Every structural assembly tested shall be capable of sustaining its dead load plus superimposed live loads equal to 1.75 times the required live loads for a period of 12 hours without failure. Tests shall be conducted with loads applied and deflections recorded in 1/4 design live load increments at 10-minute intervals until 1.25 times design live load plus dead load has been reached. Additional load shall then be applied continuously until 1.75 times design live load plus dead load has been reached. Assembly failure shall be considered as design live load deflection (or residual deflection measured 12 hours after live load removal) that is greater than the limits set in 4-5.4, rupture, fracture, or excessive yielding. Design live load deflection criteria shall not apply when the structural assembly being evaluated does not include structural framing members. An assembly to be tested shall be of the minimum quality of materials and workmanship of the production. Each test assembly, component, or subassembly shall be identified as to type and quality or grade of material. All assemblies, components, or subassemblies qualifying under this test shall be subject to a continuing qualification testing program acceptable to the regulatory agency.
A-5.1.1 Examples for when design live load deflection criteria does not apply are: exterior cladding tests where the cladding and its fastening are evaluated but the framing system, necessary to test the cladding, is not being evaluated.)
COMMITTEE STATEMENT: The proposal was revised to be in mandatory language. An appendix note was created to address the nonmandatory references of the examples as noted in the proposal. The term "metal siding" was changed to "cladding" for clarification and to identify that this is not just limited to metal siding.
NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE: 13
VOTE ON COMMITTEE ACTION:
AFFIRMATIVE: 13

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(Log #109)
Committee: MAN-STR

501- 73 - (5-1.2 [3280.401(b)]): Accept in Principle
SUBMITTER: Michael L. Zieman, RADCO
RECOMMENDATION: Add the following text after the sentence in the middle of the paragraph which ends "...rupture, fracture, or excessive yielding."
(Note: Design live load deflection criteria does not apply when the structural assembly being evaluated does not include structural framing members. For example: exterior metal siding tests where the metal siding and its fastening are evaluated but the framing system, necessary to test the metal siding, is not being evaluated.)
SUBSTANTIATION: This is common sense but the clarification is needed to correct actual and potential misinterpretations. In the example above for exterior metal siding test the framing system used in the actual home would be separately substantiated by calculations or other tests which would include an evaluation for conformance to deflection criteria in 4-5.4 [3280-305(d)].
COMMITTEE ACTION: Accept in Principle.
Revise 5-1.2 and add a new appendix item to read as follows:
5-1.2 Ultimate Load Tests. Ultimate load tests shall be performed on a minimum of three assemblies or components to generally evaluate the structural design. Every structural assembly or component tested shall be capable of sustaining its total dead

**COMMITTEE ACTION:** Accept in Principle.
Add at the end of this section "...below the outer side walls." This section now reads:
4-6.4 Requirements for Ties. Manufactured homes in Wind Zone I shall require only diagonal ties. These ties shall be placed along the main frame and below the outer walls. All manufactured homes designed to be located in Wind Zone II and Wind Zone III shall have both vertical and diagonal ties below the outer side walls.
**COMMITTEE STATEMENT:** This proposed revision establishes the clarification that both vertical and diagonal ties are to be used. This section does not mandate that each type of tie has to be installed with each other, just a combination in this location. In response to the Technical Correlating Committee's concern on the endwall application, an endwall is not considered an outer wall by the industry.
**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 16
**VOTE ON COMMITTEE ACTION:**
AFFIRMATIVE: 13
NEGATIVE: 1
NOT RETURNED: 2 Patel, Wills
**EXPLANATION OF NEGATIVE:**
MENDLEN: Revise Section 4-6.4 to read as follows:
4-6.4 All manufactured homes designed to be located in Wind Zone II and Wind Zone III shall have a vertical tie installed at each diagonal tie location below the outer side walls.
Substantiation: The above suggested revision would remove my negative comment and retain current requirements for vertical ties at each diagonal tie thereby not reducing present levels of resistance to overturning and uplift. As presently proposed, it would be possible to place fewer vertical ties at greater spacing which could significantly redistribute forces and cause premature failure of the vertical ties and/or higher loaded anchors.

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(Log #58)
Committee: MAN-STR

501- 61 - (4-6.4 [3280.306(d)]): Reject
**SUBMITTER:** Richard A. Mendlen, Dept. of Housing and Urban Development
**COMMENT ON PROPOSAL NO:** 501-65
**RECOMMENDATION:** Delete proposed revision to this section and retain existing language to read as follows:
4-6.4 All manufactured homes designed to be located in Wind Zone II and Wind Zone III shall have a vertical tie installed at each diagonal tie location. ~~both vertical and diagonal ties.~~
**SUBSTANTIATION:** The current proposal without adequate engineering justification, significantly reduces the number of ties and weakens the anchoring system required by the present Standards. The entire subject of adequate anchoring and foundation systems to resist high wind forces requires additional field studies and investigation.
**COMMITTEE ACTION:** Reject.
**COMMITTEE STATEMENT:** This action was taken based on the Technical Committee's action on Comment 501-60 (Log #31) which revised this section for clarification.
**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 16
**VOTE ON COMMITTEE ACTION:**
AFFIRMATIVE: 13
NEGATIVE: 1
NOT RETURNED: 2 Patel, Wills
**EXPLANATION OF NEGATIVE:**
MENDLEN: Revise Section 4-6.4 to read as follows:
4-6.4 All manufactured homes designed to be located in Wind Zone II and Wind Zone III shall have a vertical tie installed at each diagonal tie location below the outer side walls.
Substantiation: The above suggested revision would remove my negative comment and retain current requirements for vertical ties at each diagonal tie thereby not reducing present levels of resistance to overturning and uplift. As presently proposed, it would be possible to place fewer vertical ties at greater spacing which could significantly redistribute forces and cause premature failure of the vertical ties and/or higher loaded anchors.

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(Log #65)
Committee: MAN-STR

501- 62 - (4-6.6 [3280.306(l)]): Reject
**SUBMITTER:** Mark A. Nunn, Manufactured Housing Inst.
**COMMENT ON PROPOSAL NO:** 501-66
**RECOMMENDATION:** Revise Section 4-6.6 to read as follows:
4-6.6 Anchoring equipment-load resistance. Anchoring equipment shall be tested in the low range of each soil classification, and be capable of resisting an allowable working load equal to or exceeding 3,150 lbs ($1.43 \times 10^3$ kg) and withstanding a 50 percent overload (4,725 lb total) ($2.14 \times 10^3$kg) without failure of either the anchoring equipment or the attachment point on the manufactured home.
The minimum required test value for soil classifications are:
(a) Class 2 — 550 in.-lbs (6.35 m-kg)
(b) Class 3 — 350 in.-lbs (4.04 m-kg)
(c) Class 4a — 275 in.-lbs (3.18 m-kg)
(d) Class 4b — 175 in.-lbs (2.02 m-kg)
**SUBSTANTIATION:** This requirement would affect the manufacturing of anchor equipment. The current ground anchor certification criteria permits testing at the highest end of the soil classification. A Class 4a soil has a range from 275 to 350 inch-pounds. Anchors can be tested at the higher end of around 340 — 349 inch-pounds using a soil test probe kit torque wrench. The anchor tested in this high range would not be expected to develop the required working load at the lower end range of 275 inch-pounds. In this manner, ground anchors tested in the lower range of each soil classification would be expected to perform as intended for the entire soil classification.
This requirement would provide similar protection to the consumer as that provided by the wind zone standards, where the standard is geared toward a "worse case" scenario, rather than the opposite as currently exists with ground anchors.
Even though the committee recognized that there is some justification in establishing minimum criteria associated with soil classifications and overall application of the anchoring provisions, limits on the testing values to be used were suggested to be measurable and defined. This proposed comment seeks to clarify what is intended by the low range value for ground anchor testing.
Note: Supporting material available for review at NFPA Headquarters.
**COMMITTEE ACTION:** Reject.
**COMMITTEE STATEMENT:** The requirement for soil classification is not a requirement that is appropriately addressed within this document. These provisions should be addressed in the appropriate documents that pertain to site set and by the appropriate regulations established by the local and state authorities.
**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 16
**VOTE ON COMMITTEE ACTION:**
AFFIRMATIVE: 14
NOT RETURNED: 2 Patel, Wills

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(Log #57)
Committee: MAN-STR

501- 63 - (4-9 [3280.309]): Reject
**SUBMITTER:** Richard A. Mendlen, Dept. of Housing and Urban Development
**COMMENT ON PROPOSAL NO:** 501-71
**RECOMMENDATION:** Delete the proposed revision to this section in its entirety and retain the existing language for the Health Notice in the current 501 Standard.
**SUBSTANTIATION:** No technical justification has been provided in support of the proposed action to eliminate the Health Notice on Formaldehyde Emissions. The statement offered in support of the action as substantiation that the Health Notice does not protect the public is not accurate. After reviewing the Notice, prospective purchasers can make informed decisions regarding symptoms and potential risks to themselves and family members due to exposure to formaldehyde. The Health Notice serves as a disclosure statement to those who are extremely sensitive and more at risk and advises concerned individuals to consult their doctor or local health department.
**COMMITTEE ACTION:** Reject.

**COMMITTEE STATEMENT:** The Technical Committee stands on recommendations of the original Proposal 501-71 (Log #50). There has been significant changes associated with this material since 1985 and this notice is not necessary now because of the levels now found within a home. It is noted there is nothing restricting the home manufacturer from providing this information to the purchaser in their general information package.
**NUMBER OF COMMITTEE MEMBERS ELIGIBLE TO VOTE:** 16
**VOTE ON COMMITTEE ACTION:**
AFFIRMATIVE: 13
NEGATIVE: 1
NOT RETURNED: 2 Patel, Wills
**EXPLANATION OF NEGATIVE:**
MENDLEN: No technical justification was provided at the TC meeting in support of the proposed action to eliminate the "Health Notice on Formaldehyde Emissions:. Instead, the TC members indicated that the notice was no longer necessary because of fewer complaints and lower formaldehyde levels found in the home. Information was not provided that formaldehyde is no longer a health risk for certain individuals even at the lower formaldehyde levels. As stated in my early comment on this proposal, "the health notice serves as a disclosure statement to those who are extremely sensitive and more at risk and advises concerned individuals to consult their doctor or local health department.

(Log #66)
Committee: MAN-STR

501- 64 - (5-2 [3280.402]): Accept in Principle
**SUBMITTER:** Mark A. Nunn, Manufactured Housing Inst.
**COMMENT ON PROPOSAL NO:** 501-74
**RECOMMENDATION:** Delete Section 5-2 and substitute the following: (Underlining omitted for clarity, except for revised Section 5-2.6.)

5-2 Test Procedure for Roof Trusses.

5-2.1 Roof Load Tests. The following is an acceptable procedure for roof truss testing. Where roof trusses act as support for other members, have eave or cornice projections or support concentrated loads, roof trusses shall be tested for those conditions.

5-2.2 General. Trusses shall be permitted to be tested in a truss test fixture, which replicates the design loads, and actual support points and does not restrain horizontal movement. When tested singly or in groups of two or more trusses, trusses shall be mounted on supports positioned to give the required clear span distance (L) and eave or cornice distance (Lo) if applicable as specified in the design. Truss tests shall be performed on a minimum of three trusses to evaluate the truss design.

5-2.2.1 When trusses are tested singly, trusses shall be positioned in a test fixture with supports properly located and have the roof loads evenly applied.

5-2.2.2 When tested in groups of two or more trusses, the top chord shall be permitted to be sheathed with 1/4 in. (6 mm) thick nominal 12 in. (305 mm) wide plywood strips. The plywood strips shall be at least long enough to cover the top chords of the trusses. Adjacent plywood strips shall be separated by at least 1/8 in. (3 mm). The plywood strip shall be nailed with 4d nails or equivalent staples not closer than 8 in. (203 mm) on center along the top chords. The bottom chords of the trusses shall be permitted to be either:

(a) unbraced, or

(b) laterally braced together (not cross braced) with 1 in. x 2 in. (25 mm x 51 mm) stripping not closer than 24 in. (610 mm) on center nailed with only one 6d nail at each truss

(c) as an alternate the top and bottom chords shall be permitted to be braced and covered with a material and with the connections or method of attachment as specified for the completed manufactured home.

5-2.3 Measuring and Loading Methods. Deflections in each truss shall be measured relative to a fixed reference datum. Deflections shall be measured at the free end of an eave or cornice projection and at as many bottom chord panel points as necessary to obtain an accurate representation of the deflected truss(es) but shall be measured at least at the mid-span and at two quarter points. Deflections shall be read and recorded to the nearest 1/16 in. (1.6 mm). Dead loads shall be applied to the top and bottom chords and live load to the top chords through a suitable hydraulic, pneumatic, or mechanical system or weights to simulate loads. Load units for uniformly distributed loads shall be separated so that arch action does not occur, and shall be spaced no greater than 12 in. (305 mm) on center so as to simulate uniform loading. Bottom chord loading shall be spaced as uniformly as practical. Truss gravity loads shall be calculated based on the overall truss length (horizontal projection) including eave or cornice projections.

5-2.4 General Test Procedures. General test procedures include the following methods.

5-2.4.1 Dead Load. Measure and record initial elevation of the truss(es) in the test position at no load. When trusses are arranged according to Section 5-2.2.2(c), the no load to dead load measurement is not required. Apply dead loads to the top and bottom chord of the truss that are representative of the weights of the materials to be supported by the truss. The actual ceiling/roof assembly dead loads shall be used with a minimum of 5 psf on the top chord and 3 psf on the bottom chord. Greater dead loads shall be applied to the top and bottom chords if required, to represent the actual loads. Dead loads to be applied to the truss test assembly shall be permitted to include only the weights of materials supported by the truss and not the weight of the truss itself. However, readings from load cells (when used) on which the test truss rests shall reflect the sum of the applied load plus the weight of the truss. Apply dead loads and hold for five minutes. Measure and record the deflections.

5-2.4.2 Live Load. Maintaining the dead loads, apply live load to the top chord in approximate 1/4 live load increments until dead load plus 1.25 times the live load is reached. Measure and record the deflections at a minimum of five minutes after each live load increment has been applied. Apply incremental loads at a uniform rate such that approximately one-half hour is required to each full design live load.

5-2.4.3 Overload Phase. Additional loading shall then be applied continuously until the dead load plus 2.5 times the design live load is reached. This overload condition shall be maintained for five minutes. After five minutes, remove the overload and design live load leaving the design dead load in place. Record the truss recovery within the next four hours.

5-2.4.4 Acceptance Criteria. The truss design shall be considered to have passed if all of the following conditions are met:

(a) No load to dead load deflection shall be less than L/480 for simply supported clear spans and less than Lo/240 for eave and cornice projections, and
(b) Dead load to design live load deflection shall be less than L/240 for simply supported clear spans and less than Lo/120 for eave or cornice projections, and
(c) The truss shall maintain the overload condition for five minutes without failure, and
(d) The truss shall recover to at least L/240 for simply supported clear spans and Lo/120 for eave and cornice projections within four hours after the overload condition and design live load have been removed.

5-2.5 Test Procedure for Bowstring Trusses Only. Bowstring truss(es) test procedures include the following methods.

5-2.5.1 Dead Load. Measure and record initial elevation of truss(es) in the test position at no load. When trusses are arranged per Section 5-2.2.2(c) the no load to dead load measurement is not required. The actual ceiling/roof assembly dead loads shall be used with a minimum of 3 psf on the top chord and 2 psf on the bottom chord. Greater dead loads shall be applied to the top and bottom chords, if required, to represent the actual loads. Dead loads to be applied to the truss test assembly shall be permitted to include only the weights of materials supported by the truss and not the weight of the truss itself. However, readings from load cells (when used) on which

# Formaldehyde Concentrations in Manufactured Homes: The Current Situation

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# Formaldehyde Concentrations in Manufactured Homes: The Current Situation

*Reacting to consumer complaints and field measurements showing elevated levels of airborne formaldehyde in manufactured homes, in 1985 the US Department of Housing and Urban Development made revisions to 24 CFR 3280 intended to reduce airborne formaldehyde levels in manufactured homes. This paper provides a synopsis of how and why formaldehyde levels in new homes have changed in the 20 years since the federal regulations were amended.*

## 1. Background

Formaldehyde occurs naturally in the environment and is used in the manufacture of adhesives and binders for wood products. It is also found in an array of products, such as cloth curtains and drapes, furniture, personal care products and photographic film that home owners bring into the home. Under normal atmospheric conditions, these materials will emit formaldehyde molecules that can become suspended in the air and be inhaled.

In 1985 due to concerns of potential adverse health effects to manufactured home residents from elevated levels of formaldehyde in the indoor air of manufactured homes, the US Department of Housing and Urban Development (HUD) revised the Manufactured Home Construction and Safety Standards (MHCSS). Two sections were added: the first established maximum formaldehyde emission levels of certain materials used in manufactured homes. The second required the posting of a health notice notifying prospective manufactured home purchasers of the potential risk of formaldehyde exposure from living in a manufactured home [49 Fed. Reg. 31996; HUD 1999] (see Appendix A for a summary of these sections). (There are no model building codes regulating formaldehyde levels in site built homes [NAHB 1998]).

A number of factors contributed to HUD's decision to implement these new regulations:

- **Consumer complaints**. Numerous consumer complaints had been received over the years. Between 1978 and 1983, HUD received through various sources approximately 1,500 complaints related to formaldehyde in manufactured homes [48 Fed. Reg. 37137].
- **Elevated levels of formaldehyde in manufactured homes**. Studies had shown that formaldehyde levels in the air of manufactured homes constructed prior to the establishment of the new sections in the MHCSS could often be in excess of those thought to result in adverse health effects [48 Fed. Reg. 37137]. A study conducted in 1980 for HUD by Clayton Environmental Consultants "determined that the average level of formaldehyde in new, unoccupied homes is 0.86 parts per million (ppm). Older, occupied homes average 0.25 ppm of formaldehyde" [48 Fed. Reg. 37139]. Other studies had found peak formaldehyde levels in manufactured homes in the range of 0.2 to 0.5 ppm [Godish 1989].
- **Potential for adverse health effects**. An elevated level of formaldehyde in indoor air had been found to have adverse health effects in humans, although the symptom level varies by individual and the severity of health effects was not established [49 Fed. Reg. 31999].

The HUD formaldehyde rule went into effect on February 11, 1985 [49 Fed. Reg. 32847]. At the time HUD enacted the rule, the only existing residential ambient air formaldehyde standards in the US were in Wisconsin (0.4 ppm for manufactured housing) and Minnesota (0.5 ppm for manufactured housing) [48 Fed. Reg. 37137]. In publishing the rule, HUD concluded that "an indoor ambient formaldehyde level of 0.4 ppm provides reasonable protection to manufactured home occupants" [49 Fed. Reg. 31998]. After reviewing the available literature, HUD also concluded that "there is insufficient medical and scientific evidence to substantiate more than minimal health benefits when formaldehyde levels are reduced below 0.4 ppm."

In the ensuing years, a level of 0.1 ppm has been recommended by various organizations, such as:

- The California Air Resources Board (CARB) sets a level of 0.1 ppm as an "action level" above which it recommends taking action to reduce formaldehyde levels in the air, and a level of 0.05 ppm as a "target level" [CARB 1991].
- Health Canada similarly sets a level of 0.1 ppm as an "action level" and 0.05 ppm as a "target level" [Health Canada 1987].
- The US Consumer Products Safety Commission (CPSC) currently lists a level of 0.1 ppm as the symptom threshold for most people [CPSC 1997].
- The US Environmental Protection Agency has established 0.1 ppm as the level at which symptoms may occur [EPA 1995].

Unique factors exacerbated the formaldehyde problem in manufactured homes further encouraging HUD to establish standards. These factors included:

- Manufactured homes used more of the types of products containing formaldehyde than other types of residential structures. At the time the formaldehyde rule was enacted, a significant portion of the interior wall finish of manufactured homes was made of urea formaldehyde (UF)-bonded hardwood veneer plywood. The floor decking of manufactured homes was typically made of UF-bonded particleboard.
- Manufactured homes on average had a smaller volume of interior space than single family detached site-built homes. The smaller volume of typical manufactured homes (compared to site built homes) was assumed to exacerbate the formaldehyde concentrations in the indoor air.

## 2. The current situation

A review of the current situation with regard to formaldehyde concentrations in new homes suggests that the limits on material emissions in Section 3280.308 (see Appendix A) have had their intended effect. A confluence of factors, including the post-1985 changes in the manufacture, selection and application of materials, the trend toward larger homes and the requirement for whole house ventilation (Section 3280.103) have all contributed to significant reductions in ambient formaldehyde levels. The impact of these factors is described in the sections below.

## 2.1. Changes to the types of materials use in manufactured homes

At the time the formaldehyde provisions were adopted, plywood wall paneling (cited by HUD in its 1983 notice of proposed rulemaking as one of the two major sources of formaldehyde emissions in manufactured homes [48 Fed. Reg. 37137]) was the interior wall covering material commonly used in new manufactured homes. In the last 20 years, gypsum board has largely replaced UF-bonded plywood paneling as the finish material in new homes.

Already in 1993, 96% of all new manufactured homes utilized gypsum wallboard as the principal interior wall covering material according to a survey of manufacturers conducted for the Manufactured Housing Institute (MHI) [Ross & Hardies 1993]. Only 5% of all new homes reported in the survey utilized UF-bonded plywood paneling for any portion of the home (a small number of homes used both materials), a dramatic reversal from early 1980 s levels.

The trend away from UF-bonded materials can also be seen in the construction of manufactured home ceilings. In 1984, HUD modified Section 3280.203 to include new fire safety provisions; including a requirement for a lower flame spread rating for interior ceilings [MHI 2004]. The wood-based ceiling panels in use at the time did not comply with this requirement and therefore manufacturers moved away from this material for ceilings. By 1985 the manufactured housing industry had virtually eliminated wood ceiling panels in favor of gypsum board, a product that does not contain any formaldehyde [TMHA 2004].

## 2.2. Changes to the formaldehyde emissions of plywood and particleboard used in manufactured homes as a result of the new HUD rules

The HUD rule set standards for formaldehyde emissions from two materials commonly used in the construction of homes: particleboard and plywood. The emissions limits were set at 0.3 ppm and 0.2 ppm, for particleboard and plywood, respectively.

At about the same time, the wood products industry established voluntary standards on formaldehyde emissions for their products. The National Particleboard Association adopted a voluntary standard for formaldehyde emissions of 0.2 ppm for particleboard decking, 33% more restrictive than the HUD rule [McCredie 1992, CPA 1999]. The Hardwood Plywood and Veneer Association adopted an emissions level of 0.2 ppm, consistent with the HUD rule [ANSI 2004].[1]

Both the HUD and the wood industry standards are based on American Society for Testing and Materials (ASTM) test protocol E 1333 – 90 Standard Test Method for Determining Formaldehyde Levels From Wood Products Under Defined Conditions Using a Large Chamber [HUD 1999; ANSI 2004; CPA 1999]. The test measures formaldehyde emissions from a material sample placed in a sealed chamber. Table 1 compares the HUD requirements with current voluntary product standards.

[1] Another UF-bonded material sometimes used in manufactured homes is medium density fiberboard (MDF). MDF is commonly used in cabinets where it is typically encased in a low-permeance material such as vinyl that reduces potential formaldehyde emissions. While MDF is not presently subject to the limitations of the HUD formaldehyde rule, the Composite Panel Association's product standard for MDF limits formaldehyde emissions to 0.3 ppm [CPA 1994]. The Manufactured Housing Consensus Committee has approved, and will submit to HUD, a proposed change to 24CFR 3280 to include MDF under the formaldehyde rule at this same emissions limit.

**Table 1 Summary of material formaldehyde emission requirements**

| Material | HUD requirement | Standard requirement for maximum formaldehyde emissions | Voluntary industry product standard |
|---|---|---|---|
| Particleboard | 0.3ppm | 0.2ppm (underlayment and decking)<br>0.3ppm for other grades | ANSI A208.1-1999 |
| Plywood | 0.2ppm | 0.2ppm | ANSI/HPVA HP-1-2004 |

The new product standards dramatically reduced the formaldehyde emissions from UF-bonded bonded wood products (including plywood paneling and particleboard). From 1980 to 1985 average formaldehyde emissions from particleboard declined 85% [McCredie 1992]. On average, formaldehyde emissions from UF-bonded wood products declined between 75% and 90% from 1980 levels [McCredie 1992].

It is important to note, however, that actual concentrations of ambient formaldehyde in a home will vary depending on an array of factors including: the amount of UF-containing material present in the home, the temperature and humidity, and the amount of fresh air ventilation provided to the home. In addition, the rate of formaldehyde emission from a source material will decline as the material ages [CPSC 1997].

## 2.3. Health and formaldehyde levels

The health consequences of various formaldehyde levels continue to be a topic of debate among researchers. Particularly at very low concentration (below 0.1 ppm) there is no consensus on safe levels or durations of environmental formaldehyde exposure. The Organization for Economic Cooperation and Development in its Screening Information Data Set describes the following symptom levels (Table 2)[OECD 2004]:

**Table 2 Summary of symptoms due to air borne formaldehyde exposure [OECD 2004]**

| Symptoms | Level (ppm) |
|---|---|
| Eye irritation threshold for most people | 0.3 to 0.5 |
| Odor threshold | 0.5 to 1.0 |
| Significant eye irritation | 1.0 |
| Moderate to severe eye, nose and throat irritation | 2.0 to 3.0 |

A phenomenon known as chemical hypersensitivity affecting a small portion of the population causes a few individuals to be extremely sensitive to many industrially-produced chemicals, including some used in the manufacture of building materials and other products used in the home. While formaldehyde may be among the chemicals that, at even extremely low levels, can affect these people, many other chemicals commonly found in household items, such as cleaning products, perfumes, pesticides, personal care products, and paints may elicit symptoms in some individuals.

## 2.4. Increase in home ventilation rates

One of the provisions of the 1985 HUD formaldehyde rule is a requirement that manufacturers offer an optional ventilation system in new manufactured homes. This was replaced by HUD in 1994 with the adoption of Section 3280.103 (b) into the HUD standards establishing whole house ventilation requirements. Under the provision, manufacturers must

install in each home a whole house ventilation system "capable of providing a minimum of 0.35 air changes per hour continuously or at an equivalent hourly average rate" [HUD 1999]. The ventilation system increases the volume of indoor air exhausted from the home and outside air brought into the home, effectively diluting any indoor pollutants, if present, such as formaldehyde.

In developing the standard, HUD estimated that about 25% of the air volume in the home is exfiltrated to the outside each hour through natural means (as a result of home owner activities, building design and weather characteristics). The whole house system design is required to increase the rate of air exchange with the outside by the equivalent of 0.1 air changes per hour by mechanical means. The ventilation rule, therefore, resulted in an approximate 40% increase in dilution (reduction in concentration) of interior concentrations of air borne pollutants.

### 2.5. Home size

Part of the justification provided by HUD for singling out manufactured homes in 1985 as particularly prone to formaldehyde concentrations in indoor air, was the relatively small average home size compared with site built homes.

However, since the period in which the formaldehyde rule was developed and implemented, manufactured home design has changed dramatically in ways that impact potential indoor air pollutant concentrations. Most notably, the average floor area of manufactured homes has grown by approximately 25% since 1983, the year before HUD issued the final formaldehyde rule. By 2003, manufactured homes had an average of 1,735 square feet of floor area, about the same as site-built homes constructed at the time the HUD rule went into effect [Census 2004].

As floor area is directly proportional to volume of air in the living space of the home, this trend has tended to dilute any airborne contaminants present in the indoor air of manufactured homes. Further, manufactured homes today commonly have 8-foot ceilings (compared with 7½-feet typical in the early 1980 s), often in a cathedral configuration, further increasing their interior volumes.

### 2.6. Measured formaldehyde levels in modern manufactured homes

A review of empirical studies conducted since the implementation of the HUD rule suggests that levels of airborne formaldehyde in newly constructed manufactured homes are well below the scientifically established threshold for potential symptoms in most people according to the CPSC and others (see Section 2.3 above). This is a result of the combination of factors described above, particularly Section 3280.308 of the HUD standards limiting the formaldehyde emissions of materials used in manufactured homes and market forces dramatically altering the design and construction of manufactured homes over the past 20 years.

Since the implementation of the HUD rule, few studies have been conducted measuring formaldehyde concentrations in manufactured homes. A search of the topical literature revealed the following:

- **Concentrations and Sources of Formaldehyde and Volatile Organic Compounds in Four New Manufactured Houses** [Hodgson 1999]. This study was conducted in 1999 for the US Department of Energy by researchers at the Lawrence Livermore National Laboratory and the Florida Solar Energy Center. The researchers measured formaldehyde levels in the indoor air of four newly constructed manufactured homes on three occasions over nine months following construction of the homes. The

median formaldehyde concentration was found to be 0.037 ppm, and all concentrations were lower than the most restrictive guideline in the US at that time of 0.050 ppm (the CARB guidelines).

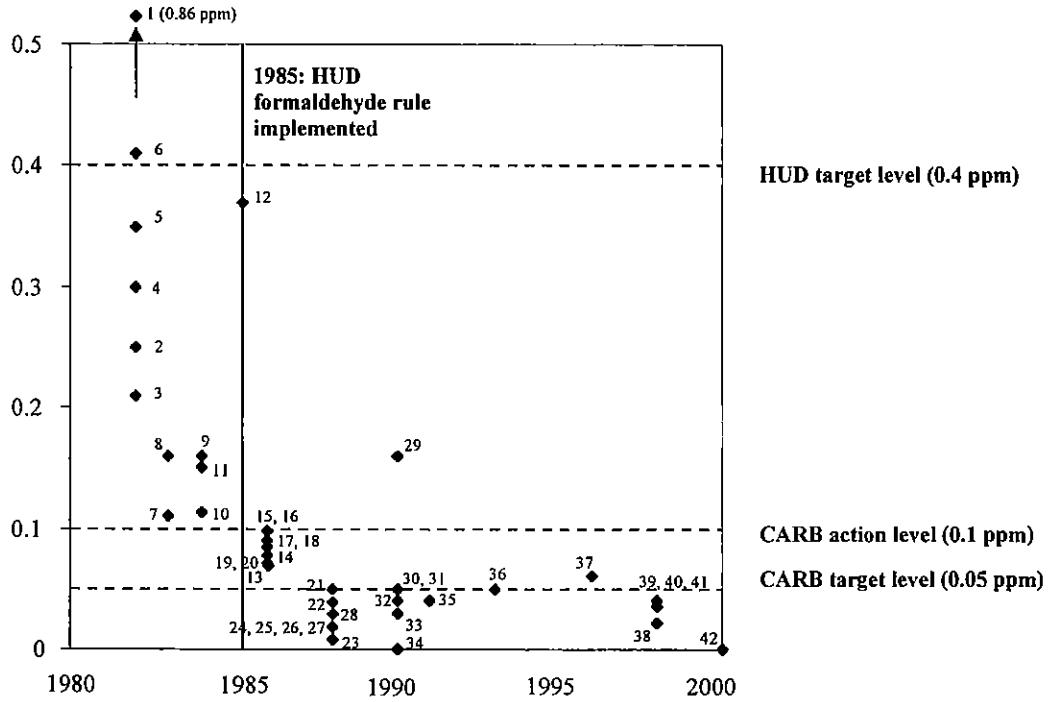
- **Pilot Study Formaldehyde Levels in Manufactured Homes from Occupant Placed and Activated Passive Monitors** [Angleton 1988]. This study was conducted in 1988 for HUD by the NAHB Research Foundation and the Hardwood Plywood Manufacturers Association. Researchers measured formaldehyde concentrations in eight occupied and furnished manufactured homes and found long-term (7-day) average measured formaldehyde concentrations ranging from 0.01 ppm to 0.05 ppm with an average of all homes of 0.03 ppm.
- **Formaldehyde Measurements in Five New, Unoccupied Energy Efficient Manufactured Homes** [Parker 1986]. In this study, conducted in 1986 by the Pacific Northwest National Laboratory, researchers measured the formaldehyde concentrations in five new energy efficient unoccupied manufactured homes built to the specifications of the Model Conservation Standards (MCS) established by the Northwest Power Planning Council. As MCS homes, they incorporated measures that resulted in an extremely tight building envelope. To compensate for the low level of natural air infiltration, homes built under the program were required to be equipped with air-to-air heat exchangers (AAHX). The average measured formaldehyde concentration for the five homes with the AAHX on (operating mode) was 0.078 ppm. Average levels for each of the homes ranged from 0.065 ppm to 0.097 ppm.

A search of the literature has not revealed any scientific studies of formaldehyde in manufactured homes, constructed since the implementation of the HUD rule that measured average operational levels of airborne formaldehyde above the EPA and CPSC threshold of 0.1 ppm.

A number of engineering firms that offer building performance and diagnostic testing services for the manufactured housing industry have had experience testing for formaldehyde in manufactured homes in the past. MHRA conducted a survey of these firms in June 2004 requesting data on measured formaldehyde levels in manufactured homes constructed since 1995. Of the five firms responding, three had had no formaldehyde-related complaints and therefore no data. Two firms provided data from the homes they had tested. Since 1995, each firm had tested a single home (see Appendix B for letters with test results from the two firms that have conducted recent testing). One of the tests indicated a level of 0.06 ppm and the other test was negative for the presence of airborne formaldehyde.

The historic data is shown on Figure 1 and illustrates the trend in levels of formaldehyde concentrations over time. Also shown on the graph are the CPSC symptom level (0.1 ppm), the CARB action and target levels (0.1 ppm and 0.05 ppm respectively), and HUD's target level (0.4 ppm). All homes in the data set constructed since 1990 are below the 0.1 ppm threshold.

**Figure 1 Formaldehyde levels in manufactured homes since 1980**




**Key to Figure 1:**

| No. | Study [reference] | Year of study | No. | Study [reference] | Year of study |
|---|---|---|---|---|---|
| 1 | Clayton new [48 Fed. Reg. 37,139] | 1982 | 22 | Angleton, et al.. [Angleton 1988] | 1988 |
| 2 | Clayton old [48 Fed. Reg. 37,139] | 1982 | 23 | Angleton, et al.. [Angleton 1988] | 1988 |
| 3 | Clayton [CARB 1992] | 1982 | 24 | Angleton, et al.. [Angleton 1988] | 1988 |
| 4 | Clayton [CARB 1992] | 1982 | 25 | Angleton, et al.. [Angleton 1988] | 1988 |
| 5 | Clayton [CARB 1992] | 1982 | 26 | Angleton, et al.. [Angleton 1988] | 1988 |
| 6 | Clayton [CARB 1992] | 1982 | 27 | Angleton, et al.. [Angleton 1988] | 1988 |
| 7 | Colome, et al. [CARB 1992] | 1983 | 28 | Angleton, et al.. [Angleton 1988] | 1988 |
| 8 | Colome, et al. [CARB 1992] | 1983 | 29 | Zieman [see Appendix B] | 1990 |
| 9 | Hanrahan, et al. [CARB 1992] | 1984 | 30 | Zieman [see Appendix B] | 1990 |
| 10 | Rogozen, et al. [CARB 1992] | 1984 | 31 | Zieman [see Appendix B] | 1990 |
| 11 | Stock, et al. [CARB 1992] | 1984 | 32 | Zieman [see Appendix B] | 1990 |
| 12 | Hanrahan, et al. [CARB 1992] | 1985 | 33 | Zieman [see Appendix B] | 1990 |
| 13 | Sexton, et al., summer [CARB 1992] | 1986 | 34 | Zieman [see Appendix B] | 1990 |
| 14 | Sexton, et al., winter [CARB 1992] | 1986 | 35 | Zieman [see Appendix B] | 1991 |
| 15 | Liu, et al. [CARB 1992] | 1986 | 36 | Zieman [see Appendix B] | 1993 |
| 16 | Parker, et al. [Parker 1986] | 1988 | 37 | Zieman [see Appendix B] | 1996 |
| 17 | Parker, et al. [Parker 1986] | 1986 | 38 | Hodgson, et al. [Hodgson 1999] | 1998 |
| 18 | Parker, et al. [Parker 1986] | 1986 | 39 | Hodgson, et al. [Hodgson 1999] | 1998 |
| 19 | Parker, et al. [Parker 1986] | 1986 | 40 | Hodgson, et al. [Hodgson 1999] | 1998 |
| 20 | Parker, et al. [Parker 1986] | 1986 | 41 | Hodgson, et al. [Hodgson 1999] | 1998 |
| 21 | Angleton, et al. [Angleton 1988] | 1988 | 42 | Conlin [see Appendix B] | 2000 |

**Note:** While the data suggests a general trend in formaldehyde concentrations over time, caution should be used in directly comparing individual points from different studies. Some points represent averages of many homes, while others represent individual homes. Likewise, the duration over which concentrations were measured, as well as climactic conditions may have varied among studies.

## 3. Conclusions and recommendations

As noted above, the conditions that led HUD to promulgate formaldehyde regulations in the early 1980 s have largely dissipated. Compared with homes constructed 20 years ago, the evidence suggests that new homes have dramatically lowered levels of air borne formaldehyde. Among the major factors accounting for the reduction are the following:

- The building materials regulated by HUD contain 75 to 90% less formaldehyde than they did prior to the HUD rule.
- Hardwood plywood paneling, the most used urea formaldehyde-containing material in pre-1985 manufactured homes, is rarely used today. It has been supplanted by non-formaldehyde containing gypsum board in over 95% of all new homes.
- Manufactured homes today are larger, and have a mandated fresh air whole house ventilation system, diluting the concentration of any remaining formaldehyde in the indoor air.

Recent measurements of formaldehyde levels in manufactured homes, albeit limited in number, provide hard evidence of the impact of these changes, and attest to the success of the HUD rule in eliminating formaldehyde contamination of indoor air as a problem in modern manufactured homes. The small number of studies on homes constructed since the passage of the HUD formaldehyde rule is likely the result of few homeowner complaints and the general attitude within the building science community that formaldehyde in manufactured homes is no longer a potential health hazard. Neither HUD, the US Environmental Protection Agency, the manufactured housing industry, nor any state or regional organization that actively studied this issue in the 1980s has seen the need to conduct tests of formaldehyde levels in manufactured homes in recent years.

Consumer complaint data relating to formaldehyde for the 12 states that HUD monitors has been requested and will be incorporated into this paper as an addendum when it becomes available. While anecdotal, a survey was conducted of the design approval primary inspection agencies (DAPIAs), organizations that would typically be involved in responding to consumer complaints. Most of the DAPIAs indicated that they had received no complaints over the past 10 years or so. Data collected by one DAPIA (RADCO) is included in this Appendix B to this report and involved a total of nine homes over a six year period, the most recent being 1996.

With regard to the HUD standards for formaldehyde, the following are recommended actions:

- The HUD rule establishing maximum formaldehyde emissions for plywood and particleboard (Section 3280.308) used in manufactured homes should remain in place as it has been instrumental in limiting ambient levels of formaldehyde in manufactured housing.
- There appears to be no justification for maintaining the Health Notice (Section 3280.309) and this provision should be repealed. The health notice required by the HUD formaldehyde rule is misleading and its implication that the air in manufactured homes contains dangerously high levels of formaldehyde is outdated and contradicted by the literature, contemporary data and experience. The levels of formaldehyde present in modern manufactured homes are lower than that recommended by authoritative sources.

  Posting of a health notice suggests that under certain conditions, that are not uncommon in new homes, people will suffer ill effects. For current construction, this has not been demonstrated and no evidence has been found to substantiate such a claim. To justify a health warning, convincing scientific evidence must be provided.

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# Appendix A—Summary of Sections 3280.308 and 3280.309

**The HUD Formaldehyde Rule**

HUD's new provisions to the MHCSS addressed materials emissions and consumer awareness:

- Section 3280.308 established maximum emission levels from particleboard and plywood used in manufactured homes. It also included product testing, certification, and labeling requirements. The materials affected were plywood, which was most commonly used as interior wall paneling in homes of that era, and particleboard, which was used for floor decking and in cabinetry.
- Section 3280.309 required a health notice to be prominently displayed in a temporary manner in the kitchen of each manufactured home, and to also be included in each manufacturer's consumer manual. The notice states that some of the building materials used in the home emit formaldehyde. It goes on to list some of the potential adverse health effects of formaldehyde and mention groups such as the elderly and children that may be of greater risk of these adverse health effects. It also mentions that ventilation equipment and air conditioning can reduce formaldehyde levels in the home. The complete text of the health notice follows.

**Important Health Notice**

*Some of the building materials used in this home emit formaldehyde.*

*Eye, nose, and throat irritation, headache, nausea, and a variety of asthma-like symptoms, including shortness of breath, have been reported as a result of formaldehyde exposure. Elderly persons and young children, as well as anyone with a history of asthma, allergies, or lung problems, may be at greater risk. Research is continuing on the possible long-term effects of exposure to formaldehyde.*

*Reduced ventilation resulting from energy efficiency standards may allow formaldehyde and other contaminants to accumulate in the indoor air. Additional ventilation to dilute the indoor air may be obtained from a passive or mechanical ventilation system offered by the manufacturer. Consult your dealer for information about the ventilation options offered with this home.*

*High indoor temperatures and humidity raise formaldehyde levels.*

*When a home is to be located in areas subject to extreme summer temperatures, an air-conditioning system can be used to control indoor temperature levels. Check the comfort cooling certificate to determine if this home has been equipped or designed for the installation of an air-conditioning system.*

*If you have any questions regarding the health effects of formaldehyde, consult your doctor or local health department.*

# Appendix B—Letters from independent engineers

To: Jordan Dentz, MHRA
Re: Formaldehyde (HCHO) Test Data
Date: July 9, 2004
From: Mike Zieman, RADCO

RADCO did a lot of HCHO testing in the 70s and early/mid 80s. By 1990 the demand for this testing was almost none existent. We did 6 tests in 1990 and one each in 1991, 1993 and 1996. We have had no requests to perform testing since then. Most testing was done for manufactures who had received a consumer complaint.

In my opinion nearly every complaint was not valid, that is, it did not relate to HCHO. A typical scenario was an older person or couple (60s, 70s or 80s) who was experiencing some type of normal age related health problem. A "friend" had mentioned HCHO to them as a possible cause or they had read something about HCHO. They got it into their head that HCHO was the problem. I can't remember any of these people stating that their doctor had confirmed their self diagnosis.

In order to give you a little more data I am including the 1990 tests though you ask to only go back to 1995.

| Date | Max HCHO ppm | Temp. at Test | Comments | |
|---|---|---|---|---|
| 96 | 0.06 | 70 F | Furnished, age at time of test 3.5 years. | |
| 93 | 0.05 | 83 F | No Furniture, age at time of test 1.5 years | |
| 91 | 0.04 | 66 F | " " | age unknown |
| 90 | 0.05 | 76 F | Furnished | age unknown |
| 90 | 0.05 | 76 F | " | age between 1.5 & 2.5 years |
| 90 | 0.00 | 76 F | " | Swamp cooler operating |
| 90 | 0.03 | 70 F | " | age unknown |
| 90 | 0.16 | 79 F | No Furniture, age at time of test 1.3 years | |
| 90 | 0.04 | 68 F | Furnished | age unknown |

Other general information:

Rule of thumb: The HCHO level doubles for every 12 °F increase in temperature.

In the August 9, 1984 Federal Register that contained the final rule for HCHO material standards HUD stated the following:

The rule sets forth material standards. HUD expects homes with materials that meet these standards to have a "targeted ambient level" of "0.40 ppm at 77 °F" or less.

I have notes relative to a HUD study I reviewed. The study was pre 1991 and if you do not have a copy I could look for it. Eight homes were tested at random in the field. The average HCHO level was 0.12 ppm.

Let me know if I can be of further help.

ComfortWorks

**ComfortWorks Engineering**
Building Systems Evaluation, Indoor Air Quality, Heating & Cooling Energy Systems, Training And Research
705 Watts Street • Durham, NC 27701 • (919) 956-5156 • (919) 956-7244 (Fax) • francis.conlin@gte.net

June 30, 2004

Jordan Dentz
Manufactured Housing Research Alliance
2109 Broadway, Suite 200
New York, NY 10023

**Re: Testing for Formaldehyde in Manufactured Housing**

Dear Jordan:

In May 2000, I visited a 2-month old home (sited 2 months) in Clayton NC to follow up reports of formaldehyde and symptoms consistent with indoor air problems. In the end, no significant elevation of formaldehyde levels was discovered. Excerpts from my report follow:

**IAQ Complaint**
The occupants reported that the air in the home had a chemical odor that caused burning of the eyes. They had experienced a variety of symptoms that included: eye burning, nausea, headaches, and respiratory difficulties that coincided with the period of time living in the home. The retailer had also observed the eye burning and odor phenomenon. The problem began 3-4 days after occupancy and seemed to be more intense after a rainstorm and periodically after that – sometimes being much stronger than others.

**Initial (flawed) formaldehyde test**
An independent environmental testing laboratory tested the air in five rooms on May-16-2000 for formaldehyde. Their analysis of the results indicated an elevated level of formaldehyde from 0.5 to 2.5 parts per million (ppm) at which point the occupants were told to leave the house. Upon reviewing the testing protocol, these tests were found to have been conducted incorrectly. The initial formaldehyde testing was conducted with a pump not certified for the particular test procedure - use of non-certified pumps for the particular formaldehyde tests are known to result in considerable measurement errors

**Final formaldehyde analysis**
I visited the house a second time on May 26, 2000. At this time the environmental testing lab conducted a second formaldehyde test of the same rooms, and building cavities under my supervision using the proper protocol under conditions designed to maximize formaldehyde levels. Since the analysis involved a subjective interpretation of an indicator color in a glass tube for which no one present had specific experience; I had duplicate sample tubes sent to the manufacturer of the testing apparatus for interpretation. Their written analysis stated:

> "The discolorations in the tubes are not characteristic of a formaldehyde indication. The discoloration for formaldehyde is a distinct pink color whereas the discolorations on these tubes range from yellowish-orange to brown". (Ed Ligus - Gas Detection Product Manager, Drager Safety, Inc.)

Having eliminated formaldehyde as a source of the air quality complaint, other sources of eye irritation were explored.

If you have any further questions of the investigation, please do not hesitate to call.

Sincerely yours,
ComfortWorks

Francis Conlin

Francis Conlin, PE

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# "An Update on Formaldehyde - 1997 Revision"

U.S. Consumer Product Safety Commission (CPSC)
Washington, DC 20207
CPSC Document #725
(reprinted by the U.S. EPA)

## What is Formaldehyde?

Formaldehyde is an important industrial chemical used to make other chemicals, building materials, and household products. It is one of the large family of chemical compounds called volatile organic compounds or 'VOCs'. The term volatile means that the compounds vaporize, that is, become a gas, at normal room temperatures. Formaldehyde serves many purposes in products. It is used as a part of:

- the glue or adhesive in pressed wood products (particleboard, hardwood plywood, and medium density fiberboard (MDF));
- preservatives in some paints, coatings, and cosmetics;
- the coating that provides permanent press quality to fabrics and draperies;
- the finish used to coat paper products; and
- certain insulation materials (urea-formaldehyde foam and fiberglass insulation).

Formaldehyde is released into the air by burning wood, kerosene or natural gas, by automobiles, and by cigarettes. Formaldehyde can off-gas from materials made with it. It is also a naturally occurring substance.

The U.S. Consumer Safety Commission has produced this booklet to tell you about formaldehyde found in the indoor air. This booklet tells you where you may come in contact with formaldehyde, how it may affect your health, and how you might reduce your exposure to it.

## Why Should You Be Concerned?

Formaldehyde is a colorless, strong-smelling gas. When present in the air at levels above 0.1 ppm (parts in a million parts of air), it can cause watery eyes, burning sensations in the eyes, nose and throat, nausea, coughing, chest tightness, wheezing, skin rashes, and allergic reactions. It has also been observed to cause cancer in scientific studies using laboratory animals and may cause cancer in humans. Typical exposures to humans are much lower; thus any risk of causing cancer is believed to be small at the level at which humans are exposed.

Formaldehyde can affect people differently. Some people are very sensitive to formaldehyde while others may not have any noticeable reaction to the same level.

Persons have developed allergic reactions (allergic skin disease and hives) to formaldehyde through skin contact with solutions of formaldehyde or durable-press clothing containing formaldehyde. Others have developed asthmatic reactions and

skin rashes from exposure to formaldehyde.

Formaldehyde is just one of several gases present indoors that may cause illnesses. Many of these gases, as well as colds and flu, cause similar symptoms.

## What Levels of Formaldehyde Are Normal?

Formaldehyde is normally present at low levels, usually less than 0.03 ppm, in both outdoor and indoor air. The outdoor air in rural areas has lower concentrations while urban areas have higher concentrations. Residences or offices that contain products that release formaldehyde to the air can have formaldehyde levels of greater than 0.03 ppm. Products that may add formaldehyde to the air include particleboard used as flooring underlayment, shelving, furniture and cabinets; MDF in cabinets and furniture; hardwood plywood wall panels, and urea-formaldehyde foam used as insulation. As formaldehyde levels increase, illness or discomfort is more likely to occur and may be more serious.

Efforts have been made by both the government and industry to reduce exposure to formaldehyde. CPSC voted to ban urea-formaldehyde foam insulation in 1992. That ban was over-turned in the courts, but this action greatly reduced the residential use of the insulation product. CPSC, the Department of Housing and Urban Development (HUD) and other federal agencies have historically worked with the pressed wood industry to further reduce the release of the chemical from their products. A 1985 HUD regulation covering the use of pressed wood products in manufactured housing was designed to ensure that indoor levels are below 0.4 ppm. However, it would be unrealistic to expect to completely remove formaldehyde from the air. Some persons who are extremely sensitive to formaldehyde may need to reduce or stop using these products.

## What Affects Formaldehyde Levels?

Formaldehyde levels in the indoor air depend mainly on what is releasing the formaldehyde (the source), the temperature, the humidity, and the air exchange rate (the amount of outdoor air entering or leaving the indoor area). Increasing the flow of outdoor air to the inside decreases the formaldehyde levels. Decreasing this flow of outdoor air by sealing the residence or office increases the formaldehyde level in the in door air.

As the temperature rises, more formaldehyde is emitted from the product. The reverse is also true; less formaldehyde is emitted at lower temperature. Humidity also affects the release of formaldehyde from the product. As humidity rises more formaldehyde is released.

The formaldehyde levels in a residence change with the season and from day-to-day and day-to-night. Levels may be high on a hot and humid day and low on a cool, dry day. Understanding these factors is important when you consider measuring the levels of formaldehyde.

Some sources – such as pressed wood products containing urea-formaldehyde glues, urea-formaldehyde foam insulation, durable press fabrics, and draperies – release more formaldehyde when new. As they age, the formaldehyde release decreases.

## What are the Major Sources?

1. ***Urea-formaldehyde foam insulation:*** During the 1970s, many home owners installed this insulation to save energy. Many of these homes had high levels of formaldehyde soon

afterwards. Sale of urea-formaldehyde foam insulation has largely stopped. Formaldehyde released from this product decreases rapidly after the first few months and reaches background levels in a few years. Therefore, urea-formaldehyde foam insulation installed 5 to 10 years ago is unlikely to still release formaldehyde.

2. ***Durable-press fabrics, draperies, and coated paper products:*** In the early 1960s, there were several reports of allergic reactions to formaldehyde from durable-press fabrics and coated paper products. Such reports have declined in recent years as industry has taken steps to reduce formaldehyde levels. Draperies made of formaldehyde-treated durable press fabrics may add slightly to indoor formaldehyde levels.
3. ***Cosmetics, paints, coatings, and some wet-strength paper products:*** The amount of formaldehyde present in these products is small and is of slight concern. However, persons sensitive to formaldehyde may have allergic reactions.
4. ***Pressed Wood Products:*** Pressed wood products, especially those containing urea-formaldehyde glues, are a source of formaldehyde. These products include particleboard used in flooring underlayment, shelves, cabinets, and furniture; plywood wall panels, and medium density fiberboard used in drawers, cabinets and furniture. When the surfaces and edges of these products are unlaminated or uncoated they have the potential to release more formaldehyde. Manufacturers have reduced formaldehyde emissions from pressed wood products by 80-90% from the levels of the early 1980's.
5. ***Combustion Sources:*** Burning materials such as wood, kerosene, cigarettes and natural gas, and operating internal combustion engines (e.g. automobiles), produce small quantities of formaldehyde. Combustion sources add small amounts of formaldehyde to indoor air.
6. Products such as **carpets or gypsum board** do not contain significant amounts of formaldehyde when new. They may trap formaldehyde emitted from other sources and later release the formaldehyde into the indoor air when the temperature and humidity change.

## Do You Have Formaldehyde-Related Symptoms?

There are several formaldehyde-related symptoms, such as watery eyes, runny nose, burning sensation in eyes, nose, and throat, headaches, and fatigue. These symptoms may also occur because of the common cold, the flu or other pollutants that may be present in the indoor air. If these symptoms lessen when you are away from home or office but reappear upon your return, they may be caused by indoor pollutants, including formaldehyde. Examine your environment. Have you recently moved into a new or different home or office? Have you recently remodeled or installed new cabinets or furniture? Symptoms may be due to formaldehyde exposure. You should contact your physician and/or state or local health department for help. Your physician can help to determine if the cause of your symptoms is formaldehyde or other pollutants.

## Should You Measure Formaldehyde?

Only trained professionals should measure formaldehyde because they know how to interpret the results. If you become ill, and the illness persists following the purchase of furniture or remodeling with pressed wood products, you might not need to measure formaldehyde. Since these are likely sources, you can take action. You may become ill after painting, sealing, making repairs, and/or applying pest control treatment in your home or office. In such cases, indoor air pollutants other than formaldehyde may be the cause. If the source is not obvious, you should consult an physician to determine whether or not your symptoms might relate to indoor air quality problems. If your physician believes that you may be sensitive to formaldehyde, you may want to make some measurements. As discussed earlier, many factors can affect the level of formaldehyde on a given day in an office or residence. This is why a professional is best suited to make an accurate measurement of the levels.

Do-it-yourself formaldehyde measuring devices are available, however these devices can only provide a "ball park" figure for the formaldehyde level in the area. If you use such a device, you must carefully follow the instructions.

## How Do You Reduce Formaldehyde Exposure?

Every day you probably use many products that contain formaldehyde. You may not be able to avoid coming in contact with some formaldehyde in your normal daily routine. If you are sensitive to formaldehyde, you will need to avoid many everyday items to reduce symptoms. For most people, a low-level exposure to formaldehyde (up to 0.1 ppm) does not produce symptoms. People who suspect they are sensitive to formaldehyde should work closely with a knowledgeable physician to make sure that formaldehyde is causing their symptoms.

You can avoid exposure to higher levels by:

- Purchasing pressed wood products such as particleboard, MDF, or hardwood plywood for construction or remodeling of homes, or for do-it-yourself projects that are labeled or stamped to be in conformance with American National Standards Institute (ANSI) criteria. Particleboard should be in conformance with ANSI A208.1-1993. For particleboard flooring, look for ANSI grades "PBU", "D2", or "D3" actually stamped on the panel. MDF should be in conformance with ANSI A208.2-1994; and hardwood plywood with ANSI/HPVA HP-1-1994. These standards all specify lower formaldehyde emission levels.
- Purchasing furniture or cabinets that contain a high percentage of panel surfaces and edges that are laminated or coated. Unlaminated or uncoated (raw) panels of pressed wood products will generally emit more formaldehyde than those that are laminated or coated.
- Using alternative products such as wood panel products not made with urea-formaldehyde glues, lumber or metal.
- Avoiding the use of foamed-in-place insulation containing formaldehyde, especially urea-formaldehyde foam insulation.
- Washing durable-press fabrics before use.

## How Do You Reduce Existing Formaldehyde Levels?

The choice of methods to reduce formaldehyde is unique to your situation. People who can help you select appropriate methods are your state or local health department, physician, or professional expert in indoor air problems. Here are some of the methods to reduce indoor levels of formaldehyde.

1. Bring large amounts of fresh air into the home. Increase ventilation by opening doors and windows and installing an exhaust fan(s).
2. Seal the surfaces of the formaldehyde-containing products that are not already laminated or coated. You may use a vapor barrier such as some paints, varnishes, or a layer of vinyl or polyurethane-like materials. Be sure to seal completely, with a material that does not itself contain formaldehyde. Many paints and coatings will emit other VOCs when curing, so be sure to ventilate the area well during and after treatment.
3. Remove from your home the product that is releasing formaldehyde in the indoor air. When other materials in the area such as carpets, gypsum boards, etc., have absorbed formaldehyde, these products may also start releasing it into the air. Overall levels of formaldehyde can be lower if you increase the ventilation over an extended period.

One method NOT recommended by CPSC is a chemical treatment with strong ammonia (28-29% ammonia in water) which results in a *temporary* decrease in

formaldehyde levels. **We strongly discourage such treatment** since ammonia in this strength is extremely dangerous to handle. Ammonia may damage the brass fittings of a natural gas system, adding a fire and explosion danger.

## For more information:

For a copy of "The Inside Story: A Guide to Indoor Air Quality," contact The U.S. Environmental Protection Agency's **Indoor Air Quality Clearinghouse [IAQINFO]** at:

P.O. Box 37133
Washington, DC 20013-7133
1-800-438-4318
(703) 356-4020
(fax) (703) 356-5386
iaqinfo@aol.com

For more information about biological pollutants, asbestos, and indoor air quality in your home, write to:

U.S. Consumer Product Safety Commission EXIT disclaimer
Washington, D.C. 20207
CPSC's toll-free hotline: 800-638-2772

American Lung Association EXIT disclaimer
1740 Broadway
New York, N.Y. 10019-4374
(local ALA offices also have information)

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Indoor Air Quality Home

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# Sources of Indoor Air Pollution - Organic Gases (Volatile Organic Compounds - VOCs)

Organic chemicals are widely used as ingredients in household products. Paints, varnishes, and wax all contain organic solvents, as do many cleaning, disinfecting, cosmetic, degreasing, and hobby products. Fuels are made up of organic chemicals. All of these products can release organic compounds while you are using them, and, to some degree, when they are stored.

EPA's Total Exposure Assessment Methodology (TEAM) studies found levels of about a dozen common organic pollutants to be 2 to 5 times higher inside homes than outside, regardless of whether the homes were located in rural or highly industrial areas. Additional TEAM studies indicate that while people are using products containing organic chemicals, they can expose themselves and others to very high pollutant levels, and elevated concentrations can persist in the air long after the activity is completed.

## Sources

Household products including: paints, paint strippers, and other solvents; wood preservatives; aerosol sprays; cleansers and disinfectants; moth repellents and air fresheners; stored fuels and automotive products; hobby supplies; dry-cleaned clothing.

## Health Effects

Eye, nose, and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some organics can cause cancer in animals; some are suspected or known to cause cancer in humans.

The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those with no known health effect. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed. Eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics. At present, not much is known about what health effects occur from the levels of organics usually found in homes. Many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans.

Sources of Indoor Air Pollution
- Asbestos
- Biological Pollutants
- Carbon Monoxide
- Formaldehyde/Pressed Wood Products
- Household Cleaning and Maintenance, Personal Care, or Hobbies
- Lead
- EPA Mercury website
- Nitrogen Dioxide
- Pesticides
- Radon
- Respirable Particles
- Secondhand Smoke/Environmental Tobacco Smoke
- Stoves, Heaters, Fireplaces, and Chimneys

Read "The Inside Story: A Guide to Indoor Air Quality" [EPA 402-K-93-007, April 1995]

## Levels in Homes

Studies have found that levels of several organics average 2 to 5 times higher indoors than outdoors. During and for several hours immediately after certain activities, such as paint stripping, levels may be 1,000 times background outdoor levels.

## Steps to Reduce Exposure

- Use household products according to manufacturer's directions.
- Make sure you provide plenty of fresh air when using these products.
- Throw away unused or little-used containers safely; buy in quantities that you will use soon.
- Keep out of reach of children and pets.
- Never mix household care products unless directed on the label.

***Follow label instructions carefully.***

Potentially hazardous products often have warnings aimed at reducing exposure of the user. For example, if a label says to use the product in a well-ventilated area, go outdoors or in areas equipped with an exhaust fan to use it. Otherwise, open up windows to provide the maximum amount of outdoor air possible.

***Throw away partially full containers of old or unneeded chemicals safely.***

Because gases can leak even from closed containers, this single step could help lower concentrations of organic chemicals in your home. (Be sure that materials you decide to keep are stored not only in a well-ventilated area but are also safely out of reach of children.) Do not simply toss these unwanted products in the garbage can. Find out if your local government or any organization in your community sponsors special days for the collection of toxic household wastes. If such days are available, use them to dispose of the unwanted containers safely. If no such collection days are available, think about organizing one.

***Buy limited quantities.***

If you use products only occasionally or seasonally, such as paints, paint strippers, and kerosene for space heaters or gasoline for lawn mowers, buy only as much as you will use right away.

***Keep exposure to emissions from products containing methylene chloride to a minimum.***

Consumer products that contain methylene chloride include paint strippers, adhesive removers, and aerosol spray paints. Methylene chloride is known to cause cancer in animals. Also, methylene chloride is converted to carbon monoxide in the body and can cause symptoms associated with exposure to carbon monoxide. Carefully read the labels containing health hazard information and cautions on the proper use of these products. Use products that contain methylene chloride outdoors when possible; use indoors only if the area is well ventilated.

***Keep exposure to benzene to a minimum.***

Benzene is a known human carcinogen. The main indoor sources of this chemical are environmental tobacco smoke, stored fuels and paint supplies, and automobile emissions in attached garages. Actions that will reduce benzene exposure include eliminating smoking within the home, providing for maximum ventilation during painting, and discarding paint supplies and special fuels that will not be used immediately.

***Keep exposure to perchloroethylene emissions from newly dry-cleaned materials to a minimum.***

Perchloroethylene is the chemical most widely used in dry cleaning. In laboratory studies, it has been shown to cause cancer in animals. Recent studies indicate that people breathe low levels of this chemical both in homes where dry-cleaned goods are stored and as they wear dry-cleaned clothing. Dry cleaners recapture the perchloroethylene during the dry-cleaning process so they can save money by re-using it, and they remove more of the chemical during the pressing and finishing processes. Some dry cleaners, however, do not remove as much perchloroethylene as possible all of the time. Taking steps to minimize your exposure to this chemical is prudent. If dry-cleaned goods have a strong chemical odor when you pick them up, do not accept them until they have been properly dried. If goods with a chemical odor are returned to you on subsequent visits, try a different dry cleaner.

**From the IAQ Tools for Schools kit - IAQ Coordinator's Guide - www.epa.gov/iaq/schools/tfs/guidee.html**

| Description | Sources | Standards or Guidelines |
|---|---|---|
| Volatile organic chemicals (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. | VOCs are emitted by a wide array of products numbering in the thousands. Examples include: paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings, office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues and adhesives, permanent markers, and photographic solutions. | No standards have been set for VOCs in non industrial settings. OSHA regulates formaldehyde, a specific VOC, as a carcinogen. OSHA has adopted a Permissible Exposure Level (PEL) of .75 ppm, and an action level of 0.5 ppm. HUD has established a level of .4 ppm for mobile homes. Based upon current information, it is advisable to mitigate formaldehyde that is present at levels higher than 0.1 ppm. |
| **Health Effects** | **Control Measures** | |
| Key signs or symptoms associated with exposure to VOCs include conjunctival irritation, nose and throat discomfort, headache, allergic skin reaction, dyspnea, declines in serum cholinesterase levels, nausea, emesis, epistaxis, fatigue, dizziness. | Increase ventilation when using products that emit VOCs. Meet or exceed any label precautions. Do not store opened containers of unused paints and similar materials within the school. Formaldehyde, one of the best known VOCs, is one of the few indoor air pollutants that can be readily measured. Identify, and if possible, remove the source. If not possible to remove, reduce exposure by using a sealant on all exposed surfaces of paneling and other furnishings. Use integrated pest management techniques to reduce the need for pesticides. | |

## Additional Resources

**Indoor Air Fact Sheet No. 4 (revised) - Sick Building Syndrome**

Explains the term "sick building syndrome" (SBS) and "building related illness" (BRI). Discusses causes of sick building syndrome, describes building investigation procedures, and provides general solutions for resolving the syndrome. [EPA **402-F-94-004**, April 1991]

**Indoor Air Pollution: An Introduction for Health Professionals**

Assists health professionals (especially the primary care physician) in diagnosis of patient symptoms that could be related to an indoor air pollution problem. Addresses the health problems that may be caused by contaminants encountered daily in the home and office. Organized according to pollutant or pollutant groups such as environmental tobacco smoke, VOCs, biological pollutants, and sick building syndrome, this booklet lists key signs and symptoms from exposure to these pollutants, provides a diagnostic checklist and quick reference summary, and includes suggestions for remedial action. Also includes references for information contained in each section. This booklet was coauthored with the American Lung Association, the American Medical Association, and the U.S. Consumer Product Safety Commission. [EPA **402-R-94-007**, 1994]

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# Formaldehyde in the Home

Back to the main indoor air quality page

## Formaldehyde

Formaldehyde is an important chemical used widely by industry to manufacture building materials and numerous household products. It is also a by-product of combustion and certain other natural processes. Thus, it may be present in substantial concentrations both indoors and outdoors.

Sources of formaldehyde in the home include building materials, smoking, household products, and the use of unvented, fuel-burning appliances, like gas stoves or kerosene space heaters. Formaldehyde, by itself or in combination with other chemicals, serves a number of purposes in manufactured products. For example, it is used to add permanent-press qualities to clothing and draperies, as a component of glues and adhesives, and as a preservative in some paints and coating products.

In homes, the most significant sources of formaldehyde are likely to be pressed wood products made using adhesives that contain urea-formaldehyde (UF) resins. Pressed wood products made for indoor use include: particleboard (used as subflooring and shelving and in cabinetry and furniture); hardwood plywood paneling (used for decorative wall covering and used in cabinets and furniture); and medium density fiberboard (used for drawer fronts, cabinets, and furniture tops). Medium density fiberboard contains a higher resin-to-wood ratio than any other UF pressed wood product and is generally recognized as being the highest formaldehyde-emitting pressed wood product.

Other pressed wood products, such as softwood plywood and flake or oriented strandboard, are produced for exterior construction use and contain the dark, or red/black-colored phenol-formaldehyde (PF) resin. Although formaldehyde is present in both types of resins, pressed woods that contain PF resin generally emit formaldehyde at considerably lower rates than those containing UF resin.

Since 1985, the Department of Housing and Urban Development (HUD) has permitted only the use of plywood and particleboard that conform to specified formaldehyde emission limits in the construction of

prefabricated and mobile homes. In the past, some of these homes had elevated levels of formaldehyde because of the large amount of high-emitting pressed wood products used in their construction and because of their relatively small interior space.

The rate at which products like pressed wood or textiles release formaldehyde can change. Formaldehyde emissions will generally decrease as products age. When the products are new, high indoor temperatures or humidity can cause increased release of formaldehyde from these products.

During the 1970s, many homeowners had urea-formaldehyde foam insulation (UFFI) installed in the wall cavities of their homes as an energy conservation measure. However, many of these homes were found to have relatively high indoor concentrations of formaldehyde soon after the UFFI installation. Few homes are now being insulated with this product. Studies show that formaldehyde emissions from UFFI decline with time; therefore, homes in which UFFI was installed many years ago are unlikely to have high levels of formaldehyde now.

## Health Effects of Formaldehyde

Formaldehyde, a colorless, pungent-smelling gas, can cause watery eyes, burning sensations in the eyes and throat, nausea, and difficulty in breathing in some humans exposed at elevated levels (above 0.1 parts per million). High concentrations may trigger attacks in people with asthma. There is evidence that some people can develop a sensitivity to formaldehyde. It has also been shown to cause cancer in animals and may cause cancer in humans.

## Reducing Exposure to Formaldehyde in Homes

***Ask about the formaldehyde content of pressed wood products, including building materials, cabinetry, and furniture before you purchase them.***

If you experience adverse reactions to formaldehyde, you may want to avoid the use of pressed wood products and other formaldehyde-emitting goods. Even if you do not experience such reactions, you may wish to reduce your exposure as much as possible by purchasing exterior-grade products, which emit less formaldehyde. For further information on formaldehyde and consumer products, call the EPA Toxic Substance Control Act (TSCA) assistance line (202-554-1404).

Some studies suggest that coating pressed wood products with polyurethane may reduce formaldehyde emissions for some period of time. To be effective, any such coating must cover all surfaces and edges and remain intact. Increase the ventilation and carefully follow the manufacturer instructions while applying these coatings. (If you are sensitive to formaldehyde, check the label contents before purchasing coating products to avoid buying products that contain formaldehyde, as they will emit the chemical for a short time after application.)

***Maintain moderate temperature and humidity levels and provide adequate ventilation.***

The rate at which formaldehyde is released is accelerated by heat and may also depend somewhat on the humidity level. Therefore, the use of dehumidifiers and air conditioning to control humidity and to maintain a moderate temperature can help reduce formaldehyde emissions. (Drain and clean dehumidifier collection trays frequently so that they do not become a breeding ground for microorganisms.)

Increasing the rate of ventilation in your home will also help in reducing formaldehyde levels.

**Sources:** Pressed wood products (hardwood plywood wall paneling, particleboard, fiberboard) and furniture made with these pressed wood products. Urea-formaldehyde foam insulation (UFFI). Combustion sources and environmental tobacco smoke. Durable press drapes, other textiles, and glues.

**Health Effects:** Eye, nose, and throat irritation; wheezing and coughing; fatigue; skin rash; severe allergic reactions. May cause cancer. May also cause other effects listed under "organic gases."

**Levels in Homes:** Average concentrations in older homes without UFFI are generally well below 0.1 (ppm). In homes with significant amounts of new pressed wood products, levels can be greater than 0.3 ppm.

### Steps to Reduce Exposure:

- Use "exterior-grade" pressed wood products (lower-emitting because they contain phenol resins, not urea resins).
- Use air conditioning and dehumidifiers to maintain moderate temperature and reduce humidity levels.
- Increase ventilation, particularly after bringing new sources of formaldehyde into the home.

## Subject-Specific Publications

**An Update on Formaldehyde** - U.S. Consumer Product Safety Commission

The U.S. Consumer Safety Commission has produced this booklet to tell you about formaldehyde found in the indoor air. This booklet tells you where you may come in contact with formaldehyde, how it may affect your health, and how you might reduce your exposure to formaldehyde.

## Additional References Include:

**American Lung Association**
1740 Broadway
New York, NY 10019-4374
(local ALA offices also have information)

**The Formaldehyde Institute, Inc.**
1330 Connecticut Ave., N.W.
Washington, DC 20036

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**Contact information:**

# Environmental Health & Safety Online

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770-263-8700 (please EMAIL rather than call - our advice is staffed by UNPAID volunteer employees)

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