

RE: Formaldehyde emissions from fiberglass insulation with phenol formaldehyde binder

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Summary: Avoiding composite wood and other products made with added formaldehyde is a common requirement of green building credits in LEED and a variety of other rating systems due to formaldehyde's toxicity. Insulation, however, is sometimes not included in these requirements under the assumption that occupants do not receive as much exposure to formaldehyde emissions from insulation as they do from composite wood and other formaldehyde-emitting interior finish products.* This is because of an assumption that the phenol-based formaldehyde binders commonly used in batt fiberglass insulation do not emit formaldehyde at levels of concern and that even if they do emit formaldehyde, the drywall between the insulation and the indoor space protects the occupants from exposure to significant emissions.

This memo describes research indicating that fiberglass insulation using phenol-based formaldehyde binders may in fact expose occupants to potentially hazardous levels of formaldehyde - even through drywall - and does warrant avoidance.

Formaldehyde is a carcinogen and respiratory irritant: Formaldehyde has been classified as a known carcinogen in humans by the State of California¹ and the World Health Organization's International Agency for Research on Cancer.² Formaldehyde also causes eye, nose, and respiratory irritation and can be an asthma trigger, with children more susceptible than adults.³

Axten study shows significant formaldehyde emissions from fiberglass batt insulation: A study by Axten⁴ used Air Quality Sciences (AQS) facilities to test specimens of R-13 thermal fiberglass insulation from four manufacturers reportedly using phenol formaldehyde-based binders.[†] Testing was done of wall assemblies with different combinations of insulation, vapor barrier, drywall and paint in a small-scale environmental chamber operated following the guidelines of ASTM D5116 measuring total volatile organic compounds (TVOC) and formaldehyde. The assemblies were tested at 1, 2, 7, 14, 31 and 58 days.

Emission rates at 7 days ranged from 5.1 $\mu\text{g}/\text{m}^2 \cdot \text{hr}$ for unprepared drywall alone to 51.1 $\mu\text{g}/\text{m}^2 \cdot \text{hr}$ for insulation alone. Drywall over the insulation reduced the 7 day emission to 29.6 and preparing the drywall with GreenGuard certified primer and latex paint reduced the 7 day emission rate to 20.3. Adding a polyethylene vapor barrier further slowed emissions to 13.4.

Emissions are near or in excess of established standards: Using modeling parameters for an office to predict resulting formaldehyde concentrations, all of the assemblies without a vapor barrier failed the California 01350⁵ 13.5 ppb standard at 7 days. After 14 days, the unprepared insulation/drywall assembly still did not pass and while the other samples passed the test, even the samples with vapor barriers were still emitting formaldehyde into the occupied space at almost half of the 13.5 ppb standard. Worse yet, at the end of the 58 day testing period, emissions had not significantly been reduced from the 7 and 14 day levels for any of the samples, and in fact, rates for several of the samples actually increased to levels at which most of the assemblies would again fail the 01350 test.

* Some product certifying systems, however, do already restrict all types of added formaldehyde in products. Canada's EcoLogo program, for example, does not allow any added formaldehyde in products seeking certification under its CCD-016: Thermal Insulation standard.

[†] While phenol formaldehyde (CAS #9003-35-4) is reportedly used, a December 2008 survey of MSDSes from five major manufacturers (Certaineed, Owens Corning, Knauf, Guardian, Ottawa Fiber) revealed that all were actually using a related CAS #25104-55-6, variously called "Phenol formaldehyde resin cured", "Urea extended phenol formaldehyde resin", "Phenol formaldehyde urea polymer", or "Urea, polymer with formaldehyde and phenol" meaning the phenol formaldehyde binder is extended with urea.

Current formaldehyde emission standards are not health protective: It should be noted that the 13.5 ppb standard for formaldehyde is not a conservative, health-protective level. The GreenGuard[®] and CA 01350 systems require that modeled emissions not exceed one-half long-term chronic exposure level (CREL) for each of 80 chemicals evaluated by the State of California - except in the case of formaldehyde. Formaldehyde is an exception because one-half of the 2.5 ppb (3 ug/m²) CREL is considered impractical to meet since outdoor air frequently exceeds that level. The standards compromised instead on use of the 27 ppb (33ug/m³) eight hour occupational reference exposure level (REL) that was current when the standard was established as the basis rather than the 2.5 ppb chronic reference exposure levels (CREL). Hence, the standards are not particularly protective for long-term exposure to formaldehyde emissions. No product got to within double the actual CREL.

| AQS Sample | Sample description | | | Formaldehyde emissions factors µg/m ² •hr - number of hours | | | | | Modeled concentration - ppb | | | |
|--------------|-------------------------|-----------------------|-------------------------------------|--|------|------|------|--------------|-----------------------------|----------|---------|----------|
| | | | | | | | | | Green Guard | CA 01350 | | |
| ID | Insulation material | Vapor barrier | Emitting face | 24 | 48 | 168 | 744 | 1392 | 7 days | 7 days | 14 days | 58* days |
| 11642-020AA | Unfaced Fiber Glass | None | None | 51.1 | 41.2 | 28.9 | 32 | 25.4 | 25.9 | 18.9 | 9.6 | 16.6 |
| 11642-030AA | Unfaced Fiber Glass | None | Unprepared Drywall | 28.9 | 28.9 | 29.6 | 31.1 | 33 | 25 | 18.2 | 17.1 | 20.3 |
| 11642-040 AA | Unfaced Fiber Glass | None | Drywall Prep w/GG cert Primer&Latex | 27.8 | 24.4 | 20.3 | 21.1 | not reported | 18.3 | 13.3 | 9.3 | 13.8 |
| 11642-050AA | Kraft faced Fiber Glass | None | Unprepared Drywall | 25.8 | 21.5 | 20.9 | 24.5 | 32.1 | 19.2 | 14 | 10 | 21.5 |
| 1164207 0AA | Kraft faced Fiber Glass | None | Drywall Prep w/GG cert Primer&Latex | 28.7 | 26.2 | 19.9 | 18.2 | 17.3 | 17.8 | 13 | 8.5 | 11.3 |
| 11642-080 AB | Unfaced Fiber Glass | Poly secured to studs | Unprepared Drywall | 17.8 | 14.1 | 13.1 | 25.6 | 21.8 | 11.7 | 8.6 | 6.2 | 14.3 |
| 1164209 0 AB | Unfaced Fiber Glass | Poly secured to studs | Drywall Prep w/GG cert Primer&Latex | 18.9 | 16.2 | 13.4 | 18.4 | 14.9 | 12 | 8.8 | 5.9 | 9.8 |

* 58 day CA 01350 modeling results are calculated from Axtel 7 day and 58 day emission factors and 7 day modeling results

OEHHA revised the 8 hour REL for formaldehyde to 7 ppb⁶ in December of 2008 and is expected to revise the 01350 standard accordingly. At this new REL, none of the assemblies would pass 01350 (requiring emissions to be less than 50% of the REL) at 14 days and they all would still be out of compliance at 58 days.

Current formaldehyde levels in homes, schools and offices cause thousands of cancers: It is important to note that the RELs discussed above developed by the State of California are for *non-cancer* health effects. As previously noted, formaldehyde is classified by several agencies as a “known carcinogen” the classification expressing the most confidence in the science. The California Air Resources Board has summarized the science bluntly stating that there is no known safe level of exposure. They have further calculated that “*if the California population were exposed to current, average indoor levels of formaldehyde over a lifetime, ARB staff estimate that about 4000 excess cases of cancer would be expected to develop, or about 115 excess cases of cancer per million people exposed.*”⁷ Assuming that national levels of exposure are similar to California, extrapolating that risk to the population of the United States (currently over 305 million people)⁸, excess case level that would translate into over 35,000 excess cases of cancer nationwide.

Give this analysis, products with positive formaldehyde emissions can still result in a significant cancer risk even if they easily pass the 01350 limits.

⁶ Note that GreenGuard uses the lower of ½ CRELs and 1/100 TLVs in its Children & Schools standard and hence covers more VOC. Its standard Indoor Air Quality Certified program, however, uses much looser limits than 01350.

Current VOC emission standards are not designed for homes: The situation worsens in the case of exposure in the home. The California 01350 standard on which most of the most aggressive VOC emission standards are currently based assumes an office building with constant forced ventilation of at least three-quarters of an air change per hour - or a school with even higher rates. Most homes have no forced ventilation system and may have air change rates of less than one-quarter. If air change rates go down, the resulting concentrations of VOCs will go up proportionally. With many unventilated homes having one-third (or less) of the air change rate as for ventilated offices, the VOC concentrations would be three times or more the levels they would be in ventilated office buildings. In this case, none of the phenol formaldehyde-based fiberglass batt assemblies would likely meet the California 01350 standard adjusted for the air change rate in most homes.

The State of California recommends avoiding products with added formaldehyde: Some confusion was cast on the question of formaldehyde and batt insulation by a study done conducted by the California Department of Health Services (DHS) for the California Integrated Waste Management Board in 2003⁹ which while not identifying individual products, appeared to indicate that formaldehyde free insulation products may also emit formaldehyde in excess of 01350 limits. DHS has since indicated that the study should not be used to identify individual products for selection¹⁰ and the state continues to recommend the avoidance of products with added formaldehyde.¹¹ Subsequent testing of batt products with no added formaldehyde has repeatedly shown passage of the 01350 test¹² and have shown no detectable emissions of formaldehyde.¹³

Alternatives are available: Two manufacturers currently produce fiberglass batt insulation products with no added formaldehyde. Johns Manville uses an acrylic binder and Knauf EcoBatt utilizes a rapidly renewable based binder. Two manufacturers make recycled cotton batt insulation, without added formaldehyde (Bonded Logic Ultra Touch & EcoBlue). One manufacturer previously made fiberglass batt insulation (Owens Corning Miraflex) with a mechanical bond and no binder, but discontinued production due to low demand.¹⁴ This indicates that there is not a monopoly on technologies for making fiberglass batt insulation without added insulation and given a clear market signal from green building rating systems, even more competitive production could begin promptly.

Conclusion - Avoidance of all formaldehyde binders is attainable and warranted: Based on these results, it is evident that fiberglass insulation using phenol formaldehyde does emit significant levels of formaldehyde at the 14 day California 01350 emissions test measurement point and at least for several months beyond with no sign of tapering off at that point. In some cases for office buildings (and likely all cases for homes), emissions exceed the 01350 current formaldehyde limit. In most cases for office buildings they fail the draft standard level currently proposed by the State of California. Even when they do not technically fail a current 01350 test, formaldehyde emissions are high enough to pose a chronic health and cancer risk. Alternative insulation products without formaldehyde-based binders that pass the 01350 test are available now and even more competitive products could be available rapidly if encouraged with a clear market signal. This indicates that screening to avoid the use of formaldehyde binders in fiberglass insulation is attainable and warranted.

Footnotes

¹ State Of California Environmental Protection Agency, Office Of Environmental Health Hazard Assessment, "Safe Drinking Water And Toxic Enforcement Act Of 1986 - Chemicals Known To The State To Cause Cancer Or Reproductive Toxicity" (commonly referred to as "Proposition 65" or Prop 65), September 29, 2006 http://www.oehha.ca.gov/prop65/prop65_list/files/P65single092906.pdf

² International Agency for Research on Cancer (IARC) Monographs on Evaluation of Carcinogenic Risks for Humans - Formaldehyde <http://monographs.iarc.fr/ENG/Meetings/88-formaldehyde.pdf>

³ Prioritization of Toxic Air Contaminants - Children's Environmental Health Protection Act – http://www.oehha.ca.gov/air/toxic_contaminants/pdf_zip/formaldehyde_final.pdf Formaldehyde, OEHHA, October, 2001. See the PharosWiki page (<http://www.pharosproject.net/wiki/index.php?title=Formaldehyde>) for more on formaldehyde health risks.

⁴ C.W. Axten "Formaldehyde and Total Volatile Organic. Compound Emissions from Thermal Insulation Products," 2003 presentation to the Formaldehyde Product Stewardship Committee, www.formaldehyde.org/powerpoint1.ppt, accessed 12/9/2008

⁵ "California 01350" refers to the California Department of Health Services Standard Practice CA/DHS/EHLB/R-174 developed for testing and setting threshold levels for emissions of VOCs. http://www.cal-iaq.org/VOC/Section01350_7_15_2004_FINAL_PLUS_ADDENDUM-2004-01.pdf

⁶ California Environmental Protection Agency (Cal/EPA), OEHHA, TSD for Noncancer RELs, December 2008, http://www.oehha.org/air/hot_spots/2008/AppendixD1_final.pdf <http://www.oehha.org/air/allrels.html>

⁷ CARB Fact Sheet: "Indoor Air Quality Guideline: Formaldehyde in the Home" (Aug. 2004)
<http://www.arb.ca.gov/research/indoor/formaldGL08-04.pdf>

⁸ US Census Bureau, U.S. POPClock Projection <http://www.census.gov/population/www/popclockus.html> accessed 3/3/2009

⁹ Building Material Emissions Study, CA Integrated Waste Management Board, November 2003,
<http://www.ciwmb.ca.gov/greenbuilding/specs/section01350/metstudy.htm>

¹⁰ Letter from Jed M. Waldman, Ph.D., Chief, Indoor Air Quality Section California Department of Health Services, to Mr. Tim Carey, Manager, Product Stewardship, Johns Manville, RE: State of California Building Materials Emission Study (2003). Note also that the IMWB improperly identifies the binders as "urea formaldehyde."

¹¹ Indoor Air Quality Guideline: Formaldehyde in the Home, California Air Resources Board, 2004
<http://www.arb.ca.gov/research/indoor/formaldGL08-04.pdf>

¹² The Johns Manville fiberglass product and the Bonded logic recycled cotton product both have maintained listing on the Collaborative for High Performance Schools' Low-Emitting Materials (LEM) Table,
http://www.chps.net/manual/lem_table.htm#BuildingI last accessed 12/15/2008

¹³ Section 01350 Emissions Test Results, Johns Manville Formaldehyde Free Building Insulation Product, Berkeley Analytic Associates, October 11, 2006.

¹⁴ Owens Corning: Pink Panther Energy Blog,
http://saveenergy.owenscorningblog.com/2008/02/question_is_miraflex_insulatio.html , Question: Is Miraflex insulation still available, accessed 2/28/08

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