

Dynamic Small Chamber Emissions Testing

Compliance Report per
California DPH Standard Practice
Section 01350

Temple-Inland
Greenglass® Liner Board Drywall
(exemplar for partial product line bracketing)



Prepared for:

Temple-Inland

303 South Temple Drive
Diboll, Texas 75941

Submitted by:

Materials Analytical Services, LLC

3945 Lakefield Court
Suwanee, Georgia 30024

November 4, 2009

MAS Project No. 0900792-01



November 4, 2009

Mr. Patrick Miller
Temple-Inland EHS
303 South Temple Drive
Diboll, Texas 75941



patmiller@templeinland.com

Subject: **Dynamic Small Chamber Emissions Testing
Compliance Report per California DPH Standard Practice (Section 01350)
Greenglass® Liner Board Drywall
MAS Project No. 0900792-01**

Dear Mr. Miller

Materials Analytical Services, LLC (MAS) is pleased to submit this report for emissions testing relative to potential VOC off-gassing from Temple-Inland's **Greenglass® Fire Rated Liner Board** herein referred to as "drywall" submitted for analysis in September 2009. This report summarizes our rationale for sample selection, testing procedures and the results of our analytical measurements.

This project was conducted in general accordance with the Emission Testing guidelines specified under ASTM D 5116-97. Specific testing parameters and compound emission limits were based on the California Department of Public Health (CDPH) Standard Practice (Section 01350) test method and California's Office of Environmental Health Hazard Assessment (OEHHA) Chronic Reference Exposure Limit (CREL) list respectively.

The liner board exemplar tested herein was selected by MAS to serve as a "worst" case scenario of a broader group of Temple-Inland gypsum board products bracketed in a common product class referred to as "Paperless Drywall" (representative of lower-volume special application products manufactured with fiberglass faces and a wide range of additives to enhance performance). Based on data obtained from a series of prior R&D emission tests – the **Greenglass® Fire Rated Liner Board from Temple-Inland's West Memphis, AR plant (sample no. 0900792-01)** was determined to be the highest emitter of VOCs in the bracketed "Paperless Drywall" class and thus selected for the full CDPH compliance test.

Based on our analytical test results summarized herein, **the Greenglass® Fire Rated Liner Board from Temple-Inland's West Memphis, AR plant and all specified drywall products¹ bracketed under this emissions testing program meet the performance standard established for low-emitting materials under the Collaborative for High Performance Schools (CHPS) program.** It is important to note; that qualified project uses of the Temple-Inland Greenglass® Fire Rated liner board and all designated compliant bracketed drywall products are eligible for 1 credit point EQ 2.3.6 under the CHPS program. Further, by successful conformance with the CHPS standard, the subject liner board and all designated compliant bracketed drywall products also meets the criteria of **MAS Certified Green** program.

¹ (refer to the Appendices of this report for a complete listing of liner board products certified under this emissions test)



MAS is pleased to have been of service to you. If you have any questions or comments, or if we can be of further assistance to you, please do not hesitate to contact us.

Sincerely,
MATERIALS ANALYTICAL SERVICES, LLC

A handwritten signature in black ink that reads "John Darius Soltes".

John Darius Soltes
Senior Consultant

A handwritten signature in black ink that reads "William R. Stapleton".

William R. Stapleton
Analytical Chemist

Enclosures: Appendix A – Chain-of-Custody
 Appendix B – List of Bracketed CHPS Compliant Temple-Inland Drywall Product



COMPLIANCE EMISSIONS TEST

By California DPH Standard Practice (Section 01350)

Drywall Panel Evaluation

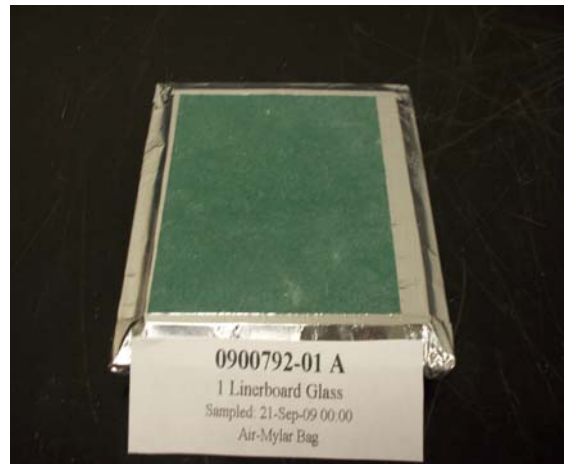
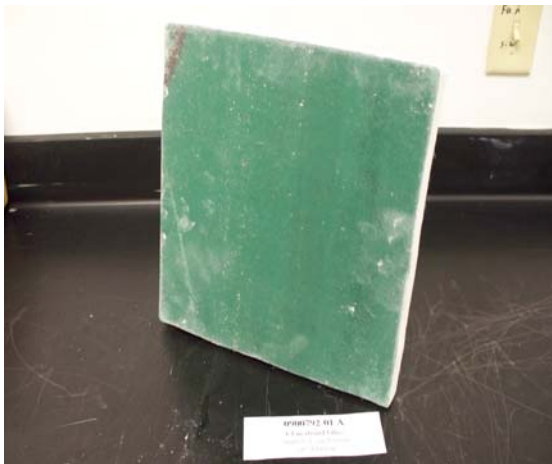
Project No: 0900792-01

BACKGROUND & SAMPLE DESCRIPTION

On September 21, 2009, the Temple-Inland of Austin, Texas submitted an exemplar of their **Greenglass® Fire Rated Liner Board** to MAS for emissions testing (refer to photos below).

An exemplar of the liner board was delivered to our Suwanee, Georgia office by Federal Express. The manufacturer and sample specifics as described in the accompanying chain-of custody are summarized below:

Manufacturer:	Temple-Inland West Memphis, AR Plant 540 East Barton West Memphis, AR 72301 Phone No.: 870-702-3185
Product Name:	Greenglass® Fire Rated Liner Board
Number of Samples:	4 pieces submitted (approximately 12” x 12” x 5/8”)
Manufacture Date:	September 21, 2009
Collection Date:	September 21, 2009
Shipping Date:	September 21, 2009
Laboratory Arrival Date:	September 22, 2009



Sample ID 0900792-01 Greenglass® Fire Rated Liner Board exemplar as submitted and tested



SAMPLE HANDLING & EMISSIONS TESTING

Upon arrival at the laboratory, the sample was assigned a specific lab ID number for tracking purposes. Identification of each of the regular and Greenglass® Fire Rated liner board sample submitted and a timeline of milestone dates (relative to sampling and analysis) are summarized below:

Sample ID	Sample Description	In-Chamber Conditioning / Testing Start/Stop Date Duration	In-Chamber VOC / Aldehyde Sampling	Date of VOC / Aldehyde Sample Analysis
0900792-01	<p>Greenglass® fire rated liner board – 5/8” fiberglass-faced gypsum liner panels designed for use in elevators, mechanical /electrical shafts, stairwells and area separation walls.</p> <p>Approx. 12” x 12”</p>	<p>10/15/09 - 10/25/09 10 days</p> <p>10/26/09- 10/29/09 4 days</p>	<p>10/26/09 @ 24 hrs 10/27/09 @ 48 hrs 10/29/09 @ 96 hrs</p>	<p>10/29/09 10/30/09</p>

To prepare the submitted liner board sample for chamber testing; a 6 inch x 6 inch piece was cut from the submitted gypsum wallboard and placed in a stainless steel test tray (which effectively reduces emissions from product backing). An inert aluminized metal tape was used to cover the sides of the cut board so that the resulting exposed area was a 5.5 inch x 5.5 inch square. Following preparation, the tray containing the sample was placed inside one of MAS’s small (53 liter) stainless steel emissions chambers on the chamber floor beneath a fan (to facilitate even air circulation around the sample).

Off gassed emissions from the subject product were sampled and analyzed in general accordance with the ASTM D 5116-97 guide for Emissions Testing using chamber methods. The specific parameters for sample conditioning, collection of samples and analysis of compounds of interest were conducted in accordance with the California Department of Public Health (CDPH) Standard Practice - *Testing Of Volatile Organic Emissions From Various Sources Using Small-Scale Environmental Chambers* (Section 01350) test method and MAS’s standard chamber emissions testing procedures using an abbreviated 24-hr test interval. Under the provisions of these methods, testing consisted of the following procedural steps:

- Specific procedures for specimen receiving, handling, and preparation
- Storage of test specimens in original shipping containers prior to emissions testing for up to 10 days in a ventilated and conditioned room maintained at a temperature of 23 ± 3°C and a relative humidity of 50% ± 15%.
- For quality assurance purposes the emission chambers are air purged and the interiors thoroughly cleaned to remove residual compounds prior to all new product tests. In addition, air samples are collected and analyzed from the chamber exhaust prior to loading to establish background levels.



- Sample placement within MAS’s small stainless steel emission chamber (interior volume – 53 liters) and allowed to equilibrate / condition for 10-days. Following placement, air flow into the chamber is maintained at the following specifications: ventilation rate = 0.891 l/min, temperature = 23 ± 1°C, relative humidity = 50 ± 5% RH.
- Collection of air samples at 24, 48 and 96-hours following 10-day sample conditioning period. Air samples are collected from the small chamber exhaust port utilizing mass flow controllers calibrated at 200 cc/min for VOCs and at 300 cc/min for aldehydes.
- Tenax TA® tubes (drawn in duplicate) are used for VOC analysis which is performed by thermal desorption gas chromatography/mass spectrometry (TD-GC/MS) using a modified EPA TO 17 method. Samples are also collected on DNPH tubes for Aldehyde analysis which is performed using high performance liquid chromatography (HPLC) using a modified NIOSH 2016 method.
- Instrument calibration, analysis of quality control samples and quantitation of the of the following target list of chemicals of concern:
 - 80 Chemicals with established Chronic Reference Exposure Levels (CRELs) specified by the California’s Office of Environmental Health Hazard Assessment (OEHHA). A CREL is an airborne concentration level that would pose no significant health risk to individuals indefinitely exposed to that level. CRELs are based solely on health considerations and are developed from the best available data in the scientific literature.
 - Chemicals listed as: (a) probable or know carcinogens, or (b) reproductive toxicants.
 - Total Volatile Organic Compounds (TVOC) between n-C₅ and n-C₁₇
 - MAS Calibrated Compounds
 - Acetaldehyde
 - Benzene
 - Caprolactam
 - 2-Ethylhexanoic Acid
 - Formaldehyde
 - 1-Methyl-2-Pyrrolidinone
 - Naphthalene
 - Nonanal
 - Octanal
 - 4-Phenylcyclohexene
 - Styrene
 - Toluene
 - Vinyl Acetate
 - Acrolein
- Reporting and speciation of top tentatively identified compounds.



The parameters for the small chamber testing conducted by MAS included:

Parameter	Symbol	Units	Value
Chamber Volume	V	m ³	0.053
Loading Factor	L	m ² m ⁻³	0.368
Air Exchange Rate	a	h ⁻¹	1
Area Specific Flow Rate	q _A	m h ⁻¹	2.35
Temperature	T	°C	23
Relative Humidity	RH	%	50

RESULTS OF TESTING

The CDPH Standard Practice emissions testing protocol is designed to measure the release of volatile organic compounds from a given material over a 4-day sampling period. Air samples are collected and analyzed at 24, 48 and 96-hour intervals (following an initial 10-day conditioning period). Fourteen volatile organic compounds (VOCs) are individually calibrated for using a combination of gas chromatography/mass spectrometry (GC/MS) and high performance liquid chromatography (HPLC) in accordance with the referenced methodology.

The results of the emissions testing are summarized in the tables presented below and on the following pages. The actual emissions measured are characterized as a concentration in µg/m³ and as an emission factor in micrograms emitted per square meter of material per hour (ug/m²/hr).

Table I
Total Volatile Organic Compounds (TVOC)
as Measured by GC/MS

Sample ID#	Sample Interval in hours	TVOC Concentration in µg/m ³	TVOC Emission Factor in µg/m ² h
0900792-01	24	62	170
	48	53	140
	96	47	130



Table II
Formaldehyde, Acetaldehyde and Acrolein
as measured by HPLC

Sample ID#	Sample Interval in hours	Target Compound	Concentration in $\mu\text{g}/\text{m}^3$	Emission Factor in $\mu\text{g}/\text{m}^2 \text{ h}$
0900792-01	24	Formaldehyde	<1.5	<4.1
	48	Formaldehyde	<1.5	<4.1
	96	Formaldehyde	<1.5	<4.1
	24	Acetaldehyde	<1.4	<3.7
	48	Acetaldehyde	<1.4	<3.7
	96	Acetaldehyde	<1.4	<3.7
	24	Acrolein	<0.8	<2.3
	48	Acrolein	<0.8	<2.3
	96	Acrolein	<0.8	<2.3

Table III
Speciation of Top Ten Identified* IVOCs after 96 hours by GC/MS

Sample ID#	CAS Number	Tentatively Identified Compounds	Library Match %	Conc. in $\mu\text{g}/\text{m}^3$	Emission Factor in $\text{mg}/\text{m}^2 \text{ h}$	Match Quality
0900992-01	629-62-9	pentadecane	95	8.4	23	Good
	629-59-4	tetradecane	97	7.4	20	Good
	544-76-3	hexadecane	97	6.3	17	Good
	629-50-5	tridecane	97	4.1	11	Good
	629-78-7	heptadecane	98	4.2	11	Good
	4971-18-0	cyclopentanone, 2-ethyl-	59	2.8	7.7	Poor
	589-92-4	cyclohexanone, 4-methyl-	59	1.7	4.5	Poor
	4461-48-7	2-pentene, 4-methyl-	53	1.4	3.8	Poor
	80655-44-3	decahydro-4,4,8,9,10-pentamethylnaphthalene	46	1.3	3.7	Poor
	66-25-1	n-hexanal	94	<1.3	<3.6	Good

*All IVOCs other than the 14 MAS individually calibrated compounds calculated using the average response factor of toluene calibration standards. Match qualities of less than **85%** are not considered to be proof of chemical identity per EPA protocols.



DISCUSSION OF CHAMBER DERIVED DATA

The emissions testing protocol is designed to measure the release of volatile organic compounds from a given material over time. Eleven volatile organic compounds (VOCs) were individually calibrated for our analysis of the off-gassed emissions from the subject sample by GC/MS. Of these compounds none were detected above laboratory detection limits.

Total volatile organic compounds (TVOC) are defined as the compounds eluting between hexane ($n\text{-C}_6$) and hexadecane ($n\text{-C}_{16}$) and in this protocol quantified as toluene (*please note that there are no specific TVOC limits specified under CHPS*). The measured concentration of total volatile organic compound (TVOC) obtained at each of the three sampling intervals is presented in **Table I**. The concentration of TVOC off-gassed from the tested liner board is representative of low levels. This concentration decreases slightly over the three sampling intervals.

The measured concentration of aldehydes (Formaldehyde, Acetaldehyde and Acrolein) obtained at each of the three sampling intervals are presented in **Table II**. None of the aldehydes measured by HPLC were detected above laboratory detection limits at any of the sampling intervals.

The top ten individual volatile organic compounds (IVOC) off-gassing from the tested liner board (identified after 96 hours by GC/MS) are presented in **Table III**. All ten of these compounds were tentatively identified by library search and quantified as a toluene equivalent instrument response. None of the compounds presented in **Table III** appear on the California CREL list of compounds of concern.

Please note, that in Table III, the Library Match % is a comparison of mass spectra by the library search algorithm of the Chemstation G1701DA mass spectrometry software package with the Wiley and NBS 75K mass spectral database. The search methods that we use apply a “match quality” to the search result, based upon a scale of 100%. MAS tentatively identifies compounds with a minimal match quality of $\geq 85\%$. Anything less than that value is flagged in **red** (please note the sum concentration of the IVOC’s does not necessarily correlate with the TVOC concentration under the analytical conditions).

DISCUSSION AND RATIONALE OF MODELED DATA

In order to compare the chamber derived data to the standards set up under California Section 01350 and the Collaborative for High Performance Schools (CHPS) criteria for Low Emitting Materials an emission factor for the tested liner board is calculated based on the 96-hour data. This emission factor is then applied to the defined parameters of that product in a typical school classroom and/or private office environment (accounting for the specified room sizes and ventilation rates).

In the case of walls, the California Section 01350 guide specifies certain standard material areas and area specific flow rates to be used in the calculation of predicted air concentrations for all wall products. These parameter values reflect a surface area of 94.6 m^2 and a flow rate of $1.98 \text{ m}^3 \text{ h}^{-1} \text{ m}^{-2}$ for a classroom and a surface area of 46.3 m^2 and a flow rate of $0.45 \text{ m}^3 \text{ h}^{-1} \text{ m}^{-2}$ for an office. The results of these emissions predictions are presented on the following page in **Table IV**.



Table IV
Emission Factors and Predicted Air Concentrations for the Temple-Inland Greenglass® Liner Board Drywall in Typical Building Environments

VOC Name	Based on the Calculated Small Chamber Data in $\mu\text{g}/\text{m}^2/\text{hr}$	Calculated Building Concentration Predictions in $\mu\text{g}/\text{m}^3$		Reference OEHHA $\frac{1}{2}$ CREL Values in $\mu\text{g}/\text{m}^3$	Testing Comment
	96 th hour (4 days)	Classroom*	Private Office**		
Total VOCs (TVOC)	130	65	290	NA	NA
Formaldehyde	<4.1	<2.1	9.2	16.5	PASS / PASS
Acetaldehyde	<3.7	<1.9	8.4	70	PASS / PASS
Acrolein	<2.3	<1.2	<5.4	0.03	PASS / PASS
Vinyl Acetate	<3.6	<1.8	<8.1	100	PASS / PASS
Benzene	<3.6	<1.8	<8.1	30	PASS / PASS
Toluene	<3.6	<1.8	<8.1	150	PASS / PASS
Styrene	<3.6	<1.8	<8.1	220	PASS / PASS
Octanal	<3.6	<1.8	<8.1	7.2	PASS / PASS
1-methyl-2-pyrrolidone	<3.6	<1.8	<8.1	160	PASS / PASS
Nonanal	<3.6	<1.8	<8.1	13	PASS / PASS
2-ethylhexanoic acid	<3.6	<1.8	<8.1	25	PASS / PASS
Naphthalene	<3.6	<1.8	<4.1	4.5	PASS / PASS
Caprolactam	<3.6	<1.8	<8.1	100	PASS / PASS
4-PC	<3.6	<1.8	<8.1	9.3	PASS / PASS

*- Assumes a classroom size of 24' x 40' x 8.5' with a ventilation rate of 0.9 h⁻¹ as defined by CA/DHS/EHLB/R-174

** - Assumes a private office size of 10' x 12' x 9' with a ventilation rate of 0.75 h⁻¹ as defined by CA/DHS/EHLB/R-174

CONCLUSIONS

Based on the data obtained during our test summarized in Table IV, MAS offers the following conclusions and recommendations:

- Emissions of VOCs from the tested drywall were very low. None of the 80+ compounds regulated by the State of California were detected at concentrations in excess of the laboratory detection limits. As such predicted building concentrations from the drywall are well below the $\frac{1}{2}$ CREL limits reference in the CHPS program.



- **The Temple-Inland Greenglass® fire rated liner board from Temple-Inland’s West Memphis, AR plant and all specified drywall products bracketed under this emissions testing program meet the performance standard established for low-emitting materials under the CHPS program.**
- **It is important to note; that qualified project uses of the Temple-Inland Greenglass® fire rated liner board and all designated compliant bracketed drywall products are eligible for 1 credit point EQ 2.3.6 under the CHPS program.**
- **Further, by successful conformance with the CHPS standard, the subject liner board and all designated compliant bracketed drywall products also meets the criteria of **MAS Certified Green®** program**

LIMITATIONS

This report is intended for the use by Temple-Inland only. If other parties wish to rely on this report, please have them contact us so that a mutual understanding and agreement of the terms and conditions for our services can be established prior to their use of this information.

It should be noted that emissions generally decay over time; as such the representativeness of the analytical data reported is directly dependant upon the age and conditions under which the tested sample was received.

All certifications for product emissions testing are valid for a period of 1-year from the date of a MAS issued Emissions Testing Compliance Report. Compliance certifications are strictly limited to only the referenced product tested and/or specific variations and bracketed products explicitly referenced in the Emissions Testing Compliance Report and Appendices.

APPENDIX A
Chain of Custody



Materials Analytical Services LLC

3946 Lakefield Court
 Suwanee, Georgia 30024
 Phone: 770-866-3200
 Fax: 770-866-3259



Standard Method (Section 01350)

**PRODUCT EMISSIONS TESTING
 CHAIN OF CUSTODY**

Client Information
Company: Temple - Inland
Street Address: 540 E. Barton
City/State: West Memphis, AR
Zip/Postal Code: 72301
Country: USA
Contact Name: Clifton Edison
Title: Quality Supervisor
Phone Number: 870-702-3185
Fax Number: 870-702-3200
Email Address: Clifton.Edison@Temple-Inland.com

Specific Building Parameters (per CHPS)
Organization:
City/State/Country:
Office or School:
Material exposed area (ft ²):
Building volume (ft ³):
Room floor area (ft ²):
Ceiling height (ft):

Manufacturer Information (if different)
Company:
City/State/Country:
Contact Name/Title:
Phone Number:

Furnishing Construction Details (as applicable)
Covering Type: Fabric <input type="checkbox"/> (Primary Fiber type: _____), Vinyl <input type="checkbox"/> , Leather <input type="checkbox"/>
Polymer Type(s): Nylon <input type="checkbox"/> , PVC <input type="checkbox"/> , PE <input type="checkbox"/> , PP <input type="checkbox"/> , PU <input type="checkbox"/> , PS <input type="checkbox"/> , PC <input type="checkbox"/> , ABS <input type="checkbox"/> , Acrylic <input type="checkbox"/> , Lexan <input type="checkbox"/>
Substrate Type: MDF <input type="checkbox"/> , Particle Board <input type="checkbox"/> , Plywood <input type="checkbox"/> , Solid Wood (Type: _____)
Finish Type: Oil <input type="checkbox"/> , Water <input type="checkbox"/> , Catalyzed <input type="checkbox"/> , Conversion <input type="checkbox"/> , Polyurethane <input type="checkbox"/> , Laminate <input type="checkbox"/> , Other <input type="checkbox"/>
Foam Type: Polyurethane <input type="checkbox"/> , Memory <input type="checkbox"/> , Latex <input type="checkbox"/> , Evlon <input type="checkbox"/> , High Resilience <input type="checkbox"/> , High Density <input type="checkbox"/>
Paint Type: Latex <input type="checkbox"/> , Oil <input type="checkbox"/> , Low VOC <input type="checkbox"/> , No VOCs <input type="checkbox"/> , PowderCoat <input type="checkbox"/>

Sample Details
Sample ID: 1" Linerboard Glass
Product Name:
Product Type: Ceiling/Wall Panels <input checked="" type="checkbox"/> , Flooring <input type="checkbox"/> , Trim <input type="checkbox"/> , Wall Paint <input type="checkbox"/> , Wall Coverings <input type="checkbox"/> , Thermal Insulation <input type="checkbox"/> , Furnishings (desks <input type="checkbox"/> chairs <input type="checkbox"/> other <input type="checkbox"/>) , Other <input type="checkbox"/>
Date Manufactured: 9/21/09 or unknown inventory stock <input type="checkbox"/>
<input checked="" type="checkbox"/> Warehouse <input type="checkbox"/> , Vendor Supplied <input type="checkbox"/>
Sample Collected by: Bernice Jackson
Date & Time Collected: 9-21-09 @ 12:03
Number of Sample Pieces: 4

Notes or Comments from Manufacturer:

Shipping Details
Packed By: Bernice Jackson
Shipping Date: 9-21-09
Carrier/Airbill Number: FedEx

Laboratory Receipt (to be completed by Laboratory Representative)
Received By: Nancy Seal
Received Date: 9-22-09
Condition of Shipping Package: ok
Condition of Sample: ok
Remarks: - this is part 1 of a 2 part project - additional samples to come

Sample Handling				
Relinquished By	Company	Received By	Company	Date/Time
		Nancy Seal	MAS	9/22/09

APPENDIX B

List of Bracketed CHPS Compliant Temple-Inland
Drywall Products

List of CHPS Compliant Temple-Inland Drywall Products

(Based on Emissions Testing and Bracketing Program Created for Temple-Inland)

Qualified Products¹ & Options

Effective: November 2009 – November 2010

Product Class	Product Type	Additional Constituents‡
Paperless	Regular interior	fiberglass (1), wax (1), mildewcide (1)
	Fire rated interior	fiberglass (2), wax (1), mildewcide (1)
	Regular sheathing	fiberglass (1), wax (2), mildewcide (1)
	Fire rated sheathing	fiberglass (2), wax (2), mildewcide (1)
	Shaft Liner*	fiberglass (2), wax (2), mildewcide (1), vermiculite (2), gypsum (2)
	<i>Fire rated roof decking†</i>	fiberglass (2), wax (2), mildewcide (1)
	Regular tile backer	fiberglass (1), wax (2), mildewcide (1), acrylic backing (2)
	<i>Fire rated tile backer†</i>	fiberglass (2), wax (2), mildewcide (1), acrylic backing (2)
	<i>Impact resistant†</i>	fiberglass (2), wax (2), mildewcide (1), laminate, adhesive, gypsum (2)

¹-Inclusive of specified products manufactured at the West Memphis, Arkansas plant

‡- Additives in drywall considered to potentially impact emissions. The (#) indicates qualitative amount

* - Identified as highest emitting product in Paperless Drywall class from representative R&D testing. This product served as “worst” case exemplar for the full CDPH Standard Practice 14-day emission test

† - proposed products not currently in production