WOOD I-JOIST MANUFACTURERS ASSOCIATION

Measurement of the Volatile Organic Compounds Emitted from Engineered Wood Products via a Sealed Caul Plate Collection Method

Established April, 2007

Introduction

The sealed caul plate test methodology (SCPTM) was developed to provide a more realistic and cost effective estimation of fugitive volatile organic compound (VOC) and fugitive hazardous air pollutant (HAP) emissions from engineered lumber products. The SCPTM serves as a reasonable compromise between two already established estimation alternatives.

The first alternative is mass balance. Mass balance estimation assumes the chemical constituents within a product are all released to the environment during the manufacturing of the engineered lumber product. Mass balance is a very conservative estimation since it significantly overstates the actual emissions measured by source testing. Mass balance estimation, while conservative, typically does not include those emissions from the wood itself, which can be a large contributor to the emissions profile.

The second alternative is source testing. Source testing samples emissions at point sources (i.e., roof stacks, etc.) or fugitive emissions from non-point sources. Whereas point source testing is generally reliable, it is also expensive, particularly for fugitive emission sources. Test results are reliant on strong capture efficiencies which are expensive to obtain and not always achievable.

The third alternative is the SCPTM. The SCPTM is a laboratory-scale method that quantifies the emissions contributed from both the adhesive and the wood substrate in a controlled environment that emulates the actual manufacturing process (e.g., pressing, cool down, etc.). Results from the SCPTM have been accepted for air permitting purposes; including those at major sources, by Lane Regional Air Protection Agency (LRAPA) and the Oregon Department of Environmental Quality (ODEQ) as well as similar regulatory agencies in other states.

Emission factors generated by way of the SCPTM have been in use for approximately 10 years.

Background

The SCPTM was first pioneered in the early to mid 1990s when it became apparent that mass balance and source testing failed to properly characterize the VOC and HAP emission profile representative of engineered lumber products and their typical fugitive, non-point sources. Hexion (formerly Borden Chemical) and Weyerhaeuser Company (formerly Trus Joist MacMillan) jointly developed the SCPTM procedure. Other adhesive suppliers recognized the value of the SCPTM procedure and developed very similar laboratory-scale testing methods.

Over the 15 year period of use, each adhesive supplier developed their own subtle variants on the SCPTM methodology. The net result has been that emission factors vary significantly between suppliers. For permitting purposes, Weyerhaeuser Company to date has addressed this variability by way of employing the highest, most conservative SCPTM emission factors in its applicable air permits.

Subsequently, Weyerhaeuser Company in 2006 invited Dynea, Georgia Pacific, and Hexion phenol-formaldehyde based adhesive suppliers to participate in the development of the voluntary, industry-standardized SCPTM under the auspices of the WIJMA Adhesive Subcommittee. The test method presented is the result of deliberations between the four companies with respect to the emissions from testing rectangular, veneer-based products from hot-pressing technologies.

The committee believes that the standardized, SCPTM procedure will gain wider acceptance as more complex regulatory requirements arise. The SCPTM procedure below provides a reliable, regulatory means for legitimately deriving estimated emission factors in a laboratory environment.

Acronyms:

WIJMA = Wood I-Joist Manufacturers Association

Scope

This method encompasses the collection, measurement and quantification of specific volatile organic compounds (VOCs) that are emitted during the manufacture of engineered wood products in a laboratory environment. As written, it’s directly pertinent to the determination of the amounts of methanol, formaldehyde, and phenol that are emitted during the hot pressing, simulated ‘hot stacking’, and simulated ‘cool-down’ of exterior plywood and laminated veneer lumber (LVL) glued with phenol/formaldehyde (PF) resin based adhesives. It’s believed, however, that the method can be adapted – with modifications – for the measurement of the VOCs emitted during the manufacture of other engineered wood products glued with similar adhesives.

Principle

The methanol, formaldehyde, and phenol emitted during the hot pressing, simulated ‘hot stacking’ and simulated ‘cool down’ of exterior plywood and laminated veneer lumber (LVL) are captured within the confines of a sealed caul plate. Those compounds, present in gaseous form in the air space encompassed within the sealed caul plate, are forced into a series of collection solutions via a continuous flow of clean/dry air from a pressurized cylinder through the sealed caul plate. Once that process is completed, the collection solutions are diluted to concentrations ideally suited for instrumental analysis. They are then analyzed to determine their methanol, formaldehyde and phenol content. The weight of the veneers used to assemble the plywood or LVL test specimen, the weight of the adhesive applied to those veneers, and the concentrations of the VOCs detected in the collection solutions are subsequently used to calculate the total amounts of methanol, formaldehyde, and phenol that are emitted during the test. The results are typically reported as “grams of VOC (e.g. methanol) per gram of adhesive” or “lbs. of VOC per lb. of adhesive”. [NOTE: The results reported as such include the methanol, formaldehyde and, phenol emitted from both the veneer and the adhesive. The procedure, however, can also be used to measure the emissions from just the veneer(s) used in the plywood or LVL. Those assemblies are referred to as ‘blanks’.]

Test Apparatus – See Appendix A

Emission Collection Procedure

1) A suitable quantity of veneer (of the species and thickness of interest) is procured, cut-up into 12-in. x 12-in. pieces, and systematically sorted such that the pieces selected for use in one test panel/billet are closely similar to those selected for use in ‘matching’ panels/billets. The veneer is then equilibrated to a targeted moisture content (MC). The equilibration process typically takes four to five days; when it’s properly conducted, all of the veneer pieces should be within ±0.5% of the targeted MC (e.g. 5.5 – 6.5% for a 6.0% MC target). When the process is completed, the veneer is removed from the equilibration chamber and sealed in plastic bags to keep its MC at the targeted level prior to use.

2) The adhesive used in the test can be procured from a production plant’s inventory or prepared in the laboratory. If it’s prepared in the laboratory, it can be manufactured using resin procured from a plant’s inventory or resin from a laboratory batch. Irrespective of its source, the resin should be aged (i.e. stored) at 25°C in a vented container (e.g. a 1gallon polyethylene jug) for 16 – 24 hours prior to use in the manufacture of the adhesive. Similarly, irrespective of its source (i.e. a production sample or a lab batch), the adhesive should also be aged at 25°C in a vented container for 16 – 24 hours prior to use in the sealed caul plate test.

3) The laboratory hot press is turned on and adjusted to the desired temperature and pressure settings at least 30-minutes prior to beginning panel/billet assembly.

4) The sealed caul plate is placed on the bottom press platen shortly after the hot press is turned on so that it reaches an equilibrated temperature prior to beginning panel/billet assembly.

5) Two sets of three collection impingers are prepared for each test. The weights of each 'dry' impinger are measured and recorded. Approx. 200-ml of de-ionized water is added to each impinger and their 'wet' weights are measured and recorded. One set of impingers is then assembled and suspended in an ice bath, taking care to insure that the impinging tubes are extended well below the surfaces of the collection solutions (i.e. near the bottoms of the tubes). [NOTE: Connection of the first set of collection impingers to the Swagelok® valve outlet is not made until just before the panel/billet being tested is placed into the hot press.]

6) The adhesive to be tested is poured onto the spreader rolls and allowed to equilibrate for approx. 10-minutes. At the end of that process, the spreader roll gap and doctor roll settings are adjusted so that the weight of the adhesive applied to test pieces of veneer is within ±1.5 grams of the targeted spread weight to be applied to each 12-inch x 12-inch veneer. [For example, the weight of the adhesive applied to a "test" veneer should be 30.5 – 33.5 grams for a targeted spread weight of 32-grams/ft^2.] The spreader roll gap and doctor roll settings should be adjusted so that: a) adhesive "squeeze-out" on the edges of the veneers is minimized, and 2) the amount of the adhesive that's applied to the bottom ('loose') and top ('tight') sides of the veneers is approximately equivalent.

7) Additional adhesive is then poured onto the spreader rolls such that the ratio of the mixture of 'fresh' and 'aged' adhesive on each roll is approx. 50:50. The adhesive is then equilibrated on the rolls for an additional 2-3 minutes. A test veneer is run through the spreader rolls and the weight of the adhesive applied to it is measured. If the weight of the applied adhesive is close to the center of the targeted range, lay-up and assembly of the first panel/billet can begin. If the weight is outside of or at the extreme edges of the acceptable range, however, the spreader settings must be "fine-tuned" and the process described in Step #6 above repeated until the targeted spread weights are consistently applied to test pieces.

8) The veneer to be used in the individual panel/billet assemblies should be removed from the plastic bags it's stored in while the adhesive is equilibrating on the spreader rolls. The total weight of the pieces of veneer slated for use in each panel/billet is measured and recorded.

9) The first (i.e. 'bottom' or 'back') veneer used in each panel/billet is placed on the assembly table "loose-side-up". All of the remaining veneers in the panel/billet are oriented "tight-side-up". The veneers that have adhesive applied to them are also run through the spreader rolls "tight-side-up." When assembling plywood panels, the grain patterns of the 'core' veneers are oriented at right angles (90 degrees) to the grain patterns of the ('face', 'back', or 'center') veneers directly adjacent to them. When assembling LVL billets, the grain patterns of all of the veneers are oriented in the same direction.

10) The panel/billet assemblies should be laid up and assembled expeditiously while still allowing sufficient time between running individual veneers through the spreader rolls to maintain a consistent spread rate. [NOTE: Experience indicates that a typical lay-up time for a 7-ply, ¾-inch thick plywood panel is approx. 3-minutes. A typical lay-up time for a 13-ply, 1 ½ -inch thick LVL billet is approx. 6-minutes.]

11) The weight of each panel/billet is recorded immediately after the lay-up and assembly process is completed. The weight of the applied adhesive is then calculated by subtracting the weight of the uncoated veneers (Step #8 above) from the weight of the assembled panel/billet. [NOTE: To define spread weight variability, the weights of the adhesive applied to each 'core' veneer during the panel/billet lay-up process can be measured and recorded.]

12) The first set of collection impingers is connected to one of the ports of the Swagelok® valve that's, in turn, connected to the tubing from the 'outlet' port of the sealed caul plate. A flow of clean dry air (from the pressurized cylinder) is established through the flow meter into the 'inlet tube' of the sealed caul plate. [NOTE: No air should be flowing through the collection impinger train at this point as the caul plate is still open to the atmosphere.]

13) The panel/billet assembly is then quickly placed into the center of the sealed caul plate and the hot press is closed. [NOTE: Sufficient pressure has to be employed to prevent air leaks between the hot press platens and sealed caul plate surfaces (or gaskets). That pressure may be higher than the pressures typically employed in the manufacture of plywood and LVL.]

14) The hot pressing cycle is started as soon as the press is completely closed and air flow into and through the caul plate is established. A constant air flow rate of 1.8 liters/minute rate is regulated by the (previously calibrated and adjusted) flow meter.

15) The second set of collection impingers is attached to the other port of the Swagelok® valve before the hot pressing cycle is concluded.

16) At the conclusion of the hot pressing cycle the air flow through the first set of collection impingers is terminated by turning the Swagelok® valve handle such that the air flow is directed into the second set of collection impingers. The heat input to the hot press platens is then promptly turned off. The air flow rate for the simulated 'hot stack/cooldown' part of the test is maintained at 1.8 liters/min. (NOTE: Additional ice may have to be added to the ice bath to keep the collection impingers adequately chilled during lengthy 'hot stack/cool-down' cycles.) The first set of collection impingers is disconnected from the Swagelok® valve and its connection couplings are sealed closed. The impingers are then removed from the ice bath (see Step #18 below).

17) At the conclusion of the simulated 'hot stack/cool-down' cycle the hot press is opened and the air flow (from the pressurized cylinder) is terminated. The second set of collection impingers is disconnected from the Swagelok® valve and its connection couplings are sealed closed. The impingers are then removed from the ice bath.

18) After disconnection from the sealed caul plate apparatus and removal from the ice water bath, the outsides of the collection impingers (and their corresponding connection tubes) are promptly dried off. The connection tubes are removed and each impinger is weighed to determine its 'final' weight. [NOTE: The 'net' weights of the VOCs collected in each impinger are calculated by subtracting the respective impingers' 'wet' weights (calculated in Step #5) from their 'final' weights.] The contents of each collection impinger are then quantitatively transferred into a (previously weighed) 'dry' amber glass jar. Each collection impinger and its respective connection tubing are rinsed three times with small quantities of de-ionized water; each rinse solution is transferred into the same glass jar that the contents of the impinger were transferred into. Following the third rinse, the glass jar is weighed to determine its 'final' weight. The 'net' weight of the solution in each jar is calculated by subtracting the jar's 'dry' weight from its 'final' weight.

19) The amber glass sample jars are kept tightly sealed and refrigerated (at 4±°C). Aliquots of the solutions can be removed from each jar and transferred into the small vials typically used in analytical labs. If that procedure is used, the vials should be almost completely filled (to minimize the head space above the liquid) and kept cool until the solutions are analyzed.

20) The concentrations of methanol, formaldehyde, and phenol in the collection solutions are determined via high pressure liquid chromatography (HPLC) and/or gas chromatography (GC). The analyses of each collection solution are run in triplicate; the results are then averaged and the 'mean' values used for subsequent calculations. [NOTE: Standardized analytical test procedures for the analyses of the collection solutions have yet to be developed and agreed to. Irrespective of that, the test procedures that are used should meet (or exceed) recognized scientific standards for accuracy and precision.]

Calculations

1) Once the concentrations (expressed in weight percentages) of methanol, formaldehyde and phenol in the collection solutions are determined, the weights of the respective VOCs in each solution are calculated by multiplying the 'net' solution weights (from Step #18) by the concentrations (i.e. weight percentages) of each VOC (from Step #20). Those weights are most often expressed in milligrams.

2) The amounts of methanol, formaldehyde, and phenol emitted from each panel/billet during its hot pressing cycle are calculated by summing up the weights (of each respective VOC) found in the first set of collection impingers. Similarly, the amounts of methanol, formaldehyde, and phenol emitted from each panel/billet during its simulated 'hot stacking/cool-down' cycle are calculated by summing up the weights (of each respective VOC) found in the second set of collection impingers. Those amounts are also expressed in milligrams.

3) The total amounts of methanol, formaldehyde, and phenol emitted from each panel/billet over the duration of the test is calculated by summing up the weights (of each respective

VOC) found in both sets of collection impingers. Those amounts are also expressed in milligrams.

4) The total amounts of each VOC are then divided by the weight of each panel/billet tested to determine the unit weight of each VOC emitted per unit weight of each panel/billet tested. The results are most often expressed as "milligrams of VOC per gram of panel/billet".

5) Standard conversion factors are then employed to convert the results to "grams of VOC per gram of adhesive" or "lbs. of VOC per lb. of adhesive".

Precision and Bias

To determine a precision and biased statement, matched veneer and adhesive samples were sent to three separate laboratories for sample preparation, pressing, emission collection and calculation of test results. The round robin testing was deemed to produce satisfactory results by the WIJMA Adhesive Subcommittee.

Statistical Analysis: Data returned from three laboratories was analyzed according to established statistical procedures to determine repeatability and reproducibility limits at the 95% acceptance level. The data was also analyzed using Grubbs Test (J. Frank Rudisill and E. Earl Burch, 'Quality Management and Measurement Systems' Quality Associates of Clemson Inc., pp 9-3, 9-4 1999) to identify outliers in the data before statistical analysis of the round robin data.

Definition of Precision: The precision of this method is expressed in terms of the repeatability (variability between independent test results gathered within a single laboratory) and reproducibility (variability among single test results gathered from different laboratories).

Precision Statement: The precision statement in this method is based on the methanol values from the adhesive only. This is because the values in the methanol data set, unlike those for formaldehyde and phenol, were not precariously close to the detection limits of the test method. It should also be noted that any quantification of phenol from the wood represents phenolic compounds rather than just phenol (CAS# 108-95-2).

The repeatability standard deviation has been determined to be (1.31E-03 ± 4.75E-04 grams methanol/ gram adhesive).

The reproducibility standard deviation has been determined to be (1.31E-03 ± 5.76E-04 grams methanol/gram adhesive).

Comment on Precision: The within lab variability (i.e. the variability that one could reasonably expect with a single lab performing collection and analysis) was not significantly different from the between lab variability when compared to the measured values. The variability indicated by the statistical analysis suggests that it is inherent to the test method and is within acceptable limits for its use.

Definition of Bias: The bias in the method refers to a systematic error that contributes to the difference between the mean of a large number of test results and an accepted reference value.

Bias Statement: No information on bias is presented as no reference board sample containing a reference value of methanol was available during the testing.

Sample Report - See Appendix B

WIJMA Adhesive Subcommittee Members (at the time of protocol development)

Weyerhaeuser Company
- Rob Brooks
- Dale Wonn
- Marv Lewallen

Dynea Resins
- Gary Remillard
- Blair Wilding
- Reggie Mbachu

Georgia Pacific Resins
- Jeff Balogh

Hexion Specialty Chemicals
- Bill Arndell
- Todd Miller

Appendix A

Testing Apparatus

Hot Press – a laboratory scale hot press equipped with automatic temperature and pressure controls. The hot press platens can be heated electrically, with hot oil, or with steam. The platens need to be adequately sized (e.g. 24-inches x 24-inches) to accommodate the dimensions of the caul plate.

Caul Plate – a machined aluminum caul plate fabricated to be closely similar to the examples exhibited in Figures A1 or A2. The plates' outside dimensions are typically 19 – 22-inches (length) x 19 – 22 inches (width) x ¾-inches (exact thickness). The air 'inlet' and 'outlet' holes in the front edge of the plate are tapped to receive stainless steel tubing. When the test is conducted, the 'inlet' and 'outlet' tubes can be fitted with Swagelok® female "quick-disconnect" couplings. The outlet pipe is fitted with a Swagelok® #SS44XF4 "T" fitting (with valve).

Spacer Plate – an equivalently dimensioned (to the caul plate) ¾-inch thick aluminum 'spacer' plate is required to test 1 ½-inch thick LVL billets. The caul plate and spacer plate are most frequently aligned by drilling several holes into the top surface of the caul plate and mounting pins onto the mating surface of the spacer plate.

VOC Collection Apparatus - the equipment listed below is required to assemble the VOC collection apparatus exhibited in Figure A3.

a. Compressed air cylinder containing clean, dry (i.e. breathable) air
b. Gas Flow Meter – Cole Parmer #G-03216-18 (or equivalent).
c. Collection Impingers – Environmental Supply Company #GP-105 (or equivalent).
d. Glass U-tube Connectors – Environmental Supply Company # GP-106 (or equivalent).
e. Teflon Socket Adapters – Environmental Supply Company #GPT-S28-6L (or equivalent).
f. #28 Ball Joint Clips – Environmental Supply Company #GP-109 (or equivalent).
g. Connection Tubing – Teflon tubing, 1/4" I.D. x 3/8" O.D. x 1/16" wall thickness
h. Ice Bath – a chest or 'cooler' appropriately sized to accommodate (sets of three) collection impingers that are surrounded by and immersed in ice.
i. Amber Glass Bottles
j. Gasket Material (optional) – Durlon® 8500
k. O-ring Gaskets (optional)

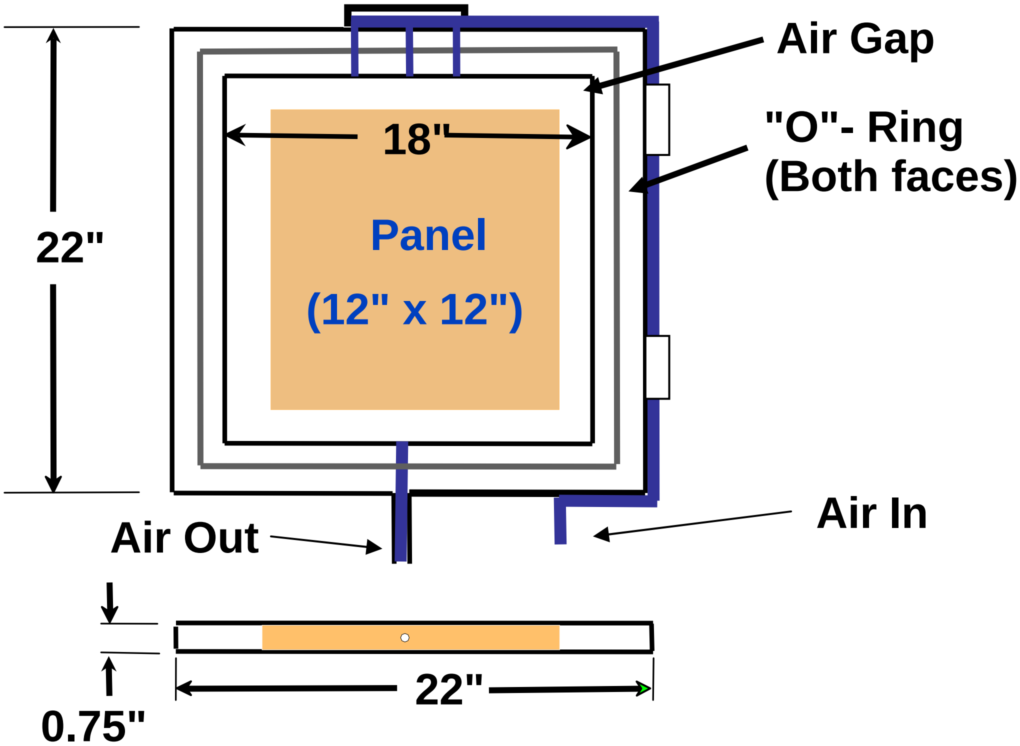

Figure A1 – First Examples of Caul Design

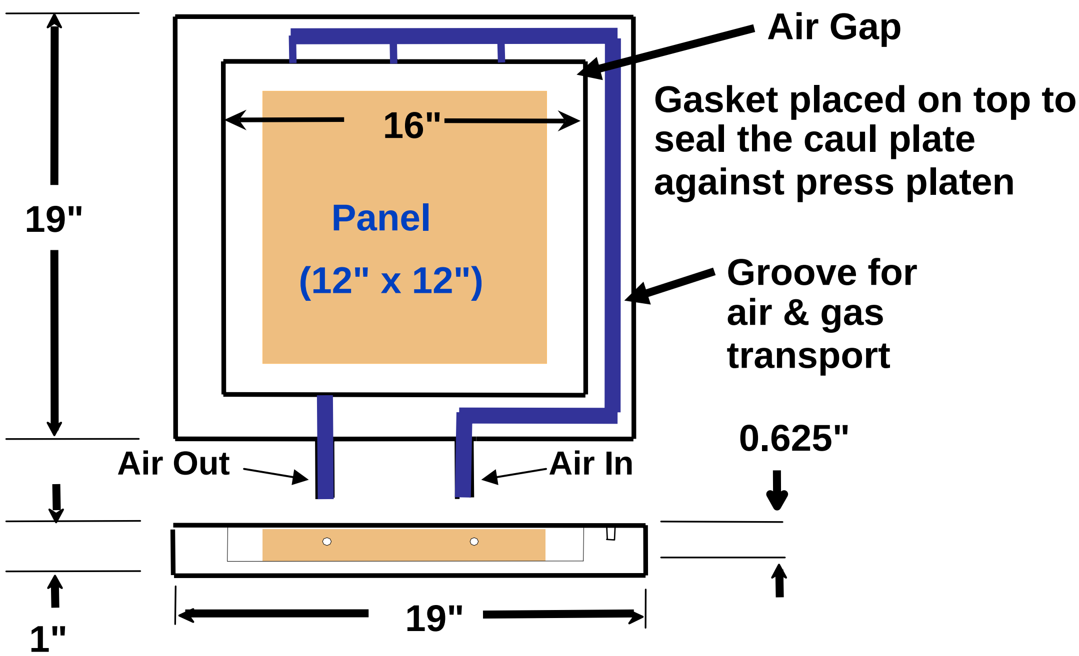

Figure A2 – Second Example of Caul Design

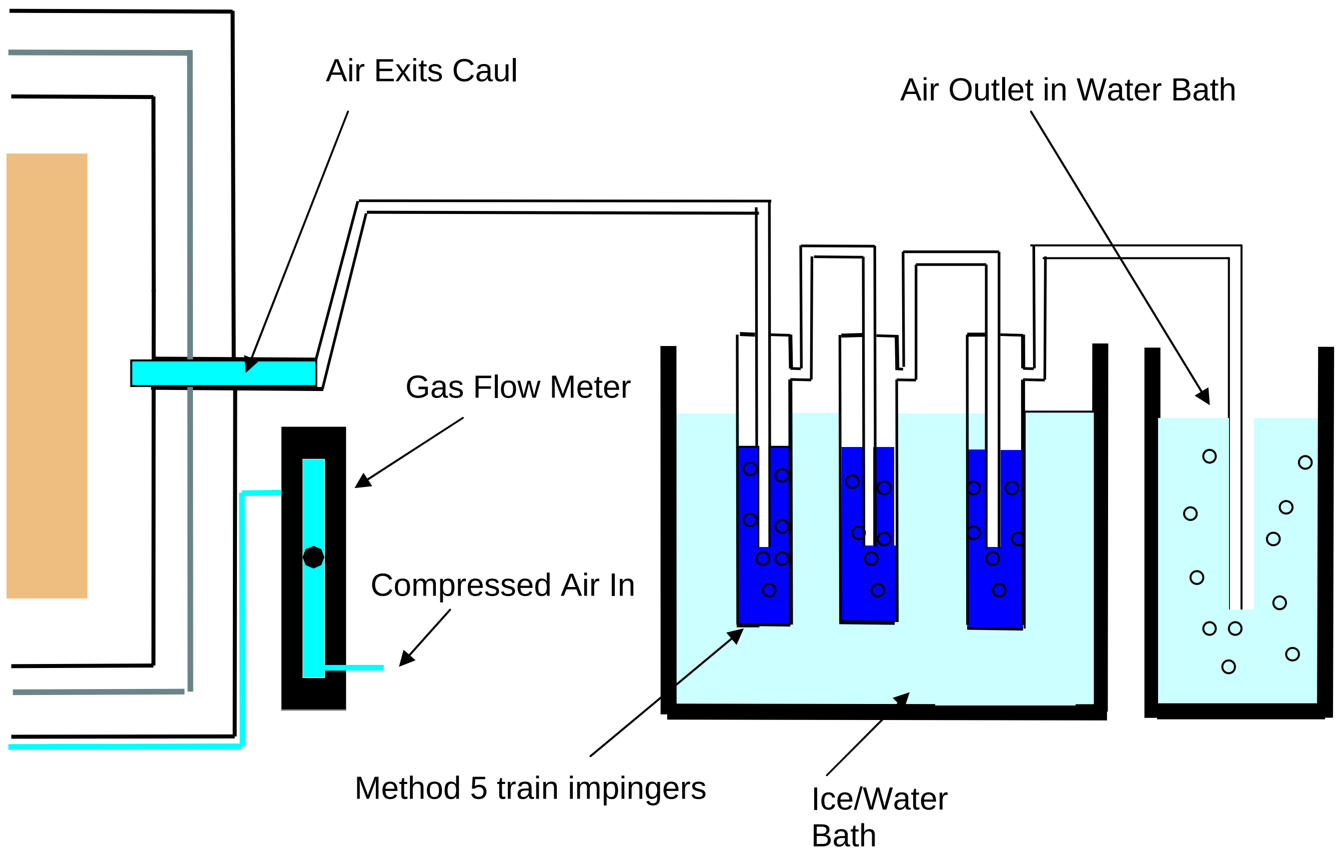

Figure A3 - Schematic of Sample Train

Appendix B

Example Report - Wood Alone

Summary of Principal VOC Emissions During Simulated LVL Pressing and C

Supplier:	
Adhesive:	
Date Tested:	
Reporting Date:	
Wood Species	
Nominal Veneer Thickness:	

Wood alone

Pressing and Collection						Analytical Analysis					
Run ID	Veneer wt (g)	Trap Number	Time (min.)	Jar Label	Collected Impinger wt (g)	Formaldehyde Conc (ppm)	Methanol Conc (ppm)	Phenol Conc (ppm)	Other VOC Conc (ppm)	Formaldehyde Total (g/g)	Methanol Total (g/g)
1	2334.0	A	20	1 A - 20	288.73	45.5	55.81	0.3	0.3	2.07E-05	3.17E-05
1		B	20	1 B - 20	267.04	0.91	1.17				
1		C	20	1 C - 20	257.33	0.06	0.96				
1		A	140	1 A - 140	316.14	108.2	175.0	0.3	0.3		
1		B	140	1 B - 140	247.65	2.8	6.96				
1		C	140	1 C - 140	240.10	0.21	1.02				
2	2086.5	A	20	2 A - 20	281.39	31.5	45.04	0.2	0.2	2.04E-05	3.48E-05
2		B	20	2 B - 20	245.41	0.57	0.64				
2		C	20	2 C - 20	248.55	0.05					
2		A	140	2 A - 140	314.81	105.1	185.0	0.4	0.4		
2		B	140	2 B - 140	251.57	1.57	5.89				
2		C	140	2 C - 140	255.80	0.09	0.63				
3	2120.6	A	20	3 A - 20	282.85	42.8	47.30	0.2	0.2	1.93E-05	2.54E-05
3		B	20	3 B - 20	252.70	0.75	0.38				
3		C	20	3 C - 20	257.69	0.05					
3		A	140	3 A - 140	301.83	93.3	130.1	0.3	0.3		
3		B	140	3 B - 140	237.63	1.56	4.56				
3		C	140	3 C - 140	245.71	0.08					

NOTE: In this section, for values below the
the detection limit, enter 0.0 or leave blank

Lower Detection Limits (ug/g)
Phenol 0.1
HCHO 0.03
MeOH 0.5

	Formaldehyde Wood (g/g)	Methanol Wood (g/g)
	2.01E-05	3.06E-05
1 St. Dev.	7.6E-07	4.8E-06

Example Report - Adhesive Alone

Summary of Principal VOC Emissions During Simulated LVL Pressing and Cool I

Supplier:	
Adhesive:	
Date Tested:	
Reporting Date:	
Wood Species	
Nominal Veneer Thickness:	

Totals

Formaldehyde Total (g/g)	Methanol Total (g/g)	Phenol Total (g/g)	Other VOC Total (g/g)	Total VOC (g/g)
2.07E-05	1.55E-03	2.00E-06	1.23E-05	1.54E-03
2.04E-05	1.40E-03	2.04E-06	2.60E-05	1.41E-03
1.93E-05	1.49E-03	2.26E-06	2.26E-06	1.47E-03

Averages

	Formaldehyde Adhesive (g/g)	Methanol Adhesive (g/g)	Phenol Adhesive (g/g)	Other VOC Adhesive (g/g)	Total VOC Adhesive (g/g)
	2.01E-05	1.48E-03	2.10E-06	1.35E-05	1.48E-03
1 st. dev.	7.6E-07	7.2E-05	1.399E-07	1.190E-05	6.46E-05

Example Report – Wood + Adhesive

Summary of Principal VOC Emissions During Simulated LVL Pressing and Cool Down

Supplier:	
Adhesive:	
Date Tested:	
Reporting Date:	
Wood Species	
Nominal Veneer Thickness:	

Wood + Adhesive

Pressing and Collection							Analytical Analysis			
Run ID	Veneer wt (g)	Adhesive wt (g)	Trap Number	Time (min.)	Jar Label	Collected Impinger wt (g)	Formaldehyde Conc (ppm)	Methanol Conc (ppm)	Phenol Conc (ppm)	Other VOC Conc (ppm)
4	2366.2	177.3	A	20	4 A - 20	337.50	65.1	455.8	0.8	6
4			B	20	4 B - 20	284.85	2.34	6.04		
4			C	20	4 C - 20	258.15	0.13			
4			A	140	4 A - 140	354.70	49.4	537.1	0.8	1
4			B	140	4 B - 140	265.29	1.6	23.62		
4			C	140	4 C - 140	262.78	0.12	0.72		
5	2131.1	182.4	A	20	5 A - 20	320.35	46	442.5	0.8	5
5			B	20	5 B - 20	257.62	1.47	5.00		
5			C	20	5 C - 20	260.21	0.06			
5			A	140	5 A - 140	331.77	44.8	541.7	0.9	10
5			B	140	5 B - 140	234.70	1.2	20.98		
5			C	140	5 C - 140	239.43	0.07	0.52		
6	2101.5	180.5	A	20	6 A - 20	307.44	52.1	460.0	0.9	0.9
6			B	20	6 B - 20	238.57	2.12	5.96		
6			C	20	6 C - 20	231.04	0.11			
6			A	140	6 A - 140	342.61	44.7	551.9	0.9	0.9
6			B	140	6 B - 140	243.61	1.46	24.08		
6			C	140	6 C - 140	256.14	0.1			

NOTE: In this section, for values below the
the detection limit, enter 0.0 or leave blank

Totals

Formaldehyde Total (g/g)	Methanol Total (g/g)	Phenol Total (g/g)	Other VOC Total (g/g)	Total VOC (g/g)
Below Detection Limit - Less than Wood Alone	1.58E-03	2.08E-06	1.24E-05	1.59E-03
Below Detection Limit - Less than Wood Alone	1.44E-03	2.13E-06	2.61E-05	1.47E-03
Below Detection Limit - Less than Wood Alone	1.51E-03	2.33E-06	2.33E-06	1.52E-03

Lower Detection Limits (ug/g)
Phenol 0.1
HCHO 0.03
MeOH 0.5

Averages

	Formaldehyde Adhesive (g/g)	Methanol Adhesive (g/g)	Phenol Adhesive (g/g)	Other VOC Adhesive (g/g)	Total VOC Adhesive (g/g)
	Below Detection Limit	1.51E-03	2.18E-06	1.36E-05	1.53E-03
1 st. dev.	NA	7.0E-05	1.331E-07	1.191E-05	6.35E-05