MEMO BIFMA

To: Whom It May Concern

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Subject: **Application Guide for Users of ANSI/BIFMA M7.1-2011(R2016)**

This Furniture Emissions Application memo was the result of the efforts of members of the BIFMA Furniture Emissions Subcommittee. It's purpose is to aid users of the ANSI/BIFMA M7.1-2011(R2016) Standard Test Method for Determining VOC Emissions from Office Furniture Systems, Components, and Seating. This is an informative document only and was not part of the ANSI process. The following are eight (8) Frequently Asked Questions relative to testing for Furniture Emissions:

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1) How should 'benching systems' be tested?

Benching Systems are defined in ANSI/BIFMA X5.5-2014 as "a series of primary surfaces interconnected longitudinally to a length greater than 72 inches by an integrated (shared) support structure to extend the span of the overall surface. Benching systems are designed to be a primary workstation for simultaneous use by multiple users and may also have desk extension surfaces." A task team studied actual benching systems layouts and believes the **open-plan** scenario in the standard provides an appropriate test method for benching systems.

2) How is the determination made between open-plan and private office?

ANSI/BIFMA M7.1-2011(R2016) allows for two building concentration based scenarios for determination of compliance for workstations: the private office and the open plan. Each of these scenarios are defined in Table 11.1 from ANSI/BIFMA M7.1-2011(R2016). These parameters allow for the calculation of the effect of VOC emissions from a workstation on the building's indoor air quality. In general, the private office scenario has less stringent emission criteria than the open plan scenario due to the higher air flow rate provided in the private office model. This means that for all workstations, using the material areas for the workstation components established in the standard, passing the open plan scenario demonstrates passing for private office as well.

Table 11.1. Standard Office Environment Parameters

Parameter	Open Plan Workstation	Private Office Workstation	Seating
Floor Area per Workstation with Common Area (m^2)	5.95	23.78	24.8*
Modeled Building/Room Volume (m^3)	16.3	65.2	
Modelled Air Flow, Q, (m^3/h)	15.02	34.68	
Workstation Components			
Panel Vertical Area (m^2)	11.08	7.63	
Work Surface Horizontal Area (m^2)	6.10	6.73	
Storage External Surface Area (m^2)	4.57	10.55	
Total Potential Emitting Surface Area (m^2)	21.75	24.91	Largest of represented product(s)

ANSI/BIFMA M7.1-2011(R2016) provides the following instructions in section 11.3 for selecting which scenario should be used:

> "*Determinations of compliance for workstations, workstation components or individual furniture items shall be made using the open plan and/or private office standard environments, depending on the product type, application, and intended use... The choice of which standard environment(s) to use for compliance is specified by the requestor (typically the product manufacturer).*"

ASHRAE. 2007. Definition of Standard Office Environments for Evaluating the Impact of Office Furniture Emissions on Indoor VOC Concentrations by Carter, R. and Zhang, J. -

> *"Based on the analysis, the representative "worst-case" standard* ***open plan*** *office environment for a single workstation system is defined as 5.94 m^2 (64 ft^2) floor area by 2.74 m (9 ft) high (576 ft^3 or 16.3 m^3), accounting for a standard 1.83 m x 1.83 m (6 ft x 6 ft) open plan workstation system, traffic area, and support space for shared copiers, files, storage, etc. The space is assumed to be occupied by a single occupant and has an outdoor or clean air ventilation rate of 4.17 L/s (8.84 cfm), in accordance with ASHRAE Standard 62.1-2004. The representative "worst-case" standard* ***private office*** *environment for a single workstation system is defined as 23.78 m^2 (256 ft^2) floor area by 2.74 m (9 ft) high (2304 ft^3 or 65.2 m^3), accounting for a standard 13.38 m^2 (144 ft^2) private office workstation system, traffic area, and support space for shared copiers, files, storage, etc. The space is assumed to be occupied by a single occupant and has an outdoor or clean air ventilation rate of 9.63 L/s (20.4 cfm) in accordance with ASHRAE Standard 62.1-2004."*

For all workstations compliance should be based on choosing the scenario that best reflects the intended use by the manufacturer. The scenario chosen will be identified by any claim made.

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3) How is 'worst-case' determined?

Note: One of the most significant variables impacting the accuracy and representativeness of VOC emission testing and certification of Low-Emitting Furniture is the practice of product bracketing exercised by third party certifiers, manufactures and testing laboratories. The complexity of this issue and its impact on certifying products that have not been individually tested is clearly understood when we consider the following factors:

- A typical furniture manufacturer likely has at least 10 to 50 products (and many several hundred products). And that all of those products have 10+ options available (beside color and shape) that can impact emissions.
- Many of these manufactures use more than one type of engineered wood substrate like; particleboard, thin hardboard and MDF in the construction of their products (all potentially significant sources of formaldehyde and off-gassed VOCs).
- Most manufacturers have 2 or more suppliers of those engineered wood substrates and many of those products come from multiple manufacturing plants operated by the supplier.
- The age, storage history and hydration levels of tested products has a significant impact on the rate at which they off-gas target VOCs.
- Most manufacturers have a variety of options for covering these raw substrates such as high pressure veneers, low pressure laminates, various types of balance/backer sheets, use of various types of edge banding and various types of top coat finishes (high UV solids, acid catalyzed, water based, polyurethanes and lacquered paints).
- Emissions from the various glues and adhesives (another source of VOCs) used to adhere laminates, edge banding, veneers, and structural joints in the manufacturing of furniture.
- Some furniture manufacturers also sell seating and upholstered goods that incorporate foams, textiles and a broad range of polymers (all sources of VOCs).
- Lastly consider all these variables across typical furniture categories like swivel seating, tables, lounge seating, full work stations, and storage pieces, while accounting for all the options, and multiple material suppliers and multiple manufacturing plants and some items that are made by another manufacturer but sold as a private label.
- Then determine how many separate product categories and compliance emission tests within those categories would seem necessary to confidently validate compliance of all those products.

Considering all these variables, typically the first 3 to 5 years of working with a furniture manufacturer to assess VOC emissions from a broad product line requires a lot of transparency, a significant amount of R&D testing and the acquisition and exchange of detailed product construction and emission knowledge between all parties.

For third party certifiers, manufacturers and testing laboratories begin to address all the potential factors that will affect bracketing decisions, a logical starting place is to begin with a search of the ANSI/BIFMA M7.1 method for the word "bracketing". Unfortunately however, no specific references to bracketing are found in the method. Broadening the search for guidance, a logical second search would be for the word "worst- case", which is first found in the method, with most references specifically found in Section 9 starting on page 30:

9. Selection, Collection and Preparation of the Test Specimen(s)
9.1.1. Representative (Worst-case) specimens shall be selected for testing.

In this section of the method, the tern "worst-case" is used, but there is no definition given for it or "representative". Further, neither term appears in Section 3 under definitions. As such the Subcommittee proposes the following definitions:

- **Representative** - refers to a product selected from a group of products bracketed together in a common category possessing like traits. In the case of furniture emissions typically this would be a group of products sharing the same general type of construction, used in the same general manner, sharing the same primary emitting sources of VOCs that off-gas and decay at similar rates.
- **Worst-case** - refers to a specific product within the grouped category of products that is suspected of being one of the highest emitters of VOCs in the group by virtue of its chemical formulation, raw materials used, mass or volume or type of construction.

9.1.2 To demonstrate compliance for a specific product(s), only that product shall be tested.

- In most cases, but not all, this reference in the method represents a rare situation where there is only one product that a manufacturer wants tested and subsequently certified if found compliant. In these instances the terms representative and worst-case simply do not apply.

9.1.3 Compliance of a broad set of products may be demonstrated by using the results from a limited number of representative models. A range, series or category of products with varying characteristics may be grouped together for testing purposes if the products can be expected to perform similarly during testing (i.e., having the same general construction, materials, and manufacturing processes).

- This section of the method generally provides an accurate description of bracketing, although the examples at the end cannot cover all considerations. Products performing similarly during testing and possessing the same general construction … are two different things. Performing the same means demonstrating a similar VOC emission profile and decay rate. In most circumstances (but not all), bracketing takes on a practical (if not limiting) function of compliance. As an example VOC emissions off-gassed from furniture can be currently evaluated in three separate ways according to the BIFMA e3:
    - **7.6.1** - At 7-days relative to emissions of TVOC, Total Aldehydes, 4-PC and Formaldehyde
    - **7.6.2** - At 14-days relative to limits set for 30 compounds of interest (which do not include TVOC, Total Aldehydes or 4-PC).
    - **7.6.3** - At 14-days for formaldehyde at a low-level consistent with the CA CREL

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Bracketing cannot and does not effectively work if products are grouped in a common category in which only a subset of that category only passes one of the standards (like 7.6.1) and another subset of the same category only passes another standard (like 7.6.2). This dysfunction becomes apparent because without testing every product in that category; it is impossible to accurately represent which product will comply to what standard. In instances where testing results confirm this situation, the bracketing plan must be altered (typically by creating a new category or splitting into an existing category).

This issue is further compounded when various certification schemes require compliance with one or more standards as can be the case under LEED and is the case under CHPS.

9.1.4 If test results are to be considered representative of a group of products or materials, a representative specimen that has the potential to have the highest VOC emissions shall be selected from the group. A case-by-case product line analysis by the manufacturer in consultation with the laboratory(ies) and/or certification body(ies) is required, taking into consideration any special attributes, materials, methods of manufacture/construction, etc. See Section 7 and Appendix 2 for additional requirements for product configurations and size.

- In this section of the method references are made to established surface area specifications/apportionments for open plan work stations vs. private office and for calculating simplified surface areas and considerations to be taken when evaluating compliance by direct scaling. While important these considerations do not directly impact bracketing other than determinations of individual component conformance by direct scaling typically involves a significant number of individual tests.

To advance a practical structured guideline for product line "bracketing" and selection of "worst-case" samples within a bracket group of products or category, we recommend the following considerations be made:

STEP 1
Based on the current testing protocols and VOC limits established in ANSI/BIFMA M7.1 the first testing and bracketing consideration that should be made (at least initially) is that seating products should be bracketed separately from all other furniture (including storage, desking, workstations, etc.), due to a separate emission requirement.

STEP 2
The next step in developing a successful bracketing plan is a basic knowledge of chemical off-gassing from materials commonly used in the construction of furniture. The table provided is based on general knowledge of common chemicals present in construction materials and their off-gassing characteristic.

Overall the emissions from topcoat wood finishes and potential emissions from exposed and/or not tightly sealed uses of engineered woods used will typically represent the biggest sources of VOCs off-gassed from finished furniture products. Other factors impacting emissions are:

- the actual source/brand of raw materials used (frequently certain materials are higher or lower emitters than others)

- the amount/quantity of suspect material used in a particular product vs others
- the emission rate of the individual VOCs being off-gassed (some will be decaying, others steady state and some increasing over time)
- how tightly the emitting raw materials are sealed from direct exposure to air flow
- hydration and density of emitting materials (dryer substrates may off-gas at higher rates and denser substrates may off-gas for longer periods)

STEP 3
The next step in developing a product testing and bracketing plan is to make an initial decision on the overall scope of the project (ie: what products to initially focus on and which to leave out). This decision will typically be affected by market demand for certification, specific product sales volume and the likelihood of a given products compliance with applicable VOC emission standards. The scope decision inevitably impacts the amount of emission testing necessary to verify compliance of a line of products, which directly impacts the overall cost of conducting the testing and certification program.

STEP 4
The next step in the process is to review the <u>specific materials used to produce products</u> within the identified scope. During this step it will be important to also identify the suppliers for all <u>significant suspect VOC emitting materials</u> (to account for the inevitable variations that exist in those materials from supplier to supplier; that will also need to be accounted for).

A useful tool in aiding in the completion of this step is to review product catalogs and spec sheets containing images of the products and available options. In addition, it is recommended that MSDS sheets be reviewed for the specific chemical content for all suspect materials.

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TABLE I
Typical VOC Emission Characteristics from Common Furniture Construction Materials

Material	**Common Impact**	**Weighted Concern**	**Comments**
Solid Wood	Total Aldehydes	Low	Not a significant concern (typically very low emitting).
Engineered Wood Substrates	TVOC, Total Aldehydes and Formaldehyde	Moderate to High	**Resins used to bind wood particles together may contain formaldehyde and other aldehydes.** Substrates which have surfaces that are not overlaid, tightly sealed or are exposed represent a significant the source of concern. Substrates that are CARB II compliant, certified NAUF or ULEF would help to minimize formaldehyde off-gassing.
Topcoat Wood Finishes	VOCs, Formaldehyde and sealing underlying materials	High to Moderate	Helpful in reducing off-gassing from engineered wood substrates. Most clear coat and tinted finishes are inherently high VOC emitters due to their chemical composition. As a category 100% UV solid finishes tend to be lower emitting. As a category catalyzed lacquers and conversion varnishes tend to be higher emitting.
High & Low Pressure Laminate, Thermofoil and Melamine Surfaces	VOCs and sealing underlying materials	Low	Helpful in reducing off-gassing from engineered wood substrates. Not a significant issue (typically very low emitting).
Backer/Balance Sheets	Sealing underlying materials	Low to Moderate	Helpful in reducing off-gassing from engineered wood substrates. Certain backer/resin based sheets can off-gas formaldehyde.
Molded Solid Plastic Surfaces & Components	VOCs	Low	Polyethylene, polypropylene and nylon parts - likely not an issue (typically low emitting).
Glass & Acrylic Panels	Minimal	Very Low	Historical testing shows these materials are very low to non-emitting.
Metal / Steel Parts and Tubing	Minimal	Very Low	Generally considered inherently a non-emitter of VOCs. Historical testing of parts with brushed, chrome and powder coated finishes applied to metal does not impact emissions.
Electrical & Hydraulic Components	Minimal	Very Low	Historical testing shows these materials are very low to non-emitting.
Foams, Gels Padding and Strapping	VOCs	Low to Moderate	Emissions dependent on type of material used - likely not a significant issue. (Soy based foams and most Polyurethane foams typically are very low emitting). Note: emissions of applied fire retardants may or may not be measureable.
Textiles and Coverings	VOCs and sealing underlying materials –	Low to Moderate	Historical testing shows most woven textiles (regardless of protective coatings applied) are typically not a significant concern. **Based on porosity coverings will impact the rate at which VOCs from underlying materials are emitted.** Polymer based coverings (including vinyls) will off-gas VOCs.
Adhesives, Glues & Hot Melts	VOCs, Total Aldehydes and Formaldehyde	Moderate	Emissions dependent on type and quantity of material- likely not a significant issue. Products that dry hard tend to be much lower emitters than products that remain flexible.
Part Lubricants & Grease	VOCs	Low	Based on typical small quantity use, these products likely not an issue.

Note: the information contained in this table is based on published and unpublished findings and is provided only as broad guide to aide in understanding typical sources of VOC emissions associated with furniture. Actual VOC off-gassing will inevitably vary from product to product. As such the specific emissions from materials used in a manufacturer's product line should be initially and periodically verified through raw material and/or finished product testing.

STEP 5
The next step is to develop and implement a comparative R&D testing plan based on the materials used and the various construction options, which will be considered for products in the same category.

An initial test plan will typically evaluate VOC emissions from each suspect material and construction combination using short duration, screening tests. It is recommended to focus on at least initially the substrate cores and the outermost finishes applied to those substrates (utilizing as assessing the actual finish constructions of the assembled furniture line). The most effective way to proceed with this step is to have the manufacturer prepare a series of small representative samples of the various suspect constructions to be loaded and tested in small-scale chambers.

As an example, if a manufacturer builds office furniture (workstations and individual components) out of a combination of materials utilizing various constructions (as most manufacturers do) – a comprehensive initial test plan might include the following samples:

1. Thickest particleboard work surface with HPL laminate top and backer sheet bottom applied and finished with a PVC edge.
2. Thickest particleboard work surface with a top-coated wood veneer top; a backer sheet bottom; and edges of solid wood.
3. Nominal thickness vertical panel constructed of MDF with melamine applied on 2 sides and finished with a PVC edge.
4. Nominal thickness vertical panel constructed of MDF with top coated wood veneer applied on 2 sides and finished with wood veneer edge banding.
5. A small scaled down drawer box or drawer side utilizing painted MDF sides and a raw hardboard drawer bottom.

In certain circumstances, the number of samples to be initially tested in this example scenario could double if multiple suppliers are utilized or multiple top-coat finishes are offered. Note: to minimize overall testing costs in this initial evaluation phase, laboratories may run single point 24 to 72-hour tests for comparison purposes as opposed to full 7-day (2) sampling point compliance tests.
Material samples necessary for this initial phase of testing should be sized appropriately to meet the prescribed loading ratio for small-chamber emission testing. *In this critical step it is important to test samples which are closely as possible constructed in the exact manner as the actual full-scale constructions/assembled products you are attempting to represent*. In a nutshell this task is easy to say and in practice difficult to accurately replicate. The primary challenges are inclusivity and proportionality.

STEP 6
In this step you'll need to evaluate the analytical data from the initial R&D testing. This data should provide several important pieces of information necessary to complete a final compliance testing plan and begin to construct a bracketing plan. This information should provide:

1. Initial knowledge of VOC emissions from construction materials used and how these roughly compare to each other.

2. Knowledge if certain materials /constructions will likely need to be excluded from a certification program due to high VOC emissions that cannot be readily or easily reduced.
3. Knowledge of which materials and suppliers of those materials are inherently lower emitter than others and could be bracketed under a higher emitting worst-case product (relative to compliance).
4. Identification of the material/construction of a worst-case product to be used for initial compliance evaluation in each unique product category defined in the bracketing plan.

As has been suggested earlier in this document, product bracketing plans should reflect similar product use, similar VOC emission profiles and decay rates but most importantly should be reflective of the same breadth of IAQ compliance, which for BIFMA furniture is compliance with 7.6.1, 7.6.2 and 7.6.3. It is important to also remember that bracketing plans are often a fluid convention that will change over time.

STEP 7
In this step, identified worst-case products in each product category will need to be newly constructed and submitted for full 7-day compliance test in accordance with the ANSI/BIFMA M7.1 test methodology within a maximum 15-day window covering the time period between product construction completion and receipt at the laboratory for testing .

Note: all laboratories performing this test should be ISO 17065 compliant with the ANSI/BIFMA M7.1 test methodology specifically listed in their scope of accreditations in accordance. In many cases, especially for furniture utilizing complex construction and all upholstered seating products; it is best initially to test worst-case products as fully assembled pieces of furniture to establish a base line for comparison vs. using a series of small-scale chamber tests to evaluate separate component construction following a direct scaling approach. The advantages to testing fully assembled products include:

- Ease in sample construction (routine and familiar) no scaling or custom fabrication required.
- Component and material integrity and proportionality are accurate and guaranteed.
- Potential reaction and canceling effects of different constructions in heterogeneous products are fully accounted.
- Hidden and integrated construction impacts are fully accounted.
- Minimizes and simplifies reporting product emissions and comparisons to applicable standards.

STEP 8
The test data derived from the compliance testing of worst-case products serves as the basis of validating all initial compliance claims to Indoor Air Quality (IAQ) emission standards established for furniture under the ANSI/BIFMA e3 Sustainability Standard for that product and all assumed lower or similar-emitting products bracketed in the same product category. *It is important to note that the results of compliance testing can and often will necessitate that changes be made to the*

bracketing plan relative to product assignment to a particular category prior to obtaining actual emission test data necessary to validate that decision.

STEP 9

In this final and re-occurring step in maintaining a defensible product testing and bracketing plan, furniture products deemed initially compliant with applicable IAQ standards are periodically reassessed to confirm/validate the on-going compliance of all tested and bracketed products. According to the ANSI/BIFMA M7.1 method, <u>the validity of emission test results and IAQ compliance should be reconsidered when there are packaging, supplier, material and/or manufacturing changes made in the construction of certified furniture products that may impact the VOC emission rates and profiles of those products</u>. The reference goes on to state that this reassessment should also occur when manufacturers wish to have new products be considered for inclusion into an existing bracketing plan. With regards to frequency of product retesting the ANSI/BIFMA X7.1 standard and ANSI/BIFMA M7.1 method indicate (respectively) that all products shall be retested at an interval not exceeding three years or the time period established in the certification program for which the test is conducted.

When considering the need and frequency of retesting it is important to understand that it is likely that certain subjective assumptions were made in the creation of most if not all product bracketing plans including the assignment of untested products deemed lower or like VOC-emitting products to a specific grouping or product category. These assumption and product assignments are necessary to revisit and revalidate. The breadth of a given product grouping or category and the number of products contained in that bracket will typically dictate the amount and frequency of emission testing necessary. In general there is little benefit to be gained from retesting the same exact product on an on-going basis (if manufacturing process, materials and/or suppliers remain unchanged).

<u>Selecting a Worst-Case Material/Component/Product Sample for Emission Testing</u>

Note: the rationale behind selecting a worst-case sample for emission testing is two-part. The first and most obvious reason is to reduce the overall certification program costs associated with evaluating potential compliance of large product lines of similarly constructed goods by allowing the emissions data obtained from one or two worst-case sample(s) (embodying materials and constructions that have been determined to be the highest VOC-emitting of available options) that will still readily comply with one or more of the referenced VOC emission limits established under BIFMA. The second reason for testing worst-case samples is to minimize the time required and the number of chamber emission compliance tests of materials/components/products that are known or suspected as having similar VOC off-gassing emission profiles as exemplars already tested.

Accounting for VOC Emission Variables

To accurately identify a representative worst-case sample from a broad range of products and options, it will be necessary to first establish a baseline of emission data from each of the significant <u>suspect VOC emitting materials used in those products</u>. Equally important is the need to recognize that there are a host of variables which will impact the actual chemical emission and decay rates from those materials. By identify these variables and understanding the role that they play in chemical off-gassing, the laboratory and/or third-party certifier can account for those affects in the specifications of a worst-case sample for the manufacturer to submit for compliance evaluation. These variables include (see Table II):

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TABLE II
Common Variables Impacting Chemical Emissions

Variable	Effect
Product Age	Most VOCs exhibit predictable decay patterns over time. In general **newly manufactured materials or those previously "sealed"** (meaning exterior packaging or storage in a production stack or roll has prevented air from readily circulating around the material) **will off-gas at a higher rate than older or openly stored products**. Relative to emission testing, new or tightly sealed products tend to exhibit comparatively higher overall VOC emissions and as such should be purposely selected/specified samples for worst-case testing.
Edge Effects and Proportionality	The sides or cut edges of many raw materials and panel assemblies (especially engineered wood substrates and laminated materials) tend to off-gas at a disproportionately higher rate than the larger surface areas of finished (front and back) faces of those materials. This is important to understand and address in selecting/specifying samples for worst-case testing. ***This is especially important when assessing compliance using direct scaling as small samples typically prepared for small-scale chamber testing have a skewed high ratio of exposed edge-to-face surface area which can have the effect of overestimating VOC emissions from the edges if measures (such as paraffin wax sealing) are not taken to address the issue***. It is additionally important to accurately address the presence and account for increased VOC emissions emanating from predrilled cord management holes, component assembly screw holes and shelving support holes. The potential presence of these unsealed holes serve to create pathways for significant VOC off-gassing from substrate materials that if not accounted for **will tend to have the impact of falsely skewing the VOC emissions lower than they would actually be in a fully assembled product tests which incorporate those constructions**.
Hydration Level	Hydration refers to the absorption of water vapor (moisture) from the surrounding environment. Composite woods and other porous construction materials are hygroscopic in nature. This means that they are constantly exchanging water vapor with the air in a room; picking it up when atmospheric relative humidity is high, and giving it off when relative humidity is low. The moisture content of hydroscopic materials are therefore generally controlled by the relative humidity of the surrounding air. **Emissions rates of some chemicals (such as formaldehyde which is notably found in many engineered wood products) are suspected of being directly related to the taking-in of moisture**. In other words if the tested product has a low moisture content relative to the surrounding air (in the chamber which it is placed), it will tend to off-gas higher levels of formaldehyde as the product absorbs water. Typically the rate and concentration of off-gassed formaldehyde will increase until such time as the material is fully hydrated, after which it will begin to exhibit a period of steady state followed by decreasing formaldehyde emissions and a normal decay curve. Historical testing of furniture and interior construction products has revealed that emissions of certain VOCs (including formaldehyde) can vary appreciably between identical/same/duplicate products due to variations in hydration (as well as uncontrollable variations in construction). **This variable is a naturally occurring process that is not one easily controlled by a manufacturer.**
Hidden Construction	Many products especially wood based furniture have varied and complex constructions that are difficult to replicate accurately when testing small samples of materials and assemblies as opposed to testing a fully assembled product. **This issue is compounded when evaluating emissions from storage pieces that frequently use different materials, finishes and construction in their unexposed interior components than what tis used in their exposed exterior assemblies**. It is important and necessary to understand and address the common construction practice where abutting panels are joined without having the edges of at least one of those panels fully sealed. To accurately address this issue, an exemplar of a abutted assembly must be constructed and tested. **Testing panels separately that are fully sealed will tend to have the impact of falsely skewing the VOC emissions lower than they would actually be in a fully assembled product test.**

Simplified Considerations for Selecting Worst-Case Workstations, Desks and other Wood Based Furniture Products and Components from a Broad Product Line

Rule 1: A larger sized product is not necessarily a higher emitter of VOCs than a similarly constructed smaller sized product. With the exception of BIFMA defined Open Plan and Private Office Standard Work Stations tested fully assembled (in which specific quantities of surface areas are defined for each workstation type and each type of distinct surface – vertical panel, work surface and storage) compliance with IAQ limits is based on emission factors (EF) which accounts for the varying sizes of a particular model or style of product tested.

Rule 2: While there are always some rare exceptions, typically solid wood cores will emit fewer VOCs than cores constructed of hardwood plywood (HWPW). Typically HWPW cores will emit fewer VOCs than particleboard (PB) and medium density fiberboard (MDF). Comparative emissions of PB and MDF vary widely dependent on the manufacturer of the substrate, the chemistry used in the resins and the density of the product.

Rule 3: Singularly top coated finishes (including clear-coats, varnishes, stains and paints) are comparatively higher emitter of VOCs than high and low pressure laminates, melamine, thermofoils and backer/balance sheets applied to wood substrates due to their high volatile chemical composition. Note: There is significant variability in the off-gassing emission profiles exhibited by topcoat finishes (polyurethanes, catalyzed lacquers, conversion varnishes, UV solid, etc.). As such all available finish options in a given line need to be comparatively tested with full 7-day compliance tests prior to making any bracketing decisions relative to inclusion or worse-case. Variations in underlying tint and filler coats typically have little impact on the VOC emissions off-gassed from the (outermost) topcoat finish used.

Rule 4: High temperature manufacturing processes and use of drying/curing ovens will have the effect of driving off VOCs from finished goods, which in-turn will lower the VOC emissions from those products measured during screening and compliance chamber tests.

Rule 5: Typically emissions for most metal, glass, acrylic and hard plastic components are very low.

Rule 6: Unsealed edges of engineered wood substrates are significant emitters of VOCs off-gassed from their resinous core. Look for occurrences of these in exemplars of finished goods. They are commonly found on in pre drilled screw holes shelving support holes, cord management holes and on floor and rear/wall facing panels that are not typically seen. Unsealed edges also occur at the intersection of abutted panels where it is impractical to apply edge banding (like on the sides and back edges of shelves in a cabinet or where vertical supports rest on horizontal worksurfaces like hutches).

Rule 7: Finished products with significant surface areas that are concealed behind doors and panels not accounted for in simplified surface area calculations will be significantly higher emitters of VOCs and have higher EFs than comparable constructions where all or most emitting surfaces are accounted for in the reported surface area calculations.

Rule 8: Worst-case samples should reflect the highest emitting finish, substrate core, construction and options, but only to the extent that it will likely still comply with one or more of the applicable IAQ emission standards. *It does not make since to purposely or repeatedly test materials/components/products that are known or anticipated to exceed VOC limits.*

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Rule 9: Worst-case samples shall be newly constructed and assembled from supplies that are the most recently available or newly unwrapped/unsealed. Samples should arrive at the laboratory in a timeframe consistent with typical or rush orders (minimizing cure and off-gassing periods), but in no instances exceeding a maximum of 15-days from completion of manufacturing to receipt at the laboratory for testing.

Rule 10: Unlike evaluations of office workstations, desks, tables and storage pieces, compliance evaluations of seating products under the current BIFMA standard are not evaluated based on emission factors (EF), and as such larger sized products typically (but not always) are higher emitters of VOCs than a similarly constructed smaller sized products.

Rule 11: Where applicable the previous rules 2 thru 7 apply also to seating.

Rule 12: Foams, gels and paddings used in the construction of upholstered furniture, arm and neck supports will emit VOCs, but comparatively at relatively low levels. This said comparative R&D testing is typically necessary to identify the worst-case scenario between frequently many choices. Larger and thicker pads/cushion supports typical are higher emitters of VOCs than a similarly constructed smaller/thinner product.

Rule 13: Historical testing shows most woven textiles (regardless of protective coatings applied) are singularly not typically a significant source of off-gassed VOCs. Based on porosity, coverings will impact the rate at which VOCs from underlying materials are emitted (including emissions substrate woods, adhesives and foams). Polymer based coverings (including vinyls) will singularly off-gas VOCs. Given this fact, the impact of those emissions will typically delineate polymer-based coverings as a worst-case scenario compared to most woven textiles (in cases where both are offered). It should be noted, however that because polymer based coverings are comparatively less porous than their woven counterparts, the overall impact of their usage may not consistently represent a worst-case due to their impact of restricting the emissions of underlying sources. Over the course of an on-going certification program, the impact of the very wide range of covering options should be thoroughly explored.

Rule 14: Because of the range of materials used in construction of many seating products, comparatively the use of adhesives can play a measurable role in the overall VOC off-gassing profile from these products.

4) Can VOC emissions from residential office furniture be tested and assessed using ANSI/BIFMA M7.1?

ANSI/BIFMA M7.1 describes two office workstation scenarios, a private office case-goods scenario and an open-plan modular workstation scenario. These scenarios include specifications for the surface areas of the primary workstation components consisting of worksurface, vertical panels and storage. Office desking and workstations primarily intended for use in residences typically are more similar in their configurations to the private office case-goods specifications than to the open-plan office workstation specifications. Therefore, the BIFMA Furniture Emissions Subcommittee has determined that VOC emissions from residential office desking and workstation items can be measured as described in M7.1 for private office case goods. All of the testing pathways described in M7.1 for workstations are applicable.

The analysis presented below shows that conformity of the test results for residential furniture items intended for use by adults can be assessed as described for private office case goods in ANSI/BIFMA X7.1 and ANSI/BIFMA e3 (Sections 7.6.2 and 7.6.3). Either the concentration approach or the emission factor approach can be used. This assessment is anticipated to result in a conservative determination of test item conformity. Residential furniture items that are intended for use primarily by children or that may be placed in a closed child's bedroom or nursery should NOT be assessed using ANSI/BIFMA furniture emission standards.

The guidance for adult residential office desking and workstation items is based on a comparison of the dilution ventilation airflow rate per workstation in the private office scenario of M7.1 with the dilution ventilation airflow rates per workstation in three published modeling scenarios for either entire residences or the main living space of residences. The precaution against using ANSI/BIFMA standards for residential children's furniture is based on a similar comparison using a published small bedroom model as the reference.

The whole house or residential main living area scenarios are: 1) a new single family dwelling whole-house model published as an informative appendix in CDPH/EHLB/Standard Method V1.1 (CDPH, 2010); 2) journal article publications of floor areas and ventilation rates in existing U.S. family houses (Chen et. al., 2014 and Persily et al., 2010); and 3) UL 2818 certification standard for chemical emissions from building materials, finishes and furnishings (UL, 2014). All three of these scenarios assume perfect air mixing throughout the space. UL 2818 also defines a nursery/single closed bedroom residential modeling scenario that is for UL certification of bedding and nursery furniture items. The scenarios are summarized and compared in Table III.

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Table III

ANSI/BIFMA M7.1 private office exposure scenario for VOC inhalation exposures compared to exposure scenarios for new and existing residences.

		Office[a]	New Residence[b]	Existing Residence		Bedding/ Nursery
Parameter	**Unit**	**M7.1 Private Office**	**CDPH Appendix B**	**Chen et.al.[c] 1973-1998**	**UL Green-guard[d] Living/Dining**	**UL Green-guard[e] Bedroom**
Floor area	m^2	23.78	211	161[f]	92.1	14.3
Ceiling height	m	2.74	2.59	2.44	2.74	2.44
Volume	m^3	65.2	547	393	252	34.9
Outdoor airflow rate	m^3/h	34.68	127[g]	173	114	15.7
Air change rate	1/h	0.53	0.23	0.44[h]	0.45[i]	0.45[i]
Workstation surface area	m^2	24.91	91.4	124	81.7	11.3
Area-specific airflow rate, Q/A ratio	m/h	1.39	1.39	1.39	1.39	1.39

a. Private office modeling scenario and private office workstation defined in Table 11.1, ANSI/BIFMA M7.1, 2011.
b. New single family residence modeling scenario defined in Appendix B, Table B-1, CDPH Standard Method V1.1, 2010.
c. Parameters for existing single-family houses from 1973 to 1998 summarized in Chen et. al., 2014.
d. Open living/dining/kitchen area residential modeling scenario defined in Table 6.5.1, UL Standard 2818, 2014.
e. Nursery/single bedroom area residential modeling scenario defined in Table 6.5.1, UL Standard 2818, 2014.
f. Median floor area of single-family houses from 1973 to 1998 from U.S. Census, 2013.
g. Ventilation airflow rate for four-bedroom residence from ASHRAE Standard 62.2-2007, Table 4.1a.
h. Median air change rate for homes built prior to 1998 from Persily et al., 2010.
i. Typical residential ventilation rate U.S. EPA Exposure Factors Handbook, Table 19-1, 2011.
j. Calculated workstation surface area for area-specific airflow rate of 1.39 m/h.

The comparisons in Table 1 show that there is considerably more dilution ventilation rate per unit area (i.e., area-specific airflow rate, m/h) for a single, standardized private office workstation in the new residence scenario and in the existing residence/main living & dining area scenarios than in the M7.1 private office scenario. In all three residence scenarios, the calculated area-specific airflow rates are more than three times the value for the private office scenario. In practical terms, this means that placement of three private office workstations in an available residence modeling scenarios will result in predicted VOC concentrations that do not exceed the predicted VOC concentrations for the M7.1 private office scenario.

For the nursery/single closed bedroom modeling scenario in UL 2818, there is less outdoor airflow rate and lower area-specific air flow rate than for the M7.1 private office scenario. This means that placement of a single, private office workstation in the nursery modeling scenario will result in predicted VOC concentrations that exceed the predicted VOC concentrations for the M7.1 private office scenario.

References

CDPH, 2010

Chen et. al., 2014

Persily et. al., 2010

UL, 2014

U.S. Census, 2013

U.S. EPA, 2011

5) What about repeatability of emissions testing?

Chamber accuracy parameters are given in Table 8.1 of the standard and data requirements in section 10.4.

Six independent test labs participated in an uncertainty study conducted in 2012 and 2013. Data review and a statistical analysis was conducted at Syracuse University. Dr. Jensen Zhang issued the report of the analysis on May 24, 2013 titled, "On the repeatability of concentration measurements in standard emission testing by commercial labs following ANSI/BIFMA M7.1." The conclusions are as follows:

1. The overall repeatability of the VOC sampling and analysis is sufficient for the testing.
2. At the concentration ranges defined by +/-50% of pass/fail criteria for the workstation and seating, the mean relative standard deviation for all the chemicals investigated were less than 5%.
3. There is a trend that the relative standard deviation of duplicates increases when the measured concentration decreases.

Contact BIFMA for a full copy of the report.

6) Does CARB testing relate to the ANSI/BIFMA test method?

Making Sense of the CARB Formaldehyde Regulations for Composite Wood Substrates and Understanding How Using Compliant or Non-Compliant Formaldehyde Emitting Substrates Will Impact IAQ Compliance of Office Furniture to Applicable VOC Emission Standards

California Air Resources Board (CARB) promulgated regulations in 2007 that specifically address manufactured engineered wood panels for sale in California, targeting maximum formaldehyde emission limits for specific products. Today these regulations are referred the Composite Wood Products Airborne Toxic Control Measures (ATCM). Emission limits were phased in over a period from 2009 to 2012. Compliance with these standards requires third party certification, product labeling, chain-of-custody documentation, record keeping and facility inspection. The existing formaldehyde limits (referred to as Phase II standards) are summarized below:

Table IV
Phase II CARB Formaldehyde Emission Ceilings for Composite Woods

Engineered Wood Type	Max. Formaldehyde Emission
Hardwood Plywood Veneer Core (HWPW-VC)	0.05 ppm
Hardwood Plywood Composite Core (HWPW-CC)	0.05 ppm
Particle Board (PB)	0.09 ppm
Medium Density Fiber Board (MDF)	0.11ppm
Thin Medium Density Fiber Board (Thin MDF)	0.13 ppm

While there are some naturally occurring emissions of formaldehyde from solid wood, they are typically at very low levels. The concern and presence of formaldehyde in composite woods stems from use of formaldehyde based resins used to tightly bond the wood fibers and wood particles together in composite wood products. The permissible emission limit of formaldehyde (expressed in parts per million [ppm]) varies between the engineered wood types based on the relative abundance of resin typically present to manufacture the product. As such, the limits established for hardwood plywood (HWPW) – because of lower resin content are considerably lower than medium density fiberboard (MDF) – which has a much higher resin content. Since the regulations were established CARB has since added to additional certification levels available to manufacturers of composite wood products. These are:

- **Ultra Low Emission Formaldehyde (ULEF)** – this designation is for formaldehyde containing resins formulated such that the formaldehyde emissions from composite wood products are consistently below applicable Phase 2 emission standards.

- **No Added Formaldehyde (NAF)** – this designation is for resins formulated with no added formaldehyde as part of the resin cross linking structure, and include resins made from soy, polyvinyl acetate, or methylene diisocyanate.

While the aforementioned standards and designations are directly applicable to engineered wood manufacturers selling products in California, ultimately they do not address in full the significant contribution to VOCs and other aldehydes potentially off-gassed from CARB II compliant composite woods. **As such, furniture manufacturers should not assume that by incorporating CARB II compliant, ULEF and NAF composite woods into their products that they will by default comply with the formaldehyde emission limits set in the ANSI/BIFMA e3 Sustainability Standard 7.6.1, 7.6.2 and 7.6.3.** It is important to understand that total formaldehyde emissions from finished furniture while frequently contributed to by the substrate core also stem from use of certain topcoat finishes, adhesives, and other construction materials. Refer to the summary table below to more clearly understand the comparative formaldehyde limits established under CARB and those applicable under BIFMA:

Table V
Comparison of Phase II CARB Formaldehyde Emission Ceilings to Formaldehyde Limits Established for Finished Furniture to be Certified as Low-VOC Emitting under BIFMA

Engineered Wood Type	Max. CARB Phase II Formaldehyde Emission[1]	ANSI/BIFMA e3 Emission Standards for Finished Furniture					
		7.6.1 Workstation	7.6.1 Seating	7.6.2 Workstation	7.6.2 Seating	7.6.3 Workstation	7.6.3 Seating
Hardwood Plywood	50 ppb or 61.4 $\mu g/m^3$	50 ppb	25 ppb	16.5 $\mu g/m^3$	8.25 $\mu g/m^3$	9 $\mu g/m^3$	4.5 $\mu g/m^3$
Particle Board	90 ppb or 110.5 $\mu g/m^3$						
Medium Density Fiberboard	110 ppb or 135.1 $\mu g/m^3$						
Thin MDF	130 ppb or 159.6 $\mu g/m^3$						

[1]For easy comparison purposes the established CARB ceilings are expressed in units of parts per billion (ppb) and in $\mu g/m^3$ – Note: The CARB and ANSI/BIFMA test methods are not identical.

A quick review of the comparative data contained in the table above, demonstrates that furniture manufacturers constructing products solely out CARB II compliant composite woods would likely face a very difficult time meeting the emission standards established for finished furniture. In fact, it becomes rather obvious that even if emissions of the composite woods used are ½ that of the allowable limit for formaldehyde that it would still represent a significant challenge to have the furniture comply with BIFMA standards, given the probability that other components of the finished furniture (including topcoat finishes, adhesives, foams, etc.) will also contribute to off-gassed formaldehyde emissions. With this insight, it becomes clear that to singularly address formaldehyde compliance of finished furniture with the BIFMA standards, that it is advantageous to tightly seal the substrate core with low emitting finishes, materials and laminates and/or utilize the lowest formaldehyde emitting substrate available.

It should be noted that many manufacturers of composite woods have aggressively worked to lower formaldehyde emissions from their products by eliminating or reducing the amount of formaldehyde used in their binding resins. In some cases, this has been achieved by manufacturers switching from formaldehyde to other types of aldehyde-based resins. While this strategy is effective to meet CARB compliance it does not guarantee meeting the BIFMA 7.6.1 standard which sets a limit not only for Formaldehyde, but also for Total Aldehydes. Further, it should be cautioned that the singular use of no added formaldehyde (NAF) resins and ultra-low emitting formaldehyde resins (ULEF) will not automatically insure that furniture made of these materials will actually comply with the much lower emission standards established for finished furniture. Lastly, it is important to fully recognize that the compliance concerns relative to use of engineered wood substrates is not limited to formaldehyde emissions. Many of the available composite woods are also significant sources of VOC emissions including hexanal and toluene. Again tightly sealing all composite wood cores will go a long way in reducing the overall VOC emissions off-gassed from finished furniture and in-turn help furniture manufacturers comply with IAQ emission limits.

7) How should testing be conducted for school furniture?

California 01350 refers to ANSI/BIFMA M7.1 for furniture or allows for 336-hr point, (excluding private office workstations). Use California 01350 criteria (section 4.3).
Note – An individual desk is 27 units and individual seating is considered 27 units for the 01350 test.

8) Why is 4PCH listed in the standard?

4-Phenylcyclohexene (4-PCH) (CAS RN 4994-16-5) remains a key performance criteria in ANSI/BIFMA X7.1-2011. By extension, it remains a key criteria for pre-eminent certification programs that address emissions from office furniture and furnishings such as UL GREENGUARD, The Carpet & Rug Institute (CRI) Green Label, and SCS Indoor Advantage certification programs, among others. Why is this? Its inclusion within these standards and certification schemes stems back to toxicological studies in 1990's and 2000'. The basis for purchasing low-emitting products, the State of Washington EPA Headquarters building, included criteria for this chemical as a result. From that point, certification and performance-based criteria for chemical emissions included criteria for this chemical. Generally it is a result of carpet emissions and indoor air quality issues from carpeting. Specifically, carpets constructed with Styrene-Butadiene Rubber (SBR) backings. Additionally, carpets with SBR latex adhesives (or the use of those adhesives themselves) were also sources of this chemical. At minimum, the chemical is considered an odorant and possible irritant, and was (at least in part) responsible for the creation of ongoing schemes of indoor air quality testing from products that occurred with a frequency of every quarter (or four times per year) in the CRI Green Label Program.

As knowledge of this issue grew and products were modified, the question is whether or not criteria remains necessary for furniture emissions testing are asked. To answer this question, it is suggested that laboratories be engaged to determine whether reasonable emissions (i.e. non-conformities to the base criteria) of 4-PCH have been identified in some period of time. It is a reasonable assumption that, as the source of emissions is very well known, that much like the carpet industry, a substantial decline of 4-PCH emissions is expected. If the same is found with office furnishings, it is reasonable that it be considered for removal from ANSI/BIFMA X7.1 at the period of next revision.

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