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VOC TEST REPORT

ANSI/BIFMA

25 January 2017

1 Sample Information

Sample name	Capella CF121
Batch no.	-
Production date	161214
Product type	Office chair
Sample reception	19/12/2016

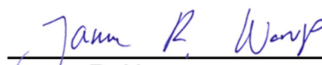
2 Brief Evaluation of the Results

Regulation or protocol	Conclusion	Version of regulation or protocol
ANSI/BIFMA	Pass	ANSI/BIFMA M7.1-2011 "American National Standard for Office Furnishing"

Full details based on the testing and direct comparison with limit values is available in the following pages



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3 Applied Test Methods

3.1 General Test References

Regulation, protocol or standard	Version	Reporting limit VOC [$\mu\text{g}/\text{m}^3$]	Calculation of TVOC	Combined uncertainty ^a [RSD(%)]
CEN/TS 16516	October 2013	5	Toluene equivalents	22.5%
ISO 16000 -3 -6 -9 -11	2006-2011 depending on part	2	Toluene equivalents	22.5%
ASTM D5116	2010	-	-	-
ANSI/BIFMA	ANSI/BIFMA M7.1-2011	2	Toluene equivalents	22.5%
CDPH	CDPH/EHLB/Standard Method V1.1. (February 2010)	2	Toluene equivalents	22.5%

3.2 Specific Laboratory Sampling and Analyses

Procedure	External Method	Internal S.O.P.	Quantification limit / sampling volume	Analytical principle	Uncertainty ^a [RSD(%)]
Sample preparation	ISO 16000-11:2006, EN16402:2013, CDPH, AgBB/DIBt, EMICODE	71M549810	-	-	-
VOC emission chamber testing	ISO 16000-9:2006, CEN/TS 16516:2013	71M549811	-	Chamber and air control	-
Sampling of VOC	ISO 16000-6:2011, CEN/TS 16516:2013	71M549812	5 L	Tenax TA	-
Analysis of VOC	ISO 16000-6:2011, CEN/TS 16516:2013	71M542808B	1 $\mu\text{g}/\text{m}^3$	ATD-GC/MS	10%
Sampling of aldehydes	ISO 16000-3:2011, CEN/TS 16516:2013	71M549812	35 L	DNPH	-
Analysis of aldehydes	ISO 16000-3:2011, EN 717-1, CEN/TS 16516:2013	71M548400	3-6 $\mu\text{g}/\text{m}^3$	HPLC-UV	10%

The results are only valid for the tested sample(s).

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4 Test Parameters, Sample Preparation and Deviations

4.1 VOC Emission Chamber Test Parameters

Parameter	Value	Parameter	Value
Chamber volume, V[L]	119	Preconditioning period	-
Air Change rate, $n[h^{-1}]$	0.5	Test period	04/01/2017 – 11/01/2017
Relative humidity of supply air, RH [%]	50 ± 3	Specific ventilation rate, q [$m^3/unit/h$]	0.5
Temperature of supply air, T [$^{\circ}C$]	23 ± 1	Loading factor [$unit/m^3$]	1

4.2 Preparation of the Test Specimen

The sample was transferred directly into the chamber.

4.3 Picture of Sample



4.4 Deviations from Referenced Protocols and Regulations

No deviations from the referenced test methods were observed.

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4.5 VOC Emission Test Results after 3 and 7 Days

	CAS No.	Retention time [min]	ID-Cat	3 day conc. [µg/m³]	3 day SER [µg/(unit*h)]	7 day conc. [µg/m³]	7 day SER [µg/(unit*h)]
VOC Compounds							
Tetrahydrofuran (THF) *	109-99-9	2.30	1	4.4	2.2	4.5	2.2
1-Butanol	71-36-3	2.58	1	3.7	1.8	-	-
1-Methoxy-2-propanol *	107-98-2	2.70	1	5.4	2.7	2.5	1.3
1,2-Propandiol (Propylene glycol) *	57-55-6	3.63	1	32	16	28	14
2-Propanol, 1-ethoxy- *	1569-02-4	3.92	2	2.6	1.3	2.1	1.1
Dimethylformamide *	68-12-2	4.55	1	260	130	210	110
Cyclopentanone *	120-92-3	4.79	1	18	8.8	17	8.4
Hexanal	66-25-1	5.02	1	3.9	2.0	3.5	1.7
Butyl acetate	123-86-4	5.37	1	2.7	1.3	2.3	1.2
2-Propanol, 1-(2-propenyloxy)-*	21460-36-6	6.03	2	4.3	2.1	2.8	1.4
1-Methoxy-2-propyl acetate	108-65-6	6.53	1	3.3	1.7	2.3	1.2
Cyclohexanone *	108-94-1	6.96	1	4.0	2.0	2.6	1.3
α-Pinene *	80-56-8	7.71	1	3.0	1.5	-	-
3-Carene *	13466-78-9	8.95	1	6.7	3.4	3.1	1.5
Dipropylene glycol dimethyl ether *	111109-77-4	8.99	1	5.2	2.6	13	6.4
Not identified *	-	9.07	4	2.1	1.0	-	-
Not identified *	-	9.16	4	17	8.3	6.2	3.1
Limonene	138-86-3	9.22	1	2.7	1.4	-	-
n-Undecane	1120-21-4	10.14	1	3.8	1.9	2.6	1.3
2-Ethylhexanoic acid *	149-57-5	10.33	1	13	6.3	7.9	3.9
Dipropylenglycol- mono-t-butylether *	132739-31-2	10.85	1	21	11	9.0	4.5
Not identified *	-	11.09	4	2.4	1.2	-	-
n-Dodecane	112-40-3	11.35	1	6.3	3.2	15	7.6
Not identified *	-	11.88	4	2.5	1.3	-	-
Caprolactam *	105-60-2	11.99	1	16	8.2	15	7.6
n-Tridecane	629-50-5	12.43	1	6.9	3.5	5.9	3.0
Butylhydroxytoluene BHT *	128-37-0	14.60	1	2.0	1.0	-	-
Not identified *	-	14.64	4	2.6	1.3	2.7	1.4
1,6-Dioxacyclododecane-7,12-dione *	777-95-7	14.99	2	11	5.5	11	5.5

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	CAS No.	Retention time [min]	ID-Cat	3 day conc. [µg/m³]	3 day SER [µg/(unit*h)]	7 day conc. [µg/m³]	7 day SER [µg/(unit*h)]
TVOC toluene eq.				200	100	150	74
TVOC specific				450	220	350	170
Aldehydes							
Formaldehyde	50-00-0		1	< 3	< 4	< 3	< 4
Acetaldehyde	75-07-0		1	< 3	< 4	< 3	< 4

4.6 Results as Extrapolated to 14 Days VOC Emission

	CAS No.	Retention time [min]	ID-Cat	14 day SER µg/(unit*h)]	14 day office air conc. [µg/m³]	¼ CHREL [µg/m³]
VOC Compounds						
Dimethylformamide *	68-12-2	4.55	1	120	4.8	20
TVOC toluene eq.				58	2.3	-
TVOC specific				140	5.6	-
Aldehydes						
Formaldehyde	50-00-0		1	< 4	< 2	9
Acetaldehyde	75-07-0		1	< 4	< 2	70

4.6.1 Calculation of Concentration after 14 Days

The emission rates (SER) after 3 and 7 days were extrapolated to 14 day emission rates using equation 8, 9, 10 given in ANSI/BIFMA M7.1-2011.

$$(8) \quad E_{14} = a \cdot t_3^{-b}$$

$$(9) \quad b = \frac{\ln E(t_1) - \ln E(t_2)}{\ln t_2 - \ln t_1}$$

$$(10) \quad a = E(t_1) \cdot t_1^b = E(t_2) \cdot t_2^b$$

E_{14} = Emission rate after 14 days (336 hours)

t_1 = 3 days (72 hours), t_2 = 7 days (168 hours) and t_3 = 14 days (336 hours)

The emission rates as calculated after 14 days were used to calculate model room concentrations using the following formula:

$$C = \frac{A \cdot E}{Q}$$

with:

- C Model room concentration, $\mu\text{g}/\text{m}^3$
- A Number of workstation units = 1
- E Unit specific emission factor, $\mu\text{g}/(\text{unit} \cdot \text{h})$
- Q Ventilation rate, workstation unit: $24.8 \text{ m}^3/\text{h}$

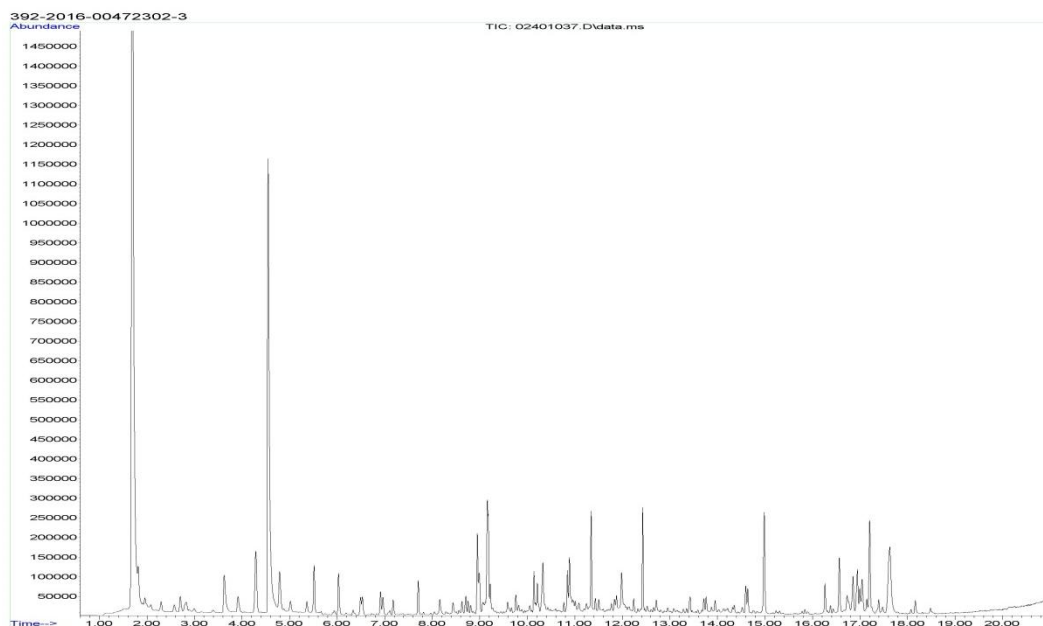
5 Summary and Evaluation of the Results

5.1 Comparison with Limit Values of ANSI/BIFMA

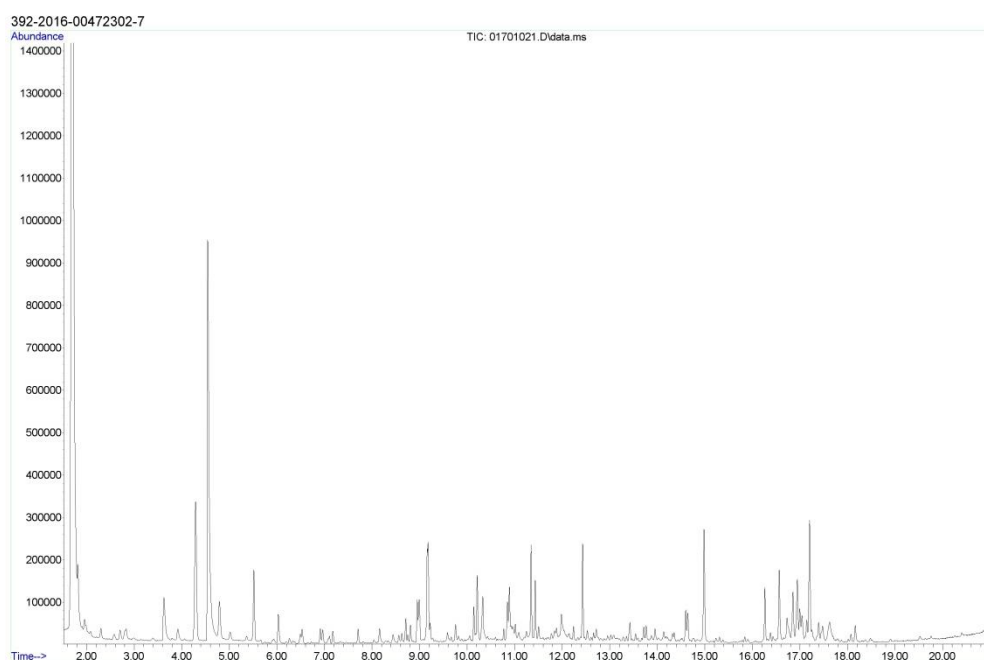
Parameter	Results after 7 days		
	Concentration mg/m ³	Limit values Systems Furniture mg/m ³	Limit values Seating mg/m ³
TVOC	0.17	< 0.5	< 0.25
Formaldehyde	< 5 ppb	< 50 ppb	< 25 ppb
Total aldehydes (other)	< 5 ppb	< 100 ppb	< 50 ppb
4-Phenylcyclohexene	< 0.002	< 0.0065	< 0.00325
Individual compounds with CHREL-value after 14 days	complies		

6 Appendices

6.1 Chromatogram of VOC Emissions after 3 Days



6.2 Chromatogram of VOC Emissions after 7 Days



Please consider the different scales.

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6.3 How to Understand the Results

6.3.1 Acronyms Used in the Report

- < Means less than
- > Means bigger than (Tube/GC-MS overload)
- * Not a part of our accreditation
- α Um(%) is given as 2x RSD%. Please see section regarding Uncertainty in the Appendices.
- § Deviation from method. Please see deviation section
- a The method is not optimal for very volatile compounds. For these substances smaller results and a higher measurement uncertainty cannot be ruled out.
- b The component originates from the wooden panels and is thus removed.
- c The results have been corrected by the emission from wooden panels.
- d Very polar organic compounds are not suitable for reliable quantification using tenax TA adsorbent and HP-5 GC column. A high degree of uncertainty must be expected.

SER Specific emission rate.

6.3.2 Explanation of ID Category

Categories of Identity:

- 1: Identified and specifically calibrated
- 2: Identified by comparison with a mass spectrum obtained from library and supported by other information. Calibrated as toluene equivalent.
- 3: Identified by comparison with a mass spectrum obtained from a library. Calibrated as toluene equivalent.
- 4: Not identified, calibrated as toluene equivalent.

6.4 Qualitative Description of VOC Emission Test

6.4.1 Test Chamber

The test chamber is made of stainless steel. A multi-step air clean-up is performed before loading the chamber, and a blank check of the empty chamber is performed.

The chamber operation parameters are as described in the test method section (CEN/TS 16516, ISO 16000-9, internal method no.: 71M549811).

6.4.2 Expression of the Test Results

All test results are calculated as specific emissions rate, and as extrapolated air concentration in the European Reference Room (CEN/TS 16516, AgBB, EMICODE, M1 and Indoor Air Comfort).

6.4.3 Testing of VOCs

The emissions of volatile organic compounds are tested by drawing sample air from the test chamber outlet through Tenax TA tubes after the specified duration of storage in the ventilated test chamber. Analysis is performed by ATD-GC/MS using HP-5 column (30 m, 0.25mm ID, 0.25µm film) (CEN/TS 16516, ISO 16000-6, internal methods no.: 71M549812 / 71M542808B).

The results of the individual substances are calculated in three groups depending on their retention time when analyzing using a non-polar column (HP-1):

- Volatile Organic Compounds (VOC) are defined as: All substances eluting between and including n-hexane (n-C6) and n-hexadecane (n-C16)
- Semi-Volatile Organic Compounds (SVOC) are defined as: All substances eluting after n-hexadecane (n-C16) and before and including n-docosane (n-C22)
- Very Volatile Organic Compounds (VVOC) are defined as: All substances eluting before n-hexane (n-C6).

Total Volatile Organic Compounds (TVOC) is calculated by summation of all individual VOCs with a concentration $\geq 5 \mu\text{g}/\text{m}^3$. The TVOC can be expressed either in toluene equivalents as defined in CEN/TS 16516 and similar to ISO 16000-6, or as the sum of concentrations using specific or relative response factors. In the case of summation of concentrations using authentic or relative response factors, the toluene equivalent is applied to all non-target and non-identified VOCs before summing up. Compounds regarded as VOC in line with the above definition but elute before n-C6 or after n-C16 on the HP-5 column are treated as VOC, and are thus added to the TVOC.

This test only covers substances which can be adsorbed on Tenax TA and can be thermally desorbed. If emissions of substances outside these specifications occur then these substances cannot be detected (or with limited reliability only).

6.4.4 Testing of Aldehydes

The presence of aldehydes after the specified duration of storage in the ventilated test chamber is tested by drawing air samples from the test chamber outlet through DNPH-coated silicagel tubes after the specified duration of storage in the ventilated test chamber. Analysis is performed by solvent desorption and subsequently by HPLC and UV/diode array detection (CEN/TS 16516, ISO 16000-3, VDI 3862 Blatt 3, internal methods no.: 71M549812 / 71M548400).

The absence of formaldehyde and other aldehydes is stated if UV detector response at the specific wavelength is lacking at the specific retention time in the chromatogram. Otherwise it is checked whether the reporting limit is exceeded. In this case the identity is finally checked by comparing full scan sample UV spectra with full scan standard UV spectra.

6.4.5 Maximum Allowable Emission Factors

Below is given the maximum allowable emission factor after 14 days, as defined by BIFMA, for compounds with a CHREL value.

Compound	CAS nr.	Max allowable emission factor Private office $\mu\text{g}/(\text{m}^2 \cdot \text{h})$
Ethylbenzene	100-41-4	696
Styrene	100-42-5	313.5
1,4-Dichlorobenzene	106-46-7	278.5
Epichlorohydrin	106-89-8	1.05
Ethylene glycol	107-21-1	139
1-Methoxy-2-propanol	107-98-2	2437
Vinyl acetate	108-05-4	69.5
Toluene	108-88-3	104.5
Chlorobenzene	108-90-7	348
Phenol	108-95-2	69.5
2-Methoxyethanol	109-86-4	21
Ethylene glycol monomethyl ether acetate	110-49-6	31.5
n-Hexane	110-54-3	2437
2-Ethoxyethanol	110-80-5	24.5
2-Ethoxyethyl acetate	111-15-9	104.5
1,4-Dioxane	123-91-1	1044.5
Tetrachloroethylene	127-18-4	12.2
Formaldehyde	50-00-0	11.5
Isopropanol	67-63-0	2437
Chloroform	67-66-3	104.5
N,N-Dimethyl Formamide	68-12-2	28
Benzene	71-43-2	21
1,1,1-Trichloroethane	71-55-6	348
Acetaldehyde	75-07-0	48.5
Methylene Chloride	75-09-2	139
Carbon Disulfide	75-15-0	278.5
Trichloroethylene	79-01-6	209
1-Methyl-2-Pyrrolidinone	872-50-4	111.5
Naphthalene	91-20-3	3
Xylenes (m-, o-, p-Xylene combined)	108-38-3, 95-47-6, 106-42-3	243.5

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6.5 Quality Assurance

Before loading the test chamber, a blank check of the empty chamber is performed and compliance with background concentrations in accordance with CEN/TS 16516 / ISO 16000-9 is determined.

Air sampling at the chamber outlet and subsequent analysis is performed in duplicate. Relative humidity, temperature and air change rate in the chambers is logged every 5 minutes and checked daily. A double determination is performed on random samples at a regular interval and results are registered in a control chart to ensure the uncertainty and reproducibility of the method.

The stability of the analytical system is checked by a general function test of device and column, and by use of control charts for monitoring the response of individual substances prior to each analytical sequence.

6.6 Accreditation

The testing methods described above are accredited on line with EN ISO/IEC 17025 by DANAK (no. 522). This accreditation is valid worldwide due to mutual approvals of the national accreditation bodies (ILAC/IAF, see also www.eurofins.com/galten.aspx#accreditation).

Not all parameters are covered by this accreditation. The accreditation does not cover parameters marked with an asterisk (*), however analysis of these parameters is conducted at the same level of quality as for the accredited parameters.

6.7 Uncertainty of the Test Method

The relative standard deviation of the overall analysis is 22%. The expanded uncertainty U_m equals 2 x RSD. For further information please visit www.eurofins.dk/uncertainty.