

QUINETTE GALLAY RENAISSANCE
 240, rue de Rosny
 93108 MONTREUIL Cedex
 FRANCE

Eurofins Product Testing A/S
 Smedeskovvej 38
 8464 Galten
 Denmark

CustomerSupport@eurofins.com
 www.eurofins.com/VOC-testing

VOC TEST REPORT ANSI/BIFMA

7 May 2018

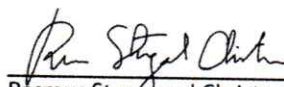
1 Sample Information

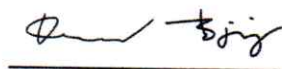
Sample name	Cube Skate
Batch no.	-
Production date	12/04/2018
Product type	Chair
Sample reception	16/04/2081

2 Brief Evaluation of the Results

Regulation or protocol	Conclusion	Version of regulation or protocol
ANSI/BIFMA, section 7.6.1	Pass	ANSI/BIFMA e3-2014e "Furniture Sustainability Standard"
ANSI/BIFMA, section 7.6.2	Pass	ANSI/BIFMA e3-2014e "Furniture Sustainability Standard"
ANSI/BIFMA, section 7.6.3	Pass	ANSI/BIFMA e3-2014e "Furniture Sustainability Standard"

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


 Rasmus Stengaard Christensen
 Analytical Service Manager, MSc in Chemistry


 Thomas Bjerring
 Consultant



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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* [RSD(%)]
EN 16516	October 2017	5	Toluene equivalents	22%
ISO 16000 -3 -6 -9 -11	2006-2011 depending on part	2	Toluene equivalents	22%
ASTM D5116	2010	-	-	-
ANSI/BIFMA	ANSI/BIFMA M7.1-2011 (R2016)	2	Toluene equivalents	22%
ANSI/BIFMA	e3-2014e	-	-	-
CDPH	CDPH/EHLB/Standard Method V1.2. (January 2017)	2	Toluene equivalents	22%

3.2 Specific Laboratory Sampling and Analyses

Procedure	External Method	Internal S.O.P.	Quantification limit / sampling volume	Analytical principle	Uncertainty* [RSD(%)]
Sample preparation	ISO 16000-11:2006, EN16402:2013, CDPH, AgBB/DIBt, EMICODE	71M549810	-	-	-
VOC emission chamber testing	ISO 16000-9:2006, EN 16516:2017	71M549811	-	Chamber and air control	-
Sampling of VOC	ISO 16000-6:2011, EN 16516:2017	71M549812	5 L	Tenax TA	-
Analysis of VOC	ISO 16000-6:2011, EN 16516:2017	71M542808B	1 $\mu\text{g}/\text{m}^3$	ATD-GC/MS	10%
Sampling of aldehydes	ISO 16000-3:2011, EN 16516:2017	71M549812	35 L	DNPH	-
Analysis of aldehydes	ISO 16000-3:2011, EN 717-1, EN 16516:2017	71M548400	3-6 $\mu\text{g}/\text{m}^3$	HPLC-UV	10%



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4 Test Parameters, Sample Preparation and Deviations

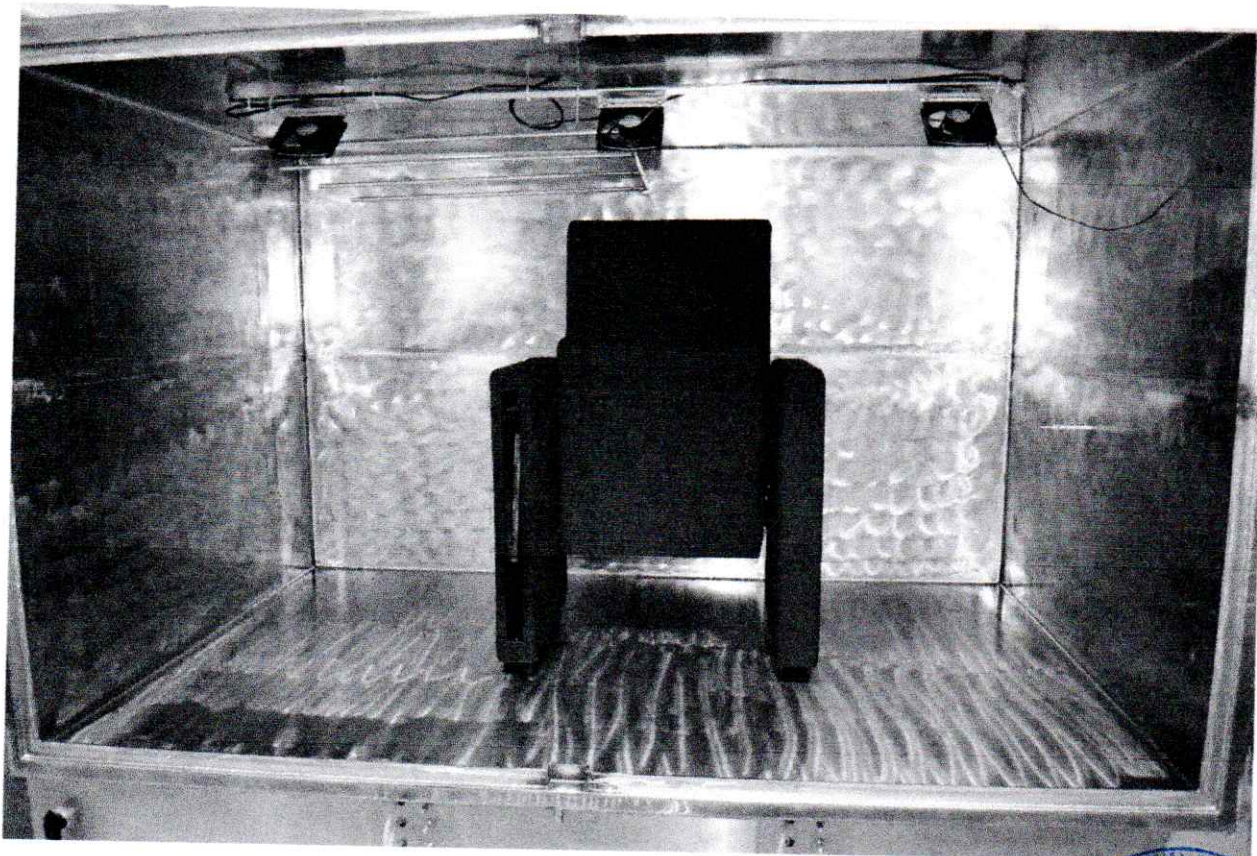
4.1 VOC Emission Chamber Test Parameters

Parameter	Value	Parameter	Value
Chamber volume, V[L]	3200	Preconditioning period	-
Air Change rate, n[h ⁻¹]	1.0	Test period	20/04/2018-27-04/2018
Relative humidity of supply air, RH [%]	50 ± 3	Specific ventilation rate, q [m ³ /unit/h]	1.0
Temperature of supply air, T [°C]	23 ± 1	Loading factor [unit/m ³]	1

4.2 Preparation of the Test Specimen

The sample was assembled and 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]	7 day conc. [µg/m³]	3 day SER [µg/(unit·h)]	7 day SER [µg/(unit·h)]
VOC Compounds							
Acetic acid * ^d	64-19-7	1.90	1	43	58	140	190
Ethylacetate	141-78-6	2.18	1	< 2	3.4	< 7	11
Not identified *	590-86-3	2.97	3	< 2	3.1	< 7	10
Toluene	108-88-3	3.91	1	18	11	59	35
Hexanal	66-25-1	4.64	1	7.6	6.7	24	22
Ethylbenzene	100-41-4	5.98	1	2.1	< 2	8.5	< 7
m/p-Xylene *	179601-23-1	6.15	1	12	< 2	39	< 7
o-Xylene	95-47-6	6.61	1	14	3.0	46	7.8
Not identified *		10.75	4	2.5	< 2	7.9	< 7
Not identified *		11.47	4	2	< 2	6.6	< 7
Not identified *		13.17	4	3	< 2	9.5	< 7
TVOC toluene eq.				73	38	240	120
TVOC specific				110	89	370	290
Aldehydes							
Formaldehyde	50-00-0		1	28	29	90	94
Acetaldehyde	75-07-0		1	< 3	< 3	< 4	< 4

4.6 Results as Extrapolated to 14 Days VOC Emission

	CAS No.	Retention time [min]	ID-Cat	Concentration [µg/m³]	Limit value open plan [µg/m³]
VOC Compounds					
Acetic acid * ^d	64-19-7	1.90	1	9.8	
Ethylacetate	141-78-6	2.18	1	< 2	
3-Methylbutanal *	590-86-3	2.97	3	< 2	
Toluene	108-88-3	3.91	1	< 2	75
Hexanal	66-25-1	4.64	1	< 2	
o-Xylene	100-41-4	5.98	1	< 2	175
TVOC toluene eq.				2.7	
TVOC specific				9.6	

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	CAS No.	Retention time [min]	ID- Cat	Concen- tration [µg/(m³)]	Limit value open plan [µg/m³]
Aldehydes					
Formaldehyde	50-00-0		1	3.7	8.25
Acetaldehyde	75-07-0		1	< 3	



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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: $24.8 \text{ m}^3/\text{h}$



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5 Summary and Evaluation of the Results

5.1 Comparison with Limit Values of ANSI/BIFMA; section 7.6.1

Parameter	Results after 7 days		
	Concentration mg/m ³	Limit values Workstation systems mg/m ³	Limit values Seating mg/m ³
TVOC _{toluene}	0.038	≤ 0.5	≤ 0.25
Formaldehyde	23 ppb	≤ 50 ppb	≤ 25 ppb
Total aldehydes (other)	24 ppb	≤ 100 ppb	≤ 50 ppb
4-Phenylcyclohexene	< 0.002	≤ 0.0065	≤ 0.00325

5.2 Comparison with Limit Values of ANSI/BIFMA; section 7.6.2

Individual compounds with CHREL-value after 14 days	Complies
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5.3 Comparison with Limit Values of ANSI/BIFMA; section 7.6.3

Parameter	Results after 14 days		
	Concentration µg/m ³	Limit values Workstation systems µg/m ³	Limit values Seating µg/m ³
Formaldehyde	3.7	≤ 9	≤ 4.5

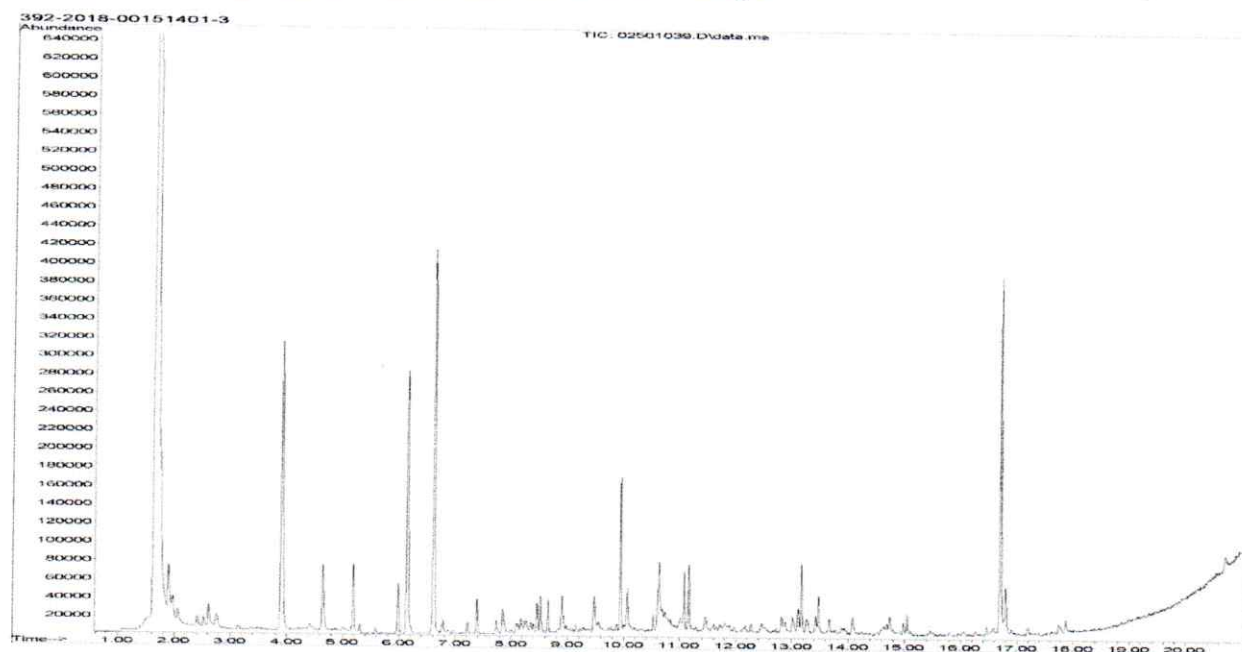


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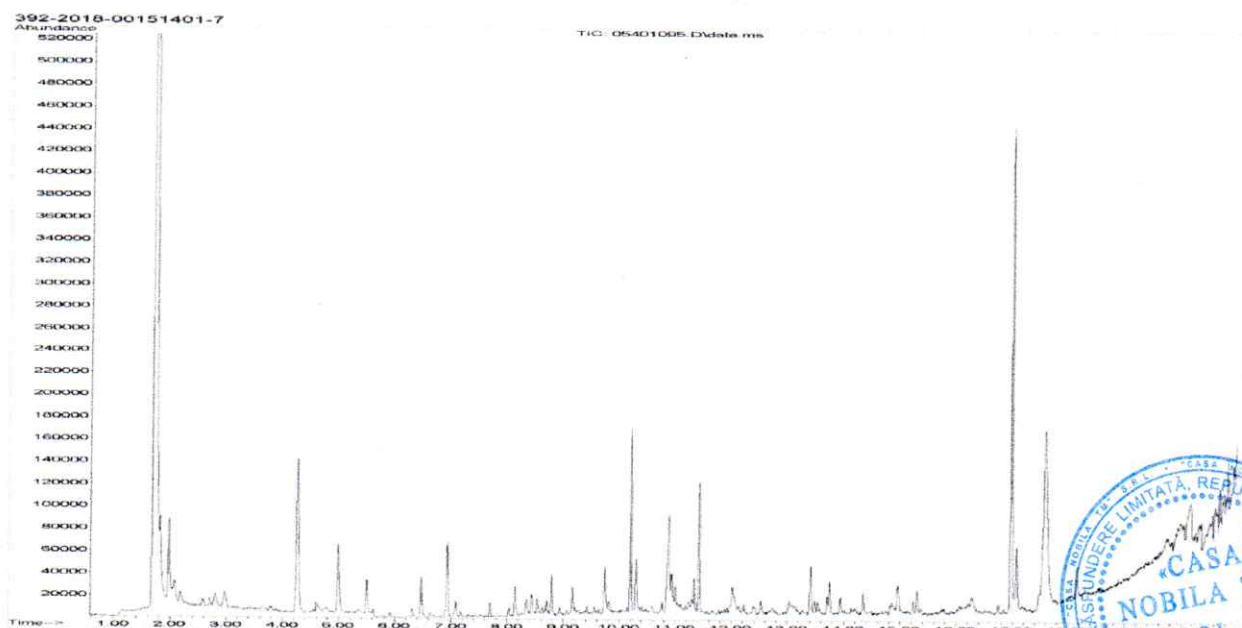
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6 Appendices

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
 - ▣ 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.



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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 (EN 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 (EN 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) (EN 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 EN 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

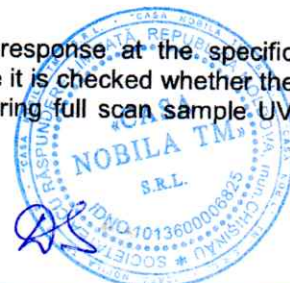
The presence of aldehydes after the specified duration of storage in the ventilated test chamber is tested by drawing air samples from the test chamber outlet through DNPH-coated silicagel tubes after the specified duration of storage in the ventilated test chamber. Analysis is performed by solvent desorption and subsequently by HPLC and UV-diode array detection (EN 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.

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6.4.5 Maximum Allowable Emission Factors

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

Compound	CAS nr.	Max allowable concentration	Max allowable concentration
		Workstation $\mu\text{g}/\text{m}^3$	Seating $\mu\text{g}/\text{m}^3$
Ethylbenzene	100-41-4	100	500
Styrene	100-42-5	450	225
1,4-Dichlorobenzene	106-46-7	400	200
Epichlorohydrin	106-89-8	1.5	0.75
Ethylene glycol	107-21-1	200	100
1-Methoxy-2-propanol	107-98-2	3500	1750
Vinyl acetate	108-05-4	100	50
Toluene	108-88-3	150	75
Chlorobenzene	108-90-7	500	250
Phenol	108-95-2	100	50
2-Methoxyethanol	109-86-4	30	15
Ethylene glycol monomethyl ether acetate	110-49-6	45	22.5
n-Hexane	110-54-3	3500	1750
2-Ethoxyethanol	110-80-5	35	17.5
2-Ethoxyethyl acetate	111-15-9	150	75
1,4-Dioxane	123-91-1	1500	750
Tetrachloroethylene	127-18-4	17.5	8.75
Formaldehyde	50-00-0	16.5	8.25
Isopropanol	67-63-0	3500	1750
Chloroform	67-66-3	150	75
N,N-Dimethyl Formamide	68-12-2	40	20
Benzene	71-43-2	30	15
1,1,1-Trichloroethane	71-55-6	500	250
Acetaldehyde	75-07-0	70	35
Methylene Chloride	75-09-2	200	100
Carbon Disulfide	75-15-0	400	200
Trichloroethylene	79-01-6	300	150
1-Methyl-2-Pyrrolidinone	872-50-4	160	80
Naphthalene	91-20-3	4.5	2.25
Xylenes (m-,o-, p-Xylene combined)	108-38-3, 95-47-6, 106-42-3	350	175

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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 EN 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.

