Test Report

Report No.: 890653-2-AB

DANISH TECHNOLOGICAL INSTITUTE

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Hbk/jle
Order no.: 890653
No. of appendices: 4

Assignor: Normann Copenhagen ApS
Østerbrogade 70
2100 Copenhagen
Denmark

Material: HYG 2-seater sofa, with oak legs and Camira fabric, mainline flax.

Sampling: The test material was sampled by the assignor and received in cardboard at the Danish Technological Institute 2020-03-19.

Method: ANSI/BIFMA M7.1-2011 (R2016) – Standard test method for determining VOC emissions from office furniture systems, components and seating.

Details of test methods are shown in appendix 2.

Period: The chamber testing was carried out from 2020-03-24 to 2020-03-31.

Result: The estimated building concentrations (C_{bldg}) of the tested furniture and limit of indoor air concentrations after 7 days (168 hours) are shown in the following table:

	Tested Seating C_{bldg}	Emissions Limits* Seating C_{bldg}
$TVOC_{(toluene)}$ (mg/m³)	0.20	≤ 0.25
Formaldehyde (ppb)	1.3	≤ 25
Total aldehydes (ppb)	2.2	≤ 50
4-Phenylcyclohexene (mg/m³)	< 0.001	≤ 0.00325

* ANSI/BIFMA M7.1 Table A1.1.

Detailed results for emissions are shown in Appendix 3.
Estimated building concentrations are shown in Appendix 4. The estimated building concentrations are below the allowable limits; hence the tested furniture is low-emitting according to LEED v4 for Interior Design and Construction, January 5, 2018.

Note: The test results does not apply to furniture with other materials than the tested sample, such as plywood legs or leather covers.

Storage: The test material will be picked up by the assignor after testing unless otherwise agreed.

Terms: Accredited testing was carried out in compliance with international requirements (EN/ISO/IEC 17025:2005) and in compliance with Danish Technological Institute's General Terms and Conditions regarding Commissioned Work accepted by Danish Technological Institute. The test results apply to the tested products only. This report may be quoted in extract only if the laboratory has granted its written consent.

Date/place: 2020-05-15, Danish Technological Institute, Taastrup, Building and Construction

Signature:

Digitally signed by:
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Test responsible

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Co-signatory

ilac-MRA DANAK TEST Reg.no. 2

Sample information

Material information given by assignor:

Chain of Custody form (CoC)
ANSI BIFMA / CDPH 01350

DANISH TECHNOLOGICAL INSTITUTE

Manufacturer details	
Company	**Normann Copenhagen ApS**
Address	**Østerbrogade 70, 2100 Copenhagen**
Country	**Denmark**
Contact name	**Søren Stryhn-Petersen**
Contact title	**CTO**
Phone	**+45 22844421**
E-mail	**ssp@normann-copenhagen.com**

Sample details	
Sample ID	**HYG 2-seater sofa, with oak legs and Camira fabric, mainline flax**
Product category	**Sofas and lounge chairs**
Product name	**HYG & Era series – sofas and lounge chairs**
Manufacturers ID. no.	[redacted]
Date manufactured	**March 12th. 2020**
Sample collection location	[redacted]
Samples collection time and date	
Sample collected by	
Number of sample pieces	**1 pc. HYG Sofa**
Disposal of sample material after test:	☐Scrap/discard ☒Storage and pick-up

Shipping details	
Packed by	**Søren Stryhn-Petersen**
Shipping date	**March 12th 2020**
Carrier	**Søren Stryhn-Petersen**
Air bill number	**Road delivery**

IMPORTANT:
Please wrap samples in airtight plastic in protective cardboard box/pallet and enclose this chain of custody form.

Please send the sample to:
Danish Technological Institute
Gregersensvej, Port 3K
DK-2630 Taastrup
Attn. Helene Bendstrup Klinke – Phone + 4572202173

Send electronic copy of test order form to: E-lab@dti.dk

Test laboratory	
Reception date & initials	20200319/mHon
Laboratory ID	890653-2

Add

Sample information

Additional information given by assignor:

normann COPENHAGEN

Appendix 1 – ANSI BIFMA/CDPH 01350

April 23rd. 2020

Test sample information:

Test sample ID: HYG sofa in full upholstery with solid oak legs
Seat material: Fabric is Camira – Mainline Flax). Rigid foam shell with steel frame, Foam cushion HR foam 60H (000023)
Leg materials: Solid oak wood, with clear lacquer
Glides: Made in HDPE

The test sample represents the following furniture with the following materials:

1) HYG lounge series – Sofa and lounge chairs tall and low
2) ERA lounge series – Sofa and lounge chairs tall and low
3) SUM lounge series – Sofa modules and lounge chair

The HYG series comes in following versions.

HYG sofa

HYG Lounge chairs Tall and low

Sample information

HYG Lounge series can be delivered with legs made of

- Solid oak wood with clear lacquer or painted
- Swivel legs in aluminium

The ERA series comes in following versions.

ERA sofas.

ERA lounge chairs:

Sample information

ERA sofa and lounge chairs can be delivered with legs made of:

- Plywood
- Steel with Chrome
- Steel with powder coating
- Rocking steel legs with chrome
- Aluminum swivel (only lounge chairs)

The SUM series comes as a lounge chair or sofa in modules

SUM lounge chair

SUM sofa modules

SUM lounge chair and sofa modules will be delivered with aluminum legs.

All HYG, ERA and SUM sofas and lounge chairs will be delivered as upholstery version. The upholstery version will consist of following materials:

- PUR foam shell
- Fabric: Camira - Main line flax, ERA, Oxygen, Synergy, ZAP, Oceanic, Yoredale, Zap, and Aquarius. Gabriel – Fame, Fame Hybrid, Breeze Fusion. Kvadrat – Hallingdal, Steelcut Trio and Remix.
- Leather: Sørensen leather - Ultra and Victory
- Low emission HR foam

Results Emissions

Chamber testing:

The test material was unwrapped and placed in the chamber.

Photo of test material in the chamber:

Climate chamber	24 m^3 Polished stainless steel
Temperature	23ºC ± 1ºC
Relative humidity	50% RH ± 5% RH
Air velocity at the surface of the specimen	0.1 – 0.3 m/s
Air change rate (n)	0.52 h^{-1} ± 0.05 h^{-1}
Area change flow rate	12.4 m^3/h

The test material was tested in the emission chamber without prior conditioning.

Air samples were taken from the climate chamber outlet air with calibrated pumps according to ISO 16000-6 on Tenax tubes (3-4 L) and ISO 16000-3 on DNPH tubes (60 L)

Results Emissions

The concentration approach was applied for emission testing.

The measured chamber concentrations are shown in Tables 1 and 2.

Results from the VOC analysis are shown in Table 1.

Method: ISO 16000-6: 2011. Indoor air – Part 6: Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID.
Analysis of the air sampled on Tenax was performed at the Wilhelm Klauditz Institut (WKI) under DAkkS accreditation number D-PL-11140-05-02. Report no. MAIC-2020-1268.

Table 1: Emission of volatile organic compounds (VOCs) between n-C6 and n-C16 measured by GC-MS (µg/m³)*

	72 hrs (3 days)				168 hrs (7 days)			
Chemical class/compound name	**#1**	**#2**	**Mean**	*% diff*	**#1**	**#2**	**Mean**	*% diff*
Aromatic hydrocarbons								
Toluene	2	< 2	1	>100	2	< 2	1	>100
m,p-Xylene (m-Xylene)	4	4	4	0	2	2	2	0
Styrene	45	41	43	9	27	29	28	7
o-Xylene (m-Xylene)	3	3	3	0	< 2	2	1	>100
Alkylbenzene (Toluene)	3	3	3	0	< 2	< 2	0	0
Alkylbenzene (Toluene)	7	6	7	15	3	4	4	29
Alkylbenzene (Toluene)	11	10	11	10	4	5	5	22
Alkylbenzene (Toluene)	12	12	12	0	6	7	7	15
Alkylbenzene (Toluene)	5	4	5	22	3	3	3	0
Aliphatic hydrocarbons								
Cyclohexane	9	8	9	12	5	5	5	0
saturated aliphatic hydrocarbons C9-C16 (Toluene)	100	91	96	9	55	58	57	5
saturated aliphatic hydrocarbons C9-C16 (Toluene)	18	16	17	12	9	10	10	11
saturated aliphatic hydrocarbons C9-C16 (Toluene)	5	5	5	0	3	3	3	0
saturated aliphatic hydrocarbons C9-C16 (Toluene)	4	4	4	0	2	3	3	40
saturated aliphatic hydrocarbons C9-C16 (Toluene)	6	5	6	18	4	4	4	0
saturated aliphatic hydrocarbons C9-C16 (Toluene)	2	< 2	1	>100	< 2	< 2	0	0
Cycloalkanes	< 2	< 2	< 2	0	< 2	< 2	< 2	0
Terpenes								
alpha-Pinene	2	2	2	0	< 2	< 2	0	0
Terpene (Toluene)	5	4	5	22	4	5	5	22
Terpene (Toluene)	5	5	5	0	3	4	4	29
Longifolene	5	5	5	0	3	4	4	29
Alcohols								
Diacetone alcohol	120	115	118	4	50	60	55	18
Glycols/Glycol ethers	< 2	< 2	< 2	0	< 2	< 2	< 2	0
Aldehydes								
n-Hexanal	2	2	2	0	< 2	< 2	0	0
Benzaldehyde	4	3	4	29	2	2	2	0

Results Emissions

	72 hrs (3 days)				168 hrs (7 days)			
Chemical class/compound name	**#1**	**#2**	**Mean**	*% diff*	**#1**	**#2**	**Mean**	*% diff*
Ketones								
2-Pentanone, 4-hydroxy- (Toluene)	2	2	2	0	< 2	< 2	0	0
Halocarbons								
Chloroprene derivatives (Toluene)	4	4	4	0	3	3	3	0
Chloroprene derivatives (Toluene)	20	18	19	11	12	13	13	8
Chloroprene derivatives (Toluene)	14	12	13	15	9	10	10	11
Acids								
Acetic acid	12	< 2	6	>100	2	3	3	40
2-Ethylhexanoic acid	10	10	10	0	7	9	8	25
Esters								
Ethyl acetate	12	12	12	0	7	8	8	13
1-Methoxy-2-propyl acetate	2	< 2	1	>100	< 2	< 2	0	0
Benzoic acid, 4-ethoxy-, ethyl ester (Toluene)	8	7	8	13	6	6	6	0
Others								
Octamethylcyclotetrasiloxane (D4)	6	6	6	0	3	4	4	29
N,N-Dimethylbenzylamine	17	15	16	13	9	12	11	29
Decamethylcyclopentasiloxane (D5)	3	3	3	0	2	2	2	0
4-tert-Butylphenol (Toluene)	9	8	9	12	8	9	9	12
2,4,6-Tri-tert-butylphenol (Toluene)	15	12	14	22	12	12	12	0
Sums								
TVOC Toluene (ISO 16000-6)	949	849	899	11	603	650	627	8
Sum VOC (C6-C16)	513	457	485	12	267	301	284	12

* Single substances/volatile compounds were quantified with pure reference standards, and in some cases the substances shown in subscript were used for the quantification.

< 1 Not detected (< 1 µg/m^3)
Measured concentrations just above limit of quantification (LOQ) of 1 µg/ m^{2}h will result in higher standard deviation from mean value.

Definitions according to ISO 16000-6:

VOC (C6-C16): Volatile organic compounds, between hexane (C6) and hexadecane (C16)
VVOC (<C6): Very volatile organic compounds, eluting before hexane, not included in TVOC
SVOC (>C16): Semi-volatile organic compounds, eluting after hexadecane, not included in TVOC
TVOC: Total volatile organic compounds is the sum of all VOCs eluting between C6 and C16, quantified as toluene equivalents.

Results Emissions

Results from aldehyde analysis are shown in Table 2.

Method: ISO 16000-3: 2011. Indoor Air – Part 3: Determination of formaldehyde and other carbonyl compounds – Active sampling method.
Analysis of the air sampled on DNPH was performed at the Danish Technological Institute under DANAK accreditation number 90. Report no. 923787.

Table 2: Emission of lower aldehydes (C1-C4) by HPLC analysis (µg/m³)

	72 hrs (3 days)				168 hrs (7 days)			
Compound name	**#1**	**#2**	**Mean**	***% diff***	**#1**	**#2**	**Mean**	***% diff***
Formaldehyde	< 2	< 2	< 2	0	< 2	< 2	< 2	0
Acetaldehyde	< 2	< 2	< 2	0	< 2	< 2	< 2	0
Propanal	-	< 2	< 2	> 100	-	-	-	0
Butanal	-	-	-	0	-	-	-	0
Arolein	-	-	-	0	-	-	-	0

- Not detected. Limit of detection (LOD) is 0.5 µg/m³ (formaldehyde, acetaldehyde, butanal), 0.8 µg/m³ (propanal) and 3.3 µg/m³ (acrolein).
  Measured concentrations just above limit of quantification (LOQ) of 1 µg/ m²h will result in higher standard deviation from mean value

Building Concentration

Estimated indoor air concentrations in a building

The tested furniture is seating, hence the measured concentrations from chamber testing must be adjusted to a standard office scenario using the default ventilation rate of per seating unit: Q=24.8 m^3/h.

The concentration approach was applied for emission testing of the 2-seater sofa. Emissions correspond to 2 chairs (1-seaters), however the emissions were considered as "1 chair" in order to reflect worst case. Hence, calculations of building concentrations were carried out reflecting the worst-case emission scenario of seating in a building.

According to Table 11.1 (ANSI/BIFMA M7.1) the standard office environment parameter "modelled air flow (Q)" for seating is 24.8 m^3/h for both open plan working stations and private office work stations.

The chamber ventilation rate was $Q_{chamber}$ = 12.4 m^3/h, hence the measured chamber concentrations ($C_{chamber}$) in Tables 1 and 2 must be multiplied by a factor:

$Q_{chamber}$ = 12.4 m^3/h

Q_{bldg} = 24.8 m^3/h

$C_{bldg} \times Q_{bldg} = C_{chamber} \times Q_{chamber}$

$$C_{bldg} = \frac{12.4\ m3/h}{24.8\ m3/h} \times C_{chamber} = 0.50 \times C_{chamber}$$

Estimated building concentrations are shown in Tables 4 and 5.

The building concentrations after 14 days (336 h) were calculated from the emission factors after 3 days (72 h) and 7 days (168 h) by the power-of-law model according to the formulas given in ANSI/BIFMA M7.1 chapter 11.2.

The estimated building concentrations were calculated and results are shown in Tables 3 and 4.

Table 3: Estimated building concentrations C_{bldg} of volatile organic compounds (VOCs) between n-C6 and n-C16 measured by GC-MS (µg/m^3)*

Chemical class/compound name	3 days	7 days	14 days
Aromatic hydrocarbons	0.5	0.5	0.5
Toluene	2.0	1.0	0.6
m,p-Xylene (m-Xylene)	21.5	14.0	9.9
Styrene	1.5	0.5	0.2
o-Xylene (m-Xylene)	1.5	< 0.1	< 0.1
Alkylbenzene (Toluene)	3.3	1.8	1.1
Alkylbenzene (Toluene)	5.3	2.3	1.1
Alkylbenzene (Toluene)	6.0	3.3	2.0
Alkylbenzene (Toluene)	2.3	1.5	1.1
Alkylbenzene (Toluene)			
Aliphatic hydrocarbons	4.3	2.5	1.6
Cyclohexane	47.8	28.3	18.4
saturated aliphatic hydrocarbons C9-C16 (Toluene)	8.5	4.8	3.0
saturated aliphatic hydrocarbons C9-C16 (Toluene)	2.5	1.5	1.0
saturated aliphatic hydrocarbons C9-C16 (Toluene)	2.0	1.3	0.9
saturated aliphatic hydrocarbons C9-C16 (Toluene)	2.8	2.0	1.5
saturated aliphatic hydrocarbons C9-C16 (Toluene)	0.5	< 0.1	< 0.1
saturated aliphatic hydrocarbons C9-C16 (Toluene)	-	-	-
Cycloalkanes			
Terpenes	1.0	< 0.1	< 0.1

alpha-Pinene	2.3	2.3	2.3
Terpene (Toluene)	2.5	1.8	1.3
Terpene (Toluene)	2.5	1.8	1.3
Longifolene			
Alcohols	58.8	27.5	14.8
Diacetone alcohol	-	-	-
Glycols/Glycol ethers			
Aldehydes	1.0	< 0.1	< 0.1
n-Hexanal	1.8	1.0	0.6
Benzaldehyde			
Ketones	1.0	< 0.1	< 0.1
2-Pentanone, 4-hydroxy- (Toluene)			
Halocarbons	2.0	1.5	1.2
Chloroprene derivatives (Toluene)	9.5	6.3	4.4
Chloroprene derivatives (Toluene)	6.5	4.8	3.7
Chloroprene derivatives (Toluene)			
Acids	3.0	1.3	0.6
Acetic acid	5.0	4.0	3.3
2-Ethylhexanoic acid			
Esters	6.0	3.8	2.6
Ethyl acetate	0.5	< 0.1	< 0.1
1-Methoxy-2-propyl acetate	3.8	3.0	2.5
Benzoic acid, 4-ethoxy-, ethyl ester (Toluene)			
Others	3.0	1.8	1.1
Octamethylcyclotetrasiloxane (D4)	8.0	5.3	3.7
N,N-Dimethylbenzylamine	1.5	1.0	0.7
Decamethylcyclopentasiloxane (D5)	4.3	4.3	4.3
4-tert-Butylphenol (Toluene)	6.8	6.0	6.0
2,4,6-Tri-tert-butylphenol (Toluene)			
Sums	332.0	195.8	127.1
TVOC Toluene (ISO 16000-6)	242.5	142.0	91.7

Table 4: Estimated building concentrations C_{bldg} of lower aldehydes (C1-C4) by HPLC analysis (ppb)

Compound name	3 days	7 days	14 days
Formaldehyde	1.6	1.3	1.2
Acetaldehyde	0.8	0.7	0.6
Propanal	< 0.1	-	-
Butanal	-	-	-
Acrolein	-	-	-

According to ANSI/BIFMA M7.1 Table A1.1 and ANSI/BIFMA X7.1 Standard for Formaldehyde and TVOC Emissions from Low-emitting Office Furniture and Seating Table A1.1, the evaluation of indoor air concentrations from furniture in a building must meet the criteria limits for giving LEED EQ Credit 4.5 Low-Emitting Materials, Systems Furniture and Seating. The results are shown in Table 5.

Higher aldehydes analysed by GC-MS VOC analysis (Table 3) were converted to ppm and included in the sum of total aldehydes (Table 5).

Building Concentration

Table 5: Estimated building concentrations of tested furniture and limit of indoor air concentrations after 7 days.

	Tested Seating C_{bldg}	Emissions Limits* Seating C_{bldg}
$TVOC_{(toluene)}$ (mg/m^3)	0.20	≤ 0.25
Formaldehyde (ppb)	1.3	≤ 25
Total aldehydes (ppb)	2.2	≤ 50
4-Phenylcyclohexene (mg/m^3)	< 0.001	≤ 0.00325

* ANSI/BIFMA M7.1 Table A1.1.

The building concentrations are below the maximum allowable limit after 7 days, and hence is low emitting furniture and compliant with LEED v4 for interior design and construction.

The estimated building concentrations according to the above ANSI/BIFMA office furniture calculations of volatile compounds in air after 3, 7 and 14 days, respectively are shown Table 6 with reference to CDPH 01350 table 4-1, where the allowable concentration limit CREL (Chronic Reference Exposure Level) are stated for evaluation of the 14 days (336 hrs) building concentrations.

Note: CDPH01350 evaluation is only relevant for classroom furniture according to LEED v4.

Building Concentration

Table 6: Estimated building concentrations of tested furniture at 3, 7 and 14 days of target CREL VOCs from Proposition 65 and Table 4-1 in CDPH 01350*.

Compound Name	CAS No.	$C_{(3\ d)}$ (µg/m³)	$C_{(7\ d)}$ (µg/m³)	$C_{(14\ d)}$ (µg/m³)	Allowable $C_{(14\ d)}$** (µg/m³)
Acetaldehyde	000075-07-0	1.5	1.2	1.0	70
Benzene	000071-43-2	-	-	-	1.5
Carbon disulfide	000075-15-0	-	-	-	400
Carbon tetrachloride	000056-23-5	-	-	-	20
Chlorobenzene	000108-90-7	-	-	-	500
Chloroform	000067-66-3	-	-	-	150
Dichlorobenzene (1.4-)	000106-46-7	-	-	-	400
Dichloroethylene (1.1)	000075-35-4	-	-	-	35
Dimethylformamide (N.N-)	000068-12-2	-	-	-	40
Dioxane (1.4-)	000123-91-1	-	-	-	1500
Epichlorohydrin	000106-89-8	-	-	-	1.5
Ethylbenzene	000100-41-4	-	-	-	1000
Ethylene glycol	000107-21-1	-	-	-	200
Ethylene glycol monoethyl ether	000110-80-5	-	-	-	35
Ethylene glycol monoethyl ether acetate	000111-15-9	-	-	-	150
Ethylene glycol monomethyl ether	000109-86-4	-	-	-	30
Ethylene glycol monomethyl ether acetate	000110-49-6	-	-	-	45
Formaldehyde	000050-00-0	2.0	1.7	1.4	9
Hexane (n-)	000110-54-3	-	-	-	3500
Isophorone	000078-59-1	-	-	-	1000
Isopropanol	000067-63-0	-	-	-	3500
Methyl chloroform	000071-55-6	-	-	-	500
Methylene chloride	001634-04-4	-	-	-	200
Methyl *t*-butyl ether	000075-09-2	-	-	-	4000
Naphthalene	000091-20-3	-	-	-	4.5
Phenol	000108-95-2	-	-	-	100
Propylene glycol monomethyl ether	000107-98-2	-	-	-	3500
Styrene	000100-42-5	21.5	14.0	9.9	450
Tetrachloroethylene	000127-18-4	-	-	-	17.5
Toluene	000108-88-3	0.5	0.5	0.5	150
Trichloroethylene	000079-01-6	-	-	-	300
Vinyl acetate	000108-05-4	-	-	-	100
Xylenes, technical mixture (o.m.p)	000106-42-3 000108-38-3 000095-47-6 001330-20-7 179601-23-1	3.5	1.5	0.8	350

- Not detected

*CDPH 01350 (2017) Standard method for the testing and evaluation of volatile organic chemical emissions from indoor sources using environmental chambers. Version 1.2.

**All maximum allowable concentrations are one-half the corresponding CREL adopted by Office of Environmental Health Hazard Assessment (OEHHA) agency of California Environmental Protection Agency (CalEPA).

Results from Table 6 show the building concentrations of target CREL VOCs are below the maximum allowable limit after 14 days.