

# Emission of formaldehyde from furniture

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*Publication date:*
2016

*Document Version*
Publisher's PDF, also known as Version of record

Ministry of Environment and Food of Denmark
Environmental Protection Agency

# Emission of Formaldehyde from Furniture

Test Results and Assessment of Impact on Indoor Air Quality

Environmental project No. 1815, 2016

**Title:**

Emission of Formaldehyde from Furniture

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**Published by:**

The Danish Environmental Protection Agency
Strandgade 29
1401 Copenhagen K
Denmark
www.mst.dk/english

**Photography:**

Helene B. Klinke

**Year:**

2016

**ISBN no.**

978-87-93435-12-4

# Contents

# Foreword

This investigation was supported by the Danish Environmental Protection Agency. It was carried out in order to clarify whether emission of formaldehyde from furniture may give poor indoor air quality causing health risks for building occupants. The indoor air quality is important to public health and formaldehyde is one of many chemicals influencing the indoor air quality. Formaldehyde has a wide range of sources, among others furniture. Existing legislation regulates the emission from wood-based panels used in furniture. This investigation aimed at the emission from single pieces of furniture and scenarios for entire room furnishing. The tested products are examples of furniture on the Danish market, but the selection is not representative. The investigation was carried out by the Danish Building Research Institute and the Danish Technological Institute. Lasse Borgstrøm Eriksen is acknowledged for assembling furniture and preparing of samples.

# Summary and Conclusion

The emission of formaldehyde from 20 different pieces of furniture, representing typical furniture on the Danish marked, was measured in climate chambers. Most tests show low emission of formaldehyde, however, there are a few exceptions. One product emitted significant amounts of formaldehyde during chamber testing. However, at a loading according to the Danish Indoor Climate Labelling for furnishing an entire room, the impact on the air quality in the room was low due to the required and typical surface area of the tested furniture. Another product, having a high emission of formaldehyde as well as a high load in the standard room, resulted in a high concentration of formaldehyde both during chamber tests and in the loaded standard room. Even with a moderate emission of formaldehyde, furniture with large surface area such as bookcases and kitchen front doors can have a significant impact on the indoor air. The results show that certain scenarios of furnishing, including furniture with large surface areas in relation to room volume can emit formaldehyde resulting in concentrations above the WHO recommended limit of 0.1 mg $m^{-3}$. In one of the scenarios resulting in a concentration of more than 0.1 mg $m^{-3}$ in the air the furniture all fulfilled the requirement of the CE-mark in class E1 when replacing the approximated surface area of the furniture with the area of construction plates as described in the Danish Building Regulation for the emission of formaldehyde from wood-based panels used for construction. This high concentration will result in annoying odor, sensory irritation and unsatisfactory indoor air quality.

# 1. Introduction

Formaldehyde is an indoor pollutant caused by emission from a wide range of sources, including wood based products, glue, specific paints and lacquer, furniture, clothes and cleaning agents. A comprehensive review of formaldehyde in the indoor environment is given by Salthammer et al. (2010). Among other things, the review covers indoor sources, sampling and analysis, material testing, indoor guidelines, emission data and indoor concentrations. A review of the non-cancer effects of formaldehyde and the relevance for setting an indoor air guideline is given by Wolkoff and Nielsen (2010). This review concludes that an air quality guideline for formaldehyde of 0.1 mg $m^{-3}$ is considered protective against both acute and chronic sensory irritation of the airways. This value is in line with the WHO air quality guideline of 0.1 mg $m^{-3}$ as a maximum 30-minute average value (WHO, 2010). In a review from 2013 Nielsen et al. conclude that all together, the WHO (2010) guideline value is not contradicted, but rather supported by recent studies.

The use of formaldehyde as a component of adhesives is of particular significance for the indoor environment (Salthammer et al., 2010). The urea-formaldehyde adhesives are commonly used in the manufacturing of wood-based material and furniture due to their rapid curing, compatibility with additives and low price. The urea-formaldehyde adhesives have poor water resistance and in the presence of water this property causes a hydrolysis with a release of formaldehyde. Melamine-urea-formaldehyde adhesives are similar to urea-formaldehyde adhesives, whereas phenol-formaldehyde adhesives are very stable and water resistant and have a high adherence to wood. Melamine-urea-phenol-formaldehyde adhesives are used for production of moisture-proofed wood based products and construction materials (Salthammer et al., 2010).

This paper presents the results of chamber measurements of the emission of formaldehyde from twenty individual pieces of furniture. The results are used to assess the impact on the indoor air quality. The assessment is made for a model room loaded with the individual furniture as well as scenarios with a combination of furniture. These values are compared to the WHO air quality guideline of 0.1 mg $m^{-3}$ (WHO, 2010).

## 1.1 Regulations

In Denmark formaldehyde emission from wooden construction panels has been regulated since the early 1980s. In 1983 a regulation for wood-based panels used in products like furniture was given by The Danish Ministry of the Environment (1983). According to this regulation the emission of formaldehyde from the wood-based panels should not exceed a level causing a room air concentration above 0.15 mg $m^{-3}$ (Danish Environmental Agency, 1983). In order to make a measure for the room air concentration operational in relation to a test of a species in a climate chamber, a set of conditions for the chamber and the test species were defined. For this regulation the conditions were set to match the concentration in the room, i.e. the test specie do not meet the requirements if the concentration of formaldehyde in the test chamber exceeded 0.15 mg $m^{-3}$. The conditions defined the area of the emitting surface relative to the volume of the test chamber as well as the air exchange rate. Further, parameters like temperature and relative humidity were defined as these parameters have an influence on the emission rate. For the regulation for wood-based panels the conditions in the test chamber included the following specifications:

- Temperature: 23° C,
- Relative humidity: 45%,

- Air exchange rate of 0.25 $h^{-1}$,
- Load of the climate chamber: 2.25 $m^2$ $m^{-3}$ (i.e. the emitting surface area relative to volume of the chamber).

This load corresponds to an emitting surface covering floor, ceiling and walls in a model room with an area of 7 $m^2$ and a room height of 2.4 m. These dimensions together with a width and length of respectively 2.2 m and 3.2 m are consistent with a model room defined by the Nordtest method NT BUILD 358 (Nordtest, 1990). The maximum equilibrium concentration of 0.15 mg $m^{-3}$ according to this regulation, results in a maximum area specific emission rate of 0.017 mg $m^{-2}$ $h^{-1}$ from the emitting surface, giving the specified load, air exchange rate, temperature and relative humidity.

In the Danish building regulation the emission of formaldehyde from wood-based panels used for construction are subject to a harmonized standard and must be CE-marked with an indication that the product comply with the E1 class (Danish Energy Agency, 2010). This refers to the standard DS/EN 13986:2004, where products, added formaldehyde-containing materials as part of the production process, shall be tested and classified into one of two classes: E1 or E2. Compliance to the E1 class implies that the air concentration at defined conditions of a test chamber do not exceed 0.124 mg $m^{-3}$. The conditions in the test chamber are defined in standard EN 717-1:2004. Concerning temperature and humidity, this method defines the same conditions as the regulation from the Danish Environmental Agency (temperature at 23° C and a relative humidity at 45%, respectively), though the load and air exchange rate of the chamber differ. For the method specified in EN 717-1:2004 the load is 1 $m^2$ $m^{-3}$ and the air exchange rate is 1 $h^{-1}$. At these conditions the numerical value of the concentration in the test chamber equals the specific emission rate, i.e. the maximum allowed concentration of 0.124 mg $m^{-3}$ refers to a maximum specific emission rate of 0.124 mg $m^{-2}$ $h^{-1}$. If a specific emission rate of 0.124 mg $m^{-2}$ $h^{-1}$ is applied to the model room mentioned above with a load of 2.25 $m^2$ $m^{-3}$ and an air exchange rate of 0.25 $h^{-1}$, the concentration of formaldehyde in the air of the room would be 1.12 mg $m^{-3}$. At the same load, but with an air exchange rate of 1 $h^{-1}$ the concentration of formaldehyde in the air of the model room would be 0.28 mg $m^{-3}$.

The testing and labelling specifications for furniture of the Danish Indoor Climate Labelling (DICL) refers to a third set of conditions defined in ISO 16000-9:2006. This standard is used for determination of the emission of volatile organic compounds from building products and furnishing. Formaldehyde is one of many volatile organic compounds. This ISO method operates at the same temperature of 23° C, but a slightly higher relative humidity of 50 % in the test chamber.

As wood-based panels are widely used in furniture these might also contribute to the concentration of formaldehyde in the indoor air. Further, veneering and preparation with acid-curing lacquer may cause long term emissions of formaldehyde (Kirkeskov Jensen et al., 2001). Due to the use of formaldehyde as a fumigant and preservative, fabrics and foams of the furniture can also be a source of formaldehyde. In Germany formaldehyde emission from the whole furniture and/or all wooden boards in the furniture is regulated by law and to comply with the E1 class of EN 13986:2004 (Chemikalien-Verbotsverordnung-ChemverbotsV, 1993).

In addition to the requirements for the wooden-based panels and construction products, the Danish building regulation (Danish Energy Agency, 2010) defines that these products should not give rise to unsatisfying health conditions in the indoor air. The WHO recommendation with the air quality guideline of a maximum of 0.1 mg $m^{-3}$ is mentioned. Measurements of formaldehyde in Danish dwellings demonstrated that higher formaldehyde concentrations can be found (Kolarik et al., 2012).

# 2. Methods

Furniture were purchased and tested for emission of formaldehyde in climate chambers. Below is a description of chambers and chamber conditions, preparation of test pieces as well as determination of formaldehyde concentration and emission rate.

## 2.1 Purchase of furniture

Twenty pieces of furniture containing composite wood were purchased from consumer retail stores. A set of criteria were used as a starting point to purchase the test species:

- The product contain plywood, chipboard, molded wood or MDF boards, preferably also including surfaces treated with acid-curing lacquer
- The test species belong to typical home furnishing
- The product should be in stock, i.e. available within normal delivering time

Based on our knowledge of the Danish consumer oriented marked we selected acquired furniture catalogues. In these catalogues we identified pieces of furniture that could be suspected of emitting formaldehyde. For these products we looked further for any documentation that could reject our suspicion. If such documentation was found they were excluded from the investigation. One product was eliminated due to information on the website that no acid-curing lacquer is used. Another product was eliminated due to information from the staff in the store that all lacquered products were treated with UV-lacquer.

In general, purchasing the furniture on normal consumer conditions revealed difficulties getting information about the products, their formaldehyde emission and whether acid-curing lacquer had been used. Several stores were visited in order to gain information about materials and surface treatment. Attempts to get the information were done through inspection of furniture and their labels as well as asking the staff. At most places the staff referred to the factory as they did not know themselves what kind of lacquer was used and they didn't have access to the information.

It was the intention to get information about production date, though this was in general not possible.

Some products were purchased from the store or their stock, while others, mainly larger furniture, were ordered from web sites and sent to the laboratory.

## 2.2 Preparation of test pieces

Simple pieces of furniture were cut to size and sealed according to the standard EN 717-1:2004 and tested in small chambers. This applies to kitchen front doors, a dining chair and a stool. To obtain a material load of 1 $m^2/m^3$ in the 0.225 $m^3$ chambers, test pieces were cut from the product, making a 300 mm x 375 mm square. The cut edges were sealed with aluminum foil. Until preparation of the test specimen the products were kept in their original packaging. After preparation and until entering the chamber, the test pieces were stored airtight in polyethylene plastic bags.

The more complex furniture like armchairs, bookshelves, wardrobes and coffee tables were tested in large chambers, where the product was assembled immediately before the test began. Surface area

of the furniture was determined through measurements. According to the Society of Danish Indoor Climate Labelling's Testing and Labelling Criteria for Furniture (DICL), the furniture, as provided by the supplier, was treated as a whole, including components like shelves, cushions, padding, table tops, legs etc. This also applied to components that might be surface treated. Figure 1 shows a chest of drawers in a test chamber.

FIGURE 1. CHEST OF DRAWRS IN TEST CHAMBER

## 2.3 Test chambers and conditions

The chambers are made of polished stainless steel and the following four sizes: 0.225 $m^3$, 1 $m^3$, 15 $m^3$ and 24 $m^3$ were all used. The chamber volume is the total air volume of the unloaded chamber. The air exchange rate ($h^{-1}$) of the chamber is the quotient of air volume passing through the chamber per hour ($m^3\ h^{-1}$) and the chamber volume ($m^3$). This is also given as the air flow ($l\ s^{-1}$), taking the volume of the chamber into consideration. Air flows were measured by hot wire anemometer in a length of duct designed for flow measurements.

All emission tests in 0.225 $m^3$ and 1 $m^3$ chambers were conducted with an air exchange rate of 1 $h^{-1}$ (± 5%). Emission tests in 15 $m^3$ chambers were conducted with an air exchange rate of 0.55 $h^{-1}$ (± 5%), whereas tests in 24 $m^3$ chamber were conducted with an air exchange rate of 0.59 $h^{-1}$ (± 5%).

The loading factor L ($m^2\ m^{-3}$) is the ratio of the total surface area of the test piece to the volume of the chamber. The test pieces placed in 0.225 $m^{-3}$ chambers were cut to give a loading factor of 1 $m^2\ m^{-3}$ and the area of the edges were excluded by sealing. For the larger chambers the loading factor varied as a result of variable surface areas of the individual products and the fixed chamber volume. All chambers have an internal fan resulting in well mixed air and an air velocity ($m\ s^{-1}$) passing the test piece at 0.1-0.3 $m\ s^{-1}$. Figure 1 shows a test piece in a 0.225 $m^{-3}$ chambers.

FIGURE 1. KITCHEN FRONT DOOR, CUT TO SIZE AND WITH SEALED EDGES, IN A 0.225 $M^{-3}$ CHAMBER.

When the formaldehyde concentration in the chamber remains constant, the steady-state condition is defined (see below). During this condition the concentration of formaldehyde (mg $m^{-3}$) was determined. The chambers were kept at a temperature of 23°C (± 0.5 °C). The relative humidity was 45% (± 3%) during the test. Conditions in climate chambers comply with the EN 717-1:2004 standard.

## 2.4 Determination of formaldehyde

Formaldehyde was measured continuously by a spectrophotometric method using continuous flow technology (Skalar analyzer). Formaldehyde reacts with ammonium ions and acetyl acetone and forms a yellow complex (diacetyldihydrolutidine), the Hantzsch reaction (Nash, 1953). The on-line measurements were used to determine the decay and steady-state of the formaldehyde emission. The limit of detection (LOD) of the method is 0.01 mg $m^{-3}$.

After reaching the steady-state, the concentration of formaldehyde in the air of the chamber was measured according to the standard EN 717-1:2004. The measurement was done by sampling air with a flow rate of about 0.8 l $min^{-1}$ through two consecutive 100 ml washing bottles with water. The formaldehyde was absorbed in the water and subsequent the amount was determined by the Hantzsch reaction. The volume of sampled air was finally corrected to a standard pressure of 1013 hPa.

The measurements of the concentrations were done according to the standard; however test pieces resulting in stable concentrations of less than 0.05 mg $m^{-3}$ after a few days were suspended from further investigation in order to screen as many furniture samples as possible within the time frame of the project. For the continued measurements the measured values after 28 days were taken as steady state values in compliance with the standard EN 717-1:2004.

The Specific Emission Rate, SER (mg $m^{-2}$ $h^{-1}$), was calculated by the following equation 1:

$$SER = C*n*V/A \quad (1)$$

Where C is the measured test chamber concentration (mg $m^{-3}$), n is the air exchange rate in test chamber ($h^{-1}$), V is the volume of test chamber ($m^3$) and A is the exposed surface area of test specimen ($m^2$).

As the air exchange rate and loading factor (V/A) equals 1 $m^2$ $m^{-3}$ and 1 $h^{-1}$, respectively in the 0.225 $m^3$ chambers, the SER becomes equal to the formaldehyde concentration in these chambers.

## 2.5 Calculation of impact on indoor air

The assessment of the impact of the furniture on the indoor air is done according to the Danish Indoor Climate Labelling's Testing and Labelling Criteria (DICL) for Furniture (Danish Society of Indoor Climate´s Testing and Labelling Criteria, 2005a) and kitchens (Danish Society of Indoor Climate´s Testing and Labelling Criteria, 2005b). DICL defines a standard room with a volume of 30 $m^3$, a floor area of 12 $m^2$ and a ceiling height of 2.5 m. The air exchange rate is 0.5 $h^{-1}$.

The obtained results from the test chamber measurements are converted to a concentration, $C_s$, in the standard room. The emission rate in the standard room ($R_s$) is calculated according to equation 2:

$$R_s = C_s*n_s*V_s/A_s \quad (2)$$

Where $n_s$ is the air exchange rate in standard room ($h^{-1}$), $V_s$ is the volume of standard room ($m^3$) and $A_s$ is the exposed surface area of furniture ($m^2$).

It is assumed, that SER = $R_s$. Therefore, the concentration of the standard room can be calculated from equation 3:

$$C_s = (C*n*V/A) / (n_s*V_s/A_s) \quad (3)$$

DICL has a list of different types of furniture and their maximum occurrence in the standard room. For book shelves without backing there is a maximum cover of 8 $m^2$ of the wall surface. For open bookcases with backing there is a maximum cover of 6 $m^2$ wall surface. For light chairs like dining chairs there is a maximum of six pieces, whereas the maximum for an armchair is two. For furniture along wall, like chest of drawers and for tables the standard room has one piece. The resulting concentration in the standard room is found from $C_s$ times the amount of pierces or corrected to a maximum cover of wall surface. In this investigation the backing area of the tested bookcases are determined and the loading of the standard room is calculated by up scaling the backing cover of the bookcase to 6 $m^2$ wall surface and the. The area of the kitchen front doors were up scaled to 11.16 $m^2$. The values found from converting the test results to the standard room are compared to the concentration in the guideline from WHO of 0.1 mg $m^{-3}$ (for a half hour mean value).

# 3. Results and discussion

The products are divided in six groups: kitchen front doors, bookcases, chairs, cabinets, chest of drawers and tables. The products are named by a number and type of product, information of material and surface treatment are given in table A1.1-A1.6 in Appendix 1. Information related to formaldehyde found on the homepage of the store as well as how the products are obtained is also listed in the tables. The results presented below are divided according to the size of the chamber they were tested in.

Below the results and discussion is divided according to:

- The concentration of formaldehyde measured in the test chamber
- The emission rate estimated from the chamber air concentration together with a calculation converting this emission rate to the concentration in a standard room containing a defined amount of the test species
- A set of scenarios with a calculation of the air concentration in the standard room with a typical furnishing

## 3.1 Concentrations

The concentration in the chamber depends on the emission from the product and the test conditions. Figure 2 shows the measured concentration of formaldehyde over time in the 0.225 $m^3$ chamber for the test species that were cut to fit a loading of 1 $m^2$ $m^{-3}$ and air exchange of 1 $h^{-1}$ (no. 1-8). The starting point is the placement of the test specie in the chamber. As all these products are tested with the same load of the chamber the measured concentrations are mutually comparable. The test conditions apply directly to the EN 717-1:2004 standard, which means that the concentration in the test chamber is comparable to the E1 class (0.124 mg $m^{-3}$) for wood-based panels and construction products.

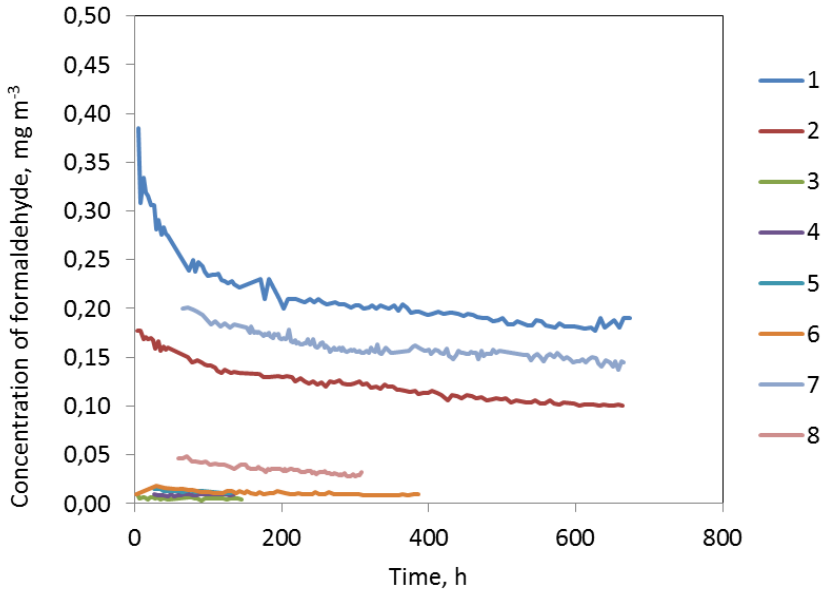

**FIGURE 2. THE MEASURED CONCENTRATION OF FORMALDEHYDE OVER TIME (HOURS FROM ENTERING THE CHAMBER) IN THE 0.225 M³ CHAMBER FOR THE TEST SPECIES THAT WERE CUT TO FIT A LOADING OF ONE (TEST SPECIE NO. 1-8).**

The time course of concentrations shows small variation between products. Test specie no. 1, 2 and 7 have a relatively high concentration at the beginning of the test period and show a marked decrease over time. Test specie no. 8 has a low concentration at the beginning and shows a less pronounced decrease.

Table 1 and 2 list the product number, type of furniture, number of days from commencement of tests until reaching the final measured concentration in test chamber, area of test specimen and whole product and the air flow in the test chamber. In Table 1 the values are given for the chamber size 0.225 $m^3$, whereas table 2 list the values for the chamber size 1 $m^3$, 15 $m^3$ and 24 $m^3$. For the larger chambers the load and the air exchange rate of the chamber differs from the conditions defined by the EN 717-1:2004 standard. The load differs for the different products as they are tested as a whole and have different surface areas. As a consequence, the concentration values are not mutually comparable and they are not directly comparable to the E1 class. Therefore, the measured concentrations are further calculated to area specific emission rates, which are comparable to the requirements given for building products, see next section. Some of the pieces of furniture gave rise to high concentrations of formaldehyde, whereas most of the tested species resulted in a concentration of less than 0.05 mg $m^{-3}$ formaldehyde after a few days. In these cases the testing was finalized after a minimum of four days, except for the coffee table, which was tested only one day due to very low concentrations. The concentrations listed below are the final concentrations measured with the continuous method.

**TABLE 1**
TEST SPECIES, TYPE OF FURNITURE, TIME FROM LOADING OF TEST SPECIES TO THE MEASUREMENT OF FINAL CONCENTRATION, AREA OF TEST SPECIMEN AND PRODUCT, AIR FLOW IN TEST CHAMBER AND FINAL CONCENTRATION MEASURED IN THE TEST CHAMBER. THE VALUES ARE GIVEN FOR THE 0.225 $M^3$ CHAMBER.

| Number ID | Type of furniture | Days of measurement | Area, specimen $m^2$ | Area, product $m^2$ | Air flow l $s^{-1}$ | Final concentration mg $m^{-3}$ |
|---|---|---|---|---|---|---|
| | | | **0.225 m³ chamber** | | | |
| **1** | Stool | 28 | 0.225 | 1.21 | 0.06 | 0.18 |
| **2** | Chair | 28 | 0.225 | 0.77 | 0.06 | 0.10 |
| **3** | Kitchen front door | 6 | 0.225 | 0.84 | 0.06 | < 0.01 |
| **4** | Kitchen front door | 6 | 0.225 | 0.84 | 0.06 | 0.01 |
| **5** | Kitchen front door | 6 | 0.225 | 0.84 | 0.06 | 0.01 |
| **6** | Kitchen front door | 19 | 0.225 | 0.84 | 0.06 | 0.01 |
| **7** | Kitchen front door | 28 | 0.225 | 0.84 | 0.06 | 0.15 |
| **8** | Kitchen front door | 10 | 0.225 | 0.84 | 0.06 | 0.03 |

Test species number 1, 2 and 7 showed formaldehyde emissions causing concentrations above 0.05 mg $m^{-3}$ and were followed by a full test according to EN 717-1:2004. After 28 days, the concentration of formaldehyde was measured to 0.17 mg $m^{-3}$, 0.09 mg $m^{-3}$ and 0.15 mg $m^{-3}$, respectively. These values are in good agreement with the measurements determined by the continuous method (Skalar). Test species number 1 and 7 give rise to concentrations higher than the E1 class for wood-based panels and construction products.

**TABLE 2**
TEST SPECIES, TYPE OF FURNITURE, TIME FROM TEST SPECIES ENTERING THE CHAMBER TO THE CONCENTRATION MEASURED (DAYS OF MEASUREMENT), AREA OF PRODUCT, AIR FLOW IN TEST CHAMBER AND FINAL CONCENTRATION MEASURED IN THE TEST CHAMBER. THE VALUES ARE GIVEN FOR THE THREE CHAMBER SIZES: 1 $M^3$, 15 $M^3$ AND 24 $M^3$.

| Number ID | Type of furniture | Days of measurement | Area, product $m^2$ | Air flow $l\ s^{-1}$ | Final concentration mg $m^{-3}$ |
|---|---|---|---|---|---|
| | | **1 $m^3$ chamber** | | | |
| **9**[1] | Coffee table | 6 | 1.6 | 0.28 | < 0.01 |
| **10** | Bookcase | 6 | 1.1 | 0.31 | 0.02 |
| **11**[2] | Armchair | 7 | 1.4 | 0.28 | < 0.01 |
| | | **15 $m^3$ chamber** | | | |
| **12** | Cabinet | 5 | 5.1 | 2.3 | 0.01 |
| **13** | Armchair | 5 | 2.6 | 2.3 | 0.01 |
| **14** | Chest of drawers | 4 | 10.0 | 2.3 | 0.02 |
| **15**[2] | Armchair | 5 | 3.6 | 2.3 | < 0.01 |
| **16** | Dining table | 5 | 5.8 | 2.3 | < 0.01 |
| **17** | Bookcase | 6 | 8.5 | 2.3 | 0.02 |
| **18** | Bookcase | 7 | 10.2 | 2.3 | 0.03 |
| | | **24 $m^3$ chamber** | | | |
| **19** | Armchair | 5 | 2.9 | 3.9 | 0.01 |
| **20** | Bookcase | 6 | 10.5 | 3.9 | 0.01 |
| **21** | Cabinet | 6 | 12.7 | 3.9 | 0.02 |

[1] Legs were testes separately and showed concentration values below the detection limit. [2] No. 11 and 15 is the same chair, though no. 11 is without cushion.

## 3.2 Emission rates and standard room concentrations

The specific emission rate (SER) is calculated from the concentration in the test chamber, the air exchange rate, the volume of the chamber and the exposed surface area of the test specie according to equation 1. In Table 1 the value of the concentration [mg $m^{-3}$] in the test chamber of test species no. 1-8 corresponds to the value of specific emission rate (SER) [mg $m^{-2}$ $h^{-1}$] as the items were cut to fit a loading of 1 $m^2$ $m^{-3}$ and the air exchange rate was 1 $h^{-1}$. As seen from Table 1 test specie no. 1 and 7 exceed the value of 0.124 mg $m^{-2}$ $h^{-1}$ (comparable to the E1-class for wooden-based panels and construction products), whereas test species 1, 2, 7 and 8 exceed the specific emission rate for the regulation for wood- based panels from the Danish Ministry of Environment (1983), see also Table 5.

Table 3 show the product specific emission rate for the test species 1-8, i.e. the area specific emission rate is recalculated to cover the whole product. Further, Table 3 shows the air

concentration of formaldehyde in the DICL standard room, calculated according to equation 3, taking the area specific emission rate derived from the results from the test chamber and the volume, air exchange rate and exposed surface area in the standard room into account. The DICL standard room is defined with a volume of 30 $m^3$ and an air exchange rate of 0.5 $h^{-1}$. The exposed surface area is calculated as the surface area of the product times the number of pieces or, as relevant for the kitchen front door and bookcases, cover of wall surface. The number of pieces or the maximum wall cover area according to the DICL standard room is also listed in Table 3. Products having concentrations in the chambers below the detection level is left out (no. 3).

**TABLE 3**
CUT SAMPLES TESTED IN 0.225 $M^3$ CHAMBERS. THE AREA AND PRODUCT SPECIFIC EMISSION RATE, THE MEASURED CONCENTRATION FROM THE TEST CHAMBER CONVERTED TO THE DICL STANDARD ROOM, THE NUMBER OF PIECES OR MAXIMUM WALL COVER AREA ACCORDING TO THE STANDARD ROOM AND THE RESULTING CONCENTRATION IN THE STANDARD ROOM AND LOADED WITH THE NUMBER OF SPECIES OR WALL COVER

| Number ID | Type of furniture | Product specific emission rate mg $h^{-1}$ | Load in standard room, pieces or $m^2$ | Concentration in loaded standard room, mg $m^{-3}$ |
|---|---|---|---|---|
| 1 | Stool | 0.65 | 1 pcs | 0.01 |
| 2 | Chair | 0.23 | 6 pcs | 0.03 |
| 4 | Kitchen front door | 0.03 | 11.16 $m^2$ | 0.01 |
| 5 | Kitchen front door | 0.03 | 11.16 $m^2$ | 0.01 |
| 6 | Kitchen front door | 0.03 | 11.16 $m^2$ | 0.01 |
| 7 | Kitchen front door | 0.38 | 11.16 $m^2$ | 0.11 |
| 8 | Kitchen front door | 0.08 | 11.16 $m^2$ | 0.02 |

As seen from Table 1 the area specific emission rate of the stool (no. 1) is high, though as seen from table 3 the stool only contributes with a small amount of formaldehyde in the air of the standard room, as the room is loaded with only one piece. However, the kitchen front door (no. 7), having a high area specific emission rate (Table 1), also result in a high concentration in the standard room. This is due to the load of kitchen front doors in the standard room, which correspond to a surface area of 11.16 $m^2$ according to DICL. This product emitted formaldehyde to an extent that converted to the loaded standard room exceeds the recommended WHO value of 0.1 mg $m^{-3}$ as the highest average half hour concentration (see also Table 5).

Table 4 shows the same parameters as Table 3 together with the area specific emission rate (SER), though for the chamber size 1, 15 and 24 $m^3$. Products having concentrations in the chambers below the detection level is left out (no. 9, 11, 15 and 16).

**TABLE 4**
FURNITURE TESTED IN 1, 15 AND 24 $M^3$ CHAMBERS. THE AREA AND PRODUCT SPECIFIC EMISSION RATE, THE MEASURED CONCENTRATION FROM THE TEST CHAMBER CONVERTED TO THE DICL STANDARD ROOM, THE NUMBER OF PIECES OR MAXIMUM WALL COVER AREA ACCORDING TO THE STANDARD ROOM AS WELL AS THE RESULTING CONCENTRATION IN THE STANDARD ROOM AND LOADED WITH THE NUMBER OF SPECIES OR WALL COVER

| Number ID | Type of furniture | Area specific emission, (SER), mg $m^{-2}$ $h^{-1}$ | Product specific emission, mg $h^{-1}$ | Load in standard room, pieces or $m^2$ wall surface | Concentration in loaded standard room, mg $m^{-3}$ |
|---|---|---|---|---|---|
| **1 $m^3$ chamber** | | | | | |
| **10** | Bookcase | 0.02 | 0.07 | 6 $m^2$ (49 pcs) | 0.07 |
| **15 $m^3$ chamber** | | | | | |
| **12** | Cabinet | 0.02 | 0.25 | 4 $m^2$ (8 pcs) | 0.05 |
| **13** | Armchair | 0.03 | 0.25 | 2 pcs | 0.01 |
| **14** | Chest of drawers | 0.02 | 0.05 | 1 pcs | 0.01 |
| **17** | Bookcase | 0.02 | 0.50 | 6 $m^2$ (4 pcs) | 0.04 |
| **18** | Bookcase | 0.02 | 0.74 | 6 $m^2$ (4 pcs) | 0.06 |
| **24 $m^3$ chamber** | | | | | |
| **19** | Armchair | 0.05 | 0.42 | 2 pcs | 0.02 |
| **20** | Bookcase | 0.01 | 0.42 | 6 $m^2$ (4 pcs) | 0.04 |
| **21** | Cabinet | 0.02 | 0.85 | 4 $m^2$ (1 pcs) | 0.02 |

As seen from Table 4 only one test specie (no. 20) have an area specific emission rates below the value for the regulation for wood- based panels from the Danish Ministry of Environment (1983). Compared to an area specific emission rate corresponding to the E1-class for wood-based panels and construction products, the obtained values are low (see also Table 5).

Since bookcases can cover 6 $m^2$ of the wall surface, the air of the standard room is affected by two bookcases (no. 10 and 18), when the emission is converted to the loaded standard room. For these two bookcases the concentration in the loaded standard room are approaching the WHO guideline value of 0.1 mg $m^{-3}$ (see also Table 5). The bookcase no. 18 is common, whereas bookcase no. 10 is a small bookcase (35 cm x 35 cm) and the up scaling to 6 $m^2$ might be doubtful as a realistic scenario. Considering the burden of the standard room is calculated with an air exchange rate of 0.5 $h^{-1}$, one might be concerned that the values can be critical in residential buildings as they often have a lower air exchange rate and further, the concentration of formaldehyde is often found to have a negative relation to the air exchange rate (i.e. Langer & Bekö, 2013; Kolarik et al., 2011; Salthammer et al., 2010; Gilbert et al., 2006).

Table 5 summarizes the area specific emission rates of the different products and the comparison to the regulations and air quality guideline. The table lists the product number, the area specific emission rate and whether the area specific emission rate is fulfilling the E1 class (according to DS/EN 13986:2004 and EN 717-1:2004) as well as the regulation for wood-based panels used in products like furniture (The Danish Ministry of the Environment, 1983). The E1 class corresponds to an area specific emission rate at a maximum of 0.124 mg $m^{-2}$ $h^{-1}$, whereas the regulation from the Danish Ministry of Environment has a maximum value of 0.017 mg $m^{-2}$ $h^{-1}$. In tests where the concentration in the test chamber was below the detection limit no area specific emission value is

given. The values are also listed in Table 1 and Table 3. The concentration calculated with the maximum occurrence of the furniture in a standard room according to the DICL for Furniture (Danish Society of Indoor Climate´s Testing and Labelling Criteria, 2005a) and kitchens (Danish Society of Indoor Climate´s Testing and Labelling Criteria, 2005b) is also listed in Table 5. These values are also listed in Table 3 and 4 and are comparable to the WHO air quality guideline of 0.1 mg $m^{-3}$ (as a maximum 30-minute average value). Further it is listed which products are included in the scenarios presented in section 3.3. As seen from Table 5 scenario 1 and 3 include products, that did not fulfil the requirement of E1 class (DS/EN 13986:2004 and EN 717-1:2004), though this is not the case for scenario 2. All scenarios include a product that do not fulfil requirement of The Danish Ministry of the Environment (1983).

**TABLE 5**
THE PRODUCT NUMBER (ID), THE AREA SPECIFIC EMISSION RATE, WHETHER THE AREA SPECIFIC EMISSION RATE FULFILS THE REQUIREMENTS TO E1 CLASS (ACCORDING TO DS/EN 13986:2004 AND EN 717-1:2004) AS WELL AS THE REGULATION FOR WOOD-BASED PANELS USED IN PRODUCTS LIKE FURNITURE GIVEN BY THE DANISH MINISTRY OF THE ENVIRONMENT (1983). FURTHER, THE CONCENTRATION WITH THE MAXIMUM OCCURRENCE OF THE FURNITURE IN A STANDARD ROOM ACCORDING TO THE DICL FOR FURNITURE (DANISH SOCIETY OF INDOOR CLIMATE´S TESTING AND LABELLING CRITERIA, 2005A) AND KITCHENS (DANISH SOCIETY OF INDOOR CLIMATE´S TESTING AND LABELLING CRITERIA, 2005B) ARE LISTED TOGETHER WITH A COLUMN INDICATING WHICH PRODUCTS ARE INCLUDED IN THE SCANERIOS IN SECTION 3.3. CONCENTRATIONS BELOW THE DETECTION LIMIT IN TEST CHAMBER ARE MARKED "< LOD".

| ID | Area specific emission rate (SER) mg $m^{-2}$ $h^{-1}$ | Fulfils requirement of E1 class (DS/EN 13986:2004 and EN 717-1:2004) | Fulfils requirement of The Danish Ministry of the Environment (1983) | Concentration in loaded standard room according to DICL mg $m^{-3}$ | Included in scenario number (section 3.3) |
|---|---|---|---|---|---|
| 1 | 0.18 | No | No | 0.01 | 1 |
| 2 | 0.10 | Yes | No | 0.03 | 2,3 |
| 3 | < LOD | Yes | Yes | | - |
| 4 | 0.01 | Yes | Yes | 0.01 | - |
| 5 | 0.01 | Yes | Yes | 0.01 | - |
| 6 | 0.01 | Yes | Yes | 0.01 | - |
| 7 | 0.15 | No | No | 0.11 | 3 |
| 8 | 0.03 | Yes | No | 0.02 | - |
| 9 | < LOD | Yes | Yes | | - |
| 10 | 0.02 | Yes | No | 0.07 | - |
| 11 | < LOD | Yes | Yes | | - |

| | | | | | |
|---|---|---|---|---|---|
| **12** | 0.02 | Yes | No | 0.05 | - |
| **13** | 0.03 | Yes | No | 0.01 | 1 |
| **14** | 0.02 | Yes | No | 0.01 | 1,2 |
| **15** | < LOD | Yes | Yes | | - |
| **16** | < LOD | Yes | Yes | | 2,3 |
| **17** | 0.02 | Yes | No | 0.04 | - |
| **18** | 0.02 | Yes | No | 0.06 | 1,2 |
| **19** | 0.05 | Yes | No | 0.02 | - |
| **20** | 0.01 | Yes | Yes | 0.04 | - |
| **21** | 0.02 | Yes | No | 0.02 | - |

We were informed that several of the chosen products have a surface treatment with acid-curing lacquer (no. 3, 5, 6, 7, 8, 10, see appendix A1). Only one kitchen front door (no. 7) showed high emission rate. One could conclude that the acid-curing lacquer products not necessarily have a negative impact on the indoor air quality, though our experience with acid-curing lacquer tell us that the result also might be due to misinformation.

## 3.3 Scenarios

A set of typical furnishing scenarios corresponding to the loaded standard room (Table 3 and 4) is defined. The scenarios are defined in Table 6. For the scenarios it is assumed that the contribution from each individual piece of furniture is linearly addable. Experience has shown that this assumption might not always be correct. One can speculate whether the emission is affected by the air concentration and introduce a complexity in calculations of resulting concentration from having several sources together. Ignoring that this complexity might exist, it is seen from table 5 that all three scenarios are close to or exceeding the WHO guideline value of formaldehyde in indoor air at 0.1 mg $m^{-3}$ as a half hour mean value.

**TABLE 6**
THREE FURNISHING SCENARIOS OF THE STANDARD ROOM AND THE RESULTING CONCENTRATION OF FORMALDEHYDE IN THE AIR FROM SIMPLE ADDITION OF SOURCES.

| Scenario number | Furniture load of standard room | Include ID | Resulting concentration of formaldehyde mg $m^{-3}$ |
|---|---|---|---|
| 1 | One stool, two armchairs, one chest of drawers and bookcase (6 $m^2$ wall surface), | 1, 13, 14 & 18 | 0.10 |
| 2 | Six dining chairs,, one chest of drawers, one dining table and one bookcase (6 $m^2$ wall surface) | 2, 14, 16 & 18 | 0.11 |
| 3 | Six dining chairs, kitchen front door (11.16 $m^2$ surface) and one dining table | 2, 7 & 16 | 0.14 |

It may be seen that assuming simple addition of sources the furniture alone can cause a concentration of formaldehyde in the indoor air above the WHO guideline value.

# 4. Conclusion

Some of the tested furniture has high emission rates, though for most products the emissions were low. One of the products, a stool (also functioning as a chair without back or small table), shows a high emission rate, though it has a low occurrence in a standard room according to the Testing and Labelling Criteria for Furniture of the Danish Indoor Climate Labelling (DICL) and therefore, the impact on the indoor air is low. Another product, a kitchen front door, shows a high emission rate and due to a high occurrence, covering large surfaces, it can have a negative effect on the indoor air, exceeding the WHO guideline level of 0.1 mg $m^{-3}$ for a half hour mean value.

Two bookcases are found to have a serious impact on the formaldehyde concentration in the loaded standard room. Even though their area specific emission rates are moderate, their large surface areas result in emissions that have a significant impact on concentration in the standard room.

The selected typical furnishing scenarios may result in concentrations close to or above 0.1 mg $m^{-3}$, documenting that furniture on the Danish marked may cause formaldehyde concentrations in indoor air that exceed the value recommended by WHO as the highest average half hour concentration that will not cause sensory irritation or increased risk of diseases.

Formaldehyde has other sources than furniture. The concentration in indoor air that may be reached as the more realistic combined result of emissions from furniture, other consumer products, construction products and human activities may be much higher that recommended by WHO.

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## Appendix 1: Product information

The products are divided in six groups: kitchen front doors, bookcases, chairs, cabinets, chest of drawer and tables. The products are named by a number. Table A1.1-A1.6 cover the six groups and the different types of products are listed with a number of the product together with information about material, surface treatment and information of relevance for formaldehyde found on the home page of the provider. Informations related to formaldehyde found on the homepage of the store as well as how the products are obtained are also listed in the Table. Further, it is listed how the product is obtained.

**TABLE 7**
PRODUCT INFORMATION, KITCHEN FRONT DOORS

| Number ID | Material | Information about surface treatment obtained from the store | Info on homepage | Obtained by: |
|---|---|---|---|---|
| **3** | 19 mm MDF | Acid-curing lacquer | Certified "Dansk Indeklima Mærkning" | Purchased from stock, wrapped in plastic. Cut up and edge sealed |
| **4** | 16 mm MDF | Water based UV-lacquer | Certified "Dansk Indeklima Mærkning" | Purchased from stock, wrapped in plastic. Cut up and edge sealed |
| **5** | 16 mm MDF | Acid-curing lacquer | Certified "Dansk Indeklima Mærkning" | Purchased from stock, wrapped in plastic. Cut up and edge sealed |
| **6** | 19 mm MDF | High gloss acid-curing lacquer | Polyurethane lacquer Certified "Dansk Indeklima Mærkning" | Purchased from stock, wrapped in plastic. Cut up and edge sealed |
| **7** | 19 mm MDF | Acid-curing lacquer | Clipboard E1 approved | Ordered from the factory. Received by carrier. Cut up and edge sealed |
| **8** | 18 mm clipboard with walnut veneer | Tinted acid-curing lacquer | Clipboard E1 approved | Ordered from the factory. Received by carrier. Cut up and edge sealed |

**TABLE 8**
PRODUCT INFORMATION, BOOKCASES

| Number ID | Material | Surface/treatment | Obtained by: |
|---|---|---|---|
| **10** | 12 mm MDF (35x35x35 cm) | Two-component acid-curing lacquer | Purchased from shop packed in cardboard box |
| **17** | MDF. 10 shelves (71x201x32 cm) | Lacquer (info from brochure handed out in store) | Ordered from Webshop. Received by carrier |
| **18** | Main parts: Particleboard, fibreboard, recycled paper filling Back: Fibreboard 6 shelves (120x40x128 cm) | Foil | Ordered on basis of web information. Received by carrier. |
| **20** | Main parts: Particleboard. Birch veneer Back panel: Fibre board 5 shelves (80x39x202 cm) | Main parts: Clear acrylic lacquer Back panel: Foil | Ordered on basis of web information. Received by carrier. |

**TABLE 9**
PRODUCT INFORMATION, CHAIRS.

| Number ID | Type/material | Surface/treatment | Obtained by: |
|---|---|---|---|
| **1** | Stool (or chair without back or small table) molded birch (52x46x42 cm) | matte lacquered | Purchased in store, wrapped loosely in plastic |
| **2** | Dining chair. Plywood (43x89x46 cm) | Lacquer | Purchased in store, loosely wrapped in plastic. On stock in cardboard with 4 chairs |
| **13** | Armchair Frame: Particleboard, solid wood, fiberboard, plywood. Fill: Polyester, polyurethane | Fabric | Ordered on basis of web information. Received by carrier |
| **15** | Armchair. Glued frame. Rail: birch veneer. Fill: Polyester (in tables no. 11 is the wooden part alone of no. 15) | Clear acrylic lacquer. Fabric | Ordered on basis of web information. Received by carrier. |

| | | | |
|---|---|---|---|
| **19** | Armchair. Containing: Particleboard, plywood, cardboard, solid beech, fibreboard. Fill: Polyester, polyurethane | Fabric | Ordered on basis of web information. Received by carrier. |

**TABLE 10**
PRODUCT INFORMATION, CABINETS

| Number ID | Type/material | Surface/treatment | Obtained by: |
|---|---|---|---|
| **12** | Box with 1 door and 1 drawer<br>MDF, Masonite<br>(106x36x46 cm) | Lacquer, white gloss | Ordered from Webshop. Received by carrier |
| **21** | Ward robe<br>MDF<br>5 shelves, 3 drawers, 3 doors<br>(160x200x60 cm) | Lacquer | Ordered from Webshop. Received by carrier |

**TABLE 11**
PRODUCT INFORMATION, CHEST OF DRAWERS.

| Number ID | Type/material | Surface/treatment | Obtained by: |
|---|---|---|---|
| **14** | Wood black ash.<br>2 low and 3 high drawers<br>(74x87x49 cm) | Lacquer | Ordered from Webshop. Received by carrier |

**TABLE 12**
PRODUCT INFORMATION, TABLES

| Number ID | Type/material | Surface/treatment | Obtained by: |
|---|---|---|---|
| **9** | Coffee table:<br>black ash veneer<br>(120x41x60 cm)<br>Two legs, of full width of the table, also black ash veneer | Lacquered | Ordered from Webshop. Received by carrier |
| **16** | Dining table:<br>Table top MDF<br>(200x75x100 cm) | White gloss lacquer | Ordered from Webshop. Received by carrier |

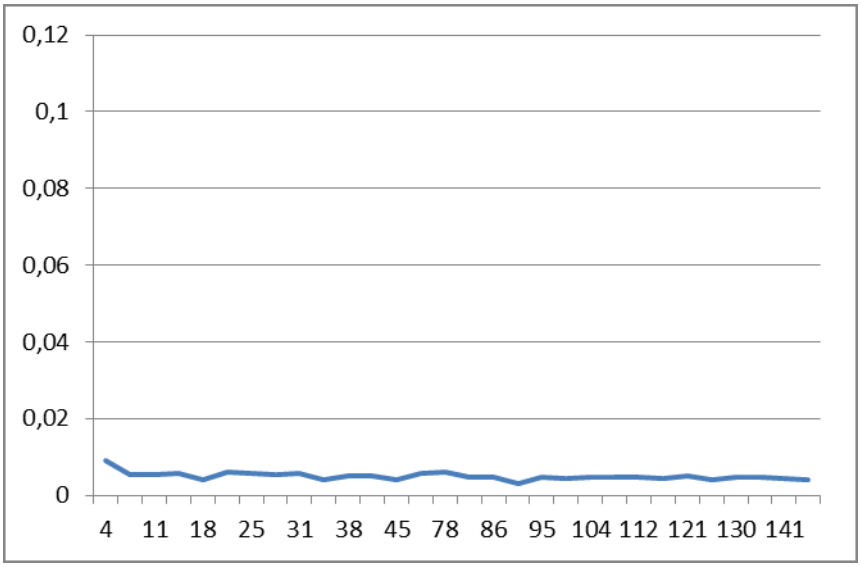
## Appendix 2: Climate chamber results

Below is presented the concentration of formaldehyde in the test chambers for the different products. The products are divided in six groups: kitchen front doors, bookcases, chairs, cabinets, chest of drawer and tables. Table A2.1-A2.6 cover the six groups and the different types of products are listed with date of test start and test finish, the order number, the number of the product according to appendix 1 as well as a figure showing the concentration over time in the test chamber.

All figures have hour from the start of the test as the unit of the x-axis and concentration of formaldehyde (mg $m^{-3}$) as the unit of the y-axis.

TABLE A2.1 KITCHEN FRONT DOORS

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 08-10-2013
Date of test finish: 14-10-2013
Order no.: 574052-4
[Kitchen front door, no. 3]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 10-10-2013
Date of test finish: 16-10-2013
Order no.: 574052-5
[Kitchen front door, no. 4]

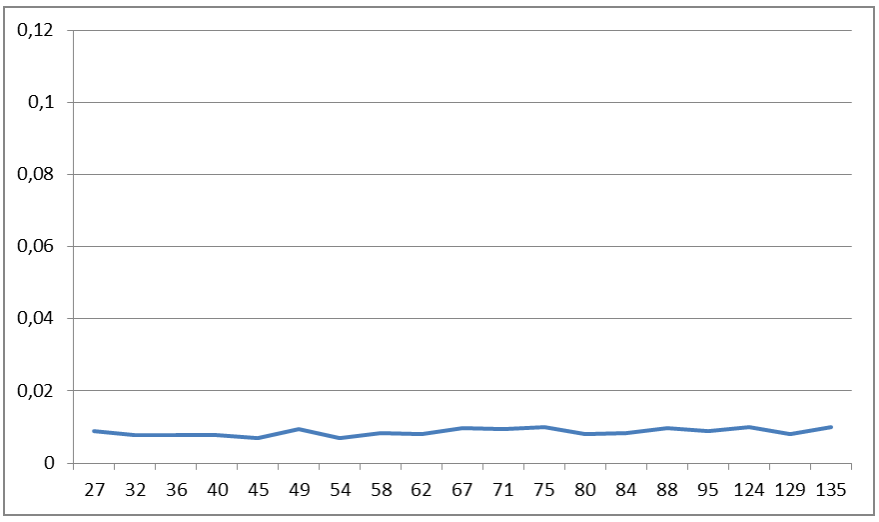
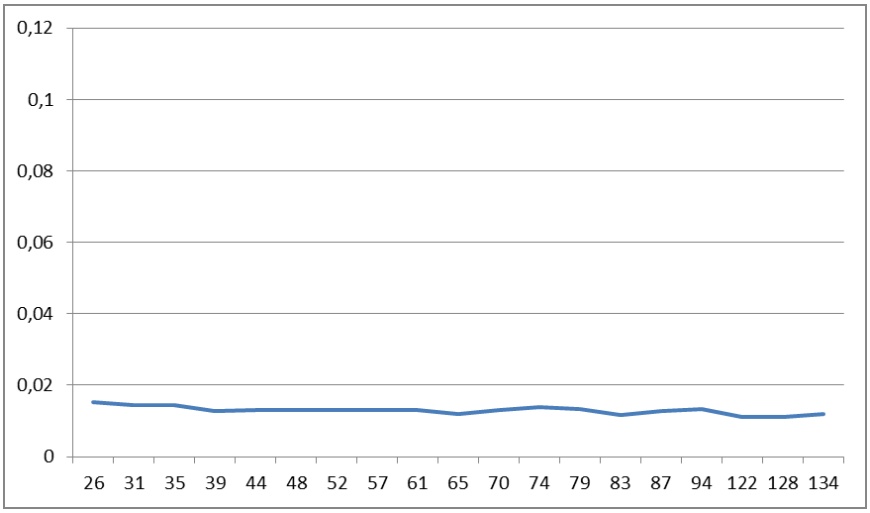


TABLE A2.1 CONTINUED

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 10-10-2013
Date of test finish: 16-10-2013
Order no.: 574052-6
[Kitchen front door, no.5]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 11-10-2013
Date of test finish: 30-10-2013
Order no.: 574052-7
[Kitchen front door, no. 6]

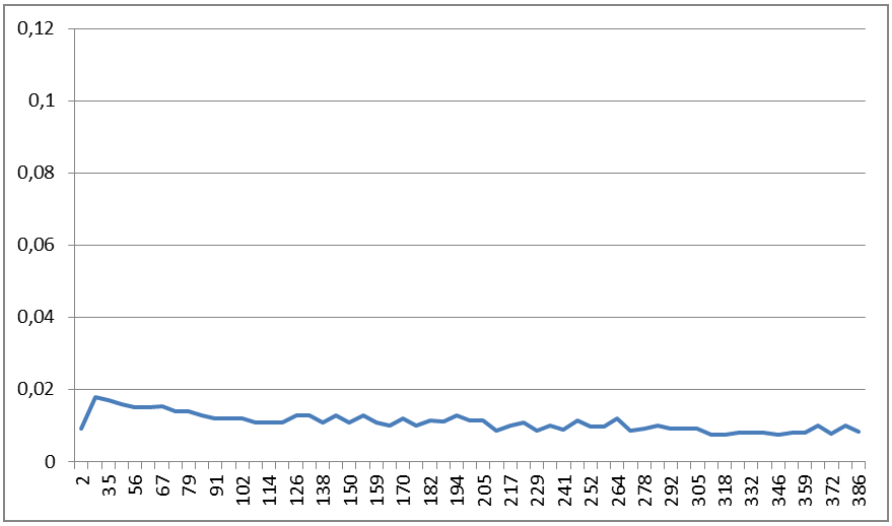
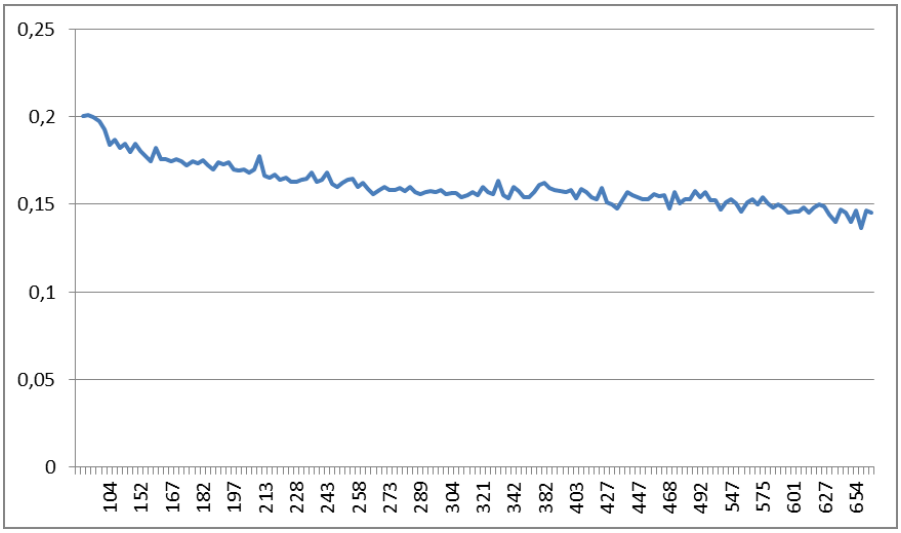
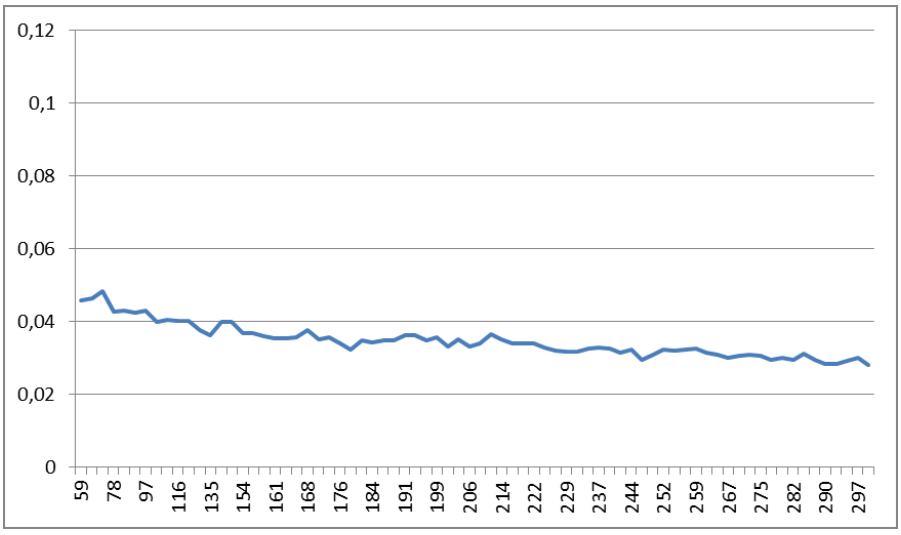


TABLE A2.1 CONTINUED

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 05-11-2013
Date of test finish: 03-12-2013
Order no.: 574052-17
[Kitchen front door, no.7]

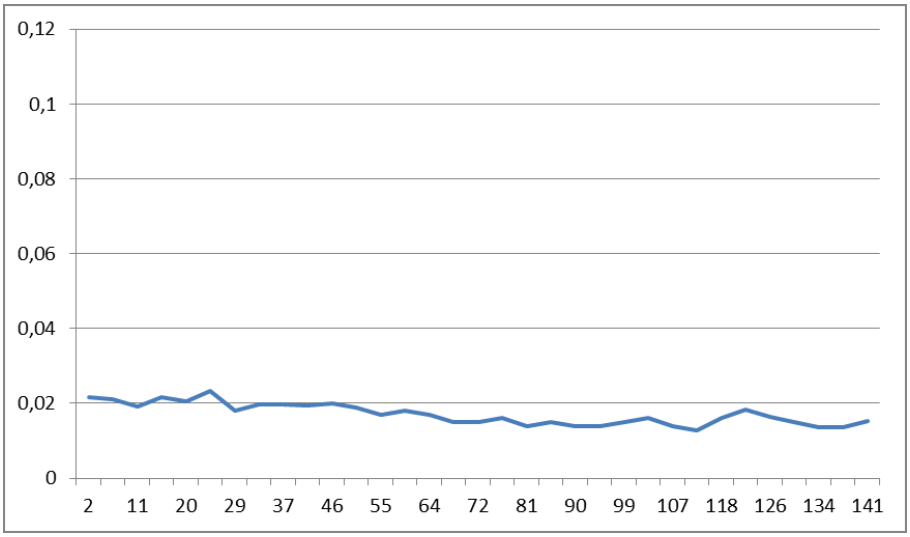



Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 05-11-2013
Date of test finish: 15-11-2013
Order no.: 574052-18
[Kitchen front door, no. 8]



### TABLE A2.2 BOOKCASES

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 27-11-2013
Date of test finish: 03-12-2013
Order no.: 574052-22
[Bookcase, no.10]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 27-11-2013
Date of test finish: 03-12-2013
Order no.: 574052-23
[Bookcase, no. 17]

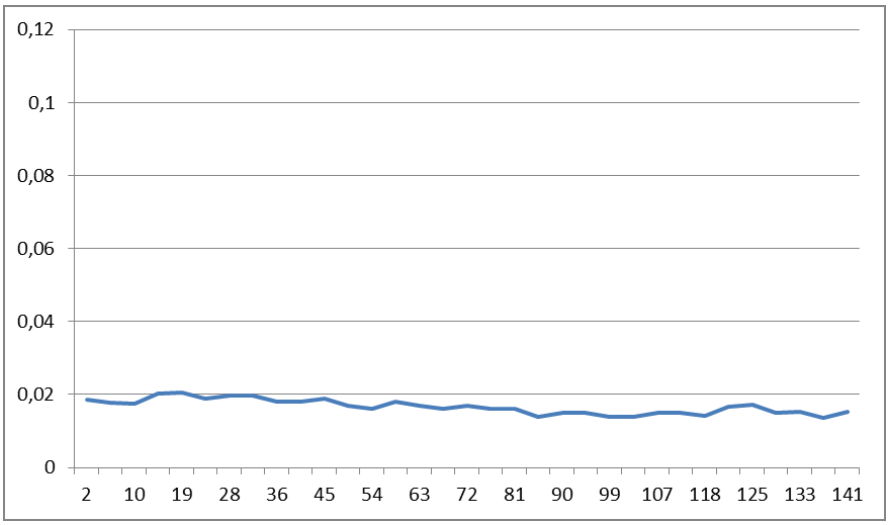
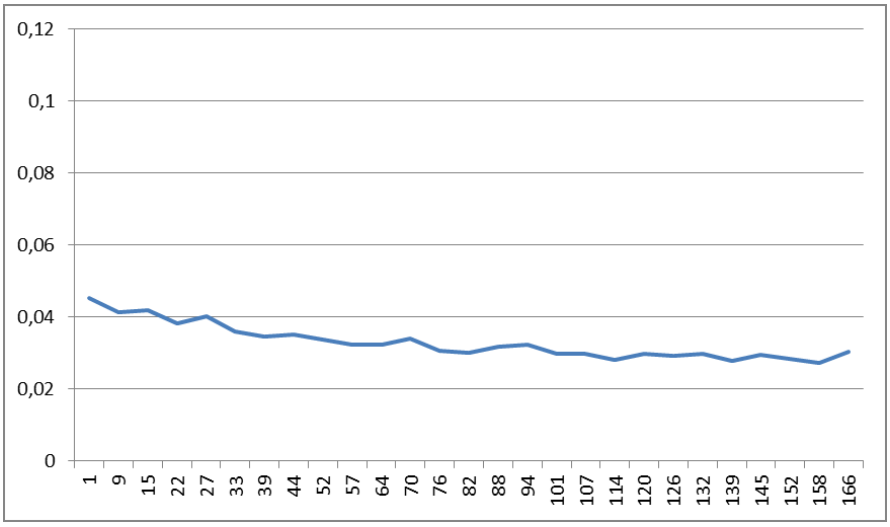


TABLE A2.2 BOOKCASES, CONTINUED

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 04-11-2013
Date of test finish: 11-11-2013
Order no.: 574052-22
[Bookcase, no.18]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 30-10-2013
Date of test finish: 05-11-2013
Order no.: 574052-23
[Bookcase, no. 20]

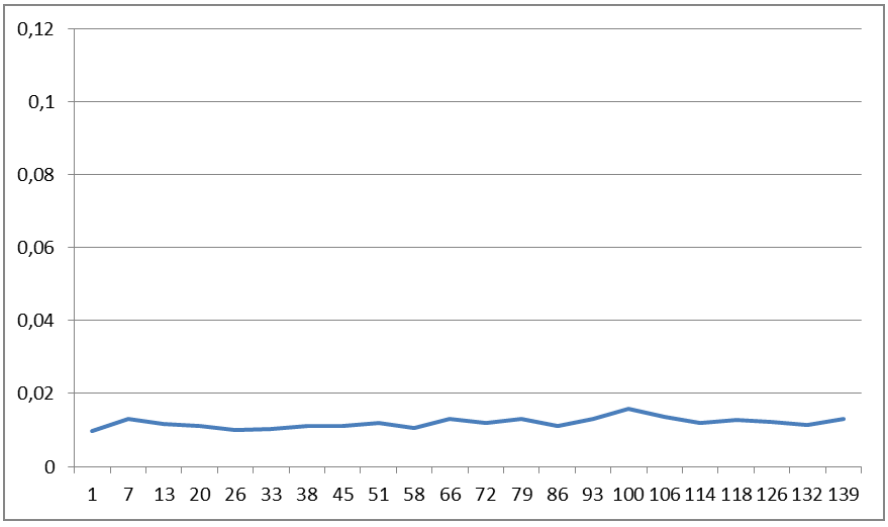
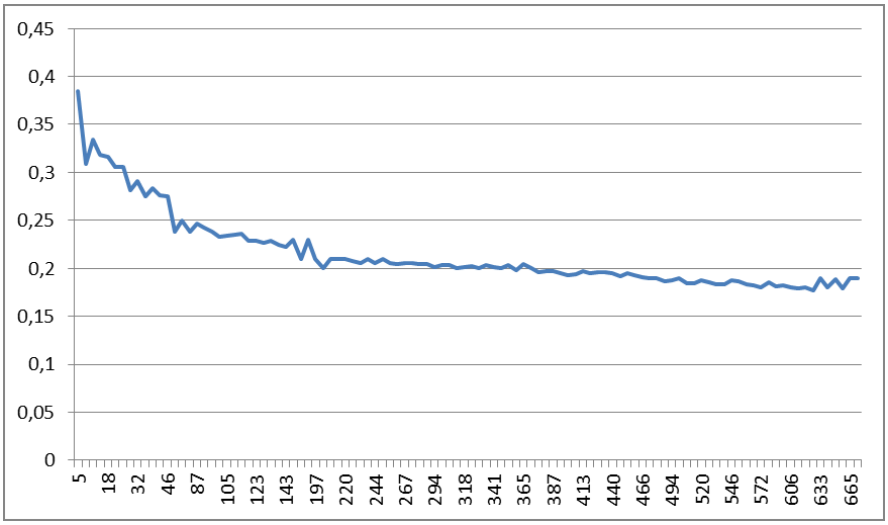


TABLE A2.3 CHAIRS TABLE A2.1 CONTINUED

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 08-10-2013
Date of test finish: 05-11-2013
Order no.: 574052-2
[Stool (chair without back, small table), no. 1]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 08-10-2013
Date of test finish: 05-11-2013
Order no.: 574052-3
[Dining chair, no. 2]

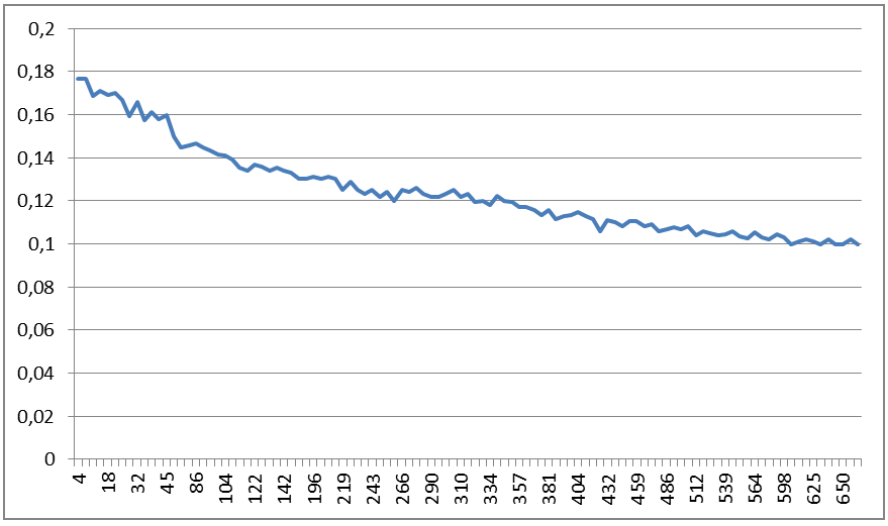
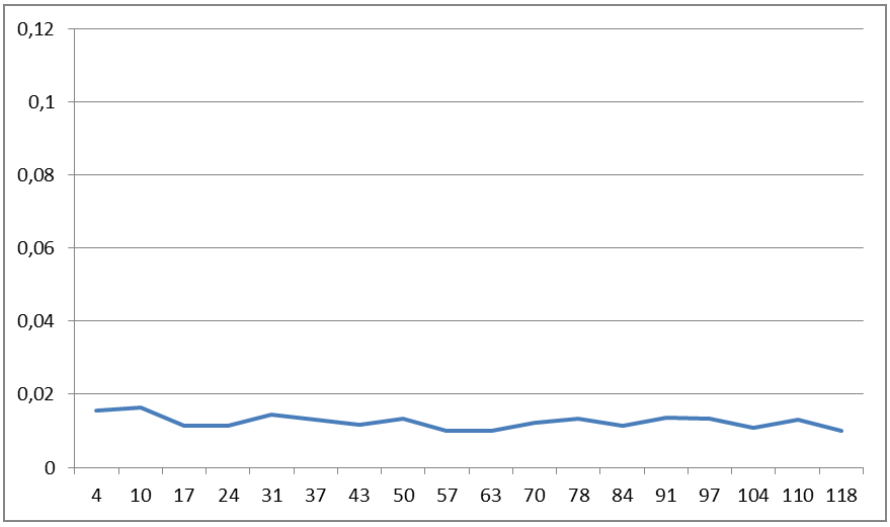


TABLE A2.3 CHAIRS, CONTINUED

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 25-10-2013
Date of test finish: 30-10-2013
Order no.: 574052-10
[Armchair, no.13]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 04-11-2013
Date of test finish: 11-11-2013
Order no.: 574052-15
[Armchair, only frame, no 11 – part of no. 15]

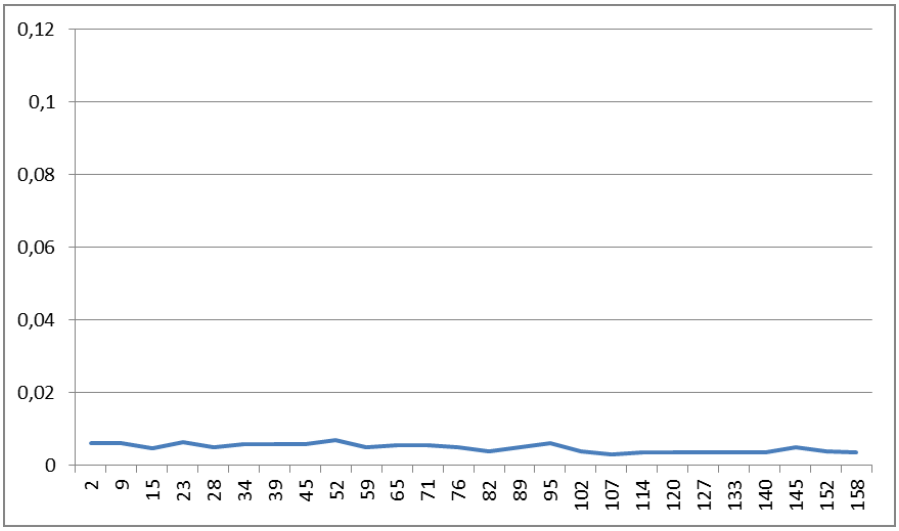
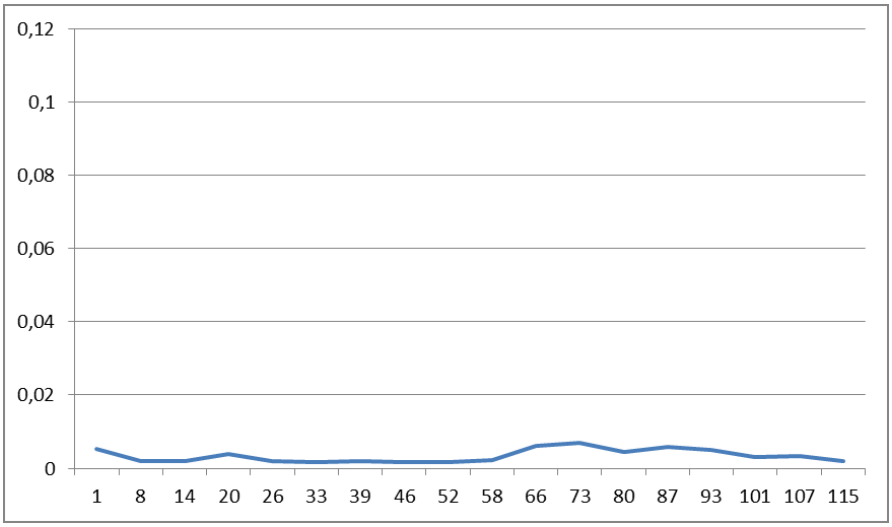


TABLE A2.4 CHAIRS CONTINUED

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 30-10-2013
Date of test finish: 04-11-2013
Order no.: 574052-12
[Armchair, no.15]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 25-10-2013
Date of test finish: 30-10-2013
Order no.: 574052-11
[Armchair, no. 19]

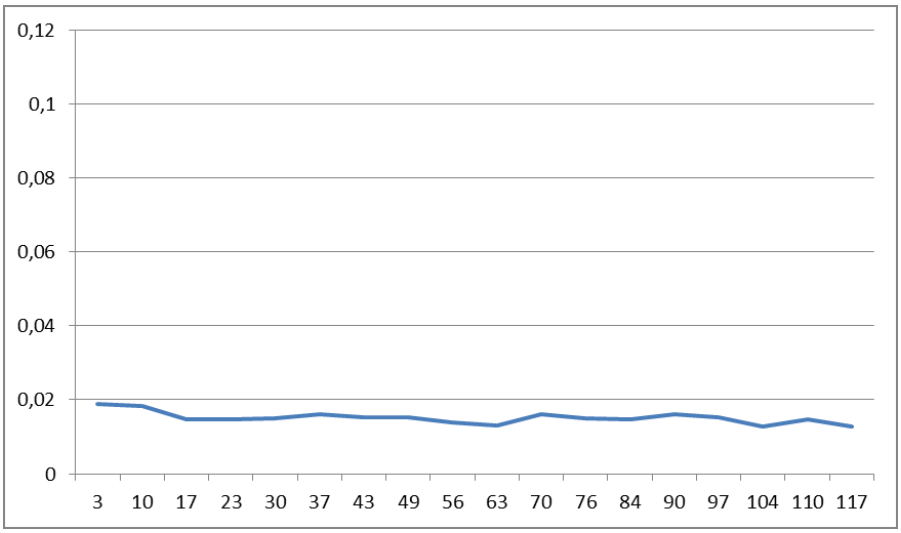
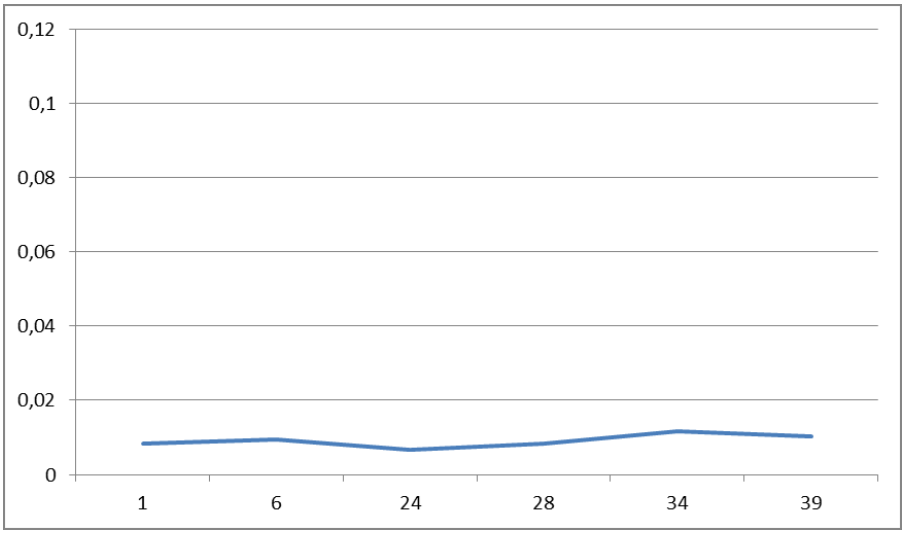


TABLE A2.5 CABINETS

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 11-10-2013
Date of test finish: 16-10-2013
Order no.: 574052-8
[Cabinet, no.12]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³
Date of test start: 08-10-2013
Date of test finish: 15-10-2013
Order no.: 574052-1
[Wardrobe, no. 21]

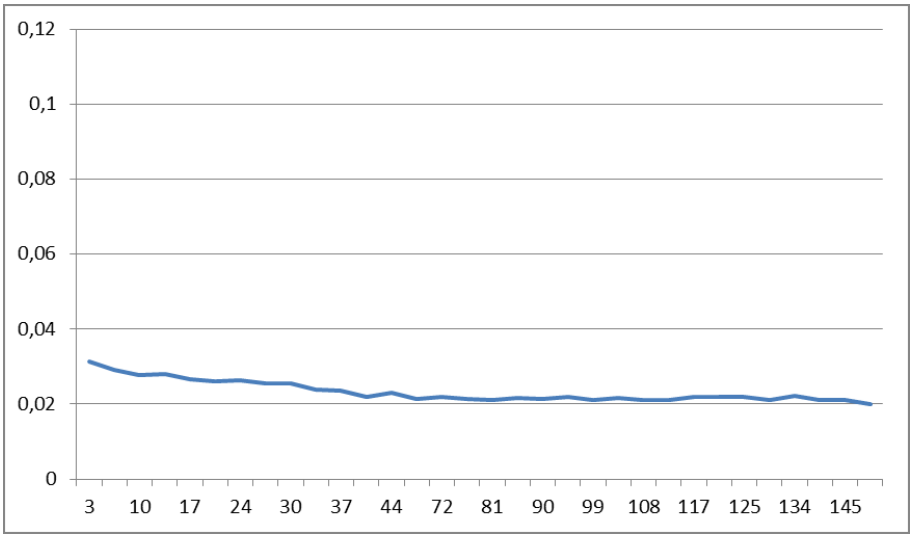


**TABLE A2.5 CHEST OF DRAWERS.**

Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 18-11-2013
Date of test finish: 22-11-2013
Order no.: 574052-19
[Chest of drawers, no.14]

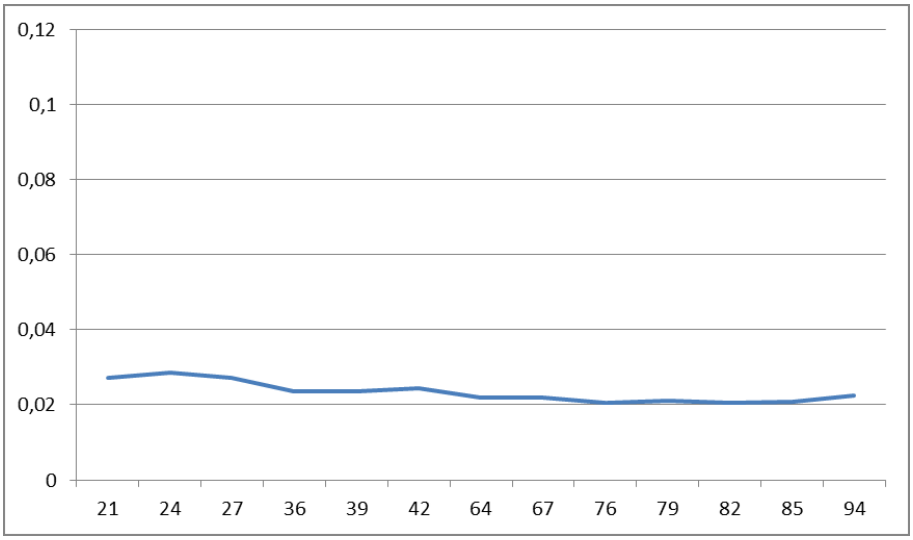
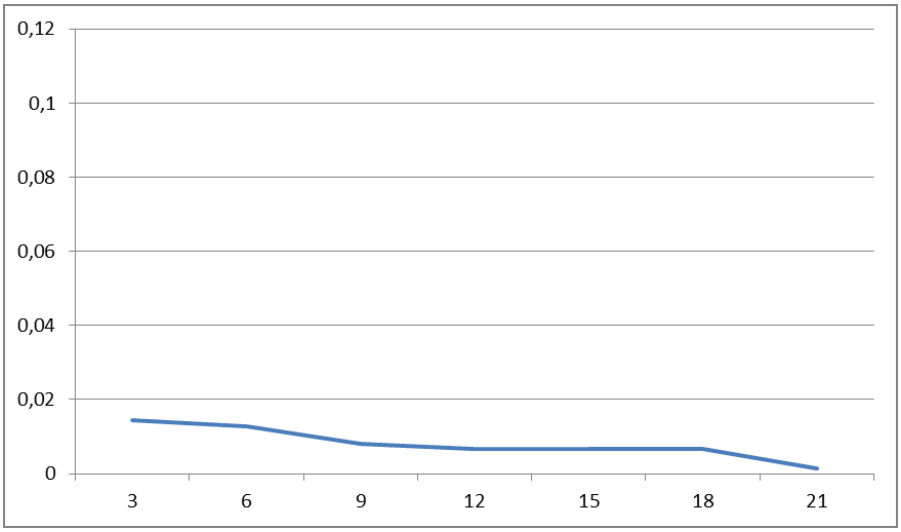
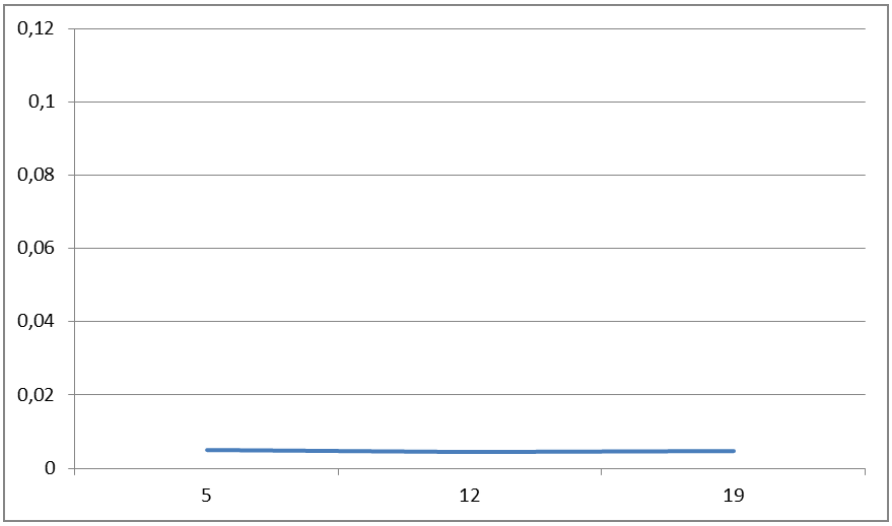


**TABLE A2.6 TABLES**

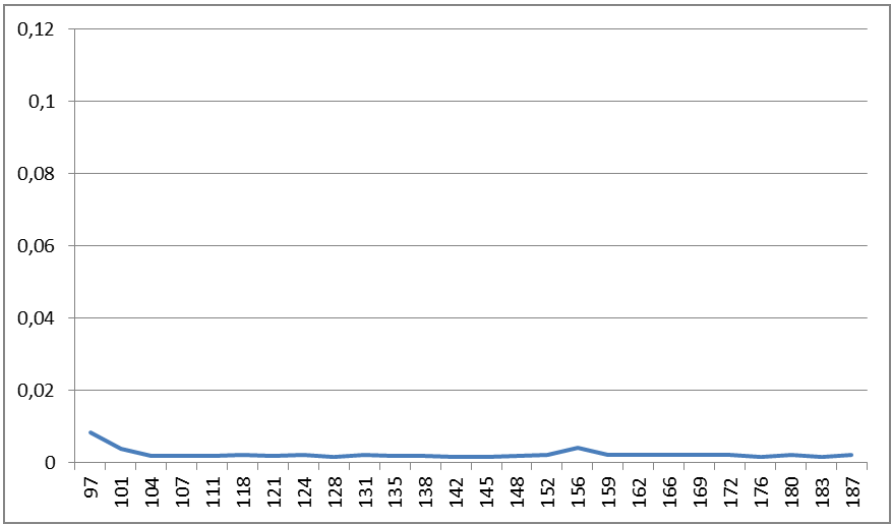
Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 05-12-2013
Date of test finish: 06-12-2013
Order no.: 574052-24
[Coffee table (without legs), no.9]




Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³ (all measurements below LOD)
Date of test start: 04-11-2013
Date of test finish: 05-11-2013
Order no.: 574052-16
[Coffee table, leg – no. 9a]



Formaldehyde concentration in mg/m³ as function of time (hours)
Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis. Limit of detection (LOD): 0.01 mg/m³
Date of test start: 22-11-2013
Date of test finish: 27-11-2013
Order no.: 574052-20
[Dining table, no.16]



## Appendix 3: Analysis reports according to DANAK accreditation

Three products showed formaldehyde emission at a high level. After achievement of the steady-state, i.e. in this case after 28 days, the concentration of formaldehyde in the air of the chamber was determined according to the standard EN 717-1:2004. This procedure is done according to DANAK accreditation and the three reports are presented here. It is the products named no. 2 (stool), 3 (dining chair) and 16 (kitchen front door).

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2450 København SV

Order no. 574052-2
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Initials hbk/jbh/ac

# Test Report

Material: Stool

Sampling: The test material was sampled by the assignor and received at the Danish Technological Institute 08-10-2013.

Method: EN 717-1 2004. "Wood-Based Panels – Determination of Formaldehyde Release – Part 1: Formaldehyde Emission by the Chamber Method. Annex A3". The test material was exposed vertical/on the bottom with sealed edges in the climate chamber.

**Climate Chamber Conditions**

| | |
|---|---|
| Climate chamber | 225 L Polished stainless steel |
| Temperature | 23ºC ± 0.5ºC |
| Relative humidity | 45% ± 3% RH |
| Air change | 1 $h^{-1}$ ± 0.05 $h^{-1}$ |
| Air velocity at the surface of the specimen | 0.1 – 0.3 m/s |
| Material load | 1 $m^2/m^3$ |

Period: The testing was carried out between 08-10-2013 and 05-11-2013.

Result: The emission of formaldehyde for the tested sample after 28 days in the chamber is:

0.17 mg/m³ (average of final measurements 05-11-2013)

The result fulfils the E1 requirement regarding the emission of formaldehyde (0.124 mg/m³).

Results in detail are given in the appendices:
Appendix 1: Determination of formaldehyde emission
Appendix 2: Formaldehyde concentration in $mg/m^3$ as function of time (hours) (not part of accreditation)

Storage: The test material will be destroyed after 1 month, unless otherwise agreed.

Terms: The test has been performed according to the attached conditions, which are according to the guidelines laid down by DANAK (The Danish Accreditation). The testing is only valid for the tested specimen. The test report may only be extracted, if the laboratory has approved the extract.

27-01-2014, Danish Technological Institute, Indoor Environment, Taastrup

Test responsible

Co-reader

DANISH TECHNOLOGICAL INSTITUTE

Order no. 574052-2
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Initials hbk/jbh

# Determination of formaldehyde emission

Chamber method EN 717-1

| | |
|---|---|
| Client | SBI |
| Person in charge | Helene B. Klinke |
| Material | Stool |
| Date of receipt | 08-10-2013 |
| Date of test start | 08-10-2013 |
| Date of test end | 05-11-2013 |

Test conditions

| | |
|---|---|
| Chamber volume | 225 L |
| Temperature | 23°C ± 0.5°C |
| Relative humidity | 45% RH ± 3% RH |
| Air change | 1 $h^{-1}$ ± 0.05 $h^{-1}$ |

Results

Method of analysis: Acetylacetone (Hantzsch-reaction) flourometric analysis.

Final measurements

| Date | Std. curve no. | Absorption wash bottle A | Absorption wash bottle B | Air Volume L | Concentration C[A] µg/mL | Concentration C[B] µg/mL | Concentration C mg/m$^3$ |
|---|---|---|---|---|---|---|---|
| 05-11-2013 | 35 | 0.456 | 0.137 | 11.0 | 0.098 | -0.006 | 0.174 |
| 05-11-2013 | 35 | 0.350 | 0.137 | 7.0 | 0.063 | -0.006 | 0.170 |

Report generated by chamber method software version 2.20 of 16-01-2014.

Helene B. Klinke

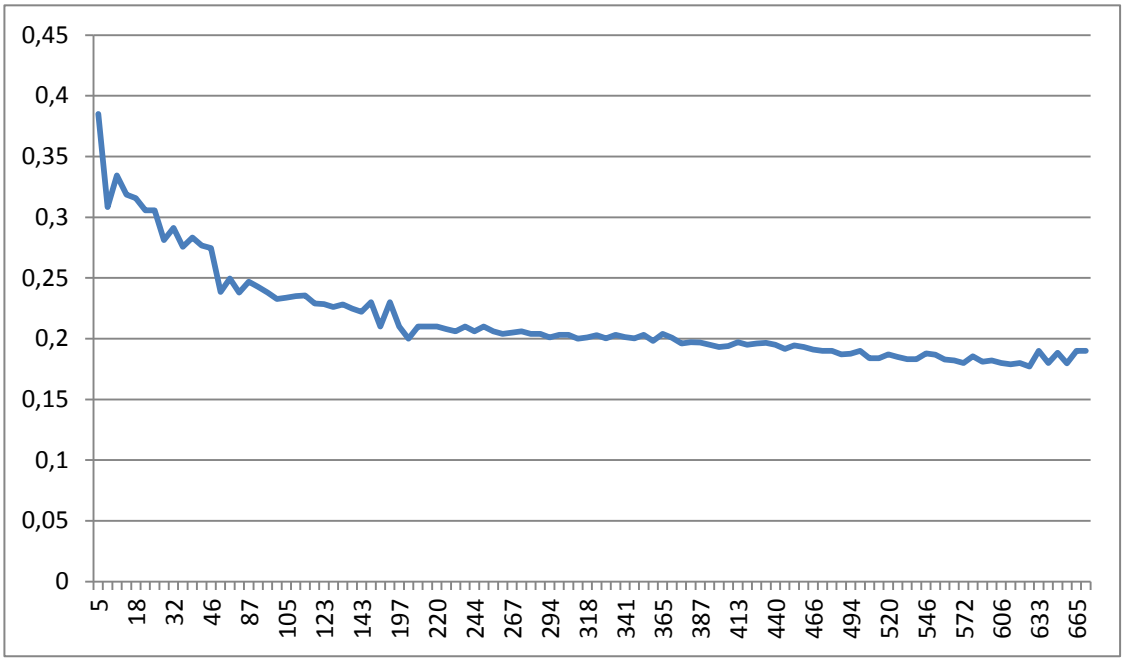
DANISH TECHNOLOGICAL INSTITUTE

| | |
|---|---|
| Order no. | 574052-2 |
| Appendix no. | 2 |
| Page | 1 of 1 |
| Initials | hbk/jbh |

## Formaldehyde concentration (mg/m$^3$) as function of time (h)

*Not part of accreditation.*

Material: Stool




Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m³

Date of test start: 08-10-2013
Date of test finish: 05-11-2013

The general conditions pertaining to assignments accepted by Danish Technological Institute shall apply in full to the technical testing and calibration at Danish Technological Institute and to the completion of test reports and calibration certificates within the relevant field.

**Danish Accreditation (DANAK)**

DANAK was established in 1991 in pursuance of the Danish Act No. 394 of 13 June 1990 on the promotion of Trade and Industry.

The requirements to be met by accredited laboratories are laid down in the "Danish Agency for Trade and Industry's ("Erhvervsfremme Styrelsens") Statutory Order on accreditation of laboratories to perform testing etc. and GLP inspection. The statutory order refers to other documents. where the criteria for accreditation are specified further.

The standards DS/EN ISO/IEC 17025 "General requirements for the competence of testing and calibration laboratories" and DS/EN 45002 "General criteria for the assessment of testing laboratories" describe fundamental criteria for accreditation. DANAK uses guidance documents to clarify the requirements in the standards. where this is considered to be necessary. These will mainly be drawn up by the "European co-operation of Accreditation (EA)" or the "International Laboratory Accreditation Co-operation (ILAC)" with the purpose of obtaining uniform criteria for accreditation. In addition. DANAK draws up Technical Regulations with specific requirements for accreditation that are not contained in the standards.

In order for a laboratory to be accredited it is. among other things. required:

- that the laboratory and its personnel are not subject to any commercial. financial or other pressures. which might influence their technical judgement
- that the laboratory operates a documented quality system
- that the laboratory has at its disposal all items of equipment. facilities and premises required for correct performance of the service that it is accredited to perform
- that the laboratory management and personnel have technical competence and practical experience in performing the service that they are accredited to perform
- that the laboratory has procedures for traceability and uncertainty calculations
- that accredited testing or calibration is performed in accordance with fully validated and documented methods
- that the laboratory keeps records. which contain sufficient information to permit repetition of the accredited test or calibration
- that the laboratory is subject to surveillance by DANAK on a regular basis
- that the laboratory shall take out an insurance. which covers liability in connection with the performance of accredited services

Reports carrying DANAK's logo are used when reporting accredited services and show that these have been performed in accordance with the rules for accreditation.

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2450 København SV

Order no. 574052-3
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# Test Report

Material: Chair

Sampling: The test material was sampled by the assignor and received at the Danish Technological Institute 08-10-2013.

Method: EN 717-1 2004. "Wood-Based Panels – Determination of Formaldehyde Release – Part 1: Formaldehyde Emission by the Chamber Method. Annex A3". The test material was exposed vertical/on the bottom with sealed edges in the climate chamber.

**Climate Chamber Conditions**

| | |
|---|---|
| Climate chamber | 225 L Polished stainless steel |
| Temperature | 23ºC ± 0.5ºC |
| Relative humidity | 45% ± 3% RH |
| Air change | 1 $h^{-1}$ ± 0.05 $h^{-1}$ |
| Air velocity at the surface of the specimen | 0.1 – 0.3 m/s |
| Material load | 1 $m^2/m^3$ |

Period: The testing was carried out between 08-10-2013 and 05-11-2013.

Result: The emission of formaldehyde for the tested sample after 28 days in the chamber is:

0.09 mg/m³ (average of final measurements 05-11-2013)

The result fulfils the E1 requirement regarding the emission of formaldehyde (0.124 mg/m³).

Results in detail are given in the appendices:
Appendix 1: Determination of formaldehyde emission
Appendix 2: Formaldehyde concentration in $mg/m^3$ as function of time (hours) (not part of accreditation)

Storage: The test material will be destroyed after 1 month, unless otherwise agreed.

Terms: The test has been performed according to the attached conditions, which are according to the guidelines laid down by DANAK (The Danish Accreditation). The testing is only valid for the tested specimen. The test report may only be extracted, if the laboratory has approved the extract.

24-01-2014, Danish Technological Institute, Indoor Environment, Taastrup

Test responsible

Co-reader

DANISH TECHNOLOGICAL INSTITUTE

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Initials hbk/jbh/ac

# Determination of formaldehyde emission

Chamber method EN 717-1

| | |
|---|---|
| Client | SBI |
| Person in charge | Helene B. Klinke |
| Material | Chair |
| Date of receipt | 08-10-2013 |
| Date of test start | 08-10-2013 |
| Date of test end | 05-11-2013 |

Test conditions

| | |
|---|---|
| Chamber volume | 225 L |
| Temperature | 23°C ± 0.5°C |
| Relative humidity | 45% RH ± 3% RH |
| Air change | 1 $h^{-1}$ ± 0.05 $h^{-1}$ |

Results

Method of analysis: Acetylacetone (Hantzsch-reaction) flourometric analysis.

Final measurements

| Date | Std. curve no. | Absorption wash bottle A | B | Air Volume L | Concentration C[A] µg/mL | C[B] µg/mL | C mg/m$^3$ |
|---|---|---|---|---|---|---|---|
| 05-11-2013 | 35 | 0.295 | 0.138 | 10.0 | 0.045 | -0.006 | 0.083 |
| 05-11-2013 | 35 | 0.340 | 0.138 | 12.0 | 0.060 | -0.006 | 0.094 |

Report generated by chamber method software version 2.20 of 16-01-2014.

Helene B. Klinke

DANISH TECHNOLOGICAL INSTITUTE

| | |
|---|---|
| Order no. | 574052-3 |
| Appendix no. | 2 |
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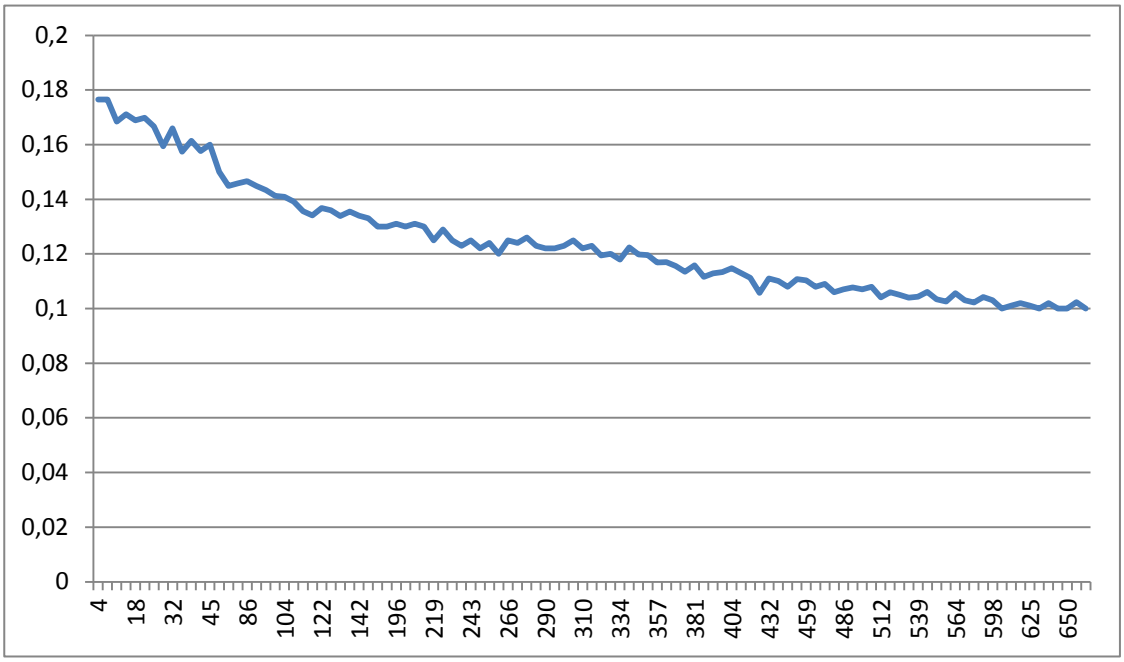
## Formaldehyde concentration (mg/m$^3$) as function of time (h)

*Not part of accreditation.*

Material: Chair




Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m$^3$

Date of test start: 08-10-2013
Date of test finish: 05-11-2013

The general conditions pertaining to assignments accepted by Danish Technological Institute shall apply in full to the technical testing and calibration at Danish Technological Institute and to the completion of test reports and calibration certificates within the relevant field.

**Danish Accreditation (DANAK)**

DANAK was established in 1991 in pursuance of the Danish Act No. 394 of 13 June 1990 on the promotion of Trade and Industry.

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In order for a laboratory to be accredited it is. among other things. required:

- that the laboratory and its personnel are not subject to any commercial. financial or other pressures. which might influence their technical judgement
- that the laboratory operates a documented quality system
- that the laboratory has at its disposal all items of equipment. facilities and premises required for correct performance of the service that it is accredited to perform
- that the laboratory management and personnel have technical competence and practical experience in performing the service that they are accredited to perform
- that the laboratory has procedures for traceability and uncertainty calculations
- that accredited testing or calibration is performed in accordance with fully validated and documented methods
- that the laboratory keeps records. which contain sufficient information to permit repetition of the accredited test or calibration
- that the laboratory is subject to surveillance by DANAK on a regular basis
- that the laboratory shall take out an insurance. which covers liability in connection with the performance of accredited services

Reports carrying DANAK's logo are used when reporting accredited services and show that these have been performed in accordance with the rules for accreditation.

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2450 København SV

Order no. 574052-17
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# Test Report

Material: Kitchen front door

Sampling: The test material was sampled by the assignor and received at the Danish Technological Institute 04-11-2013.

Method: EN 717-1 2004. "Wood-Based Panels – Determination of Formaldehyde Release – Part 1: Formaldehyde Emission by the Chamber Method. Annex A3". The test material was exposed vertical/on the bottom with sealed edges in the climate chamber.

**Climate Chamber Conditions**

| | |
|---|---|
| Climate chamber | 225 L Polished stainless steel |
| Temperature | 23ºC ± 0.5ºC |
| Relative humidity | 45% ± 3% RH |
| Air change | 1 $h^{-1}$ ± 0.05 $h^{-1}$ |
| Air velocity at the surface of the specimen | 0.1 – 0.3 m/s |
| Material load | 1 $m^2/m^3$ |

Period: The testing was carried out between 05-11-2013 and 03-12-2013.

Result: The emission of formaldehyde for the tested sample after 28 days in the chamber is:

0.15 mg/m³ (average of final measurements 03-12-2013)

The result does not fulfil the E1 requirement regarding the emission of formaldehyde (0.124 mg/m³).

Results in detail are given in the appendices:
Appendix 1: Determination of formaldehyde emission
Appendix 2: Formaldehyde concentration in $mg/m^3$ as function of time (hours) (not part of accreditation)

Storage: The test material will be destroyed after 1 month, unless otherwise agreed.

Terms: The test has been performed according to the attached conditions, which are according to the guidelines laid down by DANAK (The Danish Accreditation). The testing is only valid for the tested specimen. The test report may only be extracted, if the laboratory has approved the extract.

27-01-2014, Danish Technological Institute, Indoor Environment, Taastrup

Test responsible

Co-reader

DANISH TECHNOLOGICAL INSTITUTE

Order no. 574052-17
Appendix no. 1

Initials hbk/jbh

# Determination of formaldehyde emission

Chamber method EN 717-1

---

| | |
|---|---|
| Client | SBI |
| Person in charge | Helene B. Klinke |
| Material | Kitchen front door |
| Date of receipt | 04-11-2013 |
| Date of test start | 05-11-2013 |
| Date of test end | 03-12-2013 |

Test conditions

| | |
|---|---|
| Chamber volume | 225 L |
| Temperature | 23°C ± 0.5°C |
| Relative humidity | 45% RH ± 3% RH |
| Air change | 1 $h^{-1}$ ± 0.05 $h^{-1}$ |

Results

Method of analysis: Acetylacetone (Hantzsch-reaction) flourometric analysis.

Final measurements

| Date | Std. curve no. | Absorption wash bottle A | Absorption wash bottle B | Air Volume L | Concentration C[A] µg/mL | Concentration C[B] µg/mL | Concentration C mg/m$^3$ |
|---|---|---|---|---|---|---|---|
| 02-12-2013 | 37 | 0.429 | 0.085 | 16.0 | 0.111 | 0.005 | 0.145 |
| 02-12-2013 | 37 | 0.383 | 0.088 | 14.0 | 0.097 | 0.006 | 0.147 |

Report generated by chamber method software version 2.20 of 16-01-2014.

Michael Berger

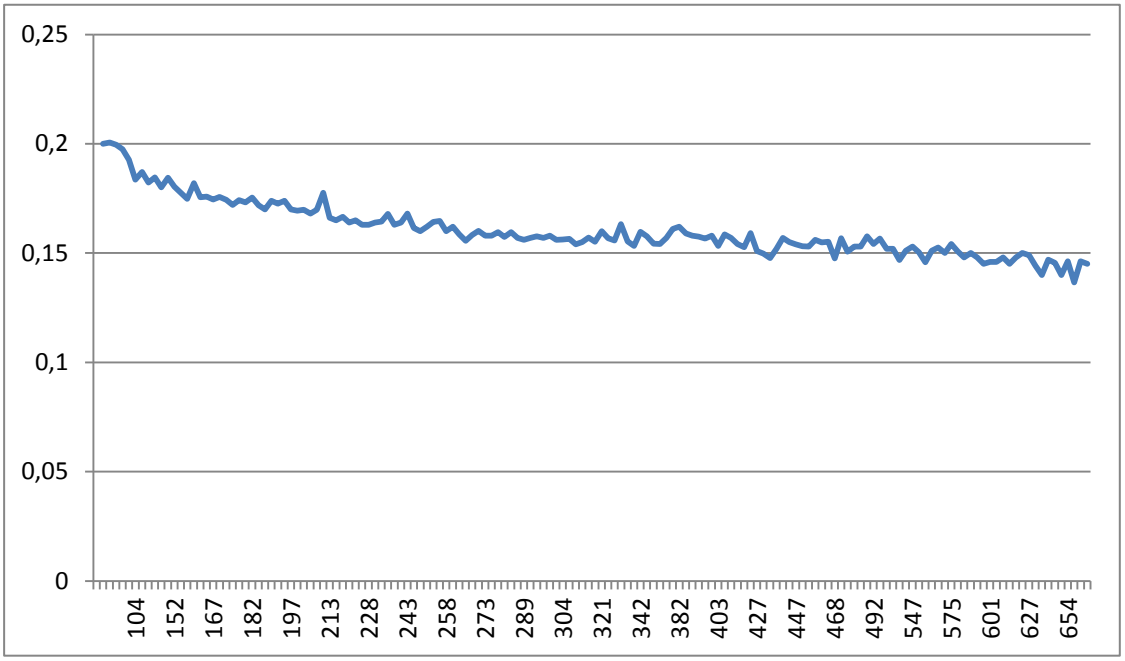
DANISH TECHNOLOGICAL INSTITUTE

| | |
|---|---|
| Order no. | 574052-17 |
| Appendix no. | 2 |
| Page | 1 of 1 |
| Initials | hbk/jbh |

## Formaldehyde concentration (mg/m$^3$) as function of time (h)

*Not part of accreditation.*

Material: Kitchen front door




Measured by automatic analyser marked 'SKALAR'.
Method of analysis: Acetylacetone (Hantzsch-reaction) photometric analysis.
Limit of detection (LOD): 0.01 mg/m$^3$

Date of test start: 05-11-2013
Date of test finish: 03-12-2013

The general conditions pertaining to assignments accepted by Danish Technological Institute shall apply in full to the technical testing and calibration at Danish Technological Institute and to the completion of test reports and calibration certificates within the relevant field.

**Danish Accreditation (DANAK)**

DANAK was established in 1991 in pursuance of the Danish Act No. 394 of 13 June 1990 on the promotion of Trade and Industry.

The requirements to be met by accredited laboratories are laid down in the "Danish Agency for Trade and Industry's ("Erhvervsfremme Styrelsens") Statutory Order on accreditation of laboratories to perform testing etc. and GLP inspection. The statutory order refers to other documents. where the criteria for accreditation are specified further.

The standards DS/EN ISO/IEC 17025 "General requirements for the competence of testing and calibration laboratories" and DS/EN 45002 "General criteria for the assessment of testing laboratories" describe fundamental criteria for accreditation. DANAK uses guidance documents to clarify the requirements in the standards. where this is considered to be necessary. These will mainly be drawn up by the "European co-operation of Accreditation (EA)" or the "International Laboratory Accreditation Co-operation (ILAC)" with the purpose of obtaining uniform criteria for accreditation. In addition. DANAK draws up Technical Regulations with specific requirements for accreditation that are not contained in the standards.

In order for a laboratory to be accredited it is. among other things. required:

- that the laboratory and its personnel are not subject to any commercial. financial or other pressures. which might influence their technical judgement
- that the laboratory operates a documented quality system
- that the laboratory has at its disposal all items of equipment. facilities and premises required for correct performance of the service that it is accredited to perform
- that the laboratory management and personnel have technical competence and practical experience in performing the service that they are accredited to perform
- that the laboratory has procedures for traceability and uncertainty calculations
- that accredited testing or calibration is performed in accordance with fully validated and documented methods
- that the laboratory keeps records. which contain sufficient information to permit repetition of the accredited test or calibration
- that the laboratory is subject to surveillance by DANAK on a regular basis
- that the laboratory shall take out an insurance. which covers liability in connection with the performance of accredited services

Reports carrying DANAK's logo are used when reporting accredited services and show that these have been performed in accordance with the rules for accreditation.

DANISH TECHNOLOGICAL INSTITUTE

**Raw data**

## Data
**Order no.:** 57405217
**Material: Hvid front. SVANE**

| Time (Hours) | Conc. (mg/m3) |
|---|---|
| 66 | 0.200 |
| 72 | 0.201 |
| 79 | 0.199 |
| 85 | 0.197 |
| 92 | 0.193 |
| 104 | 0.184 |
| 110 | 0.187 |
| 117 | 0.182 |
| 123 | 0.185 |
| 130 | 0.180 |
| 136 | 0.184 |
| 152 | 0.180 |
| 154 | 0.178 |
| 157 | 0.175 |
| 159 | 0.182 |
| 162 | 0.175 |
| 165 | 0.176 |
| 167 | 0.175 |
| 169 | 0.176 |
| 172 | 0.174 |
| 175 | 0.172 |
| 177 | 0.174 |
| 180 | 0.173 |
| 182 | 0.175 |
| 184 | 0.172 |
| 188 | 0.170 |
| 190 | 0.174 |
| 192 | 0.173 |
| 195 | 0.174 |
| 197 | 0.170 |
| 200 | 0.169 |
| 203 | 0.170 |
| 205 | 0.168 |
| 207 | 0.170 |
| 210 | 0.178 |
| 213 | 0.166 |
| 215 | 0.165 |
| 218 | 0.167 |
| 220 | 0.164 |
| 222 | 0.165 |
| 226 | 0.163 |
| 228 | 0.163 |
| 230 | 0.164 |
| 233 | 0.164 |
| 235 | 0.168 |
| 238 | 0.163 |
| 241 | 0.164 |
| 243 | 0.168 |
| 245 | 0.161 |
| 248 | 0.160 |
| 251 | 0.162 |
| 253 | 0.164 |
| 256 | 0.165 |
| 258 | 0.160 |
| 260 | 0.162 |
| 264 | 0.159 |
| 266 | 0.156 |
| 268 | 0.158 |
| 271 | 0.160 |
| 273 | 0.158 |
| 276 | 0.158 |
| 279 | 0.160 |
| 281 | 0.157 |
| 283 | 0.160 |
| 286 | 0.157 |
| 289 | 0.156 |

| | |
|---|---|
| 291 | 0.157 |
| 294 | 0.158 |
| 296 | 0.157 |
| 298 | 0.158 |
| 302 | 0.156 |
| 304 | 0.156 |
| 306 | 0.157 |
| 309 | 0.154 |
| 312 | 0.155 |
| 316 | 0.157 |
| 318 | 0.155 |
| 321 | 0.160 |
| 324 | 0.157 |
| 327 | 0.156 |
| 330 | 0.163 |
| 333 | 0.155 |
| 336 | 0.153 |
| 345 | 0.158 |
| 348 | 0.154 |
| 350 | 0.154 |
| 373 | 0.157 |
| 379 | 0.161 |
| 382 | 0.162 |
| 388 | 0.159 |
| 391 | 0.158 |
| 394 | 0.157 |
| 396 | 0.157 |
| 400 | 0.158 |
| 403 | 0.153 |
| 409 | 0.158 |
| 413 | 0.157 |
| 416 | 0.154 |
| 420 | 0.153 |
| 424 | 0.159 |
| 427 | 0.151 |
| 430 | 0.150 |
| 433 | 0.148 |
| 437 | 0.152 |
| 440 | 0.157 |
| 444 | 0.155 |
| 447 | 0.154 |
| 451 | 0.153 |
| 454 | 0.153 |
| 457 | 0.156 |
| 460 | 0.155 |
| 464 | 0.155 |
| 468 | 0.148 |
| 471 | 0.157 |
| 475 | 0.151 |
| 478 | 0.153 |
| 484 | 0.153 |
| 488 | 0.158 |
| 492 | 0.154 |
| 496 | 0.157 |
| 530 | 0.152 |
| 534 | 0.152 |
| 539 | 0.147 |
| 543 | 0.151 |
| 547 | 0.153 |
| 552 | 0.150 |
| 556 | 0.146 |
| 561 | 0.151 |
| 565 | 0.153 |
| 570 | 0.150 |
| 575 | 0.154 |
| 579 | 0.151 |
| 583 | 0.148 |
| 588 | 0.150 |
| 592 | 0.148 |
| 601 | 0.146 |
| 605 | 0.146 |
| 609 | 0.148 |
| 614 | 0.145 |
| 618 | 0.148 |

| | |
|---|---|
| 622 | 0.150 |
| 631 | 0.144 |
| 635 | 0.148 |
| 640 | 0.147 |
| 646 | 0.145 |
| 650 | 0.149 |
| 654 | 0.146 |
| 662 | 0.146 |
| 665 | 0.145 |

**Emission of Formaldehyde from Furniture**

The emission of formaldehyde from 20 pieces of furniture, representing a variety of types, was measured in climate chambers. Most tests show low emissions but certain scenarios of furnishing, including furniture with large surface areas in relation to room volume can emit formaldehyde resulting in concentrations above the WHO recommended limit of 0.1 mg m-3

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