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Survey and risk assessment of toluene and other neurotoxic substances in children's rooms

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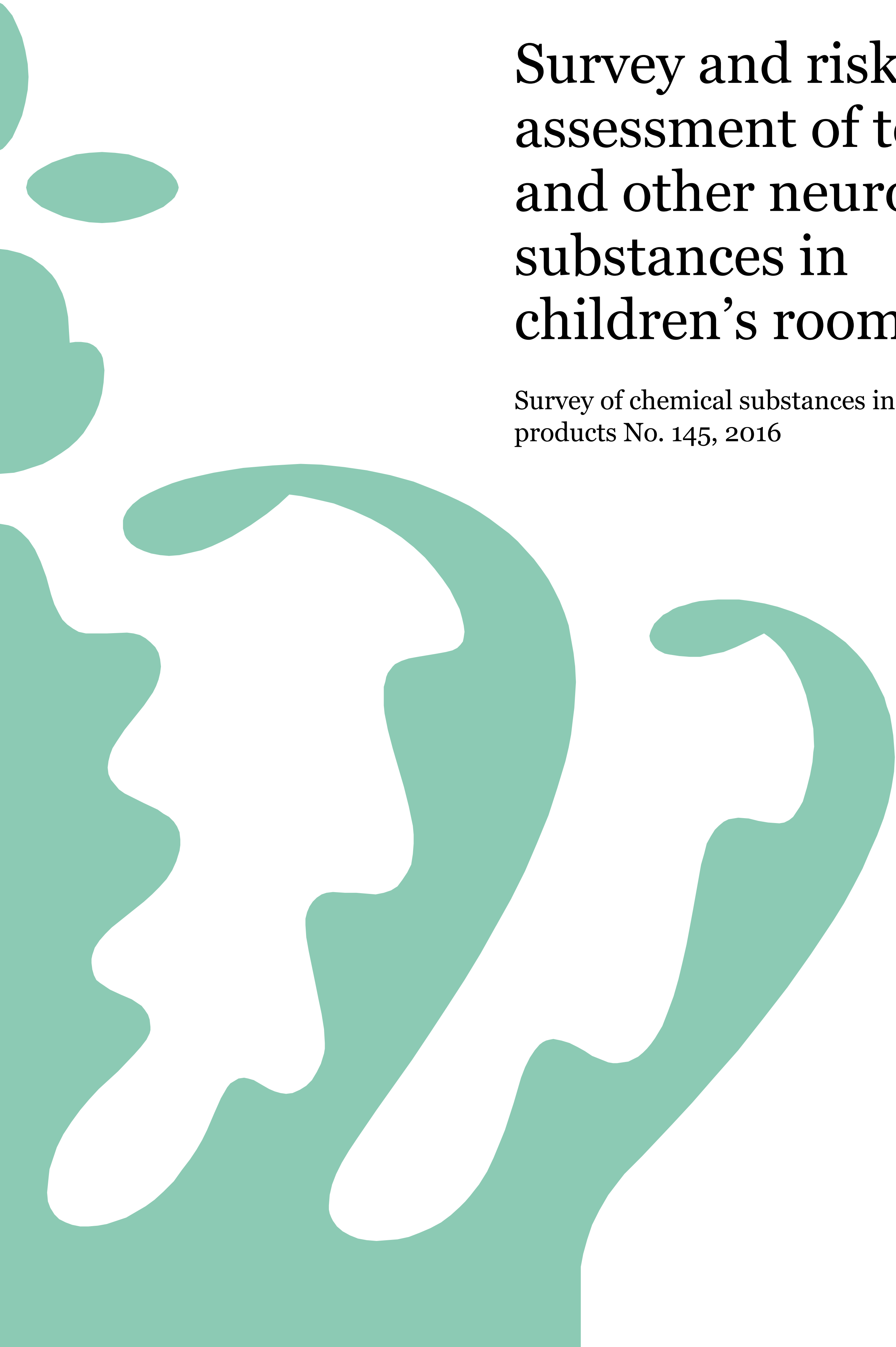

Title:

Survey and risk assessment of toluene and other neurotoxic substances in children´s rooms

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Contents

Foreword

This study is part of the Danish EPA's program for surveying chemicals in consumer products and is a follow-up on the Danish EPA strategy for risk management of toluene from 2015.

The study aims:

- To compile knowledge of toluene and other neurotoxic substances with similar effects / mode of action
- To focus on children in relation to hazard and exposure assessments of these substances
- To identify relevant products and make measurements of the emission of these substances
- To assess the exposures and risk associated with children´s rooms.

The project was carried out from April 2015 to December 2015 in a collaboration between DHI and Statens Byggeforskningsinstitut (Danish Research Building Institute), SBI.

The project was followed by a steering committee with the following members:

Shima Dobel, Danish EPA
Grete Lottrup Lotus, Danish EPA
Barbara Kolarik, SBi
Lars Gunnarsen, SBi
Poul Bo Larsen, DHI (project manager)

Summary

Purpose

Children are considered particularly sensitive to substances that may affect the central nervous system, as their central nervous systems are under development - and thus particularly sensitive - up to adulthood. It is therefore essential to know the exposure of children to toluene and similar neurotoxic substances in order to assess whether such exposures could pose a risk for adverse effects on the developing central nervous system. The purpose of the project is to investigate whether exposure to toluene and other substances with similar mode of action in children's bedrooms can be problematic for children's health. This is to be assessed in relation to the exposure that children will be subjected to in a typical children´s room, and also taking into account the exposure to toluene and other substances with the same mode of action from other sources than those in the children´s room.

Assessment of toluene and other neurotoxic substances

In the project, other chemicals with harmful effects on the central nervous system are identified from literature searches. Particular emphasis is given to volatile substances such as toluene, which therefore may occur together with exposure to toluene, and also for which there is good documentation of chronic adverse effects on the central nervous system. The literature is also reviewed to achieve tolerable levels of exposure (LCI values, Lowest Concentration of Interest)[1] for the designated substances for the protection against chronic nerve damage in children.

When calculating the tolerable exposure levels, the fact that children in relation to their bodyweight inhale larger volumes of air than adults is taken into account, and an additional uncertainty factor is used to take into account children's sensitivity regarding effects on the central nervous system.

The following table specifies the list of volatile substances, which are internationally recognised for their potential of causing chronic damage to the central nervous system, as well as estimations suggestions for LCI values for the substances. The LCI values should be regarded as the maximum concentrations of the substances that children may be exposed to for a longer period without increased risk for adverse effects.

LCI VALUES FOR PROTECTION AGAINST NEUROTOXIC EFFECTS IN CHILDREN (1-3 YEARS)

Substance	LCI value children mg/m³	Substance	LCI value children mg/m³
n-hexane	0.700	Trimethylbenzenes	0.100
n-heptane	-	Diisopropylbenzene	0.200
Benzene	0.600	Phenyloctane	0.275

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[1] As a basis for the determination of tolerable exposure levels for the substances the results and the data from the following report were used:
"Harmonisation framework for health based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept" from Joint Research Centre/ EU-Commission (JRC/EU-Commission 2013). The report derives toxicologically based tolerable values (in the report referred to as EU LCI values, "Lowest Concentration of Interest") for a number of individual substances, which are relevant to emissions from building materials to the indoor environment.

Substance	LCI value children mg/m³	Substance	LCI value children mg/m³
Toluene	0.725	C7-C12 hydrocarbons, total	1.425
Xylenes	0.125	Monochloromethane	0.045
Ethylbenzene	0.200	Dichloromethane	4200
Styrene	0.175	Trichloroethylene	1.625
Methylstyrene	0.200	Tetrachloroethylene	1.650
Propylbenzenes	0.240		

Exposure levels and risk assessment, literature data
After identification of the relevant substances, the report examines from literature surveys the possible sources of exposure that may be present in a children´s room (for example from building materials, furnishing, toys, electronics, etc.). Here, mainly the knowledge from the Danish EPA's database covering findings from the many consumer projects is used. Based on knowledge on the emission of substances from a number of these products and on knowledge from international literature on background exposure from other sources, the exposure is assessed in relation to the above LCI values. Should the exposure exceed the LCI values, this will indicate a potential risk towards adverse effects on the central nervous system in children.

Generally, the emission and exposure data from the literature did not result in levels that exceeded the LCI values, and therefore no detectable risk in children could be shown. However, there was one particular exposure scenario with electronics products that could result in a theoretical risk, as the simultaneous use of 8 new electronics products was calculated to cause an unacceptably high emission of neurotoxic substances in children´s room. The risk, however, disappeared after three months of use of the products as the emissions gradually were reduced.

Identification of sources for follow-up emission analyses
To update knowledge and to clarify whether there today may be unwanted high levels of exposure to neurotoxic substances of children, a number of products that were most likely to contain critical substances were identified from the literature.
The following products were selected for emission analysis in small climate chambers; in a full scale mock-up of a children´s room, or during active use of the product:

PRODUCTS AND SCENARIOS SELECTED FOR EMISSION ANALYSIS IN THIS PROJECT

Small scale measurements	Measurements in mock-up children´s room	Measurements during activities
RUBBER FIGURES TAPE BALLOONS COMICS/ PRINTED MATERIAL CUDDLY TOYS WITH FRAGRANCE MODELLING CLAY PLAY TENT FRESHLY PAINTED/LACQUERED SHELVES OR WALLS	LAMINATE FLOOR BED DESK TWO DIFFERENT TYPES OF SHELVES/ CABINETS DECORATION FOIL ON WALL SELF-ADHESIVE SHELF PAPER COMPUTER SCREEN LAPTOP CHARGER PLAYSTATION TELEVISION	PAINTING WITH PERMANENT AND WHITE BOARD MARKERS IRONING PLASTIC BEADS

Emission analyses of selected products and scenarios

Small-scale measurements were made in 0.051 m^3 glass CLIMPAQ chambers. The activity full scale measurements and the children´s room mock-up were set up in a large climate chamber with a floor area of 17.4 m^2 and a volume of 31.8 m^3. Both the small chambers and the large chamber were ventilated with HVAC system, with the temperature set at 23 ^{o}C and 50 % relative humidity. Each emission analysis began with measuring the background concentrations in the empty climate chamber. The emission measurements were taken 24, 48 and 72 hours, and 2 weeks after set up in order to assess the immediate and the long-term exposure. The emission measurements of activities lasted for 100 minutes.

Air was collected on a tube with charcoal by means of a pump with a flow of 1 l/ min and a pumping time of 100 minutes. The samples were then send to and analysed by an accredited laboratory.

Emission of toluene was measured during use of permanent and white board. During the activity of ironing plastic beads, a minor emission of the substances n-decane and n-undecane was found, while other chemicals, which in previous studies were measured in high concentrations, including toluene, xylenes, ethylbenzene, styrene and propylbenzene, were below the detection limit in this study. In both these active full scale measurements, high concentrations of TVOC (Total Volatile Organic Compounds) were found indicating significant emission of other substances, which, however, were not identified in this study.

In the mock-up scenario, only minor emission of toluene, xylenes, and small concentrations of TVOC was measured. It should, however, be emphasised that it was not possible to keep the electronic equipment turned on, because it automatically went into stand-by mode after only a few minutes. As emission from electronics is particularly expected by prolonged use at elevated temperature, the measurements do not reflect emissions from electronics.

In the small-scale scenarios with the selected products, the highest emissions were found from freshly painted and lacquered surfaces. Here, the emissions of 20 substances were detected 24 hours after setup. However, for most of the substances the levels fell to below the detection limit after 72 hours. Smaller emissions of single substances also after 24 hours were found from tape, swim articles, balloons, modelling clay and a teddy bear with fragrance, but with a downward trend within 48 hours. The only product with more prolonged emission was rubber figures, for which emission of xylenes remained above the detection limit even after 2 weeks.

Measuring in children´s rooms

To confirm or reject the relatively low exposure levels found in relation to the small-scale and full scale emission measurements, follow-up measurements of the neurotoxic substances were carried out in children´s rooms in private homes. The sampling were performed in 19 children´s rooms, covering all age groups from 1-18 years, as the furniture, decorations, etc. of the rooms can vary significantly dependent on gender and age of the child.

Prior to the survey, the families were asked not to clean the room the day before the sampling and also to close the windows in the morning. If possible, the time of sampling was agreed, so that no cooking took place during the sampling period. As for emission measurements, the air was collected on charcoal tubes using a pump, with airflow of 1 l/min. Measurement of air change rate, temperature and relative humidity were made in the children´s room during the sampling.

The air exchange was generally very low in the children´s rooms with an average of 0.35 per hour. Toluene was the most frequently observed substance and was measured above the detection limit in all the 19 children´s rooms, followed by *m-/ p*-xylene, undecane, and dodecane. In general, the measured concentrations were in accordance with results from the emission measurements from the small chambers and mock-up. However, there were a few children´s room, where concentrations were either at level with the highest emission measurements or even higher. For these children´s rooms, renovating activities taking place in the house, glue and paint for the construction of aircraft models, and the presence of many plastic and rubber figures were identified as the possible significant sources.

There was one child room with highly elevated concentrations of several chemicals in the indoor air, including benzene. On subsequent inspection it turned out that the outer wall of the child room bordered a shed, in which was a lawn mower, petrol, and a number of white spirit containing products in plastic containers were stored. There was a distinct odour of solvents in the shed. The substances measured in the children´s room were typical components of petrol and white spirit, and penetration of the vapours into the child room could thus explain the high concentrations.

With regard to children´s rooms with a lot of electronic equipment, no elevated levels of either benzene, toluene, ethylbenzene, or xylenes could be detected. Neither age, sex, traffic nor cooking showed correlation with the measured concentrations. There was a tendency to measure more substances above detection limit as well as higher concentrations of toluene, xylenes and TVOC in children´s rooms with air exchange of less than 0.25 times per hour (less than half of the building recommendations as indicated in BR10).

Risk assessment of measured data
To illustrate the worst-case scenario, the concentrations of all measured emissions are summed in an overall scenario, as further description of more detailed scenarios will not be necessary if the overall sum scenario does not pose a risk.

The risk characterisation ratios are calculated (RCR, where the RCR = exposure level/ LCI value) for emission concentrations for all the neurotoxic substances for both 24-hour and 72-hour measurements. The 72-hour measurements are considered the most relevant for assessing the risks of prolonged exposure.
RCR values above the value 1 are an indication that exposure exceeds the LCI values and that there is a potential risk. The table below shows the total concentrations of each of the measured substances, their tolerable levels (LCI values for 1-3 year-olds) and the calculated RCR values.

CUMULATED EXPOSURE LEVELS FOR EMISSION CONCENTRATIONS FROM ALL PRODUCTS AND SCENARIOS MEASURED IN THIS PROJECT

Substance	Total exposure level 24h/ 72h µg/m³	LCI value for toddlers µg/m³	RCR24h/ RCR72h
Toluene	52.4/ -	725	0.072/ -
Ethylbenzene	13.8/ 2.7	200	0.069/ 0.014
Xylenes	71.8/ 18.1	125	0.574/ 0.145
Styrene	3.8/ -	175	0.022/ -
Ethyltoluene + trimethylbenzenes, isomers	56.8/3.5	100	0.568/ 0.035
Propylbenzene, isomers	4.00/ -	200	0.020/ -
Trichloroethylene	9.2/ -	1625	0.006/ -
RCRsum of single substance RCR-			**1.331/ 0.194**

Substance	Total exposure level 24h/ 72h µg/m^3	LCI value for toddlers µg/m^3	RCR24h/ RCR72h
values			
C7-C12 hydrocarbons, total	374/48	1425	0.262*/ 0.034*

* RCR for C7-C12 hydrocarbons should not be confused with RCRsum, as the LCI value for C7-C12 hydrocarbons is a separate value based on data for the total content of C7-C12 hydrocarbons.

For none of the measured individual substances, the RCR value was above 1. Since the substances have very similar effects on the central nervous system, it is considered relevant to add up the contributions of the risk characterisation ratios for the single substances, and it can be seen that the sum of the RCR values (RCRsum = 1.325) exceeds the value 1 after 24 hours of evaporation. Thus, this is an expression of a risk if this exposure level is maintained over a longer period. The main contribution (equivalent to RCR = 0.6) is however due to contributions from freshly painted surfaces (walls and wooden panels), which underlines the importance of allowing freshly painted surfaces to evaporate a few days before the room is used or the panels are mounted in the room. After 72 hours, the sum of the RCR values for all emissions had substantially declined to RCRsum = 0.194, i.e. a value significantly below 1. This indicates that the measured levels and the overall scenario for the children´s room do not give rise to concern in terms of long-term exposure to neurotoxic substances.

The obtained RCR values from the theoretical exposure scenarios can then be seen in the context of the RCR values that can be calculated from the measured levels in the 19 children´s rooms in private homes. When the three most “polluted” children´s rooms were selected for risk assessment, RCRsum values of 0.16; 0.42 and 2.49 could be calculated. Thus, only one of the 19 children´s rooms achieved an RCRsum value above 0.42.

The source of the very high and concerning RCR value for the most polluted child room could, as mentioned earlier, be explained by the fact that the outer wall of the child room bordered a shed containing a petrol driven lawnmower and cans of petrol and white spirit, and that vapours from these sources have possibly penetrated into the children´s room.

This example shows that careless storage and handling of fuel and solvents in and around the house can affect indoor air quality significantly, and that this may occur relatively unnoticed, particularly among residents of villas.

Overall assessment

Overall, the emission measurements performed for construction materials and household furniture, as well as the emission tests with a large number of toys show that the emissions of volatiles from children´s room-related products do not generally occur at levels causing concern for chronic neurotoxic effects in children. This is supported by a number of measurements performed in children´s rooms in private homes, where the levels of the neurotoxic substances were generally low.

However, the measurements in the children´s rooms showed that levels of concern may occur in the indoor air due to other sources. This may be due to incorrect storage of petrol/ white spirit or other organic solvents in or around the house, or the increased levels may be associated to freshly painted/ laquered surfaces (especially when using products containing white spirit).

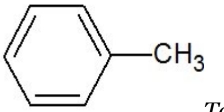
Unfortunately it was not possible in the project to obtain an accurate picture regarding the evaporation from electronics, which in previous studies were indicated to contribute significantly to the substances of concern in this project. This was because the purchased electronic equipment spontaneously went into stand-by mode. However, the measurements in children´s rooms with a lot of electronic equipment suggest that the electronics today do not cause elevated levels of chronic neurotoxic substances, however, the data for this statement are considered limited.

It should be noted that the project only has made assessments in terms of levels of volatile, chronic neurotoxic substances, and that the total evaporation and its content of other substances has not been assessed for other effects such as odour and mucous membrane irritation.

1. Introduction

1.1 Background

Toluene is an organic solvent and is on the Danish EPA list of undesirable substances as toluene is classified for harmful effects on fetal development and also for chronic effects on the central nervous system after repeated or prolonged exposure. Toluene is registered under REACH in an amount in the range of 1 - 10 million tons per year. The substance is widely used both in industrial and consumer products, where toluene is mainly used as a solvent. Toluene is an essential component in gasoline with an average content of about 11%. In the outdoor air in busy streets concentrations around 3.5 mg/m³ have been measured in Copenhagen.



Toluene

Children are considered particularly sensitive to substances that can affect the central nervous system, as the central nervous system is under development - and thus particularly sensitive –until adulthood. It is therefore important to know children´s exposure to toluene and similar neurotoxic substances with the same effects, in order to assess the extent to which children may be exposed to neurotoxic substances that may pose a risk for the developing central nervous system.

1.2 Purpose

The purpose of the project is to investigate whether exposure to toluene and other substances with the same mode of action can be problematic for children's health. This will be assessed in relation to the exposure that children will be subjected to in a typical children´s room, and also taking into account the exposure to toluene and other substances with the same mode of action from other sources than those in the children´s room.

1.3 Project phases

The project is divided into three phases:

Phase 1: Assessment of toluene and other substances with the same mechanism of action
Phase 1 is covered by the chapters 2, 3, 4 and 5.

Chapter 2 comprises assessment of toluene and similar neurotoxic substances. Based on literature searches, this chapter identify other substances with harmful effects on the central nervous system. Particular attention is paid to substances, for which simultaneous exposure together with toluene may occur, and where there is good documentation of the substance's chronic adverse effects on the central nervous system.
Also, the literature is reviewed to determine tolerable levels of exposure for the selected substances for protection against adverse chronic neurotoxic effects in children.

In Chapter 3, knowledge is collected on the exposure to the selected substances in Chapter 2, focusing on exposure from products relevant to children´s rooms. Furthermore, data is collected with regard to the measured levels of the substances in the indoor environment.

Also, the extent of the "background exposure" from other sources is assessed, e.g. from outdoor air, transport, wood combustion and foods, all of which may be relevant to consider for an overall exposure assessment.

In Chapter 4, a preliminary risk assessment is made based on the calculated and measured levels in Chapter 3, as the levels are compared with the tolerable exposure levels estimated in Chapter 2.

In Chapter 5, specific products are identified, which are evaluated to be relevant to children´s rooms, and which with a certain probability are expected to contain one or more of the chronic neurotoxic substances. From the literature - especially the Environmental Protection Agency's consumer projects and LOUS projects - relevant products for use in children´s rooms are identified, e.g. toys, electronics, furniture, and building materials. A complete list of product types is made, which then can be used as a pick list and the selection of concrete products that should be subject to emission analyses in phase 2 of the project.

Phase 2a: Emission analyses

In this phase described in Chapter 6, products, from which emission is assessed to be most likely, are selected. For these products, the emission of the selected substances is measured, partly grouped in small climate chambers and partly combined in an experimental set-up with the size and furnishing of a children´s room (a mock-up scenario). Furthermore, the emission is measured in relation to relevant activities occurring in a children´s room.

Phase 2b: Measurements in children´s rooms in private homes

To confirm or reject the exposure levels measured in Phase 2a, field measurements in children´s rooms in private homes were subsequently decided on. Field measurements were performed in 19 children´s rooms. The results and methods are described Chapter 7.

Phase 3: Risk assessment

In Chapter 8, data are collected from the emission analyses and the analyses in children's rooms, and the information is used for the generation of exposure scenarios that illustrate realistic worst-case scenarios in a children´s room.

Both from calculated and from measured exposure levels, the total exposure is assessed in relation to the tolerable levels set for the substances in Chapter 2, and it is assessed whether there is an unacceptable risk for chronic effects of the central nervous system in children.

2. Assessment of toluene and other neurotoxic substances

Based on literature search, other chemicals with harmful effects to the central nervous system are identified in this chapter. Particular attention is paid to substances where simultaneous exposure to toluene may occur, and where there is documentation of the substances' chronic adverse effects to the central nervous system.
The literature is reviewed to establish tolerable levels of exposure to the selected substances for protection against chronic neurotoxicity in children.

2.1 Hazard characterisation of toluene and comparable substances

Toluene is a well-known neurotoxic substance and exposure to toluene and other similar neurotoxic substances may influence in particular children's central nervous systems, as this under development until adolescence. However, there is much uncertainty about which neurotoxic substances are present in indoor air and to what extent, and thus also much uncertainty about the overall health impact from these substances.

Evaporation tests and indoor measurements have shown that volatile substances rarely appear alone, but are often present in mixtures from different substances. The first phase of this project is therefore to identify comparable substances with low vapour pressure and with similar neurotoxic effects that may be relevant for this project.

2.1.1 Toluene’s harmful effects to the nervous system

As the starting point of the project is toluene and its neurotoxic effects, the most importadnt data for the understanding of toluene’s harmful effects on the central nervous system are briefly escribed. The description is based on the updated knowledge regarding toluene provided in the Danish EPA LOUS report (Danish EPA 2014a).

2.1.1.1 Physical and chemical properties relevant to the effects

The physical-chemical properties of toluene is considered to be of importance to the harmful effects seen.
Toluene has a boiling point of 111 °C and thus a relatively high vapour pressure of 3.73 kPa (equal to 28 mm Hg) at 25 °C, which means that the substance can easily evaporate, and therefore relatively high concentrations of toluene in the air may occur. Furthermore, the water solubility of toluene is relatively low (< 600 mg/L) and the fat solubility is high (logP (octanol/water) = 2.73). These properties imply that when toluene is inhaled and absorbed into the blood, the substance is distributed rapidly to fat tissue and the most fatty organs (e.g. the brain) from which it is relatively slowly excreted. This means that by repeated exposure, substantially higher concentrations of toluene can build up in the central nervous tissue than in the blood. These properties thus promotes that the substance can exert its toxic effect in the central nervous system (Danish EPA 2014a).

2.1.1.2 Absorption and distribution of toluene in the body

If inhaled, toluene is rapidly absorbed in humans through the lungs, and about 50% of the inhaled amount of toluene is retained and absorbed. By the oral route animal studies have shown that toluene is absorbed at nearly 100% in the gastrointestinal tract. In contact with skin the absorption of liquid toluene is limited (set to 3.6% of the applied dose in the REACH registration of the substance) while absorption of toluene vapours through the skin is considered negligible.

After absorption, toluene is distributed to the body with the highest concentration in fatty tissues. There is an up-concentration in the brain relative to the concentration in the blood.
Toluene is transported through the placenta into the fetus, and the concentration of toluene in the fetus is reported to be approx. 75% of the concentration in maternal blood. Toluene also pass into the breast milk.
Within few hours after inhalation, the concentration of toluene in the blood decreases, as toluene is transported to other tissues and organs of the body. Secretion and elimination from tissues and organs takes place over a longer period with half-lives up to 3 days.

About 20% of the absorbed toluene is excreted unchanged through exhaled air while about 80% is converted in the liver through oxidation by the P450 enzyme system. Toluene is converted primarily to benzyl alcohol, benzaldehyde and benzoic acid. Benzoic acid is coupled to glycine and excreted in the urine as hippuric acid. Other metabolites occur to a lesser extent (Danish EPA 2014a).

2.1.1.3 Neurotoxic effects

Acute effects
In volunteers short-term exposure to toluene at 285 mg/m^3 has caused headaches, dizziness, malaise and lethargy. In neuropsychological tests, this further resulted in impaired performance. In relation to these acute effects, a no-effect level (NOAEC) of 150 mg/m^3 has been set (Danish EPA 2014a). Due to the acute effects, toluene is classified STOT SE3, H336 (May cause drowsiness or dizziness).

Effects from repeated/prolonged exposure
In humans, repeated high concentration exposure to toluene (abuse e.g. sniffing) has caused impaired brain function and severe damage in the brain tissue. Long-term exposure in the occupational environment (e.g. more than 12 years of exposure in the printing industry) has also resulted in chronic brain disorders. Also, occupational studies have shown that exposure to toluene has contributed to hearing loss in workers. Further, studies have shown that worker exposure to toluene in combination with noise promotes the negative effects of noise on the hearing (Danish EPA 2014a).

Toxic effects in the ear and hearing loss has also been observed in experimental animals. In rats, this was observed after 2 weeks of exposure at 3750 mg/m^3 of toluene, while a no-effect level (NOAEC) was found at 2625 mg/m^3 in connection with 16 weeks of exposure. Exposure to toluene has further been found to cause a reduced number of nerve cells in certain areas of the brain (hippocampus) as well as influence the neurochemical processes of the brain (Danish EPA 2014a).

Based on these findings, toluene has obtained the harmonized classification STOT RE 2; H373 (May cause damage to organs through prolonged or repeated exposure).

2.1.1.4 Developmental effects

In humans, occupational data has shown that exposure to toluene may cause increased risk of spontaneous abortion.
Data from pregnant toluene abusers have shown that toluene may cause neurological damage to the fetus similar to what is known from fetal alcohol syndrome.

In female rats exposed to 4560 mg/m^3 during gestation and lactation, toluene has caused neurotoxic effects in the offspring observed in behavioral testing as impaired learning ability (Danish EPA 2014a).
Based on these effects, toluene has obtained harmonized classification as Repr. 2; H361d (Suspected of damaging the unborn child).

2.2 Identification of comparable substances

Toluene is commonly found in the indoor air, and in homes with an average and upper 95th percentile level of 6.5 mg/m^3 and 28.4 mg/m^3, respectively (see Table 3.3). There are several sources for this, and toluene together with other volatile compounds are present as a result of evaporation from consumer products such as toys, furnishings and building materials.
To assess the overall exposure to toluene and other neurotoxic substances, it is therefore relevant to look at the other related volatile substances that can evaporate to the indoor air and that may affect the central nervous system.

The detection of such substances is partly done by reviewing the literature, Danish EPA has collected and assessed relevant for this project (see Appendix1) and partly via Internet search, with particular focus on exposure of children and neurotoxic effects, e.g. by combinations of the following search terms:

- child(ren); consumer; exposure, VOC, indoor, solvent, chemical, neurotoxic*; air quality; nervous system, development

The following sections describe step by step how the designation of other relevant neurotoxic substances has occurred. It has been the intention as far as possible to identify substances for which data have sufficiently documented their chronic neurotoxic effects, as this ensures that the subsequent risk assessment can be made based on specific data on effect levels of the neurotoxic effects. Furthermore, a wider and more general inclusion of "various organic solvents" without any criteria for the documentation for their neurotoxic effects could easily undermine the validity of the project.

2.2.1 Priority substances based on selected references (Appendix 1)

Initially, the references from the Danish Environmental Protection Agency's bibliography were reviewed to identify comparable neurotoxic substances (see the examination and selection in Appendix 1); the criterion by the review was that there should be documentation for the chronic neurotoxic properties of the substances. This resulted in the following list of neurotoxic substances:

Hydrocarbons:

- n-hexane (a,b)
- n-heptane (b)
- benzene (b)
- toluene (a,b)
- xylenes (a,b)
- ethylbenzene (a,b)
- n-propylbenzene (a)
- styrene (a,b)
- methylstyrene (a)

Chlorinated solvents:

- monochloromethane (b)
- dichloromethane (b)
- 1,1,1-trichloroethane (b)
- trichloroethylene (a,b)

-tetrachloroethylene (b)

Alcohols:

-methanol (b)
-ethanol (b)

Ketones:

- methyl ethyl ketone (b)
- methyl butyl ketone (b)

a) the substance is stated as chronic neurotoxic by EEA (2009)

b) the substance is stated as chronic neurotoxic by *DGUV (2007)*

The main references for this selection was partly *the European Agency report* on chemical substances with harmful effects on hearing (indicated by "a") (*EAA 2009*), and a German report published by *Deutsche Gesetzliche Unfallversicherung,* that for the interest of occupational accident insurances has reviewed documentation regarding chronic neurotoxicity of several solvents (indicated by "b") (*DGUV 2007*).
The selection of the substances from these reports is in accordance what has been concluded by the other references in Appendix 1 that also were consulted and that contributed with documentation for the substances listed above.

However, it should be noted that the above gross list is very largely obtained from knowledge of chemical exposure in the working environment, so in connection with this project it has also to be considered to which extent all of these substances are relevant for consumer products/ building materials and indoor environment in children´s rooms.

Below, the substances are shortly reviewed.

2.2.2 Hydrocarbons

Besides the LOUS report on toluene (Danish 2014a), the LOUS reports from Danish Environmental Protection Agency include: n-hexane, styrene and white spirit, which have been put on the list of undesirable substances due to the substances' chronic neurotoxic effects and/or the developmental/ reprotoxic effects.

White spirit (not mentioned in section 2.2.1) is a mixture of several hundred hydrocarbons, primarily comprising of hydrocarbons isomers having 7-12 carbon atoms. The qualities of white spirit classified for chronic neurotoxicity (STOT RE1) include the traditional qualities with a content of about 85-90 % of saturated alkanes/cycloalkanes and a content of aromatic hydrocarbons of typically 10-15 %. It should be pointed out that neither the EU Scientific Committee for establishing limit values in the working environment, SCOEL, nor the European Commission's report on "information notices on occupational diseases: a gudie to diganosis" distinguish between the various white spirit qualities, so in these organisations' assessments aromatic-free white spirit is also considered as causing chronic neurotoxicity (SCOEL 2007; European Commission 2009).

Furthermore, the focus on hydrocarbons as neurotoxic substances is supported by a recently published report from the Joint Research Centre/ EU Commission that has identified a number of indoor-relevant substances and assessed them in order to determine the health-based limit values (JRC / EU Commission 2013). A total of 21 indoor-relevant substances were prioritised for further evaluation, and among these chronic neurotoxicity was designated as the critical effect for the following five hydrocarbons:

- toluene

- xylenes
- ethylbenzene
- styrene
- trimehtylbenzenes

For these substances, the JRC/ European Commission (2013) report calculated acceptable levels in indoor air specifically considering the neurotoxic effects (see Table 2.1).

For other very comparable hydrocarbons JRC/ European Commission (2013) recommended to use read-across to the above substances to determine tolerable indoor air quality levels, as these substances were considered as having similar effects. This was recommended for the substances:

- propylbenzene
- diisopropylbenzene
- phenyloctane (octylbenzene)

2.2.3 Selection of hydrocarbons

Overall - based on the descriptions in Section 2.2.1 and 2.2.2 – it is scientifically justified to identify the following hydrocarbons and hydrocarbon mixtures as focus substances for this project:

- n-hexane
- n- heptane
- benzene
- toluene
- xylenes
- ethylbenzene
- propylbenzene
- styrene
- methylstyrene
- trimehtylbenzenes
- diisopropylbenzene
- phenyloctane (octylbenzene)
- white spirit (corresponding to C7-C12 hydrocarbons)

In relation to this project and its analytical work, this will mean using methods of collection and analysis for hydrocarbons in the range of C6 to C14.

2.2.4 Chlorinated solvents

List of chlorinated solvents identified in Section 2.2.1:

- monochloromethane
- dichloromethane
- 1,1,1-trichlorethane
- trichloroethylene
- tetrachloroethylene

The European Commission (2009) report states trichloroethylene as a neurotoxic substance with effects on the hearing. Grandjean and Landrigan (2014) indicate that for tetrachloroethylene there is sufficient evidence that the substance affects the developing central nervous system. Furthermore, the data indicate that the neurotoxic effects of trichloroethylene, tetrachloroethylene and dichloromethane are to some extent comparable, as there are correlations via possible common mode of action of the substances (Bale et al. 2011).

US EPA/ IRIS (2003a) has indicated monochloromethane (methyl chloride) to be known for its neurotoxic effects. It should be mentioned that monochloromethane, dichloroethane and trichloroethylene are all classified for carcinogenic effect with Carc2, H351, whereas trichloroethylene is classified as Carc1B; H350 and Muta2; H341. The carcinogenic effects of the substances and assessment of possible cancer risks are outside the scope of this project, where the focus is on the chronic effects to the nervous system of the substances.
However, it is possible that the general concern for carcinogenic effects of the substances has resulted in restricted use of the substances, and therefore they may occur rather seldom in consumer products and furniture, building materials and in the indoor environment.

It is not assessed to be relevant to include 1,1,1-trichloroethane in the project, as this substance is subject to very strict restrictions under the PIC Convention due to the ozone-depleting effect of the substance. At the same time, the substance is registered under REACH for use in chemical synthesis only, and no use of the substance has been found by searching the Nordic product register SPIN.

Relevant chlorinated compounds regarding chronic neurotoxicity related to this project are as follows:

- monochloromethane
- dichloromethane
- trichloroethylene
- tetrachloroethylene

In relation to this project, the priority of these chlorinated hydrocarbons will imply using methods of sampling and analysis of chlorinated C1-C2 compounds.

2.2.5 Alcohols

Methanol and ethanol different from the other organic solvents, as these substances are miscible with water and after absorption are distributed into the water phase of the body. Methanol appears on the Danish EPA list of unwanted substances. The neurotoxic effects of methanol are known especially for acute oral exposure, where ingestion of methanol in relatively small amounts may cause blindness due to damage to the optic nerve caused by the metabolic conversion of methanol to formic acid (Danish EPA 2013). Damage to the central nervous system of ethanol is known especially from alcohol abuse. Today even relatively moderate amounts of alcohol consumed during pregnancy are considered harmful to the fetus.
Although evaporation, for example from cleaning with denatured ethanol, may occur the substances methanol and ethanol are not known as general indoor air problems in connection with evaporation and inhalation.

Overall, it seems not to be relevant to focus further on methanol and ethanol in this project.

2.2.6 Ketones

Methyl ethyl ketone and methyl isobutyl ketone are mentioned in DGUV (2007). However, the documentation for including these substances was made in 1996. In this documentation reference is made to a total of six publications from 1976-1985; several of these publications refer to the well-known neurotoxic substance methyl n-butyl ketone, which is a substance known to cause peripheral neuropathy.

US EPA in 2003 reassessed methyl ethyl ketone and methyl isobutyl ketone, and from sub-chronic inhalation studies did not find basis for consider neurotoxic effects as the critical effects in relation to exposure, as only reversible effects on the central nervous system are seen related to high acute exposure (US EPA/ IRIS 2003b+c). In relatively new cancer studies in mice and rats, methyl isobutyl ketone at exposure levels up to 7200 mg/m^3 for two years caused kidney damage and liver damage as critical effects, while there were no signs of neurological damage (NTP 2007). So, overall, there seems to be no basis for including methyl ethyl ketone and methyl isobutyl ketone in this project.

Regarding the well-known neurotoxic substance methyl-n-butylketone, it can be mentioned that this is not currently registered under REACH, and therefore the use of the substance in the EU is less than 100 tonnes per year. As the substance is reported not to be used in the Nordic countries, cf. the Nordic SPIN database, it is not considered relevant to further include this substance in the project. The possibility remains however that the substance may be present in articles imported from non-EU countries.

Overall, it is considered not relevant to include these ketones in the project.

2.2.7 Overall priorities

Based on the above, the selection of the priority substances can be illustrated by the following figure:

Priority substances based on Appendix 1		**JRC/EU-Commission (2013) report**		**LOUS-projects**		**Further assessment**		**Priority substances**
Hydrocarbons: n-hexane n- heptane benzene toluene xylenes ethylbenzene n-propylbenzene styrene methylstyrene *Chlorinated solvents:* monochloromethane dichloromethane 1,1,1-trichloroethane trichloroethylene tetrachloroethylene *Alcohols:* methanol ethanol *Ketones:* Methyl ethyl ketone Methyl butyl ketone	+	toluene ethylbenzene xylenes styrene trimethylbenzenes propylbenzene diisopropylbenzene phenyloctane (octylbenzene)	+	n-hexane toluene styrene white spirit (C7-C12 hydrocarbons)	→	Sections 2.2.4. 2.2.5 2.2.6: From other references, assessment of the relevance of the Appendix 1 identified: *-chlorinated substances* *-alcohols* *-ketones*	→	*Hydrocarbons:* n-hexane n- heptane benzene toluene xylenes ethylbenzene propylbenzene styrene methylstyrene trimehtylbenzenes diisopropylbenzene phenyloctane (octylbenzene) white spirit (corr.to C7-C12 hydrocarbons) *Chlorinated subst.:* monochloromethane dichloromethane trichloroethylene tetrachloroethylene

FIGURE 2.1 SCHEMATIC OVERVIEW OF THE IDENTIFICATION AND PRIORISATION OF THE SUBSTANCES CONCLUDED AS HAVING CHRONIC NEUROTOXIC EFFECTS.

2.3 Assessment of tolerable exposure levels

This section gather knowledge regarding tolerable exposure levels of the neurotoxic substances identified in Section 2.2.7.

2.3.1 Toluene and other hydrocarbons

The starting point is to determine the tolerable exposure levels for the following selected hydrocarbons:

- n-hexane
- n-heptane
- benzene
- toluene
- xylenes
- ethylbenzene
- propylbenzene
- styrene
- methylstyrene
- trimethylbenzenes
- diisopropylbenzene
- phenyloctane (octylbenzene)
- white spirit (C7-C12 hydrocarbons)

2.3.1.1 LCI values elaborated by the Joint Research Centre/ EU-Commission, 2013

The starting point for the assessment of these substances is the report*"Harmonisation framework for health based evaluation of indoor emissions from construction products in the European Union using the EU-LCI concept"* from Joint Research Centre/ EU-Commission (JRC/EU-Commission 2013).

The report derives toxicologically based tolerable values (in the report referred to as EU-LCI values, Lowest Concentration of Interest) for a number of individual substances, which are relevant for the emission from building materials to the indoor climate.
The assessments of the substances are based on data from acknowledged expert assessments / risk assessments from, for example:

- EU (e.g. risk assessment reports)
- RIVM reports (National Institute for Public Health and the Environment, The Netherlands)
- Health Canada (Federal department, Canada)
- US EPA (US Environment Protection Agency)
- ATSDR (Agency for Toxic Substances and Disease Registry, USA)
- OEHHA (Office of Environmental Health Hazard Assessment, California Environment Protection Agency)
- ANSES (French Agency for Food, Environmental and Occupational Health & Safety)
- WHO (World Health Organisation)
- SCOEL (EU Scientific Committee on Occupational Exposure Limits).

From the data in these sources, the critical effect levels (NOAECs and LOAECs) are identified, andan LCI value is calculated from the methods used under REACH when tolerable exposure levels (DNEL or Derived No Effect Level) are derived.

In the JRC/ European Commission (2013) report, LCI values were derived for the substances listed in Table 2.1 below:

TABLE 2.1. DERIVATION OF TOLERABLE EXPOSURE LEVELS IN THE INDOOR AIR, EU-LCI VALUES (JRC/ EU-COMMISSION 2013)

	Toluene	Xylenes	Ethylbenzene	Styrene	Propylbenzene*	Trimethyl-benzene	Diisopropyl-benzene*	Phenyloctane*
CAS	108-88-3	1330-20-7	100-41-4	100-42-5	103-65-1	25551-13-7	99-62-7 100-18-5	2189-60-8
Critical effects	Colour vision	Neurotox	Hearing loss	Hearing loss	Ref. Subst. ethylbenzene	Neurotox	Ref. Subs. xylenes	Ref. Subs. ethylbenzene
NOAEC						123 mg/m3		
LOAEC	123 mg/m³	62 mg/m³	867 mg/m³	42.5 mg/m³				
Factor for adjusting the duration of the exposure	4.2*	4.2*	4.7*	4.2*		5.6*		
Overall uncertainty factor* (assessment factors)**	10	30	216	45		50		
EU-LCI mg/m³	2,900	0,500	0,850	0,250 (0,700)**	0,950	0,450	0,750	1,100

Ref. Subs = refers to read-across to a reference substance where the value for this substance is used as the basis for the assessment. The EU-LCI value is adjusted proportionally to the difference in the molecular weight between the target substance and the reference substance.

* this conversion factor is used to calculate the concentration from the exposure conditions in animal studies, e.g. 6h/d, 5d/week, to continuous human exposure 24h/d; 7d/week (i.e. in this case 24h/6h x 7d/5d = 5.6 as conversion factor)

** see text below regarding styrene

*** the use of uncertainty factors for individual substances is described below

Toluene
JRC/European Commission (2013) concluded a LOAEC of 123 mg/m3 with respect to effects of the colour vision in workers as the critical effect that occurred at the lowest exposure levels of toluene. For calculation of the LCI value, exposure in the workplace is converted to 24 hours in the indoor environment by a factor of 4.2 (corr. to 24h/8h x 7d/5d = 4.2). Then an uncertainty factor of 2 (JRC/European Commission (2013) typically uses 2 or 3 for extrapolation from LOAEC to NOAEC based on expert assessment) is used, extrapolating from an LOAEC to an NOAEC value and using an uncertainty factor of 5 to take into account the greater sensitivity in the general population than in the group of workers (JRC/European Commission (2013) argues for using an intraspecies factor of 5, when data from workers are extrapolated to the general population, and an intraspecies factor of 10 when the starting point is animal data). Thus, a total uncertainty factor of 10 is obtained and JRC/European Commission (2013) derives a rounded LCI value for toluene of 2900 mg/m3.

Xylenes
JRC/European Commission (2013) indicates effects on the central nervous system (dizziness and lack of appetite), as well as eye and respiratory irritation in workers with a LOAEC of 62 mg/m3 as the effects that have occurred at the lowest exposure levels of xylenes.
When calculating the LCI value, the exposure from the working environment is converted to 24 hours continuous exposure the indoor environment by a factor of 4.2.
Then an uncertainty factor of 3 is used, extrapolating from LOAEL to a NOAEC value, and an uncertainty factor of 5 is used, as the starting point is data from workers to be extrapolated to the general population. (JRC/ European Commission (2013) argues for using an intraspecies factor of 5, when data from workers are extrapolated to the general population, while an intraspecies factor of 10 is used when the starting point is animal data). Further, an uncertainty factor of 2 is used as the exposure duration from the occupational study was 7 years and not lifelong exposure. Thus, a total uncertainty factor of 30 and a rounded LCI value of 0.500 mg/m3 were obtained.

Ethylbenzene
JRC/ European Commission (2013) indicates toxicity of the ears at a LOAEC of 867 mg/m3 in a 90-day rat study as the effect that occurred at the lowest exposure levels of ethylbenzene. For calculation of the LCI value, the exposure in the animal study is converted to 24 hours continuous indoor exposure by a factor of 4.7 (24h/6h x 7d/6d = 4.7).
Then an uncertainty factor of 3 is used to extrapolate from LOAEL to a NOAEC value. An uncertainty factor of 3.6 is used to extrapolate from animals to humans (deviation from the usual factor of 2.5 used in REACH for inhalation studies, as specific data is used regarding the absorption rate of the substance). Next, an uncertainty factor of 10 is used to consider differences in sensitivity in the general population (JRC/European Commission (2013) argues of using an intraspecies factor of 5, when data from workers are extrapolated to the population, while an intraspecies factor of 10 is used when the starting point is animal data). Finally, an additional uncertainty factor of 2 is used to extrapolate to chronic exposure. Thus, a total uncertainty factor of 216 is obtained and JRC/ European Commission (2013) hereby obtains a rounded LCI value for ethylbenzene of 0.850 mg/m3.

Styrene
JRC/European Commission (2013) indicates impairment of colour vision, hearing impairment and impaired reactions in workers at a LOAEL of 42.5 mg/m3 as the effects that have occurred at the lowest exposure levels of styrene.
For calculation of the LCI value, exposure in the working environment is converted to 24 hours in the indoor environment by a factor of 4.2 (24h/8h x 7d/5d = 4.2).
Then, an uncertainty factor of 3 is used extrapolating from a LOAEL to a NOAEC value. An additional uncertainty factor of 3 is used to consider other severe effects (genotoxicity) of the substance, and an intraspecies uncertainty factor of 5 is used to consider higher sensitivity in the general population compared to workers. (JRC/European Commission (2013) argues of using an

intraspecies factor of 5, when data from workers are extrapolated to the population, while an intraspecies factor of 10 is used when the starting point is animal data). Thus, JRC/European Commission (2013) obtains an overall uncertainty factor of 45 and a rounded LCI value for styrene of 0.250 mg/m^3.
This project assesses the substance solely from its neurotoxic effects, so without using an uncertainty factor of 3 for the genotoxic effect of the substance, an LCI value for styrene of 0.70 mg/m^3 is obtained.

Trimethylbenzenes
JRC/European Commission (2013) indicates neurotoxic effects in rats with a NOAEC of 123 mg/m^3 in a 90-day study as the effects that occurred at the lowest exposure levels of trimethylbenzenes. When calculating the LCI value, the exposure in the animal study is converted to 24 hours continuous exposure in the indoor environment by a factor of 5.6 (24h/6h x 7d/5d = 5.6).
An uncertainty factor of 2.5 is used to extrapolate from animals to humans in connection with an inhalation study (normal factor used in REACH for inhalation studies). Then an uncertainty factor of 10 is used to consider differences in sensitivity in the general population. Finally, an additional uncertainty factor of 2 is used to extrapolate to chronic exposure. Thus, an overall uncertainty factor of 50 is obtained and JRCEuropean Commission (2013) obtains a rounded LCI value for trimethylbenzenes of 0.45 mg/m^3.

Propylbenzene
JRC/ European Commission (2013) indicates that no data are available for the substance to calculate an actual LCI value. Because of structural similarity, the substance is considered to have similar neurotoxic potential as ethylbenzene, which can then be used as a reference substance. A rounded LCI value of 0.950 mg/m^3 is calculated for propylbenzene based on ethylbenzene's LCI value of 0.860 mg/m^3 (the non-rounded value) and adjusting for the ratio between the molecular weights of the two substances (MW propylbenzene: 120.2 / MW ethylbenzene: 106.2).

Phenyloctane
JRC/ European Commission (2013) indicates that no data are available for the substance to calculate an actual LCI value. Because of structural similarity, the substance is considered to have similar neurotoxic potential as ethylbenzene, which can then be used as a reference substance. A rounded LCI value of 1.100 mg/m^3 is calculated for phenyloctane based on ethylbenzene's LCI value of 0.860 mg/m^3 (the non-rounded LCI-value) and adjusting for the ratio between the molecular weights of the ethylbenzene and butylbenzene* (MW butylbenzene: 134.3 / MW ethylbenzene: 106.2).
* If there is greater structural difference than 2 CH_2 groups per aliphatic chain between the subtances JRC/European Commision (2013) uses a maximum molecular weight from the read-across substance + molecular weight of 2 CH_2 groups, which in this case corresponds to the molecular weight of butylbenzene.

Diisopropylbenzene
JRC/European Commission (2013) indicates that no data are available for the substance to calculate an actual LCI value. Because of structural similarity, the substance is considered to have similar neurotoxic potential as xylenes, which can then be used as a reference substance. A rounded LCI value of 0.750 mg/m^3 is calculated for diisopropylbenzene based on xylenes' LCI value of 0.492 mg/m^3 (non-rounded value) and adjusting the ratio between the molecular weights of the two substances (MW diisopropylbenzene: 162.3 /MW xylenes: 106.2).

2.3.1.2 LCI values assessed for other hydrocarbons

The JRC/European Commission (2013) report has not derived EU-LCI values for the following hydrocarbons:

- *n*-hexane
- n-heptane
- benzene
- methylstyrene
- white spirit

For the purpose of this project, LCI values for these substances (Table 2.2) have been calculated from the available data, particularly from expert assessments.

TABLE 2.2. CALCULATION OF LCI VALUES FOR OTHER HYDROCARBONS

	n-hexane	benzene	methylstyrene	white spirit
CAS	108-88-3	71-43-2	-	-
Critical effects	Neurotox	Neurotox	Neurotox	Neurotox
NOAEC **LOAEC**	430 mg/m^3 As BMCL	Read-across toluene	Read-across styrene	240 mg/m^3
Factor for adjusting exposure duration	2	-	-	4.2
Overall uncertainty factor (assessment factors)	300	-	-	10
LCI rounded mg/m^3	0.700	2.450	0.800	5.700

n-hexane

SCOEL (1995a) recommended a limit value in the working environment of 72 mg/m^3 based on a LOAEL of 250 mg/m^2 for electrophysiological changes in the peripheral nerves of workers. US EPA in 2008 reevaluated n-hexane and found in a 16-week inhalation study in rats, a dose-related reduction in the peripheral nerve conduction velocity at exposure levels 1762, 4230 and 10574 mg/m^3 (US EPA/IRIS 2008a) From these data, a benchmark concentration (BMCL) of 430 mg/m^3 was calculated as a starting point for the calculation of a reference concentration. In relation to the BMCL value, an uncertainty factor of 3 was used to extrapolate from animals to humans, an uncertainty factor of 10 was used to protect sensitive individuals in the population, including children (data from newborn rat pups showed no higher sensitivity compared to adults) and an uncertainty factor of 3 was used to account for deficiencies in the overall data. Overall, a rounded safety factor of 300 was used, and the reference value (corresponding to an LCI value) was calculated to 0.7 mg/m^3.

n-heptane

SCOEL (1995b) recommended a limit value in the working environment of 2085 mg/m^3 based on a NOAEC of 12 500 mg/m^3 in a 16-week rat inhalation study, as no electrophysiological effects could be found in this study. US EPA in 2008 assessed n-heptane and did not find adequate data to calculate a reference concentration (US EPA/IRIS 2008b). Overall, the data show that n-heptane has a significantly lower neurotoxic potential, so it is not considered relevant to estimatean LCI value, as this will be very high.

Benzene
The relevance for calculating an LCI value for benzene in terms of neurotoxic effects is considered limited as benzene is known as a very potent carcinogen, and therefore an LCI value for protection against carcinogens will be orders of magnitude lower than for the protection against neurotoxic effects.
An indicative LCI value for neurotoxic effects can be calculated with toluene used as a reference substance, and using the LCI value of toluene as a starting point:
LCI-Benzene: LCI-toluene x MW benzene/MW toluene = 2.90 mg/m^3 x 78.11/ 92.14 = 2458 mg/m^3
Corresponding to a rounded LCI value of 2450 mg/m^3.

Methylstyrene
Similarly, an LCI value for methyl styrene can be calculated with styrene as a reference substance:
LCI-Methylstyrene: LCI-styrene x MW methylstyrene/MW styrene = 0.7 mg/m^3 x 118.2/ 104.15 = 0.794 mg/m^3 corresponding to 0.800 mg/m^3.

White spirit
SCOEL (2007) indicates NOAEL in workers to 40 ppm (240 mg/m^3) for chronic neurotoxic effects, whereas IPCS/WHO (1996) considered this level as a LOAEC.
The 240 mg/m^3 is related to an 8-hour workday 5 days a week, and therefore a conversion factor of 24/8 x 7/5 = 4.2 is used, corresponding to a continuous exposure level of 57 mg/m^3.
An uncertainty factor of 2 is used, because there is uncertainty about whether the 240 mg/m^3 shall be considered a NOAEC or a LOAEC. As data are obtained from a larger population of exposed workers, it is estimated that the differences in sensitivity between the workers have been considered. JRC/ European Commission (2013) uses in their report for such data an intrapecies factor of 5 to take into account the particularly sensitive individuals in the general population compared to workers.
Thus, an LCI value of *5700 mg/m^3 for white spirit* is obtained (the sum of C7-C12 hydrocarbons).

2.3.1.3 LCI values for all the prioritised hydrocarbons

Thus, the following LCI values are obtained for the group of hydrocarbons in terms of chronic neurotoxic effects:

TABLE 2.3 OVERVIEW OF LCI VALUES FOR CHRONIC NEUROTOXIC EFFECTS OF HYDROCARBONS

Substance	LCI value mg/m^3
n-hexane	0.700
n-heptane	-
Benzene	2.450
Toluene	2.900
Xylenes	0.500
Ethylbenzene	0.850
Styrene	0.700
Methylstyrene	0.800
Propylbenzenes	0.950

Substance	LCI value mg/m³
Trimethylbenzenes	0.450
diisopropylbenzene	0.750
phenyloctane	1.100
White spirit **C7-C12 hydrocarbons**	5.700

2.3.2 Chlorinated solvents

The following chlorinated solvents documented as having a chronic neurotoxic potential have been selected:

- monochloromethane
- dichloromethane
- trichloroethylene
- tetrachloroethylene

Monochloromethane (methylchloride)

US EPA in 2003 assessed that the most critical effects from exposure to monochloromethane is damage to the cerebellum. As a starting point for calculating a limit value, an 11-day inhalation study in mice was used. In this study exposure for 22 hours per day caused marked degenerative changes in the cerebellum. Based on the study, a NOAEL of 50 ppm corresponding to 103 mg/m³ could be established (US EPA / IRIS 2003a).

Corrected to continuously over a day, this corresponded to a NOAC of 94.4 mg/m³.

To achieve a health-based limit value, US EPA used at a factor of 3.3 to extrapolate to humans, and a factor of 10 to consider differences in sensitivity of the general population. Finally, a factor of 10 was used to extrapolate from 11 days of exposure to life-long exposure and then a factor of 3.3 in order to take into account the incomplete data in terms of whether children are more sensitive due to the developing central nervous system.

Altogether, a total uncertainty factor of 1000 was used resulting in a limit value (reference concentration) of 0.09 mg/m³ (US EPA / IRIS 2003a). Thus, for monochloromethane, an LCI value of 0.9 mg/m³ can be established.

Dichloromethane

DGUV (2007) indicates that the effects on the central nervous system and visual effects have been found in controlled studies in humans at exposure levels of 1060 mg/m³ to 2820 mg/m³ dichloromethane.

US EPA/IRIS (2011) indicates that in a 90-day rat inhalation study, no effects were found after exposure at 2000 ppm. In this study neurological effects were studied by a number of behavioural tests as well as by histopathological examinations.

US EPA/ IRIS (2011) indicates the effect on the liver as the most critical effect of exposure to dichloromethane as this effect on the liver was found at an exposure of 500 ppm in a chronic inhalation study in rats.

SCOEL (2009c) places more emphasis on observations in the working environment and indicates that exposure at levels up to 100 ppm has not caused harmful effects. Based on this, SCOEL suggests a limit value in the working environment of 100 ppm (353 mg/m³), with a short-term value of 200 ppm to prevent acute neurotoxic effects.

Based on a NOAEL of 353 mg/m³ for workers, an LCI value can be calculated for the general population.

The exposure in the working environment is converted to 24 hours of continuous exposure:

353 mg/m³ / (24h/8h x 7d/5d) = 84 mg/m³

As suggested by JRC/ EU Commission (2013), a factor of 5 is used to consider the fact that there may be higher sensitivity in the general population in relation to the workers.
On this basis, an LCI value for dichloromethane of 16.8 mg/m^3 is obtained.

Trichloroethylene
WHO (2010) indicates in their "Guidelines for Indoor Quality" that the most critical effect of trichloroethylene is the carcinogenic effect and indicates in this regard 2.3 µg/m^3 as an exposure level that increases the lifetime cancer risk by 10^{-6} (i.e. this lifetime exposure level in a population theoretically will result in one additional cancer case among 1 million inhabitants).
Further, it is indicated that inhalation studies in rats and rabbits after 6 to 18 weeks of inhalation at exposure levels from 50 ppm to 3200 ppm have shown electrophysiological changes in the brain, delayed nerve impulse by audio signals and effects on the vision. LOAEC was indicated as 50 ppm (274 mg/m^3) for electrophysiological effects of the brain.
SCOEL (2009a) indicates that it is difficult from the available data to define a threshold value for neurological effects in the working environment associated with exposure to trichloroethylene. However, increased incidence of chronic brain damage was reported among workers at estimated levels at about 274 mg/m^3 in connection with the use of trichloroethylene as a degreaser.
DGUV (2007) assesses the NOAEC in the working environment to be 274 mg/m^3, as effects were seen at higher levels of 380 mg/m^3 and 540 mg/m^3.
On this basis, 274 mg/m^3 is considered a LOAEC in the working environment.
Based on a LOAEC of 274 mg/m^3 for workers, an LCI value can be calculated for the general population.
The exposure in the working environment is converted to 24 hours of continuous exposure:
274 mg/m^3 /(24h/8h x 7d/5d)= 65 mg/m^3.
There is some uncertainty about the NOAEL in the working environment, and therefore a factor of 2 is used to extrapolate from LOAEC to NOAEC. Then, as argued by JRC/EU Commission (2013) an intraspecies factor of 5 is used to consider the fact that there may be higher sensitivity in the general population compared to workers.
On this basis, an LCI value of 6.5 mg/m^3 is obtained for trichloroethylene.

Tetrachloroethylene
WHO (2010) indicates in their "Guidelines for Indoor Quality" that the most critical effect of tetrachloroethylene is nephrotoxicity effect and therefore proposes a limit value in the indoor environment of 0.25 mg/m^3.
Further, it is stated that acute exposure in humans may cause CNS effects at about 340 to 2040 mg/m^3. Several studies suggest that relatively low levels of tetrachloroethylene can affect the colour vision in humans. In dry cleaning workers, impaired colour vision has been found down to an exposure level of 30 mg/m^3.
In mice orally dosed with tetrachloroethylene as newborns, behavioural effects were seen in adulthood, which indicates a particular sensitivity in the developmental phase of the nervous system.
WHO (2013), however, does not consider effects on the central nervous system as critical to the setting of a limit value in the indoor environment.
DGUV (2007) proposes a NOAEL value of 345 mg/m^3 for tetrachloroethylene in relation to the neurotoxic effects associated with occupational environmental exposure, but simultaneously indicates that the data are very uncertain.
SCOEL (2009b) proposes a limit value in the working environment of 20 ppm (138 mg/m^3) and states in that regard that this level is also considered a NOAEC in terms of neurotoxic effects.
The studies, that found effects on the colour vision at lower levels, are considered by SCOEL to be too insufficient and uncertain to be further included in the assessment.

Based on a NOAEL of 138 mg/m^3 for workers, an LCI value for tetrachloroethylene can be calculated for the general population.

The exposure in the working environment is converted to 24 hours of continuous exposure:
138 mg/m^3 / (24h/8h x 7d/5d) = 33 mg/m^3.

As suggested by JRC/ EU Commission (2013), an intraspecies factor of 5 is used to consider the fact that there may be higher sensitivity in the general population in relation to the workers.

On this basis, an LCI value of 6.6 mg/m^3 is obtained for tetrachloroethylene.

2.3.2.1 LCI values for prioritised chlorinated solvents

TABLE 2.4 CALCULATED TOLERABLE EXPOSURE LEVELS, LCI VALUES FOR NEUROTOXIC EFFECTS OF CHLORINATED HYDROCARBONS

Substance	LCI value mg/m^3
Monochloromethane	0.090
Dichloromethane	16.800
Trichloroethylene	6.500
Tetrachloroethylene	6.600

2.4 Children’s exposure and sensitivity

2.4.1 Exposure

Above, the tolerable concentrations in the air (the indicated LCI-levels which again correspond to DNEL-values as used in the REACH regulation) have been calculated from the daily inhalation volume of an adult. As default value, an adult of 70 kg is considered to inhale 20 m^3 air per day, i.e. the person inhales 0.29 m^3/kg bw/d (NCM 2011).
Children aged 1-3, with an average body weight of 11.6 kg inhale on average 7.0 m^3 air per day corresponding to 0.60 m^3/kg bw/d; that is twice as high a dose of air per kg body weight as adults (NCM 2011).

This means that if the tolerable air concentration is calculated based on data on adults, the limit value should actually be a factor of 2 lower for children to achieve the same exposure per kg body weight.

2.4.2 Sensitivity

It is generally accepted that organ systems under development can be more sensitive than the fully developed organs. Thus, there is a particular focus on the increased sensitivity of the development of the nervous system, the immune system and also the sexual development in children. In such situations, where the critical effects of chemicals are related to these organ systems/processes, REACH guidelines R8 concerning the derivation of DNEL values states that an increased intraspecies assessment factor can/should be used compared to the traditional factor (ECHA 2012a).

The European Scientific Committee on Consumer Products (SCCP) in 2006 assessed the safety of the use of toluene in nail polish and indicates in the assessment in relation to children that there is no specific data available illustrating to which extent children are more sensitive than adults. As no particular practice concerning increased sensitivity of children towards neurotoxic effects has been found in the literature, this project takes a pragmatic approach, and use an additional uncertainty factor of 2 to consider children's higher sensitivity associated with neurodevelopment.

2.4.3 Adjustment of tolerable exposure

Based on the above aspects it is found relevant to adjust the above estimated LCI values to achieve more specific values with regard to children's higher exposure (a factor of 2) and sensitivity (an additional factor of 2). The above estimated LCI values will therefore be adjusted by a factor of 4 to obtain LCI values specifically applicable to children, see Table 2.5.

TABLE 2.5. LCI VALUES FOR PROTECTION AGAINST NEUROTOXIC EFFECTS IN CHILDREN (1-3 YEARS)

Substance	LCI value child mg/m³	Odour threshold* mg/m³
n-hexane	0.700**	5.3
n-heptane	-	2.7
Benzene	0.600	8.6
Toluene	0.725	1.1
Xylenes	0.125	0.16-1.5
Ethylbenzene	0.200	0.67
Styrene	0.175	0.13
methylstyrene	0.200	-
propylbenzenes	0.240	0.02-0.04
trimethylbenzenes	0.100	0.56-0.79
diisopropylbenzene	0.200	-
phenyloctane	0.275	-
White spirit C7-C12 hydrocarbons	1425	0.5-5
Monochloromethane	0,045***	-
Dichloromethane	4200	556
Trichloroethylene	1.625	21
Tetrachloroethylene	1.650	5.2

*odour thresholds from Nagata (2003). The odour threshold for white spirit is from Danish EPA (2008a)

** the value is not adjusted, as data on exposure at the development stage are included in the calculation of the value

***for monochloroethane, a correction factor of 2 was used for children's higher exposure, as US EPA for the calculation of their reference value has taken into account that data are missing for particularly sensitive stages and thus implicitly considered children's special sensitivity

The table includes an additional column with odour limits for several of the substances. These values show that the LCI value for several of the substances is below the odour threshold, i.e. odour cannot be regarded as an early warning signal. That is, if the odour can be perceived the LCI values for several of the substances have already been exceeded.

3. Exposure assessments based on literature data

This chapter summarises the knowledge of the exposure for the selected substances in Chapter 2, focusing on exposure to products relevant to a children´s room. Furthermore, data are collected regarding measured levels of the substances in the indoor environment. Then, we assess the extent, to which "background exposure" from other sources occurs, such as outdoor air, transport, wood combustion and foods, which should be involved in an overall exposure assessment.

3.1 Exposure sources in the children´s room

To calculate any risk, it is important to know the exposure in the children´s room. As the focus of this project is chronic neurotoxic effects, it was found most relevant to evaluate the average exposure over time, as the LCI values are derived as protective levels for chronic continuous exposure. In the assessment of exposure scenarios, the exposure estimation should therefore be made in order to evaluate the total load of the substances over time.

If there is knowledge of the emission rate of the individual chemical substances from a specific article (e.g. a consumer product/toy, a piece of furniture or a building material), an exposure scenario can be set for each individual source. For each of these products, the amount of the product in the children´s room has to be considered, and also whether the exposure scenario should include the initial use phase (i.e. when the product is new or the surface is newly treated), or whether to consider an average scenario over a longer period in which the evaporation from the product is at a lower and more constant level after the initial period.

A number of parameters are relevant for the exposure estimation in the children´s room:

- Which chemical substances evaporate from an article/a product
- The area-specific emission rate of the individual substances (depends on the temperature, the product age, etc.)
- Amount/surface of the article in the room/children´s room
- The combination/distribution of the various articles from which evaporation may occur (toys, furniture, building materials)
- Age of the various articles
- The volume of the children´s room
- Air change in the children´s room

The sources of exposure for the specific substances can as mentioned include a wide range of consumer products, household wares and building materials, so overall, because of the many sources and variables, it can be very complex to develop exposure scenarios and calculate realistic average contributions (or worst-case contributions) from the individual sources.

Thus, a number of assumptions must be made in terms of volume/quantity of each source in the children´s room, emission rates of the individual volatile substances from the source. Further a critical point is the likelihood that several or all current articles, appearing in a children´s room at exactly the same time, contain and emit the critical substances.

As mentioned, another important factor is the age combination of the toys, home articles/building materials, as many new products may have high peak emissions of VOC substances during the first days /weeks, after which the emission falls to very low levels, while other products may emit substances at a lower but more constant rate.

Wisthaler (2012) described the time-dependent decrease of the emission rate from a painted surface and also compared this to the change in the emission rate from carpets and wood flooring, see Table 3.1.

TABLE 3.1 EMISSION RATE FROM PAINTED SURFACE, CARPET AND WOOD FLOORING (WISTHALER 2012)

	Area-specific emission rate (µg/hour/m²)				
	1 hour	*1 day*	*1 week*	*1 month*	*1 year*
	Solvent based paint				
Nonane	100 000	100	0	0	0
Decane	200 000	2000	0	0	0
Undecanes	120 000	12 000	0	0	0
Pentyl-cyclohexane	10 000	3 000	0	0	0
Dodecane	10 000	15 000	0	0	0
Xylenes	70 000	10	0	0	0
3,4-ethyltoluene	10 000	100	0	0	0
Trimethylbenzenes	16 000	700	0	0	0
	Wooden flooring				
Nonane	5	5	4	3	<1
Decane	50	50	40	30	<1
Undecane	50	50	40	20	<1
Toluene	10	10	10	10	3
p-xylene	10	10	10	10	1
Ethylbenzene	3	3	3	3	<1
Trimethylbenzenes	20	20	20	10	<1
	Carpet				
4-phenylcyclohexane	30	30	50	30	5
Toluene	300	40	20	10	1
Styrene	50	20	6	3	1

It appears that exposure from a painted surface, such as a shelf, is very low, if the shelf has been allowed to evaporate for a week before the mounting in the room. If paint with organic solvents is used in the room, this will, however, give a very high exposure during the first week. However, in such situations, the smell of the substances is considered to limit the exposure, as the strong odour e.g. from white spirit containing alkylbenzenes will encourage thorough ventilation of the room.
It can also be seen that there is a more constant contributions from evaporation from a carpet and a wooden floor through the first months to year of the use of the products.

The overall challenge is therefore to provide exposure scenarios that are both realistic and at the same time are likely to give rise to high concentrations of the emitted substances as this could then represent worst case scenarios of possible concern.

3.2 Calculated indoor climate levels of neurotoxic substances

Despite the methodological challenges by calculating an overall exposure level in a room, the Danish Environmental Protection Agency's report "Overall health assessment of chemical substances in the indoor environment from various consumer products" from the 2006 has used this approach (Danish EPA 2006a). Here exposure calculations were made based on measured data (from the Danish EPA's consumer projects) regarding ingredients in consumer products for a number of selected substances, including benzene, toluene, xylenes and styrene.

As indicated in Appendix 2, these substances were found in a wide range of consumer products in the series of the Danish EPA's consumer projects. In the Danish EPA (2006a) report modelling is done based on emission rates from the products in a children´s room (a room of 17.4 m^3 with an air change of 0.5 times per hour) equipped with 28 products/articles with potential evaporation. For the emitted hydrocarbons, especially electrical appliances/electronics could be designated as important for a sustained evaporation to the indoor environment, see Table 3.2.

TABLE 3.2 CALCULATED CONCENTRATIONS OF SELECTED HYDROCARBONS IN A CHILDREN´S ROOM. THE VALUES IN THE TABLE INDICATE EVAPORATION FROM NEW/USED PRODUCTS (DANISH EPA 2006A).

	Benzene µg/m^3	Toluene µg/m^3	Xylenes µg/m^3	Styrene µg/m^3
Computer	0.8 / 0.7		10.5 / 8.6	2.5 / 1.8
Monitor		38.3 / 16.0	24.2 / 7.9	14.8 / 4.1
Game console		0.2 / 0.2	0.7 / -	1.8 / 0.2
Decorative lamp		6.7 / 1.0	23.0 / 4.7	0.3 / -
TV		2.0 / 2.2	1.8 / 2.0	1.5 / 1.4
Mobile phone/ Charger		2,0 / -	0,1 / -	
Charger/ transformer			25.6 / 15.2	
Rechargeable batteries			19.5 / 5.3	0.8 / 0.2
Total	0.8 / 0. 7	49.2/19.4	105.4/43.7	21.7 / 7.7

In a relatively new publication, Lim et al. (2014) measured the content of BTEX (benzene, toluene, ethylbenzene and xylenes) in 207 selected consumer products. Of the 207 products, 59 products contained BTEX (divided between 18 product types). From the measured content, the contribution of each of the 18 product types to the indoor environment was calculated to a 20 m^3 room with an air change of 1.34 times per hour.

> For benzene, the highest levels in the indoor air were estimated due to evaporation from the use of glue (0.74 mg/m^3) and correction fluid (0.095 mg/m^3).
>
> For toluene, the highest levels in the indoor air were estimated due to evaporation from use of tapes (4.07 mg/m^3) and glue (2.54 mg/m^3).

For ethylbenzene, the highest levels in the indoor air were estimated due to evaporation from use of marker pens with permanent colour (345 mg/m3), shoe polish (12.4 mg/m3) and leather cleaner (9.45 mg/m3).

For xylenes, the highest levels in the indoor air were estimated from evaporation when using marker pens with permanent colour (285 mg/m3) and shoe polish (3.91 mg/m3).

The above can be considered short-term exposure levels associated with the use of chemical products, while other products such as wall and floor coverings will contribute with more constant and somewhat prolonged exposure. Lim et al. (2014) found that a self-adhesive wallpaper resulted in the highest contribution in the form of toluene into the air of 0.036 mg/m3.

Lim et al., (2014) then calculated partly the inhaled dose of BTEX and partly the dose obtained in contact with skin, as skin absorption rates in the range of 0.05 % and 3 % were used for the four substances. The calculations showed that dermal exposure was many orders of magnitude (often 106 times) lower than via inhalation and thus contributed only slightly to the total exposure.

To put these calculated indoor exposure levels made by the Danish EPA (2006a) and Lim et al., (2014) into perspective, the levels can be compared to measurements of actual indoor levels of the substances in private homes, see below.

3.3 Measured levels in the indoor environment

3.3.1 Hydrocarbons

A very important source of information regarding measured levels in the indoor environment is a publication concerning the European AIRMEX study (Geiss et al., 2011). In this study, 14 VOC substances were measured in 11 European cities. The measurements consisted of measurements inside public buildings, schools and kindergartens, private homes, and personal exposure measurements using portable equipment. The measurements were made during a week in the summer and during a week in the winter in the 11 cities. Below the results obtained for the VOCs relevant to this project (i.e. neurotoxic substances) are given. The values in Table 3.3 are given partly as median values and partly as 95th percentile values, as the latter can be considered more relevant for situations with specific indoor sources.

TABLE 3.3. MEASURED CONCENTRATIONS (FOR 11 EUROPEAN CITIES) OF HYDROCARBONS IN THE AIR (STATED AS MEDIAN VALUE/ 95TH PERCENTILE VALUE). DATA FROM THE AIRMEX-STUDY (GEISS ET AL., 2011).

Substance	Outdoor µg/m3	Schools & public buildings µg/m3	Private homes µg/m3	Portable measurement µg/m3
n-hexane	1.1 / 3.6	1.7 / 7.6	1.4 / 3.5	2.4 / 9.7
n-heptane	0.4 / 0.7	0.6 / 3.1	0.7 / 2.4	0.9 / 3.8
methylcyclohexane	0.3 / 1.2	0.7 / 14.1	0.5 / 3.7	0.8 / 9.2
n-decane	5.7 / 9.4	13.1 / 22.4	15.6 / 30.5	22.7 / 35.2
n-undecane	0.5 / 1.9	1.4 / 6.3	2.3 / 20.0	2.4 / 8.4
n-dodecane	5.7 / 9.4	13.1 / 22.4	15.6 / 30.5	22.7 /35.2
Benzene	2.1 / 8.0	2.6 / 11.9	1.9 / 4.9	5.3 / 13.6
Toluene	4.8 / 33.2	7.1 / 47.6	6.5 / 28.4	11.7 / 55.3

Substance	**Outdoor** µg/m³	**Schools & public buildings** µg/m³	**Private homes** µg/m³	**Portable measurement** µg/m³
Xylenes	3.4 / 21.7	4.1 / 28.6	4.0 / 13.0	6.7 / 42.3
Ethylbenzene	1.1 / 6.1	1.3 / 7.4	1.1 / 3.8	1.8 / 8.2
Styrene	0/ 1.1	0 / 2.4	0 / 1.0	0 / 2.5
1,2,4-trimethylbenzene	0.9 / 8.2	1.2 / 13.6	1.1 / 6.6	1.6 / 8.8
Total	26.0 / 104.7	46.9 / 197.2	50.7 / 148.3	79.0 / 232.2

By grouping the data according to northern European cities and southern European cities, it was observed that indoor levels for the total content of aromatic hydrocarbons was about 4 times higher in cities in southern Europe compared to cities in northern Europe. Thus, the figures in the table may be considered to overestimate the levels of the northern European conditions.

As the table shows, the indoor levels for all substances are higher than the outdoor levels, which points towards sources in the indoor environment. Also, it can be seen that the portable levels are approximately 1.5 times higher than the residential levels, which may be attributed to activity based exposures where the person is closer to the source and may be more heavily exposed compared to the average contamination level in the indoor air. Further, people who during the day are staying in different microenvironments may also be subjected to additional types of exposure, e.g. during transportation in heavy traffic or when refueling at petrol stations.

By looking at the levels in private homes in Table 3.3, it can be seen that the 95th percentile value for toluene corresponds roughly with the estimate in Table 3.2, while the measured levels of xylenes and styrene in Table 3.3 are significantly lower than estimated in Table 3.2. However, it is difficult from this to assess whether the modelling carried out in Section 3.2 provides a true picture of the exposure in the indoor environment. This will require more standardised circumstances when comparing model calculations and indoor air measurements.
However, in this project, a closer link between modelling and emission measurements from individual products will be made using both measurements in emission chambers and measurements from a mock-up chamber (a chamber simulating a children´s room).

3.3.2 Chlorinated compounds

Trichloroethylene
For trichloroethylene, WHO (2010) indicated an average content of 1 µg/m³ with a 95th percentile value of 7.4 µg/m³ based on indoor measurements in France during 2003-2005.

Tetrachloroethylene
For tetrachloroethylene, WHO (2010) indicated an average content of 1.4 µg/m³ with a 90th percentile value of 5.2 µg/m³ based on indoor measurements in France during 2003-2005.

Especially for tetrachloroethylene there is data from Denmark as the Danish EPA has made several indoor measurements in neighbouring apartments to dry cleaning (using tetrachloroethylene as cleaning liquid) as well as in homes without any known sources (Danish EPA 2001).

Data from a study involving 24 homes without any known tetrachloroethylene sources is summarised in table 3.4, below. The measurement results are grouped into several concentration intervals from the detection limit of 0.02 µg/m³ to the highest measured value of 2.2 µg/m³.

Subsequent investigation showed that in homes with a tetrachloroethylene content above 1 µg/m^3, they had recently brought home dry-cleaned clothes (Danish EPA 2001).

TABLE 3.4 DISTRIBUTION OF MEASUREMENT RESULTS FROM INDOOR ENVIRONMENTAL STUDY OF 24 HOMES IN DENMARK (DANISH EPA 2001)

Concentration level of tetrachloroethylene	Number of measurements	Percentage
<0.02 -0.10 µg/m3	16	66 %
0.11 -0.25 µg/m3	2	8 %
0.26 -1.0 µg/m3	3	13 %
1.1 – 3.0 µg/m3	3	13 %
Total	24	100 %

In connection with the use of tetrachloroethylene for dry-cleaning, the Danish Environmental Protection Agency has conducted a number of assessments and measurements of tetrachloroethylene in newly cleaned clothes and in the indoor environment. Here it was found that the newly cleaned clothes could contribute significantly to the level of exposure in the indoor environment. A newly cleaned suit and a newly cleaned winter coat with a measured residual content of 0.01- 0.03 w/w % of tetrachloroethylene were found to contribute for the first two weeks with an average elevated level of tetrachloroethylene of 92 µg/m^3 in a room in a poorly ventilated, small apartment, and 13 µg/m^3 in a room in an average house. In other part of the homes the average level during the first 14 days were 27 µg/m^3 and 5 µg/m^3 in the apartment and in the house, respectively.

Monochloromethane and dichloromethane

For these substances there are no data related to indoor air levels. As for trichloroethylene and tetrachloroethylene, there has been focus on these substances and the use of these because of suspected carcinogenic effect of the substances. Thus, the levels of these substances in indoor air are not considered to be higher than those for tri- and tetrachloroethylene.

3.3.3 Activity related exposures

Since hydrocarbons and chlorinated substances may be present in glue/adhesives and partly in paints, coatings and degreasers, there might be highly elevated exposure by occasional activities using such products, e.g. by repair work and hobby activities.

The LOUS report for toluene described consumer scenarios in connection with hobby gluing, spray paint and gluing of a carpet based on the information in the EU risk assessment report. These scenarios achieved respective inhalation concentrations/levels in the room of 7 mg/m^3; 1000 mg/m^3 and 195 mg/m^3 related to the activity (Danish EPA 2014a).

The LOUS report for white spirit reported measured exposure levels in connection with painting in the interval of 270 – 6140 mg/m^3 with the highest levels in connection with painting in poorly ventilated rooms. For shoe polish with 85 % content of white spirit, an exposure level of 960 mg/m^3 was estimated (Danish EPA 2014c).

These figures show that although the activities may take place rarely, they will each contribute with momentary very elevated levels, which can make a significant contribution to the average-weighted exposure.

The LOUS report for styrene reported long-term exposure to styrene of 5 µg/m³ for emissions from polymeric building materials, including carpets (Danish EPA 2014b).

3.3.4 Background exposure

3.3.4.1 Exposure in cars

The selected neurotoxic hydrocarbons forms a major component of petrol. In motor fuel that mainly consists of C5-C10 hydrocarbons, aromatic hydrocarbons constitute around 20-50 %, where the majority of the aromatics content is from BTEX, especially with toluene as predominant. As passengers in cars, people will be exposed to the hydrocarbons from evaporation of the fuel or from unburned residues in the exhaust.

Fedoruk & Berger (2003) measured VOC concentrations in three different car brands from 1993, 1997 and 1997. The VOC level was widely depending on the brand and temperature. The following levels were given in the article, Table 3.5.

TABLE 3.5 MEASURED VOC VALUES IN CAR CABINS DURING DRIVING AND WITH THE ENGINE OFF (FEDORUK & KERGER 2003)

Substance	Stationary cars under hot conditions µg/m³	Running car with air conditioning µg/m³	Car in heavy traffic µg/m³
Hexane	5.2	1.8	9.9
3- methylpentane	3.1	2.8	26
Benzene	1.9	2.4	26.4
Toluene	71.4	11.8	101.3
Xylenes	17.4	5.1	73.6
Ethylbenzene	4.2	2.0	14.3

Faber et al. (2014) measured VOC in the cabins of 9 different new cars with the engine off and the windows closed. Here, the emissions was considered due to evaporation from the cabin components rather than the contribution of the motor fuel (see Table 3.6).

TABLE 3.6 HYDROCARBON LEVELS IN THE CABINS OF NEW CARS (FABER ET AL., 2014)

Substance	Highest average values from two sets of measurements µg/m³	Ranges µg/m³
Hexane	5.8	2.8 - 9.9
Alkanes C6-C15 hydrocarbons	612	316.6 – 878.4
Cycloalkanes C6-C10	162	46.6 – 247.5
Benzene	11.4	8.0 – 19.6
Toluene	54.7	35,5 – 74,8
Xylenes	45.3	26.5 – 64.8
Ethylbenzene	8.8	5.9 – 11.1

Substance	Highest average values from two sets of measurements µg/m^3	Ranges µg/m^3
Styrene	4.3	3.7 – 5.2
Propylbenzenes	5.4	2.1 – 11.6
Trimethylbenzenes	28.1	18.9 – 36.7
Aromatic C6-C11 hydrocarbons	237	136.6 – 266.3

The table shows that the sum of the C6-C15 hydrocarbons may reach a level of about 1 mg/m^3 in the cabins of new cars.

3.3.4.2 Wood combustion

Different VOC substances, including benzene, toluene, ethylbenzene and xylenes (BTEX), as well as particles have been described as potential critical components of wood combustion.
An Australian study examined whether the indoor environment in homes with wood stoves was extra affected in terms of the content of BTEX (NHT 2004). 28 homes without wood stoves and 49 homes with wood stoves were examined using outdoor, indoor and portable measurements during 7 days in the summer and 7 days in the winter.

By statistical processing of data, it was concluded that the stoves did not influence the BTEX levels indoors, while outdoor levels of the substances were affected by using the stoves. Generally, higher BTEX indoor air levels than outdoor air levels were measured, and highest in the winter. The average indoor levels of BTEX in the winter was for benzene 2.29 µg/m^3, toluene 6.39 µg/m^3, ethylbenzene 0.57 µg/ m^3 and xylenes 3.29 µg/m^3. These levels were approximately twice as high as the outdoor levels.
The indoor levels are comparable with the levels stated for the 11 European cities in Table 3.3.

Though the data are scarce, it is estimated from this rather thorough investigation described above that wood combustion is generally not a significant source of exposure to BTEX substances in the indoor environment.

3.3.4.3 Drinking water

In Denmark, there is very strict requirements for the content of hydrocarbons and chlorinated compounds in drinking water. The following limit values regarding the quality of drinking water have been set (Ministry of the Environment 2011):

Benzene: 1 µg/l
Styrene: 1 µg/l
Alkylbenzenes: 1 µg/l (sum of trimethylbenzenes)
Volatile organic chlorinated compounds: 1 µg/l (individually); 3 µg/l (sum)

Thus, the population will be exposed to those substances from drinking water to an insignificant degree compared with inhalation exposure as described above.

3.3.4.4 Food

The WHO background documents for establishing limit values in drinking water estimated the ingestion of the substances through food as well. For the substances benzene, toluene, ethylbenzene, dichloromethane, trichloroethylene and tetrachloroethylene, it was assessed that the content in food is very low, and that exposure through food is negligible compared to exposure via inhalation at the existing background levels.

For styrene, WHO assessed an intake via food to be about 5 mg/day as a result of migration of styrene from polystyrene packaging used in food packaging (WHO background documents): http://www.who.int/water_sanitation_health/dwq/chemicals/en/).

If it is assumed that a 1-3 year-old child with a body weight of 11.6 kg consumes 5 µg styrene from food and 1 µg styrene from drinking water, this total amount of 6 µg styrene can be compared with the exposure via the air at a tolerable level of styrene in the air of 0.175 mg/m^3 (LCI value indicated in Table 2-5). As the child in average inhales 7 m^3 air per day, the exposure via the air will be: 7 m^3/d x 0.175 mg/m^3 = 1.2 mg per day. I.e. the inhalation exposure at the LCI value causes about 200 times higher exposure than the oral background exposure.

On this basis, the oral background exposure is not expected to be significant relative to exposure via inhalation of the designated substances, and therefore oral exposure will not be considered further in this project.

4. Risk assessments based on literature data

In this chapter, a preliminary risk assessment is made from the calculated and measured levels in Chapter 3, as the levels are compared with the tolerable exposure levels calculated in Chapter 2.

4.1.1 Risk assessment of exposure to one and several neurotoxic substances

The risk assessment in this project is carried out along the lines used in connection with the REACH chemicals regulation (ECHA 2012b).

Risk assessment is made by calculating the risk characterization ratio, RCR for each of neurotoxic substances, where RCR:

$$RCR(1) = \frac{Calculated\ or\ measured\ exposure\ (1)}{LCI\ value(1)}$$

If the calculated or measured exposure to the substance (1) exceeds the LCI value for the substance, and RCR (1) thus becomes higher than 1, the exposure scenario is considered to pose an unacceptable risk.

To assess the risk of concurrent exposure to several of the substances, summation of the individual RCR values is used:

$$RCR(sum) = RCR(1) + RCR(2) + \ \ldots RCR(n)$$

If $RCR_{(sum)}$ exceeds 1, the overall exposure to these substances within a group of substances is considered to pose an unacceptable risk.

4.1.2 Risk assessment of exposure levels in the indoor environment

Table 4.1 below shows a comparison of measured exposure values for the designated hydrocarbons and chlorinated solvents as well as calculation of the RCR values.

In the column *indoor environment,* RCR values were calculated from the levels in indoor air corresponding to the 95th percentile for housing from Table 3.3.

In the column *transport,* the exposure levels of heavy traffic from Table 3.5 were used, as the contribution is based on one hour of daily transport, and therefore the concentrations in the table below are given as 1/24 of the values in Table 3.5. For 7-C12 hydrocarbons, data from Table 3.6 were used.

TABLE 4.1 RISK ASSESSMENT AND CALCULATED RCR VALUES FOR EXPOSURE TO NEUROTOXIC SUBSTANCES IN THE INDOOR ENVIRONMENT AND DURING TRANSPORT

Substance	LCI value, children µg/m³	Indoor environment exposure 95th perc. in µg/m³/ RCR	Transport exposure in µg/m³/ RCR
n-hexane	175	3.5 /0.020	0.4/0.002
n-heptane	-	2.4/-	
Benzene	600	4.9/0.008	1.1/0.002
Toluene	725	28,4/0,039	4,2/0,006
Xylenes	125	13.0/0.104	1.9/0.015
Ethylbenzene	200	3.8/0.019	0.4/0.002
Styrene	175	1.0/0.006	0.2/0.001
Methylstyrene	200	-	
propylbenzenes	240	-	0.2/0.001
trimethylbenzenes	100	6.6/0.066	1.2/0.012
diisopropylbenzene	200		
Phenyloctane	275		
C7-C12 hydrocarbons, sum	1425	(148.3/0.104)	(49/0.034)
Monochloromethane	45	-	
Dichloromethane	4200	-	
Trichloroethylene	1625	-	
Tetrachloroethylene	1650	27*/0.016	
RCRsum		**0.278**	**0.041**
****C7-C12 hydrocarbons, total**	1425	148.3/0.104	49/0.034

*For tetrachloroethylene, a worst-case scenario is used corresponding to bringing home every 2 weeks newly cleaned clothes to a small, badly ventilated apartment.

** RCR for C7-C12 hydrocarbons is not included in RCRsum, as the LCI value for C7-C12 hydrocarbons is a separate criterion based on data for the sum of C7-C12 hydrocarbons.

The table shows that RCR_{sum} can be calculated to 0.28 for the indoor environment at 95th percentile values measured in the major European AIRMEX study.
When adding to this, the exposure contribution from 1-hour car transport, the RCRsum value increases by 0.04 to approximately 0.32.

The general picture, up to an exposure level corresponding to a 95th percentile level of the measured values, does not indicate any risk of exceeding an RCR_{sum} value of 1.

However, it is worth noting that 5 % of the indoor environment values in homes in the AIRMEX study is higher than the values listed in the table and that the maximum values for e.g. toluene, xylenes and trimehtylbenzene were 161 µg/m³, 49 µg/m³ and 59 µg/m³, respectively.

RCR in relation to these measured maximum levels can be calculated to 0.22 for toluene, 0.39 for xylenes, and 0.59 for trimethylbenzenes. Although not listed in the publication regarding AIRMEX (Geiss et al. 2011), it must be assumed that elevated indoor values of the lower aromatic hydrocarbons (toluene-xylenes-trimethylbenzenes) accompany each other, as they often originate simultaneously from hydrocarbon mixtures, e.g. in gasoline.

This indicates that in rare cases, probably in connection with specific sources, the sum of the RCR values for neurotoxic hydrocarbons could exceed a value of 1 in the indoor environment.

4.1.3 Risk assessment of the calculated exposure levels

If, however, the estimated indoor environment values associated with degassing from 8 new and 8 used electronic products as indicated in Table 3.2 are used as a starting point for the risk assessment, the following RCR values can be calculated, see Table 4.2.

TABLE 4.2 RISK ASSESSMENT AND CALCULATION OF RCR VALUES FOR EXPOSURE TO NEUROTOXIC SUBSTANCES IN THE INDOOR ENVIRONMENT FROM ELECTRONIC PRODUCTS

Substance	LCI value µg/m³	Indoor environment Exp. from new electronic products µg/m³/ RCR	Indoor environment Exp. from used electronic products µg/m³/ RCR
Benzene	600	0.8/0.001	0.7/0.001
Toluene	725	49.2/ 0.068	19.4/ 0.027
Xylenes	125	105./0.843	43.7/0.350
Styrene	175	21.7/0.124	7.7/0.044
RCRsum		-/**1.036**	-/**0.422**

The table shows that an RCRsum value of above 1 is obtained in connection with a scenario where all electronic products are new and are used in the same room. For both the new and used electronic products, the evaporation of xylenes is the most critical for the size of the RCR values.

4.1.4 Overall assessment of exposure and risk

From the above it appears that in order for the RCR values and the sum of these to exceed 1, it will probably require that one or more sources in the children´s room has a high initial evaporation, which influences the indoor environment for a limited duration: days/weeks/possibly months.

Based on the available data, it is difficult to say whether the calculated levels in the indoor environment from the evaporation of electronics (and other products) are accurate. To clarify this and to gain knowledge on RCR values under realistic worst-case conditions, more standardised emission measurements of selected toys, furniture and building materials have to be performed as basis for updated calculations.

5. Identification of sources for follow-up emission analyses

This chapter will identify specific products that are considered relevant to children´s rooms, and that with a certain probability are considered to contain one or more of the chronic neurotoxic substances. From the literature - especially the Danish EPA's consumer projects and the LOUS projects - children´s room relevant products are selected, such as toys, electronics, furniture, and building materials. An overall list of product categories is developed for the use of selecting specific products for the subsequent emission analyses in phase 2 of the project.

5.1 Sources

5.1.1 Consumer products/ toys

Initial identification of consumer products with content/emission of neurotoxic substances was undertaken by using the information in:

- the Danish EPA's database of substances found in consumer products (data from all Danish EPA consumer projects)
- the Danish EPA's LOUS projects
- using web-search as mentioned in Section 2.2

More details on this and identification of child relevant consumer products, furniture and building materials is specified in Appendix 2 and 3.

From the review in Appendix 2, the following list of priority products, which might occur/be used in the children´s room, can be established:

- Plastic beads
- Rubber figures
- Textile impregnation spray
- Cuddly toys
- Igloo tents/small tents (including inflatable plastic tents/houses)
- Printed material/comics
- Christmas decorations
- Computer/TV screens
- Markers
- Transformers/chargers
- Lamps

Additional literature search identified studies in which evaporation of toluene/ethylbenzene/xylenes was reported from printed material/magasines, rubber balloons, pencils/pens, tape,

slippers and bath/swim rings. Evaporation of hexane was found from glue, tape, modelling clay and rubber bands (Kataoka et al., 2012).
These data give rise to further inclusion of:

- Rubber balloons
- Bath/swim rings
- Slippers
- Modelling clay
- Tape
- Glue

5.1.2 Household furniture and building materials

Based on the review in Appendix 3, the following products are likely to contribute significantly to the exposure to the mentioned substances:

- Paint and laquer
- Carpets*
- Wood-based panels for flooring
- Larger furniture
- Self-adhesive wallpapers and foils

Furthermore, cleaning agents may be considered a possible source of exposure (mainly short-term) to toluene and chlorinated solvents.

**Please note that measurements and information on evaporation from carpets used in children´s room is covered by another ongoing Danish EPA project (Danish EPA 2016), and relevant data regarding the emission of volatile neurotoxic substances from this projects will be included here.*

5.1.3 Gross list for the selection of toys, furniture and building materials

Altogether, this gives the following gross list (Table 5.1) in terms of types of toys, furniture and building materials as relevant for emission of one or more of the neurotoxic substances.

TABLE 5.1 GROSS LIST FOR THE SELECION OF TOYS, FURNITURE AND BUILDING MATERIALS AND MEASURED OR ESTIMATED INDOOR/INHALATION LEVELS (IN µG/M³ IF NOT OTHERWISE INDICATED)

Product	BTEX	Styrene	Alkanes C6-C12	Other substances	Reference
Plastic beads	T: 720 X: 430	720			Danish EPA 2006a
Rubber figures, Perfumed	T 11,7 E 1,9 X 1,1	-	-	Dichloro-methane <50 mg/kg	Danish EPA 2006b
Textile impregnation Spray	X 5,5 mg/g	-	780 mg/g ”hydrocar-bons”		Danish EPA 2008b
Cuddly toys	T 20 X 3,3	-	Hexane 3.0		Danish EPA 2006b
Play tents/ igloo tent	T 19 X+E 9	19	15	Tetrachlo-roethylene	Danish EPA 2004

Product	BTEX	Styrene	Alkanes C6-C12	Other substances	Reference
				2	
Printed magasines/ comics	T ca. 2000		-		Danish EPA 2006a
Christmas decorations	B 230 mg/kg T 25 mg/kg E 47 mg/kg X 280 mg/kg	82 mg/kg	-		Danish EPA 2003a
Computer- / TV/ Monitor	B 0,8 T 38,5 X 35,4	19	-		Danish EPA 2006a
Markers			Heptane 0,7 Octane 1,4		Danish EPA 2006b
	T 0,6 mg/m^3 E 345 mg/m^3 X 285 mg/m^3				Lim et al. 2014
Transformers/ chargers	T 14,8 E 8,5 X 15,2				Danish EPA 2003b
Lamps	T 1 E 3.2 X 4.7				Danish EPA 2005b,
Balloons	B		Dodecane Undecane		Danish EPA 2007,
	TEX				Kataoka et al. 2012
Modelling clay			Hexane		Kataoka et al. 2012
Swim rings	TEX				Kataoka et al. 2012
Slippers	TEX				Kataoka et al. 2012
Tape	T 4 mg/m^3 E 0.12 mg/m^3 X 0.04 mg/m^3				Lim et al. 2014,
	T		Hexane		Kataoka et al. 2012
Glue	T		Hexane Hexane		Danish EPA 2014c+d, Kataoka et al. 2012, Lim et al. 2014
	B 0.7 mg/m^3 T 2.5 mg/m^3 X 1.6 mg/m^3				
Paint and laquer	10-15%		80-85%		Danish EPA 2014c
Dry-cleaned clothes				Tetrachlo-roethylene	Danish EPA 2001

Product	BTEX	Styrene	Alkanes C6-C12	Other substances	Reference
				<27	
Carpets	Aromatic hydrocarbons		Alifatic hydro-carbons		Danish EPA 2015, Whisthaler 2012
Wooden panels, flooring	TEX		Alifatic hydro-carbons		Whisthaler 2012, Lin et al. 2009
Furniture	B 2,45 T 535 E 563 X 678	371		Trichloro-ethylene 0.79 Tetrachlo-roethylene 5.59	Ho et al. 2011 (concentrations from a 5 m^3 test chamber)
	Trimethyl-benzene				Shinohara et al. 2009
Self-adhesive wallpaper and foils	T 36				Lim et al. 2014

B: benzen; T: toluen; E: ethylbenzen; X: xylener

It should be noted that the comparison of the indicated concentrations in the table for the different products must be made with great caution as the measurements/ estimates underlying the values may have been made in different ways and with different assumptions.

This list will form the basis for the selection of products for purchase and emission analyses (Chapter 6).

6. Emission analyses of selected products and scenarios

This chapter describes methods and shows results from emission measurements. A number of children´s room relevant products including furniture, electronics, decoration and toys have been selected for emission measurements from the product list presented in Chapter 5. A list of the selected products can be seen in table 6.1, below.

The emission of toluene and other neurotoxic substances has partly been studied in small scale (CLIMPAQ chamber) and partly in full scale in a large climate chamber.
Full scale measures have included active use of plastic beads and permanent/white board markers as well as a study of total emissions from furniture, building materials and electronics in a full scale mock-up of a children´s room. Emissions from paints and lacquers were measured separately in small scale (CLIMPAQ). This was done in order to separate the potentially high emission from these products from emissions from other building materials. Emissions from the toys and other small products typically found in a children´s room were also measured in small scale (CLIMPAQ) where the products were grouped as indicated in Table 6.1. All the air samples were analysed for the identified neurotoxic substances as listed in figure 2.1, section 2.2.7 with the exception of methylstyrene, diisopropylbenzene and phenyloctane (octylbenzene), which could not be quantified by the laboratory.

TABLE 6.1. THE LIST OF PRODUCTS SELECTED FOR EMISSION MEASURMENTS

Product	Number of tested articles (from different producers)	Emission scenario
Building materials		
Laminate flooring	1	Children´s room mock-up/full scale
Acrylic wall paint applied on gypsum board	2	Small scale (CLIMPAQ)
Alkyd wood paint, applied on wooden board	2	
Laquer for wood, applied on wooden board	1	
Furniture	4 (a desk, a bed and 2 kinds of shelf combinations)	Children´s room mock-up/full scale
Electronics	3 (computer screen, laptop charger and	Children´s room mock-up/full scale

Product	Number of tested articles (from different producers)	Emission scenario
	playstation)	
Toys and decorations		
Plastic beads	5	Active full scale
White board and permanent markers	6	Active full scale
Self-adhesive decoration foil and shelf paper	2	Children´s room mock-up/full scale
Balloons	4	Small scale (CLIMPAQ)
Rubber figures	5	Small scale (CLIMPAQ)
Play tent	1	Small scale (CLIMPAQ)
Comics /printed advertising materials	5	Small scale (CLIMPAQ)
Plastic beach articles	3 (a beach ball, a swim ring and water wings)	Small scale (CLIMPAQ)
Modelling clay	3	Small scale (CLIMPAQ)
Teddy bear with lavendar odour for heating in the microwave	1	Small scale (CLIMPAQ)
Tape	6	Small scale (CLIMPAQ)

6.1 Method

6.1.1 Small and full scale climate chambers

The small scale measurements were made in CLIMPAQ chambers ("Chamber for Laboratory Investigation of Materials, Pollution and Air Quality") at SBi (Figure 6.3). The chambers are constructed of glass in order to reduce the absorption of chemicals and facilitate cleaning. The CLIMPAQ chamber has a volume of 0.051 m^3, in which the space for the test samples is 20 x 20 x 80 cm.

The active full scale measurements and children´s room mock-up, where the total emissions from furniture, building materials and electronics were examined, were set up in a large climate chamber with a floor area of 17.4 m^2 and volume of 31.8 m^3. The walls of the full scale chamber consist of glass, mounted in aluminium frames, and the floor consists of low-emitting high pressure laminate on medium density fiberboard (Figures 6.1 and 6.2).

Both the small chambers and the large chamber are ventilated with the HVAC system, which makes it possible to control the temperature and humidity as required. The inlet air is filtered through a carbon filter and a fine EU7 filter to ensure low concentrations of contaminating gases, vapours and particles in the supplied air. The chambers were washed before the study.

6.1.2 Material preparation and measurement/analysis procedure

The products selected for emission measurements (table 6.1) were purchased in Danish retail stores or on the Internet. Each product/material sample was selected, collected, transported and stored in a manner that ensured that the emission characteristics of the test specimen were representative of the emission characteristics of the material in the use situation as well as the "worst-case use situation" immediately after unpacking at home. All products were kept in the original packaging or wrapped in aluminium foil and not opened until just before placement in the climate chamber. Each emission test began with measuring the background concentration in the empty climate chamber. Emission measurements took place 24, 48 and 72 hours and 2 weeks after placement of the products to achieve a time profile for the emission, and in order to better assess the long-term exposure. Collection of the air after 2 weeks was performed in duplicate. In full scale, 24-hour and 72-hour collections were performed in duplicate. Both samples were, however, only analysed in special cases, i.e. in the case of unclear or inconsistent result from the first sample. Two blind tests were also analysed (i.e. unused collection tubes).

Air was collected on an SKC tube with charcoal using a pump with a flow rate of 1 l/min and a pumping time of 100 minutes. Immediately after collection, the tubes were closed with original plastic plugs, placed in an Rilsan bag and frozen to -20 °C until analysis. At the laboratory (ALS Global), the coal from the coal tubes was transferred to a glass, to which was added carbon disulfide (CS2). Coal and CS2 were extracted for 16 hours on a shaking table, after which the solvent was pipetted and analysed by GC/MS (single substances) and / or GC/FID (hydrocarbon-screening). CS2 of the brand Rathburn was used for extraction of the collected compounds. The laboratory was accredited for these analyses.
Detection limits and uncertainties of analyses are shown in Appendix 5.

Temperature and humidity were measured continuously during tests in both small-scale and full scale climate chambers with HOBO U12-013 data loggers (Onset, USA). Air change rate was measured twice, before and after emission measurements using decay of CO_2. CO_2 was dosed from gas cylinder to both small and large chambers, and the decay was measured with photoacoustic monitor (INNOVA 1312 Photoacoustic Multi-gas Monitor, LumaSense Technologies A/S) for at least 30 minutes. Air exchange was calculated as slope of the linear regression performed on log-transformed concentrations.
The air change rate in CLIMPAQ chambers was also verified before each sampling with anemometer (Dantec Flowmaster Precision anemometer 54N60) with a straight tube probe connected to the air outlet of CLIMPAQ. The tube was calibrated so that the measured air velocity in the tube could be directly related to the air exchange in the chamber.

6.1.3 Active full scale emission measurements

For two products, emission measurements were made in the breathing zone during active use. This was done for the ironing of plastic beads, and for drawing/colouring with permanent and white board markers (Figure 6.1). These emission measurements were made in full scale climate chamber (Section 6.1.1). The active sampling lasted for 100 minutes with continuous ironing or drawing/colouring and sampling were made in duplicate. Both air samples were analysed.

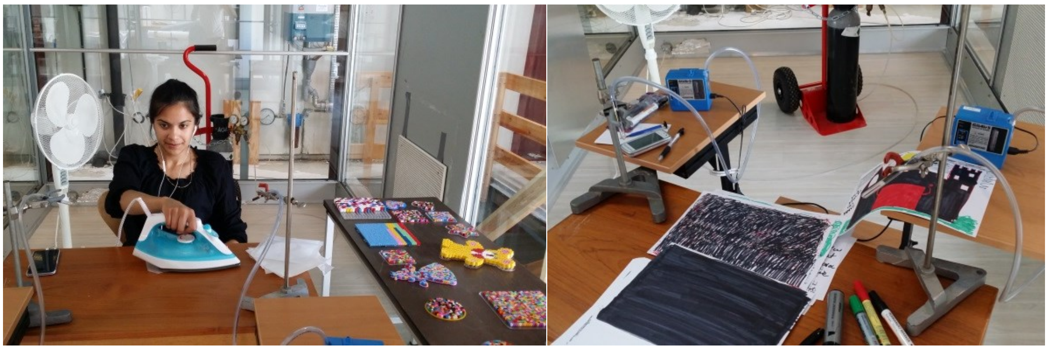


FIGURE 6.1. COLLECTION DURING ACTIVE USE OF PLASTIC BEADS (LEFT) AND MARKERS (RIGHT)

6.1.4 Children´s room mock-up emission measurements

A full scale mock-up of a children´s room was set up to measure the total emission from relevant children´s room furniture, building materials and electronics. The entire floor area in the full scale climate chamber was covered with new laminate flooring. The mock-up room was equipped with a bed, a desk and two kinds of closets/shelf combinations. Self-adhesive decorative foil was pasted on a wall and self-adhesive shelf paper on another wall. The room was also equipped with a new computer monitor, laptop charger/power supply, play station and an older television (proved necessary as the play station did not work without a television and a new one was not purchased) (Figure 6.2).

FIGURE 6.2. MOCK-UP OF A CHILDREN´S ROOM

The temperature during emission measurements was 22 ±0.2 °C and the relative humidity of 52 ±3 % RH. Air change rate in the climate chamber was 0.49 h^{-1}. An oscillating fan ensured a good mixing of the air in the climate chamber.

6.1.5 Small-scale CLIMPAQ emission measurements

Emissions from the toys and other small products that can be found in a children´s room and evaporation of paint were measured in small scale chambers (CLIMPAQ), see table 6.1 and Figure 6.3. In order to relate emission measurements in small scale to normal conditions in buildings, a scaling is required, which means that the area specific airflow rate of the specimens should be calculated according to a model children´s room. The area-specific airflow rate (q, $m^3/(m^2h)$) is calculated from equation 1:

$$q = \frac{n}{L} = \frac{Q}{A_{pr} \cdot x} \qquad \text{Equation 1}$$

where

n is air change rate in the model room (h^{-1})

L is loading factor in the model room (m^2/m^3)
Q is supply airflow rate in the climate chamber (m^3/h)
A_{pr} is the area of one test specimen in the climate chamber (m^2)
x is number of test specimens to be mounted in the climate chamber

The air change rate in the model room, *n*, was calculated as 0.5 h^{-1}, corresponded to the requirements of the building regulation for minimum fresh air supply of 0.3 l/sm^2 (BR 10), assuming a ceiling height of approximately 2.5 m. Loading factor in the model room (*L*) for some construction products and building materials are given in Nordtest method NT Build 482. For the other tested products (e.g. toys), loading factor was calculated according to the best estimate of the sample's occurrence in a typical children´s room or "worst-case use situation". Where the assessment was hard to make, overload was preferred to underload, to ensure that no source was overlooked. The following quantities were used in connection with the load of the model room: 100 balloons (not inflated), 150 rubber figures, 1 beach ball, 1 swim ring and 1 pair of water wings, one play tent, 130 publications/books/ advertising booklets and 6 m of tape. As a result of the Nordtest Metode NT Build 482, the loading factor for wall paint was calculated to 31 m^2, corresponding to the wall and ceiling area in the model room. The loading factor of furniture paint and furniture lacquer was calculated to 8 m^2, equivalent to approximately 1 shelf unit.

For modelling clay, the air change rate in CLIMPAQ was set to 0.5 h^{-1} with three small packets of modelling clay. This high load was chosen to measure the potential exposure in the breathing zone of a child playing with modelling clay. For a teddy bear with lavender fragrance for heating in a microwave oven, the air change rate was close to 0 h^{-1} with one teddy bear to simulate exposure of the sleeping child with the teddy bear close to child's face. In the two scenarios, an extra air sample was collected immediately after setup. The temperature during emission measurements in CLIMPAQ was 23 ±0.7 °C and the relative humidity was 51 ±4 % RH.

FIGURE 6.3. SETUP IN CLIMPAQ CHAMBERS. FROM THE LEFT, TOP: CLIMPAQ CHAMBERS AT SBI, WALL AND WOOD PAINT USED ON GIPSUMBOARD AND WOODEN BOARD, BALLOONS, RUBBER FIGURES, PLAY TENT, DOWN: COMICS, RUBBER BEACH-ARTICLES, MODELLING CLAY, TEDDY BEAR, TAPE

6.1.6 Exposure

By emission measurements under steady-state from samples with small surface areas and air concentrations significantly below the vapour pressure of the substances and under normal conditions (i.e. temperature, humidity, etc.), the concentration in a climate chamber depends on the emission from the surface of the material and the ventilation rate in the climate chamber.

Concentrations measured in the CLIMPAQ chamber can therefore be converted to air concentration in a model children´s room according to equation 2.

$$C_M = C_c \cdot q \cdot \frac{L}{n} \qquad \text{Equation 2}$$

where
C_M is the concentration of a chemical substance in the air of the model room (mg/m^3)
C_C is the concentration of a chemical substance in the air of the climate chamber (mg/m^3)
q is the area specific airflow rate (m^3/m^{2}h)
L is loading factor of the material in the model room (m^2/m^3)
n is air change rate in the model room (h^{-1})

The Danish EPA (2006a) has previously assessed the exposure in children´s rooms from the following standard considerations with respect to the children´s rooms:

V = 17.4 m^3 (from a floor area of 7 m^2)
n = 0.5 h^{-1}
These conditions are in accordance with the guidelines in Northern Test method NT Build 482. The same basis was used in the assessments of this project.

6.1.7 Example of calculations

Below is an example of calculations of the area specific airflow rate for wall paints and conversion of the measured concentration in CLIMPAQ to a model children´s room. Calculations for the other products tested in small scale were made after the same principle.

According to equation 1, the area specific airflow rate is calculated as:

$$q = \frac{n}{L} = \frac{0{,}5}{\frac{31}{17.4}} = 0.28\frac{\text{m}^3}{\text{m}^2\text{h}}$$

Where n is air change rate in the model room corresponding to 0.5 h^{-1} and L is the loading factor in the model room (m^2/m^3). As a result of the Nordtest Metode NT Build 482, the loading factor for wall paint was calculated to 31 m^2, corresponding to the wall and ceiling area in the model room, divided by 17.4 m^3 as model room volume.

From equation 1, we could either calculate the test specimen area in the CLIMPAQ setup with fixed air change rate in CLIMPAQ, or calculate the air change rate based on the test specimen surface. Due to limited space in the CLIMPAQ chamber, we have chosen the second option. Wall paint was applied to gypsum boards with an area of 0.14 m^2 (0.2 x 0.7 cm). The two boards were painted on both sides i.e. in total four surfaces. Thus, the total area of the test specimen surface was 0.56 m^2. The air change rate in CLIMPAQ was therefore determined to:

$$n_{CLIMPAQ} = \frac{Q_{CLIMPAQ}}{V_{CLIMPAQ}} = \frac{q \cdot A_{pr} \cdot x}{V_{CLIMPAQ}} = \frac{0.28 \cdot 0.14 \cdot 4}{0{,}051} = 3.1\text{h}^{-1}$$

With these calculations, the measured concentrations in CLIMPAQ can be interpreted directly as expected concentrations in a children´s room with a size of 17.4 m^3 and an air change rate of 0.5 h^{-1} and the stated loading factors (see Section 6.1.5).

$$C_M = C_c \cdot q \cdot \frac{L}{n} = C_C \cdot 0.28 \cdot \frac{\frac{31}{17.4}}{0.5} = C_c$$

6.2 Results

All results (raw data) from the emission measurements are shown in Appendix 4. In addition to the identified neurotoxic substances, a number of other chemicals were quantified as part of the laboratory analysis package.

6.2.1 Emission measurements during activities

The results of active full scale emission measurements appear from Table 6.2 and Table 6.3.

Emission of toluene was measured during drawing with permanent and white board markers. Significant emissions of n-heptane, octane and xylenes from markers have been measured in previous studies (Appendix 2), but in the present study, none of these substances were found at levels above the detection limit. However, the very high concentration of TVOC measured here indicates significant emission of other substances, which however, were not further identified in our study.

During ironing of plastic beads, smaller emissions of the substances n-decane and n-undecane were found in contrast to previous studies. Decane has been measured in previous studies, but in about three times higher concentrations. Other chemicals, which in previous studies were measured in high concentrations (Appendix 2) including toluene, xylenes, ethylbenzene, styrene, and propyl benzene, were below the detection limit in the current investigation. As in studies with markers, the high TVOC concentrations cannot be explained by any of the quantified substances, but must be ascribed to other volatile substances.

TABLE 6.2. CONCENTRATIONS (μg/m³) MEASURED DURING USE OF MARKERS

	Background	Duplicate measurements in the breathing zone
Toluene	<1.9*	37/ 38
TVOC	<97*	17.000/24.000

*The detection limits depend on the volume of the sample, and are therefore specific for each sample. The detection limit of each substance is shown in Appendix 5.

TABLE 6.3 CONCENTRATIONS (μg/m³) MEASURED DURING IRONING OF PLASTIC BEADS

	Background	Duplicate measurements in the breathing zone	Measuring in the middle of the room
n-Decane	<2.5*	6.0/ 6.7	4.8
n-Undecane	<2.5*	22/ 24	16
TVOC	<100*	210/230	180

*The detection limits depend on the volume of the sample, and are therefore specific for each sample. The detection limit of each substance is shown in Appendix 5.

6.2.2 Children´s room mock-up emission measurements

The results of measurements from the children´s room mock-up appear from Table 6.3. The measurements were carried out in the same climate chamber as the active full scale emission measurements. The concentration of toluene and m-/p-xylenes was slightly above the detection limit 24 hours after setup, but fell below the detection limit after 48/72 hours. None of the other measured substances were found in the air at the setup. It should, however, be emphasised that we failed to keep the electronics on, because it automatically went into stand-by mode after only a few minutes after they have been turned on. As emission from electronics is particularly expected by prolonged use, when the temperature rises, the measurements do therefore not reflect emissions from electronics. As indicated before, previous studies had found significant emission of toluene, xylenes, ethylbenzene and styrene for electronics (Appendix 2). These substances were either not measured in the current study or they were measured at very low concentrations , close to the detection limits.

TABLE 6.4 CONCENTRATIONS (µg/m^3) MEASURED IN CHILDREN´S ROOM MOCKUP

	Background	24 hours	48 hours	72 hours	2 weeks
Toluene	<2.1*	2.5	2.5	<1.9*	<1.8*
m-/p-Xylene	<2.1*	2.5	<2.0*	<1.9*	<1.8*
TVOC	<110*	160	130	120	92

*The detection limits depend on the volume of the sample, and are therefore specific for each sample.

The detection limit of each substance is shown in Appendix 5.

6.2.3 Small-scale CLIMPAQ emission measurements

As expected, the largest emissions were found from paint and lacquer treated surfaces. Before the boards were set up (gypsum board for wall paint (water based acrylic paint) and wooden board for furniture paint/lacquer (white spirit based alkyd paint/lacquer)), they were painted twice and left outside the chamber until they were hand dry (about 2 hours). The painted, dry boards were subsequently placed in the small climate chamber. As shown in Table 6.4, 20 chemicals were measured in the air above the detection limit 24 hours after setup. After 72 hours, only heptane, octane, decane, undecane, dodecane, m-/p-xylene and 1,2,4-trimethylbenzene were measured above the detection limit, but the concentration of these substances fell below the detection limit after 2 weeks.

TABLE 6.5 EMISSIONS FROM PAINT (µg/m^3)

	Background	24 hours	48 hours	72 hours	2 weeks
n-Heptane	<4.4*	24	13	6,1	< 5.0*
n-Octane	< 4.4*	28	15	6,9	< 5.0*
n-Nonane	< 2.2*	7.1	< 3.9*	< 2.4*	<2.5*
n-Decane	< 2.2*	23	9.6	4.3	< 2.5*
n-Undecane	< 2.2*	18	7.4	3.9	< 2.5*
n-Dodecane	<2.2*	9.9	5.5	2.7	< 2.5*
Toluene	< 1.8*	3.3	< 2.0*	< 1.9*	< 2.0*
Ethylbenzene	<1.8*	9.1	3.1	< 1.9*	< 2.0*
m-/p-Xylene	< 1.8*	29	9.6	4.3	< 2.0*
o-Xylene	< 1.8*	9.8	3.3	< 1.9*	< 2.0*
Styrene	< 2.2*	3.8	< 2.4*	< 2.4*	<2.5*
Naphthalene	< 2.2*	4.5	< 2.4*	< 2.4*	< 2.5*
Trichloroethylene	< 2.2*	6.4	< 2.4*	< 2.4*	5.0
n-Propylbenzene	< 2.2*	4.0	< 2.4*	< 2.4*	<2.5*
2-Ethyltoluene	< 2.2*	4.4	< 2.4*	< 2.4*	< 2.5*
3-Ethyltoluene	< 2.2*	8.8	2.5	< 2.4*	< 2.5*
4-Ethyltoluene	< 2.2*	6.1	< 2.4*	< 2.4*	< 2.5*

1,2,3-Trimethylbenzene	< 2.2*	9.8	2.8	< 2.4*	< 2.5*
1,2,4-Trimethylbenzene	< 2.2*	23	7.7	3.5	< 2.5*
1,3,5-Trimethylbenzene	<2.2*	4.6	< 2.4*	< 2.4*	< 2.5*
TVOC	< 88*	870	280	140	160

*The detection limits depend on the volume of the sample, and are therefore specific for each sample.

The detection limit of each substance is shown in Appendix 5.

Emissions from tape, swim articles, rubber figures, comics and balloons appear from Table 6.6.

Toluene was the only substance measured in the climate chamber with tape, and only 24 hours after setup. Emission of toluene from tape was measured previously (Kataoka et al. 2012), while ethylbenzene and xylenes measured by Kataoka et al. (2012) were below the detection limit in the current study.

One day after setup, small emission of nonane, naphthalene and trichloroethylene was measured from swim articles (beach ball, swim ring and water wings). In addition, higher concentrations of trichloroethylene was measured 2 weeks after the setup than after 24 hours. As trichloroethylene is a very volatile substance, a reduction rather than an increase of the concentration would be expected. Furthermore, a similar level of the substance was measured in one of the non-exposed sampling tubes (blank). This may indicate some kind of contamination during the analysis. Therefore, it was chosen to disregard thise result.

Emissions of ethylbenzene and xylenes from rubber figures were measured above the detection limit 24, 48 and 72 hours after setup, and the concentration of xylenes was still above the detection limit after 2 weeks. These substances had been measured in previous studies, however in lower concentrations (see table 5.1).

None of the focus substances were measured in the samples from the climate chamber with comics and printed advertising materials. Significant concentrations of TVOC was, however, measured after 24 hours and 72 hours after setup (however, not after 48 hours), suggesting emissions of other substances, however not further identified and quantified in this study.
One day after setup, minor emissions of decane and undecane were measured from balloons, but fell below the detection limit after only 48 hours. Slightly higher emission of undecane, but not decane, has also been measured in previous studies (Appendix 2).

TABLE 6.6 EMISSIONS FROM TAPE, SWIM ARTICLES, RUBBER FIGURES, COMICS AND BALLOONS (µg/m^3)

	Background	24 hours	48 hours	72 hours	2 weeks
		Tape			
Toluene	< 1.8*	6.9	< 2.0*	< DL	< DL
		Swim articles			
n-Nonane	< 2.2*	5.6	< 2.5*	< DL	< DL
Naphthalene	< 2.2*	4.5	< 2.5*	< DL	< DL
Trichloroethylene	< 2.2*	2.8	< 2.5*	< DL	6.8
		Rubber figures			
Ethylbenzene	< 1.8*	4.7	3.0	2.7	< DL
m-/p-Xylene	< 1.8*	15	9.2	8.4	3.4

o-Xylene	<1.8*	9.6	6.1	5.4	2.2
TVOC	<88*	130	<100*	<100*	<98*
Comics and printed advertising materials					
TVOC	<83*	220	<95*	580	<97*
	<83*	***Balloons***			
n-Decane	<2.4*	4.2	<2.5*	<2.6*	<2.8*
n-Undecane	<2.4*	5.6	<2.5*	<2.6*	<2.8*

*The detection limits depend on the volume of the sample, and are therefore specific for each sample. The detection limit of each substance is shown in Appendix 5.

As previously mentioned, the emission from modelling clay and teddy bear was performed at reduced ventilation (see 6.1.5). This was chosen to better represent exposure in the child's breathing zone at play and during sleep. An additional measurement was made immediately after setup. The teddy bear was heated in a microwave oven according to instructions just before placement in the climate chamber. Minor emission of m-/p-xylenes from both products was found immediately after setup. Furthermore, modelling clay emitted toluene, while n-dodecane was found in the air of the chamber with the teddy bear. The previously found hexane in modelling clay (Kataoka et al. 2012) was not measured in concentrations above the detection limit in the current study. Modelling clay also gave high emission of unidentified substances, as shown by the high concentrations of TVOC.

TABLE 6.7 EMISSIONS FROM MODELLING CLAY (µg/m^3)

	Background	Immediately after setup	24 hours	48 hours	72 hours	2 weeeks
m-/p-Xylene	< 1,7*	3.0	< 2.0*	< 2.0*	< 1.9*	< 2.0*
Toluene	< 1,7*	2.2	< 2.0*	< 2.0*	< 1.9*	< 2.0*
TVOC	< 87*	3500	1500	710	290	< 98

*The detection limits depend on the volume of the sample, and are therefore specific for each sample. The detection limit of each substance is shown in Appendix 5.

TABLE 6.8 EMISSIONS FROM TEDDY BEAR WITH LAVENDER FRAGRANCE (µg/m^3)

	Background	Immediately after setup	24 hours	48 hours	72 hours	2 weeks
n-Dodecane	-[1]	7.4	<2.6*	<2.5*	< 2.6*	< 2.7*
m-/p-Xylene	-[1]	2.9	< 2.0*	<2.0*	< 2.1*	< 2.1*

*The detection limits depend on the volume of the sample, and are therefore specific for each sample. The detection limit of each substance is shown in Appendix 5.

[1] Missing measurement due to pump failure.

6.2.4 Results grouped after chemicals

This section presents results from Sections 6.2.1-6.2.3 grouped according to the measured chemicals to make it possible to calculate a child's total exposure to the substances in a model children´s room. Overall, the measured concentrations were lower than found in previous studies. The very low levels measured in connection with the mock-up measurements, and e.g. rubber figures, may be because of difficulties in purchasing specific products (more or less randomly) having contents of the critical neurotoxic chemicals. Thus, the results show that there generally is a low emission of the analysed substances from various types of products. This may indicate increased awareness in product development concerning use of chemical substances that may be problematic in relation to health. In some cases (e.g. markers, plastic beads, modelling clay, comics) the results suggest that known neurotoxic substances are no longer used or have been substituted with other chemicals.

TABLE 6.9. EMISSION OF NEUROTOXIC SUBSTANCES FROM PRODUCTS EXAMINED IN THE CURRENT PROJECT (µg/m³)

Measured substances	Sources	Concentration during use or after 24 hours	48 hours	72 hours	2 weeks
Toluene	Markers	37.5	-	-	-
	Mock-up*	2.5	2.5	<DL	<DL
	Tape	6.9	<DL	<DL	<DL
	Modelling caly	2.2 (immediate), <DL (24)	<DL	<DL	<DL
	Paint/lacquer	3.3	<DL	<DL	<DL
m-/p-Xylene	Mock-up*	2.5	<DL	<DL	<DL
	Modelling clay	3.0 (immediate), <DL (24)	<DL	<DL	<DL
	Teddy bear	2.9 (immediate), <DL (24)	<DL	<DL	<DL
	Paint/lacquerRu	29	9.6	4.3	<DL
	bber figures	15	9.2	8.4	3.4
o-Xylene	Paint/lacquer	9.8	3.3	<DL	<DL
	Rubber figures	9.6	6.1	5.4	2.2
Ethylbenzene	Rubber figures	4.7	3.0	2.7	<DL
n-Heptane	Paint/lacquer	24	13	6.1	<DL
n-Octane	Paint/lacquer	28	15	6.9	<DL
n-Nonane	Swim articles	5.6	<DL	<DL	<DL
n-Decane	Plastic beads	6.3	-	-	-
	Paint/lacquer	23	9.6	4.5	<DL
	Balloons	4.2	<DL	<DL	<DL
n-Undecane	Plastic beads	23	-	-	-
	Paint/lacquerBa	18	7.4	3.9	<DL
	lloons	5.6	<DL	<DL	<DL
n-Dodecane	Paint/lacquer	9.9	5.5	2.7	<DL
	Teddy bear	7.4 (immediate), <DL (24)	<DL	<DL	<DL
Trichlorethylene	Paint/lacquer	6.4	<DL	<DL	5.0
	Swim articles	2.8	<DL	<DL	6.8
2-Ethyltoluene	Paint/lacquer	4.4	<DL	<DL	<DL
3-Ethyltoluene	Paint/lacquer	8.9	2.5	<DL	<DL
4-Ethyltoluene	Paint/lacquer	6.1	<DL	<DL	<DL
1,2,3-Trimethylbenzene	Paint/lacquer	9.8	2.8	<DL	<DL
1,2,4-Trimethylbenzene	Paint/lacquer	23	7.7	3.5	<DL
1,3,5-Trimethylbenzene	Paint/lacquer	4.6	<DL	<DL	<DL

Measured substances	Sources	Concentration during use or after 24 hours	48 hours	72 hours	2 weeks
Naphthalene	Swim articles	4.5	<DL	<DL	<DL
	Paint/lacquer	4.5	<DL		
Styrene	Paint/lacquer	3.8	<DL	<DL	<DL
Ethylacetate	Markers	22	-	-	-
	Modelling clay	7.3 (immediate), <DL (24)	<DL	<DL	<DL
n-Propylbenzene	Paint/lacquer	4.0	<DL	<DL	<DL
TVOC	Markers	20500	-	-	-
	Plastic beads	220	-	-	-
	Mock-up	160	130	120	<DL
	Modelling clay	1300 (immediate), <DL (24)	710	290	<DL
	Swim articles	130	<DL	<DL	<DL
	Paint/lacquer	870	280	140	160
	Comics	220	<DL	580	<DL

*Mock-up contains furniture, flooring, electronics and self-adhesive foils

6.2.5 Comparing the measurement data with literature data

In the following table, the measured levels of this project (Tables 6.1 to 6.9) are compared with the values indicated in the literature (Table 5.1). The comparison should be taken with caution as assumptions and methods to determine the levels may be different.

TABLE 6.10. COMPARISON BETWEEN LITERATURE DATA AND MEASURED DATA IN THIS PROJECT

Product/scenario	Literature data (source) µg/m³	Measured in this project µg/m³
Plastic beads, ironing	Danish EPA (2006a)	
Toluene	720	-
Xylenes	430	-
Styrene	720	-
n-decane		6.7
n-undecane		24
Markers	Lim et al. (2014)	
Toluene	610	38
Ethylbenzene	345 000	-
Xylenes	285 000	-
Tape	Lim et al. (2014)	
Toluene	4 000	6.9
Ethylbenzene	120	-
Xylenes	40	-
Rubber figures	Danish EPA (2006b)	
Toluene	11.7	-
Ethylbenzene	1.9	4.7
Xylenes	1.1	24.6
Comics/ printed material	Danish EPA (2006a)	

Product/scenario	**Literature data (source) µg/m3**	**Measured in this project µg/m3**
Toluene	approx. 2000	-
Teddy bear/cuddly toy	Danish EPA (2006b)	
Toluene	20	-
Xylenes	3.3	2.9
Hexane	3.0	-
n-dodecane	-	7.4
Mock-up/furniture	Ho et al. (2011)	
Toluene	535*	2.5
Xylenes	678*	2.5

*concentrations measured in a 5 m^3 emission chamber with air exchange of 0.5 per hour and load between 0.4 and 1 m^2/m^3

For plastic beads, markers, tape and comics/ printed advertising materials, significantly lower levels are seen in this project than the levels stated in the literature. Rubber figures show a higher level in the measurements of this project where the aggregated emission from the different plastic and rubber figures was examined with assumed high load (150 figures in a small children´s room), unlike previously studied emission from one head of a plastic doll with fragrance. The mock-up scenario shows that furniture and building materials evaporate substantially less than what was found by Ho et al. (2011), but with a big difference in methodology and assumptions.

The overall picture is that this project finds a lower rate of evaporation of the neurotoxic substances than immediately expected from literature data. It should be noted, however, that relatively higher evaporation of other, unidentified volatile substances (listed as TVOC) was found from ironing plastic beads, using markers, modelling clay, swim articles, comics, painted surfaces and from the children´s room mock-up scenario. However, the TVOC fraction may hardly contain any chronic neurotoxic substances, as the substances known to be chronic neurotoxicants have been identified in this study in Chapter 2 and quantified in the present study.

The relatively low evaporation levels measured in this project might indicate that the focus in recent years from media, organisations, enterprises and governments in terms of chemistry in everyday life (- particularly in relation to children's products) has resulted in a positive product development, achieving products with a lower content of chemical substances of concern. As the measurements have been made on randomly selected products, the low evaporations may also be due to chance. It was therefore decided to make measurements in children´s rooms to confirm or reject the low emissions.

7. Field measurements in children´s rooms

This chapter describes methods and shows results of field measurements of toluene and other neurotoxic substances in 19 children´s rooms. Measurements were carried out to confirm or reject the relatively low emissions of the children´s room-related products found in small-scale and full scale emission measurements (Chapter 6).

7.1 Methods

7.1.1 Children´s rooms

Because of time limits (the measurements were not originally planned), the children´s rooms were not randomly recruited via e.g. advertisements but recruited among employees, neighbours and friends. It was, however, required that all age groups from 1-18 years were included, as interior and design of children´s rooms and therefore exposure may vary significantly with gender and age.

7.1.2 Measurement and analysis procedures

Sampling of air for analyses of toluene and other neurotoxic substances in the children´s rooms was carried out about 1 meter above the floor, and as far as possible in the middle of the room, i.e. about 1 m from the window, the door and the wall surface. The window and the door of the children´s room were closed during the sampling period, and there was no access to the children´s room. The families were asked prior to the study not to clean the day before and to close the windows in the morning. If possible, the sampling time was agreed, so that no food was prepared during the sampling period. The sampling was carried out during the month of October 2015. A typical measuring setup in a children´s room is shown in Figure 7.1.

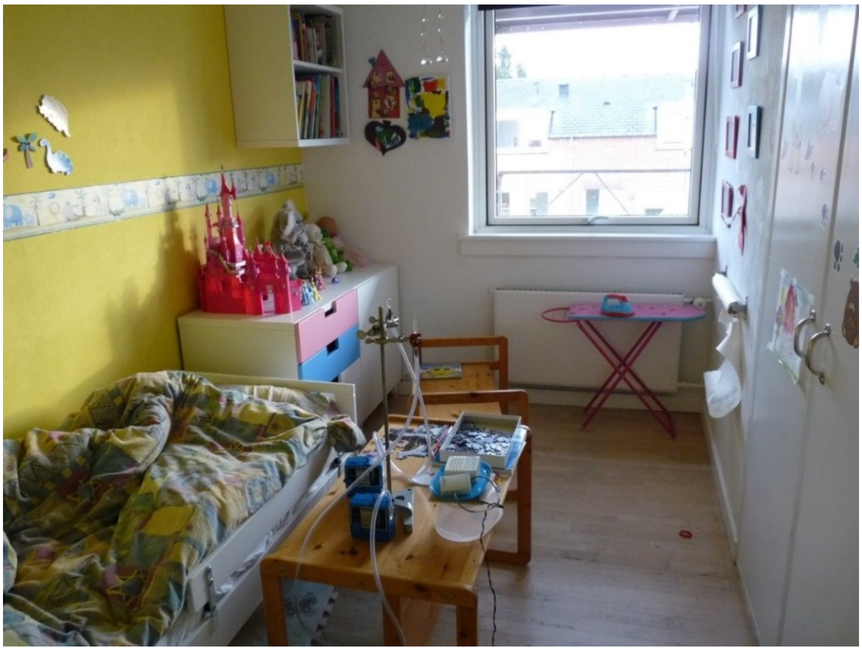


FIGURE 7.1 EXAMPLE OF SETUP IN FIELD MEASUREMENTS

Air was sampled on an SKC tubes with charcoal using a pump with a flow rate of 1 l/min and a pumping time of about 2 hours. Compared to emission measurements, the pumping time was prolonged by about 0.5 h to reduce the detection limit of the analysis. A mixing fan was used to obtain good mixing of the air during the measurement. Immediately after sampling, the tubes were sealed with original plastic plugs, placed in an Rilsan bag and frozen to -20 °C until analysis. The analysis procedure is described in Section 6.1.2. Detection limits and analysis uncertainty appear from Appendix 6. The sampling was carried out in duplicate and both samples were analysed. Furthermore, two field blind tubes were analysed (i.e. sample tubes not used).

In each children´s room, air change rate with decay of CO2 was also measured. The gas was dosed to the room up to a concentration of 1500-5000 ppm immediately after starting the air sampling, and decay was measured throughout the collection period, i.e. for about 2 hours. The measurement was conducted using CARBOCAP® CO2 meter connected to the HOBO U12 -013 data loggers (Onset, USA). Air temperature and relative humidity were measured in parallel with HOBO data loggers. Air change rate was calculated as the slope of the linear regression performed on log-transformed concentrations *versus* the time in hours.

7.2 Results

7.2.1 Description of children´s room characteristics

Table 7.1 shows characteristics of the 19 studied children´s rooms indicating the child's gender and age, building construction year, results from air change rate measurements, average temperature and relative humidity during the sampling period. As shown in the table, the sampling was made in four teenager’s rooms (≥13 years), two schoolchildren’s rooms (6-12 years) and two sibling’s room, where a school child shared the room with a preschool child, and 11 toddlers’ rooms (1-5 years). Most children lived in detached houses or terrace houses, and only two apartments were included in the study. Cooking had taken place in three houses during the sampling period, and three houses were close to a busy road. The air change rate was generally very low in the measured children´s rooms. The air change rate of 0.5h^{-1} as a minimum requirement according to the Building Regulations (BR10) was achieved in just four children´s rooms. Two of these were affected by a leaky window/door and two had mechanical ventilation. The low values of air change rate measured in this study is consistent with a recent Danish study, where an average air exchange of 0.46 h^{-1} was measured among 500 children´s rooms on Fyn and of which 57 % of the rooms had a ventilation rate below the BR requirements (Bekö et al. 2010). It should be emphasised that our measurements were made with closed doors and windows in the children´s rooms and therefore shows infiltration rate and air exchange during sampling. In contrary it was allowed to keep windows and doors open as usual in the investigation by Bekö et al. (2010) and therefore the results show the actual air change rate, to which the child is exposed.

TABLE 7.1. INFORMATION CONCERNING THE CHILD, THE BUILDING, AIR CHANGE RATE MEASUREMENTS (ACR), AVERAGE TEMPERATURE (T) AND RELATIVE HUMIDITY (RH) IN THE SAMPLING PERIOD OF 19 CHILDREN´S ROOMS

Information on the child			Information on the house				Sampling conditions		
No.[a]	Gender	Age (years)	Construction year	Cooking in the sampling period	Close to busy road	Other possible sources	ACR, h^{-1}	T, °C	RH, %
1	Boy	11	1995/2008	No	No		0.14	22.7	56
2	Girl and boy	4; 2	1948	No	No		0.20	22	65
3	Girl and boy	3; 5	1970	Yes (a little)	No	Many rubber figures	0.05	22.1	65
4	Boy	17	1987	No	Yes	Electronics	0.18	26.9	53
5	Boy	5	1960	No	No		0.13	19.9	54
6	Boy	13	1981	No	No	Electronics	0.17	24.5	51
7	Boy	3	1959	No	No	Carpet	0.88[b]	23.9	49
8	Girl and boy	4; 1.5	2013	No	No		0.74[c]	23.2	41
9	Boy	4; 2	1960	No	No		0.19	25.0	47
10	Boy	2	1960	No	No		0.14	19.7	53
11	Boy	5	1962	No	No	Carpet	0.38	20.5	53
12	Girl and boy	5; 7	1973[d]	No	Yes	Lots of plastic toys; some electronics	-[e]	22.9	53
13	Boy	1	1970	Yes (a little)	No		1.2[c]	21.4	59
14	Girl and boy	5; 7	1954	No	No	Renovation of the house	0.12	22.6	57
15	Girl	5	1954	No	No	Adjacent shed with storage of petrol etc. (follow-up visit)	0.25	20.1	62
16	Boy	12	1960	No	No	Aircraft models, some electronics	0.24	21.5	55
17	Girl	16	1960	Yes	No	Electronics	0.29	22.6	51
18	Girl	3	1894[d]	No	Yes		0.84[f]	20.9	55
19	Boy	18	1964	No	No	Electronics	0.16	21.1	55

[a] Children´s room number. [b] Window slightly open, also in the measuring period. [c] Mechanical ventilation. [d] Apartment. [e] Sampling was not performed due to lack of doors throughout the apartment. [f] The door to the children´s room was very leaky (sliding door).

7.2.2 Concentrations of neurotoxic substances in children´s rooms

Table 7.2 shows the average concentrations of the chemicals found in at least three children´s rooms, as well as the lowest and highest measured values. There was a children´s room with significantly higher concentrations of several chemicals in the indoor air (child room 15, Table 7.1, Table 7.2). Therefore, averages with and without this child room are shown. Detailed results for the chemicals measured in more than three children´s rooms are shown in Table 7.3.

TABLE 7.2 AVERAGE CONCENTRATIONS AND THE LOWEST AND HIGHEST VALUES MEASURED IN CHILDREN´S ROOMS. AVERAGES, EXCL. CHILD ROOM 15, ARE SHOWN IN PARENTHESES

	No. of children´s room with concentration >DL	Average (excl. room 15) µg/m3	Min µg/m3	Max µg/m3
n-Heptane	4	13.1 (8.8)	4.4	27
n-Decane	4	7.4 (7.4)	1.9	22
n-Undecane	12	3.5 (3.5)	1.9	11
n-Dodecane	12	2.5 (2.5)	1.8	3.9
Methylcyclohexane	3	6.0 (4.9)	2.1	8.3
Cyclohexane	4	12.0 (2.4)	2.0	43
Ethylacetate	12	12.1 (11.5)	5.5	34
Toluene	19	21.0 (9.1)	1.6	230
Ethylbenzene	9	6.9 (3.2)	1.4	37
m-/p-xylene	14	12.7 (5.2)	1.5	110
o-xylene	6	8.5 (2.3)	1.7	36
Trichloroethylene	5	20.3 (22.5)	2.6	49
TVOC	12	430 (338)	100	1500

TABLE 7.3 DETAILED RESULTS OF CHEMICAL MEASUREMENTS IN CHILDREN´S ROOMS (µg/m³) (IN DUPLICATE)

No[a].	Age[b]	n-Heptane	n-Decane	n-Undecane	n-Dodecane	Methyl cyclohexane	Cyclohexane	Ethylacetate	Toluene	Ethyl benzene	m-/p-xylene	o-xylene	Trichloro ethylene	TVOC
2	1			1.9/<2.0[c]	2.2/<2.0[c]			15/13	4.7/4.6	1.6/1.7	3.4/3.3	1.8/2.0		360/400
3	1			3.9/3.6	1.9/<1.8[c]			8.3/8.8	54/53	8.3/7.3	22/21	3.3/3.2		1000/980
5	1								2.4/2.6					<100[c]
7	1								2.8/2.7					180/120
8	1								<1.5[c]/1.6					<100[c]
9	1						2.4/<1.8[c]	6.4/6.6	12/12	1.7/1.8	5.6/5.5			260/350
10	1							7.0/6.6	8.5/7.9		4.0/3.9		7.8/38	100/150
11	1			2.1/2.0	2.4/2.2				2.5/2.5					<100[c]
13	1		<1.7[c]/1.9	3.2/3.1	2,8/2.6			10/11	4.8/5.6		1.5/1.9		9.4/4.6	<100[c]
15	1	25/27		3.2/3.8	2,3/2.4	8.3/8.2	39/43		230/230	37/33	110/110	36/36		1400/1500
18	1	4.4/5.1				2.4/2.1		<4.2/7.4	3.9/4.6		1.9/2.1		<2.1/41	<100[c]
1	2			2.5/2.4	2.9/2.9				4.0/4.1	2.6/2.4	2.3/2.3	1.7/<1.6[c]		<81/110
12	2				1.8/1.9				4.8/5.4					<100[c]
14	2	4.8/5.2	19/22	9.9/11	2.9/2.7		2.1/2.4	6.7/5.8	15/16	5.0/5.3	8.5/9.2	<1.4[c]/2.9		420/460
16	2	16/17		2.6/2.5	2.2/2.3	7.3/7.9	2.5/2.9	29/34	18/20	2.8/2.9	8.0/8.5	2.2/2.3	4.3/49	100/220
4	3		2.4/2.5	3.7/3.1	3.0/2.9			9.0/10	4.0/4.3		2.2/2.6			470/470
6	3			3.8/2.6	3.9/3.0			14/11	5.8/4.1	1.7/<1.6[c]	3.3/2.4	1.7/<1.6[c]		160/140
17	3			3.2/2.3	1.9/<1.9[c]			23/22	6.2/6.3		2.2/2.4			100/170
19	3		2.0/2.2	2.1/3.0	2.2/2.1		2.0/<1.7[c]	5.8/5.5	3.3/3.6	1.4/1.5	2.7/2.8		<1.8[c]/26	370/390

[a] Children´s room number in the study according to table 7.1

[b] 1: toddlers + young children (0-5 years), 2: schoolchildren (6-12 years), 3: teenagers (>13 years); [c] detection limit depended on sample volume and is therefore individual for each collection tube

The following chemicals were found in a few children´s rooms:

- n-Hexane: 2 children´s rooms – no.15 and 16; concentrations 32 and 16 µg/m^3
- n-Octane: 1 children´s room - no. 15; concentration 7.1 µg/m^3
- n-Nonane: 2 children´s rooms – no. 14 and 15; concentrations 3.4 and 2.3 µg/m^3
- 2-methylhexane: 2 children´s rooms – no. 15 and 16; concentrations 23.5 and 9.1 µg/m^3
- Benzene: 1 children´s room – no. 15; concentration 20.5 µg/m^3
- iso-propylbenzene: 1 children´s room – no. 15; concentration 2.2 µg/m^3
- n-propylbenzene: 1 children´s room – no.15; concentration 7.4 µg/m^3
- 2-Ethyltoluene: 1 children´s room – no. 15; concentration 5.8 µg/m^3
- 3-Ethyltoluene: 2 children´s rooms – no. 14 and 15; concentrations 2.1 and 21.5 µg/m^3
- 4-Ethyltoluene: 1 children´s room – no. 15; concentration 10.3 µg/m^3
- 1,2,3-Trimethylbenzene: 1 children´s room – no. 15; concentration 3.9 µg/m^3
- 1,2,4-Trimethylbenzene: 2 children´s rooms – no. 14 and 15; concentrations 3.2 and 23 µg/m^3
- 1,3,5-Trimethylbenzene: 1 children´s room – no. 15; concentration 7.9 µg/m^3
- Dichloromethane: 1 children´s room – no.11; concentration 3.3 µg/m^3
- 1,2-Dichloroethane: 1 children´s room – no. 6; concentration 2.8 µg/m^3
- Tetrachloroethylene: 1 children´s room – no.11; concentration 2.8 µg/m^3
- Chloromethane: 1 children´s room – no. 3; concentration 5.1 µg/m^3

7.2.3 Discussion of data

Toluene was the most frequently found substance and was measured above the detection limit in all 19 children´s rooms, followed by m-/p-xylene, undecane, dodecane and ethylacetate. Generally, the measured concentrations were in accordance with results from the emission measurements (Table 6.9). However, a few children´s rooms (Table 7.3) had concentrations either on level with the highest emission measurements (after 24 hours), or even higher. For these children´s rooms, we therefore tried to identify the sources from photographs and notes taken during the sampling period and compare them to the measured emissions from children´s room articles.

The higher concentrations of n-heptane, n-decane and n-undecane in *child room 14* could be explained by the renovation that took place in the house, as emissions of these substances at similar concentration levels are measured from paint/lacquer.
Higher concentrations of n-heptane, ethylacetate and toluene were measured in *child room 16* belonging to an older schoolboy with great interest in the construction of aircraft models. These three substances are used as solvents in e.g. paints and adhesives, which may explain their presence in the indoor air of this room.

Higher concentrations of ethylbenzene, xylenes and toluene measured in *child room 3* might be explained by the many plastic and rubber figures found in this room, where the concentrations of xylenes and ethylbenzene were at similar levels with the ones measured in our study of emission from the rubber figures (Table 6.6). Emission of toluene from the measured rubber figures, however, was significantly lower than the concentration measured in the child room; but a very high emission from a perfumed rubber figure was found previously (Table 5.1).

However, we could not explain the many and very high concentrations of a number of substances measured in *child room 15*. Neither strong potential sources in the room or ongoing renovations in the house were identified. The house was located on a quiet road and no cooking took place in the sampling period. By follow-up it turned out, however, that the outer wall of the children´s room bordered a shed, in which a lawn mower, petrol and a number of white spirit containing products were kept, all stored in plastic containers. There was a distinct odour of solvents in the shed. Furthermore, the shed had been renovated with a new facade of pressure-impregnated wood and epoxy floor a few months ago. There was also a cellar under the children´s room containing some paint and similar products. The substances measured in the children´s room are typical

components of petrol and white spirit, and penetration of the vapours into the children´s room could possibly explain the high concentrations.
Follow-up measurements were made in the child room, in the parents' bedroom and in the basement under the child room to clarify concentrations in the house and verify the sources. The concentrations of BTEX in the child room were at this follow-up measurement lower than at the first measurement, but still the highest among all 19 children´s rooms. The difference from the first measurement may be due to other temperature and ventilation conditions, and analytical uncertainty. The concentrations were highest in the child room, which confirms that the source is located in or close to the child room. The results are shown in Appendix 6. The family was recommended to remove the identified sources from the shed and ventilate the house frequently and regularly.

The measurements did not show increased emission of substances in rooms with many electronic sources. Neither benzene, toluene, xylenes nor ethylbenzene were found in elevated concentrations in children´s rooms 4, 6, 17 and 19 with many electronic sources.

There was no clear relationship between the presence of substances and the measured concentrations in relation to age, gender, transport and cooking. A study on a larger and more representative sample of children's rooms would however be required to investigate those relationships.

There was a tendency to find more substances as well as higher concentrations of toluene, xylenes and TVOC in children´s rooms with ventilation below 0.25 h^{-1}, i.e. less than half of the BR10 recommendations. The relationship did not change after the exclusion of the 4 children´s rooms with high concentrations (no. 3, 14, 15, 16). Due to the small sample size, the tendency was not statistically examined.

7.2.4 Comparison with other indoor air measurements

As the measured average values in children´s rooms (see average values in Table 7.2 without child room no. 15) are compared with average values in houses measured in the European AIRMEX project (see Table 1, Appendix 3), it appears that the measured levels in children´s rooms for single substances are higher than the average values in the AIRMEX study. Thus, the average value for n-heptane (8.8 µg/m^3) in children´s rooms is 7 times higher than the average value in the AIRMEX study (1.2 µg/m^3). Heptane was only measured in 4 children´s rooms in the current study, including children´s rooms 15 and 16, while the concentrations for the remaining two children´s rooms were about 5 µg/m^3. The average concentrations in the indoor air of the aromatic hydrocarbons toluene (8.8 µg/m^3), ethylbenzene (3.2 µg/m^3) and xylenes (7.5 µg/m^3) in present study do not differ substantially from the data in the AIRMEX study (toluene: 11.7 µg/m^3; ethylbenzene: 1.5 µg/m^3; xylenes: 5.6 µg/m^3).

8. Risk assessment based on measured data

This chapter describes the results of risk assessment for the measured values in the project. As mentioned in Chapter 4, the risk assessment is carried out by comparing the measured values in Chapters 6 and 7 with the tolerable exposure levels (LCI values) indicated in Chapter 2 (Table 2.5).

Risk assessment is made partly for the results from the emission measurements in climate chambers and partly for the results from the field measurements. Furthermore, a risk assessment of carpets for children´s room is included based on emission analysis of new carpets made in a parallel project (Danish EPA 2016).

8.1 Risk assessment of levels measured from mock-up scenarios and climate chamber measurements

As shown in Table 2.5, the tolerable exposure levels (LCI values) for the individual hydrocarbons are in the range of 100 µg/m^3 (for trimethylbenzenes) to 725 µg/m^3 (for toluene). The LCI sum value of all C7-C12 hydrocarbons is 1425 µg/m^3. For the chlorinated hydrocarbons relevant to chronic neurotoxicity, the LCI values for young children are in the range of 45 µg/m^3 (monochloromethane) to 4200 µg/m^3 (dichloromethane). The LCI values are set to protect young children aged 1-3 years, as this age group is considered particularly sensitive and exposed to volatile neurotoxic substances in the indoor air.

As a first step these values may be compared to the highest evaporation levels measured in the previous chapter, all of which were measured after the first 24 hours.

Painting with markers, Table 6.2: 38 µg/m^3 toluene (measured during activity)

Ironing plastic beads, Table 6.3: 30.7 µg/m^3 (n-decane + n-undecane, measured during acitiviy)

Mock-up children´s room, Table 6.4:
2.5 µg/m^3 toluene
2.5 µg/m^3 xylenes

Emission from paint and lacquer, Table 6.5: 3.3 µg/m^3 toluene
39 µg/m^3 xylene
230 µg/m^3 sum of hydrocarbons

Emission from other articles, Tables 6.6; 6.7; 6.8:
9.1 µg/m^3 sum of toluene
30.5 µg/m^3 sum of xylenes
81.7 µg/m^3 sum of hydrocarbons

All these values were obtained as peak concentrations, i.e. in connection with a specific activity where emission takes place or after the first 24 hours of emission from the product. This means that the average long-term exposure will be significant lower, as evidenced by the much lower values measured after 72 hours and after 2 weeks of evaporation, where the levels of many of these substances were below the detection limit. For all measurements it is seen that they are each significantly below the indicated LCI values as shown in table 2.5.

As a next step a very conservative exposure scenario can be made if all emission values from all sources as given in tables 6.2 to 6.9 are included in one overall scenario.

Table 8.1 below shows a modified version of Table 6.9, now including LCI values and exposure values for the substances, as well as the RCR values calculated based on the 24 hour and 72 hour emission values.

TABLE 8.1. RISK ASSESSMENT (RCR) OF EMISSION OF CHRONIC NEUROTOXIC SUBSTANCES FROM PRODUCTS BASED ON 24-HOUR AND 72-HOUR CONCENTRATIONS, RCR = CONCENTRATION/ LCI VALUE

Measured substances	Sources	concentration µg/m^3 24h/72h	RCR 24h/ RCR 72h
Toluene	Markers	37.5 / -	
	Mock-up*	2.5 / -	
	Tape	6.9 / -	
LCI: 725 µg/m^3	Modelling clay	2.2 / -	
	Paint/lacquer	3.3 / -	
	sum	**52.4 / -**	**0.072 / -**
m-/p-Xylene	Mock-up*	2.5	
	Modelling clay	3.0	
	Teddy bear	2.9	
	Paint/lacquer	29 /4.3	
	Rubber figures	15 / 8.4	
o-Xylene	Paint/lacquer	9.8 / -	
	Rubber figures	9.6 / 5.4	
LCI: 125 µg/m^3	**Sum m-/p-/o-xylenes**	**71.8 / 18.1**	**0.574 / 0.145**
Ethylbenzene	Paint/lacquer	9.1 / -	
	Rubber figures	4.7 / 2.7	
LCI: 200 µg/m^3	**sum**	**13.8 / 2.7**	**0.069 / 0.014**
Styrene	Paint/lacquer	3.8 / -	
LCI: 175 µg/m^3	**sum**	**3.8 / -**	**0.022 / -**
2-Ethyltoluene**		4.4 / -	
3-Ethyltoluene**		8.9 / -	
4-Ethyltoluene**		6.1 / -	
1,2,3-Trimethylbenzene		9.8 / -	
1,2,4-Trimethylbenzene		23 / 3.5	
1,3,5- Trimethylbenzene		4.6 / -	
LCI: 100 µg/m^3	**sum**	**56.8 / 3.5**	**0.568 / 0.035**
n-Propylbenzene	Paint/lacquer	4.0 / -	
LCI: 200 µg/m^3	**sum**	**4.0 / -**	**0.020 / -**
Trichlorethylen	Swim articles	2.8 / -	
	Paint/ lacquer	6.4 / -	

Measured substances	Sources	concentration µg/m^3 24h/72h	RCR 24h/ RCR 72h
LCI: 1625 µg/m3	**sum**	**9.2/ -**	**0.006 / -**
RCRsum			**1.331 /0.194**
n-Heptane	Paint/lacquer	24 / 6.1	
n-Octane	Paint/lacquer	28 / 6.9	
n-Nonane	Paint/lacquer Swim articles	7.2 / - 5.6 / -	
n-Decane	Plastic beads Paint/lacquer Balloons	6.3 / - 23 / 4.3 4.2 / -	
n-Undecane	Plastic beads Paint/lacquer Balloons	23 / - 18 / 3.9 5.6 /-	
n-Dodecane	Paint/lacquer Teddy bear	9.9 / 2.7 7.4 / -	
Naphthalene	Swim articles Paint/lacquer	4.5 / - 4.5 / -	
C7-C12 hydrocarbons, total LCI: 1425 µg/m^3	**Sum of all measured hydrocarbons**	**373.8 / 48.2**	**0.262*** / 0.034*****

*furniture/electronics/self-adhesive foils

**same LCI value used for ethyltoluenes as well as for trimethylbenzenes

*** RCR for C7-C12 hydrocarbons is not included in RCRsum, as the LCI values for C7-C12 hydrocarbons are a separate criterion based on data for the sum of C7-C12 hydrocarbons

As can be seen, all RCR values of the individual substances are significantly below 1, except for xylenes and ethyltoluenes + trimethylbenzenes with RCR values of 0.574 and 0.568.
This means that when the RCR values of all individual substances are added, the RCR sum value exceeds 1 (RCR = 1.365). The highest RCR values for xylenes and ethyltoluenes + trimethylbenzenes, however, are predominantly caused by evaporation from newly painted surfaces measured after the first 24 hours.

The RCR value for the levels of C7-C12 hydrocarbons in total is 0.262, i.e. less than 1. In other words, a higher RCR value is obtained when the RCR values of the individual hydrocarbons are added compared to an RCR value calculated from the LCI value for C7 -C12 total.

If evaporation is seen in a slightly longer time perspective, it appears that after 72 hours for xylenes, evaporation decreased from 38.8 g/m^3 to 18.1 µg/m^3 and for ethyltoluenes + trimethylbenzenes from 56.8 g/m^3 to 3.5 µg/m^3 (see Table 6.8). Thus, waiting a few days before placing newly painted shelves etc. in a living space can avoid unnecessary exposure the volatile substances to a great extent.

The RCR values and the sum of these for the 72-hour measurements (RCRsum = 0.194 and RCR for C7-C12 hydrocarbons = 0.034) are both significantly below 1, and therefore these levels do not present any risk for chronic neurotoxic effects in relation to prolonged/ continuous stay in the children´s room.

However, it should be emphasised that it has not been possible in this project to provide an updated picture of evaporation from electronics, as prolonged use of electronics could not be simulated due to the stand-by mode in the devices.

8.2 Risk assessment of the measured levels of emission from carpets in children´s room

A parallel project conducted emission measurements from 20 different carpets in small climate chambers (EPA 2016). A wide range of carpets, preferably with childrens' motives and carpets imported from countries outside the EU, were purchased for analysis for a number of VOC substances and other non-volatile substances.

Emission of volatile substances (VOCs) from the carpets was measured on pieces of carpet lying on the bottom of the climate chamber according to ISO 16000-9 at 23 °C and 50% relative humidity and with a material load of 1 m^2/m^3 and air flow 1 time per hour. Collection of VOC was made on Tenax® collecting tubes, which were removed after 1 day and 28 days. The collecting tubes were analysed by thermal desorption and GC-MS with a detection limit for each VOC substance equal to 1 $\mu g/m^3$ according to ISO 16000-6. The measured content of each carpet was reported as the carpet's area-specific emission rate, E_C, (i.e. mg/m^2 per hour).

From the results of the measurements of the 20 carpets, the carpet with the highest emission of neurotoxic substances was selected for risk assessment in this project. The carpet (carpet no. 14 in the project) was imported from Turkey and had a cover of synthetic wool and a back of jute (bast fibers). The carpet appeared with a coloured animal motif and had a surface area of 2.8 m^2.

With knowledge of the area-specific emission rate (EC), the concentration in a children´s room can be calculated:

$$C_M = E_c \cdot \frac{A}{V \cdot n}$$

Where

C_M: concentration of a chemical substance in the air of the model children´s room (mg/m^3)
E_C: the area-specific emission rate from the object in the climate chamber (mg/m^2 h)
A: the area of the material in the children´s room: Here set to 2.8 m^2 carpet
V: volume of the model children´s room (m^3). Here set to 17.4 m^3
n: the air change rate in the model children´s room (h^{-1}). Here set to 0.5 t^{-1}

$$C_M\left(\frac{mg}{m3}\right) = E_c \cdot \frac{2.8m2}{17.4\ m3 \cdot 0.5\ \mathrm{h-1}} = E_c \cdot 0.32\ t/m$$

Table 8.2 states the area specific emission values of the neurotoxic substances identified in the carpet (i.e. emission is given in µg substance/m^2 carpet per hour).

TABLE 8.2. EMISSION OF NEUROTOXIC SUBSTANCES FROM A CHILD CARPET AFTER 24 HOURS AND ESTIMATION OF THE RISK (RCR)

Substance name	Area-specific emission rate after 24 hours E_c µg/m²/h	Concentration in children´s room 24 hours µg/m³	LCI µg/m³	RCR
Chlorinated hydrocarbons				
Dichloromethane	1	0.32	4200	0.00008
Hydrocarbons:				
Heptane	1	0.32	-	
Decane	18	5.8	-	
Undecane	71	22.7	-	
Dodecane	78	25.0	-	
Sum of aliphatic hydrocarbons C7-C12	191	61.1	-	
Toluene	2	0.64	725	0.0009
Naphthalene	8	2.56	-	
Sum of aromatic hydrocarbons C7-C12	17	5.44	-	
Sum, C7-C12 hydrocarbons	208	66.6	1425	0.15

It can be seen that the emission from the carpet does not result in RCR values above 1, and that the RCR value for the sum of hydrocarbons is 0.15 in relation to the emission levels after the first 24 hours.

However, this scenario is worst case, as the emission rate is determined from the emission after the first 24 hours after unpacking the carpet. To assess the long-term exposure, it will be more relevant to use the emission values after a longer period (in this project measured after 28 days). The result of risk assessment for long-term exposure appears in Table 8.3.

TABEL 8.3. EMISSION OF NEUROTOXIC SUBSTANCES FROM A CHILD CARPET AFTER 24 DAYS AND ESTIMATION OF THE RISK (RCR)

Substance name	Area-specific emission rate after 28 days E_c µg/m²/h	Concentration in children´s room 28 days µg/m³	LCI µg/m³	RCR
Dichloromethane	-	-	4200	
Heptane	-	-	-	
Decane	-	-	-	
Undecane	-	-	-	
Dodecane	5	1.6	-	

Substance name	**Area-specific emission rate after 28 days E_c µg/m²/h**	**Concentration in children´s room 28 days µg/m³**	**LCI µg/m³**	**RCR**
Sum of aliphatic hydrocarbons C7-C12	5	1.6	-	
Toluene	-	-	700	
Naphthalene	-	-	-	
Sum of aromatic hydrocarbons C7-C12	-	-	-	
Sum C7-C12 hydrocarbons	5	1.6	1425	0,001

It can be seen that after the initial emission, the levels decreases significantly and after 28 days the emission contribution from the carpet to the content in indoor air is very low. Thus, after 28 days an RCR Value of 0.001 is achieved for the carpet.

As the above carpet was chosen as worst-case among 20 different child carpets, it can be concluded that in general there seems not to be a concern in relation to emission of neurotoxic substances from the carpets.

However, it must be noted that the assessment here is solely related to chronic neurotoxic substances and does not include assessment of other substances and other types of effects, such as emissions of carcinogens, or emissions leading to indoor air quality nuisances, such as odour and mucous membrane irritation.

8.3 Risk assessment of measured indoor air levels in childrens rooms

When assessing the measured indoor air levels, it was chosen to make independent assessments of the two children´s rooms with the highest emission, see data in Table 7.3. These are children´s rooms no. 3 and no. 15. Children´s room no. 15 stands out as by far the most concerning children´s room. In addition children´s room no. 16 was selected for assessment, as relatively high emissions of hydrocarbons were found together with emission of trichloroethylene.

Table 8.4 below lists the indoor exposure levels of the children´s rooms, the LCI values of the individual components, and the calculated RCR values.

TABLE 8.4. INDOOR AIR LEVELS IN THREE CHILDREN´S ROOMS (WORST-CASE); TOLERABLE EXPOSURE LEVELS (LCI VALUES FOR CHRONIC NEUROTOXIC EFFECTS) AND CALCULATED RCR VALUES

	Child´s room 3			Child´s room 15			Child´s room 16		
	Conc. μg/m^3	LCI μg/m^3	RCR	Conc. μg/m^3	LCI μg/m^3	RCR	Conc. μg/m^3	LCI μg/m^3	RCR
n-hexane				32	-		16	-	
Cyclohexane				43	-		2.9	-	
n-heptane + methylcyclohexane				58.8	-		34.0	-	
n-octane				7.1	-				
n-nonane				2.3	-				
n-undecane	3.9	-		3.8	-		2.6	-	
n-dodecane	1.9	-		2.4	-		2.3	-	
Benzene				20.5	600	0.03			
Toluene	54	725	0.07	230	725	0.32	20	725	0.03
Ethylbenzene	8.3	200	0.04	37	200	0.19	2.9	200	0.01
Xylenes	25.3	125	0.20	146	125	1.17	10.8	125	0.09
Ethyltoluenes, sum of isomers				37.6	100*	0.38		100*	
Propylbenzenes, sum of isomers				9.6	200	0.05		200	
Trimethylbenzenes sum of isomers				34.8	100	0.35		100	
Chloromethane	5.1	45	0.11						
Trichloroethylene							49	1625	0.03
Sum RCR			**0.42**			**2.49**			**0.16**
C7-C12 hydrocarbons, total	93.4	1425	0.07**	664.9	1425	0.47**	91.5	1425	0.06**

*LCI value for trimethylbenzene used for ethyltoluenes as well.

** RCR for C7-C12 hydrocarbons is not included in RCRsum, as the LCI value for C7-C12 hydrocarbons is a separate criterion based on data for the sum of C7-C12 hydrocarbons

For child room no. 15, an RCR value of 2.49 was obtained, which means a significantly reduced safety margin in terms of risk for chronic neurotoxic effects. The concentration of benzene, however, is considered very high and most concerning, as prolonged stay with a content of 20.5 μg/m^3 must be considered to contribute to increased cancer risk. WHO (2013) indicates in their guidelines for indoor air pollution that a benzene level of 0.17 μg/m^3 corresponds to a 10^{-6} increased lifetime risk for of cancer (i.e. a lifetime risk of 10^{-4} at a benzene concentration of 17 μg/m^3. In EU a limit value for benzene of 1 μg/m^3 has been set for ambient air to protect the population from carcinogenic effects.

Apart from child room no. 15, the most contaminated of the 19 other children´s rooms are child room no. 3 and 16, for which a cumulative RCR value of 0.42 and 0.16, respectively, was calculated. Thus, all the 17 other children´s rooms would have RCR values around or below 0.16.

In overall, based on these data and assuming that the above sample of children´s rooms may be representative of children´s rooms in general, there should be no concern for the emission of chronic neurotoxic substances to the indoor air.

Child room no. 15 is, however, considered as a special case. Here it was demonstrated that the source of the contamination was l petrol and white spirit in a shed that bordered the outer wall of the children´s room. Nevertheless, this case demonstrate that in some rare cases, there may be non-intended high levels of chronic neurotoxic substances as well as carcinogens in the indoor air of a children´s room.

8.4 Overall assessment, uncertainties and limitations

Overall assessment

Overall, the emission tests of building materials and household furniture as well as emission tests with a variety of toys show that emissions of volatile neurotoxic substances in levels causing health concerns for chronic neurotoxic effects in children do not generally occur. This is also supported by a number of measurements performed in children´s rooms in private homes, where the levels of the neurotoxic substances were generally low in a risk assessment context.

However, the measurements in the children´s rooms showed that critical levels may occur in indoor air due to other emission sources e.g. chemical products. Thus, critical levels s may occur due to incorrect storage of petrol/ white spirit or other organic solvents elsewhere in or around the house, or for shorter duration in connection with freshly painted surfaces, especially with alkyd paint (white spirit based paint).

Generally, other background exposure to volatile chronic neurotoxic substances, e.g. through drinking water and food, is considered insignificant, whereas some exposure may occur e.g. to hydrocarbons during transportation in cars, because of emission from interior parts in the cabin and vapours from fuel and exhaust.

Uncertainties

The approach to this project has been to try to build exposure scenarios representing worst-case circumstances regarding emission of neurotoxic substances in children´s rooms. Thus, the selection and purchase of furniture/ furnishings, and toys, etc. was carried out based on the knowledge and experience of the types of products most likely to cause emission of the chronic neurotoxic substances. Although the purchase of the products was targeted, there will always be an element of chance in whether the purchased products have a high content of the focus substances, as it was not possible to make a chemical analytical screening and further selection of products in connection with the purchase.

On the other hand, it can be said that this randomness factor ensures the establishment of a more realistic scenario, as the likelihood of a family selecting only the worst products when shopping for a children´s room also will be minimal.

Although risk assessments will always be subject to some uncertainty, the uncertainties in the risk assessments of this report rather lead to an overestimation of risk than an underestimation. The risk assessments were carried out from the emission levels after the first 24 hours, i.e. when the emission was highest. The emission levels for all products measured declined significantly after 72 hours and after 2 weeks, and therefore the exposure (and hence the risk) will be significantly lower over time.

It should be noted that possible low exposure levels below the detection limits were not taken into account in the risk assessments. The error by ignoring these low levels is however, considered insignificant as the detection limits for most substances were more than a factor of 100 below the respective LCI values.

There are also uncertainties associated with the limited knowledge in relation to some of the neurotoxic substances, and therefore the estimated LCI values (tolerable levels) should be considered as estimates rather than exact values.

Limitations
Unfortunately it was not possible to obtain a true picture regarding the emission from electronics, which otherwise in previous studies were indicated to contribute significantly to the emission of neurotoxic substances. This was because the purchased electronic equipment enters into standby mode automatically, so realistic measurements for long-term use of the equipment under warmed up conditions could not be made.

However, it does not seem to be relevant to make risk assessment based on more than 10 years old data for emissions from electronic equipment, as electronics today is very different from 10 years old electronics. However, the measurements from those of the children´s rooms equipped with many electronic devices did suggest that the indoor air contribution to volatile neurotoxic substances from electronics today is limited. Still, knowledge is lacking regarding emission from new electronic equipment.

For an overall assessment of chronic neurotoxic effects in children, knowledge is still lacking in relation to how to include contributions from other types of neurotoxic substances in the risk assessment. This may be contributions from non-volatile compounds such as PCB, poly and perfluorinated organic compounds (e.g. PFOS/PFOA), lead and mercury, which all are known as neurotoxic substances.

Finally, it should be noted that the assessment in this project solely focuses on neurotoxic effects, and that effects from emission of other substances and other health effects (e.g. cancer, asthma, allergy) are not covered in the report. In indoor environment context, it may also be important to assess the overall emissions and the effects with regard to eye and respiratory tract irritation, odour and nuisance, as well as more non-specific effects covered by the so-called "sick building syndrome".

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US EPA/IRIS, 2008a. IRIS n-Hexane CAS 110-54-3. http://toxnet.nlm.nih.gov/

US EPA/IRIS, 2008b. IRIS n-Heptane CAS 142-82-5. http://toxnet.nlm.nih.gov/

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Appendix 1: Selection of comparable substances

The EPA has listed the following sources as particularly relevant for the implementation of the project:

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Danish EPA (2015). Strategi for risikohåndtering af toluen (National strategy for risk management of toluene). Only in Danish, 1 January 2015: http://mst.dk/media/130319/4-toluen.pdf

*Dutch Health Council (2008). Occupational exposure to organic solvents: effects on human reproduction, 12 June 2008: http://www.gezondheidsraad.nl/sites/default/files/200811OSH.pdf

*Dutch Institute for Public Health and the Environment, RIVM (2007). Risks of containers containing dangerous volatile substances to human health and the environment, RIVM Rapport 609021091/2009: http://www.rivm.nl/dsresource?objectid=rivmp:16735&type=org&disposition=inline&ns_nc=1

ECB (2003). EU Risk assessment report toluene, CAS No: 108-88-3. EUR 20539 EN: http://publications.jrc.ec.europa.eu/repository/handle/111111111/8774

Ellermann, T., Nøjgaard, J.K., Nordstrøm, C., Brandt, J., Christensen, J., Ketzel, M. & Jensen, S. S. (2012). The Danish Air Quality Monitoring Programme. Annual Summary for 2011. Scientific Report from DCE – Danish Centre for Environment and Energy, Aarhus University. http://www2.dmu.dk/Pub/SR37.pdf

*European Agency for Safety and Health at Work (2009). Combined exposure to noise and ototoxic substances. ISBN -13: 978-92-9191-276-6: https://osha.europa.eu/en/publications/literature_reviews/combined-exposure-to-noise-and-ototoxic-substances

*German Institute for Occupational Safety and Health (2009). Exposition gegenüber ototoxischen Gefahrstoffen (Exposure to ototoxic hazardous substances). Only in German. Poster 2009: http://www.dguv.de/medien/ifa/de/pub/poster/2009_067.pdf

*German Social Accident Insurance (2007). Polyneuropathie oder Enzephalopathie durch organische Lösungsmittel oder deren Gemische (Polyneuropathy or encephalopathy caused by organic solvents or mixtures thereof). Only in German. BK 1317, BK-Report 2/2007.

*Giordano, G. and Costa, L.G. (2012). Review article – Developmental neurotoxicity: some old and new issues. International Scholarly Research Network, ISRN Toxicology, Volume 2012, Article ID 814795.

*Grandjean, P. and Landrigan, P.J. (2006). Developmental neurotoxicity of industrial chemicals. The Lancet 368.9553 (2006): 2167-2178.

* Jensen, A.A. and Knudsen, H.N. (2006). Total health assessment of chemicals in indoor climate from various consumer products. Survey of Chemical Substances in Consumer Products. No. 75 2006. Danish Environmental Protection Agency. http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/Udgiv/publications/2006/87-7052-214-6/html/default_eng.htm

Moldoveanu S, Coleman W. and Wilkins J. (2008). Determination of Benzene and Toluene in exhaled Cigarette Smoke. Contributions to Tobacco Research 23: 107-114. http://www.degruyter.com/view/j/cttr.2008.23.issue-2/cttr-2013-0853/cttr-2013-0853.xml

NOVANA Program (2014). Miljøfremmede stoffer og metaller i vandmiljøet. Tilstand og udvikling 2004 – 2012. Under publication.

Tukes (2013). Substance Evaluation Report - Background document for the purpose of substance evaluation under REACH for Substance name Toluene. EC No 203-625-9. Tukes Finnish Safety and Chemical Agency, 12 November 2013: http://echa.europa.eu/information-on-chemicals/evaluation/community-rolling-action-plan/corap-table/-/substance/1520/search/+/term

As can be seen from the titles, some of the articles include only issues relating to toluene, while other articles describe the levels in the environment or in relation to particular sources such as cigarette smoke. There remains the * marked sources indicating that they concern volatile organic substances and their harmful neurotoxic effects. Below these references are screened for their coverage of chronic neurotoxic substances:

***Dutch Health Council (2008). Occupational exposure to organic solvents: effects on human reproduction, 12 June 2008: http://www.gezondheidsraad.nl/sites/default/files/200811OSH.pdf**

This report assesses the epidemiological data from the working environment regarding damage to reproduction and fetal development associated with exposure to these substances:

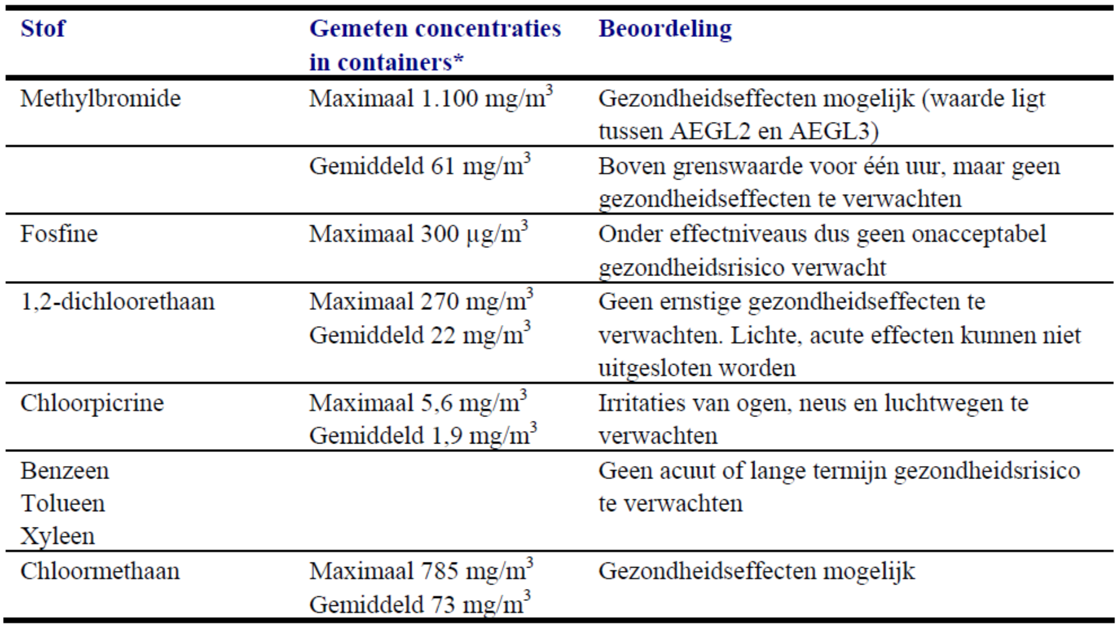
- Ethyleneglycolethers
- Toluene
- Styrene
- Acetone
- Tetrachloroethylene
- Methylenechloride

Der henvises kun i begrænset omfang til dyreeksperimentelle data for stofferne idet vurderingen alene hviler på, hvad der kan konkluders på de eksisterende humane data.
Data vedrørende fertilitet og spontan abort vurderes ikke relevante i diskussionen vedr. neurotoksiske effekter, hvorfor data i nærværende projektsammenhæng alene vurderes på baggrund af udviklingsmæssige effekter.
Ud fra disse kriterier var der kun data for ethylenglycolethere der udviste en vis sammenhæng med forekomst af misdannelse bla. ifm. nervesystemet, mens der for de andre stoffer, ud fra de tilgængelige human data, ikke kunne spores effekter mht. fosterudvikling/ misdannelser.
Det angives i rapporten at følgende glycolethere er klassificeret med R61(Kan skade barnet under graviditeten): EGEE, EGEEA, EGME, EGMEA, 1PG2ME , 1PG2MEA, DEGME. Det oplyses dog ikke nærmere om dette specifikt omfatter skader på udviklingen af centralnervesystemet.

***Dutch Institute for Public Health and the Environment, RIVM (2007). Risks of containers containing dangerous volatile substances to human health and the environment, RIVM Rapport 609021091/2009: http://www.rivm.nl/dsresource?objectid=rivmp:16735&type=org&disposition=inline&ns_nc=1**

Omhandler malinger af afdampning af stoffer fra fragt i containere (bl.a data med afgasning fra madrester). Følgende stoffer og deres indhold blev vurderet:

Tabel 3 Samenvattend overzicht van de risicobeoordeling voor omstanders



Stof	Gemeten concentraties in containers*	Beoordeling
Methylbromide	Maximaal 1.100 mg/m^3	Gezondheidseffecten mogelijk (waarde ligt tussen AEGL2 en AEGL3)
	Gemiddeld 61 mg/m^3	Boven grenswaarde voor één uur, maar geen gezondheidseffecten te verwachten
Fosfine	Maximaal 300 µg/m^3	Onder effectniveaus dus geen onacceptabel gezondheidsrisico verwacht
1,2-dichloorethaan	Maximaal 270 mg/m^3 Gemiddeld 22 mg/m^3	Geen ernstige gezondheidseffecten te verwachten. Lichte, acute effecten kunnen niet uitgesloten worden
Chloorpicrine	Maximaal 5,6 mg/m^3 Gemiddeld 1,9 mg/m^3	Irritaties van ogen, neus en luchtwegen te verwachten
Benzeen Tolueen Xyleen		Geen acuut of lange termijn gezondheidsrisico te verwachten
Chloormethaan	Maximaal 785 mg/m^3 Gemiddeld 73 mg/m^3	Gezondheidseffecten mogelijk

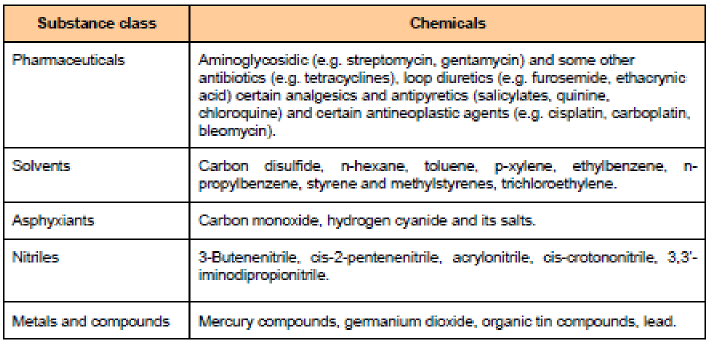
* waar de gemiddelde concentratie is vermeld, betreft dit de gemiddelde concentratie in containers waarin de stof aangetroffen is en het betreft de hoogste gemiddelde waarde over vier afzonderlijke jaren (zie Tabel 1)

Der foretages ikke nærmere vurdering vedrørende stoffernes neurotoksiske effekter, blot kan ses af benzen, toluen og xylen er nævnt.

***EEA (2009). European Agency for Safety and Health at Work (2009). Combined exposure to noise and ototoxic substances. ISBN -13: 978-92-9191-276-6: https://osha.europa.eu/en/publications/literature_reviews/combined-exposure-to-noise-and-ototoxic-substances**

I denne rapport fra det Europæiske Arbejdsmiljøagentur fokuseres på kemiske stoffer med toksiske effekter på hørelsen dvs. ototoksiske stoffer.

Følgende industrikemikalier anføres som ototoksiske stoffer i rapportens konklusion:



Substance class	Chemicals
Pharmaceuticals	Aminoglycosidic (e.g. streptomycin, gentamycin) and some other antibiotics (e.g. tetracyclines), loop diuretics (e.g. furosemide, ethacrynic acid) certain analgesics and antipyretics (salicylates, quinine, chloroquine) and certain antineoplastic agents (e.g. cisplatin, carboplatin, bleomycin).
Solvents	Carbon disulfide, n-hexane, toluene, p-xylene, ethylbenzene, n-propylbenzene, styrene and methylstyrenes, trichloroethylene.
Asphyxiants	Carbon monoxide, hydrogen cyanide and its salts.
Nitriles	3-Butenenitrile, cis-2-pentenenitrile, acrylonitrile, cis-crotononitrile, 3,3'-iminodipropionitrile.
Metals and compounds	Mercury compounds, germanium dioxide, organic tin compounds, lead.

Rapporten angiver endvidere at samtidig eksponering for lægemidler med forskelligt virkningsmekanisme i øret kan medføre forøget response. Tilsvarende for de aromatiske opløsningsmidler er fundet en forstærkende effekt, men her som følge af at de påvirker hinandens omsætning i kroppen, da de omdannes via de samme enzymatiske processer.

For de ototoksiske opløsningsmidler gennerelt gælder at deres skadelige effekter på hørelsern forstærkes ved samtidig udsættelse for støj.

***German Institute for Occupational Safety and Health (2009). Exposition gegenüber ototoxischen Gefahrstoffen (Exposure to ototoxic hazardous substances). Only in German. Poster 2009: http://www.dguv.de/medien/ifa/de/pub/poster/2009_067.pdf**

I denne poster vurderes eksponeringen med ototoksiske stoffer i arbejdemiljøet i Tyskland. Følgende ototoksiske stoffer udpeges for hvilke der angives måledata i arbejdsmiljøet:

Toluen
Ethylbenzen
Xylener
Styren
n-hexan
n-heptan
Carbondisulfid
Carbonmonoxid
Cyanider
Hydrogencyanid
Kviksølv og kviksølvforbindelser
Ud over måleresultater og antal af overskridelser af græneværdierne i arbejdsmiljøet angives ikke yderligere data.

***German Social Accident Insurance (2007). Polyneuropathie oder Enzephalopathie durch organische Lösungsmittel oder deren Gemische (Polyneuropathy or encephalopathy caused by organic solvents or mixtures thereof). Only in German. BK 1317, BK-Report 2/2007.**

For de nedennævnte neurotoksiske stoffer angives dels data for stofferne og dels lægefaglige anbefalinger for hvorledes de kroniske nerveskader kan diagnosticeres (både mht. perifer neuropathti) og kroniske skader på centralnervesystemet.). Stofferne er udpeget på baggrund af én videnskabelig udredning, hvor der anføres konkrete humane data m.h.t. kroniske neurotoksiske effekter på det perifere nervesystem og centralnervesystemet (perifer neuropati og kronisk toksisk encephalopati):

Alifatiske kulbrinter:	n-Hexan, Heptan
Ketoner:	Methyl-Ethyl-Keton, Methyl-Butyl-Keton
Alkoholer:	Methanol, Ethanol
Aromatiske kulbrinter:	Benzen, Toluen, Xylen, Styren
Chlorerede kulbrinter:	monochlormethan, dichlormethan, 1,1,1-Trichlorethan, Trichlorethylen, Tetrachlorethylen

I det videnskabelige baggrundsdokument anføres endvidere mulige virkningsmekanismer dels en mere overordnet virkningsmåde for den samlede gruppe af organiske opløsningsmidler som følge af stofferne fedtopløselige egenskaber og deres fordeling til fedtfasen i nervecellerne, samt mere specifikke virkemåder, som følge af dannelse af særligt neurotoksiske metabolitter (trichlorethanol fra trichlorethylen og 2,5 hexandion fra n-hexan).

***Giordano, G. and Costa, L.G. (2012). Review article – Developmental neurotoxicity: some old and new issues. International Scholarly Research Network, ISRN Toxicology, Volume 2012, Article ID 814795.**

I denne artikel anføres, at nervesystemet under udvikling hos foster og børn er mere følsomme over for en række neurotoksiske stoffer end nervesystemet hos voksne. Som eksempeer herpå beskrives mere detaljeret effekterne af methylkviksølv, bly, polybrrmerede diphenylethere og organophosphater (insekticider). Som eksempler på flygtige neurotoksiske opløsningsmidler og fosterbeskadigende effekt nævnes ethanol og toluen.

***Grandjean, P. and Landrigan, P.J. (2006). Developmental neurotoxicity of industrial chemicals. The Lancet 368.9553 (2006): 2167-2178.**

I denne oversigts artikel identificeres over 200 stoffer der anses at være neurotoksiske over for mennesker. Stofferne omfatter både stoffer med evidens for akut narkotisk effekt såvel som stoffer med evidens for kroniske nerveskader.

Stofferne omfatter:

Metaller og uorganiske forbindelser: 25 stoffer og stofgrupper, hvoraf der anføres at for 3 af stofferne/ stofgrupperne: arsen, bly og methylkviksølv er der evidens for at stofferne kan påvirke nervesystemet under udviklingen hos fostre og unge.

Organiske opløsningsmidler: 43 stoffer, hvoraf der for 2 stoffer: ethanol og toluen anføres, at der evidens for at stofferne påvirker nervesystemet under udviklingen hos fostre og unge.

Andre organiske forbindelser: 43 stoffer/ stofgrupper, hvor der for 1 stofgruppe: Poylchlorerede biphenyler (PCB) anføres, at der evidens for at stofferne påvirker nervesystemet under udviklingen hos fostre og unge.

Pesticider: 90 stoffer, hvoraf der for ingen at stofferne foreligger data og evidens for evt. påvirkning af nervesystemet under udvikling.

Artiklen understreger pga den store mangel af data for alle disse stoffer, at stofferne ikke kan anses for sikre med hensyn til påvirkning af nervesystemet, og at yderligere testning for effekter på nervesystemet under det udvikling er påkrævet.

I en nylig publiceret opdatering af denne artikel angives at der blandt de organiske opløsningsmidler nu yderligere kan føjes tetrachlorethylen som et stof der påvirker centralnervesystemet under fosterudviklingen. (Grandjean, P & Landrigan PJ (2014). Neurobehavioural effects of developmental toxicity. Lancet Neurol, 13, 330-338.)

*** Jensen, A.A. and Knudsen, H.N. (2006). Total health assessment of chemicals in indoor climate from various consumer products. Survey of Chemical Substances in Consumer Products. No. 75 2006. Danish Environmental Protection Agency. http://www2.mst.dk/common/Udgivramme/Frame.asp?http://www2.mst.dk/Udgiv/publications/2006/87-7052-214-6/html/default_eng.htm**

Denne rapport beskriver kilder til og niveauer i indeklimaet til en række stoffer. Desuden angives tolerable eksponeringsniveauer, samt angivelse af stofferene kritiske effekter. De berørte stoffer og stofgrupper omfattede:
-Phenol
-Formaldehyd
-Acetaldehyd
-Benzen
-Toluen
-Xylener
-Styren
-Limonen
-Bromererede flammehæmmere
-Phthalater
-Perfluorerede alkylfrobindelser

Neurotoksicitet nævnes som kritiske effekter for phenol (også akut toksicitet), toluen, xylener. For styren nævnes at stoffet er reproduktionstoksisk.
Phenol anses dog ikke for relevant med hensyn til kronisk neurotoksicitet, idet hverken IRIS/US EPA (2001) eller Danish EPAs LOUS-rapport vedr. phenol angiver neruotoksicitet som en væsentlig effekt af phenol efter gentagen dosering.

Vurdering af kilderne m.h.t. toluen og udpegning af sammenlignelige, neurotoksiske stoffer

For at udpege lignende neurotoksiske stoffer sammenlignet med toluen anses det Europæisk Arbejdsmiljøagentur for en primær kilde. Her samt i posteren German Institute for Occupational Safety and Health (2009) fokuseres netop på kemiske stoffer med neurotoksiske effekter med indflydelse på høresansen. Disse referencer fokuserer imidlertid på stoffer i arbejdsmiljøet, men inden for gruppen opløsningsmidler peges der på en række stoffer (typisk kulbrinter) der også er velkendte i indeklimaet:

- n-hexan
- n- heptan
- toluene
- xylener
- ethylbenzen
- n-propylbenzene
- styren
- methylstyren
- trichlorethylen

Inddrages dernæst data fra den omfattende tyske arbejdsforsikringrapport vedrørende organiske opløsningsmidler og deres kroniske neurotoksiske skader kan yderligere stoffer inddrages:

Methyl-Ethyl-Keton,
Methyl-Butyl-Keton
Methanol,
Ethanol
monochlormethan,
dichlormethan,
1,1,1-Trichlorethan,
Tetrachlorethylen

Ved gennemgangen af ovenstående kan følgende bruttoliste af flygtige, neurotoksiske stoffer der kan afgasse til indeklimaet således nævnes:

Kulbrinter:

- n-hexan
- n- heptan
- toluen
- xylener
- ethylbenzen
- n-propylbenzene
- styren
- methylstyren

Klorerede opløsningsmidler:

- monochlormethan,
- dichlormethan,
- 1,1,1-Trichlorethan,
- trichlorethylen
- tetrachlorethylen

Alkoholer:

- methanol
- ethanol

Ketoner:

- Methyl-Ethyl-Keton,
- Methyl-Butyl-Keton

Appendix 2: Identification of relevant products containing toluene and other volatile substances with potential for chronic neurotoxicity

2.1 Danish EPA database regarding chemicals found in consumer products

In order to identify consumer products that may be relevant for children´s exposure to toluene and the other neurotoxic substances searches were made in the Danish EPA database regarding chemicals found in consumer products. The chemical name (and/ or CAS no.) was entered and from the hits found in the database the most relevant products in relation to children´s exposure were selected, see table below:

Chemical substance	**Total number of hits in MST database on consumer products**	**Selected hits that may be relevant for this project**	**Content** no unit clearly indicated in the database but typically as **µg/m^3 or mg/kg**
n-hexane	6	**Cuddly toys** **Textile colours**	16 -
n-heptane	13	**Textile spray impregnation** **Tusch pens** **Textile cube**	**267** **220** 49
octane	9	**Tusch pens** **Textile cube** **Slimy toy** **Magazines** **Leather polish**	**440** 21 1 - -
nonane	5	**Textile spray impregnation** **Magazines** **Leather polish**	- - -
decane	13	**Plastic pearls** **Textile spray impregnation** **Cuddly toy** **Igloo tent** **Magazines** **Leather polish**	27.5 - 10 15 - -
Undecane	11	**Textile spray impregnation** **Ballons** **Textile cube** **Cuddly toy** **Magazines**	- 11 17 24 -
dodecane	17	**Plastic pearls** **Textile spray impregnation** **Textile cube** **Ballons**	11.5 - 20 2.8

		Eraser **Igloo tent** **Magazines**	- 55 -
benzene	21	**Ballons** **Monitor** **Textile cube** **Cuddly toy** **Christmas decoration** **TV**	2.4 6.5 14 12 **119-230** 5
toluene	98	**Small tents** **Rubber figures with perfume** **Christmas decoration** Mobil phone **Monitor** **Plastic pearls** **Spray paint** **Transformer** **Magazines** **Cuddly toys with perfume** **TV**	13-19 140-**6700** 21-25 29 **140-333** 9-**720** **Max 36000** **128-307** **Max 2097** 68 19
xylenes	80	**Magazines** **Tent** **Shoe polish** **Plastic pearls** **Christmas decorations** **Rubber figures** **Cuddly toy** **Transformer/charger** **Chargeable batteries** **Lamp** **Textile impregnation spray** **Slimy toy** **Monitor** **Tusch pens** **Gel candles** **Computer**	17 3-9 40 **430** **280** **620** 11 5-94 **170** **200** 55 **100** 33-82 2.5 15-20 91
ethylbenzene	34	**Plastic pearls** **Rubber figure** **Lamp** **Computer** **TV** **Rechargeable batteries** **Slimy toy** **Textile colours** **Christmas decoration** **Monitor** **Transformer**	**935** **1100** **180** 66 3 **140** **100** 19 31-47 14 74
Propyl benzene **Isopropyl benzene**	3 2	**Plastic pearls** **Textile colours**	33-**430** -
Styrene	51	**Plastic pearl plate** **Plastic pearls**	**375-20000** **720**

		Textile cube **Computer** **Monitor** **TV** **Lamp** **Rechargeable batteries** **Textile colours** **Christmas decorations** Play console Bed linens	37 22 4-15 13 1.5 7.2 6.6 82 16 2
methyl styrene	1	**Textile colours**	-
trimethyl benzene	0		
diisopropyl benzene	0		
phenyloctan	0		
white spirit	1	**Shoe cream**	**880 000**
monochloromethane	0		
dichloromethane	10	**Rubber figure** **Slimy toy** **Magazines** **Textile colours** **Textile impregnation spray**	<50 3 1.8 **130** -
trichloroethylene	0		
tetrachloroethylene	4	**Tents**	1-2

In the column of selected hits the items occurring several times are in **bold**. In the column of content the content values above 100 are in **bold**.

From this screening the following items seems relevant for further consideration with respect to selection for emission sampling and analytical measurements:

Plastic pearls
Rubber figures
Textile spray impregnation
Textiles with colored motives
Cuddly toy
Igloo tent
Magazines
Leather polish
Chrismas decoration
Christmas spray
Monitors
Tusch pens
Cuddly toy
Transformers/ charger
Lamps

Furthermore surface treated and glued articles such as furniture and tennis/ sport shoes may be considered as relevant as well.

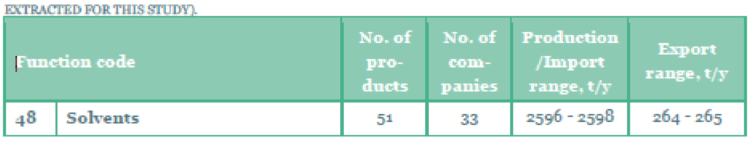
2.2 Danish LOUS projects

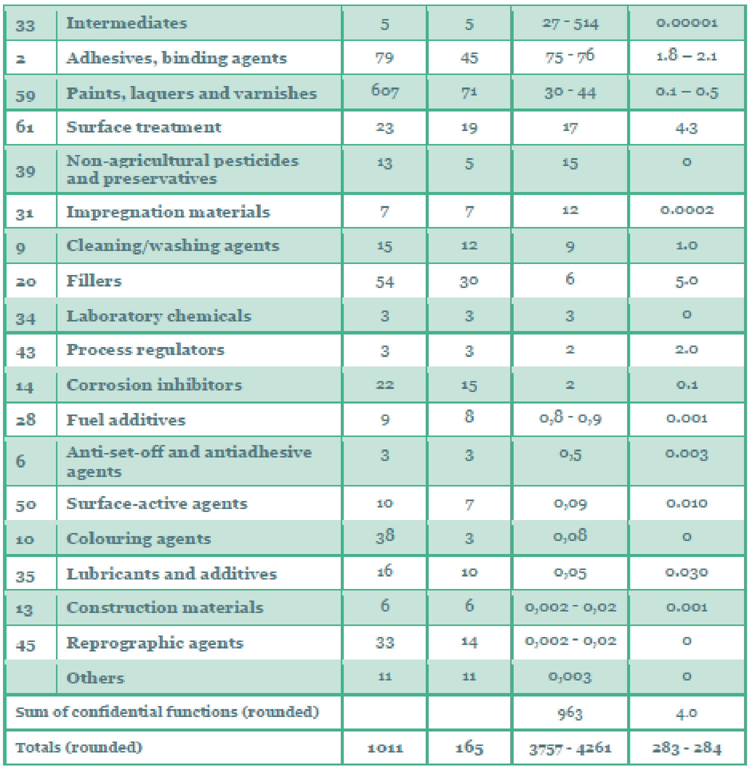
Also the LOUS projects on toluene, n-hexane, styrene and white spirit may be used for identifying further data on the use of the substances:

LOUS report on toluene, extracts:

In the LOUS report the follow product uses in Denmark was listed:

OVERVIEW OF REGISTRATIONS FOR TOLUENE BY FUNCTION IN THE DANISH PRODUCT REGISTER (2012 DATA EXTRACTED FOR THIS STUDY).



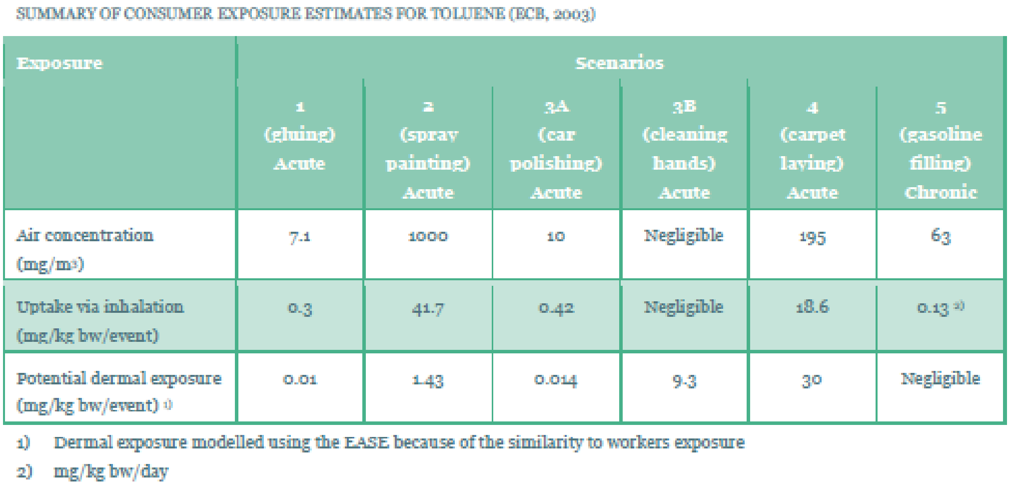


Function code		No. of products	No. of companies	Production /Import range, t/y	Export range, t/y
48	Solvents	51	33	2596 - 2598	264 - 265
33	Intermediates	5	5	27 - 514	0.00001
2	Adhesives, binding agents	79	45	75 - 76	1.8 – 2.1
59	Paints, laquers and varnishes	607	71	30 - 44	0.1 – 0.5
61	Surface treatment	23	19	17	4.3
39	Non-agricultural pesticides and preservatives	13	5	15	0
31	Impregnation materials	7	7	12	0.0002
9	Cleaning/washing agents	15	12	9	1.0
20	Fillers	54	30	6	5.0
34	Laboratory chemicals	3	3	3	0
43	Process regulators	3	3	2	2.0
14	Corrosion inhibitors	22	15	2	0.1
28	Fuel additives	9	8	0,8 - 0,9	0.001
6	Anti-set-off and antiadhesive agents	3	3	0,5	0.003
50	Surface-active agents	10	7	0,09	0.010
10	Colouring agents	38	3	0,08	0
35	Lubricants and additives	16	10	0,05	0.030
13	Construction materials	6	6	0,002 - 0,02	0.001
45	Reprographic agents	33	14	0,002 - 0,02	0
	Others	11	11	0,003	0
Sum of confidential functions (rounded)				963	4.0
Totals (rounded)		1011	165	3757 - 4261	283 - 284

Further the LOUS report mentions that under REACH (AppendixXVII), the concentration of toluene in adhesives and spray paints is restricted to ≤ 0.1%. Also the content of toluene in nail polish is restricted to 25 % according to the cosmetics regulation and warnings against the use by children have to be applied: “Keep out of reach of children. To be used by adults only”.

There are no specific restrictions of toluene in other types of products where consumer exposure can occur, such as paints or thinners.

Further a summary of 5 consumer exposure scenarios is given:



SUMMARY OF CONSUMER EXPOSURE ESTIMATES FOR TOLUENE (ECB, 2003)

Exposure	Scenarios					
	1 (gluing) Acute	2 (spray painting) Acute	3A (car polishing) Acute	3B (cleaning hands) Acute	4 (carpet laying) Acute	5 (gasoline filling) Chronic
Air concentration (mg/m^3)	7.1	1000	10	Negligible	195	63
Uptake via inhalation (mg/kg bw/event)	0.3	41.7	0.42	Negligible	18.6	0.13 [2]
Potential dermal exposure (mg/kg bw/event) [1]	0.01	1.43	0.014	9.3	30	Negligible

1) Dermal exposure modelled using the EASE because of the similarity to workers exposure

2) mg/kg bw/day

Thus, the LOUS report on toluene indicates that carpet gluing, spray painted and glued items (especially newly painted item) may be relevant sources for exposure in a child´s room

LOUS report on n-hexane, extracts:

The data from the publicly available part of the Danish Product Register (SPIN database) show that the main non-confidential uses of n-hexane are as solvent, in degreasers and, in minor amounts in miscellaneous products like cleaning and washing agents, paints and laqueres, adhesives, lubricants, anti-corrosion materials, casting slips for plastic, process regulators.

The non-confidential uses add up to 11.9 tonnes in 2011, while the total consumption is reported to be approximately 246 tonnes.

Further the following table was given:

CONSUMER PRODUCTS CONTAINING *N*-HEXANE AND USE CONDITIONS BASED ON EXPOSURE MODEL PARAMETERS (ENVIRONMENT CANADA, 2009)

Consumer product	Maximum conc. of *n*-hexane in %	Frequency of use (events/year)	Exposure duration (min)
Construction Adhesive	30	2	240
Gasket Sealant	25	3	45
Spray Paint	20	2	20
Weatherstrip Adhesive	15	N/A	N/A
Spray Adhesive	30	12	240
Weatherstrip Cement	8.9	7	16

n-Hexane is not restricted in the REACH regulation (Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals).

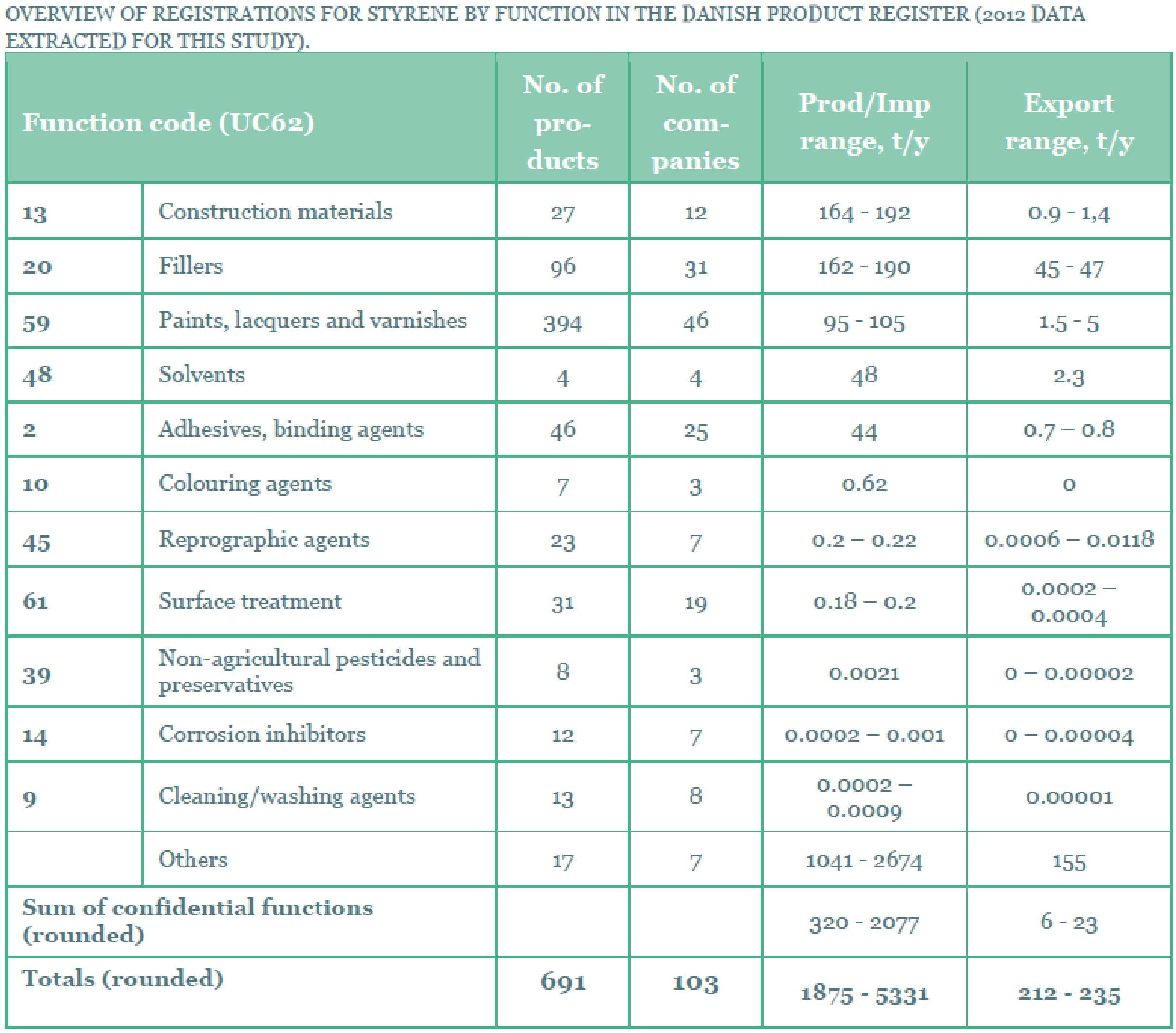
n-Hexane is registered with a full registration under REACH in the 10,000 - 100,000 t/y band.

n-Hexane is included in the first Community Rolling Action Plan (CoRAP 2012-2014) for evaluation in the year 2012 by Germany due to concerns about human health. N-hexane was selected for substance evaluation due to the CMR-properties and neurotoxic effects. The intention of the substance evaluation is to evaluate the risks arising from the aggregated exposure. The current status is marked as “ongoing” (May 2014).

Thus, for n-hexane glued and freshly spray-painted items may be relevant for exposure in a child´s room.

LOUS report on Styrene, extracts:

In the LOUS report the following product uses are given:



OVERVIEW OF REGISTRATIONS FOR STYRENE BY FUNCTION IN THE DANISH PRODUCT REGISTER (2012 DATA EXTRACTED FOR THIS STUDY).

Function code (UC62)		No. of products	No. of companies	Prod/Imp range, t/y	Export range, t/y
13	Construction materials	27	12	164 - 192	0.9 - 1,4
20	Fillers	96	31	162 - 190	45 - 47
59	Paints, lacquers and varnishes	394	46	95 - 105	1.5 - 5
48	Solvents	4	4	48	2.3
2	Adhesives, binding agents	46	25	44	0.7 – 0.8
10	Colouring agents	7	3	0.62	0
45	Reprographic agents	23	7	0.2 – 0.22	0.0006 – 0.0118
61	Surface treatment	31	19	0.18 – 0.2	0.0002 – 0.0004
39	Non-agricultural pesticides and preservatives	8	3	0.0021	0 – 0.00002
14	Corrosion inhibitors	12	7	0.0002 – 0.001	0 – 0.00004
9	Cleaning/washing agents	13	8	0.0002 – 0.0009	0.00001
	Others	17	7	1041 - 2674	155
Sum of confidential functions (rounded)				320 - 2077	6 - 23
Totals (rounded)		**691**	**103**	**1875 - 5331**	**212 - 235**

According to the LOUS report no specific restrictions in relation to the use of styrene in consumer products apply.

In relation to flooring materials the LOUS report refers to the data from the EU Risk Assessment report (2008). In this report, several studies (mostly from North America published in the period 1969 – 1995) on indoor and ambient air concentrations of styrene were reviewed. Low concentrations of styrene have been reported for indoor air as a result of emissions from flooring materials. It was suggested that flooring materials emitted most of the styrene within the first two weeks of manufacture (up to 200 µg/m³), while after a month the emissions appeared to fall dramatically (“almost nothing”).

Styrene butadiene rubber (SBR), which is used for products such as carpet backing, was the only polymer reported to contain residual levels of styrene. In the studies providing both indoor and ambient data, indoor air levels of styrene were greater than levels in ambient air, sometimes linked to smoking (depending on the information available).

Exposure from long-term low-level sources is therefore made up of the following components:

- Emissions from polymeric building materials, incl. carpets (inhaled) - 5 µg/m³ (80 µg/day).

Thus, In relation to exposure in a child´s room emission from especially construction materials, fillers, paint and laquers and adhesives may be relevant.

LOUS report on white spirit, extracts:
The LOUS report indicates the following main uses of white spirit (with about 15% aromatic content) in Denmark according to the Danish Product Registry 2013:

Solvents	2358 tonnes
Cleaning agents	541 tonnes
Paints and lacquers	341 tonnes
Fuels and fuel additives	370 tonnes
Surface treatment	152 tonnes
Non-agricultural pesticides and preservatives	77 tonnes

However, it should be noted that these uses are spread over a total of 987 products of which 497 are paints and lacquers.

For dearomatized white spirit the following uses are indicated:

Solvent and thinners	4725 tonnes
Paint and lacquers	1275 tonnes
Cleaning/washing agents	1018 tonnes
Adhesives binding agents	647 tonnes
Corrosion inhibition	339 tonnes
Reprographic agents	261 tonnes
Fuels	212 tonnes
Non-agricultural pesticides and preservatives	111 tonnes
Surface-active agents	103 tonnes

No specific restrictions apply to the content of white spirit in consumer products.

Thus, freshly painted surfaces/ items would be relevant for exposure in a child´s room.

Overall evaluation of the data from the LOUS reports
The uses of the substances n-hexane, toluene, styrene and white spirit to a great extent overlap. Thus the substances are used as solvents, cleaning agents, paint and laquers, and in glue/adhesives. Thus products and articles (e.g. *construction materials, furniture, clothing, toys, impregnation products, polishes, cosmetics etc.*) in which the solvents are a part or where they have been used in the manufacturing process may have a potential for emission and exposure of the consumers.
As the hydrocarbon substances are closely related and often occur at the same time in various mixtures of organic solvents it is not surprising that the substances have been found in the same type of products as identified by the data from the Danish consumer database.

Appendix 3: Identification of relevant building and finishing materials containing toluene and other volatile substances with potential for chronic neurotoxicity

Identification of building and finishing materials which potentially can contain the chemicals of interest was performed by searching the Danish Product Register (SPIN) database for building-specific applications, scientific database (SCOPUS) for articles on emission of the chemicals of interest from building materials and general Internet search. Findings from the Danish LOUS project are not reported here, as they are in detail described in appendix 2.

3.1 Indoor air concentrations in homes.

Concentrations of volatile organic compounds in indoor and outdoor environments have been measured in several studies, showing variations due to season, local conditions such as proximity to busy road or industry as well as indoor sources and human activities. Concentrations of benzene, toluene, xylenes and styrene measured in European buildings and published between 1990 and 2008 were summarised in a literature review by Sarigiannis et al. (2011). For benzene the mean reported indoor concentrations varied between 0.7 and 44 $\mu g/m^3$, for toluene between 3.5 and 358 $\mu g/m^3$, for xylenes between ND and 88 $\mu g/m^3$ and for styrene the mean concentrations varied between ND and 30 $\mu g/m^3$ (Sarigiannis et al. 2011). Several VOCs identified as priority compounds in indoor environments in so called INDEX project (Koistinen et al. 2008), were recently measured in European public and apartment buildings as part of AIRMEX study (Geiss et al. 2011), reporting concentrations of these compounds being in the lower end of the ranges reported by Sarigiannis et al. (2011) (Geiss et al. 2011, Table 1).

In contrary to these studies in occupied buildings, Shin and Jo (2012) measured concentrations of several VOCs in 107 newly-build apartments in Korea at pre-occupancy stage, which excludes emissions for household products, occupants and occupant activities and furniture. 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene were found above detection limit in 78% and 81% apartments respectively, styrene was found in 75% of apartments, while benzene, ethylbenzene, toluene, xylenes, hexane and heptane were found in all the investigated apartments. The indoor to outdoor ratios for all these compounds was >1, indicating sources amount building materials (Shin and Jo 2012, Table 1).

TABEL 1. MEAN INDOOR CONCENTRATIONS IN NEWLY BUILD APARTMENTS IN KOREA, MEASURED AT PRE-OCCUPANCY STAGE AND INDOOR CONCENTRATIONS MEASURED IN OCCUPIED APARTMENTS IN SEVERAL EUROPEAN COUNTRIES.

	Apartments in Korea, Shin and Jo 2012		Apartments in EU, Airmex study, Geiss et al. 2011	
VOC	Mean indoor concentration, µg/m³	I/O	Mean indoor concentration, µg/m³	Personal inhalation, µg/m³
Benzene	3.9	2.1	2.8	4.7
Ethylbenzene	8.2	2.4	1.5	3.2
Styrene	2.7	2.8	0.4	0.4
Toluene	184	6.0	11.7	22.4
1,2,4-trimethylbenzene	3.1	2.0	2.7	3.1
1,3,5-trimethylbenzene	6.5	5.4	-	-
m,p-xylene	14	2.3	3.8	10.5
o-xylene	2.8	2.2	1.8	4.2
n-hexane	4.4	2.5	2.5	4.0
n-heptane	10	8.3	1.2	1.4

3.2 Emission from building materials

Emission of BTEX and some other volatile substances with potential for chronic neurotoxicity from building materials and building-related materials has been measured or estimated in several studies. Missia et al. (2010) have investigated emission of BTEX from selected building materials using Field and Laboratory Emission Cell (FLEC). The study suggested that approximately 40% of indoor air concentration of benzene, xylenes and toluene originate from paint, carpet and furniture, and a bit smaller amounts from linoleum (op to 11%). Carpet, ceiling and wall were further found to contribute significantly to indoor toluene concentration in a Japanese study (Shinohara et al. 2009), with contribution ratio of 22%, 27 and 14% respectively and smaller contribution from door and furniture (due to smaller area per room volume). Emission of several other volatile substances with potential for chronic neurotoxicity including ethylbenzene, m,p-xylenes, 1,3,5-Trimethylbenzene and 1,2,4-Trimethylbenzene from carpet, ceiling, wall and furniture was also measured above DL in this study (Shinohara et al. 2009). Presence of toluene, but not the other 3 BTEX compounds in linoleum, vinyl wallpaper, duplex wallpaper and self-adhesive wallpaper was further confirmed by Lim at al. (2014a), with the latest having especially high toluene content (15-1012 ppm, mean 348 ppm; 3 products). Another Korean research group has published results of chamber emission studies of VOCs and carbonyls from 179 PVC-coated, 122 paper-backed and 31 natural material-coated 3 wallpapers. Emission of toluene, o-xylene, 1,2,4-trimethykbenzene, ethylbenzene and m,p-xylenes was measured above limits of detection in 82%, 79%, 78%, 77% and 77% of the samples respectively, with toluene having the highest emission rate among these compounds, with mean emission rate at 0.008 mg/m²h, ranging from >DL to 0.226 mg/m²h (Lim at al. 2014b). Emission of toluene, ethylbenzene and m,p-xylenes was further shown from wooden floor covering made of hardwood plywood (Lin et al. 2009). A Chinese group have calculated that building materials and paint solvent contribute with approx. 82% to the personal exposure to benzene in Chinese homes, while household cleaning chemicals contributes with approx. 87% to the

personal exposure to toluene (Liu et al. 2014). Kataoka et al. (2012) found significant emission of toluene from plywood and particle board, and high emission for toluene, ethylbenzene, xylenes and n-decane from water-based paint.
Finally sealants have recently been shown to emit BTEX and chlorinated compounds (Danish EPA, 2015). Toluene, ethylbenzene and xylenes were found in most of the investigated samples (n=32). Silicon based sealants have shown tendency to have a higher content of chlorinated compounds (including tetrachloroethylene and trichloroethylene) and the polyurethanebased sealants higher concentrations of ethylbenzene and xylenes (Danish EPA, 2015). It was however concluded, that under normal air change rate, emission form these sources several days after application have negligible impact on indoor air concentrations.

3.3 Source identification based on SPIN database

The Danish Product Register (SPIN) database was searched for the content of the chemicals of interest in building-related applications. These included construction materials, furniture, other wood products, paints, lacquers and laquers, adhesives and binding agents, solvents as well as cleaning and washing agents. Results of this search are presented in Table 2.

TABLE 2. USE OF TOLUENE AND OTHER VOLATILE SUBSTANCES WITH POTENTIAL FOR CHRONIC NEUROTOXICITY IN BUILDING-RELATED APPLICATIONS. DATA FROM SPIN.

Building/finishing material	Chemical[1]	Use in t/y (2012)
Construction materials	Styrene	190
	Ethylbenzene	1.4
	1,3,5-Trimethylbenzene	<1
Manufacture of furniture	Toluene	40.2
	Ethylbenzene	3
	1,2,4-Trimethylbenzene, styrene, n-hexane, o-xylene	<1
Manufacture of wood and products of wood and cork, except furniture	Toluene	2.2
	Ethylbenzene, styrene	<1
Rubber and plastic products	Styrene	286.7
	Toluene	15.6
	Ethylbenzene	9
	Methylstyrene, n-hexan	<1
Paints, lacquers, varnishes	Ethylbenzene	107.4
	Styrene	100.6
	Toluene	43.7
	1,2,4-Trimethylbenzene	8.9
	1,3,5-Trimethylbenzene	4.2
	n-Heptane	2.7
	o-Xylene	1.9
	Propylbenzene	1.8

	Benzene , p-xylene, m-xylene, 1,2,3- trimethylbenzene	<1
Adhesives, binding agents	Toluene	74.1
	Styrene	43.3
	Ethylbenzene	17.0
	m-Xylene	12.3
	p-Xylene	5.9
	n-Heptane	2
	o-Xylene	1.5
	Benzene, n-hexane, 1,2,4 trimethylbenzene	<1
Solvents	Toluene	2337.3
	n-Hexane	242.7
	Styrene	45.5
	Benzene	39.3
	Ethylbenzene	21.1
	n-Heptane	8.9
	1,2,4-Trimethylbenzene	3.1
	1,3,5-Trimethylbenzene	<1
Cleaning and washing agents	Dichloromethane	22.4
	Trichloroethylene	7.5
	Toluene	7.5
	n-Heptane	4.7
	Tetrachloroethylene	3.5
	n-Hexane	1.5
	Benzene, ethylbenzene, 1,2,4-trimethylbenzene	<1

[1] m-Diisopropylbenzene, p-diisopropylbenzene and phenyloctan have either not found in SPIN of data were marked as confidential. Monochloromethan according to SPIN was only used in Denmark in the period 2006-8.

3.4 Summary

The conducted literature search has identified several sources for the volatile substances with potential for chronic neurotoxicity among building materials and building-related products. Taking into account area of the emitting surface, paints and lacquers, wooden floor coverings, carpets and bigger pieces of furniture should be considered in the calculation of the total exposure. Self-adhesive wallpapers used for decoration on bigger surfaces can be of high importance as well. Finally cleaning agents might contribute to short-term exposure, especially to toluene and some of the chlorinated compounds.

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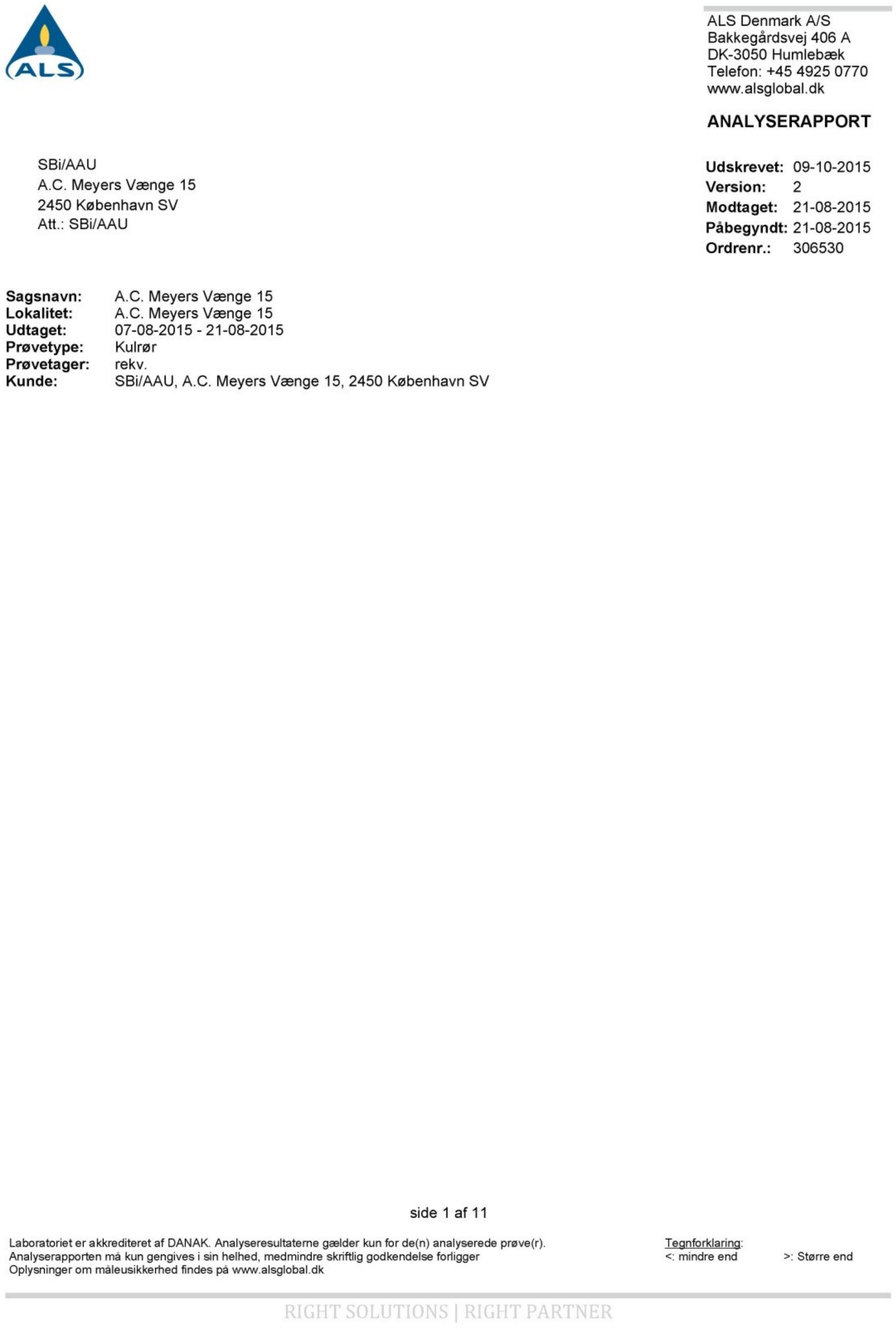
Appendix 4: Results from laboratory analysis of the air samples collected in the emission tests



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ANALYSERAPPORT

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Prøvetype:	Kulrør
Prøvetager:	rekv.
Kunde:	SBi/AAU, A.C. Meyers Vænge 15, 2450 København SV

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Laboratoriet er akkrediteret af DANAK. Analyseresultaterne gælder kun for de(n) analyserede prøve(r).
Analyserapporten må kun gengives i sin helhed, medmindre skriftlig godkendelse forligger
Oplysninger om måleusikkerhed findes på www.alsglobal.dk

Tegnforklaring:
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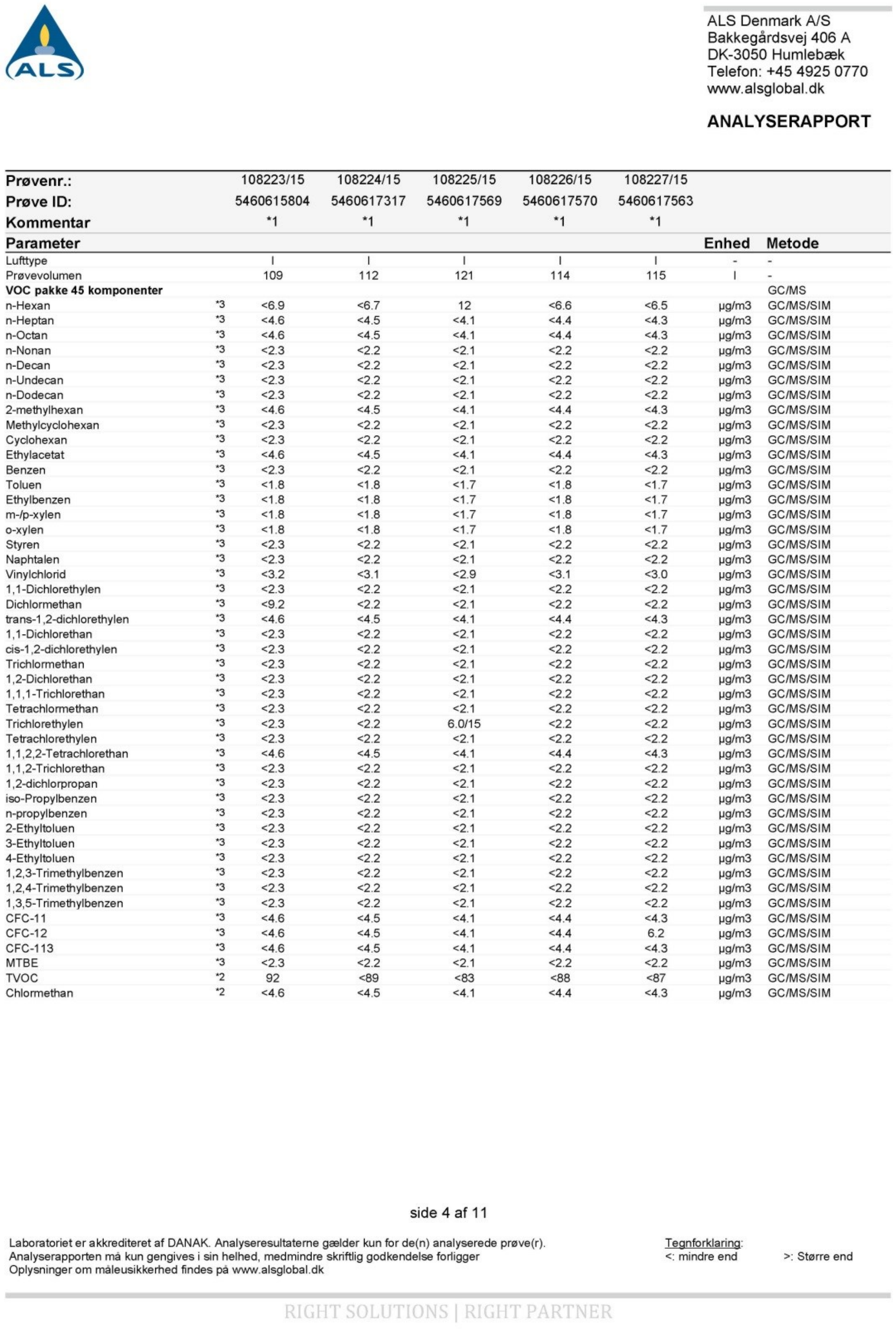
ANALYSERAPPORT

Prøvenr.:		108213/15	108214/15	108215/15	108216/15	108217/15		
Prøve ID:		5460617296	5460617298	5460617294	5460617300	5460617293		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		103	105	104	100	102	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.3	<7.1	<7.2	<7.5	<7.4	µg/m3	GC/MS/SIM
n-Heptan	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
n-Octan	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
n-Decan	*3	<2.4	<2.4	<2.4	<2.5	6.0/15	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.4	<2.4	<2.4	<2.5	22	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.9	19	24	<5.0	<4.9	µg/m3	GC/MS/SIM
Benzen	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
Toluen	*3	<1.9	37	38	<2.0	<2.0	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<1.9	<1.9	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<1.9	<1.9	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
o-xylen	*3	<1.9	<1.9	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
Styren	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.4	<3.3	<3.4	<3.5	<3.4	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Dichlormethan	*3	<9.7	<9.5	<9.6	<10	<9.8	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
CFC-11	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
CFC-12	*3	9.5	8.1	7.6	9.6	9.8	µg/m3	GC/MS/SIM
CFC-113	*3	<4.9	<4.8	<4.8	<5.0	<4.9	µg/m3	GC/MS/SIM
MTBE	*3	<2.4	<2.4	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
TVOC	*2	<97	17000	24000	<100	210	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.9	<4.8	<4.8	<5	<4.9	µg/m3	GC/MS/SIM

ANALYSERAPPORT

Prøvenr.:		108218/15	108219/15	108220/15	108221/15	108222/15		
Prøve ID:		5460617301	5460617302	5460617295	5460617568	5460617624		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		104	94	94	110	103	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.2	<8.0	<8.0	<6.8	<7.3	µg/m3	GC/MS/SIM
n-Heptan	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
n-Octan	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
n-Decan	*3	6.7	4.8/15	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
n-Undecan	*3	24	16	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
Benzen	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
Toluen	*3	<1.9	<2.1	<2.1	2.5/15	<1.9	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<1.9	<2.1	<2.1	<1.8	<1.9	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<1.9	<2.1	<2.1	2.5/15	<1.9	µg/m3	GC/MS/SIM
o-xylen	*3	<1.9	<2.1	<2.1	<1.8	<1.9	µg/m3	GC/MS/SIM
Styren	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.4	<3.7	<3.7	<3.2	<3.4	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Dichlormethan	*3	<9.6	<11	<11	<9.1	<9.7	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
CFC-11	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
CFC-12	*3	11	9.7	12	8.5	11	µg/m3	GC/MS/SIM
CFC-113	*3	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM
MTBE	*3	<2.4	<2.7	<2.7	<2.3	<2.4	µg/m3	GC/MS/SIM
TVOC	*2	230	180	<110	160	120	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.8	<5.3	<5.3	<4.5	<4.9	µg/m3	GC/MS/SIM



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ANALYSERAPPORT

Prøvenr.:		108223/15	108224/15	108225/15	108226/15	108227/15		
Prøve ID:		5460615804	5460617317	5460617569	5460617570	5460617563		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		109	112	121	114	115	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<6.9	<6.7	12	<6.6	<6.5	µg/m3	GC/MS/SIM
n-Heptan	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
n-Octan	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
n-Decan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
Benzen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Toluen	*3	<1.8	<1.8	<1.7	<1.8	<1.7	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<1.8	<1.8	<1.7	<1.8	<1.7	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<1.8	<1.8	<1.7	<1.8	<1.7	µg/m3	GC/MS/SIM
o-xylen	*3	<1.8	<1.8	<1.7	<1.8	<1.7	µg/m3	GC/MS/SIM
Styren	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.2	<3.1	<2.9	<3.1	<3.0	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Dichlormethan	*3	<9.2	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.3	<2.2	6.0/15	<2.2	<2.2	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
CFC-11	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
CFC-12	*3	<4.6	<4.5	<4.1	<4.4	6.2	µg/m3	GC/MS/SIM
CFC-113	*3	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM
MTBE	*3	<2.3	<2.2	<2.1	<2.2	<2.2	µg/m3	GC/MS/SIM
TVOC	*2	92	<89	<83	<88	<87	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.6	<4.5	<4.1	<4.4	<4.3	µg/m3	GC/MS/SIM

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Laboratoriet er akkrediteret af DANAK. Analyseresultaterne gælder kun for de(n) analyserede prøve(r).
Analyserapporten må kun gengives i sin helhed, medmindre skriftlig godkendelse forligger
Oplysninger om måleusikkerhed findes på www.alsglobal.dk

Tegnforklaring:
<: mindre end
>: Større end

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ANALYSERAPPORT

Prøvenr.:		108228/15	108229/15	108230/15	108231/15	108232/15		
Prøve ID:		5460617565	5460617571	5460617572	5460617567	5460617566		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		113	114	114	106	103	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<6.6	<6.6	<6.6	<7.1	<7.3	µg/m3	GC/MS/SIM
n-Heptan	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
n-Octan	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
n-Decan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.4	<4.4	<4.4	<4.7	7.3	µg/m3	GC/MS/SIM
Benzen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Toluen	*3	<1.8	<1.8	<1.8	<1.9	2.2/15	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<1.8	<1.8	<1.8	<1.9	<1.9	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<1.8	<1.8	<1.8	<1.9	3.0/15	µg/m3	GC/MS/SIM
o-xylen	*3	<1.8	<1.8	<1.8	<1.9	<1.9	µg/m3	GC/MS/SIM
Styren	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.1	<3.1	<3.1	<3.3	<3.4	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
CFC-11	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
CFC-12	*3	<4.4	<4.4	<4.4	5.4	<4.9	µg/m3	GC/MS/SIM
CFC-113	*3	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM
MTBE	*3	<2.2	<2.2	<2.2	<2.4	<2.4	µg/m3	GC/MS/SIM
TVOC	*2	<88	<88	<88	<94	3500	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.4	<4.4	<4.4	<4.7	<4.9	µg/m3	GC/MS/SIM

Tegnforklaring:
<: mindre end
>: Større end

ANALYSERAPPORT

Prøvenr.:		108233/15	108234/15	108235/15	108236/15	108237/15		
Prøve ID:		5460617564	5460617767	5460617768	5460617772	5460617765		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		99	100	105	102	102	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.6	<7.5	<7.1	<7.4	<7.4	µg/m3	GC/MS/SIM
n-Heptan	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
n-Octan	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
n-Decan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
n-Dodecan	*3	7.4	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
2-methylhexan	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Ethylacetat	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
Benzen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Toluen	*3	<2.0	6.9/15	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<2.0	<2.0	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
m-/p-xylen	*3	2.9/15	<2.0	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
o-xylen	*3	<2.0	<2.0	<1.9	<2.0	<2.0	µg/m3	GC/MS/SIM
Styren	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.5	<3.5	<3.3	<3.4	<3.4	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
CFC-11	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
CFC-12	*3	10	6.2	7.0	6.4	<4.9	µg/m3	GC/MS/SIM
CFC-113	*3	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM
MTBE	*3	<2.5	<2.5	<2.4	<2.5	<2.5	µg/m3	GC/MS/SIM
TVOC	*2	<100	<100	220	<98	1500	µg/m3	GC/MS/SIM
Chlormethan	*2	<5.1	<5.0	<4.8	<4.9	<4.9	µg/m3	GC/MS/SIM

Tegnforklaring:
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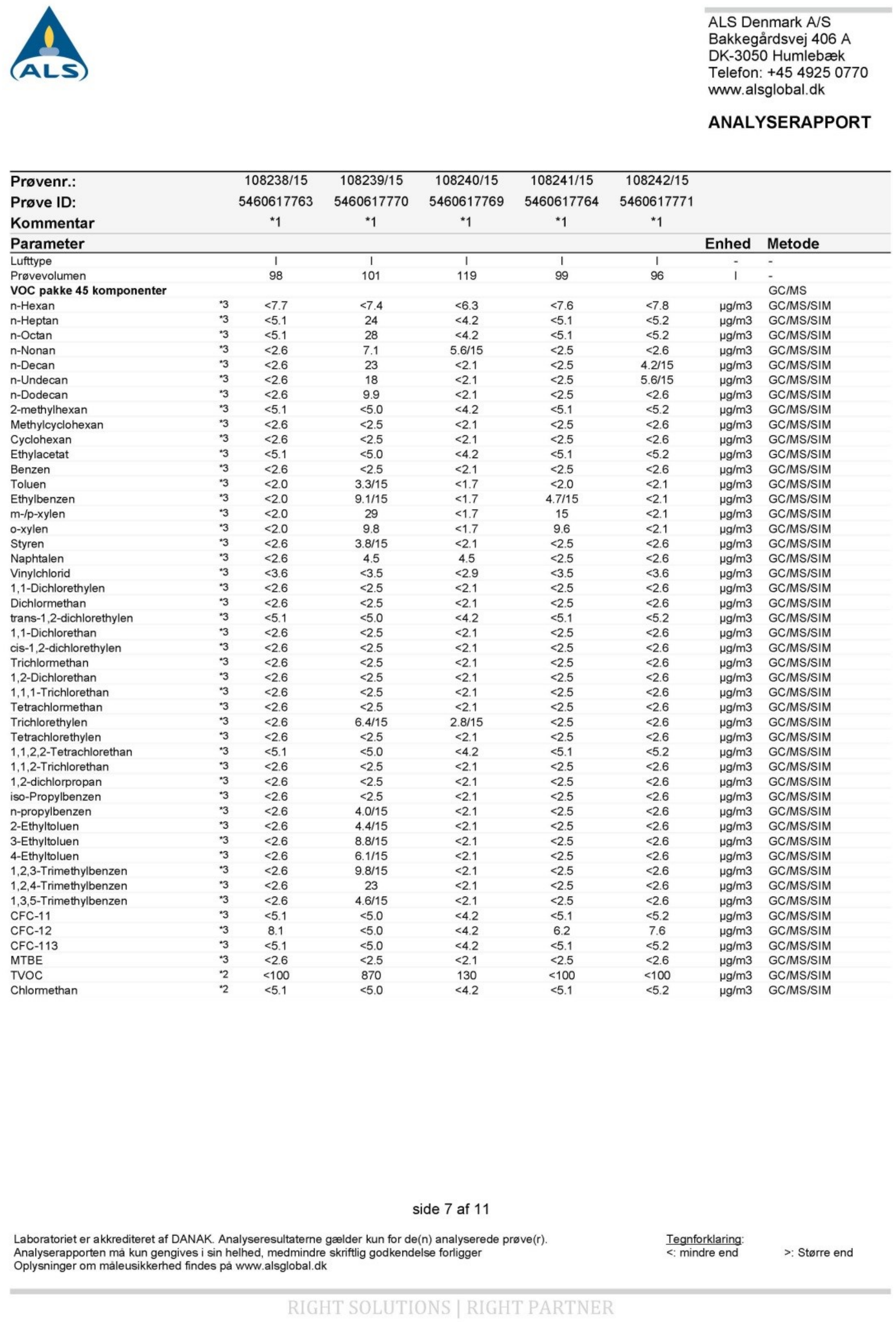
>: Større end



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ANALYSERAPPORT

Prøvenr.:		108238/15	108239/15	108240/15	108241/15	108242/15		
Prøve ID:		5460617763	5460617770	5460617769	5460617764	5460617771		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		98	101	119	99	96	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.7	<7.4	<6.3	<7.6	<7.8	µg/m3	GC/MS/SIM
n-Heptan	*3	<5.1	24	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
n-Octan	*3	<5.1	28	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.6	7.1	5.6/15	<2.5	<2.6	µg/m3	GC/MS/SIM
n-Decan	*3	<2.6	23	<2.1	<2.5	4.2/15	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.6	18	<2.1	<2.5	5.6/15	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.6	9.9	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
2-methylhexan	*3	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Ethylacetat	*3	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
Benzen	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Toluen	*3	<2.0	3.3/15	<1.7	<2.0	<2.1	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<2.0	9.1/15	<1.7	4.7/15	<2.1	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<2.0	29	<1.7	15	<2.1	µg/m3	GC/MS/SIM
o-xylen	*3	<2.0	9.8	<1.7	9.6	<2.1	µg/m3	GC/MS/SIM
Styren	*3	<2.6	3.8/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.6	4.5	4.5	<2.5	<2.6	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.6	<3.5	<2.9	<3.5	<3.6	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.6	6.4/15	2.8/15	<2.5	<2.6	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.6	4.0/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.6	4.4/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.6	8.8/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.6	6.1/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.6	9.8/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.6	23	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.6	4.6/15	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
CFC-11	*3	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
CFC-12	*3	8.1	<5.0	<4.2	6.2	7.6	µg/m3	GC/MS/SIM
CFC-113	*3	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM
MTBE	*3	<2.6	<2.5	<2.1	<2.5	<2.6	µg/m3	GC/MS/SIM
TVOC	*2	<100	870	130	<100	<100	µg/m3	GC/MS/SIM
Chlormethan	*2	<5.1	<5.0	<4.2	<5.1	<5.2	µg/m3	GC/MS/SIM

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Laboratoriet er akkrediteret af DANAK. Analyseresultaterne gælder kun for de(n) analyserede prøve(r).
Analyserapporten må kun gengives i sin helhed, medmindre skriftlig godkendelse forligger
Oplysninger om måleusikkerhed findes på www.alsglobal.dk

Tegnforklaring:
<: mindre end
>: Større end

RIGHT SOLUTIONS | RIGHT PARTNER

Prøvenr.:		108243/15	108244/15	108245/15	108246/15	108247/15		
Prøve ID:		5460617627	5460617626	5460615809	5460617631	5460617628		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		100	106	102	103	95	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.5	<7.1	<7.4	<7.3	<7.9	µg/m3	GC/MS/SIM
n-Heptan	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
n-Octan	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
n-Decan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
2-methylhexan	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Ethylacetat	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
Benzen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Toluen	*3	<2.0	<1.9	<2.0	<1.9	<2.1	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<2.0	<1.9	<2.0	<1.9	<2.1	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<2.0	<1.9	<2.0	<1.9	<2.1	µg/m3	GC/MS/SIM
o-xylen	*3	<2.0	<1.9	<2.0	<1.9	<2.1	µg/m3	GC/MS/SIM
Styren	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.5	<3.3	<3.4	<3.4	<3.7	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
CFC-11	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
CFC-12	*3	6.1	7.6	7.0	7.4	10	µg/m3	GC/MS/SIM
CFC-113	*3	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM
MTBE	*3	<2.5	<2.4	<2.5	<2.4	<2.6	µg/m3	GC/MS/SIM
TVOC	*2	<100	580	<98	290	<110	µg/m3	GC/MS/SIM
Chlormethan	*2	<5.0	<4.7	<4.9	<4.9	<5.3	µg/m3	GC/MS/SIM

ANALYSERAPPORT

Prøvenr.:		108248/15	108249/15	108250/15	108251/15	108252/15		
Prøve ID:		5460617629	5460617632	5460617625	5460617630	5460615980		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		l	l	l	l	l	-	-
Prøvevolumen		104	99	101	97	97	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.2	<7.6	<7.4	<7.7	<7.7	µg/m3	GC/MS/SIM
n-Heptan	*3	6.1/15	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
n-Octan	*3	6.9	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
n-Decan	*3	4.3/15	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
n-Undecan	*3	3.9/15	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
n-Dodecan	*3	2.7/15	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
Benzen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Toluen	*3	<1.9	<2.0	<2.0	<2.1	<2.1	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<1.9	<2.0	2.7/15	<2.1	<2.1	µg/m3	GC/MS/SIM
m-/p-xylen	*3	4.3/15	<2.0	8.4/15	<2.1	<2.1	µg/m3	GC/MS/SIM
o-xylen	*3	<1.9	<2.0	5.4/15	<2.1	<2.1	µg/m3	GC/MS/SIM
Styren	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.4	<3.5	<3.5	<3.6	<3.6	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	3.5/15	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
CFC-11	*3	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
CFC-12	*3	9.0	9.0	8.0	11	8.6	µg/m3	GC/MS/SIM
CFC-113	*3	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM
MTBE	*3	<2.4	<2.5	<2.5	<2.6	<2.6	µg/m3	GC/MS/SIM
TVOC	*2	140	<100	<99	<100	<100	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.8	<5.1	<5.0	<5.2	<5.2	µg/m3	GC/MS/SIM

ANALYSERAPPORT

Prøvenr.:		108253/15	108254/15	108255/15	108256/15	108257/15		
Prøve ID:		5460615981	5460615709	5460615982	5460615974	5460615976		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		I	I	I	I	I	-	-
Prøvevolumen		103	100	102	94	100	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.3	<7.5	<7.4	<8.0	<7.5	µg/m3	GC/MS/SIM
n-Heptan	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
n-Octan	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
n-Decan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
Benzen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Toluen	*3	<1.9	<2.0	<2.0	<2.1	<2.0	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<1.9	<2.0	<2.0	<2.1	<2.0	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<1.9	<2.0	<2.0	<2.1	<2.0	µg/m3	GC/MS/SIM
o-xylen	*3	<1.9	<2.0	<2.0	<2.1	<2.0	µg/m3	GC/MS/SIM
Styren	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.4	<3.5	<3.4	<3.7	<3.5	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
Trichlorethylen	*3	<2.4	<2.5	<2.5	<2.7	5.0/15	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
CFC-11	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
CFC-12	*3	8.2	<5.0	6.4	8.3	11	µg/m3	GC/MS/SIM
CFC-113	*3	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM
MTBE	*3	<2.4	<2.5	<2.5	<2.7	<2.5	µg/m3	GC/MS/SIM
TVOC	*2	<97	<100	<98	<110	160	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.9	<5.0	<4.9	<5.3	<5.0	µg/m3	GC/MS/SIM

Tegnforklaring:
<: mindre end >: Større end

ANALYSERAPPORT

Prøvenr.:		108258/15	108259/15	108260/15	108261/15	108262/15		
Prøve ID:		5460615975	5460615979	5460615977	5460615708	5460615706		
Kommentar		*1	*1	*1	*1	*1		
Parameter							**Enhed**	**Metode**
Lufttype		l	l	l	l	l	-	-
Prøvevolumen		102	97	90	-	-	l	-
VOC pakke 45 komponenter								GC/MS
n-Hexan	*3	<7.4	<7.7	<8.3	<10	<10	µg/m3	GC/MS/SIM
n-Heptan	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
n-Octan	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
n-Nonan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
n-Decan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
n-Undecan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
n-Dodecan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
2-methylhexan	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
Methylcyclohexan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Cyclohexan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Ethylacetat	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
Benzen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Toluen	*3	<2.0	<2.1	<2.2	<2.5	<2.5	µg/m3	GC/MS/SIM
Ethylbenzen	*3	<2.0	<2.1	<2.2	<2.5	<2.5	µg/m3	GC/MS/SIM
m-/p-xylen	*3	<2.0	3.4/15	<2.2	<2.5	<2.5	µg/m3	GC/MS/SIM
o-xylen	*3	<2.0	2.2/15	<2.2	<2.5	<2.5	µg/m3	GC/MS/SIM
Styren	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Naphtalen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Vinylchlorid	*3	<3.4	<3.6	<3.9	<5.0	<5.0	µg/m3	GC/MS/SIM
1,1-Dichlorethylen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Dichlormethan	*3	<2.5	<2.6	<2.8	<10	<10	µg/m3	GC/MS/SIM
trans-1,2-dichlorethylen	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
1,1-Dichlorethan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
cis-1,2-dichlorethylen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Trichlormethan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,2-Dichlorethan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,1,1-Trichlorethan	*3	<2.5	<2.6	<2.8	<2.5	<2.5	µg/m3	GC/MS/SIM
Tetrachlormethan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
Trichlorethylen	*3	6.8/15	<2.6	<2.8	6.8	<5.0	µg/m3	GC/MS/SIM
Tetrachlorethylen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,1,2,2-Tetrachlorethan	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
1,1,2-Trichlorethan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,2-dichlorpropan	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
iso-Propylbenzen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
n-propylbenzen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
2-Ethyltoluen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
3-Ethyltoluen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
4-Ethyltoluen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,2,3-Trimethylbenzen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,2,4-Trimethylbenzen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
1,3,5-Trimethylbenzen	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
CFC-11	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
CFC-12	*3	8.1	8.6	9.3	<5.0	<5.0	µg/m3	GC/MS/SIM
CFC-113	*3	<4.9	<5.2	<5.6	<5.0	<5.0	µg/m3	GC/MS/SIM
MTBE	*3	<2.5	<2.6	<2.8	<5.0	<5.0	µg/m3	GC/MS/SIM
TVOC	*2	<98	<100	<110	<100	<100	µg/m3	GC/MS/SIM
Chlormethan	*2	<4.9	<5.2	<5.6	<0.5	<0.5	µg/m3	GC/MS/SIM

Kommentar

*1 Ingen kommentar

*2 # Underleverandør: GBA Desellschaft für Bioanalytik mbH, DAkkS D-PL-14170-01-00

*3 Underleverandør: GBA Desellschaft für Bioanalytik mbH, DAkkS D-PL-14170-01-00

Trine Kornbeck

Tegnforklaring:
<: mindre end
>: Større end

Kilde	Tidspunkt	Prøve ID	Kilde	Tidspunkt	Prøve ID
Blank 1		5460615708	**Legetelt**	24 timer	5460617772
Blank 2		5460615706	**Modellervoks**		5460617765
Tuschpenne	baggrund	5460617296	**Bamse**		5460617763
	måling i indånding zone	5460617298	**Maling og lak**		5460617770
		5460617294	**Strandartikler**		5460617769
Perler	baggrund	5460617300	**Gummifigurer**		5460617764
	måling i indånding zone	5460617293	**Balloner**		5460617771
		5460617301	**Tape**	72 timer	5460617627
	midt i rummet	5460617302	**Tegneserier**		5460617626
Mock up	baggrund	5460617295	**Legetelt**		5460615809
	24 timer	5460617568	**Modellervoks**		5460617631
	72 timer	5460617624	**Bamse**		5460617628
	14 dage	5460615804	**Maling og lak**		5460617629
Tape	baggrund	5460617317	**Strandartikler**		5460617632
Tegneserier		5460617569	**Gummifigurer**		5460617625
Legetelt		5460617570	**Balloner**		5460617630
Modellervoks		5460617563	**Tape**	14 dage	5460615980
Maling og lak		5460617565	**Tegneserier**		5460615981
Strandartikler		5460617571	**Legetelt**		5460615709
Gummifigurer		5460617572	**Modellervoks**		5460615982
Balloner		5460617567	**Bamse**		5460615974
Modellervoks	umiddelbart efter opsætning	5460617566	**Maling og lak**		5460615976
Bamse		5460617564	**Strandartikler**		5460615975
Tape	24 timer	5460617767	**Gummifigurer**		5460615979
Tegneserier		5460617768	**Balloner**		5460615977

Appendix 5: Limits of quantification and uncertainty of analysis for the chemical compounds analysed in laboratory emission testes and field measurements in child rooms

	LOQ (µg/sample)	Analysis uncertainty, %
n-Hexan	0.75	15
n-Heptan	0.5	15
n-Octan	0.5	15
n-Nonan	0.25	15
n-Decan	0.25	15
n-Undecan	0.25	15
n-Dodecan	0.25	15
2-methylhexan	0.5	20
Methylcyclohexan	0.25	20
Cyclohexan	0.25	20
Ethylacetat	0.5	20
Benzen	0.25	8.6
Toluen	0.2	12.6
Ethylbenzen	0.2	8.6
m-/p-xylen	0.2	8.6
o-xylen	0.2	14.2
Styren	0.25	12.6
Naphtalen	0.25	20
Vinylchlorid	0.35	13.2
1,1-Dichlorethylen	0.25	13.2
Dichlormethan	0.25	13.2
trans-1,2-dichlorethylen	0.5	13.2
1,1-Dichlorethan	0.25	13.2
cis-1,2-dichlorethylen	0.25	13.2
Trichlormethan	0.25	13.2
1,2-Dichlorethan	0.25	13.2
1,1,1-Trichlorethan	0.25	13.2
Tetrachlormethan	0.25	13.2
Trichlorethylen	0.25	13.2
Tetrachlorethylen	0.25	13.2
1,1,2,2-Tetrachlorethan	0.5	13.2
1,1,2-Trichlorethan	0.25	13.2

	LOQ (µg/sample)	Analysis uncertainty, %
1,2-dichlorpropan	0.25	13.2
iso-Propylbenzen	0.25	8.6
n-propylbenzen	0.25	8.6
2-Ethyltoluen	0.25	8.6
3-Ethyltoluen	0.25	8.6
4-Ethyltoluen	0.25	8.6
1,2,3-Trimethylbenzen	0.25	8.6
1,2,4-Trimethylbenzen	0.25	8.6
1,3,5-Trimethylbenzen	0.25	8.6
CFC-11	0.5	20
CFC-12	0.5	20
CFC-113	0.5	20
MTBE	0.25	20
Chlormethan	0.5	20
TVOC	10	20

Appendix 6: Results from the additional measurements taken in child room 15

DANAK
TEST Reg.nr. 90

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Statens Byggeforskningsinstitut
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2450 København SV

Analyserapport nr. 672946

Akkrediterede analyser, udført ved Kemisk og Mikrobiologisk Laboratorium, er akkrediteret under Dansk Akkreditering (DANAK), registreringsnummer 90.

Opgave:	3 kulrør til analyse for VOC Sag: 2014_277
Prøvetagning ved:	Rekvirenten
Prøvemodtagelse:	19. november 2015
Analyseperiode:	19. – 25. november 2015
Bemærkninger:	Resultaterne af analysen samt redegørelse for anvendt(e) metode(r) vedrører kun de(t) analyserede emne(r) eller de(n) til analyse udtagne delprøve(r).

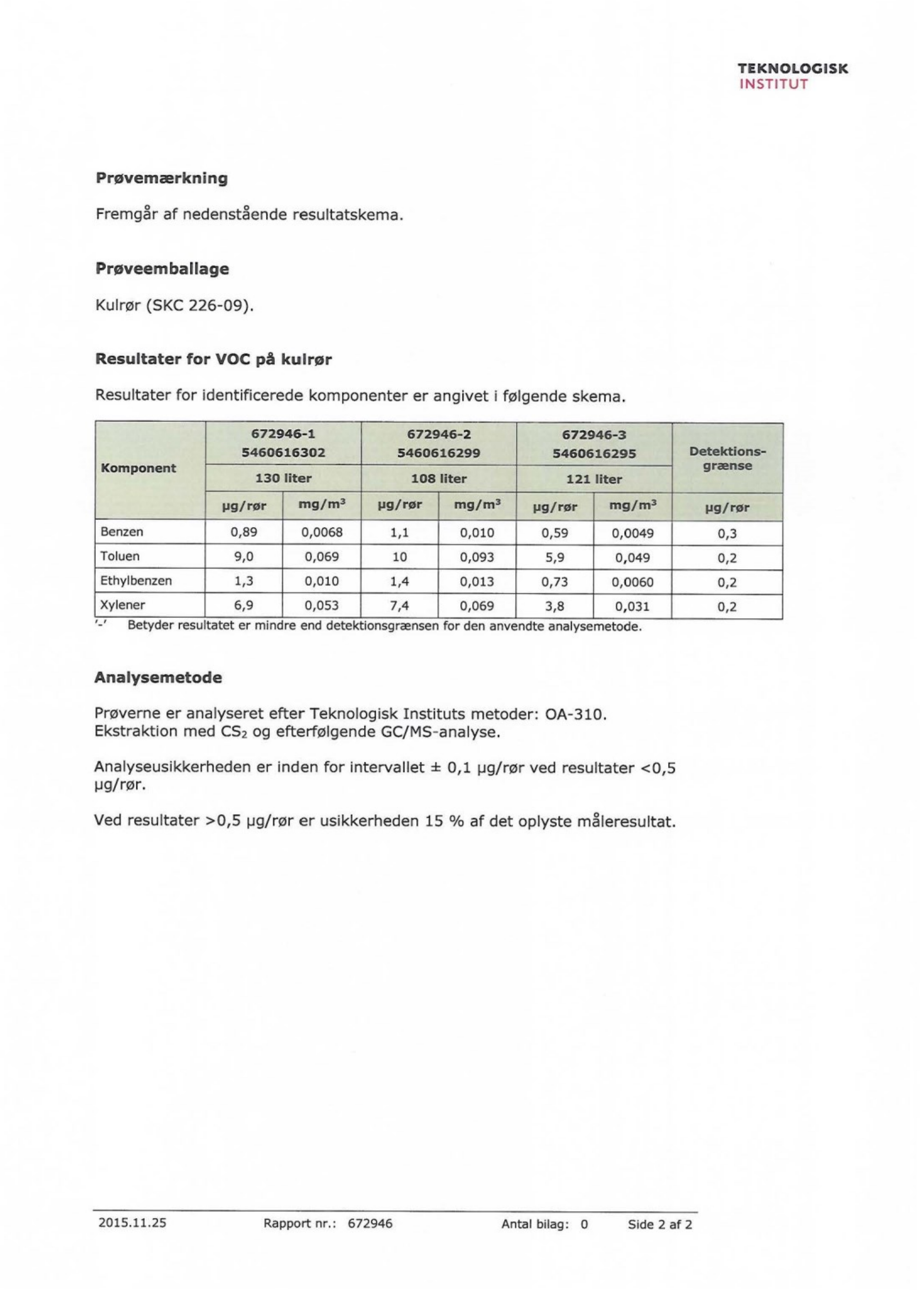
Analysen er udført i henhold til Teknologisk Instituts almindelige vilkår for rekvirerede opgaver samt de af DANAK fastsatte retningslinjer for akkrediteret prøvning. Analyserapporten må kun gengives i uddrag, hvis Kemisk og Mikrobiologisk Laboratorium skriftligt har godkendt uddraget.

Kemisk og Mikrobiologisk Laboratorium

Paul Lyck Hansen
Seniorkonsulent

Tenna S. La
Tenna Stengaard Larsen
Laborant

2015.11.25 Rapport nr.: 672946 Antal bilag: 0 Side 1 af 2



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Prøvemærkning

Fremgår af nedenstående resultatskema.

Prøveemballage

Kulrør (SKC 226-09).

Resultater for VOC på kulrør

Resultater for identificerede komponenter er angivet i følgende skema.

Komponent	672946-1 5460616302		672946-2 5460616299		672946-3 5460616295		Detektions-grænse
	130 liter		108 liter		121 liter		
	µg/rør	mg/m^3	µg/rør	mg/m^3	µg/rør	mg/m^3	µg/rør
Benzen	0,89	0,0068	1,1	0,010	0,59	0,0049	0,3
Toluen	9,0	0,069	10	0,093	5,9	0,049	0,2
Ethylbenzen	1,3	0,010	1,4	0,013	0,73	0,0060	0,2
Xylener	6,9	0,053	7,4	0,069	3,8	0,031	0,2

'-' Betyder resultatet er mindre end detektionsgrænsen for den anvendte analysemetode.

Analysemetode

Prøverne er analyseret efter Teknologisk Instituts metoder: OA-310.
Ekstraktion med CS_2 og efterfølgende GC/MS-analyse.

Analyseusikkerheden er inden for intervallet ± 0,1 µg/rør ved resultater <0,5 µg/rør.

Ved resultater >0,5 µg/rør er usikkerheden 15 % af det oplyste måleresultat.

Survey and risk assessment of toluene and other neurotoxic substances in children’s rooms

The purpose of the project was to investigate whether exposure to toluene and other neurotoxic substances can be problematic for children's health. This was assessed in relation to the exposure that children will be subjected to in a typical children´s room, and also taking into account the exposure from other sources. Based on knowledge from literature a number of products that were most likely to contain the relevant substances were identified. The measured concentrations of the substances were generally low from the analyses in small and large scale climate chambers. To confirm or reject the relatively low exposure levels found, follow-up measurements of the neurotoxic substances were carried out in 19 children´s rooms in private homes. In general, the measured concentrations were in accordance with results from the climate chambers. However, there were a few children´s room, where concentrations were either at level with the highest emission measurements or even higher. For these children´s rooms, renovating activities taking place in the house, glue and paint for the construction of aircraft models, and the presence of many plastic and rubber figures were identified as the possible significant sources. There was one child room with highly elevated concentrations of several chemicals in the indoor air. It turned out that the outer wall of the child room bordered a shed, in which was a lawn mower, petrol, and a number of white spirit containing products in plastic containers were stored. The concentration of neurotoxic substances in this particular child room was posing a risk.

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