

EUROPEAN CONCERTED ACTION

INDOOR AIR QUALITY & ITS IMPACT ON MAN

COST Project 613

Environment and Quality of Life

Report No. 2

FORMALDEHYDE EMISSION FROM WOOD BASED MATERIALS:

Guideline for the determination of steady state concentrations in test chambers



Commission of the European Communities
Directorate General for Science, Research and Development
Joint Research Centre - Institute for the Environment

EUROPEAN CONCERTED ACTION INDOOR AIR QUALITY & ITS IMPACT ON MAN

COST Project 613

Environment and Quality of Life

Report No. 2

FORMALDEHYDE EMISSION FROM WOOD BASED MATERIALS:

Guideline for the determination of steady state concentrations in test chambers

prepared by

Working Group 3

on behalf of the Community - COST Concertation Committee



Commission of the European Communities
Directorate General for Science, Research and Development
Joint Research Centre - Institute for the Environment

**Published by the
COMMISSION OF THE EUROPEAN COMMUNITIES
Directorate-General
Information Market and Innovation
Batiment Jean Monnet
LUXEMBOURG**

LEGAL NOTICE

Neither the Commission of the European Communities nor any person acting on behalf of the Commission is responsible for the use which might be made of the following information.

Cataloguing data can be found at the end of this publication.

Luxembourg: Office for Publications of the European Communities, 1989

© ECSC - EEC - EAEC, Brussels - Luxembourg, 1989

Printed in Italy

PREFACE

This document has been prepared on behalf of the Community COST Concertation Committee with the aim of providing a basis for a European harmonisation in the determination of formaldehyde emitted from wood based materials.

In the course of the work, it became rapidly clear that the task was more than providing the technical information needed to carry out sound measurements. In addition to this, boundary conditions had to be defined for such measurements, taking into account a number of parameters, such as room temperature, air humidity and amount of formaldehyde-emitting material in the room, which all determine the formaldehyde level. When preparing this document the members of the working group were in favour of the figures given in chapter 3. However, during the final discussion of the document at the level of the Concertation Committee, no unanimity could be reached with regard to the figure for the air exchange rate due to wide variation in existing test methods (see ref. 1, 2, 6, 9). Whereas the majority of the members of the Committee agreed with the figure of 1 h^{-1} as proposed by the working group, a minority was in favour of setting the air exchange rate to $0,5 \text{ h}^{-1}$.

It has to be emphasized that the final selection of figures for these parameters in any standard at the European level is a process which may include considerations beyond the mandate of the Committee.

DEDICATION

This guideline is devoted to the memory of **Monique Romeis** who died in a car accident on her way to the working group meeting where the draft proposal was finalized. As head of the Department for Wood Preservation at the Centre Technique du Bois et de l'Ameublement she was highly experienced in the matter of this guideline and made essential contributions to it. Her colleagues gratefully acknowledge her expertise and her friendly and constructive way of collaboration.

We share her memory and miss her presence.

CONTENTS

1. <i>Introduction</i>	1
2. <i>General characteristics of the test chamber</i>	2
2.1 Chamber size	2
2.2 Chamber design	4
2.3 Construction materials	5
2.4 Chamber tightness	5
2.5 Quality of purge air	5
2.6 Chamber cleaning	5
2.7 Instrumentation	5
3. <i>Specification of values for the environmental parameters influencing the steady state concentration of formaldehyde</i>	6
3.1 Temperature	6
3.2 Relative humidity	6
3.3 Air exchange rate	6
3.4 Loading factor	7
3.5 Air velocity	7
4. <i>Handling of source materials, chamber air sampling and analysis</i>	7
4.1 Sample preparation	7
4.2 Sample positioning	8
4.3 Position of air sampling probe	8
4.4 Sampling frequency	8
4.5 Duration of a test	8
4.6 Sampling and analytical method	8
5. <i>Quality control</i>	9
5.1 Control of chamber equipment	9
5.2 Chamber blank	9
5.3 Accuracy of the analytical method	9
5.4 Control of chamber performance	9
6. <i>References</i>	10
7. <i>Figures</i>	12
<i>Participants in Working Group 3</i>	14
<i>Letter of P. Nielsen</i>	15
<i>Annex 1</i>	17

1. INTRODUCTION

In different European countries and at Community level initiatives are under way to protect the population from exposure to potentially harmful concentrations of formaldehyde in indoor air. These initiatives include

- defining guideline concentrations for indoor environments and
- taking measures to prevent guideline concentrations being exceeded in indoor environments

Apart from tobacco smoke, major sources of formaldehyde in indoor air are materials with relatively large surfaces composed of or containing glues, foams, impregnating agents or varnishes based on urea-formaldehyde polymers and co-polymers. Such sources may be wood based materials (uncoated or coated panels), furniture, insulating materials like urea formaldehyde foam (UFFI) and mineral wool, textiles like curtains and carpets etc.

For the time being wood based materials and varnishes have raised particular concern. Therefore this document will focus on wood panels containing and/or coated with formaldehyde based polymers and will also give some consideration to furniture made thereof.

In a closed environment or room the presence of these materials may give rise to a contamination of the air by formaldehyde the level of which depends on

- **material properties** typical for a given type of wood panel (or furniture made thereof) and a given set of production conditions
- **room temperature**
- **relative humidity**
- **loading factor** (= ratio of emitting surface area to room volume)
- **air exchange rate**
- **air velocity** at the emitting surface and potentially of
- **sinks** (e.g. reactive surfaces) continuously removing formaldehyde.

Protection of the population requires that formaldehyde concentrations in indoor air do not exceed guideline values. For various reasons room temperature, humidity, air exchange rate and air velocity are not suitable for controlling HCHO concentrations, in particular because these parameters have themselves a direct influence on human health and comfort and therefore must be kept within certain limits. In practice control of the material properties is the most effective means to protect the population from unwanted exposure to formaldehyde.

Under real life conditions most of the parameters influencing the formaldehyde concentration in indoor air are subject to frequent changes. Therefore the level of air contamination by formaldehyde in a room at a given time depends usually not only on the instantaneous values of these parameters but also on previous conditions and activities in the room.

...

Therefore characterization of sources requires that the parameters influencing the air concentration of formaldehyde be kept constant for a sufficiently long period of time until a **steady state concentration** is established. Moreover, if the properties of different materials or sources have to be compared to one another or to a standard, steady state concentrations have to be determined at a unique set of values of room temperature and humidity, loading factor, air exchange rate and air velocity. In addition no uncontrolled sinks should influence the steady state concentration.

Control of all these parameters in a setting which resembles as much as possible real life conditions requires environmental or test chambers.

THE SCOPE OF THIS DOCUMENT

is to describe a **method** which allows the measurement of steady state concentrations of formaldehyde emitted from wood based materials in a reproducible way using a large scale, walk-in type test chamber and in particular

- to **define features of** such **chambers**,
- to **specify values for the environmental parameters** influencing steady state concentrations of formaldehyde therein and
- to describe procedures for the **handling of source materials** and the **sampling and analysis of formaldehyde**.

2. GENERAL CHARACTERISTICS OF THE TEST CHAMBER

- 2.1 **Chamber type.** Chambers of very different size have been used to study steady state concentrations of formaldehyde emitted from wood based materials. They fall essentially into two classes:
small scale chambers with volumes ranging from about 0,02 to 1 m³ and
large scale chambers of the "walk-in" type with volumes ranging from about 12 m³ to about 80 m³.

Both types of chambers have advantages and disadvantages (see Table 1). Although this guideline describes a reference method for the determination of steady state concentrations of formaldehyde produced by emissions from wood based materials using **large scale walk-in test or environmental chambers**, most parts of this guideline are also applicable to tests with small scale chambers. The preference given to large scale chambers is based on the following arguments:

- Large scale test chambers offer the advantage that real life situations can
- be more readily simulated. This is of particular importance, if compliance of materials with a regulation requires that under real life conditions their formaldehyde emissions must not cause steady state concentrations exceeding a given value.
- In the Federal Republic of Germany a large scale chamber method has been adopted as a reference method for the determination of formaldehyde emissions from particle board (1) and a similar method is under discussion

in the U. S. A. (2). For wood products a large chamber method will be adopted in the Federal Republic of Germany.

- comparative measurements (3,4,5) suggest that there are systematic differences between steady state concentrations determined by means of small scale and of large scale test chambers.
- Large scale test chambers allow emission measurements of entire pieces of furniture

Table 1. Advantages and disadvantages of small and large scale test chambers

	advantages	disadvantages
small scale chambers	- relatively low cost of construction and operation - more likely to be widely applied - less test material needed - increased flexibility (at about the same cost a larger number of chambers can be run simultaneously)	- need for replicate tests (sample inhomogeneity) - need for additional sample preparation (sealing of edges) - sample size limited
large scale chambers	- possibility to simulate real life situations - reduced influence of sample inhomogeneity - large-size products can be tested as a whole (e.g. furniture, construction components) - smaller influence of chamber surfaces	- increased cost of construction and operation (energy, clean air and water) - large amount of sample material needed (transportation cost) - supply of clean air may become a problem

Large scale test chambers with volumes of at least 12 m³ are considered appropriate*) in this document in view of the fact that volumes of presently available large scale (walk-in) test chambers in Europe range from 12 to 80 m³ (see Annex 1) and that there is for the time being no evidence that for chambers of these dimensions the size has a measurable or significant influence on the determination of steady state formaldehyde concentrations. However, appropriately designed round robin tests are required in order to demonstrate the equivalence of walk-in test chambers of different sizes.

It should also be pointed out that more comparative measurements between small and large scale chambers are required in order to establish correlations between steady state concentrations determined with these two types of chambers and to evaluate the influence which the volume of small scale chambers appears to have on the correlation (4).

*) It is recommended that new test chambers to be built in the future should be designed to a volume in multiples of 4 m³, in order to bring in line sample size, loading factor and chamber volume.

2.2 Chamber design. The design takes into account:

- the sample size (1m x 2m, see section 4.1)
- the air circulation

The dimensions of the chamber (height, surface area) are not defined precisely. However, the following requirements have to be fulfilled:

- chamber volume of at least 12 m³ (see section 2.1);
- samples of the required size have to be positioned parallel to each other and to the direction of the air flow;
- samples have to be equally spaced and separated from each other by at least 25 cm;
- samples have to be at least 25 cm away from the chamber walls, at all points.

An example of the positioning of samples in a chamber is given in fig. 1.

The air in the chamber is mixed by circulation. The circulation rate must be adjustable and allow a sufficient air velocity around the boards under test (see introduction to chapter 3 and section 3.5). Different designs are in use for air mixing. Two extreme solutions are schematically shown in fig. 2. In case (a) a parallel air flow is forced through the useful space of the chamber whereas in case (b) a circular flow is induced, the pattern of which will depend on the exact position and direction of the fan(s). Intermediate solutions are possible where metal sheets are used to a varying extent to guide the air flow through the chamber.

In any case a test of the proper performance of the air mixing equipment has to be carried out (see also section 3.5). For this purpose the air velocity in the properly loaded chamber (see fig. 1 this section and section 3.4) has to be measured at the following locations:

- a) midway between the surfaces of all test boards,
- b) at a distance from the outer surfaces of the samples nearest to the chamber walls which is equal to the distance used in a) above (i.e. half the distance between two adjacent boards).

Air mixing is appropriate if an air velocity of 0.3 ± 0.1 m/sec exists between the boards closest to the centre of the chamber and simultaneously a minimum velocity of 0.1 m/sec is maintained at all other measurement points (see section 3.5).

Sensors for relative humidity and temperature are placed in a position representative of the chamber (not less than 30 cm from the wall and at an air velocity not less than 0.1 m/sec). No water condensation must occur in the chamber under test conditions.

A separate air circuit enables the introduction of fresh air from which formaldehyde has to be removed according to the requirements specified in section 2.5 (e.g. by a chemical or adsorption filter). Fresh or purge air has to be introduced into the chamber in a way that it does not come in contact with

the humidity and temperature sensors before efficient mixing with the chamber air. Therefore, the sensors should have a minimum distance of 1m from the fresh air inlet.

- 2.3 Construction materials.** Materials for chamber walls and sealings are of importance due to their potential ad- or absorption and emission capabilities. In general, the smaller the chamber the greater is the potential influence of chamber materials on chamber performance (the internal surface to volume ratio is inversely proportional to the chamber dimensions). The following requirements have to be fulfilled:
- the internal wall material must be as inert as possible to formaldehyde. The most commonly used material for large scale environmental chambers is stainless steel (treated by sandblowing and electropolishing). Aluminium has also been reported to perform well for formaldehyde emission measurements (3,4).
 - chamber construction should require a minimum of sealing materials. Teflon or teflon coated elastomers have given best results with respect to inertness.
- 2.4 Chamber tightness.** The chamber must be sufficiently tight in order to ensure that any errors in the emission measurements caused by losses of HCHO from the chamber or diffusion into it are negligible. This condition is fulfilled if
- (a) the air exchange rate due to leaks determined by tracer gas dilution is $\leq 1\%$ of the air exchange rate as specified in section 3.3.
- or if
- (b) the air flow leaking from the closed chamber at an overpressure of 1000 Pa is $\leq 10^{-4}$ chamber volumes per minute.
- 2.5 Quality of purge air.** The air supplied to the chamber must not contain formaldehyde at a level higher than $6 \mu\text{g}/\text{m}^3$ (5 ppb) (or any other substance that interferes with the analytical method).
- 2.6 Chamber cleaning.** If the background concentration of formaldehyde in the chamber is higher than $12 \mu\text{g}/\text{m}^3$, appropriate cleaning procedures must be adopted. A cleaning method applicable to small chambers is described in the Nordtest method 481-84 (6). Larger chambers are preferably flushed with clean air at the maximum achievable temperature.
- 2.7 Instrumentation.** Temperature, relative humidity and air exchange rate (or fresh air flow) are regulated by sensors. Sensors for temperature and relative humidity are positioned as described in section 2.2. In addition instrumentation for the continuous recording of temperature, relative humidity (or wet bulb temperature) and air exchange rate (or fresh air flow) must be provided. These parameters have to be recorded continuously during an experiment.

3. SPECIFICATION OF VALUES FOR THE ENVIRONMENTAL PARAMETERS INFLUENCING THE STEADY STATE CONCENTRATION OF FORMALDEHYDE

The level of the steady state concentration of formaldehyde in a test chamber loaded with materials containing urea-formaldehyde polymers or co-polymers depends on the values of the environmental parameters given below. Therefore distinct values have to be specified for these parameters, if the emission of a material is to be compared with a standard or if different materials are to be compared with one another. The choice of any distinct value for the parameters discussed in this chapter in general does not influence the performance of the test method itself and in particular its **reproducibility**, with the exception of the **air velocity** in the chamber, as explained below. Therefore the choice of values for these parameters has to be based on other than strictly methodological arguments. The working group examined various related methods (1,2,6,9) and selected values for temperature, relative humidity, air exchange rate and loading factor which it considered to agree best with these methods*).

According to theoretical considerations and experimental evidence (7), at low air velocities formaldehyde emission may lead to an increased formaldehyde concentration near to the emitting surface which reduces the formaldehyde transfer to the bulk chamber air, i.e. the emission rate. The only practical way to control this influence is to provide an air velocity high enough to make such an effect negligible. Experience (3,8) suggests that air velocities of 0.3 ± 0.1 m/s (determined near the centre of the loaded chamber as described in section 2.2 above) fulfil this requirement.

Though 0.3 m/s is the maximum admitted indoor air velocity in some European countries**), it should be pointed out that real life air velocities at emitting surfaces in residential or other non industrial indoor spaces will often be considerably lower than this value.

Knowledge is still incomplete on the interdependency between the steady state concentration in the chamber, the air velocity during test and the type and characteristics of the material to be tested. Therefore more data are required and further work is recommended. These studies should also improve our understanding of the relationship between test chamber results and real life situations.

3.1 Temperature. The test temperature should be $23 \pm 0.5^\circ\text{C}$.

3.2 Relative humidity. The test should be carried out at a relative humidity of $45 \pm 3\%$.

3.3 Air exchange rate. Emission measurements should be performed at an air exchange rate $n = 1 \pm 0.03$ chamber volumes per hour. However, a deviation of up to $\pm 10\%$ of the value of 1 chamber volume per hour is admitted for technical reasons (see sections 3.4 and 4.1) in order to balance a corresponding

*) see, however, enclosed letter of P.A. Nielsen (p. 16)

**) see e.g. DIN 1946

deviation of the loading factor from the value of 1. In any case the air exchange rate must not vary during an experiment by more than $\pm 3\%$.

- 3.4 **Loading factor.** The loading factor L [m^2/m^3], i.e. the ratio of the surface area [m^2] of the test material to the total chamber volume [m^3], should be $L=1$. In order to ease sample preparation (see section 4.1) a deviation of up to $\pm 10\%$ from the value of $L=1$ is admitted, on condition that the ratio $L/n=1$ is maintained, i.e. that the air exchange rate n is appropriately adjusted.
- 3.5 **Air velocity.** The air velocity has to be monitored before each test in a position as close as possible to the centre of the loaded chamber, midway between the surfaces of adjacent test pieces. The air velocity at this point should be 0.3 ± 0.1 m/s (see section 2.2).

4. HANDLING OF SOURCE MATERIALS, CHAMBER AIR SAMPLING AND ANALYSIS

- 4.1 **Sample preparation.** Boards to be tested are cut into pieces with dimensions of $1\text{m} \times 2\text{m}$, whenever they are sufficiently large. Smaller pieces may be tested if necessary. Some of these pieces are placed in the chamber in order to achieve a loading factor as close as possible to $L = 1\text{m}^2/\text{m}^3$ (both faces of a panel are taken into account).

To obtain a ratio $L/n = 1$, it is possible to either adjust the size of one $1\text{m} \times 2\text{m}$ piece so that L is exactly $1\text{m}^2/\text{m}^3$ or adjust the ventilation rate so that the ratio of L to n equals 1. These adjustments must, however, remain within 10% of the values specified in sections 3.3 and 3.4 above.

The edges of sample pieces to be analyzed have to be treated as indicated in table 2. For edge sealing, coverage with self-adhesive aluminium tape or with two layers of a two-component polyurethane lacquer with low solvent content has proven satisfactory.

Table 2: Treatment of edges of sample boards..

type of board	edges	
	calculation of surface	sealing
uncoated	not required	not required
coated (edges uncoated)	not required	not required
fully coated products (including veneer board)	not required	yes

5. QUALITY CONTROL

Several indications have been given above, concerning the control of the correct construction and operation of the chamber, (including air mixing and the purity of fresh air supplied to the chamber) and the precision of sampling and analysis. In addition the following aspects should be taken into account:

- 5.1 **Control of chamber equipment.** Sensors of temperature, relative humidity (or wet bulb temperature) and air exchange rate (or fresh air flow) should be calibrated on a regular basis.
- 5.2 **Chamber blank.** The background formaldehyde concentration in the chamber must be measured before each test, under the conditions specified in sections 3.1, 3.2 and 3.3 and at an air velocity of 0.3 ± 0.1 m/sec measured in the centre of the unloaded chamber. The background concentration must not exceed $12 \mu\text{g}/\text{m}^3$.
- 5.3 **Accuracy of the analytical method.** This parameter is ideally controlled by analysing an atmosphere with a known concentration of formaldehyde in the test chamber, provided the presence of polymeric forms of formaldehyde is checked as a potential source of errors (3). However, in view of the difficulties to produce atmospheres with known concentrations of formaldehyde, the participation in interlaboratory comparisons is recommended as a means to control the quality of the analytical procedure.
- 5.4 **Control of chamber performance.** When starting to work with a new chamber or when the geometric arrangement of the pieces to be tested is changed, the appropriateness of the chamber air mixing and velocities as prescribed in section 3.5 may be assessed by the following additional test: formaldehyde concentrations in the chamber are measured at four different values of L/n including $n=0$ (in this case the equilibrium concentration corresponding to the vapour pressure is obtained). These measurements are performed under standard conditions of temperature, humidity and air mixing, using uncoated particle or medium density fibre board samples (there is insufficient experience with other materials). The reciprocals of the formaldehyde concentrations obtained are plotted versus the n/L values adopted: in a well performing chamber a straight line should be obtained with intercept very close to the reciprocal of the concentration observed for $n=0$ (6).

- 4.2 **Sampling positioning.** Test panels have to be positioned and spaced in order not to obstruct the air flow (see section 2.2 above).
- 4.3 **Position of the air sampling probe.** Air samples should be collected in the air outlet duct of the chamber, as close as possible to the chamber in order to minimize losses due to ad- or absorption in the duct tubing.
- 4.4 **Sampling frequency.** At least one sample per working day has to be taken. A higher sampling frequency is recommended, in particular at the beginning of a test.
- 4.5. **Duration of a test.** The emission measurement has to be continued until the following conditions are fulfilled:
- a. Four consecutive measurements (performed at different days) must give results within 0.95-1.05 of their mean and show no progressive increase or decline. If they show a progressive increase the test should be continued. If they show a progressive decline, the test can be stopped if the least square line through four points measured on four consecutive working days has a slope $\leq 3\%$ of the mean concentration per day.
 - b. The test is stopped anyway after 10 days for particle and fibre boards and after 25 days for plywood and coated boards. A period of 25 days should also be adopted for poorly defined materials.
 - c. In any case the steady state (or final) concentration is calculated taking the mean of the concentration values measured on the last day.
- 4.6 **Sampling and analytical method.** The sampling method involves passing appropriate amounts of the test chamber air through an absorbing medium in which formaldehyde is quantitatively retained. The analytical procedure must be specific for formaldehyde and have a detection limit of at least 5% of any limit value for the steady state concentration with which the tested material has to comply.

Methods using the following reagents have proved to be adequate:

- .1 **pararosaniline** (10, 11)
- .2 **acetylacetone** (detection by photometry or fluorimetry) (12, 13). No standard procedure exists for this method as yet.
- .3 **chromotropic acid** (14, 15, 16)
- .4 **2,4-dinitrophenylhydrazine** (17, 18, 19)

Several of these methods have been compared to one another (20, 21). Quoted references are given as examples and are not comprehensive.

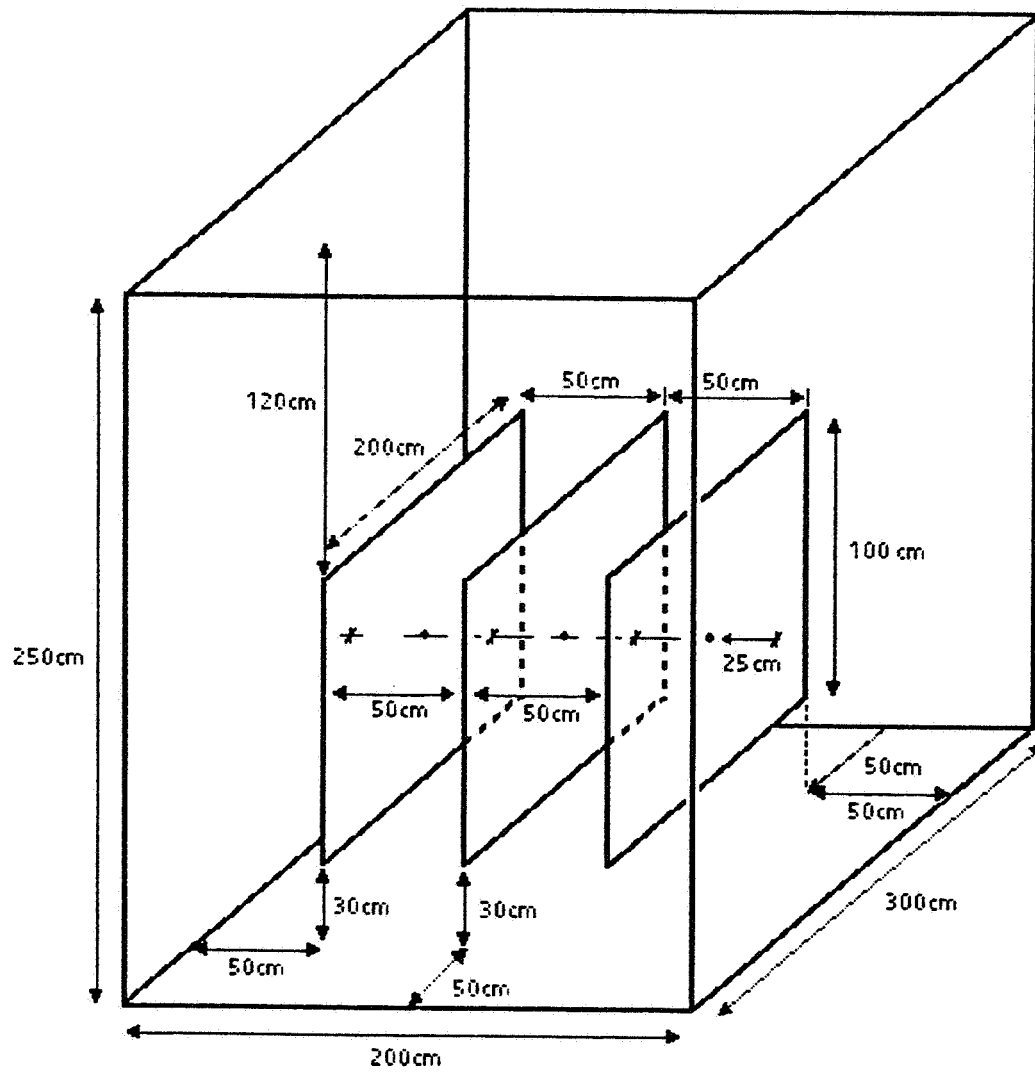
Analysis of each sample must be carried out in duplicate and the mean result used for the determination of the formaldehyde concentration in the test chamber. If the difference between duplicate measurements is $>6\%$ of the mean, the determination should be repeated (this is based on a standard deviation of 2%, which is currently attained, and the 95 probability percentile).

6. REFERENCES

1. a. ETB-Richtlinie über die Verwendung von Spanplatten hinsichtlich der Vermeidung unzumutbarer Formaldehydkonzentrationen in der Raumluft - Fassung April 1980. Herausgegeben vom Ausschuß für Einheitliche Technische Baubestimmungen (ETB). Beuth Verlag, Berlin 1980
b. ETB-Richtlinie über die Klassifizierung von Spanplatten bezüglich der Formaldehydabgabe. Appendix to reference 1 a.
2. Formaldehyde Test Method - 2: Large scale test method for determining formaldehyde emissions from wood products - Large chamber method FTM2 - 1985. National Particleboard Association: Gaithersburg, Maryland, 1985
3. NEWTON L.R., ANDERSON W.H., LAGROON H.S. and STEPHENS K.A. Large-scale test chamber methodology for urea-formaldehyde bonded wood products. In "Formaldehyde Release from Wood Products" edited by B. Meyer, B.A. Kottes Andrews and R.M. Reinhardt. ACS Symposium Series 316, American Chemical Society, Washington 1986, pp. 154-187
4. BLACK M.S. and MASON C.J. Continuation of environmental chamber optimization and correlation of large scale / small scale chambers for determining formaldehyde emission rates. Final Georgia Tech Report prepared for the Formaldehyde Institute Inc. (FI), Washington DC, 1987
5. MARUTZKY R. and FLENTGE A. Die Prüfraum-Methode als Referenzverfahren nach Gefahrstoff-Verordnung. WKI-Bericht Nr. 19; Fraunhoferinstitut für Holzforschung, Braunschweig 1988, pp. 5-18
6. Nordtest method 481-84: Building materials, "Emission of gases and vapours". Danish Building Research Institute, Division of Building Physics. Document R15-82, PAN/MLJ, ID 680147, Hørsholm 1986
7. HOETJER J.J. and KOERTS F. Experiences with a model for the formaldehyde release of particle boards. In "Formaldehyde Release from Wood Products" edited by B. Meyer, B.A. Kottes Andrews and R.M. Reinhardt. ACS Symposium Series 316, American Chemical Society, Washington 1986, pp. 125-144
8. MARUTZKY R., MEHLHORN L., ROFFAEL E. AND FLENTGE A. Prüfverfahren nach Gefahrstoffverordnung als Grundlage für formaldehydarme Holzwerkstoffe. Holz als Roh- und Werkstoff 46, 1988, pp. 253-258
9. CEN report CR 213 prepared by Technical Committee CEN/TC 91, Brussels, May 1984
10. Netherlands Norm NEN 2795: Bepaling van de concentratie van methanal (formaldehyde) - Fotometrische methode met pararosaniline. Nederlands Normalisatie-instituut, Delft 1985

11. VDI-Richtlinie 3484, Blatt 1: Messen von Aldehyden - Bestimmen der Formaldehyd-Konzentration nach dem Sulfit-Pararosanilin-Verfahren. VDI-Verlag, Düsseldorf, 1979
12. BISGAARD P., MØLHAVE L., RIETZ B. and WILHARDT P. Quantitative determination of formaldehyde in air using the acetylacetone method. *Analytical Letters* 16(A17&18), 1983, pp. 1457-1468
13. MENZEL W., MARUTZKY R. and MEHLHORN L. Formaldehyd-Meßmethoden. WKI-Bericht No. 13: Fraunhofer-Institut für Holzforschung, Braunschweig, 1981
14. NIOSH - Method 3500, U.S. Department of Commerce, NIOSH Manual of Analytical Methods, Vol.1, National Institute for Occupational Safety and Health, Washington D. C., 1977, pp. 125-1 - 125-9
15. CLERMONT L.P. and CARROLL M.N. Improved chromotropic acid determination of formaldehyde evolution from wood composites. *Forest Prod. J.* 26(8), 1976, pp. 35-37
16. SCHLÜTER L.G. Messung von Formaldehyd in der Raumluft. *Gesundheits-Ingenieur* 106, 1985, pp. 200-204
17. IBN-BIN Document 324 SC 2/66 F 1988-05-17: Projet de méthode normalisée pour la détermination de formaldehyde dans l'air
18. VDI-Richtlinie 3862 (Vorentwurf): Messen gasförmiger Emissionen. Messen aliphatischer und aromatischer Aldehyde und Ketone nach dem DNPH-Verfahren. Verein Deutscher Ingenieure, 1988
19. TUSS H., NEIZERT V., SEILER W. and NEEB R. Method for determination of formaldehyde in the pptv-range by HPLC after extraction as 2,4-dinitrophenylhydrazone. *Fresenius Z. Anal. Chem.* 312, 1982, pp. 613-617
20. AHONEN I., PRIHA E. and ÄIJÄLÄ M.L. Specificity of analytical methods to determine the concentration of formaldehyde in workplace air. *Chemosphere* 13, 1984, pp. 521-525
21. VAN DER WAL J.F., KORF C., KUYPERS A.T.J.M. and NEELE J. Interference by chemicals in the determination of formaldehyde. *Environ. Internat.* (1988), in press

Fig1 : Example of a chamber and the positioning of samples



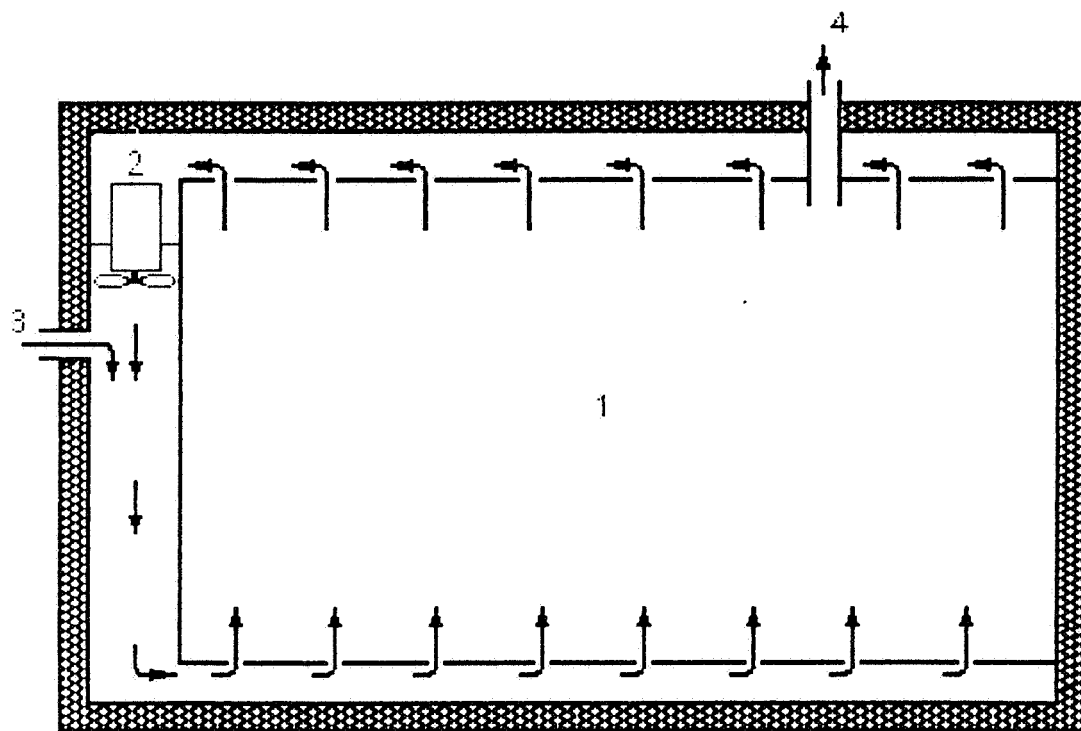


Fig. 2a: Mixing of the atmosphere in a test chamber enforcing a parallel air flow through the useful space of the chamber,

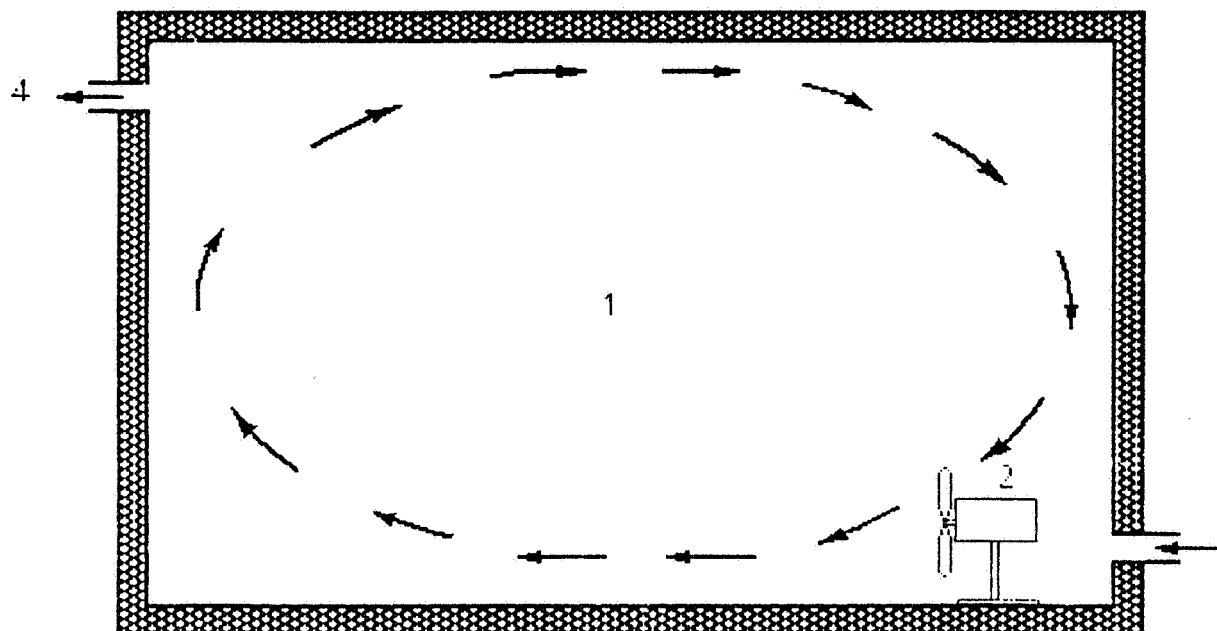


Fig. 2b: Mixing of the atmosphere in a test chamber with a circular air flow,

...

1 test chamber
3 air inlet

2 ventilator
4 air outlet

PARTICIPANTS IN WORKING GROUP 3

Dr. Derrick CRUMP
Department of the Environment
Building Research Establishment
Garston
Watford WD2 7JR

Ir Jan.F. VAN DER WAL
TNO - MT
Afdeling Binnenmilieu
Schoemakerstraat 97
Postbus 217
NL - 2600 AE Delft

Mr. Wilfried HAELVOET
Technisch Centrum van de
Houtnijverheid
Steenweg op Alseberg 830
B-1180 Brussel

Commission of the EC

Dr. Maurizio DE BORTOLI
The Environment Institute
CEC - Joint Research Centre
I-21020 Ispra (Varese)

Dr. Rainer MARUTZKY
Fraunhofer Institut für Holzforschung
Bienroder Weg 54 E
D-3300 Braunschweig

Dr. Helmut KNÖPPEL
Address: see M. De Bortoli

Dr. Peter. A. NIELSEN
SBI - Danish Building Research Institute
Postboks 119
DK-2970 Hörsholm

Observer of the European Confederation of Woodworking Industries

Mme Monique ROMEIS (†)
Chef du Département
Préservation du Bois
CTBA
10, Avenue de Saint-Mandé
F-75012 Paris

Dr. Adolf BARGHOORN
VHI
Wilhelmstraße 25
D-6300 Giessen

Dr. Maurizio De Bortoli
Chemistry Division
CEC-Joint Research Centre
I-21010 Ispra (Varese)
Italy

POST:
SBI, POSTBOKS 119
DK-2970 HØRSHOLM
VISIT:
DR. NEERGAARDS VEJ 15

TELEFON 02 86 55 33
TELEFAX 02 86 75 35
POSTGIRO 5 40 27 86

SBI j.nr.
C2-EF PAN/TAK
re

ref.

dato
1988.09.21

Dear Helmut and Maurizio,

Thank you very much for your hospitality and for the Draft Proposal.

I think it turned out to be quite a good document. As mentioned during our last meeting, there is one thing, however, that I do not like and that is an air exchange rate in the chamber of 1 h^{-1} .

I would prefer at lower air exchange rate. I do not think that the air exchange rate should be above $0,5 \text{ h}^{-1}$. My argumentation for this is as follows:

- The test conditions shall be as close to real life conditions as possible.
- In Denmark and in many other countries where energy saving has a high priority, there is no air exchange rate of 1 h^{-1} in the dwellings. In the Danish Building Regulations 1982 there is the following requirement for Residential buildings: 'There shall be means in every dwelling unit of making a total air change of not less than 0,5 times per hour'. Owing to energy saving measures it has become necessary to have this stipulation, because the air exchange was so low that air quality problems arose, for example caused by formaldehyde. Indoor air problems caused by formaldehyde are often connected with a low air exchange rate often considerably below $0,5 \text{ h}^{-1}$.

If it is a question of protecting the population from exposure to potentially harmful concentrations of formaldehyde in indoor air you cannot -in my opinion - use an air exchange rate exceeding $0,5 \text{ h}^{-1}$.

The reason for an air exchange rate of 1 h^{-1} is 'the choice of values for temperature, rel. humidity air exchange rate and loading factor has been based on argument (b) (harmonization with already existing similar methods) taking into consideration various related existing methods (1, 2, 6, 9).

If you take a look at these references you will get the following results:

1. a. ETB Richtlinie über die Verwendung von Spanplatten hinsichtlich der Vermeidung unzumutbarer Formaldehydkonzentrationen in der Raumluft-Fassung April 1980. Herausgegeben vom Ausschuss für Einheitliche Technische Baubestimmungen (ETB). Beuth Verlag, Berlin 1980.
b. ETB-Richtlinie über die Klasseifizierung von Spanplatten bezüglich der Formaldehydabgabe. Appendix to reference 1 a.

Air exchange rate 1 h^{-1}

2. Formaldehyde Test Method -2: Large scale test method for determining formaldehyde emissions from wood products - Large chamber method FTM2 - 1985. National Particleboard Association: Gaithersburg, Maryland, 1985.

The chamber test shall be conducted at $0,5 \pm 0,05$ air changes per hour.

6. Nordtest method 481-84: Building materials, 'Emission of gases and vapours'. Danish Building Research Institute, Div. of Building Physics. Document R15-82, PAN/MLJ, ID 680147, Hørsholm 1986.

Air change rate $0,250 \pm 0,013 \text{ h}^{-1}$.

9. CEN report CR 213 prepared by Technical Committee CEN/TC 91, Brussels, May 1984.

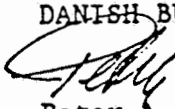
The rate of ventilation shall be between 0 and $10,0 \text{ h}^{-1}$.

EPA, USA is also using an air exchange rate of $0,5 \text{ h}^{-1}$ when measuring emissions.

I think the best compromise must be an air exchange rate of $0,5 \text{ h}^{-1}$ and I hope that you agree.

As I yet do not possess all the information about 'Large scale 'Walk-in' test chamber' I shall be sending Table 1 at a later stage.

Yours sincerely,
DANISH BUILDING RESEARCH INSTITUTE



Peter A. Nielsen

Annex 1: Large scale "walk-in" test chambers in Europe

Institute*	Volume m ³	Height m	Width m	Depth m	Int. Wall Material	Air Mixing a/b**
Laboratory of Heating and Air Conditioning, Technical University of Denmark, Lyngby (<i>two identical chambers</i>)	25,4	2,8	3,6	2,5	stainless steel	a/b
IMA, University of Århus, Denmark	79,0	2,7	5,7	5,7	stainless steel	b
IMA, University of Århus, Denmark	32,4	2,7	3,0	4,2	stainless steel	b
IMA, University of Århus, Denmark	41,7	2,4	3,7	4,7	aluminium	b
WKI, Fraunhofer-Institut für Holz-forschung, Braunschweig, BRD	48	2,4	2,8	6,4	stainless steel	a
WKI, Fraunhofer-Institut für Holz-forschung, Braunschweig, BRD	38	1,95	2,8	5,25	stainless steel	a/b
CTBA, Centre Technique du Bois e de l'ameublement, Paris, France	29,1	2,56	2,77	4,11	P.V.C.	a
F.M.P.A., Stuttgart, BRD	40	2,4	2,8	6	aluminium	b
T.C.H.N.-C.T.I.B., Brussels, Belgium	27,9	2,11	3,31	4,01	stainless steel	
TNO Division of Technology for Science, Delft, The Netherlands	15	2,5	2,5	2,3	steel coated with alkyd resin	
CEC, Joint Research Centre, Ispra, Italy (u)	30	2,5	3	4	stainless steel	b
VEB WTZ der holzverarbeitenden Industrie, Dresden***, DDR	40	2,37	3,80	4,40	aluminium	a/b
Bundesanstalt für Materialforschung und -prüfung, Berlin	20	2,4	2,0	3,0	stainless steel	a
Institut für Wasser-, Boden-, und Lufthygiene/BGA, Berlin, BRD	12	2,0	2,0	3,0	aluminium	a/b
Österr. Holzforschungsinstitut, Objekt 212, 1030 Wien. Austria	38,5	2,44	4,97	3,175	AW-100 plywood covered with aluminium foil	a
CNR, Istituto per la Tecnologia del Legno S.Michele a./Adige (TN), I (u)	28,7	2,20	3,26	2,64	stainless steel	a
Food and Consumer Product Inspection Service, The Hague, Netherlands	25,9	2,4	3,6	3	stainless steel	a

* "(u)" after Institute, if the chamber is under construction

** a = "laminar" air movement in chamber (see fig. 1a); b = circular air movement in chamber (see fig. 1b); a/b = intermediate solution

*** two similarly constructed chambers

European Communities - Commission

**EUR 12196 — European concerted action
Indoor air quality and its impact on man.
COST Project 613:
Guideline for the determination of steady state
concentrations in test chambers.**

Working Group 3

Luxembourg. Office for Official Publications of the European Communities

1989 — I-VI, 20 pp. — 21.0x29.7 cm

Series: Environment and quality of life

EN

This guideline has been prepared by a working group of the concerted action "Indoor Air Quality and Its Impact on Man" (COST project 613) and describes a method for the determination of formaldehyde emissions from wood based materials using large scale, walk-in type environmental chambers. The guideline describes essential features of the chambers to be used, such as size, inner wall and sealing materials, tightness, air circulation and position of sensors for temperature and humidity. Moreover values for temperature, relative humidity, air exchange rate, loading factor and air velocity in the chamber are recommended.

The guideline also deals with sample preparation and positioning in the chamber, and with formaldehyde sampling and analysis. In addition questions of quality control are discussed.