EUROPEAN COLLABORATIVE ACTION

INDOOR AIR QUALITY & ITS IMPACT ON MAN

Environment and Quality of Life

Report No 21

European Inter-laboratory Comparison on VOC emitted from building materials and products

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INDOOR AIR QUALITY & ITS IMPACT ON MAN

(ECA-IAQ)

Environment and Quality of Life

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European Inter-laboratory Comparison on VOC emitted from building materials and products

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Abstract

Eighteen laboratories from 10 European countries participated in a comparison organised in the frame of the project VOCEM, a 2.5 year research collaboration among 4 research institutes and 4 industrial companies. The VOCEM project (*"Further development and validation test chamber method for measuring VOC emissions from building materials and products"*) has been partially funded by the European Commission (Contract no. SMT4-VT95-2039). The scope of the project was to improve the procedure used to measure VOC emitted from building materials and products in small test chambers. The inter-laboratory comparison included the GC-MS determination of 5 target compounds from carpet , 8 from PVC cushion vinyl and 2 from paint; for the first time, chamber recovery (sinks), homogeneity of solid materials and possible contamination during transport were tested. The results show that the intra-laboratory variance (random errors) is much smaller than the inter-laboratory variance (systematic errors). Causes of the largest inter-laboratory discrepancies were: (a) analytical errors; (b) losses of the heaviest compounds due to sorption on the chamber walls; (c) non homogeneity of the materials. The output of this work concerns both the objective of labelling materials with regard to their VOC emissions and the pre-standard drafted by CEN for this type of determination.

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INTRODUCTION

In February 1996, four research institutes and 4 industrial companies (see list in the 'acknowledgement' section) started the European research project named VOCEM ("*Further development and validation test chamber method for measuring VOC emissions from building materials and products*"), partially funded by the European Commission. The objective of the project was to investigate reasons for the inter-laboratory discrepancies observed in previous international comparison experiments on material emission measurements [1-3], which had been organized in the frame of the European Collaborative Action *Indoor Air Quality and Its Impact on Man* (ECA-IAQ) as a validation of guidelines for small chamber emission studies [4-5]. The VOCEM project intended to develop an improved procedure, which hopefully would reduce discrepancies within acceptable limits, as tested through an inter-laboratory comparison. The research carried out within the VOCEM Project is described elsewhere [6].

The last international comparison [2] had shown that the contribution of analytical errors to the overall inter-laboratory variance was very important. Therefore, this comparison exercise included two analytical inter-laboratory comparisons, compulsory to any laboratory willing to participate in the material emission comparison. Their results are also summarised below. Other major features included in the experimental protocol, based on the research carried out within the VOCEM project, were the control of air velocity in the chamber, very important for "wet" materials like paint, a chamber recovery test, i. e. a test to estimate VOC losses onto chamber walls and, on a voluntary basis, the monitoring of possible material contamination during transport by means of diffusion samplers. Moreover, the homogeneity of the solid materials tested (carpet and PVC) was verified, in order to assess whether a lack of homogeneity could contribute to inter-laboratory variance.

All these features made this comparison unique in the field of material emission measurements. The output of this work is especially interesting for two objectives: (a) the use of emission measurements for the purpose of labelling or otherwise controlling material emissions and (b) the pre-standard drafted by CEN (European Committee for Standardisation) for this type of determination [7], as the protocol of the VOCEM comparison was shaped tightly on the pre-standard, apart from a few specific topics where the results of the VOCEM project have been taken into account (e.g. recovery tests).

The laboratories participating in the comparison are listed in Appendix 1.

EXPERIMENTAL PROCEDURE

Analytical comparisons

The first preliminary analytical comparison requested the determination of n-octane, n-dodecane, 2-butoxyethanol, 2-ethylhexanol, limonene, hexanoic acid and TXIB (2,2,4-trimethyl-1,3-pentanediol diisobutyrate) in aliquots of two liquid solutions, containing the compounds, respectively, at 10-20 and 200-300 $ng \cdot \mu l^{-1}$; the second comparison requested sampling by each participant, using his/her own sampling equipment, a calibrated atmosphere, generated in the large test chamber at the JRC-EI. The compounds were the same as above at concentrations of 15-200 $\mu g \cdot m^{-3}$.

Selection and distribution of the test materials

Three materials were selected for the comparison: (a) carpet (polyammide with primary SBR and secondary polypropilene backing), manufactured by Vorwerk & Co (Hameln, Germany); (b) PVC flooring (vinyl cushion), manufactured by Sommer SA (Wiltz, Luxembourg); (c) paint (water based acrylic latex), manufactured by Tikkurila OY (Vanta, Finland). The characteristics of these materials are reported in Appendix 2, which includes also example gas-chromatograms of their emissions, obtained at the JRC-EI with a slightly polar GC column (7 % of phenylsilicone). Material batches were prepared on purpose for the interlaboratory comparison and distributed to the participants directly by the manufacturers: paint (November 1997) in 1 liter metal cans, carpet (February 1998) and PVC (March 1998) in ~ 1 x 1.5 m rolls. Sampling of carpet from the batch was carried out according with a procedure agreed upon with the producers; it included defining a grid of 36 identical elements ~ 1 x 1.5 m (after discarding the first 4 m and lateral margins of 0.5 m), numbering of all these elements and sampling at random, as defined by a random number generator (RNG). The PVC followed the same procedure, except that there were no lateral margins. The carpet rolls were protected with three envelopes: non adhesive Al tape, wrapping diagonally the roll and two polyethene sheets. The PVC rolls were also protected with the same Al sheet and one polyethene sheet externally. Diffusion samplers, provided in advance by certain laboratories on a voluntary basis, were installed on some material packages, in order to discover possible contamination of the material by VOC during transport.

Selection of the target compounds

Out of the overall emission patterns, the compounds to be determined were selected by the JRC-EI, using the following criteria: compounds of low and high concentration, of low and high polarity, covering a relatively wide volatility interval. Thus five target compounds were selected for carpet, eight for PVC and two for paint (see Tables 2-6, 14-21 and 32-33); in addition, also the sum of the remaining unidentified VOC as toluene equivalent was requested, so that the addition of the two terms (target compounds + total of unidentified peaks) agrees with the recent TVOC definition given by the ECA-IAQ [8]. Due to the lack of pure reference compounds in the laboratory, four out of the eight compounds selected for PVC were only identified as branched isomers of C7, C8 or C9 alkylbenzene derivatives; however, recognition was not at all problematic because they were very prominent peaks. As no appropriate response factor could be used for these compounds, the participants had been invited either to use the response factor of one isomer for

each type of molecule (if available in the laboratory, e. g. n-heptylbenzene for the C7 alkylbenzene branched isomer) or to use the response factor of toluene. A test carried out at the JRC-EI has shown that the differences in the FID responses for toluene, n-heptylbenzene and n-octylbenzene were less than 4 %.

Homogeneity tests

The verification of the homogeneity of carpet and PVC was carried out at the JRC-EI through the determination of the target compounds emitted from four samples of each material, extracted from the production batch with the random procedure mentioned above. Specimens cut out of the samples were introduced into a 20.8 *l* test chamber and the concentrations of the target compounds determined through quadruplicate sampling and measurements after 24 h. The chamber conditions for these measurements were in accordance with the comparison protocol for PVC, whereas, due to the low emission rate of carpet, the area specific emission rate for this material was halved, in order to obtain more reliable measurements. Detailed experimental conditions and results of these analyses are reported in Appendix 3.

Test chamber conditions, quality assurance / quality control

The following chamber conditions were requested: 23 ● 1 °C for temperature, 50 ± 5 % for RH, 0.2 $m \cdot s^{-1}$ for air velocity; the area specific ventilation rate requested was 1.0 $m^3 \cdot m^{-2} \cdot h^{-1}$ for carpet and PVC and 2.5 $m^3 \cdot m^{-2} \cdot h^{-1}$ for paint.
Table 1 summarises chamber capacity, chamber wall material and measured air velocity for each participating laboratory.

The protocol requested duplicate determinations at each of three sampling times after t_0 (time of introduction into the chamber), i.e. 24, 48 and 72 hours; in addition for paint, considering the difficulty to prepare films with very reproducible thickness, duplicate tests were requested.

No normalisation of the analytical portion of the procedure was attempted, because, on one side, each analyst works better with a known and tested procedure, rather than with a procedure imposed from outside; on the other side, the participants had already carried out two preliminary analytical comparisons within this project. A summary of the instruments and procedures they used is presented in Appendix 4. The comparison protocol included a number of directions from the point of view of quality assurance / quality control (control of chamber physical parameters, determination of the chamber recovery, determination of the paint film thickness, etc.). The data provided by the laboratories to answer these requirements are collected in Appendix 5.

Determination of the area specific emission rates

Concentrations were converted to area specific emission rate (SER_a, $\mu g \cdot m^{-2} \cdot h^{-1}$) values through multiplication by the area specific ventilation rate ($m^3 \cdot m^{-2} \cdot h^{-1}$), which means assuming steady state conditions in the chamber. This is not far from the truth for carpet and PVC and even for paint (see ECA-IAQ 1997a)[10]. The choice was dictated by the concern of avoiding additional errors due to the use of mathematical models; considering that the objective was to compare laboratory performance under identical conditions, rather than assess the emission rate of the test materials, identically biased results were preferred to unbiased results, but affected by additional unknown random errors.

Preparation of paint specimens

Particular attention was given to the preparation of paint specimens, with the aim of obtaining films of uniform and reproducible thickness. The protocol requested the use of paint applicators of 0.20 mm recess height and recommended their combination with electromechanical devices, in order to realise a more constant application speed; in fact, only three laboratories were equipped with the latter type of device, the other participants applying paint manually. The materials recommended as substrate were polyester sheet and aluminium plate; two laboratories used stainless steel (see Table 1). On the basis of preliminary tests, the protocol recommended that paint specimens be introduced into the chamber immediately after preparation, under the area specific ventilation rate defined for the test: the first 24 h period until the first sampling may thus be considered a conditioning time.

Statistical evaluation of results

The statistical treatment of the results was carried out employing a computerised procedure, which included [1,9]: (a) the test for data normality employing the Shapiro-Wilk test and, in connection, (b) the identification of outliers, defined as the values exceeding 1.5 times the interval between quartiles, i. e. the interval between the 75 percentile value and the 25 percentile value; (c) the one-way and two-way analysis of variance; (d) the calculation / identification of means, medians, minimum and maximum values, quartiles, standard deviations and coefficient of variations (c.v.).

RESULTS AND DISCUSSION

(a) General aspects

Eighteen laboratories, from ten countries and the EC-JRC, effectively participated in the VOCEM material comparison analysing the VOC emitted from at least one material. Table 1 lists the test chambers they have used: as it appears from the table, 6 laboratories used two chambers to test the same material and this offers an additional possibility to study any bias due to the chamber and/or the material (see below). Overall the comparison included 16 different chambers, with three different wall materials and capacity between 35 cm^3 and 1 m^3.
The analysis of the emissions from carpet and especially from PVC proved to be relatively difficult: this appears also from the fact that some laboratories did not report emission rates for certain compounds emitted from these materials. One additional difficulty was the wide variation in emission rate, and hence concentration, of the target compounds: from the very low n-decane (carpet, close to detection limit) to the very high butoxyethoxyethanol (PVC, overloading the analytical column) and paint compounds (for which much reduced air volumes had to be sampled).

All the values reported as "not detected" or as "0" or as smaller than the appropriate detection limit have been labelled as zero in the following tables; hyphens indicate results not reported.

The within-laboratory variance, derived from the requested duplicate determinations, can be summarised as follows: individual c. v. values range between zero and 38 %; mean values over the laboratories, grouped by compound, range between a minimum of 2.3 % (Texanol) and a maximum of 10 % (2-phenoxyethanol): the "difficult" compounds show the highest inter-laboratory as well as within-laboratory variance. Of course, there are also differences among laboratories, certain showing systematically low c. v. (1-2 %, e.g. laboratories No 1 and 7), others systematically high values (10-20 %, e. g. laboratory No 10; No 5 for carpet), others showing variable c. v. values, depending on the material and/or on the sampling time.

(b) Carpet

Tables 2-7 report, for each compound and for the total of unidentified compounds, all individual values of the area specific emission rate (SER_a, $\mu g\ m^{-2}\ h^{-1}$), with calculated means, standard deviations and coefficients of variation (c.v. %) for duplicate determinations. Tables 8-13 report median, mean, standard deviation and coefficient of variation over the laboratories, for each compound and for the total, for each sampling time and run, after exclusion of the outliers.

Much higher variations are observed for n-decane and 2-phenoxyethanol, compared with the other target compounds: this is explained by the very low concentrations of these compounds. Moreover, 2-phenoxyethanol is polar and hydrophilic and can be easily adsorbed in the analytical system: a test carried out at the JRC-EI showed that the FID response factor at 9 ng injected was 1.5 times lower than at 45 ng injected.

(c) PVC

Tables 14-22 report, for each compound and for the total, all individual values of the area specific emission rate (SER_a, $\mu g\ m^{-2}\ h^{-1}$), with calculated means, standard deviations and coefficients of variation for duplicate determinations. Tables 23-31 report median, mean, standard deviation and coefficient of variation over the laboratories, for each compound and for the total, for each sampling time and run, after exclusion of the outliers.

Most target compounds from this material present high variations, with the coefficients of variation exceeding 40 %: reasons to explain, at least partially, this finding are given below.

(d) Paint

Tables 32-40 report, for each compound and for the total, all individual values of the area specific emission rate (SER_a, $\mu g\ m^{-2}\ h^{-1}$), with calculated means, standard deviations and coefficients of variation for duplicate determinations. Tables 41-43 report median, mean, standard deviation and coefficient of variation over the laboratories, for each compound and for the total, for each test, sampling time and run, after exclusion of the outliers. All the data on paint weight and film thickness reported by the participants are presented in Appendix 5.

Whereas the inter-laboratory variations for Texanol are within satisfactory limits (they are even among the lowest in this comparison), the variations observed for 2-(2-ethoxyethoxy)-ethanol are much higher; such variations, however, occur also within the laboratory itself, at least for certain laboratories, and are not associated with the paint film thickness (see SER_a of laboratories 7A, 8A, 8B and 9 in Tables 35-37). An hypothesis to explain these unpredictable variations is that this compound be not homogeneously distributed and/or emitted within/from the paint mass (see below).

(e) Analysis of variance

This analysis was carried out after checking that the results were normally distributed: this operation was carried out submitting each data set to the Shapiro-Wilk test for normality at the 5 % probability level; by data set we mean the SER_a results obtained by the laboratories in one run at one sampling time for one compound (for carpet and PVC there are 6 data sets per compound, for paint 12 and overall there are 126 data sets with 2080 individual data, including the total of unidentified compounds). Only 4 data sets exhibited a normal distribution before any manipulation, whereas almost all data sets passed the normality test only after elimination of one or more outliers; infact, only 12 data sets could not be classified as normally distributed, after discarding outliers, in most cases with a probability slightly below 5 %; in particular, at 48 h (time selected for the analysis of variance) only one data set did not pass the test. The search for outliers was performed stepwise (one outlier per run). The number of outliers per compound ranged between 0 and 33; more meaningful than absolute numbers is the percent of outliers on the total of the individual results: such a percent was always smaller than 10 %, except for 3 PVC compounds, C7 alkylbenzene (24 %), C8 alkylbenzene-2 (15 %) and TXIB (18 %), and for Texanol from paint (20 %). Such fractions of data discarded are high, but on one side this is the outcome of the objective criterion used, on the other side almost half (42 %) of the outliers for these 4 compounds are due to two laboratories only (No 11 and 13). Few laboratories (No 9, 11, 13, 14, 17) account for a very large portion (62 %) also of the total number of outliers, whereas only 5 laboratories did not present outliers at all (No 1, 3, 4, 7, 15). An additional type of deviation, not taken into account with outliers, is due to the results labelled as "zero", i. e. the compounds that have not been detected by certain laboratories and the many cases of compounds simply not reported: this defect occurred mainly with some PVC target compounds.

The analysis of variance was carried out on the data thus obtained, limited to the data at 48 h. The reason for preferring results after 48 h is that, after 24 h, an extraordinary small air volume

(100 cm^3) had to be collected for paint emission analyses, because of the very high concentrations; hence higher random errors can be expected, and after 72 h the concentrations were too low for some compounds. Besides, the dispersion of the SER_a values, as indicated by the c.v. is on the average substantially equivalent at the three measurement times. The results are presented in Table 44, in terms of apportioned standard deviations (limited to "key" compounds). This table shows that the factor "between-laboratory", i. e. the factor including all kind of bias (due to analysis, lack of homogeneity in the material, etc.), is much more important than the "within-laboratory" factor, which includes all random errors (sampling, analysis, etc.). In the case of paint, in addition to sampling and analysing twice at each test time, the entire test was repeated and therefore, for this material, Table 44 includes an additional column for the factor "test". Whereas for Texanol the variance associated with this factor is non significant and anyhow very small, for (2-ethoxyethoxy)ethanol the contribution of the "test" factor to variance is highly significant, accounting for almost the same fraction to the total as the between laboratory variance.

(f) Attempting to explain interlaboratory discrepancies

Errors due to deviations from the protocol

A first and obvious cause of error in this domain is chamber temperature during the test, which affects directly the emission rate. An interesting insight on this influence in quantitative terms is supplied by Laboratory No 9, where first paint tests have been erroneously carried out at 24.9 °C; the final results delivered, obtained repeating the tests at 23.4 °C (nearer to the requested temperature of 23 °C), can thus be compared with the results obtained at the higher temperature. Confining the comparison to Texanol, because of the very high intra-laboratory variations of the other target compound, it appears that the increased temperature of 1.5 °C produces, on the average, an increased emission rate of 11.7 %, which is statistically significant ($p < 0.05$). This result confirms that temperature is a very important factor in determining the emission rate. However, almost all the participants had temperature fluctuations within the limits requested in the protocol (see Appendix 5, Table 1) and no important temperature bias is reported. Therefore, temperature cannot be considered a major factor contributing to the discrepancies observed.

A second possible cause of error, which appears from the laboratory reports, is the deviation from the requested values of the area specific ventilation rate. Table 4 in Appendix 5 lists all the values of this parameter adopted by the laboratories and it appears that 7 of them are markedly lower than requested (lab. 2B for carpet, PVC and paint; lab. 11 for carpet; lab. 13 for PVC; lab. 15A for carpet and PVC). Also this parameter, within a certain range, can influence the emission rate: the emission (mass transport) is controlled by a vapour phase concentration gradient, which may be reduced at lower ventilation rates, with resulting higher vapour phase concentrations. Looking for any association between the 7 low values of the area specific ventilation rate and low SER_a values, only the mean SER_a at 48 h for butoxyethoxyethanol (PVC) and for paint compounds (two tests) were considered, because they displayed the highest concentrations. Of the total 7 SER_a values, 4 are within ± 15 % of the median value, two are lower than the median (43 and 64 %) and one is higher (28 %). These findings are not a clear indication in favour of the hypothesis that the deviation from the protocol of the area specific ventilation rate has contributed markedly to the dispersion of the results, unless errors of opposite sign have masked the effect looked for.

Errors due to adsorption losses (sinks) as evidenced through recovery tests

The comparison protocol included the request for a chamber recovery test, i.e. a test with introduction into the chamber of sources of five selected VOC with emission rates determined by

weight loss. A high loss in then test for a certain compound could explain a low results, in the material emission comparison, for the same or similar compound. The valid results of this test, carried out by 8 laboratories, are reported in Appendix 5, Table 2. This table presents the ratio between the emission rate derived from the concentration measured in the chamber and the emission rate derived from the weight loss of the source: the lower the ratio, the larger the losses due to adsorption (sinks); the ratio can therefore be named "recovery". The CEN pre-standard already quoted [7] considers chamber recovery as acceptable if it is > 80 % for toluene and n-dodecane. However, there were two intrinsic defects in the test as it was proposed; on one side, the recommended sizes of the diffusion sources (vials and Petri dish) were appropriate for 1 m^3 chambers and therefore produced excessively high concentrations in the smaller chambers used; on the other side, for the two alcohols to be used in the test the emission rates derived by weighing where lower than the emission rates derived measuring the concentrations in the chamber (sometimes even negative values were obtained!); this is most probably due to the condensation of water vapour from the atmosphere into the liquid phase of these two hydrophilic compounds, which balanced their weight loss by evaporation.

From Table 2 in Appendix 5 it appears that certain test chambers have recovery values particularly low for n-dodecane and/or TXIB (Laboratories No 8A, 8B, 10, 12 and 18); one would therefore logically expect that emission rate values obtained in such chambers for these compounds be on the low side. We have looked for this association and the result is the following. Analysing the 20 SER_a values determined for dodecane and tridecane from carpet and tetradecane and TXIB from PVC (the heavier alkanes should be lost even more than dodecane) measured in the 5 chambers, only 7 SER_a values are lower than the median, in 3 cases substantially lower (0 % to 76 %) and in 4 cases marginally lower (87-94 %); in the remaining 13 cases the SER_a values are either equal or above the median. Only for laboratory 10, 3 out of 4 SER_a values are lower (in 2 cases substantially lower) than the median and this fact may be attributed to chamber losses. For the other laboratories, two hypotheses may be conceived: either the sink test is not representative of losses occurring during the emission measurements or, more likely, other errors (see below for laboratory No 8) are overbalancing adsorption losses.

Errors in the chemical analysis

As mentioned above, two comparison exercises, limited to sampling and to the GC-MS analysis, were organized as a condition to participate in the material emission comparison. The participants agreed that, in order to evaluate results, the following quality criteria to be used: (a) the variability of replicate determinations within the laboratory must be such that the coefficient of variation does not exceed 10 %; (b) the deviations from the known reference value must not exceed ± 20 % for the mean and ± 50 % for individual results. The 1st exercise, where a relatively high number of deviations occurred, was considered as a "tuning" opportunity. For the results of the 2nd exercise, an objective evaluation was carried out, attributing the score of 1 to each result not complying with the above criteria; out of a maximum possible total of 35, the scores accumulated by the laboratories ranged between 0 and 20, the four highest being laboratory No 13 (20), No 11 (14), No 15 (11) and No 18 (8). Three of these laboratories are included in the group of 5 laboratories which measured the lowest and highest SERa values (see above). Laboratory No 15 seems to have managed to reduce analytical errors after these preliminary exercises.

An important analytical error, affecting material emission results, is due to the mode of integrating GC peaks and to the presence of co-eluting substances. Underneath the peaks, complex gas-chromatograms normally present an unresolved background, which appears like a continuum above the instrumental baseline. This phenomenon, occurring in our case to a limited extent with

carpet and much more with PVC (see Fig. 1 in Appendix 2), and the fact that certain target compounds co-elute with other compounds, make the integration of peaks more complicated. In such cases, reliable analysis results can only be obtained using a MS detector and by basing the quantitation on single undisturbed ions. If an isotopic isomer of the target compound as internal standard is not available, an external standard can be used. This must be exactly the same compound as the target compound, because generally in MS detection performed on single ions response factors cannot be borrowed from similar compounds, like it is justified in FID detection. This condition was not realised for certain PVC target compounds, for which no reference material was available in the laboratory. But even in this case, a MS investigation on the GC target peaks, besides identifying the target compound can remarkably improve FID quantitation for the following reasons: (a) determination of the nature of the hump underneath the peak and drawing of a realistic integration baseline; (b) determination of peak purity; (c) identification of any co-eluting compound and estimation of its contribution to the peak area. In order to show the benefit of such an investigation and to evaluate the possible bias of reported SER_a for PVC caused by the factors above, an analysis was carried out at the JRC-EI, whereby, for each target compound, the TIC (Total Ion Current) peak areas obtained integrating valley-to-valley and integrating to the baseline were compared with the peak areas obtained integrating the signal due to specific ions. This investigation showed that, under the adopted conditions, (a) the integration valley-to-valley yielded values within 10 % of the best estimate based on the pure ion(s); (b) the integration to the baseline, except for phenol and butoxyethoxyethanol, systematically yielded values in excess; for the C7 alkylbenzene this error was about 15 %, for the other 5 compounds between 50 and 110 %.

In order to check whether high SER_a values of the latter 6 compounds could be associated with incorrect integration, after delivery of the results the participants were requested to communicate which GC integration procedure they had adopted: 10 participants stated to have used the valley-to-valley integration; among the others, 3 (lab. 8, 13 and 18) used baseline integration (the remaining 5 did not give useful information). The association between integration to the baseline and SER_a values above the median appears very clearly for 2 of the 3 laboratories but not for the third one (No 8), which however has reported low chamber recovery (see above); hence its results may be affected by two errors of opposite sign, which balanced each other. In fact, out of 22 SER_a values (6 compounds times 3+1 laboratories, as laboratory 8 used two chambers; two values are missing) there are 15 values higher, one equal and 6 lower than the median of all laboratories; if the double data set of lab 8 is excluded, out of the remaining 12 values only one is lower and one equal to the median, all the others higher. The algebraic mean percent deviation, compared to the median, is +38 % over the 22 cases and +58 % over the 12 cases. Therefore, the conclusion is that this type of error has a substantial contribution to the variance of the results.

Errors due to the non homogeneity of the materials

The results of the tests carried out to verify homogeneity are reported in detail in Appendix 3 and show that carpet and PVC were in fact non homogeneous, although if this is not true for two of the target compounds emitted from PVC (butoxyethoxyethanol and TXIB). These conclusions are based on the F-test for the significance of variances, which was applied to the concentrations of nominally identical specimens or groups of specimens: most F values found were highly significant ($p<0.01$); The difference from specimen to specimen is roughly 50 % for carpet (with the exception of n-decane, for which it is 250 %) and 20 % for PVC; it must be observed that, due to the very good reproducibility of the determinations, even small differences result highly significant. These differences must have contributed to the overall variance of the results and the smaller the area of the specimen analysed, the larger such a contribution would be.

Errors due to large deviations in the paint film thickness
The participants were requested to report values of the coating density (mg cm^{-2}) and of film thickness (μm); the former value is more reliable because, on one hand, the thickness value depends on the measurement position within the specimen, and, on the other hand, weighing errors are in general much smaller than errors associated with electronic instruments, such as those used for measuring film thickness. The variability of the film coating density over the 26 measured specimens is the following (see Table 5 in appendix 5): minimum 5.8, mean 9.0, maximum 16.7 mg cm^{-2}; the c.v. is 30 %. Compared with the previous inter-laboratory comparison on paint where the spreading of the coating density showed a c. v. of 61 % [2], the variability has been reduced to half. There is a relatively nice correlation (see Fig. 1 in Appendix 5) between coating density and thickness. However, repeating the correlation calculations on the detailed data supplied by Laboratories No 4 and 7, it appears that the slopes for the two data sets are different by a factor 1.4: this difference, probably due to the calibration of the electronic gauge used to measure the film thickness, contributes to the spreading of data points in Fig. 1, Appendix 5 and points out the need for standardisation on this topic.

The possible influence of paint film thickness on the SER_a values has been investigated attempting to correlate values of Texanol SER_a at 48 h, for test 1 and test 2, with the reported coating density of the paint specimens. However, there is no correlation (see Fig. 3 in Appendix 5), probably because of the masking effects of other errors. In fact, for example, laboratories No 4 and 6 have practically identical SER_a values, despite a factor 2 in their coating densities (1.6 in thickness); looking for the correlation within the same laboratory, the only two laboratories having appreciable (~ 30 %) differences in coating density between test 1 and test 2 (No 8A and 9) in fact show SER_a differences of 10 and 15 %.

An additional aspect relevant to the paint film characteristics, to which much attention has been dedicated in this project, is the type of device used to spread the paint, i. e. manual or electromechanical. Only three laboratories were equipped with an electromechanical device before the comparison (see Table 5, Appendix 5) and all of them used the FLEC (laboratory 15 in addition used also a different chamber), for which a circular paint specimen of 70 mm diameter was required. Therefore the possibility of drawing comparative conclusions on the two methods is very limited. However, the following can be observed: (a) the reproducibility of coating density and film thickness at the two laboratories (No 8A, 8B and 9) is not better than at the laboratories which used the manual method (e.g. No 7A, 17 and 18); (b) the 3rd laboratory (No 15) in fact obtained a very good reproducibility: the reason reported is that they succeeded in developing an improved manipulation procedure (which consisted in fixing firmly the substrate discs on the vacuum plate of the electromechanical applicator by means of a sheet of paper of appropriate porosity interposed between the discs and the vacuum plate); (c) these facts and the unsatisfactory reproducibility in the coating density reported by laboratory No 8B for the FLEC chamber show that also the electromechanical applicator requires considerable skill to obtain films of higher quality than with the manual procedure.

Errors due to possible contamination of carpet and PVC during transport (diffusion samplers)
The possibility of this type of errors, i. e. that a solid material be contaminated by air pollutants during transport and storage, has been long discussed; it has been object of limited investigation in the research program of the VOCEM project and, though no evidence of this phenomenon was found, it was decided that as many material packages as possible would be monitored during transport, by inserting diffusion (passive) samplers between the outer and the inner wrappings. At the end this resulted in the analysis of 5 and 7 samplers accompanying the same number of, respectively, carpet and PVC packages. The detailed analysis results of the diffusion samplers are

reported in Appendix 7. These results deserve the following comments: (a) the target compounds are reported as present in all the carpet-associated samplers and only in part of the PVC-associated samplers; (b) in some cases (more evident: lab. 7 for carpet and PVC, lab. 15 and 17 for carpet) the relative proportions of the compounds are similar to those observed in the emission measurements (SER_a) of the respective material: this seems to indicate that the sampler load came from the test material emission; (c) lab. 10 reported completely different chromatograms for the diffusion sampler accompanying PVC and the test material emission, i. e. no target compound was found in the sampler; (d) the upper average mass per compound adsorbed on the samplers was of the order of magnitude of 1 μg: this is the mass emitted in less than 1 h by 1 m^2 of carpet for the lowest compound (n-decane); infact, the samplers have been sampling for 200-400 hours. Altogether these findings do not give any clear cut judgement; however, it appears that no significant losses of emitted compounds and no significant contamination of test materials occurred.

Errors connected to the use of different chambers

This type of errors is evidenced by the fact that 6 laboratories used two chambers for one or more materials. Table 45 summarises the output of the investigation on this type of error, in terms of the ratio between the SER_a observed with the two chambers for the same compound and the same material. The table shows that the ratio ranges between 1.0 (i. e. identical results) and almost 3 (nearly 5 in one case with paint). Within the same laboratory, analytical errors should be similar and hence ruled out, unless the air volumes sampled from the two chambers have been largely different and hence adsorption losses in the analytical system could have been different. However, even compounds like undecane and tetradecane, not very sensitive to such losses, show widely different results. If the unrealistic idea that high errors affect the measurement of the air flow through one of the chambers is rejected, two hypotheses can be formulated to explain the differences: either much larger wall adsorption losses occur in one of the chambers or the inhomogeneity of the material causes the discrepancies (or both factors play a role). The latter hypothesis is supported by the fact that the largest ratios in Table 45 (all the 10 values > 1.8) occur when one of the chambers is the FLEC, in which specimens of only 0.018 m^2 are analysed; however, the same hypothesis is contradicted by the observation that large values of the ratio occur also for butoxyethoxyethanol and TXIB, the two compounds for which the PVC appears homogeneous (see Appendix 3). Finally, most values of the ratio are in the sense that SER_a data obtained with a FLEC are lower than those obtained with the other chambers.

A separate comment is required by the portion of Table 45 dealing with paint: here the Texanol results obtained in the two chambers are in very close agreement (less than 20 % difference) and this supports the inhomogeneity hypothesis put forward above for the solid materials: paint in fact should be a very homogeneous material. However, the results for 2-(2-ethoxyethoxy)ethanol present large discrepancies and even the largest discrepancy in all the table (laboratory 2). This observation, together with the large discrepancies between results of the two tests within the same laboratory (see above), seems to indicate that this compound is not homogeneously distributed and/or emitted in/from the paint.

(g) Progress done in the VOCEM Project compared with previous international comparisons

The VOCEM Project was originated by the observation that the results of the two international comparisons organised by the ECA-IAQ [1,2] were not satisfactory, because of excessive inter-laboratory discrepancies, for "wet" materials, like a liquid floor-wax and a paint. This

inconvenience was particularly severe in view of the introduction of labelling schemes or material certification procedures. Therefore, it is now particularly important to assess the progress achieved with the present inter-laboratory comparison. To this purpose we shall use, as an indicator, the coefficient of variation associated with the SER_a results. A simple and quick mode of evidencing the progress in these terms is to compare the c.v. ranges observed for each compound in the various data sets with those reported previously: Table 46 enables the reader to make such a comparison. The ranges refer to the lowest and highest c.v. values observed in the multiple data sets and the mean is the mean c.v. over all the data sets. Considering that materials and compounds are not all the same in the two terms of the comparison, the following can be concluded: (a) there is a very pronounced reduction of the dispersion for both paint compounds, Texanol being now entirely satisfactory; (b) if n-decane in carpet is excluded because of its concentration near the detection limit, there is a pronounced reduction of the dispersion for alkanes (PVC versus carpet); (c) there is substantial equivalence for the other common compound, i. e. phenol, which however already presented an acceptably low dispersion for the PVC in the previous inter-comparison [1]. If the value of 40 % for interlaboratory c.v. is considered acceptable (as it was stated for PVC in the 1st comparison), then 7 out of the 15 target compounds fall within this condition.

CONCLUSIONS

The exercise described has been highly positive *per se*, because it enabled to assess the state-of-the-art in the field, and even more for the insight on the main causes of errors it brings about: for the first time, tests on chamber recovery, material homogeneity and material contamination during transport have been carried out in connection with an inter-laboratory comparison. The results are particularly interesting considering that a pre-standard has been drafted by CEN on the topic.

From the analysis of variance, the between-laboratory factor appears to make by far the largest contribution to the overall variance. Analytical errors are probably the most important contribution to this fraction of the variance. Therefore, we strongly recommend that, in future inter-laboratory comparisons on material emissions, the analytical quality of the participants be verified through preliminary analytical comparisons, as we have done; however, these should focus more closely on the effective emission patterns to be determined.

In addition to analytical errors, differences among material specimens, due to non homogeneity of the materials also contribute to inter-laboratory variance. In fact, despite the efforts by the producers, the carpet and PVC batches, produced especially for this exercise, were not completely homogeneous: significant differences in the emission rate have been observed among the tested specimens, for almost all the compounds. This finding must be taken adequately into account, particularly when very small material specimens are tested, as those required by the smallest chambers or cells. Moreover, we recommend that, in future comparison exercises, the effective homogeneity of the materials to be tested to be verified, possibly in advance, by analyses of several specimens at one single laboratory.

The efforts in the preparation of reproducible paint films have produced a significant improvement, compared with the ECA-IAQ 2nd Inter-laboratory Comparison. However, further inter-laboratory investigations are needed in order to better define the appropriate standardisation conditions, both in the preparation of paint specimens and in the determination of their thickness.

A third important cause of inter-laboratory variance is due to VOC sorption on chamber walls: this has been evidenced because the protocol included a recovery test. However, further investigations are needed for the standardisation of recovery tests and for their interpretation.

The spread of results, if used to estimate the progress realised with the VOCEM project compared with the previous comparisons, shows that: (a) there is a very pronounced reduction of the dispersion for Texanol from paint and for alkanes (carpet versus PVC); (b) seven target compounds (out of 15) show acceptable inter-laboratory dispersion (values of the c.v. < 40 %).

The repeated experience of inter-laboratory comparisons has shown to be highly positive in singling out error sources and thereby improving the reliability of emission testing results. However, this comparison has shown that a non negligible fraction of laboratories has not fully complied with the protocol, both in carrying out the measurements and in reporting: we do not know whether this is due to negligence or to the pressure, increasingly exerted on many research institutes, previously totally supported by public funds, to get their resources through customer oriented work.

Though there is, of course, always space for further improvement in any type of determination, on one hand it should be borne in mind that in the field of the health effects of pollutants we know

little and in the little we know the uncertainties are by far larger than those evidenced by this comparison; on the other hand it appears unrealistic to expect substantial improvements in the homogeneity of materials used indoors and in the accuracy and reproducibility of emission test results. This should be taken into account when establishing procedures and conditions for testing and for labelling indoor materials with respect to their VOC emissions.

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REFERENCES

1. ECA-IAQ (European Collaborative Action "Indoor Air Quality and its Impact on Man"), 1993. *Determination of VOCs emitted from indoor materials and products. Interlaboratory comparison of small chamber measurements.* Report No. 13, EUR 15054 EN. Luxembourg: Office for Official Publications of the European Communities

2. ECA-IAQ (European Collaborative Action "Indoor Air Quality and its Impact on Man"), 1995. *Determination of VOCs emitted from indoor materials and products: Second interlaboratoriy comparison of small chamber measurements.* Report No. 16, EUR 16284 EN. Luxembourg: Office for Official Publications of the European Communities

3. Colombo, A., De Bortoli, M., Tichenor, B.A. (1993) "International comparison experiment on the determination of VOCs emitted from indoor materials using small test chambers" In: Saarela, K., Kalliokoski, P. and Seppänen, O. (eds.), Proceedings of Indoor Air '93, International Conference on Indoor Air Quality and Climate, Helsinki, Vol. 2, pp. 573-578.

4. ECA-IAQ (European Concerted Action "Indoor Air Quality and its Impact on Man") (1991) "Guideline for the characterization of volatile organic compounds emitted from indoor materials and products using small test chambers" Report Nr. 8, EUR 13593 EN. Luxembourg: Office for Official Publications of the European Communities.

5. ASTM (1990) "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Material/Products", ASTM D 5116.

6. VOCEM Project (1997) "further development and validation test chamber method for measuring VOC emissions from building materials and products" SMT4-VT95-2039, Research Report.

7. CEN (European Committee for Standardisation) European Pre-standard (prENV) *Air Quality, Building products - Determination of the emission of volatile organic compounds* (1998).

8. ECA-IAQ (European Collaborative Action "Indoor Air Quality and its Impact on Man"), 1997b. *Total volatile organic compounds (TVOC) in indoor air quality investigations.* Report No. 19, EUR 17675 EN. Luxembourg: Office for Official Publications of the European Communities.

9. Haswell, S. J. (Ed) (1992) "Practical guide to chemometrics" Marcel Dekker, Inc., New

10. ECA-IAQ (European Collaborative Action "Indoor Air Quality and its Impact on Man"), 1997 a. *Evaluation of VOC emissions from building products - Solid flooring materials.* Report No. 18, EUR 17334 EN. Luxembourg: Office for Official Publications of the European Communities.

Table 1. Chambers used by the participants in the VOCEM material comparison (capacity in m³)

Lab Nr.	Carpet	PVC	Paint
1	1.0 ss	NP	NP
2	2A 1.0 ss	2A 1.0 ss	2A 1.0 ss
	2B FLEC	2B FLEC	2 B FLEC
3	1.0 ss HCE 1000	NP	NP
4	0.255 ss	0.255 ss	0.255 ss
5	0.50 p	0.50 p	NP
6	1.0 ss HCE 1000	1.0 ss HCE 1000	FLEC
7	0.45g	0.45g	7A 0.021g
	-	-	7B FLEC
8	8A 1.0 ss	8A 1.0 ss	8A FLEC
	8B Climpaq	8B Climpaq	8B Climpaq
9	1.0 ss	9A1.0 ss	FLEC
		9B FLEC	
10	1.0 ss	1.0 ss	NP
11	FLEC	FLEC	NP
12	0.250 ss	0.250 ss	0.250 ss
13	NP	FLEC	FLEC
14	1.0 ss HCE 1000	1.0 ss HCE 1000	14A 1.0 ss HCE 1000
			14B FLEC
15	15 A FLEC	15 A FLEC	FLEC
	15 B 0.016 ss	15 B 0.016 ss	-
16	0.225 ss	0.225 ss	NP
17	1.0 ss	1.0 ss	1.0 ss
18	0.125 g	0.125 g	0.125 g

NOTES:

g = glass
p = plexiglass
ss = stainless steel
CLIMPAQ = glass chamber of 0.051 m³ capacity
FLEC = stainless steel chamber of 35 cm³ capacity
NP = not participating

Table 2. *Individual values of SER_a: n-decane from carpet*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
1	2.1	2	2.05	0.071	3.449	0.8	0.9	0.85	0.071	8.319	0.5	0.5	0.5	0	0
2_A	5	5	5	0	0	2	2	2	0	0	2	2	2	0	0
2_B	4.1	4.1	4.1	0	0	2	2	2	0	0	2	2	2	0	0
3	1.1	1.1	1.1	0	0	0.4	0.4	0.4	0	0	0.1	0.1	0.1	0	0
4	2.1	2.4	2.25	0.212	9.428	0.6	0.9	0.75	0.212	28.284	0.2	0.2	0.2	0	0
5	1.5	2.4	1.95	0.636	32.636	0	0	0	0	--	0	0	0	0	--
6	2.2	2.2	2.2	0	0	0.8	0.8	0.8	0	0	0.4	0.5	0.45	0.071	15.713
7	2.5	1.7	2.1	0.566	26.937	0.8	0.8	0.8	0	0	0.5	0.5	0.5	0	0
8_A	2	2	2	0	0	1	1	1	0	0	0	0	0	0	--
8_B	3	3	3	0	0	2	2	2	0	0	1	1	1	0	0
9	3.5	3.4	3.45	0.071	2.050	1.9	1.8	1.85	0.071	3.822	1.2	1.2	1.2	0	0
10	0.45	0.7	0.575	0.177	30.744	0.3	0.5	0.4	0.141	35.355	0	0	0	0	--
11	0.76	0.61	0.685	0.106	15.484	0	0	0	0	--	0	0	0	0	--
12	2.7	2.8	2.75	0.071	2.571	1.2	1.2	1.2	0	0	0.64	0.59	0.615	0.035	5.749
14	2.7	2.2	2.45	0.354	14.431	2.3	2.1	2.2	0.141	6.428	1.4	1.2	1.3	0.141	10.879
15_A	1.3	1.4	1.35	0.071	5.238	0.6	0.7	0.65	0.071	10.879	0.3	0.3	0.3	0	0
15_B	1	1	1	0	0	0.3	0.3	0.3	0	0	0	0	0	0	--
16	5.2	4.1	4.65	0.778	16.727	1.9	1.8	1.85	0.071	3.822	1.4	0.8	1.1	0.424	38.569
17	2.3	2.7	2.5	0.283	11.314	0.9	0.9	0.9	0	0	0.4	0.4	0.4	0	0
18	1.6	1.6	1.6	0	0	1.1	1.1	1.1	0	0	0.7	0.9	0.8	0.141	17.678

Table 3. Individual values of SER_a: n-undecane from carpet

LAB	RUN1_24	RUN2_24	MEAN_24	SD_24	CV_24	RUN1_48	RUN2_48	MEAN_48	SD_48	CV_48	RUN1_72	RUN2_72	MEAN_72	SD_72	CV_72
	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
1	12.2	12.1	12.15	0.071	0.582	6.8	7	6.9	0.141	2.050	4.5	4.6	4.55	0.071	1.554
2_A	21	23	22	1.414	6.428	12	14	13	1.414	10.879	8	8	8	0	0
2_B	14	14	14	0	0	9	10	9.5	0.707	7.443	8	8	8	0	0
3	11.5	11.4	11.45	0.071	0.618	6.6	6.7	6.65	0.071	1.063	4.6	4.5	4.55	0.071	1.554
4	15.7	17	16.35	0.919	5.622	9.1	9.9	9.5	0.566	5.955	6	5.7	5.85	0.212	3.626
5	8.9	12.3	10.6	2.404	22.681	5.5	4	4.75	1.061	22.330	6.9	4.7	5.8	1.556	26.821
6	13.3	14	13.65	0.495	3.626	7.5	7.6	7.55	0.071	0.937	4.6	5	4.8	0.283	5.893
7	13.3	13.1	13.2	0.141	1.071	6.8	6.8	6.8	0	0	4.5	4.5	4.5	0	0
8_A	11	11	11	0	0	6	6	6	0	0	6	6	6	0	0
8_B	14	14	14	0	0	9	9	9	0	0	5	5	5	0	0
9	15.7	15.6	15.65	0.071	0.452	11.1	10.4	10.75	0.495	4.604	8.6	8.3	8.45	0.212	2.510
10	10.4	16.4	13.4	4.243	31.661	8.4	12	10.2	2.546	24.957	5.1	8.6	6.85	2.475	36.130
11	8.47	7.85	8.16	0.438	5.373	4.52	4.49	4.505	0.021	0.471	3.05	2.97	3.01	0.057	1.879
12	14	16	15	1.414	9.428	10	10	10	0	0	6.1	5.3	5.7	0.566	9.924
14	12.1	10.3	11.2	1.273	11.364	7.5	6.5	7	0.707	10.102	4.5	4.1	4.3	0.283	6.578
15_A	10	10.2	10.1	0.141	1.400	6.3	6.5	6.4	0.141	2.210	4.7	4.8	4.75	0.071	1.489
15_B	11.2	11.6	11.4	0.283	2.481	7.3	7.5	7.4	0.141	1.911	5.1	5	5.05	0.071	1.400
16	22.9	20.7	21.8	1.556	7.136	9.5	9	9.25	0.354	3.822	4.9	4.8	4.85	0.071	1.458
17	16.9	14.2	15.55	1.909	12.278	6.1	4.9	5.5	0.849	15.428	3.1	3.8	3.45	0.495	14.347
18	10.4	10.9	10.65	0.354	3.320	4.8	4.9	4.85	0.071	1.458	1.9	2.4	2.15	0.354	16.444

Table 4. *Individual values of SER_a: n-dodecane from carpet*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
1	15.9	15.7	15.8	0.141	0.895	11.7	11.8	11.75	0.071	0.602	9.7	9.6	9.65	0.071	0.733
2_A	22	24	23	1.414	6.149	18	18	18	0	0	13	14	13.5	0.707	5.238
2_B	13	14	13.5	0.707	5.238	10	10	10	0	0	9	9	9	0	0
3	17.5	17.3	17.4	0.141	0.813	13.3	13.2	13.25	0.071	0.534	10.5	10.3	10.4	0.141	1.360
4	18.4	20.5	19.45	1.485	7.635	14.2	15.2	14.7	0.707	4.810	11.8	11.4	11.6	0.283	2.438
5	9.3	13.3	11.3	2.828	25.030	7.1	5.2	6.15	1.344	21.846	9.9	6.9	8.4	2.121	25.254
6	19	19.7	19.35	0.495	2.558	14.4	13.9	14.15	0.354	2.499	11.2	12	11.6	0.566	4.877
7	20	19.5	19.75	0.354	1.790	13.6	13.6	13.6	0	0	10.8	10.8	10.8	0	0
8_A	15	15	15	0	0	12	12	12	0	0	9	9	9	0	0
8_B	17	17	17	0	0	13	14	13.5	0.707	5.238	11	11	11	0	0
9	15.7	16.1	15.9	0.283	1.779	13.6	12.9	13.25	0.495	3.736	12.3	11.9	12.1	0.283	2.338
10	14.7	25.3	20	7.495	37.477	15.5	22.9	19.2	5.233	27.253	11.5	20	15.75	6.010	38.161
11	8.09	8.05	8.07	0.028	0.350	6.53	6.48	6.505	0.035	0.544	4.83	4.89	4.86	0.042	0.873
12	17	17	17	0	0	13	14	13.5	0.707	5.238	10	10	10	0	0
14	15.6	14.5	15.05	0.778	5.168	13	12	12.5	0.707	5.657	10.1	9.5	9.8	0.424	4.329
15_A	10.8	11	10.9	0.141	1.297	8.8	9.1	8.95	0.212	2.370	8	8.1	8.05	0.071	0.878
15_B	12.5	13	12.75	0.354	2.773	10	10.3	10.15	0.212	2.090	8.5	8.6	8.55	0.071	0.827
16	34	33.6	33.8	0.283	0.837	21.1	18.7	19.9	1.697	8.528	11.5	12.2	11.85	0.495	4.177
17	29.7	25.5	27.6	2.970	10.760	15.3	11.1	13.2	2.970	22.499	9.4	12.6	11	2.263	20.570
18	18.3	18.8	18.55	0.354	1.906	14.6	15.4	15	0.566	3.771	9.5	8.1	8.8	0.990	11.249

Table 5. *Individual values of SER_a: 2-phenoxyethanol from carpet*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
1	3.4	3.3	3.35	0.071	2.111	2.5	2.9	2.7	0.283	10.476	2.3	2.6	2.45	0.212	8.658
2_A	21	26	23.5	3.536	15.045	15	17	16	1.414	8.839	13	13	13	0	0
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	7.2	6.8	7	0.283	4.041	6	5.3	5.65	0.495	8.761	5.7	5.4	5.55	0.212	3.822
4	4.1	5.3	4.7	0.849	18.054	1.6	3.4	2.5	1.273	50.912	2.4	2.6	2.5	0.141	5.657
5	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
6	3.6	2.8	3.2	0.566	17.678	3	3	3	0	0	3	2	2.5	0.707	28.284
7	3.9	3.5	3.7	0.283	7.644	2.4	2.3	2.35	0.071	3.009	2.1	2	2.05	0.071	3.449
8_A	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
8_B	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
9	6	6	6	0	0	5.3	5.1	5.2	0.141	2.720	5	5	5	0	0
10	4.4	5.7	5.05	0.919	18.203	4.1	6.7	5.4	1.838	34.046	4	6.1	5.05	1.485	29.404
11	0.67	0.64	0.655	0.021	3.239	0.44	0.49	0.465	0.035	7.603	0.78	0.79	0.785	0.007	0.901
12	1.4	1.5	1.45	0.071	4.877	0.92	0.94	0.93	0.014	1.521	0.54	0.34	0.44	0.141	32.141
14	8.9	9.3	9.1	0.283	3.108	4	--	4	0	0	3.3	3	3.15	0.212	6.734
15_A	1.4	1.4	1.4	0	0	1	1.1	1.05	0.071	6.734	1	0.9	0.95	0.071	7.443
15_B	2.6	2.5	2.55	0.071	2.773	2	2.1	2.05	0.071	3.449	2	1.9	1.95	0.071	3.626
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
18	3.1	3.2	3.15	0.071	2.245	2.9	2.8	2.85	0.071	2.481	2.5	2.4	2.45	0.071	2.886

Table 6. *Individual values of SER_a: n-tridecane from carpet*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
1	6.9	6.7	6.8	0.141	2.080	5.8	6	5.9	0.141	2.397	5.5	5.5	5.5	0	0
2_A	13	12	12.5	0.707	5.657	9	12	10.5	2.121	20.203	8	8	8	0	0
2_B	6.9	6.9	6.9	0	0	6.9	6.9	6.9	0	0	6.9	6.9	6.9	0	0
3	8.5	7.8	8.15	0.495	6.073	7.4	7.1	7.25	0.212	2.926	6.9	6.5	6.7	0.283	4.222
4	6.7	6.4	6.55	0.212	3.239	5.8	5.9	5.85	0.071	1.209	4.7	4.7	4.7	0	0
5	4.4	6.6	5.5	1.556	28.284	3.3	2.9	3.1	0.283	9.124	5	3.9	4.45	0.778	17.479
6	8.3	8.6	8.45	0.212	2.510	7.1	7.3	7.2	0.141	1.964	6.2	6.6	6.4	0.283	4.419
7	7.9	7.8	7.85	0.071	0.901	6.5	6.6	6.55	0.071	1.080	6.1	6.1	6.1	0	0
8_A	8	8	8	0	0	7	6	6.5	0.707	10.879	6	6	6	0	0
8_B	8	8	8	0	0	9	9	9	0	0	8	8	8	0	0
9	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	3.3	5.1	4.2	1.273	30.305	3.7	5.2	4.45	1.061	23.835	3	4.4	3.7	0.990	26.755
11	2.58	2.6	2.59	0.014	0.546	2.62	2.47	2.545	0.106	4.168	2.32	2.21	2.265	0.078	3.434
12	6.2	5.9	6.05	0.212	3.506	5	5	5	0	0	4.5	4.2	4.35	0.212	4.877
14	6.3	6	6.15	0.212	3.449	5.6	5.5	5.55	0.071	1.274	5.1	4.8	4.95	0.212	4.285
15_A	4.4	4.5	4.45	0.071	1.589	4	4.2	4.1	0.141	3.449	4	4	4	0	0
15_B	5.8	5.9	5.85	0.071	1.209	4.9	5.3	5.1	0.283	5.546	4.8	4.8	4.8	0	0
16	17.5	17.4	17.45	0.071	0.405	13.4	12.9	13.15	0.354	2.689	8.7	8.4	8.55	0.212	2.481
17	6	5.5	5.75	0.354	6.149	3.6	3.1	3.35	0.354	10.554	2.9	3.6	3.25	0.495	15.230
18	7	7.7	7.35	0.495	6.734	6.7	6	6.35	0.495	7.795	6.6	7	6.8	0.283	4.159

Table 7. Individual values of SER_a: total of unidentified compounds from carpet

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
1	333	341	337	5.657	1.679	298	294	296	2.828	0.956	222	241	231.5	13.435	5.803
2_A	226	211	218.5	10.607	4.854	160	148	154	8.485	5.510	133	116	124.5	12.021	9.655
2_B	135	132	133.5	2.121	1.589	104	104	104	0	0	99	92	95.5	4.950	5.183
3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	119.2	140.2	129.7	14.849	11.449	80.5	80.5	80.5	0	0	62.6	63.2	62.9	0.424	0.675
5	108.7	186.6	147.65	55.084	37.307	92.4	62.6	77.5	21.072	27.189	71.6	67.5	69.55	2.899	4.168
6	260	242	251	12.728	5.071	238	230	234	5.657	2.417	180	193	186.5	9.192	4.929
7	335	304	319.5	21.920	6.861	213	208	210.5	3.536	1.680	179	180	179.5	0.707	0.394
8_A	90	86	88	2.828	3.214	69	64	66.5	3.536	5.317	45	58	51.5	9.192	17.849
8_B	131	150	140.5	13.435	9.562	93	87	90	4.243	4.714	70	75	72.5	3.536	4.877
9	115.9	130	122.95	9.970	8.109	107.9	113.1	110.5	3.677	3.328	108.7	116	112.35	5.162	4.594
10	129.8	227.5	178.65	69.084	38.670	95	172.9	133.95	55.084	41.123	95.5	151.5	123.5	39.598	32.063
11	27.34	25.85	26.595	1.054	3.962	20.79	20.17	20.48	0.438	2.141	28.51	29.42	28.965	0.643	2.222
12	300	290	295	7.071	2.397	230	240	235	7.071	3.009	160	160	160	0	0
14	261	246	253.5	10.607	4.184	231	211	221	14.142	6.399	176	167	171.5	6.364	3.711
15_A	52.8	53	52.9	0.141	0.267	39.1	40.5	39.8	0.990	2.487	32.4	33.6	33	0.849	2.571
15_B	44.1	42.7	43.4	0.990	2.281	38	36	37	1.414	3.822	24.6	24.4	24.5	0.141	0.577
16	344	313	328.5	21.920	6.673	211	203	207	5.657	2.733	350	149	249.5	142.128	56.965
17	144.1	115.7	129.9	20.082	15.459	49.9	48.6	49.25	0.919	1.866	39.6	56.7	48.15	12.092	25.112
18	133	148	140.5	10.607	7.549	187	180	183.5	4.950	2.697	151	178	164.5	19.092	11.606

Table 8. Summary of SER_a distribution: n-decane from carpet

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	20	2.36	2.15	0.45	5.20	1.40	2.85	1.71	1.31	55.4
RUN2_24	20	2.32	2.20	0.61	5.00	1.50	2.90	1.38	1.18	50.7
RUN1_48	20	1.05	0.85	0.00	2.30	0.50	1.90	0.53	0.73	69.8
RUN2_48	20	1.06	0.90	0.00	2.10	0.60	1.80	0.46	0.68	64.1
RUN1_72	20	0.64	0.45	0.00	2.00	0.05	1.10	0.43	0.65	102.5
RUN2_72	20	0.61	0.50	0.00	2.00	0.05	0.95	0.38	0.62	101.7

Table 9. Summary of SER_a distribution: n-undecane from carpet

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	18	12.39	12.15	8.47	16.90	10.40	14.00	5.71	2.39	19.3
RUN2_24	19	13.30	13.10	7.85	20.70	11.00	15.60	8.96	2.99	22.5
RUN1_48	20	7.69	7.40	4.52	12.00	6.20	9.05	4.12	2.03	26.4
RUN2_48	20	7.86	7.25	4.00	14.00	6.25	9.95	6.92	2.63	33.5
RUN1_72	18	5.26	4.95	3.05	8.00	4.50	6.00	1.90	1.38	26.2
RUN2_72	13	4.75	4.80	3.80	5.70	4.50	5.00	0.24	0.49	10.3

Table 10. Summary of SER_a distribution: n-dodecane from carpet

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	18	15.54	15.80	8.09	22.0	12.50	17.90	13.60	3.69	23.7
RUN2_24	19	17.12	17.00	8.05	25.5	14.00	19.70	21.47	4.63	27.1
RUN1_48	19	12.51	13.00	6.53	18.0	10.00	14.40	8.54	2.92	23.4
RUN2_48	19	12.47	12.90	5.20	18.7	10.30	14.00	11.55	3.40	27.3
RUN1_72	19	10.35	10.10	8.00	13.0	9.40	11.50	1.78	1.33	12.9
RUN2_72	19	9.99	10.00	4.89	14.0	8.60	11.90	4.79	2.19	21.9

Table 11. Summary of SER_a distribution: 2-phenoxyethanol from carpet

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	17	2.98	3.10	0.00	8.90	0.00	4.00	7.04	2.65	89.0
RUN2_24	17	3.06	2.80	0.00	9.30	0.00	4.40	7.67	2.77	90.6
RUN1_48	17	2.13	2.00	0.00	6.00	0.00	2.95	3.63	1.90	89.5
RUN2_48	16	2.26	2.20	0.00	6.70	0.25	3.20	4.42	2.10	93.1
RUN1_72	17	2.04	2.10	0.00	5.70	0.00	2.75	3.16	1.78	87.2
RUN2_72	17	2.06	2.00	0.00	6.10	0.00	2.60	3.79	1.95	94.5

Table 12. Summary of SER_a distribution: n-tridecane from carpet

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	18	6.68	6.80	2.58	13.00	4.40	7.95	5.37	2.32	34.7
RUN2_24	18	6.78	6.65	2.60	12.00	5.50	7.80	3.88	1.97	29.1
RUN1_48	18	5.77	5.80	2.62	9.00	3.70	6.95	3.47	1.86	32.3
RUN2_48	18	5.91	5.95	2.47	12.00	4.20	6.75	5.00	2.24	37.8
RUN1_72	19	5.54	5.50	2.32	8.70	4.50	6.90	3.16	1.78	32.1
RUN2_72	19	5.56	5.50	2.21	8.40	4.20	6.90	2.87	1.69	30.5

Table 13. Summary of SER_a distribution: total of unidentified compounds from carpet

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	19	173.15	133.00	27.34	344.00	108.70	261.00	10683.52	103.36	59.7
RUN2_24	19	178.13	150.00	25.85	341.00	115.70	246.00	9028.10	95.02	53.4
RUN1_48	19	134.61	104.00	20.79	298.00	69.00	213.00	6872.07	82.90	61.6
RUN2_48	19	133.86	113.10	20.17	294.00	62.60	208.00	6724.75	82.00	61.3
RUN1_72	19	117.29	99.00	24.60	350.00	45.00	176.00	6814.01	82.55	70.4
RUN2_72	19	113.23	116.00	24.40	241.00	58.00	167.00	4066.01	63.77	56.3

Table 14. Individual values of SER_a: phenol from PVC

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	172	175	173.5	2.121	1.223	146	151	148.5	3.536	2.381	120	131	125.5	7.778	6.198
2_B	146	--	146	0	0	118	123	120.5	3.536	2.934	93	102	97.5	6.364	6.527
4	94.8	87.6	91.2	5.091	5.582	91.3	86.8	89.05	3.182	3.573	74	75.3	74.65	0.919	1.231
5	52.9	52.4	52.65	0.354	0.672	53.1	49.4	51.25	2.616	5.105	44.7	45.3	45	0.424	0.943
6	115.2	113.1	114.15	1.485	1.301	97.3	95.8	96.55	1.061	1.099	83.7	85.9	84.8	1.556	1.834
7	101.9	92.1	97	6.930	7.144	88.8	89.2	89	0.283	0.318	75.2	75.2	75.2	0	0
8_A	91	93	92	1.414	1.537	80	75	77.5	3.536	4.562	74	71	72.5	2.121	2.926
8_B	117	122	119.5	3.536	2.959	109	96	102.5	9.192	8.968	90	91	90.5	0.707	0.781
9_A	115.8	115.4	115.6	0.283	0.245	96.4	99.1	97.75	1.909	1.953	82.7	83.4	83.05	0.495	0.596
9_B	228.5	235	231.75	4.596	1.983	205.2	214.7	209.95	6.718	3.200	175.3	181.1	178.2	4.101	2.301
10	113	148.4	130.7	25.032	19.152	104	135	119.5	21.920	18.343	98.4	120.9	109.65	15.910	14.510
11	362	364	363	1.414	0.390	296	305	300.5	6.364	2.118	220	254	237	24.042	10.144
12	78	78	78	0	0	78	90	84	8.485	10.102	76	76	76	0	0
13	52	50	51	1.414	2.773	114	103	108.5	7.778	7.169	111	99	105	8.485	8.081
14	137	126	131.5	7.778	5.915	121	118	119.5	2.121	1.775	112	116	114	2.828	2.481
15_A	87.5	93.2	90.35	4.031	4.461	67.5	69.6	68.55	1.485	2.166	62.3	64.6	63.45	1.626	2.563
15_B	108.8	106.5	107.65	1.626	1.511	89.2	88.1	88.65	0.778	0.877	78.6	82	80.3	2.404	2.994
16	125.3	121.7	123.5	2.546	2.061	113.4	108.5	110.95	3.465	3.123	109.4	103.3	106.35	4.313	4.056
17	33	24.4	28.7	6.081	21.189	33	15.1	24.05	12.657	52.629	27.3	20.7	24	4.667	19.445
18	65	66	65.5	0.707	1.080	73	70	71.5	2.121	2.967	52	50	51	1.414	2.773

Table 15. *Individual values of SER_a: 2-(2-butoxyethoxy) ethanol from PVC*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	542	554	548	8.485	1.548	487	498	492.5	7.778	1.579	449	449	449	0	0
2_B	364	--	364	0	0	329	341	335	8.485	2.533	318	323	320.5	3.536	1.103
4	310.2	315	312.6	3.394	1.086	303	296.4	299.7	4.667	1.557	261.8	270	265.9	5.798	2.181
5	311.4	305.1	308.25	4.455	1.445	232.2	218.2	225.2	9.899	4.396	218.6	229.2	223.9	7.495	3.348
6	456.8	435.9	446.35	14.779	3.311	405.7	391.5	398.6	10.041	2.519	350.3	365.2	357.75	10.536	2.945
7	357.7	352.7	355.2	3.536	0.995	323.7	316.9	320.3	4.808	1.501	304.8	305.2	305	0.283	0.093
8_A	319	318	318.5	0.707	0.222	306	295	300.5	7.778	2.588	319	308	313.5	7.778	2.481
8_B	426	453	439.5	19.092	4.344	415	381	398	24.042	6.041	364	371	367.5	4.950	1.347
9_A	267.2	266.4	266.8	0.566	0.212	249.4	258.5	253.95	6.435	2.534	192.4	196.1	194.25	2.616	1.347
9_B	697.2	721.4	709.3	17.112	2.413	674.6	687.9	681.25	9.405	1.380	573.4	578.2	575.8	3.394	0.589
10	353.6	455.8	404.7	72.266	17.857	261.8	353	307.4	64.488	20.979	280	459.4	369.7	126.855	34.313
11	617	611	614	4.243	0.691	551	567	559	11.314	2.024	492	535	513.5	30.406	5.921
12	320	320	320	0	0	320	370	345	35.355	10.248	320	330	325	7.071	2.176
13	126	123	124.5	2.121	1.704	268	232	250	25.456	10.182	247	238	242.5	6.364	2.624
14	426	426	426	0	0	364	358	361	4.243	1.175	363	371	367	5.657	1.541
15_A	347.1	349	348.05	1.344	0.386	248.4	244.8	246.6	2.546	1.032	229.8	223	226.4	4.808	2.124
15_B	352.2	342.7	347.45	6.718	1.933	284.2	279.2	281.7	3.536	1.255	225.7	219.8	222.75	4.172	1.873
16	552.6	515.5	534.05	26.234	4.912	466.9	451	458.95	11.243	2.450	470.7	434.9	452.8	25.314	5.591
17	27.9	21	24.45	4.879	19.955	22.5	33.4	27.95	7.707	27.576	18.3	24.7	21.5	4.525	21.049
18	350	346	348	2.828	0.813	434	418	426	11.314	2.656	237	239	238	1.414	0.594

Table 16. *Individual values of SER_a: C7 alkylbenzene from PVC*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	67.1	89.7	78.4	15.981	20.383	61.1	57.5	59.3	2.546	4.293	55.2	54	54.6	0.849	1.554
5	25.1	23.1	24.1	1.414	5.868	22.8	20.3	21.55	1.768	8.203	15.5	15.3	15.4	0.141	0.918
6	197.9	223.7	210.8	18.243	8.654	173.5	179.6	176.55	4.313	2.443	159.9	164.4	162.15	3.182	1.962
7	66.9	66.1	66.5	0.566	0.851	56.1	56.4	56.25	0.212	0.377	51.6	51.6	51.6	0	0
8_A	80	76	78	2.828	3.626	67	69	68	1.414	2.080	68	66	67	1.414	2.111
8_B	109	115	112	4.243	3.788	98	91	94.5	4.950	5.238	85	87	86	1.414	1.644
9_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	78.6	103.4	91	17.536	19.271	73.8	95.6	84.7	15.415	18.199	74.4	98.4	86.4	16.971	19.642
11	445	438	441.5	4.950	1.121	308	312	310	2.828	0.912	231	253	242	15.556	6.428
12	78	79	78.5	0.707	0.901	73	84	78.5	7.778	9.909	69	70	69.5	0.707	1.017
13	86	93	89.5	4.950	5.530	150	148	149	1.414	0.949	151	138	144.5	9.192	6.362
14	110	108	109	1.414	1.297	86	88	87	1.414	1.626	80	84	82	2.828	3.449
15_A	78.3	82.2	80.25	2.758	3.436	56.5	56.7	56.6	0.141	0.250	52.3	54.1	53.2	1.273	2.392
15_B	96.5	95.9	96.2	0.424	0.441	72.2	71.2	71.7	0.707	0.986	66.1	66.7	66.4	0.424	0.639
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	12.9	15.3	14.1	1.697	12.036	13	13.4	13.2	0.283	2.143	10	11.1	10.55	0.778	7.373
18	144	147	145.5	2.121	1.458	174	187	180.5	9.192	5.093	106	103	104.5	2.121	2.030

Table 17. Individual values of SER_a: C8 alkylbenzene-1 from PVC

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	69.6	66.8	68.2	1.980	2.903	62	61.8	61.9	0.141	0.228	56.5	55.5	56	0.707	1.263
5	22.3	19.2	20.75	2.192	10.564	20.1	18	19.05	1.485	7.795	13.4	13.3	13.35	0.071	0.530
6	123.3	146.1	134.7	16.122	11.969	112.6	115.7	114.15	2.192	1.920	105	108.1	106.55	2.192	2.057
7	70.7	69.9	70.3	0.566	0.805	60	60	60	0	0	55.5	55.4	55.45	0.071	0.128
8_A	31	29	30	1.414	4.714	27	31	29	2.828	9.753	30	29	29.5	0.707	2.397
8_B	45	48	46.5	2.121	4.562	42	40	41	1.414	3.449	38	40	39	1.414	3.626
9_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	81.2	104.9	93.05	16.758	18.010	79.6	104.8	92.2	17.819	19.327	82	104	93	15.556	16.727
11	273	281	277	5.657	2.042	209	208	208.5	0.707	0.339	169	176	172.5	4.950	2.869
12	64	64	64	0	0	61	70	65.5	6.364	9.716	58	59	58.5	0.707	1.209
13	93	110	101.5	12.021	11.843	174	151	162.5	16.263	10.008	173	180	176.5	4.950	2.804
14	111	106	108.5	3.536	3.259	86	86	86	0	0	77	79	78	1.414	1.813
15_A	74.7	80.3	77.5	3.960	5.109	54.6	56.7	55.65	1.485	2.668	52	52.1	52.05	0.071	0.136
15_B	98.1	92.6	95.35	3.889	4.079	68.4	69.3	68.85	0.636	0.924	65.3	64.1	64.7	0.849	1.311
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	15.5	15.1	15.3	0.283	1.849	12.6	11.4	12	0.849	7.071	12.3	11.9	12.1	0.283	2.338
18	136	135	135.5	0.707	0.522	179	181	180	1.414	0.786	100	105	102.5	3.536	3.449

Table 18. *Individual values of SER_a: C8 alkylbenzene-2 from PVC*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	193.1	177.6	185.35	10.960	5.913	108.5	108.4	108.45	0.071	0.065	99.6	96.7	98.15	2.051	2.089
5	39.3	35.6	37.45	2.616	6.986	37.8	34.2	36	2.546	7.071	23.9	23.8	23.85	0.071	0.296
6	138.5	153.7	146.1	10.748	7.357	124.8	127.9	126.35	2.192	1.735	121.8	121.8	121.8	0	0
7	112.4	112	112.2	0.283	0.252	97.1	97.3	97.2	0.141	0.145	90.5	90.8	90.65	0.212	0.234
8_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
8_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	40.2	57.6	48.9	12.304	25.161	43.3	56.4	49.85	9.263	18.582	45.8	56	50.9	7.212	14.170
11	419	423	421	2.828	0.672	334	335	334.5	0.707	0.211	277	300	288.5	16.263	5.637
12	120	120	120	0	0	120	140	130	14.142	10.879	120	120	120	0	0
13	163	167	165	2.828	1.714	307	286	296.5	14.849	5.008	268	266	267	1.414	0.530
14	156	156	156	0	0	130	128	129	1.414	1.096	120	124	122	2.828	2.318
15_A	109.1	106	107.55	2.192	2.038	80.2	81.3	80.75	0.778	0.963	74.7	76.5	75.6	1.273	1.684
15_B	138.5	132.6	135.55	4.172	3.078	105.1	104.2	104.65	0.636	0.608	100.8	100.8	100.8	0	0
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	15.5	18.9	17.2	2.404	13.978	17.7	16.5	17.1	0.849	4.962	16.2	16.9	16.55	0.495	2.991
18	258	270	264	8.485	3.214	318	327	322.5	6.364	1.973	196	200	198	2.828	1.428

Table 19. *Individual values of SER_a: n-tetradecane from PVC*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	63.4	69.8	66.6	4.525	6.795	66.9	67.2	67.05	0.212	0.316	62.1	60	61.05	1.485	2.432
5	24.7	21.6	23.15	2.192	9.469	34.6	33.8	34.2	0.566	1.654	24	24.4	24.2	0.283	1.169
6	61.6	60.1	60.85	1.061	1.743	53.9	50.3	52.1	2.546	4.886	45.8	46.6	46.2	0.566	1.224
7	41.9	39.9	40.9	1.414	3.458	37	36.9	36.95	0.071	0.191	35.8	35.5	35.65	0.212	0.595
8_A	67	63	65	2.828	4.351	57	60	58.5	2.121	3.626	61	59	60	1.414	2.357
8_B	95	102	98.5	4.950	5.025	88	83	85.5	3.536	4.135	40	82	61	29.698	48.686
9_A	44.8	44.7	44.75	0.071	0.158	40	40.2	40.1	0.141	0.353	35.4	35.7	35.55	0.212	0.597
9_B	126.9	122.6	124.75	3.041	2.437	108.3	96.7	102.5	8.202	8.002	97.2	99.3	98.25	1.485	1.511
10	35.3	49.2	42.25	9.829	23.263	36.4	47	41.7	7.495	17.974	39	50.2	44.6	7.920	17.757
11	100	101	100.5	0.707	0.704	90	88	89	1.414	1.589	78	84	81	4.243	5.238
12	24	24	24	0	0	26	31	28.5	3.536	12.405	28	28	28	0	0
13	65	70	67.5	3.536	5.238	134	128	131	4.243	3.239	130	112	121	12.728	10.519
14	67	63	65	2.828	4.351	57	56	56.5	0.707	1.252	53	55	54	1.414	2.619
15_A	43.7	45.7	44.7	1.414	3.164	34.7	35	34.85	0.212	0.609	33	34.3	33.65	0.919	2.732
15_B	48.8	48.5	48.65	0.212	0.436	38.5	39.1	38.8	0.424	1.093	45	36.3	40.65	6.152	15.134
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	25	20.3	22.65	3.323	14.673	18	20.9	19.45	2.051	10.543	19.7	14.1	16.9	3.960	23.431
18	33	32	32.5	0.707	2.176	39	39	39	0	0	30	31	30.5	0.707	2.318

Table 20. *Individual values of SER_a: C9 alkylbenzene from PVC*

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	54.2	53.2	53.7	0.707	1.317	54.6	55	54.8	0.283	0.516	50.8	49.2	50	1.131	2.263
5	13.5	12.3	12.9	0.849	6.578	17.6	15.2	16.4	1.697	10.348	10	10.7	10.35	0.495	4.782
6	165.9	185.7	175.8	14.001	7.964	156.8	156.8	156.8	0	0	141.5	149.2	145.35	5.445	3.746
7	43.9	51.4	47.65	5.303	11.130	45.3	45.1	45.2	0.141	0.313	42.5	42.4	42.45	0.071	0.167
8_A	48	43	45.5	3.536	7.770	45	47	46	1.414	3.074	41	32	36.5	6.364	17.436
8_B	59	61	60	1.414	2.357	70	68	69	1.414	2.050	54	40	47	9.899	21.063
9_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
9_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	20.8	25.6	23.2	3.394	14.630	20.6	26.5	23.55	4.172	17.715	21.6	27	24.3	3.818	15.713
11	139	137	138	1.414	1.025	124	123	123.5	0.707	0.573	107	118	112.5	7.778	6.914
12	51	51	51	0	0	51	60	55.5	6.364	11.467	51	53	52	1.414	2.720
13	80	79	79.5	0.707	0.889	164	161	162.5	2.121	1.305	138	141	139.5	2.121	1.521
14	91	90	90.5	0.707	0.781	78	77	77.5	0.707	0.912	72	74	73	1.414	1.937
15_A	66.9	65.9	66.4	0.707	1.065	50.2	51.4	50.8	0.849	1.670	46.7	47.5	47.1	0.566	1.201
15_B	79.1	81.6	80.35	1.768	2.200	64.8	64.6	64.7	0.141	0.219	62.7	62.6	62.65	0.071	0.113
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
18	146	164	155	12.728	8.212	189	198	193.5	6.364	3.289	118	122	120	2.828	2.357

Table 21. Individual values of SER_a: TXIB from PVC

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2_B	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4	14	13.6	13.8	0.283	2.050	16.1	15.9	16	0.141	0.884	15.5	13.6	14.55	1.344	9.234
5	11.4	9.6	10.5	1.273	12.122	10	9.3	9.65	0.495	5.129	9.2	9.3	9.25	0.071	0.764
6	16.5	15.4	15.95	0.778	4.877	12.9	13.6	13.25	0.495	3.736	10.3	11.4	10.85	0.778	7.169
7	32.4	31.4	31.9	0.707	2.217	29.4	29.4	29.4	0	0	29.3	28.8	29.05	0.354	1.217
8_A	41	36	38.5	3.536	9.183	38	40	39	1.414	3.626	52	42	47	7.071	15.045
8_B	64	70	67	4.243	6.332	64	61	62.5	2.121	3.394	59	62	60.5	2.121	3.506
9_A	42.1	42.1	42.1	0	0	46.1	44.9	45.5	0.849	1.865	39	36.7	37.85	1.626	4.297
9_B	119.7	112.2	115.95	5.303	4.574	114.9	106	110.45	6.293	5.698	108.8	110.7	109.75	1.344	1.224
10	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
11	13	13	13	0	0	16	17	16.5	0.707	4.285	15	17	16	1.414	8.839
12	570	580	575	7.071	1.230	520	590	555	49.497	8.918	510	510	510	0	0
13	112	107	109.5	3.536	3.229	223	192	207.5	21.920	10.564	224	221	222.5	2.121	0.953
14	95	97	96	1.414	1.473	94	91	92.5	2.121	2.293	96	93	94.5	2.121	2.245
15_A	12.9	13.9	13.4	0.707	5.277	14.3	15.2	14.75	0.636	4.315	12.4	11.9	12.15	0.354	2.910
15_B	24.4	27.8	26.1	2.404	9.211	24.8	25.9	25.35	0.778	3.068	25.6	25.9	25.75	0.212	0.824
16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17	0	0	0	0	--	0	0	0	0	--	0	0	0	0	--
18	37	38	37.5	0.707	1.886	45	46	45.5	0.707	1.554	37	36	36.5	0.707	1.937

Table 22. Individual values of SER_a: total of unidentified compounds from PVC

LAB	RUN1_24 µg m^{-2} h^{-1}	RUN2_24 µg m^{-2} h^{-1}	MEAN_24 µg m^{-2} h^{-1}	SD_24 µg m^{-2} h^{-1}	CV_24 %	RUN1_48 µg m^{-2} h^{-1}	RUN2_48 µg m^{-2} h^{-1}	MEAN_48 µg m^{-2} h^{-1}	SD_48 µg m^{-2} h^{-1}	CV_48 %	RUN1_72 µg m^{-2} h^{-1}	RUN2_72 µg m^{-2} h^{-1}	MEAN_72 µg m^{-2} h^{-1}	SD_72 µg m^{-2} h^{-1}	CV_72 %
2_A	2342	2446	2394	73.539	3.072	2093	2147	2120	38.184	1.801	1932	1893	1912.5	27.577	1.442
2_B	2023	--	2023	0	0	1802	1869	1835.5	47.376	2.581	1740	1709	1724.5	21.920	1.271
4	1040.2	1014.4	1027.3	18.243	1.776	1344	1322	1333	15.556	1.167	1122.4	1059.6	1091	44.406	4.070
5	1489.3	1536.6	1512.95	33.446	2.211	1453.7	1386.2	1419.95	47.730	3.361	837.1	821.6	829.35	10.960	1.322
6	7484.4	8649.8	8067.1	824.062	10.215	7216.3	7579	7397.65	256.468	3.467	6972.9	7304.5	7138.7	234.477	3.285
7	1620	1715	1667.5	67.175	4.028	1237	1235	1236	1.414	0.114	1161	1189	1175	19.799	1.685
8_A	1595	1480	1537.5	81.317	5.289	1480	1508	1494	19.799	1.325	1600	1535	1567.5	45.962	2.932
8_B	2425	2645	2535	155.563	6.137	2371	2254	2312.5	82.731	3.578	2137	2250	2193.5	79.903	3.643
9_A	1150.4	1154.6	1152.5	2.970	0.258	1071.7	1032.3	1052	27.860	2.648	857.6	875.6	866.6	12.728	1.469
9_B	3565.6	3434.9	3500.25	92.419	2.640	3048.9	2631.3	2840.1	295.288	10.397	2423.5	2724.7	2574.1	212.981	8.274
10	1964.3	2865.9	2415.1	637.527	26.398	1922.3	2566.3	2244.3	455.377	20.290	2092.4	2707.3	2399.85	434.800	18.118
11	1043	1034	1038.5	6.364	0.613	804	769	786.5	24.749	3.147	648	669	658.5	14.849	2.255
12	1350	1370	1360	14.142	1.040	1180	1450	1315	190.919	14.519	1160	1210	1185	35.355	2.984
13	1667	1627	1647	28.284	1.717	3182	3295	3238.5	79.903	2.467	3919	3737	3828	128.693	3.362
14	2630	2590	2610	28.284	1.084	2260	2220	2240	28.284	1.263	2080	2140	2110	42.426	2.011
15_A	1763	1744	1753.5	13.435	0.766	1241	1249	1245	5.657	0.454	1133	1136	1134.5	2.121	0.187
15_B	1858	1830	1844	19.799	1.074	1269	1283	1276	9.899	0.776	1211	1215	1213	2.828	0.233
16	3398	3256	3327	100.409	3.018	2915	2775	2845	98.995	3.480	2822	2692	2757	91.924	3.334
17	2574	2552	2563	15.556	0.607	2482	2343	2412.5	98.288	4.074	2110	2141	2125.5	21.920	1.031
18	2359	2439	2399	56.569	2.358	3151	3211	3181	42.426	1.334	2158	2301	2229.5	101.116	4.535

Table 23. Summary of SER_a distribution: Phenol from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	18	100.34	105.35	33.00	172.00	65.00	116.40	1253.61	35.41	35.3
RUN2_24	17	97.93	93.20	24.40	175.00	66.00	118.55	1400.57	37.42	38.2
RUN1_48	18	92.94	93.85	33.00	146.00	73.00	111.20	714.90	26.74	28.8
RUN2_48	18	92.37	92.90	15.10	151.00	70.00	105.75	970.35	31.15	33.7
RUN1_72	18	81.35	80.65	27.30	120.00	62.30	95.70	604.63	24.59	30.2
RUN2_72	18	82.92	82.70	20.70	131.00	64.60	100.50	763.25	27.63	33.3

Table 24. Summary of SER_a distribution: 2-(2-butoxyethoxy)-ethanol from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	16	378.49	352.90	267.20	552.60	319.50	426.00	6663.78	81.63	21.6
RUN2_24	17	381.71	349.00	123.00	611.00	315.00	444.45	13671.84	116.93	30.6
RUN1_48	18	347.18	321.85	232.20	551.00	261.80	410.35	8623.68	92.86	26.7
RUN2_48	18	348.31	347.00	218.20	567.00	258.50	386.25	8808.49	93.85	26.9
RUN1_72	18	313.51	311.40	192.40	492.00	229.80	356.65	7877.23	88.75	28.3
RUN2_72	20	323.49	315.50	24.70	578.20	233.60	402.95	16614.41	128.90	39.8

Table 25. Summary of SER_a distribution: C7 alkylbenzene from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	11	90.40	80.00	66.90	144.00	78.00	109.00	530.24	23.03	25.5
RUN2_24	11	95.94	93.00	66.10	147.00	79.00	108.00	498.29	22.32	23.3
RUN1_48	11	61.77	67.00	13.00	98.00	56.10	73.80	626.42	25.03	40.5
RUN2_48	11	63.92	69.00	13.40	95.60	56.40	88.00	740.37	27.21	42.6
RUN1_72	12	61.09	67.05	10.00	106.00	51.95	77.20	740.86	27.22	44.6
RUN2_72	12	63.43	66.35	11.10	103.00	52.80	85.50	836.24	28.92	45.6

Table 26. Summary of SER_a distribution: C8 alkylbenzene-1 from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	14	73.96	72.70	15.50	136.00	31.00	95.55	1350.23	36.75	49.7
RUN2_24	14	77.64	75.10	15.10	146.10	29.00	105.45	1672.05	40.89	52.2
RUN1_48	15	83.19	62.00	12.60	209.00	42.00	112.60	3605.17	60.04	72.2
RUN2_48	15	84.31	69.30	11.40	208.00	40.00	115.70	3379.43	58.13	68.9
RUN1_72	15	72.47	58.00	12.30	173.00	38.00	100.00	2334.01	48.31	66.7
RUN2_72	15	75.49	59.00	11.90	180.00	40.00	105.00	2633.43	51.32	68.0

Table 27. Summary of SER_a distribution: C8 alkylbenzene-2 from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	12	123.63	129.25	15.50	258.00	74.65	159.50	4730.55	68.78	55.6
RUN2_24	12	125.58	126.30	18.90	270.00	81.80	161.50	4703.77	68.58	54.6
RUN1_48	10	86.45	101.10	17.70	130.00	37.80	114.25	1603.86	40.05	46.3
RUN2_48	10	89.42	100.75	16.50	140.00	34.20	118.15	1743.45	41.75	46.7
RUN1_72	11	91.75	99.60	16.20	196.00	45.80	120.00	2622.58	51.21	55.8
RUN2_72	11	93.39	96.70	16.90	200.00	56.00	121.80	2626.72	51.25	54.9

Table 28. Summary of SER_a distribution: n-tetradecane from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	16	52.51	46.80	24.00	100.00	34.15	66.00	541.41	23.27	44.3
RUN2_24	16	53.43	48.85	20.30	102.00	35.95	66.40	612.63	24.75	46.3
RUN1_48	15	47.80	39.00	18.00	90.00	34.70	57.00	439.19	20.96	43.8
RUN2_48	16	51.51	43.60	20.90	96.70	35.95	63.60	488.08	22.09	42.9
RUN1_72	15	41.99	39.00	19.70	78.00	30.00	53.00	253.05	15.91	37.9
RUN2_72	16	48.46	41.45	14.10	99.30	32.65	59.50	561.89	23.70	48.9

Table 29. Summary of SER_a distribution: C9 alkylbenzene from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	14	63.74	56.60	0.00	146.00	20.80	79.55	1771.69	42.09	66.0
RUN2_24	13	57.77	53.20	0.00	137.00	25.60	72.45	1264.71	35.56	61.6
RUN1_48	15	75.39	54.60	0.00	189.00	45.00	124.00	3243.81	56.95	75.5
RUN2_48	15	76.57	60.00	0.00	198.00	45.10	123.00	3289.82	57.36	74.9
RUN1_72	15	63.79	51.00	0.00	141.50	41.00	107.00	1918.27	43.80	68.7
RUN2_72	15	64.57	49.20	0.00	149.20	32.00	118.00	2182.13	46.71	72.3

Table 30. Summary of SER_a distribution: TXIB from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	13	23.75	16.50	0.00	64.00	11.40	34.70	347.23	18.63	78.4
RUN2_24	16	39.19	29.60	0.00	112.20	13.30	56.05	1394.93	37.35	95.3
RUN1_48	13	24.35	16.10	0.00	64.00	10.00	33.70	370.44	19.25	79.1
RUN2_48	14	29.23	21.45	0.00	91.00	9.30	42.45	642.55	25.35	86.7
RUN1_72	15	33.94	25.60	0.00	108.80	10.30	52.00	1083.80	32.92	97.0
RUN2_72	13	22.66	17.00	0.00	62.00	9.30	32.40	325.59	18.04	79.6

Table 31. Summary of SER_a distribution: total of unidentified compounds from PVC

RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
RUN1_24	19	1992.46	1858.00	1040.20	3565.60	1489.30	2425.00	516495.8	718.68	36.1
RUN2_24	18	2040.80	1787.00	1014.40	3434.90	1370.00	2571.00	566638.4	752.75	36.9
RUN1_48	19	1910.93	1802.00	804.00	3182.00	1241.00	2482.00	592022.0	769.43	40.3
RUN2_48	19	1923.48	1869.00	769.00	3295.00	1283.00	2566.30	562089.2	749.73	39.0
RUN1_72	18	1623.61	1670.00	648.00	2822.00	1122.40	2101.20	391013.4	625.31	38.5
RUN2_72	19	1789.78	1709.00	669.00	3737.00	1136.00	2301.00	674451.4	821.25	45.9

Table 32. *Individual values of SER_a: 2-(2-ethoxyethoxy) ethanol from paint at 24 h*

LAB	T1_RUN1_24 µg m^{-2} h^{-1}	T1_RUN2_24 µg m^{-2} h^{-1}	T1_MEAN_24 µg m^{-2} h^{-1}	T1_SD_24 µg m^{-2} h^{-1}	T1_CV_24 %	T2_RUN1_24 µg m^{-2} h^{-1}	T2_RUN2_24 µg m^{-2} h^{-1}	T2_MEAN_24 µg m^{-2} h^{-1}	T2_SD_24 µg m^{-2} h^{-1}	T2_CV_24 %
2_A	20260	--	20260	0	0	--	--	--	--	--
2_B	3373	--	3373	0	0	15795	--	15795	0	0
4	7897.2	6061.6	6979.4	1297.965	18.597	6269.5	5401.7	5835.6	613.627	10.515
6	32868	29600	31234	2310.825	7.398	--	--	--	--	--
7_A	7570	7620	7595	35.355	0.466	10824	10824	10824	0	0
7_B	4038	4008	4023	21.213	0.527	--	--	--	--	--
8_A	1365	1450	1407.5	60.104	4.270	5278	5338	5308	42.426	0.799
8_B	3913	3910	3911.5	2.121	0.054	8768	8320	8544	316.784	3.708
9	4843	4661	4752	128.693	2.708	12848	12858	12853	7.071	0.055
12	20000	18000	19000	1414.214	7.443	25000	21000	23000	2828.427	12.298
13	55	100	77.5	31.820	41.058	--	--	--	--	--
14_A	11300	10700	11000	424.264	3.857	10600	10500	10550	70.711	0.670
14_B	19100	20000	19550	636.396	3.255	17900	18400	18150	353.553	1.948
15	2174	2147	2160.5	19.092	0.884	2359	2506	2432.5	103.945	4.273
17	9878	10197	10037.5	225.567	2.247	11581	10890	11235.5	488.611	4.349
18	3233	2883	3058	247.487	8.093	2710	2393	2551.5	224.153	8.785

Table 33. *Individual values of SER_a: 2-(2-ethoxyethoxy) ethanol from paint at 48 h*

LAB	T1_RUN1_48 µg m^{-2} h^{-1}	T1_RUN2_48 µg m^{-2} h^{-1}	T1_MEAN_48 µg m^{-2} h^{-1}	T1_SD_48 µg m^{-2} h^{-1}	T1_CV_48 %	T2_RUN1_48 µg m^{-2} h^{-1}	T2_RUN2_48 µg m^{-2} h^{-1}	T2_MEAN_48 µg m^{-2} h^{-1}	T2_SD_48 µg m^{-2} h^{-1}	T2_CV_48 %
2_A	5109	--	5109	0	0	--	--	--	--	--
2_B	1033	--	1033	0	0	4760	--	4760	0	0
4	1358.4	1463.2	1410.8	74.105	5.253	1288.6	1006	1147.3	199.828	17.417
6	8170	8405	8287.5	166.170	2.005	4013	4165	4089	107.480	2.629
7_A	1240	1230	1235	7.071	0.573	2597	2548	2572.5	34.648	1.347
7_B	509	524	516.5	10.607	2.054	--	--	--	--	--
8_A	575	533	554	29.698	5.361	985	933	959	36.770	3.834
8_B	1150	1143	1146.5	4.950	0.432	1585	1440	1512.5	102.530	6.779
9	745	745	745	0	0	2271	2330	2300.5	41.719	1.813
12	1300	2200	1750	636.396	36.365	1900	2000	1950	70.711	3.626
13	33	38	35.5	3.536	9.959	--	--	--	--	--
14_A	2360	2270	2315	63.640	2.749	2040	1970	2005	49.497	2.469
14_B	4170	4230	4200	42.426	1.010	3790	3900	3845	77.782	2.023
15	332	329	330.5	2.121	0.642	353	390	371.5	26.163	7.043
17	2023	2164	2093.5	99.702	4.762	--	2364	2364	0	0
18	498	485	491.5	9.192	1.870	220	307	263.5	61.518	23.347

Table 34. *Individual values of SER_a: 2-(2-ethoxyethoxy) ethanol from paint at 72 h*

LAB	T1_RUN1_72 µg m^{-2} h^{-1}	T1_RUN2_72 µg m^{-2} h^{-1}	T1_MEAN_72 µg m^{-2} h^{-1}	T1_SD_72 µg m^{-2} h^{-1}	T1_CV_72 %	T2_RUN1_72 µg m^{-2} h^{-1}	T2_RUN2_72 µg m^{-2} h^{-1}	T2_MEAN_72 µg m^{-2} h^{-1}	T2_SD_72 µg m^{-2} h^{-1}	T2_CV_72 %
2_A	1893	--	1893	0	0	--	--	--	--	--
2_B	3880	--	3880	0	0	1634	--	1634	0	0
4	602.7	668.2	635.45	46.315	7.289	463.2	463	463.1	0.141	0.031
6	2953	3203	3078	176.777	5.743	2060	1848	1954	149.907	7.672
7_A	389	389	389	0	0	1017	1009	1013	5.657	0.558
7_B	129	129	129	0	0	--	--	--	--	--
8_A	380	358	369	15.556	4.216	355	338	346.5	12.021	3.469
8_B	455	458	456.5	2.121	0.465	700	670	685	21.213	3.097
9	201	218	209.5	12.021	5.738	592	607	599.5	10.607	1.769
12	670	640	655	21.213	3.239	690	520	605	120.208	19.869
13	25	20	22.5	3.536	15.713	--	--	--	--	--
14_A	816	806	811	7.071	0.872	680	685	682.5	3.536	0.518
14_B	1460	1400	1430	42.426	2.967	1330	1290	1310	28.284	2.159
15	129	128	128.5	0.707	0.550	144	139	141.5	3.536	2.499
17	1310	972	1141	239.002	20.947	1084	1051	1067.5	23.335	2.186
18	165	185	175	14.142	8.081	75	73	74	1.414	1.911

Table 35. *Individual values of SER_a: Texanol from paint at 24 h*

LAB	T1_RUN1_24 µg m^{-2} h^{-1}	T1_RUN2_24 µg m^{-2} h^{-1}	T1_MEAN_24 µg m^{-2} h^{-1}	T1_SD_24 µg m^{-2} h^{-1}	T1_CV_24 %	T2_RUN1_24 µg m^{-2} h^{-1}	T2_RUN2_24 µg m^{-2} h^{-1}	T2_MEAN_24 µg m^{-2} h^{-1}	T2_SD_24 µg m^{-2} h^{-1}	T2_CV_24 %
2_A	8696	--	8696	0	0	--	--	--	--	--
2_B	9167	--	9167	0	0	8155	--	8155	0	0
4	8294.8	7681.5	7988.15	433.669	5.429	6133.4	6963.9	6548.65	587.252	8.968
6	7768	7055	7411.5	504.167	6.802	--	--	--	--	--
7_A	8630	8730	8680	70.711	0.815	9234	9183	9208.5	36.062	0.392
7_B	7923	7971	7947	33.941	0.427	--	--	--	--	--
8_A	8383	8340	8361.5	30.406	0.364	11300	11313	11306.5	9.192	0.081
8_B	7655	7413	7534	171.120	2.271	9108	9050	9079	41.012	0.452
9	8038	8046	8042	5.657	0.070	8954	8932	8943	15.556	0.174
12	10000	8300	9150	1202.082	13.138	12000	9600	10800	1697.056	15.713
13	2825	3575	3200	530.330	16.573	--	--	--	--	--
14_A	16400	16300	16350	70.711	0.432	15600	15300	15450	212.132	1.373
14_B	17600	18200	17900	424.264	2.370	17900	18500	18200	424.264	2.331
15	6597	6769	6683	121.622	1.820	6644	6917	6780.5	193.040	2.847
17	12370	13425	12897.5	745.998	5.784	14852	12889	13870.5	1388.051	10.007
18	1505	1843	1674	239.002	14.277	1725	1920	1822.5	137.886	7.566

Table 36. Individual values of SER_a: Texanol from paint at 48 h

LAB	T1_RUN1_48 µg m^{-2} h^{-1}	T1_RUN2_48 µg m^{-2} h^{-1}	T1_MEAN_48 µg m^{-2} h^{-1}	T1_SD_48 µg m^{-2} h^{-1}	T1_CV_48 %	T2_RUN1_48 µg m^{-2} h^{-1}	T2_RUN2_48 µg m^{-2} h^{-1}	T2_MEAN_48 µg m^{-2} h^{-1}	T2_SD_48 µg m^{-2} h^{-1}	T2_CV_48 %
2_A	6269	--	6269	0	0	--	--	--	--	--
2_B	6286	--	6286	0	0	6006	--	6006	0	0
4	4693	5097.9	4895.45	286.308	5.848	4449	4468.7	4458.85	13.930	0.312
6	4498	4593	4545.5	67.175	1.478	4695	4870	4782.5	123.744	2.587
7_A	5740	5660	5700	56.569	0.992	5828	5803	5815.5	17.678	0.304
7_B	4870	4913	4891.5	30.406	0.622	--	--	--	--	--
8_A	5565	5625	5595	42.426	0.758	6425	5860	6142.5	399.515	6.504
8_B	5215	5055	5135	113.137	2.203	4040	4043	4041.5	2.121	0.052
9	4905	4882	4893.5	16.263	0.332	5622	5611	5616.5	7.778	0.138
12	3300	5700	4500	1697.056	37.712	4300	3800	4050	353.553	8.730
13	2250	2140	2195	77.782	3.544	--	--	--	--	--
14_A	10200	10300	10250	70.711	0.690	9410	9500	9455	63.640	0.673
14_B	11400	11700	11550	212.132	1.837	11700	11800	11750	70.711	0.602
15	3741	3938	3839.5	139.300	3.628	3890	4130	4010	169.706	4.232
17	4812	5037	4924.5	159.099	3.231	--	6019	6019	0	0
18	1160	1135	1147.5	17.678	1.541	1113	1205	1159	65.054	5.613

Table 37. *Individual values of SER_a: Texanol from paint at 72 h*

LAB	T1_RUN1_72 µg m^{-2} h^{-1}	T1_RUN2_72 µg m^{-2} h^{-1}	T1_MEAN_72 µg m^{-2} h^{-1}	T1_SD_72 µg m^{-2} h^{-1}	T1_CV_72 %	T2_RUN1_72 µg m^{-2} h^{-1}	T2_RUN2_72 µg m^{-2} h^{-1}	T2_MEAN_72 µg m^{-2} h^{-1}	T2_SD_72 µg m^{-2} h^{-1}	T2_CV_72 %
2_A	4806	--	4806	0	0	--	--	--	--	--
2_B	4856	--	4856	0	0	4466	--	4466	0	0
4	3707.1	3538.3	3622.7	119.360	3.295	3652.7	3004.8	3328.75	458.134	13.763
6	3688	3630	3659	41.012	1.121	4460	4093	4276.5	259.508	6.068
7_A	4280	4280	4280	0	0	4112	4087	4099.5	17.678	0.431
7_B	3589	3566	3577.5	16.263	0.455	--	--	--	--	--
8_A	7773	7690	7731.5	58.690	0.759	3453	3493	3473	28.284	0.814
8_B	3653	3608	3630.5	31.820	0.876	3020	2833	2926.5	132.229	4.518
9	3710	3746	3728	25.456	0.683	4061	4033	4047	19.799	0.489
12	3900	3800	3850	70.711	1.837	3000	2600	2800	282.843	10.102
13	1500	1375	1437.5	88.388	6.149	--	--	--	--	--
14_A	7650	7330	7490	226.274	3.021	6980	6870	6925	77.782	1.123
14_B	8900	8450	8675	318.198	3.668	9380	8920	9150	325.269	3.555
15	2670	2781	2725.5	78.489	2.880	2791	2942	2866.5	106.773	3.725
17	4879	4987	4933	76.368	1.548	4974	5275	5124.5	212.839	4.153
18	783	1033	908	176.777	19.469	590	648	619	41.012	6.626

Table 38. Individual values of SER_a: total of unidentified compounds from paint at 24 h

LAB	T1_RUN1_24 µg m^{-2} h^{-1}	T1_RUN2_24 µg m^{-2} h^{-1}	T1_MEAN_24 µg m^{-2} h^{-1}	T1_SD_24 µg m^{-2} h^{-1}	T1_CV_24 %	T2_RUN1_24 µg m^{-2} h^{-1}	T2_RUN2_24 µg m^{-2} h^{-1}	T2_MEAN_24 µg m^{-2} h^{-1}	T2_SD_24 µg m^{-2} h^{-1}	T2_CV_24 %
2_A	723	--	723	0	0	--	--	--	--	--
2_B	1515	--	1515	0	0	705	--	705	0	0
4	198.1	161.3	179.7	26.022	14.481	119.8	158.1	138.95	27.082	19.491
6	--	--	--	--	--	--	--	--	--	--
7_A	654	981	817.5	231.224	28.284	782	782	782	0	0
7_B	1097	1107	1102	7.071	0.642	--	--	--	--	--
8_A	665	640	652.5	17.678	2.709	790	758	774	22.627	2.923
8_B	418	358	388	42.426	10.935	548	393	470.5	109.602	23.295
9	579	385	482	137.179	28.460	597	607	602	7.071	1.175
12	1400	1000	1200	282.843	23.570	1500	1100	1300	282.843	21.757
13	100	125	112.5	17.678	15.713	--	--	--	--	--
14_A	386	242	314	101.823	32.428	736	428	582	217.789	37.421
14_B	656	743	699.5	61.518	8.795	880	913	896.5	23.335	2.603
15	199	216	207.5	12.021	5.793	177	228	202.5	36.062	17.809
17	6715	6367	6541	246.073	3.762	9065	8865	8965	141.421	1.577
18	0	0	0	0	--	0	0	0	0	--

Table 39. Individual values of SER_a: total of unidentified compounds from paint at 48 h

LAB	T1_RUN1_48 µg m^{-2} h^{-1}	T1_RUN2_48 µg m^{-2} h^{-1}	T1_MEAN_48 µg m^{-2} h^{-1}	T1_SD_48 µg m^{-2} h^{-1}	T1_CV_48 %	T2_RUN1_48 µg m^{-2} h^{-1}	T2_RUN2_48 µg m^{-2} h^{-1}	T2_MEAN_48 µg m^{-2} h^{-1}	T2_SD_48 µg m^{-2} h^{-1}	T2_CV_48 %
2_A	275	--	275	0	0	--	--	--	--	--
2_B	510	--	510	0	0	385	--	385	0	0
4	96.2	98.1	97.15	1.344	1.383	49.1	73.2	61.15	17.041	27.868
6	--	--	--	--	--	--	--	--	--	--
7_A	221	231	226	7.071	3.129	429	404	416.5	17.678	4.244
7_B	249	324	286.5	53.033	18.511	--	--	--	--	--
8_A	535	498	516.5	26.163	5.065	410	405	407.5	3.536	0.868
8_B	230	260	245	21.213	8.658	230	235	232.5	3.536	1.521
9	407	204	305.5	143.543	46.986	286	308	297	15.556	5.238
12	380	350	365	21.213	5.812	300	210	255	63.640	24.957
13	50	58	54	5.657	10.476	--	--	--	--	--
14_A	201	170	185.5	21.920	11.817	175	250	212.5	53.033	24.957
14_B	306	291	298.5	10.607	3.553	341	309	325	22.627	6.962
15	104	109	106.5	3.536	3.320	84	102	93	12.728	13.686
17	1804	1685	1744.5	84.146	4.823	--	2857	2857	0	0
18	0	0	0	0	--	0	0	0	0	--

Table 40. *Individual values of SER_a: total of unidentified compounds from paint at 72 h*

LAB	T1_RUN1_72 µg m^{-2} h^{-1}	T1_RUN2_72 µg m^{-2} h^{-1}	T1_MEAN_72 µg m^{-2} h^{-1}	T1_SD_72 µg m^{-2} h^{-1}	T1_CV_72 %	T2_RUN1_72 µg m^{-2} h^{-1}	T2_RUN2_72 µg m^{-2} h^{-1}	T2_MEAN_72 µg m^{-2} h^{-1}	T2_SD_72 µg m^{-2} h^{-1}	T2_CV_72 %
2_A	145	--	145	0	0	--	--	--	--	--
2_B	235	--	235	0	0	144	--	144	0	0
4	54.6	48.8	51.7	4.101	7.933	61.2	60.8	61	0.283	0.464
6	--	--	--	--	--	--	--	--	--	--
7_A	176	186	181	7.071	3.907	227	202	214.5	17.678	8.241
7_B	177	207	192	21.213	11.049	--	--	--	--	--
8_A	1015	605	810	289.914	35.792	285	320	302.5	24.749	8.181
8_B	245	170	207.5	53.033	25.558	165	168	166.5	2.121	1.274
9	156	153	154.5	2.121	1.373	142	158	150	11.314	7.542
12	470	170	320	212.132	66.291	170	120	145	35.355	24.383
13	38	25	31.5	9.192	29.182	--	--	--	--	--
14_A	119	134	126.5	10.607	8.385	111	136	123.5	17.678	14.314
14_B	202	227	214.5	17.678	8.241	235	249	242	9.899	4.091
15	32	33	32.5	0.707	2.176	24	29	26.5	3.536	13.342
17	1435	1374	1404.5	43.134	3.071	1830	1616	1723	151.321	8.782
18	0	0	0	0	--	0	0	0	0	--

Table 41. Summary of SER_a distribution: 2-(2-ethoxyethoxy) ethanol from paint

TEST, RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
T1_RUN1_24	16	9491.70	6206.50	55.00	32868.00	3303.00	15200.00	82835619	9101.41	95.9
T1_RUN2_24	12	5978.13	4334.50	100.00	18000.00	2515.00	8908.50	25139104	5013.89	86.5
T2_RUN1_24	12	10827.71	10712.00	2359.00	25000.00	5773.75	14321.50	43061925	6562.16	63.8
T2_RUN2_24	11	9857.34	10500.00	2393.00	21000.00	5338.00	12858.00	36095285	6007.94	60.9
T1_RUN1_48	13	1012.03	1033.00	33.00	2360.00	498.00	1270.00	442828	665.45	65.8
T1_RUN2_48	12	1093.68	944.00	38.00	2270.00	504.50	1813.60	612816	782.83	71.6
T2_RUN1_48	12	2150.22	1970.00	220.00	4760.00	1136.80	3193.50	2057644	1434.45	66.7
T2_RUN2_48	12	1946.08	1985.00	307.00	4165.00	969.50	2456.00	1518492	1232.27	63.3
T1_RUN1_72	15	771.85	455.00	25.00	2953.00	165.00	1310.00	664102	814.92	105.6
T1_RUN2_72	13	490.09	389.00	20.00	1400.00	129.00	654.10	157705	397.12	81.0
T2_RUN1_72	13	832.63	690.00	75.00	2060.00	355.00	1050.50	335429	579.16	69.6
T2_RUN2_72	12	724.42	638.50	73.00	1848.00	400.50	1030.00	255888	505.85	69.8

Table 42. Summary of SER_a distribution: Texanol from paint

TEST, RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
T1_RUN1_24	11	8286.53	8294.80	6597.00	10000.00	7768.00	8696.00	772236	878.77	10.6
T1_RUN2_24	9	7811.72	7971.00	6769.00	8730.00	7055.00	8173.00	409602	640.00	8.2
T2_RUN1_24	12	10133.78	9171.00	1725.00	17900.00	7399.50	13426.00	20305150	4506.12	44.5
T2_RUN2_24	11	10051.63	9183.00	1920.00	18500.00	6963.90	12889.00	19726078	4441.40	44.2
T1_RUN1_48	14	4521.71	4841.00	1160.00	6286.00	3300.00	5390.00	2166562	1471.92	32.6
T1_RUN2_48	10	5050.09	5046.00	3938.00	5700.00	4593.00	5361.45	291122	539.56	10.7
T2_RUN1_48	9	5028.33	4695.00	3890.00	6425.00	4040.00	5725.00	893529	945.27	18.8
T2_RUN2_48	10	4580.97	4669.35	1205.00	6019.00	3800.00	5707.00	2094909	1447.38	31.6
T1_RUN1_72	13	3540.08	3707.10	783.00	4879.00	2670.00	4090.00	1534848	1238.89	35.0
T1_RUN2_72	10	3531.13	3619.00	1375.00	4987.00	2781.00	3773.00	891930	944.42	26.7
T2_RUN1_72	10	3798.97	3856.85	2791.00	4974.00	3000.00	4286.00	536830	732.69	19.3
T2_RUN2_72	10	3300.88	3248.90	648.00	5275.00	2600.00	4060.00	1519986	1232.88	37.4

Table 43. Summary of SER_a distribution: total of unidentified compounds from paint

TEST, RUN	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Variance	Std.Dev.	C.V.
		$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	$\mu g\ m^{-2}\ h^{-1}$	%
T1_RUN1_24	14	613.58	616.50	0.00	1515.00	198.10	694.00	212211.	460.66	75.1
T1_RUN2_24	12	496.53	371.50	0.00	1107.00	188.65	862.00	146751.	383.08	77.2
T2_RUN1_24	11	621.35	705.00	0.00	1500.00	177.00	790.00	175437.	418.85	67.4
T2_RUN2_24	10	536.71	517.50	0.00	1100.00	158.10	770.00	125794.	354.67	66.1
T1_RUN1_48	14	254.59	239.50	0.00	535.00	96.20	343.00	26534.93	162.90	64.0
T1_RUN2_48	12	216.09	217.50	0.00	498.00	103.55	307.50	19650.85	140.18	64.9
T2_RUN1_48	11	244.46	286.00	0.00	429.00	84.00	385.00	22404.76	149.68	61.2
T2_RUN2_48	10	229.62	242.50	0.00	405.00	73.20	308.50	18657.76	136.59	59.5
T1_RUN1_72	12	131.63	150.50	0.00	245.00	46.30	189.50	6854.74	82.79	62.9
T1_RUN2_72	11	123.07	153.00	0.00	227.00	33.00	186.00	6561.86	81.01	65.8
T2_RUN1_72	11	142.20	144.00	0.00	285.00	61.20	227.00	7921.72	89.00	62.6
T2_RUN2_72	10	144.28	147.00	0.00	320.00	29.00	185.00	9739.94	98.69	68.4

Table 44. *Results of the analysis of variance on the SER_a data of representative compounds*[1]

Material and compound	**number of valid data**	**mean** $\mu g\ m^{-2}\ h^{-1}$	S_{bL} $\mu g\ m^{-2}\ h^{-1}$ **(%values)**	S_{wL} $\mu g\ m^{-2}\ h^{-1}$ **(%values)**	S_T $\mu g\ m^{-2}\ h^{-1}$ **(%values)**
Carpet					
n-undecane	40	7.78	2.21 (28)	0.77 (10)	-
n-dodecane	38	12.49	2.90 (23)	0.87 (6.9)	-
2-phenoxyethanol	33	2.19	1.92 (88)	0.58 (27)	-
PVC					
2-(2-butoxyethoxy)ethanol	36	347.7	90.9 (26)	20.5 (5.9)	-
C7 alkylbenzene	22	62.8	25.5 (41)	5.53 (8.8)	-
C9 alkylbenzene	30	76.0	57.1 (75)	2.73 (3.6)	-
TXIB	27	26.8	19.0 (71)	0.46 (1.7)	-
Paint					
2-(2-ethoxyethoxy)ethanol	49	1281	553 (43)	164 (13)	501 (39)
Texanol	43	4876	631 (13)	456 (9.4)	230 (4.7)

[1] The headings of the columns with the letter S designate the standard deviation components, the subscripts have the following meaning:

bL = between laboratory;
wL = within laboratory;
T = test.

Table 45. *Comparison of results obtained within the same laboratory with different chambers*

Ratio of mean SERa values (24 h)

CARPET

	lab.2 1m³ /FLEC	**lab.8 1m³ /CLIMPAQ**	**lab.15 0.016 m³ /FLEC**
n-decane	1.22	0.67	0.74
n-undecane	1.57	0.79	1.13
n-dodecane	1.70	0.88	1.17
n-tridecane	1.81	1.00	1.31
2-phenoxyethanol	-	-	1.82

PVC

	lab.2 1m³ /FLEC	**lab.8 1m³ /CLIMPAQ**	**lab.9 1m³ /FLEC**	**lab. 15 0.016 m³ /FLEC**
phenol	1.18	0.77	0.50	1.19
2-(2- butoxyethoxy) eth.	1.51	0.72	0.38	1.00
C7 benzene	-	0.70	-	1.20
C8 benzene 1	-	0.65	-	1.23
C8 benzene 2	-	-	-	1.26
C9 benzene	-	0.76	-	1.21
n-tetradecane	-	0.66	0.36	1.09
TX IB	-	0.57	0.36	1.95

PAINT (48 h, mean test 1)

	lab.2(1) 1m³ /FLEC	**lab.7 0.021 m³ /FLEC**	**lab.8 Climpaq /FLEC**	**lab.14 1m³ /FLEC**
Texanol	1.00	1.16	0.92	0.89
2-(2-ethoxyethoxy) eth.	4.95	2.39	2.06	0.55

(1) One single determination

Table 46. *Summary of result dispersion in the VOCEM comparison on material emission and in the two previous ECA-IAQ comparisons [c. v. % of SER_a]*

Material and compound	**ECA-IAQ 1st or 2nd comparison**		**VOCEM comparison**	
	min-max	mean	min-max	mean
PVC				
phenol	32-41	37	29-38	33
1,2,4-trimethylbenzene	31-36	33	-	-
n-decane	41-47	43	-	-
n-undecane	39-44	41	-	-
2-(2-butoxyethoxy)ethanol	-	-	22-40	29
C7 alkylbenzene	-	-	23-46	37
C8 alkylbenzene-1	-	-	50-72	63
C8 alkylbenzene-2	-	-	46-56	52
n-tetradecane	-	-	38-49	44
C9 alkylbenzene	-	-	62-76	70
TXIB	-	-	78-97	86
Σ unidentified compounds	36-49	43	36-46	40
Paint				
2-(2-butoxyethoxy)ethanol	100-225	135	-	-
2-(2-ethoxyethoxy)ethanol	-	-	61-105	75
Texanol	66-143	99	8.2-45	27
Σ unidentified compounds	-	-	60-77	66
Carpet				
n-decane	-	-	51-103	74
n-undecane	-	-	10-34	23
n-dodecane	-	-	13-27	23
2-phenoxyethanol	-	-	87-95	91
n-tridecane	-	-	29-38	33
Σ unidentified compounds	-	-	53-70	60

APPENDIX 1

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APPENDIX 2

Characteristics of the materials used in the comparison

Carpet

Manufacturer	VORWERK
Model	Texback Modena
Type	tufted, no dye (recycled material in the polyethene powder coating used to fix the secondary backing)
Pile	polyamide, 4.2 mm thickness
Backing	primary SBR, secondary polypropilene
Total thickness	6.9 mm
Weight	1260 g m^{-2}

PVC flooring

Manufacturer	SOMMER
Model	cushion vinyl
Type	multilayer: 1) transparent wear layer; 2) printing layer; 3) impregnated - calendered layer; 4) foam layer; no recycled material used
Total thickness	3.2 mm
Weight	3100 g m^{-2}

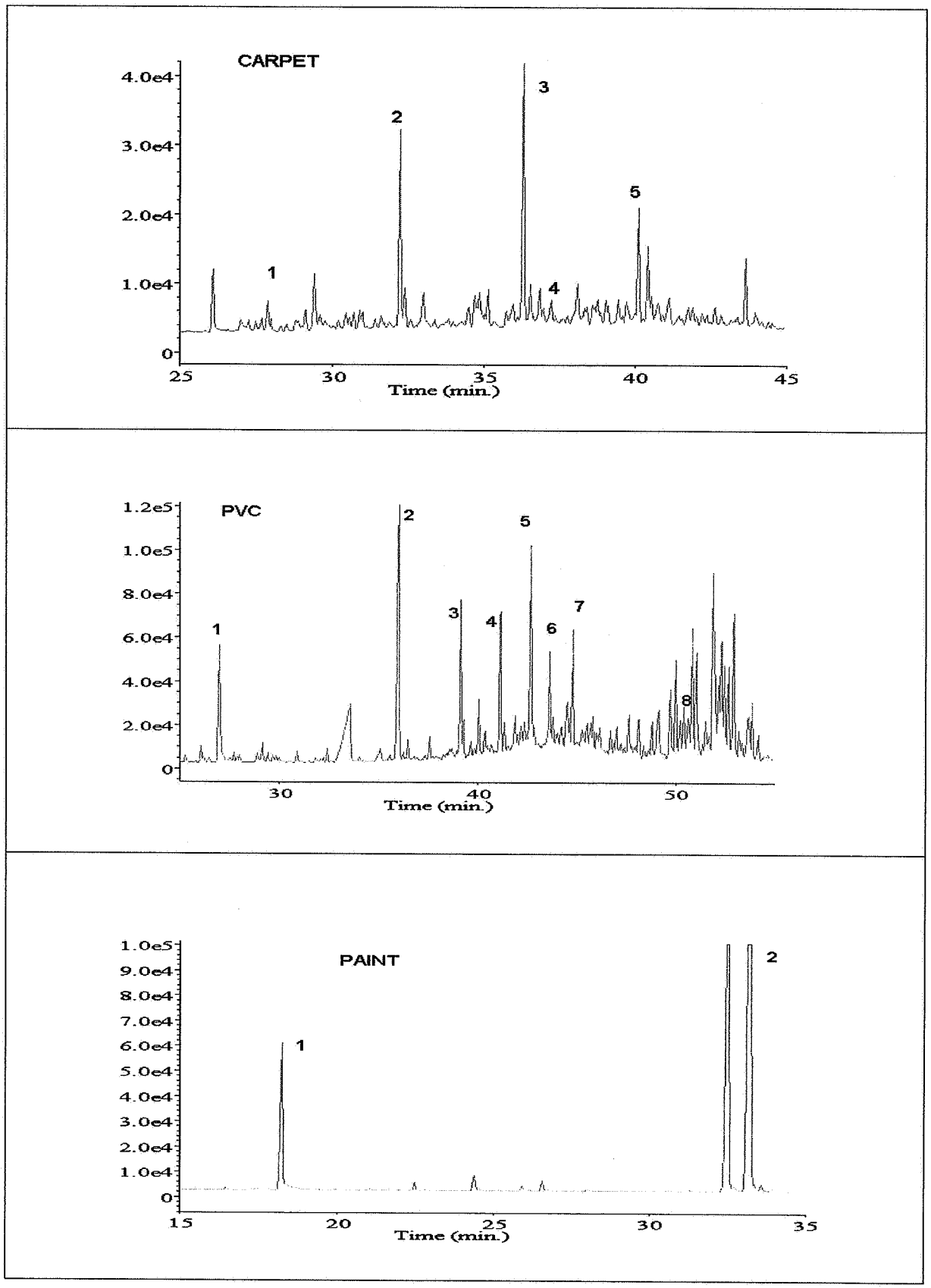
Paint

Manufacturer	Tikkurila OY
Type	Latex paint, water-borne, essentially solvent-free acrylic emulsion

Composition

Raw material	*weight %*
Acrylic latex binder	48.8
2-(2-ethoxyethoxy)ethanol	0.7
Texanol™	0.7
Additives	6.3
Water	12.6
Pigments	30.9
Total	100.0

Figure 1 *Gas-chromatograms of the emissions from the three test materials; numbers indicate target compounds (see Tables 1-3).*



APPENDIX 3

Homogeneity tests on carpet and PVC under the aspect of the emission rate of the target compounds

Criteria and procedure

The homogeneity of a material, under the aspect of VOC emission rate, can be determined if one laboratory performs several measurements on different specimens of the same material and verifies whether the dispersion of the results is greater than the dispersion of the analytical procedure.

The tests were carried out at the JRC-EI in the new 20.8 *l* chamber with controlled air velocity, under the environmental conditions requested by the VOCEM material testing protocol (23 ± 0.5 C, 50 % ± 5 % RH, 0.2 m s^{-1}). Unfortunately, because of the break-down of the fan motor during the last test on PVC, for this material only three tests are available. The area specific ventilation rate (1.0 m^3 m^{-2} h^{-1}) has been maintained for PVC and halved for carpet, in order to have higher chamber concentrations and hence smaller analytical errors. The tests have been carried out with the relatively high chamber air change rate of 8.0 h^{-1} (in order to reduce adsorption phenomena), i.e. 2.77 *l* min^{-1}, and material areas of 0.1664 and 0.3328 m^2, respectively for PVC and carpet. The air flow rate through the chamber was regulated by a mass flow controller and measured at the beginning and at the end of each test by a certificated electronic flowmeter: each recorded flow value was the mean of 10 consecutive measurements and the c.v. associated with the mean of the eight recorded values is 1.1 %. The average chamber temperature during these seven tests was 23.3 or 23.4 C, with short term fluctuations in ranges of 0.25 up to 0.40 C (with the exception of 0.62 C in one test).

Material specimens were cut out of a new sample-roll for each test, i.e. four rolls for each material. These samples (~1 x 1.5 m) have been selected at random and cut out of the same special batch from which also the samples distributed to the participants had been cut at random (see Experimental procedure). From each sample-roll, four (for carpet) or two (for PVC) 26 x 32 cm rectangles were cut and introduced into the chamber: the material area analyzed was thus 0.333 m^2 for carpet and 0.166 m^2 for PVC. Carpet specimens were introduced into the chamber without any further treatment, PVC specimens after sealing the bottom surface and the edges with adhesive Al sheet. The specimens were cut out in the central part of the rolls, always discarding margins (for carpet: 11 cm on the 1 m sides and 38 cm on the 1.5 m sides; for PVC: 34 cm on the 1 m sides and 40 cm on the 1.5 m sides). All the operations of opening the rolls, cutting specimens, etc. and the related times were reproduced attentively, to reduce as much as possible random variations in the results.

The chamber has been cleaned before each sequence of four material tests (the carpet was first) and the chamber background measured. In the morning of the first day, the material was introduced and 24 h after t_0 (time of closing the chamber) four 1-2 *l* samples were collected in sequence within less than half an hour. The material was then removed and the chamber flushed during at least 24 h, then a new specimen was introduced.

Results and comments

The concentrations of target compounds measured in the chamber with carpet specimens are reported in Tables 1 to 5; each table contains the four replicate results obtained for each of the four specimens. The analogous results obtained for PVC are reported in Tables 6 to 13; these are limited to three rolls because during one of the tests the fan motor stopped and the concentrations measured were unreliable. On the values reported in these tables the F test for the significance of variance has been carried out: the variance was calculated for each apparently homogeneous data set (e.g. rolls 2, 23 and 34 in Table 1) and again calculated including also the apparently non homogeneous data set. Then the ratio of the two variances (F value) was compared with the tabulated F values for the appropriate number of degrees of freedom: if the F values for the particular ratio exceeds the tabulated value, then the added data set can be considered non homogeneous with the other ones, at the selected probability of error. Tables 14 and 15, respectively for carpet and PVC, summarize the results of the F-tests. It appears that both materials where non homogeneous, even if this is not true for two compounds emitted from PVC (butoxyethoxyethanol and TXIB). The amount of the difference is roughly 50 % for carpet (with the exception of n-decane: 250 %!) and 20 % for PVC; it must be observed that, due to the very good reproducibility of the determinations, even small differences result highly significant. A possible explanation of the homogeneity of TXIB put forward by the producer is the following: during the heating phase of the material (200 C), this compound condensates on the walls of the furnace and this deposit of TXIB contaminates by diffusion successive batches; therefore the distribution of the compound in the material is rather homogeneous. No explanation is found for the homogeneity of butoxyethoxyethanol.

The lack of homogeneity observed is tightly linked with the material area analyzed: it may be argued that larger specimens (e.g. 1 m^2) will most probably show less variations; however, the material area analyzed by the participants is in some cases 1 m^2, but in most cases much smaller (in the case of the FLEC 0.018 m^2, see Table 4 in Appendix 5). Therefore, the variations reported here in Tables 1-13 are probably an underestimate of the unhomogeneity contribution to the overall variance of carpet and PVC results in the comparison.

Table 1

Carpet:	n-decane			(µg . m-3)
	Determination			
Roll	1	2	3	4
2	4.1	4.1	4.1	4.1
15	10.4	9.5	10.1	10.0
23	4.1	4.0	4.1	4.1
34	4.0	3.8	3.9	3.9

Table 2

Carpet:	n-undecane			(µg . m-3)
	Determination			
Roll	1	2	3	4
2	24.8	24.6	24.9	25.0
15	37.2	36.2	39.3	40.0
23	21.3	21.2	22.8	23.4
34	22.2	22.3	22.2	22.9

Table 3

Carpet:	n-dodecane			(µg . m-3)
	Determination			
Roll	1	2	3	4
2	28.8	28.5	28.9	29.1
15	40.9	37.8	41.0	41.3
23	25.4	25.3	27.5	27.4
34	27.4	27.4	27.4	27.3

Table 4

Carpet:	2- phenoxyethanol			(µg . m-3)
	Determination			
Roll	1	2	3	4
2	5.0	5.0	5.1	5.1
15	6.2	6.1	6.8	6.7
23	4.6	4.5	4.6	4.6
34	4.4	4.4	4.4	4.4

Table 5

Carpet:	n -tridecane			(µg . m-3)
	Determination			
Roll	1	2	3	4
2	9.9	9.8	9.9	10.0
15	13.1	13.4	13.4	12.3
23	8.0	8.5	8.5	8.4
34	7.9	8.0	8.0	8.0

Table 6

PVC:	Phenol			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	122	127	120	121
16	124	126	126	126
28	153	144	144	147

Table 7

PVC:	2-(2-butoxyethoxy) ethanol			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	431	433	433	435
16	434	438	439	444
28	439	450	448	448

Table 8

PVC:	C7 alkylbenzene			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	96.4	96.7	97.0	96.9
16	98.1	99.4	100.3	100.4
28	119	118	118	126

Table 9

PVC:	C8 Alkylbenzene-1			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	101.9	101.6	101.8	102.4
16	103.3	104.4	105.3	105.2
28	125	124	124	132

Table 10

PVC:	C8 Alkylbenzene-2			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	153	153	154	154
16	155	157	158	158
28	184	182	182	192

Table 11

PVC:	n-tetradecane			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	52.7	52.2	52.4	52.1
16	52.4	52.7	52.7	52.8
28	55.2	54.1	54.2	57.3

Table 12

PVC:	C9 Alkylbenzene			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	66.9	66.7	66.9	66.7
16	68.0	68.2	68.7	68.8
28	79.6	78.5	77.9	82.1

Table 13

PVC:	TXIB			(µg . m-3)
	Determination			
Roll	1	2	3	4
12	35.1	34.4	34.4	34.9
16	35.3	34.9	35.3	35.6
28	36.5	35.3	35.2	36.4

Table 14 Summary of homogeneity test on CARPET

Roll No.	Mean $\mu g.m^{-3}$	Std dev. $\mu g.m^{-3}$	Ratio of means	F value	significance [1]
		n- decane			
2+23+34	4.025	0.106	-	-	-
15	10.0	0.37	-	-	-
15/2+23+34	-	-	2.48	644	***
		n-undecane			
23+34	22.29	0.76	-	-	
2+23+34	23.13	1.39	-	-	
15	38.18	1.77			
2/23+34	-	-	1.54	3.35	*
15/2+23+34	-	-	1.65	24.4	***
		n-dodecane			
2+23+34	27.53	1.23	-	-	-
15	40.25	1.64	-	-	-
15/2+23+34	-	-	1.46	22.6	***
		2- phenoxyethanol			
23+34	4.488	0.099	-	-	-
2+23+34	4.675	0.290	-	-	-
15	6.45	0.35	-	-	
2/23+34	-	-	1.13	8.54	**
15/2+23+34	-	-	1.43	8.54	**
		n-tridecane			
23+34	8.163	0.256	-	-	
2+23+34	8.742	0.881	-	-	
15	13.05	0.52	-	-	
2/23+34	-	-	1.21	11.8	***
15/2+23+34	-	-	1.49	5.59	**

[1] * $p < 0.05$
** $p < 0.01$
*** $p << 0.01$

Table 15 Summary of homogeneity tests on PVC

Roll No.	Mean $\mu g.m^{-3}$	Std dev. $\mu g.m^{-3}$	Ratio of means	F value	significance [1]
		phenol			
12+16	124.0	2.67	-	-	-
28	147.0	4.24	-	-	-
28/12+16	-	-	1.19	19.3	***
		2-(2-butoxyethoxy) ethanol			
12+16	435.9	4.22	-		
28	439.3	6.64	-		
28/12+16	-		1.01	2.47	NS
		C7 alkylbenzene			
12+16	98.15	1.66	-	-	-
28	120.25	3.86	-	-	-
28/12+16	-	-	1.23	45.1	***
		C 8 alkylbenzene -1			
12+16	103.24	1.54	-	-	-
28	126.25	3.86	-	-	-
28/12+16	-	-	1.22	56.2	***
		C 8 alkylbenzene -2			
12+16	155.25	2.12	-	-	
28	185.00	4.76	-	-	
28/12+16	-	-	1.19	49.7	***
		n-tetradecane			
12+16	52.50	0.262	-	-	-
28	55.20	1.49	-	-	-
28/12+16	-	-	1.05	35.2	***
		C9 alkylbenzene			
12+16	67.61	0.908	-	-	-
28	79.53	1.86	-	-	-
28/12+16	-	-	1.18	43.5	***
		TXIB			
12+16	34.99	0.429	-	-	-
28	35.85	0.695	-	-	-
28/12+16	-	-	1.02	2.33	NS

[1] * $p < 0.05$
** $p < 0.01$
*** $p << 0.01$
NS = non significant

APPENDIX 4

Instruments and procedures used by the participants

Lab. Nr.	Adsorbent (mg)	Desorption apparatus	GC Column	Identification, quantification
1	Tenax-TA	Perkin Elmer ATD 400	DB - 5MS (50 m)	MSD
2	Tenax-TA	Perkin Elmer ATD 400	BPX5 (non-Polar 50mx0,32mm, 1,0µm)	MSD Hewlett -P. 5972/5971, FID
3	Tenax-TA	Gerstel TDS-A	HP- Ultra (50mx0.32mm ,0.52µm)	MSD Hewlett-P 5972, SIM
4	Tenax-TA(160)	Dani STD 3350	HP-PONA(50mx0.20mm, 0.50µm)	MSD, FID
5	Tenax-TA(160)	Gerstel TDS-A	HP-PONA(50mx0.20mm, 0.50µm)	MSD Hewlett-P 5970B, SIM
6	Tenax-TA (130)	Gerstel TDS-A	Rtx-200 (25mx0,25mmx0,25µm)	MSD Hewlett-P 5972, Scan 25-400
7	Tenax-TA(200)	Perkin-Elmer ATD 400	Mega PS-264 (25mx0.32mm, 1.1µm) (1)	MSD Hewlett-P 5972, FID
8	Tenax-TA(200)	Perkin-Elmer ATD 400	SGE BPx5 (5% phenyl)	MSD Hewlett-P 5971, FID
9	Tenax-TA(250)	Perkin-Elmer ATD 400	PONA -type (50mx0.20mm, 0.5µm)	MSD Hewlett-P 5972, FID
10	Tenax	Perkin-Elmer ATD 400	BP 10 (SGE, 50mx0,25mm) for PVC	
11	Tenax	Perkin Elmer ATD 400		MS, FID
12	Tenax-TA	Perkin-Elmer ATD 400	HP-5-Ms	MS, SIM
13	Tenax-TA	Dynatherm	SPB-5	FID
14	Tenax	Gerstel TDS 2	a) RTX -1(60m, 0.32mm, 0.5µm) (2)	FID
			b) RTX -5(30m, 0.32mm, 1.0µm)+	FID after the 1st column
			+RTX - 200 (30m, 0.25mm, 1.0µm)	MSD after the 2nd column
15	Tenax-TA(150)	Perkin Elmer ATD-400	DB-5MS (30m, 0.25mm, 1.0µm)	MSD Hewlett P. 5973, FID
16	Tenax-TA	Perkin Elmer ATD-400	HP5MS (30m, 0.25mm, 0.25µm)	MS Perkin Elmer Q-mass 910, FID
17	Tenax-TA(250)	Perkin Elmer ATD-400	CP-Sil 8 CB (60m, 0.25mm., 0,25µm)	MS Ion- Trap detector
18	Tenax-TA	Perkin Elmer ATD-400	PONA (50m, 0.2mm, 0.5µm)	MS Finnigan Mat, ITD 800 (Ion Trap)

(1) Methylsilicone +7% phenylsilicone

(2) column type a) was used for all compounds, except phenoxyethanol for which combination b) was used.

APPENDIX 5

Quality Assurance and Quality Control

Quality of chamber environmental parameters

The fluctuation intervals for temperature, relative humidity and air flow rate are summarized in Table 1 for those laboratories who reported such information. With the exceptions of the temperature fluctuations at laboratories 5, 16 and 18, all the other fluctuations intervals comply with the protocol.

Background concentrations of target compounds in the test chambers

The background concentrations reported by the participants are presented in Table 1. In general these values are < 1 $\mu g\ m^{-3}$ which is adequate to the needs of tests like those described in this report. However, in the case of carpet, the emission of n-decane and of 2-phenoxyethanol was so low that the concentrations measured are close to such background: this means that the corresponding results may have been affected by the background.

Recovery (sink) tests

The protocol included testing the recovery efficiency of the test chamber used for the VOCEM comparison by generation of vapours of 5 target compounds (n-octane, 2-butoxyethanol, 2-ethylhexanol, n-dodecane and TXIB) inside the chamber and measurement of their concentrations at selected times (24, 48, 72 and 100 h). The recovery efficiency is defined as the ratio of the concentration measured to the concentration expected on the basis of the weight loss of the source. Table 2 shows the recovery results at 24 h and 100 h reported by the laboratories which carried out the test. In addition, laboratories No 5 and 15 carried out the test, but the former did not find any weight decrease for the five sources and the latter was unable to carry out the measurements because the concentrations in the chamber were too high. For both laboratories no recovery data are available. Very low recovery values are observed by certain laboratories for TXIB, which, however, does not bring any explanation to the results. In fact, laboratories 8A, 8B and 12, which reported TXIB recoveries in the range 28 - 63 % (see Table 2), have values of the SER_a (PVC, see Table 14) either in the average or even very high (lab. 12 is an outlier!). To the contrary, laboratories 4 and 6, with high (> 80 %) TXIB recoveries, report very low SER_a results. This is probably explained by the overwhelming predominance of other errors associated with the laboratory (see the main text). A further aspect of the data in Table 2 is the tendency to have lower recovery values at 100 h than at 24 h for n-octane and n-dodecane: this trend, unexplained, is opposite to the trend which can be expected considering the progressive filling up of sorption sites. Laboratory No 7 carried out the recovery test in the chamber used for paint emission testing in a way different from that described in the protocol: the following is the summary description of the procedure employed and of the results. A crucial aspect of sink tests is the "degree of filling" of the adsoption sites (i.e. which mass of the compound, and possibly of other compounds, is already adsorbed), which will never be known; however, the results of a test will depend very much on this parameter. Therefore, to avoid such an uncertainty, an experimental design was aimed at whereby

the previous history of the chamber should not bias the result of each new test: this condition is realized if the concentration in the chamber remains constant. In order to achieve more easily this condition, it was decided to generate the constant concentration atmosphere within a different (large) test chamber and to use air sampled from this chamber as supply air to the chamber under test.

The introduction of the target compounds into the chamber is usually done preparing permeation tubes or diffusion vials, which are located inside the chamber, in order to rule out possible losses within duct(s): the weight loss observed on a certain vial between the start and the end of the test enables to infer the emission rate of the compound contained and hence the expected chamber concentration. This mode of introduction has certain disadvantages: (a) the emission rate cannot be easily regulated; (b) diffusion vials cannot be used with hydrofilic (e.g. alcohols) or oxydizable (e.g. aldehydes) compounds, because the weight loss (if any) is not proportional to the mass vaporized, due to water vapour condensation or to oxydation processes; (c) the emission rate from diffusion vials depends on the air velocity on their opening; (d) a number of vials equal to the number of target compounds is needed. A new device has been recently made available on the market, which was adopted as introduction method, because it overcomes such inconveniencies. This device (manufactured by Microdrop Gesellschaft für Microdosiersysteme, Norderstedt, Germany) produces microdrops of (almost) any liquid, as a consequence of the pulses generated inside a capillary by a piezoceramic actuator: a wide concentration range can thus be obtained in the chamber, regulating the frequency and the duration of the pulses.

A liquid mixture was prepared with equivalent fractions of the five compounds requested for the recovery test and injected into the large chamber by the microdrop device, so that concentrations between 0.28 and 0.32 mg m^{-3} for each compound were obtained. This atmosphere was pumped into the chamber under test using a metal bellow pump followed by a mass flow controller.
The whole experimental set-up was installed in a space thermostatized at 23 ± 0.5 C. The RH inside the chamber under test was maintained at 50 ± 5 % by the humidity regulation system of the large chamber. The concentrations of the five target compounds were measured in the inlet duct and in the chamber under test at 4 different air change rates (see Table 2). After each flow change, at least 24 h (in some cases 48 or 72 h) were allowed for equilibration before sampling; for each flow, at least triplicate determinations were carried out in the inlet duct and in the chamber. The determinations were carried out sampling, at a flow rate of 200 m*l* min^{-1} ,1 *l* of air through a Tenax TA cartridge.

The results are presented in Table 3 in terms of ratio between the chamber concentration and the inlet concentration. With the exception of TXIB in the two first tests, the values of the ratio are always 0.90 or higher; the expected influence of the air change rate (the higher the latter, the lower the sink losses) is evidenced by the means, with the exception of the test at 15 h^{-1}, for which there is no explanation. The difference between the means obtained on the 1st and on the 2nd of April (1.0 and 5.0 h^{-1}, respectively) is significant ($p<0.01$).

Deviations from the protocol

This is the last aspect considered in the protocol under the heading "Quality assurance/quality control", but certainly it is not the least: the reason for requesting such a piece of information is the possibility to explain deviating results. The reported deviations are partially presented in the last column of Table 1 and, for the aspect of the area specific ventilation rate, in Table 4; this table reports also the area of the analysed material, in view of a possible explanation of discrepancies on the basis of material unhomogeneity.

The most important deviations from the protocol are probably those concerning the value of the area specific ventilation rate (see Table 4): these deviations and the possible consequences have already been discussed in the main text (see Results and discussion, (e) Attempting to explain discrepancies).

Paint film thickness

The participants have used both manual and electromechanical paint applicators with 0.2 mm recess height. The characterization of the dry film has been limited to the coating density (weight per unit area) and to the thickness determined by an electronic gauge (see the Protocol); with one exception (lab. No 18 shipped the plates to the JRC-EI for thickness determination), the determinations have been performed by the participants. The results are reported in Table 5. For the film thickness determination Tikkurila had prepared a template of size A4, with 9 measuring positions, which however is valid only for the specimens prepared for the largest chambers. This standard has been used only by few participants.

There are at least two type of errors in the preparation of the paint film: one type depends on the amount of paint spread upon the selected area of the substrate; the second type is linked with the fact that, within such area, the thickness is not constant. The first type of error is evidenced by the fluctuations of the parameter named coating density; such fluctuations occurr among laboratories, but also within each laboratory. The second type of error is evidenced by the standard deviations associated with the values of the film thickness reported in Table 5. There is a further complicating factor to be considered: the laboratories using chambers larger than the FLEC may have prepared and introduced into the chamber more than one paint specimen (plate); in these cases there is the additional variations between plates, within the same laboratory. It is not clear whether the reported variations associated with the film thickness reflect the variations within plate and/or between plates. For an appreciation of these errors, we have deemed useful to report the correlation between coating density and film thickness for individual plates, prepared within one single laboratory, using the detailed paint data of laboratories No 4 and 7, which supplied it. Laboratory No 4 prepared 4 plates for each of the two tests; laboratory No 7 prepared 3 plates for each of 3 tests (one was not reported) and one plate for FLEC. Figures 1 and 2 show, respectively, the correlation between coating density and film thickness for all the laboratories and for the two selected laboratories. One comments is evident: the slopes found at laboratories No 4 and 7 are quite different (a factor 1.4): this fact (probably due to the calibration of the electronic gauge) explains, at least partially, the dispersion in Figure 1 and shows that standardization is needed on this topic. Keeping in mind all these observations, it is not amazing that the data in Table 5 do not show a striking improvement in terms of film thickness going from the manual to the electromechanical application.

A further correlation was tested: that between the coating density (preferred to film thickness because considered more reliable, for the reason above) and the area specific emission rate (SER_a) of Texanol at 48 h. The plot represented in Figure 3, shows that there is no correlation, even if the three very low data points are discarded.

Table 1 *Summary of quality assurance / quality control by the participants in the vocem comparison on material emission*

Lab. No.	chamber temp. [std dev °C]	RH [std dev %]	air change rate [std dev. %]	chamber background of target compounds[1] [µg m^{-3}]	deviations from protocol
1	0.1	2	3	<1	-
2					area specific ventil. rate (see Tab. 4)
3	0.1	2	3	<1	RH 46 %
4	1	5	2	<4.6	-
5[2]	20-23	49-64	3		-
6	0.1	2	3	<1	-
7	0.5	5	3	<1; <2[3]	-
8	1	5	2.5	b. d.[4]	-
9	0.7	0.5	3	<1	PVC: 24 °C; 42% RH 9A
10	0.1	1	3	1	air vel. 0.4 m s^{-1}
11	0.4	1	2	<1	area specific ventil. rate (see Tab. 4)
12	1	5		<0.5; <1[5]	-
13				<5	area specific ventil. rate (see Tab. 4)
14				<0.01	-
15	1	5		<1	area specific ventil. rate (see Tab. 4)
16	2	5			-
17	1	5	5	<1	-
18	2	2	4	<1	-

[1] These concentrations refer to target compounds
[2] Maximum range of temperature and RH
[3] This background concentration refers to the target compounds which are oxyalcohols
[4] Below detection, value not reported.
[5] This background concentration refers to TXIB

Table 2 Summary of recovery (sink) test

Lab. Nr.	n-Octane			n-Dodecane			TXIB		
	ER_w	ER_c/ER_w		ER_w	ER_c/ER_w		ER_w	ER_c/ER_w	
	($\mu g\ h^{-1}$)	24h	100h	($\mu g\ h^{-1}$)	24h	100h	($\mu g\ h^{-1}$)	24h	100h
4	2659	1.16	0.89[2]	50.4	0.99	0.89	731.2	1.00	0.94
6	-	-	-	69.3	1.11	1.23	2245	0.81	0.86
7[1]	192.8	1.11	1.06	94.4	0.94	0.90	1093	0.79	0.80
8A	3970	0.93	0.78	69	1.094	0.61	1635	0.36	0.45
8B	4260	0.93	0.83	73	0.84	0.73	1173	0.52	0.63
10	6821	1.14	1.03[2]	409.9	0.92	1.18	4498	0.31	0.42
12	3130	1.00	0.68	48.8	1.31	0.95	1650	0.28	0.34
14	4720	1.01	0.99	389	1.01	1.04	2990	0.99	1.00
18	3560	1.36	1.08	30	0.50	0.47	-	-	-

Notes: ER_w = emission rate by weight
ER_c = emission rate by concentration

[1] '0.45 m^3 glass chamber used for carpet and PVC
[2] value at 72h because the source dried before 100h

Table 3 Recovery (sink) tests carried out by laboratory Nr.7 under different air change rates and constant concentrations. Chamber of 0.021m^3 capacity used for paint tests.

C chamber/ C inlet						
Date	30 March	1 April	2 April	3 April	7 April	9 April
Air change rate [h^{-1}]	15	1.0	5.0	10	1.0	1.0
n-octane	0.98	0.93	1.00	0.98	0.90	0.91
2-butoxyethanol	0.97	0.93	0.97	0.98	0.90	0.92
2-ethtyl-1-hexanol	0.95	0.95	0.98	0.97	0.93	0.94
n-dodecane	0.94	0.93	0.98	0.97	0.92	0.92
TXIB	0.77	0.87	1.00	1.04	0.90	0.92
Mean	0.922	0.922	0.986	0.988	0.910	0.922
Std. dev.	0.0864	0.0303	0.0134	0.0295	0.0141	0.0110

Table 4 Material area analyzed and ventilation rate adopted for the tests by the participants

Lab. Nr.	Carpet		PVC		Paint	
	area [m²]	area specific ventilation rate [m³ .m⁻² .h⁻¹]	area [m²]	area specific ventilation rate [m³ .m⁻² .h⁻¹]	area [m²]	area specific ventilation rate [m³ .m⁻² .h⁻¹]
1	0.5	1.0	NP	NP	NP	NP
2A	1.0	1.0	1.0	1.0	0.4	2.5
2B	0.0177	0.339	0.0177	0.339	0.0038	1.57
3	0.986	0.989	NP	NP	NP	NP
4	0.217	1.00	0.216	1.0	0.0888	2.50
5	0.25	1.0	0.25	1.00	NP	NP
6	1.00	1.00	0.96	1.00	0.00385	2.50
7A	1.04	1.00	0.907	1.00	0.0675	2.52
7B	-	-	-	-	0.00385	2.50
8A	0.8	1.0	0.8	1.0	0.0038	2.49
8B	0.3	1.0	0.3	1.0	0.12	2.50
9A	0.3	1.0	0.4	1.0	0.00385	2.51
9B	-	-	0.0177	1.03	-	-
10	1.0	1.0	0.5	2.0	NP	NP
11	0.0177	0.614	0.0073	0.823	NP	NP
12	0.125	1.00	0.125	1.00	0.054	2.50
13	NP	NP	0.0177	0.339	0.0038	2.53
14A	1	1	1	1	0.400	2.50
14B	1	1	1	1	0.00385	2.50
15A	0.0177	0.338	0.0177	0.388	0.00385	2.50
15B	0.00818	1.0	0.00818	1.0	-	-
16A	0.0177	1.02	0.0177	1.02	0.0177	1.02
16B	0.225	1.0	0.225	1.0	-	-
17	1	1	0.9	1.0	0.3	2.50
18	0.123	1.0	0.123	1.0	0.0504	2.48

NP = not participating

Table 5 Physical data on paint specimens

Lab. Nr.	Application mode[1]	Substrate material[2]	Coating density [mg.cm^{-2}]		Film thickness[3] [mm]	
			Test 1	Test 2	Test 1	Test 2
2A	(5)	(5)	(5)	-	68	-
2B	(5)	(5)	(5)	(5)	64	89
4	M	P	7.5	6.6	51± 13	56± 11
6	M	Al	16.7	13	93	76
7A	M	SS	9.1	9.1	37 ± 5.4	38± 2.2
7B	M	Al	8.2	-	38 ± 4.1	-
8A	E	P	5.8	7.6	38± 4.5	53± 6
8B	E	P	6.9	6.7	47± 7	49± 8
9	E	P	7.8	9.9	39 ± 8	54±24
12	M	(5)	7.2	7.4	(5)	(5)
13	M	P	7.3	-	50	-
14A	M	P	9.2	8.9	50	52
14B	M	SS	12.6	12.9	80	80
15	E	P	5.8	5.8	37	38
16	(5)	(5)	(5)		(5)	-
17	M	Al	12.5	12.1	69±12	68± 8
18[4]	M	P	7.4	7.9	35± 4.7	35± 6.1

[1] Manual application (M) or electromechanical application (E)
[2] Al = aluminium
ss = stainless steel
p = polyester
[3] Mean and standard deviation reported by the participants
[4] Film thickness measurements carried out at the JRC-EI
[5] not reported

Figure 1 *Correlation between coating density (mg.cm^{-2}) and film thickness (μm) for all the paint specimens prepared for the comparison.*

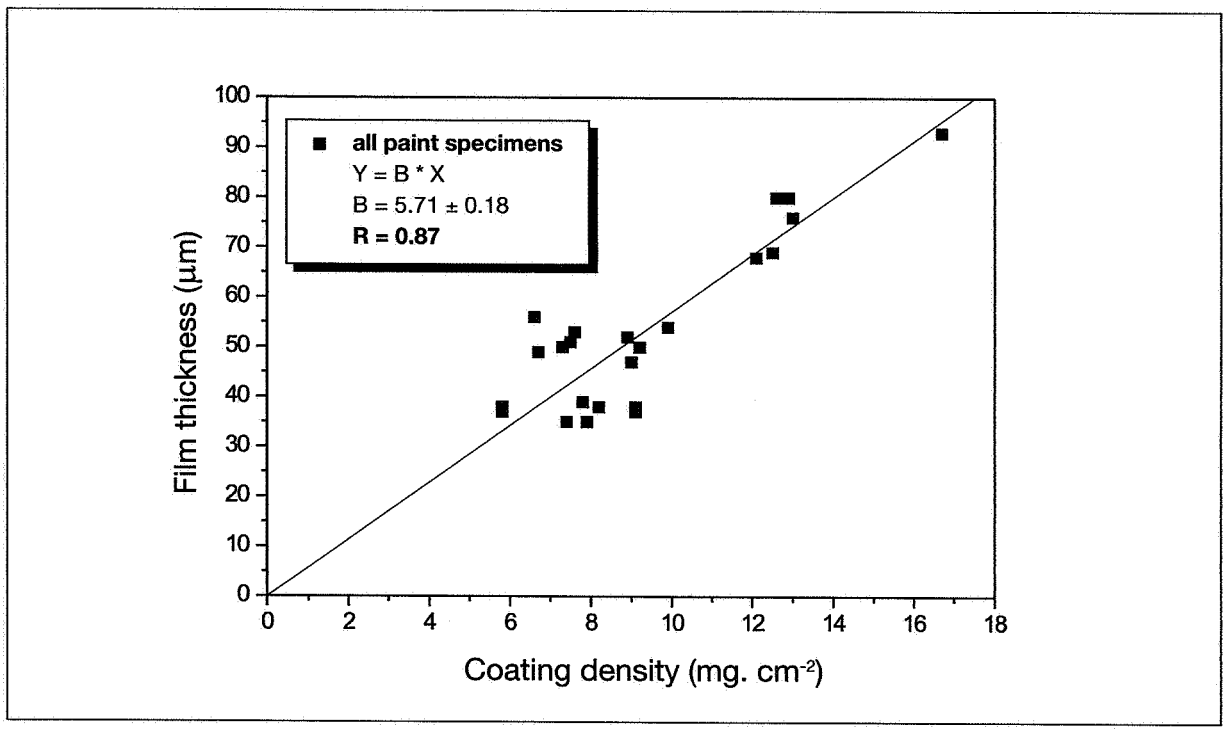


Figure 2 *Correlation between coating density (mg.cm^{-2}) and film thickness (μm) for the paint specimens prepared by Laboratories No. 4 and 7.*

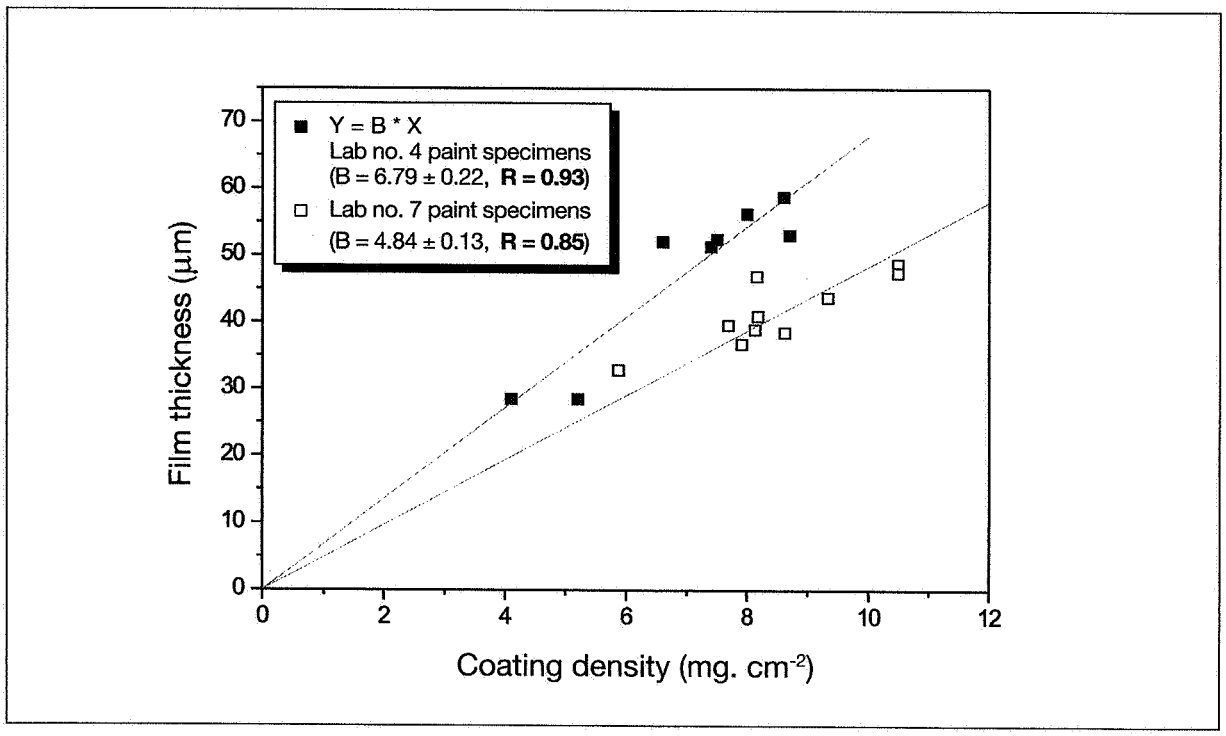
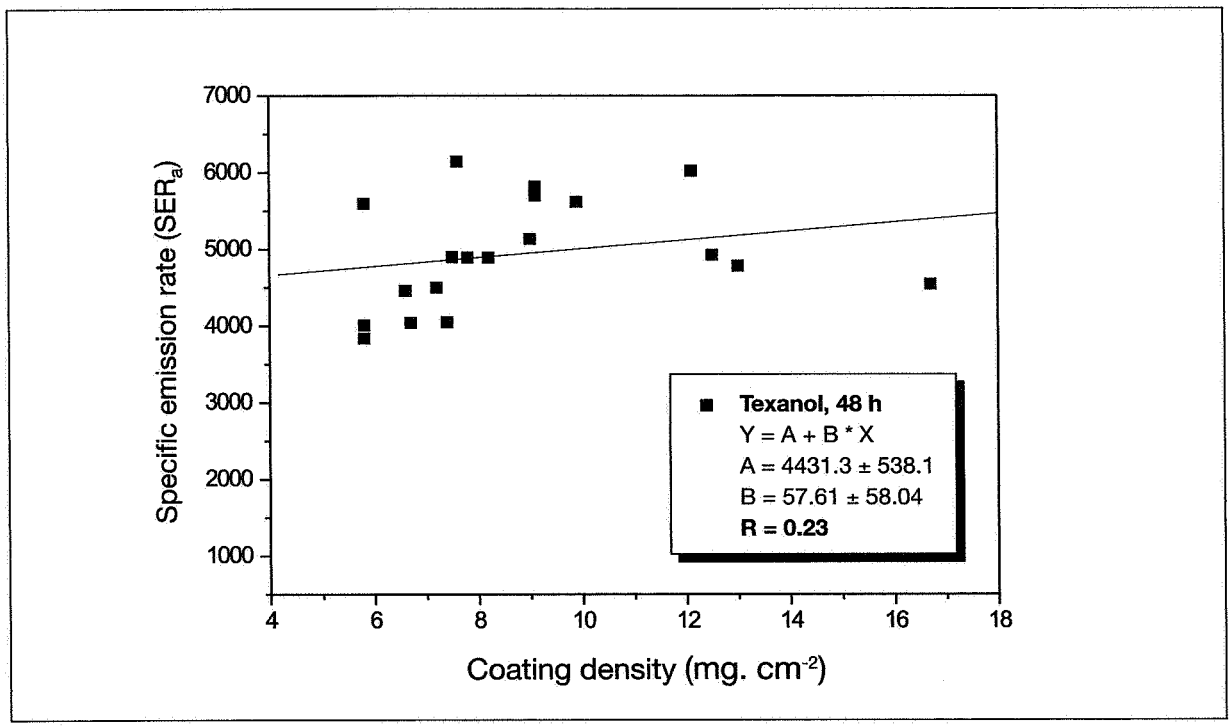


Figure 3 *Correlation between coating density (mg.cm^{-2}) and area specific emission rate (SER_a, µg.m^{-2}.h^{-1}) for Texanol at 48 h.*



APPENDIX 6

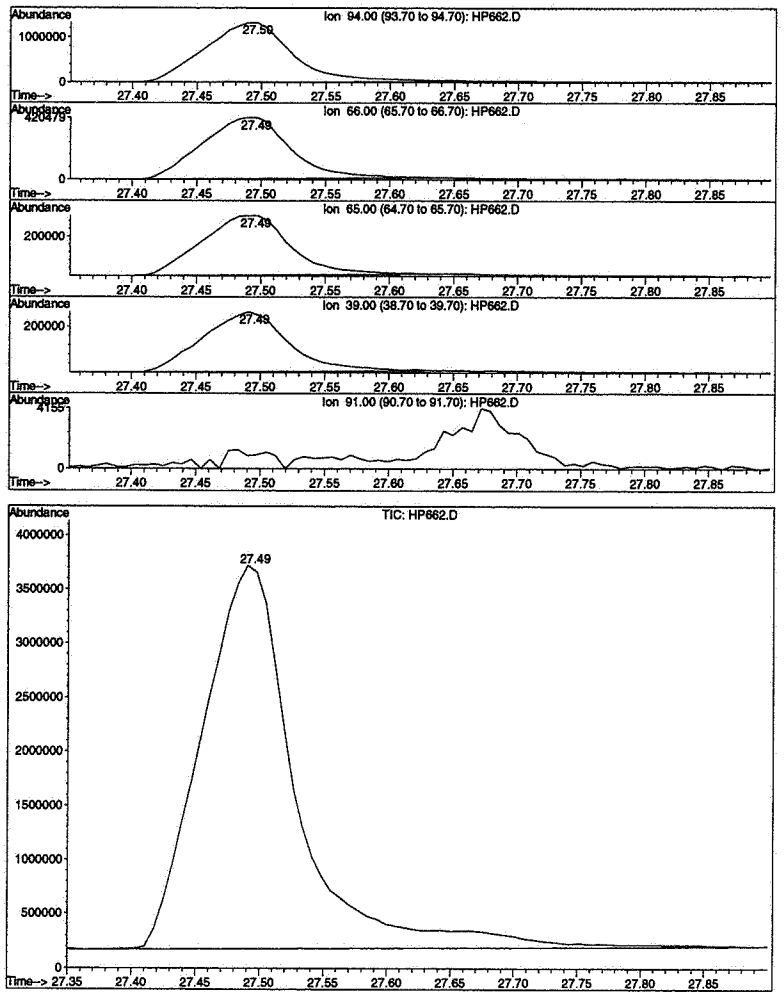
Investigation carried out at the JRC-EI on the possible errors in the integration of GC peaks of the PVC target compounds

The MS analysis of the purity of each peak has been carried out comparing GC peaks of different ions with the whole (TIC, Total Ion Current) GC peak, quantified both through the baseline integration and through the valley-to-valley integration. The following eight figures show, one for each of the target compounds, the profiles of such peaks.

The table which follows summarizes quantitative data in relative terms, because for the 4 alkylbenzenes no pure reference compound was available to define the response factor. The TIC area integrated valley-to-valley has been set as 100 and the other areas have been normalized accordingly. A short comment for each compound clarifies which of the relative values is more appropriate, i.e. more representative of the pure compound.

This data give the possibility to estimate the extent of this type of error (other errors affecting the results of course remain), knowing which type of integration and MS identification has been used for a certain compound at a certain laboratory.

File : C:\HPCHEM\1\DATA\HP662.D
Operator : HASCH
Acquired : 14 May 1998 15:56 using AcqMethod TCT80
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



Phenol

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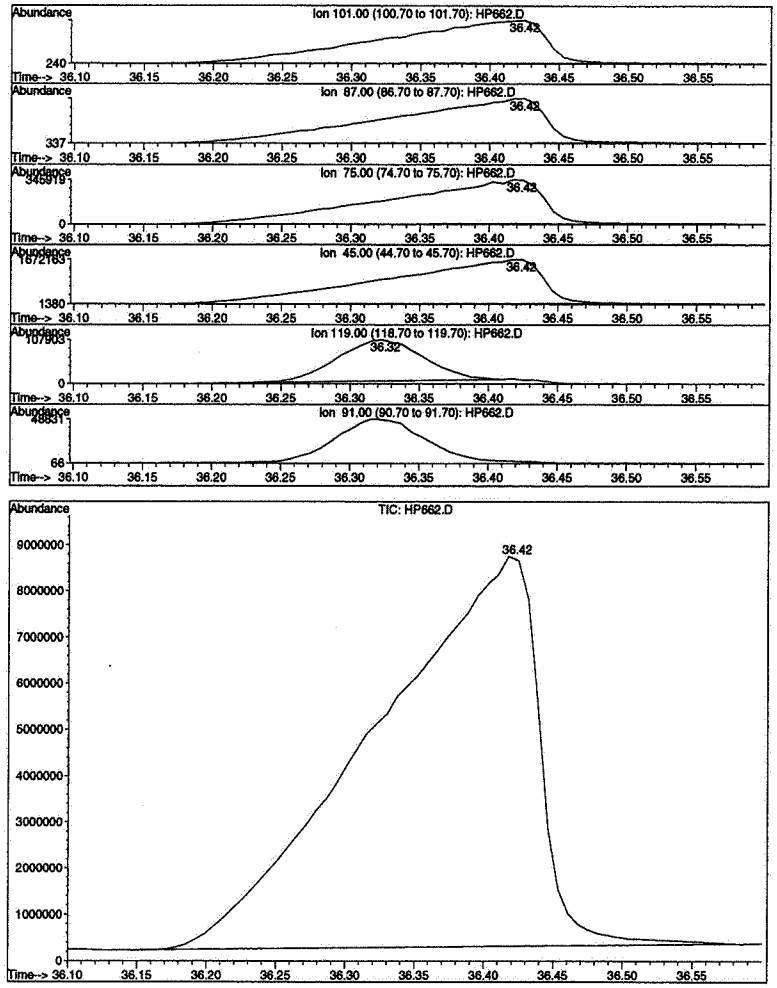
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



2-(2-butoxyethoxy) ethanol

File : C:\HPCHEM\1\DATA\HP662.D
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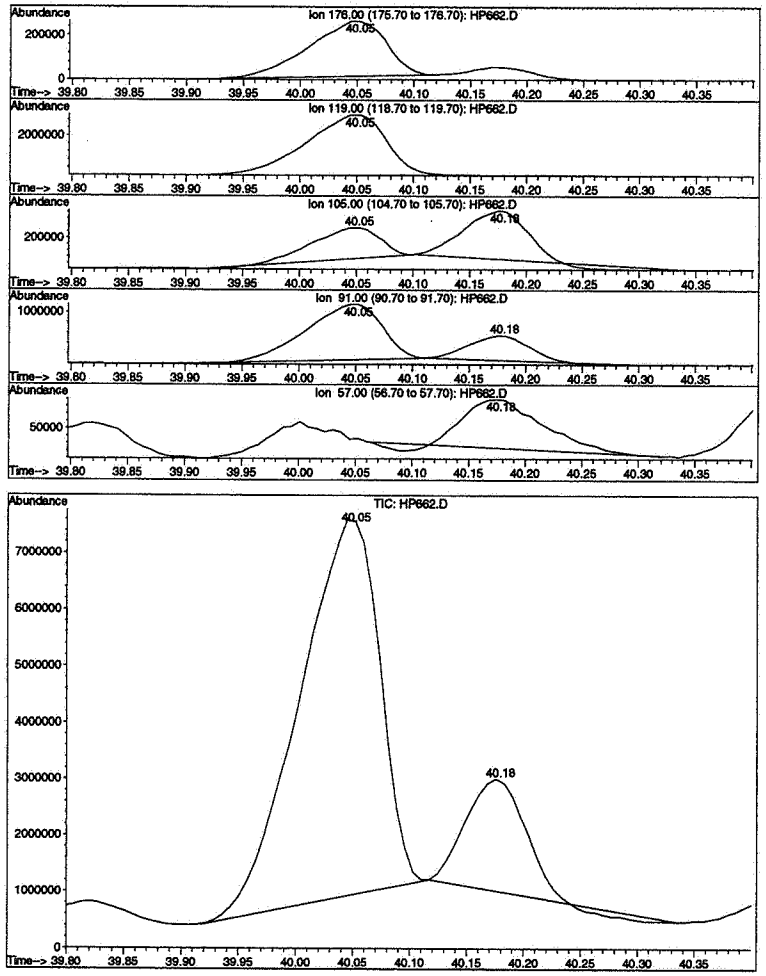
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



C7 alkylbenzene

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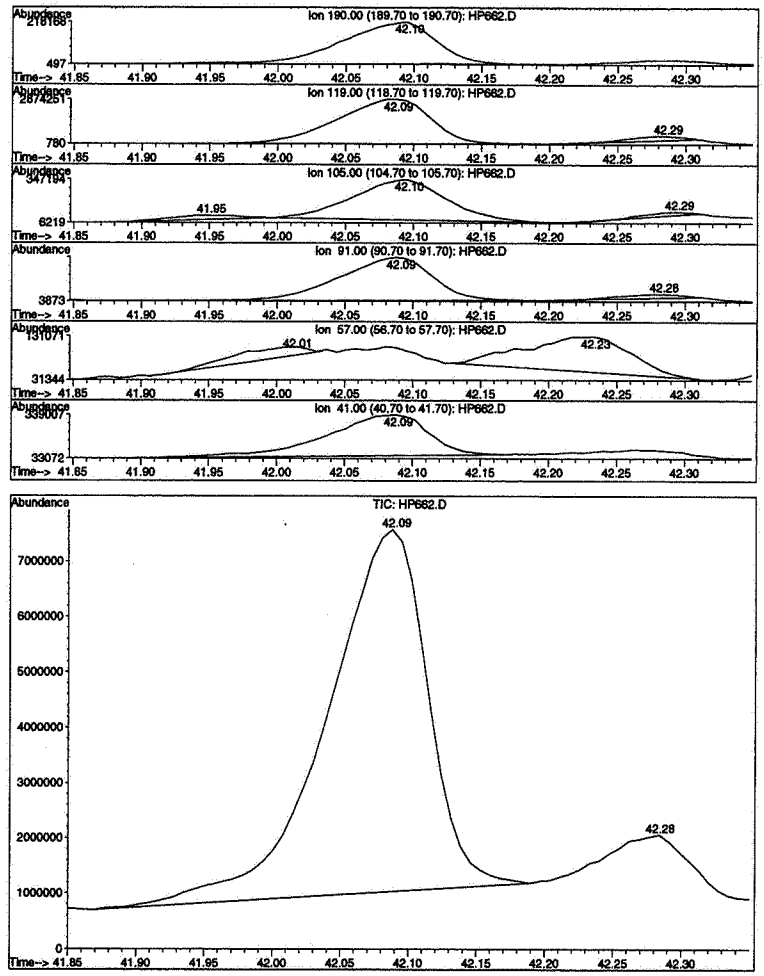
Vial Number: 1



C8 alkylbenzene-1

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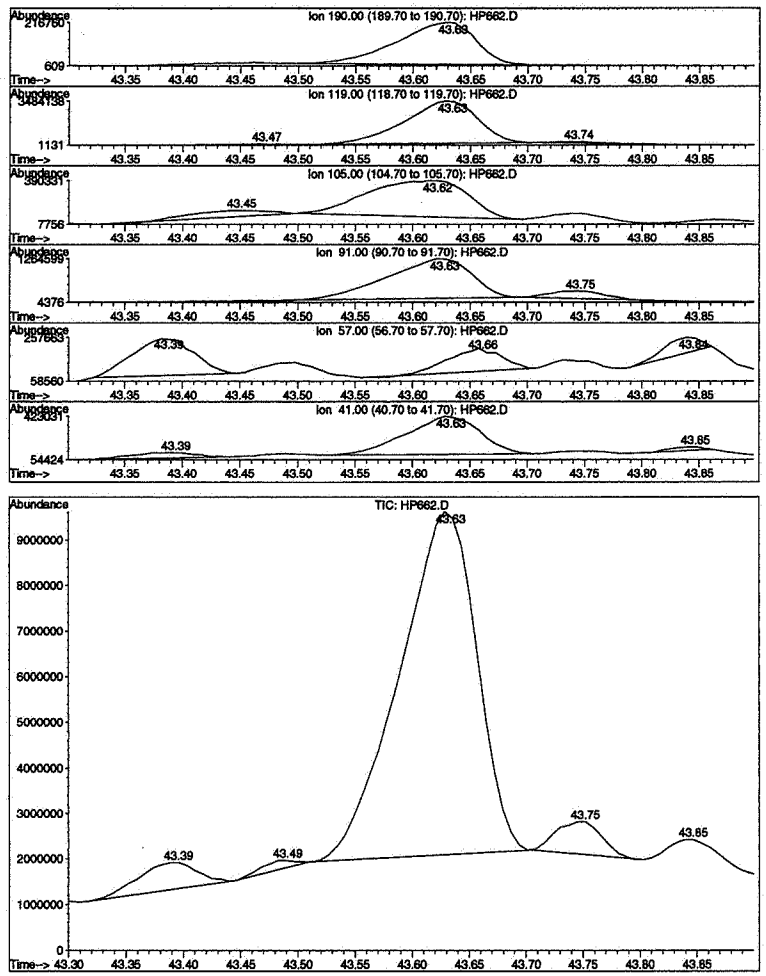
Acquired : 14 May 1998 15:56 using AcqMethod TCT80
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



C8 alkylbenzene-2

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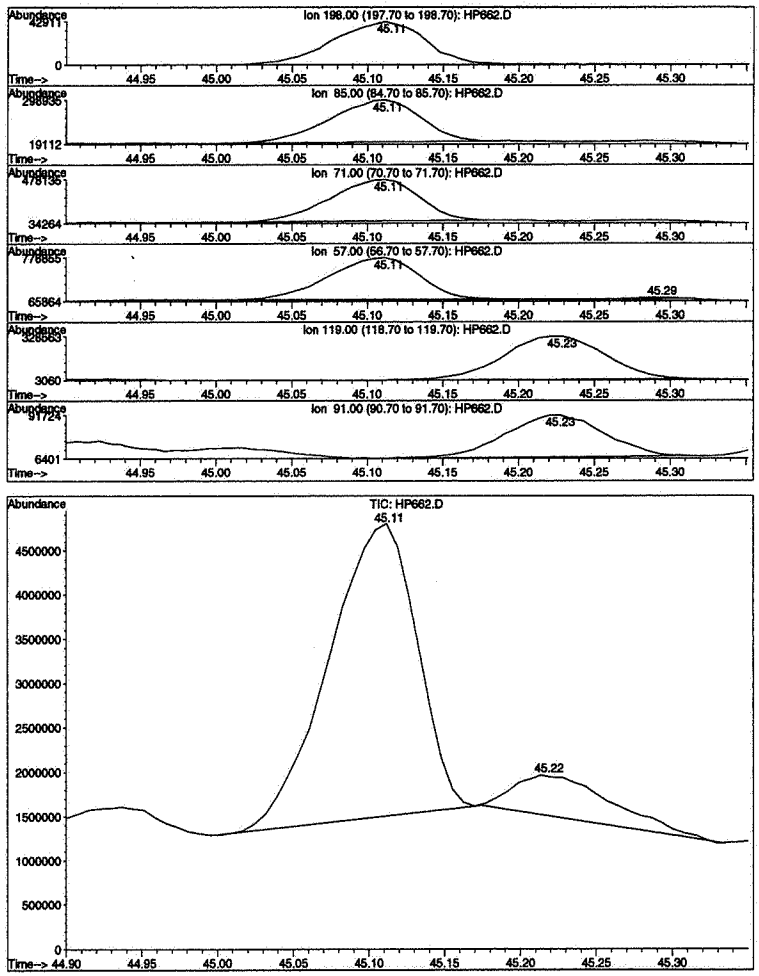
Acquired : 14 May 1998 15:56 using AcqMethod TCT80
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



n-tetradecane

File : C:\HPCHEM\1\DATA\HP662.D
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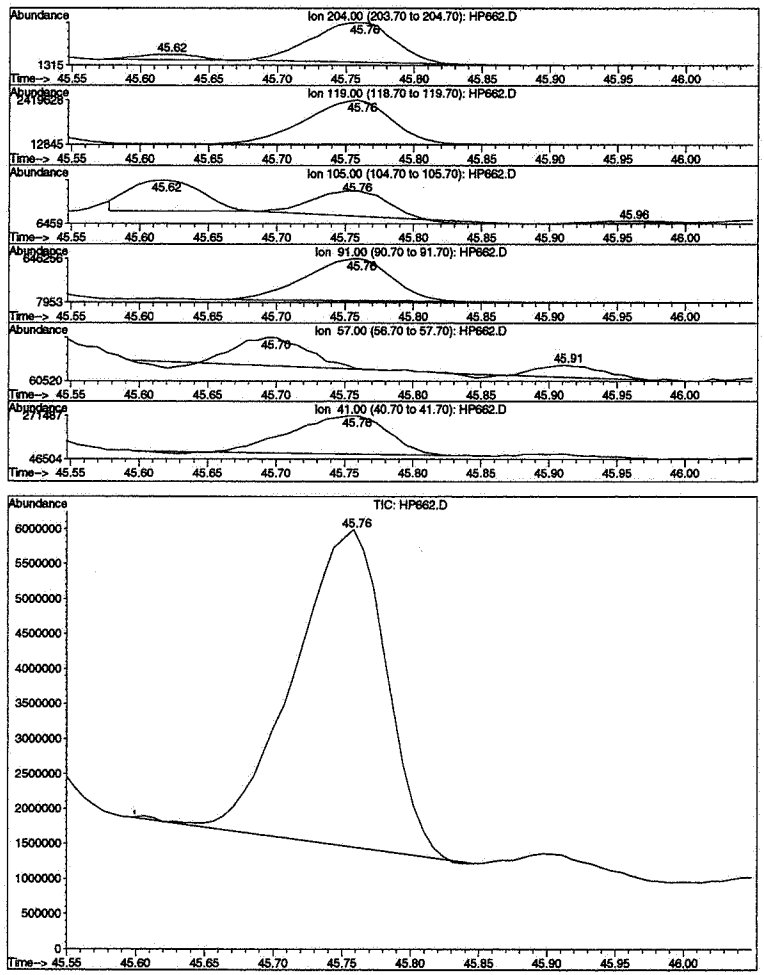
Acquired : 14 May 1998 15:56 using AcqMethod TCT80
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



C9 alkylbenzene

File : C:\HPCHEM\1\DATA\HP662.D
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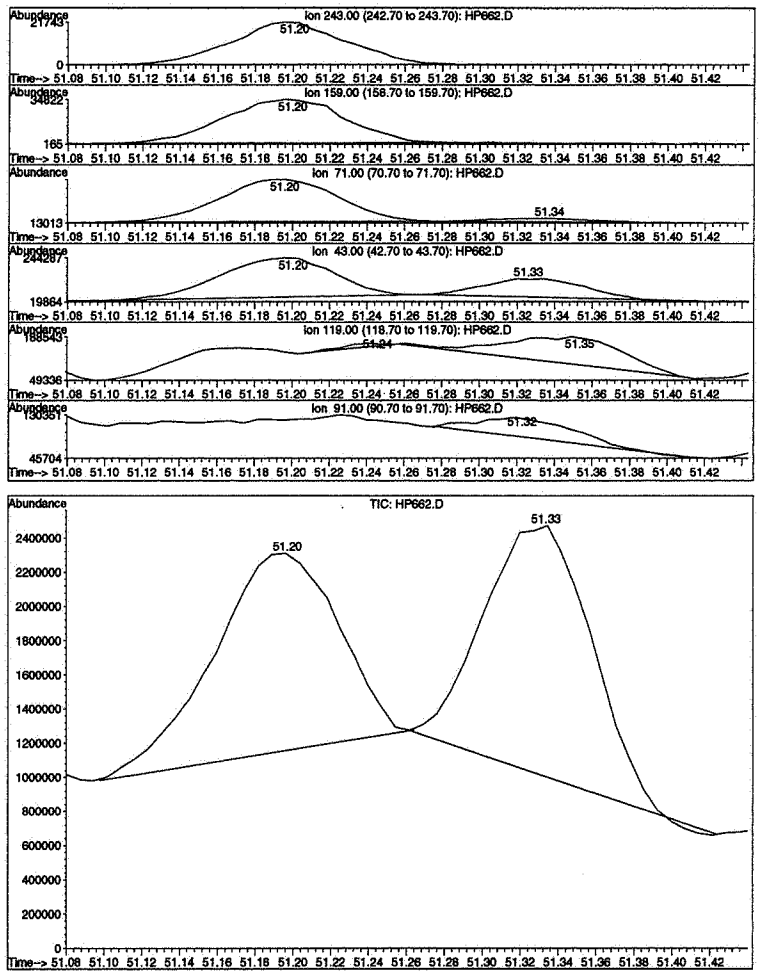
Acquired : 14 May 1998 15:56 using AcqMethod TCT80
Instrument : 5972
Sample Name: PVC019
Misc Info : 11 air 201 chamber 24h PVC T275
Vial Number: 1



TXIB

Quantification based on the total signal and on specific ions.

The use of MS-data for quantitation requires reference compounds of identical chemical structure as the compounds under investigation. Single mass integrals without interferences are preferred over TIC integrals for calculations. Internal standards are of great help to increase the precision of analytical results. In absence of references, quantitation can only be performed by use of FID signals. Here MS examination of the purity of chromatographic peaks of the target compounds can help the judgement of FID results.

PHENOL

Ret. time: 27.49 min

Ion	mass 94	mass 66	mass 65	mass 39	Total val	Total base
Area	61559426	19877920	14417121	11729579	182648296	179586876
Rel. Area	**92.0**	**91.8**	**93.1**	**93.4**	**100.0**	**94.6**

Remarks: *A small peak on the tail of the PHENOL peak was included in the integral in TIC integration modes. As consequence all single ion integrations show lower concentrations than TIC-integrations.*

2-(2-ButOEthO)EthOH

Ret. time: 36.42 min

Ion	mass 101	mass 87	mass 75	mass 45	Total val	Total base
Area	10610969	18979636	26821290	131112977	691170633	692174233
Rel. Area	**103.4**	**99.6**	**99.9**	**98.8**	**100.0**	**98.3**

Remarks: *A small amount of an alkylbenzene is coeluting (masses 119 and 91). Peak shape is very bad due to polarity and overload (ca. 600ng). All single mass- and the TIC-integrations are suitable.*

C7-ALKYLBENZENE

Ret. time: 40.05 min

Ion	mass 176	mass 119	mass 105	mass 91	Total val	Total base
Area	11694437	148391093	12076524	48503902	322086388	386577595
Rel. Area	**95.5**	**103.2**	**115.9**	**95.0**	**100.0**	**120.0**

Remarks: *Except for mass 119 all single mass integrations and therefore also the TIC integrations show some interferences. Best choice for calculations is to use only mass 119.*

First C8-ALKYLBENZENE
Ret. time: 42.09 min

Ion	mass 190	mass 119	mass 105	mass 91	Total val	Total base
Area	10511226	135889431	15026814	47881805	334127932	456956178
Rel. Area	**96.3**	**92.0**	**89.5**	**93.5**	**100.0**	**136.8**

Remarks: *In the TIC integration modes a small peak in front of the target peak is included in the integrationl eading to a too high result. The least disturbed masses 119 and 91 are the best suited ones.*

Sec. C8-ALKLYLBENZENE
Ret. time: 43.63 min

Ion	mass 190	mass 119	mass 105	mass 91	Total val	Total base
Area	9946028	146676899	19187290	58456659	353024235	618604089
Rel. Area	**103.2**	**94.2**	**120.3**	**107.5**	**100.0**	**175.2**

Remarks: *In this case there are no masses without disturbances from unresolved compounds in the background. Difficult to judge, anyway best choice seems to base calculations on integral of mass 119.*

N-TETRADECANE
Ret. time: 45.11 min

Ion	mass 198	mass 85	mass 71	mass 57	Total val	Total base
Area	1820650	11032726	17055865	28388137	132896424	249114408
Rel. Area	**121.5**	**111.3**	**106.6**	**109.4**	**100.0**	**185.5**

Remarks: *Except for mass 198 all single ion integrals show some interferences; the same happens for the TIC integrations. For calculations mass 57 is preferred over mass 198 because it's signal is much stronger.*

C9-ALKYLBENZENE
Ret. time: 45.76 min

Ion	mass 204	mass 119	mass 105	mass 91	Total val	Total base
Area	5083600	105634135	5039655	26606251	210314418	346355739
Rel. Area	**88.0**	**100.1**	**61.5**	**94.0**	**100.0**	**164.7**

Remarks: *In all single ion integrations mass 119 is the only one without remarkable interferences. Difficult to judge TIC integrations. Calculations should be based on the integral of mass 119.*

TXiB
Ret. time: 51.20 min

Ion	mass 243	mass 159	mass 71	mass 43	Total val	Total base
Area	921954	1535131	21229619	8087572	52525706	123688520
Rel. Area	**103.8**	**104.0**	**97.4**	**84.2**	**100.0**	**230.5**

Remarks: *In this case the two TXiB very specific masses 243 and 159 are the least disturbed ones by chemical noise and therefore are the most suited ones for calculations.*

Table 1 *Amounts of target compounds measured in the diffusion samplers (µg/sampler)*

	Lab. 1	Lab. 4	Lab. 7(1)	Lab. 8	Lab. 12	Lab. 15	Lab. 17
CARPET							
n - decane	1.20	2.71	0.75	(3)	(3)	2.08	12
n - undecane	0.83	3.44	3.15	(3)	(3)	6.3	24
2 - phenoxy ethanol	0.063	0.090	0.15	(3)	(3)	0.01	n.d.
n - dodecane	0.78	3.04	2.62	(3)	(3)	6.01	20
n - tridecane	0.40	1.52	1.17	(3)	(3)	3.1	8
PVC							
Phenol	(2)	n.d.	0.040	n.d.	<0.05	1.08	0.1
2 - (2 butoxyethoxy) ethanol	(2)	0.023	0.052	0.16	<0.05	0.095	0.7
C7 alkylbenzene	(2)	n.d.	0.018	0.070	<0.05	0.005	n.d.
C8 alkylbenzene 1	(2)	n.d.	0.016	0.040	<0.05	0.023	n.d.
C8 alkylbenzene 2	(2)	n.d.	0.040	-	<0.05	0.018	n.d.
n - tetradecane	(2)	0.014	0.039	0.050	<0.05	0.012	n.d.
C9 alkylbenzene	(2)	n.d.	0.015	0.030	<0.05	0.037	n.d.
TXIB	(2)	0.006	n.d.	0.29	<0.05	0.116	n.d.

(1) Mean of two samplers
(2) Not participating with this material
(3) No samplers accompanying this material
n.d. = not detect

APPENDIX 8

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European Commission

EUR 18698 – European Collaborative Action 'Indoor Air Quality and Its Impact on Man': European Inter-laboratory Comparison on VOC emitted from building materials and products

The Steering Committee

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Eighteen laboratories from 10 European countries participated in a comparison organised in the frame of the project VOCEM, a 2.5 year research collaboration among 4 research institutes and 4 industrial companies. The VOCEM project (*"Further development and validation test chamber method for measuring VOC emissions from building materials and products"*) has been partially funded by the European Commission (Contract no. SMT4-VT95-2039). The scope of the project was to improve the procedure used to measure VOC emitted from building materials and products in small test chambers. The inter-laboratory comparison included the GC-MS determination of 5 target compounds from carpet , 8 from PVC cushion vinyl and 2 from paint; for the first time, chamber recovery (sinks), homogeneity of solid materials and possible contamination during transport were tested. The results show that the intra-laboratory variance (random errors) is much smaller than the inter-laboratory variance (systematic errors). Causes of the largest inter-laboratory discrepancies were: (a) analytical errors; (b) losses of the heaviest compounds due to sorption on the chamber walls; (c) non homogeneity of the materials. The output of this work concerns both the objective of labelling materials with regard to their VOC emissions and the pre-standard drafted by CEN for this type of determination.