

Physical and Chemical Exposure Unit  
Chemical Release from Textiles



## European survey on the release of formaldehyde from textiles

Conducted within the CHEM TEST project  
On behalf of DG SANCO



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The mission of the Institute for Health and Consumer Protection is to provide scientific support to the development and implementation of EU policies related to health and consumer protection.

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## **1. Executive summary**

Consumers are increasingly exposed to hundreds of potentially hazardous chemicals in their everyday life. These compounds can come into contact with their bodies through three different pathways: inhalation, ingestion and dermal absorption.

Formaldehyde is commonly used in several textile production processes; for example after treatment of substantive dyeing, hardening of casein fibres, as a wool protection agent, anti mould and above all as a cross linking agent in resin finishing.

In some cases, allergic contact dermatitis (ACD) can be attributed to clothing treated with textile finish resins (TFRs), also named durable press resins or permanent press clothing resins. Under normal and foreseeable use, the majority of these resins can release formaldehyde, which has been classified as carcinogenic to humans by IARC (International Agency for Research on Cancer). TFRs are widely used in cotton, cotton/polyester or wrinkle-resistant linen. The frequency of ACD cases due to textile formaldehyde resin has been reported to be between 0.2% and 4.2% after 1990.

The scope of this work was threefold: 1) to make a survey on the level of releasable formaldehyde which can be found in textile products manufactured anywhere in the world and sold on the European market; 2) to develop a method to mimic foreseeable conditions of use better than standard methods EN ISO 14184-1 or 14184-2 do; 3) based on the results of the survey, to evaluate dermal exposure for children and adults.

The focus was put on dermal exposure that can result from the direct contact of the skin with textile products. Therefore the sampling was planned with the objective to cover textile clothing in particular.

A total of 221 samples were purchased in 21 out of 27 EU Member States of the European Union. Although it is not compulsory to indicate the origin on labels in Europe, whenever possible efforts were made to buy samples with labels stating the country of production. Garments were purchased from a variety of sources, including department stores, shops and open air markets, and with various compositions, such as cotton, mixtures with cotton and mixtures with wool.

About 94 % of all the samples were textile clothing, whereas 6 % were classified as linen (bedding pillowcases and sofa cushion covers). The whole population was considered as a target, so clothing samples designed for men, women and children

were analysed (about one third each). With regard to children, samples were purchased both for babies under the age of two and for children up to the age of 14. Several types of garments were taken into consideration, such as shirts, T-shirts, underwear, socks, pyjamas, trousers and dresses. Some sweaters were also analysed, which can be classified either in direct contact with the skin or not, depending on the scenarios. In the case of shirts, some samples had an “easy care” label and a few also an “Oeko-Tex” label. About 31 % of the samples were printed articles.

To evaluate the release of formaldehyde from textiles, all the samples were analysed with the standard method EN ISO 14184-1 (water extraction), which tries to simulate the real conditions of use though an extraction in water at 40 °C. For comparison purposes, 127 samples were also analysed with the standard method EN ISO 14184-2 (vapour absorption), which mimics possible exposure due to inhalation. Samples were analysed in triplicate and uncertainties at 95 % of probability were calculated for all measurements.

In the absence of European legislation concerning the maximum level of formaldehyde that can be released from textiles, the results of the survey were compared with the limits established by the following two voluntary labelling schemes: the European Ecolabel (Commission Decision 2002/371/EC) and the private Oeko-Tex Standard 100, which consider ecological and consumer protection criteria. The limit is 300 mg/kg for textiles not in direct contact with the skin and decorative materials in both schemes. For textiles in direct contact with the skin, Ecolabel established a limit of 30 mg/kg and Oeko-Tex Standard 100 set 75 mg/kg. Moreover, Oeko-Tex Standard 100 established a limit for textiles for babies which should release less than 20 mg/kg of formaldehyde.

With regard to the water extraction method, 11% of samples intended to come into contact with the skin (including bedding pillowcases and sofa cushion covers) exceeded the limit of 30 mg/kg established in the voluntary labelling scheme Ecolabel. About 3% also exceeded the limit of 75 mg/kg for adults considered by the Oeko-Tex Standard 100. 11% of garments for babies under the age of two showed a release of formaldehyde higher than 20 mg/kg, whereas it should be not detectable both by the Japanese law 112 and Oeko-Tex Standard 100. Two of them also exceeded the Ecolabel limit of 30 mg/kg.

No differences were observed in the release of formaldehyde from samples manufactured in various geographical areas (Europe, China, rest of the world) and

purchased from various sources (shops, department stores and open air markets), as percentages of samples exceeding the Ecolabel limit from the different purchase and manufacturing sources were similar.

All textile categories were represented among the samples which released more than 30 mg/kg of formaldehyde, but shirts seem to be the category with the highest risk of exceeding the limit of 30 mg/kg. Moreover, five out of ten “easy care” labelled shirts went beyond the Ecolabel limit. Similarly, pure cotton and mixtures containing wool seem to release more formaldehyde than garments made of mixtures containing cotton and other fibres.

With regard to the vapour absorption method, 22% of the 127 analysed samples contained a level of formaldehyde higher than the Ecolabel limit of 30 mg/kg. About 12% of the samples released over 75 mg/kg of formaldehyde. 397 mg/kg was the highest measured value. The vapour absorption method gave frequently higher results than the water extraction method for release of formaldehyde of over 30 mg/kg.

With the intention to better simulate the release of formaldehyde that could be enhanced by sweat and rubbing, the EN ISO 14184-1 standard method was modified using some artificial perspiration solutions instead of water as an extraction medium, one for acid and one for basic sweat. In order to increase the effect of rubbing, the extraction was carried out either with a Head Over Heels instrument or, alternatively, with a washing machine generally used to determine colour fastness. To further enhance the rubbing effect, some experiments were carried out with ten 12 mm diameter stainless steel balls in each washing machine vessel. Results obtained with the Head over Heels apparatus were lower than the ones obtained with the usual water bath, most probably due to the fact that the temperature could not be set to 40 °C in this instrument, but only to room temperature (25 °C). On the contrary, results obtained with washing equipment were mainly higher than those obtained with the unmodified EN ISO 14184-1 standard method. The use of stainless steel balls slightly increased the release of formaldehyde from textiles. The comparison of results obtained using different extraction solutions seemed to depend quite a lot on the sample and probably on the type of resin applied and on the finishing conditions. The release of formaldehyde was mainly higher with perspiration simulants than with water, either the acid or the basic one, depending on the sample. In conclusion, to better simulate foreseeable conditions of use, the ideal solution seemed to use sweat

simulants, together with stainless steel balls and washing machine. Moreover the modified method represents a “worst case” scenario compared to the standard one.

Washing equipment was also used to mimic domestic washing. Several washing cycles were performed on sample 112, an “easy care” men’s shirt. After the first washing cycle, released formaldehyde decreased by 90% in the case of the water extraction method and by 40% in the case of the vapour absorption one.

Lastly, Roff’s method was applied to samples that showed the highest results in order to measure the global amount of formaldehyde after hydrolysis of the resin. Measurements were performed in triplicate also in this case. As expected, the total content of formaldehyde after hydrolysis was very high, ranging from about 400 mg/kg to 19000 mg/kg.

Data on formaldehyde release obtained with the water absorption method and with the worst case modified method were used to estimate adult and child dermal exposure following the recommendations of the Technical Guidance Document. From data obtained with the EN-14184-1 standard method and the modified one, the maximum dermal uptakes evaluated in the case of a child were 3.1 and 4.5 mg/kg bw respectively and, in the case of an adult, 1.2 and 1.7 mg/kg bw.



## 2. Introduction

Consumers are exposed at an increasing rate to hundreds of chemicals which can come into contact with their body through three different pathways: inhalation, ingestion and dermal absorption. Hazardous chemical substances with undesirable effects have been used in several consumer products on the European market. The lack of data on human exposure still represents a major bottleneck in the risk assessment process today; particularly so in the case of data on human exposure to chemicals released from consumer products and articles. A second bottleneck in the assessment of human exposure to chemicals is the lack of validated methodologies to measure the release of chemicals from articles during normal and foreseeable product use.

In the frame of its work on human exposure to chemical stressors released from consumer products and the ChemTest project funded by DG Sanco, the Physical and Chemical Exposure Unit (which is part of DG Joint Research Centre's Institute for Health and Consumer Protection) has conducted a European survey on the level of formaldehyde that can be released from textiles which are in direct contact with the skin. Three purposes were pursued during this work: first of all, to evaluate the real situation on the European market; secondly, to develop a new method that better mimics real conditions of use in comparison to the existing ones; and thirdly, to assess whether the detected amounts of released formaldehyde are hazardous to human health through dermal exposure.

Formaldehyde was chosen because it has been classified as carcinogenic to humans by IARC (International Agency for Research on Cancer)<sup>1</sup> and because of its widespread use in several textile processes. For instance, it is used after treatment of substantive dyeing (to improve wash fastness) and hardening of casein fibres (during wet finishing) and with various aims such as wool protection agent, anti mould, cross linking agent in resin finishing.

In some cases, allergic contact dermatitis (ACD) can be attributed to clothing treated with textile finish resins (TFRs), also named durable press resins or permanent press clothing resins. Under normal and foreseeable use, the majority of these resins can release formaldehyde. TFRs are widely used for cotton, cotton/polyester or wrinkle-resistant linen.<sup>2</sup> The frequency of ACD due to textile formaldehyde resins has been reported to be between 0.2% and 4.2% after 1990.<sup>3-8</sup>

In Europe, no legal restrictions are presently applicable to the content of formaldehyde in textiles, whereas in other countries, such as Japan, limitations have been in place for over thirty years. However, two voluntary labelling schemes are available: the European Ecolabel, introduced with a Commission Decision<sup>9</sup> and focusing more on ecological criteria, and the private Oeko-Tex Standard 100, which also focuses on consumer protection. Both Ecolabel and Oeko-Tex Standard 100 foresee limits for formaldehyde that vary depending on textile categories. In particular, Ecolabel established the limits of 30 mg/kg for formaldehyde released from textiles in direct contact with the skin (75 mg/kg for Oeko-Tex Standard 100) and 300 mg/kg for textiles which have no direct contact with the skin (same limit for Oeko-Tex Standard 100). In addition, Oeko-Tex Standard 100 established that textiles for babies up to two years old should release less than 20 mg/kg.

### 3. Analytical methods

Two standard methods are available for measuring the release of formaldehyde from textiles: the water extraction method (EN ISO 14184-1)<sup>10</sup> and the vapour absorption method (EN ISO 14184-2)<sup>11</sup>.

The first method (EN ISO 14184-1) is based on the extraction of a weighed amount of sample material (approx. 1.0 g) with water at 40 °C for one hour (an oscillating water bath was used). The extract is then filtered and treated with acetylacetone (Nash reagent), with which formaldehyde reacts to give a yellow compound (3,5-diacetyl-1,4-dihydrolutidine). The colour development is obtained in half an hour at 40 °C. The absorbance of the reaction product is measured at 412 nm and the quantification of formaldehyde is performed with the use of external standards.



**Picture 1:** a) Various steps of method EN ISO 14184-1; b) oscillating water bath.

The second method (EN ISO 14184-2) is based on the absorption in water of formaldehyde vapour released by a weighed amount of sample material (approx. 1.0 g) suspended over water in a sealed jar. The jar is placed in an oven at 49°C for 20 hours. The quantification of formaldehyde in the aqueous solution is performed, as in the previous method, by a colorimetric reaction with Nash reagent.

The quantification limit for both methods is 20 mg/kg and results under this limit should be reported as non detectable, as errors could be high in this case. However, in this study the results of analyses are reported, even if lower than the quantification limit, as no interferences were experienced. All the samples were analysed in triplicate, so that uncertainties at 95 % of probability could be calculated for all measurements.

Sampling was performed by cutting five big specimens, taken from different areas of each garment, into little squares about 1 cm wide. The pieces were then mixed and part of them was weighted to prepare three replicates of about 1 gram each.



**Picture 2:** a) Sample vessel and b) oven for method EN ISO 14184-2.

The first method was applied to all samples, as it was considered a better approximation of the possible release of formaldehyde in the real conditions of use which can determine dermal exposure. The second method, which was considered to be a better simulation of possible exposure due to inhalation, was applied to 127 samples for comparison purposes.

**Table 1:** Composition of artificial perspiration solutions.

|                             |   |
|-----------------------------|---|
| Basic Perspiration Solution | 0.5 g/l $\text{C}_6\text{H}_9\text{O}_2\text{N}_3 \cdot \text{HCl} \cdot \text{H}_2\text{O}$<br>5 g/l NaCl<br>2.5 g/l $\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$<br>pH=8.0 using a solution of NaOH 0.1M |
| Acid Perspiration Solution  | 0.5 g/l $\text{C}_6\text{H}_9\text{O}_2\text{N}_3 \cdot \text{HCl} \cdot \text{H}_2\text{O}$<br>5 g/l NaCl<br>2.2 g/l $\text{NaH}_2\text{PO}_4 \cdot 2\text{H}_2\text{O}$<br>pH=5.5 using a solution of NaOH 0.1M |

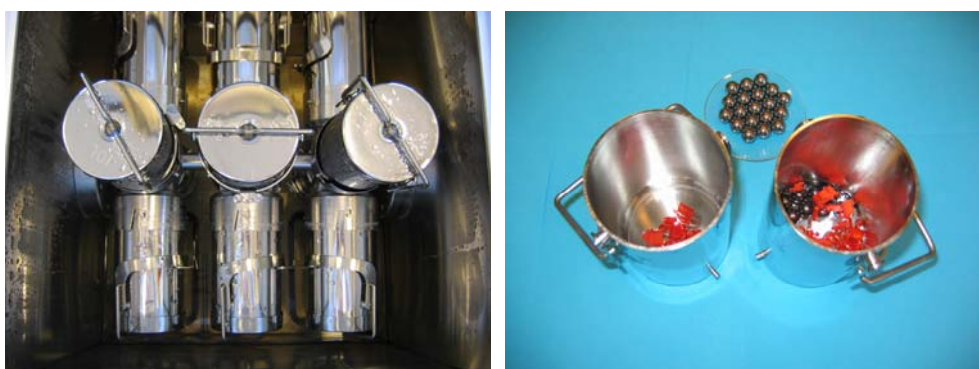
With the intention to better simulate the release of formaldehyde that can be enhanced by sweat and rubbing and to obtain a “worst case” scenario, method EN ISO 14184-1 was modified using some artificial perspiration solutions, one for acid and one for basic sweat, instead of water as an extraction medium. The other conditions of method, temperature and contact time were not modified and the quantification of formaldehyde was performed as usual with the Nash reagent. The compositions of the

two simulants are reported in Table 1. The same simulants are also used in the determination of colour fastness to perspiration following the standard method EN ISO 105-E04<sup>12</sup>.

In order to increase the effect of rubbing, instead of the oscillating water bath used for measurements performed with the method EN ISO 14184-1, the extraction was carried out alternatively either with a Head Over Heels instrument (in this case at room temperature of 25 °C) or with a Gyrowash equipment. The sample vessels were rotated up/down during the migration experiment with both kinds of instruments. To further enhance the rubbing effect, some experiments were carried out by adding 10 stainless steel balls, 12 mm diameter, in each sample vessel of the Gyrowash.



**Picture 3:** a) Head Over Heels equipment; b) sample vessels for the different methods.



**Picture 4:** a) Gyrowash apparatus; b) sample vessels for Gyrowash.

The influence of washing cycles on the release of formaldehyde was studied on one sample. Washing cycles were performed following the indications of standard method EN ISO 105 C01-C05<sup>13</sup> for colour fastness to washing. The temperature was set at 40 °C for half an hour and 5 g/l of standard soap were used with a bath ratio of 1:50.

Roff's method<sup>14</sup> was applied on the samples that showed the highest results in order to measure the global amount of formaldehyde after hydrolysis of the resin. A weighed amount of sample material (approx. 0.02 g) was hydrolysed in an aqueous solution 12 N sulphuric acid at room temperature overnight. The hydrolysed solution was then filtered and treated with chromotropic acid, with which formaldehyde reacts to give a violet compound. The absorbance of this compound was measured at 570 nm. The quantification of formaldehyde was carried out with the use of external standards and samples were analysed in triplicate.

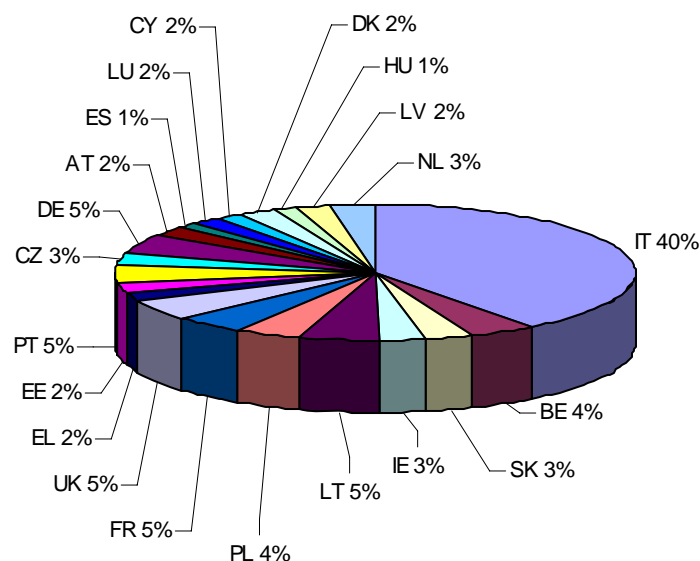
## 4. Selection of products

One of the purposes of this work was to make a survey on the level of releasable formaldehyde that can be found in textile products manufactured anywhere in the world and sold on the European market. Focus was put on dermal exposure that can result from direct contact of the skin with textile products; therefore, the sampling was planned with the objective to cover textile clothing in particular and, to a lower extent, bed linen and furnishing textiles (cushion cover for sofa).

The sampling focused on textile articles that could contain formaldehyde due to its use in durable press finishing, which provides dimensional stability and recovery from wrinkling to cotton based fabrics, and as protector in dyeing blends containing wool at high temperatures, in order to avoid damage to the wool. In addition, printed articles, socks and underwear were taken into consideration.

**Table 2:** Purchase and production countries of samples.

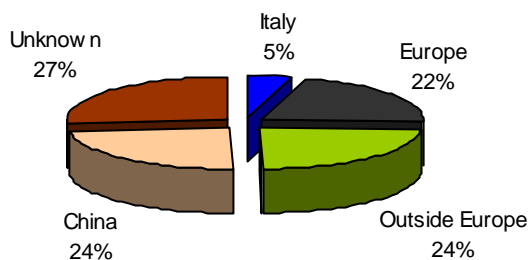
|                               | Purchase country | Production country |
|-------------------------------|------------------|--------------------|
| AT                            | 5                |                    |
| BE                            | 9                |                    |
| CY                            | 4                |                    |
| CZ                            | 6                |                    |
| DE                            | 10               |                    |
| DK                            | 5                |                    |
| EE                            | 5                |                    |
| EL                            | 4                |                    |
| ES                            | 3                |                    |
| FR                            | 10               |                    |
| HU                            | 3                |                    |
| IE                            | 6                |                    |
| IT                            | 88               |                    |
| LT                            | 11               |                    |
| LU                            | 4                |                    |
| LV                            | 5                |                    |
| NL                            | 6                |                    |
| PL                            | 9                |                    |
| PT                            | 10               |                    |
| SK                            | 7                |                    |
| UK                            | 11               |                    |
| Europe (except Italy)         |                  | 48                 |
| Italy                         |                  | 10                 |
| Outside Europe (except China) |                  | 52                 |
| China                         |                  | 52                 |
| Unknown                       |                  | 59                 |



**Fig 1:** Proportion of samples purchased in European countries.

A total of 221 samples were purchased and analysed. Samples were bought in 21 out of 27 Member States of the European Union, Italy being the most represented for practical reasons.

Although it is not compulsory to indicate the origin on labels in Europe, whenever possible efforts were made to buy samples stating the country of production. About one fourth of samples were produced in Europe, including 5 % in Italy, one fourth in the rest of the world except China, one fourth in China and it was not possible to establish the origin for 27 % of samples.

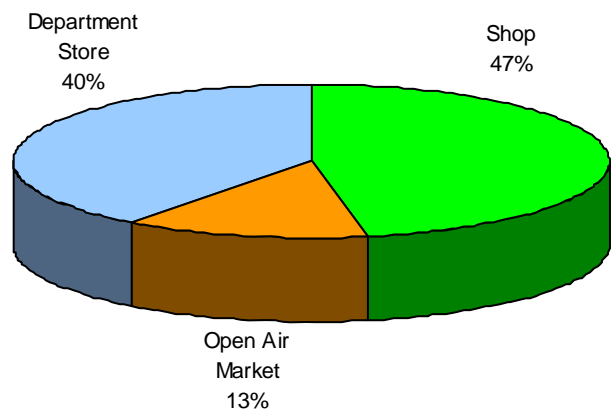


**Fig 2:** Proportion of samples by manufacturing geographical areas.

Due to the fact that some department stores apply a quality policy that requires producers to guarantee a low release of chemicals from textile products and that this

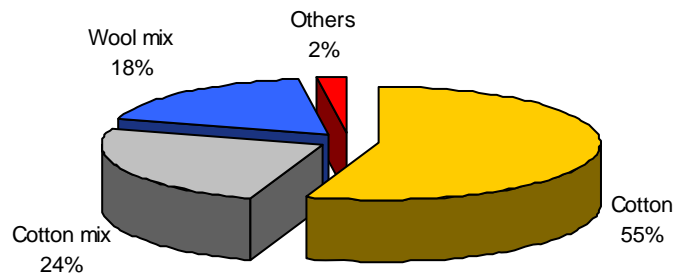


could bias the results of the survey, samples were purchased from various sources including not only department stores, but also shops and open air market.

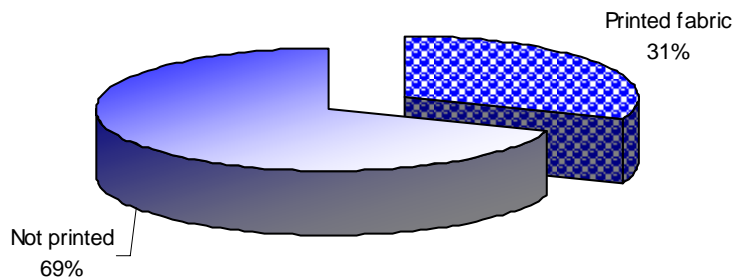


**Fig 3:** Proportion of samples by sources.

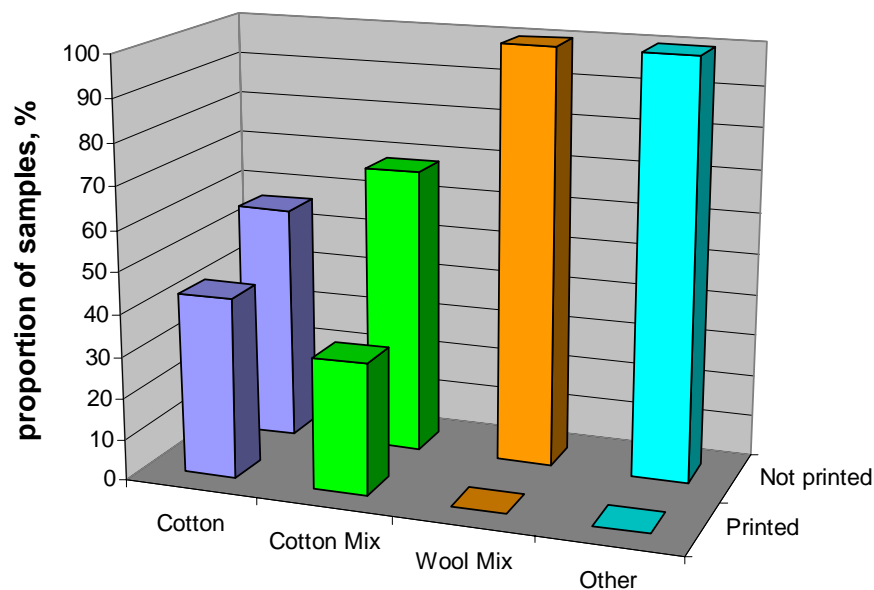
Considering the use of formaldehyde and formaldehyde based resins, samples were chosen made of cotton, mixtures with cotton and mixtures with wool, with a predominance of samples made of pure cotton. In particular, in the case of shirts, samples were preferred if an “easy care” label was present on the product. About 31 % of the samples were printed articles.



**Fig 4:** Proportion of samples by composition.

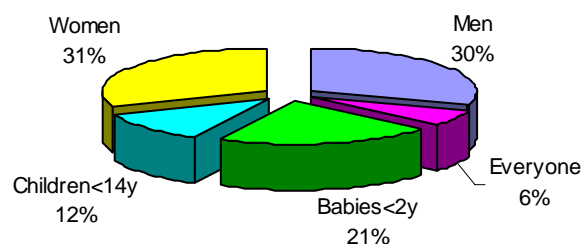


**Fig 5:** Proportion of printed and not printed samples.



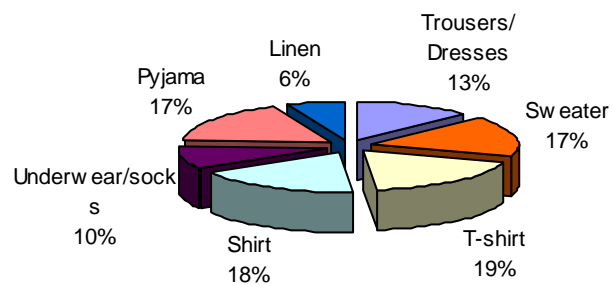
**Fig 6:** Composition of printed and unprinted samples.

About 94 % of all the samples were textile clothing, while 6 % were classified as linen (bedding pillowcase and sofa cushion covers). The whole population was considered as a target, so clothing samples designed for men, women and children were analysed (about one third each). With regard to children, samples were purchased both for babies under the age of two and for children up to the age of 14; in particular, 47 out of 73 samples made for children were designed for babies.

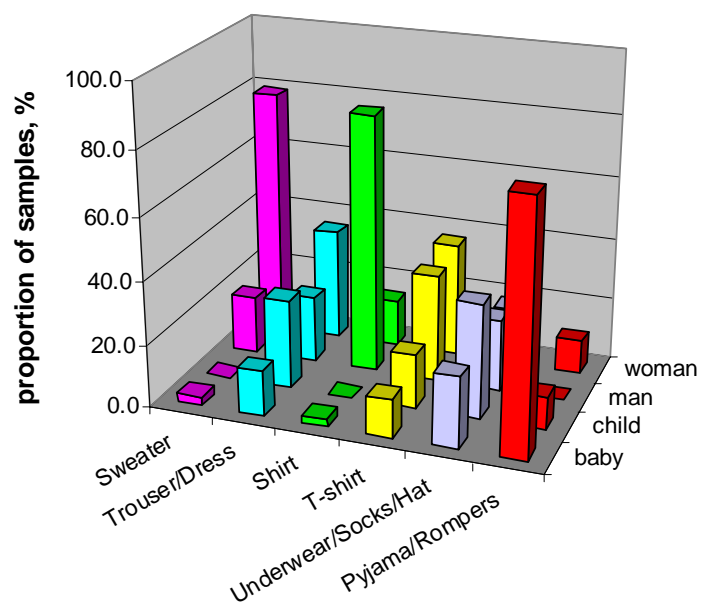


**Fig 7:** Proportion of samples by target population.

Several types of garments were taken into consideration in this study, principally articles in direct contact with the skin (such as shirts, T-shirts, underwear, socks, pyjamas, trousers and dresses) and articles like sweaters which can be either in direct contact with the skin or not, depending on the scenarios. As already mentioned cushions for sofa were considered to represent furnishing textiles which can be in direct contact with the skin.



**Fig 8:** Proportion of samples by textile categories.



**Fig 9:** Proportion of samples by target population and textile categories.

## 5. Results and discussion

Table 1 in Annex I reports the characteristics of all samples. The following abbreviations were used. W (woman), M (man), B 12 m (baby 12 months old), C 3 y (child 3 years old), OAM (open air market), S (shop), DS (department store). The standard abbreviations were used for production countries.

All samples (221) were analysed with standard method EN 14184-1 (water extraction). A total of 127 samples were also analysed with standard method EN 14184-2 (vapour absorption); in particular, all samples showing a release of formaldehyde in water higher than 20 mg/kg. The results are presented in Table 2 in Annex I. Three replicates were analysed for each sample. Results are reported as average plus or minus uncertainty, evaluated at 95 % probability.

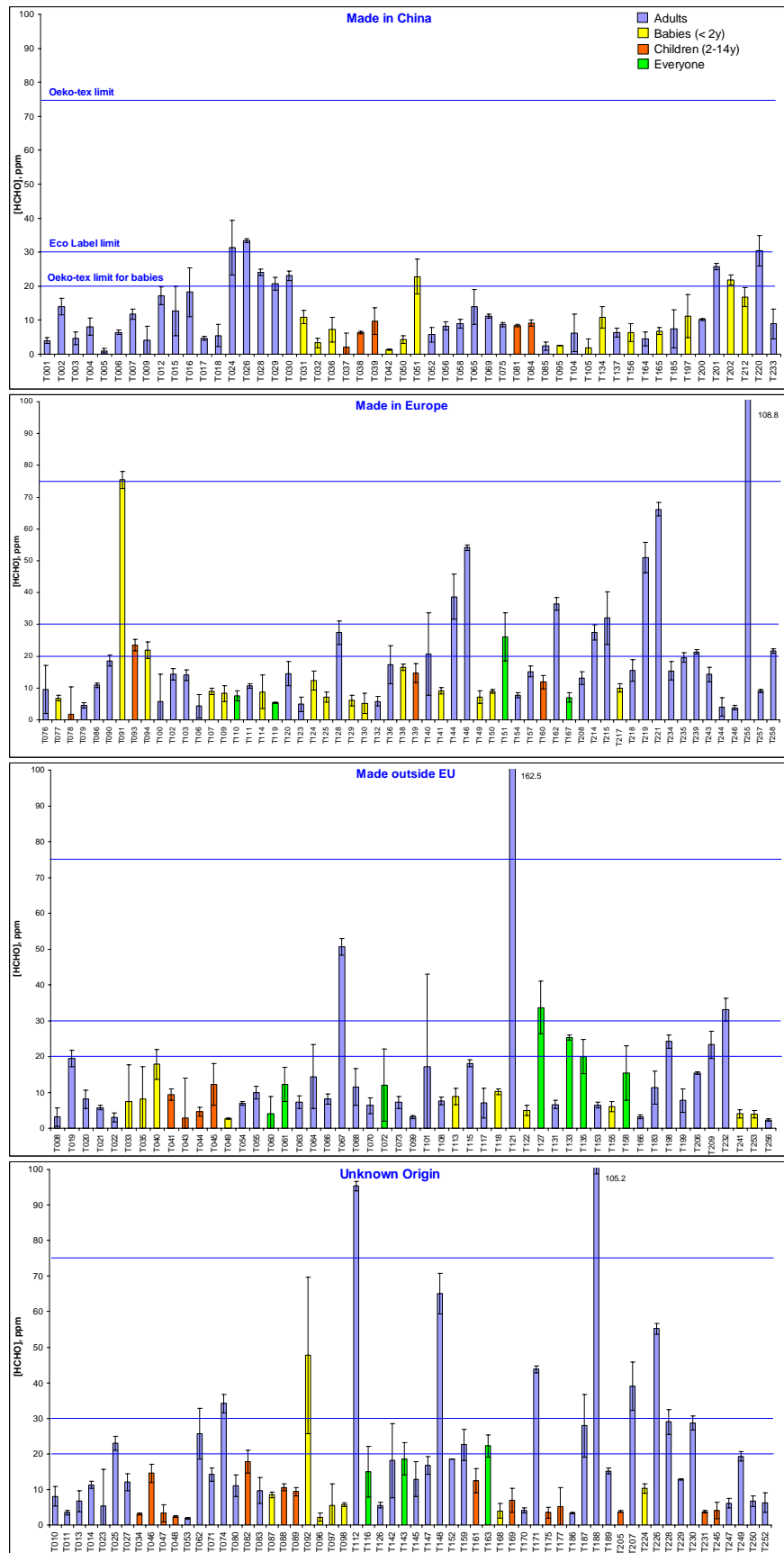
Although the quantification limit for both methods is 20 mg/kg, the quantification was performed even in the case of lower concentrations as no interferences were experienced. The calibration curve was extended accordingly.

In the case of samples T205, T208, T209 and T217, measurements A and B were carried out on specimens taken from two different samples of the same article to test if the release of formaldehyde was similar. Results confirmed this hypothesis.

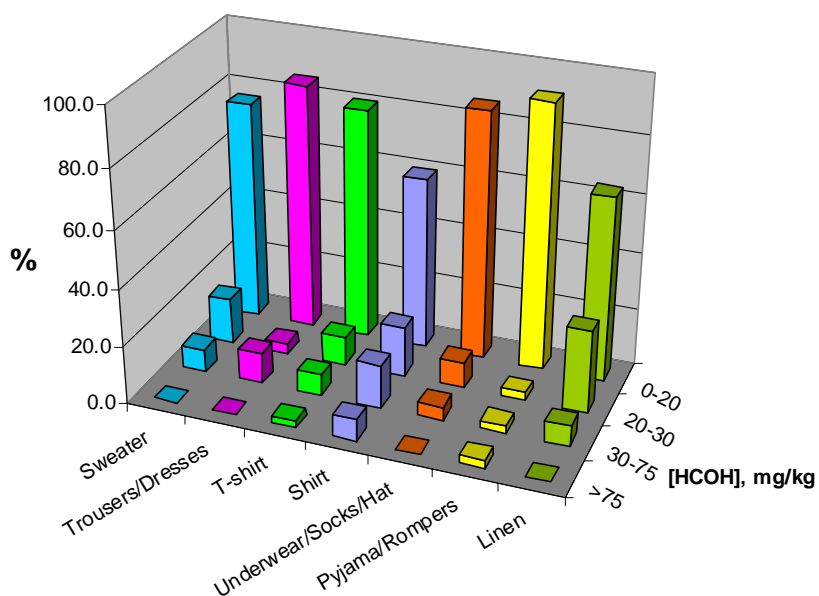
Usually in the case of printed garments, when specimens were not homogeneous because of printed and unprinted parts, a representative sampling was carried out including both parts. For two inhomogeneous printed samples with printed drawings (T088 and T092) three different samplings were carried out: firstly taking only the printed drawings, secondly only the non printed part and thirdly a representative mixture. Results showed no difference for sample T088.

Results obtained with standard method EN ISO 14184-1 (water extraction) are represented in Fig. 10, 11 and 12. In addition, Table 4 reports data for samples which released more than 20 mg/kg of formaldehyde with the same method.

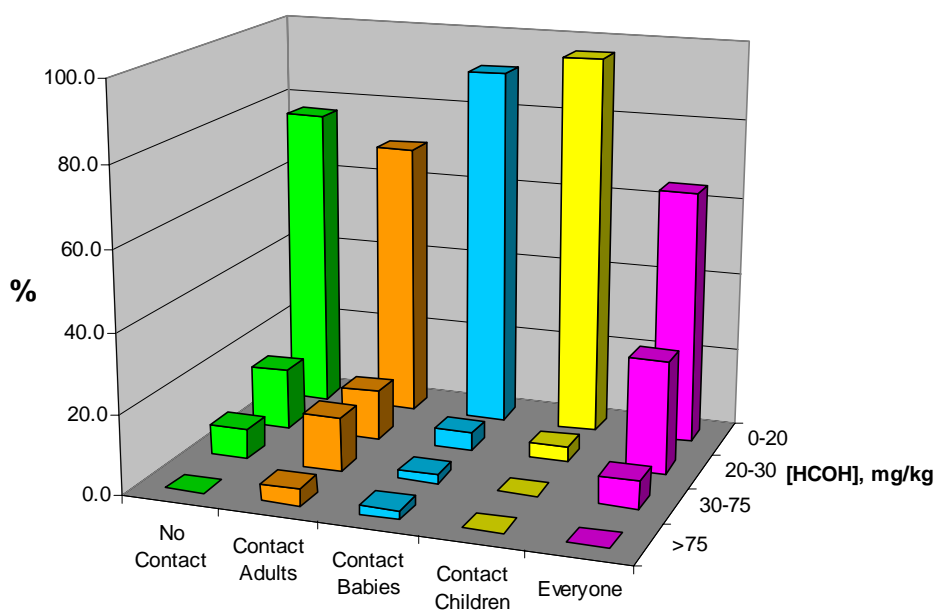
In the absence of European legal restrictions for the content of formaldehyde in textiles, the results of this survey were compared with the limit established by the voluntary labelling schemes Ecolabel and Oeko-Tex Standard 100 (see Table 3). Both schemes consider ecological criteria; Oeko-Tex Standard 100 also put the emphasis on consumer protection.



**Fig 10:** Released formaldehyde by standard method EN ISO 14184-1 (water extraction).



**Fig 11:** Proportion of samples by released formaldehyde with standard method EN ISO 14184-1 and textile categories.



**Fig 12:** Proportion of samples by released formaldehyde with standard method EN ISO 14184-1 and target population.

**Table 3:** Limit for formaldehyde release by Ecolabel and Oeko-Tex Standard 100.

|                     | Textiles for babies | Textiles in direct contact with the skin | Textiles with no direct contact with the skin | Decoration material |
|---------------------|---------------------|--|---|---------------------|
| <b>Ecolabel</b>     |                     | 30 mg/kg                                 | 300 mg/kg                                     | 300 mg/kg           |
| <b>Oeko-Tex 100</b> | < 20 mg/kg          | 75 mg/kg                                 | 300 mg/kg                                     | 300 mg/kg           |

**Table 4:** Released formaldehyde by standard method EN ISO 14184-1 (water extraction).

| JRC Code | Declared Composition                | Contact | Description        | Target    | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex | HCHO mg/kg | Unc. 95% |
|----------|-------------------------------------|---------|--------------------|-----------|----------------|--------|------------------|--------------------|--------------------|------------|----------|
| T121     | 100% Cotton                         |         | T-shirt            | W         | Yes            | S      | UK               | Turkey             |                    | 162.5      | 9.3      |
| T255     | 100% Cotton                         |         | shirt              | M         |                | S      | LV               | Germany            | EC                 | 108.8      | 3.1      |
| T188     | 35% Cotton, 65% PES                 |         | shirt              | M         |                | S      | CY               | Unknown            | EC                 | 105.2      | 6.4      |
| T112     | 100% Cotton                         |         | shirt              | M         |                | S      | FR               | Unknown            | EC                 | 95.3       | 1.4      |
| T091     | 100% Cotton                         |         | rompers            | B 6 m     | Yes            | OAM    | IT               | Italy              |                    | 75.4       | 2.6      |
| T221     | 100% Cotton                         |         | shirt              | M         |                | S      | PT               | Spain              | EC                 | 66.2       | 2.1      |
| T148     | 100% Cotton                         |         | shirt              | M         |                | DS     | DE               | Unknown            | EC                 | 65.0       | 5.7      |
| T226     | 100% Cotton                         |         | underware          | M         | Yes            | OAM    | NL               | Unknown            |                    | 55.2       | 1.5      |
| T146     | 100% Cotton                         |         | shirt              | M         |                | DS     | DE               | Slovakia           | OT                 | 54.1       | 0.9      |
| T219     | 66% Wool, 30% PES, 4% other fibers  |         | trousers           | W         |                | DS     | PT               | Spain              |                    | 51.0       | 4.7      |
| T067     | 100% Cotton                         |         | T-shirt            | M         |                | DS     | IT               | Bangladesh         |                    | 50.7       | 2.3      |
| T092 mix | 100% Cotton                         |         | rompers            | B 6 m     | Yes            | S      | IT               | Unknown            |                    | 47.7       | 22.0     |
| T171     | 100% Cotton                         |         | T-shirt            | M         |                | DS     | LU               | Unknown            |                    | 43.8       | 1.0      |
| T207     | 100% Wool                           |         | trousers           | W         |                | S      | DK               | Unknown            |                    | 39.0       | 6.8      |
| T144     | 100% Cotton                         |         | shirt              | M         |                | DS     | DE               | Germany            |                    | 38.7       | 7.1      |
| T162     | 100% Cotton                         |         | shirt              | M         |                | S      | SK               | Slovakia           |                    | 36.4       | 2.0      |
| T074     | 100% Cotton                         |         | T-shirt            | W         |                | DS     | IT               | Imported           |                    | 34.2       | 2.6      |
| T127     | 100% Cotton                         |         | sofa cushion cover | linen     |                | S      | BE               | India              |                    | 33.7       | 7.3      |
| T026     | 80% Wool, 15% Viscose, 5% Elastane  | no      | sweater            | W         |                | S      | IT               | China              |                    | 33.4       | 0.6      |
| T232     | 35% Cotton, 65% PES                 |         | shirt              | M         |                | DS     | IE               | Outside Europe     |                    | 33.1       | 3.1      |
| T215     | 60% Wool, 40% PES                   |         | trousers           | M         |                | S      | HU               | Europe             |                    | 32.0       | 8.3      |
| T024     | 80% Wool, 20% PA                    | no      | sweater            | W         |                | DS     | IT               | China              |                    | 31.4       | 8.0      |
| T220     | 55% Silk, 45% Cashmere              | no      | sweater            | W         |                | DS     | PT               | China              |                    | 30.4       | 4.4      |
| T228     | 100% Cotton                         |         | underware          | M         | Yes            | OAM    | NL               | Unknown            |                    | 29.0       | 3.5      |
| T230     | 65% PES, 35% Cotton                 |         | shirt              | M         |                | S      | NL               | Unknown            |                    | 28.7       | 1.9      |
| T187     | 35% Cotton, 65% PES                 |         | shirt              | M         |                | S      | CY               | Unknown            | EC                 | 27.9       | 8.8      |
| T214     | 50% Acrylic, 40% Wool, 10% Viscose  | no      | sweater            | M         |                | S      | HU               | Europe             |                    | 27.5       | 2.4      |
| T128     | 100% Cotton                         |         | shirt              | M         |                | S      | BE               | Slovakia           | OT/EC              | 27.4       | 3.6      |
| T151     | 100% Cotton                         |         | sofa cushion cover | linen     |                | S      | DE               | Germany            |                    | 26.1       | 7.5      |
| T201     | 53% PES, 45% Wool, 2% Elastane      |         | trousers           | W         |                | DS     | UK               | China              |                    | 25.8       | 0.9      |
| T062     | 35% Cotton, 65% PES                 |         | shirt              | M         | Yes            | DS     | IT               | Imported           |                    | 25.7       | 7.1      |
| T133     | 100% Cotton                         |         | bedding pilloccase | linen     |                | S      | EE               | India              | OT                 | 25.3       | 0.7      |
| T198     | 100% Cotton                         |         | shirt              | M         |                | S      | UK               | Morocco            |                    | 24.2       | 1.9      |
| T028     | 50% Wool, 30% Angora, 20% Elastane  | no      | sweater            | W         |                | S      | IT               | China              |                    | 24.1       | 0.9      |
| T093     | 80% Cotton, 16% PA, 4% Elastane     |         | slip               | C 12-14 y | Yes            | OAM    | BE               | Spain              |                    | 23.5       | 1.8      |
| T209 av  | 95% Cotton, 5% Elastane             |         | T-shirt            | W         | Yes            | DS     | DK               | Turkey             |                    | 23.3       | 3.8      |
| T030     | 50% Acrylic, 40% Wool, 10% Elastane | no      | sweater            | W         |                | S      | IT               | China              |                    | 23.1       | 1.4      |
| T025     | 60% Wool, 35% Acrylic, 5% Elastane  | no      | sweater            | W         |                | S      | IT               | Imported           |                    | 23.0       | 1.9      |
| T051     | 80% Cotton, 20% PES                 | no      | sweater            | B 12 m    | Yes            | DS     | IT               | China              |                    | 22.8       | 5.1      |
| T159     | 100% Cotton                         |         | shirt              | W         | Yes            | S      | ES               | Imported           |                    | 22.6       | 4.4      |
| T163     | 100% Cotton                         |         | sofa cushion cover | linen     | Yes            | S      | SK               | Unknown            |                    | 22.2       | 3.1      |
| T094     | 100% Cotton                         |         | pyjama             | B 18-24 m | Yes            | S      | IT               | Italy              |                    | 22.0       | 2.6      |
| T202     | 77% Cotton, 23% PES                 |         | T-shirt            | B 9-12 m  |                | S      | UK               | China              |                    | 21.9       | 1.5      |
| T258     | 100% Cotton                         |         | T-shirt            | M         | Yes            | S      | LV               | Latvia             |                    | 21.7       | 0.7      |
| T239     | 44% PES, 42% Cotton, 14% Viscose    |         | shirt              | W         |                | S      | PL               | Poland             |                    | 21.4       | 0.7      |
| T029     | 70% Wool, 30% PA                    | no      | sweater            | W         |                | S      | IT               | China              |                    | 20.7       | 1.8      |
| T140     | 100% Cotton                         |         | T-shirt            | M         | Yes            | DS     | CZ               | Europe             |                    | 20.7       | 13.0     |
| T135     | 100% Cotton                         |         | sofa cushion cover | linen     |                | S      | PT               | India              |                    | 20.0       | 4.7      |

With regard to results obtained with the water extraction method, 10% of all samples (23 samples out of 221) released more than 30 mg/kg of formaldehyde. The highest value was 162.5 mg/kg, measured on a woman's pure cotton printed T-shirt, bought in a shop in Manchester (United Kingdom) and produced in Turkey.

11% of samples intended for direct contact with the skin (20 out of 183 samples, including bedding pillowcases and sofa cushion covers) exceeded the 30 mg/kg limit established by Commission Decision 2002/371/EC (Ecolabel). About 3% of the samples also exceeded the limit of 75 mg/kg set by the Oeko-Tex Standard 100 for articles in contact with skin.

5 out of 46 (11%) garments for babies under the age of two showed a release of formaldehyde higher than 20 mg/kg, whereas it should be not detectable both according to Oeko-Tex Standard 100 and the Japanese law 112. Two also exceeded the Ecolabel limit of 30 mg/kg (48 and 75 mg/kg respectively).

No sweaters, considered not in direct contact with the skin, went beyond the Ecolabel and Oeko-Tex Standard 100 limit of 300 mg/kg, but three of them contained over 30 mg/kg of formaldehyde.

From the results it appears that some categories of garments are more “at risk” than others. In fact, 22% of the analysed shirts exceeded the Ecolabel limit, whereas the percentages were 11%, 10%, 8%, 7%, 5% and 4% for trousers, T-shirts, sweaters, pillowcases, rompers and underwear respectively. However, it has to be noted that the categories of trousers, underwear and pillowcases contained fewer samples than other categories. Another remarkable result is that five out of ten shirts labelled “easy care” went beyond the Ecolabel limit.

Considering the target populations of this survey, men seem to be more exposed to formaldehyde than women, babies under the age of two and children; the percentages of samples above 30 mg/kg for each category being respectively 20%, 10%, 4% and 0%. However, this result could have been influenced by the fact that the great majority of analysed shirts were for men. If the limit of 20 mg/kg is considered for babies under the age of two and for children up to the age of fourteen, the percentages become 11% and 4% respectively.

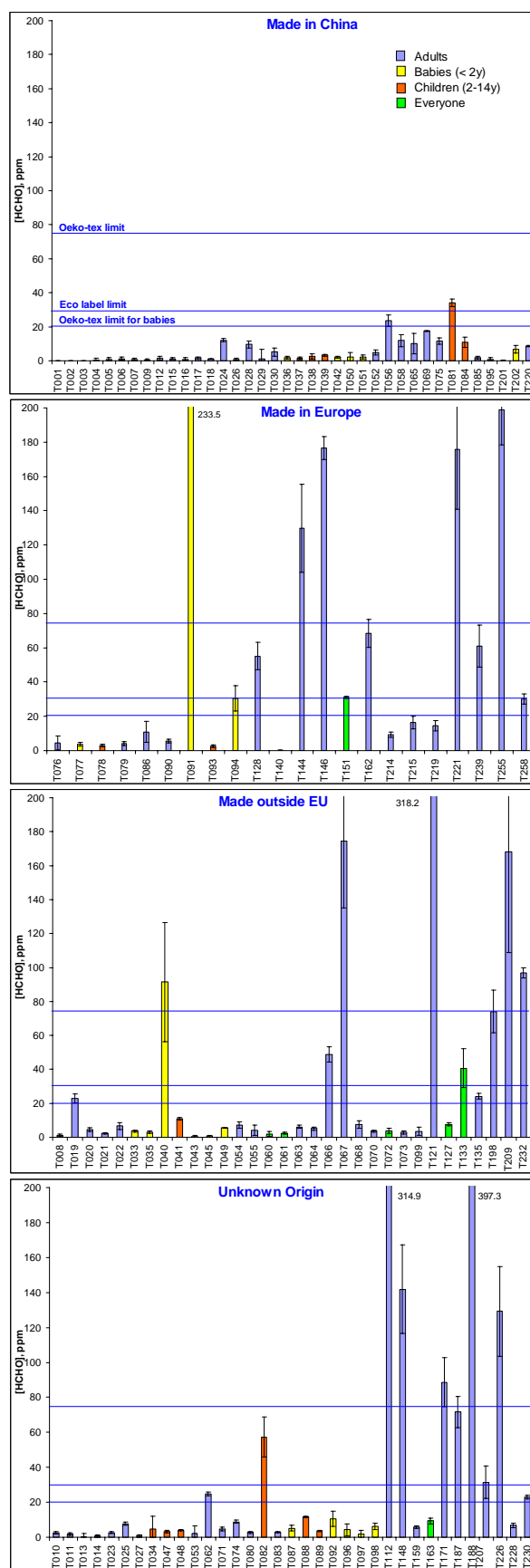
In this survey garments made of pure cotton and mixtures containing wool seem to release more formaldehyde than those made of mixtures containing cotton; the percentages of samples exceeding the limit of 30 mg/kg being 12%, 15% and 4% respectively.

Conclusive considerations considering the sample production area cannot be drawn due to similar percentages and to uncertainty caused by the number of samples with unknown origin. The percentages of samples exceeding the Ecolabel limit compared to the total number of samples in each production area were 14%, 8%, 6% and 13% for Europe, outside Europe, China and unknown origin respectively.

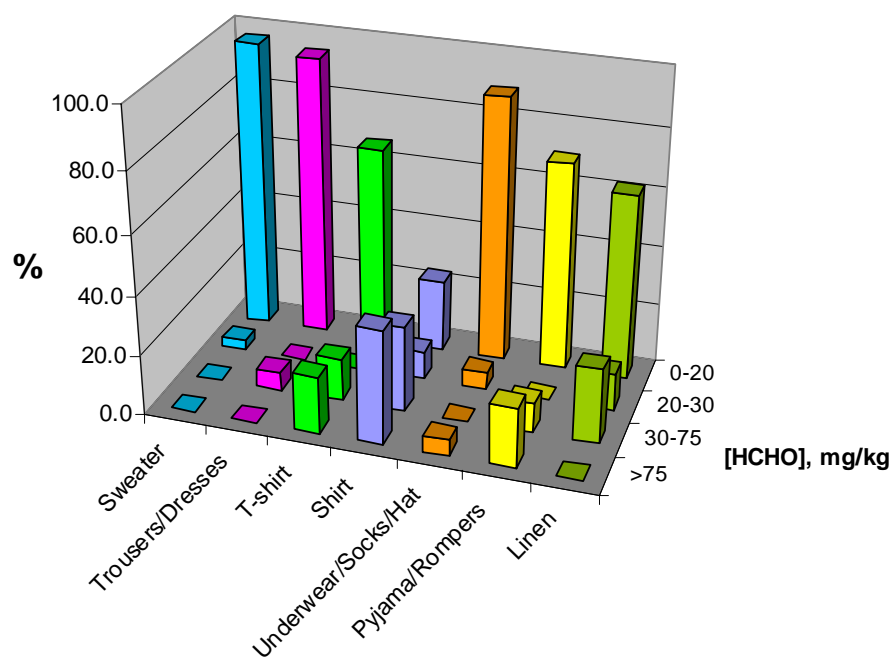
Also in the case of the different sources where samples were bought, no important differences resulted from the survey. In fact, the percentages of samples with more than 30 mg/kg for each category were 12% for shops, 11% for big department stores and 7% for open air markets.

Results obtained with standard method EN ISO 14184-2 are reported in Figures 13, 14 and 15. In addition, Table 5 reports data for samples which released more than 20 mg/kg of formaldehyde with the same method.

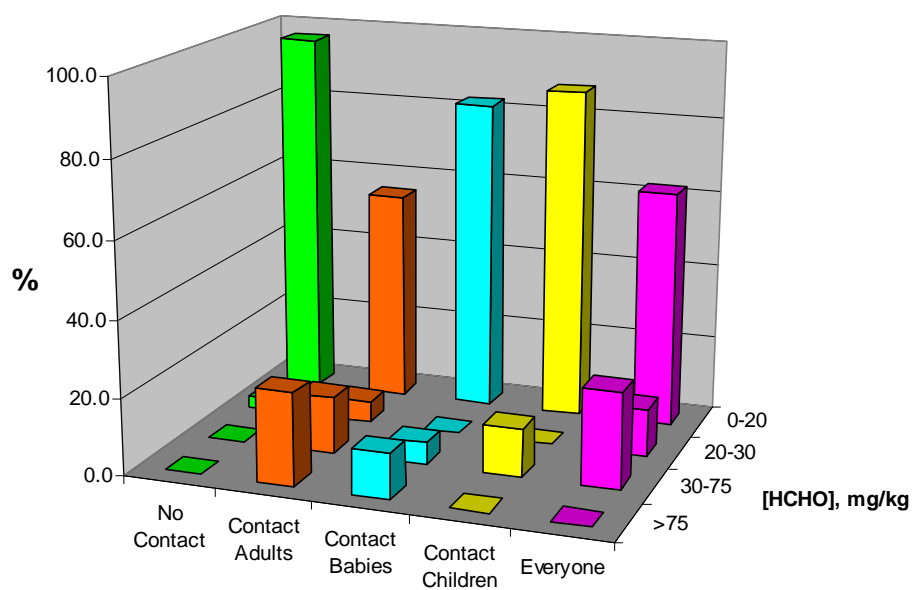




**Fig 13:** Released formaldehyde by standard method EN ISO 14184-2 (vapour absorption).



**Fig 14:** Proportion of samples by released formaldehyde with standard method EN ISO 14184-2 and textile categories.



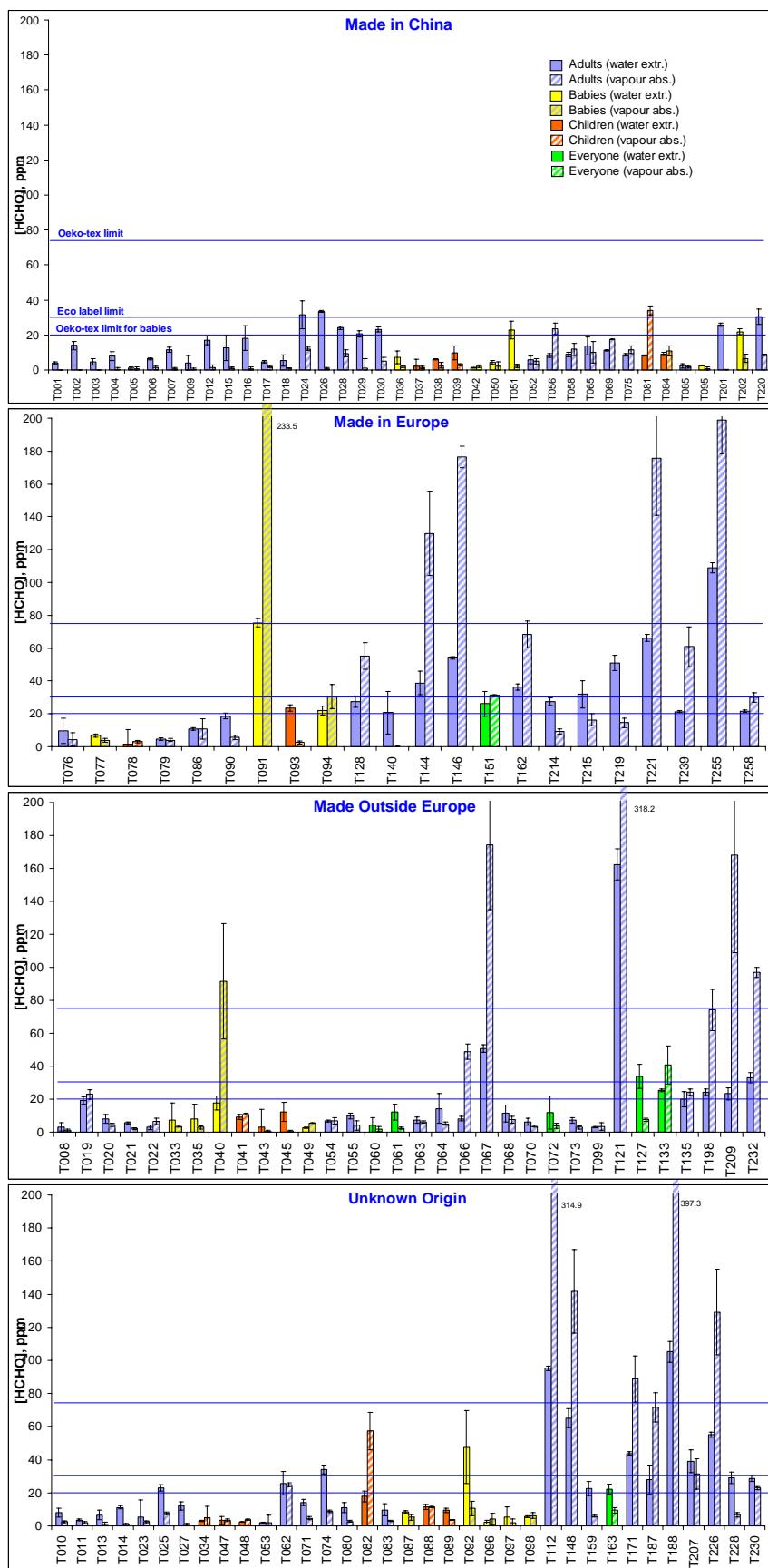
**Fig 15:** Proportion of samples by released formaldehyde with standard method EN ISO 14184-2 and target population.

**Table 5:** Released formaldehyde by standard method EN ISO 14184-2 (vapour absorption).

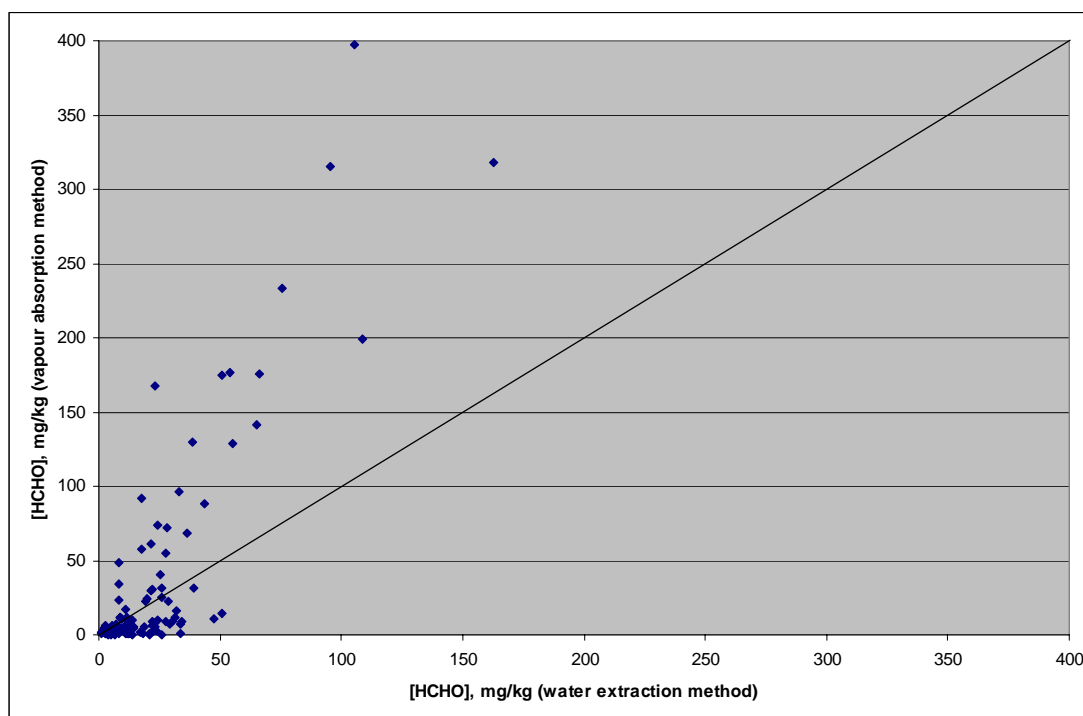
| JRC Code | Declared Composition             | Contact | Description  | Target    | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex | HCHO mg/kg | unc. |
|----------|----------------------------------|---------|--------------|-----------|----------------|--------|------------------|--------------------|--------------------|------------|------|
| T188     | 35% Cotton, 65% PES              |         | shirt        | M         |                | S      | CY               | U                  | EC                 | 397.3      | 27.7 |
| T121     | 100% Cotton                      |         | T-shirt      | W         | Yes            | S      | UK               | Turkey             |                    | 318.2      | 15.4 |
| T112     | 100% Cotton                      |         | shirt        | M         |                | S      | FR               | U                  | EC                 | 314.9      | 22.2 |
| T091     | 100% Cotton                      |         | rompers      | B 6 m     | Yes            | OAM    | IT               | Italy              |                    | 233.5      | 18.3 |
| T255     | 100% Cotton                      |         | shirt        | M         |                | U      | LV               | Germany            | EC                 | 198.7      | 20.4 |
| T146     | 100% Cotton                      |         | shirt        | M         |                | DS     | DE               | Slovakia           | OT                 | 176.5      | 6.7  |
| T221     | 100% Cotton                      |         | shirt        | M         |                | S      | PT               | Spain              | EC                 | 175.7      | 34.7 |
| T067     | 100% Cotton                      |         | T-shirt      | M         |                | DS     | IT               | Bangladesh         |                    | 174.4      | 39.3 |
| T209 av  | 95% Cotton, 5% Elastane          |         | T-shirt      | W         | Yes            | DS     | DK               | Turkey             |                    | 168.0      | 59.0 |
| T148     | 100% Cotton                      |         | shirt        | M         |                | DS     | DE               | U                  | EC                 | 141.8      | 25.3 |
| T144     | 100% Cotton                      |         | shirt        | M         |                | DS     | DE               | Germany            |                    | 129.8      | 25.7 |
| T226     | 100% Cotton                      |         | underware    | M         | Yes            | OAM    | NL               | U                  |                    | 129.2      | 25.8 |
| T232     | 35% Cotton, 65% PES              |         | shirt        | M         |                | DS     | IE               | Outside Europe     |                    | 96.8       | 3.1  |
| T040     | 100% Cotton                      |         | pyjama       | B 12 m    |                | DS     | IT               | India              |                    | 91.5       | 35.1 |
| T171     | 100% Cotton                      |         | T-shirt      | M         |                | DS     | LU               | U                  |                    | 88.7       | 13.9 |
| T198     | 100% Cotton                      |         | shirt        | M         |                | S      | UK               | Morocco            |                    | 74.1       | 12.5 |
| T187     | 35% Cotton, 65% PES              |         | shirt        | M         |                | S      | CY               | U                  | EC                 | 71.7       | 8.9  |
| T162     | 100% Cotton                      |         | shirt        | M         |                | S      | SK               | Slovakia           |                    | 68.4       | 8.1  |
| T239     | 44% PES, 42% Cotton, 14% Viscose |         | shirt        | W         |                | U      | PL               | Poland             |                    | 60.9       | 12.2 |
| T082     | 65% Cotton, 35% PES              |         | T-shirt      | C 6 y     | Yes            | OAM    | IT               | Imported           |                    | 57.3       | 11.4 |
| T128     | 100% Cotton                      |         | shirt        | M         |                | S      | BE               | Slovakia           | EC/OT              | 55.2       | 8.1  |
| T066     | 65% PES, 35% Cotton              |         | shirt        | W         |                | DS     | IT               | Bangladesh         |                    | 48.9       | 4.5  |
| T133     | 100% Cotton                      |         | pillowcase B | linen     |                | S      | EE               | India              | OT                 | 40.7       | 11.5 |
| T081     | 85% Cotton, 15% PES              |         | T-shirt      | C 10 y    | Yes            | OAM    | IT               | China              |                    | 34.1       | 2.4  |
| T207     | 100% Wool                        |         | trousers     | W         |                | S      | DK               | U                  |                    | 31.4       | 9.3  |
| T151     | 100% Cotton                      |         | pillowcase S | linen     |                | S      | DE               | Germany            |                    | 31.1       | 0.5  |
| T094     | 100% Cotton                      |         | pyjama       | B 18-24 m | Yes            | S      | IT               | Italy              |                    | 30.6       | 7.4  |
| T258     | 100% Cotton                      |         | T-shirt      | M         | Yes            | U      | LV               | Latvia             |                    | 30.0       | 3.0  |
| T062     | 35% Cotton, 65% PES              |         | shirt        | M         | Yes            | DS     | IT               | Imported           |                    | 24.8       | 1.1  |
| T135     | 100% Cotton                      |         | pillowcase S | linen     |                | S      | PT               | India              |                    | 24.2       | 1.8  |
| T056     | 100% Cotton                      |         | slip         | M         |                | DS     | IT               | China              |                    | 23.6       | 3.3  |
| T230     | 65% PES, 35% Cotton              |         | shirt        | M         |                | S      | NL               | U                  |                    | 22.9       | 1.0  |
| T019     | 100% Cotton                      | no      | sweater      | M         |                | DS     | IT               | Turkey             |                    | 22.9       | 2.8  |
| T215     | 60% Wool, 40% PES                |         | trousers     | M         |                | S      | HU               | Europe             |                    | 16.4       | 3.8  |
| T202     | 77% Cotton, 23% PES              |         | T-shirt      | B 9-12 m  |                | S      | UK               | China              |                    | 6.7        | 2.3  |

With regard to the vapour absorption method, the Ecolabel limit of 30 mg/kg was exceeded by 22% of the samples. About 12% of the samples released more than 75 mg/kg of formaldehyde, 397 mg/kg being the highest measured value for a man's cotton/polyester shirt, bought in a shop in Nicosia (Cyprus) with an unknown production country.

Results obtained using the two standard methods were often in the same range; however, sometimes the difference was not negligible. This is not surprising because different conditions are used for the migration step. The comparison of results obtained with the two methods is reported in Figures 16 and 17. In Fig. 17 the concentrations of formaldehyde measured with the two methods are reported on the x,y scales, so that all samples are represented by a point in the space. Points above the bisector line are samples in which the level of formaldehyde measured by the vapour absorption method was higher than the level measured with the other method. The picture seems to suggest that for high releases of formaldehyde (> 30 mg/kg) the EN-14184-2 standard method (vapour absorption) gives higher results than the EN-14184-1 (water extraction), whereas for lower concentration the opposite is more often true.



**Fig 16:** Comparison of results obtained by standard method EN ISO 14184-1 and EN ISO 14184-2.

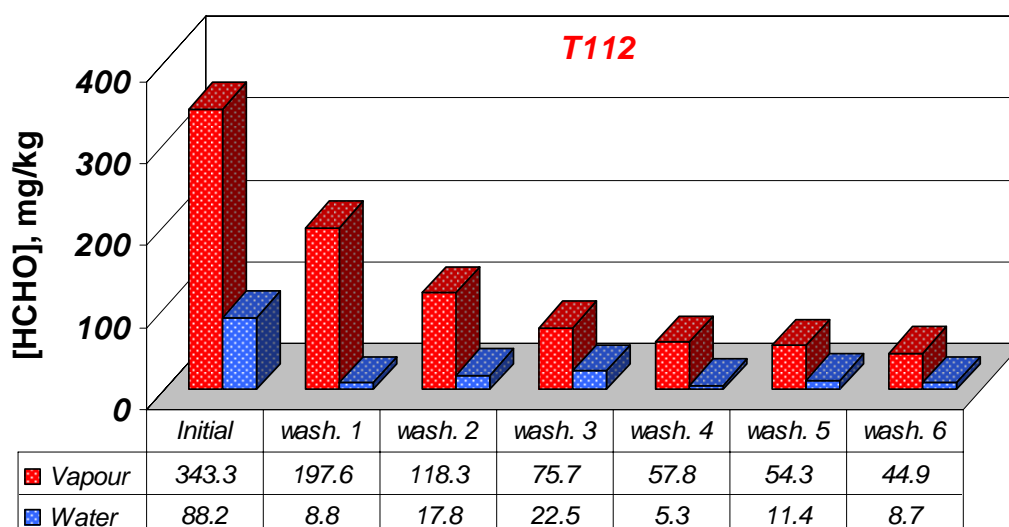


**Fig 17:** Comparison of results obtained by standard methods EN ISO 14184-1 and EN ISO 14184-2.

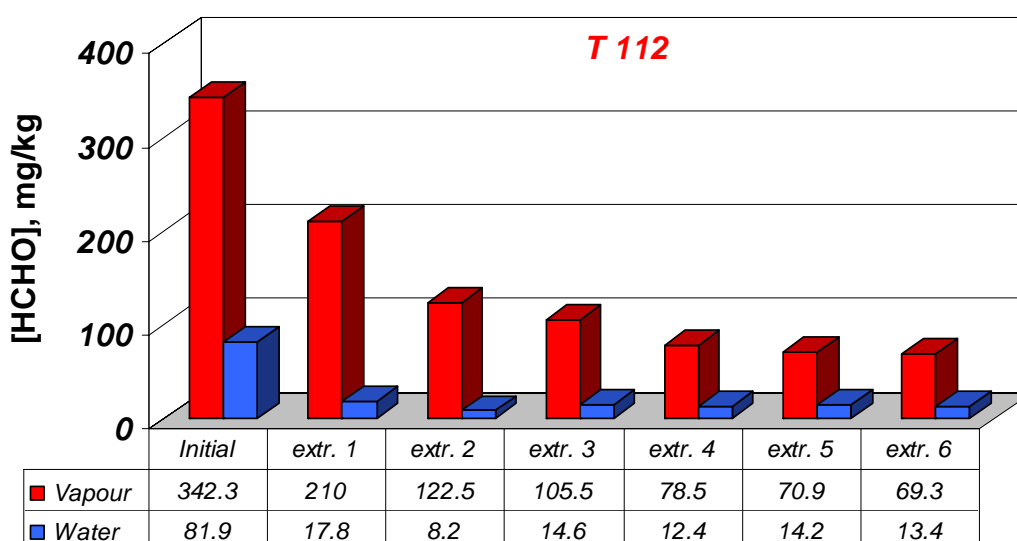
The influence of washing cycles on the release of formaldehyde was evaluated using sample 112, an “easy care” labelled pure cotton man’s shirt, as the content of formaldehyde was fairly high with both standard methods. Three specimens (triplicate) were analysed, then washed and analysed again and so on for seven washing cycles. Both standard methods were considered. As evident in Fig. 18, starting from 88 mg/kg of formaldehyde released from the unwashed article, after the first washing cycle the formaldehyde released with standard method EN-14184-1 dropped to less than 20 mg/kg (about one tenth of the original value and lower than the Ecolabel limit); then with further washing cycles the level remained low. Using standard method EN-14184-2, the level of formaldehyde released from the unwashed shirt was 343 mg/kg. This concentration gradually decreased with the number of washing cycles, but the level of formaldehyde remained higher than 30 mg/kg even after seven washing cycles (almost 45 mg/kg) and seemed to attain a plateau at about 20% of the original released level.

A different test was performed to study the release of formaldehyde by carrying out the migration test on the same specimens several times. Also in this case, results were calculated as averages of three replicates and both standard methods were considered.

As expected, over subsequent extractions, the level of released formaldehyde decreased; this is true for both methods.



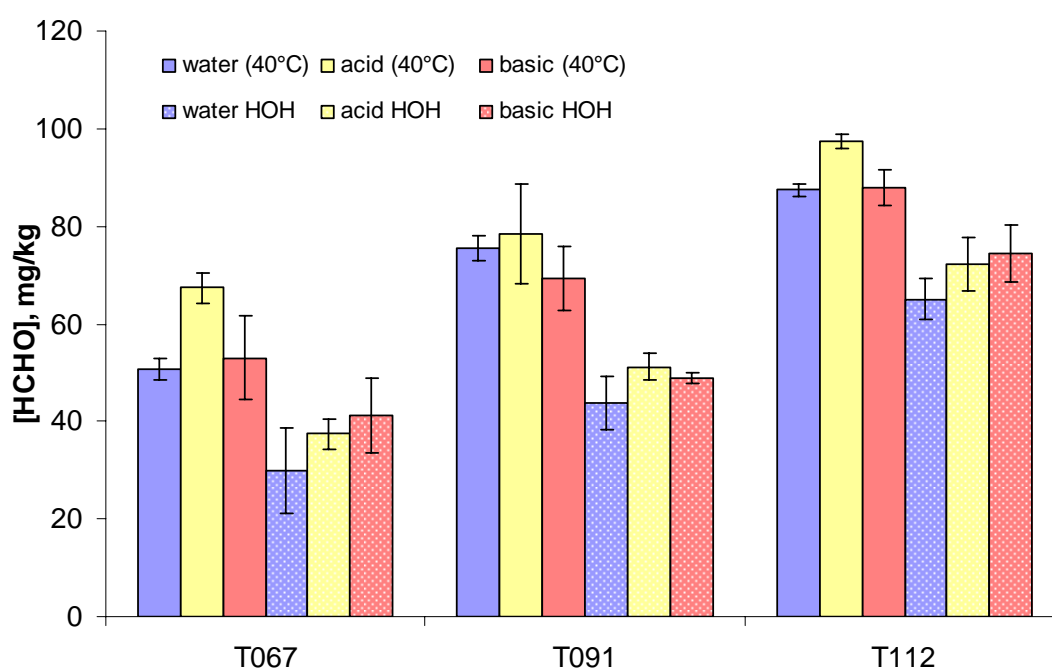
**Fig 18:** Influence of subsequent washing cycles on the release of formaldehyde.



**Fig 19:** Influence of subsequent extractions on the release of formaldehyde.

Humid conditions and high temperatures like the ones promoted by the presence of sweat and rubbing, for example under the armpits, are likely to increase the tendency of formaldehyde to be released from clothing in direct contact with skin. In an attempt to simulate this situation and to obtain a “worst case” scenario, some modifications were brought to the standard method EN ISO 14184-1.

A first series of experiments was performed on three samples with high formaldehyde release. The performance of three different extraction solutions (water, acid and basic artificial perspiration solutions) was compared, using both a normal oscillating water bath at 40 °C (as normally used for standard method EN ISO 14184-1) and a Head Over Heels instrument (see Picture 3). The Head Over Heels equipment was used with the intention to increase the rubbing effect: the extraction bottles containing samples were rotated up/down at a speed of 60 rpm. Unfortunately, in this case it was impossible to set a specified temperature, so the migration process was carried out at a room temperature of 25 °C.

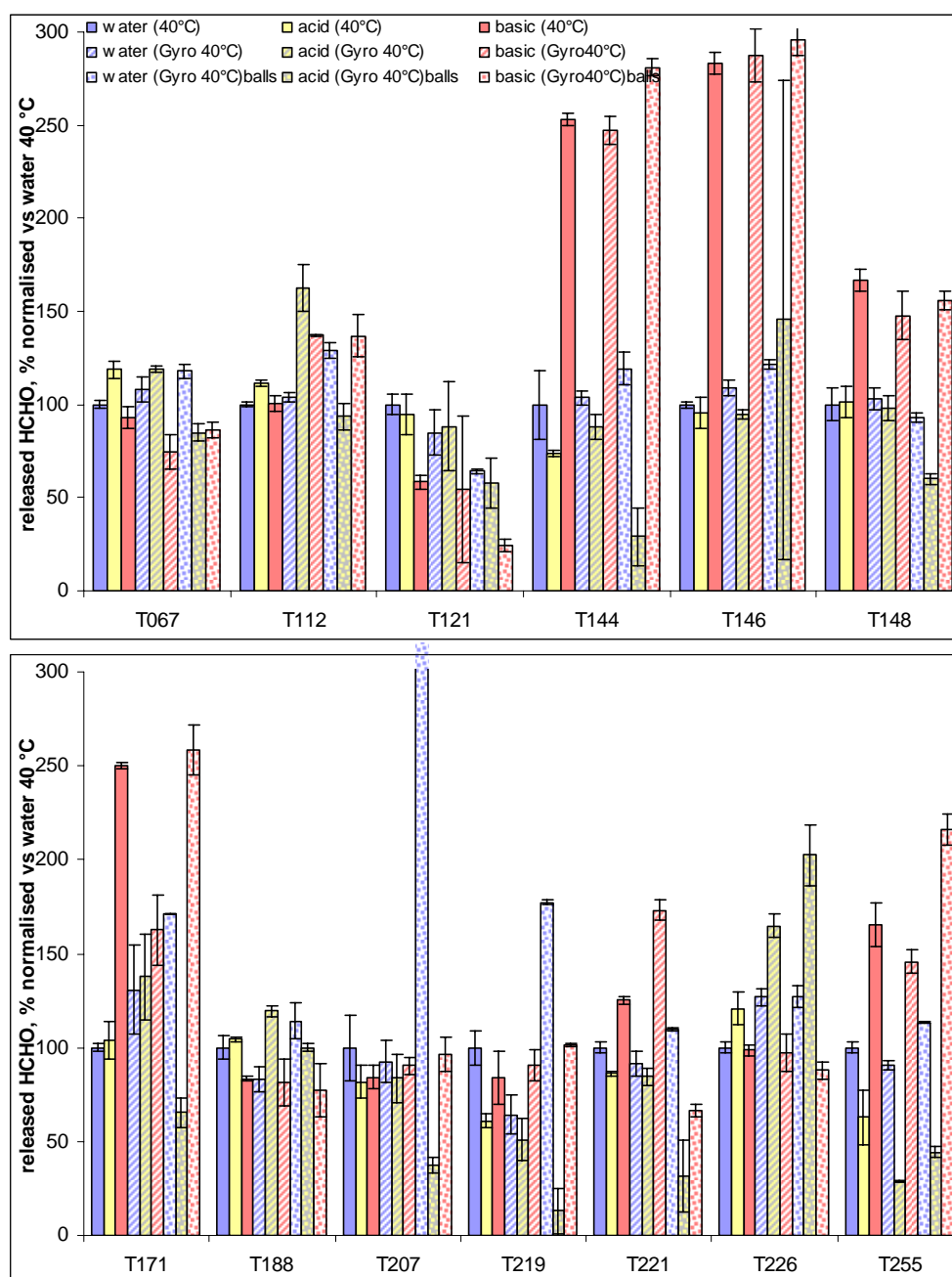


**Fig 20:** Influence of rubbing on the release of formaldehyde.

The analysed samples were T067, T091 and T112, a T-shirt, a rompers and a shirt respectively, all made of pure cotton. As reported in Fig. 20, the Head Over Heels extraction was less efficient than the one carried out in the oscillating water bath, most probably only because of the lower temperature (25 °C instead of 40 °C). In fact, this parameter can certainly have a high impact on migration processes. Comparing the different extraction media using the water bath, the acid perspiration solution seemed to be the most efficient for these samples.

In order to increase the rubbing effect while maintaining the temperature of the migration process constant at 40 °C, a Gyrowash equipment (see Picture 4) normally

used for testing colour fastness was employed. To further increase this effect, some experiments were performed adding 10 stainless steel balls, 12 mm diameter, in each sample holder of the Gyrowash. As in the case of Head Over Heels, specimens were placed in extraction vessels which were fixed to a cylinder which rotated on its own axis.



**Fig 21:** Comparison of water bath and Gyrowash extraction.



**Table 6:** Released formaldehyde by EN ISO 14184-1 standard method modified with simulants, Gyrowash and stainless steel balls.

| JRC<br>code | [HCHO], mg/kg     |              |              |                 |              |              |                                       |              |              |
|-------------|-------------------|--------------|--------------|-----------------|--------------|--------------|---------------------------------------|--------------|--------------|
|             | water bath, 40 °C |              |              | Gyrowash, 40 °C |              |              | Gyrowash 40 °C, stainless steel balls |              |              |
|             | water             | acid         | basic        | water           | acid         | basic        | water                                 | acid         | basic        |
| T067        | 66.0 ± 1.4        | 78.4 ± 3.5   | 61.4 ± 3.5   | 71.6 ± 4.8      | 78.4 ± 1.3   | 49.2 ± 4.6   | 77.9 ± 3.0                            | 56.1 ± 2.4   | 56.9 ± 2.3   |
| T112        | 95.3 ± 1.4        | 106.3 ± 1.5  | 95.9 ± 3.9   | 99.2 ± 2.3      | 154.8 ± 19.3 | 130.8 ± 0.5  | 123.0 ± 5.6                           | 89.2 ± 6.2   | 130.2 ± 14.7 |
| T121        | 162.5 ± 9.3       | 154.0 ± 16.3 | 95.1 ± 3.7   | 138.2 ± 17.2    | 143.6 ± 34.5 | 88.5 ± 35.0  | 104.5 ± 1.5                           | 93.9 ± 12.5  | 39.9 ± 1.3   |
| T144        | 38.7 ± 7.1        | 28.6 ± 0.5   | 97.9 ± 3.3   | 40.1 ± 1.5      | 34.0 ± 2.3   | 95.6 ± 7.1   | 46.1 ± 4.0                            | 11.2 ± 1.7   | 108.8 ± 4.7  |
| T146        | 54.1 ± 0.9        | 51.7 ± 4.3   | 153.3 ± 9.0  | 59.1 ± 2.5      | 51.2 ± 1.2   | 155.4 ± 22.5 | 65.8 ± 1.6                            | 78.7 ± 101.1 | 160.1 ± 14.1 |
| T148        | 65 ± 5.7          | 66.0 ± 5.5   | 108.3 ± 6.2  | 67.0 ± 3.9      | 63.8 ± 4.4   | 96.0 ± 12.6  | 60.6 ± 1.6                            | 39.1 ± 1.1   | 101.4 ± 4.9  |
| T171        | 43.8 ± 1.0        | 45.5 ± 4.5   | 109.5 ± 1.6  | 57.3 ± 13.5     | 60.3 ± 13.8  | 71.2 ± 13.5  | 74.9 ± 0.1                            | 28.6 ± 2.3   | 113.3 ± 15.2 |
| T188        | 105.2 ± 6.4       | 110.0 ± 1.4  | 87.8 ± 0.9   | 87.4 ± 5.9      | 125.5 ± 3.8  | 85.7 ± 10.4  | 120.2 ± 11.5                          | 105.1 ± 2.0  | 81.2 ± 11.6  |
| T207        | 39.0 ± 6.8        | 31.9 ± 2.8   | 32.8 ± 2.0   | 36.1 ± 4.1      | 32.7 ± 4.2   | 35.3 ± 1.6   | 123.2 ± 1.5                           | 14.6 ± 0.6   | 37.7 ± 3.5   |
| T219        | 51.0 ± 4.7        | 31.1 ± 1.1   | 42.9 ± 6.0   | 32.8 ± 3.5      | 26.0 ± 2.9   | 46.3 ± 3.8   | 90.4 ± 1.2                            | 6.7 ± 0.8    | 51.7 ± 0.4   |
| T221        | 66.2 ± 2.1        | 57.0 ± 0.8   | 82.9 ± 1.9   | 60.5 ± 3.8      | 56.0 ± 2.6   | 114.5 ± 6.1  | 72.8 ± 0.6                            | 20.8 ± 4.0   | 44.0 ± 1.5   |
| T226        | 55.2 ± 1.5        | 66.7 ± 5.9   | 54.5 ± 1.6   | 70.1 ± 3.1      | 90.9 ± 5.7   | 53.6 ± 5.2   | 70.2 ± 4.2                            | 111.8 ± 18.2 | 48.4 ± 2.1   |
| T255        | 108.8 ± 3.1       | 68.3 ± 9.7   | 180.1 ± 20.9 | 98.5 ± 2.1      | 31.2 ± 0.1   | 158.5 ± 10.1 | 123.4 ± 0.4                           | 48.1 ± 1.4   | 235.3 ± 19.9 |

Some problems were experienced when the acid perspiration solution was used in combination with stainless steel balls 304, as at the end of the migration process, the solution was lightly coloured after the colorimetric reaction even in the absence of a sample, thus creating interferences in the quantitative determination of formaldehyde. For these reasons, the results obtained with this method are probably affected by a systematic error.

The results in Fig. 21 and Table 6 show that the majority of samples released the highest quantity of formaldehyde when tested in the Gyrowash (11 out of 13), thus confirming that the rubbing effect is an important parameter in the release of chemicals from textiles. Seven out of eleven samples released more formaldehyde when stainless steel balls were used. In addition, considering the fact that of the remaining four samples, three released a higher quantity of formaldehyde in the Gyrowash without balls with the acid perspiration solution and that interferences were experienced with this simulant in combination with balls, it can be concluded that the “worst case” can usually be obtained by modifying standard method EN ISO 14184-1 using a Gyrowash for the migration step and stainless steel balls to increase the rubbing effect. In the case of the acid perspiration solution, balls should be made by stainless steel that are resistant to this solution.

Considering now the effect of substituting water with an artificial perspiration solution, the greatest proportion of samples (10 out of 13) showed the highest release of formaldehyde in the presence of sweat simulants, six of them with the basic one and four of them with the acid simulant. The increase in formaldehyde release is quite significant, in fact for ten samples it was more than 150% and up to 300% when compared with the result obtained with the unchanged standard method, i.e. water

extraction in oscillating water bath. For all the studied samples the “worst case” scenario was represented by a release of formaldehyde higher than 75 mg/kg. This is also true for sample T146 which is a shirt labelled Oeko-Tex Standard 100. The highest release was 235 mg/kg in the case of sample T255 in Gyrowash with stainless steel balls and basic perspiration solution.

The fact that the highest release (“worst case”) was not always measured with the same simulant is not surprising if we consider that samples were probably treated with different resins which can have a different chemical behaviour.

Globally, the results confirmed the idea that to better mimic real conditions of use and to obtain a “worst case” release, method EN ISO 14184-1 should be modified using artificial perspiration solutions, both the acid and the basic one, and using Gyrowash to increase the rubbing effect.

**Table 7:** Comparison total amount of formaldehyde and released formaldehyde.

|          | water extraction | vapour absorption | after hydrolisis      |
|----------|------------------|-------------------|-----------------------|
| JRC code | [HCOH]<br>mg/kg  | [HCOH]<br>mg/kg   | [HCOH] total<br>mg/kg |
| T067     | 50.7 ± 2.3 (3)   | 174.4 ± 39.3 (3)  | 806.4 ± 308.8 (3)     |
| T091     | 75.4 ± 2.6 (3)   | 233.5 ± 18.3 (3)  | 2034.8 ± 622.4 (3)    |
| T112     | 95.3 ± 1.4 (3)   | 314.9 ± 22.2 (3)  | 9354.6 ± 2098.4 (3)   |
| T121     | 162.5 ± 9.3 (3)  | 318.2 ± 15.4 (3)  | 872.2 ± 238.5 (3)     |
| T144     | 38.7 ± 7.1 (3)   | 129.8 ± 25.7 (3)  | 12769.9 ± 802.7 (3)   |
| T146     | 54.1 ± 0.9 (3)   | 176.5 ± 6.7 (3)   | 18198.8 ± 3343.8 (3)  |
| T148     | 65.0 ± 5.7 (3)   | 141.8 ± 25.3 (3)  | 14462.1 ± 1625.6 (3)  |
| T171     | 43.8 ± 1.0 (3)   | 88.7 ± 13.9 (3)   | 13903.6 ± 4064.2 (3)  |
| T188     | 105.2 ± 6.4 (3)  | 397.3 ± 27.7 (3)  | 1334.3 ± 508.7 (3)    |
| T219     | 51.0 ± 4.7 (3)   | 14.5 ± 2.8 (3)    | 383.8 ± 799.9 (3)     |
| T221     | 66.2 ± 2.1 (3)   | 175.7 ± 34.7 (3)  | 11260.5 ± 1687.5 (3)  |
| T226     | 55.2 ± 1.5 (3)   | 129.2 ± 25.8 (3)  | 2465.1 ± 1776.1 (3)   |
| T255     | 108.8 ± 3.1 (3)  | 198.7 ± 20.4 (3)  | 18646.9 ± 4605.2 (3)  |

The total content of formaldehyde was measured with Roff’s method after the hydrolysis of the resin on the same samples that showed the highest formaldehyde release. Also in this case, measurements were performed in triplicate. As expected, the total quantity of formaldehyde was very high, ranging from about 400 mg/kg to 19000 mg/kg depending on the samples.

On these samples, results showed that the total amount of formaldehyde was generally in inverse relation to the quantity of released formaldehyde in the water extraction method. In fact, samples with the highest global amount of formaldehyde (higher than 10000 mg/kg) showed the lowest per cent release (lower than 1%),

whereas samples with total concentration lower than 2500 mg/kg showed a per cent release from 2 to almost 20%. Obviously the proportion of the release is very much dependent on the type of resin used in the finishing and also on the conditions applied for the finishing. For these reasons, generalisations are not possible.

In order to assess human dermal exposure to formaldehyde released from textiles, the following equation, used in a study made by the Danish Environmental Protection Agency<sup>15</sup> and taken from the Technical Guidance Document (TGD)<sup>16</sup> after modification to the exposure scenario, was considered:

$$U_{derm} = \frac{Q_{prod} * F_{c_{prod}} * F_{AREA,derm} * N_{event}}{BW}$$

Where:

|                 |  |              |
|-----------------|--|--------------|
| $U_{derm}$      | is the potential uptake of the compound    | mg/kg bw/day |
| $Q_{prod}$      | is the amount of textile                   | kg           |
| $F_{c_{prod}}$  | is the fraction of compound in the textile | mg/kg        |
| $F_{AREA,derm}$ | is the fraction of exposed skin            |              |
| $N_{event}$     | number of exposure events                  | per day      |
| BW              | bodyweight (bw)                            | kg           |

The amount of textile in this study was considered as 500 g for an adult. In fact, it has to be noted that for the assessment of dermal exposure, full coverage of the body excepting head, hands and feet is usually used. TGD considers a total body area of 19400 cm<sup>2</sup> for men and 16900 cm<sup>2</sup> for women, the average being 18150 cm<sup>2</sup> with an estimated area including head, neck and feet of 2981 cm<sup>2</sup>. Considering an exposed body surface for an adult corresponding to about 85% of the total body area, that is 15000 cm<sup>2</sup>, and a textile of 333 g/m<sup>2</sup>, the weight of textile that covers the exposed body surface is about 500 g. In the case of a child of about one year old, the total body surface is estimated as 6700 cm<sup>2</sup>, the exposed body surface would be about 5700 cm<sup>2</sup> and the weight of textile needed to cover this area is about 190 g.

Body weights of 70 kg and 10 kg for adults and children respectively were considered, as recommended in the TGD.

The potential dermal uptake should be multiplied by the absorption factor ( $F_{ab}$ ) that takes the dermal absorption into consideration. However, in the absence of information regarding this parameter, a dermal absorption of 100% was used, as suggested in the TGD.

Data on formaldehyde release obtained with the water extraction standard method (EN ISO 14184-1) and with the worst case modified method (varying with the sample, usually Gyrowash and stainless steel balls with either acid or basic perspiration solution) were used to estimate adult and child exposure as reported below.

Calculation example:

Adult dermal exposure:  $162.5 \text{ (mg/kg)} \times 0.5 \text{ (kg)} / 70 \text{ (kg bw)} = 1.1607 \text{ mg/kg bw}$

Child dermal exposure:  $162.5 \text{ (mg/kg)} \times 0.19 \text{ (kg)} / 10 \text{ (kg bw)} = 3.0875 \text{ mg/kg bw}$

**Table 8:** Dermal uptake of formaldehyde.

| JRC Code | Declared Composition                | water      | dermal exposure |                | worst case | dermal exposure |                |
|----------|-------------------------------------|------------|-----------------|----------------|------------|-----------------|----------------|
|          |                                     | HCHO mg/kg | adult mg/kg bw  | child mg/kg bw | HCHO mg/kg | adult mg/kg bw  | child mg/kg bw |
| T121     | 100% Cotton                         | 162.5      | 1.1607          | 3.0875         | 162.5      | 1.1607          | 3.0875         |
| T255     | 100% Cotton                         | 108.8      | 0.7771          | 2.0672         | 235.3      | 1.6807          | 4.4707         |
| T188     | 35% Cotton, 65% PES                 | 105.2      | 0.7514          | 1.9988         | 125.5      | 0.8964          | 2.3845         |
| T112     | 100% Cotton                         | 95.3       | 0.6807          | 1.8107         | 154.8      | 1.1057          | 2.9412         |
| T091     | 100% Cotton                         | 75.4       | 0.5386          | 1.4326         |            |                 |                |
| T221     | 100% Cotton                         | 66.2       | 0.4729          | 1.2578         | 114.5      | 0.8179          | 2.1755         |
| T148     | 100% Cotton                         | 65.0       | 0.4643          | 1.2350         | 108.3      | 0.7736          | 2.0577         |
| T226     | 100% Cotton                         | 55.2       | 0.3943          | 1.0488         | 111.8      | 0.7986          | 2.1242         |
| T146     | 100% Cotton                         | 54.1       | 0.3864          | 1.0279         | 160.1      | 1.1436          | 3.0419         |
| T219     | 66% Wool, 30% PES, 4% other fibers  | 51.0       | 0.3643          | 0.9690         | 90.4       | 0.6457          | 1.7176         |
| T067     | 100% Cotton                         | 50.7       | 0.3621          | 0.9633         | 78.4       | 0.5600          | 1.4896         |
| T092 mix | 100% Cotton                         | 47.7       | 0.3407          | 0.9063         |            |                 |                |
| T171     | 100% Cotton                         | 43.8       | 0.3129          | 0.8322         | 113.3      | 0.8093          | 2.1527         |
| T207     | 100% Wool                           | 39.0       | 0.2786          | 0.7410         | 123.2      | 0.8800          | 2.3408         |
| T144     | 100% Cotton                         | 38.7       | 0.2764          | 0.7353         | 108.8      | 0.7771          | 2.0672         |
| T162     | 100% Cotton                         | 36.4       | 0.2600          | 0.6916         |            |                 |                |
| T074     | 100% Cotton                         | 34.2       | 0.2443          | 0.6498         |            |                 |                |
| T127     | 100% Cotton                         | 33.7       | 0.2407          | 0.6403         |            |                 |                |
| T026     | 80% Wool, 15% Viscose, 5% Elastane  | 33.4       | 0.2386          | 0.6346         |            |                 |                |
| T232     | 35% Cotton, 65% PES                 | 33.1       | 0.2364          | 0.6289         |            |                 |                |
| T215     | 60% Wool, 40% PES                   | 32.0       | 0.2286          | 0.6080         |            |                 |                |
| T024     | 80% Wool, 20% PA                    | 31.4       | 0.2243          | 0.5966         |            |                 |                |
| T220     | 55% Silk, 45% Cashmere              | 30.4       | 0.2171          | 0.5776         |            |                 |                |
| T228     | 100% Cotton                         | 29.0       | 0.2071          | 0.5510         |            |                 |                |
| T230     | 65% PES, 35% Cotton                 | 28.7       | 0.2050          | 0.5453         |            |                 |                |
| T187     | 35% Cotton, 65% PES                 | 27.9       | 0.1993          | 0.5301         |            |                 |                |
| T214     | 50% Acrylic, 40% Wool, 10% Viscose  | 27.5       | 0.1964          | 0.5225         |            |                 |                |
| T128     | 100% Cotton                         | 27.4       | 0.1957          | 0.5206         |            |                 |                |
| T151     | 100% Cotton                         | 26.1       | 0.1864          | 0.4959         |            |                 |                |
| T201     | 53% PES, 45% Wool, 2% Elastane      | 25.8       | 0.1843          | 0.4902         |            |                 |                |
| T062     | 35% Cotton, 65% PES                 | 25.7       | 0.1836          | 0.4883         |            |                 |                |
| T133     | 100% Cotton                         | 25.3       | 0.1807          | 0.4807         |            |                 |                |
| T198     | 100% Cotton                         | 24.2       | 0.1729          | 0.4598         |            |                 |                |
| T028     | 50% Wool, 30% Angora, 20% Elastane  | 24.1       | 0.1721          | 0.4579         |            |                 |                |
| T093     | 80% Cotton, 16% PA, 4% Elastane     | 23.5       | 0.1679          | 0.4465         |            |                 |                |
| T209 av  | 95% Cotton, 5% Elastane             | 23.3       | 0.1664          | 0.4427         |            |                 |                |
| T030     | 50% Acrylic, 40% Wool, 10% Elastane | 23.1       | 0.1650          | 0.4389         |            |                 |                |
| T025     | 60% Wool, 35% Acrylic, 5% Elastane  | 23.0       | 0.1643          | 0.4370         |            |                 |                |
| T051     | 80% Cotton, 20% PES                 | 22.8       | 0.1629          | 0.4332         |            |                 |                |
| T159     | 100% Cotton                         | 22.6       | 0.1614          | 0.4294         |            |                 |                |
| T163     | 100% Cotton                         | 22.2       | 0.1586          | 0.4218         |            |                 |                |
| T094     | 100% Cotton                         | 22.0       | 0.1571          | 0.4180         |            |                 |                |
| T202     | 77% Cotton, 23% PES                 | 21.9       | 0.1564          | 0.4161         |            |                 |                |
| T258     | 100% Cotton                         | 21.7       | 0.1550          | 0.4123         |            |                 |                |
| T239     | 44% PES, 42% Cotton, 14% Viscose    | 21.4       | 0.1529          | 0.4066         |            |                 |                |
| T029     | 70% Wool, 30% PA                    | 20.7       | 0.1479          | 0.3933         |            |                 |                |
| T140     | 100% Cotton                         | 20.7       | 0.1479          | 0.3933         |            |                 |                |
| T135     | 100% Cotton                         | 20.0       | 0.1429          | 0.3800         |            |                 |                |

The highest estimated dermal uptakes, based on the data obtained with the standard method, were 1.2 and 3.1 mg/kg bw for adult and child respectively, for a pure cotton

printed T-shirt. Using the data obtained with the modified method to obtain a worst case scenario, the highest dermal exposures were 1.7 and 4.5 mg/kg bw for adult and child respectively, for a pure cotton “easy care” shirt.

## 6. Conclusions

A European survey on the level of formaldehyde released from textiles, in particular textile clothing, produced all over the world has been performed. The selection of fabrics was planned among textile products that are believed to contain formaldehyde, in order to cover as many different types of fibres and type of fabrics as possible. Seven categories were considered: 1) trousers and dresses; 2) underwear, socks and hats; 3) sweaters; 4) rompers and pyjamas; 5) shirts; 6) T-shirts; 7) bedding pillowcases and sofa cushion covers. The whole population was considered as target, i.e. men, women, babies under the age of two and children up to 14 years old. Samples were bought in 21 Member States of the European Union, from different sources (shops, department stores and open air market), with different compositions (pure cotton, cotton mixtures and wool mixtures) and various production countries or areas, e.g. Europe, China, rest of the world. Part of them was printed and some were “easy care” or Oeko-Tex labelled.

A total of 221 samples were analysed with standard method EN ISO 14184-1 (water extraction) and 127 with standard method EN ISO 14184-2 (vapour absorption). Measurements were performed in triplicate and uncertainties were calculated at 95 % of probability.

In the case of the water extraction method, 11% of samples intended to be in direct contact with skin exceeded the limit established by Commission Decision 2002/371/EC (Ecolabel), i.e. 30 mg/kg. About 3% were higher than 75 mg/kg, which is the limit set by Oeko-Tex Standard 100. In the case of babies under the age of two, 11% of garments released more than 20 mg/kg of formaldehyde, which is the Oeko-Tex Standard 100 limit for babies.

The sample manufacturing area (Europe, China, rest of the world) and the purchase sources (shops, department stores and open air markets) do not seem to influence the results, as percentages of samples exceeding the Ecolabel limit from the different purchase and manufacturing sources are similar.

All textile categories were represented among the samples which released more than 30 mg/kg of formaldehyde, but shirts seem to be the category with the highest risk of exceeding the limit of 30 mg/kg (22% of them). Moreover, five out of ten “easy care” labelled shirts exceeded the Ecolabel limit. Similarly, pure cotton and mixtures

containing wool seem to release more formaldehyde than garments made of mixtures containing cotton and other fibres.

Considering the vapour absorption method, 22% of samples released more than 30 mg/kg of formaldehyde and 12% more than 75 mg/kg, 397 mg/kg being the highest measured value.

Results obtained with the two standard methods were usually in the same range for low levels of formaldehyde; however for releases of over 30 mg/kg, the vapour absorption method gives frequently higher results than the water extraction method.

Domestic washing effectively reduces the level of released formaldehyde. After the first washing cycle with the water extraction method, the level of formaldehyde was reduced to 10% of the initial value and decreased to 60% in the case of the vapour absorption method.

The standard method EN ISO 14184-1 was modified to better mimic the real conditions of use of garments. Artificial perspiration solutions (acid and basic sweat), washing machine generally used to determine colour fastness and stainless steel balls were used to increase the rubbing effect and to better reproduce the real conditions of direct skin-textile contact. The release of formaldehyde was maximised with this newly developed method.

Following the recommendations of the Technical Guidance Document, release data were used to estimate the dermal exposure of an adult and a child. The maximum estimated dermal uptakes were 1.7 and 4.5 mg/kg bw for an adult and a child respectively, with calculation based on data obtained with the modified method. The maximum estimated dermal uptakes calculated based on data obtained with the standard method EN ISO 14184-1 were 1.2 and 3.1 mg/kg bw for an adult and a child respectively.

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# **Annex I**

## **Results**






**Table 1:** Description of samples.






















| JRC Code | Picture   | Declared Composition                | Description | Target | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|-------------------------------------|-------------|--------|----------------|--------|------------------|--------------------|--------------------|
| T001     |    | 80% Cotton, 20% Viscose             | sweater     | W      |                | OAM    | IT               | China              |                    |
| T002     |    | 60% Wool, 35% Acrylic, 5% Elastane  | sweater     | W      |                | OAM    | IT               | China              |                    |
| T003     |    | 80% Wool, 15% Acrylic, 5% Elastane  | sweater     | W      |                | OAM    | IT               | China              |                    |
| T004     |    | 80% Wool, 15% Acrylic, 5% Elastane  | sweater     | W      |                | OAM    | IT               | China              |                    |
| T005     |    | 80% Wool, 20% Cotton                | sweater     | W      |                | OAM    | IT               | China              |                    |
| T006     |    | 90% Wool (Merinos), 10% Elastane    | sweater     | W      |                | OAM    | IT               | China              |                    |
| T007     |    | 55% Wool, 30% Acrylic, 15% Elastane | sweater     | W      |                | OAM    | IT               | China              |                    |
| T008     |    | 70% Acrylic, 30% Wool (Merinos)     | sweater     | W      |                | DS     | IT               | Bangladesh         |                    |
| T009     |   | 50% Wool, 50% Acrylic               | sweater     | W      |                | OAM    | IT               | China              |                    |
| T010     |  | 55% Wool, 45% Acrylic               | sweater     | M      |                | OAM    | IT               | Imported           |                    |
| T011     |  | 100% Cotton                         | sweater     | M      |                | OAM    | IT               | Imported           |                    |
| T012     |  | 50% Wool, 50% Acrylic               | sweater     | W      |                | OAM    | IT               | China              |                    |
| T013     |  | 70% Wool, 22% PA, 8% Elastane       | sweater     | W      |                | OAM    | IT               | Imported           |                    |
| T014     |  | 70% Wool, 22% PA, 8% Elastane       | sweater     | W      |                | OAM    | IT               | Imported           |                    |
| T015     |  | 70% Wool, 30% Acrylic               | sweater     | W      |                | S      | IT               | China              |                    |
| T016     |  | 90% Wool, 10% Elastane              | sweater     | W      |                | S      | IT               | China              |                    |
| T017     |  | 90% Wool, 10% Elastane              | sweater     | W      |                | S      | IT               | China              |                    |
| T018     |  | 90% Wool, 10% Elastane              | sweater     | W      |                | S      | IT               | China              |                    |
| T019     |  | 100% Cotton                         | sweater     | M      |                | DS     | IT               | Turkey             |                    |
| T020     |  | 100% Cotton                         | sweater     | M      |                | DS     | IT               | Bangladesh         |                    |

| JRC Code | Picture   | Declared Composition                | Description | Target  | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|-------------------------------------|-------------|---------|----------------|--------|------------------|--------------------|--------------------|
| T021     |    | 100% Cotton                         | trousers    | M       |                | DS     | IT               | Bangladesh         |                    |
| T022     |    | 70% Acrylic, 30% Wool               | sweater     | W       |                | DS     | IT               | Thailandia         |                    |
| T023     |    | 97% Cotton, 3% Elastane             | trousers    | W       |                | S      | IT               | Imported           |                    |
| T024     |    | 80% Wool, 20% PA                    | sweater     | W       |                | DS     | IT               | China              |                    |
| T025     |    | 60% Wool, 35% Acrylic, 5% Elastane  | sweater     | W       |                | S      | IT               | Imported           |                    |
| T026     |    | 80% Wool, 15% Viscose, 5% Elastane  | sweater     | W       |                | S      | IT               | China              |                    |
| T027     |    | 80% Wool, 20% Viscose               | sweater     | W       |                | S      | IT               | Imported           |                    |
| T028     |    | 50% Wool, 30% Angora, 20% Elastane  | sweater     | W       |                | S      | IT               | China              |                    |
| T029     |   | 70% Wool, 30% PA                    | sweater     | W       |                | S      | IT               | China              |                    |
| T030     |  | 50% Acrylic, 40% Wool, 10% Elastane | sweater     | W       |                | S      | IT               | China              |                    |
| T031     |  | 65% PES, 35% Cotton                 | hat         | B 24 m  | Yes            | DS     | IT               | China              |                    |
| T032     |  | 100% Cotton                         | hat         | B 24 m  | Yes            | DS     | IT               | China              |                    |
| T033     |  | 100% Cotton                         | T-shirt     | B 24 m  |                | DS     | IT               | Bangladesh         |                    |
| T034     |  | 100% Cotton                         | T-shirt     | C 5-6 y |                | DS     | IT               | Imported           |                    |
| T035     |  | 100% Cotton                         | T-shirt     | B 12 m  |                | DS     | IT               | Bangladesh         |                    |
| T036     |  | 59% Cotton, 40% PES, 1% Elastane    | shirt       | B 18 m  |                | DS     | IT               | China              |                    |
| T037     |  | 100% Cotton                         | trousers    | C 3-7 y | Yes            | DS     | IT               | China              |                    |
| T038     |  | 100% Cotton                         | dress       | C 3 y   |                | DS     | IT               | China              |                    |
| T039     |  | 100% Cotton                         | trousers    | C 8 y   |                | DS     | IT               | China              |                    |
| T040     |  | 100% Cotton                         | pyjama      | B 12 m  |                | DS     | IT               | India              |                    |
| T041     |  | 100% Cotton                         | T-shirt     | C 3 y   |                | DS     | IT               | Bangladesh         |                    |

| JRC Code | Picture   | Declared Composition            | Description        | Target  | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|---------------------------------|--------------------|---------|----------------|--------|------------------|--------------------|--------------------|
| T042     |    | 100% Cotton                     | trousers           | B 18 m  |                | DS     | IT               | China              |                    |
| T043     |    | 80% Cotton, 15% PA, 5% Elastane | socks              | C 6-8 y |                | DS     | IT               | Syria              |                    |
| T044     |    | 80% Cotton, 15% PA, 5% Elastane | socks              | C 6-8 y |                | DS     | IT               | Syria              |                    |
| T045     |    | 80% Cotton, 15% PA, 5% Elastane | socks              | C 6-8 y |                | DS     | IT               | Syria              |                    |
| T046     |    | 80% Cotton, 15% PA, 5% Elastane | socks              | C 6-8 y |                | DS     | IT               | Imported           |                    |
| T047     |    | 80% Cotton, 15% PA, 5% Elastane | socks              | C 6-8 y |                | DS     | IT               | Imported           |                    |
| T048     |    | 80% Cotton, 15% PA, 5% Elastane | socks              | C 6-8 y |                | DS     | IT               | Imported           |                    |
| T049     |    | 100% Cotton                     | pyjama             | B 24 m  | Yes            | DS     | IT               | India              |                    |
| T050     |   | 80% Cotton, 20% PES             | trousers           | B 12 m  | Yes            | DS     | IT               | China              |                    |
| T051     |  | 80% Cotton, 20% PES             | sweater            | B 12 m  | Yes            | DS     | IT               | China              |                    |
| T052     |  | 75% Cotton, 23% PA, 2% Elastane | socks              | W       |                | DS     | IT               | China              |                    |
| T053     |  | 100% Cotton                     | trousers           | M       |                | DS     | IT               | Imported           |                    |
| T054     |  | 100% Cotton                     | T-shirt            | M       |                | DS     | IT               | Bangladesh         |                    |
| T055     |  | 100% Cotton                     | trousers           | M       |                | DS     | IT               | Bangladesh         |                    |
| T056     |  | 100% Cotton                     | slip               | M       | Yes            | DS     | IT               | China              |                    |
| T058     |  | 100% Cotton                     | slip               | M       | Yes            | DS     | IT               | China              |                    |
| T060     |  | 100% Cotton                     | sofa cushion cover | EB      |                | DS     | IT               | India              |                    |
| T061     |  | 100% Cotton                     | sofa cushion cover | EB      |                | DS     | IT               | India              |                    |
| T062     |  | 35% Cotton, 65% PES             | shirt              | M       | Yes            | DS     | IT               | Imported           |                    |
| T063     |  | 100% Cotton                     | pyjama             | W       |                | DS     | IT               | India              |                    |
| T064     |  | 65% PES, 35% Cotton             | shirt              | M       |                | DS     | IT               | Bangladesh         |                    |






















| JRC Code | Picture   | Declared Composition            | Description | Target | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|---------------------------------|-------------|--------|----------------|--------|------------------|--------------------|--------------------|
| T065     |    | 65% PES, 35% Cotton             | shirt       | M      |                | DS     | IT               | China              |                    |
| T066     |    | 65% PES, 35% Cotton             | shirt       | W      |                | DS     | IT               | Bangladesh         |                    |
| T067     |    | 100% Cotton                     | T-shirt     | M      |                | DS     | IT               | Bangladesh         |                    |
| T068     |    | 100% Cotton                     | trousers    | W      |                | DS     | IT               | Bangladesh         |                    |
| T069     |    | 100% Cotton                     | pyjama      | W      | Yes            | DS     | IT               | China              |                    |
| T070     |    | 100% Cotton                     | T-shirt     | W      |                | DS     | IT               | Bangladesh         |                    |
| T071     |    | 100% Cotton                     | sweater     | W      |                | DS     | IT               | Imported           |                    |
| T072     |    | 100% Cotton                     | towel       | EB     |                | DS     | IT               | Pakistan           |                    |
| T073     |   | 100% Cotton                     | T-shirt     | W      |                | DS     | IT               | Turkey             |                    |
| T074     |  | 100% Cotton                     | T-shirt     | W      |                | DS     | IT               | Imported           |                    |
| T075     |  | 100% Cotton                     | pyjama      | W      | Yes            | DS     | IT               | China              |                    |
| T076     |  | 95% Cotton, 5% Elastane         | socks       | M      |                | S      | IT               | Italy              |                    |
| T077     |  | 84% Cotton, 16% PA              | socks       | B 24 m |                | S      | IT               | Italy              |                    |
| T078     |  | 84% Cotton, 16% PA              | socks       | C 3 y  |                | S      | IT               | Italy              |                    |
| T079     |  | 95% Cotton, 5% Elastane         | socks       | W      |                | S      | IT               | Italy              |                    |
| T080     |  | 75% Cotton, 20% PA, 5% Elastane | socks       | W      |                | OAM    | BE               | Not Known          |                    |
| T081     |  | 85% Cotton, 15% PES             | T-shirt     | C 10 y | Yes            | OAM    | IT               | China              |                    |
| T082     |  | 65% Cotton, 35% PES             | T-shirt     | C 6 y  | Yes            | OAM    | IT               | Imported           |                    |
| T083     |  | 80% Acrylic, 20% PA             | socks       | W      |                | OAM    | BE               | Not Known          |                    |
| T084     |  | 100% Cotton                     | trousers    | C 8 y  | Yes            | OAM    | IT               | China              |                    |
| T085     |  | 80% Cotton, 20% PES             | trousers    | W      |                | OAM    | IT               | China              |                    |
























| JRC Code | Picture   | Declared Composition                    | Description | Target    | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|---|-------------|-----------|----------------|--------|------------------|--------------------|--------------------|
| T086     |    | 95% Viscose, 5% Elastane                | T-shirt     | W         |                | OAM    | IT               | Italy              |                    |
| T087     |    | 100% Cotton                             | pyjama      | B 24 m    | Yes            | OAM    | BE               | Not Known          |                    |
| T088     |    | 100% Cotton                             | T-shirt     | C 6 y     | Yes            | OAM    | BE               | Not Known          |                    |
| T089     |    | 100% Cotton                             | T-shirt     | C 5 y     |                | OAM    | BE               | Not Known          |                    |
| T090     |    | 55% Viscose, 45% Linen                  | trousers    | W         |                | OAM    | BE               | Europe             |                    |
| T091     |    | 100% Cotton                             | rompers     | B 6 m     | Yes            | OAM    | IT               | Italy              |                    |
| T092     |    | 100% Cotton                             | rompers     | B 6 m     | Yes            | S      | IT               | Not Known          |                    |
| T093     |    | 80% Cotton, 16% PA, 4% Elastane         | slip        | C 12-14 y | Yes            | OAM    | BE               | Spain              |                    |
| T094     |   | 100% Cotton                             | pyjama      | B 18-24 m | Yes            | S      | IT               | Italy              |                    |
| T095     |  | written in chinese                      | socks       | B 12 m    |                | S      | SK               | China              |                    |
| T096     |  | 65% Cotton, 35% PES                     | T-shirt     | B 18 m    | Yes            | S      | SK               | Not Known          |                    |
| T097     |  | 82% Cotton, 14% PA, 3% PES, 1% Elastane | socks       | B 18 m    |                | S      | SK               | Not Known          |                    |
| T098     |  | 100% Cotton                             | rompers     | B 9-12 m  | Yes            | S      | SK               | Not Known          |                    |
| T099     |  | 65% Cotton, 35% PES                     | shirt       | W         |                | S      | SK               | Vietnam            |                    |
| T100     |  | 100% Cotton                             | T-shirt     | W         |                | S      | IE               | Romania            |                    |
| T101     |  | 55% Cotton, 45% PES                     | shirt       | M         |                | S      | IE               | Bangladesh         |                    |
| T102     |  | 100% Cotton                             | T-shirt     | M         |                | S      | LT               | Lithuania          |                    |
| T103     |  | 100% Cotton                             | T-shirt     | M         | Yes            | S      | LT               | Lithuania          |                    |
| T104     |  | 100% Cotton                             | T-shirt     | M         | Yes            | S      | LT               | China              |                    |
| T105     |  | 100% Cotton                             | rompers     | B 6 m     | Yes            | S      | LT               | China              |                    |
| T106     |  | 100% Cotton                             | shirt       | M         | Yes            | S      | LT               | Germany            |                    |


| JRC Code | Picture   | Declared Composition             | Description        | Target | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|----------------------------------|--------------------|--------|----------------|--------|------------------|--------------------|--------------------|
| T107     |    | 100% Cotton                      | rompers            | B 6 m  | Yes            | S      | PL               | Poland             |                    |
| T108     |    | 100% Cotton                      | T-shirt            | W      | Yes            | S      | PL               | Turkey             |                    |
| T109     |    | 100% Cotton                      | infant romper      | B 6 m  | Yes            | S      | PL               | Poland             |                    |
| T110     |    | 100% Cotton                      | sofa cushion cover | EB     |                | S      | PL               | Poland             |                    |
| T111     |    | 100% Cotton                      | T-shirt            | M      | Yes            | S      | PL               | Poland             |                    |
| T112     |    | 100% Cotton                      | shirt              | M      |                | S      | FR               | Not Known          | EC                 |
| T113     |    | 100% Cotton                      | rompers            | B 6 m  | Yes            | DS     | FR               | Tunisia            |                    |
| T114     |    | 77% Cotton , 23% PES             | rompers            | B 12 m | Yes            | DS     | FR               | France             |                    |
| T115     |   | 100% Cotton                      | shirt              | M      |                | DS     | FR               | Turkey             |                    |
| T116     |  | 100% Cotton                      | sofa cushion cover | EB     |                | DS     | FR               | Not Known          |                    |
| T117     |  | 93% Cotton, 7% Elastane          | T-shirt            | W      | Yes            | S      | FR               | Turkey             |                    |
| T118     |  | 100% Cotton                      | pyjama             | B 24 m | Yes            | S      | UK               | Indonesia          |                    |
| T119     |  | 42% PES, 31% Acrylic, 27% Cotton | sofa cushion cover | EB     |                | S      | UK               | United Kingdom     |                    |
| T120     |  | 100% Cotton                      | shirt              | M      | Yes            | S      | UK               | Portugal           |                    |
| T121     |  | 100% Cotton                      | T-shirt            | W      | Yes            | S      | UK               | Turkey             |                    |
| T122     |  | 100% Cotton                      | rompers            | B 6 m  | Yes            | S      | UK               | Egypt              |                    |
| T123     |  | 100% Cotton                      | T-shirt            | M      |                | S      | EL               | Greece             |                    |
| T124     |  | 100% Cotton                      | pyjama             | B 12 m | Yes            | S      | EL               | Greece             |                    |
| T125     |  | 50% Cotton, 50% PES              | rompers            | B 9 m  | Yes            | S      | EL               | Europe             |                    |
| T126     |  | 100% Cotton                      | shirt              | M      |                | S      | EL               | Not Known          |                    |
| T127     |  | 100% Cotton                      | sofa cushion cover | EB     |                | S      | BE               | India              |                    |

| JRC Code | Picture   | Declared Composition    | Description        | Target | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|-------------------------|--------------------|--------|----------------|--------|------------------|--------------------|--------------------|
| T128     |    | 100% Cotton             | shirt              | M      |                | S      | BE               | Slovakia           | OT / EC            |
| T129     |    | 100% Cotton             | pyjama             | B 18 m | Yes            | S      | EE               | Estonia            |                    |
| T130     |    | 100% Cotton             | rompers            | B 3 m  |                | S      | EE               | Estonia            |                    |
| T131     |    | 65% Cotton, 35% PES     | shirt              | M      |                | S      | EE               | Turkey             |                    |
| T132     |    | 100% Cotton             | T-shirt            | W      | Yes            | S      | EE               | Estonia            |                    |
| T133     |    | 100% Cotton             | bedding pillowcase | EB     |                | S      | EE               | India              | OT                 |
| T134     |    | 100% Cotton             | rompers            | B 18 m | Yes            | S      | PT               | China              |                    |
| T135     |    | 100% Cotton             | sofa cushion cover | EB     |                | S      | PT               | India              |                    |
| T136     |   | 100% Cotton             | T-shirt            | M      | Yes            | DS     | PT               | Italy              |                    |
| T137     |  | 100% Cotton             | shirt              | W      | Yes            | DS     | PT               | China              |                    |
| T138     |  | 100% Cotton             | dress              | B 12 m | Yes            | S      | PT               | Spain              |                    |
| T139     |  | 100% Cotton             | pyjama             | C 3 y  | Yes            | DS     | CZ               | Czech rep.         |                    |
| T140     |  | 100% Cotton             | T-shirt            | M      | Yes            | DS     | CZ               | Europe             |                    |
| T141     |  | 75% Cotton, 25% Acrylic | rompers            | B 3 m  | Yes            | DS     | CZ               | Czech rep.         |                    |
| T142     |  | 100% Cotton             | shirt              | M      |                | DS     | CZ               | Not Known          |                    |
| T143     |  | 100% Cotton             | bedding pillowcase | EB     | Yes            | DS     | CZ               | Not Known          | OT                 |
| T144     |  | 100% Cotton             | shirt              | M      |                | DS     | DE               | Germany            |                    |
| T145     |  | 100% Cotton             | shirt              | M      |                | DS     | DE               | Not Known          | EC                 |
| T146     |  | 100% Cotton             | shirt              | M      |                | DS     | DE               | Slovakia           | OT                 |
| T147     |  | 100% Cotton             | shirt              | M      |                | DS     | DE               | Not Known          |                    |
| T148     |  | 100% Cotton             | shirt              | M      |                | DS     | DE               | Not Known          | EC                 |

| JRC Code | Picture   | Declared Composition | Description        | Target | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|----------------------|--------------------|--------|----------------|--------|------------------|--------------------|--------------------|
| T149     |    | 100% Cotton          | rompers            | B 6 m  | Yes            | S      | DE               | Netherland         |                    |
| T150     |    | 100% Cotton          | rompers            | B 9 m  | Yes            | S      | DE               | Germany            |                    |
| T151     |    | 100% Cotton          | sofa cushion cover | EB     |                | S      | DE               | Germany            |                    |
| T152     |    | 100% Cotton          | shirt              | W      |                | S      | DE               | Not Known          |                    |
| T153     |    | 100% Cotton          | T-shirt            | W      | Yes            | S      | DE               | Bangladesh         |                    |
| T154     |    | 100% Cotton          | T-shirt            | W      | Yes            | S      | AT               | Germany            |                    |
| T155     |    | 100% Cotton          | rompers            | B 6 m  | Yes            | DS     | AT               | Turkey             |                    |
| T156     |    | 100% Cotton          | rompers            | B 1 m  |                | DS     | AT               | China              |                    |
| T157     |   | 100% Cotton          | shirt              | M      |                | S      | AT               | Europe             |                    |
| T158     |  | 100% Cotton          | sofa cushion cover | EB     |                | S      | AT               | India              |                    |
| T159     |  | 100% Cotton          | shirt              | W      | Yes            | S      | ES               | Imported           |                    |
| T160     |  | 67% PES, 33% Cotton  | pyjama             | C 4 y  | Yes            | S      | ES               | Spain              |                    |
| T161     |  | 100% Cotton          | rompers            | C 3 y  |                | S      | ES               | Not Known          |                    |
| T162     |  | 100% Cotton          | shirt              | M      |                | S      | SK               | Slovakia           |                    |
| T163     |  | 100% Cotton          | sofa cushion cover | EB     | Yes            | S      | SK               | Not Known          |                    |
| T164     |  | 100% Cotton          | T-shirt            | M      |                | DS     | FR               | China              |                    |
| T165     |  | 100% Cotton          | rompers            | B 1 m  | Yes            | DS     | FR               | China              |                    |
| T166     |  | 100% Cotton          | shirt              | M      |                | S      | FR               | Turkey             | EC                 |
| T167     |  | 100% Cotton          | sofa cushion cover | EB     |                | DS     | FR               | France             |                    |
| T168     |  | 65% Cotton, 35% PES  | rompers            | B 1 m  |                | DS     | LU               | Not Known          |                    |
| T169     |  | 100% Cotton          | pyjama             | C 4 y  | Yes            | DS     | LU               | Not Known          |                    |

| JRC Code | Picture   | Declared Composition             | Description | Target    | Printed Fabric | Source | Purchase Country | Production Country    | Easy Care Oeko Tex |
|----------|---|----------------------------------|-------------|-----------|----------------|--------|------------------|-----------------------|--------------------|
| T170     |    | 100% Cotton                      | shirt       | M         |                | DS     | LU               | Not Known             | EC                 |
| T171     |    | 100% Cotton                      | T-shirt     | M         |                | DS     | LU               | Not Known             |                    |
| T175     |    | 100% Cotton                      | trousers    | C 4 y     |                | DS     | IT               | Not Known             |                    |
| T177     |    | 100% Cotton                      | trousers    | C 8 y     |                | DS     | IT               | Imported              |                    |
| T183     |    | 100% Cotton                      | shirt       | M         |                | DS     | IT               | Bangladesh            |                    |
| T185     |    | 98% Cotton, 2% Lycra             | T-shirt     | M         |                | S      | CY               | China                 |                    |
| T186     |    | 100% Cupro                       | shirt       | M         |                | S      | CY               | Not Known             |                    |
| T187     |    | 35% Cotton, 65% PES              | shirt       | M         |                | S      | CY               | Not Known             | EC                 |
| T188     |   | 35% Cotton, 65% PES              | shirt       | M         |                | S      | CY               | Not Known             | EC                 |
| T189     |  | 100% Wool                        | trousers    | M         |                | S      | CZ               | Not Known             |                    |
| T197     |  | 100% Cotton                      | T-shirt     | B 18 m    | Yes            | S      | UK               | China                 |                    |
| T198     |  | 100% Cotton                      | shirt       | M         |                | S      | UK               | Morocco               |                    |
| T199     |  | 100% Cotton                      | T-shirt     | W         | Yes            | S      | UK               | UnitedArabianEmirates |                    |
| T200     |  | 70% Lambwool, 20% Angora, 10% PA | sweater     | W         |                | S      | UK               | China                 |                    |
| T201     |  | 53% PES, 45% Wool, 2% Elastane   | trousers    | W         |                | DS     | UK               | China                 |                    |
| T202     |  | 77% Cotton, 23% PES              | T-shirt     | B 9-12 m  |                | S      | UK               | China                 |                    |
| T205     |  | 100% Cotton                      | T-shirt     | C 11-12 y |                | DS     | DK               | Not Known             |                    |
| T206     |  | 100% Cotton                      | shirt       | M         |                | DS     | DK               | Turkey                |                    |
| T207     |  | 100% Wool                        | trousers    | W         |                | S      | DK               | Not Known             |                    |
| T208     |  | 80% Wool, 20% PA                 | sweater     | W         |                | DS     | DK               | Italy                 |                    |
| T209     |  | 95% Cotton, 5% Elastane          | T-shirt     | W         | Yes            | DS     | DK               | Turkey                |                    |

| JRC Code | Picture   | Declared Composition               | Description | Target  | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|------------------------------------|-------------|---------|----------------|--------|------------------|--------------------|--------------------|
| T212     |    | 100% Cotton                        | rompers     | B 1 m   |                | S      | HU               | China              |                    |
| T214     |    | 50% Acrylic, 40% Wool, 10% Viscose | sweater     | M       |                | S      | HU               | Europe             |                    |
| T215     |    | 60% Wool, 40% PES                  | trousers    | M       |                | S      | HU               | Europe             |                    |
| T217     |    | 80% Cotton, 20% PES                | trousers    | B 3-6 m | Yes            | DS     | PT               | Portugal           |                    |
| T218     |    | 92% Cotton, 8% Elastane            | T-shirt     | W       | Yes            | S      | PT               | Spain              |                    |
| T219     |    | 66% Wool, 30% PES, 4% other fibers | trousers    | W       |                | DS     | PT               | Spain              |                    |
| T220     |    | 55% Silk, 45% Cashmere             | sweater     | W       |                | DS     | PT               | China              |                    |
| T221     |    | 100% Cotton                        | shirt       | M       |                | S      | PT               | Spain              | EC                 |
| T224     |   | 80% Cotton, 20% PA                 | rompers     | B 3 m   |                | OAM    | NL               | Not Known          |                    |
| T226     |  | 100% Cotton                        | underware   | M       | Yes            | OAM    | NL               | Not Known          |                    |
| T228     |  | 100% Cotton                        | underware   | M       | Yes            | OAM    | NL               | Not Known          |                    |
| T229     |  | 100% Cotton                        | shirt       | M       |                | S      | NL               | Not Known          |                    |
| T230     |  | 65% PES, 35% Cotton                | shirt       | M       |                | S      | NL               | Not Known          |                    |
| T231     |  | 100% Cotton                        | dress       | C 4-6 y |                | S      | NL               | Not Known          |                    |
| T232     |  | 35% Cotton, 65% PES                | shirt       | M       |                | DS     | IE               | Outside Europe     |                    |
| T233     |  | 100% Cotton                        | T-shirt     | M       | Yes            | DS     | IE               | China              |                    |
| T234     |  | 30% Mohar, 10% Wool, 60% Acrylic   | sweater     | W       |                | S      | IE               | Italy              |                    |
| T235     |  | 98% Wool, 2% Elastane              | trousers    | W       |                | S      | IE               | Romania            |                    |
| T239     |  | 44% PES, 42% Cotton, 14% Viscose   | shirt       | W       |                | S      | PL               | Poland             |                    |
| T241     |  | 80% Cotton, 20% Viscose            | rompers     | B 3 m   | Yes            | S      | PL               | Turkey             |                    |
| T243     |  | Wool-PES                           | trousers    | W       |                | S      | PL               | Poland             |                    |

| JRC Code | Picture   | Declared Composition    | Description | Target | Printed Fabric | Source | Purchase Country | Production Country | Easy Care Oeko Tex |
|----------|---|-------------------------|-------------|--------|----------------|--------|------------------|--------------------|--------------------|
| T244     |    | 80% Acrylic, 20% Wool   | sweater     | W      |                | S      | PL               | Poland             |                    |
| T245     |    | 97% Cotton, 3% Elastane | trousers    | C 4 y  |                | S      | LT               | Not Known          |                    |
| T246     |    | 100% Cotton             | T-shirt     | W      |                | S      | LT               | Lithuania          |                    |
| T247     |    | 100% Wool               | trousers    | W      |                | S      | LT               | Not Known          |                    |
| T249     |    | 80% Wool, 20% PA        | sweater     | M      |                | S      | LT               | Not Known          |                    |
| T250     |    | 55% Cotton, 45% PES     | shirt       | M      |                | S      | LT               | Not Known          |                    |
| T252     |    | 100% Cotton             | pyjama      | W      | Yes            | S      | LT               | Not Known          |                    |
| T253     |    | 80% Cotton, 20% Viscose | rompers     | B 3 m  |                | S      | LV               | Turkey             |                    |
| T255     |   | 100% Cotton             | shirt       | M      |                | S      | LV               | Germany            | EC                 |
| T256     |  | 80% Wool, 20% Acrylic   | sweater     | M      |                | S      | LV               | Oman               |                    |
| T257     |  | 100% Wool               | trousers    | M      |                | S      | LV               | Russia             |                    |
| T258     |  | 100% Cotton             | T-shirt     | M      | Yes            | S      | LV               | Latvia             |                    |

**Table 2:** Released formaldehyde by methods EN ISO 14184-1 and EN ISO 14184-2.

|          | water extraction | vapour absorption |          | water extraction | vapour absorption |
|----------|------------------|-------------------|----------|------------------|-------------------|
| JRC code | [HCHO]<br>mg/kg  | [HCHO]<br>mg/kg   | JRC code | [HCHO]<br>mg/kg  | [HCHO]<br>mg/kg   |
| T001     | 4.0 ± 0.8        | ND                | T114     | 8.8 ± 5.3        |                   |
| T002     | 14.0 ± 2.4       | ND                | T115     | 18.1 ± 1.0       |                   |
| T003     | 4.7 ± 1.9        | ND                | T116     | 15.0 ± 7.1       |                   |
| T004     | 8.1 ± 2.5        | 0.5 ± 0.9         | T117     | 7.0 ± 4.2        |                   |
| T005     | 1.0 ± 0.7        | 0.8 ± 1.1         | T118     | 10.2 ± 0.8       |                   |
| T006     | 6.4 ± 0.6        | 1.3 ± 0.8         | T119     | 5.4 ± 0.2        |                   |
| T007     | 11.7 ± 1.5       | 0.8 ± 0.7         | T120     | 14.6 ± 3.8       |                   |
| T008     | 3.1 ± 2.5        | 1.1 ± 0.7         | T121     | 162.5 ± 9.3      | 318.2 ± 15.4      |
| T009     | 4.1 ± 2.3        | 0.5 ± 0.7         | T122     | 4.9 ± 1.4        |                   |
| T010     | 8.1 ± 2.8        | 2.5 ± 0.7         | T123     | 4.9 ± 2.3        |                   |
| T011     | 3.5 ± 0.6        | 1.8 ± 0.8         | T124     | 12.4 ± 3.0       |                   |
| T012     | 17.1 ± 2.6       | 1.6 ± 1.2         | T125     | 7.2 ± 1.6        |                   |
| T013     | 6.7 ± 3.0        | 0.4 ± 1.9         | T126     | 5.6 ± 0.8        |                   |
| T014     | 11.3 ± 1.0       | 0.7 ± 0.7         | T127     | 33.7 ± 7.3       | 7.6 ± 0.9         |
| T015     | 12.7 ± 7.3       | 1.2 ± 0.5         | T128     | 27.4 ± 3.6       | 55.2 ± 8.1        |
| T016     | 18.2 ± 7.1       | 0.9 ± 0.9         | T129     | 6.1 ± 1.7        |                   |
| T017     | 4.7 ± 0.6        | 1.7 ± 0.4         | T130     | 5.2 ± 3.2        |                   |
| T018     | 5.5 ± 3.3        | 1.1 ± 0.0         | T131     | 6.6 ± 1.2        |                   |
| T019     | 19.4 ± 2.3       | 22.9 ± 2.8        | T132     | 5.8 ± 1.5        |                   |
| T020     | 8.1 ± 2.6        | 4.5 ± 1.0         | T133     | 25.3 ± 0.7       | 40.7 ± 11.5       |
| T021     | 5.7 ± 0.6        | 2.2 ± 0.5         | T134     | 10.8 ± 3.1       |                   |
| T022     | 3.0 ± 1.3        | 6.6 ± 2.0         | T135     | 20.0 ± 4.7       | 24.2 ± 1.8        |
| T023     | 5.3 ± 10.4       | 2.6 ± 0.5         | T136     | 17.3 ± 6.0       |                   |
| T024     | 31.4 ± 8.0       | 12.1 ± 0.9        | T137     | 6.4 ± 1.3        |                   |
| T025     | 23.0 ± 1.9       | 7.8 ± 0.8         | T138     | 16.6 ± 1.0       |                   |
| T026     | 33.4 ± 0.6       | 0.9 ± 0.5         | T139     | 14.8 ± 3.0       |                   |
| T027     | 12.1 ± 2.4       | 1.0 ± 0.6         | T140     | 20.7 ± 13.0      | ND                |
| T028     | 24.1 ± 0.9       | 9.6 ± 2.1         | T141     | 9.2 ± 1.0        |                   |
| T029     | 20.7 ± 1.8       | 1.2 ± 5.4         | T142     | 18.1 ± 10.5      |                   |
| T030     | 23.1 ± 1.4       | 5.1 ± 2.3         | T143     | 18.6 ± 4.5       |                   |
| T031     | 10.9 ± 1.9       |                   | T144     | 38.7 ± 7.1       | 129.8 ± 25.7      |
| T032     | 3.3 ± 1.4        |                   | T145     | 12.9 ± 4.9       |                   |
| T033     | 7.5 ± 10.2       | 3.6 ± 0.7         | T146     | 54.1 ± 0.9       | 176.5 ± 6.7       |
| T034     | 3.1 ± 0.3        | 4.8 ± 7.1         | T147     | 16.8 ± 2.5       |                   |
| T035     | 8.2 ± 8.9        | 3.0 ± 0.9         | T148     | 65.0 ± 5.7       | 141.8 ± 25.3      |
| T036     | 7.2 ± 3.6        | 2.0 ± 0.7         | T149     | 7.1 ± 2.0        |                   |
| T037     | 2.0 ± 4.1        | 1.5 ± 0.8         | T150     | 8.9 ± 0.6        |                   |
| T038     | 6.3 ± 0.4        | 2.7 ± 1.6         | T151     | 26.1 ± 7.5       | 31.1 ± 0.5        |
| T039     | 9.7 ± 4.0        | 3.2 ± 0.6         | T152     | 18.6 ± 0.0       |                   |
| T040     | 17.8 ± 4.2       | 91.5 ± 35.1       | T153     | 6.4 ± 0.8        |                   |
| T041     | 9.3 ± 1.6        | 10.9 ± 0.7        | T154     | 7.8 ± 0.8        |                   |
| T042     | 1.3 ± 0.1        | 2.1 ± 0.7         | T155     | 6.0 ± 1.4        |                   |
| T043     | 2.9 ± 11.1       | 0.5 ± 0.8         | T156     | 6.3 ± 2.6        |                   |
| T044     | 4.6 ± 1.3        |                   | T157     | 15.2 ± 1.7       |                   |
| T045     | 12.2 ± 5.8       | 0.6 ± 0.7         | T158     | 15.4 ± 7.6       |                   |
| T046     | 14.6 ± 2.6       |                   | T159     | 22.6 ± 4.4       | 5.9 ± 0.7         |
| T047     | 3.3 ± 2.4        | 3.4 ± 0.7         | T160     | 11.9 ± 2.1       |                   |
| T048     | 2.4 ± 0.2        | 3.9 ± 0.3         | T161     | 12.5 ± 3.4       |                   |
| T049     | 2.7 ± 0.2        | 5.5 ± 0.2         | T162     | 36.4 ± 2.0       | 68.4 ± 8.1        |
| T050     | 4.3 ± 1.1        | 2.1 ± 2.6         | T163     | 22.2 ± 3.1       | 9.4 ± 1.7         |
| T051     | 22.8 ± 5.1       | 2.3 ± 1.0         | T164     | 4.5 ± 2.0        |                   |
| T052     | 5.7 ± 2.1        | 4.9 ± 1.5         | T165     | 6.8 ± 1.1        |                   |
| T053     | 1.9 ± 0.3        | 2.1 ± 4.3         | T166     | 3.2 ± 0.5        |                   |



|                | water extraction | vapour absorption |          | water extraction | vapour absorption |
|----------------|------------------|-------------------|----------|------------------|-------------------|
| JRC code       | [HCHO]<br>mg/kg  | [HCHO]<br>mg/kg   | JRC code | [HCHO]<br>mg/kg  | [HCHO]<br>mg/kg   |
| T054           | 6.9 ± 0.6        | 7.0 ± 1.9         | T167     | 7.0 ± 1.5        |                   |
| T055           | 9.9 ± 1.7        | 4.1 ± 3.0         | T168     | 4.0 ± 2.1        |                   |
| T056           | 8.3 ± 1.2        | 23.6 ± 3.3        | T169     | 6.9 ± 3.4        |                   |
| T058           | 9.0 ± 1.3        | 11.8 ± 3.4        | T170     | 4.1 ± 0.7        |                   |
| T060           | 4.1 ± 4.8        | 2.0 ± 1.5         | T171     | 43.8 ± 1.0       | 88.7 ± 13.9       |
| T061           | 12.2 ± 4.8       | 2.4 ± 0.6         | T175     | 3.5 ± 1.5        |                   |
| T062           | 25.7 ± 7.1       | 24.8 ± 1.1        | T177     | 5.2 ± 5.3        |                   |
| T063           | 7.3 ± 1.8        | 6.1 ± 0.9         | T183     | 11.4 ± 4.6       |                   |
| T064           | 14.4 ± 8.9       | 5.1 ± 0.9         | T185     | 7.5 ± 5.6        |                   |
| T065           | 13.9 ± 5.1       | 10.1 ± 6.1        | T186     | 3.4 ± 0.2        |                   |
| T066           | 8.2 ± 1.4        | 48.9 ± 4.5        | T187     | 27.9 ± 8.8       | 71.7 ± 8.9        |
| T067           | 50.7 ± 2.3       | 174.4 ± 39.3      | T188     | 105.2 ± 6.4      | 397.3 ± 27.7      |
| T068           | 11.5 ± 5.2       | 7.6 ± 2.2         | T189     | 15.2 ± 0.8       |                   |
| T069           | 11.2 ± 0.5       | 17.5 ± 0.2        | T197     | 11.2 ± 6.3       |                   |
| T070           | 6.3 ± 2.2        | 3.6 ± 0.5         | T198     | 24.2 ± 1.9       | 74.1 ± 12.5       |
| T071           | 14.2 ± 1.9       | 4.7 ± 1.0         | T199     | 7.7 ± 3.2        |                   |
| T072           | 12.0 ± 10.1      | 3.8 ± 1.4         | T200     | 10.2 ± 0.3       |                   |
| T073           | 7.2 ± 1.7        | 2.9 ± 1.0         | T201     | 25.8 ± 0.9       | ND                |
| T074           | 34.2 ± 2.6       | 8.8 ± 0.9         | T202     | 21.9 ± 1.5       | 6.7 ± 2.3         |
| T075           | 8.7 ± 0.6        | 11.6 ± 2.0        | T205 A   | 3.9 ± 0.8        |                   |
| T076           | 9.6 ± 7.6        | 4.4 ± 4.0         | T205 B   | 3.7 ± 0.7        |                   |
| T077           | 6.8 ± 0.9        | 3.8 ± 1.1         | T206     | 15.4 ± 0.4       |                   |
| T078           | 1.7 ± 8.7        | 3.1 ± 0.7         | T207     | 39.0 ± 6.8       | 31.4 ± 9.3        |
| T079           | 4.5 ± 0.8        | 4.0 ± 1.1         | T208 A   | 12.0 ± 1.0       |                   |
| T080           | 11.1 ± 3.0       | 2.8 ± 0.5         | T208 B   | 14.3 ± 5.6       |                   |
| T081           | 8.4 ± 0.3        | 34.1 ± 2.4        | T209 A   | 20.2 ± 1.8       | 168.0 ± 59.0      |
| T082           | 17.9 ± 3.2       | 57.3 ± 11.4       | T209 B   | 26.5 ± 3.7       |                   |
| T083           | 9.7 ± 3.6        | 2.9 ± 0.4         | T212     | 16.7 ± 2.8       |                   |
| T084           | 9.2 ± 0.9        | 10.9 ± 2.9        | T214     | 27.5 ± 2.4       | 9.3 ± 1.4         |
| T085           | 2.4 ± 1.2        | 1.9 ± 0.8         | T215     | 32.0 ± 8.3       | 16.4 ± 3.8        |
| T086           | 10.9 ± 0.7       | 10.9 ± 6.2        | T217A    | 13.7 ± 3.8       |                   |
| T087           | 8.5 ± 0.8        | 5.2 ± 1.6         | T217B    | 14.4 ± 2.4       |                   |
| T088(nodraw)   | 11.5 ± 1.7 (2)   | 11.6 ± 0.4        | T218     | 15.6 ± 3.4       |                   |
| T088(onlydraw) | 13.9 ± 0.1 (2)   |                   | T219     | 51.0 ± 4.7       | 14.5 ± 2.8        |
| T088(mix)      | 12.3 ± 0.3 (2)   |                   | T220     | 30.4 ± 4.4       | 8.6 ± 0.3         |
| T089           | 9.4 ± 1.2        | 3.7 ± 0.3         | T221     | 66.2 ± 2.1       | 175.7 ± 34.7      |
| T090           | 18.6 ± 1.7       | 5.6 ± 1.2         | T224     | 10.3 ± 1.3       |                   |
| T091           | 75.4 ± 2.6       | 233.5 ± 18.3      | T226     | 55.2 ± 1.5       | 129.2 ± 25.8      |
| T092(mix)      | 47.7 ± 22.0      | 10.6 ± 4.4        | T228     | 29.0 ± 3.5       | 6.8 ± 1.3         |
| T092(nodraw)   | 8.2 ± 3.2 (2)    | 7.2 ± 2.3         | T229     | 12.9 ± 0.2       |                   |
| T092(onlydra)  | 27.5 ± 106.6 (2) |                   | T230     | 28.7 ± 1.9       | 22.9 ± 1.0        |
| T093           | 23.5 ± 1.8       | 2.6 ± 0.9         | T231     | 3.7 ± 0.4        |                   |
| T094           | 22.0 ± 2.6       | 30.6 ± 7.4        | T232     | 33.1 ± 3.1       | 96.8 ± 3.1        |
| T095           | 2.6 ± 0.1        | 0.7 ± 1.1         | T233     | 8.9 ± 4.4        |                   |
| T096           | 2.2 ± 1.1        | 4.3 ± 3.5         | T234     | 15.4 ± 2.9       |                   |
| T097           | 5.5 ± 6.0        | 1.8 ± 2.3         | T235     | 19.6 ± 1.5       |                   |
| T098           | 5.7 ± 0.6        | 6.2 ± 1.7         | T239     | 21.4 ± 0.7       | 60.9 ± 12.2       |
| T099           | 3.1 ± 0.5        | 3.5 ± 2.4         | T241     | 4.0 ± 1.2        |                   |
| T100           | 5.7 ± 8.6        |                   | T243     | 14.3 ± 2.3       |                   |
| T101           | 17.2 ± 25.8      |                   | T244     | 4.0 ± 2.9        |                   |
| T102           | 14.3 ± 1.8       |                   | T245     | 4.1 ± 2.4        |                   |
| T103           | 14.1 ± 1.7       |                   | T246     | 3.8 ± 0.7        |                   |
| T104           | 6.2 ± 5.5        |                   | T247     | 6.1 ± 1.3        |                   |
| T105           | 1.8 ± 2.7        |                   | T249     | 19.3 ± 1.3       |                   |
| T106           | 4.3 ± 3.7        |                   | T250     | 6.7 ± 1.5        |                   |

|             | water extraction | vapour absorption |             | water extraction | vapour absorption |
|-------------|------------------|-------------------|-------------|------------------|-------------------|
| JRC<br>code | [HCHO]<br>mg/kg  | [HCHO]<br>mg/kg   | JRC<br>code | [HCHO]<br>mg/kg  | [HCHO]<br>mg/kg   |
| T107        | 8.9 ± 1.0        |                   | T252        | 6.3 ± 2.8        |                   |
| T108        | 7.6 ± 1.1        |                   | T253        | 3.9 ± 1.0        |                   |
| T109        | 8.3 ± 2.5        |                   | T255        | 108.8 ± 3.1      | 198.7 ± 20.4      |
| T110        | 7.5 ± 1.6        |                   | T256        | 2.3 ± 0.3        |                   |
| T111        | 10.7 ± 0.7       |                   | T257        | 9.1 ± 0.5        |                   |
| T112        | 95.3 ± 1.4       | 314.9 ± 22.2      | T258        | 21.7 ± 0.7       | 30.0 ± 3.0        |
| T113        | 8.8 ± 2.3        |                   |             |                  |                   |

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#### **Abstract**

A European survey on the level of formaldehyde released from textiles, in particular textile clothing, produced all over the world was performed. The selection of fabrics was planned among textile products that are supposed to contain formaldehyde, in order to cover as many different types of fibres and type of garments as possible. The whole population was considered as target. Samples were bought in 21 Member States of the European Union, from different sources, with different compositions and various production countries or areas. Part of them was printed and some were “easy care” or Oeko-Tex labelled. A total of 221 samples were analysed with standard method EN ISO 14184-1 (water extraction) and 127 with standard method EN ISO 14184-2 (vapour absorption). Measurements were performed in triplicate and uncertainties were calculated at 95 % of probability.

In the case of the water extraction method, 11% of samples intended to be in direct contact with skin released over 30 mg/kg, which is the limit established by the voluntary labelling scheme Ecolabel (Commission Decision 2002/371/EC). About 3% released more than 75 mg/kg, which is the limit set by the private voluntary labelling scheme Oeko-Tex Standard 100. In the case of babies under the age of two, 11% of garments released more than 20 mg/kg of formaldehyde, which is the Oeko-Tex Standard 100 limit for babies. The sample manufacturing area (Europe, China, rest of the world) and the purchase sources (shops, department stores and open air markets) do not seem to influence the results. Shirts seem to be the garment category with the highest risk of exceeding the limit of 30 mg/kg (22% of them). Moreover, five out of ten “easy care” labelled shirts exceeded the Ecolabel limit. Similarly, pure cotton and mixtures containing wool seem to release more formaldehyde than garments made of mixtures containing cotton and other fibres.

Considering the vapour absorption method, 22% of samples released more than 30 mg/kg of formaldehyde and 12% more than 75 mg/kg, 397 mg/kg being the highest measured value. Results obtained with the two standard methods were usually in the same range for low levels of formaldehyde; however for releases of over 30 mg/kg, the vapour absorption method gives constantly higher results than the water extraction method.

The influence of domestic washing was investigated. It effectively reduces the level of released formaldehyde. After the first washing cycle with the water extraction method, the level of formaldehyde was reduced to 10% of the initial value and decreased to 60% in the case of the vapour absorption method.

A new method was developed, which mimic the real conditions of use of garments better than the standard method EN ISO 14184-1. Artificial perspiration solutions (acid and basic sweat), washing machine, generally used to determine colour fastness, and stainless steel balls were used to increase the rubbing effect and to better reproduce the real conditions of direct skin-textile contact. The release of formaldehyde was maximised with this newly developed method.

Following the recommendations of the Technical Guidance Document, release data were used to estimate the dermal exposure of an adult and a child. The maximum estimated dermal uptakes were 1.7 and 4.5 mg/kg bw for an adult and a child respectively, with calculation based on data obtained with the modified method. The maximum estimated dermal uptakes calculated based on data obtained with the standard method EN ISO 14184-1 were 1.2 and 3.1 mg/kg bw for an adult and a child respectively.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.