Investigation of Oxidation Gasses from Paraffin Aromatic Candles in Toxicological Relevance to Classes of Damaging Materials

Concluding Report

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Investigation of Combustion Gasses from Paraffin Aromatic Candles in toxicological relevance to Classes of Damaging Materials

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In July of 1997 the Union of German Candle Manufacturers entrusted Ökometric GmbH with the investigation of paraffin aromatic candles and their potential for endangering the health of their users.

This analysis is part of a sequence with two already completed investigative programs examining the danger potential of different types of candles (stearin, paraffin, beeswax; Ökometric, University of Beyreuth 1994), and of their color and lacquer coatings (Ökometric 1995). The oxidation products of the investigated candles were analyzed for their polychlorinated dibenzoyl-p-dioxinen and dibenzoy/furan (PCDD/PCDF), and polycyclic aromatic cyclic hydrocarbons and short chained aldehyde contents.

The oxidation tests of aromatic candles took place in 1994 in a specially designed testing chamber, which was developed specifically for this purpose. The investigation aimed to choose the single components to be representative of their significance and installed synthetic mixes in order to make the spectrum of the inserted fragrance compositions wide and to display a high number of components in a single investigation. The Mixtures were presented together according to their chemical aspects, which means that the characteristic functions of each group served as qualifying indications. This compilation allowed evaluations of determined groups to possess a formation potential for the investigated health-damaging materials. Because of these measures that were taken, out of the 77 repeatedly utilized fragrances the following six mix groups resulted:

-- Lacton Mix Group (16 Components)

-- Aldehyde/Keton Mix Group (16 Components)

-- Alcohol Mix Group (15 Components)

-- Ether Mix Group (10 Components)

-- Terpene Mix Group (8 Components)

-- Aromatics/Polycyclene Mix Group (13 Components).

Nine paraffin candles (type 5603. 1.5% addition), with the dimensions of 23 mm x 245 mm, were burned for each of the above named aroma mixtures. The gasses generated from the burning were analyzed for their content of damaging elements.

The toxic equivalents that were measured for PCDD/PCDF were between 0.004 and 0.014 pg I-TE/g of expended candle wax. The analyzed PAK and aldehyde were for the most part near or below the test reaction limits. Benzo[a]pyrene, the indicator substance, infringed in no way 0.01% on the standardized technical set concentrations for employee protection. In one instance, formaldehyde reached a concentration of 0.5% of the maximal work place concentration (MAK). Aldehyde was consistently below 2 %, and acrolein was consistently below 0.01% of the MAK worth.

A comparison of the highly calculated concentration of the oxidation products with limiting values for in-room air with the burning of over 30 candles (i.e. on a holiday) proved no danger for the health of the inhabitants.

Through the determination of the critical volumes and a comparison with the emissions of a cigarette would this be further confirmed. as would it though a model calculation.

2 MOTIVATIONS FOR CONDUCTING THIS REPORT

On July 23, 1997 the Union of German Candle Manufacturers commissioned the Ökometric GmbH firm to carry on with their investigations of potential health dangers because of the burning of candles, which began in 1994.

In the two preceding investigations and according to instruction from the Union, Ökometric analyzed different raw candle materials (paraffin, stearin, beeswax, and wick materials) and additional materials (lacquers, pigments) for their toxicologically relevant contents in their raw materials and in their oxidation products. The raw materials were examined after possible purification processes with polychlorinated dibenzo-p-dioxinene and dibenzofuran (PCDD/PCDF), polycyclic aromatic carburetted water (PAK), chlorophenole (ClPh), chlorobenzene (ClBz), and other chosen chlorine agents. The resulting gasses that were released during burning were analyzed for PCDD/PCDF, PAK, and short chained aldehyde (i.e. formaldehyde, acrolein).

The relevant products released from aromatic candles during burning in connection with their toxicological relevance were analyzed and evaluated in this commissioned series of investigations. They took place with the help of metering devices which were already developed.

3 PRESENTATION OF PROBLEM

This investigative document is judged as an environmental chemical analysis and is connected to the toxicological classification in relation to health of humans and to damaging materials as a result of the burning of paraffin aromatic candles.

The emissions from the burning candles should therefore be investigated for polychlorinated dibenzo-p-dioxine and dibenzofuran (PCDD/PCDF), polycyclic carburetted water (PAK), and short chained aldehyde.

4 INVESTIGATION MATERIALS

Subjects of the investigation were the assorted released smoke of different types of candles and the released gasses.

4. 1 Raw Materials

The raw materials consisted of paraffin, wicks, and fragrances.

4. 1. 1 Paraffin, Wick materials

In the previous instances the given raw materials consisted of non-aromatic paraffin from a mass of type OFA 5603 and the wick material was from type R 18 3"S". They were described as being prepared in molds for the first series of investigations.

4.1.2 Fragrance Mixtures

Seven fragrance mixtures were presented together for this investigation. Their exactly defined combinations are to be concluded in the following tables.

In one of the first mixtures, the 77 most customarily used fragrance substances were presented together (Table 4-1). Out of these, six groups of fragrance mixtures were separated in accordance with their chemical formations:

- Lactone Mix Group (16 Components, Table 4-2),
- Aldehyde/Keton Mix Group (16 Components, Table 4-3),
- Alcohol Mix Group (15 Components, Table 4-4),
- Ether Mix Group (10 Components, Table 4-5),
- Terpene Mix Group (8 Components, Table 4-6),
- Aromatics/Polycyclene Mix Group (13 Components. Table 4-7).

The fragrances of the following firms were inserted for the individual components and mix groups:

Bell Flavours + Fragrances. Miltitz

Düllberg Konzentra. Hamburg.

Haarmann + Reimer GmbH. Holzminden

Kitzing GmbH, Wallerstein

The manufacture of the examined subjects was realized by the firm of Schümann Sasol GmbH & Co. , KG Hamburg. The utilized fragrance oils were mixed in accordance with the rules governing the production processes of the raw masses of candles. In the previous instances, the admixture of fragrance substances amounted to 1.5 % paraffin.

Table 4-1: Mix NR. 1 - Sixth-Part Mix Group

Product Number	Product Name	Mixture Fraction
300 101	Verto citral	5.0
131 104	Hexenol cis-3	5.0
690 688	Hexenylacetate cis. trans-3	10.0
660 345	Phenyl acetaldehyde himethyl acetal	70.0
660 567	Isoananate	5.0
690 307	Floropal / Corps 717	50.0
103 011	Dihydromy recnol	60.0.
130 524	Linalyl acetate	65.0
600 021	Citral pure H & R	20.0
100 124	Citronella oil Ceylon	20.0
100 542	White Orange oil	200.0
600 285	Claritone	80.0
130 659	Nerolin Bromelia	30.0
665 020	Crystal Nerolin Yara Yara	5.0
660 240	Methyl Naphthyl keytone beta crystal	15.0
698 337	Phellandrene alpha LP	50.0
614 079	Pinene beta supra	50.0
614 078	Pinene alpha supra	25.0
130 969	Ocimene	25.0
620 103	Menthone / Isomenthone	10.0
620 050	Thymol crystal H & R	5.0

Table 4-1 cont.

611 201	Ethyl isovalerianate	5.0
606 001	Aldehyde C 18 a.k.a.	10.0
106 182	Aldehyde C 16 a.k.a. P	25.0
606 009	Aldehyde C 14 a.k.a.	25.0
130 482	Lilial	100.0
130 965	Lyral	150.0
600 092	Mugetanol	40.0
131 409	Mayol	25.0
130 329	Farnesol 100%	15.0
130 520	Linalool	75.0
130 255	Dimethyl benzene	10.0
103 258	Phenyl ethyl dimethyl carbinol	5.0
131 364	Rose oxide rac.	5.0
130 780	Rose oxide L	5.0
130 744	Phenyl ethyl alcohol	60.0
103 936	Phenyl ethyl phenyl acetate	5.0
106 184	Citronella oil 950	45.0
601 330	Geraniol supra	30.0
600 064	Rosaphen	60.0
131 354	Damascon alpha	1.0
131 355	Damascon beta	1.0
130 273	Diphenyl oxide	100.0
613 031	Benzl acetate	50.0
130 041	Hexylzimt aldehyde alpha	143.0
660 137	Projasmone P	25.0
660 408	Benzylsalicylate	40.0
103 249	Hexylsalicylate	40.0
131 486	Ionone beta Giv.	25.0
608 025	Eugenol	80.0
660 013	Anise camphor NPU 21/22%	50.0
130 382	Heliotropen / Piperonal	10.0
660 021	Anise aldehyde supra	5.0
130 879	Vanilla	15.0
600 008	Cinnamic aldehyde P	5.0
654 060	Cinnamic alcohol	20.0
600 194	Benzaldehyde DD (oil of bitter almonds)	30.0
130 217	Cumarin	5.0
660 308	Orvelon extra	40.0
661 269	Agrumex HC	50.0
140 370	Vertofin Coeur	50.0
605 039	Longifolene rekt.	50.0
131 414	Iso E. Super	60.0
690 165	Jacaranda /Corps 749	150.0
600 267	Hexahydroiraldein	40.0
600 001	Sandolen H & R	30.0
600 138	Ambral H& R	5.0
690 974	Ambroxide pure	5.0
106 114	Globalid 100%	50.0
660 539	CPD / Cyclopentadecanolid Supra	20.0
131 535	Galanolid 50% in BB	100.0
130 866	Tonalid	20.0
103 296	Isododecan	75.0
160 102	Dipropylene glycol	20.0
160 217	Diethylphthalate	55.0

Table 4-2: Mix Group NR. 2 - Lactone Mix Group

Product Number	Product Name	Mixture Fraction
690 688	Hexenyl acetate	20.0
660 567	Isoananat	1.0
130 524	Linalyl acetate	130.0
611 025	Isoamyl butyrate	20.0
611 201	Ethyl isovalerianate	10.0
606 001	Aldehyde C 18 a.k.a.	20.0
606 009	Aldehyde C 14 a.k.a.	50.0
106 182	Aldehyde C 16 a.k.a. P	50.0
613 031	Benzyl acetate	100.0
660 408	Benzyl salizylate	80.0
103 249	Hexyl salizylate	80.0
660 308	Oryclon extra	80.0
661 269	Agrumex HC	100.0
106 114	Globalid 100%	100.0
660 539	CPD / Cyclopentade canolid supra	40.0
160 217	Diethyl phthalat	110.0
	16 Components	1000.0

Table 4-3: Mix Group NR. 3 - Aldehyde/Ketone Mix Group

Product Number	Product Name	Mixture Fraction
600 101	Verto citral	10.0
600 021	Citral pure H & R	40.0
100 124	Citronella oil Ceylon	40.0
600 285	Claritone	160.0
620 103	Menthone / Isomenthone rac	20.0
131 54	Damascon alpha	2.0
131 355	Damascon beta	2.0
130 041	Hexyl cinnamic aldehyde alpha	286.0
660 137	Projasmone P	50.0
131 486	Ionone beta Giv.	50.0
660 021	Anise aldehyde supra	10.0
130 879	Vanilla	20.0
600 008	Cinnamic aldehyde P	10.0
140 370	Vertofix Coeur	100.0
131 414	Iso E Super	120.0
600 267	Hexaydroiraldein	80.0
	16 Components	1000.0

Table 4-4: Mix NR. 4 - Alcohol Mix Group

Product Number	Product Name	Mixture Fraction
131 104	Hexenol cis - 3	10.0
103 011	Dihyronmy recnol	120.0
600 092	Mugetanol	80.0
131 409	Mayol	50.0
130 329	Farnesol 100%	30.0
130 520	Linalool	150.0
130 255	Dimethyl benzyl carbinol	20.0
130 258	Phenyl ethyl Dimethyl carbinol	10.0
130 744	Phenyl ethyl alcohol pure	120.0
106 184	Citronella oil 950	90.0
601 330	Geraniol supra	90.0
600 064	Rosaphen	120.0
654 060	Cinnamic alcohol	40.0
600 001	Sand oils H & R	60.0
160 102	Dipropylene glycol	40.0
	15 Components	1000.0

Table 4 - 5: Mix Number 5 - Ether Mix Group

Product Number	Product Name	Mixture Fraction
660 345	Phenyl acetaldehyde dimethyl acetal	140.0
130 695	Nerolin Bromelia	60.0
131 364	Rose oxide rac.	10.0
130 780	Rose oxide L	10.0
130 273	Diphenyl oxide	200.0
608 025	Eugenol	160.0
660 013	Anethol NPU 21/22 degrees C	100.0
690 165	Jacaranda wood. Corps 749	300.0
600 138	Ambral H & R	10.0
690 974	Ambroxide	10.0
	10 Components	1000.0

Table 4 - 6: Mix Number 6 - Terpene Mix Group

Product Number	Product Name	Mixture Fraction
100542	Orange oil; white	400.0
698337	Phellandrene alpha L P	100.0
614079	Pinine beta supra	100.0
614078	Pinene alpha supra	50.0
130969	Ocimene	50.0
660532	Cymene para supra	50.0
605039	Longifolen rectified	100.0
103296	Isododecane non-taxed	150.0
	8 Components	1000.0

Table 4 -7: Mix Number 7 - Aromatics/Polycyclene Mix Group

Product Number	Product Name	Mixture Fraction
690307	Floropal / Corps 717	100.0
665020	Nerolin Yara Yara crystal	10.0
660240	Methyl napthyl keton beta crystal	30.0
620050	Thymol crystal H & R	10.0
130482	Lilial	200.0
130965	Lyral	300.0
103936	Phenyl ethyl phenyl acetate	10.0
130382	Heliotropin / Piperonal	20.0
130879	Vanilla	10.0
600 094	Benzaldehyde DD	60.0
130217	Cumarin	10.0
131534	Galaxolid 50% in BB	200.0
130866	Tonalid	40.0
	13 Components	1000.0

4.2 Oxidation Products from Aromatic Candles

Through the burning of candles, the substances that are in the candles themselves can be let into the air. except for those which were dissolved by the thermal processes of burning. From there the toxocologically relevant substances could form themselves anew in the surrounding air. In the present investigation the chosen polychlorinated dibenzo-p-dioxine and -furane, the polycyclical aromatic carburetted hydrogen, and the selected aldehydes are at the center of this investigation. One can therefore proceed from the assumption that it herewith is a question of predominant secondary products that exist as a result of the burning of the key substances.

5. SAMPLES AND ANALYSIS

5.1 Raw Materials

Paraffin candles were already analyzed in the key substance investigation. The unification of the raw mass of candles and of the wick materials through PCDD/PCDF, chlorphenole, chlorbenzole, and the plant protection means a-HCH, y-HCH, o,p'-DDT and p,p'-DDT were investigated at that time. The analysis is the foundation report from which to infer (Ökometric, University of Beyreuth, 1994).

The utilized scent mixtures are exactly defined in the chemical composition, cf. Chapter 4. An analysis of the unification through the analyzed substances did not take place, so that the manufacturing limitations expected no higher contents, especially of PCDD/PCDF.

5.2 Oxidation Products from Aromatic Candles

5.2.1 Oxidation Investigation and Test Trials

5.2.1.1 PCDD/PCDF and PAK

The burning investigation through agreement of the PCDD/PCDF and PAK emissions followed the burning probe standards of the Union of German Candle Manufacturers (Standard 1; July 1994). The burning attempts occurred in the specially developed investigations apparatus, just as they did in the previous investigations programs. Nine candles burned at the same time in drought free conditions with a defined rate of change of air.

In order to avoid a falsification because of unfiltered room air, ca. 1.2 m³ of air volume (= "dead volume" of the investigation area) was guided by the testing apparatus after the lighting of the candles. Finally, the resulting gasses were lead for more than two hours over the test probe. Afterwards the closed apparatus was quickly opened in order to extinguish the candles, whereby at the same time the air would get sucked though the collection filter, so that the gasses and particles of the after-burning would be trapped. After a minimum of a one hour burning pause, a second and third burn cycle would occur according to the described schema.

The test for PCDD/PCDF and PAK followed after the "full power method": the total remaining products of burning, with air, were guided over a combination particle-gas phase-collection filter system. At the opening of an aluminum tube, a glass fibered filter filtered out the particles left in the gas current. Afterwards the gas flowed continuously though a gas phase filter element out of two PU foam filters, which had a 20 mm thick XAD2-coating. Because of the combination of the PU filter with the coating XAD2, a polystyrene resin derivative, the absorption properties of the system improved itself for lighter, more fluid PCDD/PCDF and PAK connections.

After the described procedures, seven burning experiments of the candles of the seven investigation mixtures followed, as did two reactive component experiments to determine the back ground charge.

As measurement of quality assurance, for each experiment the first PU foam filter was elevated with the help of isotope-marked PCDD/PCDF standards. The "spike standard" contained a defined mixture of 2,3,7,8-TCDD, 1,2,3,7,8-PeCDF, and 1,2,3,7,8,9-HxCDD. Through the agreement of the regained rates of the marked congener, the evidence of the quality of the of the utilized testing procedures is met.

5.2.1.2 Aldehydes

The same apparatuses, in a modified form, were used in agreement with the highly volatile aldehydes in the gasses released during the burning of the candles. The PU foam was removed and replaced with the double glass phase collection filter with the 2.4 dinitrophenyl hydrazine (DNPH).

Ten minutes after the burning of the candles, the filter carrier with the DNPH double filter was positioned in the gas emission opening. When the exhaust volume energy goes through the filter at a maximum of 60 l/h, a similar quantity conversion of the aldehyde in its according hyrdrazo compounds can also be run out. In order to prevent an

overload of the testing filters, in this instance the apparatus was driven through a divided circuit procedure. Therefore the burning time of the candles per cycle was only an hour. Also, with this the smoke produced after the extinguishing of the candles was trapped.

After this procedure, seven burning tests followed. With this two reactive component determinations took place. To further this purpose, the air in the room was sucked through a pump with a second collection filter with a volume of energy of ca. 60 l/hj, which was positioned in direct proximity to the closed testing apparatus.

5.2.2 Analysis

5.2.2.1 PCDD/PCDF and PAK

The filter was extracted on a soxhlet with toluene, and, after a column chromatic graphical purification, was analyzed and quantified with a central high solvent (for PCDD/PCDF) and, respectively, a low solvent (for PAK) mass spectrometer.

5.2.2.2 Aldehyde

As soon as the oxidation gasses of the DNPH glass phase collection filter occurred, they were converted quantitatively in the hydrazo compounds. These could be identified and quantified after the eluierung from a filter with the help of HPLC/UVD with a wavelength of 365 nm.

6. CONCLUSIONS

6.1 Raw Materials

The analysis results of the series of investigations are given again in the following :

6.1.1 Paraffin

Table 6-1: Concentration of the Contained Substances Given in ng/kg Raw Mass (Ökometric, U. of Beyreuth, 1994).

Investigated Substances	Concentration in Paraffin wax
PCDD/PCDF	0.59 ng/kg I -TEQ

6.1.2 Wicks

Table 6-2: Impurity Elements in Candle Wicks from Type R 18/3" S"

Investigated Substance	Concentration in Wicks
PCDD/PCDF	0.18 ng/kg I - TEQ

6.1.3 Aroma Mixtures

The exact chemical composition of the aroma mixtures became known through the trial arrangement and was not analytically checked afterwards.

6.2 Oxidation Products from Aromatic Candles

The concentration of the analyzed substances is for the most part very low, and frequently below the test reaction limits. Tables 6-3 and 6-4 give an overview of the dangerous elements found in the oxidation of aromatic candles. This quantity of elements is given in a per gram of the burned aromatic candle wax in the surroundings in Table 6-3. In Table 6-4, it is given in the appropriate air concentration in the burning chamber. For a comparison, the appropriate values of the first candle reports of the oxidation products in pure paraffin candles without added elements are also given.

Table 6-3: Concentration of the Determined Substances in Candles of this Experiment with the Scent Mixtures 1 to 7, Given in ng/kg Raw Mass; the Comparison V-Value presents the Concentration from Pure Paraffin Candles and How They Were Determined in Frame of the First Test Series (Ökometric, U. of Beyreuth, 1994).

Analyzed Substances	Amount of Materials of the Analyzed Substances pro g of Used Paraffin Aromatic Candle Wax							V-Value
	1	2	3	4	5	6	7	
PCDD/PCDF (pg I - TE g)	0.008	0.011	0.004	0.014	0.006	0.006	0.005	0.015
PAK (ng/g)								
Acenaphthene	0.252	0.066	0.130	0.050	0.56	0.028	0.202	< 0.08
Fluorene	1.288	0.792	1.044	0.596	1.564	0.829	0.617	< 0.03
Phenanthrene	2.539	1.585	1.345	1.455	1.765	1.506	1.175	2.81
Anthracene	0.399	0.332	0.350	0.303	0.186	0.413	0.277	0.19
Fluoranthene	0.984	0.709	0.392	0.861	0.562	0.770	0.370	0.35
Pyrene	0.556	0.464	0.273	0.231	0.350	0.208	0.153	0.20
Benz[a]anthracene	0.051	0.042	0.060	0.004	0.015	< 0.004	0.007	0.01
[illegible]	0.161	0.157	0.133	0.115	0.082	0.062	0.075	0.05
[illegible]	0.044	0.021	< 0.004	0.029	0.007	0.014	0.004	0.05
Benzo[a]pyrene	0.011	0.007	< 0.004	0.004	< 0.004	< 0.004	< 0.004	0.01
[illegible]	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.03
Benzo[ghi]perylene	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.03
[illegible]	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	< 0.004	0.07
Aldehyde (ag/g)								
Formaldehyde	94	66	87	150	181	136	163	-
Acetaldehyde	< 300	< 300	< 300	< 300	< 300	< 300	< 300	-
[illegible]	< 100	< 100	< 100	< 100	< 100	< 100	< 100	-
propionaldehyde	< 100	< 100	< 100	< 100	< 100	< 100	< 100	-

Table 6-4: Volume Equivalent Concentrations of the Determined Substances from 9 Candles of this Experiment with the Scent Mixture 1 - 7; the Comparison V-Value Presents the Concentration from Pure Paraffin Candles and how They Were Determined in Frame of the First Test Series (Ökometric, U. of Beyreuth, 1994).

Analyzed Substances	Additional Air Concentrations per m³ Air and 9 Burned Paraffin Aromatic Candles							V-Value
	1	2	3	4	5	6	7	
PCDD/PCDF (pg I-TE/m³)	0.07	0.11	0.04	0.13	0.05	0.05	0.04	0.183
PAK (pg/m³)								
Acenaphthene	2.41	0.68	1.19	0.46	0.49	0.25	1.83	< 0.91
Fluorene	12.27	8.11	9.60	5.19	13.68	7.52	5.58	< 0.31
Phenanthrene	24.20	16.22	12.37	13.27	15.44	13.65	10.62	33.51
Anthracene	3.80	3.39	3.22	2.76	1.63	3.74	2.50	2.28
Fluoranthene	9.38	7.25	3.61	7.85	4.92	6.98	3 35	4.16
Pyrene	5.30	4.75	2.15	2.10	3.06	1.89	1.39	2.37
Benz[a]anthracene	0.49	0.43	0.55	0.03	0.13	< 0.03	0.07	0.12
Chrysene (= Triphenylene)	1.53	1.61	1.22	1.05	0.72	0.57	0.68	0.63
Benzo[bjk] fluoranthene	0.42	0.21	< 0.03	0.26	0.07	0.13	0.03	0.5
Benzo[a] pyrene	0.10	0.07	< 0.03	0.03	< 0.03	< 0.03	< 0.03	0.12
Indeno[1.2.3-cd] pyrene	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.33
Benzo[ghi] perylene	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.33
Dibenz[ah = ac] anthracene	< 0/03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	0.79
Aldehyde (mg/m³)								
Formaldehyde	0.001	0.001	0.001	0.002	0.003	0.002	0.002	-
Acetaldehyde	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-
Acrolein (2-Propenal)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-
Propionaldehyde	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	-

6.3 Interpretation of the Chemical Analysis

A side mixture in heights of 1.5% to pure paraffin wax allows no large expectation of variation of the conclusions of the analysis of the pure paraffin candles. For most of the measured substances, the concentration lay near or even below the test reaction limits. In this measuring range it is common to tally the measured data with a larger dispersion so that an interpretation of a single measured conclusion of this background must happen. Evidence therefore lets itself meet, which will be briefly illuminated in the following sections.

6.3.1 PCDD/PCDF

The contents of the oxidation gasses of scent mixtures for PCDD/PCDF are as they are for the individual substances. They are also not significant for the total toxic equivalent in comparison to the oxidation products of a pure paraffin candle. The determined value of Mix Group 1 (all scent grades, Sixth-Part Mix Group) is quite exactly the middle value of Mix Groups 2 through 6. It is therefore certain that a mixture of 1.5% of the investigated scent oil has no influence on the PCDD/PCDF in the oxidation gasses.

6.3.2 PAK

The observed substances oscillated for every scent mixture in each investigated individual substance in the range of the greater order., Phenanthrene reached the highest absolute concentration with 1.17 ng/g (Aromatic Mix Group) up until

2.54 ng/g. The oxidation gasses of all measured scent mixtures for Indeno[1,2,3-cd]pyrene, Benzo[ghi]perylene, and Dibenz[ah + ac]anthracene lay below the test reaction limits of 0.004 ng/g of used wax. For Benzo[a]pyrene, only the scent mixtures 2 (Terpene Mix Group), 4 (Alcohol Mix Group), and 1 (Total Mixture)lay over the test reaction limits. It is noticeable that the highest concentration of the single PAK appeared in the standard of the oxidation products of the total mixture. Solely in the event of Flourene or Benz[a]anthracene did the concentration of air in the scent mixture 6 (Terpene Mix Group), or 3 (Aldehyde/Keton Mix Group) lay over the limits.

Table 6-5: Sequence of the Scent Mixtures for the Concentrations of the Individual PAK

PAK	Sequence of the Scent Mixtures; in Ascending Concentrations
Acenapthene	6<4<5<2<V<3<7<1
Fluorene	V<4<7<2<6<3<1<6
Phenanthrene	7<3<4<6<2<5<1<V
Antracene	5<V<7<4<2<3<1<6
Fluoranthene	V<7<3<5<2<6<4<1
Pyrene	7<V<6<4<3<5<2<1
Benz[a]anthracene	6<4<7<V<5<2<1<3
Chrysene (+ Triphenylene)	V<6<7<5<43<2<1
Benzo[bki]fluoranthene	3<7<5<6<2<4<1<V
Benzo[a]pyrene	3,5,6,7<4<2<V<1
Indeno[1,2,3-cd]pyrene	1,2,3,4,5,6,7,<<V
Benzo[ghi]perylene	1,2,3,4,5,6,7<<V
Dibenz[ah + ac]anthracene	1,2,3,4,5,6,7<<V

Over and above it is surprising that the PAK Mix Group (Mix NR. 7) showed relatively high emissions for the measured substances solely by acenaphthene. Otherwise the measured concentrations remained in the lower range. This allows itself therefore to be explained that the scent oils of this mix group show indeed aromatic polycyclic structural elements, whose similarity to the measured PAK however is smaller to classify.

6.3.3 Aldehyde

The measured concentrations of acetaldehyde, acrolein (2-propenal), and propionaldehyde lie below the test result limits after proofing through reactive components for all of the scent mixtures. The limits are certainly relatively high by the previous measurements (300 ng/g or 100 ng/g of burned wax).

Only formaldehyde could be proved in a named value above the reactive components, whereby the Lactone Mix Group, with 66 ng/g of burned wax, had the lowest measured value, and the Ether Mix Group, with 181 ng/g of burned wax, had the highest. The measured value of the Aldehyde Mix Group was, with 87 ng/g of burned wax, the second lowest. Here is also seems that the same effect occurred, as happened in the PAK. The scent oils of this mix group were indeed aldehyde structure elements and proved to be complex molecules, whose burning certainly did not result in the formation of this basis.

7 EVALUATION

In this chapter, a toxicologically relevant risk and exposure evaluation should be realized. Exposure is, on the one hand, theoretically able to be inhaled through released gasses out of seasoned raw materials and through the burn gasses, and, on the other hand, by handling the given candle.

For the inhaling exposure, border, direction, and orientation limits form the basis of the evaluation. In certain instances the following terms are used for comparative purposes:

- Maximal Workplace Concentrations (MAK-Values) or Biological Workplace Tolerance Values (BAT-Values): These are updated yearly by the Senate Commission of Testing Health-Endangering Work Materials of the German Research Group (DFG). The MAK-Value of a substance complies with the highest final concentration of this substance as gas, vapor, or suspended matter in the air at the work place. This concentration did not adversely affect the health of the employed, nor unpleasantly annoy them, even though it was regularly and for long durations of time (daily eight hours by acceptance of a 40 hour work week) exposed.

- Exposure Equivalent for Cancer Producing Work Materials (IIIA), Technical Direction Concentrations (TRK-Values): All through the senate's commission the evaluated substances were separated in to groups based on their classification in reference to their cancerous and mutation possibilities. If a cancerous or mutation potential is proved or suspected, no MAK-Value is given for the appropriate substance. It would accordingly vary between:

--unequivocal as cancer producing expelling work materials (IIIA), with Materials who, with people, act according to experience as cancer producing (IIIA 1), and

--materials, which up until now, have only worked in animal tests as cancer causing (IIIA 2), and materials with a grounded suspicion of having cancer causing potential (IIIB).

From there, the teratoma potential is worth:

A. risk of the damage being surely detected; damage can also appear by the stopping of the MAK or BAT-Values.

B. risk of damage is probable; damage can also not get shut out by the stopping of the MAK or BAT-Values.

C. risk of damage by the stopping of MAK or BAT-Values is not to be feared;

D. classification in one of the groups A-C up till now is not possible.

For this, the scientific basis for a set of limiting values does not suffice, in that cancer and gene mutation only manifest themselves first after tens of years or in following generations, and from that summations effects and repair mechanisms up till now are not well enough known. The stopping of the TRK-Values at the work place should slightly hold the risk of a negative affect on the health of the employee, but it cannot shut out the risk completely.

-Threshold-Limit-Values (TLV-Values): US-American work place limiting values set after the American Conference of Governmental Industrial Hygienists (ACGIH; 1991) the ACGIH divided up the cancer genes into confirmed human cancer genes (A1), and supposed human cancer genes (A2). Analogously the Biological Exposure Indices (BEI) were developed, which corresponded for the most part to the German BAT-Values.

(Here there is a break in the given text)

Zero altitude concentrations from substances or dust, underneath which are current people, animals and plants which are surely protected from negative effects.

-Air Quality Guidelines for Europe (WHO-Values): Through the Regional Office for Europe of the World Health Organization (WHO; 1987), air quality directrix were established. From that, these were utilized as the basis of the toxicological and ecological findings.

-Further Limiting and Orientation Values from the Netherlands, Russia, et al. insofar as is available.

-For PCDD/PCDF: I-TE-Values: The concept of the toxicity equivalent factors (TEF) is based on the fact that polychlorinated dibenzo-p-dioxine and furane belong to a common mechanism. which is responsible for their toxicity to humans and animals. Because of the WHO, the particular TE factors were established for the individual congener. The basis is the toxicity of the most toxic congeners, 2, 3, 7, 8 TCDD, whose toxicity with 1 is assessed. All remaining congener lay around or under one or more order of magnitudes.

At the moment there is a new estimation for the human and mammal toxin levels from 1, 2, 3, 7, 8-PeCDD (TEF, old: 0.5, new: 1.0), OCDD (TEF, old: 0.001, new: 0.0001) and OCDF (TEF, old: 0.001, new: 0.0001).

A combination of the limiting, standard, and orientating values for the investigated substances are shown in the following table:

Table 7-1: Analyzed Substances and their Limiting, Standard and Orientation Values

Individual Substances	Limiting, Standard, and Orientation Values
PCDD/PCDF	
Sum of the investigated congener	TRK-Value = 50 pg I-TE/m.
PAK	
Anthracene	TLV-Value suggestion (ca. 1984) 100 pg/m. (Rippen 9/1993): unequivocal cancer causing, classified by the US-American Environmental Authority (Dieter; 1990)
Benz[a]anthracene (BaA)	Toxicity equivalents (comparable to the I-TEQ by polychlorinated dibenzo dioxinene and furane. Basis substance benzo[a]pyrene 1.0 (Rippen, 3/1996). NL (1991): statistically additional cancer risks from 10. with 20 pg/kg KG per day (Rippen 3/1996). MAK/BAT-Values: carcinogens in animal tests, with no limiting values (especially work materials) (DFG 1996).

Benzo[a]pyrene (BaP)	Many faceted employed "light substance" for purification of air with PAK. TA-Air: emissions of class I (Sum of limiting values = 0.1) Toxicity equivalent (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furane, basis substance B[a]P): 1.0 (Kalberlah, et al; 1995). statistical cancer risk 0.07 per pg/m³ (LAI, 1992). Recommendation of the State Waste of Emission Protection: Surrounding air 1.3 ng/m³ (LAI 1992). D (ca. 1986): standard value for yearly means (Immersion) 10 mg/m³. D (1987): Minimal standards for precautions 1-10 ng/m³ in yearly means. BImSch V (1991): no limitations foreseen. MAK/BAT-Value: IIIBI: carcinogens in animal tests, therefore no limiting values (esp. work materials) (DFG, 1996). TRK-Value: 0.002 mg/m³ NL (1991): additional statistical cancer risks from 10⁻⁴ to 20 pg/kg KG per day (Rippen 7/1993). USA: limiting values for exposition at the work place: coke oven 8-hour-means-value 150 pg/m (PAK entire) (Sittig, 1980).
Benzo [bjk] fluoranthene (BbF, BjF, BkF)	MAK/BAT-Value: IIIA2: supposed human cancer causes, therefore no limiting values (esp. work materials). Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxidne and furanene. Basis substance B[a] P): 0.001 to 0.1 (Kalberlah et al., 1995). USA: B2 after EPA (1994).
Benzo [ghi] perylene (BghiP)	Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furnanene. Basis substance B[a]P): 0.001 to 0.1 (Klaberlah et al, 1995).
Chrysene (+ Triphenylene) (Chr)	Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furanene, basis substance B[a]P): 0.001 to 1.0 (Kalberlah et al, 1995).
Dibenzo[ah + ac] anthracene (DahA, DacA)	DahA: WHO-classification as mutations and carcinogens MAK/BAT-Values: carcinogens in animal tests, therefore no limiting values (esp. work materials) (DFG, 1996) Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furanene. Basis substance B[a]P: 1.0 (Kalberlah et al, 1995).
Fluoranthene (FA)	NL (1991): additional statistical cancer risk from 10⁻⁴ with 20 pg/kg KG per day (Rippen 2/1994). Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furanene. Basis substance B[a]P): 0.001 to 1.0 (Kalberlah et al, 1995).
Fluorene (Flu)	MAK/BAT-Value: carcinogens in animal test, therefore no limiting value (esp. work materials) (DFG 1996) Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furanene. Basis substance B[a]P: 0.1 to 0.001 (Kalberlah et al, 1995)
Indeno [1,2,3-cd] pyrene (Ind [123-cdP)	Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furanene. Basis substance B[a]P) 0.1 (Kalberlah et al 1995).
Phenenthrene (Ph)	Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furanene. Basis substance B[a]P 0 to 0.1 (Kalberlah et al, 1995). NL (1991): additional statistical cancer risks from 10⁻⁴ with 20 pg/kg KG per day (Rippen, 9/1993).
Pyrene (Py)	Toxicity equivalents (comparable to the I-TEQ with polychlorinated dibenzo dioxinene and furnanene. Basis substance B[a]P) 0 to 0.1 (Kalberlah et al, 1995) NL (1991): additional statistical cancer risks from 10⁻⁴ with 20 pg/kg KG per day (Rippen, 3/1994). UdSSR (1997): PdK 0.3 mg/m³ (Rippen, 3/1994)

Aldehyde

Formaldehyde	WHO (1987): air quality-standards for 30 minute exposition: 0.1 mg/m³ (Rippen, 8/96). D / 1986) emissions after TA air: with a mass of energy from 0.1 kg/h and more limiting value of 20 mg/m³ (Rippen, 8/1996). D (1991) interference event order: lead in appendix II. quantity waves 10,000 / 50,000 kg (> 50 weight -%) (Rippen, 8/1996). S (1993): suggested standard value for the central long time worry 12-60 pg/m³ (Rippen, 8/1996) USA (1988/89): TLV/TWA: 1 ppmv or 1.5 mg/m³ Classification in group A2: supposed carcinogens to humans (Rippen, 8/1996). TLV/STEL: 2 ppmv or 3 mg/m³ (Rippen, 8/1996). USSR (1987): PdK: 0.4 ppmv or 0.5 mg/m³ (Rippen, 8/1996). Russia (ca. 1992): max. added 20 minute concentration: 35 pg/m³ max. additional 24 hour concentration: 3 pg/m³ MAK-Value (1996): 0.5 ppmv or 0.6 mg/m³ estimate in group IIIB (grounded suspicion for cancer causing potential). Pregnancy group C (Risk of damage with stopping the MAK-Value is not to be feared) (DFG, 1996).
Acetaldehyde	MAK-Value: 50 ppm or 90 mg/m³ . Classification from Group IIIB (grounded suspicion for cancer causing potential). Pregnancy group D (classification not yet possible) (DFG, 1996). MIK-Value (1966): Length of workings: 2 ppmv or 3.7 mg/m³ . Short time workings: 6 ppmv or 11.0 mg/m³ (Rippen, 3/1996). TA Air: with an energy mass of > 0.1 kg/h: limiting value 20 mg/m³ (Rippen, 3/1996).
Acrolein = 2-Propenal	MAK-Value: 0.1 ppm or 0.25 mg/m³ IDLH: 2 ppm (NIOSH, 1994) TWA (1994): 0.1 ppm or 0.25 mg/m³ (NIOSH, 1994) ST (1994): 0.3 ppm or 0.75 mg/m³ (NIOSH, 1994).
Propionaldehyde	k. A.

For the dermal exposure and the exposure through absorption, there are currently no existing limiting values; standard and orientation values exist solely for pyrene (NL- and PdK-Values).

7.1 Risk and Exposure Evaluations for the Raw Materials

Theoretically, exposure to the raw materials is, on the one side, possible through inhalation of the fumes from seasoned raw materials. or, on the other hand, through skin contact. For small children there is the additional risk of consuming all or part of an aromatic candle.

The concentration found in pure paraffin and in paraffin wax wicks on the investigated chemical substances as prepared in the basis report of 1994 presents no toxicological danger to humans.

There has been no produced data on the toxicology of the individual aroma essences. It is certainly noteworthy that they changed partly toxicologically relevant to structurally near substances, for example: dipropylene glycol or isoamybutyrat. In light of this series of investigations, no further work on them has therefore been done.

7.2 Risk and Exposure Evaluations for the Oxidation Products

The following risk and exposure evaluations contain an evaluation of the regulated (in Germany through the MAK or TRK-Values) substances: benzo[a]pyrene, formaldehyde, acetaldehyde, and acrolein, and even the given toxic equivalents for PCDD/PCDF.

7.2.1 Comparison of the Determined Value of Emissions with Limiting Values

The comparison of the value of emissions with the existing limiting, standard and orientation values follows, in that the exhaust of the limiting values would be calculated through the candle emissions. This happens via the formula:

% of the limiting value = (emissions value of the candle/limiting value) * 100%

The results of this calculation are presented together in the following table 7-2.

Table 7-2: Calculating the MAK and TRK Values by the Burning of 9 Aromatic Candles

Substance	Emission of 9 Aromatic Candles	TRK-Value	% Calculation of the TRK-Value	MAK-Value	% Calculation of the MAK-Value
PCDD/PCDF		50 pg I-TE/m³			
Scent Mixture 1	0.07 pg I-TE/m³		0.14		
Scent Mixture 2	0.11 pg I-TE/m³		0.22		
Scent Mixture 3	0.04 pg I-TE/m³		0.08		
Scent Mixture 4	0.13 pg I-TE/m³		0.26		
Scent Mixture 5	0.05 pg I-TE/m³		0.10		
Scent Mixture 6	0.05 pg I-TE/m³		0.10		
Scent Mixture 7	0.04 pg I-TE/m³		0.08		
Benzo[a]pyrene		2,000 ng/m³			
Scent Mixture 1	0.10 pg/m³		0.0050		
Scent Mixture 2	0.07 pg/m³		0.0035		
Scent Mixture 3	<0.03 pg/m³		<0.0015		
Scent Mixture 4	0.03 pg/m³		0.0015		
Scent Mixture 5	<0.03 pg/m³		<0.0015		
Scent Mixture 6	<0.03 pg/m³		<0.0015		
Scent Mixture 7	<0.03 pg/m³		<0.0015		
Formaldehyde		2,000 ng/m³			
Scent Mixture 1	0.001 mg/m³		0.0050		
Scent Mixture 2	0.001 mg/m³		0.0035		
Scent Mixture 3	0.001 mg/m³		<0.0015		
Scent Mixture 4	0.002 mg/m³		0.0015		
Scent Mixture 5	0.003 mg/m³		<0.0015		
Scent Mixture 6	0.002 mg/m³		<0.0015		
Scent Mixture 7	0.002 mg/m³		<0.0015		
Acetaldehyde				90 mg/m³	
All Scent Mixtures	<0.010 mg/m³				<0.01
Acrolein				0.250 mg/m³	
All Scent Mixtures	<0.005 mg/m³				<2

The comparison of the oxidation products through emissions caused concentrations with the MAK or TRK-Values of the respective substance yields, in any event, that, by burning, in this case nine candles, at the same time, only fractions.

Benzo[a]pyrene, as the indicator substance, never exceeded 0.01% of the fixed employee protection technical standard concentration. Formaldehyde, in one instance, reached concentrations of 0.5 % of the maximum work place concentration (MAK), acetaldehyde was below 0.01 %, and Acrolein was below 2 % of the MAK-Value.

7.2.2 Determination of the Critical Volumes

As they were in the previous reports. the methods of the "critical volume" were originally developed for the product review in the frame of ecological balance (BUWAL 1990). The critical volume of a substance is in this case a measure of it. whose volume of air is necessary so that the released dangerous elements can be thinned in order not to exceed the limiting value. The smaller the noted volume, the lower the emissions value is in comparison to the current limiting value.

The calculation is reached with the following formula:

Critical Volume = the Released Dangerous Elements / Limiting Value

So that the limiting values make a volume of 1 m. (= 1,000 l), a critical volume means from over 1.000 l, because the emissions must be thinned in the appropriate higher volumes of air in order to stay below the limiting values. The reverse means a critical volume of under 1,000 l, that theoretically would only reach the limiting value for this volume through an out concentration of air.

The following evaluation of Table 7-3 was realized after the burning of 30 scented candles (= 600 g wax).

Table 7-3: Critical Volumes for the Burning of 30 Aromatic Candles (= 600 g Aromatic Candle Wax)

Substance	Released Dangerous Elements as a Result of Burning 30 Candles	TRK-Value	Critical Volume	MAK-Value	Critical Volume
PCDD/PCDF		50 pg I-TE/m.		-	-
Scent Mixture 1	4.8 pg		96 l		
Scent Mixture 2	6.6 pg		132 l		
Scent Mixture 3	2.4 pg		48 l		
Scent Mixture 4	8.4 pg		168 l		
Scent Mixture 5	3.6 pg		72 l		
Scent Mixture 6	3.6 pg		72 l		
Scent Mixture 7	3.0 pg		60 l		
Benzo[a]pyrene		2.000 ng/m.		-	-
Scent Mixture 1	6.6 ng		3..3 l		
Scent Mixture 2	4.6 ng		2..3 l		
Scent Mixture 3	<2.4 ng		<1.2 l		
Scent Mixture 4	2.4 ng		1..2 l		
Scent Mixture 5	<2.4 ng		<1.2 l		
Scent Mixture 6	<2.4 ng		<1.2 l		
Scent Mixture 7	<2.4 ng		<1.2 l		

Formaldehyde		-		0.6 mg/m³	
Scent Mixture 1	0.0564 mg				94 l
Scent Mixture 2	0.0396 mg				66 l
Scent Mixture 3	0.0522 mg				87 l
Scent Mixture 4	0.0900 mg				150 l
Scent Mixture 5	0.1086 mg				181 l
Scent Mixture 6	0.0816 mg				136 l
Scent Mixture 7	0.0978 mg				163 l
Acetaldehyde All Scent Mixtures	<0.06 mg	-		90 mg/m³	<0.67 l
Acrolein All Scent Mixtures	<0.06 mg	-		0.250 mg/m³	<240 l

The result of this high calculation corresponds to the results of the previous comparisons with MAK and TRK-Values. In all instances , with the improbability of a burning of 30 candles at one time, the critical volume of 1.000 liters would not be reached.

7.2.3 Comparison of Oxidation Gasses with Cigarette Smoke

The worst case scenario is that 30 candles (600 g wax), in a medium-sized room (50 m³) without proper ventilation, would burn for four hours. The dangerous elements that would be released would highly calculate in the air concentration. The resulting air concentration would compare with the concentration of the burning of one cigarette (DFG 1985).

Table 7-4: Concentration in a Living Space of 50 m³ After the Burning of 30 Aromatic Candles (600 g wax) in Contrast to a Cigarette

Substance	Quantity of Released Materials from the Burning of 30 Aromatic Candles	Concentration in the Room's Air after the Burning of 30 Candles	Concentration in the Room' s Air after the Burning of one Cigarette	MAK-Value/TRK-Value
PCDD/PCDF			0.02 pg I-TE/m³	50 pg I-TE/m³
Scent Mixture 1	4.8 pg	0.096 pg I-TE/m³		
Scent Mixture 2	6.6 pg	0.132 pg I-TE/m³		
Scent Mixture 3	2.4 pg	0.048 pg I-TE/m³		
Scent Mixture 4	8.4 pg	0.168 pg I-TE/m³		
Scent Mixture 5	3.6 pg	0.072 pg I-TE/m³		
Scent Mixture 6	3.6 pg	0.072 pg I-TE/m³		
Scent Mixture 7	3.0 pg	0.060 pg I-TE/m³		
Benzo[a]pyrene	6.6 ng	0.132 ng/m³	2.6 ng/m³	2,000 ng/m³
Scent Mixture 1	4.6 ng	0.092 ng/m³		
Scent Mixture 2	<2.4 ng	<0.048 ng/m³		
Scent Mixture 3	2.4 ng	0.048 ng/m³		
Scent Mixture 4	<2.4 ng	<0.048 ng/m³		
Scent Mixture 5	<2.4 ng	<0.048 ng/m³		
Scent Mixture 6	<2.4 ng	<0.048 ng/m³		
Scent Mixture 7	<2.4 ng	<0.048 ng/m³		

Formaldehyde			0.0305 mg/m³	0.6 mg/m³
Scent Mixture 1	0.0564 mg	0.001128 mg/m³		
Scent Mixture 2	0.0396 mg	0.000792 mg/m³		
Scent Mixture 3	0.0522 mg	0.001044 mg/m³		
Scent Mixture 4	0.0900 mg	0.001800 mg/m³		
Scent Mixture 5	0.1086 mg	0.002172 mg/m³		
Scent Mixture 6	0.0816 mg	0.001632 mg/m³		
Scent Mixture 7	0.0978 mg	0.001956 mg/m³		
Acetaldehyde All Scent Mixtures	<0.06 mg	<0.0012 mg/m³	No Specification	90 mg/m³
Acerolein All Scent Mixtures	<0.06 mg	<0.0012 mg/m³	0.185 mg/m³	0.25 mg/m³

In comparing the emissions from burning 30 candles with the smoke of one cigarette, it is shown that by PCDD/PCDF, the I-TE concentration exceeds the according concentration as a result of smoke from a single cigarette around a multiple. But. the concentration of benzo[a]pyrene that was caused because of the smoke of a cigarette never was never reached. In this case. the air concentration. which was caused by the aromatic candle emissions, was around one or two of the order of magnitude below that of the cigarette's comparison value, as with formaldehyde. Also with acrolein, the emission value of a cigarette compared to all aromatic candle mixtures through the burning of 30 candles, only reached one small fraction.

7.2.4 Absorption of PCDD/PCDF with Breathing Air

The released materials of PCDD/PCDF would confront, under worst case-consumption of the average daily PCDD/PCDF absorption, a grown citizen.

One would again consider the extreme case of burning 600 grams of wax in a time span of four hours in a room of 50 m³ without proper ventilation *after* the burning of the candles. At this moment the air contains the highest amount of PCDD/PCDF. Further, the average air volume of a grown person of 500 l/h would be based on a total breath volume of 2 m³ breath volume during this time period.

The following table 7-5 shows the percent fractions of this able to be inhaled absorption as a total daily absorption (100% = 11.5 pg I-TEQ), as also in the daily absorption through breathing (100% = 1.5 pg I-TEQ) the largest fraction of the inhaled PCDD/PCDF obtained in the sustaining of the body.

Table 7-5: The Maximal Personal Intake of a Quantity of a Substance in a Living Space (50 m³) in Comparison to the Normal Amount

Scent Mixtures	Quantity of Released Materials from the Burning of 30 Aromatic Candles	Quantity of Inhaled Substances	% of the Total Daily Absorption	% of the Daily Absorption through Respiration
Scent Mixture 1	4.8 pg	0.192 pg	0.17	13
Scent Mixture 2	6.6 pg	0.264 pg	0.23	18
Scent Mixture 3	2.4 pg	0.096 pg	0.08	6
Scent Mixture 4	8.4 pg	0.336 pg	0.29	22
Scent Mixture 5	3.6 pg	0.144 pg	0.13	10
Scent Mixture 6				
Scent Mixture 7				

In all instances additional disturbances produced themselves, who in comparison to the daily absorption quantities, are unimportant to look at. The maximum value of Mixture 4 was reached with 0.29 % of the total, or 22 % of the additional inhaled parts.

7.2.5 Summary of the Risk Evaluations

Except for being in very improbable extreme situations - burning of 30 scented candles all at the same time in a relatively small living area without ventilation - there is no danger to the health according to the measurements of determined human toxicological limiting values (MAK or TRK). The excess of the standard concentration (TRK-Values) that were assumed solely in the case of the polychlorinated dioxine and furane, can nevertheless be considered as unimportant in comparison to the daily average absorption quantities of a human. Normally, aromatic candles would be burned at the same time only in small quantities (1 to 3 candles) because of their effects, so that the patterned acceptance, which makes this result of this study comparable with those of the previous ones, locks in the security factor of 10.

A significant additional risk by the able to be inhaled absorption of candle emissions is therefore toxicologically not deductible.

8 OVERVIEW

After the results of this report, emissions caused from the burning of the investigated paraffin-aromatic candles prove no significant danger potential to humans. This completed investigation, through the formation of a complex scent mixture and seven synergistic effects, chemically similar to chosen mixtures, is in part considerable, and therefore, this draft allows a prognosis for industrial manufacturing mixtures of the employed individual components.

These investigation results have, together with the previous programs, lead and renewed an important contribution to the production assessment of candles.

Additional investigation series can concern themselves with, for example, additions to other raw candle materials, especially stearin. Further, potential synergistic effects as a result of color and scent materials or ornamental elements could be investigated for their emission values.

Over and above that, it was meaningful to investigate the carbon development which occurred because of turbulence through drafts.

PCDD/PCDF

Test specification: Reactive Component A
Laboratory NR: 292/97-8
Testing Volume: 27,435 m.

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.
Total TCDD	< 10		< 0.36
2,3,7,8-TCDD	< 1	1.00	< 0.04
Total PeCDD	< 10		< 0.36
1,2,3,7,8-PeCDD	< 1	0.50	< 0.04
Total HxCDD	< 10		< 0.36
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.04
1,2,3,6,7,8-HxCDD	6	0.60	0.22
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.04
Total HpCDD	18		0.66
1,2,3,4,6,7,8-HpCDD	13	0.13	0.47
OCDD	40	0.04	1.46
Total PCDD	88	2.47	3.21
Total TCDF	< 10		< 0.36
2,3,7,8-TCDF	2	0.20	0.07
Total PeCDF	13		0.47
1,2,3,7,8-PeCDF	3	0.15	0.11
2,3,4,7,8-PeCDF	3	1.50	0.11
Total HxCDF	17		0.62
1,2,3,4,7,8-HxCDF	8	0.80	0.29
1,2,3,6,7,8-HxCDF	3	0.30	0.11
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.04
2,3,4,6,7,8-HxCDF	3	0.30	0.11
Total HpCDF	10		0.36
1,2,3,4,6,7,8-HpCDF	4	0.04	0.15
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.11
OCDF	12	0.01	0.44
Total PCDF	62	3.43	2.26
Total I-TE		5.90	0.22

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	108
13C12-1,2,3,7,8-PeCDF	116
13C12-1,2,3,4,7,8,9-HxCDD	121

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PCDD/PCDF

Test specification: Reactive Component B
Laboratory NR: 292/97-9
Testing Volume: 33,372 m.

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.
Total TCDD	< 10		< 0.30
2,3,7,8-TCDD	< 1	1.00	< 0.03
Total PeCDD	< 10		< 0.30
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03
Total HxCDD	< 10		< 0.30
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03
1,2,3,6,7,8-HxCDD	4	0.40	0.12
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.03
Total HpCDD	28		0.84
1,2,3,4,6,7,8-HpCDD	17	0.17	0.51
OCDD	97	0.10	2.91
Total PCDD	155	2.37	4.64
Total TCDF	< 10		< 0.30
2,3,7,8-TCDF	2	0.20	0.06
Total PeCDF	16		0.48
1,2,3,7,8-PeCDF	2	0.10	0.06
2,3,4,7,8-PeCDF	3	1.50	0.09
Total HxCDF	14		0.42
1,2,3,4,7,8-HxCDF	7	0.70	0.21
1,2,3,6,7,8-HxCDF	2	0.20	0.06
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03
2,3,4,6,7,8-HxCDF	2	0.30	0.06
Total HpCDF	< 10		< 0.30
1,2,3,4,6,7,8-HpCDF	4	0.04	0.12
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.09
OCDF	16	0.02	0.48
Total PCDF	66	3.09	1.98
Total I-TE		5.45	0.16

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	104
13C12-1,2,3,7,8-PeCDF	109
13C12-1,2,3,4,7,8,9-HxCDD	112

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PCDD/PCDF

Test specification: Mean Value of A and B
Testing Volume: 30,404 m.

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.
Total TCDD	< 10		< 0.33
2,3,7,8-TCDD	< 1	1.00	< 0.03
Total PeCDD	< 10		< 0.33
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03
Total HxCDD	< 10		< 0.33
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03
1,2,3,6,7,8-HxCDD	5	0.50	0.16
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.03
Total HpCDD	23		0.76
1,2,3,4,6,7,8-HpCDD	15	0.15	0.49
OCDD	68.5	0.07	2.25
Total PCDD	121.5	2.42	4.00
Total TCDF	< 10		< 0.33
2,3,7,8-TCDF	2	0.20	0.07
Total PeCDF	14.5		0.48
1,2,3,7,8-PeCDF	2.5	0.13	0.08
2,3,4,7,8-PeCDF	3	1.50	0.10
Total HxCDF	15.5		0.51
1,2,3,4,7,8-HxCDF	7.5	0.75	0.25
1,2,3,6,7,8-HxCDF	2.5	0.25	0.08
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03
2,3,4,6,7,8-HxCDF	2.5	0.25	0.08
Total HpCDF	< 10		< 0.33
1,2,3,4,6,7,8-HpCDF	4	0.04	0.13
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.10
OCDF	14	0.01	0.46
Total PCDF	64	3.26	2.10
Total I-TE		5.68	0.19

The volume equivalent TE-Value was determined for each test with the actual testing volume. The reactive component that was determined here from here out will not be changed.

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S" plus 1.5% Scent from Sixth-Part Mix Group

Laboratory NR.: 292/97 - 1
Testing Volume: 28,678 m.
Burned Candle Mass: 273.3 g/6h (9 Candles)
Burned Candle Mass/h: 5.06 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	< 10		< 0.35	< 0.037
2,3,7,8-TCDD	< 1	1.00	< 0.03	< 0.004
Total PeCDD	< 10		< 0.35	< 0.037
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03	< 0.004
Total HxCDD	< 10		< 0.35	< 0.037
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03	< 0.004
1,2,3,6,7,8-HxCDD	8	0.50	0.28	0.029
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.03	< 0.004
Total HpCDD	15		0.52	0.055
1,2,3,4,6,7,8-HpCDD	11	0.11	0.38	0.044
OCDD	38	0.04	1.33	0.139
Total PCDD	83	2.65	2.89	0.304
Total TCDF	48		1.67	0.176
2,3,7,8-TCDF	8	0.80	0.28	0.029
Total PeCDF	17		0.59	0.062
1,2,3,7,8-PeCDF	4	0.20	0.14	0.015
2,3,4,7,8-PeCDF	5	2.50	0.17	0.018
Total HxCDF	16		0.56	0.059
1,2,3,4,7,8-HxCDF	8	0.80	0.28	0.029
1,2,3,6,7,8-HxCDF	4	0.40	0.14	0.015
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03	< 0.004
2,3,4,6,7,8-HxCDF	3	0.30	0.10	0.011
Total HpCDF	< 10		< 0.35	< 0.037
1,2,3,4,6,7,8-HpCDF	4	0.04	0.14	0.015
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.10	< 0.011
OCDF	10	0.01	0.35	0.037
Total PCDF	101	5.18	3.52	0.370
Total I-TE		7.83	0.27	0.029
I-TE Reactive Component		5.68	0.20	0.021
I-TE Caused through Candles		**2.15**	**0.07**	**0.008**

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	97
13C12-1,2,3,7,8-PeCDF	120
13C12-1,2,3,4,7,8,9-HxCDD	119

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S" plus 1.5% Scent from Lactone Mix Group

Laboratory NR.: 292/97 - 2
Testing Volume: 27,998 m.
Burned Candle Mass: 286.5 g/6h (9 Candles)
Burned Candle Mass/h: 5.31 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	10		0.36	0.035
2,3,7,8-TCDD	< 1	1.00	< 0.04	< 0.003
Total PeCDD	< 10		< 0.36	< 0.035
1,2,3,7,8-PeCDD	1	0.50	0.04	0.003
Total HxCDD	27		0.96	0.094
1,2,3,4,7,8-HxCDD	1	0.10	0.04	0.003
1,2,3,6,7,8-HxCDD	9	0.90	0.32	0.031
1,2,3,7,8,9-HxCDD	2	0.20	0.07	0.007
Total HpCDD	55		1.96	0.192
1,2,3,4,6,7,8-HpCDD	33	0.33	1.18	0.115
OCDD	76	0.08	2.71	0.265
Total PCDD	178	3.11	6.36	0.621
Total TCDF	53		1.89	0.185
2,3,7,8-TCDF	8	0.80	0.29	0.028
Total PeCDF	25		0.89	0.087
1,2,3,7,8-PeCDF	4	0.20	0.14	0.014
2,3,4,7,8-PeCDF	4	2.00	0.14	0.014
Total HxCDF	38		1.36	0.133
1,2,3,4,7,8-HxCDF	13	1.30	0.46	0.045
1,2,3,6,7,8-HxCDF	5	0.50	0.18	0.017
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.04	< 0.003
2,3,4,6,7,8-HxCDF	5	0.50	0.18	0.017
Total HpCDF	26		0.93	0.091
1,2,3,4,6,7,8-HpCDF	17	0.17	0.61	0.059
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.11	< 0.011
OCDF	19	0.02	0.68	0.066
Total PCDF	161	5.62	5.75	0.562
Total I-TE		8.73	0.31	0.030
I-TE Reactive Component		5.68	0.20	0.0198
I-TE Caused through Candles		**3.05**	**0.11**	**0.011**

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	101
13C12-1,2,3,7,8-PeCDF	115
13C12-1,2,3,4,7,8,9-HxCDD	118

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S"
plus 1.5% Scent from Aldehyde/Keton Mix Group

Laboratory NR.: 292/97 - 3
Testing Volume: 31.038 m.
Burned Candle Mass: 285.4 g/6h (9 Candles)
Burned Candle Mass/h: 5.29 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	< 10		< 0.32	< 0.035
2,3,7,8-TCDD	< 1	1.00	< 0.03	< 0.004
Total PeCDD	< 10		< 0.32	< 0.035
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03	< 0.004
Total HxCDD	10		0.32	0.035
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03	< 0.004
1,2,3,6,7,8-HxCDD	7	0.70	0.23	0.025
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.03	0.004
Total HpCDD	14		0.45	0.049
1,2,3,4,6,7,8-HpCDD	9	0.09	0.29	0.032
OCDD	36	0.04	1.16	0.126
Total PCDD	80	2.53	2.58	0.280
Total TCDF	48		1.55	0.168
2,3,7,8-TCDF	7	0.70	0.23	0.025
Total PeCDF	17		0.55	0.060
1,2,3,7,8-PeCDF	4	0.20	0.13	0.014
2,3,4,7,8-PeCDF	3	1.50	0.10	0.011
Total HxCDF	18		0.58	0.063
1,2,3,4,7,8-HxCDF	10	1.00	0.32	0.035
1,2,3,6,7,8-HxCDF	4	0.40	0.13	0.014
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03	< 0.004
2,3,4,6,7,8-HxCDF	4	0.40	0.13	0.014
Total HpCDF	11		0.35	0.039
1,2,3,4,6,7,8-HpCDF	5	0.05	0.16	0.018
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.10	< 0.011
OCDF	14	0.01	0.45	0.049
Total PCDF	108	4.39	3.48	0.378
Total I-TE		6.92	0.22	0.024
I-TE Reactive Component		5.68	0.18	0.0199
I-TE Caused through Candles		1.24	0.04	0.004

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	111
13C12-1,2,3,7,8-PeCDF	104
13C12-1,2,3,4,7,8,9-HxCDD	121

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S" plus 1.5% Scent from Alcohol Mix Group

Laboratory NR.: 292/97 - 4
Testing Volume: 30.445 m.
Burned Candle Mass: 277.6 g/6h (9 Candles)
Burned Candle Mass/h: 5.14 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	< 10		< 0.33	< 0.036
2,3,7,8-TCDD	< 1	1.00	< 0.03	< 0.004
Total PeCDD	< 10		< 0.33	< 0.036
1,2,3,7,8-PeCDD	1	0.50	0.03	0.004
Total HxCDD	36		1.18	0.130
1,2,3,4,7,8-HxCDD	2	0.20	0.07	0.007
1,2,3,6,7,8-HxCDD	9	0.90	0.30	0.032
1,2,3,7,8,9-HxCDD	1	0.10	0.03	0.004
Total HpCDD	80		2.63	0.288
1,2,3,4,6,7,8-HpCDD	43	0.43	1.41	0.155
OCDD	103	0.10	3.38	0.371
Total PCDD	239	3.23	7.85	0.861
Total TCDF	52		1.71	0.187
2,3,7,8-TCDF	8	0.80	0.26	0.029
Total PeCDF	25		0.82	0.090
1,2,3,7,8-PeCDF	5	0.25	0.16	0.018
2,3,4,7,8-PeCDF	5	2.50	0.16	0.018
Total HxCDF	44		1.45	0.159
1,2,3,4,7,8-HxCDF	11	1.10	0.36	0.040
1,2,3,6,7,8-HxCDF	7	0.70	0.23	0.025
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03	< 0.004
2,3,4,6,7,8-HxCDF	6	0.60	0.20	0.022
Total HpCDF	32		1.05	0.115
1,2,3,4,6,7,8-HpCDF	20	0.20	0.66	0.072
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.10	< 0.011
OCDF	28	0.03	0.92	0.101
Total PCDF	181	6.31	5.95	0.652
Total I-TE		9.54	0.31	0.034
I-TE Reactive Component		5.68	0.19	0.0205
I-TE Caused through Candles		**3.86**	**0.13**	**0.014**

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	117
13C12-1,2,3,7,8-PeCDF	110
13C12-1,2,3,4,7,8,9-HxCDD	122

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S"
plus 1.5% Scent from Ether Mix Group

Laboratory NR.: 292/97 - 5
Testing Volume: 30.692 m.
Burned Candle Mass: 268.5 g/6h (9 Candles)
Burned Candle Mass/h: 4.97 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	10		0.33	0.037
2,3,7,8-TCDD	< 1	1.00	< 0.03	< 0.004
Total PeCDD	< 10		< 0.33	< 0.037
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03	< 0.004
Total HxCDD	19		0.62	0.071
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03	< 0.004
1,2,3,6,7,8-HxCDD	6	0.60	0.20	0.022
1,2,3,7,8,9-HxCDD	1	0.10	0.03	0.004
Total HpCDD	28		0.91	0.104
1,2,3,4,6,7,8-HpCDD	17	0.17	0.55	0.063
OCDD	124	0.12	4.04	0.462
Total PCDD	191	2.59	6.22	0.711
Total TCDF	41		1.34	0.153
2,3,7,8-TCDF	6	0.60	0.20	0.022
Total PeCDF	17		0.55	0.063
1,2,3,7,8-PeCDF	4	0.20	0.13	0.015
2,3,4,7,8-PeCDF	4	2.00	0.13	0.015
Total HxCDF	17		0.55	0.063
1,2,3,4,7,8-HxCDF	8	0.80	0.26	0.030
1,2,3,6,7,8-HxCDF	4	0.40	0.13	0.015
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03	< 0.004
2,3,4,6,7,8-HxCDF	4	0.40	0.13	0.015
Total HpCDF	10		0.33	0.037
1,2,3,4,6,7,8-HpCDF	5	0.05	0.16	0.019
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.10	< 0.011
OCDF	21	0.02	0.68	0.078
Total PCDF	106	4.60	3.45	0.395
Total I-TE		7.20	0.23	0.027
I-TE Reactive Component		5.68	0.19	0.0212
I-TE Caused through Candles		**1.52**	**0.05**	**0.006**

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	114
13C12-1,2,3,7,8-PeCDF	115
13C12-1,2,3,4,7,8,9-HxCDD	123

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S" plus 1.5% Scent from Terpene Mix Group

Laboratory NR.: 292/97 - 6
Testing Volume: 31.784 m.
Burned Candle Mass: 288.2 g/6h (9 Candles)
Burned Candle Mass/h: 5.34 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	< 10		< 0.31	< 0.035
2,3,7,8-TCDD	< 1	1.00	< 0.03	< 0.003
Total PeCDD	< 10		< 0.31	< 0.035
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03	< 0.003
Total HxCDD	13		0.41	0.045
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03	< 0.003
1,2,3,6,7,8-HxCDD	7	0.70	0.22	0.024
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.03	< 0.003
Total HpCDD	25		0.79	0.087
1,2,3,4,6,7,8-HpCDD	15	0.15	0.47	0.052
OCDD	89	0.09	2.80	0.309
Total PCDD	147	2.64	4.62	0.510
Total TCDF	44		1.38	0.153
2,3,7,8-TCDF	8	0.80	0.25	0.028
Total PeCDF	18		0.57	0.062
1,2,3,7,8-PeCDF	5	0.25	0.16	0.017
2,3,4,7,8-PeCDF	4	2.00	0.13	0.014
Total HxCDF	18		0.57	0.062
1,2,3,4,7,8-HxCDF	7	0.70	0.22	0.024
1,2,3,6,7,8-HxCDF	4	0.40	0.13	0.014
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03	< 0.003
2,3,4,6,7,8-HxCDF	3	0.30	0.09	0.010
Total HpCDF	< 10		0.31	< 0.035
1,2,3,4,6,7,8-HpCDF	5	0.04	0.13	0.014
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.09	< 0.010
OCDF	16	0.02	0.50	0.056
Total PCDF	106	4.64	3.34	0.368
Total I-TE		7.28	0.23	0.025
I-TE Reactive Component		5.68	0.18	0.0197
I-TE Caused through Candles		**1.60**	**0.05**	**0.006**

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	111
13C12-1,2,3,7,8-PeCDF	114
13C12-1,2,3,4,7,8,9-HxCDD	120

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PCDD/PCDF

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S"
plus 1.5% Scent from Aromatics/Polycyclene Mix Group

Laboratory NR.: 292/97 - 7
Testing Volume: 29.553 m.
Burned Candle Mass: 267.3 g/6h (9 Candles)
Burned Candle Mass/h: 4.95 g (1 Candle)

	Quantity pg/Test	I-TE pg/Probe	Quantity pg/m.	Quantity pg/g burned Wax
Total TCDD	< 10		< 0.34	< 0.037
2,3,7,8-TCDD	< 1	1.00	< 0.03	< 0.004
Total PeCDD	< 10		< 0.34	< 0.037
1,2,3,7,8-PeCDD	< 1	0.50	< 0.03	< 0.004
Total HxCDD	17		0.58	0.064
1,2,3,4,7,8-HxCDD	< 1	0.10	< 0.03	< 0.004
1,2,3,6,7,8-HxCDD	5	0.50	0.17	0.019
1,2,3,7,8,9-HxCDD	< 1	0.10	< 0.03	< 0.004
Total HpCDD	22		0.74	0.082
1,2,3,4,6,7,8-HpCDD	11	0.11	0.37	0.041
OCDD	83	0.08	2.81	0.311
Total PCDD	142	2.39	4.80	0.531
Total TCDF	51		1.73	0.191
2,3,7,8-TCDF	8	0.80	0.27	0.030
Total PeCDF	16		0.54	0.060
1,2,3,7,8-PeCDF	4	0.20	0.14	0.015
2,3,4,7,8-PeCDF	4	2.00	0.14	0.015
Total HxCDF	16		0.54	0.060
1,2,3,4,7,8-HxCDF	6	0.60	0.20	0.022
1,2,3,6,7,8-HxCDF	4	0.40	0.14	0.015
1,2,3,7,8,9-HxCDF	< 1	0.10	< 0.03	< 0.004
2,3,4,6,7,8-HxCDF	3	0.30	0.10	0.011
Total HpCDF	10		0.34	< 0.037
1,2,3,4,6,7,8-HpCDF	6	0.06	0.20	0.022
1,2,3,4,7,8,9-HpCDF	< 3	0.03	< 0.10	< 0.011
OCDF	15	0.02	0.51	0.056
Total PCDF	108	4.51	3.65	0.404
Total I-TE		6.90	0.23	0.028
I-TE Reactive Component		5.68	0.19	0.0212
I-TE Caused through Candles		**1.22**	**0.04**	**0.005**

Regained Installments of the Spike-Standards (in %):

37C14-2,3,7,8-TCDD	104
13C12-1,2,3,7,8-PeCDF	115
13C12-1,2,3,4,7,8,9-HxCDD	121

PAK

Test Specification: Reactive Component A
Laboratory NR.: 292/97 - 8
Testing Volume: 27.435 m.

	Quantity ng/Test	Quantity ng/m.
Acenaphthene	159	5.80
Fluorene	263	9.59
Pheneathrene	1050	38.27
Anthracene	200	7.29
Fluoranthene	200	7.29
Pyrene	120	4.37
Benz(a)anthracene	< 10	< 0.36
Chrysene (+Triphenylene)	< 10	< 0.36
Benzo(b+j+k)fluoranthene	< 10	< 0.36
Benz(a)phyrene	< 10	< 0.36
Indeno(1,2,3-cd)pyrene	< 10	< 0.36
Benzo(ghi)perylene	< 10	< 0.36
Dibenz(ah+ac)anthracene	< 10	< 0.36
Total Investigated PAK	2062	75.16

PAK

Test Specification: Reactive Component B
Laboratory NR.: 292/97-9
Test Volume: 27,435 m.

	Quantity ng/Test	Quantity ng/m.
Acenaphthene	170	5.09
Fluorene	180	5.39
Phenenthrene	582	17.44
Anthracene	112	3.36
Fluoranthene	130	3.90
Pyrene	71	2.13
Benz(a)anthracene	< 10	< 0.30
Chrysene(+Triphenylene)	< 10	< 0.30
Benzo(b+j+k)fluoranthene	< 10	< 0.30
Benz(a)pyrene	< 10	< 0.30
Indeno(1,2,3-cd)pyrene	< 10	< 0.30
Benzo(ghi)perylene	< 10	< 0.30
Dibenz(ah+ac)anthracene	< 10	< 0.30

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PAK

Test Specification: Mean of Reactive Components A and B
Testing Volume: 30.404 m.

	Quantity ng/Test	Quantity ng/m.
Acenaphthene	165	5.43
Fluorene	222	7.30
Pheneathrene	816	26.84
Anthracene	156	5.13
Fluoranthene	165	5.43
Pyrene	96	3.16
Benz(a)anthracene	< 10	< 0.33
Chrysene (+Triphenylene)	< 10	< 0.33
Benzo(b+j+k)fluoranthene	< 10	< 0.33
Benz(a)pyrene	< 10	< 0.33
Indeno(1,2,3-cd)pyrene	< 10	< 0.33
Benzo(ghi)perylene	< 10	< 0.33
Dibenz(ah+ac)anthracene	< 10	< 0.33
Total Investigated PAK	1690	55.58

The drawn volume PAK-content was determined for each test of the actual testing volumes. The reactive component that was determined here was not changed in the following texts.

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PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Sixth-Part Mix Group	
Laboratory NR.:	292/97-1	
Testing Volume:	28.678 m.	
Burned Candle Mass:	273.3 g/6h	(9 Candles)
Burned Candle Mass/h:	5.06 g	(1 Candle)

	Quantity ng/Test	Reactive Component ng/Test	Quantity ng/m.	Quantity ng/g Burned Wax
Acenaphthene	234	165	2.41	0.252
Fluorene	574	222	12.27	1.288
Pheneathrene	1510	816	24.20	2.539
Anthracene	265	156	3.80	0.399
Fluoranthene	434	165	9.38	0.984
Pyrene	248	96	5.30	0.556
Benz(a)anthracene	24	< 10	0.49	0.051
Chrysene (+Triphenylene)	54	< 10	1.53	0.161
Benzo(b+j+k)fluoranthene	22	< 10	0.42	0.044
Benz(a)pyrene	13	< 10	0.10	0.011
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	3408	1690	60.00	6.298

The statements in ng/m. and ng/m of burned wax are respectively reactive component corrected.

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PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Lactone Mix Group	
Laboratory NR.:	292/97-2	
Testing Volume:	27.998 m³	
Burned Candle Mass:	286.5 g/6h	(9 Candles)
Burned Candle Mass/h:	5.31 g	(1 Candle)

	Quantity ng/Test	Reactive Component ng/Test	Quantity ng/m³	Quantity ng/g Burned Wax
Acenaphthene	184	165	0.68	0.066
Fluorene	449	222	8.11	0.792
Pheneathrene	1270	816	16.22	1.585
Anthracene	251	156	3.39	0.332
Fluoranthene	368	165	7.25	0.709
Pyrene	229	96	4.75	0.464
Benz(a)anthracene	22	< 10	0.43	0.042
Chrysene (+Triphenylene)	55	< 10	1.61	0.157
Benzo(b+j+k)fluoranthene	16	< 10	0.21	0.021
Benz(a)pyrene	12	< 10	0.07	0.007
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	2886	1690	42.81	4.187

The statements in ng/m³ and ng/m of burned wax are respectively reactive component corrected.

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PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Aldehyde/Ketone Mix Group	
Laboratory NR.:	292/97-3	
Testing Volume:	31.038 m.	
Burned Candle Mass:	285.4 g/6h	(9 Candles)
Burned Candle Mass/h:	5.29 g	(1 Candle)

	Quantity ng/Test	Reactive Component ng/Test	Quantity ng/m.	Quantity ng/g Burned Wax
Acenaphthene	202	165	1.19	0.130
Fluorene	520	222	9.60	1.044
Pheneathrene	1200	816	12.37	1.345
Anthracene	256	156	3.22	0.350
Fluoranthene	277	165	3.61	0.392
Pyrene	174	96	2.51	0.273
Benz(a)anthracene	27	< 10	0.55	0.060
Chrysene (+Triphenylene)	48	< 10	1.22	0.133
Benzo(b+j+k)fluoranthene	10	< 10	< 0.03	< 0.004
Benz(a)pyrene	< 10	< 10	< 0.03	< 0.004
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	2754	1690	34.43	3.748

The statements in ng/m. and ng/m of burned wax are respectively reactive component corrected.

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PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Alcohol Mix Group	
Laboratory NR.:	292/97-4	
Testing Volume:	30.445 m.	
Burned Candle Mass:	277.6 g/6h	(9 Candles)
Burned Candle Mass/h:	5.14 g	(1 Candle)

	Quantity ng/Test	Reactive Component ng/Test	Quantity ng/m.	Quantity ng/g Burned Wax
Acenaphthene	179	165	0.46	0.050
Fluorene	380	222	5.19	0.569
Pheneathrene	1220	816	13.27	1.455
Anthracene	240	156	2.76	0.303
Fluoranthene	404	165	7.85	0.861
Pyrene	160	96	2.10	0.231
Benz(a)anthracene	11	< 10	0.03	0.004
Chrysene (+Triphenylene)	42	< 10	1.05	0.115
Benzo(b+j+k)fluoranthene	18	< 10	0.26	0.029
Benz(a)pyrene	11	< 10	0.03	0.004
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	2695	1690	33.10	3.632

The statements in ng/m. and ng/m of burned wax are respectively reactive component corrected.

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PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Ether Mix Group	
Laboratory NR.:	292/97-5	
Testing Volume:	30.692 m³	
Burned Candle Mass:	268.5 g/6h	(9 Candles)
Burned Candle Mass/h:	4.97 g	(1 Candle)

	Quantity ng/Test	**Reactive Component ng/Test**	**Quantity ng/m³**	**Quantity ng/g Burned Wax**
Acenaphthene	180	165	0.49	0.056
Fluorene	642	222	13.68	1.564
Pheneathrene	1290	816	15.44	1.765
Anthracene	206	156	1.63	0.186
Fluoranthene	316	165	4.92	0.562
Pyrene	190	96	3.06	0.350
Benz(a)anthracene	14	< 10	0.13	0.015
Chrysene (+Triphenylene)	32	< 10	0.72	0.082
Benzo(b+j+k)fluoranthene	12	< 10	0.07	0.007
Benz(a)pyrene	< 10	< 10	< 0.03	< 0.004
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	2922	1690	40.26	4.604

The statements in ng/m³ and ng/m of burned wax are respectively reactive component corrected.

PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Terpene Mix Group	
Laboratory NR.:	292/97-6	
Testing Volume:	31.784 m³	
Burned Candle Mass:	288.2 g/6h	(9 Candles)
Burned Candle Mass/h:	5.34 g	(1 Candle)

	Quantity ng/Test	Reactive Component ng/Test	Quantity ng/m³	Quantity ng/g Burned Wax
Acenaphthene	173	165	0.25	0.028
Fluorene	461	222	7.528	0.829
Pheneathrene	1250	816	13.65	1.506
Anthracene	275	156	3.74	0.413
Fluoranthene	387	165	6.98	0.770
Pyrene	156	96	1.89	0.208
Benz(a)anthracene	< 10	< 10	< 0.03	< 0.004
Chrysene (+Triphenylene)	28	< 10	0.57	0.062
Benzo(b+j+k)fluoranthene	14	< 10	0.13	0.014
Benz(a)pyrene	< 10	< 10	< 0.03	< 0.004
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	2794	1690	34.88	3.851

The statements in ng/m³ and ng/m of burned wax are respectively reactive component corrected.

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PAK

Candle Type:	Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5% Scent from Aromatics/Polycyclene Mix Group	
Laboratory NR.:	292/97-7	
Testing Volume:	29.553 m.	
Burned Candle Mass:	267.3 g/6h	(9 Candles)
Burned Candle Mass/h:	4.95 g	(1 Candle)

	Quantity ng/Test	Reactive Component ng/Test	Quantity ng/m.	Quantity ng/g Burned Wax
Acenaphthene	219	165	1.83	0.202
Fluorene	387	222	5.58	0.617
Pheneathrene	1130	816	10.62	1.175
Anthracene	230	156	2.50	0.277
Fluoranthene	264	165	3.35	0.370
Pyrene	137	96	1.39	0.153
Benz(a)anthracene	12	< 10	0.07	0.007
Chrysene (+Triphenylene)	30	< 10	0.68	0.075
Benzo(b+j+k)fluoranthene	11	< 10	0.03	0.004
Benz(a)pyrene	< 10	< 10	< 0.03	< 0.004
Indeno(1,2,3-cd)pyrene	< 10	< 10	< 0.03	< 0.004
Benzo(ghi)perylene	< 10	< 10	< 0.03	< 0.004
Dibenz(ah+ac)anthracene	< 10	< 10	< 0.03	< 0.004
Total Investigated PAK	2460	1690	26.17	2.897

The statements in ng/m. and ng/m of burned wax are respectively reactive component corrected.

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ALDEHYDE

Test Specification: Reactive Component A
Laboratory NR.: 292/97-8
Testing Volume: 0.054 m.

	Quantity ng/Test	Quantity mg/m.
Formaldehyde	48	0.001
Acetaldehyde	629	0.012
Acrolein	< 250	< 0.005
Propionaldehyde	< 250	< 0.005

ALDEHYDE

Test Specification: Reactive Component B
Laboratory NR.: 292/97-9
Testing Volume: 0.054 m.

	Quantity ng/Test	Quantity ng/m.
Formaldehyde	52	0.001
Acetaldehyde	728	0.013
Acrolein	< 250	< 0.005
Propionaldehyde	< 250	< 0.005

ALDEHYDE

Test Specification: Mean of Reactive Components A and B
Testing Volume: 0.054 m.

	Quantity ng/Test	Quantity ng/m.
Formaldehyde	50	0.001
Acetaldehyde	679	0.013
Acrolein	< 250	< 0.005
Propionaldehyde	< 250	< 0.005

The drawn volume aldehyde content was determined for each test of the actual testing volumes. The reactive component that was determined here was not changed in the following texts.

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ALDEHYDE

Candle Type: Paraffin OFA 5603; Wick Wedo R 18/3"S" plus 1.5 % Scent from Sixth-Part Mix Group
Laboratory NR.: 292/97-1
Testing Volume: 0.0545 m. Part Energy
4.524 m. Full Energy
Burned Candle Mass: 63.4 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m.	Quantity ng/g Burned Wax
Formaldehyde	122	50	0.001	94
Acetaldehyde	610	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m. and ng/g of burned wax are respectively reactive component corrected.

ALDEHYDE

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S" plus 1.5 % Scent from Lactone Mix Group
Laboratory NR.: 292/97-2
Testing Volume: 0.055 m. Part Energy
4.524 m. Full Energy
Burned Candle Mass: 61.1 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m.	Quantity ng/g Burned Wax
Formaldehyde	99	50	0.001	66
Acetaldehyde	440	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m. and ng/g of burned wax are respectively reactive component corrected.

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ALDEHYDE

Candle Type: Paraffin OFA 5603; Wick Wedo R 18/3"S"
plus 1.5 % Scent from Aldehyde/Ketone Mix Group
Laboratory NR.: 292/97-3
Testing Volume: 0.0615 m. Part Energy
5.278 m. Full Energy
Burned Candle Mass: 75.8 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m.	Quantity ng/g Burned Wax
Formaldehyde	127	50	0.001	87
Acetaldehyde	626	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m. and ng/g of burned wax are respectively reactive component corrected.

ALDEHYDE

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S"
plus 1.5 % Scent from Alcohol Mix Group
Laboratory NR.: 292/97-4
Testing Volume: 0.059 m. Part Energy
4.901 m. Full Energy
Burned Candle Mass: 72.1 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m.	Quantity ng/g Burned Wax
Formaldehyde	180	50	0.002	150
Acetaldehyde	613	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m. and ng/g of burned wax are respectively reactive component corrected.

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ALDEHYDE

Candle Type: Paraffin QFA 5603; Wick Wedo R 18/3"S" plus 1.5 % Scent from Ether Mix Group
Laboratory NR.: 292/97-5
Testing Volume: 0.049 m. Part Energy
4.524 m. Full Energy
Burned Candle Mass: 64.2 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m.	Quantity ng/g Burned Wax
Formaldehyde	176	50	0.003	181
Acetaldehyde	556	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m. and ng/g of burned wax are respectively reactive component corrected.

ALDEHYDE

Candle Type: Paraffin OFA 5603, Wick Wedo R 18/3"S" plus 1.5 % Scent from Terpene Mix Group
Laboratory NR.: 292/97-6
Testing Volume: 0.051 m. Part Energy
4.750 m. Full Energy
Burned Candle Mass: 66.3 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m.	Quantity ng/g Burned Wax
Formaldehyde	147	50	0.002	136
Acetaldehyde	555	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m. and ng/g of burned wax are respectively reactive component corrected.

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ALDEHYDE

Candle Type: Paraffin OFA 5603; Wick Wedo R 18/3"S"
plus 1.5 % Scent from Aromatics/Polycyclene Mix Group
Laboratory NR.: 292/97-7
Testing Volume: 0.047 m³ Part Energy
4.524 m³ Full Energy
Burned Candle Mass: 63.6 g/Experiment

	Quantity ng/Test	Reactive Component ng/Test	Quantity mg/m³	Quantity ng/g Burned Wax
Formaldehyde	158	50	0.002	163
Acetaldehyde	715	679	< 0.010	< 300
Acrolein	< 250	< 250	< 0.005	< 100
Propionaldehyde	< 250	< 250	< 0.005	< 100

The statements in mg/m³ and ng/g of burned wax are respectively reactive component corrected.