

Research and development in sanitation technology for PCB-containing sealants

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1. BACKGROUND

The environmental hazardous and poisonous compounds known as PCBs were used as plasticizer in building materials in Sweden during the period from 1956 to 1973, mostly in soft sealants in facades, in sealing compounds in insulation glass and in some floor-coverings. PCBs were also used in electrical components, for instance capacitors in fluorescent lighting, until about 1980.

It has been shown that PCB can migrate from sealants to surrounding materials, air and ground (Jansson et al, 1997; Arnér et al, 1998, Sikander et al, 1999). In order to prevent further transport to the environment it is important that sealants with PCB are removed and replaced with PCB-free material. At demolition and renovation it is also important that building materials with PCB are handled correctly with certain care (see e.g. SFR, 1999). The Swedish Building Sector agreed in 1998 to recommend real estate owners to remove all sealants, which contain more than 500 mg PCB per kg material before the year of 2003. All materials containing more than 50 mg PCB per kg material should however be handled safely according to Swedish regulations at demolition and renovation.

At the stage where the real estate owner Vasakronan had carried out auditing of PCB in their buildings and measures were to be taken, a study of PCB migration between materials was decided upon.

2. PURPOSE

The purpose of the study was to ascertain a proper method of sanitation. Studies of PCB migration would direct to how sanitation of PCB-containing sealants and removal of PCB-contaminated material should be carried out.

3. SACRIFICING SEALANT

As a part of the project, an experiment with “sacrificing sealants” was done in a large building in Stockholm. The idea was to develop a method that eliminates the need for grinding of contaminated concrete by extracting PCB from the concrete to a new sealant compound. The experiment started with removal of sealant material in 90 holes, which were analysed with regard to PCB content. In some holes, the concrete adjacent to the original sealant were ground a few millimetres before the holes were refilled with 3 different new types of sealant compounds. These sealants were left in the holes for 1, 2, or 3 months and were then analysed

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with regard to PCBs. After removal of this sacrificing sealant a new replacement sealant could be applied.

One month after application of the sacrificing sealants, the sealant-material in 1/3 of the holes were removed and 10 samples were analysed with regard to PCB content. After two and three months the same procedure was repeated. The analysis results are shown in Table 1.

Table 1 Results from PCB-analysis of sacrificing sealants after 1, 2 and 3 months

Hole number	Time of exposure	PCB content (mg/kg)	% of original content	Original PCB content (mg/kg _{material})	Material
1	1 month (2001-07-02)	83	0,06	130 000	PU1
13	1 month	530	0,48	110 000	PU1
26	1 month	270	0,30	89 000	PU1
39	1 month	23	0,02	98 000	Ground 1-2 mm
45	1 month	230	0,15	150 000	PU2
54	1 month	140	0,11	130 000	PU2
59	1 month	690	0,63	110 000	PU2
64	1 month	310	0,32	98 000	MS-pol
70	1 month	420	0,35	120 000	MS-pol
81	1 month	740	0,62	120 000	MS-pol
2	2 months (2001-08-08)	3100	3,56	87 000	PU1
14	2 months	380	0,35	110 000	PU1
27	2 months	530	0,63	84 000	PU1
40	2 months	60	0,03	180 000	Ground 1-2mm
46	2 months	260	0,22	120 000	PU2
55	2 months	200	0,17	120 000	PU2
60	2 months	270	0,30	91 000	PU2
65	2 months	1500	1,15	130 000	MS-pol
71	2 months	780	0,49	160 000	MS-pol
82	2 months	2800	2,33	120 000	MS-pol
3	3 months (2001-09-14)	790	0,66	120 000	PU1
15	3 months	350	0,36	98 000	PU1
18	3 months	290	0,26	110 000	PU1
25	3 months	380	0,32	120 000	PU1
28	3 months	300	0,25	120 000	PU1
41	3 months	94	0,06	160 000	Ground 1-2 mm
47	3 months	400	0,40	100 000	PU2
66	3 months	1100	0,92	120 000	MS-pol
72	3 months	730	0,66	110 000	MS-pol
83	3 months	1300	0,93	140 000	MS-pol

The results for sealants where modified silicone-polymer (MS-pol) and polyurethane-1 (PU1) were used as sacrificing material show an increase of the PCB-content with time. For the third compound, polyurethane-2 (PU2), concentrations are lower and are not obviously increasing with time, see Fig. 1.

The PCB-content is relatively low compared with the original PCB-content for all sacrificing sealants, 0,5 % to 3% of the content of the original sealants. Material from the holes, which had been ground before new sealant material was applied, show very low content of PCB, less than 0,1% of the original content. The content of PCB in the original sealants in the different holes varied between 84 000 mg/kg and 180 000 mg/kg with an average of 118 500 mg/kg.

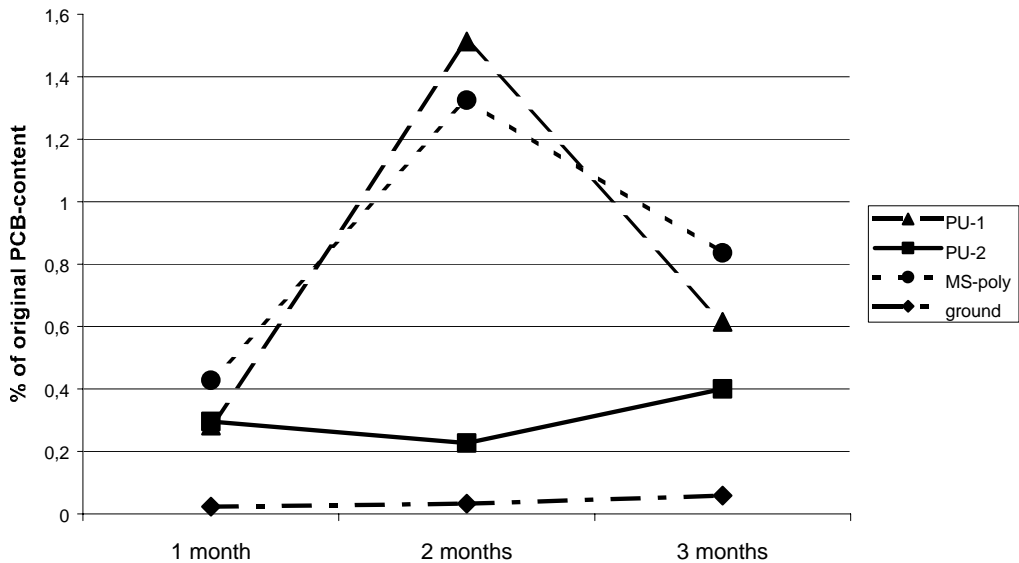


Figure 1 The content of PCB in replacement sealants (“sacrificing sealants”) after 1, 2 and 3 months for three different types of compound and for a replacement sealant applied after grinding of the adjacent concrete.

4. DIFFUSION OF PCB INTO CONCRETE

In order to predict how much and how far PCB penetrates into concrete, the diffusion coefficient for PCB in concrete was calculated from results of some surveys, which present concentrations of PCB measured in concrete at different distances from PCB-containing sealants. The values are presented in Table 2.

Table 2 Content of PCB in concrete at different distances from the sealant in different surveys given as the percentage of PCB-content in sealants.

Distance (mm)	Solna Ljung, Tolstoy, 2001	SP Borås Sundahl et al, 2000	Gothenburg Sikander et al, 1999	Stockholm Ljung, Tolstoy, 2001
1000	< 0,002%			
500	< 0,002%			
200	0,002%			
100				< 0,002%
70				< 0,002%
50	0,002%			
40				< 0,002%
20	0,003%			< 0,002%
10	0,010%			
5		3%	0,08%	
4	0,040%			
3		4%	0,60%	
2	0,180%			
1		14%	16%	
Sealant	100%	100%	100%	100%

The methods for sampling differs between the different surveys. In the study undertaken by the Swedish national testing and research institute, SP, in Borås, concrete samples were successively taken during grinding from the sealed joint and outwards into the concrete. In Solna samples were taken by drilling at a distance of 1 meter away from the sealed joint and then approaching the sealant. In Stockholm and Gothenburg the method was similar. The much higher PCB content obtained in the SP test could perhaps be explained by the presence of remains of the compound and that the grinding procedure pressed PCB into the concrete pores. This was, however, not regarded at the calculation of diffusion coefficients.

The diffusion coefficient, D , was calculated by applying Fick's 2nd law on the diffusion of PCB into concrete. By fitting the solution of Fick's law (Eq. 1) to the concentrations presented in Table 2, the diffusion coefficient could be determined. The equation presumes an isotropic material and a diffusion coefficient independent of concentraion.

$$\frac{c(x,t)}{c_{surface}} = (1 - \operatorname{erf}(\frac{x}{\sqrt{4 \cdot D \cdot t}})) \quad (1)$$

where

c	concentration in concrete	(mg/kg)
$c_{surface}$	concentration in concrete surface	(mg/kg)
x	distance	(m)
D	diffusion coefficient	(m ² /s)
t	time	(s)

The diffusion coefficient has been calculated to an average of $\sim 3 \cdot 10^{-15}$ m²/s (values between $1,7 \cdot 10^{-15}$ to $3,5 \cdot 10^{-15}$ m²/s). That is 10^{-5} lower than moisture diffusion in concrete. This means that very small PCB-amounts migrate into the concrete by diffusion, even if the time-span is longer than 30 years.

5. CONCLUSIONS

- The results show that if the sealant compound is carefully removed and the adjacent concrete is ground off 1-2 mm, very low values of PCB in new sealants are obtained. Less than 0,1 % of the original content of PCB is found after 3 months in the new sealants. Calculations with the diffusion coefficient of PCB in concrete confirms this result.
- When a sealant that contains PCB is removed, it is important to grind 1-2 mm into the concrete, or else a sacrificing sealant could be used in order to remove further 1-2 % of the PCB-content of the original sealant.
- The tests from sacrificing sealants show that one month is not enough time for the PCB to migrate into the sealant, but that probably two months will do for two of the three tested compounds, PU1 and MS-pol. One was a polyurethane and the other was a modified silicone-polymer.

The standard procedure to carry out sanitation of PCB-containing sealants is to carefully remove the sealant with a knife and then grind 1-2 mm in the concrete. According to the conclusions above, the sanitation method using a sacrificing sealant needs at least 2 months of time and includes application of sealants twice. Transport of PCB to the new sealant is probably mainly due to sealant compound remaining in pores the first 1-2 mm in the concrete. We therefore do not recommend Vasakronan to continue with this sanitation method.

Another method that is also interesting is groove cutting and milling. Vasakronan and J&W follow the development in this area, and have started further tests.

6. REFERENCES

- Ljung, Maria and Tolstoy Nikolaj, 2001, *Utvärdering av saneringsmetoder för PCB (Evaluation of methods of sanitation of PCB)* Vasakronan, Stockholm.
- Arnér, Kallhauge and Tolstoy, 1998, *Utveckling av metod för att identifiera och prioritera åtgärder för PCB-kontaminerade fastigheter*, J&W ISBN 91-7438-000-1. Stockholm.
- Jansson, Bo et al, 1997, *PCB i fogmassor*, Naturvårdsverket Rapport 4697
- Sikander, Eva et al, 1999, *Utveckling och utvärdering av metoder för utbyte av PCB-haltiga fogmassor*, SP, Sveriges Provnings- och Forskningsinstitut, Rapport 1999:07
- Sundahl, Mikael et al, 2000, *Spridning av PCB från PCB-haltiga fogmassor till angränsande byggmaterial. Provtagningar, analyser och utvärdering*. SP, Sveriges Provnings- och Forskningsinstitut, Rapport 2001:02
- Sanera PCB-haltiga fogar. Handledning för fogentreprenörer. Svenska fogbranschens riksförbund, 1999.