

IAQ Case examples

Wood preservatives xylamit as a source of indoor air pollution

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INTRODUCTION

Oily wood preservatives Xylamit were used in the residential and public building industry in Poland in the 1960s and 1970s for impregnation and fungicidal treatment. They were a source of air pollution due to the emission of toxic compounds causing the deterioration of hygienic conditions indoors. The most serious negative consequences, felt to this day, were caused by the use of these preparations to impregnate porous fibreboards laid in the ceilings of buildings as insulation in the industrial systems of residential building industry (the so-called “large panel buildings”). At the time, it was used in a great number of flats (their number is estimated at around 400,000).

The consequences of using Xylamit in the building industry are felt to this day. Despite the fact that in the 1980s conditions to remove such defects from buildings were created, there are still an unknown number of flats in Poland with fibreboards impregnated with Xylamit. The Environmental Protection Department in the Building Research Institute performs several expert opinions each year on the presence of Xylamit in buildings in different cities in Poland.

XYLAMIT TOXICITY

Xylamits were preparations used for impregnating and eliminating fungi in construction timber and wood-derived materials, made in 1958-1986. Their main components were coal tar and petroleum distillates (coal and petroleum residuum oils), used as solvents for the active components, dissolving well in oils. The main biologically-active components used in Xylamits were chlorophenols and polyphenols, chlorobenzenes, chlorinated coal residuum oils, 1-chloronaphthalene. These were usually waste materials - technical pentachlorophenols, post-distillation chlorophenol and regenerated chlorophenols - used in amounts from 4 to 20% (1,2). The quantitative composition of these raw materials varied and is not fully known. Tests performed in later years showed that technical chlorophenols could contain the halogen-derivatives dibenzo-p-dioxin and benzofurans, formed as a result of side reactions. These compounds are present in the form of numerous isomers and are

characterised by their ability to bio accumulate in the fat tissue of humans and animals. Some are considered to be the strongest acting poisons.

In the building industry during peak usage mainly the so-called dark Xylamits based on coal residuum oils were used. The toxicity of Xylamits was not determined at the time. Due to the great complexity of the chemical composition of these preparations and the varying quality of raw materials used, its evaluation posed a problem. Toxicity assessments of Xylamits carried out in 1971 and 1978 for the needs of occupational hygiene made it possible to include preparations from this group in the 4th class of harmfulness, i.e. substances with a weak toxic effect. The grounds for this classification were the small strength of the general toxic effect (acute oral toxicity 3900 mg/kg of body weight, acute inhalation toxicity 5000 mg/kg of body weight). Tests of short-term chronic toxicity carried out at the time showed that the preparation absorbed over a longer period of time, in small doses may damage solid organs, as well as cause disorders in the central and peripheral nervous system. Chlorophenols, polyphenols and chloronaphthalene, the main biologically active components in the discussed group of wood preservatives, are characterised by good solubility in fats and lipids, which is why in the body they show large affinity to lipid-rich organs and nervous tissue, causing disorders of their functions and pathological changes. (3, 4)

Xylamits were characterised by a very strong, specific chemical odour. This odour was described by the producer as “non-lasting”, which among others decided on their use in the residential building industry. Today, from a perspective of over thirty years that have passed since its usage, we can say that the smell is practically ever-lasting.

INDOOR AIR POLLUTION RESULTING FROM XYLAMIT USE

In the late 1960s - early 1970s, Xylamits were introduced in the industrialised residential building industry, developing dynamically at this time. Those wood preservatives were used to protect soft porous fibreboards used as insulation material in insulating ceilings between floors. Insulation building paper, concrete blind floors and external flooring material were placed right next to the impregnates.

There were also cases where Xylamit was used to impregnate wooden floors in public buildings (schools, offices) or wooden structures of walls or roofs in the traditional building industry. (5)

Complaints started to appear quite quickly from the users of such premises, who said that specific chemical odour were present in the flats and public buildings, which caused a series of symptoms of ill-being. The reason for these complaints, as it turned out, was the use of Xylamit impregnated fibreboards used as insulation in ceilings between floors. The characteristic odour of preservatives was clearly felt in the premises and was a great nuisance for the dwellers. As a result of indoor air pollution tests carried out at the time, it was found that the air contained phenolic compounds. (6,7,8) The evaluation of the degree of air pollution was hindered by the lack of sufficiently precise analytical methods, which would make it possible to identify and determine the concentrations of all volatile components of those wood preservatives in the air. Colorimetric methods were in general use and these only made it possible to

determine the sum of phenolic compounds in the air, without any possibility of identification. Chromatographic methods enabling such analysis appeared in laboratories studying air pollution only in the 1980s. Tests conducted by the Building Research Institute ITB since the early 1980s showed that the buildings, in which Xylamit was used, were contaminated with naphthalene, methylnaphthalenes, 1-chloronaphthalene, phenol and cresol vapours. Chlorophenols as non-volatile compounds were not detected in the air in buildings in many cases. On the other hand, chlorobenzenes, as the most volatile compounds, evaporated from the impregnated products after a year or so.

The growing number of complaints from dwellers, the substantial nuisance of the odour found beyond any doubt, and the exceeding of permitted concentrations of phenol compounds in the air showed that Xylamits were a serious cause for the deterioration of hygienic and sanitary conditions in the premises. The withdrawal of products from the Xylamits group from use in the building industry lasted several years - from the introduction of restrictions in using them for impregnating window and door joinery in 1977, to the complete ending of production of these preservatives in 1986. (9) The process of removing the consequences of using these wood preservatives in the building industry started in 1984. The removal of these defects was made possible on the basis of the Resolution of the Council of Ministers, by financing with redeemed bank credits some defects of buildings, among others caused by the emission of toxic compounds in residential and public buildings. Many investors took advantage of this opportunity and removed products impregnated with Xylamit from the buildings. Most of these works were carried out in 1984-1992. For various reasons, these renovations did not encompass all of the buildings. One of the reasons for this was the inability to determine, on the basis of an analysis of the building works documentation, what type of wood preservative was used. The dwellers were often unaware that materials impregnated with Xylamit were present in the building.

Many years have passed since the introduction of the ban on using Xylamits inside buildings, but the negative consequences of its use have not been eliminated to this day. Dwellings with Xylamite impregnated felt-boards have existed till now and occupants have been exposed for many years. The problem usually appears when the dwellers change or the building is modernised.

Each year, the Environmental Protection Department in ITB performs several expert opinions on the presence of Xylamit in premises. In the framework of these expert opinions, samples of all flooring materials are collected, in order to determine whether the ceiling contains fibreboards impregnated with Xylamit. Next, these samples are examined in laboratory conditions, in test chambers, in accordance with ITB Laboratory procedures. Chemical compounds found in the air are adsorbed on the surface of a solid adsorbent, desorbed by solvent and identified using the gas chromatography and liquid chromatography method. Standard compounds included naphthalene, phenol, cresol and their chlorine derivatives.

In Table 1 the results of expert opinions performed in 1996-2006 are presented. The air of the laboratory chambers was usually found to contain naphthalene, methylnaphthalenes, phenol, chloronaphthalene, less often cresols. In some cases, the concentration of the examined compounds was very high and exceeded many times

the permitted norms, in others, it was low, even on the limit of detection. However, in all of the tested flats there was the odour characteristic of preparations from the Xylamit group, only its intensity differed. This odour continued to be perceptible, despite the fact that very often over 30 years had passed from the time people moved in. Often in the case of samples collected in different flats in the same building, or even in different rooms in the same flat, depending on the amount of the wood preservative used and the quality of the impregnation, very large differences were found in the concentrations of chemical compounds.

Air pollution tests in flats are not performed as often. Many years of experience of both the Environmental Protection Department ITB and other institutions concerned with air pollution tests indicate that despite the fact that the odour is clearly felt in the premises, test results usually do not show that the permitted air concentrations of the components of Xylamit, i.e. chlorophenols, naphthalene, chloronaphthalene or cresols, are exceeded. Table 2 and diagram 1 present the results of tests of air pollution in premises, in which materials impregnated with Xylamit were used, carried out by the Environmental Protection Department in the last few years.

In 2002 and 2003, the Environmental Protection Department tested the air in 2 buildings during major renovation works. In these buildings, the ceilings contained built-in fibreboards impregnated with Xylamit. The tests were carried out during the renovation, after all the flooring materials were removed and the plaster was chiselled off. These works were carried out a couple of weeks before the air samples were collected. The temperature during the tests was 9-14°C, as the buildings were not heated.

Despite the total elimination of the source of pollution in the form of fibreboards impregnated with Xylamit, volatile components of the wood preservative were found in the air. The source of emission was secondarily contaminated floor slabs.

Table 1. Results of laboratory tests of volatile compound emissions from samples of flooring materials carried out in 1997-2003

Year	No. of tested samples	Range of concentrations of volatile compound vapours in chamber air [$\mu\text{g}/\text{m}^3$]			
		naphthalene	methyl-naphthalene	phenol	1-chloro-naphthalene
1997	17	2 - 829	1 - 276	-	-
1998	13	5 - 133	5 - 40	-	-
1999	5	2 - 300	1 - 255	1 - 124	51
2000	8	1 - 2058	2 - 322	1 - 121	1 - 42
2001	4	3 - 1669	5 - 297	1 - 17	-
2002	2	18-244	28-99	15-22	2-30
2003	1	25	4	3	74
2005	1	31	31	-	13
2006	3	3-102	2-111	1-69	3-53
Admissible values in category A² premises		100	Not established	20	15

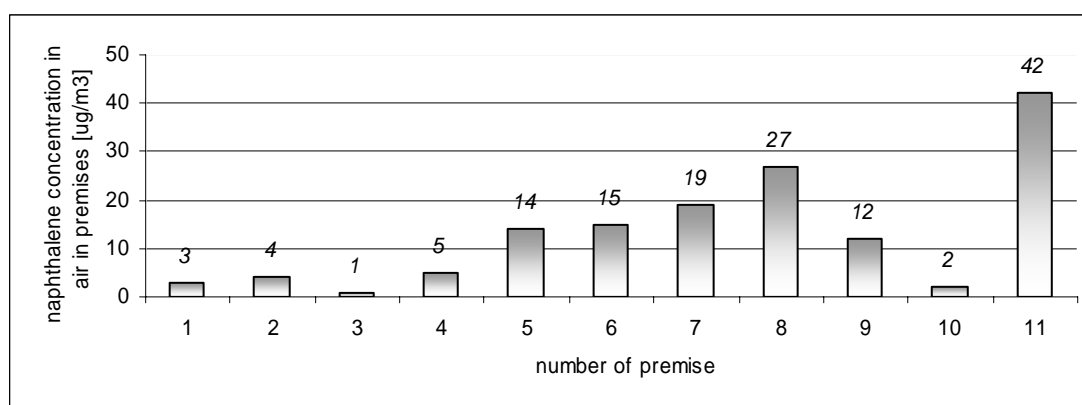


Diagram 1. Concentration of naphthalene vapours in 10 office premises in a building containing materials impregnated with Xylamit

² Admissible values according to the Regulation of the Minister of Health and Social Care of 12 March 1996 on permitted concentrations and intensities of factors harmful to health emitted by building materials, fittings and fixtures in premises intended for humans (Polish Monitor no. 19 item 231) – category A premises – residential premises, premises for permanent residence of the ill in health care institutions and for permanent residence of children and youth in educational buildings, as well as premises intended for storing food products, category B premises - all other premises, in this premises intended for people in public buildings, other than those included in A category premises and auxiliary premises

Already during the first renovation works, carried out in the 1980s, it turned out that the removal itself of all of the flooring materials and laying a new floor does not completely eliminate the nuisance. In many cases, a specific odour remained in the premises, though at a much lower intensity, upon the completion of the renovation works.

Table 2 Results of air pollution tests in premises containing materials impregnated with Xylamit

Year	Test object	Range of concentrations of volatile compound vapours in air in premises [$\mu\text{g}/\text{m}^3$]			
		naphthalene	methyl-naphthalenes	phenol	1-chloro-naphthalene
2001	Flat in municipal building. In the 1960s-it was subject to fungicidal treatment (3 measurements)	13-17	7-8	3-5	5
2002	Multi-family building during renovation. All flooring materials, plasters removed. Temperature during tests – 10/14 ⁰ C (5 premises)	2-8	1-11	-	2-19
2003	Multi-family building during renovation. All flooring materials, plasters removed. Temperature during tests – 9-15 ⁰ C (5 premises)	11-68	16-69	3-13	0 – 6
2004	Office rooms in office building (10 premises)	1-44	1-15	<1-5	<1-6
2004	Rooms in students' house (12 premises)	1-7	1-5	-	<1-4
Admissible values in class A category premises¹		100	Not established	20	15

The reason for this was the secondary contamination of floor slabs with the wood preservative Xylamit, caused by long-lasting contact with the fibreboards saturated with the preparation. The degree of contamination depended on the amount of the preparation used to impregnate the fibreboards. As a result of further observations, it was found that in order to carry out the renovation effectively, it was necessary to maximally remove the surface of floor slabs secondarily contaminated with the wood preservative Xylamit and use neutralising preparations on the floor slab and a part of the walls that could be in contact with the impregnated slab. The preparation that turned out to be an effective neutraliser was only developed in the early 1990s, and was called NEUTRAL. In the last few years, this preparation is being used increasingly often during renovations of buildings connected with removing impregnated materials.

The use of the preparation neutralising the residues of Xylamit in floor slabs prevents the emission of volatile components from surfaces secondarily contaminated with the wood preservative. This makes it possible to achieve the appropriate hygienic conditions in the renovated premises and their further use. However, it should be pointed out that the undertaken measures will only be effective if the renovations are

carried out correctly. This encompasses: a careful removal of all impregnated materials, thorough cleaning of the floor slab, secondarily contaminated (chiselling off or grinding off of the surface is recommended), thorough cleaning of the premises, precise covering of the slab with the neutralising substance, maintaining the required seasoning period of the premises before continuing with the renovation works (4-6 weeks). This is illustrated in the results of tests given in Table 3. It presents the results of air pollution tests in a multi-family 5-floor residential building, in which major renovations of the entire building were carried out, including the removal of materials impregnated with Xylamit and neutralisation. Several months after moving in, the dwellers of some of the premises began complaining about arduous smells in their flats. Air pollution tests showed increased amounts of vapours of volatile components of the wood preservative Xylamit in these flats (diagram 2). In these flats, the renovation works and neutralisation were repeated. During these renovations, it was found that the impregnated materials were not completely removed from these flats and the neutralisation was not performed precisely. Following the repeated renovation, these flats were freed of the arduous odour and the air was no longer contaminated with vapours of volatile components.

Table 3 Results of air pollution tests in the premises of a building after renovation

No. of test	Test object	Range of concentrations of volatile compound vapours in air in premises [$\mu\text{g}/\text{m}^3$]			
		naphthalene	methyl-naphthalenes	phenol	1-chloro-naphthalene
I	Flats. in which dwellers informed about the presence of a distinct odour (10 flats)	2- 14	2- 8	1-4	3-13
II	Flats, in which dwellers did not inform about the presence of a distinct odour (5 flats)	<1-3	<1-2	<1-1	<1-2
III	Flats after repeated renovation works (6 flats)	1-4	<1-1	<1	<1-2
Admissible values in category A premises¹		100	Not established	20	15

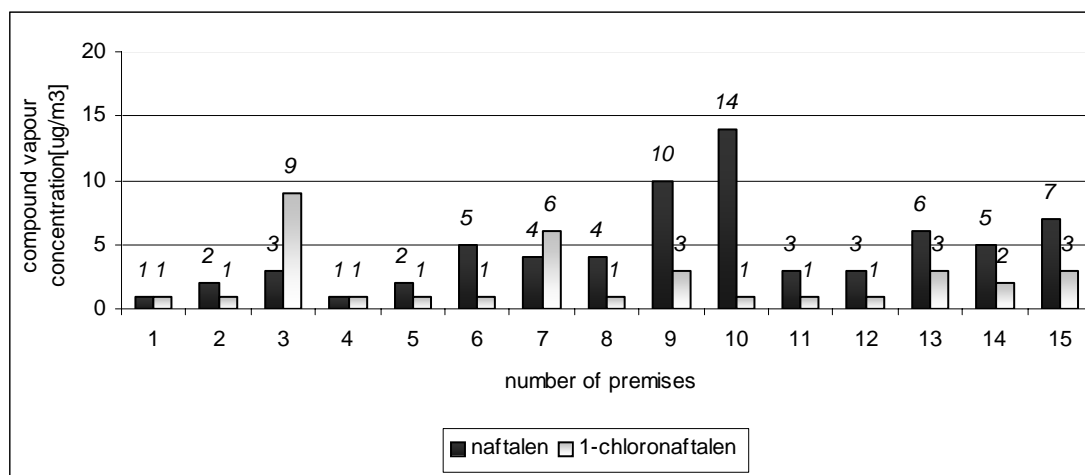


Diagram 2. Concentration of naphthalene and 1-chloronaphthalene vapours in the air in 15 flats after renovation connected with the removal of impregnated materials

Neutralisation makes it possible to achieve the appropriate hygienic conditions in flats containing materials impregnated with Xylamit enabling their further exploitation.

SUMMARY

In the period of their most extensive use in the building industry, the toxicity of wood preservatives Xylamit was not determined. The decision, based on erroneous presumptions, on introducing them in the industrialised systems of the building industry caused serious economic consequences connected with the costs of renovations lasting to this day and financed initially by the state budget, and later by the owners of the buildings. However, the health effects for the dwellers of these buildings in which fibreboards impregnated with Xylamit were used, seem to be much more serious. For a dozen or so or even tens of years they were in contact with toxic compounds - volatile components of Xylamit, such as phenol, chlorophenols, naphthalene, methylnaphthalene and chloronaphthalene, present in indoor air. These compounds are characterised by their toxic effect on living organisms and their constant presence in the air in flats most probably also affected the health of the dwellers.

Despite the passing of almost thirty years from the introduction of the ban on using Xylamit in the residential building industry, there continues to be an unknown number of buildings containing materials impregnated with Xylamit. It is impossible to state on the basis of an analysis of the building works documentation, where Xylamit was used. Other impregnating substances, such as those based on salt, were also in use at the time. The results of air pollution tests in flats, in which the presence of impregnated materials was found, carried out in the last few years have not shown any volatile components of wood preservatives to be present in the air in amounts exceeding the permitted norms. However, it should be pointed out that their presence in the air is always found. This shows that the dwellers of these flats for many years were in contact with polluted air.

The example of Xylamit shows how important it is to evaluate the properties of building materials with respect to their chemical composition and how long-lasting and costly can be the effects of introducing an untested product on the market. Products basing on chemical raw materials should undergo judicious hygienic evaluation based on emission tests or an examination of harmful substance content.

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