

## **Durability of water-based coats applied to wood and aged in natural and artificial conditions.**

ANNA POLICIŃSKA–SERWA, ANDRZEJ KĘDZIERSKI, MAREK JABŁOŃSKI

*Abstract:* Durability of water-based coats applied to wood and aged in natural and artificial conditions.

Aesthetic and decorative features were tested, as they are important for users of wood joinery. The observations were carried out before and during the ageing test that was performed in natural conditions, according to the requirements of PN-EN 927-3 and during the ageing test performed in natural conditions according to PN-EN 927-6. The level of changes was assessed in water-based coats applied to samples made of pine wood, and larch, after 24 months of natural ageing and after 12 weeks of artificial ageing.

*Keywords:* External wood joinery, paint coats applied to wood, ageing of paint coats, colour changes, appearance changes, adhesion.

### INTRODUCTION

A good paint coat has significant influence on the durability and functionality of wood joinery. Its quality depends mostly on the coating system applied, type of substrate, application technique and user's care to maintain its good condition. Very important, but not fully recognized is the impact of different natural conditions and its duration.

Solvent-based paint coats, with properties known thanks to the numerous studies [Paprzycki, Proszyk and others], are being replaced in recent years by water-based paints. These paint coats are also the subject of researchers [Proszyk, Nożownik – Mateńko, Kędzierski, Swaczyna, Sudoł and others]

This document presents results of ageing tests performed on water-based coats applied to wood and subjected to natural or artificial factors in UVTEST apparatus.

The scope of this study includes the assessment of appearance and properties of paint coats documented before ageing process and after natural (24 months) and artificial (12 weeks) ageing.

### EXPERIMENTS

The program of tests was prepared taking into account the recommendations of PN-EN 927-3:2008 standard (natural ageing) and PN-EN 927-6:2007 standard (artificial ageing).

Natural ageing exposures were completed in Warsaw.

Samples for natural and artificial ageing tests had the same shape and similar dimensions (20x78x375mm and 20x75x300). They were made of the following wood species: oak, larch, pine and spruce – samples had no sapwood and their grain orientation ranged from 5% to 45%.

The paint coats were applied to samples using the industrial method recommended by the manufacturer of the coating system. Before applying the paint coats, the wood was conditioned to reach the humidity recommended by the manufacturer of the coating system.

The coating system applied to samples of pine, spruce and larch consisted of;

- impregnant, applied by immersion;
- priming coat, applied by immersion;
- intermediate coat, applied by spraying (180-200µm of wet coat);
- protection of top cross-sections;

- topcoat (150-175µm of wet coat);

The coating system on samples applied to oak samples consisted of;

- impregnant, applied by immersion;
- priming coat, applied by immersion;
- priming coat, applied by spraying;
- topcoat, applied by spraying (150-175µm of wet coat);
- topcoat (second), applied by spraying (150-175µm of wet coat);

After hardening of coats, the first stage of testing (initial tests) was performed in laboratory conditions. These tests included the assessment of features that are the most important for windows users i.e.: appearance assessment – by assessing the degree of blistering, flaking and cracking, and by colour, gloss and adhesion measurements. The thickness of hardened coats and humidity of wood was also measured.

Samples assigned for the natural ageing were placed, horizontally, on racks inclined at 45° and their exposed surface was directed towards the equator.

The impact of natural environmental factors on the behaviour of the coats was assessed several times during the exposure - the Tables below present the results recorded 24 months after the start of the test.

The impact of artificial environmental factors on the coats was assessed after 12 ageing cycles, lasting for 12 weeks. Each cycle included:

- 24 h of condensation, T45±3<sup>0</sup>C;
- 168 h of further, consecutive exposures:
  - 2.5 h of UV exposure with UVA-340 lamp, light intensity of 0.89 W/m<sup>2</sup> (for 340 nm bandwidth), T60±3<sup>0</sup> C;
  - 0.5 h sprinkling with demineralised water, without UV exposure, sprinkling intensity: 6 – 7 l/min.

Procedures used to assess the appearance/condition of the surface of samples, based on recommendations defined in PN-EN or ISO standards – applied methods were of non-destructive nature (excluding adhesion measurements).

## RESULTS

The properties of coats before and after exposure to natural ageing in Warsaw are presented in Table 1.

The properties of coats before and after exposure to artificial ageing are presented in Table 2.

**Table 1.**

Tested feature	Test results before and after exposure to natural ageing												Test standard
	Test results, exposure time – <i>months</i> , average values												
	pine						larch						
	0		24		0		24						
<i>I</i>	2		3		4		5						6
Gloss <sup>1)</sup>	46,1		45,4		40,1		37,9						PN-EN ISO 2813
Colour <sup>2)</sup>	Colour coordinates - CIE 1976												PN ISO
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*	7724-1:2003
	37,52	14,15	15,69	35,62	11,74	11,90	36,43	13,58	15,37	35,69	11,33	11,75	7724-2:2003 PN ISO 7724-3:2003

Initial appearance					
-blistering	(S)0	(S)0	(S)0	(S)0	PN-ISO 4628-1:2005 -2; -4; -5
-flaking	(S)0	(S)0	(S)0	(S)0	
-cracking	(S)0	(S)0	(S)0	(S)3	
Adhesion <sup>3)</sup>	0	0	0	0/1	PN-EN ISO 2409:2008
<sup>1)</sup> measurements with a glossmeter, measurement angle of 60°, light beam directed in parallel to fibres, 5 measurements for each sample <sup>2)</sup> measurements with a spectrophotometer, in the following measurement conditions: lighting d/8, observer 10°, normal illuminator D65, without gloss trap, 10 measurements for each sample <sup>3)</sup> measurement with a multi-blade device with blade distance of 3 mm, 3 measurements for each sample					

**Table 2.**

Test results before and after exposure to artificial ageing												
Tested feature	Test results, exposure time – <i>weeks</i> , average values											Test standard
	pine						larch					
	0			12			0		12			
<i>I</i>	2		3		4		5		6			
Gloss <sup>1)</sup>	43,9		29,9		39,1		30,4		PN-EN ISO 2813			
Colour <sup>2)</sup>	Colour coordinates - CIE 1976											PN ISO 7724-1:2003 PN ISO 7724-2:2003 PN ISO 7724-3:2003
	L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	
	37,02	13,75	15,46	33,68	10,15	10,10	36,52	13,44	15,42	33,79	9,67	10,10
Initial appearance												
-blistering	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0
-flaking	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0
-cracking	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0	(S)0
Adhesion <sup>3)</sup>	0		0		0		0/1		PN-EN ISO 2409:2008			
<sup>1)</sup> measurements with a glossmeter, measurement angle of 60°, light beam directed in parallel to fibres, 5 measurements for each sample <sup>2)</sup> measurements with a spectrophotometer, in the following measurement conditions: lighting d/8, observer 10°, normal illuminator D65, without gloss trap, 10 measurements for each sample <sup>3)</sup> measurement with a multi-blade device with blade distance of 3 mm, 3 measurements for each sample												

After analysing the results presented in Tables 1 and 2, the following conclusions may be drawn:

- The change in gloss was assessed in accordance with PN-EN 927-1:2000. The initial gloss of samples assigned for natural ageing may be classified as semi-mat. After natural ageing process lasting for 24 months, the coats remained their semi-mat features. The initial gloss of samples assigned for artificial ageing may be classified as semi-mat. After artificial ageing process, lasting for 12 weeks, the reflectivity values ranged which is the value typical for mat coats.
- The colour change expressed as  $\Delta E^*_{ab}$ , was determined in accordance with PN ISO 7724-3:2003. Calculated colour change after exposure to natural ageing conditions amounted to 5,3 units for pine, and 4,6 units for larch. Calculated colour change after exposure to artificial ageing conditions was equal for all tested samples and amounted to 7 units. Further observations of naturally aged samples are still under way and final comparative analysis will be carried out after they are completed.

- The assessment of appearance was conducted in accordance with PN-EN ISO 4628-1:2005, -2; -4; -5.  
Both natural and artificial ageing did not cause blistering, cracking and flaking of coats applied to samples made of pine and larch wood.
- The assessment of adhesion was conducted in accordance with PN-EN 2409:2008  
Coats applied to pine and larch samples, after exposure to natural and artificial ageing maintained satisfactory adhesion. The ageing exposure did not decrease the adhesion of tested coats below required values.

## CONCLUSIONS

1. The natural ageing process (24 months) resulted in insignificant loss of gloss, whereas the artificial ageing (12 weeks) resulted in significant loss of gloss.
2. The natural ageing caused insignificant colour changes while the artificial ageing caused significant colour changes.
3. Adhesion of coats to the substrate for all samples was satisfactory.
4. Decorative features of the tested coats were influenced by the ageing process. The quality of coats after exposure to natural and artificial ageing factors was decreased, but it remained at a satisfactory level. Therefore the coating systems in long-term usage are able to adequately protect the wood against weathering, which causes its degradation.

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  - PN-EN 927-6:2007 Farby i lakiery. Wyroby lakierowe i systemy powłokowe na drewno zastosowane na zewnątrz. Część 6: Ekspozycja powłok na drewno w sztucznych warunkach atmosferycznych z użyciem lamp fluorescencyjnych UV i wody;
  - PN-EN ISO 2409:2008 Farby i lakiery. Badanie metodą siatki nacięć
  - PN-EN ISO 2813:2001 Farby i lakiery. Oznaczanie połysku zwierciadlanego niemetalicznych powłok lakierowych pod kątem 20 stopni, 60 stopni i 85 stopni

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Część 4: Ocena stopnia spękania; Część 5: Ocena stopnia złuszczenia;

- PN ISO 7724-1:2003 Farby i lakiery. Kolorymetria. Część 1: Podstawy

- PN ISO 7724-2:2003 Farby i lakiery. Kolorymetria. Część 2: Pomiar barwy

- PN ISO 7724-3:2003 Farby i lakiery. Kolorymetria. Część 3: Obliczanie różnic barwy

**Streszczenie:** *Trwałość powłok wodorozcieńczalnych na drewnie starzonych w warunkach naturalnych i sztucznych. Badano cechy estetyczno dekoracyjne – istotne dla użytkownika stolarki otworowej. Obserwacje prowadzono przed i w trakcie testu starzeniowego odbywającego się w warunkach naturalnych wg wymagań PN-EN 927-3 oraz testu starzeniowego w warunkach sztucznych wg PN-EN 927-6. Oceniono poziom zmian powłok wodorozcieńczalnych wykonanych na próbkach z drewna sosny i modrzewia, po 24 miesiącach starzenia w warunkach naturalnych i 12 tygodniach starzenia sztucznego. Nie zaobserwowano zmian zmniejszających w sposób istotny walory estetyczno –dekoracyjne i techniczne.*

Corresponding authors:

Marek Jabłoński,  
Faculty of Wood Technology,  
Warsaw University of Life Sciences – SGGW,  
02-776 Warszawa, ul Nowoursynowska 159  
Poland,  
e-mail: marek\_jablonski@sggw.pl

Andrzej Kędziński,  
Faculty of Wood Technology,  
Warsaw University of Life Sciences – SGGW,  
02-776 Warszawa, ul Nowoursynowska 159  
Poland,  
e-mail: andrzej\_kedziński@sggw.pl

Anna Policińska-Serwa  
Building Research Institute  
Department of Structures and Building Elements  
02-656 Warsaw, ul. Ksawerów 21  
e-mail: a.serwa@itb.pl