

Comparative studies of varying characteristics of wood surfaces after exposure to natural climate and accelerated aging

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Abstract: *Comparative studies of varying characteristics of wood surfaces after exposure to natural climate and accelerated aging.* Tests were conducted on predetermined elements of coated pinewood samples before and after accelerated aging and after 18, 54, 78 and 114 months of exposure to natural climate. The samples were tested for changes in colour, development of blistering or flaking and changes in gloss. Development or increase in yellowish tinge was compared between those samples that were exposed to natural climate, and those that underwent accelerated aging. The gain in yellowish tinge was three times greater, after 18 months, than in those samples which underwent accelerated aging and 6 times greater after 114 months. The prolonged exposure to natural climate made the effect of the impregnation of the samples clear to see. It was seen that the gloss of the finish was lower after 18 months than originally, but then after 54 months the finish regained some of its glossiness which then again fell after 78 and 114 months. It was also observed that using an impregnate on the wood before finishing it had no clear effect on the change in gloss after either trial period.

Keywords: windows finishing, ageing of paint, colour changes, blistering, peeling, cracking, chalking, paint adhesion

OBJECTIVES

The purpose of this research is to analyze the influence of accelerated weathering (changes in temperature and relative air humidity) and the influence of long term weathering (18, 54, 78 and 114 months) on paint coats. Paint coatings were tested for change in colour, blistering, flaking, cracking, chalking, peeling, mold resistance, adhesion, and gloss. An evaluation of the influence of pre-painting impregnation, or lack thereof, was also conducted.

METHODOLOGY

The methods for testing the necessary qualities, was outlined in a previous publication (Kedzierski, 2008). This research was conducted in accordance with PN-EN 927-3:2002. Paints and varnishes – coating materials and coating systems for exterior wood – Part 3: Natural weathering tests.

Accelerated aging (weathering) of paint coats was conducted according to standard ASTM D 3459-98 “Standard Test Method for Humid-Dry Cycling for Coatings on Wood and Wood Products”. Note however, that the time of the second stage was changed from 48 to 62 hours.

After the samples underwent accelerated aging in weather chamber they were tested for: blistering, flaking, gloss, and yellowing. Tests were performed in accordance with PN-EN 927-3:2002. The standard PN-EN 927-3:2002 requires implementation of ISO/DIS 7724-1:1997 to ISO/DIS 7724-3:1997 in order to establish colour and colour changes of tested products. Above standards were not in existence at time of testing so samples were tested for yellowing of coatings in accordance to standard PN 72/C-81546. Yellowish tinge of paint coat was measured in the beginning (W_{z1}) before accelerated aging and after (W_{z2}), and on samples not exposed to accelerated aging, before and after the tests.

$$\Delta W_z = (W_{z2} - W_{z1}) [\%]$$

The same tests of paint coats were carried out on the other group of wood samples before and after 18, 54, 78 and 114 months of exposure to normal weathering.

ANALYSIS

The following is a series of tables which depict the information gathered throughout the experimentation process. Table 1 depicts the characteristics of the paint coats before aging and Table 2 depicts those characteristics after aging. Table 3 however, shows the characteristics of the paint coats after 18, 54, 78 and 114 months of exposure to natural climate.

Tab. 1 Characteristics of Coats before accelerated aging

| Tested Characteristic | Variant | | | | | | Applied Standard |
|------------------------------|--------------|---------------------|--------------|---------------------|--------------|---------------------|---------------------|
| | A | | B | | C | | |
| | Aged Samples | Comparative Samples | Aged Samples | Comparative Samples | Aged Samples | Comparative Samples | |
| Gloss | 23,73 | 25,41 | 22,60 | 23,89 | 23,83 | 24,77 | PN-EN ISO 2813:2001 |
| Yellowish Tinge W_{z1} [%] | 4,89 | 5,12 | 4,51 | 4,58 | 4,99 | 4,92 | PN-72/C-81546 |

Tab. 2 Characteristics of Coats after accelerated aging

| Tested Characteristic | Variant | | | | | | Applied Standard |
|--|--------------|---------------------|--------------|---------------------|--------------|---------------------|---------------------|
| | A | | B | | C | | |
| | Aged Samples | Comparative Samples | Aged Samples | Comparative Samples | Aged Samples | Comparative Samples | |
| Gloss | 20,31 | 23,21 | 20,85 | 22,43 | 21,98 | 23,05 | PN-ISO 4628-5: 1999 |
| Loss of Gloss | 3,42 | 2,20 | 1,75 | 1,46 | 1,85 | 1,72 | PN-EN 927-3:2002 |
| Yellowish Tinge W_{z2} [%] | 5,73 | 5,25 | 5,37 | 4,81 | 5,84 | 5,16 | PN-72/C-81546 |
| Increase in Yellowish Tinge ΔW_z [%] | 0,84 | 0,13 | 0,86 | 0,23 | 0,85 | 0,24 | PN-72/C-81546 |

Tab. 3 Characteristics of coats exposed to 18, 54, 78 and 114 months of natural climate

| | Variant | Measured Gloss according to PN-ISO 4628-5: 1999 | Decrease in Gloss according to PN-EN 927-3: 2002 | Yellowish Tinge W_z [%] | Increase in Yellowish Tinge ΔW_z [%] |
|--|---------|---|--|---------------------------|--|
| | | According to PN-72/C-81546 | | | |
| Characteristics before any exposure to natural climate | A | 24,59 | - | 4,85 | - |
| | B | 23,68 | - | 4,69 | - |

| | | | | | |
|--|---|-------|------|-------|------|
| | C | 24,31 | - | 4,77 | - |
| Characteristics after 18 months exposure to natural climate | A | 22,29 | 2,30 | 7,41 | 2,56 |
| | B | 21,80 | 1,88 | 7,11 | 2,42 |
| | C | 22,35 | 1,96 | 7,12 | 2,35 |
| Characteristics after 54 months exposure to natural climate | A | 23,16 | 1,43 | 9,35 | 4,50 |
| | B | 22,11 | 1,57 | 8,89 | 4,20 |
| | C | 22,87 | 1,44 | 8,54 | 3,77 |
| Characteristics after 78 months exposure to natural climate | A | 23,02 | 1,57 | 9,88 | 5,03 |
| | B | 21,92 | 1,76 | 9,44 | 4,75 |
| | C | 22,62 | 1,69 | 9,14 | 4,37 |
| Characteristics after 114 months exposure to natural climate | A | 23,11 | 1,48 | 10,94 | 6,10 |
| | B | 21,81 | 1,87 | 10,12 | 5,43 |
| | C | 22,61 | 1,70 | 10,12 | 5,35 |

After analyzing the results one can conclude that the coatings of wood samples at the beginning of the tests and after accelerated aging, as well as the ones exposed to 18, 54, 78 and 114 months of normal weathering, did not show any signs of flaking, mold grow or cracking. Blistering was 3 (S2). Only gloss and yellowish tinge were affected.

Accelerated aging affected the change in increase of yellowish tinge ΔW_z . Increase in yellowish tinge was measured to be 0.84% to 0.86% and was similar for all the variants of finishes. Increase in yellowish tinge in not aged coats was measured to be 0.13% to 0.24%, and as is clear, it shows greater deviation. Paint coats exposed to accelerated aging are showing three to six times higher increase in yellowish tinge as the ones which were not aged. The increase in yellowish tinge was similar for all the samples used in all variants of finishes under 18, 54, 78 and 114 months of exposure to natural weathering tests. Increase in yellowish tinge after 18 months of exposure was measured to be 2.35% to 2.56% and was about 3 times higher than in accelerated aging samples. After 54 months of exposure to normal climate, the yellowing was 3.77% to 4.50%, about 5 times that of the samples that underwent the accelerated aging process, and about twice that of the yellowing at 18 months. After 78 months, the gain in yellowish tinge was six times that after six months, between 4.37% to 5.03%. After 114 months, the gain in yellowish tinge was 7 times that after six months, between 5.35% to 6.10%. Already, after 18 months it was possible to see the result of the impregnates on the yellowing: those sample which were not impregnated yellowed the least, those impregnated for 10 minutes were about 3% higher in their change in yellowing, and those impregnated for two minutes showed a 9% higher gain in yellowing. The results after 54, 78 and 114 months showed the same trend. After 114 months, those samples that were not impregnated showed the least yellowing, those that underwent 10 minutes of impregnating were 1% higher in yellowing, and those that underwent 2 minutes of impregnating were 14% higher in yellowing.

After 18 months of exposure to natural climate, it was possible to see that the gloss of the finish decreased by 7.7% to 14.4%. While, after 54 months, it was possible to see that the finishes regained 1.4% to 3.9% of their gloss, with respect to the gloss after 18 months. This could be due to the hardening of the coat of paint throughout the time between 18 and 54 months of exposure. After 78 months the gloss fell back down to between 6.4% and 7.4%. After 114 months, the gloss continued to fall to between 6.0% and 7.9%. The results showed no trends dependant on impregnation of the wood before painting.

CONCLUSIONS

1. Accelerated aging and 18, 54, 78 and 114 months of exposure to natural climate causes increased yellowish tinge to paint coats. The gain in yellowish tinge after 18 months was three times that of accelerated aging, and the gain after 114 months was 7 times that of accelerated aging.

2. The degree of yellowing was unaffected by the type of impregnate but only by the amount of time that the wood was exposed to it. After 114 months, those samples that were not impregnated showed the least yellowing, those that underwent 10 minutes of impregnating were 1% higher in yellowing, and those that underwent 2 minutes of impregnating were 14% higher in yellowing.
3. Accelerated aging and 18 months of exposure to natural climate caused a 7.7% to 14.4% loss in the gloss of the paint coat.
4. After 54 months the samples regained about 1.4% to 3.3% gloss with respect to their level of gloss after 18 months of exposure to normal climate.
5. Finally after 114 months, the gloss fell between 6.0% to 7.9% with regards to the gloss levels of the samples before the study began.
6. It was found that the change in gloss is independent of whether the impregnates were used or not used.

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Streszczenie: *Badania zmian właściwości powłok malarskich pod wpływem przyspieszonego starzenia i długotrwałego działania naturalnego klimatu. Zbadano podstawowe właściwości powłok malarskich na drewnie sosnowym przed i po przyspieszonym postarzeniu a także po 18, 54, 78 i 114 miesięcznym oddziaływaniu normalnego klimatu. Określone właściwości powłok to: zmiana barwy, spęcherzenie, złuszczenie i połysk. W wyniku badań stwierdzono, że sztuczne starzenie jak i też 18, 54 i 78 i 114 miesięczne oddziaływaniu normalnego klimatu powoduje wzrost zażółcenia powłok. Przyrost stopnia zażółcenia powłok po 18 miesiącach oddziaływania normalnego klimatu na powłoki był około trzykrotnie, a po 114 miesiącach siedmiokrotnie większy niż wywołany sztucznym starzeniem. Zaznaczył się wpływ impregnowania drewna na przyrost stopnia zażółcenia powłok wywołany oddziaływaniem normalnego klimatu. Sztuczne starzenie oraz 18 miesięczne oddziaływanie normalnego klimatu spowodowało spadek połysku powłok natomiast po 54 miesiącach zanotowano nieznaczny wzrost połysku powłok w stosunku do wartości jakie wykazywały po 18 miesiącach. Jednakże po 78 i 114 miesiącach nastąpił spadek połysku. Nie stwierdzono wpływu impregnowania drewna przed malowaniem na utratę połysku powłok.*

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