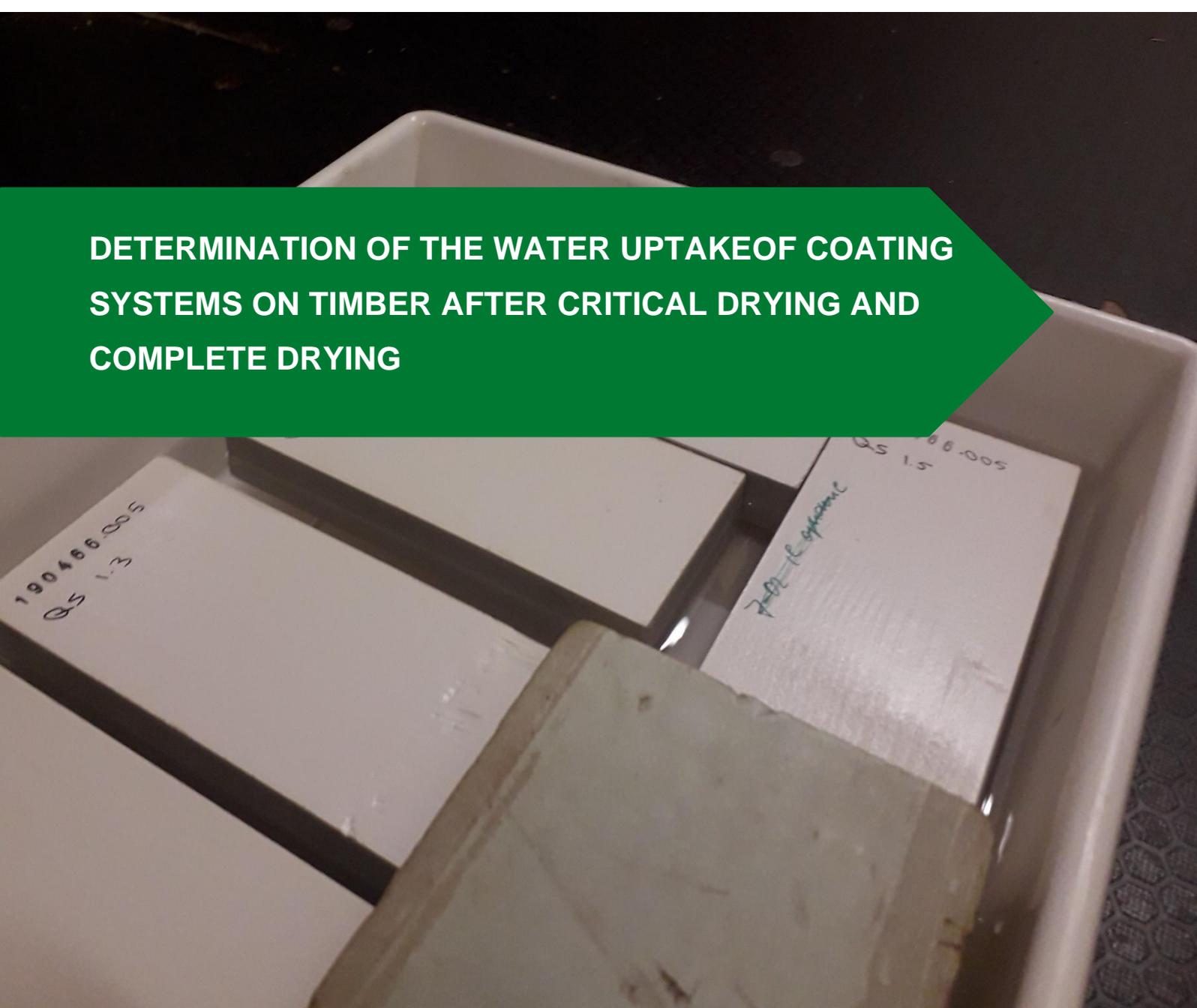




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DETERMINATION OF THE WATER UPTAKE OF COATING SYSTEMS ON TIMBER AFTER CRITICAL DRYING AND COMPLETE DRYING





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1. INTRODUCTION

This SKH-Publication describes the activities performed in order to determine the water uptake after critical drying and complete drying of coating systems on timber.

These tests are part of the overall study into the suitability of coating systems (primers, midcoat- and topcoat systems), which have been described in the Assessment Directive for the KOMO® product certificate for 'Film forming coatings for application on timber' (AD 0814) and 'Film forming mid- and topcoat systems on timber' (AD 0817).

For the corresponding assessment of adhesion, please refer to SKH-Publication 05-01.

1.1 Scope

The scope of this SKH-Publication is to correctly determine the water uptake after critical drying. Also, drying conditions that deviate from the critical process parameters, as included in the paint manufacturer's certificate, can be determined.

In addition, this publication describes the method to correctly determine the water uptake after critical drying and complete drying of coating systems on timber.\

1.2 Principle

The water uptake after critical drying is determined by determining the water absorption of coated timber. The extent of water permeability, at the moment the joinery elements leave the factory, indicates the extent of film formation. The film formation should be such that the coating protects the underlying timber against water absorption resulting in dimensional changes of the joinery elements..

1.3 Safety

Always read the safety data and product information sheet for the product in question before using paint products. Make sure to observe the safety instructions.

1.4 Definitions

Water absorption:

water absorption is defined as the number of grams of water absorbed via the test surface of the test panel after 72 hours of floating on water

Water permeability:

water uptake is the quantity of water expressed in grams per square meter that has passed through the test surface during 72 hours of floating on water.

2. REAGENTS AND AIDS

2.1 The following materials are required to carry out this test:

- the paint to be tested;
- 5 flawless test panels made of straight grained spruce, free of knots and cracks for each colour to be tested and type of determination, with the dimensions of 150 mm x 70 mm x 20 mm (length x width x thickness) and a growth-ring orientation of approx 45° with the surface;
- sealant with a maximum water uptake of 30 g/m² according to EN 927-5;
- tray with fresh water(1), placed at 20 ± 2 °C, for the determination after critical drying;
- tray with fresh water(1), placed at 20 ± 2 °C, for determination after complete drying..

1) *All water referred to in this publication has to meet the requirement of conductivity of 20 µSiemens/cm, e.g. demineralised or distilled water.*



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3. EQUIPMENT AND GLASS

The following equipment is required to carry out this test:

- brush;
- airless high-pressure spraying installation or airmix spraying installation;
- climate cabinet/room with adjustable RH, temperature, and an adjustable laminar air flow;
- calibrated scale with an accuracy of 0.01 g.

4. PROCEDURE

4.1 Production of test pieces

The test pieces are produced as follows:

- from spruce, free from knots and cracks, straight-grained and with an average growth speed (between three and eight annual rings per 10 mm), planks are sawn and planed with cross-cut dimensions of 70 ± 1 mm x 20 ± 1 mm. The angle between the annual rings and the test surface must be $45 \pm 10^\circ$. Test pieces with a length of 150 ± 2 mm are then sawn from this. The test pieces are then stored for at least 1 week at 20 ± 2 °C and 65% RH, but in any case until they reach a constant weight.
The density is then determined by weighing and dividing the weight by the volume. When a balanced timber/moisture content of approx. 12% has been reached, the density should be between 0.45 and 0.55 g/cm³;
- the pinewood panels (150 mm x 70 mm x 20 mm) are to be sealed using the sealant on the cross-cut edges, the longitudinal sides and the heart side.
Ensure that no sealant gets onto the surface to be tested;
- after sealing, the test pieces are stored for at least 1 week at 20 ± 2 °C and 65 ± 5 % RH, but in any case until a constant weight is reached;
- for each opaque paint system to be tested, 5 panels are finished on the bark side in RAL 1013 (white) and 5 in RAL 7026 (dark grey);
- for each transparent paint system to be tested, 5 panels are finished on the bark side in the 'critical' colour (the colour that is regarded as the most critical by the manufacturer).
- the paint system is applied according to the supplier's instructions, within the provisions of AD 0801 and AD 0803 with referral to AD 0817;
- the quantity of paint to be applied is calculated according to Formula 1.
During application, the quantity of paint applied is recorded by weighing.

$$LD = \frac{m_1 - m_0}{A * \left(\frac{\rho_v}{VS} \right)} \quad \text{(formula 1)}$$

- LD*: coat thickness to be applied [cm]
m₁: weight of panel with wet paint [g]
m₀: weight of panel before the application of paint [g]
VS: percentage of solid substance by volume according to manufacturer's data
ρ_v: density of the wet paint, according to manufacturer's data [g/cm³]
A: area of surface onto which paint is applied [cm²]
 for standard panel dimensions this is: 105 cm²

4.2 Paint application

- the paint is stirred for 2 minutes with a spatula and vented for 15 minutes (left to stand with the lid off);
- the panels are taken out of the climatized room (20 ± 2 °C and 65 ± 5 % RH) and the first coat of paint is applied immediately;
- by means of weighing, the paint system is applied according to the critical process parameters provided by the paint manufacturer, or applied with deviating critical process parameters according to SKH Publication 06-03 (opaque and transparent Concept II and III systems);
- in the laboratory, a flow coat layer is applied with the brush or in the flow-coat cabinet; spray coats are sprayed;
- conditions under which spray application must take place:
- type of spray gun: airless or airmix;
- type of nozzle: opening 0.009-0.13 inch, spraying angle 30°-40°, replaced after a maximum of 1,000 litres;
- adjust spraying pressure until a good spray pattern is achieved (80-120 bar, airless), depending upon nozzle and paint;
- preferably do not circulate due to air inclusion;
- conditions during application: 20 ± 2 °C en 65 ± 5 % RH;
- distance between nozzle and object: approx 30 cm;
- coat thickness to be achieved: by weighing;
- cleaning and maintenance protocol: good housekeeping.

4.3 Determination of the water uptake

The water uptake can be determined after critical- or complete drying.

4.3.1 Determination after critical drying (QS)

The water uptake after critical drying is determined as follows:

- After the final drying step as described in the critical process parameters of the principal, the test panels are weight and put in fresh water¹ of 20 ± 2 °C (bark side down) for 72 hours;
- After 72 hours the test panels are removed from the water, tapped dry with a new tissue and immediately weighed and visually assessed.

4.3.2 Determination after complete drying (HRL)

The water uptake after complete drying is determined as follows:

- After the critical drying process, as described by the principal, the test panels are conditioned for another 7 days at 20 ± 2 °C and 65 ± 5 % RH;
- Next the test panels are weight and put and put in fresh water¹ of 20 ± 2 °C (bark side down) for 72 hours;
- After these 72 hours the test panels are removed from the water, tapped dry with a new tissue and immediately weight;
- Next the test panels are conditioned at 20 ± 2 °C and 65 ± 5 % RH until a constant mass is reached. A constant mass is reached when the difference between the individual measurements after 24 hours are less than 1.5% from the average of 5 repeated measurements. In general a conditioning time of at least 4 weeks should be taken into account.
- Next the test panels are weighed again and again are put in to fresh water¹ (bark side down) of 20 ± 2 °C;
- After 72 hours the test panels are removed from the water, tapped dry with a new tissue and weighed and visually checked.

1) *All the mentioned water in this SKH-Publication is water with a conductivity of maximuml 20 µSiemens/cm, for example demineralized or distilled water.*

4.4 **Visual assessment of the layer thickness after determining the water uptake (facultative).**

When the water uptake is determined the test panels should be conditioned at 20 ± 2 °C and 65 ± 5 % RH for at least one week, after which the dry layer thickness can be determined according ISO 2808. With a microscopic assessment of the dry film thickness it is also possible to assess the uniformity of the film applied on the timber and the inclusion of air.

5. CALCULATIONS

5.1 Water permeability

The water uptake of each panel is calculated according to Formula 2:

$$\text{water uptake} = \frac{m_1 - m_0}{A} \quad [\text{g/m}^2 \text{ in 72 hours}] \quad (\text{formula 2})$$

In which:

Water uptake: m_1 (mass of test panel after 72 hours of floating on water) - m_0 (mass of panel before water-uptake test). Unit: [g]
 m_1 : mass of panel after water-uptake test [g]
 m_0 : mass of panel before water-uptake test [g]
 A : surface area bark side of panel [m²]
 for standard panel dimensions this is: 0.0105 m².

Next, determine the average and the standard deviation of the panels. If a panel shows visual damage affecting the quantity of water uptake, this is not included in the calculation of average and standard deviation. In order to calculate the average, a minimum of 4 coated panels must be representative (and without damage to the coating layer).

The following additional provisions apply to the 2nd water absorption after complete drying. If the standard deviation of the five selected measurements is greater than 15% of the average of the 5 measurements, the results of the five measurements are subjected to the so-called modified z-test in order to detect any outliers.

When Formula 3 has been complied with, there are no outliers:

$$m_i = \frac{E(MAD)(x_i - x_{median})}{MAD} \leq 3,5 \quad (\text{formula 3})$$

In which:

m_i : score for an individual value from the series
 x_i : individual value
 MAD : median of the absolute deviation in relation to the median
 $E(MAD)$: expected value of MAD (= 0.6745)

One outlier may be removed from the series. If the standard deviation still exceeds 15% of the average of the 4 remaining measurements, the test results are invalid and the test must be repeated.

5.2 Measurement uncertainty

The measurement uncertainty is calculated according to Formula 4 and consists of the error of the balance and the sawing error of the width and length of the panel.

$$\frac{\Delta \text{ water uptake}}{\text{ water uptake}} = \frac{\Delta m_1 + \Delta m_0}{m_1 - m_0} + \frac{\Delta b}{b} + \frac{\Delta l}{l} \quad (\text{formula 4})$$

In which:

Water permeability: Water absorption ($m_1 - m_0$) / test surface A. Unit: [g/m²]
m₁: mass of panel after water-absorption test [g]
m₀: mass of panel before water-absorption test [g]
b: width of panel [m]
l: length of panel [m]

In case of a weight of approx. 100 g, the balance type used (bench scale) is accurate to within 0.01 g. Sawing of the panels should be accurate to within 0.1 g.

Table 1 Example of calculations

Panel	Massa before test [g]	Mass after test [g]	Width [mm]	Length [mm]	Water absorption [g/m ²]	Absolute error water absorption [g/m ²]
1	111.17	113.31	70	150	203.8	2.3
2	109.67	111.65	70	150	188.6	2.3
3	109.31	111.41	70	150	200.0	2.3
4	90.11	92.03	70	150	182.9	2.3
5	108.87	110.87	70	150	190.5	2.3
Average					193.2	2.3
Standard Deviation					8.6	0.0

6. QUALITY CONTROL

The quantity of water absorbed by the coated wood is strongly affected by 1) the coating, 2) the sealant used, 3) the substrate, and 4) the application and drying. The water uptake of the sealant should be as low as possible (maximum 30 g/m²); therefore, a sealant with a maximum water absorption of 30 g/m² should be used.

In this work instruction, the requirements of the substrate are accurately described. More difficult points concern application and drying. These have been described as detailed as possible in this work instruction. In addition, the paint is to be applied according to the agreements made with the principal. However, errors may arise during application and drying. By assessing the panels after testing (visual damage of the coating, determination of layer thickness, etc.), it is possible to leave panels out of consideration if there is a valid reason (to a maximum of 20% rejects) when the average water uptake of the paint system is calculated.

7. REPORTING

The test report should at least contain the following:

- A reference to this publication;
- The tested paint (system);
- The tested wood species;
- The wood moisture content;
- The application and drying conditions of the tested paint (system);
- The total final drying time;
- Test method (QS or HRL);
- The average water uptake;
- The individual water uptake per test panel;
- The applied dry layer thickness;
- Any deviations from this publication.

8. LITERATURE / REFERENCES

AD 0801 Wooden façade elements, SKH Wageningen

AD 0803 Wooden exterior doors, SKH Wageningen

AD 0814 Film forming coatings for application on timber, SKH Wageningen

AD 0817 Film forming midcoat and topcoat systems on timber, SKH Wageningen

SKH-Publication 99-02. Basis for assessment for opaque primer systems on timber. SKH Wageningen

SKH-Publication 05-01. Determination of the adhesion of paint on timber. A
SKH Wageningen

SKH-Publication 06-03. Protocol for the finishing of wooden façade elements on the basis of performance requirements. SKH Wageningen

NEN-EN 927-5 (en), Paints and varnishes – Coating materials and coating systems for exterior wood – Part 5: Assessment of the liquid water permeability

International Standard ISO 2808. Paints and varnishes – Determination of film thickness