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Paints and varnishes — Coating materials and coating systems for exterior wood —

Part 2: Exposure of wood coatings to artificial weathering using fluorescent UV lamps and water

Peintures et vernis — Produits de peinture et systèmes de peinture pour bois en extérieur —

Partie 2: Vieillissement artificiel des revêtements pour bois par exposition à des lampes UV fluorescentes et à de l'eau

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by the European Committee for Standardization (CEN) (as EN 927-6:2018) and was adopted, without modification other than those given below. It was assigned to Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes* and adopted under the "fast-track procedure".

— added CIE 1964 and CIE 1976 as normative references in Clause 2;

— removed redundant UVA-340 peak emission specification from 5.2;

— citation of Annex E added in 6.1;

— text below Figure 1 has been made into a Note;

— changed “mesh” to “grit” in 6.3.2;

— added a bibliography reference to the SERVOWOOD project in Clause 8;

— changed “may” to “can” in Clause 8 to indicate the possibility of the test precision to vary, rather than a permission;

— updated symbols and units and added a Note in Table 2;

— updated symbols in A.1;

— changed “guidance” to “instructions” in A.8.2.2;

— updated grammar in B.2 to improve clarity;

— removed hypothetical statement for testing other wood species from B.4;

— changed the status of Annex C from informative to normative;

— updated the title of Annex D;

— clarified the tape strength procedure in Annex G.

A list of all parts in the ISO 16053 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Coatings from paints, varnishes and similar materials are weathered in a laboratory in order to accelerate ageing processes (caused by temperature, wetness and irradiation) which occur during natural weathering. Generally, a simple accelerating ratio between ageing during artificial and natural weathering cannot be expected due to the influencing factors having different effects according to the nature of the coating and substrate. Predictable relationships can only be expected if the effect of the important parameters (spectral distribution of the irradiance in the photochemically relevant range, temperature of the specimen, type of wetting, wetting cycle relative humidity) on the coating is known. Moreover, acceleration of the coating chemistry can cause alternative degradation pathways to be followed. However, unlike natural weathering, testing in the laboratory can be controlled by the operator and therefore the results are more repeatable and reproducible. This document incorporates the results of a precision investigation that quantifies the capability of the test in terms of repeatability and reproducibility.

Paints and varnishes — Coating materials and coating systems for exterior wood —

Part 2: Exposure of wood coatings to artificial weathering using fluorescent UV lamps and water

1 Scope

This document specifies a method for determining the resistance of wood coatings to artificial weathering performed in an apparatus equipped with fluorescent UV lamps, condensation and water spray devices.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 554, *Standard atmospheres for conditioning and/or testing — Specifications*

ISO 2409, *Paints and varnishes — Cross-cut test*

ISO 2813, *Paints and varnishes — Determination of gloss value at 20°, 60° and 85°*

ISO 4618, *Paints and varnishes — Vocabulary*

ISO 4628-1:2016, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 1: General introduction and designation system*

ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*

ISO 4628-4, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking*

ISO 4628-5, *Paints and varnishes — Evaluation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking*

ISO 4628-6, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 6: Assessment of degree of chalking by tape method*

ISO 16474-3, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 3: Fluorescent UV lamps*

ISO 18314-1, *Analytical colorimetry — Part 1: Practical colour measurement*

EN 927-1, *Paints and varnishes — Coating materials and coating systems for exterior wood — Part 1: Classification and selection*

CIE 1964, *(U*, V*, W*) color space (CIEUVW)*

CIE 1976, *L*, u*, v* color space (CIELUV)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

4 Principle

Artificial weathering of coatings using fluorescent UV lamps, condensation or water spray is carried out in order to produce a certain radiant exposure or mutually agreed total number of operation hours, based on a given degree of a change in a property or properties. The properties of the exposed coatings are compared with those of unexposed coatings, which are prepared from the same coating materials under identical conditions or with coatings whose degradation properties are known.

Radiation, temperature and humidity all contribute to the ageing process. Therefore, the apparatus specified in this document simulates all three factors.

The results obtained by this method do not necessarily directly relate to the results obtained under natural exposure conditions. The relationship between these results shall be established before the method can be used to predict performance. See B.3 for further explanations on correlation to natural weathering.

The standard test substrate is pine sapwood with the back side of panels coated. However, supplementary information on coating performance may be obtained by conducting optional tests on additional wood species, on pine, modified or impregnated by industrial processes or without coating the back side of the panels. See B.4 for further explanations on wood species.

5 Apparatus

5.1 Test chamber

The test chamber consists of an enclosure made from corrosion-resistant material which houses the lamps, a heated water tray, spray nozzles and test panel racks.

5.2 Lamps

An UV lamp emits UV radiation from a low-pressure mercury arc. The required spectral distribution is achieved by careful selection of the type of phosphor coating on the inner surface of the lamp and the nature of the glass used in the construction of the tubes.

NOTE The principal construction details are described in ISO 16474-1.

The lamp shall be of type UVA 340 in accordance with ISO 16474-3.

5.3 Device for wetting the test panels

The test panels shall be wetted by condensation from the heated water tray and by spray. To prevent spotting on to the test panels, water with a pH value between 5,0 and 7,5 and an electrical conductivity of maximum 2 mS/m, measured at (25 ± 1) °C shall be used. See Annex D.

5.4 Black panel thermometer

Set the apparatus to operate at the specified parameters. The temperature shall be monitored by a remote sensor attached to the black panel. The black panel thermometer shall be exposed to the same exposure

conditions as the specimens. Black panel thermometers shall be calibrated in accordance with the manufacturer's recommendations.

NOTE The construction of the black panel thermometer is described in ISO 16474-1.

5.5 Irradiance control

The irradiance at 340 nm shall be set to 0,89 W/(m^2·nm) (see 7.3.1).

Apparatus equipped with an irradiance control system shall be calibrated in accordance with the manufacturer's recommendations.

Lamps within the apparatus without an irradiance control system shall be rotated and replaced in accordance with the manufacturer's recommendations to compensate for lamp ageing.

6 Test panels

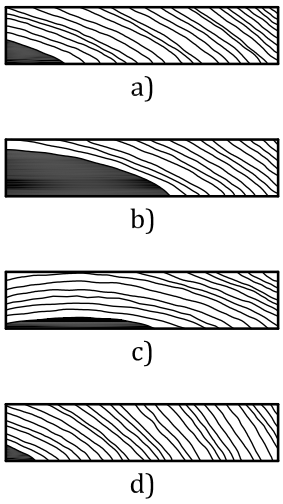
6.1 Wood

The wood shall be Scots Pine (*Pinus sylvestris*) that has been selected free of knots, cracks and resinous streaks, to be straight-grained and of normal growth rate (i.e. 3 to 8 annual rings per 10 mm). The inclination of the growth rings to the face shall be 5° to 45° (see Figure 1 a, c, and d).

The wood shall be free from blue stain and evidence of surface or bulk fungal infection. Abnormal porosity (caused by bacterial attack) shall be avoided. The procedure in Annex E shall be used to test for abnormal porosity.

The panels shall be selected to give a sapwood test surface on the convex side of the growth rings, with no heartwood (if present), closer than 10 mm to the test surface (see Figure 1b). If the presence of heartwood in the selected pine cannot be detected by a difference in the colour in the wood, it shall be checked using the test described in Annex C.

The wood shall be conditioned at (20 ± 2) °C and a relative humidity of (65 ± 5) %, in accordance with ISO 554, to constant mass.



Key

a) Example of a panel fulfilling the demands of growth ring orientation (5° to 45°) at the front side. No heartwood is closer than 10 mm to the test surface

b) This panel does not meet the specification because the heartwood is too close to the front side

c) This panel does not meet the specification because the growth ring orientation is not within the (5° to 45°) band. The growth rings incline at −10° on the left of the panel and 30° on the right. Consequently, a part of the surface contains a tangentially cut wood surface (growth ring inclination 0°), with considerable risk of crack formation.

d) This panel does not meet the specification because the growth ring orientation is not within the (5° to 45°) band and the growth rings incline 45° on the left of the panel and 70° on the right.

NOTE The topside of the panels is the exposed side; the bottom is the rear face.

Figure 1 — Cross-section of the panels

6.2 Preparation and selection of wood panels

The panels shall be nominally (150 ± 2) mm × (74 ± 1) mm and (18 ± 1) mm thick. The panels shall be planed to a smooth and uniform finish.

Any panels showing surface splitting shall be rejected. Where the presence of some minor defects in the test area are unavoidable, their position should be noted and their influence excluded during assessment of coating performance.

Mark the back of the panels to ensure that they can be identified during subsequent operations.

6.3 Preparation of coated panels

6.3.1 Wood conditioning

Prior to coating, condition the panels at (20 ± 2) °C with a relative humidity of (65 ± 5) % until the constant mass is in accordance with ISO 554. Keep the panels under the same conditions while the coating system is drying, and during subsequent storage of test panels before exposure. Panels may be transferred for brief periods to other ambient conditions where this is required for the conduct of specific operations or assessments.

6.3.2 Preparation of panels for the test coating

For each system, select four panels from the available supply. Three panels shall be used for exposure and the fourth shall serve as an unexposed reference. In order to remove oleophilic films immediately before coating, the panels shall be hand sanded (grit P150). Rounding of edges is not permitted.

Apply the coating system to all surfaces of each panel including end grain.

Apply the coating system using the method specified by the manufacturer to give a wet film thickness corresponding to the mean value (±20 %) of the manufacturer's recommended spreading rate.

Record the quantity of coating material applied to each test panel and subsequently calculate a mean value for the four panels. The values should preferably be stated in grams per square metre, but may also be expressed as wet film thickness, in micrometres (see ISO 2808). The determination of the quantity of applied coating by weighing is the preferred method.

An alternative method for test panel preparation is given in Annex F.

6.3.3 Conditioning

After the coating application, age the panels for approximately 7 days in a controlled environment at (20 ± 2) °C and a relative humidity of (65 ± 5) % before carrying out the initial panel examinations.

7 Procedure

7.1 Examination before exposure

Before exposure, carry out the following measurements:

— gloss;

— colour;

— dry film thickness (only reference panels);

— adhesion (only reference panels).

As wood is a natural material, unexpected defects can be detected in the coated panels just before exposure, even though the wood material has been selected, inspected and prepared in keeping with 6.1 and 6.2. If panels with such defects are exposed, the type, size and position of the defects shall be noted, so as to avoid any influence on the assessment after exposure.

For further details, see Annex A.

7.2 Mounting the test panels

Secure the test panels in the sample holders (whenever possible) with two exposure windows of approximately 95 mm × 64 mm. All spaces in the apparatus shall be occupied by test panels and any vacant spaces shall be occupied by blanks.

7.3 Exposure

7.3.1 Exposure cycle

An exposure cycle of one week consists of a condensation period followed by a sub-cycle of water spray and UVA 340 irradiation as given in Table 1. See B.1 for further explanations on exposure.

Table 1 — Exposure cycles

Step	Function	Temperature	Duration	Condition
1	Condensation	(45 ± 3) °C	24 h	—
2	Subcycle step 3 + 4	—	144 h consisting of 48 cycles of 3 h consisting of steps 3 and 4	—
3	UV	(60 ± 3) °C	2,5 h	irradiance set point 0,89 W/(m^2 · nm) at 340 nm
4	Spray	—	0,5 h	6 l/min to 7 l/min, UV off

7.3.2 Sample rotation and maintenance

Specimens shall be repositioned from centre to end, horizontally and vertically, after each weekly cycle.

Once a week, examine the spray pattern using a glass cover in accordance with the manufacturer's recommendations and clean the spray nozzles if necessary.

7.3.3 Duration of test

The cycle lasts for 168 h (= 1 week). The cycle shall be repeated 12 times resulting in the total test exposure of 2 016 h (= 12 weeks).

Testing the test panels shall be carried out without interruption except for servicing, maintenance of the apparatus and examination of the panels (see also B.5, for recommendation of periodical performance assessments).

7.4 Examination of test panels

At the end of the 12-week exposure period, examine the panels in accordance with Annex A. Remove the panels from the sample holder, assess blistering within 1 h and condition the panels for 7 days at a temperature of (20 ± 2) °C and a relative humidity of (65 ± 5) %.

Assess the panels for the following properties:

— flaking;

— cracking;

— chalking;

— gloss;

— colour;

— general appearance;

— adhesion.

For further details see Annex A.

8 Precision

Test precision (repeatability and reproducibility) of the artificial weathering test specified in this document was estimated in an interlaboratory study as part of the EU FP7 project "SERVOWOOD".[9]

The study consisted of three consecutive exposures of 2 000 h duration in five different laboratories (fluorescent UV exposure devices) with sets of three replicate wood panels coated with three coats of the semi-transparent Internal Comparison Product (ICP). Test panels were produced by the five participants

individually, applying a common batch of ICP to pine wood sourced locally. Performance assessments were done by different operators and using different measuring devices at the five laboratories.

The calculated repeatability and reproducibility limits of the ICP are regarded as typical for this test method (see Table 2) and may be used as basic estimates. However, test precision of exposures according to this document can vary with coating systems and assessed material properties.

For further explanations on reproducibility, see B.2.

Table 2 — Repeatability and reproducibility of standard performance parameters on ICP-coated pine panels after 2 016 h of artificial exposure

Parameter		General mean	Median	Repeatability (within laboratories)		Reproducibility (between laboratories)		
				(mean) repeatability standard deviation	95 % repeatability limit	between laboratory standard deviation	reproducibility standard deviation	95 % reproducibility limit
		m	M	s_r	$r = 1{,}96\sqrt{2}s_r$	s_L	$s_R = \sqrt{(s_L^2+s_r^2)}$	$R = 1{,}96\sqrt{2}s_R$
Blistering	Quantity	0,09	0,00	0,34	1,0	0,00	0,34	1,0
	Size (mm)	0,13	0,00	0,52	1,4	0,00	0,52	1,4
Cracking	Quantity	1,56	1,67	0,91	2,5	1,13	1,45	4,0
	Size (mm)	1,80	2,00	0,80	2,2	1,17	1,41	3,9
Flaking	Quantity	0,02	0,00	0,09	0,2	0,00	0,09	0,2
	Size (mm)	0,07	0,00	0,26	0,7	0,00	0,26	0,7
Chalking		1,18	1,00	0,75	2,1	0,45	0,87	2,4
Adhesion		0,70	1,00	0,47	1,3	0,29	0,55	1,5
General appearance		3,02	3,00	0,58	1,6	0,86	1,04	2,9
Gloss change		−56,58	−57,22	7,49	20,7	0,00	7,49	20,7
Colour change	$\Delta E^*_{ab\,sci}$	9,72	9,46	1,31	3,6	1,45	1,96	5,4
NOTE The test duration used to assess repeatability and reproducibility of standard performance parameters is according to 7.3.								

9 Expression of results and test report

The test report shall contain at least the following information:

a) all details necessary to identify the product tested, e.g. name and address of the manufacturer or supplier of the coating system tested, name or other identification marks of the coating system tested, including the batch number, description of the coating system tested;

b) the method and date of application, coating thickness and colour;

c) a reference to this document, i.e. ISO 16053-2:2024;

d) the name and address of the testing laboratory;

e) the type of apparatus used;

f) the name and brand of tape applied for adhesion testing;

g) the identification number of the test report;

h) the name and address of the organization or the person who ordered the test;

i) the date and person responsible for the sampling;

j) the classification of the coating system in accordance with EN 927-1;

k) the date of receipt of the coating system tested;

l) the exposure period (start and finishing dates);

m) the method of colour measurement, i.e. 45°:0° (specular component excluded) or di:8° (specular component included); any deviations from the test methods specified;

n) the test results;

o) the authorization date of the test report;

p) any deviations from the procedure;

q) any unusual features observed.

Annex A
(normative)

Details of the test methods

A.1 Gloss and change of gloss

Measure the specular gloss in accordance with ISO 2813 using a glossmeter at a 60° incident light angle. Obtain a minimum of two measurements on separate areas along the length of the panel, i.e. with the light beam parallel to the grain. Displace the glossmeter sidewise and obtain a minimum of two measurements on adjacent areas with the light beam incident on the panel from the opposite direction. Take the mean of all measurements obtained.

Calculate the mean values for the change of gloss of the three exposed panels, ΔG_{ex}, and of the unexposed reference panel, ΔG_{ref}. Indicate the mean of the gloss with its standard deviation before and after weathering. Indicate the change of gloss and its standard deviation.

A.2 Colour and colour change

Measure the colour in accordance with ISO 18314-1 using the measurement geometry 45°:0° or di:8°. Determine the CIE 1976 colour coordinates ($L^*a^*b^*$) for the standard illuminant D65 and standard observer 10° for each panel as a mean of a minimum four single measurements. The CIE 1964 (10°) standard observer and standard illuminant D65 shall preferably be used.

Calculate and state single measurements to one decimal place and the mean value and the standard deviation for all three panels to the nearest integer.

A.3 Blistering

The assessment for quantity (density) shall be made separately on each exposed area in accordance with ISO 4628-2.

Calculate and record the mean value to one decimal place.

A.4 Flaking

The assessment shall be made separately on each exposed area in accordance with ISO 4628-5, using a microscope of 10 × magnification.

Calculate and record the mean value to one decimal place.

A.5 Cracking

The assessment shall be made separately on each exposed area in accordance with ISO 4628-4.

Calculate and record the mean value to one decimal place.

A.6 Chalking

The assessment shall be made separately on each exposed area in accordance with the procedure described in ISO 4628-6. Take care to distinguish between chalking and dust.

Calculate and record the mean value to one decimal place.

A.7 General appearance

The general appearance is the visual impression of the tested coating system. It shall be rated on a scale as defined in ISO 4628-1:2016, Table 2, in comparison to the unexposed reference panels.

A.8 Adhesion

A.8.1 General

The assessment shall be made separately on each exposed area in accordance with ISO 2409.

A.8.2 Apparatus and material

A.8.2.1 Cutting tool

The cutting tool shall be a single-blade cutting tool with 20° to 30° edge and other dimensions as specified in ISO 2409, or a multi-blade cutting tool. The single-blade cutting tool is the preferred tool. The type of cutting tool used shall be stated in the test report.

A.8.2.2 Adhesive tape

The adhesive tape shall be (25 ± 1) mm wide, preferably transparent pressure-sensitive tape.

Instructions for determination of adhesive strength are given in Annex G. The tape shall be stored before the test for at least 2 h at (20 ± 2) °C and a relative humidity of (65 ± 5) %.

A.8.3 Procedure

The surface (and substrate) shall be clean and dry before the test.

Select an area free of blemishes and minor surface imperfections.

When cutting, use a ruler and cut through the coating down to the substrate in one steady motion.

Inspect the incisions to make sure that the film has been penetrated and the substrate is not unduly affected. If the incision is not satisfactory, make another one.

Remove two complete laps of tape from the roll and discard.

Smooth the tape into place at the area of the incisions and rub the tape firmly with a fingertip. The colour of the coating seen through the tape is a useful indication of overall contact. Within 5 min of applying the tape, remove it by seizing the free end pulling it off rapidly (but not jerking) back upon itself at an angle as close to 60° as possible.

Inspect the coated area for loss of coating; material attached to the tape shall be disregarded. Rate the adhesion in accordance with ISO 2409.

Perform the test twice on each exposed panel, recording individual results without decimals. Calculate and record the mean value for each panel to one decimal place. Calculate and state the mean value for all three panels to one decimal place.

Annex B
(informative)

Explanatory notes

B.1 Explanation of exposure cycle

The exposure cycle consists of a long initial condensation phase to generate moisture stress in the wood substrate, followed by rather short intervals of UV radiation and water spray to achieve a high number of short-term changes on the exposed surface. With this cycle, the condensation is used to move moisture into the wood substrate while the water spray serves for the removal of degraded material from the sample surface and to produce frequent cold shocks.

B.2 Reproducibility

Possible sources of differences in the operation characteristics are:

— UV output of the fluorescent lamps (ageing). This effect can be minimized by using an automatic irradiance control system;

— either the level or fluctuations of the room climate, or both, with a possible influence on the effectiveness of the condensation and/or the spray water temperature;

— water spray pattern and pressure (clogged spray nozzles) and water quality;

— schedule of the specimen rotation.

B.3 Correlation to natural weathering

Bearing in mind the general limitations of an artificial test, the artificial weathering method appears suited to assess the performance of exterior wood coatings. However, the complicated interaction of a natural exposure cannot be completely simulated with a simple artificial exposure test.

The moisture content of the wood substrate during artificial weathering is still lower than during outdoor exposure. It is not clear whether this has an effect on the correlation of the test results.

B.4 Dependency on wood species and substrate

Coating performance on pine panels should not be used to indicate performance on different wood species and substrates.

B.5 Recommendation of periodical performance assessments

Time-series types of data contain considerably more information than "final" assessments only and are particularly useful in correlation studies. That is why periodical performance assessments are recommended during exposure for additional information on degradation process. Therefore, assessments can be made after 1, 2, 3, 4, 6, 10 and 12 cycles (for gloss after each cycle, see 7.4). In this case, assessments should always be made at the end of the cycle (the driest point of cycle). To avoid wetting the samples before the assessment and to allow time for assessments, the cycle should be stopped before the last step of spraying.

Annex C
(normative)

Test for heartwood in pine

If the presence of heartwood in the selected pine cannot be detected by a difference in colour in the wood, it may be checked by the brush application of a test solution to both the end-grain and the faces of a small piece cut from the same length of timber.

Prepare this test solution by dissolving Fast Red B salt in de-ionized water at a concentration of 5 g/l. The solution should be freshly prepared and is immediately ready for use. Heartwood is indicated by the development of a deep red colour, which usually shows within about 10 min.

Fast Red B has no reported mutagenic or teratogenic effects, however, it should be treated as a suspected carcinogen. Reference should be made to up-to-date, relevant health and safety data sheets.

Annex D
(informative)

Water purification

Water of the required quality can be produced with a mixed bed deionizing system with a Type 1 anion exchanger (not Type 2), or with a combination of reverse osmosis and deionization.

Distilled or deionized water of the required quality in a tank with a continuous conductivity measurement has been found suitable. A recirculation system including a pump and filters provides the water for spraying onto the test panels and also keeps it free from contamination. The conductivity meter indicates polluted water (>2 mS/m) and therefore the time to renew the water. A weekly exchange of the water has been found sufficient.

Distilled water from heating systems can be used, provided the plumbing can be shown not to contaminate the water.