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ONR

ONR 191040

Bird –safe glass- Testing of efficiency

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Preface

Sheets of glass are amongst the most common anthropogenic reasons for death of birds. For instance, 827 bird crashes were registered at the post tower in Bonn in one year. For the entire USA there are estimates of between 97 and 970 million victims per year.

Areas of glass with free views, such as noise reduction walls, sky walks and conservatories are fateful for birds because these obstacles are invisible to them. They are also deadly traps for birds if the sky, trees or bushes are mirrored in the glass.

The often-used black stickers of predatory birds cannot prevent bird crashes. Traces of collisions are often to be found directly next to these stickers, because the birds do not recognize the predator and just narrowly avoid the black patch. Bird crashes can only be avoided if the whole glass area is marked, whereby a good contrast cover of 7% is sufficient.

To assess the efficacy of measures for bird crash prevention different methods are used. For instance, if dead birds are found in front of a marked glass sheet, the number of dead birds found is often used to assess the effectivity of the method. However, this does not take into account that predators such as martens, crows, foxes, house cats etc. usually remove the bodies quicker than the ornithologists can find them.

The interpretation of crash signs is also difficult because the birds, often weighing only a few grams, do not leave many traces. Field observations again are very time consuming. A targeted and reproducible approach has been found in the so called tunnel trials. The design of the trial and the execution are object of this ONR.

1 Area of Application

This ONR describes the assessment of the efficacy of bird-safe glass.

Bird-safe glass in the sense of this ONR is clear glass and other materials (for instance PMMA) which are made visible to birds through certain measures (for instance markings) to reduce collisions to a minimum.

This ONR applies to all free-standing glass panes (e.g. transparent noise reduction walls) and transparent glass constructions (e.g. connection corridors).

2 Normative References

The following cited documents are essential for the implementation of this document. Where the references are dated, only the named version applies. Where the references are not dated, the most recent version of the document applies (including all the changes). Legislation always applies to the current version.

ÖNORM EN 572-1, *Glass in building - Basic soda lime silicate glass products - Part 1: Definitions and general physical and mechanical properties*

ÖNORM EN 572-2, *Glass in building - Basic soda lime silicate glass products - Part 2: Float glass*

ÖNORM EN 1036-1, *Glass in building - Mirrors from silver-coated float glass for internal use - Part 1: Definitions, requirements and tests methods*

3 Terminology

For the implementation of this ONR, the following terms apply:

3.1
Attractor
Parameter, which encourages the bird to directed flight

The primary attractor in terms of this ONR is light. Secondary attractors are natural background, such as sky, vegetation or even artificial neutral backgrounds.

3.2
Marker
Application of elements that are optically recognized by birds and that make the glass pane recognizable.

The direction (orientation) of the marker can be designed, for example, in a horizontal, vertical or diagonal direction.

3.3
Dominance
The relative individual frequency of a particular bird species as a percentage of the total of the individuals used for the investigation in the test facility

3.4
Test glass
Description of the test item and reference glass, which pair wise served to test the effectiveness of the marker

3.5
Birds
Wild birds, which were used for the investigation in the test facility

4 Test methods

4.1 General

Birds were subjected to choice trials in a test tunnel, to test the effectivity of the markings under natural light conditions.

4.2 Tunnel Trial

The test facility uses the effort of the birds to fly out of a darkened area into the light. Birds adapted to daylight are removed from the wild and placed in the flight tunnel, described below, which is open at one end. The flight path is thereby determined and leads in the direction of the test panes, two obviously separate glass areas, one of which is the test item (marked glass), and one the reference glass. The illumination of the test panes is based on the reflection of natural sunlight and diffuse incidence of natural light; the natural background of the test panes is lit by natural daylight.

4.3 Choice Trial

Test item and reference glass are placed on one level (test level). Under the presumption that birds avoid recognizable obstacles, it is to be expected that well recognizable markings on the test item will induce a

greater tendency for the choice of flight direction to the side of the reference glass, while poorly recognizable markings will induce a random distribution of the choice of flight direction. Therefore, the result of the observations from this choice trial is indicative of the effectivity of the tested marking.

4.4 Reflection of Natural Light

The profile of the light (e.g. spots, strips) and the reflection characteristics, such as colour and contrast, are decisive for the effectivity of a marker. In order to test these under conditions as near as possible to natural, sunlight is reflected symmetrically, parallel and evenly onto the facing wall of the flight tunnel (see Figure 5). For this purpose the test item, reference glass and mirror are positioned appropriately in the direction of incidence of the sunlight. This is achieved by turning the entire construction around the vertical and alignment of the flight direction of the birds to appropriate azimuth direction for the altitude of the sun.

5 Test Item and Reference Glass (Test Glass)

5.1 Test Item

The test item must present a representative cut-out of the planned application of the bird safe glass in a scale of 1:1. The orientation of the marking as well as the one of the test body on the test level has to be consistent with the planned application of the bird safe glass. The side on which the bird crash is to be expected must be exposed to the bird in the test facility.

The test body is required to have a width of 50 cm and a height of 100 cm.

5.2 Reference Glass

The reference glass is a 4 mm thick float glass screen according to ÖNORM EN 572-2 with the dimensions 50 cm x 100 cm. The transmission of the reference glass must to at least 70% within the spectral area 350 nm to 400 nm and at least 80% within in the spectral area 400 nm to 650 nm, according to ÖNORM EN 572-1.

6 Test Facility

6.1 General

The test facility consists of a rotatable mounted supporting construction, to which the flight tunnel, mirror and glass holders are attached (see Figure 1).

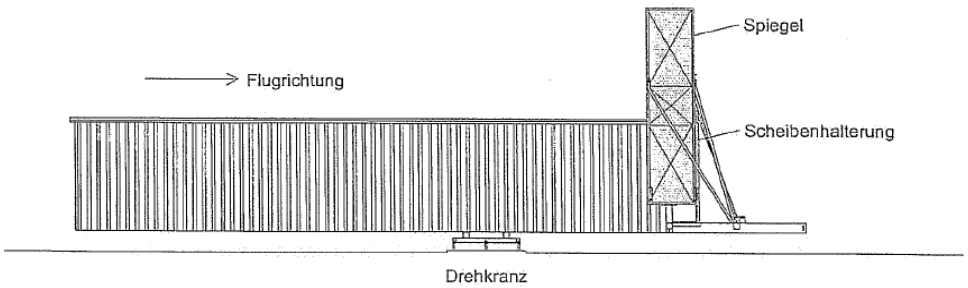

Bild 1 — Seitenansicht des Flugtunnels

Figure 1 – Side view of the flight tunnel

[*annotation* – flight direction; rotating assembly; mirror; glass holder]

6.2 Dimensions of the Flight Tunnel

The flight path must be sufficiently long to allow the bird to accelerate to flight velocity, which corresponds to that required for movement at ground level. Additionally, the markings must be based on the attractions which can be recognized by the animals, so that they can make a distinct choice in direction.

At the same time the flight path must also be short enough and must demonstrate sufficient difference in the light intensity between the starting tube and tunnel end in order to motivate the birds to a directional flight.

The total length of the supporting construction is 910 cm. The actual flight tunnel length has a length of 750 cm. The walls with the starting tube are offset to the interior by 20 cm; the catch net is found inside the tunnel, 40 cm in front of the test level. The flight path is therefore 720 cm. The test level is found 30 cm outside the tunnel, which should prevent the birds from hitting the glass panes at velocities of between 5 m sec $^{-1}$ and 10 m sec $^{-1}$.

The clear width of the tunnel is 42.5 cm in the area of the starting tube, and enables an unobstructed start.

So that the field of view of the bird is dominated by the test glass panes as much as possible, the clear width at the end of the tunnel is 102 cm, the clear height 125 cm (see Figure 2 and Figure 3).

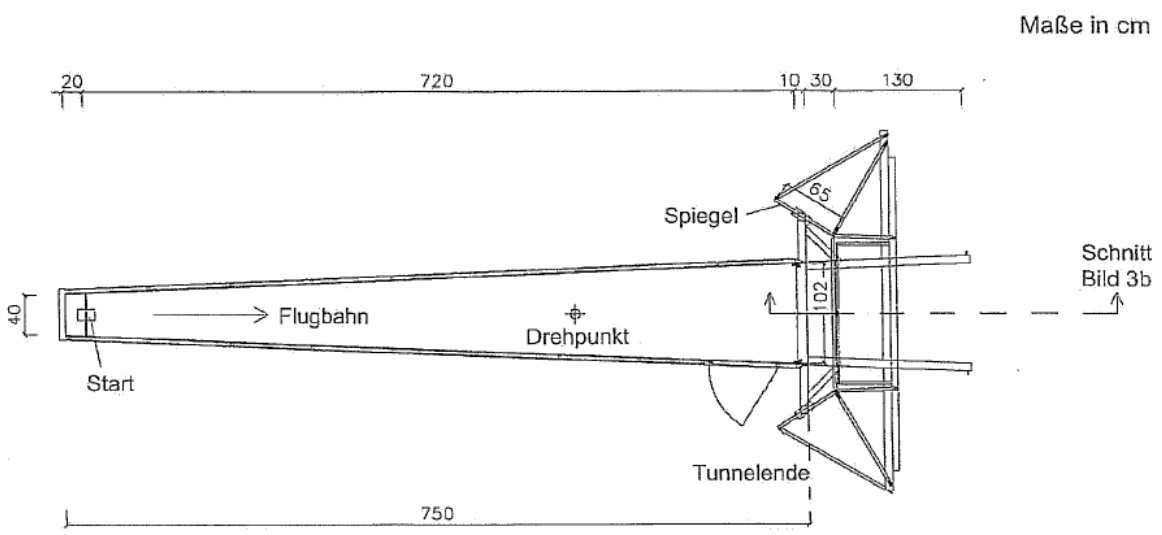

Bild 2 — Schnitt durch den Flugtunnel

Figure 2 – Cross section through the flight tunnel
[*annotation* – start; flight path; pivot point; mirror; tunnel end; sizes in cm; section Figure 3b]

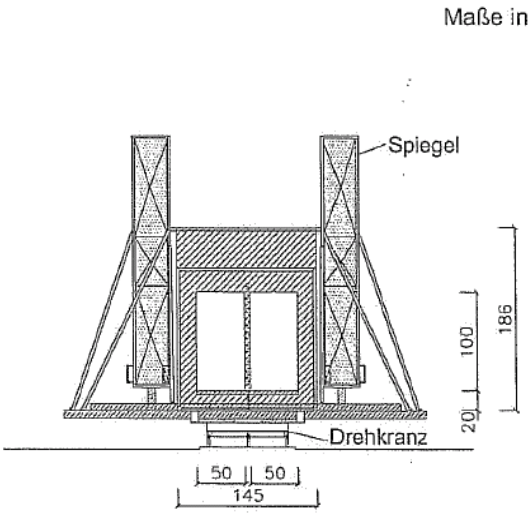

Bild 3a — Ansicht Tunnelende

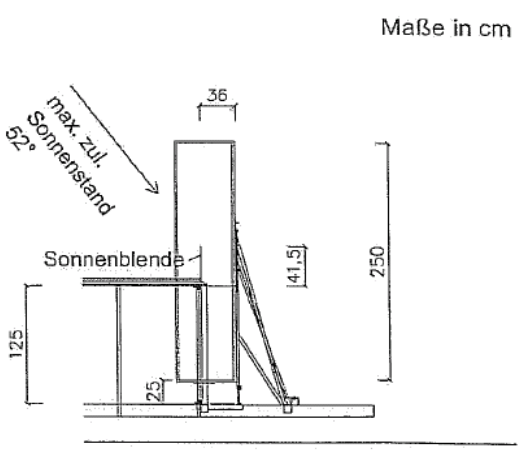

Bild 3b — Schnitt Tunnelende

Figure 3a – View of tunnel end
[*annotation* – pivot point; mirror; sizes in cm]

Figure 3b – Cross section of tunnel end
[*annotation* – max. accept altitude of the Sun 52°; sunshade; sizes in cm]

Figure 3 – Tunnel end

To Figure 3a: The tunnel has a clear height of 125 cm. The glass holder has a height of 186 cm and a width of 145 cm, through which the birds can recognize the background only through the test glass panes. The test glass panes, with the dimensions 50 cm x 100 cm are placed with a clearance of 5 cm in the glass holder in the vertical level (test level).The lower edge of the test glass panes lies 20.5 cm above the lower edge of the flight tunnel.

To Figure 3b: To prevent shadows being cast no direct incident sunlight is allowed to reach the test glass panes. Sunlight reaches the test glass panes via the mirrors. The mirrors have a height of 250 cm and a width of 65 cm. They are mounted at a height of 25 cm above the lower edge of the tunnel. A sun shade, with a height of 40 cm, shades the panes from incidence of direct sunlight to an altitude of 52°, and thereby prevents tunnel shadows being cast onto the test glass panes.

6.3 Components of the Flight Tunnel

The birds move in a targeted flight from the start in the direction of the test level, in which the test item and the reference glass pane are located. A Mist net, 40 cm in front of the test level, prevents the impact of the birds on the glass. Through the visible partition of the test panes using a dividing wall in the area of the of the tunnel end, the choice of the escape directions can be clearly attributed to one of the two glass panes.

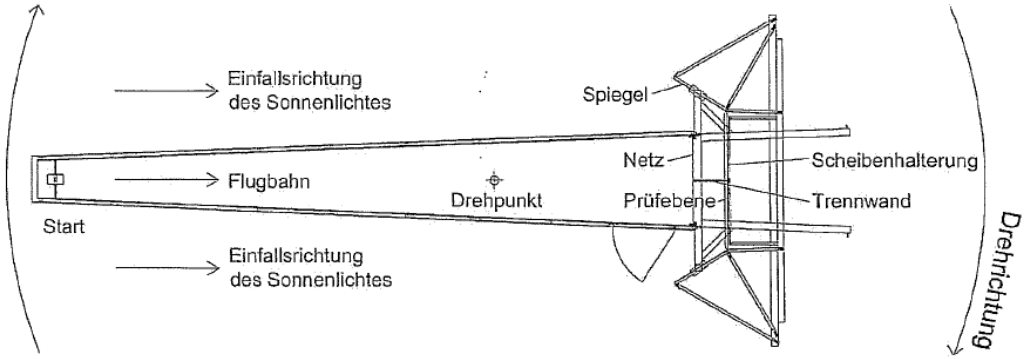

Bild 4 — Komponenten des Flugtunnels

Figure 4 – Components of the flight tunnel
[*annotation* – start; direction of incidence of the sunlight; flight path; direction of incidence of the sunlight; pivot point; mirror; net; test level; glass holder; dividing wall; direction of turn]

6.3.1 Starting tube with textile light canopy

The birds begin from a tube secured centrally on the back wall of the flight tunnel (inner diameter 10.0 cm, length 20.0 cm). The tube is shielded is the outside with light-proof textile cover. The lower edge of the starting tube lies 55.0 cm above the base of the tunnel.

6.3.2 Video camera

The flight is recorded using a video camera and followed on a monitor. The camera is located directly under the starting tube.

6.3.3 Catch net for the safety of the birds

The birds are collected in a scientific bird catch, similar to a Mist net (strand thickness 0.1 mm; mesh size 10mm), in front of the test panes. The net is professionally attached at a distance of 40 cm in front of the glass panes. It must be ensured that the birds are caught in the net and can neither impact against the glass nor be thrown backwards.

6.3.4 Dividing wall for the visible separation of the reference pane and the test item

Between the net and the test panes is a dividing wall, 2 cm thick and mounted 10 cm perpendicular to the test level, with the dimensions 40 cm x 125 cm (see Figure 4 and Figure 5). Thereby it is impossible that the birds can see the neighbouring pane at and behind the net level. This ensures that the animals can show a tendency towards the other pane at the time of hitting the net.

6.3.5 Side Access

A door fitted on the side behind the net allows access to the tunnel and a gentle freeing of the bird from the net. The door has to close light tight and may not offer an obstacle or source of danger to the birds.

6.3.6 Design of the interior of the tunnel

The interior of the tunnel may not contain any structures which could endanger the birds or influence their choice of direction. To prevent a danger to the birds, part such as the fastening of the net, the partition and the floor in front of the net have to be cushioned. A textile, opaque covering of the upper 10 cm of the net prevent the birds from crashing into the ceiling.

6.3.7 Lighting in the Tunnel

The surface of the interior of the tunnel is to be kept dark, light reflexes are to be prevented and mirroring reflective surfaces are to be avoided, to animate the birds to fly in the direction of the test panes.

6.3.8 Lighting between Tunnel and Glass Holders

The end of the tunnel, the glass holders, as well as all parts in between, are to be designed in white, to maximize the intensity of the light that strikes the glass surfaces diffusely.

6.3.9 Rotating Assembly

In order to arrange the tunnel according to the position of the sun, it has to be fitted to a slew ring at its centre of gravity (see Figure 1).

6.3.10 Sun Blinds

A sun blind of 41.5 cm height (measured from the bottom edge, Figure 3b) is fitted over the tunnel end. This ensures that up to a height of the sun of 52° no direct sun light reaches the test panes and no shades are cast onto the markings.

6.3.11 Fitting of the Test Panes

The test body and the reference pane are affixed next to each other in one level (test level) in the glass holder (board with respective openings). The distance between the panes is 5 cm.

The glass holder has a width of 145 cm and a height of 186 cm, which ensures that the birds only see the attractors through the test panes. The lower edge of the test panes is 20 cm over the lower edge of the glass holder (according to Figure 3a).

The distance between the tunnel end and the test level is 30 cm. This ensures an unhindered light flow of the sunlight/daylight via the mirrors onto the test panes without lighting the interior of the flight tunnel.

6.3.12 Mirrors

To ensure the light arriving at the test panes is as natural as possible, industrially manufactured silver mirrors according to ÖNORM EN 1036-1 with a degree of reflection of at least 50 % in the spectral range of 350 nm to 400 nm and at least 83 % in the spectral range of 400nm to 700 nm are used. This refection is measured spectrally in 5 nm steps. The angle of incidence of light only differs by a maximum of 8° from the vertical. The measurements are taken in the path of the rays.

The mirrors have a width of 65 cm and a height of 250 cm. They are mounted vertically and have an angle of 58° to the test level.

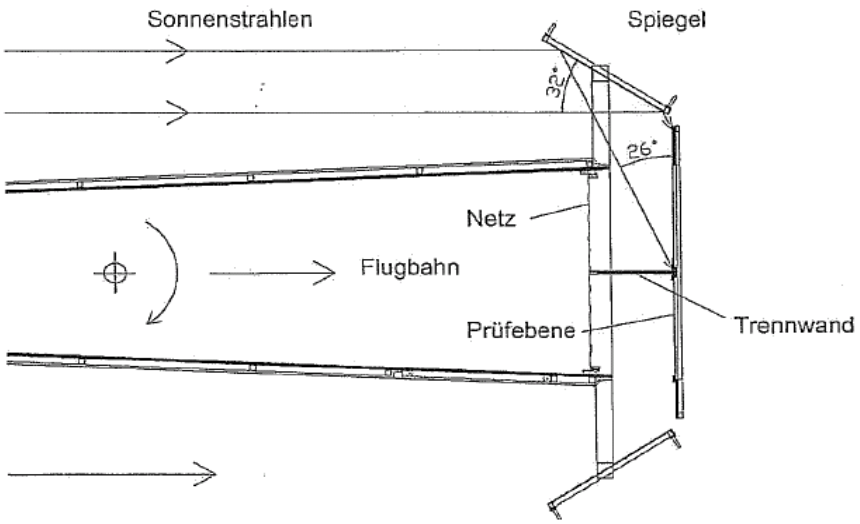

Bild 5 — Anordnung der Spiegel

Figure 5- Arrangement of the mirrors
[*annotation* – sun rays; mirror; net; flight path; test level; dividing wall]

The size of the mirrors and their positioning is sufficient for a full lighting of the panes with mirrored in sunlight at sun positions up to 52°. The width of the mirrors allows for a tolerance of the azimuth angle of up to 5°. The mirrors are at an angle of 32° to the level of incoming beams and 58° to the test level. The sunlight meets the test panes at an average horizontal angle of 26°.

6.3.13 Attractors

As an attractor behind the panes a natural background is to be chosen (such as sky, vegetation or ground). If there are specific reasons, a different background can be chosen (such as a wall). Both test panes have to have the same background.

6.4 Birds

For the test wild birds form mixed populations are used. The spectrum should contain at least 90 % singing birds from at least 4 families with a minimum of 5 % dominance.

In case of a recapture, only 20 % of the birds may be used more often than once for test flights, none of the birds may be used more than three times in a calendar year. The time between flights has to be a minimum of five hours. The birds may not be held captive between flights. The birds are not allowed to show signs of fatigue or other health impairments.

7 Running of the Tests

7.1 Pre-checks when the Facility is put into Service

The pre-checks are to check the safety and the correct working order of the facility and must be performed when the facility is put into service for the first time. Through correct positioning of the net it has to be guaranteed that the birds do not crash into the test glass. The pre-checks are carried out without the test glass pane.

It must be checked, with and without the netting, that the left and right hand sides can be flown at with equal frequency. As the position of the sun can majorly influence the choice of direction, the test flights must be carried out mornings (6:00 – 9:00), lunch time (10:00 – 12:00) and evenings (17:00 – 20:00). The sample size must contain at least 30 flights with net and 30 flights without net.

7.2 Test Flights

7.2.1 Prerequisites

When the test flights are carried out, it has to be made sure that the test body and the reference screen are clean and dry. When it rains and when there are raindrops or mist on the test glass, the test flights cannot be carried out. Between start tunnel and the test level, especially inside the tunnel, must not be any obstructing elements, light reflexes, (caused for instance by a not fully closed door) have to be prevented. It has to be taken care there are no persons or moving objects behind the test glass screens or in the optical path of the light mirrored in (causing shadows). The net may not have creases which could influence the choice of the birds.

7.2.2 Number of valid Test Flights

For the assessment of a test body at least 80 valid test flights are necessary. The test flight counts as invalid, if a bird

- obviously flies reluctantly, not quickly and decisively,
- has contact with the ceiling or one of the side walls,
- searches the side wall,
- lingers en route
- hops on the floor or
- lands in front of the net

Further, test flights are invalid, if disturbances have occurred during the test (for instance persons in the background of the screens).

Obviously invalid test flights must be repeated instantly with a different test bird.

7.2.3 Light Conditions

It must be ensured that the tests take place under different light conditions and positions of the sun. At least a third of the trials have to take place at direct sunlight (no clouds in front of the sun). At least half of the trials have to take place when the sun position is at the most 35°.

7.2.4 Adjustment of the Tunnel

The tunnel has always to be adjusted so that the direction of the bird's flight is equal to the direction of the azimuth of the incoming sunlight. This way it is guaranteed that the light shines onto the glass screens symmetrically, parallel and evenly, and shadows are symmetrical. This orientation must be adhered to, even when the sky is cloudy and the light is diffuse.

7.2.5 Start, Flight and Release

The birds, adapted to the daylight, are put into the starting pipe, from where they start instantly. They may not be adapted to the dark; no attempts may be made to calm them or similar manipulations. The camera documents the entire flight. The flight has ended when the bird is caught in the net or when the test flight is deemed invalid. The bird then is freed and released by hand.

7.3 Trial Documentation

The documentation of the test flights is reliant on the field protocol and the video recording according to 6.3.2

The following data must be recorded in a field protocol:

- date,
- time (synchronized with the camera time),
- sun (sharply marked shadows or diffuse light),
- arrangement of the trial items (left or right),
- bird species,
- observed result (left or right).

8 Analysis and Interpretation

Using the slow motion analysis of the video recording the valid flights directed at the reference pane and the test screen are determined.

The end result is determined by analysis of the decisions of the birds in the choice test. The decision to call a test pane a bird safe glass in the meaning of the present ONR is made from the percentage value of the decisions for the marked pane (test pane). If the value is at most 10 %, the test screen can be called bird safe glass in the sense of this ONR. The sample size must be $\geq$80.

9 Test Report

The test report must refer to this ONR and contain the following information:

1) Manufacturer's information:

- manufacturer of the test body,
- brand name,
- product name;

2) Composition of carrier material:

- type of carrier material; glass or plastic (for instance float glass according to ÖNORM EN 572-2),
- total thickness (in mm),
- construction (for instance tempered safety glass, laminated glass, insulated glass),
- for laminated glass, number and thickness of panes, composition of the intermediate layer,
- drawing with measurements and legend;

3) Description of the marking:

- type of marking (for instance ceramic glass colour, plastic inlay in the mass of the test body, self adhesive marking),
- colour code of the marking according to the manufacturer,
- geometry (drawing with measurements),
- statement on which level of the carrier material the marker is located;

4) Statement of important test parameters:

- when was the test carried out
- which times of the day were the tests carried out
- numbers of test flights at sun and at diffuse light
- description of attractors
- bird types and numbers per type
- numbers of valid and invalid test fights;

5) Results of the valid test flights:

- number of flights in direction of the test body, as percentage of the valid flights;

6) Statement as to whether the test body is bird safe glass according to this ONR;

7) Name and address of the testing body and signature of the person responsible for the test;

8) Date of the report

Appendix A

(informative)

Experiences from the Practice

A.1 General Notes for the Tests

The following paragraphs describe the preparations before the test period, parts of steps for the performance of the tests and finally, parts of steps for the interpretation of the results and the documentation. The recommendations result from the year-long experience made with the described test setup, made at the Biological Station Hohenau-Ringelsdorf between 2006 and 2009.

A1.1 Preparation of the Tests

A.1.1.1 Pooling and Randomization

The described tests are bound to the activities of a trapping station for scientific bird banding (requires nature protective permit). For these reasons, the tests are restricted to the time periods of scientific bird catching. Primarily, the test times are between July and September, as during these times most birds are caught, the results for the birds that have yearly cycles are minimal and the vegetation in the background of the panes is most homogenous.

As the test has components of a laboratory test and a field test (natural light, natural vegetation), the diurnal and seasonal rhythmicity of light, as well as climatic effects influence the test conditions. Therefore it is advisable to use the entire time span available for the test of the individual test items. Doing so it must be kept in mind that every test item shall be tested under the entire spectrum of influences and these [influences] shall be distributed evenly among test items. This is achieved by pooling the test items and by randomization of the sequence of the single tests. For this purpose, right from the start, a random sequence of the tests is established, which also includes an evenly distributed positioning of the reference and test panes. For minimization of the workload, a grouping to three has been proven favourable. To warrant the minimum of 80 valid tests, in practice it has proven to be adequate to plan 96 single tests for each test body. (16 repeats of three are 48 single tests, each left and right of the reference pane). Table A.1 shows a listing of groups of three of test bodies, the random sequencing of the groups of three and the random position relative to the reference pane. This sequence is noted down in the protocol sheets.

Table A.1 – Sample of a grouping of three

Left	Right
Reference pane	test item 3
Reference pane	test item 3
Reference pane	test item 3
Reference pane	test item 1
Reference pane	test item 1
Reference pane	test item 1
test item 1	Reference pane
test item 1	Reference pane
test item 1	Reference pane

A1.1.2 Design of the Protocol Sheets

The protocol sheets include the following categories: date, number of the video tape, continuous number of the single test runs, sample item left, sample item right (respectively reference pane), sun/sun covered (criterion: are the shadows sharply drawn?), type of bird, band number (if banded scientifically), time (according to camera), preliminary result (visual decision of the bird for left or right side), remarks (flies reluctantly, camera defective etc.).

A.1.13 Symmetry of the Test Panes

When producing the test items the required symmetry of the test facility has to be taken into account. The best is a marking of the test panes which is symmetrical over both middle markings of the pane. It has to be taken care, that the sample items are arranged mirrored in the left respectively right fitting area (see Figure A.1).

A.1.2 Carrying out the Tests

A.1.2.1 Handling of the Birds, Logging of the Data

In scientific bird banding it is common practice, to transport the birds on their own in little fabric bags and keep them in those bags during the steps of the tests. All tests have to be carried out without undue delay, ensuring the birds are unharmed. The birds are doing these tests one by one and are released after a single test flight. Identification and reading off of the band are performed outside the tunnel and allow the bird to adapt to the daylight meanwhile the data (see A.1.1) is logged. Then the bird is placed in the starting pipe, the camera is started and the bird flies off. The flight can be followed and assessed on the monitor of the camera. The bird is released immediately after arriving in the catch net. During the flight, nobody is allowed to stand behind the panes or in the light paths of one of the mirrors. The door may only be opened after the arrival of the bird in the net.

A.1.2.2 Invalid single Tests according to individual Observation

Based on experience, about 5 % of the flights cannot be clearly assigned. This is the case, if, for instance a bird flies reluctantly and not targeted to the test panes, lands on the floor or on one of the side walls, or lands on the front edge of the divider fitted between net and test panes. In those cases the tests are invalid and are repeated with the next bird. It is handled the same way, if the test is disturbed, by for instance leaving the door open, objects that are in the tunnel and disturb the symmetry, or persons behind the panes.

A.1.2.3 Handling of the Test Panes

The panes must be fixed wind safe and vibration free. It has proven practical to fit the panes from the rear of the glass holder and push them with a spring loaded fitting into the opening. If it rains, or dew collects, the tests must be stopped and the glass must be dried off.

Each test item has a marking on the front side which always points towards the tunnel (side approached by the bird) and a backside, which usually is unmarked. In special cases (markings on both sides, or markings that are in the pane for laminated glass or acrylic glass) front and back are to be handled according to manufacturer’s instructions.

Care must be taken that effects due to asymmetric mounting of the markings are cancelled out. For this, asymmetrically marked test bodies are to be mounted mirrored with the upper side downwards at change of sides (see Figure A.1).

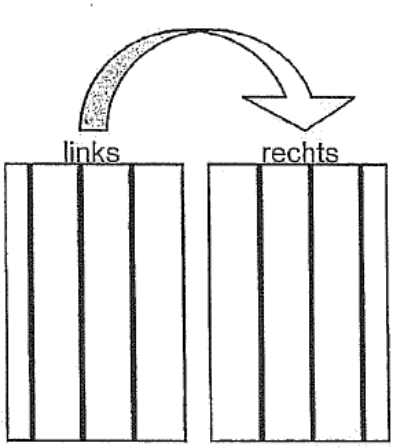

Bild A.1 — Montage unsymmetrisch markierter Scheiben

Figure A.1 – Fitting of asymmetrically marked panes
[*annotation* – left; right]

A.1.3 Analysis and Interpretation of the End Results

Deciding factor for the assessment of the test items for bird safe glass is the video analysis of all single tests. Only the slow motion view the choice of sides can be definitely fixed and the test be found valid. In some cases after being caught in the net a quick change of sides occurs. Here the moment of the crash is the deciding factor. In other cases just before hitting the net a quick avoidance manoeuvre is started, these reactions can't be counted, as the reason for those is the recognition of the net, the single test is invalid.

Further to Paragraph 8, determination of the end result, it seems to be wise for proof of integrity of the tests to incorporate the following parameters:

- number of birds that have decided for the left or right hand side themselves,

- number of birds that have decided for the marked pane on the left or right hand side themselves,

- number of birds that have decided themselves for the unmarked reference pane left, respectively right hand side.

In all cases a similar distribution is expected. Significant dissimilarities indicate faults in the experimental set-up, such as a net that has not been fitted evenly.

A.2 Differentiation according to the Lighting Conditions

To gain further insights, it is possible to differentiate by the lighting conditions. The use of light meters, with recording of the measured values by the minute, allows further differentiation. A pooling of very similar markings increases the sample pool and can offer interesting insights (for instance comparison of similar white, black, yellow markings for effectivity in front of dark backgrounds or with high global radiation). From these additional findings possibilities for differentiated fields of applications can be gained. Bird safe glass, for example, can be particularly suitable for light or dark backgrounds.

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