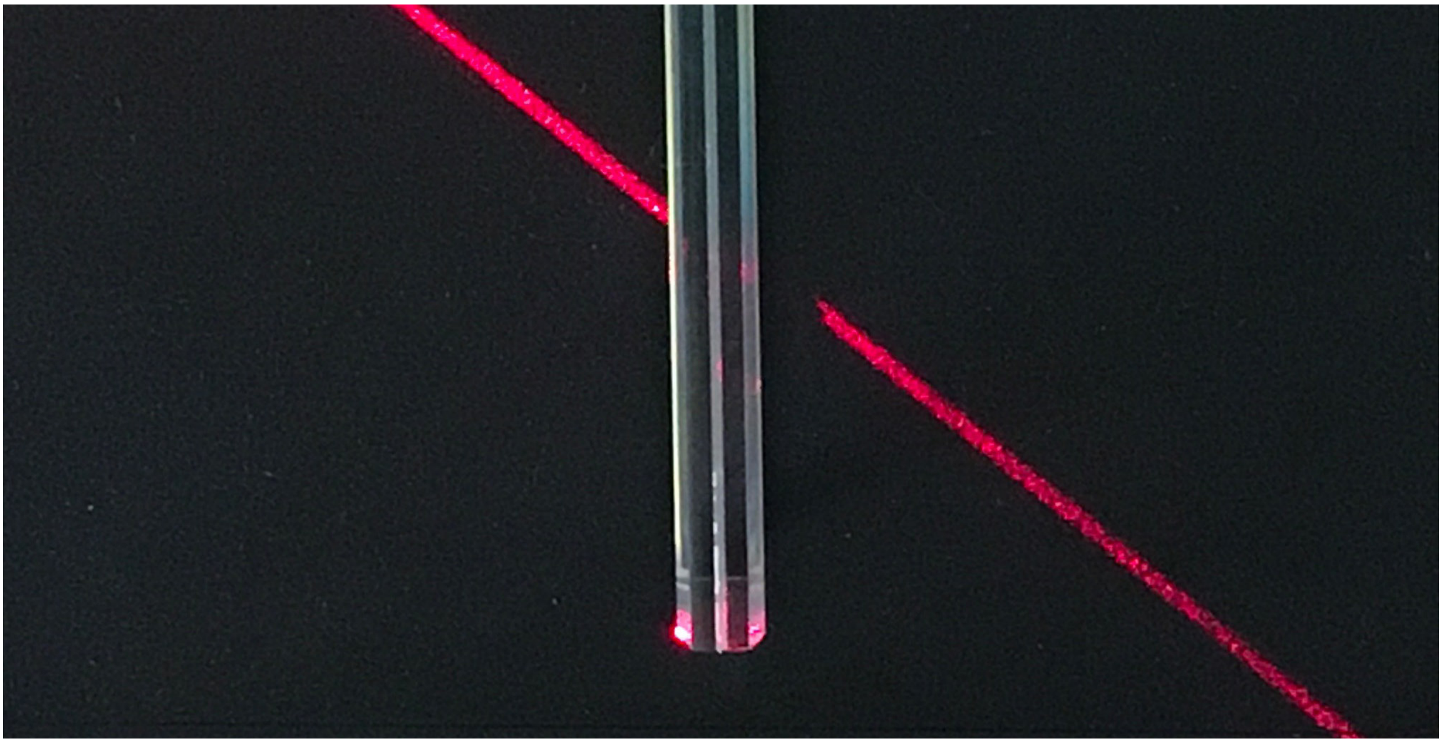
Bird-Friendly Science and Research: Myths and Realities



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Global bird-friendly solutions have been studied utilizing various testing methods, and judged based on a set of evolving common rules. Bird-friendly standards and regulations, developed from the growing body of scientific knowledge, have resulted in increasingly clear criteria in the desire to reduce bird collisions and fatalities. Non-standardized testing that was originally developed to simply understand bird perception, has been inappropriately leveraged to promulgate judgments that said tests were not designed to render. Authorities and specialists have shared increasingly restrictive parameters and conclusions based upon incomplete science, and subjective interpretations of flawed research.
This paper will discuss the limitations of bird-friendly science, review the research, dispel the myths, and reveal the realities of glazing configurations. The 2 x 4 rule and 2 x 2 rules will be presented along with a discussion of the testing procedures that helped form these guidelines. Visible marker size, shapes, and colors will be presented. The illusion of surface reflectivity and specular image reflections from glass will be deconstructed. Various testing methodologies and the changes that have occurred over the years will be analyzed and objectively evaluated.

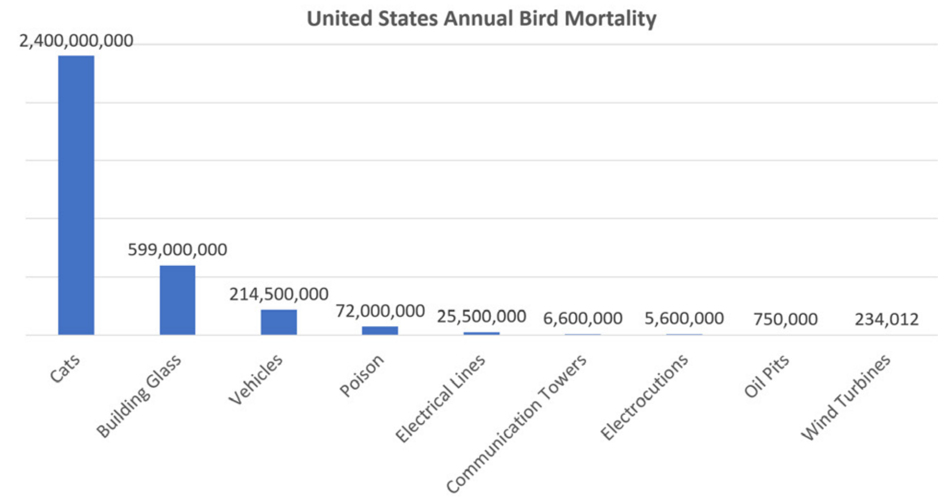


Figure 1

Dangers to birds

Birds are at risk of injury or death from many factors stemming from human activity such as impacts with man-made structures and vehicles, electrocution, poi- soning from toxins, pesticides and chemicals, and direct attacks by predatory domestic pets [1]. Billions of birds are killed in North America annually from these causes [2]. Free-ranging domestic cats have been introduced globally and have contributed to the extinction of 63 species of birds with the greatest human-caused threat to birds in the United States through this predation [3]. It is estimat- ed that cats kill approximately 2.4 billion birds annually

in just the United States [2]. According to the U.S. Fish & Wildlife Service, a wide range of human causes play a role in bird mortality [Figure 1].
Quite an incredible amount of bird mortality results from collisions between birds and man-made structures such as buildings [4].
In fact, birds colliding with buildings are by far the greatest source of bird mortality due to any type of collision in North America [5]. This is a mortality factor that the glass industry,

and those that design, specify, and produce building materials can do something about. Reducing light emission at night, increasing the amount of glass receiving visual markers, incorporating other mitigation strategies, and distancing vegetation from glassy surfaces can help moderate the dangerous reflective and invisible glass surfaces [5].

How birds see

Visual acuity

The highest known acuity of birds, such as that purported of eagles and falcons, is not substantially different from the visual keenness of humans, whereas most other species of birds have exceptionally poor visual acuity when compared to wingless building dwellers [10]. This makes it difficult to provide effective visual markers that birds can detect but humans will overlook. Most solutions therefore are developed based upon what humans see [10]. General accepted rule of thumb: if a human can't see it, it's invisible to birds.

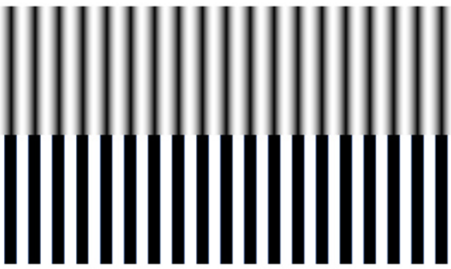


Figure 2

Spatial resolution is the ability to detect differences in a grating of alternating dark and light bars [7]. Target acuity, contrast, and movement all play a role in the ability of birds to see an object distinctly from its surroundings. One measure is presented as cycles per degree (cycles degree−1). This is an indication of how many alternating dark and light bars can be differentiated by the observer before the individual bars appear as just a single gray block within a field of view of 1 degree. Sinusoidal gratings and square wave gratings may be used in testing [Figure 2]. The square wave contains abrupt edges whereas the sinusoidal wave provides smooth transitions from dark to light.
Testing for many animals further investigates the ability to distinguish a single contrasting line against a differing background. Humans and many animals have the ability to detect a single target much smaller than would be anticipated based upon grating acuity [7].
The importance of understanding single target acuity comes into bird friendly marker design. Birds flying towards a building must be able to detect visual markers from a limited contrasting background which may include natural reflections or fly-through welcoming conditions. This detection must occur at a large enough distance for the bird to decisively change direction and avoid collision. Target acuity governs at what distance a small single object can be perceived on a uniform background such as the sky [7].
Visual acuity based upon grating testing and other observation results in a range from 5-7 minutes of arc for sparrows and robins to as precise as 0.2 minutes of arc for certain types of eagles and falcons [8]. Humans, in comparison, have visual acuity of around 0.4 minutes of arc [8]. In order to understand this a bit further, divide a circle's circumference into 21,600 arc segments. For instance, a circle drawn with a 240-inch radius from its center, has a circumference of 1508 inches. An arc of 1 minute would be 0.07 inches. An eagle could see a line 0.014 inch wide at a distance of 240 inches and a human could see a line 0.028 inches wide at that same distance. As a distinction, sparrows and robins could differentiate a line 0.42 inches wide in high enough contrast with its background at 240 inches. Other factors are involved, such as, how relative movement can increase the visual acuity of many animals.
As gratings get thinner and closer together, they begin to look like a continuous gray block [Figure 2]. The point at which the series of lines forming the grating is able to be separated from a background defines the limit of visual acuity.
Birds need to recognize the visual marker and be able to change direction in time. The average reaction time to visual stimuli was 80.64 milliseconds (ms) for the starling [9]. If the starling flies at 40 miles per hour (MPH), or 58.7 feet per second (FPS), then the bird will cover just over 5 feet before it can react to the visual stimuli. This becomes the absolute minimum distance at which the starling must perceive the visual marker for it to have a chance to avoid the surface. A combination of visual acuity, reaction time, and flight speed provide guidance for the minimum marker size needed to reduce the chance of possible accidental impact.

Color

It has been well established that bird color vision extends into the UV range. It is safe to presume that most species of birds share the ability to recognize colors into the UV region of the spectrum [10]. This paper will not address color differences in the creation of markers; suffice to say that visible markers must have substantial contrast to specular bird attractive reflections and through seen objects – if they are hoped to be effective. UV markers will only be useful when there are UV sources of light to make use of this extended spectrum.

Three-dimensional signal processing

Visual stimuli provide signals for the brain to process in order to comprehend depth, distance, and time to contact [10]. Small differences in objects' appearance in comparison to foreground and background objects are interpreted to put objects in perspective. Birds' eyes are closer together than humans and the relative differences between the depth appearances of objects, therefore, are more difficult to parse [10]. A bird may see a tree or a reflection of a tree and not be able to tell which one is in front of the other until right upon the reflection.
Object flow data is additional information processed as objects move across the retina and may be low resolution images but still able to be processed to determine speed, travel direction, and time to contact [10]. Birds may comprehend movement far better than static images, making an argument for three-dimensional active mark- ers that change in appearance as distance and approach angle shift. Three-dimensional shimmering, shifting, and shadowing visual markers have been shown to effectively reduce bird collisions when placed within a laminated sheet of glass [11].

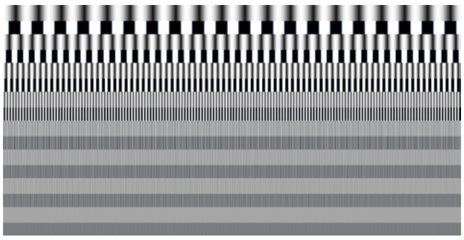


Figure 3

Field of view

Birds' eyes are spread wide and views may be more likely looking down and laterally than in the direction of travel [10]. Heightened visual acuity may extend laterally rather than straight in front of the bird, giving necessary details of surroundings and environment in order to respond to predators and other naturally occurring inputs of evolution [Figure 4]. Since the bird's eyes are only peripherally looking forward, the resolution, acuity, and optics are less likely to be optimum to detect objects straight ahead, which may make tunnel testing suspect.
The challenges of creating obvious markers on windows, or bird friendly windows to efficaciously reduce impact with what is known about bird vision are considerable. It reflects well on the industry to be transparent with efforts that follow scientific approaches with increasing knowledge. It takes more than just window design, but should include ground markers and unique approaches, and a firm understanding of science. For instance, birds

may fly into large and obvious stationary objects when the ground below signals no obstruction ahead [4].

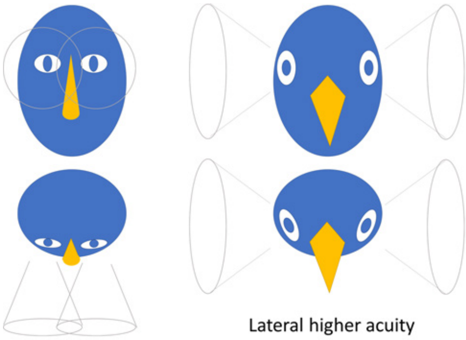


Figure 4

Bird collision avoidance research and mitigation approaches

Initial research focused on preventing collisions through the use of window coverings [12]. UV solutions that included plastics and special reflective and absorptive coatings attempted to make glass markings visible to birds but not as well perceived by humans. Decals, ceramic frit on the front surface, paint, tape, and strings provided vertical striping and grid patterns to break up reflections. External films were utilized in similar trials. Most of these solutions were placed on or in front of the glass.

Mitigation recommendations include removing foliage near windows, fitting barriers such as netting, adding decals close enough to disrupt reflections or remove what appear to be fly-through possibilities, or installing glass with UV markers [4]. For commercial buildings including high-rises, threat can be decreased by turning lights off or greatly reducing light at night [4]. Buildings should include bird friendly design fundamentals to reduce the danger to birds, however, it is not possible to affirm a building to be bird-friendly until after it is built and observed for many years [13]. The most logical way to approach this challenge is to try to determine the potential friendliness of materials prior to incorporating them into a building design.

Threat factor testing in North America

There are two highly referenced U.S.-based researchers focused on testing bird friendly glass solutions which limits the number of products that can be tested —Dr. Sheppard and Dr. Klem. The test methods are very different and as a result provide varying outcomes. The results from one test facility may differ greatly from the results of the other leading to differing conclusions on the effectiveness of materials [6]. Whether the tests are appropriate or not will be discussed.

Sheppard tests her windows in a controlled setting inside a tunnel, whereas Klem puts the panes he studies out in the field. The tunnel allows strict adherence to testing procedures in order to control as many variables as possible without outside influence. This test provides a high ability to duplicate the test and receive similar results under set conditions. Klem wanted to retain as much of the birds' natural behavior—and a lighted sky's effect on windows—as possible, so his experiments take place in an open field encircled with trees.

Criticism of muhlenberg field testing

According to Sheppard, Klem's testing allows reflections to change in a natural setting based upon the angle of approach. However, she states that most of the test birds fly towards the glass at an angle nearly perpendicular, because of the bird feeder location which makes it similar to the approach in the binomial choice protocol. The challenge of the binomial protocol of the tunnel test is that it does not create reflections on the glass [14]. Here Shep- pard acknowledges lack of reflectivity in tunnel testing.

The Klem testing protocol does mimic real windows, but it takes place in only one geographic location. The test- ing cannot be generalized to be demonstrative of other locations because of extreme differences in environments [14]. Sheppard proposes that the Klem protocol cannot be generally representative because of the huge number of different locations that are not able to be replicated in only one test location.

Sheppard suggests that protocols, such as the tunnel test, attempt to standardize test conditions and produce a listing of comparative scores, to help allow evaluations between varying designs and materials [14].

Criticism of ABC tunnel testing

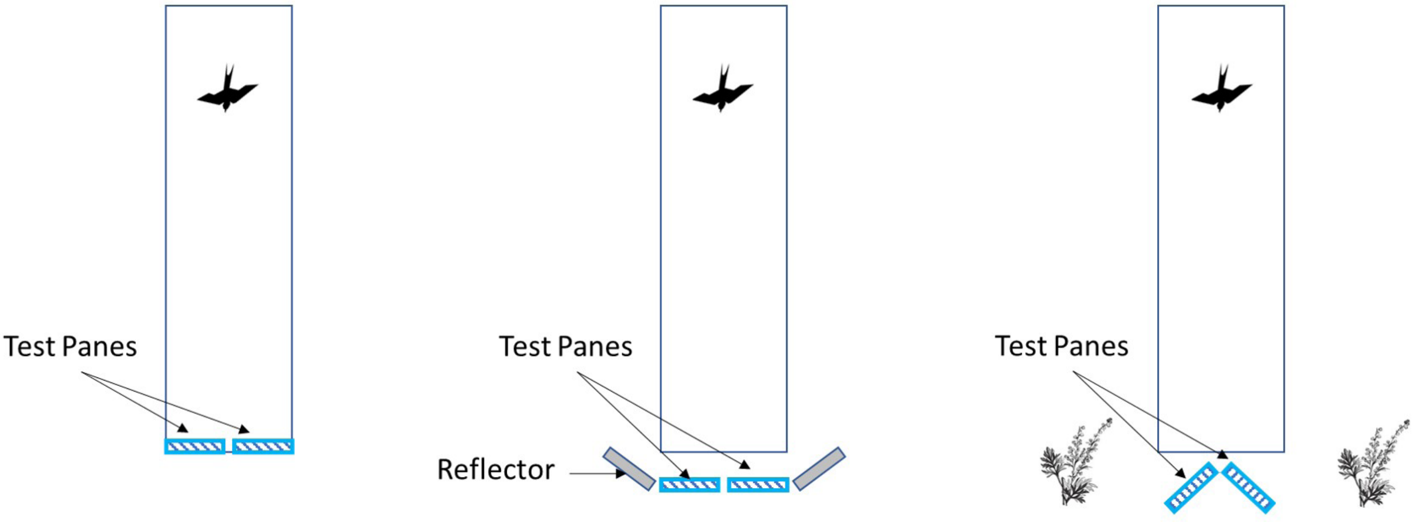
The tunnel test protocol and product endorsements of ABC are confusing and unscientific [16]. The attempt to standardize test procedures creates an even less repre- sentative environment to compare with the large number of disparate conditions, as well as even one environment. In real-world scenarios, how many birds experience being captured, released into a dark tunnel, and given a binomial choice? This simplistic fly-through test is neither representative of natural environments nor the conditions in which glass itself is installed. All results are limited to, at most, fly-through conditions with glass makeups that are never used in buildings. However, the test is repeatable and makes for easy data collection.

Sheppard chose the tunnel approach because it could evaluate more samples per season, not because it replicates what birds see when flying around buildings with windows [14]. The testing allows a comparison among different samples in how effective they are in a tunnel test. It is not a realistic test in comparison to a realistic environ- ment, however, it is valuable in understanding what birds see in this test. Lighting that differed from outdoor conditions was not important as the tunnel was built to only test visual perception and not objectively or quantitatively provide solutions for bird-friendly glass [17].

The glass being tested is moved back slightly from the rear opening of the tunnel to allow light to be reflected onto the front face (the surface that is facing the approaching birds). To be clear, light is reflected on to the face, but not directly reflected off of the face.

The manner of reflection does not create environmental specular reflections. Even so, no environmental habitat reflections (direct or indirect) were incorporated. Although tunnel testing may not be applicable to any real-life conditions, it may possibly still offer some insights into fly-through applications (from dark to light). It does not cover environmental reflective or black hole applications, yet these are two typical conditions that glass creates when used in building construction. Nonetheless, tunnel testing has been used and standardized to provide bird-friendly rat- ings for the industry in the absence of another standardized testing protocol that is acceptable to Sheppard as being capable of replicating environmental conditions.

The Evolution of Tunnel Testing – Simplified Illustration



Hohenau Tunnel 1 Design
2003 Rössler

Hohenau Tunnel 2 Design
2006 Rössler
2009 Sheppard
Mirrors reflect light onto glass illuminating side facing bird

WinTest Method, Tunnel 2
2014 Rössler
Specular reflections of vegetation, glass angled at 125 degrees from flight path

Reflectivity, contrast, and perception

Scientists studying bird friendly glass constructions confuse contrast with reflectivity when it comes to avian visual perception. A few bird-friendly authorities discuss that placing black material behind glass will make the glass more reflective. Putting black material behind the glass is done in the Klem field-testing protocol to create the "reflective" test piece. However, to be accurate, putting black material behind glass increases the contrast of the reflection to the background but does not increase the reflection itself. The perception of the reflection is increased but not the actual reflection. This becomes important when it is understood that glass reflects nearly equally from the first and second surfaces. In an insulated glass unit (IGU), with two identical clear or low-iron lites (monolithic or laminated), the glass air surfaces all reflect back towards the observer (and all nearly equally). In a normal IGU, the reflections would be considerably higher from the solar control surface (especially in reflective coatings) which would typically be surface 2. When first lite reflections are observed in addition with reflections from the 3rd and 4th surfaces, first surface reflections make up a minority of the reflection. Window glass is perceived to specularly reflect from the first surface because the parallel reflections from the multiple surface sources are relatively close together when the observer is at a distance and appear to coalesce into one highly reflected image. The specular reflection erroneously appears to be a relatively strong first surface reflection instead of the four, less intense, individual reflections that are actually occurring.

Notes on markings and testing

In the publication, Bird-Friendly Building with Glass and Light (2013), it is recognized that reflectivity occurs beyond "only" the first surface [15]. Different remediation techniques are proffered to help in bird friendly design. Since the majority of reflections in an IGU occur beyond the first surface, markings occurring before the 2nd surface may disrupt these reflections surprisingly as well as, or in some cases, better than first surface markings. The variety of markings that are able to be laminated within the first lite are different from those that can be applied on to the first surface.
In-glass markings have tested well in true reflected testing despite not many tests being performed in this manner [11]. In-glass markings allow true flexibility in color, size, and dimensionality that cannot be duplicated on the first surface – leading to an opportunity to develop unique performing products rarely tested up to this point.
Although additional reflections occur behind the first lite of glass, very few tests have incorporated these reflections since complete units are typically not tested. Fly-through conditions have not been tested with many of the countless reflective solar control or low-E coatings. IGUs that have high levels of reflections occurring on the 2nd, 3rd, or other surfaces have not been tested in meaningful quantities to draw any scientific conclusions. The industry requires IGUs with solar control coatings on surface 2 of the outer lite (whether monolithic or laminated) or surface 3 of the second lite. Contrast is increased when VLT is reduced by tints and or solar control and low E configurations. Despite industry requirements, very few IGUs were tested in appropriately configured makeups.
And again, the tunnel test configuration used in North America was never designed as a test for bird-friendly materials.

Inaccurate representations of glass properties

Sheppard inaccurately suggests that glass used in home windows has a first surface reflectivity of near 8% but because reflection takes place at both surfaces of a pane, a measurement taken perpendicular to the surface will produce a higher value, 12–14% [14]. There is no reference to where these numbers come from. However, the refer- ence provided for an earlier statement in the same document indicates an 8% reflection when viewed perpendicularly. The reference cited states a total of 8% reflection which does not match the 12 – 14% reflection Sheppard proffers without any citation to this inaccurate figure.
Sheppard suggests that if a deterrent pattern is incorporated on an internal surface, the outer surface of glass needs to have low reflectivity and that no testing is needed to

conclude that a glass with strong reflection hiding visual markers will be ineffective [14]. If Sheppard has assumed incorrectly that the first surface of glass has an 8% reflection and that perpendicularly glass has a 12-14 percent reflection, then what other assumptions have been incorrectly made that "need no testing?" If the first surface of glass has a 4.1% reflection, then is that considered low reflection? The objectivity of the discussion and best practices recommendations fade when inaccurate reflection data is postured to bolster an argument. The conclusion that hiding visual markers make glass ineffective as a bird-friendly material is obvious.
Klem suggests that the placement of visual markers is important as the outside glass surface of a window can act like a mirror under certain lighting conditions [12]. He advises that the realistic reflections off Surface #1 of the sky or trees obscure any visible pattern on the inside of glass and deceive birds, and why they behave as if the glass is invisible to them [18]. This paper shows that surface #1 is not the source of the majority of the reflection in an insulated glass unit. This premise by Klem may be what appears to be true but is not. Actual physics, testing, and data from science shows that the 1st surface typically has the minority of reflections in IGU units unless constructed specifically with high reflective 1st surface coatings.
Inaccurate representations of reflection distract from the science and weaken recommendations by calling into question the body of knowledge upon which conclusions are based.

Science of reflection

The light passing through a glass sheet is reflected off the front surface, and also on the back. In fact, the reflected light possibly bounces back and forth between the surfaces several times. The total reflectance through a glass sheet is 2·R / (1+R) [19]. According to these formulas, about 8% of the light is reflected from common soda-lime window glass in total from both surfaces, assuming a perpendicular incidence angle and no absorption and scattering (http://glassproperties.com/reflection/, 2021). The calculation for the first surface reflection (R) using the index of refraction properties for glass and air is as follows [Figure 5].

R	=	$(n_o-n_g)^2$	=	0.258064
		$(n_o+n_g)^2$		6.290064
		Reflection	=	4.10%
		n_o (air)	=	1
		n_g (glass)	=	1.508
Amount of reflection from 1st surface of glass according to science				
n = index of refraction for material				
R = reflection from the first surface				

Figure 5
Amount of reflection from 1st surface of glass according to science. n = index of refraction for material
R = reflection from the first surface

Specular Reflection

Occurs at all surfaces
- Total reflection from IGU made of low iron = 14.7%
- First surface = 4.1%
- Second surface=3.8%
- Third surface= 3.5%
- Fourth surface = 3.3%

Reflection Share
- First surface share = 27.8%
- Rest of surfaces = 72.2%
- Low E makes the first surface even less responsible for specular reflection

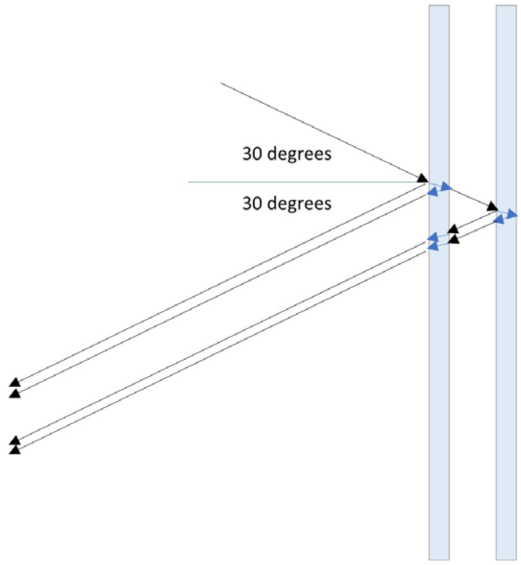


Figure 6

Specular reflection in an igu

Light reflects from all glass/air interfaces and is calculated utilizing the different indexes of refraction of the materials. The light will reflect from each interface in a relationship with the difference of indexes of refraction. The calculation of reflection from all the surfaces of an IGU made with low iron glass or two sheets of low iron laminated glass indicates that reflections are similar. Because interlayers have a very similar index of refraction to the glass itself, the reflection at the interlayer interface is below the threshold for nearly every angle (Glass = 1.52, PVB = 1.48, Ionoplast = 1.50, PET = 1.58, Air = 1.00). The index of refraction is a simple ratio of the speed of light in a vacuum divided by the speed of light in the medium. The reflection at each surface is shown in diagram [Figure 6].

Reflections of polarized light calculation and graph

S-polarized light and P-polarized light reflections were calculated for the first surface low-iron window glass on an insulated glass unit. The average reflection was well below 10% for angles of incidence up to 60 degrees from perpendicular to the surface [Figure 7]. Utilizing the formula for total reflectance through a glass sheet of 2·R / (1+R), the total reflection at a 60-degree angle is about 18% for the outer sheet of glass with just a little under half of the reflection coming from the second surface. This holds true for laminated lites as well as there is no noticeable reflection of the internal interfaces up to 70-degrees (reflection of 0.6%). Human perception threshold for visible reflections is between 0.5% and 1.0% [Gulnick, Threshold GPD Paper].

Angle	S %	P %	Average
0	4%	4%	4%
5	4%	4%	4%
10	4%	4%	4%
15	4%	4%	4%
20	5%	3%	4%
25	5%	3%	4%
30	6%	3%	4%
35	7%	2%	4%
40	8%	1%	5%
45	9%	1%	5%
50	11%	0%	6%
55	14%	0%	7%
60	18%	0%	9%
65	23%	1%	12%
70	30%	4%	17%
75	40%	11%	25%
80	54%	24%	39%
85	73%	49%	61%
90	99%	99%	99%

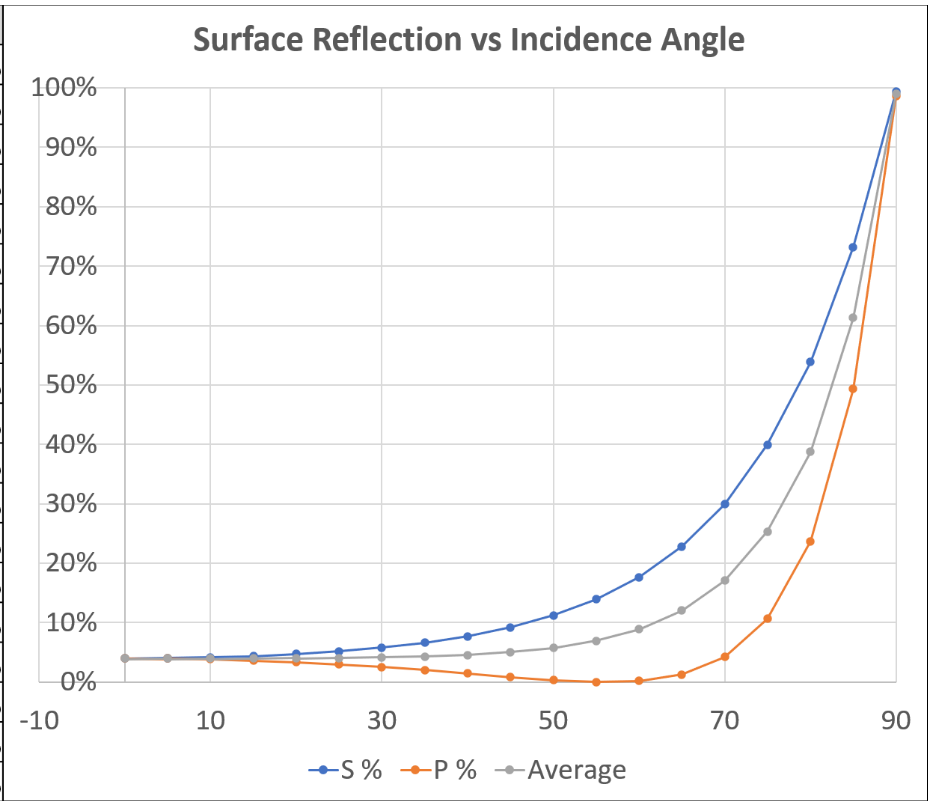


Figure 7

Laboratory testing

A laser light source was set up at a 30-degree angle of incidence to the first surface of a IGU representation. A ¼" outer low-iron lite was placed ½" from a ¼" inner low-iron lite. Photos were taken and the reflected light was observed as shown [Figure 10]. The reflected light consists of four parallel lines, each line representing a glass/air interface of dissimilar refractive indexes [Figure 8]. The laser light reflections are at the same angle as the angle of incidence (30-degrees). The intensity of the light reflections was compared and seen to be in keeping with the expected levels of reflection for each surface taking into consideration the loss of the lineal laser.

¼" Outer Lite Laminated Glass Performs Substantially Similar to ¼" Monolithic Low Iron

Several tests were performed utilizing the original representative IGU design as well as substituting ¼" low-iron laminated glass for the ¼" monolithic low-iron glass for the outer lite [Figure 9]. The only minor difference between the first and second specular reflection was the slight further difference of the 1st and 2nd reflective surfaces of the IGU (the two sides of the laminated piece of glass). No noticeable reflection occurred at the interface of the PVB and the glass due to the matching of the refractive index (1.5 for glass and 1.48 for PVB).

Discussion

The glass industry in the United States has adopted standards for bird-friendly glass design partly based upon imperfect science in an attempt to do the right thing. Some manufacturers had marketing materials already printed up for nearly a year in anticipation of pushing forward a first-surface, bird-friendly, prescriptive standard despite disagreement on the standards and science from others within the industry.

The companies involved in a billion-dollar discussion did not consider that reflection occurs off every non-matched index of refraction surface with higher reflections coming from the low-E or solar-control coatings. Even the authorities on bird-friendly glass were implying reflections come from the front surface. Besides, much of the testing done in the United States was conducted in a tunnel that was built to only test visual perception and not provide solutions for bird-friendly glass [17].

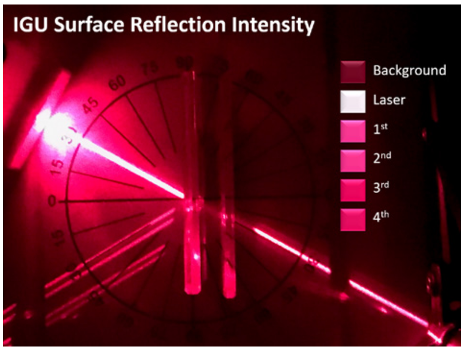


Figure 8

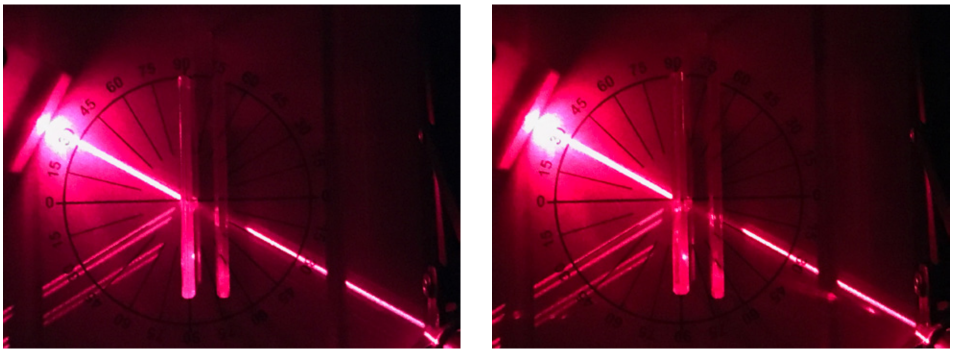


Figure 9 ¼" low-iron over ¼" low-iron monolithic

¼" low-iron laminated over ¼" low-iron monolithic

Visual Markers

Many patterns have been shown to help block, or break up, reflections to help bring the invisible glass barrier into view. from the multiple surfaces of an IGU or making a clear flight path to a tree or sky appear impassible. The further away this marker is seen, the better the chance birds have to avoid it. Knowing how human vision acuity is far superior to birds, markers need to be readily visible by humans in order for birds to have a chance.

Visual Markers

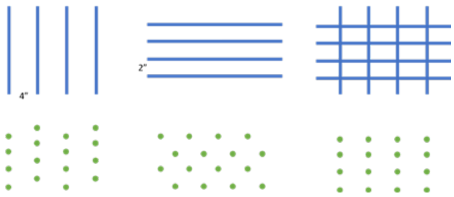


Figure 10

There appears to be some agreement in what birds are thought to see when the 2" x 4" or 2" x 2" rules are discussed and the thickness of lines, dots, or markers that help birds navigate safely are considered [Figure 11]. Tunnel testing at least has shown what birds avoid in comparison to a control in the standard set of tunnel conditions.

Horizontal lines placed 2" apart and vertical lines placed 4" apart appear to act as a barrier to birds when markers are of sufficient thickness and contrast to be seen by birds at a safe distance. Dots and other shaped visual markers may also work in these patterns. However, the visual markers also need to overcome IGU multi-surface reflections or fly-through attractants when protecting from bird clear-path confusion. Other visible markers in this type of pattern also seem to be bird-friendly. Field testing provides a confirmation of these rules.

Researchers in the United States began their bird-friendly materials quest by covering windows with plastic strips, decals, tape, and string and have continued to focus on solutions that cover the first surface. This early research was brought to the glass industry and mated with incomplete science such as the tunnel test to move towards prescriptive solutions that may help minimize bird fatalities but in no means are best practices. Again, the tunnel test as developed into a standardized test in the United States is incapable of providing a threat factor, does not test for anything other than fly-through conditions (from a dark tunnel), and was developed originally to only test to see what birds see in a binomial choice test.

Even with the tunnel test considered marginally useful to gather some data, what has not been addressed, seldom tested, and therefore not well understood in the United States is surface reflection. The unavailability of testing in comparison to the endless combinations of glass make-ups, tints, coatings, and varying reflectivity of solar-control technologies in insulated monolithic and laminated constructions is hugely inadequate. Surfaces reflectivity, color, dimensionality, and marker contrast are somewhat arbitrarily ignored without the ability to investigate the impact en masse.

Location of Visual Markers

Visual Marker Recommendations	
Outboard Lite - either monolithic glass or laminated glass	
Over Reflective Surface 1	Effective in a majority of conditions
Between Reflective Surfaces 1 and 2	Effective in a majority of conditions
Behind Reflective Surface 2	Effective in conditions where markers can overcome specular and visual reflections as viewed from the outside looking in and if solar control or low-E coating is on surface 3 or interior lite is dark tinted.
Inboard Lite - either monolithic glass or laminated glass	
Surface 3 or 4	Not recommended unless testing is supplied and reviewed for effetiveness with the specific glass and end use conditions.

Figure 11

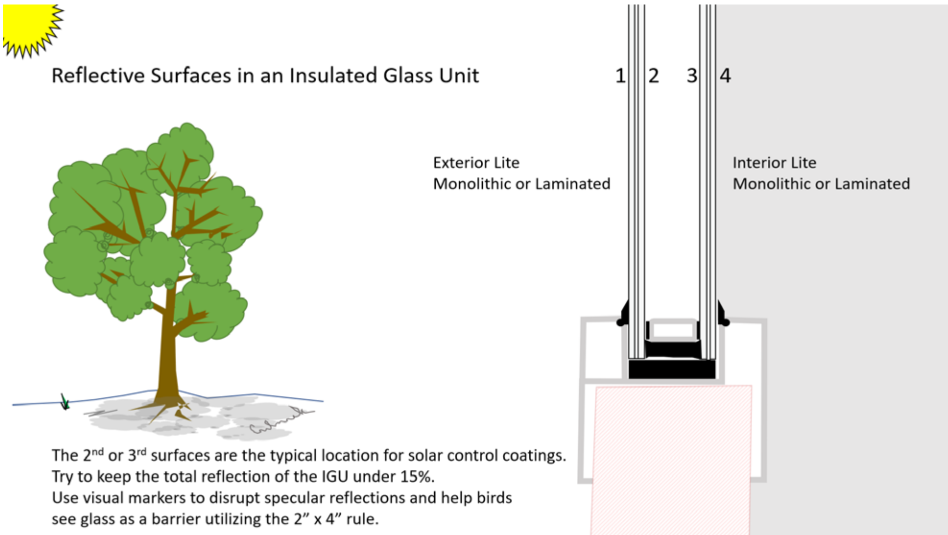


Figure 12

Reflective surface identification

Reflective surfaces appear at each transparent material interface in proportion to the mismatch of the index of refraction. For an IGU with two lites, there are 4 surfaces of reflection no matter if made up of monolithic or laminated glass [Figure 12]. Understanding that a majority of reflections occur beyond the first surface enables flexibility in bird-friendly, decorative, architectural glass design incorporating solar control and beauty for energy efficiency and aesthetic freedom.

Bird-friendly in-glass options

Markers placed within the first lite of an IGU not only can increase visibility but offer colors, chemistries, texture, and contrast that are impossible on the front surface [Figure 13].

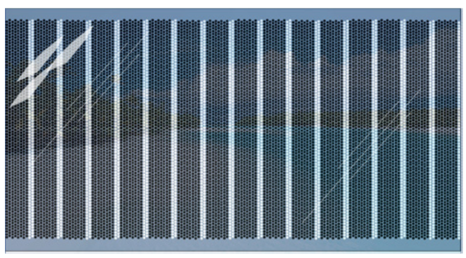


Figure 13

Testing has also shown that these solutions may in fact work better than 1st surface solutions depending on the makeup [11]. Obviously, some decorative bird-friendly solutions can only be incorporated within the outer lite of glass as they are impossible to be supplied as first surface coating solutions.

In glass designs can be bird-friendly from the outside and human-friendly from the inside. Lines, pictures, solid colors, dichroic, metallic, environmentally fitting aesthetic, or even apparently solid walls can be nearly invisible when viewed from the inside. Architectural intent and bird-friendly solutions may also provide natural light and an unblemished view of the exterior scenery for building dwellers [Figure 14].

Field testing of in-glass materials that appeared solid white or horizontal striped from the outside and provided clear views from the inside of the building complete- ly eliminated bird-fatalities [Figure 15]. There was only one recorded glancing bird-collision in the test samples caused by a bird being chased by a predator despite the control sample receiving numerous strikes.

Solutions embedded between the 1st and 2nd reflective surfaces have been shown to perform well but have received limited attention. The only marking which resulted in less than 10% wrong decisions in repeated testing by Rössler in 2005 and 2006 was an embedded horizontal marking that achieved an error rate of only 7.1% [17]. Front surface reflective light did not have any negative impact on the embedded marking's efficacy in reducing bird collisions [17]. Furthermore, this internal solution was the only marking with statistically significant differences to the worst rated markings that were tested in 2005 and 2006 [17].

According to Rössler, the high efficacy of this test can be attributed to the black filaments embedded between the 1st and 2nd surface [17]. These markings consisted of 2mm wide lines covering less than 7% of the total area and this minimalistic internal marking fared significantly better than the mean of all effective markings [17]. All of the other effective markings were on the 1st surface and yet they did significantly worse than the minimalistic visual marking that was between the 1st and 2nd surface [17].

Figure 14
Bird-friendly from the outside. Human-friendly from the inside.

Figure 15
Field study to deter or prevent bird window collisions showing control on left and McGrory 95% and 100% risk reduction samples in center and right positions.

Conclusion

It is generally accepted that the ABC tunnel test cannot be used to determine the threat-factor and any conclusions based upon results are false. Renown bird-friendly research experts have severely criticized the use of the test. The 2021 ASTM work force on creating a standard test has also admitted that a standardized tunnel test can only be used to judge fly-through applications (flying toward a lit background) and not for reflective or dark hole environments. The tunnel test can't even do this with any known certainty but only provide repeatability in itself but not be able to be related to any practical window application (birds do not navigate the airspace around buildings the way they navigate a dark tunnel). The tunnel test does not provide a threat factor. The 2021 ASTM Task Group considers the tunnel test in its bird-friendly testing standard a test method for Glazing Materials Using a Binomial Choice Protocol for Transparent Fly-through Bird Collision Deterrence. Again, this test is only for transparent fly-through conditions but historically threat factors have been predicated on this test or glass simply anointed with a threat factor by renowned authorities based upon experience that requires no testing. Other authorities conclude that the tunnel test as conducted by ABC cannot even provide a conclusive fly-through threat factor. As discussed earlier, birds do not have tunnel vision but are highly peripherally observant creatures that are far more complex in navigation. Ground conditions and surroundings impact the flight path and yet everything is tested in a straight-on flight test within a darkened tunnel. The tunnel test in the United States does not incorporate the latest innovations in environmental reflective testing as found in other countries. Notwithstanding, legislation, testing standards, and prescriptive solutions are being adopted forged from the first surface mantra of an industry.

Klem criticizes Sheppard's tunnel testing, and Sheppard criticizes Klem's field testing, and both have only the best intentions: to save as many birds as possible. Results are used to create expanded conclusions for reflective surfaces and other non-congruent applications that cannot be interpreted or generalized from a tunnel test. In 2021, The National Glass Association (NGA) has created a document entitled Best Practices for Bird-Friendly Glazing Design from the incoherent and illogical data and overreaching interpretations collected from illegitimate tunnel testing [16]. The statements of window glass properties, surface phenomena, reflection and contrast that Klem and Sheppard use are not accurate and are presented to support claims and recommendations. Conclusions are therefore based on illegitimate testing and the inaccurate beliefs of honorable and good meaning scientists. It is as though a car manufacturer's third-party safety testing agencies could only test airbags on the outside of cars, then innovative solutions that incorporate crumple zones and airbags on the inside of the car would be overlooked. Only exterior airbags would be studied and therefore the auto industry would write a best practices paper on the use of airbags on the outside of cars. This would be despite tests available in other countries that enable interior airbags to be tested.

Bird ocular perception, visual acuity, and flight path navigation in infinitely variable environments are highly complex fields of study. The industry is only etching the first surface of knowledge and to propose its prescriptive solutions developed from incomplete science are "best practices" is nothing more than tunnel vision. It is a disservice to the industry and birds and appears self-serving even if it's in a true effort to reduce bird-fatalities. On the other hand, it is "a practice" and appears to provide a reduction in bird mortality. It is truly implying that a bird in the hand is worth two in the bush. Meaning, it is far easier to study birds in your hand in a nonapplicable pseudoscientific tunnel test than to field study birds in the actual field environment of bushes, trees, sky, and sun.

In the end, buildings will be safer, but billion-dollar decisions have been prescribed from interpretation of incomplete science. Winners and losers have been anointed by the glass industry based upon input from authorities with systematic bias for front surface solutions and a misunderstanding of window reflection. This paper has shown that most reflections occur beyond the first surface. In-glass visual markers that enable a great variety of innovative solutions are available and shown to be effective in testing that incorporate natural environmental reflections [11, 17].

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