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## BOROSILICATE GLASS CONTINUES TO OUTPERFORM IN EXTERIOR AIRCRAFT LIGHTING APPLICATIONS

*Since World War II, Kopp Glass has been the leading manufacturer of precision molded, borosilicate glass lenses for exterior aerospace lighting applications. Our technical expertise and close collaboration with leading aerospace lighting manufacturers has enabled us to develop cutting edge glass molding and engineering techniques that are responsive to the needs of the aerospace industry. In this article, Kopp's resident design expert, Jim Forish, discusses how borosilicate glass lenses outperform other materials in exterior jet aircraft lighting applications and provide the lowest total cost of ownership to those who bear the maintenance burden.*

Over the last several years there has been growing confusion about how and when glass lenses should be used in exterior aircraft lighting applications. While weight reduction efforts save jet fuel, lightweight thermoplastics, specifically polycarbonate and acrylic lenses, require incessant, costly maintenance and replacement far more often than borosilicate glass lenses in order to maintain proper light transmittance and ensure safety.

### MEET KOPP'S EXPERT

James Forish, Director of Product Design, has over 17 years of experience in engineering, manufacturing, and testing aircraft lenses for a wide variety of aerospace applications including small piston powered aircraft, the iconic Concorde, and numerous military platforms.

When it comes to exterior aircraft lenses, thermoplastics are lighter weight than glass - but let's look at the math. Using numbers that I have seen, let's be really generous and assume that plastic lenses are one fourth the weight of glass lenses. This is based on the density of glass being twice that of plastic and in some cases that additional thickness is required for molding glass. If that's true, then if the navigation, anti-collision, taxi light, log and the wing tip tail glass lenses were all substituted for plastic lenses, I estimate that in many cases, the difference in weight would equate to about 4 cans of soda. In reality the weight advantage on many lenses is closer to one-half, making the difference even smaller. So yes, there will be fuel savings over the 20 to 25 year lifespan of a commercial aircraft, but that is only one dimension of performance. The costs associated with properly maintaining lighting systems that use plastic lenses is yet another dimension of performance that must also be considered. Let's take a look at the differences in performance as it relates to maintaining transmission.

## ◆ CHEMICAL DECOMPOSITION

Exterior aircraft lenses are relentlessly exposed to harsh chemicals such as jet fuel, aviation gas, hydraulic fluid and de-icing solution. Glass, particularly borosilicate glass, is highly resistant to these aggressive chemicals. I have been involved with testing all of the previously mentioned fluids on both borosilicate glass and plastic lenses. After 30 days of submersion exposure, borosilicate glass experienced no adverse effects on transmission. Polycarbonates, on the other hand, are particularly sensitive to chemical attack by jet fuel. Acrylics fair better than polycarbonates but transmission is still adversely affected.

## ⚡ THERMAL STRESS

Another important factor affecting exterior aircraft lens transmission is the variation in temperatures as a result of altitude and climate conditions. Borosilicate glass is heat resistant and it can be cycled from hot to cold, and vice versa with no effect. Kopp's borosilicate glass is engineered to routinely withstand operating temperatures in excess of 500°F and when properly heat strengthened can withstand thermal shock of  $\Delta T$  of 175°C. Some of our designs can even withstand higher thermal shock. The properties of the material are the advantage. Glass has a lower thermal expansion and can withstand much higher heat loads than plastics. Both polycarbonate and acrylic lenses can blister, discolor, craze and even deform when exposed to higher heat loads. These adverse effects require that plastic lenses be replaced sooner in an aircraft's lifecycle than borosilicate glass lenses in order to restore performance if safety is to be maintained.

## ⚙ UV DEGRADATION

When flying at higher altitudes, the detrimental effect of Ultraviolet (UV) light from the sun on polycarbonate and acrylic lenses is intensified. Once transparent, plastic lenses rapidly diffuse and become hazy as a result of exposure. You can see an example of sunlight degradation clearly in the image (Fig. 1) to the left that I photographed last summer at the EAA AirVenture Show. Unlike plastic, testing has shown that prolonged exposure to UV rays has no effect on borosilicate glass. It is completely stable and it will never



Figure 1: EAA AirVenture Show 2012 - plastic lens left side, glass lens on right side of image

yellow, blister or craze over time due to the effects of sunlight or stress from thermal expansion. Glass can spend years, even a lifetime, exposed to these elements and maintain its functionality. Recently, I reviewed a glass lens that had been subjected to an ongoing 45° southern exposure test and after 5 years of being exposed to sun, rain, snow and hail the glass was in excellent condition. Plastics, even with the addition of coatings and stabilizers, are still not at the same performance level of UV stability as borosilicate glass. Light fixture designers foster the illusion of weight and fuel savings with plastic lenses, but they must compensate for degradation in transmission in some way, frequently by driving the LEDs harder with greater power consumption or adding LEDs and related weight from heat sinks. Thus, the fuel savings from using plastic lenses are not what they appear to be.

## \* ABRASION

The primary function of lenses used in exterior aircraft lighting applications is the consistent transmission of light. This function must be performed even in areas prone to abrasion such as the leading edges of the wing and the taxi lights. Borosilicate glass is highly abrasion resistant while plastic lenses can abrade quickly in these applications. In fact, SAE Aerospace is working on a recommended practice for design and maintenance of exterior lighting with plastic that endorses designing the lighting around degraded lens output. This would mean that the design would need to allow for 20-40% loss in transmission by compensating with higher wattage incandescent bulbs, more LEDs, or driving the existing LEDs harder using more power. The recommended practice also calls for increased inspections and removing the lens if any of the following conditions are present and clearly noticeable in the lens: crazing, cloudiness, cracking, blisters, bubbles, peeling, flaking, discoloration, stains, and physical deformation.

## ❖ TRUE VALUE IN BOROSILICATE GLASS

To our knowledge, no reliable empirical data exists that tracks the frequency that plastic lenses must be changed in terms of flight hours or take-offs and landings. We have been told that some plastic lenses require replacement every 50 hours of flight time. While this level of frequency could represent extreme cases, it does illustrate why designers of exterior jet aircraft lighting systems continue to gravitate toward the tried and true value of our borosilicate glass lenses. It's hard to beat the value proposition of borosilicate glass for this demanding application because the costs of maintaining glass lenses over the life of a jet aircraft are almost nonexistent, especially when compared to lenses made from other materials. Glass lenses provide true value and safety to those who own or operate jet aircraft.