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For Pilots, Sunglasses Are Essential in Vision Protection

Sunglasses are available with lenses and frames manufactured from a variety of materials. Correctly choosing and wearing sunglasses can reduce the effects of exposure to the sun's ultraviolet radiation, which is associated with a number of eye ailments, and can reduce brightness and glare, which impair vision.

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Appropriately designed sunglasses for use on the flight deck — and elsewhere — protect the eyes by reducing glare, exposure to the sun's ultraviolet radiation (UVR), high levels of light intensity (brightness) and eye fatigue. The wrong types of sunglasses provide inadequate protection and can reduce visual acuity.

The human eye can see only a small portion of the sun's radiation spectrum. The visible spectrum consists of radiation wavelengths (light) extending from about 380 nanometers to 760 nanometers. (One nanometer is equal to one-billionth of a meter.) The eye's sensitivity to this band of radiation wavelengths produces the sensation of color, ranging from violet to red.

Wavelengths of less than about 380 nanometers cannot be seen; nevertheless, exposure to them can result in damage to the eye. Wavelengths from 100 nanometers to about 380 nanometers (known as ultraviolet rays or abiotic rays) can damage ocular tissue and cause a variety of eye diseases; the type and extent of the damage is determined by the intensity and duration of exposure.[1]

Sunglasses are intended to protect the eye from damage caused by exposure to wavelengths both within the visible spectrum and outside the visible spectrum. Effective sunglass lenses use a combination of darkness and wavelength filtering (color) to reduce brightness and glare and to protect eyes from damaging UVR.

Various factors should be considered in assessing the effectiveness of sunglasses, including lens material, the color and darkness of the lens, frame design and the effectiveness of UVR protection provided by the sunglasses.

Optical Properties, Weight Are Factors in Lens Selection

Most sunglass lenses (both prescription lenses and nonprescription lenses) are made from one of the following materials:

- Glass, which provides excellent optical properties and scratch resistance but is heavier and less impact-resistant than plastic;
- CR-39 plastic (optical plastic), which is lighter in weight and more impact-resistant than glass but which can be scratched if mishandled; a hard coating can be applied to the lens to help prevent scratches. Most sunglasses currently manufactured use CR-39 plastic lenses; and,
- Polycarbonate, a type of "high-index" optical plastic, which is lighter in weight than CR-39 plastic and more impact-resistant than any other lens material and which can be made into thinner lenses. ("High-index" refers to the relative light-refraction properties of the

lens material.) Polycarbonate lenses — developed originally for the aerospace industry — have an extremely low density and therefore, for equal vision correction, can be as much as 30 percent lighter in weight than glass and some other plastic lenses. In addition, because the lens material is so tough, the lenses can be made thinner, resulting in even lower weight and increased wearing comfort; a scratch-resistant coating typically is applied to the lens.

Regardless of the lens material, all lenses should meet the optical quality standards of prescription lenses to minimize distortion and other optical aberrations, which are more likely with low-cost nonprescription sunglasses.

Sunglasses Provide UVR Protection

The UVR region of the sun's radiation spectrum is divided into three bands, UVA (315 nanometers to about 400 nanometers), UVB (280 nanometers to 315 nanometers) and UVC (100 nanometers to 280 nanometers). As sunlight passes through the Earth's atmosphere, all UVC and 90 percent of UVB are absorbed by oxygen, carbon dioxide, ozone and water vapor. Therefore, the UVR reaching the Earth's surface is mostly UVA (with a small amount of UVB). UVA, with its longer wavelength, is responsible for the tanning of skin; the shorter wavelength UVB produces sunburn and is associated with skin cancer.

Although small amounts of UVR are necessary in the production of vitamin D, studies have found that overexposure to UVR may damage the body's immune system and deoxyribonucleic acid (DNA), the body's basic chromosomal material. UVR also thwarts the growth of plants and damages plastics, paints and fabrics. The earth's ozone layer absorbs some of the UVR that otherwise would reach the earth's surface. The United Nations World Health Organization says that the thinning of the ozone layer has resulted in an increase in the amount of UVR reaching the surface. The increase, which scientists say will persist for many years, is expected to exacerbate the adverse health effects of UVR.[2]

The level of UVR varies with location, time of day and time of year. For example, the UVR level is greatest near the equator and during times of the day and times of the year when the sun is highest in the sky. Even though UVR levels are greatest on clear, cloudless days, cloud cover does not effectively block UVR. UVR can be reflected and scattered by various surface materials; for example, snow, ice and water can reflect more than 90 percent of UVR.

UVR levels also increase by approximately 3 percent to 4 percent for every 1,000-foot increase in altitude.

UVA and UVB are primarily absorbed by the eye's lens. (The lens is located behind the colored part of the eye and focuses light onto the retina, the eye's innermost lining, which senses the presence of light and translates the image into electrical impulses, which travel along the optic nerve to the brain [Figure 1].)

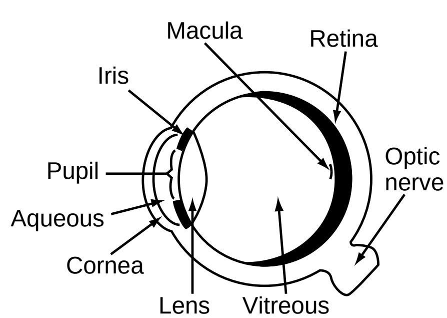
Eye health specialists say that exposure to UVR can contribute to the development of a number of eye disorders, including the following:

- Age-related cataracts, the clouding of small regions of the normally transparent tissue in the lens of the eye. Cataracts are a major cause of visual impairment and blindness worldwide. They are associated with aging and generally develop after age 50. Symptoms include the presence of glare, blurred vision, loss of color-perception acuity, double vision and the need for more light to see clearly. Exposure to UVR is among several factors that appear to increase the likelihood of developing cataracts; other factors include cigarette smoking, diabetes, exposure to high levels of ionizing radiation (such as X-rays used at aircraft maintenance facilities and industrial microwave radiation) and previous eye injury.[3]

  A 1988 study of 838 watermen who worked on the Chesapeake Bay, Maryland, U.S., found an association between cataracts and exposure to UVB. Cortical cataracts (those forming in the lens' cortex, which surrounds the nucleus, or center, of the lens) were found in 111 watermen (13 percent) and nuclear cataracts (forming in the nucleus) were found in 229 watermen (27 percent). The report on the study said that high cumulative levels of UVB exposure "significantly increased the risk of cortical cataract." No association was found between UVB exposure and nuclear cataracts or UVA exposure and cortical cataracts;[4]

- Pterygium, the growth of tissue on the sclera (the white part of the eye). The growth can spread across the cornea and distort its shape, sometimes causing changes in vision, including astigmatism (an irregularity in the shape of the cornea that prevents light from focusing properly on the retina). The growth can be removed by an ophthalmologist (a physician who specializes in eye care)[5];

Schematic Diagram of the Human Eye



Source: Stanley R. Mohler, M.D., and Flight Safety Foundation

Figure 1

- Periocular skin cancer, cancer of the skin around the eye, including the eyelid. These cancers typically are painless nodules or elevations of the skin, but they also may involve ulcerated areas, bleeding or distortion of the skin structure. Early detection and treatment can improve chances of removing the entire tumor and limiting the amount of tissue damage;[6]

- Photokeratitis, sunburn of the cornea. This temporary condition occurs after a few hours in bright sunlight (often in sunlight that is reflected off water or snow) without eye protection. Photokeratitis can be painful for one day or two days and can cause temporary vision loss; and,

- Macular degeneration, a deterioration of the macula (the retina's center, which contains the greatest concentration of light-sensitive cells and processes the details in the center of the field of vision). When the retina is exposed to excessive UVA (which is not a normal occurrence, because the eye's lens absorbs most UVA), the natural formation of the chemical called cytochrome oxidase is inhibited. This chemical transports oxygen to photoreceptor cells and other retinal cells, which eventually die without oxygen.

  Macular degeneration is the leading cause of blindness in people age 65 or older. The most common early symptoms are blurred vision and an inability to see clearly the details of objects at the center of the field of vision. The disease cannot be cured, but early diagnosis may allow for treatment that can slow the progress of the disease.[7]

Properly designed sunglasses help protect the eyes against these types of damage. Several organizations have established standards for UVR protection, including the American National Standards Institute and the Canadian Standards Association, which identify three categories of sunglasses, with the following recommended standards:[8,9]

- Cosmetic-use sunglasses, which are intended for use in mild sunlight. The standards say that cosmetic-use sunglasses should block at least 90 percent of UVB (in Canada, between 87.5 percent and 95 percent) and up to 60 percent of UVA;

- General-purpose sunglasses, which are intended for use in any outdoor activity. The standards say that general-purpose sunglasses should block at least 95 percent of UVB and at least 60 percent of UVA; and,

- Special-purpose sunglasses, which are intended for use in extremely bright environments, such as those that may be encountered during skiing or mountain climbing or at a beach. The standards say that special-purpose sunglasses should block at least 99 percent of UVB and at least 95 percent of UVA (in Canada, as much as 98.5 percent).

Other agencies have said that standards should require increased blocking of UVR, including the U.S. Food and Drug Administration, which advocates blocking 99 percent of UVB and at least 95 percent of UVA, and the American Optometric Association, which says that sunglasses (including cosmetic-use sunglasses) should block at least 99 percent of UVA and UVB. These numbers are guidelines for manufacturers, not requirements.[10]

In recent years, tags or stickers providing information about the level of UVR protection have been included on most sunglasses sold in some countries, including Canada, the United Kingdom, the United States and many countries in Europe. Some labels make general claims, such as "provides UV protection." Other labels provide more specific information about the level of protection against UVA and UVB; for example, "UV 400" means that 100 percent of UVA and UVB in wavelengths of less than 400 nanometers is blocked.

In Australia and New Zealand, a different system is used to tell consumers how much UVR protection is provided by sunglass lenses; the eye protection factor (EPF) measures the UVR-blocking capability on a scale from one (for the lowest blocking capability) to 10.[11]

UVR protection is not inherent in all lens materials. CR-39 plastic lenses do not provide UVR protection unless a UVR protective coating has been applied to the lens. Such coatings can block 100 percent of both UVA and UVB. Polycarbonate lenses have built-in UVR protection that blocks 100 percent of UVA and UVB. Glass lenses protect against UVB but not against UVA unless a UVR protective coating is applied. (Most aircraft windscreens have been treated to block transmission of UVR.)

Neither the darkness of lenses nor the price of the sunglasses should be considered an indication of how well the sunglasses will protect against UVR. The American Optometric Association says that sunglasses with the recommended levels of UVR protection are sold at all prices.[12]

Lens Tint Reduces Amount of Light Entering Eyes

The aviation environment can be very bright, especially when flying in the direction of the sun, over snow or above cloud layers. On a typical sunny day, the intensity of the sky or of sunlight reflected off snow can be as much as 35,000 candelas per square meter (3,250 candelas per square foot; a candela is the international unit for measuring luminous intensity, originally based on the light of a small flame). Layers of fresh snow can reflect up to 90 percent of sunlight. Because clouds are basically accumulations of water droplets, cloud reflectivity can vary from less than 10 percent to more than 90 percent, depending on drop sizes, liquid water content, water vapor content, thickness of the clouds and the sun angle. In addition to the UVR risks, these levels of light intensity are uncomfortable and can degrade visual performance.

The eye is capable of adapting to a range of light intensities. In response to relatively bright light, the eye's iris (the round, colored part of the eye) contracts, limiting the amount of light entering the eye. The iris can close to approximately two millimeters (0.08 inch) in diameter. The darkness of sunglass lenses further reduces the amount of light entering the eye.

A pilot's eyes need enough light for the pilot to be able to perform the aviation tasks required but not so much light as to degrade the ability to perform the tasks. One complicating factor is that the pilot sometimes must perform tasks involving two disparate light conditions — with one level of light intensity outside the aircraft and another level of light intensity on the flight deck.

Studies have shown a relationship between available light levels and visual acuity.[13,14] The studies have shown that, to be able to resolve the necessary detail to perform designated tasks, there must be a minimum level of light. At some increased level, however, the light no longer improves visual acuity but begins to degrade it, primarily because the light is too bright. Therefore, an acceptable darkness for a sunglass lens is one that reduces light transmission (perceived brightness) to a comfortable level but also provides optimal visual performance.

In one study, 60 volunteers (not pilots) were asked to wear sunglasses with lens tints providing five different darkness levels during sunny summer days and sunny winter days with freshly fallen snow.[15] The volunteers were divided into three age groups: younger than age 30, age 30 to age 39, and age 40 and older. Each volunteer's visual acuity was evaluated, and each was asked to rate his or her satisfaction with the comfort and perceived quality of vision using of each of the lens tints.

The different tint values allowed the following amounts of light transmission through the lenses: 0.8 percent, 2.5 percent, 4.8 percent, 8.9 percent and 15.8 percent. The study found that the most preferred tint values were those that allowed light transmission of 2.5 percent, 4.8 percent and 8.9 percent; the tints that allowed light transmission of 0.8 percent and 15.8 percent were rated significantly lower for satisfaction. Although there was no difference among age groups in their satisfaction ratings, the intermediate age group had better visual acuity using the mid-value filters (2.5 percent, 4.8 percent and 8.9 percent) and the older age group showed a significant loss of visual acuity with the two lower-transmission tints (0.8 percent and 2.5 percent).

A second study, conducted by the U.S. Army, resulted in different findings.[16] The purpose of the study was to investigate reported problems with quality control in Army-issue sunglasses and to determine an optimal light-transmission value. The report on the study said that "a transmission of 23 percent resulted in minimal decrease in visual performance relative to standard clinical measures." The authors of the report, however, said that lower transmission values (darker lenses) might be more appropriate in very bright environments.

The recommended light-transmission range for the civilian study translates into "light-blocking" values of approximately 91 percent to 97 percent for pilots younger than age 40, and 91 percent to 95 percent for pilots older than age 40. Because the range and choices of tint values and age groups used in the study were limited, these values should be used as guidelines.

In the United States, military sunglasses by regulation are neutral gray and have a light-transmission value of approximately 15 percent — a value similar to the 15.8 percent light-transmission value of the lenses that received a low-satisfaction rating in the civilian study. This value also was associated with reduced visual acuity for pilots in the U.S. Army study.

Polarized Lenses May Complicate Reading of Flight Instruments

Glare should not be confused with ambient brightness — the overall intensity of sunlight. Glare is produced by light sources and reflections that are of much higher intensity than ambient light intensity. In the aviation environment, a typical example of glare is the reflection of light off a surface, such as metal, water or clouds. A pilot flying an aircraft at 40,000 feet often encounters significant glare from the cloud layer below.

Glare can be uncomfortable — even painful. The normal reaction to glare is to squint or look away. A dangerous characteristic of glare is its obscuration of objects. Visual acuity also is degraded in the presence of glare.

Because glare is associated with extremely high light intensity, using tint alone for glare reduction would result in lenses that are too dark and unacceptable for visual acuity. A more effective glare-reduction technique involves polarized filters. Light waves from the sun and from artificial light sources, such as light bulbs, vibrate and radiate outward in all directions. If the light — by transmission, reflection or scattering — is affected so that its vibrations are aligned into one plane of direction or more, the light is said to be polarized. Polarization can occur naturally or artificially.

Glare that most frequently is encountered in the aviation environment comes from horizontal surfaces such as water. When light strikes the horizontal surface, the reflected light waves are polarized to the angle of that surface. A highly reflective horizontal surface, such as a lake, produces mostly horizontally polarized light. The polarized lenses in sunglasses are polarized at a fixed angle that allows only vertically polarized light to be transmitted, thereby eliminating a significant amount of glare.

Some sunglasses are labeled falsely as having polarized lenses. A simple test, however, can determine whether lenses are polarized: Find a reflective surface and hold the glasses so that you can see the surface through one of the lenses. Then, slowly rotate the glasses 90 degrees. If the reflected glare diminishes, the lenses are polarized.

Despite their glare-reduction capability, polarized sunglasses are prohibited in some air carrier operations manuals because polarized lenses can deteriorate with exposure to heat, humidity, perspiration and aviation chemicals; can introduce optical distortion; and — in rare instances — can cause color distortion.

In addition, their blocking of polarized light can cause problems in performing some tasks. Some aircraft have flight instruments that incorporate polarizing anti-glare filters. When these instruments are viewed through polarized sunglasses, the information on the instruments can disappear. Newer electronic instruments with liquid crystal displays also can become unreadable at some angles when viewed through polarized sunglasses. Polarized sunglasses also may reveal strain patterns in some laminated aircraft windshields, which may be a visual distraction.[17]

Polarized sunglasses also can mask reflections from shiny surfaces that pilots need to see, such as other aircraft, so pilots wearing polarized sunglasses have less time to react to potential conflicts with other traffic.

Some Lenses Distort Color Perception

Sunglass lenses are available in many colors. The lens color primarily is determined by which parts of the visible light spectrum are absorbed or reflected by the lenses.

The oldest method of coloring sunglass lenses involves a process called constant density, in which the color is built into the lens material to produce uniform color throughout each lens. Colored polycarbonate lenses can be produced by applying a coat of light-absorbing molecules to the surface of clear polycarbonate lenses. Another method of coloring polycarbonate lenses is to immerse them in a liquid containing the coloring dye; the dye is absorbed slowly into the lens. A darker color is achieved by leaving the lenses in the liquid for a longer period of time.

Some sunglass lenses are gradient lenses, which are darker in the upper area than in the lower area. The upper area provides protection from sunlight and glare, and the lower area provides enough light transmission for the pilot to see instruments and to read charts.

Gray lenses are all-purpose lenses that reduce the overall brightness with the least color distortion. Green lenses also reduce brightness with minimal color distortion. Lenses of most other colors cause color distortions to varying degrees. Brown lenses — sometimes recommended for improving contrast in hazy sunlight — also may distort colors. Yellow lenses filter out most of the incoming blue light and allow a larger proportion of other colors to be transmitted. The yellow color virtually eliminates the blue part of the spectrum, and many people say that these "blue-blocking" lenses make everything appear brighter and sharper.

Nevertheless, a 2000 review of more than 200 studies that had been conducted since 1912 to investigate visual performance with yellow lenses found that none of the studies had identified any measurable improvement in visual acuity, contrast sensitivity or detection capability.[18]

In addition, the review found negative aspects of wearing yellow lenses, including distortion of color perception. When the blue portion of the color spectrum is removed from a scene, there are certain predictable effects on color shifts within that scene: Blue is attenuated or removed, and white is perceived as yellow. Advocates of blue-blocking lenses say that these lenses sharpen images in the presence of haze. The appearance of haze is basically white, which means its spectral content is a balance of red, green and blue components. When the blue component is filtered out, the haze is not as apparent to the observer, but visibility through the haze remains essentially the same.

In the following report to the U.S. National Aeronautics and Space Administration Aviation Safety Reporting System (ASRS),[19] the pilot of a commuter airplane described his experience with blue-blocking lenses during a July 1992 flight to John F. Kennedy (New York, New York, U.S.) International Airport:

> In cruise flight, [the] aircraft entered an area of icing conditions. [According to] aircraft procedures, engine anti-ice was selected. On descent, [the] aircraft left icing conditions. On [the] ground during shutdown, I took my blue-blocker sunglasses off and noticed the two blue engine anti-ice status lights on the center panel were on, indicating engine anti-ice was still on. The sunglasses blocked the blue light from the engine anti-ice light bulb, making it appear the system was off.
>
> This is not the only system in the aircraft that has blue lights associated with [it]. … While this occurrence posed little safety hazard, the potential is there for further safety problems. Several pilot sunglasses use the blue-light-blocking technology, and many pilots may use these glasses unwittingly.[20]

Color distortion produces a dangerous situation in the aviation environment. At night, colored lights are used in airports to provide information to pilots. Blue lights outline many taxiways. At larger air terminals, green taxiway-turnoff lights may be used to lead pilots on a curved path from the runway centerline to the center of the intersecting taxiway. Taxiway centerline lights, if installed, also are green.

Although sunglasses should not be worn at night — or at dawn or dusk — for visual acuity reasons, if yellow lenses are worn, the wearer can experience additional problems. When seen through yellow blue-blocking lenses, pure blue light is not transmitted and all blue lights appear green. All white lights and yellow lights appear yellow. To reduce color distortion when wearing sunglasses, gray lenses or green lenses usually are recommended because they allow relatively equal light transmission across the color spectrum.

A good test of potential color-distortion problems with sunglasses is to use them to view sectional charts. If color problems are apparent, choose another pair of sunglasses.

Mirror coatings sometimes are applied to sunglass lenses to reduce glare by reflecting high-intensity light. Such lenses do not block transmission of UVR. The mirrored coating is made by applying a thin layer of vaporized metal to the surface of the sunglass lenses.[21] Mirror coatings be can scratched easily.[22]

Heat May Diminish Effectiveness of Photochromic Lenses

Photochromic lenses change from clear to dark (and back again), depending on the amount of UVR they are exposed to. The change from clear to dark typically occurs within about 30 seconds to 60 seconds; changing from dark to clear can require several minutes. Photochromic lenses can block as much as 85 percent of the incoming light (i.e., the lens allows transmission of 15 percent of the light).

The active ingredient that causes the lenses to change is either silver chloride or silver halide. This chemical is mixed evenly throughout the lens material so that the lens will darken when exposed to sunlight. In artificial lighting (indoors where UVR is absent), the photochromic molecules are basically clear. But when exposed to UVR, as in direct sunlight, a chemical process causes the photochromic molecules to change shape. The new molecular structure absorbs portions of the visible light, causing the lenses to darken. As the amount of UVR increases, more molecules change shape, producing a darker shade. When the wearer goes indoors and out of the UVR, the molecules return to their original shape, making the lenses clear again.

Both glass photochromic lenses and plastic photochromic lenses can provide adequate UVR protection, even when the lenses are clear.

Plastic photochromic lenses, however, function best in cool ambient temperatures; hot weather can prevent them from reaching their optimal darkened state. Some plastic photochromic sunglasses also lose their light-changing properties over time, depending on the materials used in the lenses, the intensity and length of UVR exposure and other factors.

Because photochromic lenses react to UVR — not to visible light — and because windscreens and windshields block most UVR, photochromic lenses do not darken when the wearers are on flight decks or in automobiles. For this reason, most sunglasses with photochromic lenses also have some color tint.

Wearers of Prescription Glasses Have Several Options

Prescription sunglasses can be produced using the same lens materials that typically are used in nonprescription sunglasses for wearers who need single-vision prescriptions, bifocal prescriptions and progressive-lens prescriptions.

Prescription sunglasses made with glass photochromic lenses may present problems, however, if the vision-correction prescription is strong and requires thick glass lenses; in these circumstances, the thickest part of the lens will be slightly darker than the thinner parts. If there is a large difference in the amount of vision correction required for each eye, the lens with the stronger prescription will be darker than the lens with the weaker prescription. These problems do not occur in plastic photochromic lenses because the differences can be adjusted within the plastic tint.

People who require prescription eyeglasses may — instead of having a separate pair of sunglasses — wear clip-on filters, which can be attached to regular prescription eyeglasses, either in front of the lenses or behind the lenses. Clip-ons can allow wearers to switch easily between sunglasses and regular prescription glasses; nevertheless, clip-ons double the number of lens surfaces that light must traverse — a factor that can add apparent haze and reflections.

Some contact lenses contain UVR protection. These contact lenses, however, are not designed to eliminate the need for sunglasses. The contact lenses cover only a small portion of the eye; sunglasses cover the entire eye and the surrounding skin.

Frames Typically Made of Plastic, Metal

Sunglass frames are manufactured from a variety of materials, typically plastics (such as polycarbonate, Kevlar and composites) or metals (such as titanium, stainless steel and aluminum).

Metal frames typically last longer and require more frequent adjustments of fit than plastic frames. Most metal frames have nose pads connected to the frame that are helpful in fitting sunglasses on people who have a narrow nose bridge or a small nose. Some people, however, are allergic to some metals; individuals with sensitive skin should consider only metal frames that are labeled as hypoallergenic.

Modern plastic frames typically are as lightweight as metal frames. Some plastic frames contract and expand with temperature changes and require frequent adjustments. Most plastic frames do not have separate nose pads attached to the frame; the absence of nose pads can cause a poor fit for some people.

Some composite-material frames are more durable than either metal frames or plastic frames and often include features such as tension springs (instead of screws) to connect the temples (the side supports of the frames that pass along each side of the head) to the lens frames or wrap-around cable earpieces to help keep sunglasses attached to the head.

Typically, with the exception of the least-expensive plastic frames, most frame materials provide acceptable performance characteristics.

Frame designs can be classified into two categories. The most common design is used typically for prescription eyeglasses — two separate lenses in lens frames connected by a nose bridge, with two nose pads attached to the lens frames (if the frames are metal), a pair of hinges and two temples. The temples can be straight stand-alone "bayonet styles" that rest on the ears, or they can wrap around the ears.

The other design is the wrap-around design, which typically consists of one large lens that wraps fully across the face and fits close to the head. Some wrap-around designs also include sidepieces that extend beyond the hinges as part of the temples to provide additional protection from sunlight. This design permits nearly full peripheral vision and effectively blocks bright sunlight and UVR. While outdoors, the side protection also provides added protection against wind and dust being blown into the eyes.

For pilots, three factors are most important in selecting sunglass frames:

- How well do the frames fit the face and head? The failure of any type of eyeglasses, including sunglasses, to remain affixed to the head while a pilot is on the flight deck can present risks to aviation safety;

- Do the frames block vision? A 1984 study evaluated the effects of eyeglass frames and temples on a pilot's field of vision. A variety of frame styles and temple styles were acquired from an optical distributor, and a vision perimeter (a device used to measure the eye's visual field) was used to measure blocked areas in pilot visual fields. The study found that the lens frames produced greater blocking of vision than the temples. The study recommended that sunglasses have large lenses, thin frames and narrow temples attached high on the frames;[23] and,

- Are the frames comfortable? If not, pilots (and other wearers) are unlikely to wear them. This is a common — and often ignored — requirement for any protective eyewear.

Choosing the correct sunglasses can protect the eyes against harmful UVR and can reduce brightness and glare to improve vision. The correct sunglasses for pilots are those that fit well, do not distort colors and provide adequate UVR-blocking capabilities.♦

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    ASRS acknowledges that its data have certain limitations. ASRS *Directline* (December 1998) said, "Reporters to ASRS may introduce biases that result from a greater tendency to report serious events than minor ones; from organizational and geographic influences; and from many other factors. All of these potential influences reduce the confidence that can be attached to statistical findings based on ASRS data. However, the proportions of consistently reported incidents to ASRS, such as altitude deviations, have been remarkably stable over many years. Therefore, users of ASRS may presume that incident reports drawn from a time interval of several or more years will reflect patterns that are broadly representative of the total universe of aviation safety incidents of that type."

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