

Environmental Vision  
Aviation Vision for the Optometric Physician  
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Theodore Roosevelt quote: “The only one who makes no mistakes is the one who never does anything.”

U.S. commercial airlines carry about 635 million passengers per year, using many different kinds of aircraft and fly 6.2 billion miles. But another category, known as “general aviation” also involves many people (92.6 million) people in aviation. General aviation includes private pilots and their passengers, and includes the use of 206,500 aircraft at 19,000 airports around the country. This category of pilots and passengers will increase with time.

The aerospace industry has a huge impact on our economy in terms of jobs, revenue, exports and related industries that support or depend on aviation (tourism, delivery, etc.).

Private (non-airline) aircraft are used in various ways: hobbyists, air combat reenactments, sky writing, reconnaissance/survey, ballooning, agriculture, fire fighting, gliders, paragliding, ultralights, air tours, air ambulance, freight (UPS, FedEx, etc.) and more.

Pilots must be certified to fly. There are three levels of certification:

- 1<sup>st</sup> class: Airline pilots who fly the big jets
- 2<sup>nd</sup> class: Commercial pilots who fly smaller aircraft
- 3<sup>rd</sup> class: Private pilots

Since the late 1970s there has been a gradual decline in the 1<sup>st</sup> and 2<sup>nd</sup> class airman certificates, but there has been an gradual increase in 3<sup>rd</sup> class certificates. Also, there is an increase in female aviators.

Pilots must pass a medical examination but some have medical restrictions. The majority of medical restrictions are due to the eyes. For example, the pilot may be required to wear a refractive correction.

#### Vision standards

- 1<sup>st</sup> and 2<sup>nd</sup> class: Far VA must be correctable to 20/20 in each eye.
- 3<sup>rd</sup> class: Far VA must be correctable to 20/40 in each eye.
- All must have 20/40 vision for intermediate distances (32 inches)
- Near must be 20/40 at 16 inches.
- Color vision must be adequate for them to do their job (vague standard).

#### Special ophthalmic considerations for pilots

- Hypoxic environment – this can decrease dark adaptation and reduce the visual field
- Low humidity - [could increase discomfort for dry eye patients, or contact lens wearers]
- Low barometric pressure - can cause fatigue
- Atmospheric conditions - fog, rain, etc.
- Glare - often it is brighter (above the clouds), or light can be coming from below (reflected off the tops of clouds, etc.
- Low light when flying at night
- Vibrations, G forces can cause glasses to fall off.
- Various different display types located at different distances, positions and using different colors

~41% of pilots need spectacles for distance vision. Pilots need and like to use sunglasses. Ideally transmittance should be about 15% and the color should be neutral gray. Less than about 8% transmittance can degrade visual acuity. Tinted/colored lenses are not recommended.

In one near accident, two military pilots were approaching the wrong runway, which was closed for repairs. It had been marked closed with yellow warning lights, but since they were wearing yellow-tinted visors, they couldn't see the lights. An alert air traffic controller noticed that they were approaching the wrong

runway and told them to abort the landing. After removing their yellow visors they were able to see the warning sign and subsequently landed safely.

About half of all pilots are over 40 years old, so about half of all pilots need some correction for near. Some bifocal or progressive lens types can affect peripheral vision, so you need to educate your aviator patients and give them time to adapt.

To reduce reflections off clothing, it is good to recommend that pilots wear dark clothing.

Seg heights should be adjusted to permit viewing of the instrument panel, but should not be so high that it interferes with the view out the cockpit. Generally, the working distance to the instruments is 20-30 inches rather than the typical 16 inches (40 cm) that we usually test for. Before prescribing bifocals, you should have the pilot measure the distances to his instruments and measure the height of the glare shield (bottom of window).

Options for presbyopic pilots:

- small or wider bifocals, depending on the type of instruments they use
- some instruments are above the head. They may need a double-D seg bifocal.
- Standard trifocals, usually about 7 mm in height, may be too narrow. You can order special lenses, such as the X-cel CRT lens that has a 14-mm height intermediate portion.
- Pilots working under red light may need a stronger than normal add since red light stimulates accommodation less than white light.

#### **Contact lenses in aviation**

Before 1976 you needed a special waiver to wear contact lenses as a pilot. Now contact lens wear is approved, and there has been a steady increase in contact lens wear among pilots. About 3.5% of airmen wear contact lenses. Problems unique to contact lenses in the aviation environment include:

- glare
- RGPs can dislodge during high-G-force flying, such as in aerobatics
- In crop dusting, soft contact lenses can absorb dangerous chemical
- Opaque lenses can reduce the visual field, and are not recommended.

Orthokeratology fall under the same rules as contact lens wear. It is increasing among pilots.

#### **Monovision**

- New rule since 1999 - must report the use of contact lenses
- Monovision is not authorized
- Bifocal contact lenses are also not allowed.
- The Delta Flight 554 accident was attributed to monovision, however the pilots was attempting to land under visually difficult conditions.
- He was attempting to land in the rain, at dusk, over water, onto an alternate runway that was usually not used.
- That runway had a decentered ILS (instrument landing system) beacon that required quick realignment of the aircraft in the last few seconds.
- Runway lights were spaced at 150 feet rather than the standard 200 feet, giving the illusion that the plane was higher than it really was.
- The plane's vertical speed indicator was giving delayed data, but the pilot didn't know that.
- Several illusions could have affected the pilot's estimate of his altitude.
- He was a experienced pilot who had been using monovision for years without any problem, until this incident.

#### **Refractive surgery**

- Permitted, but pilots who have had refractive surgery must ...
- have healed completely,
- have stable visual acuities,

- have no glare [measured by the BAT, I suppose],
- meet visual standard with this form of visual correction.

Refractive surgery is increasing among aviators. About 1.1% of Class 1 pilots have had refractive surgery. However, they face greater risks than the average person, because if they cannot meet visual requirements after refractive surgery, it could end their careers as commercial pilots. Some people invest as much as \$100,000 and years of training to become an airline pilot, so they are wary of the risks.

### **Contact lens and spectacle related accidents**

Contact lenses and spectacles can contribute to aviation accidents in the following ways:

- Spectacles may be incompatible with emergency breathing equipment. You need to prepare your pilots patients for this, and verify compatibility when they are in your office. You should not let them find out that there's a problem in the middle of an emergency.
- Loss or failure to use spectacles or contact lenses in flight. For example, in some cases the fit of the spectacles was uncomfortable, so the pilot did not use his glasses.
- Wrong Rx
- Frame breaking during a flight. All pilots should have a back-up pair of spectacles on hand at all times, during a flight.
- Monovision-related accidents
- Inappropriate sunglasses, such as tinted lenses.

### **Sunglasses**

Pilots like sunglasses and should be encouraged to wear them.

- Warn them not to wear the sunglasses when lighting is low, since it may impair vision.
- They still need clear Rx (actually two).
- All spectacles should provide 100% UV protection (block 100% of UV-A and B)
- Photochromics are not recommended for pilots—they change too slowly.
- Polarizers are not recommended. They can reveal irregularities in the cockpit window glass that can interfere with vision.
- [Military fighter pilots who are searching the sky for enemy aircraft may first see the reflection off the enemy plane when they are very far away. Polarized lenses cut specular reflections and may prevent early detection.]
- Tinted lenses, such as “Blu-blockers” or yellow tinted lenses are not recommended.
- The sunglass lenses should transmit about 15% of visible light, be neutral gray and be of good optical quality.

Monocular patients are permitted to fly. A pilot is considered monocular if one eye's BVA is worse than 20/200. They can get any class certificate with one eye.

Color standards require that the pilot be able to perceive all colors necessary to perform their duties. Pass/fail standards for most vision test are very lax.

Various visual illusions can interfere with the pilot's vision.

- Spatial disorientation occurs when there is a conflict between visual, vestibular and instrument clues
- Runways built on slopes can give the illusion that you are higher or lower than the correct elevation
- The black-hole illusion
- Autokinesis