

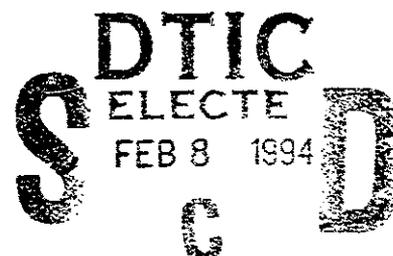
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Vision Impairment and Corrective Considerations of Civil Airmen



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16. Abstract <p>Civil aviation is a major commercial and technological industry in the United States. The Federal Aviation Administration (FAA) is responsible for the regulation and promotion of aviation safety in the National Airspace System. The Office of Aviation Medicine oversees investigations on visual disorders and vision corrective devices of airmen and air traffic controllers.</p> <p>A review of the demographics of the civil airman population was performed using FAA publications and databases. Approximately 48% of the civil airman population is ≥ 40 years of age (average age = 39.8 years). Many of these aviators are becoming presbyopic and will need corrective devices for near and intermediate vision. In fact, there has been an approximate 12% increase in the number of aviators with near vision restrictions in the last decade.</p> <p>Ophthalmic considerations for eye care practitioners prescribing and dispensing for civil aviators are discussed. This data is useful for the Office of Aviation Medicine to guide policy changes and educational programs for airmen with vision impairment and who use corrective ophthalmic lenses in the aviation environment, particularly the increasing number of presbyopic airmen.</p>					
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VISION IMPAIRMENT AND CORRECTIVE CONSIDERATIONS OF CIVIL AIRMEN

INTRODUCTION

Civil aviation is a major commercial and technological industry in the United States. The two major components of civil aviation activities are air carrier and general aviation. An estimated 278,000 people/day rely on air carriers for business and personal travel. As of 1991, there were approximately 6,054 air carrier aircraft, which include commercial air carrier operators, commuter air carriers, and air taxis (1). Aircraft types include jet, turboprop, piston, and rotary wing aircraft (helicopters), which flew an estimated 13.5 million flight hours (2). Besides the flight crew members, many aviation-related professionals (maintenance, flight line, airport support staff, etc.), who may never pilot an aircraft, depend on the air transport industry for supporting themselves and their families.

General aviation contributes more than \$38 billion to the nation's economy and provides more than 530,000 jobs (3). In 1991, general aviation aircraft flew an estimated 34.7 million flight hours. With a fleet of an estimated 268,514 aircraft, including fixed-wing, rotorcraft (helicopters and autogiros), and other aircraft (blimps, balloons, gliders and ultralights) (2), general aviation provides public air access at 16,912 airports versus only 669 served by scheduled air carriers (1). Many smaller cities and towns in the United States would not have air transportation for their goods and services without general aviation.

A primary mission of the Federal Aviation Administration (FAA) is to regulate and promote aviation safety in the National Airspace System. One tool the FAA uses to accomplish this is the medical certification of pilot applicants. Airmen can apply for one of three medical certificates: first-class, second-class, and third-class. First-class certificate holders include professional air transport pilots who normally fly large, sophisticated aircraft. Second-class certificate holders include commercial pilots who may fly cargo or commuter aircraft and for aero application (crop dusters). Third-

class certificate holders normally fly primarily for pleasure in light, privately-owned aircraft.

In the U.S., there are approximately 6,000 aviation medical examiners who examine approximately 500,000 pilot applicants each year. For first-class certification, medical examinations are performed every 6 months, second-class every 12 months, and third-class every 24 months. Medical standards for each class of medical certificate are detailed in "Part 67: Medical Standards and Certification of the Federal Aviation Regulations." Vision standards for the three classifications of pilot certificates are summarized in Table 1.

The FAA also conducts research into clinical limitations, such as vision impairment, and their impact on the effectiveness and reliability of personnel in the aviation environment. It also provides training and consultation to investigative team members on such limitations and their relevance to aviation accidents.

To properly guide FAA policy changes and educational programs for aviation personnel on vision impairment and the use of corrective ophthalmic devices, a periodic review of the demographics of the civil airman population and ophthalmic considerations for these aviators is required. The purpose of this paper is to review the demographics of the civil airman population, which was performed using FAA publications and databases. Additionally, visual corrective considerations for aviators are discussed.

DEMOGRAPHICS OF THE CIVIL AIRMAN POPULATION (4)

Over the past two decades, the demographics of the civil airman population have changed. The total airman population has decreased by approximately 9% from 1971 (740,635) to 1991 (675,067) (Note: Figure 1). As of December 31, 1991, there were approximately

TABLE 1: A SUMMARY OF VISION STANDARDS FOR CIVIL AIRMAN MEDICAL CERTIFICATES

<i>Class of Medical Certificate Type of Pilot</i>	<i>First-Class Airline Transport Pilot</i>	<i>Second-Class Commercial Pilot</i>	<i>Third-Class Private Pilot</i>
DISTANT VISION	20/20 in each eye separately without correction or at least 20/100 in each eye separately corrected to 20/20 or better with corrective lenses (glasses or contact lenses).		At least 20/50, without correction; or if vision is poorer than 20/50, must correct to 20/30 or better with corrective lenses (glasses or contact lenses).
NEAR VISION	At least 20/40 in each eye with or without correcting glasses.		At least 20/60 in each eye separately with or without correcting glasses.
HYPERPHORIA	Maximum of 1 diopter.		No standard.
ESOPHORIA & HYPERPHORIA	Maximum of 6 diopters of esophoria or exophoria.		No standard.
COLOR VISION	Normal color vision.	Ability to distinguish aviation signal red, aviation signal green, and white.	

FIGURE 1: THE TOTAL CIVIL AIRMAN POPULATION FROM 1971-91

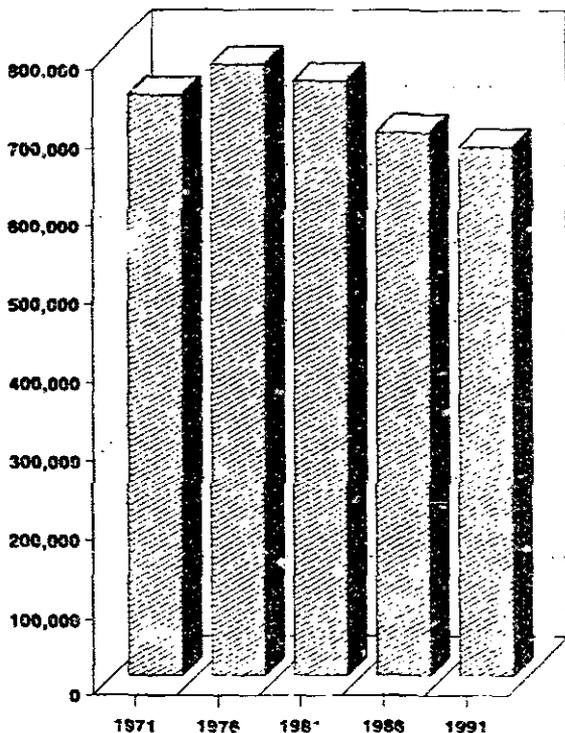
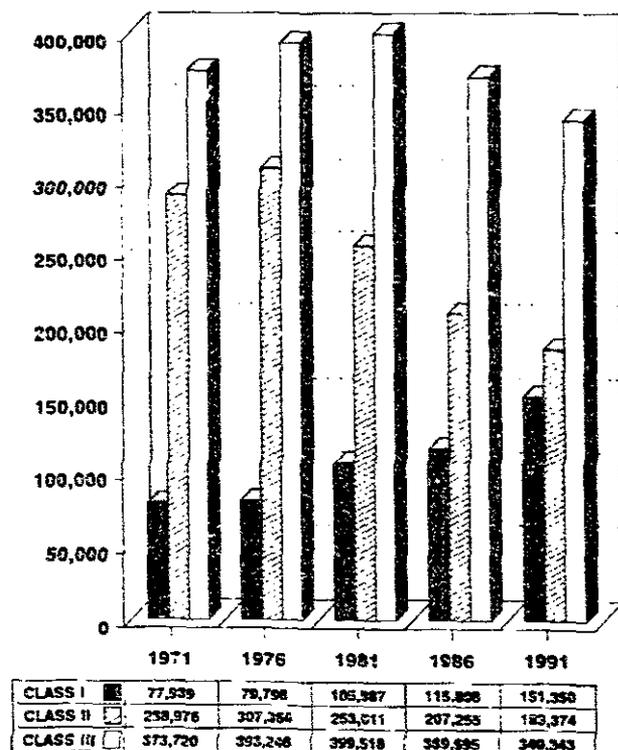


FIGURE 2: THE TOTAL CIVIL AIRMAN POPULATION BY CLASS OF MEDICAL CERTIFICATE HELD FROM 1971-91



151,350 first-class, 183,374 second-class, and 340,343 third-class airmen (Note: Figure 2). While second- and third-class airman populations have decreased 37% and 9%, respectively, the first-class airman population has increased 94% from 1971 to 1991.

Women in the total civil aviator population have increased by 25% from 1971 (31,767) to 1991 (39,674). The largest increase has occurred in first-class female airmen, from 354 to 5,716 pilots (Note: Figure 3). During the same period, total male airmen have decreased by 10%, increasing only in first-class medical certificate holders (88%) (Note: Figure 4). Still, as of 1991, civil aviation is a male dominated activity with a 16:1 male to female ratio.

By age, the percentage of airmen in the total civil airman population who are ≥ 40 years of age has increased from 36% in 1971 to more than 48% in 1991. The average age increased from 35.5 to 39.8 years, respectively (Note: Figure 5). From 1971 to

1991, by age and class of medical certificate held, aviators \geq age 40 in the first-class airman population have increased from 33% to 41%, second-class from 32% to 50%, and third-class from 40% to 50%. The greatest frequency of older aviators is within third-class certificate holders.

A common consequence of aging is an increased prevalence of medical conditions, including vision problems. From 1971-91, there was a 27% increase in the number of medical restrictions held by civil airmen and a 28% increase noted in restrictions associated with visual conditions (Note: Figure 6). Of the total medical and visual restrictions, more than half are carried by third-class airmen (4). (Note: Defective near vision [DNV] data recorded prior to 1981 are not directly comparable to data collected since that date due to changes made in the visual restriction categories.) The percentage of airmen in the total airman population with defective distance vision (DDV) increased from 34% in 1981 to 39% in 1991. In the same

FIGURE 3: THE TOTAL FEMALE CIVIL AIRMAN POPULATION BY CLASS OF MEDICAL CERTIFICATE HELD FROM 1971-91

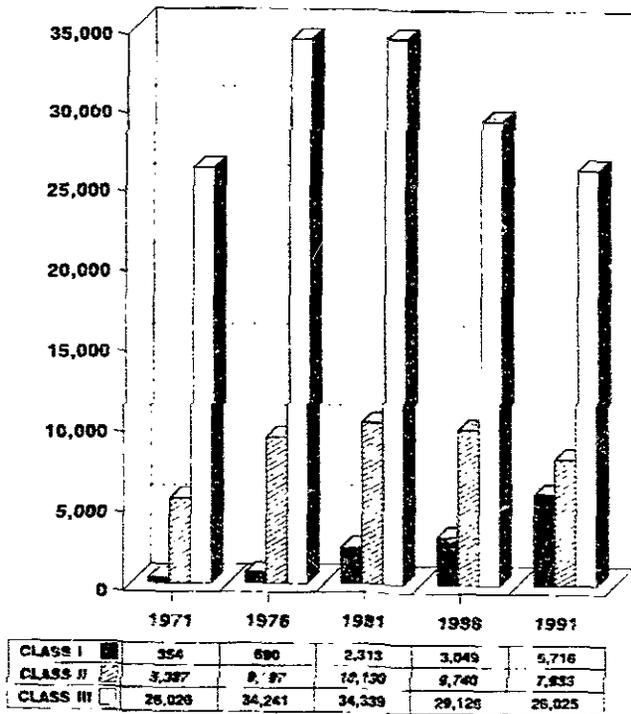


FIGURE 4: THE TOTAL MALE CIVIL AIRMAN POPULATION BY CLASS OF MEDICAL CERTIFICATE HELD FROM 1971-91

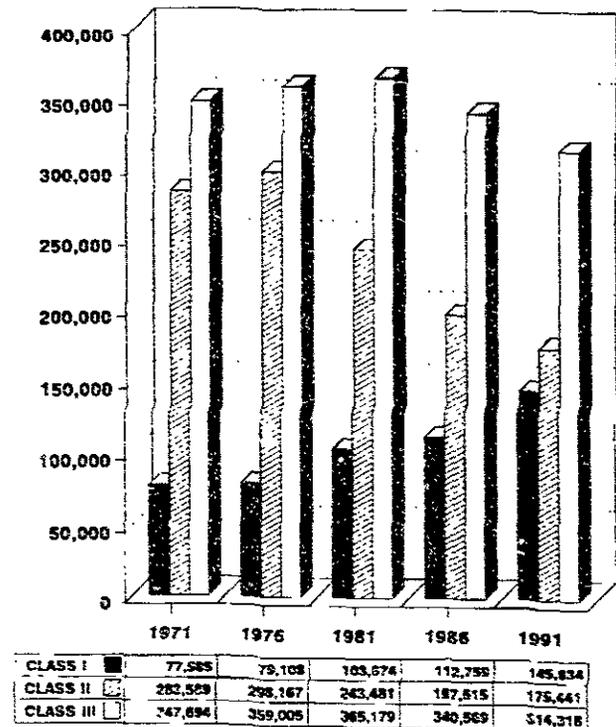


FIGURE 5: THE ≥ AGE 40 CIVIL AIRMAN POPULATION BY CLASS OF MEDICAL CERTIFICATE HELD FROM 1971-91

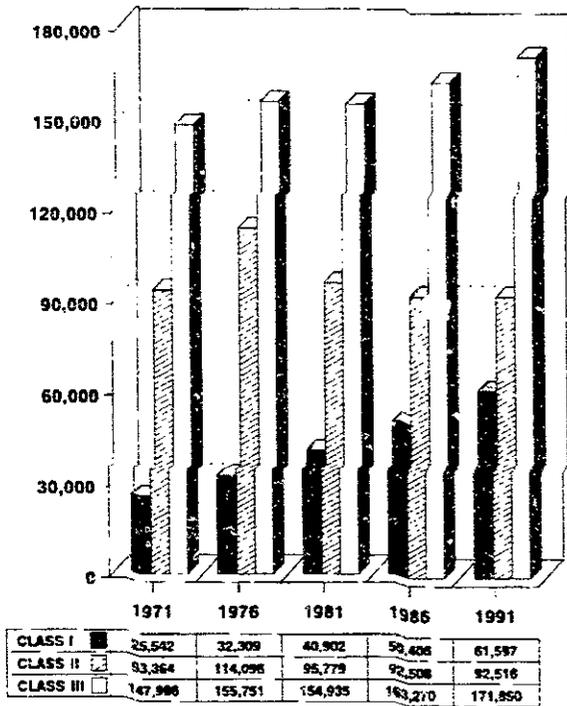
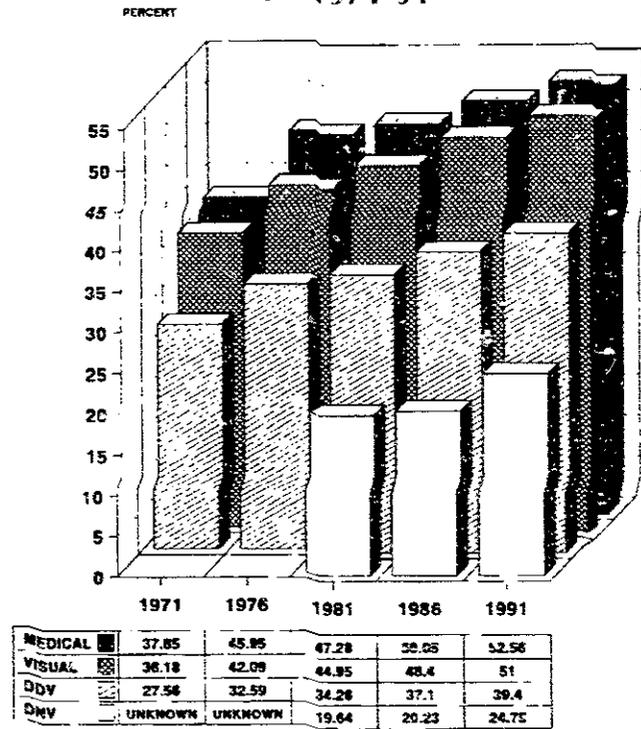


FIGURE 6: THE PERCENT OF THE CIVIL AIRMAN POPULATION WITH VARIOUS MEDICAL AND VISUAL RESTRICTIONS FROM 1971-91



DDV = DEFECTIVE DISTANT VISION
DNV = DEFECTIVE NEAR VISION

period, the percentage of those with DNV has increased from 20% to 25%. This represents a 12% increase in the absolute number of DNV restrictions compared to approximately 2% for DDV. This suggests that as the airman population continues to age, the evaluation and correction of near and intermediate vision performance of aviators will become an increasing challenge for those in the eye care profession.

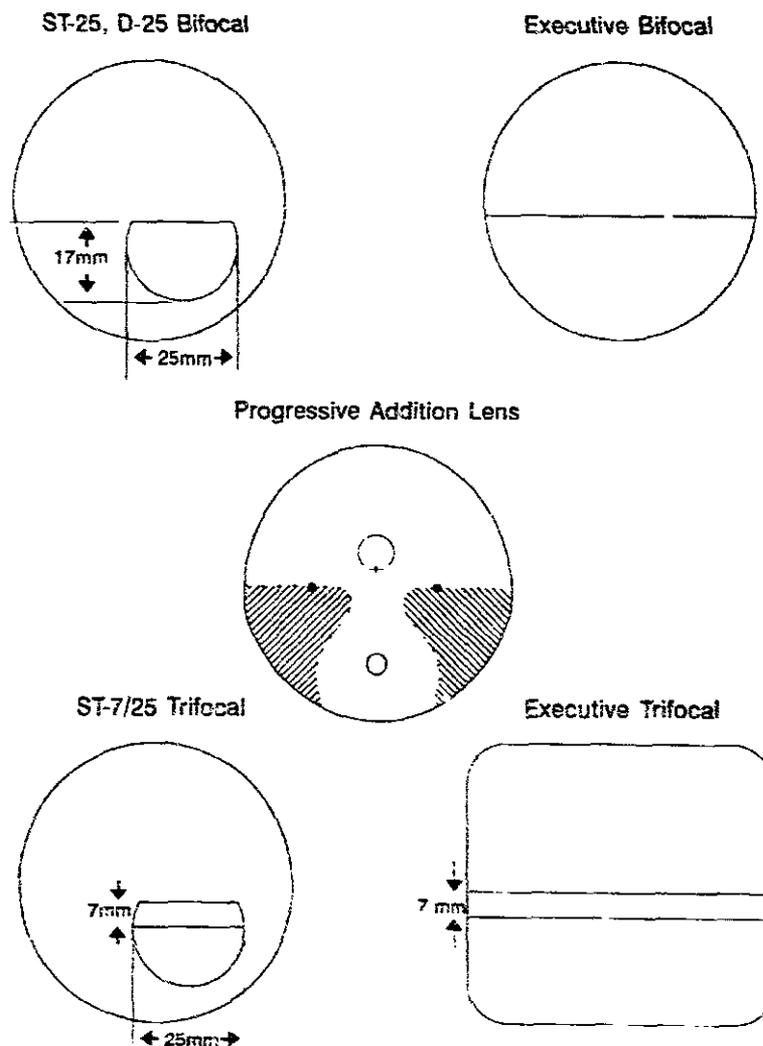
OPHTHALMIC CONSIDERATIONS FOR CIVIL AIRMEN

When an eye specialist examines and prescribes for a patient, it is necessary to ask the individual about occupational and recreational activities that might influence the use of any ophthalmic correcting devices. In general, a single correcting device is not functional for all activities. Similarly, for civil airmen the types of ophthalmic devices recommended are often determined by the flight activities being performed. Examples of these ophthalmic considerations, include:

1. For airmen who do aerobatic flying, soft contact lenses may be advisable since they are not as easily dislodged as rigid lenses. When sharp distant vision is required, rigid lenses may be considered.
2. Agricultural aircraft operators (crop dusters) may be exposed to harmful pesticides. Soft contact lenses, which can absorb chemicals into their matrix, may be contraindicated. Adequate eye protection should be recommended to these pilots.
3. Monocular pilots may receive ocular trauma from flying objects in the cockpit during turbulence or aerobatic maneuvers. Additionally, bird strikes have shattered aircraft windscreens. Eye protection devices should be recommended for all monocular aviators.
4. Monovision contact lens wear is contraindicated for flying, since it reduces stereopsis and monocular distant acuity. Those airmen who are corrected with monovision should be prescribed a second distant vision contact lens to be worn on the near vision correcting eye while flying.

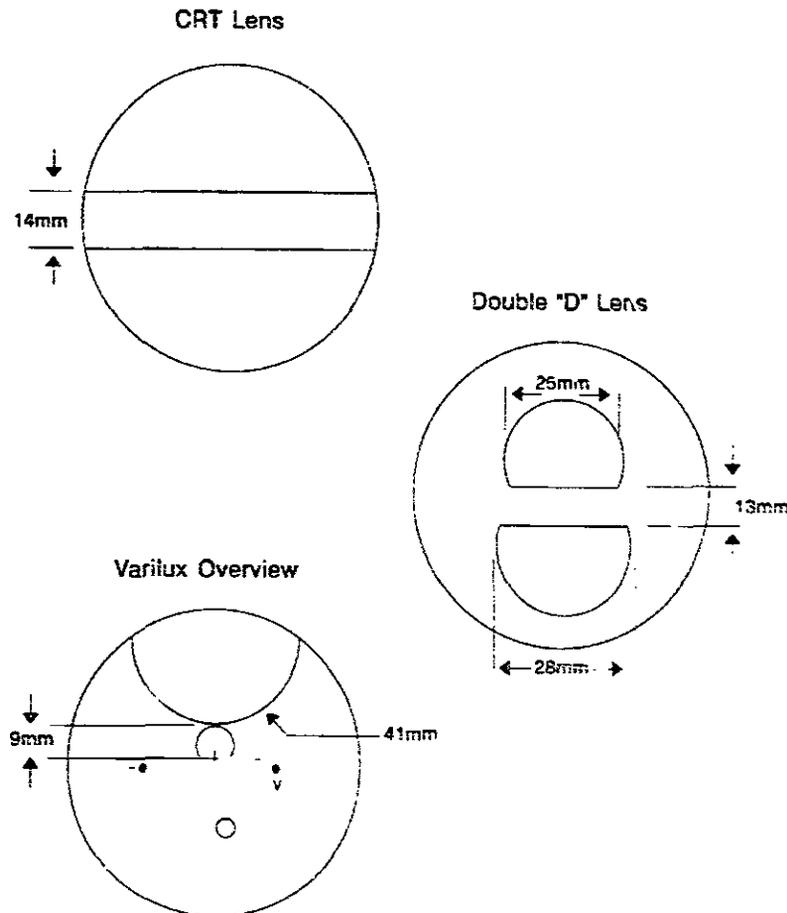
5. Opaque or translucent colored contact lenses may affect peripheral vision of the pilot (5,6), especially at dusk and at night, and should be discouraged. A visibility tint may be recommended for those visually compromised aviators who need assistance in locating their contact lens.
6. Since the pilot is exposed to many glare sources in aviation, proper eye protection from glare should be recommended. However, color vision is important to the airman, and tints that distort color vision should be avoided.
7. Polarizing spectacles reveal windscreen striations in plastic or tempered glass (7) and produce visual fatigue and distortion (8). Such lenses should be avoided.
8. A thick frame temple may break the seal of an oxygen mask. Communication headsets may affect the fit of the frame. Appropriate spectacle frames should be considered in dispensing for aviators.
9. Seating position (reclining, head forward, or normal) would have a major influence on bifocal segment heights. It is recommended that the bifocal segment be set at a height that will enable the pilot to see the instrument panel in front without interfering with distant viewing (9). To determine correct segment position, the pilot should mark the height on the lens with a grease pencil while seated in the cockpit. Presbyopic pilots who fly multiple aircraft may require different sets of spectacles for each aircraft.

FIGURE 7: STANDARD BIFOCAL AND TRIFOCAL LENSES



10. Smaller segment bifocals (e.g., ST- or D-25) allow for distant peripheral vision around the bifocal segment. However, for more sophisticated aircraft with wide instrument arrays or large navigational charts, a wider reading area (e.g., Executive bifocal) may be preferred (Note: Figure 7).
11. For presbyopic pilots who view instruments above the line of sight, an occupational or task-specific lens may be recommended. Examples include the Varilux "Overview" or a double "D" segment lens (9). The double "D" segment with a standard separation (e.g., 13 mm) of the two segments may reduce the visual field of an aviator. However, special lenses with a wider separation (e.g., 20 mm) may provide a practical solution (10). The Overview lens may not adversely affect the pilot's visual field due to the oval shape of the upper segment and the progressive power design in the lower segment (Note: Figure 7).
12. Trifocal users may find the normal intermediate segment width (7 mm) too narrow for viewing the complete instrument panel without moving the head. A lens with a modified intermediate segment (14 mm) may resolve the problem (i.e., X-Cel's CRT lens). With less sophisticated instrument panels, standard trifocals (ST-7X25, Executive) and progressive addition lenses may be recommended (Note: Figures 7 & 8).
13. Since sensitivity to glare increases with age, a recommendation to older pilots to wear darker clothes to reduce reflected light from the panel display and windscreen may be suggested.
14. Many pilots advance their seats forward on take-off and landing to improve their external visibility. In flight, aviators often move their seats back to provide more comfort to their legs and back. Therefore, pilots may be 30+ inches from the instrument panel and navigational charts 20-36

FIGURE 8: OCCUPATIONAL LENSES



inches from the eyes (10). The normal distance for a near vision correction is 14-16 inches. Focal lengths of near and intermediate vision lenses should be properly prescribed.

15. Changes in lens types (single vision to bifocal, bifocal to trifocal, bifocal to progressive addition, etc.) can affect peripheral vision and depth perception. The airman should be advised that new lenses can distort vision and alter visual cues (visual scene appears to slant, objects appear larger or smaller than actual size) while performing flight maneuvers (take-off, landing).
16. Red light in the cockpit should be avoided since it reduces accommodative ability, which is especially detrimental to presbyopic pilots. If red light is required, a more hyperopic and increased near addition lens power may be prescribed (10).

CONCLUSIONS

Civil aviation is a major industry in the United States contributing billions of dollars to the economy and providing hundreds of thousands of jobs for Americans. The percentage of airmen who are ≥ 40 years of age have increased from 36% in 1971 to more than 48% with an average age 39.8 years in 1991. During the same period, vision restrictions have increased by 28%. With aging, the use of near and intermediate corrective lenses generally increases. In the civil airman population the number of near vision restrictions has increased approximately 12% from 1981-91. The correction of near and intermediate vision conditions for older pilots will be a major challenge for the eye care clinicians in the next decade and beyond.

The FAA promotes aviation safety in civil aviation. Clinical eye specialists can contribute to aviation safety by providing therapeutic ophthalmic devices or treatments that can improve and protect the vision of airmen in the aviation environment. Knowledge of the unique vision and environmental requirements of the civilian airman can assist the clinician in suggesting alternate vision corrective devices better suited for a particular aviation activity.

REFERENCES

1. United States Department of Transportation. Administrator's Fact Book. December 1992. Washington, DC: Federal Aviation Administration. Report No. ABA-20.
2. United States Department of Transportation. Census of U.S. Civil Aircraft. December 1991. Washington, DC: Federal Aviation Administration. Office of Aviation Policy, Plans, and Management Analysis. Report No. APO-110.
3. United States Department of Transportation. The General Aviation Plan. October 1992. Washington, DC: Federal Aviation Administration. Flight Standards Service General Aviation and Commercial Division.
4. United States Department of Transportation. Aeromedical certification statistical handbook. 1971-1991. Washington, DC: Federal Aviation Administration. Civil Aeromedical Institute, Aeromedical Certification Division. Report No. AC 8500-1.
5. Good GW, Ricer C. Effects of opaque iris contact lenses upon visual field testing. *Contact Lens Spectrum*. Mar 1993; 8:33-40.
6. Insler MS, Hendricks C, George DM. Visual field constriction caused by colored contact lenses. *Arch Ophthalmol*. Dec 1988; 106:1680-2.
7. Swearingen JJ, Johnson GR. Strain patterns in aircraft windshields and visibility through polaroid sun glasses. 1948. Oklahoma City, OK: United States Civil Aeronautics Administration, Aeronautical Center, Civil Aviation Medical Research Laboratories. Report No. AC 8500-1.
8. Hart LG. Aviation vision and the optometrist. *Can J Optom*. Spring 1987; 49:20-23.
9. Holmes C, Jolliffe H, Gress J, et al. Guide to occupational and other visual needs: commercial airline pilot. 1958. Los Angeles, CA: The Vision Ease Corporation. Study No. 48.
10. Backman HA, Smith FD. Vision in the aircraft cockpit. The design and prescription of multifocal lenses for civil pilots. 1977. Lexington, MA: Irek Corporation.