HEREDITY, DISEASE AND AGEING PRESENT CREW-MEMBERS WITH INCREASED RISK OF HEARING LOSS

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Exposure to loud noises during flight operations and while off duty compounds the risk, but earplugs and headsets help counteract hearing loss.

DIFFERENT CAUSES & ICAO STANDARDS

Hearing loss has a variety of causes, some of them hereditary, some a result of disease and some a normal part of the ageing process. For pilots - and for people in many other occupations the risk of hearing loss is compounded by repeated on-the-job exposure to noise, as well as by exposure to loud noises during off-duty hours.

Standards established by the International Civil Aviation Organization (ICAO) recommend that applicants for pilot medical certificates should *"be free from any hearing defect which would interfere with the safe performance of duties in exercising the privileges of the licence".*

For a Class 1 medical certificate, ICAO standards say that applicants shall have no hearing loss, *"in either ear separately, of more than 35 [decibels (dB)] at any of the frequencies 500 hertz (Hz), 1,000 [Hz] or 2,000 [Hz], or more than 50 dB at 3,000 Hz"* (Hearing loss often does not occur at all frequencies simultaneously.)

Nevertheless, an applicant with a hearing loss exceeding those specifications could be granted a Class 1 medical certificate, according to ICAO standards, if the applicant *"has a hearing performance in each ear separately [that is] equivalent to that of a normal person, against a background noise that will simulate the masking properties of flight deck noise upon speech and beacon signals; and the applicant has the ability to hear an average conversational voice in a quiet room, using both ears, at a distance of two [meters (seven feet)] from the [medical] examiner, with the back turned to the examiner."*

In some instances, pilots who do not meet those requirements can obtain medical certificates.

For example, Scandinavian Airlines System (SAS) Capt. Erik Reed-Mohn, who flies McDonnell Douglas MD-80s and MD-90s, has had a restriction on his pilot certificate for more than two years that limits him to flying "with or as co-pilot" because of a hearing loss in one ear… *"I woke up one morning two-and-a-half years ago, and I was deaf in the right ear,"* said Reed-Mohn, who also is manager of governmental and external affairs for the SAS Flight Academy. *"I had a cold ... so I didn't think about [the hearing problem] until two days later, when the cold was gone and the hearing didn't come back."* Doctors diagnosed a viral infection in his ear and told him that most people who experience similar infections regain their hearing after six weeks to eight weeks.
In his case, that did not happen. *"My estimate is that I hear 5% [of what I heard before],"* Reed-Mohn said. *"I was grounded for two and-a-half months while I went through the tests."* The first tests assessed his hearing and balance. Other examinations were needed to ensure that he did not have a brain tumor. Reed-Mohn said that he learned later, that, if he had received steroidal treatment within 48 hours after he experienced hearing loss, he might have been able to avoid permanent damage. Today, Reed-Mohn wears a hearing aid in his right ear, and because the aircraft he flies are relatively quiet, he has experienced few problems as a result of his hearing loss, he said. *"I have to tell the co-pilot and the purser that I'm deaf in my right ear," he said. "I have to turn the volume up fairly high [on the speaker]. The only thing I miss is if a co-pilot speaks very softly ... at the same time I'm listening to [an air traffic controller or recorded information on] the radio."*

Morten Ydalus, a Boeing 737 captain for Braathens Safe, lost all hearing in his right ear in 1987, after he fell from a 15ft (five-meter) staircase, fracturing his skull in several places and destroying the right auditory nerve and cochlea. Afterward, physicians told him that he would never fly again.

"After one year of sick leave, I got to the point where I had to make a decision on "loss of licence" and my future," Ydalus said. *"When I contacted the head of [civil aviation authority] medical licensing in Norway, he said that it was a possibility that I could get back my license. ... I had to go through three weeks of medical examinations, [tests by] psychologists and several EEG [electroencephalogram] tests. I have a military background, and luckily, they had old EEGs on file. ... This probably saved my license. After several runs in the simulator, with emphasis on the ability to function with one ear, I got my license back in 1988"* [with the 'with or as co-pilot' restriction]. ...

"In the beginning, it was a little bit strange. But I adjusted, and after about one year, I really didn't think much about it. At times, the captains I flew with completely forgot that I was deaf in one ear."
When he became a captain in 1995, Ydalus said, *"I was a little worried what effect my hearing deficiency would create when I changed seats. In the start, it was worse to sit in the left seat, especially inter-cockpit communication without [an] interphone. I made it my policy to always brief my copilots on my hearing problem; in that way, they also can compensate. Flying generally works without problems."*

Stanley R. Mohler, M.D., vice chairman and director of aerospace medicine at Wright State University School of Medicine in Dayton, Ohio, U.S., said that the experiences of Reed-Mohn and Ydalus in dealing with their hearing losses are typical for airline pilots.
In most instances, pilots who lose hearing have few difficulties adjusting to flying, because they either develop their own strategies for coping with their reduced ability to hear or adjust to flight-deck use of hearing aids to compensate for hearing losses, Mobler said.

There are no special considerations involved in fitting pilots with hearing aids, which today generally are fully digital or digitally programmed analog devices that use digital signal processing to amplify sound, help the wearer hear better and - in some instances - reduce background noise, Mohler said.

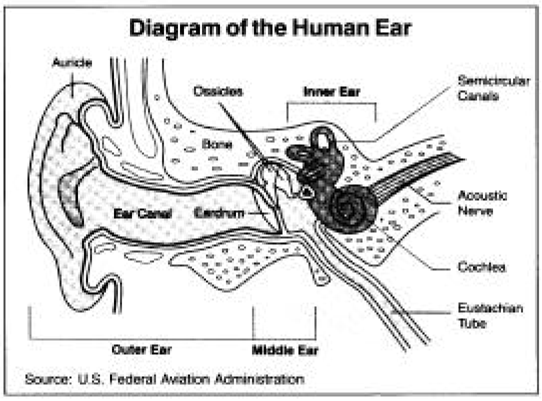

Figure 1

In the United States, the Federal Aviation Administration (FAA) issues airman medical certificates to pilots with defective hearing or deafness. Leslie Downey, administrative specialist in the FAA Aeromedical Certification Division, said that records showed that, as of 31 Dec 98, FAA medical certificates were held by 4,210 pilots in that category: 744 of those pilots held first-class medical certificates; 1,434 pilots held second-class medical certificates; and 2,032 pilots held third-class medical certificates. Of the total, medical certificates issued to 175 pilots with the most severe hearing losses - including 15 pilots with first-class medical certificates - carry a restriction that the certificate is *"not valid for flying where radio use is required."* Those pilots were required to pass medical flight tests. Also of that total, medical certificates issued to 1,263 pilots whose hearing loss is less severe including 89 pilots with first-class medical certificates - require that they wear *"hearing amplification"* during flight. In some instances, those pilots also were required to pass medical flight tests.
Noise-related hearing loss is the second-most common form of sensorineural hearing loss, that is, hearing loss associated with damage to the inner ear, auditory nerve or auditory nerve pathways in the brain. (The most common form is age-related hearing loss, also known as presbycusis.) The human ear consists of the outer ear and the ear canal; the middle ear, which includes the eardrum and an air-filled chamber containing three small bones known as ossicles;

and the inner ear, which is composed of the cochlea (the organ of hearing) and the semicircular canals (which together constitute the organ of balance) (Figure 1). The outer ear collects ambient sound waves, which are conducted through the ear canal to the eardrum, a thin, skin-covered membrane separating the outer ear from the middle ear. The sound waves cause the eardrum to vibrate, and the vibration is amplified by the ossicles, which then cause vibration in the cochlea. That vibration results in a pressure wave in the fluid inside the cochlea, and the pressure wave moves thousands of hairlike sensors on the walls of the cochlea. Their movement produces electrical signals that are transmitted by the auditory nerve to the brain, which processes the signals and identifies the specific type of sound.

Every sound has three variables: duration; frequency (the property of sound that is pitch - bass or treble, for example), which is measured in wave oscillations or wave cycles per second, known as hertz; and intensity, which is a measurement of pressure or loudness, expressed in decibels.

Humans typically can hear sounds with frequencies from about 20 Hz, below the frequencies of the lowest notes on a piano, to at least 16,000 Hz or 20,000 Hz, higher than the frequencies of the highest notes on a piccolo. Sensitivity is greatest to frequencies between 500 Hz and 4,000 Hz. Conversations, for example, typically occur between 500 Hz and 3,000 HZ.

Each decibel is equal approximately to the smallest degree of difference of loudness ordinarily detectable by the human ear, the range of which includes about 130 dB on a scale beginning with 1 dB for the faintest audible sound. Other sounds on the scale include normal conversation at about 6OdB, a ringing telephone at 80 dB and a jet engine during takeoff at 140 dB. The scale is logarithmic so an increase of 3 dB means that the sound is twice as loud and each decrease of 3dB represents a halving of loudness.

People exposed - without hearing protection - to noises of more than about 85 dB for long periods of time may experience permanent hearing loss. Temporary hearing loss may follow unprotected exposure for several hours to noises of more than about 90 dB. Unprotected short-term exposure to louder noises may cause other ailments in the ears: Discomfort may occur during even brief exposure to noises of 120 dB, pain may occur during exposure to noises of 130 dB, and the eardrums may rupture during exposure to noises of 140 dB.

"We have some evidence that [crew-members] do suffer noise-induced loss of hearing over the years of a normal career," said Claus Curdt-Christiansen, M.D., chief of ICAO's aviation medicine section .

In testimony before a December 1999 FAA public hearing on occupational safety and health issues for airline employees, Jerome C. Goldstein, M.D., a member of the board of directors of the Deafness Research Foundation, said, *"Aircraft are inherently very noisy machines, and ... our concern is that exposure to airplane noise within the cabin can have a long-term and damaging effect on hearing".* The non-profit national foundation, based in New York, New York, U.S., and established in 1958, funds research aimed at curing and preventing all forms of hearing loss. Some of the foundation's research has showed that - although decibel levels vary, depending on the type of aircraft, the phase of flight, the seat position a crew-member occupies, the altitude and the weather - cabin noise levels in a "typical jet-engine airplane at takeoff" were measured between 95 dB and 98 dB and in a turboprop airplane at about 110 dB. An older jet airplane can have cabin noise levels during cruise flight of more than 90 dB and slightly more if the airplane has tail-mounted engines, he said. (The Boeing Co. has measured noise levels on the flight decks of Boeing aircraft at between 72 dBA and 76 dBA during cruise flight. The dBA measurement is based on a scale weighted toward sounds at higher frequencies.)

In some countries, including Canada, occupational safety and health regulations for aviation workers are enforced by aviation authorities. Transport Canada, for example, enforces aviation occupational safety and health regulations included in Part 11 of the Canada Labour Code that limit the noise level exposure of crew-members and passengers to 87 dB during a 24-hour period, whether they are in the air or on the ground. If noise levels are higher, hearing protection must be worn.

In the United States, when an aircraft is in operation - that is, whenever a flight crew-member or cabin crew-member is on board, even if the aircraft is on the ground and the engines are not operating - FAA regulates noise exposure for crewmembers. U.S. Federal Aviation Regulations Part 25.771 requires that *"vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the airplane."*

Noise exposure for most other workers in the United States (including individuals working in or around aircraft that are not in operation) is regulated by the U.S. Occupational Safety and Health Administration (OSHA), which requires employers to administer hearing-conservation programs for workers whose noise exposure equals or exceeds an eight-hour time-weighted average of 85 dBA. Hearing-conservation programs include monitoring noise exposure and providing "suitable hearing protectors" for workers whose exposure exceeds the allowable limit.

In the United Kingdom the Noise At Work Regulations (1989) set a "first action level" (an average of 85 dbA over an eight-hour working day) at which employers must provide suitable personal hearing protection. A "second action level" (average of 90 dbA over eight hours) and a peak action level (200 pascals or above) both require employers to establish clearly identified "hearing protection zones". Hearing protection should be worn by employees entering these zones. Employees likely to be exposed to any level of noise above the first action level are to be provided with adequate information, instruction and training.

Gary Davis, assistant manager of the FAA Air Transportation Division, said that FAA officials are considering proposing new rules to establish hearing-conservation programs that would be based on noise-exposure limits established by OSHA but with modifications that would take into consideration the fluctuating noise levels in aircraft that may expose crew-members to high decibel levels for periods of about 15 minutes at a time. On the flight deck, pilots are exposed to multiple sources of noise - from aircraft power-plants, transmission systems, propellers, rotors, hydraulic and electrical actuators, cabin air conditioning systems and air pressurization systems, cockpit advisory systems and alert systems, and communications equipment.

PASSIVE & ACTIVE NOISE ATTENUATION

Two techniques are available to pilots for reducing the amount of cockpit noise that enters their ears : passive attenuation and active attenuation.
Passive attenuation involves imposing a physical barrier against the sound waves by using earplugs or full-cup headsets. Earplugs provide noise reduction of between 5 dB and 30 dB for frequencies below 1,000 Hz and between 30 dB and 40 dB for frequencies higher than 1,000 Hz. Passive attenuation headsets provide noise reduction of less than 20 dB for frequencies below 1,00OHz and noise reduction of between 25 dB and 40 dB for frequencies higher than 1,000 Hz.
A 1998 report by the Air Line Pilots Association, International (ALPA) about a study of various types of sound-attenuation equipment said, "The most important aspect of passive noise attenuation ... is that headsets alone provide little protection in the lower ranges of the frequency spectrum."

Active noise reduction (ANR) headsets, however, are effective in lower frequencies and work by using a small microphone near each ear to measure ambient noise. Electronic circuitry determines the prevalent lower frequency of the ambient noise, and the headset generates an opposite phase signal of the same magnitude" and sends that signal to a speaker in the ear-cup. When the new signal is combined with the ambient noise, they cancel each other. The result is silence !

The ALPA study, which included assessments of several types of ANR headsets by pilots for regional airlines and major airlines, said that the regional airline pilots preferred headsets that attenuate as much noise as possible, and pilots for major airlines preferred smaller headsets that allowed for easier communication on the flight deck while also attenuating low-frequency noise.

"In a quieter cockpit without a 'hot' intercom system [a voice-activated system that does not require other action, such as depressing a button on the control yoke], these pilots seemed to view the bulkier headsets as providing too much attenuation," the ALPA study said. *"Several pilots commented that they had to pull the earphone off of one ear just to hear the requests of the other pilot, thus defeating the purpose of the headset."*

Ydalus said that he and his B-737 copilots use headsets to listen to all communications and transmit with a boom microphone. *"We remove the ear-cup on the side [of the headset] towards the other pilot for intercockpit communication," he said. "in order to use the interphone, I have to press a button on the yoke [and] transmit with my boom [microphone], a very ... annoying procedure. Using this, you will not achieve a normal conversation."*

Curdt-Christiansen said that the use of a single earphone is "common practice" among pilots especially those in aircraft without intercoms - who want to "keep the other ear free for conversation" even though specialists have encouraged full use of headsets for hearing protection.

Andrew Ursch, aviation product manager for the David Clark Co., which manufactures aviation headsets and intercoms, said that, even when pilots are flying aircraft with relatively quiet flight decks, "there's still enough ambient background noise ... to have long-term hearing damage. Ursch said that the most effective way to address the problem is to combine the use of an ANR headset and an intercom, which allows pilots to *"turn the volume up so they can bear better."* As they adjust the volume of the intercom, the ANR headset cancels ambient noise, he said.

Hearing specialists recommend intensified efforts to educate pilots, flight attendants and others about the risks of noise-induced hearing loss, along with the use of hearing-protection devices, including earplugs and headsets. Even for those who already have experienced hearing loss, use of protective equipment should prevent further damage.

TYPES OF HEARING LOSS

Hearing loss can be caused by various conditions, including:

- Exposure to loud noises (above about 85dB) destroys the hearing receptors, hair-like sensors in the inner ear, by breaking or bending the receptors and making them less efficient. This type of hearing loss often is accompanied by tinnitus, a ringing or hissing sound that originates in the ear. Noise-related hearing loss can be prevented by wearing earplugs or ear muffs. Hearing aids often are useful for people with severe noise-related hearing loss;

- Age-associated hearing loss, which appears to be related partly to the extent of an individual's lifetime exposure to noise, causes sensorineural hearing loss, that is, hearing loss associated with damage to the inner ear, auditory nerve or auditory nerve pathways in the brain. Age-associated hearing loss begins after age 20 and affects men more often than women. Hearing aids often are prescribed;

- A mechanical obstruction, such as an accumulation of ear wax in the ear canal or an accumulation of fluid in the middle ear, can block conduction of sound, causing conductive hearing loss. The condition can be treated by removing the wax or draining the fluid;

- A hereditary problem, exposure to loud noise, an infection of the inner ear, specific medications and specific diseases (such as Meniere's disease, which also is characterized by tinnitus and dizziness) can damage the inner ear, auditory nerve or auditory nerve pathways in the brain, causing sensory hearing loss. Treatments vary;

- Brain tumors, infections, brain disorders and nerve disorders (such as those caused by strokes), and specific hereditary diseases (such as Refsum's disease, in which tissues accumulate phyantic acid, a product of fat metabolism) can damage nerves, causing neural hearing loss. Treatments vary; and,

- Demyelinating diseases (which destroy the nerve covering) can damage auditory nerve pathways in the brain, also causing neural hearing loss.