E•A•RCAL[SM] Laboratory

From: Elliott H. Berger

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Re: Pressure changes experienced due to use of earplugs in flight

Use of earplugs in flight in both jets and commuter aircraft can provide a more relaxing and enjoyable experience, and improve one's ability to ignore distracting/annoying noises and conversations, to be better able to work or sleep. Many types of earplugs can provide these benefits. The purpose of this article is to discuss potential safety concerns that may arise from such use due to changes in cabin pressure, and whether earplugs may exacerbate or mitigate such issues.

Noise levels on jet aircraft generally range from the upper 70-decibel (dB) range to the lower 80s, although in the aft end of rear-engine jets the sound levels can be even higher. Though generally not hazardous to one's hearing for the durations typically encountered, these levels can be annoying and fatiguing. However, the levels on small commuter aircraft can be even higher, sometimes approaching the hazardous range. Foam earplugs can provide very high levels of consistent and achievable protection in these environments.

Another feature of air flight is the change in cabin pressure due to ascent or descent, or loss of pressurization. Changes in cabin pressure will affect the air contained within the middle ear cavity thus exerting force on the eardrum, and may also affect the eardrum from the other side if air is entrapped within the earcanal by the presence of an earplug.

Generally, notable or serious problems only occur during descent, since under conditions of either ascent or loss of pressure while at altitude, the changes in ambient pressure are in the direction of a decrease rather than an increase. In the case of ascent the pressure in the middle ear or under the plug (i.e., between the plug and the tympanic membrane) is greater than ambient, and air simply passes out of the system. This occurs since the eustachian tube (which connects the throat and sinuses to the middle ear) allows air to pass outwards relatively easily, like air being expelled from a balloon. For earplugs, pressure can be released by the plug either backing out of the earcanal or breaking its seal, or through the plug itself if its materials or construction are designed with that in mind.

Under conditions of descent, and especially in the extreme case of rapid and uncontrolled descent, problems can arise. Air does not easily pass in through the eustachian tube (like trying to inflate a new and tight balloon), and thus the pressure in the middle ear may be lower than ambient. Presuming the case of an unplugged ear, a pressure differential will arise across the tympanic membrane (due to the increasing pressure in the earcanal) causing the drum to bulge inward. This can be painful and in extreme cases, such as rapid descent from 18,000 feet to sea level, a difference in pressure of half an atmosphere could be produced. The eardrum would be forced in with a pressure equal to that of a column of mercury 380 mm (~15 in.) high, causing a rupture.

Eardrum ruptures, although dramatic and painful, usually heal spontaneously if kept clean, and protected from infection. Typically there will be no resultant permanent impairment of hearing.

When an ear is plugged with a premolded plug, or other type of insert that causes a pneumatic (airtight) seal, then an additional chamber of entrapped air is created, i.e., one between the earplug and eardrum, in addition to the one in the middle ear cavity. During descent, when ambient pressure increases, the plug will be forced inwards since the air cannot pass the plug. This can be painful and make the plug more difficult to withdraw. Hematomas of the canal lining may result. However, eardrum rupture is still unlikely to occur. As long as the wearer can reach the plug to withdraw it and break the seal, no discomfort should result.

The preferred case is a plug that "leaks," i.e. an earplug that blocks sound waves but at the same time allows a measured passage of air into the earcanal to limit the rate of increase of pressure on the outside of the eardrum. Foam earplugs like the E•A•R® Classic® plugs, or specially designed plugs like the EarPlanes premolded earplugs with CeramX™ Filters, provide this type of slow leakage. In the case of the earplug, the leakage is between the foam and the surrounding earcanal surfaces and/or through the foam itself, and in the case of the premolded plugs, thru the internal filter element. Therefore these plugs do not create an airtight seal. This assures the best safety and comfort in flight, as is supported (in the case of vinyl foam earplugs) by over 30 years of experience in the U. S. Air Force (Berger and Gasaway, 1990).

Anecdotal evidence suggests that some passengers may even experience less ear discomfort with these slowly leaking earplugs than when no earplugs are worn at all. This presumably occurs because these plugs reduce the rate of change of pressure that is experienced in the earcanal. In turn this provides more time for the eustachian tube to balance the pressure in the middle ear in order to equalize the force on the two sides of the eardrum. For this function to be effective, the plugs must be inserted while at maximum altitude before descent begins. Better yet wear them for the entire flight to fully benefit from possible benefits during ascent, and from the noise reduction that they provide.

In conclusion, earplugs are not only safe and comfortable for use in flight, but can be recommended for protection from noise for a more enjoyable flight experience. In the case of foam earplugs and specially designed filtered earplugs they may even reduce discomfort due to pressure changes in the aircraft cabin.

Berger, E. H. and Gasaway, D. C. (1990). " Use of earplugs in flight," E•A•R 90-6/HP, Aearo Technologies, Indianapolis, IN.