NIOSH HEALTH HAZARD EVALUATION REPORT

HETA #2002-0354-2931
Horizon Air
Seattle, Washington

February 2004

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

PREFACE

The Hazard Evaluation and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employers or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Randy L. Tubbs of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Chad Dowell, HETAB. Desktop publishing was performed by Shawna Watts. Review and preparation for printing were performed by Penny Arthur.

Copies of this report have been sent to employee and management representatives at Horizon Air, the Association of Flight Attendants, AFL-CIO, and the Federal Aviation Administration. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed from the following internet address: www.cdc.gov/niosh/hhe/hhesearch.html. Single copies of this report will be available for a period of three years from the date of this report. To expedite your request, include a self-addressed mailing label along with your written request to:

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Aircraft Cabin Noise at Horizon Air

Flight attendants requested that NIOSH evaluate noise exposures during aircraft operations. The noise levels encountered during flight in the Q200, Q400, and CRJ jet were measured in the front, middle, and rear sections of the cabin during scheduled flights. Two examples of each type of aircraft were surveyed.

What NIOSH Did

- We measured noise levels in the cabins of six aircraft. This was done during take-off, landing, and at cruising altitude.
- We spoke to the flight attendants about their noise concerns.

What NIOSH Found

- The noise levels on individual flights are not great enough to increase a flight attendant's or passenger's risk for hearing loss.
- If the NVS system is not working on turboprop aircraft, there could possibly be noise overexposure.
- The pattern of noise measured in the cabin is of a type that can lead to interference in communication between employees and between employees and the passengers.

What Horizon Air Managers Can Do

- Aircraft with broken NVS systems should be grounded until they are repaired.
- Horizon Air should apply for approval from the FAA for flight attendants to wear hearing protection devices when the NVS system does not operate and the aircraft must be flown.
- Once approval for hearing protection devices is obtained, "musician-type" ear plugs should be given to a small group of flight attendants to see how they change listening conditions in the cabin.

What the Horizon Air Employees Can Do

- Flight attendants should report NVS systems that do not appear to be working.
- Flight attendants should volunteer to wear specialized hearing protection devices to see if they improve listening conditions in the cabin.
- Crew members should wear hearing protection devices whenever they are outside of the aircraft on the tarmac.

CDC Workplace Safety and Health

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HETA Report #2002-0354-2931

NIOSH

Health Hazard Evaluation Report 2002-0354-2931
Horizon Air
Seattle, Washington
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Randy L. Tubbs

SUMMARY

A request for a health hazard evaluation (HHE) from flight attendants at Horizon Air in Seattle, Washington, was received by the National Institute for Occupational Safety and Health (NIOSH) on September 23, 2002. The flight attendants were concerned that their long work shifts may result in overexposure to noise from the airplanes to which they were assigned. Particular concern was noted about Horizon Air's fleet of turboprop aircraft when the noise and vibration suppression (NVS) system was inoperable.

An initial site visit was made to Horizon Air in Portland, Oregon on November 12, 2002, to meet with a management official and the local flight attendant's union president to describe the survey. Once approval to operate noise measuring equipment aboard aircraft was obtained, a survey of the three types of aircraft used by Horizon Air, the Bombardier Q200 and Q400 turboprop and CRJ regional jet, was conducted from May 19-22, 2003. Two examples of each aircraft type were chosen by the company, and the NIOSH investigator traveled on several scheduled flights to capture noise levels in the front, middle, and rear of the passenger cabin. One-third octave band spectra were integrated for 15-second periods and stored in the noise analyzer for later analysis. Five minutes of the noise exposures encountered during take-off, landing, and at cruising altitude were stored for each aircraft. This measurement protocol allowed for the reporting of one-third octave band noise spectra for the various riding locations along with overall A-weighted and unweighted noise levels. An estimate of the flight attendants' noise dose was calculated from the spectral measurements collected on each flight.

Noise measurements showed that the levels encountered on individual flights were not enough to increase an employee's or the public's risk for hearing loss, and therefore, no health hazard was identified. Even when the noise exposures from the multiple flights taken by the flight attendants during a day's schedule were combined, the attendants would need to take 12-24 of these flights per day before realizing an increased risk of occupational hearing loss. The noise results along with data published by Bombardier do show that the NVS system needs to be operating according to specifications to keep the noise levels below evaluation criteria. Recommendations about hearing protection and the NVS system are offered in this report.

Keywords: SIC4512 (Air Transportation, Scheduled), flight attendants, noise, spectral levels, noise dose, hearing protection devices, HPDs

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INTRODUCTION

On September 23, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request from flight attendants to conduct a health hazard evaluation (HHE) at Horizon Air in Seattle, Washington. The requestors were concerned about the noise exposures encountered by flight attendants in the cabin of the aircraft used by the airline. Their concern was that flight attendants can work 12-13 hours per day, which might expose them to noise for a sufficient duration to place them at risk for occupational hearing loss. However, they felt that the noise levels experienced by the public were most likely not hazardous because of the relatively short time they spend on the aircraft.

A NIOSH investigator visited Horizon Air in Portland, Oregon, on November 12, 2002, and met with Horizon Air management and the president of the Association of Flight Attendants, Horizon Council 17 to discuss the HHE request and a plan to survey the noise encountered by the flight attendants. At this meeting, it was decided to measure area noise spectra in different locations of the cabin while transporting passengers on scheduled flights. Only one location in the cabin would be measured during a flight to minimize movement of the investigator within the cabin while in the air. After a delay in receiving approval for the NIOSH equipment to be used onboard during scheduled flights, the evaluation was conducted the week of May 19, 2003. At the end of the last day of measurements, a closing conference was held with company and union representatives to discuss the activities of the survey and show the kind of results that would be disseminated in the final report.

BACKGROUND

Horizon Air was founded in Seattle, Washington, in 1981. In 1986, the company was acquired by Alaska Air Group, Inc., but remained independently managed. The general office is located in Seattle and its primary maintenance base is in Portland, Oregon. It currently has about 4000 employees and serves more than 40 cities in the Pacific Northwest. The fleet consists of 37-seat Bombardier Q200 and 70-seat Bombardier Q400 turboprop aircraft and 70-seat Bombardier CRJ-700 regional jets. The Fairchild F-27 turboprop aircraft had been phased out of Horizon Air's fleet at the time of the HHE and was not included in any of the measurements. The Q200 has two turboprop engines with four-blade propellers. The wings connect to the top of the fuselage near the middle of the cabin. The Q200 has a maximum cruise speed of 334 miles per hour (mph). The Q400 has two turboprop engines with six-blade propellers. The wings connect in a manner similar to the Q200 aircraft. The Q400 has a maximum cruise speed of 414 mph. The CRJ-700 has two turbofan jet engines that connect to the fuselage near the rear of the aircraft. The regional jets have a maximum cruise speed of 544 mph. On the Q200, the flight attendant seat is next to the main cabin door facing the rear of the aircraft. On the Q400, there is the same seat forward and also a second jumpseat in the galley between the two aft exit doors. On the CRJ-700, one flight attendant seat is next to the main cabin door behind the cockpit door facing the rear of the aircraft. The other flight attendant seat is forward facing in the back of the plane next to the lavatory.

Both styles of turboprop aircraft are equipped with a noise and vibration suppression (NVS) system that reduces the vibrations in the fuselage, which stops much of the noise from reaching the cabin through an active control technology. During flight, microphones throughout the cabin transmit noise information to a computer. Additional information on propeller speed is also fed to the computer. The computer continuously analyzes this information and sends signals to active tuned vibration absorbers mounted on the fuselage frame. The absorbers produce vibration that is 180° out of phase with the engine vibrations, thus reducing the original vibrations before they are transmitted to the passenger cabin.

The concerned flight attendants reported experiencing pain and ringing in their ears by the end of their shift. The noise reportedly was particularly bad on the smaller Q200 aircraft. Often the employees had to work on turboprop aircraft with the NVS system out of order which made the noise situation worse. The attendants reported that the airline did not allow them to wear hearing protection devices (HPDs) to protect their ears from the noise.

METHODS

A flight schedule was arranged by Horizon Air which allowed the NIOSH investigator to be on three consecutive flights of the same aircraft. This schedule was repeated for two different aircraft from each of the three types flown by the company. Thus, the first two days of the survey were spent measuring noise levels in two Q200 and two Q400 airplanes. The regional jet measurements were made on the last two days of the survey. Because of scheduling changes on the second day of regional jet measurements, the third leg of the CRJ-700 was made on a different aircraft than the first two legs of the itinerary. On each aircraft tested, the NIOSH investigator was seated in a front, middle, or back location in the cabin during an entire leg of the flight collecting spectral noise measurements during takeoff and landing, and at cruising altitude.

The spectral noise measurements were made with a Larson-Davis Laboratory Model 2800 Real-Time Analyzer and a Larson-Davis Laboratory Model 2559 ½" random incidence response microphone. The microphone was connected to the analyzer with a 6-ft. cable. The analyzer allows for the analysis of noise into its spectral components in a real-time mode. The ½"-diameter microphone has a frequency response range (± 2 decibels [dB]) from 4 Hertz (Hz) to 21 kilohertz (kHz) that allows for the analysis of sounds in the region of concern. One-third octave bands consisting of center frequencies from 25 Hz to 20 kHz were integrated for 15 seconds and stored in the analyzer. The analyzer was set in the auto-store mode so that a 15-second sample was automatically stored at the end of the period and the analyzer reset to instantly begin the next 15-second sample period. The series of sample periods was continued for a total of 5 minutes, thus yielding 20 samples for each of the aircraft activities. Takeoff sampling was started when the aircraft first began to move on the runway and ended 5 minutes later. Samples taken at cruise altitude were collected once the aircraft had leveled off in the sky for a period of 5 minutes. Finally, landing samples began when the pilot lowered the landing gear and continued for 5 minutes or, in some cases, until the aircraft came to a stop at the gate.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits

(RELs),[1] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[2] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[3] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criteria.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

Noise-induced loss of hearing is an irreversible, sensorineural condition that progresses with exposure. Although hearing ability declines with age (presbycusis) in all populations, exposure to noise produces hearing loss greater than that resulting from the natural aging process. This noise-induced loss is caused by damage to nerve cells of the inner ear (cochlea) and, unlike some conductive hearing disorders, cannot be treated medically.[4] While loss of hearing may result from a single exposure to a very brief impulse noise or explosion, such traumatic losses are rare. In most cases, noise-induced hearing loss is insidious. Typically, it begins to develop at 4000 or 6000 Hz (the hearing range is 20 Hz to 20000 Hz) and spreads to lower and higher frequencies. Often, material impairment has occurred before the condition is clearly recognized. Such impairment is usually severe enough to permanently affect a person's ability to hear and understand speech under everyday conditions. Although the primary frequencies of human speech range from 200 Hz to 2000 Hz, research has shown that the consonant sounds, which enable people to distinguish words such as "fish" from "fist," have still higher frequency components.[5]

The A-weighted decibel (dBA) is the preferred unit for measuring sound levels to assess worker noise exposures. The dBA scale is weighted to approximate the sensory response of the human ear to sound frequencies near the threshold of hearing. The decibel unit is dimensionless, and represents the logarithmic relationship of the measured sound pressure level (SPL) to an arbitrary reference sound pressure (20 micropascals, the normal threshold of human hearing at a frequency of 1000 Hz). Decibel units are used because of the very large range of sound pressure levels which are audible to the human ear. Because the dBA scale is logarithmic, increases of 3 dBA, 10 dBA, and 20 dBA represent a doubling, tenfold increase, and 100-fold increase of sound energy, respectively. It should be noted that noise exposures expressed in decibels cannot be averaged by taking the simple arithmetic mean.

The OSHA standard for occupational exposure to noise (29 CFR 1910.95)[6] specifies a maximum PEL of 90 dBA for a duration of 8 hours per day. The regulation, in calculating the PEL, uses a 5 dB time/intensity trading relationship, or exchange rate. This means that a person may be exposed to noise levels of 95 dBA for no more than 4 hours, to 100 dBA for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dBA is allowed by this exchange rate. The duration and sound level intensities can be combined in order to calculate a worker's daily noise dose according to the formula:

$$\text{Dose} = 100 \text{ X } (C_1/T_1 + C_2/T_2 + ... + C_n/T_n),$$

where C_n indicates the total time of exposure at a specific noise level and T_n indicates the reference duration for that level as given in Table G-16a of the OSHA noise regulation. During any 24-hour period, a worker is allowed up to 100% of his daily noise dose. Doses greater than 100% are in excess of the OSHA PEL.

The OSHA regulation has an additional action level (AL) of 85 dBA; an employer shall administer a continuing, effective hearing conservation program when the 8-hour time-weighted average (TWA) value exceeds the AL.

The program must include monitoring, employee notification, observation, audiometric testing, hearing protectors, training, and record keeping. All of these requirements are included in 29 CFR 1910.95, paragraphs (c) through (o). Finally, the OSHA noise standard states that when workers are exposed to noise levels in excess of the OSHA PEL of 90 dBA, feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard,[7] and the ACGIH,[2] propose exposure criteria of 85 dBA as a TWA for 8 hours, 5 dB less than the OSHA standard. The criteria also use a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, a worker can be exposed to 85 dBA for 8 hours, but to no more than 88 dBA for 4 hours or 91 dBA for 2 hours. Twelve-hour exposures have to be 83 dBA or less according to the NIOSH REL.

RESULTS

Fifteen-second, one-third octave band samples of the cabin noise were collected for 5 minutes each during take-off, landing, and at cruise altitude for the Q200, Q400, and CRJ aircraft. These noise samples were obtained in three different seat locations in each aircraft; the front, middle, and rear of the cabin. Each individual sample contains the 1/3 octave band sound levels from 25 Hz through 20000 Hz along with the overall unweighted SPL and the overall dBA levels. The overall median SPLs measured for the Q200, Q400, and CRJ were 96.6 dB, 93.4 dB, and 93.3 dB, respectively, for all seat (front, middle, and back) and operation (take-off, cruise, and landing) conditions. For noise measurements made with the A-weighting function applied, the three aircraft types had median levels of 80.7 dBA, 80.9 dBA, and 80.0 dBA for the Q200, Q400, and CRJ, respectively, across all conditions. For the turboprop aircraft, these measurements were obtained with the NVS operational.

To further define the noise measurements, the data were analyzed by flight activity and seat location for each aircraft type. These data are presented in Table 1. There was little difference in the A-weighted noise levels at cruise altitude between the three aircraft types. The highest measured median levels were 83.8 dBA, 83.2 dBA, and 84.3 dBA for the Q200, Q400, and CRJ, respectively. These levels were measured in the front of the passenger compartment for the two turboprop aircraft and in the rear area of the commuter jet. Comparisons between the weighted and unweighted noise levels found relatively large differences. At cruising altitude, the Q200 noise levels were 17.4 dB higher for the unweighted measurements, 14.5 dB higher in the Q400, and 15.4 dB higher in the CRJ. The spectral data from the three aircraft types reveal the high levels of low frequency sound as shown in Figures 1-3. The low frequency noise component is more pronounced in the turboprop aircraft. For the Q200, maximum SPL is seen at 63 and 80 Hz, along with a maximum at the harmonic frequencies of 125 and 160 Hz. For the Q400, the maximum SPL is at 80 Hz. The CRJ does not exhibit such a distinct maximum SPL. The highest level was recorded at 100 Hz during aircraft operations at cruise altitude.

During take-off, the highest median noise levels for the five-minute measurement period were 81.7 dBA, 83.7 dBA, and 83.1 dBA for the Q200, Q400, and CRJ, respectively (Table 1). The seat location where these measurements were captured was in the front for the Q200 and in the rear of the passenger compartment for the Q400 and CRJ. During landing, the highest median noise levels for the three aircraft were found to be less intense. Levels of 79.9 dBA, 79.6 dBA, and 78.9 dBA were measured in the same seat locations as for take-off in the Q200, Q400, and CRJ, respectively. The above noise levels are median values over the entire five-minute measurement periods which do not take into account the individual variations in noise emissions during take-off and landing operations. Inspection of each 15-second measurement revealed similar patterns in the three aircraft surveyed. The highest levels for the Q200 were 87.0 dBA and 88.2 dBA for take-off (middle seat) and landing (front seat) during a 15-second measurement. These maximum levels consistently occurred during the first 30 seconds of take-off and during the 45 seconds following touchdown on the runway. For the Q400, the highest take-off measurement was 91.8 dBA in a middle seat and 88.4 dBA in a back seat. The same pattern of occurrence during take-off and landing operations was seen in the Q400 as was observed in the Q200. The maximum levels measured during take-off and landing occurred later in the operation for the CRJ. The highest measurements were 90.0 dBA during take-off and 90.3 dBA during landing, both in a middle seat. These maximum levels generally happened 2-3 minutes after the aircraft initiated movement on the runway during take-off and about 1 minute after touchdown.

To compare the flight attendants noise exposures to the NIOSH evaluation criteria, dose calculations for each of the five-minute measurement periods were made according to the NIOSH REL formula. The allowable time (T) at the measured dBA level (L) was determined according to the following formula.[7]

$$T(\text{min}) = \frac{480}{2^{(L-85)/3}}$$

The accumulated dose for each flight leg was calculated by adding the dose at take-off with the dose measured during landing along with the noise dose accumulated during the time at cruising altitude. For the calculations, it was assumed that the 5 minutes measured at cruising altitude would be representative of the complete time the aircraft was in the air. Therefore, the landing and take-off times were subtracted from the total flight time. The remaining time was used to prorate the dose that would accumulate during the total cruising altitude period. For example, for a 60-minute flight, the take-off time (5 minutes) and landing time (5 minutes) are subtracted from the total flight time leaving 50 minutes of cruising altitude time. The accumulated dose for the measured five-minute period is multiplied by 10 (10, five-minute periods in the remaining 50 minutes of cruising altitude) giving the dose for cruising. The cruising dose is added to the landing dose and the take-off dose, yielding the total dose for that particular flight. These values for the three riding positions in each of the six aircraft evaluated during the survey are shown in Table 2. Flight times ranged from 15 minutes to 98 minutes. The shortest measured flights of 15 minutes yielded an accumulated dose of less than 1%. The maximum dose calculated for the flights was 11.44% for an approximate one-hour flight in the back of a Q400. If this dose was the only noise to which an individual was exposed on that day, this would equate to an 8-hour TWA of 75.6 dBA.

DISCUSSION

The highest median noise levels for all three types of aircraft measured at cruising altitude were 83-84 dBA over the five-minute measurement period. Noise levels were measured between 87 and 92 dBA during take-off and landing operations. While some of these noise levels exceed the NIOSH and OSHA recommendations and regulations,[1,6] it should be noted that these reported values are for very short time frames, 15 seconds or 5 minutes. To compare these measured noise levels to the criteria, the person would have to be constantly exposed to the noise for 8 hours to produce a TWA. However, both flight attendants and airline customers are not constantly exposed to these noise levels. The data in Table 2 show the longest flight taken during this survey was 98 minutes which accounted for 6.0% – 6.5% of a daily noise dose which is allowed to reach 100% and still be within the REL. For the airline customer, these individual flight exposures represent very little risk for hearing loss. The highest measured dose was 11.4% for a one-hour flight in the rear of the Q400. The flight crew on this same flight was also on the other two legs of the Q400 for that day and they would have accrued a total of 24.1% of their daily noise dose during this schedule. Using this group of flights as an example, a crew could fly these three legs up to four times in a day and still not exceed the NIOSH REL. For the flight attendants on the Q200, the three legs yielded accumulated noise doses of 8.9% and 12.5% for flight times of 99 and 107 minutes, respectively.

A crew would be able to fly this triad flight schedule eight times in a day and be equal to the NIOSH REL. On the longer CRJ flights, the attendants accrued a total of 19.0% and 17.4% daily noise doses for the three flight legs equaling 213 and 211 minutes, respectively. This kind of schedule could be repeated five times in a day and result in noise levels below the REL.

A major complaint reported in the HHE request by the flight attendants was flying the turboprop aircraft when the NVS system was not operating. This condition did not occur during the NIOSH evaluation. However, it is possible to reasonably predict what the noise levels would be if the system was not operational. The maker of the Q200 and Q400 has information on their website about the noise suppression capabilities of the NVS system.[8] They supply a figure on the harmonic components of the aircraft cabin noise both with and without the NVS activated. At 80 Hz, one of the predominant frequencies measured in the Q200 and Q400 in this survey (Figure 1 and 2), they report a noise reduction of 11.3 dB afforded by the suppression system. At 160 Hz, the reduction is reported at 17.0 dB. This noise suppression system is necessary to keep the cabin noise below the OSHA and NIOSH noise criteria. A 10-15 dBA increase in cabin noise would change the levels measured at cruising altitude in this survey to 93-98 dBA, which would increase the risk of potential hearing damage to employees if the exposures were allowed to continue for long periods. At 98 dBA, the NIOSH REL allows a daily exposure for 23 minutes and 49 seconds, a time period well within the flight attendants' routine flight schedules.

The Federal Aviation Administration (FAA), U.S. Department of Transportation, published a Federal Register notice in 1975 asserting its complete and exclusive responsibility for the regulation of occupational safety and health standards of employees engaged in civil aircraft operations.[9] Because OSHA has statutory authority governing the occupational safety and health of most employees, the FAA and OSHA entered into a Memorandum of Understanding in August 2000 to establish a procedure for coordinating and supporting enforcement of the Occupational Safety and Health Act with respect to the working conditions of employees on aircraft in operation (other than flight deck crew) and for resolving jurisdictional questions. An FAA / OSHA Aviation Safety and Health Team was formed and a report was issued in December 2000. Included in this report was a section on occupational exposure to noise where the team looked at the application of OSHA's general industry standards on occupational noise to employees on aircraft in operation. Although the team reports that they have no data as to the levels of noise encountered by employees during operation, they felt that many of the OSHA provisions, such as training and testing, could be applied without any effect on aviation safety. However, the team felt that engineering and administrative controls and the use of HPDs would impact aviation safety and would therefore require FAA approval. On June 18, 2002, the Aviation Safety and Health Team released an Action Plan proposing an Aviation Safety and Health Partnership Program which would expand the FAA's role in worker safety and health issues. OSHA's role in this program would be advisory only. On May 15, 2003, the FAA issued a Departmental Order (1110.134) describing a voluntary Aviation Safety and Health Partnership Program (ASHPP) with a rulemaking committee consisting of members from the FAA, air carriers, and air carrier employee unions.

While it appears that the use of HPDs during airborne operations by flight attendants requires FAA approval, the noise levels measured in this HHE survey show that they may not be necessary to protect the hearing of the employees under normal operating circumstances. The noise intensities and the flight durations do not exceed the NIOSH REL for occupational noise. However, the use of specialized HPDs by flight attendants may help improve communication conditions between attendants and between the attendants and the passengers. The spectral noise data show three or four third-octave bands that are greater than the rest of the bands, particularly for the turboprop aircraft (Figures 1-2). These predominant bands are low frequency sounds, between the 63 and 250 Hz center frequencies. They will mask the speech levels contained within these bands as well as mask higher frequency speech signals due to an upward spread of masking.[10] The NIOSH spectral data are confirmed by the data reported by the manufacturer.[8] There are HPDs on the market that are characterized as flat spectrum, moderate attenuation devices, sometimes referred to as "musician earplugs".[11] They offer levels of attenuation from 9 – 25 dB and tend to lower sound equally over the entire spectrum. Thus, they do not have the characteristic shape of increasingly higher attenuation of sound in the high frequencies. For the turboprop aircraft, this type of HPD would reduce the low frequency sound that tends to mask speech while not adversely lowering the higher frequencies that contain consonant sound information.

CONCLUSIONS

The results of this survey show that the flight attendants who work on the Q200 and Q400 turboprop aircraft and the CRJ regional jet should not be exposed to enough hazardous noise in the passenger cabin during normal flight operations (including a fully functional NVS system) to adversely affect their hearing. The noise doses calculated from the data demonstrate that flight attendants could fly 12 to 24 legs per day, five days a week, of the type surveyed by NIOSH in this evaluation. It must be noted that measurements were not made for other situations where flight attendants may receive additional noise exposures, such as when aircraft are parked on the tarmac waiting for customers to board and disembark the aircraft. These noise doses would be added to the values calculated for the cabin during flight operations to calculate the daily noise burden. For the general public who fly only 1-3 legs in a day, there is no risk for hearing loss solely from the exposures that they would encounter in the aircraft surveyed.

The use of HPDs by the flight attendants is not necessary to protect them from noise experienced in the cabin under normal operating conditions. However, when the NVS system is not operating on the Q200 or Q400, the noise levels could be intense enough to warrant their use. Also, the noise levels around the aircraft while they are parked on the tarmac are loud enough to necessitate the use of HPDs by crew members who must walk around the aircraft.[12] The flight attendants may also want to try some of the moderate attenuation, flat spectrum devices available on the market to help improve communications during flight operations. However, FAA approval appears necessary for HPD use by the flight attendants.

RECOMMENDATIONS

Based on the findings and observations of this evaluation and on other research published on airline noise exposures, the following recommendations are offered to Horizon Air to improve the work environment of their flight attendants.

1. The NVS system on the turboprop aircraft is necessary to keep cabin noise levels below workplace regulations and guidelines. The flight crew needs to report system malfunctions to maintenance immediately when they feel the system is not working. Horizon Air should take these aircraft out of service until repairs are made because the increased noise levels will exceed workplace regulations within the time period that these aircraft normally fly between scheduled destinations. If they must be flown, HPDs should be available to the crew and the passengers to reduce exposures until the NVS system is operational. If FAA approval is necessary for HPD usage, then the company should begin to seek approval as soon as is possible to prevent noise overexposures during equipment malfunction.

2. If FAA approval of hearing protection is obtained for the flight attendants, a small program should be initiated to evaluate the flight attendants perceptions of changes in communications between attendants and pilots, attendants and passengers, and between themselves when the musician-type ear plugs are worn during all or part of the flight.

3. Hearing protection should be available to all flight crew members for use whenever personnel are required to leave the aircraft and move about the tarmac. Several of the airports surveyed by NIOSH had commuter aircraft park on the tarmac in close proximity to each other. Even if the aircraft to which a crew member is assigned has turned off its engines, adjacent aircraft may still be producing high levels of noise. Additional noise can come from ground equipment used during operations, such as ground power units (GPUs) and air-conditioning carts.

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Table 1
Median Noise Levels for Seat Location and Operation in Each Aircraft Type
Horizon Air
Seattle, WA
HETA 2002-0354
May 19-22, 2003

Flight Operation	Seat Location	Q200		Q400		CRJ	
		dB SPL	dBA	dB SPL	dBA	dB SPL	dBA
Take-off							
	Front	97.9	81.7	92.1	78.9	83.8	75.8
	Middle	95.8	79.8	95.0	81.9	92.5	79.9
	Back	100.5	80.4	97.7	83.7	97.8	83.1
Cruise							
	Front	101.2	83.8	90.9	83.2	84.0	80.1
	Middle	92.9	78.7	93.8	82.7	95.9	80.5
	Back	99.2	81.2	97.0	82.5	95.5	84.3
Landing							
	Front	90.5	79.9	87.7	77.3	89.7	74.6
	Middle	88.3	75.8	89.7	75.3	94.5	77.6
	Back	93.4	78.2	93.5	79.6	92.6	78.9

The median overall noise levels, both unweighted (dB SPL) and weighted (dBA), from the real-time analyzer are shown for the three riding positions during each of the three flight operations. The Q200 and Q400 are turboprop aircraft and the CRJ is a regional jet aircraft.

Table 2
Accumulated Noise Doses for Seat Location in Each Aircraft
Horizon Air
Seattle, WA
HETA 2002-0354
May 19-22, 2003

Aircraft	Seat	Origin	Destination	Flight Time [min]	Dose	8-hr TWA [dBA]
Q200 - #360						
	1B	Portland	Pendleton	41	4.83%	71.8
	4D	Pendleton	Pasco	15	0.70%	63.5
	8E	Pasco	Portland	43	3.39%	70.3
Q200 - #354						
	1B	Portland	Pendleton	42	7.47%	73.7
	5E	Pendleton	Pasco	15	0.97%	64.8
	8E	Pasco	Portland	50	4.09%	71.1
Q400 - #407						
	1B	Portland	Redding	63	6.70%	73.3
	8A	Redding	Eureka/Arcata	27	2.32%	68.6
	18E	Eureka/Arcata	Portland	61	5.50%	72.4
Q400 - #413						
	1B	Portland	Redding	61	9.15%	74.6
	8D	Redding	Eureka/Arcata	24	3.54%	70.5
	17E	Eureka/Arcata	Portland	63	11.44%	75.6
CRJ - #604						
	1B	Seattle/Tacoma	Fresno	98	6.03%	72.8
	9A	Fresno	Portland	85	6.71%	73.3
	15D	Portland	Seattle/Tacoma	30	6.28%	73.0
CRJ - #605						
	1B	Seattle/Tacoma	Fresno	98	6.54%	73.2
	9A	Fresno	Portland	89	6.86%	73.4
#614	15D	Portland	Seattle/Tacoma	32	3.96%	71.0

The calculated dose percentages were obtained from the spectral data collected on the aircraft and are shown for each flight taken by the NIOSH investigator. The dose from the five minute take-off period plus the dose from the five minute landing period were added to the dose calculated for the cruising altitude value over the remaining flight time period. The 8-hr TWA is calculated from the dose percentage according to the NIOSH formulation.

Figure 1
One-Third Octave Band Spectra
Q 200 - Cruise Altitude, Front of Cabin
Horizon Airlines
Seattle, WA
May 19-22, 2003

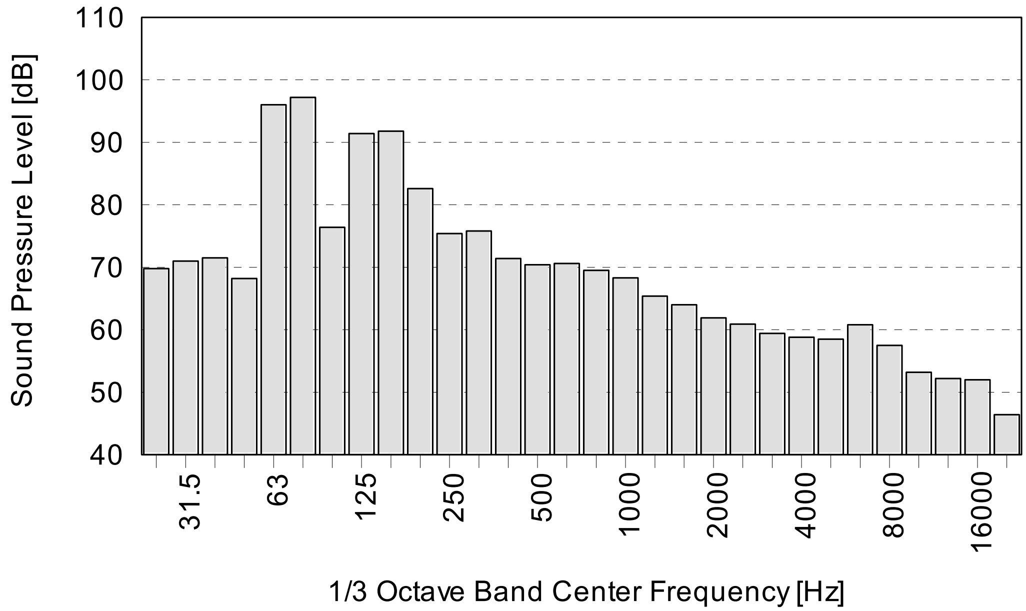


Figure 2
One-Third Octave Band Spectra
Q 400 - Cruise Altitude, Front of Cabin
Horizon Airlines
Seattle, WA
May 19-22, 2003

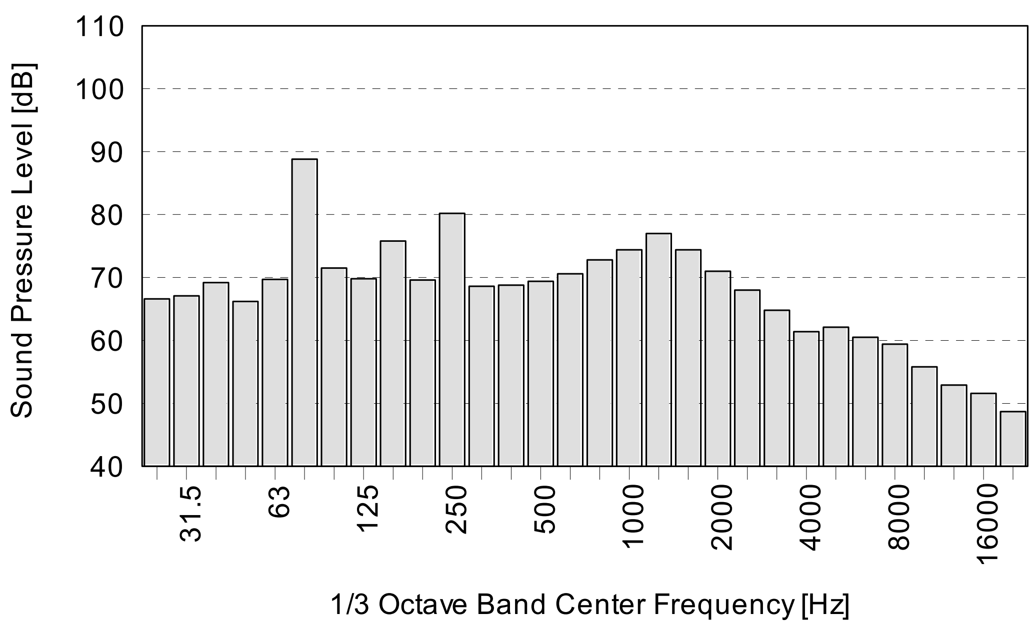
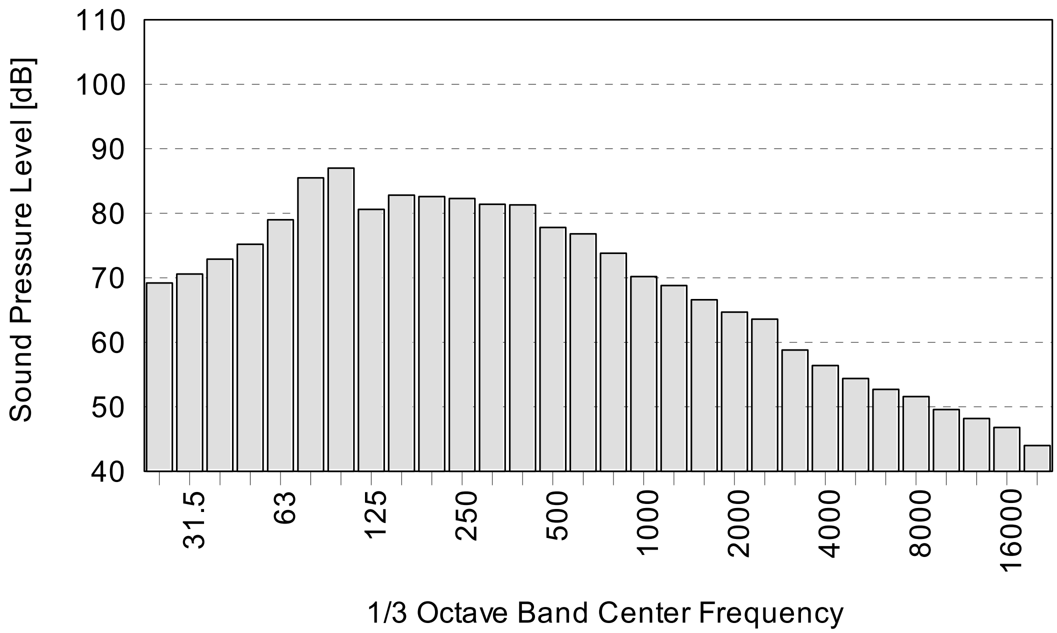


Figure 3
One-Third Octave Band Spectra
CRJ - Cruise Altitude, Rear of Cabin
Horizon Airlines
Seattle, WA
May 19-22, 2003



Each of the three figures shows the riding position on each aircraft that yielded the maximum noise spectrum.

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