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Case Studies

Noise Exposure to Airline Ramp Employees

Dawn Tharr, Column Editor

Reported by Randy L. Tubbs

Introduction

The National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from employees at a major airline. The employees were concerned about noise levels they experienced on the ramp area as they serviced inbound and outbound aircraft. Of particular concern was the noise emitted by a regional jet aircraft and its auxiliary power unit (APU) which is located in the tail of the vehicle. The employees felt that the noise from the aircraft was affecting their hearing, leading to permanent damage to their ears.

Background

During the evaluation, aircraft were parked in an open area of the airport and passengers were shuttled to and from the planes and terminal in buses. Up to four rows of aircraft were parked in the ramp area. Approximately 100 ramp personnel worked two shifts, servicing the aircraft when the planes were on the ground. Their tasks included baggage handling, aircraft maintenance, lavatory service, and catering.

The aircraft taxi to their parking locations with the engines operating. Once parked, the pilot will turn off the engine, which stops the on-board ventilation system. In order to keep the air in the cabin cooled or heated, either the APU or ground power unit (GPU) and air conditioning (A/C) cart will be placed in service. The APU is an on-board engine that supplies power to the aircraft and the ventilation system, and is most often located in the tail of the aircraft. On the regional jet, the APU is exhausted down toward the ground through the end of the plane's tail section. The door for the baggage compartment is located adjacent to the tail section on the port side of the aircraft.

The noise created by the APU was specified in the HHE request as the cause for employees' concerns. Personal noise dosimeter measurements were taken of customer service agents during a full-shift workday to evaluate the noise impact from the APU. Area spectral measurements were also taken at fixed locations around the aircraft. The company's hearing conservation program was reviewed with particular attention given to the kinds of hearing protection offered to the employees.

Methods

Noise dosimeters (Quest Technologies, model Q-300, Oconomowoc, WI) were worn by employees during the day shift at the airport ramp. The noise dosimeters were attached to the employee's belt, and a small remote microphone was fastened to the employee's shirt at a point midway between the ear and the outside of the employee's shoulder. At the end of the shift, the dosimeters were removed and paused to stop data collection. The information was downloaded to a personal computer for interpretation with QuestSuite for Windows computer software. The dosimeters were calibrated before and after the work shift according to the manufacturer's instructions.

Real-time area noise sampling was conducted with a Larson-Davis Laboratory Model 2800 Real-Time Analyzer and a Larson-Davis Laboratory Model 2559 (Provo, UT) half-inch random incidence response microphone. The analyzer allowed for the analysis of noise into its spectral components in a real-time mode. The $\frac{1}{2}$-inch diameter microphone has a frequency response range (±2 dB) from 4 Hz to 21 kHz that allowed for the analysis of sounds in the region of concern. One-third octave bands consisting of center frequencies from 20 Hz to 20 kHz were integrated and stored in the analyzer. The analyzer was mounted on a tripod and placed at various locations around the jet aircraft. The microphone was positioned at approximately what would have been the level of employees' ears if they had been in the area. Measurement locations for the regional jet were the tail section below the APU, the end of the baggage conveyor, and the mobile stairs that passengers used to enter and exit the aircraft. Similar tail section locations of other jet aircraft were measured to allow comparison of noise levels emitted by other types of APUs.

Evaluation Criteria

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.[1] 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 to 20,000 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 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.[2]

The A-weighted decibel [dB(A)] is the preferred unit for measuring sound levels to assess worker noise exposures. The dB(A) 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 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 dB(A) scale is logarithmic, increases of 3 dB(A), 10 dB(A), and 20 dB(A) 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)[3] specifies a maximum permissible exposure limit (PEL) of 90 dB(A) 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 dB(A) for no more than 4 hours, to 100 dB(A) for 2 hours, etc. Conversely, up to 16 hours exposure to 85 dB(A) 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:

$$\text{Dose} = 100\text{X}\ (C1/T1 + C2/T2 + \cdots + Cn/Tn),$$

where Cn indicates the total time of exposure at a specific noise level, and Tn 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 percent of his daily noise dose. Doses greater than 100 percent are in excess of the OSHA PEL.

The OSHA regulation has an additional action level (AL) of 85 dB(A); 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 recordkeeping. 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 dB(A), feasible engineering or administrative controls shall be implemented to reduce the workers' exposure levels.

NIOSH, in its Criteria for a Recommended Standard,[4] and the ACGIH,[5] propose exposure criteria of 85 dB(A) as a TWA for 8 hours, which is 5 dB less than the OSHA standard. The criteria also uses a more conservative 3 dB time/intensity trading relationship in calculating exposure limits. Thus, a worker can be exposed to 85 dB(A) for 8 hours, but to no more than 88 dB(A) for 4 hours or 91 dB(A) for 2 hours.

Results

Six employees volunteered to wear a noise dosimeter for their entire work shift to measure their personal exposures. Two of the customer service agents were assigned to the "Bravo" line on the ramp, three worked the "Charlie" line, and one was responsible for the air conditioning cart. The agent who was responsible for the air conditioning cart spent much of the day driving the cart to aircraft throughout the ramp area. The weather in the area at the time of the evaluation was good and caused no delays in the arrival or departure of aircraft.

Collection of data with the Quest dosimeters allows a direct comparison between the noise levels with the OSHA PEL, AL the NIOSH recommended exposure limit (REL). As a result, three different criteria are used simultaneously to calculate the employee's noise dose. The OSHA criteria use a 90 dB(A) criterion and 5 dB exchange rate for both the PEL and AL. The difference between the two is the threshold level employed, with a 90 dB(A) threshold for the PEL and an 80 dB(A) threshold for the AL. (The threshold level is the lower limit of noise values included in the calculation of the criteria; values less than the threshold are ignored by the dosimeter). The NIOSH criterion differs in that the criterion is 85 dB(A), the threshold is 80 dB(A) and it uses a 3-dB exchange rate.

The results of the noise dosimeter evaluation are reported in Table I. When the data are compared to the three evaluation criteria, all six of the employees' noise exposures were in excess of the NIOSH REL of 85 dB(A), ranging from 88 to 94 dB(A) for an 8-hour TWA. When the dosimeter data were compared to the OSHA criteria, the employees were all below the PEL of 90 dB(A); however, five of six employees exceeded the AL criteria of 85 dB(A). The maximum dB(A)-slow noise levels measured during the sampling period were between 111 and 116 dB(A). Inspection of the dosimeter data for the minute-by-minute exposures showed a pattern of intermittent noise levels throughout the work shift. Several times during the day, an employee's noise exposures would be near 100 dB(A) for a short time period. However, there were also several times where the levels would drop below 75 dB(A), while the employees were working in areas not directly near the aircraft. Examples of these data for the "Charlie" and "Bravo" line employees are shown in Figures 1 and 2.

Area noise spectral measurements were made throughout the day around aircraft parked in the ramp area and at gate areas. Particular attention was paid to the regional jets and other larger jets

TABLE I
Personal noise dosimeter results

Ramp location	Sample time (hh:mm)	OSHA PEL[A]	OSHA AL[B]	NIOSH REL[C]	Maximum level[D]
Bravo line–"a"	07:58	87.4 dB(A)	89.3 dB(A)	93.6 dB(A)	116.5 dB(A)
Charlie line–"a"	08:13	86.6 dB(A)	88.4 dB(A)	91.6 dB(A)	113.4 dB(A)
Bravo line–"b"	08:10	85.7 dB(A)	87.3 dB(A)	92.4 dB(A)	111.8 dB(A)
Charlie line–"b"	07:56	85.9 dB(A)	88.3 dB(A)	91.2 dB(A)	111.5 dB(A)
Charlie line–"c"	08:10	82.9 dB(A)	86.2 dB(A)	89.6 dB(A)	111.2 dB(A)
Ramp area	07:19	79.0 dB(A)	83.4 dB(A)	88.3 dB(A)	116.3 dB(A)
Evaluation criteria		90 dB(A)	85 dB(A)	85 dB(A)	

[A] = Data collected with a 90 dB criterion, 90 dB threshold, and 5 dB exchange rate.
[B] = Data collected with a 90 dB criterion, 80 dB threshold, and 5 dB exchange rate.
[C] = Data collected with an 85 dB criterion, 80 dB threshold, and 3 dB exchange rate.
[D] = Maximum slow-response level measured during the sampling period.

used by the airline to compare the effects of the APUs on ground personnel. The spectral measurements were taken at locations near the tail, baggage compartment conveyor belt, and stairway used by passengers to enter and exit the aircraft. The results of the overall measurements are summarized in Table II. The overall area noise measurements clearly show that the APU on the regional jets is the loudest noise exposure for ramp employees. The A-weighted levels ranged from 116 to 120 dB(A), while the unweighted noise levels ranged from 120 to 124 dB sound pressure level (SPL). The measurements made on the five regional jets showed minimal variability. The noise spectrum of the loudest APU measured for the regional jet #928 is shown in Figure 3 as an example of the frequency components generated by this piece of equipment. Inspection of the graph shows that the sound levels increase with increasing frequency, with the maximum one-third octave band at 1250 Hz, having 122 dB of sound pressure. This pattern of increasing sound levels with increasing frequency was seen in all of the regional RJ145 aircraft.

Frequency spectrum measurements were also made of the APUs of four additional larger aircraft flown by the airline. The results of the overall dB SPL and dB(A) levels are reported in Table II, and the graphic presentation of the frequency spectra are shown in Figures 4 through 7. The loud, high-frequency component seen in the regional jets' noise pattern is not as great in the larger aircraft. Noise above 500 Hz was always greater for the regional aircraft.

During the site visit, airline officials provided the NIOSH investigator with a list of the hearing protection devices (HPDs) that are provided to their employees. Because the noise measurements determined that the regional jet #928 was the loudest piece of equipment that ramp employees worked around, the noise spectrum for this jet was used as the noise spectrum to compute the noise reduction afforded by each of the HPDs used by airline employees. The calculations were made according to the method described in the OSHA noise regulation as NIOSH Method 1, and the results are shown in Table III.[3,6] The attenuation data used in this analysis were those provided by the manufacturers, calculated according to the American National Standards Institute (ANSI) S3.19-1974.[7] The calculations show that the ear plugs and ear muffs supplied to the employees provide sufficient attenuation to reduce the noise to acceptable levels. The ear muffs reduce

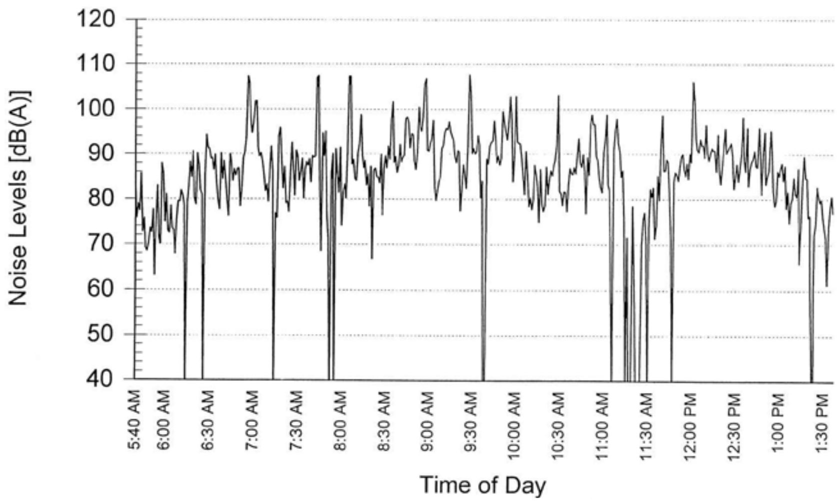

FIGURE 1
Noise dosimeter results: Bravo line–"a."

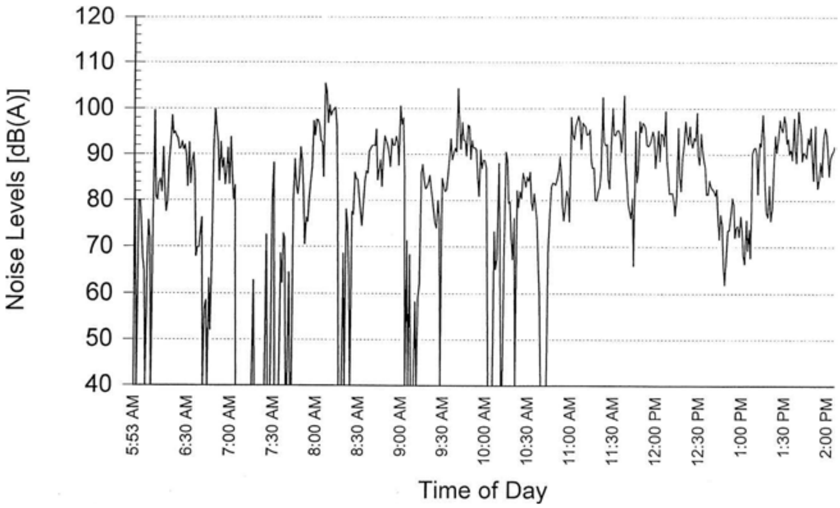

FIGURE 2
Noise dosimeter results: Charlie line–"a."

the APU noise spectrum to an effective level of 78 dB(A); ear plugs reduce the noise to a range of 78 to 82 dB(A). The three semi-insert, banded devices offer the least amount of attenuation, reducing the noise to levels ranging from 84 to 89 dB(A), values that could be potentially hazardous to the employees' hearing.

Discussion

The noise dosimeter measurements made on the six employees revealed exposure levels that were consistently below OSHA's PEL of 90 dB(A) as an 8-hour TWA. However, the OSHA AL, at which implementation of a hearing conservation program by the employer is required, was exceeded in five of six measurements. One employee who worked in the general ramp area handling air-conditioning carts, had a personal TWA noise level of 83.4 dB(A). When the noise data were compared with the NIOSH recommended exposure limit, all of the employees were found to exceed the REL, accumulating at least 200 percent of their allowable daily noise dose in the 8-hour shift. The data collected by NIOSH during this health hazard evaluation agreed with noise data collected by the airline in December 1998.

Table II
Area overall noise measurements

		Overall noise levels	
Aircraft	Measurement location	dB SPL	dB (A)
Regional jet #927	tail section; APU on	121	117
	baggage conveyor; APU on	101	97
Regional jet #926	tail section; APU on	124	120
	baggage conveyor; APU on	97	93
	passenger stairs; APU on	93	90
Regional jet #954	tail section; APU on	122	118
	baggage conveyor; APU on	102	98
	inside baggage compartment; APU on	93	89
Regional jet #948	tail section; APU on	120	116
	baggage conveyor; APU on	99	96
	passenger stairs; APU on and turboprop aircraft taxiing from line in front	95	90
Regional jet #928	tail section; APU on	124	120
	baggage conveyor; APU on	101	107
	passenger stairs; APU on	94	92
Regional jet #957	tail section; APU off; A/C cart running	100	89
DC 10	tail section; APU on	106	102
Boeing 777	tail section; APU on	97	90
Boeing 737	tail section; APU on	99	93
MD 80	tail section; APU on	101	97

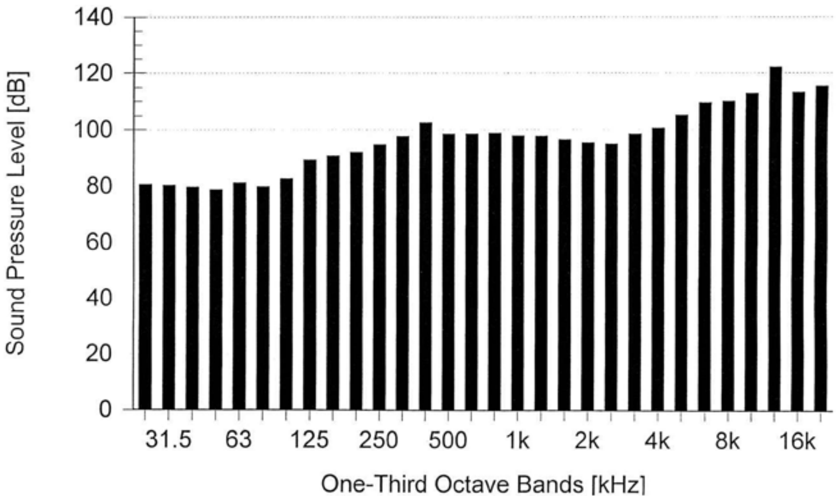

FIGURE 3
One-third octave band noise measurements. Regional jet #928 below APU in tail section.

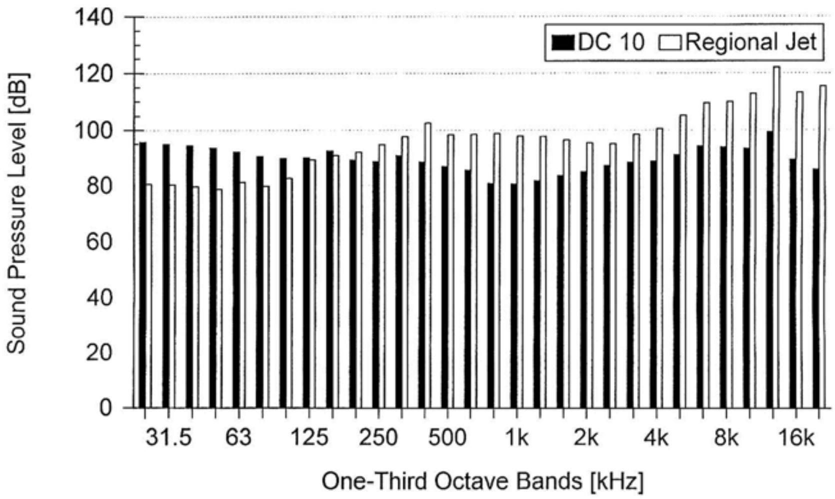

FIGURE 4
Below APU in tail section.

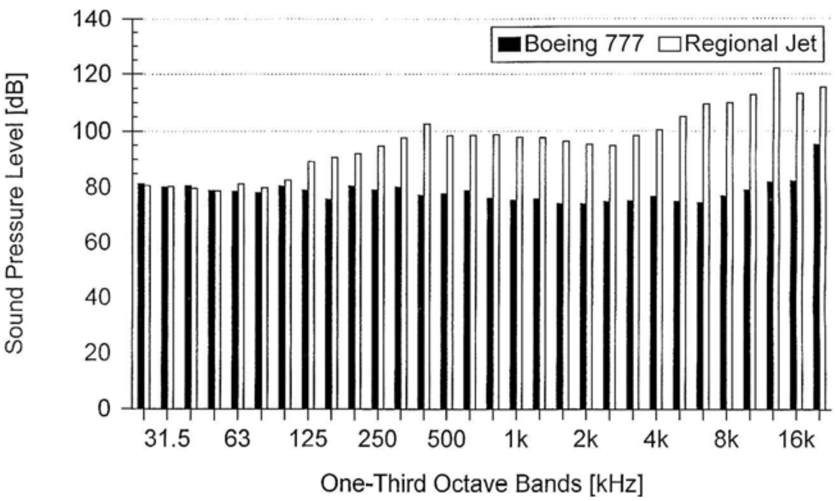

FIGURE 5
Below APU in tail section.

Area noise measurements identified the area around the regional jet's APU in the tail of the aircraft as the noisiest location for the ramp employees. The noise levels ranged from 116 to 120 dB(A). However, observations of the employees found that the ramp employees do not routinely work in this area. The closest location where they were found to spend appreciable amounts of time is the baggage conveyor where the noise spectra were measured at 93–98 dB(A). An analysis of the HPDs provided to the employees showed that most of them were capable of providing sufficient attenuation to the noise from the APU. However, the semi-insert devices would be lacking if the employees were around the noise for the entire work shift. The comparison of the regional jet's APU to other larger jets revealed higher noise levels associated with the regional jets. The power unit on the smaller aircraft was at least 18 dB(A) louder than any of the other planes measured during the evaluation.

The use of ground power sources does reduce the noise levels to near 90 dB(A), as compared to the 116–120 dB(A) noise levels associated with the APU. However, mechanics and technicians contend that the use of ground power sources are less reliable, producing electrical power surges that negatively affect the aircraft's onboard computers. Also, the A/C unit on the aircraft is pneumatic and can only be operated by the APU or jet engine. That is why a ground A/C cart is brought to jets that do not have the APU running. During the closing meeting of the evaluation, it was noted by an engineer that a hush kit for the regional jet is available to reduce the noise emitted by the APU.

The evaluation of the HPDs offered to employees was completed without any derating factor that is required for OSHA compliance activities.[8] The manufacturers' attenuation data were not obtained according to the subject fit method of ANSI S12.6-1997.[9] If a derating factor was used in evaluating the HPDs, or if subject fit data from the manufacturers of the devices were substituted into the analysis, then the effective levels reported in Table III would be higher. Thus, the employees need to be diligent in the selection, use, and care of their HPDs to protect themselves from the risk of hearing loss from the noise of the aircraft and their auxiliary equipment.

Conclusions

Ramp employees are exposed to noise levels that could be potentially damaging to their hearing. In most instances, the HPDs that the company provides are effective in reducing the exposures to levels that do not increase their risk of occupational hearing loss. However, because of the exposure levels, the airline should continue to provide their employees all of the components of a hearing loss prevention program, including noise monitoring, audiometric testing, HPDs, and recordkeeping. The company should continue to pursue ways to control noise exposures to the ramp employees through changes in work practices, facility redesign, and retrofit controls for the aircraft.

Recommendations

The following recommendations are offered by NIOSH investigators to reduce the risk of occupational noise-induced hearing loss for ramp employees. The recommendations are based on the measurements made during this evaluation along with observations made of the work environment.

1. The airline needs to continue its efforts in hearing conservation as mandated by OSHA regulations. The

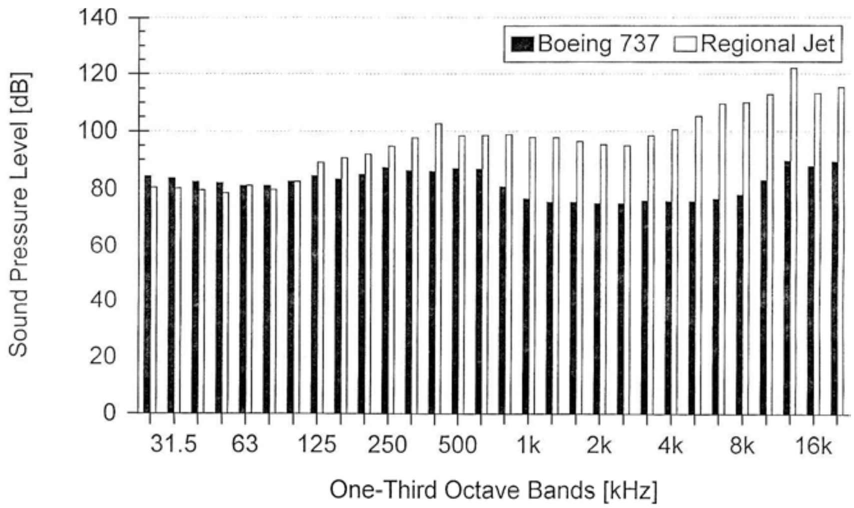

FIGURE 6
Below APU in tail section.

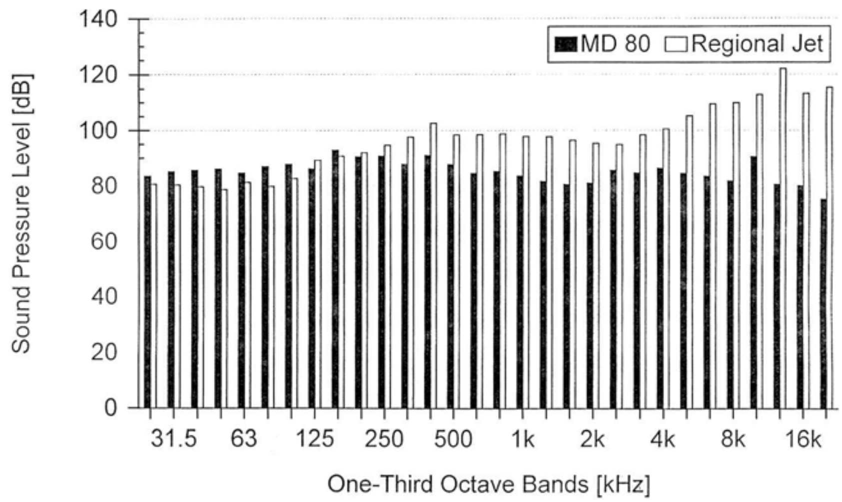

FIGURE 7
Below APU in tail section.

Table III
Evaluation of hearing protection devices

Regional jet #928 octave band sound levels										
Octave band										
Frequency (Hz)	31.5	63	125	250	500	1k	2k	4k	8k	16k
Sound level (dB)	80.8	82.6	95.3	100.9	104.8	103.3	99.8	104.1	113.5	120.8

Hearing protection devices' effective levels[A]

HPD model	EAR foam plugs	Peltor ear muffs	3M 1100 foam plugs	North Silent Band-it
Effective level	77.8 dB(A)	78.2 dB(A)	81.9 dB(A)	83.6 dB(A)
HPD model	EAR caboflex	Moldex Pura-fit 6900 plugs	Moldex Jazz Band 6506 (behind the head)	Moldex pocket-pak plugs
Effective level	88.8 dB(A)	79.4 dB(A)	84.9 dB(A)	78.7 dB(A)

[A]Based on Regional Jet #928 noise spectrum.

personal dosimeter measurements made for this survey revealed that the OSHA AL was exceeded in five of six full-shift measurements.[3] The NIOSH measurements confirm the company's noise survey conducted in December 1998. Additionally, the NIOSH criterion was exceeded in all six measurements, confirming that the ramp employees are at an increased risk of occupational hearing loss.[4]

2. The auxiliary power units on the regional jets produce damaging levels of noise. Employees should not be allowed to work near the APUs while they are operational. If mechanical work on the unit necessitates that it be on, then the mechanic should be in double hearing protection, for example, ear muffs placed over well-fitted ear plugs.
3. The airline should investigate the feasibility of the retrofit muffler noted by the aircraft company's engineer for their existing fleet of regional jets. Deliveries of future aircraft should address the issue of noise produced by the power units in the contract specifications. The finding that the noise produced by the APUs on other jets was less than that produced by the regional jet shows that quieter designs are possible.
4. Observations of employees on the ramp during the evaluation revealed that HPD use was not at full compliance. The noise levels produced by the aircraft are sufficient to produce permanent hearing loss in employees. Therefore, the employees should be expected to comply with the requirement of using hearing protection whenever they are on the ramp.

REFERENCES

1. Ward, W.D.: Anatomy & Physiology of the Ear: Normal and Damaged Hearing. Chapter 5. In: Berger, E.H.; Ward, W.D.; Morrill, J.C.; Royster, L.H., Eds.: Noise & Hearing Conservation Manual. 4th ed. American Industrial Hygiene Association, pp. 177–195 (1986).
2. Suter, A.H.: The Ability of Mildly Hearing-Impaired Individuals to Discriminate Speech in Noise. Joint EPA/USAF Study, EPA 550/9-78-100, AMRL-TR-78-4, Environmental Protection Agency, Washington, DC (1978).
3. Code of Federal Regulations CFR [29 CFR 1910.95 (1992)], U.S. Government Printing Office, Office of Federal Register, OSHA, Washington, DC.
4. National Institute for Occupational Safety and Health. Criteria for a Recommended Standard: Occupational Noise Exposure (revised criteria 1998). NIOSH, U.S. Department of Health and Human Services, Public Health Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 98-126, Cincinnati, OH (1998).
5. 1999 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents. American Conference of Governmental Industrial Hygienists, Cincinnati, OH (1999).
6. Kroes, P.; Fleming, R.; Lempert, B.: List of Personal Hearing Protectors and Attenuation Data, DHEW (NIOSH) Publication No. 76-120. U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, OH (1975).
7. Method for the Measurement of Real-Ear Protection of Hearing Protectors and Physical Attenuation of Ear Muffs. Acoustical Society of America, ANSI S3.19-1974 (Revised 1979), ANSI, New York (1975).
8. CPL 2-2.35A-29 CFR 1910.95(b)(1), Guidelines for Noise Enforcement; Appendix A, OSHA Directive No. CPL-2-2.35A (December 19, 1983). OSHA U.S. Department of Labor, Occupational Safety and Health Administration, Washington, DC (1983).
9. Methods for Measuring the Real-Ear Attenuation of Hearing Protectors. Acoustical Society of America, ANSI S12.6-1997. ANSI New York (1997).

EDITORIAL NOTE: Randy L. Tubbs, Ph.D. is with the Hazard Evaluation and Technical Assistance Branch of the National Institute for Occupational Safety and Health. More detailed information on this evaluation is contained in Health Hazard Evaluation Report No. 99-0060-2766, available through NIOSH, Hazard Evaluation and Technical Assistance Branch, 4676 Columbia Parkway, Cincinnati, Ohio 45226; phone: (800) 35-NIOSH; fax: (513) 533-8513.