

Airbag hazards explored

Airbags and hearing loss

The controversy over hearing loss from airbag developments has received some illumination in a recent paper in the Journal of the Acoustical Society of America by G R Price and J T Kalb ("Auditory Hazard from Airbag Noise Exposure" JASA Vol 106, No.5 November 1999, 2629-2637).

There have been continuing claims of hearing damage from airbag noise and some effort by manufacturers to develop intelligent bags, whose deployments are responsive to the nature of the triggering decelerations, rather than giving a simple "yes-no" decision. Price and Kalb have now put exposure effects of noise from airbag deployment on a more scientific basis. Peak pressures in the passenger compartments may exceed 170dB, with a total acoustical energy similar to that in the crew area of a howitzer! Initial tests, when airbags were first proposed back in the 1960s, indicated little hazard, but developing experience has revealed that the hearing of sensitive individuals may be damaged. As the totality of hazard has grown with the increasing adoption of airbags and also with their use in additional locations within the vehicle, such as for side impact, Price and Kalb decided that it was time for a fresh look at the problem.

Damage risk standards

The first issue they came up against was that there are no accepted risk standards for use with airbag noise. The individual impulses exceed recognised damaged risk criteria, but experience is that widespread damage has not occurred. This is an indication that current damage risk criteria over-rate the hazard for pulses of the type produced by airbags, which have a high spectral composition at low frequencies. As a result, there is no effective standard by which the specific

properties of airbag noise exposures can be rated. Further, the pressure time histories will vary according to whether a vehicle is an open-top convertible, has open windows or how "leaky" it is when all doors and windows are closed. Earlier work had shown, through a simulation experiment, that threshold shift following airbag noise exposure was greater when the low frequency components were removed. This could be because the high level of low frequency pressure might approach the upper limit of the displacement of the stapes, thus reducing the transmission of the damaging higher frequencies, which arise from the flow noise as the airbag is being filled. So there is a conundrum. A vented passenger compartment, which would reduce the low frequencies, and hence the peak pressure, might result in greater hazard! Price and Kalb set out to obtain pressure time histories and hearing loss from "quiescent biological ears", obtained with anaesthetised cats.

Exposures

A total of 36 cats took part. They were supported with one at the driver and one at the passenger head positions of a mid-sized pick-up truck, whilst the bags were operated electrically. Compartment venting was a) doors open, b) doors and windows closed, c) doors and windows closed and sealed. A comparison of hearing levels before and after exposure gave the temporary threshold shifts. Repeat measurements were made on all cats after one month's recovery, to determine the permanent shift, and after a further five month's on half of the cats. In all cases, the hearing threshold were obtained from head electrodes, which measured the brain-stem-evoked responses to tone pips at 1, 2, 4, 8 and 16 kHz. The maximum measurable shift was 70-80dB.

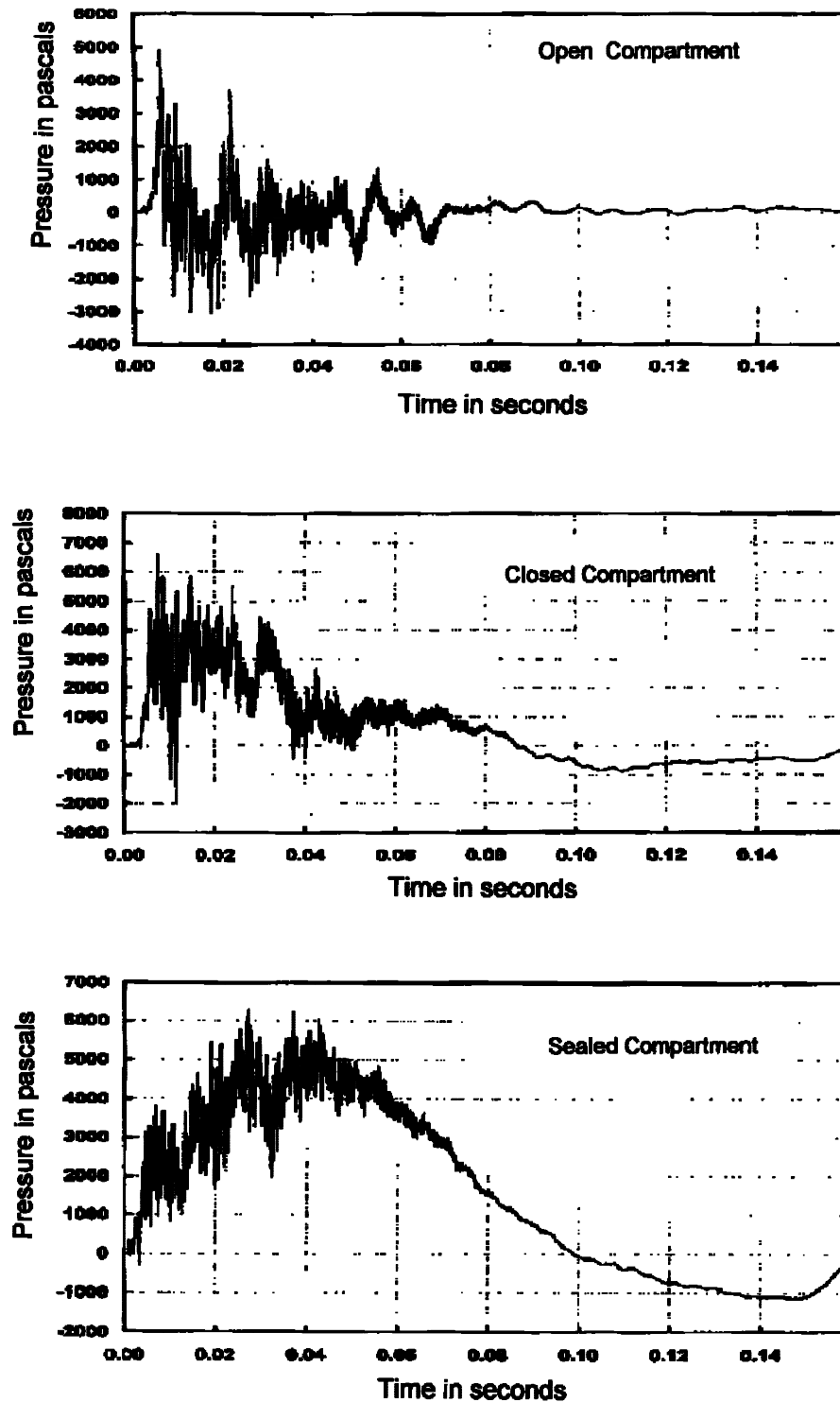


Figure 1.
 Top: Driver's right ear position. Doors open. Both airbags
 Middle: Driver's right ear position. Doors closed. Both airbags
 Bottom: Driver's right ear position. Doors closed and sealed. Passenger airbag only

Exposure time histories

Time histories were very dependent on measurement conditions, as shown in Fig 1. Here the time histories at the driver's right ear position, when both driver and passenger airbags were deployed, are shown for doors open, doors closed and for doors sealed when the passenger airbag alone was

deployed. The open compartment shows high frequencies superimposed on a lower frequency decaying swing of about 100Hz. With doors closed there is a build up of pressure between about 10ms and 30ms from start, representing a low frequency pulse, whilst for the sealed compartment this LF swing is higher and longer. The results are

Table 1. Measurements

venting	peak SPL average dB	energy unweighted	energy A-weighted
		J/m ²	J/m ²
Open	168.2	191	56
Closed	171.4	124	81
Sealed	170.1	2599	40

summarised in Table 1. The peak level of about 170dB is to be expected from the relative volumes of cab space and airbags. (Cab space 2m³, driver air bag 0.08m³, passenger airbag 0.06m³).

Results

The cats suffered severe hearing loss. Initially, around 60dB at 4kHz and a little less at lower and higher frequencies, but recovery had reduced the losses to 20 - 40dB after one month. The initial hearing loss was greatest in the open compartment, exceeding the other conditions by 10-15dB. The measurements after a further five months indicated improvement in some cases, but continued loss in those animals which had suffered most initial loss. On average, recovery was to about 20dB less than the initial loss.

Interpretation of the experiments in relation to an A-weighted energy measure indicated that this failed at very high intensities. Taking the airbag work together with other work on gunfire, suggests that relatively little energy at high SPL's may cause large losses. One proposal is that there is a critical level, which in this case will be between 115dB and 140dB, where "the

loss mechanism becomes fundamentally mechanical in nature and relatively little energy produces large losses".

The interpretation of the experiment in relation to human exposure is not too clear, since previous work on humans has indicated that airbag deployment is not a big problem for the human ear.

Responses, in the final split second of awareness before an accident, may include a protective contraction of the middle ear muscle. Perhaps the cat ear is more sensitive than the human, or the full extent of hearing loss from accidental air bag exposure by humans is not known - there may be a lot out there waiting to be discovered, as people are not always aware of their high frequency hearing loss. Similarities between the cat ear and the human ear indicate that there is a risk of permanent hearing damage from airbags for, at least, a small percentage of humans. Indeed, the authors state that, for the human ear, "a vented passenger compartment and middle ear muscles not already contracting at the start of the impulse could result in permanent hearing losses in a significant portion of those exposed."

So it may be safer to keep your windows closed!

Karaoke threatened

Karaoke nights could soon become a thing of the past, if Neil Kinnock's daughter-in-law - a Danish MEP - succeeds in a plan to slash "acceptable noise levels in European workplaces." Backed by pan-European socialist colleagues, Helle Thorning-Schmidt - the wife of Kinnock's son, Stephen - is attempting to reduce the legal levels of noise exposure for EU employees to 83 decibels. Not surprisingly, British publicans are vociferously opposing the plans, which they say would lead to even moderately loud background music being banned. "It's totally ridiculous," says Mark Hastings, a spokesman for the British Beer and Pub Association. "British drinkers will have to convert to Trappism before going for a pint if this ludicrous proposal becomes law."