In-cabin noise

In-cabin noise is an important influence on the driver's comfort level. The driver's seat is a workplace and the driver is likely to spend up to about 60 hours per week sitting in it. So what is a legal level for noise and what is a comfortable level?

A national noise exposure standard for workplaces has been adopted Australia-wide. The noise limit has two aspects, which are a C-scale, 140 dB(C) maximum level and an A-scale, eight-hour average of 85 dB(A).

Both limits apply to the driver's ears. The first limit is not relevant to a truck cabin because it is a high value usually arising from impact noise from machinery, which does not occur in truck cabins, such as jackhammering. Note that the C-scale, which can be selected on the noise meter, is applicable when considering physical damage to the ear. The second limit, 85 dB(A) is the relevant one for trucks. The A-scale noise limit is measured using a 'filter' that models the sensitivity of the human hearing at different frequencies.

The main sources of cabin noise are presented in Table A. They are listed generally in order of importance, however this can differ between truck models. Notice that high-frequency noise, such as turbo-charger noise, is weighted highly by the A-scale.

Cabin noise is not regulated by the Australian Design Rules. ADR 83/00 does regulate drive-by noise and air-brake noise.

SOURCE OF NOISE	MAIN FREQUENCY RANGE	BASIS
Exhaust noise	60 – 100 Hz	3 pulses per engine revs.
Cooling fan noise	300 – 500 Hz	12 – 15 pulses per engine rev from the cooling fan
Turbo-charger noise in exhaust	500 – 2000 Hz	30,000 – 100,000 RM
Engine brake exhaust noise	120 – 200 Hz	6 pulses per engine revs.
Engine block noise	120 – 200 Hz	6 pulses per engine revs.
Wind noise around the windscreen and mirrors	50 – 200 Hz	Causes by wind vortices coming off protruding parts
Transmission and tailshaft	100 – 500 Hz	Depends upon gear selection. Mainly transmission whine
Tyre noise	8.5 Hz revolution. Tread noise up to 500 Hz	Tread noise arises from distortion of the tyre at the road interface.
Air-intake noise	60 -100 Hz	3 pulses per engine rev

Table A

The limit levels for a heavy-duty prime mover (engine power > 320 kW) are:

- Drive-by noise is measured on each side at 7.5m from the centre line of the truck during low speed acceleration tests. The peak limit is 84 dB(A). Note that this is not an average limit.
- Air-brake valve noise (Service brake, park brake and air regulator). The peak noise is measured at 7.0m from the side of the stationary vehicle. The engine can be off. The peak limit is 72 dB(A).
- Stationary exhaust is measured at 500mm from the end of the exhaust pipe with the engine at ¾ speed. This noise is not limited but it must be reported.

The stationary exhaust noise levels that manufacturers have reported are available at: http://rvcs.infrastructure.gov.au/stationarynoise.htm. This information has been provided for road agency roadside enforcement officers to use as the basis for checking whether an in-service truck has excessive exhaust noise or not. I don't believe that this information is being used.

If the truck has a fan clutch, the cooling fan does not usually contribute to drive-by noise measurement because the test is done with the fan on automatic setting. It doesn't come on during the test. So far noise is not usually relevant to the ADR 83/00 compliance. Nor is the engine brake noise.

The same sound sources that affect the exterior noise also affect the cabin. Proximity of the source to the driving location is an important factor. As a guide the ranking of noise sources in the cabin is:

- Exhaust pipe noise transmitted through air or via the cabin structure.
- Engine brake noise transmitted as per exhaust noise.
- Cooling fan noise transmitted via the firewall or engine tunnel.
- Engine noise transmitted through the cabin mounts and firewall or engine tunnel.
- Transmission and drivetrain noise transmitted through the cab mounts or cabin floor.
- Wind noise arising around the windscreen and mirror brackets.
- Tyre noise from the front tyres.
- Air-intake noise comes from cabin mounted air cleaners, if they exist.

Noise reduction is a challenging task because it can be difficult to identify the predominant source of the noise. Very little benefit comes from reducing any noise source other than the dominant one. Noise shielding using open and closed cell plastic sheets is commonly used on cabin panels and under the floor. Cabin floor coverings can also have a heavy barrier in the middle that reflects noise back. Cabin mounts must have flexible elements that disrupt the transmission of noise frequency vibrations. None of these countermeasures are easy to retrofit.

It is the manufacturer's job to do the development work that reduces cabin noise level.

Putting noise-absorbing fibrous packing into sections of the muffler can reduce engine brake noise, but this packing can degrade with time. Closing the exhaust pipe off with a butterfly valve (as used in an exhaust brake) can also substantially educe engine brake noise can be substantially reduced, but this has never been mandated in Australia.

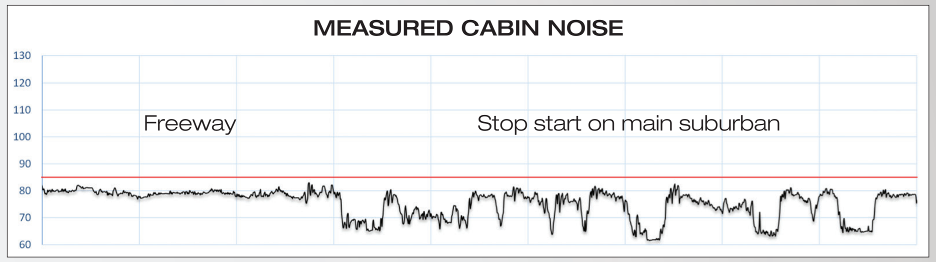

Figure 1
These levels are a long way above the 'low 70s'. Based upon my recent experience the test truck was about three dB(A) too noisy for comfort. There is little chance that truck manufacturers will agree to an industry code of practice for in-cabin noise and there is even less chance that a design rule for in-cabin noise will be developed. It is up to truck purchasers to consider the comfort of the driver and determine the noise level that is likely to be experienced in the truck model being considered for purchase.

The Western Australian Code of Practice *Managing Noise at Workplaces* states: "Long periods of repeated exposure to workplace noise between 75 and 85 dB(A) present a small risk of hearing disability to some people. [At] about 85 dB(A) the risk increases substantially."

An average level of 85 dB(A) in a truck cabin is an unsafe level because of the disturbing and tiring effects of noise exposure. There are many studies that show that concentration falls off when workers are exposed to continuous moderate noise exposure. The SA work safety authority provides the following guidance or acceptable workplace average noise levels:

- 50 dB(A) where work is being carried out that requires high concentration levels.
- 70 dB(A) where routine work is being carried out that requires speed or alertness.

Noise levels in the 'low 70s' are appropriate for a truck cabin. No hard limit can be applied because of the variable conditions that occur, but I believe that noise at the driving position should be below 75 dB(A) for 95 per cent of driving conditions.

I recently measured the noise experienced by the driver of an older bonneted prime mover pulling a laden trailer on suburban main roads and a suburban freeway. The cooling fan was turned on, which did produce a worst-case result. Part of the noise record is shown in the Figure 1, with the red line identifying 85 dB(A).

As a guide the noise levels the driver experienced were:

- Accelerating away from traffic lights: 82 dB(A);
- Driving on a main suburban road at speeds up to 70 km/h: 76 dB(A);
- Driving at 90 – 100 km/h on a freeway: 78 dB(A);
- Idle and waiting at traffic lights: 65dB(A).

Peter Hart
Chairman, ARTSA