Control of in-cabin Vibrations

Surprisingly, the Australian Design Rules have never set maximum vibration exposure standards for occupants of truck cabins. Whilst the ADRs seek to minimise road-safety risks, the 'occupational health and safety risks' have not been in scope. OH&S risks have traditionally been regulated by the state and territory work safety organisations.

None of the work safety regulators in Australia have introduced mandated exposure limits for in-cabin vibrations. In contrast, the European Union has. In this article, I will describe the European initiatives and argue that Australia needs to follow suit.

All OH&S regulations identify exposure to vibration as a factor that needs to be controlled and all regulations classify a truck cabin as a workplace. In-cabin vibration exposure has the potential to affect driver health due to road-safety risks from the effects of fatigue and control disturbances to throttle steering and brake controls.

Other factors include discomfort when sitting, physiological effects such as vision disturbance or stress and visual and cardiovascular disturbance resulting in chronic health problems. In the longer term these can also result in ailments such as lower back, shoulder and neck pain.

There is research that argues that long-distance truck drivers suffer all these effects. It is established that crash rates

The mobile phone can measure vibrations in three directions.

involving heavy vehicles are higher on rough roads than on comparable smooth roads.

It is also established that career truck drivers have relatively high heart disease levels and musculoskeletal ailments.

Fatigue has always been a problem. Therefore, cabin ride quality is a key safety consideration.

The European Union has mandatory limits on whole-body vibration exposure, which can be summarised as follows.

The assessment of exposure to vibration is based upon the average acceleration experienced over an eight-hour period (denoted "A8"). Accelerations in any direction are treated equally. The acceleration is quantified as a Root Mean Squared value.

The European limit (EU Directive 2002/44/EC) for whole body exposure in any workplace is 1.15 m/s² (A8). An 'Action level' (A8) of 0.5 m/s² applies.

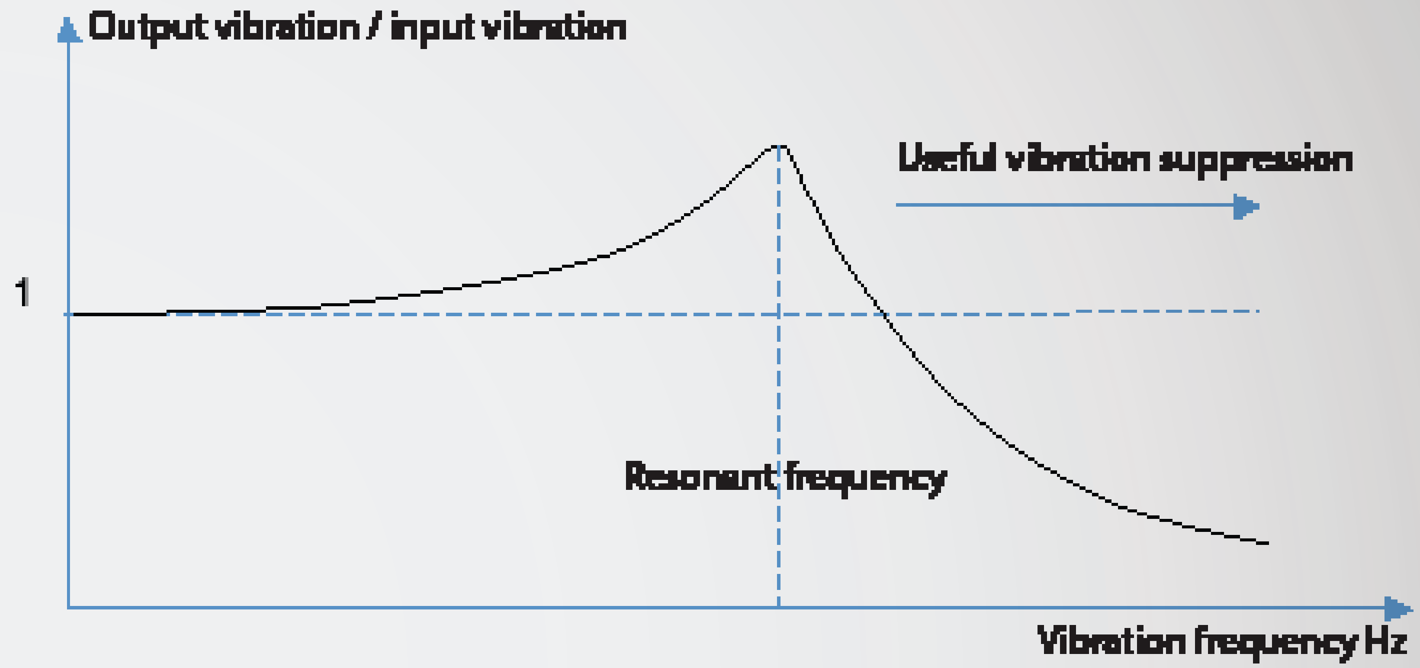
Average vibrations above the Action level should be monitored and actions taken to reduce levels. There are also Limit and Action Levels for hand / arm vibrations which are 5 m/s² and 2.5 m/s² (A8).

Drivers will describe whole body vibration levels above 2 m/s² as 'extremely uncomfortable' and vibrations less than 0.5 s/s² as 'comfortable'. Instantaneous vibration levels in the intermediate range 0.5 – 1.5 m/s² are commonly experienced in a truck cabin.

The vibration frequencies experienced in a truck cabin are mainly between one – 10Hz. Cabin vibrations of less than one Hz are experienced as floating movements, which over an extended period can cause drowsiness. At higher frequencies in the range five – 10 Hz, body resonances can occur, which result in discomfort or ailments over the longer term.

Unlike fixed machines, trucks experience variable road conditions, so vibration levels depend upon the roughness of the road. This greatly complicates the assessment of vibration exposure in a truck.

Australia has not adopted the European vibration exposure limits. Vibration exposure is identified as an important work-safety consideration but no regulated maximum limits are specified in Australia. Therefore, Australia lacks a benchmark level.



The usual form of a suspension frequency response

So how can cabin vibrations be measured? Until recently specialist measuring gear was needed.

Now instantaneous acceleration levels can be measured using a mobile phone. Drivers can monitor their exposure levels easily using a smart phone. This provides an opportunity for fleet managers to learn more about the vibration levels that their drivers experience. It also provides a means by which drivers could support a claim of damage arising from cabin vibration levels.

So how can vibration levels be reduced? Here are some methods.

1. Drive on smooth roads.
2. Fit a suspension seat that has a published frequency response.
3. Choose a truck with a superior cabin suspension.
4. Use a suspension seat with a low natural frequency.
5. Specify taper-leaf front suspension springs.
6. Use tyres that are well balanced. In particular, insist that the out-of-balance weight of a retreaded tyre is measured and kept to ~ 200g.
7. Use a long wheelbase truck. This reduces the pitching frequency.
8. Fit a tyre central inflation system. Tyre pressure can be adjusted to reduce vibration levels on particularly rough roads.

I could have also specified an airbag drive-group suspension but for some applications, such as tip-trucks, this is not practical.

All suspensions have a resonant frequency. If the vibration frequency is well below the resonance frequency then the vibration is transmitted un-attenuated.

Near to the resonance frequency the vibrations are amplified. Above the resonance frequency the vibration is reduced. The typical suspension response is shown in the Figure.

As a guide the resonant frequency of a suspension seat is 1.5 – two Hz. The heavier the occupant, the lower is the resonant frequency.

Tyres have a resonant frequency of about 10 Hz although this depends upon the inflation pressure. Therefore a Central Tyre Inflation System (CTI) can be used to adjust tyre pressure and lower the resonant frequency. The various suspensions operate independently.

Cabin suspensions fall into two designs – firstly, fixed front mounts with a single rear spring-suspended mount, typically used on bonneted trucks; and secondly, dual coil-spring suspended front mounts and dual suspended rear mounts; typically used on COE trucks.

The first arrangement has the advantage that a single rear mount provides better isolation from chassis rail vibrations, including out-of-balance tyre vibrations. The second arrangement has the advantage that all mounts provide some isolation.

The rear-mount springs can be coil springs or airbag springs. An airbag spring suspension will probably have a lower natural frequency than a coil-spring suspension; so the cabin with two airbag rear supports will have a 'floatier feel' than coil spring suspensions.

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