Australian / New Zealand Governments' response to truck compression brake noise

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The use of noisy compression brakes is a major source of community disturbance in Australia and New Zealand. Current laws in Australia and New Zealand do not directly limit the level of noise that can be created by the use of compression brakes. There are no specific controls regulating the use of such brakes in Australia although local by-laws have been used for this purpose in parts of New Zealand. A range of non-regulatory initiatives have been implemented in both countries to reduce the community impact of compression brake noise. Several "noise camera" systems have also been tested. Noise cameras have used both noise level and noise character as indicators of excessive compression brake noise. Efforts by Governments to address compression brake noise have sought to balance, the often competing, considerations of road safety and impacts on truck maintenance costs as well as community impact such as sleep disturbance.

1 INTRODUCTION

Noise from heavy vehicle compression brakes is a common cause of community complaint in both Australia and New Zealand. It is particularly disturbing because it is often clearly audible above most ambient sounds, it is has a distinctive (machine gun) characteristic, and it starts and

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stops abruptly. Most complaints about compression brakes relate to their use in urban areas at night time.

Governments in Australia and New Zealand have not prohibited the use of compression brakes due to fear that vehicle safety may be compromised [1]. They have also avoided imposing regulations against "excessive noise" because this is subjective, and may be difficult to defend in court.

Compression brakes are commonly referred to as "engine brakes", "exhaust brakes", "Jake brakes" or occasionally as "air brakes" in Australia and New Zealand.

There are indications that some truck owners tamper with their vehicles in such a way as to compromise the exhaust muffler system, increasing compression brake noise. This is done either to increase vehicle power or to deliberately increase noise [2-3]. Other heavy vehicles may have defective muffler systems due to lack of maintenance. A survey of 244 heavy trucks on US I-65 in Indiana found that 5.3% did not have functioning mufflers [3].

2 WHAT COMPRESSION BRAKES ARE, AND HOW THEY WORK

A compression brake is one of several alternative retarding systems that supplement the service braking system of a heavy vehicle. Diesel powered vehicles typically use retarding systems because diesel engines do not have as effective engine braking as gasoline powered vehicles. Compression brakes appear to be the most popular type of retarding system on Australian and New Zealand trucks, due to their high performance, as well as low cost and mass compared to alternative technologies.

The operation of compression brakes is explained as follows. It is normal for the fuel supply to a four stroke internal combustion engine to be cut off when the driver releases the accelerator pedal, stopping combustion from occurring in the engine. The upward movement of any piston in its compression stroke will slow the crank shaft slightly, as the piston compresses air in its cylinder. However, when the piston moves back down in what would normally be the power stroke, it is accelerated by the compressed air in the cylinder. Hence energy that is absorbed from the crank shaft by compressing air is returned to the crank shaft.

When a compression brake is activated, it momentarily opens the exhaust valve at the top of the compression stroke, allowing the compressed air to vent out of the engine through the exhaust system. This releases the energy from the compressed air in the cylinder.

There are two effects of the compression brake. Firstly, it means that the power that is absorbed from the crank shaft during the compression stroke is not returned to the crank shaft during the power stroke. This means that the angular velocity of the crank shaft is reduced, slowing the vehicle. Secondly, an impulsive blast of air passes through the exhaust system, causing loud noise, which may or may not be effectively attenuated by the vehicle's muffler system.

Compression brakes are intended to reduce the speed of a vehicle rather than stop the vehicle. They are particularly helpful in limiting the speed of a vehicle on a long down-grade, both limiting fade of the service brakes due to heat, and limiting wear on the service brakes. However,

their use in Australia and New Zealand is also common on level terrain where they may be used to ensure compliance with speed limits, control speed in heavy traffic, assist with gear changes, or to reduce the speed of vehicles approaching intersections.

It is understood that new trucks manufactured in Australia, which are fitted with compression brakes, are generally fitted with mufflers which reduce noise from compression brakes to acceptable levels. However, the authors are aware of claims that some trucks have excessive compression brake noise even with original equipment mufflers [3]. A small proportion of trucks have poorly maintained mufflers, or in some cases, no mufflers at all. This results in particularly high noise levels from compression brakes, as well as during normal driving.

3 HEAVY VEHICLE NOISE REGULATION

There are broadly two sets of vehicle regulation in Australia – Australian Design Rules (ADRs), which are enforced federally and apply to new vehicles (original equipment), and in-service standards, which are enforced by the nine states and territories. Essentially the in-service standards require the owners of vehicles to maintain them in a safe condition, and limit modifications. They do not require the owners to improve their vehicles to a standard that is more stringent than the ADRs which governed manufacture.

Original equipment vehicle noise is regulated in Australia by Australian Design Rule ADR 83/00. This rule, which is based on the European ECE 51 passby noise regulation stipulates the maximum SPL measured by a microphone located 7.5 m from the centreline of the vehicle under specified acceleration conditions [4]. The limit is 81 dB(A) for most heavy trucks, including an allowance of one decibel for vehicles with diesel engines. ADR 83/00 is approximately two decibels more stringent than the American heavy vehicle noise standard CFR Title 40 [4]. ADR 83/00 does not address noise under the condition of braking, meaning that the noise from new trucks whilst braking is unregulated.

It is interesting to note that until 1977, CFR Title 40 included a deceleration test, intended to address compression noise. A report by the US Environmental Protection Agency recommended the withdrawal of the deceleration test based on the premise that mufflers capable of adequately attenuating engine noise under acceleration would also adequately attenuate compression brake noise [5].

In Australia, in-service limits on motor vehicle noise are enforced by the State Authorities, using a stationary noise test. This test measures the SPL at a specified location 0.5 m from the exhaust outlet with the engine running at three quarters of the speed at which maximum power is developed. The measured noise levels are compared to limits included in the state environmental regulations which are based on engine type (spark or compression ignition, gross vehicle mass and date of vehicle manufacture) [6].

Vehicles which Police suspect may be excessively noisy may be required to submit to stationary noise testing at approved test laboratories. Consequences for non compliance with in-service noise standards vary between states and include fines and cancellation of vehicle registration.

Noise emissions from vehicles are controlled in New Zealand by the Land Transport Rules: Vehicle Equipment 2004, and in particular an amendment made to those rules in 2007. There are no rules specifically for noise from compression brakes, but the other general rules control exhaust noise which could be interpreted as including compression brake noise.

The first applicable rule limits the noise emissions of new vehicles entering New Zealand. In a drive-by test in accordance with ISO 362, BS 3425, SAE J1470, ADR 28/01, TRIAS 20 or another approved method, heavy vehicles with a power output over 150 kW must not exceed 88 dB(A) and those under 150 kW must not exceed 86 dB(A). There is also a requirement that any modification must not increase the noise output from the exhaust.

Once vehicles are in service in New Zealand, there is a second rule for heavy vehicles that noise from the exhaust system must not be *"noticeably and significantly louder than the noise output from the vehicle's original exhaust system at the time of the vehicle's manufacture"*. Land Transport Rules also allow the Police to act if noise from any vehicle is excessive.

5 "NOISE CAMERAS" - SPL BASED NOISE ENFORCEMENT

Efforts to enforce a limit on the use of noisy engine brakes started in Tasmania in 2003. This small-scale program was based on attended recording of SPL, combined with video recording. By manually reviewing recorded data from several locations in the state, it was possible to identify a number of exceptionally noisy trucks. The owners of these trucks were sent letters advising that their trucks were abnormally noisy, and requesting that they be repaired. No penalty was applied.

This system did not apply a particular limit on SPL, because actual SPL levels are obviously a function as much of the environment and microphone location as they are of the truck. Rather, the loudest few percent of trucks at any one location were targeted. Anecdotally, the program was successful at encouraging some truck owners to upgrade their vehicles.

A similar program was undertaken in Victoria in 2010, and is being repeated in 2012. Unlike Tasmania, the owners of trucks which are abnormally noisy are issued improvement notices requiring them to submit their trucks for stationary noise testing under Victoria's Environment Protection (Vehicle Emissions) Regulations 2003 [6]. The truck owners are required to present certificates of compliance from the stationary noise tests or face cancellation of their registration. In 2010, eighty-one notices were issued, and five registrations were cancelled.

6 "NOISE CAMERAS" - RMS MODULATION NOISE STANDARD

The notion of a "noise camera" was conceived within the South Australian Department for Transport, Energy and Infrastructure around 1996 [7]. The intent was that an automated road-side camera would photograph passing trucks with excessively noisy compression brakes, having been triggered by a noise measurement. An infringement notice would automatically be issued on the basis of the detection.

The first prototype noise camera was triggered on the basis of SPL. Subsequent systems were developed under contract by Acoustic Technologies Pty Ltd in New South Wales. These used an algorithm referred to as "RMS Modulation" that was designed to specifically identify

compression brake noise to the exclusion of other environmental noises. The details of the RMS Modulation algorithm are beyond the scope of this paper. Suffice to say it is based on converting the noise signal to an RMS amplitude signal, passing it through a 5 Hz to 80 Hz band pass filter, then measuring the amplitude of its modulation. A limit of 3 dB is applied to the modulation [8].

In 2007, Australia's National Transport Commission (NTC) proposed a regulation based on RMS Modulation [9]. The Australian Transport Council, comprising all State and Federal Ministers with responsibility for transport, unanimously approved the regulation in the same year [10]. All that remained was for the states to draft legislation, develop the testing technology to an evidentiary standard, and establish back office processing systems. It was anticipated that the systems used by the states to process speed camera fines would be leveraged.

New South Wales took the lead in progressing the regulation toward implementation, with an understanding that the other states would implement the system developed in NSW. Three distinct detection systems were developed in New South Wales since 2007. These were:

- Fully automated fixed gantry mounted systems. These systems photograph the suspect vehicle and record audio and video signals, in order that an operator can manually review the data and confirm that a vehicle is unambiguously identifiable as the source of the noise. Two systems were installed on arterial roads with steep down grades. Advisory notices (without threat of penalty) were issued to owners of noisy trucks based on data from these systems. Anecdotally, the use of noisy compression brakes at these locations has reduced.
- A trailer mounted mobile camera system, which also recorded still photo, audio and video data. This system was intended to operate unattended, and to be moved from place to place in order to cover large areas of the state.
- A hand held system, without a camera. The intent was that it would be operated by a Police Officer, who will intercept any trucks using noisy compression brakes, and issue an infringement notice.

Several challenges were encountered in the development of the RMS Modulation based regulation. The most significant obstacles are described below.

- The RMS Modulation measurement is difficult for non technical people to understand. If an infringement is challenged in court, the Judge or Magistrate may choose not to enforce it because he or she does not fully understand how the detection system works.
- It is difficult for the owner or driver of a vehicle to know whether the noise from the vehicle's compression brakes are over or under the RMS Modulation limit of 3 dB. New South Wales proposed addressing this by issuing two warning notices for noisy trucks and imposing a penalty only after three detections. The challenge with this approach is that unless the number of detection sites is high, a noisy truck may never be detected three times.
- It is not yet clear that the detection equipment is of an evidentiary standard. There is a possibility that an infringement notice could be challenged on the basis of the accuracy or calibration of the instrumentation, or on the basis that it may have been tampered with. Also, the system does not use a directional array of microphones, so it may be difficult to demonstrate that the sound that was measured in fact came from the vehicle that was identified as the source of the noise.

- In the case of unattended recordings, an automated number plate recognition system is used to identify the vehicle in the photograph. However, the test method requires that an operator manually review audio and video recordings in order to confirm that the measured noise does in fact appear to be coming from the suspect truck, and there is no source of ambiguity, such as multiple vehicles being present. It is anticipated that this operator may need to present in court if an infringement notice is challenged.
- There is no plan to implement the RMS Modulation limit at an original equipment standard through the Australian Design Rules, so there will be no requirement for truck manufacturers to ensure that their products comply with it. Although it is likely that modern trucks will comply as built, it is arguable that imposing an in-service regulation where no original equipment regulation exists is unfair to truck owners. In any case, if the RMS Modulation limit was imposed on new trucks now, it could be argued that imposing an in-service limit on trucks already built would be retrospective.

7 ADVISORY SIGNS AND LOCAL CONTROLS

A number of road controlling authorities in Australia and New Zealand have installed advisory road signs in residential areas requesting that truck drivers avoid using their compression brakes. In Australia guidelines for the placement of advisory signs preclude their use in areas where compression brakes are most likely to be used. For example, they indicate that signs should not be used within 300 m in advance of traffic signals, curves, sections of road that are commonly congested, nor on downhill grade [1, 8-9]. Advisory signs do not appear to have significantly reduced the impact of compression brake noise, and it has even been suggested that noisy compression brake usage has increased as a result of advisory signs [9].

In New Zealand there are a number of advisory "No Engine Braking" signs that have been installed on the approaches to townships throughout the country. Signs are also used by some local authorities that require mandatory compliance with local bylaws. For example, the city of Hamilton has created a bylaw [11] using the provisions of the Local Government Act and Land Transport Act to prohibit the use of compression brakes within defined urban areas of the city. Such bylaws typically only apply to local authority roads. For state highways the NZ Transport Agency could potentially use provisions recently made in the Land Transport Act. This allows road controlling authorities to restrict the use of compression brakes on any section of road under their control where the permanent speed limit does not exceed 70 km/h. To date this provision has not been used or tested in NZ.

8 EDUCATION OF TRUCK DRIVERS AND OPERATORS

There have been a number of efforts over several years to reduce community disturbance caused by compression brake noise by educating truck drivers and operators. Efforts in a number of Australian states and in New Zealand have in particular focused on appealing to drivers to avoid using their compression brakes at night and in urban areas. These attempts have included industry codes of practice. Whilst industry associations and some freight companies are supportive of efforts to reduce compression brake noise, they do not have influence on the whole industry. As well as large freight companies, many trucks are owned and driven by independent operators who are difficult to engage with such schemes [9].

A number of road controlling authorities have published brochures and magazine articles with input from key stakeholders such as the Australian Trucking Association and the NZ Road Transport Forum [12-13].

These measures do not appear to have had significant impact [9]. Anecdotal evidence would suggest that after an initial impact they need constant reinforcement to remain effective.

8 OTHER RESPONSES

A range of other responses to compression brake noise have been considered in Australia and New Zealand. These include:

- The establishment of an Australian Design Rule limiting compression brake noise. Consistent with the objectives of the World Forum for Harmonization of Vehicle Regulations, Australia and New Zealand generally avoid the introduction of unique motor vehicle standards, unless there is compelling reason for them. It has been argued that the introduction of an ADR that limits compression brake noise is unnecessary because original equipment heavy vehicles already have acceptable noise levels under conditions of braking.
- Prohibition of the use of compression brakes in built up areas. This has been rejected on the grounds that it would compromise safety where steep down-grades in urban areas warrant the use of retarding systems on heavy vehicles [2].
- Prohibition on the use of "noisy" compression brakes except in emergency. Several jurisdictions in North America, for example Ohio currently impose such regulations. This approach has been rejected because the imposition of such regulations would be essentially subjective. It is believed that Police Officers would be reluctant to issue infringement notices which could be challenged in court on the grounds that the noise was not unreasonable or unnecessary.
- Construction of noise barriers and sound-proofing of houses. These measures are already used in Australia and New Zealand, although there use is primarily aimed at reducing general road traffic noise rather than noise from compression brakes due to practicality and cost issues.
- Geometric road design. Increasingly avoidance of adverse environmental and social effects is beginning to influence road design in both Australia and New Zealand. In particular urban design principles applied to infrastructure improvement projects encourage a more holistic approach to design. The authors are not aware of any examples where the potential for noise from compression brakes has been avoided through design. There is, however, anecdotal evidence to suggest there are lessons to be learnt from projects where the "as-built" design appears to have unintentionally exacerbated compression braking noise in certain locations.

9 COMPETING DEMANDS

Measures to address compression noise must be balanced against other considerations. In particular, there is a concern in Australia and New Zealand that regulations that discourage the use of compression brakes may compromise road safety if they result in the failure of vehicle service brakes due to excessive heat or excessive wear if a driver avoids the use of compression

brakes. It is noted that in 1989, Pennsylvania considered e a prohibition on the use of noisy compression brakes but decided not to proceed due to safety concerns [3].

A lesser consideration is the need to avoid the imposition of costs on the freight industry. It is clear that the use of compression brakes reduces wear on the service brakes of heavy vehicles, and the cost of relining brakes is a small but significant proportion of the cost of operating a heavy vehicle.

10 CONCLUSION

Managing compression brake noise remains a challenge for Governments in Australia and New Zealand. Considerable effort has been directed toward non-regulatory approaches such as education over the last fifteen years, with little apparent impact. To date, Governments in both countries have avoided the prohibition due to legal issues. The mainstream approach in Australia is the development of an RMS Modulation based noise camera, with supporting legislation. Whilst New South Wales has demonstrated that noise camera systems can work well, there remain issues of legal considerations. To date noise cameras have not been used in New Zealand where the focus remains largely on the use of local bylaws and education to reduce the community impact caused by compression brake noise.

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