Project Summary

Locomotive horn evaluation: effectiveness at operating speeds

This study is part of the **Highway-Railway Grade Crossing Research Program**, an undertaking sponsored by Transport Canada, major Canadian railways, and several provincial authorities. The program is part of Direction 2006, a cooperative initiative with the goal of halving the number of grade crossing and railway trespassing incidents by 2006.

This study examined locomotive horn placement and sound emission levels, and made recommendations to ensure that horns provide adequate warning while addressing noise concerns from crews and residents near the tracks. The report includes detailed technical specifications for horns and their placement on the locomotive that would make them a more effective warning device.

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Objectives

This study examined the placement of horns on locomotives and makes recommendations to improve crossing safety while addressing noise complaints from crews and residents near the tracks.

Findings

The study found that the location of the horn was very important to its effectiveness. Sound output in front of the train deteriorates as speed increases, unless the horn is located at the front of the engine. Horns mounted behind or close to the engine exhaust hood performed worse than in any other location.

The study also examined the difficulties in providing an adequate auditory warning in situations involving a train travelling at high speeds and vehicles requiring long clearance times, such as a tractor-trailer. Providing adequate advance warning at passive grade crossings for trains travelling at high speeds also poses a particular challenge.

In terms of effectiveness, a horn's harmonic content was found to be more important than its fundamental frequency. A broader harmonic spectrum improves detection of the sound in vehicles and increases the perception of urgency that it conveys.

The report concludes that concern about noise in communities can be addressed without unduly compromising the effectiveness of the warning. One option is to modify the existing fixed-distance warning sequence to a fixed-time warning. A second method is to use front mounted, two-level horns. The normal rule-based warning would be sounded at a lower level and the loudest level would be used only in emergencies.

Test rig used to measure sound output.

In-cab noise considerations are the main constraint to positioning the horn in its most effective warning position. Determining the optimal method of resolving in-cab noise problems would require analytic and experimental investigation, but the report concludes that adequate methods are currently available.

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Conclusions and Recommendations

Based on the laboratory and field testing, the study makes numerous recommendations for changes to policies and policy directions on the part of Transport Canada and the railways to increase the effectiveness of locomotive horns. These include:

- that Transport Canada implement rules that call for horns to be placed at roof level, or where their effectiveness cannot be unduly compromised at normal operating speeds, and that all new locomotives be built with horns located at the front of the locomotive
- that all locomotives that can travel faster than 105 km/h have a horn mounted up front with an output sound pressure level of at least 110 dB A at 30 m. If railway operating rules dictate that this horn be reserved for emergency use only, then the normal horn should be positioned on the locomotive such that it provides a 30 m equivalent output of at least 100 dB when measured at full speed at angles between 25 degrees and 45 degrees from the forward facing direction
- that any railway that frequently runs through urban areas without whistle bans consider the use of two-level horns
- that maximum limits be defined only for lateral angles from the locomotive rather than in front of the locomotive, and that the maximum limit be set at 135 dB at trackside on a 10 km/h pass-by test at 1.5 m above the top of passenger platforms and 2.0 m horizontal from the nearest rail
- that Canadian railways seek a waiver for Canadian-based locomotives that cross the border to a proposed U.S. limit on 111 dB on loud-mode output
- that the frequency content of the assembled horn on the locomotive, when measured in stationary tests at 61 m, be such that the minimum 1/3-octave-band-SPL in the range 2,000 Hz to 3,150 Hz is not less than F below the maximum 1/3 octave band SPL in the range 250 Hz to 1250 Hz, where F equals 12 dB for trains exceeding 105 km/h and 15 dB otherwise
- that the tones of the locomotive's horn be readily recognizable as being from a train, and not similar to other common warning devices such as used in road transport or in a factory
- that locomotive horns should be composed of fundamental frequencies consistent with at least two flutes, no lower than 250 Hz and no higher than 660 Hz
- that any existing or future locomotives operating over 105 km/h should have a front-mounted five-flute horn available in emergency situations

- that those railways that implement a two-level or emergency-only horn select the combination of frequencies such that some dissonance exists in the loud level
- that existing horns located behind and close to the engine exhaust hood should be moved or an alternative emergency horn should be added at the front of the locomotive. If railway operating rules dictate that this alternative horn be reserved for emergency use, then the normal horn(s) should be positioned such that it provides a 30 m equivalent output of at least 100 dB A at angles between 25 degrees and 45 degrees from the forward facing direction when measured at full operating speed
- that Transport Canada produce awareness-raising that recommends motorists roll down both windows and turn off all noise sources at crossings in poor visibility conditions in order to hear a train approaching
- that provincial and municipal highway authorities bar school buses and tractor-trailers from using passive grade crossings of high-speed rail lines in conditions of poor visibility (e.g. fog, heavy snow)

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