THE INFLUENCE OF POLICY ON CRASH RATE OF LONG COMBINATION VEHICLES

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ABSTRACT

A comprehensive safety performance study in Alberta Canada has found that Long Combination Vehicles (LCV) operating under special permit have crash rates that are approximately 5 times less than common tractor semi-trailers operating on the same roads. The safety benefit is attributed in large part to the special permit policy governing LCV operations in the province. This paper describes the methodology used in the study including the means by which vehicle distance traveled estimates were conducted for calculating crash rate. It also discusses the collision causal factors, truck at fault analysis and crash rate findings. A brief review of policy elements thought to be key influencing factors for LCV safety performance benefits is also included.

INTRODUCTION

The Province of Alberta, Canada, commissioned Woodrooffe & Associates to conduct an in-depth analysis of the safety and economic performance of long combination vehicles (LCV) operating within the province(1,2). The study also included a review of rail transport efficiency in relation to LCV operation (3). This paper focuses on one aspect of the study, specifically; the comparative performance of LCVs with respect to common five and six axle tractor semi-trailers operating under normal size and weight regulation. LCVs operating in Alberta do so under a highly accountable and progressive special permit system. The paper will examine provincial policy governing the operation of the LCVs and discuss how it may influence safety outcomes.

Vehicle description

Long Combination Vehicles (LCVs) are tractor trailer combinations, consisting of a tractor with two or three trailers having a combined combination length exceeding the regular limits of 25 meters. These vehicles have been operating on Alberta highways since 1969. In Alberta, the maximum gross vehicle mass applicable to LCVs is 63,500 kilograms while the maximum configuration length is 37 meters (121.4 feet). LCVs are further defined according to size, with three length classifications:

Rocky Mountain Double- A combination vehicle consisting of a tractor, a 12.2 m (40 feet) to 15.2 m (53 foot) semi-trailer, and a shorter 7.3 m (24 feet) to 5.5 m (28 feet) trailer. The total length does not exceed 31 m (102 feet). The maximum gross combination mass varies depending on the trailer articulation details used to couple the two trailers and the number of axles. If the connection forms an A-train (i.e. a simple drawbar A-dolly connection) then the maximum gross combination weight is limited to 53,500 kg. If a double drawbar dolly is used forming a C-train, the maximum gross combination mass is increased to 60,500 kg. If the connection forms a B-train, (i.e. the second semi-trailer is attached with a fifth wheel fixed to the lead trailer chassis) then the maximum gross combination weight is increased to 63,500 kg provided the vehicle has eight axles. These vehicles are typically used when cargo considerations are governed by operational logistics because, unlike other LCV's, the Rock Mountain Double is permitted to operate on some high standard two-lane undivided roads where there are adequate shoulders to accommodate vehicle tracking characteristics.

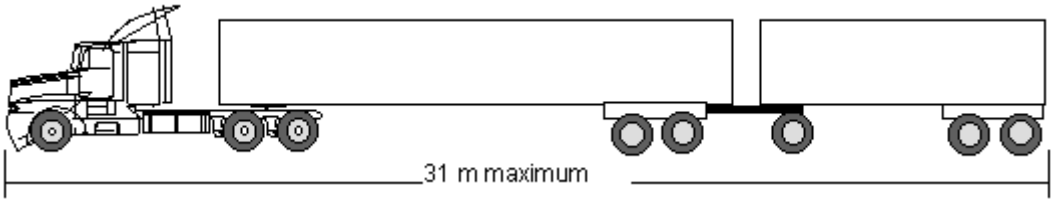

Figure 1. Rocky Mountain Double.

Turnpike Double- A tractor plus double trailers of similar length. Each trailer is between 12.2 m (40 feet) and 16.2 m (53 feet). The overall vehicle length limit is 38 m and the maximum gross combination mass is 63,500 kg. The additional mass afforded to the Turnpike Double is attributed to the superior dynamic characteristics of this vehicle. The Turnpike Double is typically used for carrying cargo that benefits from the additional cubic capacity of the trailer arrangement.

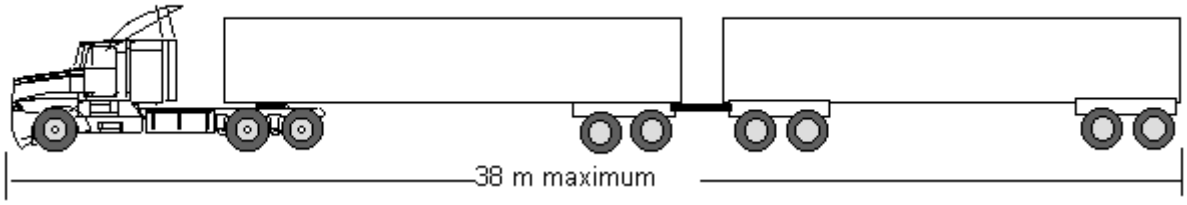

Figure 2. Turnpike Double.

Triple Trailer- This combination consists of a tractor with three trailers of approximately the same length. The typical trailer length is approximately 7.3 m and 8.5 m (24 to 28 feet) with an overall vehicle length of 35 meters and the gross combination mass limit of 63,500 kg. The Triple Trailer is used for carrying cargo that benefits from the additional cubic capacity of the trailer arrangement or from the operational flexibility of having three smaller trailers that can be easily redistributed as separate vehicle units at the point of origin and destination.

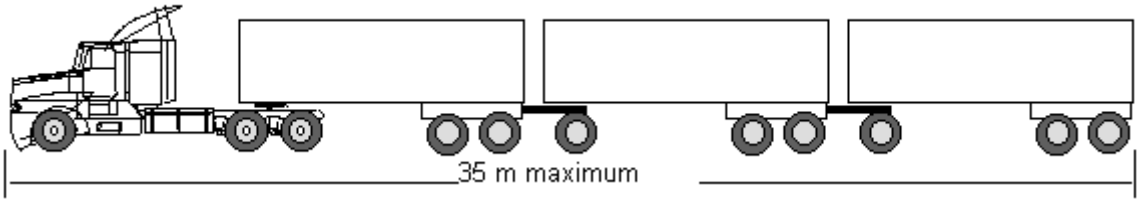

Figure 3. Triple trailer.

DEFINING THE ROAD SYSTEM AND VEHICL DISTANCE DATA

Road system examined

The operation of LCVs in Alberta is restricted to specific routes or a sub-network within the entire provincial road and highway system (shown in Figure 4). This is in recognition that the length of LCVs normally exceeds the allowable overall length of 25 metres for truck-trailer combinations. To facilitate safe passing and maneuvering, Turnpike Double and Triple Trailer combinations are only allowed to operate on 4-lane highways. The Rocky Mountain Double is the only LCV that can operate on all 4-lane highways and select high standard 2-lane highways in the province.

Out of the total provincial primary highway system of 13,776 km, the sub-network allowing LCV's to operate consists of approximately 2,800 km. LCV vehicles can travel at 100 or 110 km/hr depending on the road class. All routes over which the largest LCV configurations (Turnpike Doubles and Triple Trailers), are permitted to operate, were included. That is, all 4-lane divided highways in the province of Alberta plus those 2-lane highways where Rocky Mountain Doubles may operate.

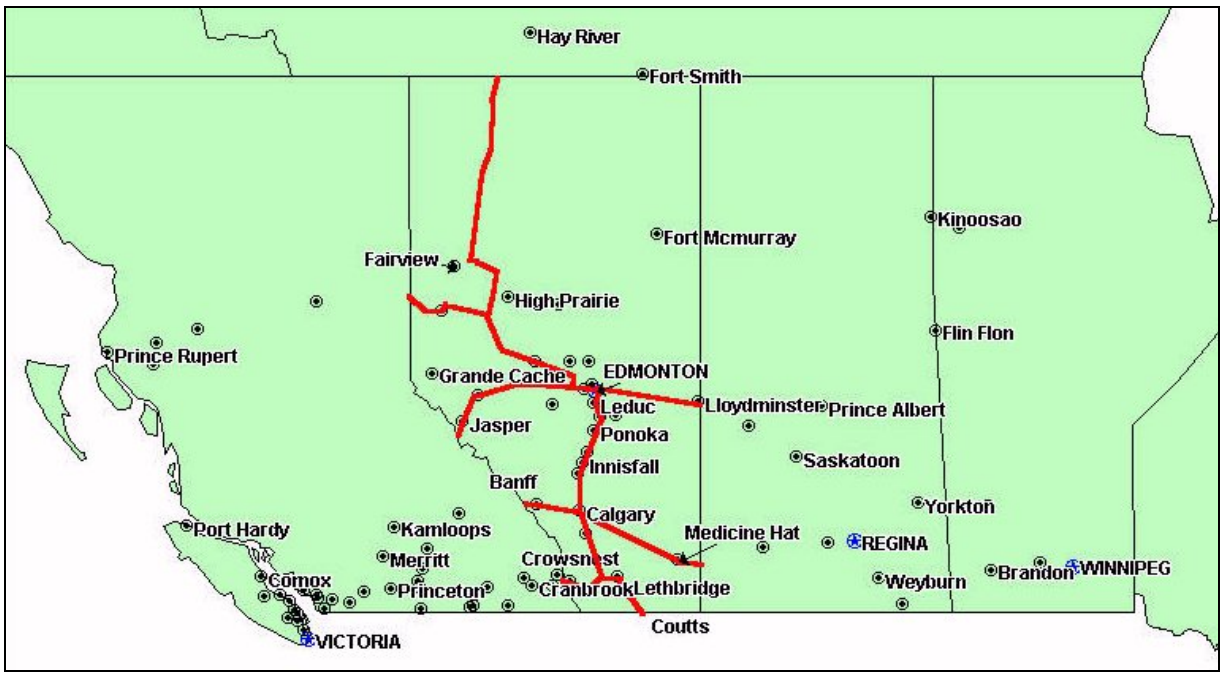

Figure 4. LCV Highway segments in Alberta.

Estimating vehicle distance traveled

Alberta Infrastructure provided the consultant with highway traffic count statistics (for all highway segments in the sub-network) for each of the years 1995 to 1998. These statistics contain the Annual Average Daily Traffic (AADT) counts for all vehicles traveling on each highway route in either direction. The AADT statistics are given as the daily weighted averages over the entire Highways Control Sections and Traffic Control Sections. The (weighted) daily average traffic volume for a traffic control section is estimated using the travel distances at monitored sites within the traffic control section. The (weighted) daily average vehicle classification for a traffic control section is estimated using the cumulative travel distances and historical classification from manual traffic counts, at monitored sites within the traffic control section.

The AADT statistics measure traffic volumes for the following vehicle types; personal vehicle, recreational vehicle, buses, single unit trucks and tractor-trailer trucks. Thus, it was possible to estimate the total volume for the LCV sub-network.

In order to estimate the volume of commercial vehicles and LCVs using the sub-network highway an additional vehicle survey was required. The LCV vehicle mix on the sub-network was determined from the 1999 Canadian Council of Motor Transport Administrators (CCMTA) National Road Survey. Hourly traffic counts were maintained, on a continuous basis, during the week of July 13-19^{th,} 1999.

The total traffic volume by vehicle type was developed by generating estimates of travel distance for each class of vehicle on the sub-network. The information was used to determine the LCV collision exposure rate relative to other vehicles. It included all Turnpike and Triple routes and the expanded Rocky Mountain Double routes. The routes analyzed are representative of the various highway segments found in Alberta. From this information, the total distance-traveled by each vehicle type was determined and was used as the denominator in the collision exposure rate equation.

$$\text{Collision rate by vehicle type} = \frac{\text{Number of vehicles of a given type involved in collisions}}{\text{Total kilometers traveled by that vehicle type}}$$

The collision rate calculation is based upon the type of vehicle involved in an incident. In this analysis, “the vehicle involved in the collision” is the primary investigative factor therefore the “total” number of vehicles involved in the collisions are represented and form the numerator of the collision exposure rate equation. When examining vehicle involvement, the numbers of all vehicles involved in the collisions are recorded. If

there are 100 collisions involving 200 private vehicles, the number of vehicles involved in the collisions will be counted as 200. This method is known as "Collisions by Vehicle Type."

Detailed analysis of collision rates was restricted to the sub-network, given the difficulty in resolving the collisions per kilometers traveled, by vehicle type, within an urban area, which would be essential for comparative purposes. Therefore, urban LCV collisions were considered only in the detailed case-by-case analysis of the police accident reports where contributing factors to LCV collisions were investigated.

When comparing exposure levels amongst the different vehicle types from within this study it is important to note that the volume of traffic and the distance-traveled by each vehicle type is based on the total traffic volume as indicated by each of the Control Sections (as defined by Alberta Transportation) on the highway. The method used to calculate the vehicle distance by LCVs recognized the time of day operating restrictions on LCV use. Thus, daily traffic count volumes were adjusted to reflect the fact that they could not operate 365 days of the year.

For a given section of highway there are one or more Control Sections used to measure traffic volume. Each Control Section has one or more Traffic Control Sections. A Traffic Control Section is a portion of roadway having similar characteristics. The average length of each Traffic Control Section is approximately 50 kms. These occur at intersections of roads along a highway Control Section and are used to record the turning movements of vehicles entering or leaving a portion of highway. They act as additional control points for measuring the traffic volume on the respective roads and for classifying vehicles.

Error and uncertainty discussion

The estimated accuracy for LCV activity applicable for the higher traffic volume links (Calgary-Edmonton corridor, Trans-Canada, Yellowhead) would be within ± 2 or ± 3 percent. The accuracy of LCV activity on individual links for the rest of the sub-network would show greater uncertainty, perhaps ± 10 percent due to sample size factors cited. There are statistical sampling considerations required when using roadside commercial trucking surveys to estimate annual movements of vehicle populations.

These considerations are more pronounced for small samples such as "one day roadside surveys" and "low volume route linkages," where the observed variances in samples point to a significant uncertainty in the overall magnitude of the population being sampled. This being recognized, "most" of the LCV activity sampled for the province of Alberta occurs on Highway 2 between Calgary and Edmonton as well as on the Yellowhead Corridor and Trans Canada Highway Corridor. For these routes, the "sampling frequency" associated with measurement of AADT values coupled with the "cross checks" from vehicle classification studies, "weigh in motion sampling" and "national parks gate screen counts," enable considerably better precision in our estimates. The quality of vehicle classification information was maximized by using data from the National Road Survey which was based on a 7 day, 24 hour sample.

ANALYSIS OF LCV COLLISIONS

General LCV crash numbers

Within Alberta there were 53 collisions involving LCVs, during the period 1995 to 1998. It is important to recognize that this data set is small and care must be taken when interpreting the findings. Of this total, 3 were fatal collisions and 2 were within the sub-network, 26% (14) resulted in injury and 68% (36) involved property damage only. Of the 14 injury collisions, 13 resulted in minor injuries (injuries not requiring hospital admission).

Table 1. LCV collision distribution.

Configuration Type	Collisions		
	Sub-Network	Urban	Total
Rocky Mountain Double	11	1	12
Turnpike Double	20	10	30
Triple	6	5	11
Total	37	16	53

Note: The sub-network refers to the LCV Highway Segments referred to in Figure 4.

Table 1 reveals that sub-network accounted for 70% (37 out of 53) of the collisions during the period 1995 to 1998. Of this total, 2 were fatal collisions, 24% (9) resulted in injury and 70% (26) involved property damage only.

All of the LCV collisions on the sub-network occurred on the open road. Most (88%) of the urban LCV collisions occurred at intersections where other vehicles disobeying traffic signals and were found to be responsible for 29% of the urban LCV collisions. On average, road surface and weather conditions were possible factors in 49% of all sub-network collisions and 31% of all urban collisions. There were only 2 reported cases of an LCV rear-ending another vehicle. Both of these collisions involved Triples and both occurred at city intersections. Table 2 provides crash details by LCV type and urban and rural areas.

Table 2. LCV Collision details for all sub-network and urban collisions 1995-1998.

Configuration	Sub-network	Urban
Rocky Mountain Doubles	**Total collisions = 11** • 8 single vehicle collisions, 5 of which were animal related and 3 were road surface condition related. • 2 involved other vehicles. • 1 related to road construction. • All collisions occurred on the open road. 4 of the 5 animal collisions occurred on 2-lane roads. • In total 8 of the collisions may be related to road surface conditions.	**Total collisions = 1** • LCV sideswiped by a vehicle where alcohol was involved. • Occurred at an intersection. • No collisions were related to road surface condition.
Turnpike Doubles	**Total collisions = 20** • 6 single vehicle collisions, 3 of which were animal related, 2 were road condition related and 1 was fatigue related. • 14 involved other vehicles of which 6 were road condition related. • 1 related to road construction. • All collisions occurred on the open road • All of the animal collisions occurred on 4-lane divided roads. • In total 8 of the collisions may be related to road surface conditions.	**Total collisions = 10** • 8 occurred at intersections. • 8 involved errors by other vehicles, including 3 disobeyed traffic signals and 1 improper turn. • 2 were the fault of the LCV. • In total 4 of the collisions may be related to road conditions.
Triples	**Total collisions = 6** • 4 single vehicle collisions, 1 animal related, 2 were road condition related and 1 was mechanical related (2 occurred on 2-lane roads). • 2 involved other vehicles 1 of which was road condition related. • All collisions occurred on the open road • The animal collision occurred on a 2-lane road. • In total 2 of the collisions may be related to road surface conditions.	**Total collisions = 5** • 5 occurred at intersections. • 3 involved errors by other vehicles including 1 disobeyed traffic signal. • 2 were the fault of the LCV, both were rear end collisions. • In total 1 of the collisions may be related to road surface conditions

Probable fault long combination vehicles

Probable fault in each crash was determined by detailed study of the police collision report information. In all collisions involving wildlife or highway debris, the LCV was not considered to be at fault. Unusual events such as an LCV trailer decoupling or a trailer of an LCV being overturned by wind were assumed to be the fault of the LCV. In all other cases, the LCV was considered to be at fault when the investigating officer indicated that the LCV had not been driven properly.

The analysis found that LCVs were not at fault in any of the fatal or major injury collisions within the provincial road network. Of the three fatal crashes, one fatal incident involved a pedestrian attempting to cross a 4-lane divided highway at night. The second fatal collision occurred when a passenger car entered a divided highway traveling in the wrong direction. The third fatality occurred when a passenger car failed to stop at an intersection controlled by a flashing red light and collided with an LCV. In none of the fatality collisions were the LCV be considered at fault.

Adverse conditions long combination vehicle collisions

The LCV collision data displayed in Figure 5 indicates that a significant number (42%) of collisions occurred under "adverse conditions." For the purpose of this report, adverse conditions included "weather" related items such as high wind, fog, snow, sleet and rain conditions as well as "road surface" factors such as snow or ice covered roads. In addition, wet roads or poor road quality (loose gravel in construction zones) were also considered to be adverse road surface factors. It should be noted that this represents a relatively strict definition of adverse conditions.

Adverse conditions (weather and road) were present in 67% of the Rocky Mountain Double collisions, 43% of the total Turnpike Double collisions, and road surface factors in 27% of the total Triple LCV collisions. Combining all LCV crashes, adverse conditions were present in 42% of the cases.

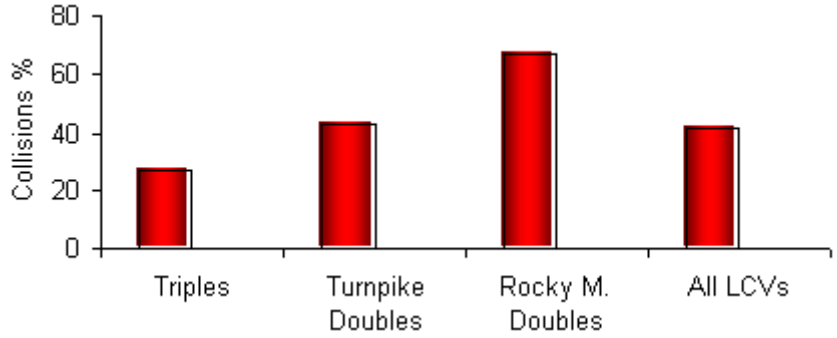

Figure 5. Percent of LCV collisions occurring under adverse conditions (weather and road).

LCV crash rates

The results of the crash rate analysis are found in Table 3 and Figure 6. The findings show that LCVs have the lowest collision rate when compared with common tractor semi-trailers in Alberta. Tractor-Semi vehicles collision exposure rate is approximately 5 times higher than that of all LCVs in aggregate with respect to all collisions (PDO + injury + fatal). In this analysis, urban crashes were not included due to unreliable vehicle travel data within urban confines. Therefore these data are of collisions occurring on highways at highway speed.

Table 3. Collision rates by vehicle type (within the sub-network 1995-98).

Vehicle Type	Per 100 million km traveled			
	Total Vehicles in Collisions	Fatal	Injury	PDO
Tractor Semi	79.52	3.29	21.74	54.49
Rocky Mountain	10.31	0.00	1.87	8.43
Turnpike Doubles	20.00	2.00	5.00	13.00
Triples	16.87	1.69	4.22	10.96
All LCV	15.80	0.85	3.84	11.10

Note: PDO indicates Property Damage Only collisions

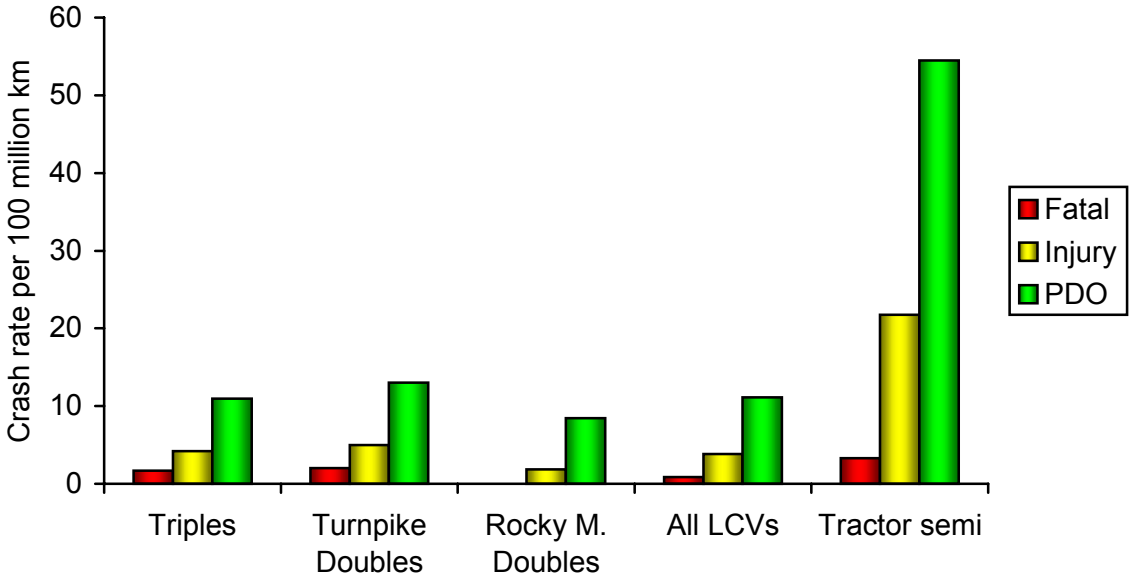

Figure 6. Crash rates of special permit LCV's and common tractor semi-trailers.

Within the LCV class, Rocky Mountain Doubles have the lowest collision rate. The collision rate for Turnpike Doubles is approximately 1.94 times higher than the Rocky Mountain Doubles. The Triple Trailer LCV collision rate is 1.64 times higher than the Rocky Mountain Doubles. However despite the relative difference in involvement between the Rocky Mountain Double and the Triple Trailer LCV, the collision rate for Triples was found to be 4.71 times lower than the common Tractor Semi-Trailer. The key finding is that LCVs operating in Alberta under the special permit program have superior safety performance, as measured by crash rate, than the common tractor semi-trailer operating under normal policy on the same roads. The study results tend to support the argument that imposing restrictions on LCV movements during adverse conditions is an important part in managing safety risk.[1]

THE INFLUENCE OF POLICY ON CRASH RATE

The large difference in crash rate performance between LCVs and tractor semi-trailers in Alberta cannot be attributed to vehicle dynamic factors. The tractor semi-trailer operates at lower gross combination mass than LCVs and it is known to be a relatively stable vehicle. The tractor semi-trailer is the most common commercial vehicle in the province. It operates without special permit under normal commercial vehicle weight and dimension laws. As with LCVs, its primary operating environment is on the rural highway network. In light of these conditions the reason for the difference in crash rate performance between LCVs and tractor semi-trailers can be linked more convincingly to policy.

LCVs operate under a special permit program governed by strict operating conditions. The structure and enforcement mechanisms of the policy engender a level safety consciousness within the LCV fleet, which far exceeds that found in other vehicle classes. The principle motivating factor for heightened safety performance is related to the special safety requirements and fact that Special Permit can easily be revoked for safety performance failure. The special permit system requires that operators be trained to meet and maintain the requirements outlined in the Canadian Trucking Alliance's " Longer Combination Vehicles Driver's Manual."

[1] Alberta Transportation conducted a *Driver Behaviour by Vehicle Type Report (4)*. Two measures of driver behaviour were analyzed: adherence to speed limits and adherence to safe following times. The study found that drivers of larger vehicles travel slower and have greater following times than drivers of smaller vehicles. Findings are presented for the time of day, and for the volume and speed of traffic. Here is a pdf version of the study. The web link worked for me this morning at, you can then navigate to the report.
http://www.trans.gov.ab.ca/TransportationModes/Road.asp

Drivers must obtain an annual certificate verifying that they are in compliance with the following requirements:

The driver:

- Holds a valid Class 1 driver's license or equivalent.
- Has passed a recognized air brake course or has an air endorsement.
- Has a minimum of 24 months or 150,000 km of driving experience with articulated vehicles.
- Has passed a recognized driver's medical examination within the past 24 months.
- Has passed a Professional Driver Improvement Course within the past 48 months.
- Has passed the Canadian Trucking Alliance's "Longer Combination Vehicles Driver Training Course."
- The driver's abstract, dated not more than one month prior to the issue date of the Drivers Certificate, must show no driving-related criminal code convictions in the prior 36 months; no more than 2 moving violations in the prior 12 months; and no more than 3 moving violations in the prior 36 months. The date of conviction and the current date will be the dates used to determine time periods.
- In the past 12 months the driver has been instructed on all current regulations, permit conditions and issues covering the operation of LCVs.

The permit conditions also place controls on where LCVs can operate including hours of operation (time of day), vehicle dimensions such as wheelbase, hitch offset and dolly drawbar length. The policy also contains operational requirements such as adverse weather restrictions, requirements that the vehicles track properly and do not sway, and requirements that vehicles do not cross opposing lanes of traffic unless absolutely necessary.

The Alberta policy governing LCV movements is designed to reduce high risk travel of the LCV fleet. This is done by restricting movement in urban areas during peak hours or during inclement weather. An example of the kind of operational restrictions placed on LCVs follows:

On multi-lane Highways

Within 40 km of the corporate boundaries of the cities of Calgary and Edmonton:

Movement will NOT be allowed:

- Traveling OUTBOUND from 4:00pm to 8:00pm on Fridays
- Travelling INBOUND from 4:00pm to 8:00pm on Sundays
- When a statutory holiday falls on a Friday, movement will NOT be allowed traveling OUTBOUND from 4:00pm to 8:00pm on the preceding Thursday
- When a statutory holiday falls on a Monday, movement will NOT be allowed traveling INBOUND from 4:00pm to 8:00pm on the Monday

CONCLUSIONS

LCVs operating in Alberta under a special permit policy were found to have a significantly lower crash rate (factor of 5) than common tractor semi-trailer trucks.

This positive safety performance is attributed to Alberta Transportation's permit conditions governing the operation of LCVs. The policy was found to be a vital influencing factor in the creation of a safe operating environment in Alberta. The effective conditions include selective routing, restrictions on vehicle speed, restricted time of day operation, enhanced driver qualification requirements and operating restrictions for adverse road and weather conditions. The particular elements, including road type, driver competence, vehicle speed and adverse weather conditions have been found to be significant factors in collision causation.

Adverse conditions (weather and road surface) accounted for 42% of all LCV collisions. This point underscores the significance of weather and road surface conditions as a frequent contributing factor on the safety performance of all vehicles including LCV operations. Although the policy has weather based travel restrictions, it is apparent that a more restrictive adverse condition policy would produce additional safety benefits.

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