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CHALLENGES TO USING PERFORMANCE CRITERIA AS A BASIS FOR VEHICLE WEIGHT AND DIMENSION REGULATIONS

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ABSTRACT

Vehicle performance criteria provide a valuable quantifiable means of predicting whether or not vehicle configurations can operate safely within the parameters laid out by the highway geometry, traffic volumes, as well as vehicle weights and dimensions. Over the past fifteen years, standard measures for vehicle performance have been developed to ensure that heavy truck combinations meet or exceed performance targets for rollover resistance, braking performance, turning movements, swing-out and trailer sway.

While the performance criteria associated with these stability and handling characteristics can provide evaluations on the basis of sound engineering principles, regulation and policy development must also consider whether the application of the criteria is practical and in the general public interest. Good public policy must be based upon the overall safety and efficiency of the roadway system. The policy maker must balance between the theoretical thresholds and the practical realities. From an enforcement perspective, performance based regulations would be cumbersome to implement because of the many different vehicle combinations. Regulations and policies need to be easily understood, enforceable and maintain the integrity of the roadway system and the safety of the general public without placing unnecessary restrictions on the trucking industry.

This paper provides an overview of the technical criteria used to evaluate heavy trucks in Canada, a discussion of the problems associated with strict interpretation and implementation of the criteria, and presentation of options for balancing all concerns that must be addressed for good public policy.

1. INTRODUCTION TO PERFORMANCE BASED REGULATIONS

The rapid growth in truck transportation over the past thirty years has been accompanied by steady increases in the size and weight of trucks and truck-trailer combinations. On the whole, these increases have been accomplished without major changes in the design of highway infrastructure and without compromising the safety of the highway system.

However, as truck size has increased, the available capacity and safety margins have been reduced in a number of areas, including:

- bridges and pavements;
- turning space at intersections;
- the opportunities available for passing on two lane roads; and
- the handling characteristics of the trucks themselves.

In this context, effective regulatory policy seeks to balance the need for an efficient and productive truck transportation industry in support of the economy, with the obligations to protect the safety of the highway system and manage the extensive public investment in the infrastructure. For these reasons, the importance of sound weight and dimension regulations has grown significantly over the years.

Weight and dimension regulations were originally intended to ensure that the size and weight of trucks did not exceed the structural capacity of highways and bridges. While this objective remains true today, it is also recognized that these regulations also directly influence the design of trucks, their stability and handling characteristics, the space required for turning and the compatibility of trucks with other vehicles on the highway.

It is also important to realize that vehicle performance is only one aspect of developing trucking regulations and policies. Public servants must recognize the delicate balance that exists between the components of good regulations and the need to respond to the political will by providing the best technical information available. These performance criteria are not a panacea for trucking regulations. Saskatchewan's experience has shown that they cannot be taken in a literal context as a form of regulation. However, vehicle performance criteria can serve as the basis for standard technical input to the development of regulations that promote safe vehicles and that optimize the use of the infrastructure.

These issues were the subject of extensive research in the mid-1980's. As a result, heavy truck weight and dimension limits in Canada were modified and expanded to place limits on vehicle weights and dimensions which directly influence vehicle handling, turning, and stability and control performance.

While it may be intuitively obvious, the stability and handling characteristics of large, heavy trucks are different than for passenger cars in almost all aspects including acceleration times, braking distances, turning space requirements and resistance to rollover.

In addition there is a wide range of performance between the various types of configurations found within the commercial truck fleet.

The regulations governing truck size and weight include limits that are designed to ensure that the performance of heavy truck combinations meets or exceeds performance targets. These targets are reflected in a number of areas, including resistance to rollover in both turning and evasive manoeuvres, braking performance, space required to negotiate turns, front and rear swing-out in turning, and trailer sway.

Figure 1 provides an example of how the limits apply to control front swing-out.

The objective of this limit is to reduce the likelihood that the front corner of the trailer will project into the adjacent lane of traffic when a tractor-trailer combination turns onto a highway. With this control, the maximum amount of front swing-out which could occur would be no greater than about 0.8 m. The front corner of the trailer is visible to the truck driver through the turn, and extra precautions can be taken to ensure that there is no intrusion into the adjacent lane.

In recent years interest in the concept of performance based regulations has been steadily growing in many areas of public policy. This has been spurred by broad-based efforts to eliminate unnecessary regulation, harmonize regulations between jurisdictions, and at the extreme, to deregulate where possible and practical. In this context, the appeal of performance based regulations seems to lie in the prospect of clearly articulating the expected outcome of the public policy requirement. This approach holds promise of coupling an explanation of why a requirement exists with the more traditional description of specific regulated limits or conditions.

In the vehicle weight and dimensions regime, performance based regulations are sometimes viewed as a radical alternative to conventional regulated limits on height, length, width and weight. Rather than describing how large a truck and/or its components can be, and how much it can weigh, some advocates of true performance based regulations suggest that a vehicle must be considered acceptable if it can meet all desired targets for performance. These targets can encompass as many areas as deemed necessary, including turning characteristics, stability and handling properties, horizontal and vertical clearance, impact on bridges and pavements etc.

While it may be difficult to dispute the logic of this concept, on closer examination, the implications for implementation can become quite daunting:

- Highway design standards, road and traffic conditions and geographic factors can vary widely within public road networks. Selection of performance measures suited to the entire network would, by necessity, have to address the most restrictive conditions within the system. Alternatively, portions of the road network could be grouped by standard or conditions, with different performance targets established by class or grouping of roads.

- Many aspects of truck performance cannot be determined through normal inspection procedures. Assessing offtracking, swingout at front and rear, roll stability, pavement or bridge impact performance would require careful consideration of appropriate tests. As such tests could not likely be undertaken at normal inspection facilities, alternative means of assessing compliance would be required. The "type certification' approach used for certifying aircraft performance may be possible in applications where the vehicle configuration and payload do not change. However, the flexibility which characterizes trucking can bring daily changes in equipment (different tractors with different trailers) and widely different types of payload, implying changes in performance which would have to be understood.
- Computer modeling can provide easily usable templates, but the models depend upon input values which can vary significantly in the field. Accurate representation of spring factors associated with tire and suspension type can lead to misplaced faith in the output values. While the models may be based upon information provided by manufacturers, the vehicles operating in the field may not be maintained at the level necessary to provide the same performance over time as the manufacturer's specifications may state. Also, programs such as central tire inflation impact on the operational characteristics of the tires. Failure to recognize the potential differences between theory and practice can lead to a false sense of security with the performance criteria.

It is important to note that every control placed on the size or weight of heavy trucks has a direct and important influence on the stability, handling or turning characteristics of the vehicle. There must be a balance between the safety of the travelling public, preservation of transportation infrastructure and support of economic activity without placing unnecessary restrictions on the trucking industry. Consequently, the impacts that changes in these limits would have on the performance of the truck combination needs to be carefully considered in the context of protecting the safety and integrity of the highway system.

Through careful consideration of the performance criteria and balancing the relevant economic and political input factors for vehicle weight and dimension regulations, public servants can develop regulations which optimize utilization of the existing road network, provide cost efficiencies to the trucking industry and improve safety.

2. SASKATCHEWAN'S EXPERIENCE

Saskatchewan Department of Highways and Transportation (DHT) recognizes that shippers and carriers do not always have vehicles and loads that fall within the current regulations for maximum allowable weights and dimensions. Saskatchewan's current permit system exists to allow these loads to be shipped, for a fee, within specified guidelines and conditions.

In Saskatchewan, dimension permits are issued for width, height, overall length, box length, trailer wheelbase, effective overhang, and kingpin setback.

DHT initiated a review of its permit system and fee structure in 1994. The purpose of the review was to develop a permit system proposal that responded to Saskatchewan's trucking industry needs. As part of the permit system review, vehicle performance criteria were used to establish guidelines for fair application of policies for the trucking industry. Good public policy must balance the concerns for safety of the general public and preservation of the highway network while facilitating economic growth by not imposing unrealistic constraints on the trucking industry. One of the recommendations of the review included, for dimension permits, a less complicated system for users of the permit system. The proposed system included implementing *General Operating Regulations (GOR)*. Over the long term, approximately 90 per cent of the dimension permits would be eliminated if the new regulation was implemented.

The proposed general operating regulations would apply to vehicles and loads that met one of the following criteria:

- Length > 23 m to 36 m;
- Width > 2.6 m to 4.4 m; or
- Height > 4.15 m.

Figure 2 provides the dimension breakdown for length and internal dimensions, width and height. Figure 3 specifies the conditions that the carriers would have to follow.

For example, a lane intrusion of one metre was the upper limit that required little evasive manoeuvres by oncoming traffic, based on a lane width of 3.7 m. For the next dimension range, the upper limit of 2.6 m for lane intrusion was chosen because the load would severely encroach into the oncoming traffic. These same principles were used for width ranges. Vehicle performance criteria provided the framework for development of the dimension ranges. Variables such as lane and shoulder width, exposure rates, low traffic volumes, and passing requirements were factored into the calculations for establishing range limits. Since many of Saskatchewan's highways have less than 500 vehicles per day, the risk in allowing overdimension loads is reduced without compromising the criteria.

These restrictions were derived from existing permit conditions. They were streamlined to ensure consistency of application. The operating regulations strictly addressed the operating characteristics of vehicles and established an acceptable threshold limit. Using this reasoning appeared to move application of performance criteria closer to regulation.

Even though sound engineering principles were used to develop the new regulatory framework, implementation of the principles into functional and enforceable regulations proved to be difficult. This is a perfect example where theory and practice do not always complement each other.

3. DIFFICULTIES ENCOUNTERED

The most significant problem associated with using strict interpretations of performance criteria for regulations was the nature of the criteria itself. Since the criteria are based upon input values (such as center of gravity, suspension width and stiffness, etc.), true performance based regulations should also address those input factors. However, field enforcement personnel are generally not in a position to evaluate many of these input factors. They are limited to evaluating weights and dimensions that can be easily measured during a quick evaluation of a vehicle at a scale location or at a roadside inspection.

Enforceable regulations must address weights and dimensions, which are once removed from the primary inputs affecting vehicle stability characteristics. For example, roll stability is highly dependent upon the center of gravity height, suspension width and suspension type, but these are not easily measured in the field, so the regulations must be based upon measurables such as track width and axle loadings.

While the tabular format for the regulations was relatively simple to develop and provided an easy-to-follow summary, the tables could not be adopted into law. The legal regulations had to have a text format in order to be enforceable by field staff. Field staff indicated that they required specifically numbered sections of the regulations for reference when filing a charge. The judiciary concurred that the charges, which do not refer to very specific violations, would probably not be upheld in court. The tables had to be placed into linear text with each section appropriately numbered for easy and unquestionable reference. Placing the tables into text was not so difficult, but the resulting draft regulations proved to be very long. This was clearly contrary to the original intent of simplifying the regulations.

The complexity of the engineering principles did not lend itself to simple regulations. When combinations of input factors are considered, the enforceability became practically impossible. For example, the maximum hitch offset is required to ensure that the vehicle is not configured such that the "tail wags the dog". However, as the weight of the trailing unit decreases relative to the towing unit, the hitch offset can increase without reducing the safety performance of the vehicle. Transport Compliance staff felt they could not effectively enforce regulations that required them to obtain measurements then interpret the legality of a vehicle from a chart on the basis of the measurements. This would be impractical and probably would lead to many violations going undetected.

According to strict interpretation of the performance criteria, compliance with some thresholds can depend upon a combination of dimension and weight. In these instances regulatory compliance cannot be associated with the vehicle, but only with the vehicle under certain loading conditions. Ideally, an owner should be able to look at a trailer in the yard and determine whether it is legal. For example, current regulations set the minimum track width for a semi-trailer at 2.5 m; this is necessary to accommodate the maximum legal height of 4.15 m. However, a vehicle with a narrower track width can still comply with the performance criteria as long as the maximum height is reduced. The owner should not be

placed in a situation where a trailer is legal only under limitations. Perhaps more commonly, the owner should not be required to "marry" vehicles in the fleet such that certain trailers can be towed only by certain power units because the wheelbases must balance to comply with the offtracking requirements. The complexity took on a new level when vehicle speed was factored into the equation for criteria such as load transfer ratio. This is another instance where simplicity could not be achieved by strictly maintaining the integrity of the performance criteria.

As the draft regulations continued to evolve, it became clear that the key to practical regulations would be simplicity and enforceability. It was essential to keep the regulations simple, not only for the truckers who must live and work with the regulations on a daily basis, but also for the compliance staff who must interpret the regulations and defend them in court, if necessary. From an engineering perspective, the intent of the performance criteria was evident, but the theoretical thresholds could not be practically and strictly interpreted to produce operational vehicle weight and dimension regulations. Compromises had to be made.

The Department also tried pictorial regulations as a means of showing the intent. Figure 4 illustrates how the conditions which apply to a vehicle could be easily illustrated in a pictorial format. Despite the simplicity of presentation, the judiciary indicated that violations would not be upheld in court unless the violations could be specifically referenced. The pictorial format was not enforceable.

The difficulties encountered were all a result of stakeholder input. They were good reminders that engineering principles provide good tools for regulatory development, but cannot be taken at face value as the regulations themselves. Although, the final regulations followed a more conventional framework, they respected the performance criteria while giving due regard for the practical concerns of the stakeholders.

4. APPROACHES TO THE DIFFICULTIES

Despite the difficulties encountered, DHT remained committed to the principles of the vehicle performance criteria. Ultimately, the thresholds could be respected through permit programs because the permit conditions would specify the conditions that apply to a given vehicle. While this would allow the Department to optimize the thresholds to allow any vehicles, which comply, all vehicles would have to operate according to a permit. This is not only impractical, but also undesirable.

For the vehicle weight and dimension regulations, the performance criteria serve as a guide for addressing the safety of the vehicles. Since the regulations could not easily address every scenario, the worst case scenario was chosen. For example, a conventional 16.2 m semi-trailer with a maximum wheelbase of 12.5 m can comply with the offtracking thresholds if the maximum wheelbase of the power unit is limited to 6.2 m. These figures have been included in the regulations. If the power unit is towing a 14.6 m or a 13.7 m

trailer, the vehicle performance will be well within the maximum threshold value. Thus the regulations reflect the "worst case scenario".

If the example noted above involves a power unit with a longer wheelbase but it never hauls a trailer longer than 13.7 m, it can be allowed to operate on the highway system without violating the performance thresholds. Situations such as this are addressed within the permit system. By requiring that the vehicle operate with a permit, the operator is aware that the power unit is restricted. It does not comply with the regulations, so it is not "legal". It cannot go into a shipper's yard and connect with any trailer in the fleet. This restriction unto itself is a disincentive for anyone to want to operate such a vehicle in Saskatchewan. However, since it can comply with the performance threshold, the Department will consider allowing it to operate under a "single trip permit". In this example, the permit would limit the trailer length to correspond with the power unit wheelbase. Field staff who recognize that the power unit wheelbase exceeds that allowed in the regulations would then have to ask to see the permit to confirm the operating conditions.

Permit options can be applied in several ways, but for them to be effective they should address the exception rather than the norm. Saskatchewan's permit policies strike a compromise which recognize that some situations will arise where a vehicle can comply with the performance criteria and may not be able to comply with the regulations in a cost effective manner. Under these circumstances, permits are available as a means of supporting economic activity which might otherwise not occur or occur with less efficiency.

5. FUTURE OPPORTUNITIES

Saskatchewan's vehicle weight and dimension regulations reflect the performance criteria governing the movement of vehicles and loads by the trucking industry. Permits are required for vehicles and loads that exceed the regulations. In Saskatchewan, the criteria are also used as a basis for issuing permits. Without a permit process, these vehicles would not be allowed to operate on the highway system, which would have a detrimental effect on the province.

As managers of the road transportation system, DHT must ensure the long term sustainability of the network for future generations while balancing its role of supporting economic and social well being. Further work needs to be done to support the development of new vehicles. Practical permit policies founded on the vehicle performance criteria will enable Saskatchewan to consider new configurations that are not addressed in the regulations. Through this process, industry will understand the issues that must be considered before a new configuration is allowed to operate on the highway system.

The most significant initiative, which we feel we can undertake in Saskatchewan, is education. By promoting awareness of the concerns about performance criteria and the need to balance between the economic and technical issues, the industry and public will

have a greater appreciation for the vehicles using the highway system. Industry will realize that vehicles cannot simply be made bigger to carry more weight as a means of increasing efficiency. Also, by helping the industry to understand the basis for the regulations, we can assist them in appreciating the implications of violating the regulations. Through a public education program, the Department can minimize the impact of negative feelings toward big trucks. If the public is made aware of the factors affecting truck safety they may better understand that we, as regulators are minimizing their risks and not simply conceding to the wishes of industry. As public awareness of performance criteria increases, there will be less reluctance by the legal system to recognize tabular or pictorial based regulations that more accurately reflect the performance thresholds.

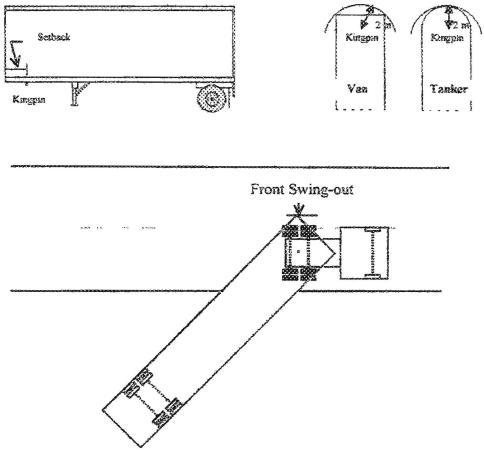


Figure 1 Controlling Front Swing-out - Kingpin Setback Limit

	Dimension	Conditions
Kingpin Setback	> 2 m ≤ 4 m	E, G, H
	> 3.3 m ≤ 6 m	A, B, C, E, F, H, I
	> 5.7 m	Special Case
Effective Overhang	> 35% ≤ 70%	E, G, H
	> 70% ≤ 100%	A, B, C, E, F, H, I
	> 100%	Special Case
Total Overall Length for Single Trailer	> 23 m ≤ 30 m	E, F, G, H, K
	> 30 m ≤ 36 m	A, B, D, E, F, G, H, I. K
	> 36 m	Special Case
Total Trailer Wheelbase For Unarticulated Length	> 12.5 m ≤ 15.4 m	E, G, H
	> 15.5 m ≤ 16 m	A, B, C, E, F, H, I
	> 16 m	Special Case
Total Trailer Wheelbase for Articulated Length	> 17 m	Special Case
Width	> 2.6 m ≤ 3.05 m	E, G, H
	> 3.05 m ≤ 3.3 m	A, E, G, H
	> 3.3 m ≤ 3.65 m	A, B, E, F, G, H
	>3.65 m ≤ 4.4 m	A, B, C, E, F, H, I, J
	> 4.4 m (single trip only)	A, B, C, E, F, H, I, J
Height	> 4.15 m	J

Note: Box length permits are available. Conditions, if applicable, are derived from other length parameters.

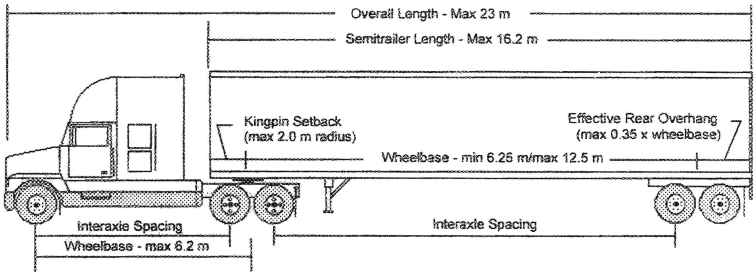
Figure 2 Proposed Regulation Conditions for Length, Width and Height

Condition	Restriction	Particulars of Restriction
A	Travel is not permitted	• on Sundays or public holidays • when visibility is 1000 m or less • when the highway is slippery • on December 24, 26, 27, 31 and January 2 when Christmas and New Year's Day fall on a Sunday
B	Travel is not permitted from 3:00 p.m. to midnight	• on any day prior to a public holiday • on any Friday during the summer from Friday prior to Canada Day until Labour Day • on any Friday when the following Monday is a public holiday
C	Travel is not permitted	• from sunset to sunrise of the following day
D	Travel is not permitted	• from sunset to sunrise of the following day on any two-lane highway
E	During day light hours	• flags will mark the portions of the load that extends beyond the extremities of the vehicle.
F	Lights	• two amber rotating lights are required.
G	Night travel	• amber lights shall be located 30 cm above the headlights on the front corners of the load • amber lights shall be spaced not more than 8.0m apart on both sides of the load • red lights visible from the side and the rear shall be located on the rear corners of the load • red clearance lights shall mark the end of any load extending beyond the vehicle • the trailer shall be equipped with extendible clearance lights
H	Signs	• A "D" sign is required at the rear of the load on a multi-lane highway and at the front and rear of the load on a two-lane highway
I	Escort Vehicle	• required at the rear on a multi-lane highway and at the front and rear on a two-lane highway
J	Route	• Travel on any given route is subject to approval dependent on structural clearances from SaskTel, SaskPower, CN/CP Telecommunications and Saskatchewan Highways and Transportation
K	Vehicle Speed	• restricted to a maximum of 90 kph if total overall length exceeds 25 m

Figure 3 Conditions for Length, Width and Height

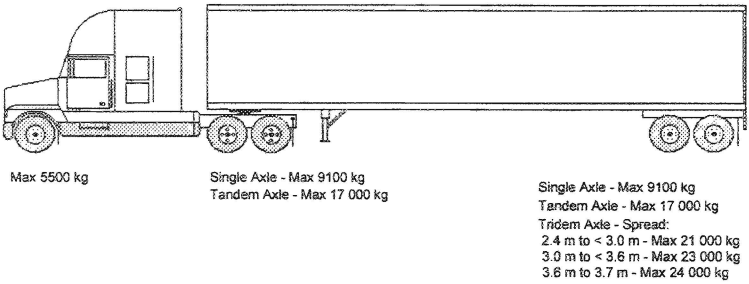
Category 1: Tractor Semitrailer

Part I - Dimension Limits



DIMENSION	LIMIT
Tandem Axle Spread	Minimum 1.2 m/Maximum 1.85 m
Tandem Axle Spread	Minimum 1.2 m/Maximum 1.85 m
Tridem Axle Spread	Minimum 2.4 m/Maximum 3.7 m
Track Width	Minimum 2.5 m/Maximum 2.6 m
Interaxle Spacings	
Single Axle to Single, Tandem or Tridem Axle	Minimum 3.0 m
Tandem Axle to Tandem Axle	Minimum 5.0 m
Tandem Axle to Tridem Axle	Minimum 5.5 m

Figure 4 Pictorial Format



WEIGHT	LIMIT
Tridem Axle:	
Axle Spread 2.4 m - less than 3.0 m	Maximum 21 000 kg
Axle Spread 3.0 m - less than 3.6 m	Maximum 23 000 kg
Axle Spread 3.6 m - 3.7 m	Maximum 24 000 kg
Gross Vehicle Weight Limits	
Three Axles	Maximum 23 700 kg
Four Axles	Maximum 31 600 kg
Five Axles	Maximum 39 500 kg
Six Axles - with 2.4 to < 3.0 m spread tridem	Maximum 43 500 kg
with 3.0 m to < 3.6 m spread tridem	Maximum 45 500 kg
With 3.6 to 3.7 m spread tridem	Maximum 46 500 kg

Figure 5 Pictorial Format for Weight Limits