Portable Wheel Load Weighers

A GUIDE

Procedures to Follow in Assessing the Accuracy of

Portable wheel Load Weighers

by Comparison with Fixed Scales

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An Addendum Addressing Weight Enforcement Procedures Using Portable Wheel Load Weighers is Included

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A Guide for the Assessment of Accuracy by Weighing Laden Vehicles to Compare Portable with Platform Scales

WARNING
Failure to employ correct procedures will produce invalid results

General Overview:

Anyone wishing to do the best job possible will want to use equipment that, in his/her mind, measures up to their expectations and the requirements of the job parameters. For officers or inspectors whose duties include the enforcement of weights and loads legislation and regulations, the accuracy of the portable wheel load scales assigned for their use must unquestionably fall within the prescribed limits. Enforcement personnel like to test the accuracy under real life conditions by weighing axles and axle groups of vehicles on portable scales and then compare the noted weights with those registered on platform scales. There is nothing wrong with this approach. Test bench results and calibration results are fine, but to the officers who talk to very knowledgeable commercial vehicle drivers in what is sometimes an adversarial relationship, the weighing equipment must have proven itself to be completely reliable and accurate when used where it counts - on the road.

The most common method of carrying out such a comparative procedure is the simplest and the most obvious - i.e. - record the weight of an axle or axle group on the portable scales, (this is usually carried out in the parking area of a weigh station), and then move the vehicle to the platform scales to record the same axle or axle group weight. Unfortunately, this procedure is so open to errors that it can be completely invalid as a basis for comparison.

The only infallible method is to take all of the axle weights simultaneously -i.e.- place the portable scales on the platform scale deck, move the vehicle into position, note the weights on all scales, subtract the weight of the portable scales from the platform scale reading and then make comparison. Weighing at different times, which necessitates movement of the vehicle, will only occasionally produce a reliable result - the problem is that we never know which result is the reliable one. ***Simultaneous weighing is the only reliable method***. The following paragraphs and the appendices offer detailed explanation.

The Errors:

Causative error factors most prevalently encountered when the vehicle or the vehicle combination is moved between comparative weighings are as follows:

(i) the load distribution between axles within an axle group changes;

(ii) the pavement surface in the portable scale weighing area is not even;

(iii) the distribution of the load carried by the vehicle has shifted (e.g. - liquid, garbage, livestock etc);

(iv) the deck of the platform scale has deflected under the weight of the axle(s);

(v) only two portable scales have been used to weigh axles of a tandem, triple or quad axle group thus necessitating two, three of four moves;

(vi) lift or belly axle(s) are installed on the vehicle(s);

(vii) brake application or non-application effects axle load distribution;

(viii) the non-use of leveling pads or the use of pads not matching the portable scales has effected axle load distribution;

(ix) the 120 kg. driver was in the cab for some of the weighings and out for the remainder.

Some of the above factors can create extremely large errors which, cumulatively, may total several thousand kilograms; others are small but the cumulative effect may be large. Other factors, such as longitudinal and lateral gradients, do not need to be covered in this guide since they do not come into play in the typical set-up used by personnel organizing these checks. Few of us have time to read long reports and the aim here is to get the message across as succinctly as possible - therefore - points (i) to (ix) are discussed in detail in appendix "A". Please read this if you are not familiar with any of the points noted - some of the facts may surprise you.

Simultaneous Weighing:

The procedure used depends on whether two, four or six portable scales are the subject of the comparison check. If only two scales are available and the laden vehicle is a two axle truck then the task is simple - however - two scales and a triple axle assembly create problems to overcome in order to ensure a fair comparison of portable/platform weights. The following discussion commences with the easiest scenario:

**********_6 Portable Scales_ - Two different checks can be carried out as follows:

(a) Comparison of the Weight Total from the 6 Scales -
Procedure: this example uses a triple axle group which fits on one deck of the platform scale. The group is moved into position on the portable scales which are placed on the platform scale deck.

Individual portable scale weights must be noted at the same time as the platform scale reading is noted. The total of the portable scale weights is compared with the platform scale reading ***minus the sum of the weights of the portable scales***. We now have a valid basis for comparison of the total of the weights on the portable scales with the weight recorded by the platform scale.

In doing these comparisons, remember that the scale accuracy required in Canada for enforcement is +/-0.5%; the portables are tested to this standard; the fixed scales, however, are generally tested to the federal accuracy requirement for trade standard which is +/-0.1%. Any comparative test weighing can only be accurate to the sum of these accuracy limits ie +/- 0.6%.

(b) Comparison of Pairs Using 6 Portable Scales-

The foregoing procedure affords comparison of the total of the weights noted on the portable scales. In order to assess the comparative accuracy of pairs of portable scales the same method as outlined in (a) is used to split-weigh a tandem or a tridem axle group.

Procedure: position one axle at the edge of one deck and the other axle(s) of the group on the adjacent deck and with each axle on a pair of portable scales. The resultant weight readings afford a valid basis for comparison and assessment.

(Note that the word tridem was coined to denote a triple axle assembly which has load equalization characteristics incorporated in the design and manufacture).

***********4 Portable Scales*

If one or two axles are weighed, whether a two axle straight truck with an axle on adjacent decks or a tandem on one deck, the procedure and results will be the same as outlined above.

The weighing of a tridem or tri-axle in order to compare four portable scales with the weights recorded on a platform scale will not provide as valid a comparison as would be achieved by weighing a tandem or the single axles of a truck or tractor unit. The triple axle assembly could certainly be positioned at the edges of adjacent decks, as described above for 6 scales, with the use of appropriate leveling pads under the one axle of the group which is alone on one of the decks. Please note that any inaccuracy which may be induced in the platform scale reading because the axles are located near the deck edge along with the scale test tolerances when making any comparison. Also note that any inaccuracy in the platform scale's weight measurement would not normally exceed the legislated +/-0.1% tolerance - it is better, though, if the weighings can be carried out with the axles centered on the decks. (Please refer to Appendix A for more detail on this point, in particular the effects of possible platform scale deck deflection under load).

***2 Portable Scales*

Using the procedure outlined above, the comparative weighing of single axles on the portable scales positioned at platform deck center, and subtracting the portable scale weights from the noted platform scale weight, will provide valid results.

Two scales may be used to split weigh as outlined above. In weighing a triple axle assembly, the axle to be weighed is positioned on the portable scales at the edge of one deck, (as noted, not the best situation), and the other two axles are positioned on suitable leveling pads near the edge of the adjacent deck. As above, portable and platform scale readings are taken simultaneously and the weight of the portable scales is subtracted from the platform scale reading. The procedure will provide results valid for comparison and assessment of portable scale accuracy. A tandem axle group may be checked in similar fashion.

****&**** ***Caution****:*

Valid results cannot be obtained by weighing axles supported by a combination of portable scales and leveling pads placed on the same deck. E.g. - it may seem logical that a tandem weighed in this manner would give useable results if the platform weight for the tandem was halved thereby giving a single axle weight for comparison with the portable scale reading.
Unfortunately, this only applies if the tandem provides true load equalization and, as is often the case, the axles do not share an equal portion of the load.

Summary:

During my career, which has involved highway construction, maintenance, snow removal and ice control, commercial vehicle legislation and regulation enforcement programs, I have met with many people across Canada and the United States to discuss common issues and to develop standardized programs. For the most part, industry, union and government front line workers, their supervisors and managers and the policy makers and administrators never have cause to think about some of the less obvious facts that are encountered by looking at them through a microscope. The common errors listed above and discussed in Appendices A, B & C should help to explain. What seems simple and obvious on the surface often becomes complex on closer examination. For example, if the load equalization performance of a multiple axle assembly is not as designed, (because of deterioration due to age, parts malfunctions, incorrect retrofits or repairs etc.), a small unevenness of the ground surface of ½"(12mm) could cause a weight increase on an axle of hundreds of kilograms. With gremlins like this lurking around, the procedures used to compare one weight measuring device against another must be devoid of any possible glitches. There have been many occasions when I have become aware of the frustrations encountered, mainly by the enforcement officers, in trying to ascertain, for their own peace of mind and because they are professionals, that their portable scales measure up to the task. It is mostly with the officers and inspectors responsible for the enforcement of weights and loads legislation, regulations and policies in mind that this document has been written

I welcome any response, feed-back, suggestion and will be open to respond to questions regarding this subject and the contents of this guide and appendices.

Appendix A

Any attempt to check the accuracy of portable weigh scales by field investigation must be guided by valid methodology and avoidance of error prone pitfalls. This appendix enumerates the most common mistakes, some of which will produce extremely large errors and some will be small. The sum of the small ones, however, if all in the same direction, can accumulate to make a large distortion of the truth.

The one item that brings all of these error factors together to give invalid data for comparative consideration is **the movement of the vehicle between the recording of the scale weight readings.** Move the vehicle and you do not have a valid basis for the assessment of the accuracy of the portable weigh scales relative to the platform scale.

Please note: the topic here is the comparison of two different weighing devices - it does not relate to enforcement practices. A further comment is made regarding enforcement at the end of this appendix and in greater detail in Appendix C.

Error Details:

(i) Axle Group Load Distribution:

Multi-axle assemblies installed on commercial vehicles by the manufacturer generally have load equalization characteristics. Some perform very well, especially when brand new. Some do not perform well. Good or bad, they all age and load equalization performance may deteriorate, especially if preventative maintenance programs are not diligently adhered to by the operator.
Poor maintenance, poor design, poor installation, retrofits, dirt, grime, salt, ice etc. etc. all may adversely effect the load equalization response of an axle group.

It can not be assumed that the vehicle chosen for the comparison check is fitted with an axle group that absolutely equally distributes the load bearing on it. In most cases the load will not be equally shared. The Feb. 12, 1988 MOU on Vehicle Weights and Dimensions in Canada called for the adoption, by all jurisdictions, of equalization of 1,000 kgs. within axle groups. Most enforcement officers are made aware daily as they go about their business that tandem axles, tri-axles or tridem axles do not equally share loads. From the enforcement and compliance perspective this does not pose an operational problem since, at the time of weighing, the axle group or the axles within a group are either in an overweight condition or legally loaded. The officer does not try again by having the vehicle moved in the hope that the load distribution will change such that one of the axles of the group will prove to be overweight (assuming that the jurisdiction allows split weighing).

Now - with this knowledge - why would anyone try to assess the portable scales by moving the weighed vehicle from the portable scales to the platform scales? Hopefully they will not and if they do hopefully someone who knows better will tell them what is wrong with the procedure.

Over the years I have, out of curiosity and a desire to know what is actually happening, observed successive split weighings of tridems with moves of a few feet or around the yard and back across a quad deck facility and many times the weight variance on an axle within an axle group has exceeded 1,000 kgs. Just think about what this does to the assessment of portable weigh scales! The officer who is unaware of what is taking place is going to jump to the conclusion that the portable scales are inaccurate when, in fact, nothing may be further from the truth. Any checks carried out must be conducted simultaneously, and in the case of a tridem or tri-axle assembly preferably with six portable scales placed on the platform scale deck.

(ii) Uneven Weighing Site:

Uneven means humps and hollows. Small undulations of fractions of inches may produce inaccurate readings amounting to hundreds of kilograms. (Note - uneven does not mean that the ground surface is sloped. Uneven means that the axles of a group do not rest in the same plane. The humps or hollows have raised or lowered some axles relative to the others).

The fact that the axles are not in the same plane means that some axles of a group, even if the load equalization is functioning perfectly, could support more or less than would be the case if weighed on even terrain.

If only two scales were to be used to weigh a tri-axle the vehicle would have to be maneuvered onto the portable scales three times. If it happens, which it easily can, that each axle in turn assumes a disproportionately large share of the load, (because the two portable scales are positioned on a hump and the leveling pads are in hollows), the difference between these readings and those on the platform scale could amount to thousands of kilograms. Hardly a good basis for comparison!

If six portable scales were to be used, the individual axle weights recorded on the platform could differ greatly from the portable scale readings, however, with the use of six scales the total axle group weight should compare more closely. Even so, this method is still not recommended, especially when taking into account all the other gremlins.

(iii) Load Shifts During Move:

This item is self explanatory. Liquid, livestock, granular materials, farm produce in bulk and garbage - on one occasion we were asked to use a loaded (actually overloaded) garbage truck in a non-simultaneous demonstration.

(iv) Deck Deflection under Load:

In jurisdictions where lift axles are not allowed the deflection of a scale deck does not have a detrimental effect on weights recorded for vehicles weighed on these decks.

Deck deflection is of concern if units equipped with lift axles are weighed or if a weight comparison procedure is conducted wherein the axles of a tri-axle assembly are split-weighed with one axle at the edge of one deck and the other two axles on the adjacent deck. When a deck deflects the load carried by the axles at the high point will bear a greater load than the axle located at a lower level.

(v) Only Two Portable Scales Used:

As described above, whenever the vehicle is moved between weighings errors are incurred as a result of the redistribution of the weight carried by axles in a multi-axle group. Point (ii) of this appendix points out the major role played by an uneven surface, especially when only two portable scales are used.

(vi) Lift Axles:

Apart from the host of other problems engendered by lift axles, a vehicle so equipped will, on average, represent the worst case scenario when a move occurs between comparative weighings. If simultaneously weighed, as outlined in the guide, valid results will be obtained.

(vii) Brake Application:

This factor is not an obvious one, nevertheless, it is very real and can have a moderately adverse effect on the weights recorded. If the brakes were applied for some of the weighings and not for others the weights recorded will not provide a valid basis for comparison. Even successive weighings on a platform scale with brakes applied is no guarantee of repeated same weights; successive weighings without brake application give more consistent results.

(viii) Leveling Pads:

Appropriate leveling pads must be used within an axle group when sufficient portable scales are unavailable. Non use of leveling pads or pads of incorrect thickness has the same effect as weighing on uneven surfaces.

The load transfer through the articulation points of vehicles in a combination is small and leveling pads are therefore only essential within an axle group. (The foregoing assumes, and it's almost heresy to state it, that a lift axle installed on a vehicle must be considered as a member of the group of adjacent 'load sharing' axles and as such must have the benefit of a leveling pad when the other axles of the group are being weighed).

(ix) Driver's Weight:

A simple and obvious factor but easy to overlook. Assume that the driver weighs 120 kgs. and that a two axle truck is used for the check. Well, the point is plain before being stated. If the truck is weighed in the parking area with the driver in the vehicle and then he gets out after driving onto the platform scale deck but before the weights are recorded an approximate weight discrepancy of 60 kgs. per axle is built in. Since the officer conducting the weighing in the back yard area is making his way to the scale-house via the back door he may not notice that the driver alighted from the truck.

General Comment:

Any of the above factors may skew the results rendering a comparison invalid. If more than one factor gets in the mix, which is usually the case, the error is compounded even further.

Although it may appear that certain of the procedures involving a move of the vehicle could produce a fair result it's just not worth the try. There are too many variables. And , it could happen that a poorly performing piece of equipment comes out looking good with only a couple of test weighings because the errors have worked in its favour. **Much better to take the surefire route and weigh simultaneously.**

With regard to the procedures followed by agencies tasked with weights and loads legislation, regulation and policy enforcement, the practice in jurisdictions in Canada is varied.
However, the predominant principle has been, for fixed sites, the installation multi-deck weigh stations which accommodate vehicle combinations in a single weighing and, for mobile operations, policies which enable the prudent use of portable scales**.** As noted above, the unequal and changing loads carried by individual axles of an axle group will distort the picture for the scale comparison purpose but, from the enforcement perspective**,** the axle(s) are either overweight or legal at the time of weighing.

Appendix B

Examples of Points Listed in the Guide and Appendix A:

The following illustrative samples were all taken on the weighing devices indicated at various weigh scale locations across Canada. The reference numbers are as listed for the items in the Guide and Appendix A.

(i) Load Within an Axle Group Changes Between Weighings: or, stated differently, load equalization is not taking place. The following example lists the weights for tandems and tridems of tractor semi-trailer vehicle combinations:

Axle Groups	Steer	Drive Tandems	Trailer(s) - Tridems and Tandems	
Vehicle A-Double Train	**5650**	**8450 + 8450**	**9000 + 8700**	**8800 + 9250**
B -Tractor>Semi	**4940**	**9050 + 9250**	**8175 + 8760**	
C -Tractor>Semi	**5200**	**7700 + 7625**	**6075 + 7450**	
D -Double Train	**5600**	**7050 + 7200**	**8200+7350+7650**	**7650 + 7900**

Some of the axle groups display excellent load equalization characteristics others range from fair to poor to quite bad. Interestingly, only the trailer tandem on vehicle C falls outside of the 1988 TAC recommended limit of 1000 kgs but, in spite of this apparent nod of approval for all the other axle groups shown, only vehicle A drives would have given a valid result for the purpose of the assessment and comparison of weighing devices where the recorded weights were not taken simultaneously.

(ii) & (viii) Uneven Weighing Surfaces: the presence of any irregularities in the surface plane within the bounds of the weighing area upon which the axles of the vehicle or vehicle combination rest can be a cause for invalid results during comparative weighing checks. Whether the uneven surface is caused by undulations in the ground surface or the non-use of leveling pads the distortion of the weight results is the same. As stated elsewhere in this guide, the effect on load distribution between vehicles of a combination is small in comparison with the effect within axle groups. One anomaly should be noted however and this involves the weighing of a tractor semi-trailer's drive axles on relatively thick portable wheel load weighers without leveling pads under the steer axle. In this case, the tractor steer and drive axles tend to act as an axle group and with the drives being raised relative to the other axles of the combination a load transfer to the drive axle group occurs. The next example demonstrates this load transference:

Tractor>Semi Axle Groups		Steer	Drive Tandem	Trailer Tandem
(a) All Axles on Scales-	**First Weighing**	**5600**	**7900+8000=15900**	**7900+8050=15950**
	Second	**5650**	**7850+7950=15800**	**7950+7950=15900**
	Average kgs	**5625**	**15850**	**15925**

(b) Steer, Drives and Tandems Weighed Separately - Leveling Pads not Placed under other Axles-70mm Portable Scale Height

Second	**5450**	**8250+8100=16350**	**8000+7850=15850**
Average	**5450**	**16325**	**16000**

Something isn't quite right here, is it? This should be a good example - the drive axles have gained 16325-15850=475 kgs, which was to be expected and the steer axle shows a loss of 175 kgs but **the trailer tandem also shows a gain of 75 kgs and with the load transfer it should have lost.** Well, this example was chosen for a reason - to make sure we're using correct thinking at all times.

So what's wrong here? A couple of things- actually error factors already discussed including this topic - i.e. the trailer tandems were not in the same plane as the other axles (no leveling pads - incurs a slight error) but more importantly all weights were not taken simultaneously (the cardinal rule for making comparisons has been broken!). Also, the semi-trailer being weighed is carrying a load of granular material - load shift?

Was there a weight transfer to the drive axles? We can strongly suspect that this is the case and if the weighing were to be carried out with the portable scales under the drive axle group only with no leveling pads under the other axles and with the whole affair positioned on the decks of a multi-deck facility we would be able to conduct a valid test because all weights can be recorded simultaneously. Give it a try with several vehicle combinations and check out the tridem and tandem axle groups too. The results should resemble the weights shown in the following examples which were carried out on decks of a fixed facility with the lead axle of a tridem **raised** by 13 mm and then13 mm **lower:**

(c) Poor Load Equalization:

Tridem Axle	**Vehicle# 1**			**Vehicle# 2**		
	+13mm	**-13mm**	**Diff.**	**+13mm**	**-13mm**	**Diff.**
Lead	**10330**	**8980**	**-1350**	**10250**	**9160**	**-1090**
Second + Third	**16790**	**17630**	**+840**	**18580**	**19080**	**+500**
Total	**27020**	**26610**	**-1010**	**28830**	**28240**	**-590**

(d) Good Load Equalization:

Tridem Axle	**Vehicle#3a**			**Vehicle#3b**		
	+13mm	**-13mm**	**Diff.**	**+13mm**	**-13mm**	**Diff.**
Lead	**8920**	**8800**	**-120**	**9080**	**8840**	**-240**
Second + Third	**18060**	**18180**	**+120**	**18070**	**18160**	**+90**
Total	**26980**	**26980**	**0**	**27150**	**27000**	**-150**

All these figures may have caused the reader to lose sight of the purpose of this discussion, which is: unless a unit acts almost perfectly, as in (d) above, uneven ground will invalidate comparative test results and, of course, weights taken for enforcement purposes will also be invalid.

(iv) Deck Deflection: Unfortunately, the record of weighings that were taken at a quad deck facility are amongst the missing so the evidence on this point will be anecdotal.
All four decks deflected under load and the longest one, which was 23 feet, deflected by just under an inch, (this was an imperial units deck but it weighed in metric). Soon after installation the enforcement officers noticed that vehicle combinations with lift would show a gradual loss in weight carried by the lift axle as it moved from the edge of the deck to the center after which the weight registered would rise back to the initially indicated weight.
The drop in weight from the edge to the center often exceeded 1000 kgs. In jurisdictions where lift axles are not permitted, deflection of the decks of a weigh scale when subjected to a load should not adversely affect the accuracy of the results for enforcement purposes but I cannot affirm this view not having investigated the issue. At issue here, however, is the comparative weighing process and since deck deflection introduces another possible error factor it is again recommended that any comparative weighing be performed simultaneously.
Any deck deflection will not affect the weights recorded simultaneously on two separate devices when the portable weighing device is placed on the (deflecting) deck of the fixed device.

(vi) Lift axle on a Tractor Semi-trailer: using a quad-deck facility each axle group of this vehicle combination was weighed four separate times, (i.e. a total of 16 time based weighings), and although it is by no stretch of the imagination the worst example of the malevolent lift axle that could be found it does serve the purpose of demonstrating why a vehicle so equipped must not be used for comparing the weights recorded on two different weighing devices.

*GVW - Please note that the GVW computed by adding each of the axle group weights is not accurate since every weight shown was recorded at a different instant in time.
The simultaneous weighing of all the axle groups resulted in an actual GVW of 50390 kgs.

Axle Group		**Steer**	**Tandem Drives**	**Lift Axle**	**Trailer Tandem**	*** GVW**
Weighing	**# 1 – kgs**	**5620**	**17800**	**9760**	**18360**	**51540**
	# 2	**5540**	**17720**	**9170**	**22780**	**55210**
	# 3	**5520**	**17820**	**8920**	**17880**	**50140**
	# 4	**5440**	**17810**	**9230**	**18130**	**50610**

Compare the above with the actual weight as taken on the quad-deck when all groups were weighed at the same time as follows:

Actual Weight	**5620**	**17720**	**8920**	**18130**	**50390**

The action of the lift-axle, as a result of the changing air pressure in the system as the air pressure went down and up with use and subsequent recharging by the air compressor, caused:

- small variations in the load carried by the steer and drive groups;
- sizeable variations in the load carried by the lift axle from a low of 8920 kgs to a high of 9760 kgs;
- extreme variations in the trailer tandem axle load and the GVW amounting to differences of 4900 kgs and 5070 kgs respectively

Appendix B

From the weight enforcement perspective it is easy to understand, in the light of this example, how critical it is to follow the correct procedures or invalid overload reports may be filed.

(vii) The Effect of Brakes: in this example the tractor semi-trailer was not moved after the brakes were released and yet the weight variation was pronounced. This could have been due in part to the presence of the lift axle. Whatever the case, it points out that if the weighings had been used for comparison of the accuracy of portable wheel load scales their accuracy would have been questioned.
The weighing in this case was done on a quad-deck facility with rigid (i.e. non-deflecting) decks.

Axle Group	Steer	Tandem Drives		Lift Axle	Trailer Tandem	GVW
Brakes Applied		**5430**	**17510**	**7900**	**16090**	**46930**
Without Brakes		**5380**	**17630**	**7250**	**16530**	**46790**
Difference		**- 50**	**+120**	**-650**	**+440**	**-140**

Summary:

Many other sample weighings could have illustrated the various points but hopefully the ones listed will suffice to help clarify the points raised. I am certain that if any weight enforcement officer or inspector were to start checking into these factors that similar results would be found and I am also certain that most of them could greatly expand my knowledge level through their experience. As such, I would be pleased to receive any related information and examples that would shed additional light on the subject.

Appendix C

Recommended Enforcement Practice for the Use of Portable Wheel Load Weighers

Purpose:

The primary objective in writing this guide is to give a summary of the do's and don't's involved in making comparative weighings on fixed platform scales and portable scales in order to assess the accuracy of the portable scales. In preparing the guide the need to address commonly used weight enforcement procedures, especially some of the less understood pitfalls, became apparent.

This Appendix is therefore mainly intended to be a handy reference for enforcement officers but may also serve as an information brochure for the use of anyone who has an interest in road transportation systems, in particular:

adherence to and enforcement of weights & loads legislation and regulations;

design and maintenance of the roadway infrastructure;

design and manufacture of vehicles and vehicle components and

design and manufacture of fixed, portable and in-motion weighing devices.

Weight Enforcement:

In Canada, the construction and maintenance of all levels of roads, from the paved major arterials to the graveled local ones, are the responsibility of the provinces and territories and their municipalities. The federal government does cost share in certain cases and also constructs and maintains a small portion of the total network. However, since each province and territory has the major stake, they also develop and enact legislation and regulations controlling the movement of vehicles on these public highways.

Decades ago, weight enforcement and weighing for trade could be accomplished on single deck platform scales and enforcement for mobile units was much simpler than today. Fixed facilities now have multiple decks to accommodate the variety of vehicle combinations encountered. Mobile enforcement officers are commonly equipped with 6 portable wheel load weighers although enforcement is carried out by officers equipped with 2 scales. Whether 2, 4, 6 or 8, the officer must understand how to weigh vehicle axles with the scales available in order to obtain readings that are valid for use in filing an overload or overweight infraction report. No matter how many scales are at hand, improper use may invalidate the use of the scale readings recorded.

The imposition of penalties, whether monetary or sanctions, as a result of invalid readings is not necessary. Unfortunately, it often happens that neither the enforcement officer nor personnel representing the trucking industry have a good understanding of the large errors that improper procedures may produce. Distortions of hundreds, and sometimes thousands, of kilograms do occur. Sometimes in the trucking concern's favour; other times not. With understanding of the reasons for following certain procedures and for avoiding the error prone procedures the operation of correctly laden vehicles on public highways need not be quite as susceptible to operation in an overload condition. Unfortunately, even correct enforcement procedure will not remedy unequal load equalization, snow and ice accretion, load moisture absorption etc.

Procedural Pitfalls:

(a) Leveling Pads:

Great when used wisely; can be disastrous when not. If all axle groups had perfect, 100% load equalization all the time, the use of leveling pads would be straightforward when used within axle groups. They need not be placed under all axles of a vehicle or vehicle combination as the following explains:

i. Within axle groups, if sufficient numbers of portable scales are not available for all axles within the group, leveling pads must be used. However, since we can not count on load equalization being a fact, an overweight report must only be made for the axle or axles found overweight at each individual weighing - i.e. - the total of two or three separate weighings can not be used to find the axle group overweight. The lack of certainty of load equalization between axles of the group renders the procedure of taking the sum to be an invalid one. (See also the example below).

ii. The problem encountered in (i) does not come into play between the axles of vehicles of a vehicle combination. The relatively small effect on weight transfer due to the fifth wheel or pintle hook-up between vehicles means that there is, from the enforcement perspective, load equalization between vehicles.

iii. The thickness of the leveling pads must match the thickness of the portable scales or the results will be invalid.

(b) Shifting Loads:

Otherwise valid results can be negated if the load shifts between weighings. (Refer to the garbage truck example given below).

(c) Other Factors:

The portable weighing equipment must be used in accordance with the manufacturer's instructions. Items such as the re-zeroing of the scale reading between weighings; batteries low; operating temperature below specified limit; impediments between the scale backing plate and the ground surface exceed specified maximum size etc. require observance.
Any or all of error factors (i) to (ix) listed in the guide can come into play as indicated in various examples given in the guide and appendices.

Examples: (a) "B" Train Double - 2 Scales used in conjunction with leveling mats within axle groups:

Axle Groups	**Steer**	**Drive Axles**	**Tridem**	**Tandem**	**GVW**
Portable Scales Kgs	**5600**	**7050+7200 =14250**	**8200+7350+7650 =23200**	**7650+7900 =15550**	**58600**
Platform Scales Kgs	**5616**	**15456**	**20476**	**13656**	**55204**

Since the tridem and tandem axle groups did not equalize the loads, the series of weight taken on the portable scales is indicative of the variations in the weight that may be borne at any instant in time by each of the individual axles of the group. It changes every time the "B" Train is moved. With regard to an overload condition at any instant in time, if any axle were to be overweight as weighed on the portable scales, and if the jurisdiction does allow split-weighing, an overweight offence report would be valid. Taking the totals of two or three separate weighings would not form a valid basis for an overload report. The same applies to the GVW computed from the individual scale readings. (See also line 16 of Table 1).

(b) Garbage truck with tandem drive axles - 6 portable scales - vehicle was weighed initially on the portable scales - the load shifted during the move to the platform scale:

Axle Group	**Steer**	**Tandem Drives**	**GVW**
Portable Scales Kgs	**7080**	**21980**	**29060**
Platform Scales Kgs	**7290**	**21750**	**29040**

Which weights are valid? Answer - they all are valid. The axle group weights recorded on the portable scales reflect the load distribution and the GVW at that instant in time and are therefore valid to use for the overload report. The fact that the load then shifted does not invalidate the weights subsequently recorded on the platform scales. Note that the GVW compares well with a difference of only 20 kgs.

If this same vehicle had been weighed using 2 or 4 scales and the load had shifted during the move between weighings then the axle weights recorded would be valid but the GVW total would be invalid. Since the shift caused a load transfer of slightly over 200 kgs the GVW would be off by the same amount. (Please note that this last statement is used for example only - in a real life scenario the enforcement officer would recommence once he became aware of the load shift).

(c) Load Transfer Between Vehicles of a Combination Caused by Belly Axle:

A tractor semi-trailer fitted with a belly lift axle (i.e. far enough ahead of the trailer's tandem axles that it could not be considered part of a tri-axle group) was weighed on both platform scales and portable scales with movement of the vehicle combination between each of the weighings. The weights recorded for the tractor demonstrate the load transfer that can occur:

	First Weighing		**Second Weighing**		**Load Transfer**	
Axles	**Steer**	**Drives**	**Steer**	**Drives**	**Steer**	**Drives**
Platform Scales kgs	**4770**	**12330**	**4710**	**12480**	**-60**	**+150**
Portable Scales kgs	**4750**	**12485**	**4700**	**12420**	**-50**	**-65**

The load transfer of 150 kgs is small in comparison with what can happen between the axles of a non-equalizing axle group, however, it may be greater than the 150 kgs and the effect must certainly be taken into account when weighing combinations equipped with belly axles.

Each enforcement officer could undoubtedly refer to better examples drawn from his/ her experience. The examples given above are actual weights taken on a variety of scales in several provinces and will hopefully serve to assist in an understanding of some of the difficulties encountered by enforcement officers during their daily effort to carry out fair and accurate weight enforcement.

Recommended Enforcement Practice for the Use of Portable Wheel Load Weighers

Vehicle Configurations - Axles Steer Drive(s) Trailer(s)	Line	2 Scales				4 Scales				6 Scales				8 Scales			
		S	D	T	G	S	D	T	G	S	D	T	G	S	D	T	G
O O	1	V	x	x	V	V	x	x	V	V	x	x	V	V	x	x	V
O O + O	2	V	x	x	V	V	x	x	V	V	x	x	V	V	x	x	V
O O > O	3	V	x	x	V	V	x	x	V	V	x	x	V	V	x	x	V
O O + OO	4	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O O + O O	5	V	x	x	V	V	x	x	V	V	x	x	V	V	x	x	V
O OO	6	V	x	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO + O	7	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO + OO	8	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO + OOO	9	V	I	I	I	V	V	I	I	V	V	V	V	V	V	V	V
O OO > O	10	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OO	11	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OOO	12	V	I	I	I	V	V	I	I	V	V	V	V	V	V	V	V
O OO + O O	13	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO + O OO	14	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OO > OO	15	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OOO > OO	16	V	I	I	I	V	V	I	I	V	V	V	V	V	V	V	V
O OO > O+O O	17	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OO+O O	18	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OO+O OO	19	V	I	x	I	V	V	x	V	V	V	x	V	V	V	x	V
O OO > OOOO	20	V	I	x	I	V	V	x	I	V	V	x	I	V	V	x	V
O OO > O(L)OO	21	V	I	I	I	V	V	I	I	V	V	V	V	V	V	V	V

Table 1

Legend:

S - Single axle, steer axle
D - Two axle group - dual, tandem
T - Three axle group - tri-axle, tridem including tandem + lift/belly axle
G - Gross Vehicle Weight

V - Valid weight obtainable
I - Invalid weight obtained
x - Not applicable
(L) -Lift or belly axle
Articulation points: + single/double pintle or pole
➢ fifth wheel

O -Single axle
OO -Two axle group
OOO -Three axle group
OOOO -Four axle group

How to Read: line 5 - truck with pole hook-up to two-axle trailer. Only two scales needed to obtain valid weights.
line 16 - TAC "B" Train Double
- 2 Scales: only valid weight obtainable is for single & steer axles;
- 4 Scales: single, steer & 2 axle group weights are valid;
tridem weight & GVW scale readings are invalid;
- 6 & 8 Scales: All weights obtained are valid for overload report.

Leveling Pads: The use of leveling pads affords more latitude to the enforcement program dependant on the split weighing provisions of a jurisdiction's legislation, regulation and/or policy. (See text on pages 1-3 of this appendix for further clarification)

Explanation of Vehicle Configurations:

Line			
	1	**O O**	Truck or truck tractor - single axle steer single axle drive
	2	**O O + O**	Truck + pony trailer
	3	**O O > O**	Tractor semi-trailer - all with single axles
	4	**O O + OO**	Truck + pony trailer - two axle group on the trailer
	5	**O O + O O**	Truck + full trailer - two single axles on each
	6	**O OO**	Truck or truck tractor - single steer axle two axle drive group
	7	**O OO + O**	Truck + single axle pony trailer
	8	**O OO + OO**	Truck + pony trailer with two axle group
	9	**O OO + OOO**	Truck + pony trailer with three axle group
	10	**O OO > O**	Tractor semi-trailer - two axle group drive axles -which is usually a tandem > single axle semi-trailer.
	11	**O OO > OO**	Tractor semi-trailer - two axle groups on each which are usually tandems (i.e. load equalizing design).
	12	**O OO > OOO**	Tractor semi-trailer > three axle group on the trailer - Tri-axle or tridem
	13	**O OO + O O**	Tractor + full trailer with single axles
	14	**O OO + O OO**	Tractor + full trailer with single axle and two axle group
	15	**O OO > OO > OO**	Tractor > semi-trailer > semi-trailer - the two axle groups must be tandems in most jurisdictions
	16	**O OO > OOO > OO**	**TAC** "B" Train Double - tandems and tridems are a requirement in Canadian jurisdictions
	17	**O OO > O + O O**	Tractor > semi-trailer + full trailer with single axles on both trailers
	18	**O OO > OO+O O**	Tractor > semi-trailer with two axle group + full trailer with single axles
	19	**O OO > OO+O OO**	**TAC** "A" & "C" Train Doubles - tractor > semi-trailer + full trailer - tandems required for all groups
	20	**O OO > OOOO**	Tractor > semi-trailer with four axle group - quadrem (i.e. load equalization) is jurisdiction dependant
	21	**O OO > O(L)OO**	Tractor > semi-trailer with three axle group consisting of a lift axle and usually a tandem. This three axle group seldom functions as a tridem.

Notes:

The vehicle configurations shown are by no means an exhaustive tabulation of all the combinations that a weights and loads enforcement officer or inspector will encounter but the samples given should enable the user to decide on the validity of filing an overload report for combinations not shown.

Although the lift axle has been treated as if it belongs in a group, careful consideration must be given since it may be far enough removed from the adjacent axle(s) to render the GVW invalid even if 6 scales have been used. In the extreme case, the lift axle is nothing more than a belly axle and is really not a part of the three axle group. See the text on pages 1-3 of this appendix for more information