WHITE PAPER

Performance-Based Brake Tester – Suspension Effects

LIT NO: WP100412 **DATE:** October 2012

On April 1, 2008 CVSA approved a new method for DOT inspectors to check commercial vehicle brakes and enforce the minimum brake performance requirements in Federal Motor Carrier Safety Regulation 393.52. The test uses a machine called a Performance Based Brake Tester or PBBT.

The intent of testing with this equipment is to verify that a vehicle can provide a minimum level of brake force as a percentage of its measured weight. PBBT testers can come in flat plate or roller dynamometer (roller dyno) form. This memo will concentrate on the roller dyno styles. One style is permanent and built into the ground with an access pit (reference Figure 1).

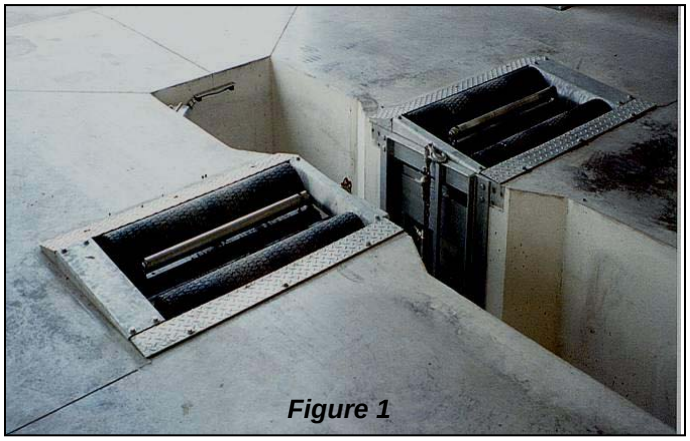


Figure 1

The second style of PBBT is a portable unit that can be carried behind a vehicle and used at a weigh station or rest area, as shown in Figure 2.

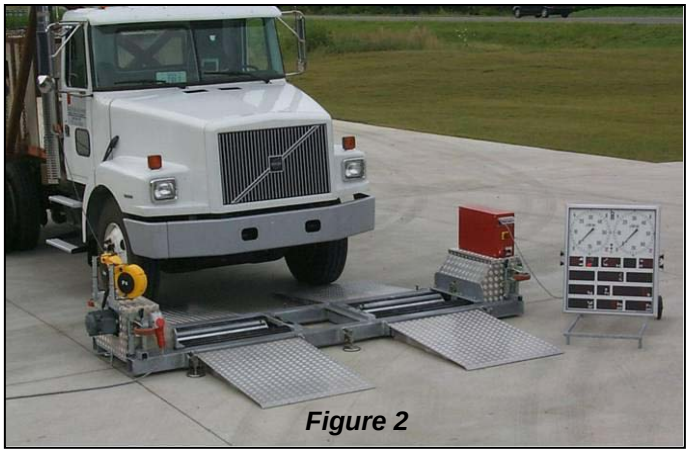


Figure 2

These units are currently used by DOT inspectors in seven states (WI, IN, TN, FL, GA, SC, & KS) plus Alberta, Canada, but they are also being used by fleets and Service Providers to proactively check vehicles for compliance with the federal regulations, as well as their own self-defined pass/fail criteria.

Hendrickson has learned from our recent testing that the roller dyno method of testing can produce very different results depending on the style of suspension tested. The critical detail in the testing is when the weight on the suspension is recorded for use in the calculation of the ratio of brake force to vehicle weight (BFtot/GVW).

The test procedure calls for each axle to move onto the machine rollers, the rollers spin 1-3 mph, and the driver applies the brakes. The machine captures the maximum brake force reached before the tire slips. The brake forces for all axles are added together and the number is divided by the sum of the weights recorded for each axle, and then this ratio is used for compliance and must be above .435, according to FMCSA 393.52 and the CVSA North America O.O.S. criteria section 1.1.

There are two ways to record the weight in these tests. The first is to weigh the axle when the rollers start spinning, prior to the application of the brakes, and use this weight in the calculation of BF tot/GVW. This is called the static weight method.

The second method is to monitor the axle weight continuously during the brake application and to record the axle weight at the point the maximum brake force takes place for use in the calculation. This method is called the dynamic weight method.

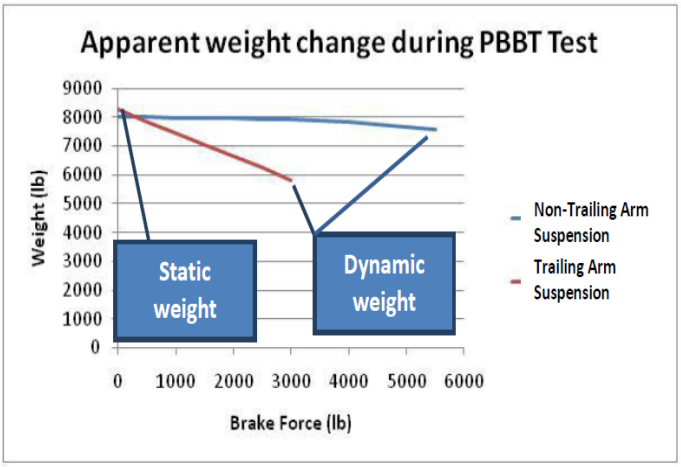
The first method (static weight acquisition) has been used for many years, and at the time of implementation of PBBTs for enforcement of FMCSR 393.52, it was also not known that the type of suspension would significantly influence the calculated results from the roller style PBBTs.

What we have learned:

When a trailer with a trailing arm suspension is tested on a roller dyno there is a substantial off-loading (up to 30%) that takes place on the axle being tested. The reduction in weight results in the tires slipping on the drive rollers (known as "lock-up") before the brake can reach full torque.
The brake torque reached when the tire slips on the roller is the brake torque used in the calculation.

This off-loading takes place to a much lower degree in non-trailing arm suspensions. This phenomenon can only occur in this testing procedure on single axle roller dynamometer tests. Some suspension types are also known to gain weight during the brake application.

Braking of a single axle's rotating tires, while the remaining non rotating tire axles are held stationary and locked in place by each brake's torque is not possible in normal operation of a tractor-trailer. In this test, the non tested axles on the tractor trailer are not allowed to move with the trailing arm axle being tested, which results in the non tested axles wedging the trailer up as the tested brake creates torque. This artificial "wedging" reduces the down force on the tested axle and causes the tested tires to slip before the brake can reach full torque (reference Figure 3).



Suspension Style vs. Brake Force (Axle Weight Off-loading)

Figure 3

During normal braking some axles may unload, but others have to increase in load, as the total weight of the vehicle does not change. Testing axles individually, however, allows the effect of individual unloading (or loading) to accumulate, which cannot happen during an actual stop of the vehicle.

In addition to this effect, the rate that the brake is applied can also affect the recorded force of that axle. A slow steadily increasing pedal apply gives the tires on that axle the best opportunity to get to maximum grip. A rapid apply can cause a tire to slip sooner before the maximum brake force can be reached.

A second issue we have uncovered is that several fleet customers are testing trailers independently. The federal regulation specifies a minimum ratio of total "braking force as a percentage of gross vehicle [single unit] or combination weight", commonly referred to as retardation, which is a ***Total Combined Vehicle Measurement (Tractor and Trailer)***. Testing trailers by themselves is not equivalent to the federal requirement.

The problem:

If a PBBT test is performed using the static weight method on a vehicle with trailing arm suspensions, the total vehicle weight can be overrepresented in the calculation.

Since the unloading of the axle during the test results in the brake force locking the wheel (and thus stopping the test) at a brake force value lower than the maximum brake capacity, the test result can indicate a lower ratio of total braking force to total vehicle weight when compared to a vehicle without trailing arm suspensions (Figure 4).

The method of acquiring the axle weight used in the compliance calculation is not specified in the current CVSA PBBT test procedure or FMCSA Functional Specification.

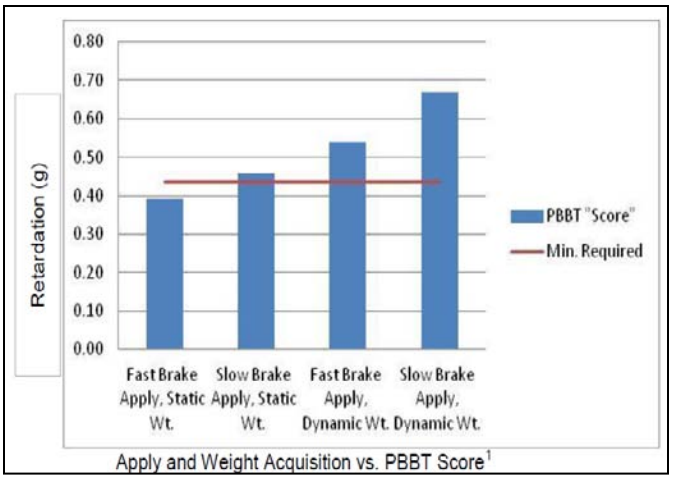


Figure 4

Hendrickson has performed actual vehicle tests comparing the fully loaded (80,000 lbs GVWR)vehicle stopping performance at 20 mph (per FMCSA 393.52) between different trailer suspension types and found the following results, as shown in Figure 5):

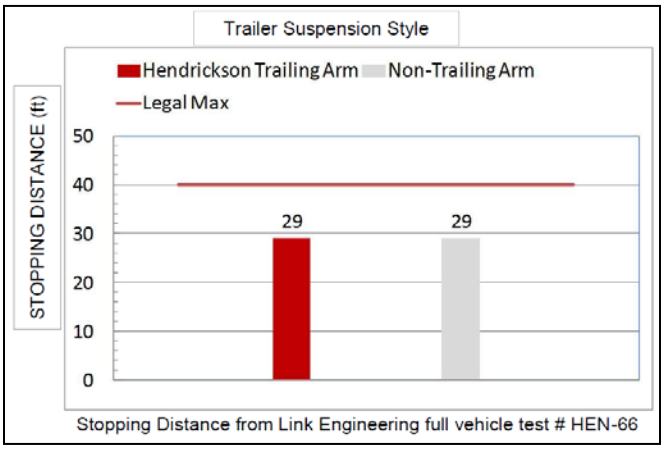


Figure 5

Possible solutions:

PBBT tests for enforcement use or confirming compliance with the FMCSRs must use the dynamic weight of the axle in the ratio calculation, and test a full combination vehicle, not independent trailers.

The change to dynamic weighing will not impact the testing of vehicles with non-trailing arm suspensions. The use of dynamic weight acquisition on PBBTs is recognized and already used in some countries outside the U.S. (Europe, New Zealand and France) and is being considered by others.

Another solution, though not as effective, is to ensure that the brakes are applied slowly and at a steadily increasing rate during the test. This will ensure lock up does not occur prematurely, which leads to an even lower brake force being delivered to the PBBT rollers at the time the test is terminated.

The most effective solution is a combination of both dynamic weight acquisition *and* slow brake apply. Additionally, PBBT machines are frequently configured to automatically end a test if during the test the brakes are not applied within some "time out" duration period.

In the event that a PBBT machine is configured so as to not allow a gradual brake application lasting approximately ten seconds—the accepted duration in the CVSA PBBT for enforcement procedures—within the "time out" period, then it may be necessary to increase the machine's "time out" period.

What Hendrickson has done:

Hendrickson met with CVSA in April 2011 and alerted them of this issue. We have also informed the PBBT manufacturers of this issue. All of the PBBT manufacturers that attended CVSA annual meeting expressed willingness to work with their customers to accommodate changes, as needed, to dynamic, rather than static weight measurement.

CVSA has agreed to share this information with their PBBT user member jurisdictions. Fleets have *not* been alerted to this issue.

What Hendrickson needs to do:

Hendrickson needs to pass this information to all of our customers who have PBBTs so that they are

aware of the potential issue. If needed, the Hendrickson engineering group will go through the detailed reports with fleets.

The fleets will need to contact the manufacturer of their PBBT to have the equipment software updated to use dynamic weight, if it is not used already. Finally, once again, fleets need to be reminded that this is a full combination vehicle test.

The Hendrickson Engineering Team will continue to work with CVSA in improving the use and understanding of PBBTs as they become used more often across North America.

Hendrickson Canada
250 Chrysler Drive, Unit #3
Brampton, ON Canada L6S 6B6
905.789.1030
Fax 905.789.1033

Trailer Commercial Vehicle Systems
2070 Industrial Place SE
Canton, OH 44707-2641 USA

866.RIDEAIR (743.3247)
330.489.0045
Fax 800.696.4416

Hendrickson Mexicana
Circuito El Marqués Sur #29
Parque Industrial El Marqués
Pob. El Colorado, Municipio El Marqués,
Querétaro, México C.P. 76246
+52 (442) 296.3600
Fax: +52 (442) 296.3601