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ORNL/TTG/BWPT/PVS/Rev5

Performance-Based Brake Tester Valuation Study

DRAFT

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ORNL/TTG/BWPT/PVS/Rev5

Commercial Motor Vehicle Roadside Technology Corridor

PBBT VALUATION STUDY

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ACRONYMNS, ABBREVIATIONS, AND DEFINITIONS

Term	Definition
CMV	Commercial Motor Vehicle
Creeper	Mechanics rolling inspection creeper
FMCSA	Federal Motor Carriers Safety Administration
GVW	Gross Vehicle Weight
HM	Hazardous Material
NAS	North American Standard
OOS	Out-of-service
ORNL	Oak Ridge National Laboratory
PBBT	Performance-Based Brake Tester
SPE	Skill Performance Evaluation
State Trooper	Commissioned police officer additionally trained in commercial vehicle enforcement
TDOS	Tennessee Department of Safety
THP	Tennessee Highway Patrol

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ABSTRACT

The Oak Ridge National Laboratory's Energy and Transportation Science Division, in collaboration with the Federal Motor Carrier Safety Administration and the Tennessee Highway Patrol (THP) Commercial Vehicle Enforcement (CVE), conducted a Performance-Based Brake Tester (PBBT) Valuation Study. The purpose of the study was to determine the PBBT's ability to increase the number of contacts with commercial motor vehicles (CMVs) and explore how the PBBT affects the CMV out-of-service (OOS) rate. The PBBT is a roller dynamometer which measures the vehicle's established brake force and calculates brake efficiency to indicate the effectiveness of the vehicle's brakes. Several test scenarios were employed using North American Standard (NAS) Level-1, 2, and 3 CMV inspection criteria. The first three scenarios employed both an NAS inspection (Level-1, 2, or 3) and PBBT test for a given test vehicle. In the fourth testing scenario the PBBT was used as a screening tool to determine if Level-1 inspections were necessary. A fifth scenario, designed to determine the time savings associated with the use of an inspection pit, involved conducting a series of Level-1 inspections at the Greene and Knox County CMV Inspection Stations. Two additional scenarios were included as a result of initial analysis: the use of a Level-2 in conjunction with a PBBT and the use of the PBBT in a stand-alone inspection (NAS Level-4). Inspections conducted using an inspection pit saved only 2.4 min over having to crawl underneath the CMV via an inspection creeper, but resulted in a greater OOS rate. The results of this study indicate that it takes an average of 16.0 min to conduct a Level-4 PBBT test and approximately 9.0 min to conduct a PBBT in conjunction with an NAS-Level inspection. On average, it takes 3.1 min longer to conduct a PBBT test than the brake stroke measurement currently conducted as part of the NAS Level-1 inspection. Based on this testing (including only the time to conduct the inspection) NAS Level-2 and 3 inspections each take an average of 10.3 min and 6.6 min, respectively. For this short-term test, the NAS Level-1 scenario resulted in the highest OOS rate compared to the other scenarios.

Based on the testing times, the use of the Level-3 inspection would result in the highest number of CMV contacts in a given period of time. In most cases, the NAS Level-4 special inspection using the PBBT screening test was found to be the least time-consuming, but this inspection does not involve a check of the driver's credentials or equipment. The data collected in this study was used to develop a worksheet to help determine the most effective use of personnel in a given time period based on typical inspection times and OOS rates.

1. PROJECT OVERVIEW

The Federal Motor Carriers Safety Administration (FMCSA) requested the Oak Ridge National Laboratory's (ORNL) Transportation Technology Group and the Tennessee Highway Patrol (THP) to conduct a study regarding the use of a CMV inspection pit and Performance-Based Brake Tester (PBBT). The purpose of this study was to determine the effects of following in regard to time savings and OOS rate: the use of a CMV inspection pit to conduct NAS Level-1 inspections, comparison of NAS Level-1, 2, and 3 inspections, and the use of a PBBT. Figure 1 shows a CMV being tested on the PBBT.

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Figure 1. CMV Testing on the PBBT

1.1 NAS INSPECTIONS

The inspections conducted as a part of this testing are described in the following sections as listed in the *North American Standard Out-Of-Service Criteria Handbook and Out-Of-Service Pictorial Edition*, 2007.

1.1.1 NAS Level-1

The NAS Level-1 is an inspection that includes examination of driver's license, medical examiner's certificate and Skill Performance Evaluation (SPE) Certificate (if applicable), alcohol and drugs, driver's record of duty status as required, hours of service, seat belt, vehicle inspection report (if applicable), brake systems, coupling devices, exhaust systems, frame, fuel systems, lighting devices (turn signals, brake lamps, tail lamps, head lamps and lamps/flags on projecting loads), safe loading, steering mechanism, suspension; tires, van and open top trailer bodies, wheels and rims, windshield wipers, emergency exits for buses, and Hazardous Materials (HM) requirements as applicable. HM required inspection items will be inspected by certified HM inspectors.

1.1.2 NAS Level-2

The Level-2 inspection includes the examination of driver's license, medical examiner's certificate and SPE Certificate (if applicable), alcohol and drugs, driver's record of duty status as required, hours of service, seat belt, vehicle inspection report (if applicable), brake systems, coupling devices, exhaust systems, frame, fuel systems, lighting devices, safe loading, steering mechanism, suspension, tires, van and open-top trailer bodies, wheels and rims, windshield wipers, emergency exits on buses, and HM requirements as applicable. This inspection includes only the items which can be inspected without physically getting under the vehicle.

1.1.3. NAS Level-3

In the Level-3 inspection, driver's license, medical examiner's certificate and SPE Certificate, driver's record of duty status, hours of service, seat belt, vehicle inspection report, and HM requirements are inspected.

1.1.4. NAS Level-4

Level-4 inspections typically include one-time examinations of a particular item. In this study, the item of interest is the overall braking efficiency, as measured by a PBBT. The completion of a Level-4 requires the inspector to record the information in Aspen, as with other NAS inspections.

1.2. TEST SCENARIOS

The PBBT Valuation Study involved a series of seven test scenarios performed June 2-July 13, 2009. All tests were conducted within an 8-hour shift during daylight hours. Each test was conducted at the Greene Co. CMV Inspection Station except for the inspection pit savings scenario, part of which was conducted at the Knox Co. CMV Inspection Station. THP provided commissioned officers (state troopers) to conduct the study. ORNL randomly selected vehicles for testing by requesting that all vehicles be brought over the scales and choosing the tenth CMV for testing. The tests were conducted in the scenarios described below.

1.2.1 Inspection Pit Time Savings

This test was conducted June 2-5. The first two days of testing were conducted at the Knox Co. CMV Inspection Station, and the last two days were conducted at the Greene Co. CMV Inspection Station. ORNL secured two dedicated state troopers to conduct all four days of testing. The method used for testing was to time an entire NAS Level-1 inspection, making note of the time spent conducting the vehicle portion (manual inspection of the equipment). The purpose of this test was to compare the times required when using a mechanic's rolling inspection creeper versus the time needed when using an inspection pit to conduct the vehicle portion of the inspection.

1.2.2 NAS Level-1 Inspection Augmentation

This test was conducted June 15-16. The method of testing was to perform both a PBBT test and an NAS Level-1 inspection on each test vehicle. The time periods recorded were those to conduct the PBBT test and the entire Level-1, as well as the vehicle portion of the inspection and the brake stroke measurements within the Level 1.

1.2.3 NAS Level-2 Inspection Augmentation

This test was conducted June 17-18. The method of testing was to begin by performing a PBBT test. If the driver passed the PBBT, the state trooper performed a NAS Level-2 inspection. If the driver failed the PBBT, the state trooper performed an NAS Level-1 inspection. Times recorded for this test were those for the PBBT, and the Level-2 or Level-1. For vehicles which were given a Level-1, the time required to complete vehicle portion of Level-1 was also noted.

1.2.4 NAS Level-3 Inspection Augmentation

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This test was conducted on June 19 and 22. A PBBT test was performed and timed; if the driver passed the PBBT, an NAS Level-3 inspection was conducted and timed. Otherwise, an NAS Level-1 inspection was conducted and this time (as well as the time for the vehicle portion) was recorded.

1.2.5 NAS Level-1 Replacement

The data for this test scenario was taken on June 26. The method of testing was to begin by performing a PBBT test and timing this test. If the driver passed the PBBT, the driver was released and no further inspection was performed. If the driver failed the PBBT, an NAS Level-1 inspection was performed; the total time to complete the entire inspection and the portion of time to complete the vehicle portion of the inspection were recorded.

1.2.6 PBBT with NAS Level-2

The next test scenario was conducted on June 29. The purpose of this test was to see how effective and time efficient it would be to merge the PBBT into the NAS Level-2 Inspection. Both of these were performed on each vehicle. The times collected were for the PBBT and the Level-2.

1.2.7 Stand-Alone PBBT Test

This test was conducted on July 13 and involved running a stand-alone PBBT test on each vehicle. The PBBT times were recorded by task: gathering the drivers' information and running the PBBT.

2. PERFORMANCE-BASED BRAKE TESTER

The PBBT is a roller dynamometer with the capability of measuring a vehicle's rolling resistance, weight, and brake force. The vehicle's tires are placed on and between the red rollers shown in Figure 2. The driver is asked to maintain a minimum of 90-100 psi of system air pressure at all times. The PBBT will start rolling the wheels as if the vehicle were traveling forward and attain a rotational speed of approximately 2 mph. As the driver gradually depresses the brake, the PBBT records the force being activated in lbf. This data is sent directly to the PBBT desktop computer. This process is repeated for each axle until the entire vehicle has been tested. The overall result reported is the brake efficiency, the ratio of the total braking force to the gross vehicle weight (GVW). Figure 2 shows the parts of the Greene Co. CMV Inspection Station's PBBT, the machine used for all of the PBBT testing in this report.

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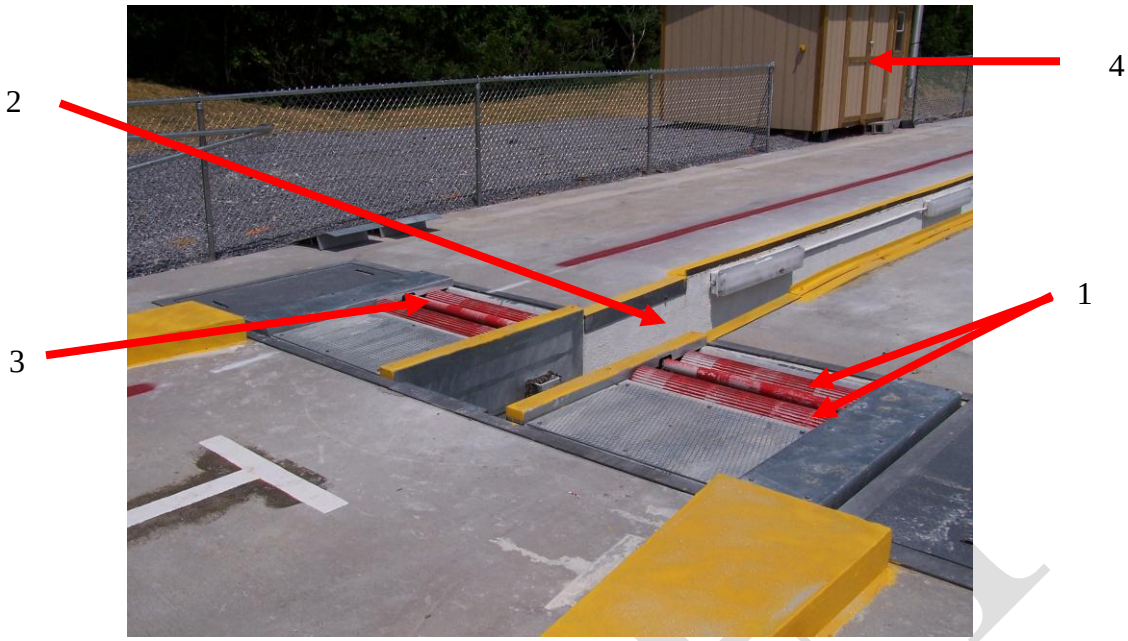

Figure 2. Diagram of PBBT

Figure 2 Legend:	
1. Dynamometer rollers	3. Inspection pit
3. Tachometer roller	4. Location of PBBT computer

The overall vehicle brake efficiency is calculated from the sum of the wheel-end brake forces divided by the total vehicle weight. In order to pass the PBBT, the overall vehicle has to score a 43.5 or higher. Anything below a 43.5 is failing. An unsuccessful PBBT test results in an invalid test output. An invalid test may occur because the driver slams on the brakes (brake application is too fast) or the trailer is too lightly loaded (potentially resulting in scores over 100). Figure 3 shows the PBBT display with its dials showing the brake forces being applied at the right and left wheel-ends during a PBBT test.

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Figure 3. PBBT Display

By law, a failed PBBT test is a direct OOS violation, but the PBBT test cannot be used in lieu of the brake stroke measurements taken in a Level-1 inspection. Some potential causes for a vehicle to fail a PBBT test are excessively worn brake linings, worn excessively worn brake drums, cracked brake drums, air system leaks (including air suspension leaks), broken push rods, or other defects in the vehicle's foundation brake system.

3. DATA AND ANALYSIS

3.1 INSPECTION PIT TIME SAVINGS

The purpose of this specific study was to provide insight on how using an inspection pit compares to using the traditional method of a NAS Level-1 inspection, in which a creeper is used to crawl underneath the CMV. Figure 4 shows a state trooper using an automotive mechanic's creeper to perform a brake stroke measurement.

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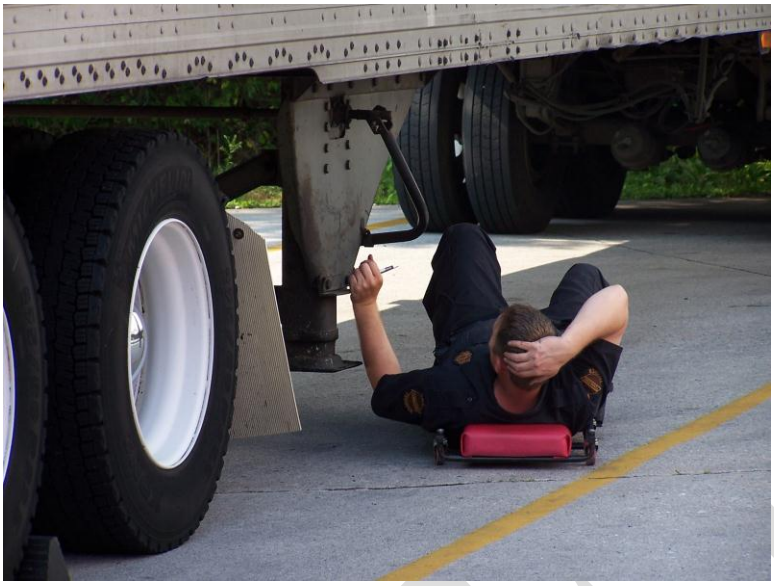

Figure 4. State Trooper Performing an NAS Level-1 Inspection with an Automotive Type of Inspection Creeper

Figure 5 displays the inspection pit at Greene County. The variables tested for were inspection times, OOS rate, and number of CMVs contacted within the test period.

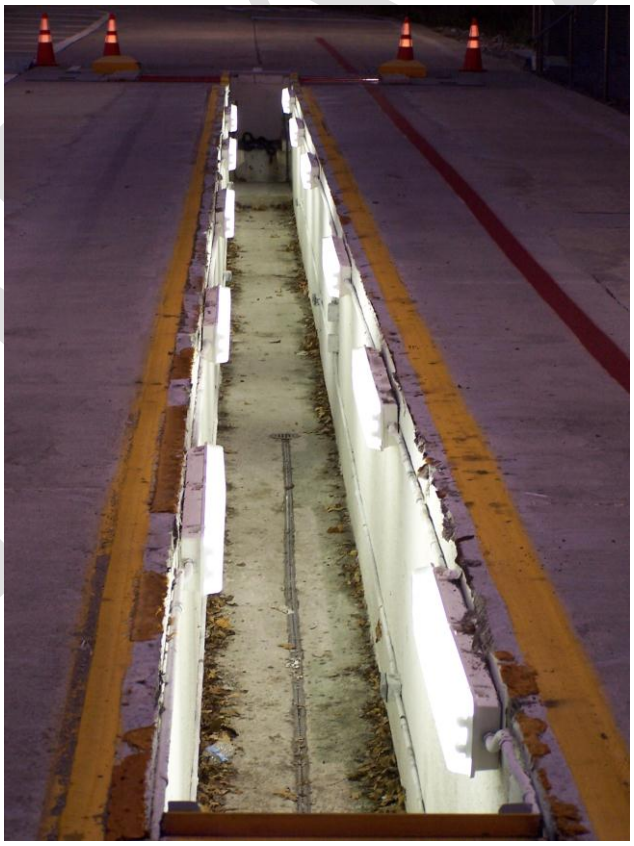

Figure 5. Greene Co. CMV Inspection Station Inspection Pit

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Using an inspection pit saved 2.3 min in the vehicle portion of the inspection as opposed to an inspection performed without the benefit of a pit, as shown in Table 1.

Table 1. Average Times for Vehicle Portion of Level-1 Inspection with and without a Pit

Location	Vehicle Time (min)
Knox Co. – No Inspection Pit	21.0
Greene Co. – Using Inspection Pit	18.7

There were a total of 39 vehicles inspected in this test scenario. Although approximately the same number of vehicles were conducted at each location, there were approximately twice as many vehicles placed OOS using the inspection pit. is shown in Table 2 contains a summary of enforcement actions taken during this course of this testing.

Table 2. Overall Enforcement Statistics for Two Days of Testing at Each Location

Enforcement Action	Knox Co. (No Pit)	Greene Co. (With Pit)
Level-1 Inspections	20	19
Warnings	23	25
OOS Actions	4	9

The increased number of vehicles put OOS could be due to a more thorough inspection process for the Greene Co. inspections: both troopers indicated they felt they were able to conduct a more thorough inspection with the inspection pit versus the creeper. The inspection pit allowed them to walk underneath the entire CMV so they could check bushings, air leaks, brake linings, and other components more easily. Additionally, the use of the inspection pit made possible the inspection of tractor drive axles and trailers that could not otherwise have been inspected; some vehicles have obstructions that prevent an officer from crawling under the vehicle.

Inspections performed at the Greene Co. Inspection Station involved less noise from the road due to the inspection pit's location away from other CMVs. Thus, the state trooper could hear air leaks well; this also made communication from driver to trooper easier. The inspection pit was shown to be a more efficient and effective tool to conduct a Level-1 inspection.

3.2 NAS LEVEL-1 INSPECTION AUGMENTATION

The purpose of this test scenario was to compare the time required to conduct a PBBT test to the time needed to perform the brake stroke measurement portion of the Level-1 inspection. Figure 6 shows a state trooper performing a brake stroke measurement.

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Figure 6. Brake Stroke Being Measured

Other parameters of interest were the OOS rate and the overall time savings afforded to the Level-1 inspection by the use of the PBBT test in lieu of the brake stroke measurement. This test method was completed for 17 CMVs. Table 3 shows the average times for various components of the NAS Level-1 Inspection Augmentation.

Table 3. Average Times for NAS Level-1 Inspection Augmentation

Component	Time (min)
PBBT (for this scenario)*	10.8
Total Level-1	32.2
Vehicle Portion of Level-1	13.1
Brake Stroke Portion of Level-1	5.4

*Excluding time to enter into Aspen

The times shown in Table 3 reflect the average times for all vehicles tested in the three days that this scenario was used. The PBBT time included the time to explain the test to the driver, collect the driver's information, and complete the testing of the vehicle. The PBBT test took approximately twice as long as the brake stroke measurement. Out of these 17 inspections, there were a total of 9 CMVs put OOS. Out of these nine, only five vehicles failed the PBBT. The other four passed the PBBT but were put OOS on other criteria. Only one of these was placed OOS solely due to brake stroke lengths. In order to fail the brake stroke measurement, 20% of the vehicle's wheel-ends have to be out-of-adjustment. These OOS vehicles had problems including inoperative brakes, air leaks, or insufficient brake force.

3.3 NAS LEVEL-2 AND LEVEL-3 INSPECTION AUGMENTATIONS

The purpose of these two test scenarios was to quantify time savings with the PBBT and determine the resulting effect in OOS rate. There were 12 CMVs inspected for the Level-2 inspection augmentation and 15 CMVs inspected for the Level-3 Inspection Augmentation. Table 4 shows the average times for these two test scenarios. Vehicles were first given a PBBT test. Vehicles which failed this test were given a Level-1, and vehicles which passed were given a Level-2 or Level-3 according to the scenario being employed.

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Table 4. Average Times for Components of the NAS Level-2 & 3 Inspection Augmentation Scenario

Component	Time (min)
PBBT	9.4
Level-2	23.7
Level-3	14.9
Level-1	33.4

Based on the difference between the Level-2 and Level-3 inspections, it took an average of 5.6 min to perform the vehicle walk-around. On average, conducting a Level-2 in conjunction with a PBBT saved approximately 5.3 min over performing a Level-1 alone. Conducting a Level-3 with a PBBT resulted in a time savings of 10.9 min over a conducting a full Level-1.

3.4 NAS LEVEL-1 REPLACEMENT

The purpose of the NAS Level-1 Replacement test scenario was to determine how using a PBBT test in lieu of a Level-1 would affect the number of CMVs contacted and the OOS rate. As shown in Table 5, in a given time period nearly three times the number of CMV contacts could be made with the PBBT as opposed to using a traditional Level-1.

Table 5. Average Times for NAS Level-1 Replacement

Component	Time (min)
PBBT*	9.0
Level-1	32.0

*Excluding time to enter into Aspen

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3.5 PBBT WITH LEVEL-2

The PBBT with Level-2 Test was a new test plan integrated into the PBBT Valuation Study after preliminary analyses. ORNL decided to conduct this test because the initial analysis of data from the NAS Level-2 Inspection Augmentation (Section 3.3) indicated that this scenario might be the most efficient methodology to place the maximum number of vehicles OOS in a given amount of time. Additional support for this scenario can from the state trooper that conducted some of the tests in which the PBBT was used as a screening tool. He felt that it was necessary to have proper tire inflation to use the PBBT. The Level-2 inspection encompasses tire inflation. Table 6 displays the results of this test scenario.

Table 6. Average Times for PBBT and Level-2

Component	Time (min)
PBBT*	8.0
Level-2	17.7

*Excluding time to enter into Aspen

3.6 STAND-ALONE PBBT

In the Stand-Alone PBBT test scenario, a PBBT test was performed for each vehicle to determine how much time it takes to run a PBBT test, excluding the time it takes to gather the driver's information and enter it into the computer. This test involved 15 CMVs. Table 7 displays the average times for each portion of this test and compares these times to the time needed to measure the brake stroke.

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Table 7. Average Times for PBBT and Brake Stroke Measurement

Component	Time (min)
Total PBBT time*	7.1
Running PBBT	5.1
Driver info collected	2.0
Brake Stroke Measurement**	5.8

*Excluding time to enter into Aspen
**Estimate from other test scenarios

The data collected shows that it takes approximately 5.1 min to run just the PBBT test and approximately 2.0 min to collect the driver information. The brake stroke measurement data shown in Table 7 is an average of data collected in other scenarios. From this test scenario, the vehicle portion of the PBBT test was found to be slightly faster that the brake stroke measurement conducted in the Level-1 inspection.

3.7 OVERALL DATA COLLECTION AND ANALYSIS

A total of 132 CMVs were contacted during the PBBT Valuation Study contacted. Within the data collected, analyses were performed to quantify time savings with the PBBT and determine differences in the OOS rates between the various test scenarios in an effort to determine the number of various types of inspections during a given time period. Table 8 summarizes the enforcement actions performed during the course of this testing.

Table 8. Summary of Enforcement Activity during Testing

Date (s)	Test Scenario	Number of CMVs				
		Total Contacted	Passed PBBT	Failed PBBT	Invalid PBBT	Placed OOS
June 2-5	Inspection Pit Time Savings	39	N/A	N/A	N/A	13
June 15-16,26	Level-1 Inspection Augmentation	19	12	5	2	10
June 17,18	Level-2 Inspection Augmentation	12	7	5	0	4
June 19,22	Level-3 Inspection Augmentation	15	9	3	3	4
June 23,24	Level-1 Replacement	22	17	4	1	5
June 29	Level-2 with PBBT	10	8	1	1	1
July 13	Stand-Alone PBBT	15	9	5	1	0*
TOTAL		**132**	**62**	**23**	**9**	**37**

* PBBT results were not entered into Aspen for this scenario, therefore no vehicles were placed OOS.

The information collected in this test was used to generate a worksheet to compare the estimated number of CMV contacts and OOS orders for various types of inspections. A sample worksheet for a 4-hour time period period is shown in

Table 9.

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Table 9. CMV Enforcement Resource Evaluation Worksheet

Category	Inspection Type	Summary Statistics		Estimate for Inspection Period	
		Average time (min)	OOS Rate	CMV Contacts	CMVs/Drivers OOS
Existing Inspections	**Level-1**	**45**	**26.6%**	5	1
	Level-2	**20**	**22.4%**	12	3
	Level-3	**15**	**9.2%**	**16**	1
	Level-4 Special: PBBT	16	24.4%	15	**4**
Hybrid Inspections	Level-2 + PBBT	31	34.5%	7	2
	Level-3 + PBBT	26	29.5%	9	3
Other	PBBT to replace BrStr in Level-1	48	23.6%	5	1

*Estimates shown are based on a 4-hr inspection period using estimated times for Level-1,2,and 3 inspections provided by CVSA, OOS rates from the 2009 Safety Check where available, and experimentally-determined values from this study where national data were not available.

Another goal of this study was to see how the time to conduct a PBBT compared to equivalent times for NAS Level-1, 2, and 3 inspections. Table 10 displays the average time results on all of the test data with the exception of data collected as part of the inspection pit comparison study.

Table 10. Overall Average Times

Component	Time (min)
Total Level-1	32.5
Vehicle Portion	*13.1*
Brake Stroke	*5.9*
Level-2	19.8
Level-3	14.9
Level-4 Special: PBBT	16.0
Conduct Test	*9.0*
*Complete Aspen report**	*7.0*

*Estimate from trooper feedback (~5 min for identifying information and ~2 min for PBBT results)

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4. LESSONS LEARNED

The PBBT Valuation Study results empirically show how the PBBT and inspection pit can be useful. As described in the following sections, a number of lessons were learned throughout the period of testing.

4.1 INSPECTION PIT

4.1.1 Thoroughness of Inspection

The use of an inspection pit allowed the trooper to complete a more thorough inspection due to a variety of factors. At the Greene Co. CMV Inspection Station, the state trooper could see better with the lights on in the pit instead of having to use a flash light. The increased visibility made it possible to check the vehicles more thoroughly. Air leaks could be heard more easily for inspections done at the pit because there were no trucks running in the immediate vicinity of the inspection area, unlike the inspection area at Knox Co. At Greene Co. CMV Inspection Station, the troopers were able to mark all of the brakes at one time, completing the brake stroke measurements more efficiently. At the Knox Co. CMV Inspection Station, brake stroke measurements had to be recorded one axle at a time due to the time it took for the trooper to get into position with the creeper.

4.1.2 Disadvantages in Time

At the Knox Co. CMV Inspection Station, state troopers had trouble crawling underneath the CMV to inspect the brakes on the drive axles because many CMV had low side panels and/or a low airbag support bar. Because the inspection pit allowed for a more thorough inspection, the troopers could inspect more of the vehicle; thus, they spent more time inspecting the vehicles. Another cause for the minimal time savings associated with the pit was that only one truck could be inspected at a time using the pit. This limited the number of vehicles which could be contacted in a given period. Also, state troopers assigned to the Greene Co. CMV Inspection Station likely have a more efficient inspection process when using the pit, which comes from the "learned experience" of using the pit over time.

4.2 USE OF THE PBBT

4.2.1 Additional Vehicle Condition Indicators

In some cases, the use of the PBBT allowed air supply issues to be noticed immediately because the tractor was not able to maintain the required 90-100 psi for a proper PBBT test. Low scores on the PBBT (under 10) for the wheel-end served as an indicator of braking problems, such as a severe air system leak, bad air distribution valve, bad S-cam bushings, or a grease/oil leak within the braking system.

4.2.1 Concerns Regarding PBBT Usage

A PBBT test may take longer than usual at times because some axles do not test as well or drivers are not accustomed to the test. For example, in some cases if the driver slams on the brakes it will lock his brakes up; in this case, the axle would need to be re-tested. Trailers carrying chips or any other lightweight items do not work well with the PBBT and often have tested efficiencies in excess of 100. In this case, the test results usually come up invalid due to the lightly-laden trailer axle. Lastly, if the driver could not get the CMV's differential to release, the test result was not valid due to the inability to test the locked differential. While the PBBT provides information about the condition of a vehicle's brakes beyond what could be determined from visual inspection methods, some state troopers are hesitant to use the PBBT because they

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cannot always pinpoint the cause for failed PBBT test. Perhaps a more significant reason for slow adoption of the PBBT by the troopers into their regular enforcement protocols is the fact that currently the state of Tennessee does not get credit within the CSP for this type of inspection.

5. SUMMARY OF RESULTS AND CONCLUSIONS

In conclusion, the PBBT Valuation Study provided valuable information regarding time savings, OOS rates, and the number of vehicles which could be contacted using various inspection methods. The inspection pit was shown to be beneficial because its use doubled the OOS rate in the small sample of vehicles tested, although it did not appear to increase the number of vehicles contacted. This is explained by the better access to the underside of the vehicle, allowing the officer to conduct a more thorough inspection.

Referring to Table 9, the Level-4 Special (PBBT) Inspection has the best OOS and provides nearly the best CMV contact rate, but does not provide any check of the driver or carrier. For this testing, the Level-1 inspection had the lowest contact rate and OOS rate of all existing inspections and potential hybrid inspections studied. By substituting the PBBT test for the brake stroke measurement portion of the Level-1 very little time was saved and there was not change in the OOS.

The best inspection use methodology would seem to be combining the PBBT test with the Level-2 or Level-3 inspection to optimize the CMV contacts and OOS for a given time period.

6. FUTURE DIRECTION

For more conclusive results, further testing would need to be conducted on a larger sample of vehicles. By collecting more data, a greater statistical significance could be given to the data and resulting time comparisons. A recommended scenario would be to conduct a long-term test using the data from Table 9 to choose the most efficient and effective inspection method and compare it to the method that is currently used to determine if the expected benefits from the new method can be realized over time.

Issues with variability could be addressed by conducting a future study using the same officer for each test scenario. In the case of this testing, each officer had a different order of conducting a Level-1, and they all had a different result in times. By conducting more controlled testing, it would be easier to identify which inspection level that the PBBT could be best used in conjunction with for a more efficient use of time and more effective OOS rate.

7. REFERENCES

Commercial Vehicle Safety Alliance, *North American Standard Out-Of-Service Criteria Handbook and Out-Of-Service Pictorial Edition*, Washington, DC, 2007.

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Appendix A. TEST PLAN

NON-CONVENTIONAL INSPECTION METHODOLOGY USING A PERFORMANCE-BASED BRAKE TESTER

A Short-term evaluation to determine the potential percent increase in CMV contacts and out-of-service rates by integrating a PBBT into current North American Standard Inspections with the Commercial Motor Vehicle Roadside Technology Corridor and to quantify time savings

Background

While the results of a Performance-Based Brake Tester (PBBT) evaluation are currently approved to be used as a stand alone inspection for out of service (OOS), they cannot be used in lieu of physical brake stroke measurements in an NAS Level -1 Inspection, this evaluation propose non-conventional uses of the PBBT evaluation to gage their potential value in increasing a Commercial Motor Vehicle (CMV) Enforcement Officer's ability to contact more CMVs and increasing the OOS rate in a given period of time.

This evaluation will: 1) determine the increase in CMV contacts that can be realized in an eight-hour shift by a CMV inspector by substituting and/or augmenting current inspections with a PBBT; 2) determine the increase in the OOS rate by substituting and/or augmenting current inspections with a performance-based brake tester; 3) quantify any time savings afforded by substituting the PBBT in place of the current inspection's physical measurement of brake stoke within the NAS Level -1 inspection.

Location of the evaluations

Knox Co. CMV Inspection Station
Greene Co. CMV Inspection Station

Roles

ORNL – Draft Test Plan; Collect and Analyze Data
TDOS – Perform Evaluations per Test Plan

Environment and Governance

The testing and inspections called out in this evaluation will be conducted by TDOS staff with the support of ORNL research staff. TDOS staff will be funded using the CMV RTC MCSAP overtime grant, thus this research will not impact normal CMV inspection station operations.

This evaluation will cease during periods of inclement weather.

TDOS personnel will use this test plan for the purposes of gathering valid research data and will follow normal enforcement protocols for all CMV violations.

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PBBT uses to be evaluated:

1) NAS Level -1 Inspection Augmentation - Substitute the PBBT test for current physical brake stroke measurements. (note: this will be done using the inspection pit and using the inspection lot with creeper)
    a. Quantify – Time saving
    b. Quantify - OSS rate change
2) NAS Inspection Augmentation - Suspend NAS Level-1 Inspections and conduct:
    a. Conduct Level II inspections in concert with the PBBT
    b. Conduct Level III inspections in concert with the PBBT
3) NAS Level -1 Replacement – Using the PBBT only conduct vehicle brake assessments

Work Steps

Note: The day preceding each work day, ORNL staff will telecon with TDOS staff and verify appropriate weather conditions and staff availability. A go/no-go decision will be made for the next day's testing.

At the start of each day of testing, ORNL staff will telecon with TDOS staff and discuss the specific nature of the day's testing and the data needs. Clarification of questions will be given. At the end of each day, the testing and data collection will be discussed again.

Inspection pit time savings -

a. Using the CMV RTC overtime grant – Secure two dedicated troopers for two days to conduct NAS-Level -1 inspections at the Knox Co. CMV Inspection Station. ORNL staff will time the length of the inspections (vehicle portion and total inspection time) from start to finish and note anomalies adding to overall time.
b. Repeat step a using the same two troopers at the Greene Co. CMV Inspection Station (two dedicated troopers for an additional two days to conduct Level-1s).

NAS Level-1 Inspection Augmentation

a. At the Greene Co. CMV Inspection Station, divert all CMV traffic onto pit scale until lane is full.
b. Choose 10th vehicle in line for testing and immediately divert to PBBT.
c. Conduct a PBBT test on the CMV prior to the vehicle being placed on the inspection pit for Level -1 inspection.
d. Time PBBT test, beginning with the time the vehicle reaches the stop bar prior to the pit and ending with the time the PBBT printout is viewed.

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e. Place vehicle on the pit and conduct Level -1 inspection. Time the brake stroke measurement portion of the Level-1 inspection, beginning with the time the first mark is made on a pushrod and ending with the time the final measurement is recorded. Record this value.
f. Time vehicle-only portion of Level-1 inspection
g. Time total Level-1 Inspection.
h. Copy the Level-1 Inspection Report for ORNL staff.
i. Repeat steps a through g for at least 10 vehicles.

NAS Inspection Level-II Augmentation

a. At the Greene Co. CMV Inspection Station, divert all CMV traffic onto pit scale until lane is full.
b. Choose 10th vehicle in line for testing.
c. Divert the CMV directly to the PBBT
d. Conduct a PBBT test on the CMV prior to the vehicle/driver being inspected.
e. Time PBBT test.
f. If the vehicle passes the PBBT test, conduct a NAS Level II Inspection. Time the Level-II Inspection.
g. If the vehicle fails the PBBT test, conduct a Level-1 inspection. Record the total time for the Level-1 inspection and the time for the brake stroke measurements.
h. Repeat steps a through g for a total of 10 vehicles or entire shift (whichever is longer)

NAS Inspection Level-III Augmentation

a. At the Greene Co. CMV Inspection Station, divert all CMV traffic onto pit scale until lane is full.
b. Choose 10th vehicle in line for testing.
c. Divert the CMV directly to the PBBT
d. Conduct a PBBT test on the CMV prior to the vehicle\driver being inspected
e. Time PBBT test.
f. If the vehicle passes the PBBT test, conduct a NAS Level III Inspection. Time Level III Inspection.
g. If the vehicle fails the PBBT test, conduct a level-1 inspection. Record the total time for the level-1 inspection and the time for the brake stroke measurements.
h. Repeat steps a through g for a total of 10 vehicles or entire shift (whichever is longer)

NAS Level-1 Replacement

a. At the Greene Co. CMV Inspection Station, divert all CMV traffic onto pit scale until lane is full.
b. Choose 10th vehicle in line for testing.

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c. Divert the CMV directly to the PBBT
d. Conduct a PBBT test.
e. If CMV fails PBBT, conduct Level-I Inspection and place OOS based on the PBBT and other findings.
f. If vehicle passes PBBT, release driver and vehicle
g. Repeat steps a through f for entire shift.

PBBT Time Savings

a. At the Greene Co. CMV Inspection Station, divert all CMV traffic onto pit scale until lane is full.
b. Choose 10th vehicle in line for testing.
c. Divert the CMV directly to the PBBT
d. Conduct a PBBT test.
e. Time the driver information being collected.
f. Time PBBT test.
g. Repeat steps a through f for a total of 10 vehicles or entire shift (whichever is longer)

End of Evaluation Plan

For comments or questions concerning this document, please contact:

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Performance Based Brake Test

Vehicle ID: GA IC81K8

- WinBrake USA 1.32 -

Date: Jul 13 2009

Inspector: Preston Cox 697PC

Time: 08:21:42 AM

Test No.: 1145

Description:

Braking Force as a Percentage of Gross Vehicle Weight: 52.3 Pass

Minimum Required by FMCSR 393.52

Passenger Carrying Vehicles

- [ ] 65.2 - Vehicles w/ seating capacity of 10 or less (w/ driver) built on pass. car chassis.
- [ ] 52.8 - Vehicles w/ seating capacity more than 10 (w/ driver) built on pass. car or truck chassis with GVWR < 10,000 lbs.
- [ ] 43.5 - All other passenger carrying vehicles.

Property Carrying Vehicles

- [ ] 52.8 - Single unit vehicles less than 10,000 lbs GVWR.
- [x] 43.5 - All other property carrying vehicles or combinations of property carrying vehicles.

Individual Wheel Position Results Advisory only

Axle No.	Left	Right
1	56.0	49.9
2	36.2	44.2
3	42.2	50.4
4	63.1	62.4
5	73.8	70.3

These results represents the vehicle's current brake performance. Any changes to the vehicle weight and / or brake condition will impact the results. The test does not guarantee compliance with other brake safety inspection criteria.

PBBT Enforcement Value Study
Checklist and Timesheet

Trooper Performing Inspection				Test Scenario	B
Vehicle ID (PBBT)		Date		Time	
Procedure Overview	**NAS Level-1 Inspection Augmentation** Begin with PBBT Test; time PBBT test. Perform Level-1; time Level-1, vehicle portion, and brake stroke measurements.				

PBBT Test	1 ☐	Divert all CMV traffic onto pit scale until lane is full and direct the 10th vehicle to the PBBT.		
	2 ☐	Begin timing at the moment the vehicle stops at the stop bar prior to PBBT	Start:	: :
	3 ☐	End timing after the vehicle has stopped off the PBBT and the printout has been retrieved.	Stop:	: :
	4 ☐	Print a second copy of the PBBT for ORNL. **Note the result:** ☐ Pass ☐ Fail		

Level-1	5 ☐	Perform a Level-1 inspection, beginning timing immediately	Start: (Level-1)	: :
	6 ☐	Time of Vehicle Level-1 portion begun (right after PBBT)	Start: (Veh)	: :
	7 ☐	Time brake stroke measurements are begun (first mark is made / instruction given)	Start: (Br Str)	: :
	8 ☐	Time brake stroke measurements are completed (last measurement recorded)	Stop: (Br Str)	: :
	9 ☐	Time of Vehicle Level-1 portion ended	Stop: (Veh)	: :
	10 ☐	End timing the Level-1 when the inspection report is printed.	Start: (Level-1)	: :
	11 ☐	Print a second copy of the Level-1 for ORNL.		

Attach these two documents to this checklist and place in ORNL bin:

- ☐ PBBT printout
- ☐ Level-1 Inspection report

ORNL use only:

	PBBT	Level – 1	Br Str (pit)	Veh. Por.
Times:	_____	_____	_____	_____

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Revision History			
Revision Number	**Document ID**	**Description of Change**	**Change Effective Date**
0	Rev 0	Initial draft by ZHP	20Jul09
1	Rev 1	Incorporation of GCP's comments	22Jul09
2	Rev 2	Incorporation of MBL's comments, added contents pages	07Aug09
3	Rev 3	Second review by GJC	12Aug09
4	Rev 4	Corrected tables and associated content	18Aug09
5	Rev 5	Additional internal review (MBL, GJC), finalized table of contents	25Aug09

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