

The goal of the Federal Motor Carrier Safety Administration (FMCSA) is to reduce the number and severity of large truck-involved crashes through more commercial motor vehicle and operator inspections and compliance reviews, stronger enforcement measures against violators, expedited completion of rulemaking proceedings, scientifically sound research, and effective CDL testing, recordkeeping, and sanctions. The Office of Research and Technology manages research and technology development and deployment programs for the FMCSA.

The FMCSA R&T activities encompass a range of issues and disciplines relating to motor carrier safety, including problem assessment; policy, safety management, and outreach; drivers; truck and bus vehicle safety performance; and compliance, enforcement, and operations.

Compliance, enforcement, and operations concentrates on studies directed toward improving carrier compliance with, and/or enforcement of, existing Federal Motor Carrier Safety Regulations. Technology development and deployment focuses on identifying, collecting, and communicating information about technological advances to improve safety.



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Performance-Based Brake Testers—Round Robin Study

Introduction

In the early 1990s, the Federal Motor Carrier Safety Administration (FMCSA), formerly the Office of Motor Carriers (OMC) of the Federal Highway Administration, initiated research to evaluate various types of performance-based brake testing technologies for application to commercial vehicle inspections. The purpose of the research was to determine if performance-based brake testers (PBBTs) could be used to evaluate commercial vehicle braking capability. A PBBT is a device that assesses the braking capability of a vehicle through quantitative measure of individual wheel brake forces or overall vehicle brake performance in a controlled test. They are widely used for brake inspection in Europe and Australia and are beginning to emerge as both an enforcement tool and diagnostic aid for private sector maintenance and repair shops.

This tech brief summarizes a study based on a series of “round robin” tests (i.e., tests in which a single standard is used to evaluate the consistency of various test apparatuses) conducted by the OMC in July 1998 to assess the suitability of PBBTs for use in law enforcement. The study final report is available at <http://www.fmcsa.dot.gov>.

Background

Assessment of large truck and bus braking capability in the United States traditionally has been conducted using visual- and sensory-based inspection methods that require an inspector to crawl beneath a vehicle to check indicators of potential brake performance. The Commercial Vehicle Safety Alliance (CVSA) provides the inspection procedure and out-of-service criteria for braking systems on commercial motor vehicles (CMVs) to be used by federal, state, and provincial agencies in the United States, Mexico, and Canada. Under CVSA guidelines, if a vehicle fails to meet federal requirements, it may be placed out-of-service.

While the traditional sensory inspection method generally has been successful, it can be subjective, time-consuming, labor-intensive, and difficult. PBBTs cannot replace an inspector in finding brake defects unrelated to immediate brake performance, e.g., air leaks, chafed brake hoses, or thin brake pads. However, PBBTs provide a consistent, objective measure of a vehicle's braking performance—irrespective of brake type (disk or drum), energy supply (air, hydraulic, electric, or spring) or application method (s-cam, wedge, piston, spring, or lever and cable). Because the two techniques measure different factors, inspectors can use both performance-based and sensory evaluations to assess and maintain brake performance.

Field Test Evaluations

After analyzing various PBBT technologies in its initial research, the OMC selected several types for further evaluation in roadside field-test inspections. Researchers concluded that no insurmountable performance or operational limitations existed for roller dynamometers, flat-plate testers, or breakaway torque testers that would prevent those technologies from being used in the future for screening or enforcement. The study final report, *Development, Evaluation, and Application of*



Portable roller dynamometer



In-ground roller dynamometer

Performance-Based Brake Testing Technologies, was published in February 1999, and is available from the National Technical Information Service (PB99-134454).

Proposed Functional Specifications

In June 1998, the OMC issued a notice requesting public comments on proposed functional specifications for PBBTs. The specifications applied to a range of PBBT technologies and included requirements for functional performance, physical characteristics, environmental resistance, and operator safety. The specifications were intended to serve as a guideline for states in determining whether a particular PBBT would be eligible for funding under the Motor Carrier Safety Assistance Program (MCSAP) and to ensure a certain level of PBBT accuracy and performance. In August 2000, after the conclusion of

the round robin test series, the FMCSA issued a notice of proposed rulemaking (NPRM) and request for comments. The agency also published its final PBBT functional specifications.

Purpose

Several PBBTs were evaluated during the round robin test series in order to assess their functional performance and potential for use in law enforcement. The purpose of the tests was to evaluate the ability of current-generation PBBTs to accurately and consistently (1) measure the brake forces and wheel loads of CMVs, and (2) then predict the vehicle's deceleration capability from a 32.2 km/hr (20 mph) on-road stop.

Methodology

Researchers used two types of commercial vehicles (1) a two-axle flatbed straight truck, and (2) a three-axle tractor, two-axle flatbed semi-trailer combination. Each vehicle was tested fully laden and unladen and set up with target low brake-force to wheel-load ratios (BF/WL) on selected wheels, keeping the braking capability of the vehicle consistent with the performance-

based regulation then under consideration by the OMC, i.e., the ratio of the total brake force to the gross vehicle weight ($BF_{TOT}/GVW = 0.4$). Eight PBBTs were used in the testing—five roller dynamometers (two in-ground and three portable), two flat-plate testers, and one portable breakaway torque tester. The testing program consisted of two parts.

Part I

In the first part of the program, several evaluations were performed on vehicles with **weak brakes**.

First, to assess the accuracy and applicability of brake-force measurements, the PBBT per-wheel brake-force measurements were compared to those measured using a calibrated torque wheel, and the PBBT total brake-force measurements (BF_{TOT}) were

compared to measurements from the 32.2 km/hr on-road stops. Second, in evaluating the accuracy of wheel-load measurements, sets of cement blocks were placed on the PBBT weighing mechanisms and the PBBT results were compared to those known weights. For applicability, the PBBT-measured axle loads were compared to axle loads obtained using traditional scales. Third, to assess the applicability of the equivalent deceleration predicted using the PBBT measurements ($\text{decel}_{\text{EQ}} = \text{BF}_{\text{TOT}}/\text{GVW}$), the PBBT results were compared to decelerations achieved during 32.2 km/hr road stops. Finally, in order to evaluate the repeatability of the measurements (brake-force, wheel-load and decel_{EQ}), results from the three replicates were compared.

Part II

In the second part of the program, several evaluations were performed on the two-axle vehicle with **strong brakes**.

First, to assess the applicability of the equivalent deceleration (decel_{EQ}), the equivalent deceleration predicted by PBBT measurements was compared with the deceleration obtained during 32.2 km/hr road stops. Second, in evaluating the repeatability of the brake-force measurements, PBBT-reported brake-force measurements from three replicates were compared. Finally, the effect of wet test surfaces on the PBBT-reported brake-force measurements was assessed by comparing the maximum brake-force measurements reported under both wet and dry conditions.

Findings

Researchers determined that under most test conditions the accuracy and repeatability of most of the participating PBBTs, regardless of the principle of operation, were acceptable for meeting the proposed functional specifications and therefore for use in roadside inspection and enforcement.

Nearly all of the PBBTs were able to accurately measure the vehicle brake forces. The PBBT brake-force measurements generally agreed with the brake-force measurements of the torque wheel. The roller dynamometers as a group reported slightly higher brake-force measurements for vehicles with weak brakes on dry pavement than the corresponding reference values derived from road stops. Researchers suspected that this discrepancy was a result of either geometry of the wheel/roller contact patch or changes in brake torque output as a function of speed (the portable roller dynamometers operate at less than 2 km/hr, while the road stops were performed at 32.2 km/hr).

In contrast, several of the PBBTs had difficulty reporting accurate vehicle weights. For the most part, however, this was related to test procedures. Calibration checks of the PBBT weighing mechanisms indicated that all of the PBBTs could meet the functional specifications. Weight measurements were found to be affected by specific characteristics of the vehicles or by the elevation and ramp configurations of the portable PBBTs. Researchers recommended that consideration be given to additional criteria for judging brake effectiveness in cases in which weights are not available or cannot be measured in a representative manner due to vehicle configuration.

Recommendations

In those instances in which PBBT accuracy did not achieve acceptable performance in the round robin tests, the problems were identified and conveyed to the PBBT manufacturers as recommendations for improvement. Modifications needed to obtain acceptable PBBT performance for use in enforcement were either those consistent with the PBBT functional specifications developed for eligibility for funding through MCSAP, or those needed to improve the applicability of the PBBT results to the on-road stopping results.

The following recommendations were made to the PBBT manufacturers to assist them in meeting the functional specifications:

- alter the test surface to meet the minimum “coefficient of friction” requirement;
- standardize test protocols, including data analysis and reporting problems; and
- develop appropriate calibration procedures.

The brake-force results of some PBBTs were not affected by the condition of the test surfaces. Although the coefficient of friction in wet conditions was not part of the proposed PBBT functional specifications at the time of the round robin testing, researchers said that PBBTs for which brake-force measurements were affected by the test surface conditions should address this problem.

Proposed Rulemaking & Guidelines for Functional Specifications

After several years of research (including the round robin testing and field test evaluations) and public meetings, in August 2000 the FMCSA issued a NPRM and request for comments on pass-fail criteria for

Researcher

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Distribution

This Tech Brief is being distributed according to a standard distribution. Direct distribution is being made to the Service Centers and Divisions.

Availability

The study final report (DOT-MC-00-100) is available from the National Technical Information Service (PB-2000-105555)

Key Words

brake, brake force, brake inspection, brake performance, breakaway torque brake tester, commercial motor vehicle, flat-plate brake tester, performance-based brake tester, roller dynamometer brake tester, round robin tests

Notice

This Tech Brief is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The Tech Brief provides a synopsis of the study's final publication. The Tech Brief does not establish policies or regulations, nor does it imply USDOT endorsement of the conclusions or recommendations. The U.S. Government assumes no liability for its contents or their use.

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PBBTs (Docket No. FMCSA-99-6266). Accompanying the proposal were final functional specifications for PBBTs (Docket No. FMCSA 98-3611).

In the NPRM, the FMCSA proposed to amend the Federal Motor Carrier Safety Regulations to allow the use of PBBTs to determine compliance with existing brake performance criteria for CMVs. The brake performance criteria specify CMV requirements for minimum brake force as a percentage of actual gross vehicle weight, and minimum deceleration from 32.2 km/hr.

Like the specifications proposed in 1998, the final functional specifications for PBBTs outline generic requirements, including performance, verification and documentation, for a range of brake testing technologies. The specifications serve as a guideline for states in determining whether a particular PBBT would be eligible for funding under MCSAP and ensure a certain level of PBBT accuracy and performance.

The FMCSA currently is reviewing the comments received in response to the NPRM. The next regulatory action will occur in 2001.

Future Research

Since the round robin test program, the FMCSA has continued its research to support the use of PBBTs in evaluating CMV braking performance for enforcement purposes. This work includes investigating the feasibility of using PBBTs for enforcement of federal regulations on CMV lane stability while braking; conducting a design evaluation and cost-benefit analysis of current and proposed PBBT technologies; investigating further remaining issues in follow-up to the previous round robin testing; providing general support to the FMCSA in promoting the use of PBBTs by states and motor carriers; and identifying the training needs and requirements of PBBT users.

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