DEPARTMENT OF TRANSPORTATION

National Highway Traffic Safety Administration

49 CFR Part 571

[Docket No. NHTSA–2009–0083]

RIN 2127–AJ37

Federal Motor Vehicle Safety Standards; Air Brake Systems

AGENCY: National Highway Traffic Safety Administration (NHTSA), DOT.

ACTION: Final rule.

SUMMARY: This document amends the Federal motor vehicle safety standard on air brake systems to improve the stopping distance performance of truck tractors. The rule requires the vast majority of new heavy truck tractors to achieve a 30 percent reduction in stopping distance compared to currently required levels. For these heavy truck tractors (approximately 99 percent of the fleet), the amended standard requires those vehicles to stop in not more than 250 feet when loaded to their gross vehicle weight rating (GVWR) and tested at a speed of 60 miles per hour (mph). For a small number of very heavy severe service tractors, the stopping distance requirement will be 310 feet under these same conditions. In addition, this final rule requires that all heavy truck tractors must stop within 235 feet when loaded to their ''lightly loaded vehicle weight'' (LLVW).

The purpose of these amendments is to reduce the number of fatalities and injuries associated with crashes involving tractor-trailer combinations and other vehicles. In addition, we anticipate that this rule will prevent a substantial amount of property damage through averting or lessening the severity of crashes involving these vehicles. Once all subject heavy truck tractors on the road are equipped with enhanced braking systems, we estimate that annually, approximately 227 lives will be saved and 300 serious injuries will be prevented. In addition, this final rule is expected to prevent over $169 million in property damage annually, an amount which alone is expected to exceed the total cost of the rule.

There are a number of simple and effective manufacturing solutions that vehicle manufacturers can use to meet the requirements of this final rule. These solutions include installation of enhanced drum brakes, air disc brakes, or hybrid disc/drum systems. We note that currently a number of vehicles in the commercial fleet already utilize these improved braking systems and already realize performance that would meet the requirements of the amended standard.

DATES: *Effective Date:* This final rule is effective November 24, 2009.

Compliance Date: Three-axle tractors with a GVWR of 59,600 pounds or less must meet the reduced stopping distance requirements specified in this final rule by August 1, 2011. Two-axle tractors and tractors with a GVWR above 59,600 pounds must meet the reduced stopping distance requirements specified in this final rule by August 1, 2013. Voluntary early compliance is permitted before those dates.

Petitions for Reconsideration: If you wish to submit a petition for reconsideration of this rule, your petition must be received by September 10, 2009.

ADDRESSES: Petitions for reconsideration should refer to the docket number above and be submitted to: Administrator, Room W42–300, National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE., Washington, DC 20590.

See the **SUPPLEMENTARY INFORMATION** portion of this document (Section VI; Rulemaking Analyses and Notice) for DOT's Privacy Act Statement regarding documents submitted to the agency's dockets.

FOR FURTHER INFORMATION CONTACT: For non-legal issues, you may call Mr. Jeff Woods, Office of Crash Avoidance Standards (Telephone: 202–366–6206) (Fax: 202–366–7002).

For legal issues, you may call Mr. Ari Scott, Office of the Chief Counsel (Telephone: 202–366–2992) (Fax: 202–366–3820).

You may send mail to both of these officials at National Highway Traffic Safety Administration, 1200 New Jersey Avenue, SE., Washington, DC 20590.

SUPPLEMENTARY INFORMATION:

Table of Contents

I. Executive Summary

a. Background and Safety Problem Addressed by the Regulation

On March 10, 1995, NHTSA published three final rules [1] as part of a comprehensive effort to improve the braking ability of medium and heavy vehicles.[2] While the major focus of that effort was to improve directional stability and control through adoption of antilock brake system (ABS) requirements, the 1995 rules also reinstated stopping distance requirements for medium and heavy vehicles, replacing earlier requirements that had been invalidated in 1978 by the United States Court of Appeals for the 9th Circuit due to reliability issues (*see PACCAR* v. *NHTSA,* 573 F.2d 632 (9th Cir. 1978)).

Currently, stopping distance requirements under FMVSS No. 121, *Air Brake Systems*, vary according to vehicle type. Vehicles are tested under three different test conditions: (1) Loaded-to-GVWR; (2) unloaded; and (3) emergency braking conditions. Under the loaded-to-GVWR condition, when stopping from 60 mph, air-braked buses must stop within a distance of 280 feet, air-braked single unit trucks must stop within 310 feet, and air-braked truck tractors must comply within 355 feet.[3] Under the unloaded [4] condition at 60 mph, air-braked buses are required to stop within 280 feet, while single-unit trucks and truck tractors must stop within 335 feet. Under the emergency brake [5] 60 mph requirements, air-braked buses and single-unit trucks must stop within 613 feet, while tractors must stop within 720 feet.

Data from the agency's 2000–2002 GES database and the agency's 2004–2006 FARS database indicate that the involvement of large trucks in fatal and injury-producing crashes has slightly declined, while vehicle-miles-traveled (VMT) has increased. However, because the number of registered heavy vehicles has increased, the net effect is that the total number of crashes remains high. According to the 2006 data: [6]

- 385,000 large trucks were involved in traffic crashes in the U.S.
- 4,732 large trucks were involved in fatal crashes, resulting in 4,995 fatalities (12 percent of all highway fatalities reported in 2006). Seventy-five percent of the fatally injured people were occupants of another vehicle; 16 percent were truck occupants, and 8 percent were nonoccupants.
- 106,000 people were injured in crashes involving large trucks. Seventy-six percent of the injured people were occupants of another vehicle; 22 percent were truck occupants, and 2 percent were nonoccupants.

According to a report [7] published by the Analysis Division of the Federal Motor Carrier Safety Administration (FMCSA), the fatality rate for large truck crashes was 66 percent higher than the fatality rate for crashes involving only passenger vehicles (defined as a car or light truck) in 2005. When the FMCSA report considered combination trucks (*e.g.*, tractor and trailer combinations) separately, the crash fatality rate was nearly double that of passenger vehicles. Conversely, the crash fatality rate for single-unit trucks was approximately 23 percent higher than for passenger vehicles. The FMCSA data indicate that for all types of crashes involving large trucks, those involving trucks with a GVWR over 26,000 pounds have the highest rate of crash involvement.

It is expected that in most cases reductions in stopping distances for large trucks will result in a reduction of the impact velocity, and hence the severity of a crash. In some cases, reduced stopping distances will prevent a crash from occurring entirely (*i.e.*, a vehicle with a reduced stopping distance will stop short of impacting another vehicle). Based on the crash data in the June 2005 NHTSA report titled ''An Analysis of Fatal Large Truck Crashes,'' [8] improvements in stopping distance will provide benefits in the following types of crashes: Rear-end, truck striking passenger vehicle; passenger vehicle turned across path of truck; and straight path, truck into passenger vehicle. It is estimated that these types of crashes account for 26 percent of fatalities involving large trucks, or 655 fatalities annually. In addition, it is possible that some head-on collisions could be reduced in severity, since improvement in braking performance could reduce impact speeds.

NHTSA has been exploring the feasibility of reducing the stopping distance under FMVSS No. 121 for heavy air-braked vehicles by 20–30 percent based on testing of current vehicles. We have initially focused on air-braked truck tractors, since the available crash data indicate that these vehicles are the ones most frequently involved in fatal truck crashes. By promulgating a more stringent requirement for air-braked heavy tractor stopping distances, it is our intent to reduce fatalities and injuries relating to this class of vehicles. It is our belief that development of advanced air disc brakes, enhanced larger capacity drum brakes, and advanced ABS, offer cost-effective means to reduce heavy truck stopping distances and to reduce injuries and damage from large tractor crashes effectively.

b. Notice of Proposed Rulemaking

On December 15, 2005, NHTSA published a Notice of Proposed Rulemaking (NPRM) in the **Federal Register** (70 FR 74270) [9] proposing to amend FMVSS No. 121 so as to reduce

[1] 60 FR 13216 (Dockets #92–29 and 93–69), 60 FR 13287 (Docket #93–06), March 10, 1995.

[2] Medium and heavy weight vehicles are hydraulic-braked vehicles over 10,000 pounds GVWR, and all vehicles equipped with air brakes; hereinafter referred to collectively as heavy vehicles.

[3] For heavy truck tractors (tractors), the current stopping distance test in the loaded-to-GVWR condition is conducted with the tractor coupled to an unbraked control trailer, with weight placed over the fifth wheel of the tractor, and a 4,500 pound load on the single axle of the trailer. This test method isolates the braking performance of the tractor so that only that system's performance is evaluated. The performance of a tractor in an FMVSS No. 121 stopping distance test does not directly reflect the on-road performance of a tractor/semi-trailer combination vehicle that has braking at all wheel positions.

[4] In the unloaded condition, vehicles are tested at lightly loaded vehicle weight (LLVW).

[5] Emergency brake system performance is tested with a single failure in the service brake system of a part designed to contain compressed air or brake fluid.

[6] *See Traffic Safety Facts 2006—Large Trucks,* National Center for Statistics and Analysis (NCSA), report number DOT HS 810 805, *http://www.nrd.nhtsa.dot.gov/Pubs/810805.pdf.* The NCSA report uses the term ''large trucks,'' which in practical terms describes the same segment of the vehicle population as ''heavy vehicles.''

[7] *Large Truck Crash Facts 2005* (report number FMCSA–RI–07–046, *http://www.fmcsa.dot.gov/facts-research/research-technology/report/Large-Truck-Crash-Facts-2005/Large-Truck-Crash-Facts-2005.pdf.*

[8] DOT HS 809 569, *http://www.nrd.nhtsa.dot.gov/Pubs/809-569.pdf*; Docket # NHTSA–2005–21462–5 via Web site references.

[9] Docket No. NHTSA–2005–21462.

the required stopping distances for the loaded and unloaded service brake distances and emergency brake distances for truck tractors by 20 to 30 percent. These amendments would apply to nearly all of the 130,000 tractors manufactured annually. NHTSA also proposed a lead time of two years to implement these amendments, given that vehicles tested by the agency and industry were able to meet the proposed requirements without modifications other than the use of improved foundation brakes. Finally, NHTSA indicated that it was considering revising the dynamometer testing procedures to ensure adequate braking capability for trailer foundation brakes.

The NPRM included figures from the accompanying Preliminary Regulatory Impact Analysis (PRIA) indicating that enhanced brake system specifications would result in a range of costs and benefits based on the specific requirements and the choices made to reach those requirements. We note that in some instances, the cost estimates in the PRIA do not correspond to the numbers in the FRIA or those cited in the Final Rule. This is because NHTSA has updated its cost estimates during the interim period, and the FRIA uses 2007 dollars.

The NPRM also discussed the results of testing conducted at NHTSA's Vehicle Research and Test Center (VRTC), as well as data from Radlinski and Associates provided to NHTSA. These data strongly suggested that with improved foundation brakes, typical three-axle tractors [10] would be able to meet the proposed requirements for reduced stopping distance, although the Radlinski data did not include data on two-axle or severe service [11] tractors. The data also indicated that some vehicles in service today would meet the enhanced requirements with no additional modifications.

NHTSA requested comments on a number of subjects in the NPRM. Comments were requested generally on the proposal to reduce stopping distances 20–30 percent and on the costs of the proposal. Comments were also requested on a variety of specific subjects, such as the possible changes in dynamometer testing procedures, the application of Advanced ABS and Electronically Controlled Braking Systems (ECBS), and the lead time that would be required to implement the proposed changes. Finally, NHTSA requested comments on the VRTC and Radlinski testing, as well as information from vehicle manufacturers regarding vehicle modifications (other than to foundation brakes) that might be required to meet the proposal's enhanced braking specifications.

[10] As explained below, ''typical'' three-axle tractors have a GVWR less than or equal to 59,600 pounds.

[11] As explained below, ''severe service'' tractors refer to tractors with a GVWR over 59,600 pounds.

c. Summary of Public Comments

Commenters brought up a variety of issues in response to the NPRM. Most commenters supported NHTSA's proposal to reduce the stopping distance requirements for heavy truck tractors. In general, safety organizations recommended adopting the 30 percent reduction in stopping distances for all heavy truck tractors. On the other hand, truck manufacturing groups recommended that the agency reduce the stopping distance requirements by 20–25 percent, and limit the scope of the reductions to standard three-axle tractors. In their comments, manufacturers cited the increased costs and complexity of upgrading to the stricter stopping distance requirements, as well as potential problems that could be encountered with upgrading the requirements for two-axle and severe service tractors. Many commenters also discussed the vehicle testing NHTSA cited in the NPRM, along with providing independent test and cost-benefit data.

Other aspects of Standard No. 121 mentioned in the NPRM received comments as well. Several commenters recommended against making any changes to the emergency braking requirements in the Standard. Regarding brake dynamometer specifications, some commenters also recommended that no changes be made. Several commenters suggested that the brake burnish procedure could be returned to an older procedure, known as a ''hot burnish,'' that existed before 1993. Finally, attention was called to the possible ramifications of the stopping distance changes for issues like cargo securement and brake power at lower speeds.

d. Requirements of the Final Rule

After careful consideration of the public comments on the NPRM, we are promulgating this final rule, which amends the requirements of FMVSS No. 121 by reducing the specified stopping distance for the vast majority of heavy truck tractors by 30 percent. For a small number of very heavy, severe service tractors, the stopping distance requirement is reduced by a smaller amount. The reduction applies to service brake stopping distance but does not, however, apply to emergency braking distances.

For heavy trucks in the loaded-to-GVWR condition, the stopping distance requirements from an initial speed of 60 mph are as follows:

- A tractor with two or three axles and a GVWR of 70,000 pounds or less must stop within 250 feet.
- A tractor with three axles and a GVWR greater than 70,000 pounds must stop within 310 feet.
- A tractor with four or more axles and a GVWR of 85,000 pounds or less must stop within 250 feet.
- A tractor with four or more axles and a GVWR greater than 85,000 pounds must stop within 310 feet.[12]

For heavy trucks in the unloaded condition, the agency is reducing the specified stopping distance from 60 mph by 30 percent, to a 235-foot requirement. This requirement applies to all tractors, including those severe service tractors for which the loaded-to-GVWR stopping distance requirement has been set at 310 feet.

Stopping distance requirements for heavy air-braked tractors are provided in Tables I through III (*See* Section III). The tables list the following information:

- Table I lists the requirements and details the explanation for stopping distance requirements in the loaded-to-GVWR condition for two- and three-axle tractors with a GVWR of 70,000 pounds or less, and tractors with four or more axles with a GVWR of 85,000 pounds or less.
- Table II lists the requirements and details the explanation for stopping distance requirements in the loaded-to-GVWR condition for three-axle tractors with a GVWR greater than 70,000 pounds, and tractors with four or more axles and a GVWR greater than 85,000 pounds.
- Table III lists the stopping distance requirements and details the explanation for all tractors in the unloaded condition.

In addition, to reduce a possible source of test variability, the agency is adding a specification to the unloaded condition testing requirement in FMVSS No. 121 that the fuel tank is filled to 100 percent of capacity at the beginning of testing and may not be less than 75 percent of capacity during any part of the testing.

Finally, it should be noted that there were several changes suggested in the NPRM that we are not incorporating into this final rule amending FMVSS No. 121. These include:

[12] We note that tractors with any axle with a GAWR of 29,000 pounds or greater will continue to be excluded from FMVSS No. 121 requirements in accordance with paragraph S3.

- There is no change in the emergency brake stopping distance requirement.
- There are no changes to the dynamometer test requirements.

e. Lead Time

After carefully considering the public comments on the NPRM, the agency has decided to tie the lead time to the specific type of heavy truck in light of the anticipated challenges in making the necessary modifications. For the reasons discussed below, we have decided to provide the majority of three-axle tractors with two years lead time from the date of today's final rule, and we are providing two-axle and severe service tractors with four years lead time.

NHTSA's test data indicate that for typical three-axle tractors with improved brake systems (*i.e.,* enhanced drum brakes or air disc brakes), compliance with the new stopping distance requirements can be readily achieved. Therefore, the agency is specifying a compliance date that is two years from the date of publication of the final rule for typical three-axle tractors. ''Typical three-axle'' tractors are defined as having three axles and a GVWR less than or equal to 59,600 pounds.

Available test data also indicate that two-axle tractors with improved brake systems can meet a 250-foot loaded-to-GVWR stopping distance requirement. However, we believe additional lead time is needed for manufacturers to evaluate new brake systems more fully to ensure compatibility with existing trailers and converter dollies when used in multi-trailer combinations, and to minimize the risk of vehicle stability and control issues. With regard to severe service tractors, available test data and analysis indicate that the 250-foot and 310-foot loaded-to-GVWR stopping distance requirements, depending on the vehicle's GVWR, are achievable. However, only limited development work has been performed on these vehicles, and additional lead time is needed for manufacturers to complete testing and validation of new brake systems for these vehicles. In light of these facts, NHTSA has decided that additional lead time is necessary for all two-axle tractors, and severe service tractors with a GVWR greater than 59,600 pounds. Accordingly, for those vehicles the compliance date for today's final rule is four years from the date of publication.

f. Specific Decisions and Differences Between the Final Rule and the Notice of Proposed Rulemaking

In the NPRM, NHTSA discussed a number of potential actions intended to improve vehicle safety by reducing heavy air-braked tractor stopping distance through amendments to FMVSS No. 121. The available data showed that it was both technically feasible and cost-effective to require improved foundation brakes on air-braked tractors that could achieve a 20–30 percent reduction in stopping distance. The main differences between the NPRM and the final rule include decisions to: (1) Specify a 30 percent reduction in stopping distance for the vast majority of tractors, with a smaller reduction for a small number of very heavy severe service tractors; (2) continue the standard's emergency braking requirements without change; (3) alter the stopping distance requirements for reduced speed tests to account for brake system reaction time and the available tire-road friction; and (4) extend the effective date for compliance by two-axle and severe service tractors. The rationales for these decisions are discussed briefly below, followed by a more complete explanation later in this document.

In the NPRM, NHTSA proposed reducing the required stopping distance for heavy air-braked tractors by 20–30 percent. This range was based on available test results and cost analyses (described below). In the final rule, NHTSA is requiring a 30 percent reduction in the required stopping distance for the vast majority of tractors. We note that the agency's final regulatory impact analysis (FRIA) estimated that greater safety benefits would be attained with a 30-percent reduction in stopping distance requirements compared to the benefits estimated for a 20-percent reduction. It estimated that more than twice as many benefits in fatalities and serious injuries prevented are projected for the 30-percent case versus the 20-percent case. The differential in estimated property damage reductions is even greater, with approximately five times the property damage prevented for the 30-percent case versus the 20-percent case. NHTSA testing and analysis demonstrated that nearly all two-axle and three-axle tractors will be able to meet the 30 percent reduction by using improved foundation brakes that are readily available. For a small percentage of severe service tractors (estimated to be approximately one percent), namely three-axle tractors with a GVWR over 70,000 pounds and tractors with four or more axles and a GVWR over 85,000 pounds, we concluded that a 30 percent reduction is not currently practicable. For those vehicles, the stopping distance is reduced by 13 percent, from the currently mandated level to the level of similar single-unit trucks.

While the NPRM proposed reducing emergency brake stopping distances by 20–30 percent, we decided not to adopt this part of the proposal. Comments received from the Truck Manufacturers Association (TMA) indicated that in order to meet the agency's proposed emergency brake stopping distance requirements, manufacturers would need to modify the ABS algorithms to allow more drive wheel lockup. This modification could be detrimental to vehicle stability and control. NHTSA considered this, as well as the relative rarity of a crash-imminent situation during a brake failure, and decided to maintain the status quo.

In the final rule, NHTSA is also altering the stopping distance requirement for speeds less than 60 mph from the original figures cited in the NPRM. Several commenters argued that the reduced stopping distance values in the proposed Table V of FMVSS No. 121 did not take into account the brake system reaction time and average deceleration. In the final rule, the stopping distances for speeds less than 60 mph have been adjusted to take these factors into consideration.

Finally, the final rule provides additional lead time for several types of tractors to comply with the reduced stopping distance requirements. The NPRM had proposed a two-year lead time for all tractors to meet the reduced stopping requirements. With regards to typical three-axle tractors (three-axle tractors with a GVWR of 59,600 pounds or less), the available test data showed that compliance to the new stopping distance requirements can be readily achieved without the need to make significant modifications to other vehicle systems. As stated above, however, the agency believes that additional lead time is needed for manufacturers to develop and evaluate improved braking systems more fully for two-axle and severe service tractors. Therefore, the lead time has been extended for those types of vehicles by an additional two years.

g. Costs and Benefits

A 30 percent reduction in required stopping distance will realize significant benefits, both in terms of injuries and fatalities prevented, as well as in property damage prevented. The agency's analysis in the FRIA estimates that, with a 30 percent reduction in stopping distance requirements, 227 fatalities and 300 serious injuries will be prevented. In addition, it is estimated that a 30 percent reduction in stopping distance will realize significant reductions in property damage. According to the FRIA, using a 3 percent discount rate, $205M of property damage will be prevented annually. Using a 7 percent discount rate, the figure is $169M.

The range of figures in terms of net costs are based on what types of foundation brakes, disc brakes or enhanced drum brakes, are used to meet the new stopping distance requirements. The figures are derived based on an average annual production of about 130,000 truck tractors (82 percent of which are typical three-axle tractors, ten percent two-axle tractors, and eight percent severe service tractors). Each typical three-axle tractor contains one steer axle and two drive axles, as do most severe service tractors. Each two-axle tractor contains one steer axle and one drive axle. Therefore, the agency estimates that in total, the final rule will require the upgrading of 130,000 steer axle brakes and 247,000 drive axle brakes. In order to compute the total cost of complying with the reduced stopping distance rule, the agency calculated the number of axles that will need to be upgraded with improved foundation brakes, and multiplied that number by the cost of the brake. The agency estimated the cost of enhanced drum brakes for the steer axle at $85, and for drive axles at $65. The agency estimated the cost of disc brakes to be $500 per axle at all wheel positions.

Because the agency is not certain how truck manufacturers will choose to comply with the final rule, using the above figures, the agency created a range of costs of compliance. The most expensive means of compliance would be to use a $500 disc brake at all wheel positions, while the least expensive means of compliance would be to use enhanced drum brakes at all wheel positions. The FRIA estimates that the incremental cost to add disc brakes to all wheel positions would be $1,475 per tractor ($192M total cost), while the incremental cost to add enhanced drum brakes would be $211 ($27M total cost). One commenter (Freightliner) provided cost information, stating that the cost of disc brakes would be $1,627 for a three-axle tractor and $963 for a two-axle tractor, while the cost of drum brakes for a three-axle tractor would be $222. In addition, the commenter stated that development and manufacturing costs would need to be added, although it did not elaborate on what these costs would be. The agency notes that these figures are very similar to its own estimates.

NHTSA testing indicated that for standard three-axle tractors, it is likely enhanced drum brakes at the steer axle and drive axle positions will enable the tractors to meet a 250-foot stopping distance requirement in FMVSS No. 121. For two-axle tractors and severe service tractors, it is likely that disc brakes would be required at all wheel positions. Considering that standard three-axle tractors comprise roughly 82 percent of all tractors, it seems likely that the total costs will be skewed toward the lower end of the range. In the FRIA, the agency estimates that the incremental average cost per tractor, given these assumptions, will be $413 per vehicle ($54M total). NHTSA notes that this figure is substantially lower than the lowest figure in the range of estimated savings in property damage ($169M).

The FRIA estimates that the net cost per equivalent life saved (NCELS) will range from $108,000 to net benefits based on property damage savings alone (that is, the costs of implementing this final rule will be less than the costs saved in damaged property, irrespective of the injuries and fatalities prevented). The high figure ($108,000 NCELS) is derived by taking the highest estimated cost figure and the lowest estimated property damage prevented. Conversely, the low figure (net benefits) is derived from using the low cost estimate and the high benefits estimate.

II. Background

a. Existing Brake Technologies for Heavy Air-Braked Trucks

The relevant brake technologies at issue in this rulemaking can be divided into two categories, S-cam drum brakes (drum brakes) and air disc brakes (disc brakes).

The most common type of foundation brake used in air brake systems for heavy vehicles is the S-cam brake. This is a leading/trailing type of brake with fixed pivot type shoes. Upon brake application, air pressure enters the brake chamber causing the diaphragm to push the pressure plate, which in turn applies a force to the end of the brake slack adjuster. This force creates a torque on the camshaft, and rotates the camshaft to which the S-cam is attached. The camshaft head, which is S-shaped, forces the brake shoes against the surface of the brake drum to create the retardation force for braking. Enhanced S-cam drum brakes are essentially larger and wider versions of standard S-cam drum brakes. On the steer axle, for example, the diameter of the brake drum is 16.5 inches versus 15 inches for the standard steer axle drum, and this produces more braking torque. Typically the enhanced steer axle drum brake lining is 5 inches wide instead of the standard steer axle brake lining width of 4 inches. On the drive axles, both standard and enhanced S-cam drum brakes use a 16.5 inch diameter drum, while the standard lining width is 7 inches versus 8 or 8.625 inches for the enhanced drum brake. The increased width of the lining and brake drum provides greater thermal capacity, so that enhanced S-cam drum brakes operate cooler, contributing to longer life, and they are also less prone to fade during high-speed stops.

Air disc brakes are also used on commercial vehicles, but are still used in relatively small numbers in the U.S. A disc brake is basically a C-clamp with the retardation force applied by friction pads that squeeze the brake rotor mounted between them. All air disc brake systems are composed of a rotor, brake linings, a caliper, an adjusting mechanism, and an air brake chamber, among other parts, and there are many different designs to accomplish their function. Disc brakes offer a number of favorable performance characteristics including linear torque output and high resistance to fade, although they are substantially more expensive than drum brakes.

b. Current Requirements of FMVSS No. 121

Under the current FMVSS No. 121 requirements, most truck tractors are required to stop within 355 feet, when tested at 60 mph in the loaded-to-GVWR condition while pulling an unbraked control trailer. Standard No. 121 also requires that truck tractors stop within 335 feet, when tested at 60 mph in the unloaded condition. Finally, the standard requires an emergency brake stopping distance of 720 feet, when tested at 60 mph in the unloaded condition. Currently, the standard does not specify different requirements for different vehicles based on their number of axles or on their GVWR, except that vehicles with a GAWR (gross axle weight rating) of 29,000 pounds or more are exempt from the standard, as are certain vehicles with a GVWR greater than 120,000 pounds.

Before testing, brakes are burnished according to the procedure specified in paragraph S6.1.8 of the standard. The tractor is coupled to an unbraked control trailer and loaded so that the combined weight of the tractor and trailer equals the GVWR of the tractor. Thermocouples are installed in the brake linings to measure the brake temperatures. The burnish consists of 500 snubs (reductions in speed) from 40 mph to 20 mph using the service brakes at a deceleration rate of 10 ft/sec^2;. Each subsequent snub is conducted at a distance interval of 1 mile from the point of the beginning of the previous snub.

c. Summary of the NPRM

On December 15, 2005, NHTSA published an NPRM in the **Federal Register** (70 FR 74270) [13] proposing to amend FMVSS No. 121 to reduce the required stopping distance for the loaded and unloaded service brake conditions and emergency brake conditions for heavy truck tractors by 20 to 30 percent. NHTSA proposed a lead time of two years to implement this requirement, given that vehicles tested by the agency and private industry were able to meet the proposed requirements without modifications other than improved foundation brakes. In addition, NHTSA suggested that it was considering revising dynamometer testing procedures to ensure adequate braking capability for trailer foundation brakes.

In the NPRM, NHTSA stated that it believed the reason that many truck operators had not progressed to readily-available, more advanced brake systems was because truck operators did not have this cost savings information available. Further, the proposal stated that truck operators are cost-sensitive in terms of the initial purchase price of the vehicle and are reluctant to add different types and sizes of brake components to their specifications. The agency noted that the proposed requirements would result in net cost savings for truck operators if the savings resulting from decreased property damage are taken into consideration.

NHTSA also provided data from its Vehicle Research and Test Center (VRTC) to compare the performance of air-braked tractors and trailers equipped with a variety of brake system configurations. These data indicated that the tested vehicles would be able to comply with a 20–30 percent reduction in the stopping distance requirements with modifications only to the foundation brake systems. Testing was also conducted on heavy trucks with a failed primary reservoir in order to generate data on emergency stopping distances; the results indicated that the same modifications that improved service brake stopping distances also improved emergency braking stopping distances.

Industry data provided by Radlinski and Associates (Radlinski), commissioned by two brake lining manufacturers, were also cited in the NPRM. These data related to standard three-axle tractors equipped with enhanced, larger-capacity S-cam drum brakes at all axle positions. These data indicated that the tractors were able to meet the 30 percent reduced stopping distance requirement without disc brakes, and the braking performance in these tests exceeded that of NHTSA's own tests at the VRTC, in some cases even when disc brakes were applied at all positions.

In the NPRM, NHTSA requested comments on a variety of topics to further the agency's understanding of the ramifications of various measures for improving braking systems. As a preliminary matter, comments were solicited on the safety need for improved braking distances. Comments were also requested on the implications of improving stopping distances by 20 percent and 30 percent, including necessary lead time, needed vehicle modifications, and issues regarding brake balance. The agency also sought comments on the Radlinski data, as well as information on developments in electronically-controlled braking systems (ECBS) and advanced ABS, and how these systems could benefit heavy vehicle safety.

d. Summary of Public Comments on the NPRM

NHTSA received 27 comments on the December 2005 NPRM, from heavy vehicle manufacturers (International Truck and Engine Corporation (International); Freightliner LLC (Freightliner)), brake suppliers (Arvin Meritor; Meritor WABCO (Meritor); WABCO Vehicle Control Systems (WABCO); Honeywell Bremsbelag GmbH (Honeywell); Bendix Commercial Systems/Spicer Foundation Brake (Bendix); Haldex Brake Products Corporation (Haldex); Brake Pro), industry organizations and associations (Truck Manufacturers Association (TMA); Heavy Duty Brake Manufacturers Council (HDBMC); American Trucking Associations (ATA); Owner Operators Independent Drivers Association (OOIDA); National Automobile Dealers Association (NADA)), automobile safety advocates (Insurance Institute for Highway Safety (IIHS); Advocates for Highway and Auto Safety (Advocates)), a foreign government (People's Republic of China), and concerned organizations and individuals (John W. Klegey; Automotive Safety Office (ASO); Roger L. Adkins; Graham Lower; Timothy Larrimore; Anonymous; University of Washington; Roger Sauder). All of the comments on the NPRM can be reviewed in Docket No. NHTSA–2005–21462. Commenters expressed a range of views, with vehicle manufacturers, brake suppliers, and trade associations generally supporting the NPRM. Advocacy groups generally recommended that the agency adopt a standard at the stricter end of the range (toward 30 percent) for all tractors, while most of the trucking industry comments recommended that NHTSA reduce the stopping distances by 20–25 percent (instead of 20–30 percent), and only for typical three-axle tractors. As part of its comments, TMA provided a crash data analysis indicating that typical three-axle tractors comprise 82 percent of tractor production and are involved in 91 percent of fatal crashes involving tractors.

The following overview of the public comments reflects the key issues raised by the commenters, including the safety and cost benefits of reducing stopping distances, recommended percentages for reducing stopping distances, as well as issues of technical feasibility and stability that arise from increasing brake torque. Other issues were raised as well, including reduced stopping distances in the unloaded vehicle condition, emergency brake stopping distances, maintenance issues, recommended dynamometer testing changes, and brake burnish procedures. Comments were also received in response to NHTSA's questions about the validity and applicability of the Radlinski testing data, the impact of ECBS and advanced ABS, and on the margin of compliance for testing in accordance with FMVSS No. 121. A few commenters recommended that the government undertake additional, cooperative studies with industry in order to gather data for two-axle and severe service tractors. Finally, comments were provided on the implications of reduced stopping distance for reduced test speed stopping distance testing and for issues of cargo securement under high-deceleration conditions.

Although the agency also requested comments on trailer stopping distance test data and efforts to improve the braking performance of single-unit trucks, few comments were received regarding those issues. Likewise, only a small number of comments addressed the agency's requests for information about the costs of improved braking systems, as well as any increase in weight. The issues raised in the public comments are discussed in further detail and addressed below in Section III, *The Final Rule and Response to Public Comments.*

General Need To Reduce Stopping Distance Performance for Tractors

Support for NHTSA's proposal to reduce the stopping distance performance of heavy truck tractors was

[13] Docket No. NHTSA–2005–21462.

nearly universal. Highway safety advocacy organizations, such as Advocates and IIHS, supported the largest reduction of stopping distances within the range proposed by NHTSA (*i.e.,* a 30 percent reduction from the current requirements of FMVSS No. 121 for all tractors). Most of the trucking industry comments favored a 25 percent reduction in stopping distances, but those commenters recommended limiting the new requirements to standard three-axle tractors, which account for over 80 percent of tractor production. It should be noted that some industry commenters suggested reducing stopping distances by only 20 percent, the lowest reduction proposed by NHTSA.

Comments on the Proposal To Reduce Service Brake Stopping Distance Performance by 20–30 Percent in the Loaded-to-GVWR Condition

The majority of commenters fell into two groups, those who supported 30 percent reductions in stopping distances for all tractors, and those who supported less stringent requirements. Most trucking industry comments (from truck manufacturers and brake suppliers) urged 25 percent reductions for standard three-axle tractors only. In making these recommendations, the trucking industry commenters argued that data had not been provided for two-axle and severe service tractors, and that operational problems (*e.g.,* brake balance, stability, and steering pull) could occur if brake output is increased for those tractors. Specifically, TMA suggested that amending FMVSS No. 121 to require heavy trucks to stop within shorter distances may force manufacturers to implement designs that could cause poorer real-world stopping performance and instability. On this point, TMA stated that one of the reasons current production tractors are equipped with low-power steer axle brakes is for low-level brake applications, and that tractors designed only to achieve maximum straight-line decelerations when fully loaded may not perform well during normal brake applications.

In contrast, other commenters, including some brake suppliers (Bendix and Wabco) as well as Advocates and IIHS, supported a 30 percent reduction in stopping distance for all tractors. These commenters cited the agency's safety benefit analysis as justifying the cost of the improvement. Advocates also argued that there are other benefits associated with the use of disc brakes, including greater resistance to fading.[14] Bendix stated that more powerful brakes, both disc and enhanced drum, are currently available and being used on the road with no significant operational problems.

Comments on the Proposal To Reduce Service Brake Stopping Distance Performance by 20–30 Percent in the Lightly Loaded Condition

Few comments were received on this topic. However, TMA stated that currently, standard three-axle unloaded tractors start to experience rear wheel slip during brake applications of approximately 30 psi or more.

Comments on the Proposal To Reduce Emergency Braking Stopping Distance by 20–30 Percent

Comments from the trucking industry opposed the proposed reduction in emergency braking stopping distance. Many commenters stated that NHTSA had not provided any crash data or any other rationale to justify why any such reduction is necessary. These commenters also stated that the occurrence of a crash-imminent situation at the same time as a primary or secondary brake system failure is likely to be extremely rare.

Comments on the Proposed Two-Year Lead Time

Trucking industry commenters and NADA argued that, for standard three-axle tractors, a two-year lead time is adequate to meet a 25 percent reduction in stopping distance. No specific recommendations were offered for two-axle or severe service tractors, although ATA suggested a two-stage implementation strategy for standard three-axle tractors and all other tractors. These commenters also stated that if the agency decides on a 30 percent reduction in stopping distance, longer lead times would be required for brake system development and evaluation.

Haldex and other commenters also recommended that the stopping distance reduction be timed as to not coincide with the 2010 effective date for new engine emission standards, set to become effective by the Environmental Protection Agency.

Vehicle Modifications Necessary To Meet Proposed Reductions in Stopping Distance

Commenters from the trucking and brake industry stated that the largest percentage of improvements in stopping distance would be achieved by using more powerful steer axle brakes; either enhanced drum brakes (larger in width and/or diameter than standard drum brakes) or disc brakes. Most commenters added that more powerful brakes on the drive axles would further contribute to braking performance. Freightliner indicated that 97 percent of its fleet would require brake improvements to meet a 25 percent stopping distance reduction.

Commenters from the trucking industry suggested, but provided little specific information on, other modifications to the vehicle that may be necessary to achieve the improved braking performance. These modifications include chassis structural analysis, redesign, and validation. TMA stated that packaging larger steer axle brakes could result in steering problems. On the other hand, brake suppliers suggested that these issues could be resolved.

For two-axle tractors, several commenters stated that instability could prove to be a problem. Accordingly, TMA stated that for two-axle tractors with a short wheelbase, the following modifications would be necessary to allow the tractor to comply with a 30 percent reduction in the FMVSS No. 121 test: (1) Steer axle brakes would need to be enhanced; and (2) drive axle brake torque would need to be reduced to prevent wheel lockup (a condition which would prove hazardous during normal road braking situations). TMA indicated that these problems could be mitigated by added electronic stability systems, but that such systems could increase stopping distance and dramatically increase cost.

Margin of Compliance Issues

Commenters on this issue stated that tractor manufacturers target a 10 percent margin of compliance to account for test conditions and vehicle variability. Haldex stated that with a 10 percent margin of compliance on a 25 percent reduction in stopping distance, manufacturers would strive to achieve a total reduction in stopping distance of 35 percent.

Cost and Weight of Improved Braking Systems

Few commenters provided information on the issues of cost and weight of improved braking systems in response to NHTSA's request. Freightliner provided cost information on improved foundation brakes, but without supporting data. According to Freightliner's figures, installing enhanced drum brakes on a three-axle tractor would add $222 to the cost,

[14] "Brake Fade" is a term used to describe a temporary decrease in torque output of a brake when exposed to certain conditions, such as high heat.

while adding disc brakes would cost an additional $1,627; the cost of adding disc brakes to a two-axle tractor would be $963. TMA commented that for two-axle and severe service tractors, NHTSA did not provide a cost analysis, and it argued that increasing stopping performance would result in cessation of production of certain vehicles manufactured in low volumes because manufacturers would not be able to amortize the manufacturing/engineering costs, which would in turn limit market choice.

With regard to weight, Bendix stated that, currently, the heaviest drum brake weighs 32 lbs. more than the lightest disc brake, while the heaviest disc brake weighs 134 lbs. more than the lightest drum brake. WABCO stated that its disc brakes are equivalent in weight to high performance drum brakes.

Brake Balance Issues With Existing Trailers

Commenters provided relatively little information on the issue of brake balance with existing trailers. Truck manufacturers stated that brake balance information will need to be further evaluated. Some brake manufacturers provided comments as well. For example, Bendix stated that its tests of disc-braked tractors had shown no objectionable brake balance issues. ArvinMeritor, however, stated that if stopping distance were reduced by more than 25 percent, drive axle torque would need to be increased, which would cause disruptive issues with the existing trailer fleet.

Braking Performance of Single-Unit Trucks

Commenters provided relatively little information regarding single-unit trucks. Haldex and Bendix suggested that further testing needs to be done, and that the government should work with industry to develop test data on the subject. Bendix stated that currently, single-unit trucks have a higher center of gravity than tractors, and that their stopping distances are about 15 percent shorter than tractors.

Developments in Advanced ABS and ECBS Systems and Their Effects on Stopping Distance Performance

Several brake suppliers provided comments on the state of advanced ABS and ECBS on stopping distance performance. Specifically, WABCO stated that currently, ABS systems installed on tractors uses modified individual regulation (MIR), which reduces yaw movement [15] on split-coefficient road surfaces. According to the commenter, with larger foundation brakes, this system should not require significant modification, and it could help alleviate potential problems with larger brakes. Bendix also stated that electronic stability programs for rollover prevention and yaw stability are available on a variety of truck tractors.

Haldex stated that ECBS may improve stopping distance by reducing the interval it takes between the time when the vehicle operator depresses the brake pedal to the time when brake forces are actually generated. However, Haldex also stated that because FMVSS No. 121 requires redundant brake control systems, ECBS is not a viable option for heavy vehicles at this time. Haldex, like a number of other commenters, stated that advanced ABS does not reduce stopping distance.

Dynamometer Testing Requirements

Truck manufacturers and brake suppliers both recommended that there be no changes to the FMVSS No. 121 dynamometer requirements. Some brake manufacturers, such as Haldex and HDBMC, stated that current dynamometer testing procedures in FMVSS No. 121 impose no appreciable limitations on the useable brake torque, and expressed concern that changes in dynamometer requirements could have the effect of limiting their options.

Arvin Meritor and Bendix stated that they were planning on conducting further dynamometer testing, and would present the results to NHTSA. However, NHTSA has not received any additional information on this issue.

Brake Burnish Issues

A comment by HDBMC stated that in order to achieve a reduction in stopping distance, higher torque front brakes would be required on truck tractors. According to the commenter, the higher torque front brakes would do more of the work during burnish, thus lowering the rear brake temperatures and reducing the conditioning of the rear brakes. HDBMC stated that coupled with the trend toward wider rear brake configurations, this will result in lower temperatures for rear brakes, and the critical temperature needed to properly condition the rear brakes would not be achieved. In order to address this issue, HDBMC recommended the agency reinstate the FMVSS No. 121 burnish procedure that existed prior to 1993. HDBMC also stated that because the specification for rear-axle burnishing was reduced when the standard was amended in 1993,[16] parking brake performance has been negatively affected, and this problem would be expected to worsen under the agency's reduced stopping distance proposal.

Arvin Meritor also commented on the burnish issue, requesting that an optional burnish procedure be added to the FMVSS No. 121 dynamometer test. The commenter's recommended procedure calls for six optional stops, using 100 PSI pressure from a starting speed of 60 mph, at the conclusion of the 350 °F brake burnish.

Comments on Tractor Stopping Distance Data

Comments from manufacturers raised two objections to the stopping distance data provided by NHTSA. To begin with, several commenters stated that the agency's proposal was non-specific, because it specified a range of potential stopping distance reductions, rather than a pinpoint proposal. Further, commenters stated that NHTSA performed testing only on typical three-axle tractors. For example, TMA stated that the absence of data on two-axle and severe service tractors should preclude the agency from issuing a rulemaking on those types of tractors at this time. TMA and Bendix provided their own testing data from tractors with enhanced foundation brakes, which in general showed significant improvements in performance.

With regards to the Radlinski testing data referred to in the NPRM, few commenters provided specific comments. Instead, most commenters simply noted that the data were limited to standard three-axle tractors. Bendix added that it believes the Radlinski test data is representative of improvements that can be achieved.

A cooperative testing system for tractor stopping distance was recommended by a variety of commenters, including International, Freightliner, HDBMC, and Arvin Meritor. In addition, the TMA recommended the agency initiate a test program for two-axle and severe service tractors.

In-Use Truck Brake System Maintenance

Several commenters (truck manufacturers and brake suppliers) commented on the need for better servicing and maintenance of truck brakes, noting that in-service brakes frequently fall short of the standards set for brakes sold with new vehicles. Brake

[15] Yaw movement refers to vehicle rotation producing lateral sliding, due to tires on one side of the road producing more friction than tires on the other side.

[16] Docket # 2005–21462–20.

Pro stated that the vast majority (85 percent) of trucks, tractor-trailers, and trailers in North America have had some form of brake system component maintenance work or replacement work done on them, and would no longer necessarily meet the new vehicle stopping distance standards. TMA stated that 45 percent of trucks involved in crashes where brakes were the primary avoidance system had non-compliant brakes.

Reduced Test Speed Stopping Distance Requirements

HDBMC and Bendix argued that brake system reaction time is not taken into account in the NPRM's proposed tables in the reduced speed test requirements. They argued that this resulted in unrealistic stopping distances. Both commenters provided recommendations for adjusting the lower test speed stopping distances to account for brake system reaction time.

Cargo Securement

OOIDA commented that if tractors with improved brake systems are able to achieve higher deceleration rates, this could affect the safety of cargo securement systems, and they provided information on the Federal Motor Carrier Safety Administration's (FMCSA's) recent regulatory changes in this area.[17]

III. The Final Rule and Response to Public Comments

a. The Final Rule

i. Summary of Requirements

In light of the estimated benefits, in terms of lives saved and property damage avoided, we are upgrading the brake performance requirements of FMVSS No. 121 for air-braked tractors. The requirements of this regulation have been drafted so as to advance the safety and braking performance of truck tractors without imposing overly high costs on the trucking industry or requiring technical advances beyond what are available in the commercial market today. In overview, the final rule specifies 30 percent decreases in required stopping distance for the vast majority of air-braked tractors. The rule also sets somewhat less stringent requirements for a small percentage of truck tractors in light of practicability concerns.

Specifically, the upgrade to FMVSS No. 121 set forth in this final rule specifies a 30 percent reduction in stopping distance that is expected to apply to approximately 99 percent of air-braked tractors. The reduction lowers the maximum stopping distance from the current distance of 355 feet to 250 feet when tractors are tested in the loaded-to-GVWR condition from 60 mph. For three-axle tractors with a GVWR of over 70,000 pounds, and four (or more) axle tractors with a GVWR of over 85,000 pounds, the stopping distance requirement in the loaded-to-GVWR condition is being set at 310 feet.

The decision to adopt a 250-foot stopping distance is based on the agency's analysis of the potential safety benefits that may be achieved by using enhanced braking technology and the costs and feasibility of upgrading the requirements to the new level. NHTSA research demonstrated that for most tractors—including standard three-axle tractors which comprise over 80 percent of the commercial fleet—the upgrade could be achieved at relatively low cost and with minimal impact to tractor design specifications. Specifically, research demonstrated that relatively low-cost enhanced drum brakes would be adequate to achieve stopping distances within 250 feet, with a margin of compliance of 10 percent.[18] For most of the remaining tractors, including two-axle and most severe service tractors, NHTSA concluded that the upgraded requirements were also attainable, although more powerful disc brakes and other design changes may need to be implemented in order to stop within the required limits without detrimental effects on stability or brake balance.

For a small number of severe service tractors with three axles and a GVWR of 70,000 pounds or more, or equipped with four or more axles and a GVWR of 85,000 pounds or more, the agency is setting a 310-foot requirement (similar to the current loaded-to-GVWR requirement for air-braked single-unit trucks). This is due to the fact that even when fitted with current disc brakes at all wheel positions, it has been demonstrated that these vehicles cannot achieve 30 percent reductions in stopping distance.

For all tractors, the stopping distance requirement in the lightly-loaded test condition is set at 235 feet, as it was determined that with improved foundation brakes, this requirement is well within the capabilities of all heavy truck manufacturers to achieve.

The required improvement in stopping distance performance is limited to service brakes, and does not include emergency braking. Several commenters argued persuasively that improvements to emergency braking performance could have deleterious effects on lateral stability and control, due to modifications to the ABS algorithms that would be required to meet the emergency braking requirements. Further, there are no data to show that tractors operating in the bobtail condition (*i.e.,* with no trailer attached) and experiencing an emergency braking situation are contributing to the heavy truck crash problem.

ii. Compliance Dates

There are two compliance dates on which the new stopping distance requirements become mandatory. For standard three-axle tractors, the new stopping distance requirements become mandatory on August 1, 2011. ''Standard three-axle tractor'' refers to typical three-axle tractors that have a steer axle GAWR less than or equal to 14,600 pounds and a combined drive axle GAWR less than or equal to 45,000 pounds, for a total GVWR equal to or less than 59,600 pounds. The agency's test data show that, for these tractors, compliance with the new stopping distance requirements can be readily achieved.

The compliance date for all two-axle tractors, as well as severe service tractors with a GVWR greater than 59,600 pounds, is August 1, 2013. NHTSA's test data indicate that two-axle tractors can meet a 250-foot loaded-to-GVWR stopping distance requirement with improved brake systems. However, additional lead time is needed for manufacturers to more fully evaluate new brake systems to ensure compatibility with existing trailers and converter dollies when used in multi-trailer combinations. Further, more time is needed to minimize the risk of vehicle stability and control issues. With regard to severe service tractors, the available test data and analysis indicate that the respective 250-foot and 310-foot stopping distance requirements can be met by improved brake systems. However, as only limited development work has been performed, these vehicles require additional lead time to ensure complete testing and validation of new brake systems.

iii. Margin of Compliance

Manufacturers need to ensure that all of their vehicles meet a test requirement established by a Federal safety standard. To account for variability, including vehicle-to-vehicle variability, they typically design vehicles with a margin of compliance.

[17] This regulation assigns certain g-forces within which cargo securement devices and systems must contain the vehicle's cargo load. *See* 49 CFR 393.102.

[18] The issue of margin of compliance is discussed later in this document.

With regard to stopping distance, the comments stated that the traditional industry compliance margin is 10 percent.[19] We note that this does not necessarily mean that manufacturers do not sometimes certify vehicles with a smaller margin of compliance. However, they do need to take whatever steps are necessary to ensure that each vehicle they certify complies with applicable requirements.

We believe that calculations of 10 percent compliance margins are useful for analytical and discussion purposes in considering what stopping distance requirements are appropriate and practicable.

We note that in this document, in many cases we have cited a ten percent margin of compliance from the average stopping distance that a vehicle test has demonstrated in testing despite the fact that a vehicle is required to meet the requirement in only one of six stops. However, since there is generally little variability in the distance achieved among multiple stops due largely to the incorporation of anti-lock braking systems, it generally doesn't make much difference whether we look at the average or best stop distance.

b. Summary of NHTSA Testing and Results Conducted After Publication of the NPRM

i. Testing Conducted on Three-Axle Truck Tractors

Available test data demonstrate that typical three-axle tractors can meet a requirement with a 30 percent reduction in stopping distance using only enhanced drum brakes, the least expensive type of improved foundation brake available. NHTSA used the same definition for a ''typical three-axle tractor'' as TMA and HDBMC, which is a 6x4 configuration (three axles with six wheel positions; a non-driven steer axle and two rear drive axles) with a GVWR below 59,600 pounds, a steer axle with a GAWR equal or less than 14,600 pounds, and tandem drive axles rated equal or less than 45,000 pounds total capacity. According to the test data from the Radlinski[20] reports (7 tests), typical three-axle tractors with enhanced S-cam drum brakes at all wheel positions achieved the target 30 percent reduction in stopping distance, with margins of compliance (based on a 250-foot stopping distance requirement) ranging from 12 to 18 percent. This is superior to the ten percent threshold used by most manufacturers.

NHTSA also conducted testing at its Vehicle Research Test Center (VRTC), using a variety of foundation brake systems.[21] The VRTC tests of two tractors showed that with disc brakes at all wheel positions, both tractors could meet the 30 percent target with compliance margins between six and 13 percent, while one of these tractors could meet the 30 percent target using a hybrid (disc/drum) configuration with disc brakes on the steer axle and standard drive axle drum brakes (16.5″ diameter drum x 7″ wide brake linings) with a six percent margin of compliance.

The above tests show that disc brakes provide an alternative means to achieve compliance with a 30 percent reduction in the stopping distance requirement. All of the all-disc braked examples could meet or exceed the ten percent margin of compliance with one exception (one VRTC test). Moreover, the agency is confident that the performance of that one example could readily be improved by increasing the torque output of that disc brake (or switching to newer, readily-available, and more powerful disc brakes).

Results for the hybrid combination of disc brakes on the steer axle and standard drum brakes on the drive axle were mixed, with one tractor meeting the 30 percent reduction in stopping distance with a six percent margin, even though the performance would be expected to match or exceed the performance of a tractor with enhanced drum brakes at all wheel positions (which, as the Radlinski testing showed, was able to meet the 30 percent reduction with margins over ten percent). Also, the agency did not test any hybrid configurations using enhanced drum brakes (standard 16.5″ x 7″ drive axle brakes were used in the agency's hybrid tests). Based on these results, one conclusion that can be drawn regarding cost is enhanced drive axle S-cam drum brakes will be necessary, at a minimum, whether used on the steer or drive axles of a standard three-axle tractor, because the available data show that standard drum brakes (15″ x 4″ steer, 16.5″ x 7″ drive) have not been able to achieve the necessary performance to meet the requirements in this final rule.

ii. Testing Conducted on Two-Axle Truck Tractors

NHTSA's testing after publication of the NPRM indicated that a Sterling 4x2 tractor is capable of complying with a 250-foot stopping distance with enhanced foundation brakes.[22] In the VRTC testing, the test tractor was purchased new and was originally equipped with larger steer axle S-cam drum brakes of 16.5″ diameter by 5″ lining width, and standard S-cam drum brakes (16.5″ x 7″) on the drive axle. In the as-received state (approximately 1,000 miles of normal road use, half of the time in the bobtail condition and half of the time towing a 48-foot flatbed trailer), the average stopping distance (based on six stops) was 241 feet from 60 mph at GVWR plus 4,500 pounds of weight on the single axle, unbraked control trailer as specified in FMVSS No. 121. However, when the foundation brakes were replaced with all new components and subjected to a complete FMVSS No. 121 burnish, the average stopping distance increased to 332 feet. Further investigation of this problem indicated that the replacement brake linings generated less torque than the original linings. This is discussed in further detail in the brake burnish section below.

The same VRTC test tractor was also tested with disc brakes. The first configuration of the VRTC testing was a hybrid brake system test. In this test, the tractor was equipped with disc brakes on the steer axle and the standard S-cam drum brakes on the drive axle (hybrid brake configuration), and again subjected to an FMVSS No. 121 burnish. The average loaded-to-GVWR stopping distance was 223 feet, meeting the proposed 250-foot stopping distance requirement with a margin of compliance of 11 percent. In the final configuration, the tractor was equipped with disc brakes on both the steer axle and drive axle. Here, the average loaded-to-GVWR stopping distance was 200 feet, a 20 percent margin of compliance.

iii. Testing Conducted on Severe Service Tractors

After publication of the NPRM, the agency conducted additional testing on a severe service truck judged to have similar service braking characteristics as a tractor of similar size and weight dimensions.[23] The test truck was a three-axle Peterbilt Model 357 with a steer axle GAWR of 18,000 pounds and tandem drive axle GAWR of 44,000 pounds. The total GVWR was 62,000

[19] Bendix stated, for example, that the traditional industry compliance margin is 10 percent. Docket # NHTSA–2005–21462–24, p. 5. TMA referred to ''a requisite 10 percent compliance margin.'' Docket # NHTSA–2005–21462–34.

[20] Docket # NHTSA–2005–21462–5, 6, 7.

[21] *See Class 8 Truck Tractor Braking Performance Improvement Study,* available at: *http://www.nhtsa.dot.gov/staticfiles/DOT/NHTSA/NRD/Multimedia/PDFs/VRTC/ca/capubs/DOTHS809700.pdf*

[22] Docket # NHTSA–2005–21462–39, p. 25.

[23] Docket # NHTSA–2005–21462–39, p. 10.

pounds, and the wheelbase was 275 inches. The vehicle was purchased as a chassis-cab and manufactured as a single-unit truck, and a load frame was attached to the frame rails for test loading purposes. Although a single-unit truck differs in many ways from a truck tractor, based on our testing we found that the single-unit truck was likely to experience similar, if more severe, dynamic load transfer onto its steer axle than if it had been tested as a tractor, thereby rendering it a reasonable surrogate for a severe service tractor in this context.

The substantive difference in braking performance for this vehicle in the truck versus tractor configuration would be apparent in emergency braking performance, for which the truck configuration would likely need to utilize spring brake modulation to meet the stopping distance requirement at GVWR (this is because there is no equivalent test requirement for tractors, since emergency braking requirements only apply in the unloaded condition), and there are also differences in parking brake performance requirements for single-unit trucks and tractors. However, neither of these brake system differences were factors during the normal service brake tests for the Peterbilt truck.

The truck used in the VRTC testing was tested with a variety of brake configurations in order to determine its stopping distance performance. The truck was originally manufactured with enhanced 16.5″ x 6″ S-cam drum brakes on the steer axle, and standard 16.5″ x 7″ S-cam drum brakes on the drive axles. It was also equipped with a 6S/6M ABS system that should provide the highest braking efficiency because the braking forces are modulated individually at each wheel position. With the OEM S-cam drum brakes, the average loaded-to-GVWR, 60 mph stopping distance was 280 feet, which would not meet the enhanced 250 feet stopping distance requirement. In a hybrid configuration with disc brakes on the steer axle and standard S-cam drum brakes on the drive axles, the average stopping distance was 251 feet. With disc brakes at all wheel positions, the average stopping distance was 224 feet, meeting the target reduced stopping distance with a better than 10 percent margin of compliance.

Another test condition that was evaluated for the severe service Peterbilt truck was to up-load the vehicle to a GVWR of 76,000 pounds and conduct 60 mph stops using all disc brakes. The average stopping distance for six stops was 254 feet and the minimum stopping distance out of the six stops was 251 feet. The standard deviation of all six stops was 3.2 feet, indicating that there was very little stop-to-stop variability, and thus this vehicle achieved very repeatable performance with disc brakes.[24]

In July 2006, the VRTC also ran simulation testing based on the results of the Peterbilt truck testing to determine braking performance at 80,000 pounds GVWR.[25] This study used the Truck Sim vehicle dynamics modeling software with which the VRTC staff has extensive experience, including validation of many modules (such as foundation brakes and ABS control systems) used in the program. This simulation study determined that with the same all-disc brake configuration, but with the GVWR increased to 80,000 pounds, a heavy truck's estimated stopping distance would be 280 feet. By increasing the brake torque on the steer axle (using type 30 brake chambers in place of type 24 chambers), the estimated stopping distance decreased to 262 feet at 80,000 pounds GVWR. Additional parametric studies (by modeling further increases in brake torque at all wheel positions) showed that if brake torque could be increased sufficiently to utilize all available tire-road friction, stopping distances as low as 227 feet could be achieved (meeting the 30 percent target with a nine percent margin of compliance). However, the agency is not aware that there are any available disc brakes currently capable of generating the requisite torque and that would also be able to be packaged within the available wheel envelope. Based upon this analysis, the agency has concluded that the 30 percent reduction in stopping distance may not be feasible for heavy truck tractors above 80,000 pounds GVWR.

c. Response to Public Comments

i. Straight-Line Braking Performance of Tractors With Improved Brake Systems

In this section, we discuss data and arguments relating to the performance of tractors with improved braking systems. The purpose of this section is to address whether various tractor configurations are capable of meeting the proposed performance requirements of FMVSS No. 121 with improved braking systems. In addition, we provide additional insight on what kind of improved brakes will be necessary for various tractor configurations to meet the requirements of the standard, and provide further refinement of our cost estimates. This portion of the final rule deals only with straight-line braking performance. Issues of stability, control, brake balance, burnish, and other issues are dealt with later in the rule.

1. Braking Performance of Typical Three-Axle Tractors With Improved Brake Systems in the Loaded-to-GVWR Condition

In the NPRM, the agency proposed to amend the standard's fully-loaded service brake stopping distance, at 60 mph, from the currently-required 355 feet to a new, reduced distance in the range of 284 feet (20 percent reduction) to 249 feet (30 percent reduction). The agency requested comments on the proposed reductions in the required stopping distance.

A number of commenters supported the agency's decision to reduce the stopping distance for typical three-axle tractors by 30 percent. Advocates and IIHS supported the 30 percent reduction proposal over the 20 percent reduction proposal, citing the significantly higher estimated benefits in terms of the number of injuries, fatalities, and property damage prevented. Advocates also suggested that the agency should mandate the use of disc brakes in addition to the reduced stopping distances, arguing that under actual service conditions, disc brakes will out-perform hybrid systems and drum brakes because disc brakes are relatively immune to fade from either water or heat. IIHS also stated that an additional benefit of the reduced stopping distance would be encouraging the use of disc brake systems, citing similar fade-resistant attributes of disc brakes.

One brake manufacturer, Bendix, commented that it supported a 30 percent reduction in stopping distance for three-axle tractors, and submitted test data to support the feasibility of this requirement. Eight tests with disc brakes at all wheel positions showed that all of the tractors tested could meet the 30 percent target with compliance margins between 21 percent and 18 percent. Data on one hybrid three-axle tractor showed that the 30 percent target was met with an eight percent margin of compliance. Finally, one all drum brake equipped tractor (drum brake sizes were not specified) met the 30 percent target with a 14 percent margin of compliance.

The TMA recommended that the stopping distance for three-axle tractors be reduced by a maximum of 25 percent, a position shared by International, Haldex, and NADA. TMA supplied test results for three-axle

[24] Docket # NHTSA–2005–21462–39, p. 23.

[25] VRTC/R&D—*Vehicle Modeling Research to Estimate Stopping Distances for 80,000-lb GVWR Trucks and Tractors Using Current Brake Technologies.* Docket # NHTSA–2005–21462–39, p. 15.

tractors as well. For three-axle tractors equipped with all disc brakes (8 tests), the 30 percent target in stopping distance reduction was met with margins of compliance ranging from 10–20 percent. In hybrid configurations with disc brakes on the steer axle and enhanced drum brakes on the drive axles (eight tests) and in all enhanced S-cam drum configurations (eight tests), the margins of compliance ranged from two to 20 percent.

In its comments, ArvinMeritor stated that for typical three-axle tractors to achieve tractor stopping distance reductions greater than 25 percent, an increase in drive axle torque would be needed. Based on the vehicle testing conducted by NHTSA (*see* above, section III, B), the agency agrees with this comment, and recognizes that improved drive axle foundation brakes will be part of meeting a requirement that reduces stopping distance by 30 percent.

For the final rule, the agency has decided to reduce the stopping distance for typical three-axle tractors in the loaded-to-GVWR condition, at 60 mph, from the currently-required 355 feet to 250 feet.[26] In arriving at this requirement, the agency reviewed the available test data of typical three-axle tractors with improved brake systems. That data showed that a 30 percent reduction is possible using a variety of enhanced brake systems. In addition, to ensure that the amended standard is practicable, the agency considered the margin of compliance that truck manufacturers typically would use during compliance to ensure that all similar production tractors would comply with the requirement, which specifies a target stopping distance of 225 feet.

Given the totality of the data provided by TMA and Bendix, NHTSA believes the test data demonstrate that for typical three-axle tractors a 30 percent reduction in stopping distance is readily achievable. In most cases a 10 percent margin of compliance was met or exceeded. Both NHTSA and commenters'data are consistent with the agency's position that a 30 percent reduction is feasible. For example, some tests demonstrate that typical three-axle tractors with enhanced drum brakes at all wheel positions are readily capable of attaining 30 percent reductions with more than a 10 percent margin of compliance, although the upper range (lowest performing) of the data from TMA on at least one tractor with enhanced drum brakes showed that the margin of compliance was approximately five percent.

NHTSA does not agree with the recommendation from Advocates that it mandate disc brakes for use in all heavy truck tractors. NHTSA has not mandated the use of disc brakes because these presumed safety benefits have not been quantified, and no data to this extent was provided by Advocates. Further, we have no information as to what the net benefit of any safety benefit unique to disc brakes would be, and how it would compare to the increased costs of disc brakes.

The agency believes that the available data demonstrate that 30 percent reductions in stopping distance are readily achievable on typical three-axle tractors. A ten percent margin of compliance has been demonstrated for the majority of tractors using disc brakes and enhanced drum brakes (the exact percentage for margin of compliance cannot be determined for some of the data for which only ranges in performance for several tests were indicated). Therefore, the agency concludes that it is practicable to achieve 30 percent reductions in stopping distance when currently-available improved foundation brakes are applied to typical three-axle tractors. We also note that many tests demonstrate that enhanced drum brakes on the steer and drive axles were sufficient for many standard three-axle tractors to meet the 30 percent reduction, allowing the lowest-cost option to be used for the vast majority of heavy truck tractors.

2. Braking Performance of Two-Axle Tractors With Improved Brake Systems in the Loaded-to-GVWR Condition

NHTSA proposed in the NPRM to reduce the stopping distance for all truck tractors, which includes two-axle tractors. As discussed below, based on agency testing and comments received, the agency concludes that all two-axle tractors can meet the 30 percent reduction in stopping distance requirements with improved braking systems. Although the agency did not include test data on two-axle tractors when the NPRM was published, since that time, the agency has completed a foundation brake study at the VRTC on a typical two-axle tractor. In addition, testing data from the TMA and Bendix also indicate that two-axle tractors are capable of meeting a 30 percent reduction in stopping distance with a ten percent margin of compliance if equipped with disc brakes.

While industry commenters generally did not support reducing stopping distance for two-axle tractors, TMA data submitted in response to the NPRM indicated that for regular service two-axle tractors (*i.e.,* with a drive axle GAWR below 23,000 pounds), the 250-foot stopping distance requirement could be met using disc brakes.[27] TMA tested two-axle tractors in hybrid brake configurations and an all-disc configuration. The first hybrid configuration (one test; disc brakes on the steer axle and standard 16.5″ x 7″ S-cam drum brakes on the drive axle) was able to meet the 250-foot requirement with a margin of compliance of approximately 12 percent. A second hybrid configuration (two tests; with disc brakes on the steer axle and enhanced 16.5″ x 8.625″ S-cam drum brakes on the drive axle) indicated that both test vehicles met the 250 foot requirement, one with a margin of approximately 15 percent, and the other with a margin of only two percent. Finally, an all-disc configuration (one test) met the proposed 30 reduction with a 22 percent margin of compliance.

TMA also provided supplemental comments in October 2006,[28] with additional data on the performance of two-axle tractors with improved foundation brakes. Two tractors with disc brakes at all wheel positions indicated that the best of six stops ranged from 206 to 213 feet in the loaded-to-GVWR condition from 60 mph, indicating margins of compliance well over ten percent. A third tractor with a hybrid disc/drum configuration was able to stop in 221 feet, giving it a 12 percent margin of compliance. A fourth tractor with enhanced S-cam drum brakes at all wheel positions had a shortest stop of approximately 248 feet, and thus a marginal compliance with a 30 percent stopping distance reduction. Three tractors tested, when tested with standard drum brakes, could not meet a 250-foot stopping distance.

Bendix also provided data indicating that two-axle tractors could meet the 30 percent stopping distance reduction.[29] Bendix provided test data on the disc/drum hybrid configuration (two tests; and the drive axle drum brake sizes were not specified). In those tests, the average stopping distances for both tractors would meet the proposed 250-foot requirement with a margin of compliance of 12 percent for one vehicle and nine percent for the other. Using the best of six stops for the poorer performing vehicle (225 feet, rather than the average stopping distance of 228 feet), the margin of compliance

[26] A 30 percent reduction from 355 feet is, in fact, 249 feet, which the agency has rounded to an even 250 feet.

[27] Docket # NHTSA–2005–21462–26, p. 5.

[28] Docket # NHTSA–2005–21462–35.

[29] Docket # NHTSA–2005–21462–24–0001, p. 9.

increases to 10 percent. Bendix test data on all-disc brake two-axle tractors (two tests) indicated that both vehicles would meet a 250-foot stopping distance requirement and that the margins of compliance were 19 and 14 percent based on the average of six stops in each test. The GAWRs for all two-axle tractor tests were 22,999 pounds or less on the drive axle and 12,000 pounds or less on the steer axle (*i.e.,* they were not severe service two-axle tractors).

Finally, in its original comments, TMA stated that drive axle brake torque would need to be reduced to prevent wheel lockup (a condition which would prove hazardous during normal road braking situations). However, we believe ABS, which has been required on all new truck tractors manufactured on or after March 1, 1997, prevents wheel lockup. Hence, this comment is not persuasive.

Based on the testing data accumulated by NHTSA and provided by the commenters, the agency has concluded that meeting a 30 percent reduction in stopping distance is achievable for currently-produced two-axle tractors with at least a 10 percent margin of compliance with all-disc configurations. To a lesser extent, the hybrid disc/drum configurations (some of which had good margins of compliance, and some of which had poor margins) may also be able to achieve the 30 percent reduction in stopping distance.

3. Braking Performance of Severe Service Tractors With Improved Brake Systems in the Loaded-to-GVWR Condition

a. Definition of Severe Service Tractor and Specific Safety Benefits

With the exception of certain vehicles with extremely high GVWRs or GAWRs that are excluded from the requirements of Standard No. 121, the reduced stopping distance requirements proposed in the NPRM were to apply to all severe service tractors. For purposes of this document, NHTSA is using TMA's definition of a three-axle severe service tractor, as a three-axle tractor having a steer axle GAWR greater than 14,600 pounds and tandem drive axles with a total GAWR greater than 45,000 pounds. In addition, severe service tractors include those tractors with twin steer axles, auxiliary axles (*e.g.,* lift axles), and/or tridem drive axles. Chassis configurations include 6x4, 8x4, 8x6, 10x6, and 14x4 layouts. Based on comments from TMA and Freightliner, the GVWR of severe service tractors is greater than 59,600 pounds and can exceed 100,000 pounds. The commenters explained that severe service tractors are used in special purpose applications such as oil field service, extreme heavy hauling, transporting earth moving equipment, and logging. The commenters further stated that operation is both on-road and off-road, and in some cases, on-road use is at relatively low speeds with the tractor-trailer combinations being accompanied by escort vehicles.

Freightliner [30] stated that severe service tractors comprise approximately seven percent of tractor production and are involved in 5.6 percent of fatal tractor crashes, according to the UMTRI report on Class 8 tractors involved in fatal crashes (included with TMA's comments).[31] To the extent possible, the agency compares fatal crash involvement rates of vehicle types based upon fatalities per 100 million vehicle miles traveled (VMT) (*see* Section II of the NPRM). As described in the NPRM, tractors have a lower overall crash rate per 100 million VMT compared to light vehicles (passenger cars, light trucks, and SUVs), but are over-represented in fatal crashes. The UMTRI report submitted by TMA [32] did not analyze tractor crash data for the three types of tractors studied (typical three-axle, two-axle, and severe service tractors) based upon VMT exposure, and the agency is not aware such VMT exposure data being available from the known crash data sources. Based upon the comments received, it appears that the on-road mileage exposure for severe service tractors is lower than for typical three-axle or two-axle tractors.[33] Nonetheless, the 5.6 percent fatality involvement rate does not indicate that severe service tractors are underrepresented in fatal crashes to an extent that the agency should consider excluding them from this final rule. Given the potential safety benefits, we believe the deciding factor in determining the loaded-to-GVWR stopping distance requirements for severe service tractors under this final rule should be dependent on the best performance that can be achieved using the available improved brake systems.

In its comments, TMA delineated several broad categories of severe service tractors that the agency believes comprise highly relevant categories. The first is three-axle severe service tractors with GVWRs ranging from approximately 60,000–70,000 pounds. These tractors have a steer axle GAWR in the 13,000–14,500-pound range and tandem drive axles rated in the approximate range of 46,000–55,000 pounds (as depicted in Figure 5 in TMA's April 2006 comments, which shows a three-axle tractor towing double trailers.) The second category of severe service tractors described by TMA are three-axle severe service tractors with GVWRs above 70,000 pounds. Finally, there are severe service tractors in 8x4, 8x6, 10x6, 14x4, and other configurations. This group of vehicles is used in special purpose or extreme heavy haul applications (as depicted in Figure 6 of TMA's comments, which shows a 10x6, twin-steer tractor with tridem drive axles.) Based upon the information provided to the agency in several *ex parte* meetings that have been held since the publication of the NPRM,[34] the typical weight ratings for the 10x6 tractor photographed would be 14,500 pounds GAWR for each steer axle and 20,000 pounds for each drive axle, yielding a GVWR of 89,000 pounds. This tractor would not be excluded from FMVSS No. 121 based on its axle ratings. Other unusual tractor configurations would also tend to have high GVWRs over 70,000 pounds and still be subject to FMVSS No. 121.

b. Three-Axle Severe Service Tractors With a GVWR Under 70,000 Pounds

Based on the agency's testing, as well as test data provided by the commenters, NHTSA believes that severe service three-axle tractors with a GVWR under 70,000 pounds can meet a 250-foot stopping distance requirement using enhanced foundation brake systems. VRTC test results and commenter data lead the agency to believe that three-axle severe service tractors with a GVWR between 60,000 and 70,000 pounds are capable of meeting the 30 percent reduction in stopping distance using available enhanced braking systems.

NHTSA's testing indicated that lower-GVWR three-axle severe service tractors will be able to meet a 250-foot stopping distance requirement. Here, NHTSA refers to the Peterbilt truck, tested by the VRTC, which is very similar to three-axle severe service tractors of the 60,000–70,000 pounds GVWR category. As stated above, the VRTC testing used a single-unit truck with comparable braking performance to a severe-service three-axle truck tractor. This tractor, when equipped with disc brakes and tested at a GVWR of 62,000 pounds, was able to meet the 250-foot stopping distance requirement with a 10 percent margin of compliance.[35] Therefore, the

[30] Docket # NHTSA–2005–21462–25.

[31] Docket # NHTSA–2005–21462–26.

[32] Docket No. NHTSA–2005–21462–26; *see* attachment, p. 16.

[33] Docket # NHTSA–2005–21462–26, p. 11.

[34] Memorandums of *ex-parte* meetings provided in Docket No. NHTSA–2005–21462–36.

[35] Docket # NHTSA–2005–21462–40.

agency believes that it is practicable to require similarly-configured tractors to achieve similar braking performance.

TMA's supplemental comments include data that enhance NHTSA's confidence in the practicability of this requirement. The data indicate that for lower GVWR three-axle severe service tractors, a 250-foot stopping distance and a ten percent margin of compliance can be achieved for three-axle, all-disc braked tractors of 62,000 and 66,000 pounds GVWR.[36] Both VRTC and TMA test data show that three-axle severe service tractors under 70,000 pounds GVWR are capable of meeting the reduced stopping distance with improved foundation brakes and can also achieve a 10 percent margin of compliance.

In its original comments,[37] TMA also stated that building a severe service tractor with improved brakes would result in production of a vehicle that is not commercially viable. TMA argued that such a vehicle would have far too aggressive brake linings, which would result in chatter and frequent failures of various brake components. TMA stated that this would be a commercially non-viable product. NHTSA notes that in its later comments submitted on October 2006, TMA tested a severe service tractor with disc brakes that was able to meet the proposed reduced stopping distance, and the organization did not further discuss these problems. NHTSA also notes that when equipped with modern enhanced braking systems, similarly-configured vehicles can meet the proposed requirements without the problems that TMA foresaw in its April 2006 comments. Therefore, the agency believes that the problems TMA described are obviated by the use of disc brakes.

In October 2006, TMA submitted supplemental comments that included additional information on severe service tractor stopping distance performance. The TMA testing included six drum and six disc brake configurations, performed on vehicles with three different drive axle GAWRs. TMA stated that the disc brakes used in these tests were prototype models that had not been fully tested for production (as dynamometer and other test data were not yet available). The agency assumes that these would be the largest practical disc brakes that would work within the available wheel and suspension envelope.

TMA's test results are discussed below, but the result we believe to be most noteworthy is that the TMA testing indicated that the proposed 30 percent reduction in stopping distance could be achieved using disc brakes. To summarize the TMA test results, when tested at a steer axle weight of 20,000 pounds and a tandem drive axle weight of 46,000 pounds, yielding a GVWR of 66,000 pounds, the baseline all-drum brake configuration (it was not specified whether the drum brakes were standard or larger sized) had a stopping distance of 262 feet. Testing of a hybrid configuration using the prototype disc brakes on the steer axle yielded a stopping distance of 229 feet, thus meeting the target with an eight percent margin of compliance. Finally, when tested with disc brakes at all wheel positions; the stopping distance was 223 feet, yielding an 11 percent margin of compliance. We note that the data for the all-disc brake test are consistent with the performance obtained by VRTC in its tests of the Peterbilt truck with a 62,000 pounds GVWR.

c. Three-Axle Severe Service Tractors With GVWR Over 70,000 Pounds

In contrast to three-axle tractors with a GVWR between 59,600–70,000 pounds, agency testing and commenters' data indicate that it is not practicable at this time for higher-GVWR three-axle severe service tractors to meet a 250-foot stopping distance requirement. In making this determination, the agency carefully considered its own data, as well as the data on high-GVWR three-axle truck tractors provided by the TMA in its comments. Nonetheless, NHTSA believes that improvements in stopping distance for these vehicles should be pursued, albeit at a level less than a 30 percent reduction. TMA's supplemental comments indicate that tractors with very high GVWRs (with regard to three-axle tractors, these have single axle weight ratings of 26,000 pounds or more, or tandem axle weight ratings of 52,000 pounds or more) make up less than one percent of annual tractor production.

The agency believes that severe service tractors over 70,000-pound GVWR can meet the stopping distance requirements for similar vehicles that are configured as single-unit trucks rather than tractors, because similarly-configured single unit trucks are currently being manufactured in compliance with FMVSS No. 121. As the service brake stopping distance requirement for single-unit trucks is 310 feet in the loaded-to-GVWR condition, the agency believes that specifying this standard on severe service tractors of similar weight is a practicable alternative to a 30 percent reduction in stopping distance.

TMA provided simulation test data for hybrid and all-disc foundation brake configurations of three-axle severe service tractors with a GVWR over 70,000 pounds.[38] The data that TMA used in its comments were based upon unspecified simulations, presumably similar to the Truck Sim work performed by VRTC. A footnote in the supplemental TMA submission indicates that one all-drum brake configuration at 72,000 pounds GVWR was verified by actual vehicle testing. The simulation results for a 72,000-pound GVWR tractor (20,000-pound steer axle load and 52,000-pound tandem drive axle load) estimated that the hybrid configuration would achieve a 248-foot stopping distance (within the 30 percent reduction target, but with little margin of compliance). When equipped with disc brakes at all wheel positions, the stopping distance was estimated at 242 feet, which would meet a 30 percent reduction in stopping distance with a three percent margin of compliance. The configuration with drum brakes[39] at all wheel positions was road tested at 72,000 pounds GVWR and had a stopping distance of 285 feet, above the 250-foot limit. TMA also stated that it is unclear what technologies would be needed to achieve high levels of braking performance improvements for tractors in this weight category.

In addition, TMA simulated a test condition with a tractor at 78,000 pounds GVWR, with a 20,000-pound steer axle load and a 58,000-pound tandem drive axle load. This tractor was not able to meet a 250-foot stopping distance with any brake combination, although it must be noted that a vehicle with a 58,000-pound tandem rating (29,000-pound GAWR per axle) is exempt from FMVSS No. 121 under Section 3, *Applicability,* paragraph (b). The stopping distance simulation results for this vehicle were 307 feet for the drum/drum configuration, 268 feet for the hybrid configuration, and 261 feet for the all-disc configuration. Despite the fact that the specific vehicle tested here would not be subject to the requirements of FMVSS No. 121, it does represent the upper edge of the GVWR range regulated under the FMVSS No. 121 requirements, and therefore the agency believes the TMA data are useful in setting stopping distance

[36] TMA comment of October 2006, docket # NHTSA–2005–21462–35.

[37] Docket # NHTSA–2005–21462–26.

[38] Docket # NHTSA–2005–21462–34.

[39] TMA did not provide dimensions for these brakes, but described them as the highest available performance brakes.

requirements for severe service tractors as part of this final rule.

In its October 2006 comments, TMA presented testing that indicated trucks with a GVWR over 70,000 pounds are incapable of meeting a 250-foot stopping distance requirement. In one example, a 72,000-pound GVWR tractor equipped with all disc brakes only achieved a three percent margin of compliance, which the agency does not consider to be enough for manufacturers to reliably build tractors with assured compliance to FMVSS No. 121. Similarly, a 78,000-pound GVWR three-axle tractor equipped with all disc brakes stopped in 261 feet, thus it did not meet a 250-foot stopping distance requirement. Because all-disc brake configurations generally produce the best available braking performance, it is not clear what advancements could be used to bring trucks of this weight within a 250-foot stopping distance. The agency therefore concludes that three-axle tractors with a GVWR greater than 70,000 pounds should be provided with a longer stopping distance requirement.

The agency has considered all of the available data and comments regarding severe service tractors to determine appropriate loaded-to-GVWR stopping distance requirements for these vehicles. The agency agrees with TMA that, based on all available information, foundation brakes that could provide loaded-to-GVWR stopping distance performance in the 250-foot range at 60 mph are not available for three-axle severe service tractors with a GVWR over 70,000 pounds. There are little or no test data available for tractors with a GVWR over 70,000 fitted with the largest available disc brakes to demonstrate that they would be able to meet a 30 percent reduction in stopping distance. In making this statement, the agency notes the TMA supplemental comments, which discuss the lack of extensive testing of prototype disc brakes.[40] Therefore, the agency does not believe it is practicable at this time to require three-axle severe service tractors over 70,000 pounds GVWR to meet the 30 percent reduction in stopping distance.

However, for three-axle tractors with a GVWR over 70,000 pounds, a 310-foot stopping distance requirement is an achievable goal. This represents a 13 percent reduction in stopping distance from the current 355-foot requirement. Based upon this requirement, and assuming a 10 percent margin of compliance, the 78,000-pound GVWR three-axle tractor, discussed in the TMA comments of October 2006, could meet the requirement with an adequate margin of compliance in a hybrid or all-disc brake configuration. Further, the 72,000-pound GVWR three-axle tractor would achieve an eight percent margin of compliance with an all-drum brake configuration. In that case, either slight improvements in the drum brakes or the installation of disc brakes on the steer axle would allow the tractor to achieve a ten percent margin of compliance. The agency believes that in both cases safety benefits will be obtained because of these improvements, but whether these benefits would be the same or smaller than for typical (non-severe service) three-axle tractors is unknown. We also note that for vehicles with a drive axle GAWR of 29,000 pounds or more, FMVSS No. 121 is not applicable, so that typically three-axle tractors with a GVWR of 78,000 pounds or more will be exempt from this requirement.

As previously discussed, the tests at VRTC of a severe service truck (used as a surrogate severe service tractor), loaded to a GVWR of 76,000 pounds and equipped with all disc brakes, had an average stopping distance of 254 feet. This represents an 18 percent margin of compliance to the 310-foot stopping distance requirement implemented under this final rule.

d. Severe Service Tractors With Four or More Axles

For severe service tractors with more than three axles, there is a similar distinction to be made between lower-GVWR tractors and higher-GVWR tractors. While the NPRM proposed reducing the stopping distance for all tractors uniformly, commenters and agency testing have indicated that a distinction should be made, similar to the distinction within severe service three-axle tractors. With regard to severe service tractors with four or more axles, we believe there are some tractor configurations that, even though they are in the severe service category, can comply with a 250-foot stopping distance requirement when most or all of the brakes are upgraded to disc brakes. A small percentage of these tractors, however, will not be able to currently comply with this requirement, and thus necessitate a different approach.

Some extra-axle tractors are based on, and perform very similarly to, severe service three-axle truck tractors. One example of this is a severe service three-axle tractor that has an auxiliary axle installed by either the truck manufacturer or by a vehicle alterer. The agency believes that its testing of a single-unit truck at VRTC provides a basis for determining the scope of this final rule with regard to similarly configured tractors. Using the VRTC three-axle Peterbilt truck as a guideline, which had GAWRs of 18,000 pounds for the steer axle, 44,000 pounds for the tandem drive axles, and a total GVWR of 62,000 pounds, we considered the installation of a lift axle placed in front of the drive axles with a GAWR of 20,000 pounds. We note that this is on the upper end of axle weight ratings for lift axles; many lower GAWR ratings for lift axles are also available. The GVWR would now be increased to 82,000 pounds, and although the agency has no full vehicle test data, the loaded-to-GVWR service braking performance of the tractor would not be expected to decrease substantially from the performance in the original three-axle configuration (this vehicle was tested with three axles at 62,000 pounds GVWR and was able to stop in 224 feet when equipped with disc brakes at all wheel positions). We make this assumption because of the auxiliary brake requirements FMVSS No. 121, which mandate high levels of fade resistance and stopping power requirements.

Although the agency does not have data on the dynamic load increases on lift axles under hard braking, we expect load transfer increases (if any) to be minimal. This assumption is based on prior analyses that show the greatest load transfer to be on the steer axle, while drive axles (and trailer axles in the case of combination vehicle tests) typically have small decreases in vertical load under hard braking.[41] Thus, it would not be expected that lift axle foundation brakes would need to be substantially increased in size to provide the needed retardation force to meet the new stopping distance requirements.

TMA provided data that confirmed NHTSA's belief that lower-GVWR severe service tractors with four or more axles are capable of meeting a 250-foot stopping distance requirement, even when using drum brakes on the drive axles. We note that the TMA supplemental data, supplied in October 2006, for the 66,000-pound GVWR three-axle severe service tractor showed that this tractor was able to achieve a stopping distance of 229 feet in a hybrid configuration (disc brakes on steer axle only), and its drive axles were rated at 23,000 pounds GAWR each. Therefore, adequately performing drum brakes that

[40] TMA comments of October 12, 2006. Docket No. NHTSA–2005–21462–34.

[41] Docket No. 21462–2005–33 (*see* slide 8 of TMA's presentation for typical load transfer of a tractor-trailer combination vehicle during hard braking).

are typically installed on auxiliary axles should be available for a 20,000-pound auxiliary axle; in other words, it is not expected that disc brakes would be needed on the auxiliary axles in order to achieve satisfactory performance.

Next, we turn to TMA comment that dynamic load transfer to the steer axle may be an issue for some severe service tractors with four or more axles, such as the twin-steer example described above with a GVWR above 85,000 pounds. Using a 20,000-pound steer axle GAWR as an example, the agency believes there is not an adequate installation envelope to install a large enough disc brake to be able to meet a 250-foot stopping distance requirement for these vehicles. There are a number of constraints on the installation envelope that limit the diameter of the disc rotor and caliper assembly that can be fit within the inside diameter of the wheel rim, including: (1) The articulation of the spindle and foundation brakes needed for adequate steering cut; (2) vertical clearance with chassis components during dynamic steer axle loading (compression during hard braking); and (3) the size of the wheels. The agency agrees with TMA that, based on all available information, foundation brakes that could provide loaded-to-GVWR stopping distance performance in the 250-foot range are not available for these tractors. Further, NHTSA is not aware of sufficient test data available for such tractors fitted with the largest disc brakes to confirm this (noted in the TMA supplemental comments citing tests of prototype disc brakes that have not been tested extensively). Because of these inherent limitations of the steer axle brakes, the agency has decided to adopt requirements for stopping distance of tractors with four or more axles and a GVWR greater than 85,000 pounds of 310 feet (rather than 250 feet) along the lines of the requirements for single-unit trucks of this size. The agency believes, for the same reasons as discussed above, that tractor-trailers can achieve similar service braking performance as similar single-unit trucks.

e. Two-Axle Severe Service Tractors

We also respond to TMA's April 2006 comments regarding what it identified as a distinct class of severe service two-axle tractors, which TMA defined as a two-axle truck tractor having a drive axle GAWR of 23,000 pounds or more. Based on our review of the commenters' data, the agency does not believe that the commenters have provided sufficient information to justify allowing these tractors to be subject to a less rigorous stopping distance requirement than other two-axle tractors, and that the proposed specifications for improved stopping distances are practicable.

Commenters' test data show that two-axle truck tractors with a higher GVWR have similar braking performance to other two-axle tractors. TMA provided test data for one severe service two-axle tractor with standard 16.5″ x 5″ S-cam drum brakes on the steer axle and standard 16.5″ x 7″ S-cam drum brakes on the drive axle.[42] The stopping distance for this tractor was approximately 315 feet, so this brake configuration would not meet a 250-foot stopping distance requirement. However, this test result does not make it necessary to exclude severe service tractors from the improved stopping distance requirement entirely.

First, we note that the two-axle tractor cited by TMA is not a typical severe service tractor because it does not have a GVWR in excess of 59,600 pounds, thereby putting it outside the standard definition of a severe service tractor.

Second, of particular significance is the fact that this test result does not show how this vehicle would perform with upgraded brakes, specifically disc brakes. Disc brakes are the type of brakes that have been demonstrated to typically provide the shortest stopping distance. Therefore, the agency declines to use the TMA data on this ''severe service two-axle tractor'' in formulating the requirements of this final rule.

We do not have test data for this specific configuration of vehicle equipped with disc brakes. However, considering that the achieved stopping distance of the severe service two-axle tractor is roughly equivalent to what many other two-axle tractors can achieve when equipped with standard S-cam drum brakes at all wheel positions,[43] NHTSA believes that ''severe service two-axle'' tractors will be able to achieve similar enhancements using enhanced S-cam drum brakes or disc brakes in lieu of standard S-cam drum brakes. Therefore, the agency is not specifying a longer stopping distance for these vehicles. However, for reasons discussed below, the agency is providing a longer lead time for all two-axle tractors.

f. Summary of Severe Service Tractors

Based upon the above analysis, the agency is setting the loaded-to-GVWR stopping distance requirements for severe service tractors as follows:

- A tractor with three axles and a GVWR of 70,000 pounds or less must stop within 250 feet.
- A tractor with three axles and a GVWR greater than 70,000 pounds must stop within 310 feet.
- A tractor with four or more axles and a GVWR of 85,000 pounds or less must stop within 250 feet.
- A tractor with four or more axles and a GVWR greater than 85,000 pounds must stop within 310 feet.

Further, the agency does not recognize a class of two-axle severe service tractors, and notes that all two-axle tractors are required to meet a 250-foot stopping distance requirement.

The agency believes that these requirements will enhance vehicle safety by ensuring that the vast majority of tractors (estimated to be approximately 99 percent of annual tractor production) will meet a requirement with a 30 percent reduction in stopping distance. The remaining one percent of tractors, which are high-GVWR severe service tractors, will be required to meet a requirement with a 13 percent reduction in stopping distance, which is equal to the current required stopping distance performance for single-unit trucks. Finally, those tractors with any axle with GAWR of 29,000 pounds or greater will continue to be excluded from the FMVSS No. 121 requirements.

4. Braking Performance of Tractors With Improved Brake Systems in the Unloaded Weight Condition

In the NPRM, the agency proposed to reduce the existing FMVSS No. 121 unloaded weight stopping distance for heavy truck tractors from 335 feet by 20 percent (*i.e.,* to 268 feet) to 30 percent (*i.e.,* to 235 feet). Testing in the unloaded weight condition (also known as lightly-loaded vehicle weight or LLVW) is performed without any trailer attached to the tractor (*i.e.,* bobtail condition), plus up to an additional 500 pounds allowed for the test driver and vehicle instrumentation. In addition, up to 1,000 pounds is allowed for a roll bar structure. The tractor is required to meet the unloaded stopping distance requirement for at least one out of six test stops.

One potential issue that arises when reducing stopping distance in the lightly-loaded condition is the issue of wheel lockup, as there is far less available tire-road friction than in the loaded-to-GVWR condition. Requirements in FMVSS No. 121, S5.3.1, paragraphs (a) through (d), specify allowances for wheel lockup during either a service brake stopping distance test in the loaded or unloaded

[42] Docket # NHTSA–2005–21462–26.

[43] Docket # NHTSA–2005–21462–26.

condition, and applies to trucks, tractors, and buses. At speeds above 20 mph, wheel lockup on certain axles is only permitted to be momentary (less than one second), while unlimited wheel lockup on auxiliary axles is permitted. At speeds below 20 mph, unlimited wheel lockup is permitted on any wheel. These wheel lockup provisions were necessary before ABS was mandated, to ensure that the test driver could bring the vehicle to a stop without loss of control due to unlimited wheel lockup. In the case of a tractor in the unloaded condition, the drive axle wheels are very easy to lock up, as there is little vertical load on them. Prior to the advent of ABS, some tractors were equipped with bobtail proportioning valves to reduce the brake pressure to the drive axles in the unloaded condition and make it easier to stop the vehicle within the required distance (using more steer axle brake power, where a substantial vertical load exists), and also to improve the on-road drivability of bobtail tractors.

However, since March 1, 1997, all tractors have been required to be equipped with ABS on at least one steer axle and one drive axle, which has virtually eliminated wheel lockup in tractors. While the relevant FMVSS No. 121 requirement states that only one rear axle of a tractor needs to be equipped with ABS, most tractors also indirectly control the wheels on the other rear axle in the case of tandem drive axles, or they employ direct ABS control of both tandem drive axles. In the case of a severe service truck or tractor with non-liftable auxiliary axles mounted rearward of the tandem drive axles, an auxiliary ABS system may be necessary on those auxiliary axles to meet the wheel lockup provisions in S5.3.1, but trucks and tractors with liftable auxiliary axles typically do not need to have ABS on those axles. In addition, the braking-in-a-curve test in S5.3.6 was included in FMVSS No. 121 to ensure that the ABS provides adequate vehicle control and stability when in a curve on slippery pavement and subjected to a full-treadle brake application. The braking-in-a-curve test ensures that the ABS is regulating the braking forces at the wheels to keep the tires rolling, so they can generate the lateral forces required for maintaining the curve, and the vehicle does not plow out of the curve during braking.

In addition, ABS systems can help greatly decrease the stopping distances for lightly-loaded tractors. Since the addition of these ABS requirements, conducting braking tests on trucks and buses in the unloaded condition has been greatly simplified. Rather than requiring the driver to modulate the brake treadle to try to achieve the required stopping distance while staying within the wheel lockup provisions in S5.3.1, the test driver can make a full treadle brake application at the initiation of the stop and the ABS ensures that the wheel lockup provisions are met. The result is much greater braking efficiency and shorter stopping distances compared to driver-modulated stops. This is evident by reviewing the VRTC test data for tractors tested in the unloaded condition. Compared to the FMVSS No. 121 requirement of stopping within 335 feet (unloaded condition), typical bobtail tractor stopping distances for tractors with improved foundation brake systems are approximately 180 feet, or 46 percent lower than the current 335-foot requirement. As an example, VRTC tests of the tractors equipped with hybrid disc/drum brakes and all-disc brakes resulted in unloaded stopping distances ranging from 176 to 183 feet (six tests), meeting a target stopping distance of 235 feet (a 30 percent reduction from the current stopping distance requirement) with margins of compliance ranging from 25 to 22 percent.

It is likely that even current standard drum brakes have the necessary torque to permit a substantial reduction in tractor stopping distance in the lightly-loaded condition. VRTC tests of the 6x4 severe service truck (used as a surrogate example of a severe service tractor) with all disc brakes (224-foot loaded-to-GVWR stopping distance) stopped in the lightly-loaded condition in 172 feet, meeting a target distance of 235 feet with a 27 percent margin of compliance. Even when tested with brake configurations that did worse in the loaded-to-GVWR test condition (all drum brakes and disc/drum brake hybrid configurations), the unloaded stopping distances were 172 feet and 178 feet. This indicates that stopping performance in the unloaded condition for this severe service vehicle was not significantly sensitive to the configuration of the foundation brakes, since any combination of foundation brakes could fully utilize the available tire-road friction of the vehicle in its light weight condition. Further, it demonstrates that the ABS system (6S/6M on this vehicle) delivered good efficiency in keeping the braking force near the peak of available tire-road friction.

Very few comments were received on the agency's proposal to reduce the stopping distance in the lightly-loaded condition by 20–30 percent. No test data were submitted on stopping performance of tractors equipped with improved braking systems tested in the lightly-loaded condition. Several commenters made recommendations. TMA and ArvinMeritor recommended 25 percent reductions in lightly-loaded stopping distances, and IIHS recommended a 30 percent reduction, but no data were provided to support these recommendations. TMA stated that currently under unloaded conditions, tractors experience some wheel slip at brake applications of 30 psi, and that if the steer axle brake is improved to meet a 30 percent reduction in stopping distance, rear wheel slip might be experienced at as little as 20 psi. However, considering that TMA is recommending a 25 percent decrease in stopping distance in the unloaded condition, we believe the shorter stopping distance achieved more than compensates for the slight increase in ABS activations under these conditions.

Based on the available data, the agency believes that a longer lightly-loaded stopping distance is not necessary for the highest-GVWR severe service tractors. Those vehicles have been provided with some relief (310-foot loaded-to-GVWR stopping distance requirement, as opposed to 250 feet) for tests in the loaded condition because of the torque-generating limitations of foundation brakes. However, the agency does not believe that any relief is needed for these tractors when tested in the lightly-loaded condition. The definition of a ''truck tractor'' in 49 CFR 571.3 specifies that it is ''primarily for drawing other motor vehicles and not so constructed as to carry a load other than a part of the weight of the vehicle and the load so drawn.'' Therefore, tractors in the lightly-loaded condition have extremely light load weights relative to their GVWR since they do not have any load-carrying capability outside of trailer towing. Tractors in the lightly-loaded condition, including the heaviest GVWR severe service tractors, can therefore achieve braking performance similar to each other.

In this final rule, the agency is setting the heavy truck stopping distance requirement in the lightly-loaded condition at 235 feet, a 30 percent reduction from the existing FMVSS No. 121 requirement. The available test data, while limited in terms of the number of tests conducted, indicate that margins of compliance of 20 percent or more can readily be attained. Severe service tractors that have lift axles would be expected to perform similarly, as the lift axles would be in the raised position during this test. To the agency's knowledge, severe service tractors equipped with improved brake systems that have non-liftable auxiliary axles, or tridem drive axles, have not been tested, but are expected to perform similarly or with only slightly longer stopping distances (*e.g.,* due to driveline and axle interactions on a tridem drive system, or slightly lower tire traction due to aggressive off-road tread patterns). However, due to the large margins of compliance already achieved, the agency believes that the 235-foot requirement is practicable for tractors that might have slightly longer stopping distances than the typical examples tested.

One minor issue that the agency is addressing is the lack of a fuel tank fill specification in FMVSS No. 121. Vehicle curb weight is measured with all fluid levels and reservoirs (*e.g.,* antifreeze, windshield washer fluid) at the recommended levels (*i.e.,* filled to capacity or other designated fill levels). The agency reviewed FMVSS No. 121 for a specification on the vehicle's fuel tank fill level during road tests and found that this is not addressed. In contrast, FMVSS No. 135, *Light Vehicle Brake Systems,* specifies under the vehicle test conditions in paragraph S6.3.2 that the fuel tank shall be filled to 100 percent of capacity at the beginning of testing and that it may not be less than 75 percent of capacity during any part of the testing.

The agency is adding a similar requirement to FMVSS No. 121 in this final rule. The lack of a fuel tank fill specification adds a possible source of test variability, such as when testing in the lightly-loaded condition where the additional weight of the fuel may be advantageous, in that it may increase the tractor test weight and thus provide additional tire friction at the drive axles. Therefore, by specifying that the fuel tank(s) must remain at least 75 percent full during all portions of the brake testing, test variability is reduced. Test severity is not increased as a result of providing this specification. We note that for the loaded-to-GVWR tests, this specification permits up to 25 percent of the fuel to be used over the course of testing without continually adding ballast or refueling the vehicle.

5. Emergency Braking Performance of Tractors With Improved Brake Systems

a. Background Information on the Emergency Braking Performance Requirement

In the NPRM, the agency proposed to reduce the emergency braking stopping distance in FMVSS No. 121 by 20 percent to 30 percent, from the current 720 feet to a value between 580 feet and 504 feet. However, in light of concerns raised in the comments, NHTSA has decided against adoption of any change in the standard's emergency brake stopping distance performance requirements.

The emergency brake system requirements in FMVSS No. 121 are tested by inducing a single failure in the service brake system of a part designed to contain compressed air, excluding specific components (*i.e.,* a common valve, manifold, brake fluid housing, or brake chamber housing).

Test data from VRTC tests of tractors in the emergency braking mode were provided in Table II of the NPRM. These tests were conducted with failed primary systems, and, therefore, the data represent the performance of tractors stopping using only the steer axle brakes. The longest stops measured were with standard, 15″ x 4″ S-cam drum brakes (636 feet for one tractor and 432 feet for the other tractor). As steer axle brake improvements were made, emergency stopping distance also improved. The best stops were with disc brakes on the steer axle (four tests), which ranged from 276 to 303 feet, demonstrating very good margins of compliance against the 720-foot FMVSS No. 121 requirement. Thus, the agency's proposed requirements of 504 feet to 580 feet for emergency brake stopping distance appeared to be achievable with improved brake systems.

b. Commenters' Responses to Proposed Emergency Braking Performance Requirement

Several commenters (Bendix, ArvinMeritor, International) recommended that the agency leave the standard's emergency brake stopping distance requirements unchanged. Bendix argued that increasing the torque output on foundation brakes would have a corresponding decrease in emergency brake stopping distance, but only if the improved brakes are used in the emergency stopping test. Thus, a tractor that has had its steer axle brake improved to meet a 30 percent reduction in stopping distance would exhibit no enhancement in emergency braking performance if the front brake circuit (secondary air system) were disabled. This would potentially cause the vehicle to fail that portion of the emergency brake stopping distance test, even with improved foundation brakes. Bendix stated that the agency has not provided evidence of a need for improved emergency braking system performance in its analysis. ArvinMeritor commented that emergency braking performance in the failed secondary air system test (*i.e.,* using only the drive axle brakes, which have a very low weight when measured in the unloaded condition) is already limited by tire-road adhesion today, thus making further improvements impossible due to wheel lockup.

In its comments, TMA stated that the emergency braking performance of tractors with improved brake systems could lead to more aggressive lockup of wheels on the drive axle(s) during emergency braking. According to TMA, increased use of ABS could cause the emergency braking performance with improved drive axle brakes to be worse than with current foundation brakes. TMA stated that truck manufacturers would need to modify the ABS algorithms to allow more drive wheel lockup to meet the agency's proposed emergency brake stopping distance requirements, and that this would be detrimental to vehicle stability and control. Further, TMA commented that the likelihood of a crash-imminent situation occurring at the same time as a failure in either the primary or secondary air systems is immeasurably small.

Although somewhat counterintuitive, the agency acknowledges that the failed secondary system braking performance of tractors might be negatively impacted by improved brake systems, as suggested by the commenters. Accordingly, we have decided that not to make any changes in the emergency brake system stopping distance requirements at this time. Maintaining the status quo for emergency brake stopping requirements is not expected to have any negative effect on achieving the estimated safety benefits of the overall heavy truck stopping distance rulemaking, because tractors operating in bobtail mode and experiencing an emergency braking situation are not significant contributors to the crash problem that has been identified.

ii. Ancillary Issues Arising From Improved Brake Systems

1. Stability and Control of Tractors With Improved Brake Systems

Several commenters (TMA, HDBMC, ATA) brought up a number of issues relating to the stability and control of tractors that arise from installation of improved brake systems pursuant to the agency's proposal to improve heavy truck stopping distance performance requirements by 30 percent. These issues included potential problems with lateral stability (especially in two-axle, short wheelbase tractors), excessive steering wheel pull, and excessive steer axle suspension jounce (compression). Commenters stated that these problems would be expected to apply to all tractors, but commenters expressed their opinion that such problems would likely be especially acute in two-axle tractors, particularly in those with a shorter wheelbase.

In a meeting held with NHTSA on March 29, 2006, representatives of TMA, HDBMC, and ATA discussed several issues involving tractors with improved brake systems that were included in presentation materials available for review in the DOT docket.[44] One issue raised in that presentation involved computer simulations provided by TMA which were conducted by Freightliner of two tractors in a braking-in-a-curve maneuver (*see* Slide 10). In that maneuver, the tractor with more powerful foundation brakes (a hybrid configuration of front disc brakes and rear drum brakes) experienced a jackknife loss-of-control, while the tractor with standard drum brakes remained stable. According to TMA's comments, this indicated that installing more powerful foundation brakes to improve performance in the straight-line stopping distance test could have the unintended consequence of inducing stability problems in some on-road driving situations. Thus, TMA raised concerns about the stability and control of short-wheelbase two-axle tractors when more powerful foundation brakes are applied. Although not depicted in the presentation slides, the following were the test conditions for the above scenario, as described by TMA at the meeting:

- The curve has a radius of 500 feet and was a high-friction dry surface (0.9 peak coefficient of friction).
- The entry speed of the tractor was 48 mph.
- The tractor was connected to a tandem-axle trailer, and the trailer was rear-loaded to 34,000 pounds weight on the trailer axles.
- The trailer was unbraked.
- A full-treadle brake application was used.

While the maneuver described by TMA has some similarities to the FMVSS No. 121 stability and control test requirement that is used as a pass-fail measure to assess the performance of a tractor's ABS (*see* S5.3.6.1), the agency does not believe that the TMA test is appropriate for assessing the vehicle's stability, due to vital differences in the test procedures, as explained below. In the FMVSS No. 121 test, the road surface is wetted and slippery (0.5 peak coefficient of friction as opposed to 0.9), and the entry speed is typically between 30 and 34 mph, as opposed to 48 mph. The loading condition of the trailer in the FMVSS test is also different. Although an unbraked FMVSS No. 121 control trailer is used, in the FMVSS test, the trailer is front loaded (*i.e.,* loaded over the kingpin at the front of the trailer) in order to load the tractor to its GVWR. In contrast, in the TMA test, the trailer was rear loaded, which puts the majority of the weight on the unbraked trailer axles rather than the tractor's drive axles. This maneuver deprives the drive axles of braking traction, and constitutes a worst-case braking scenario.

At the March 29, 2006 meeting, the agency questioned whether TMA's simulation is representative of a real-world driving situation. As explained below, the simulation appeared to the agency to be a combination of several worst-case scenarios, the first of which involves the high entry speed of the tractor that, for this curve, approaches the rollover threshold of some high-center-of-gravity tractor-trailer combinations. Second, the trailer is rear-loaded, which is not a safe operating practice. (In general, trailers should not be rear-loaded because the tractor drive axles will be too light during braking and/or acceleration.) Third, the trailer brake system was deactivated. Finally, the test assumes a full-brake application which, on the highway, represents a panic braking situation. As a result, the agency is not convinced by TMA's comment that improving the steer axle brakes will have a negative impact on lateral stability.

The agency has further reason to doubt TMA's assertion that lateral stability will be negatively impacted by improving the tractor's foundation brakes. In its comments, TMA referred to a Society of Automotive Engineers (SAE) technical paper, *A Study of Jackknife Stability of Class VIII Vehicles with Multiple Trailers with ABS Disc/Drum Brakes* (SAE 2004–01–1741). TMA stated that this study, consisting of vehicle simulation modeling to evaluate the stability of two-axle tractors towing double trailers, found that two-axle tractors with more aggressive brakes either jackknifed or ran off the road under various combinations of conditions. However, based upon the agency's review, that study seems to indicate that more powerful foundation brakes were not a cause of the jackknifing, but rather that the cause was a lack of tractor ABS. In analyzing this SAE report, the agency notes that only when the tractor ABS was disabled did instability occur, and it occurred regardless of whether the tractor was equipped with S-cam drum brakes or disc brakes. However, the type of instability exhibited varied depending upon the types of foundation brakes installed on the tractor; specifically, tractors with all drum brakes went into a jackknife (oversteer), while the tractors with disc brakes tended to plow out of the curve (understeer).

The only benefit of less powerful brakes indicated by the tractor simulations with inoperative ABS was that the lane departure occurred sooner in the maneuver when the tractor was equipped with disc brakes. We do not believe that this argument justifies a requirement that would result in installation of weaker foundation brakes. Instead, we believe that this study is more indicative of the importance to fleets in maintaining ABS on tractors, trailers, and converter dollies. It is also important to note TMA's comment that 4 to 16 percent of tractors and 8 to 26 percent of trailers in service have non-functioning ABS or ABS warning lamps. While this rulemaking does not relate to in-service maintenance issues (issues which generally fall under FMCSA's jurisdiction), proper maintenance is very important.

The agency conducted an additional investigation to determine the validity of the TMA testing regarding lateral instability. To further investigate suggestions regarding the potential for increased lateral instability, the agency held a meeting with the TMA at the VRTC in East Liberty, Ohio, on July 11, 2006.[45] At that meeting, the agency presented results of several braking-in-a-curve simulations performed at VRTC using its Truck Sim vehicle dynamics modeling software to estimate the scope of potential vehicle instability problems for two-axle tractors. In a high-friction (*i.e.,* 0.9 coefficient of friction, or mu), 500-foot radius curve braking test with a rear-loaded, unbraked trailer, a two-axle tractor with a very short wheelbase of 130 inches experienced a jackknife condition. Two other tractors with short wheelbases (142 and 148 inches) were marginally stable, meaning they were not under full control, but did stay within the 12-foot-wide lane. For comparison purposes, we note that a three-axle tractor with a 190-inch wheelbase remained stable during this maneuver. The agency also performed slippery-surface (low friction) tests at 45 mph, and found that a short-wheelbase tractor (148 inches) spun out both with standard drum brakes and with disc brakes. This test also caused a standard three-axle tractor (with drum brakes) to spin out. For a final comparison, we

[44] *See* Docket No. NHTSA–2005–21462–33.

[45] Docket No. NHTSA–2005–21462–36.

note that during a previous track test, even a high-performance sports car spun out during this maneuver at 45 mph. Again, these results demonstrated to the agency that the TMA test was too rigorous for any typical vehicle to be able to navigate the curve.

Further, we note that in its supplemental comments from October 2006, TMA submitted information about tests on four two-axle tractors that showed substantially fewer problems of lateral instability than had been suggested earlier. The results of these tests showed that two-axle tractors are capable of maintaining a high degree of lateral stability when equipped with improved foundation brakes. TMA acknowledged that these vehicles did not exhibit controllability or handling problems. Nonetheless, TMA suggested in its supplemental comments that due to the relatively large amount of testing and validation required for issues such as brake lining, brake chamber sizes, slack adjuster lengths, tire properties, ABS algorithms, and potentially electronic stability control (ESC) systems, additional lead time for two-axle tractors may be required.

In the end, after considering all of the available information on stability and control that affects shorter wheelbase, two-axle tractors, the agency has decided that an allowance for longer stopping distances is unnecessary. Only under the most severe conditions was instability found to be an issue, and rarely did it correlate with the improved braking systems. Nonetheless, the agency is aware that there is a greater need for additional design efforts and validation on two-axle tractors, so in this final rule, we are providing more lead time for manufacturers to achieve compliance with the new stopping distance requirements for these tractors, thereby providing manufacturers with more time to identify and remedy potential problems. (The issue of the compliance date is addressed in further detail below in Section III, c, viii.)

2. Brake Balance Issues on Tractors With Improved Brake Systems

Because the main factor in generating the additional brake torque to achieve a reduced stopping distance is the addition of more powerful steer axle brakes, the effects of more powerful steer axle brakes are raised by this rulemaking. These issues involve the balance of braking power generated by different tires, as well as concern that the new designs could engender off-balance brake systems. Two issues raised included the difference in brake torque generated by the steer and drive axles, and the potential for increased steering wheel pull resulting from more powerful steer axle brakes. The agency addresses each of those concerns below.

Several commenters asserted that the mandate to decrease stopping distance would necessitate less powerful drive axle brakes on two-axle tractors, because dynamic loading would cause the weight on the drive axle to be substantially less during hard braking.[46] Freightliner commented that because 31 percent of the rear axle load will transfer to the steer axle during hard braking, two-axle tractors will require less powerful drive axle brakes than they currently have. While Freightliner did not provide a rationale for this in its comment, it is presumed that this would be to improve brake balance at maximum braking, without having to cycle the ABS on the drive axle. Similarly, ATA commented that it may be necessary to reduce drive axle brake power on two-axle tractors to compensate for the weight transfer to the steer axle. In its original comments, TMA also argued that decreasing the drive axle torque by 20 percent would be necessary to prevent ABS activation, which could result in even longer stopping distances. All of these commenters argued that the combination of much more powerful steer axle brakes and less powerful drive axle brakes would result in a vehicle that would perform poorly under real-world conditions, arguing that the agency should not consider the issue of stopping distance in isolation.

The agency's test data, however, do not fit with these statements. The agency's data indicate that a reduction in drive axle torque would not be necessary to improve stopping distances in hard-braking situations. Test data from VRTC[47] tests on a two-axle tractor showed that after installing more powerful steer axle disc brakes, installing more powerful drive axle brakes only served to shorten overall stopping distance. The agency also notes that this improvement occurred without stability or control problems when tested both in the lightly-loaded and loaded-to-GVWR conditions as specified in the FMVSS No. 121 braking-in-a-curve test. In nearly every test, whether using two-axle, three-axle, or severe service tractors, the tractors that achieved the shortest stopping distances were those equipped with more powerful disc brakes at all wheel positions. In all tests, the ABS was found to perform very efficiently in limiting wheel lockup and allowing tractors with improved braking systems to maintain good stability in both straight line and braking-in-a-curve tests.

On a related topic, TMA also commented that more powerful steer axle brakes could contribute to instability through steering wheel pull. Steering wheel pull can occur when the steer axle brake on one side of the vehicle is able to produce more braking power than the brake on the other side. This is an issue that affects all tractors with enhanced steer axle brakes, not just two-axle tractors. TMA stated that on ''split-mu surfaces,'' *i.e.,* ones where one side of the road has less friction than the other (such as transitional surfaces, or when one side of the road is wet), imbalances in steer axle brakes are magnified and drivers must provide sufficiently more frequent and aggressive steering wheel input to keep the vehicle on its intended path. TMA argued that if the power of the steer axle brakes were increased, the potential effects of side-to-side imbalance would also increase.

The agency believes that disc brakes, in general, will provide better steer axle brake balance than current standard drum brakes do. This is because for any given air pressure, the torque output of drum brakes can vary by 30 percent due to hysteresis,[48] lining variations, brake adjustment, and drum condition (*e.g.,* eccentricity and being out-of-round). In comparison, for any given air pressure, disc brakes typically do not have variations in torque output exceeding 10 percent. Thus, in a tractor with two disc brakes on the steer axle under braking, there would typically be less steering wheel pull during braking, as compared to a tractor using drum brakes. However, the agency is aware that if a manufacturer chose to upgrade the steer brakes to enhanced S-cam drum brakes, there is a potential for more steering wheel pull than with standard S-cam drum brakes.

Steering wheel pull on split-mu road surfaces is a potential problem with any type of brake (although most significantly with enhanced drum brakes), but there are various steps that

[46] ''Dynamic Loading'' refers to the temporary redistribution of downward force during a hard braking incident. During rapid deceleration, proportionally more weight is borne by the front of the tractor (the steer axle) and less is borne by the rear (the drive axle and the trailer axle). In two-axle tractors, where proportionally more weight is borne by the steer axle than in other designs, the concern is that during hard braking, too little weight will be borne by the drive axles, and the available tire-road friction will not be high enough to allow them to utilize all of the available brake torque. In these situations, the ABS would be activated, lessening those brakes' effectiveness.

[47] Docket #NHTSA–2005–21462–39, p. 25.

[48] Hysteresis refers to friction in the foundation brake components.

manufacturers can take to ameliorate the problem. One approach is to utilize a modified individual wheel ABS control strategy to reduce the pressure to both steer axle brakes in the event the wheel on the low-friction surface approaches lockup. In its comments, Meritor Wabco stated that most of today's antilock systems use Modified Individual Regulation (MIR) on the steer axle to reduce the yaw moment produced when different levels of torque are generated by the steer axle brakes, a situation that typically occurs during braking on split-mu surfaces. According to the commenter, after a short amount of time, the pressure can be adjusted to match the friction at each wheel. This action can result in steering wheel pull, but it is added incrementally, so it does not surprise the driver. This method of ABS control ensures that the driver is able to easily control the vehicle during the maneuver, and it also produces a shorter stopping distance by taking advantage of the higher braking forces generated by the wheel on the high friction surface. Thus, the agency believes that the potential for additional steering wheel pull is small, and when combined with advancements in ABS and the use of disc brakes, we have decided that this is not a reason to adopt a less stringent stopping distance requirement.

3. Brake Balance and Trailer Compatibility Issues for Tractors With Improved Brake Systems

a. Brake Balance Between the Steer and Drive Axles

''Brake balance'' refers to the concept that brakes on the steer axle and drive axle(s) should provide approximately equal shares of the retardation force in response to the dynamic loads placed on them during hard braking. Currently, the drive axle brakes of many tractors produce a large percentage of the total brake torque during heavy braking, as steer axle brakes are designed for long life. When addressing the issue of good brake balance on a tractor that is loaded to its GVWR and subjected to a full treadle brake application, the agency must take into account that the vertical load on the steer axle can increase by up to 50 percent or more. It is therefore expected that manufacturers will meet the reduced stopping distance requirements in this rulemaking primarily by improving the brake torque of steer axle brakes, thus allowing good brake balance during hard braking applications.

The agency notes that a bobtail tractor (*i.e.,* with no trailer) will generally have poor brake balance. This is because the drive axles have a very low vertical loading, while the steer axle is typically closer to its rated capacity. In that case, a tractor is reliant on its ABS to prevent drive axle wheel lockup during moderate and hard brake applications. This rulemaking will not have a substantial effect on the brake balance of tractors operated in the bobtail condition.

Achieving the desired loaded-to-GVWR, limit-of-performance stopping distance reduction, as well as brake balance, will generally require upgrades to both the steer and drive axles of a truck tractor. The benefits of this rulemaking will primarily be achieved by increasing the steer axle brake power on tractors. As previously discussed, small improvements are also likely to be needed on tractor drive axles, as test data show there were no tractors complying with 30 percent reductions in stopping distance, with good margins of compliance, using standard-sized 16.5″ x 7″ drive axle S-cam drum brakes. Agency testing has shown that increasing the drive axle brake power allows better utilization of the available tire friction and reduces brake fade during a single high-speed stop and also during repetitive stops at all speeds.

Several organizations commented on the issue of brake balance between the steer and drive axles. HDMBC stated that improvements in brake torque will mainly be on the steer axles of tractors, and this will result in the steer axle doing a larger share of combination braking work that could affect brake wear balance. However, HDBMC did not recommend that NHTSA take any particular regulatory action in light of this. Haldex stated that more evaluation will be needed to determine the effects of improved braking systems on brake balance.

The agency agrees that the majority of improvements in tractor braking performance will be gained by significant increases in steer axle brake torque. The agency believes that this will result in improvements in the tractor's brake balance during maximum effort braking, as under current conditions, standard steer axle brakes do not have the same power as drive axle brakes. The agency also believes that modest increases in tractor drive axle brake torque will be necessary for most tractors, but we do not think that this will cause significant brake balance issues, as some commenters argued. In reaching this conclusion, the agency notes that the available test data show that one of the best-performing three-axle tractors (used in the Radlinski tests) was a tractor currently used in regular fleet service, so we presume that this vehicle exhibited acceptable brake balance in terms of both performance and maintenance costs. We also note that the enhanced drive axle drum brakes on this tractor (16.5″ x 8.625″) were primarily designed for long service life. This is achieved by operating at lower temperatures during low-pressure braking, thereby reducing lining wear that is temperature-sensitive.

In its comments, ArvinMeritor argued that reductions in stopping distance of over 25 percent would adversely impact brake balance and would likely result in significant dissatisfaction on the part of end users. ArvinMeritor stated that these concerns specifically include brake lining life reductions, brake drum durability problems, more frequent maintenance, and reduced vehicle uptime as a result of these issues. ArvinMeritor also stated that tractor-trailer compatibility will be a significant issue if the standard were to require stopping distance to be reduced by more than 25 percent from current levels. The commenter claimed that the mixing of new truck tractors with either new or old trailers would represent a real and disruptive issue for the trucking industry, although it failed to state why it would cause disruption.

Without any supporting data for ArvinMeritor's comment, the agency cannot accept its above-stated position, particularly given the substantial evidence in the record that tractor-trailer compatibility will not be negatively affected by the improved foundation brake systems on new truck tractors. Although the agency is not aware of any published reports on the compatibility issue of tractors with improved brake systems being used with the existing trailer fleet, we note that the tests conducted by Radlinski (using a three-axle tractor with enhanced S-cam drum brakes on both the steer and drive axles) were with a production vehicle used in regular fleet service. Those tests were conducted in 2003, and tractors such as the one tested have been in use since at least that time, with no indications of brake balance or trailer compatibility problems of which the agency is aware. Further, in 2004, the agency (in concert with other government agencies and private industry partners under cooperative agreement contract) completed field tests of 50 Volvo three-axle tractors equipped with disc brakes in regular fleet service.[49] The disc brakes were one component of several crash avoidance enhancement systems installed on these tractors. No compatibility or brake

[49] *See http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/14349.htm.*

balance issues were found among these vehicles during extensive operation with trailers equipped with standard, 16.5″ x 7″ S-cam drum brakes. Brake lining wear rates on the tractors were lower than those of standard drum brake components, and similar to the wear rates of extended life (enhanced) S-cam drum brakes.

b. Tractor-Trailer Compatibility

''Tractor-trailer compatibility'' is closely related to brake balance and has a similar definition. Traditionally, that term has been defined to mean equal truck tractor drive axle brake operating conditions and life relative to trailer axle brake operating conditions and life. The compatibility issue is important for end-users of tractor-trailers, as they desire even wear on trailer and tractor drive axle brakes. One commenter, ArvinMeritor, stated that typically, tractor-trailer compatibility does not include steer axle brakes, due to comparatively lower torque output and resulting longer life compared to the other brakes in the combination. The agency understands that under the current stopping distance requirements, typical steer axle drum brakes (15″ x 4″) have comparatively low torque output and long life compared to brakes at other wheel positions.

Several commenters argued that the majority of braking takes place at pressures between 10 psi and 15 psi, as opposed to full treadle brake applications. HDMBC commented that at these pressures, balanced brake wear is expected between the truck tractor and trailer by the end user. HDBMC stated that further evaluation may be needed in light of the increased percentage of braking contributed by the truck tractor.

Similarly, many commenters discussed how the improved stopping distance requirements in the agency's proposal would require the tractor to take on an increased percentage of the total braking of the truck tractor/trailer combination. Haldex and HDBMC both raised this issue, although neither recommended that NHTSA take any particular regulatory action in light of this issue. HDBMC stated that its purpose in commenting on this issue was to highlight the impact that reduced stopping distance requirements will have on maintenance costs and end-user acceptance of new vehicles, while Haldex merely stated that brake balance will require more evaluation.

ATA commented that tractor-trailer compatibility should not be an issue if stopping distance were reduced by only 20 percent. However, ATA did not comment on potential compatibility issues for a 30 percent reduction. ATA stated that in the case of two-axle and severe service tractors, there could be operational or safety issues associated with the reduced stopping distance proposal, and, therefore, a delay in the implementation of new requirements for those vehicles would be needed to overcome these issues.

ArvinMeritor relayed significant concerns regarding tractor-trailer compatibility in its comments. ArvinMeritor stated that reductions in stopping distance of up to 25 percent can be achieved without sacrificing brake balance or tractor-trailer compatibility. It stated that this is because that level of reduced stopping distance can be achieved by only increasing steer axle brake torque. However, it stated that for reductions of over 25 percent, increases in tractor drive axle torque will be necessary, and that this will adversely impact brake compatibility and result in more frequent brake maintenance and reduced vehicle uptime. Arvin Meritor stated that it does not have enough information on the compatibility of tractors with air disc brakes when operated with the existing trailer fleet to provide more specific comments.

NHTSA does have testing information on disc brakes, and after evaluating that data, the agency believes that disc brakes installed on a typical three-axle tractor's drive axles would not have detrimental brake balance issues during braking. Dynamometer testing was performed at VRTC on two brands of 16.5″ x 7″ S-cam drum brakes and two brands of air disc brakes (one 16.93″ rotor diameter x 1.77″ rotor thickness, the other 16.90″ x 1.77″) [50] to quantify such characteristics. In one comparison of an S-cam drum brake to a disc brake, similar torque outputs were produced when each brake was stopped on the dynamometer from an initial speed of 30 mph. However, when stopped from a high speed of 70 mph, the S-cam drum brake lost 42 percent of its maximum effectiveness while the disc brake lost only 24 percent of its maximum effectiveness. Such a disc brake, when installed on a typical tractor drive axle, would not be expected to have detrimental brake balance issues under normal, low-pressure braking because the torque output is similar to the drum brake. In addition, it provides much shorter stopping distance when under hard braking from highway speeds because of reduced brake fade.

There is also the possibility that the drive axle can be equipped with an enhanced S-cam drum brake instead of an air disc brake, as it would be in a hybrid or all-drum brake configuration. While the agency has not completed sufficient testing of enhanced drive/trailer axle S-cam drum brakes (either 16.5″ x 8″ or 16.5″ x 8.625″) under its dynamometer test program at VRTC to determine the reasons for improved torque generation, it is likely that the wider brake drum has increased thermal capacity. This is because the total friction between the lining and the drum would take place spread out over a larger area. Therefore, during a single, 60 mph stop, experience has shown that there would be less fade than for a standard 16.5″ x 7″ axle brake. The agency may conduct future dynamometer testing at VRTC to determine in further detail the characteristics of the enhanced S-cam tractor drive axle drum brake. Currently, however, the agency refers back to the use of the in-service truck tractor used in the Radlinski tests (which used enhanced drum brakes) as evidence of the lack of significant brake balance issues using enhanced S-cam drive axle drum brakes.

c. Brake Balance and Trailer Compatibility Issues for Two-Axle and Severe Service Tractors

NHTSA does not believe that two-axle or severe service tractors will have problems with regard to brake balance and trailer compatibility.

There were no comments regarding tractor-trailer compatibility for two-axle tractors, although Freightliner expressed concern that two-axle tractors may suffer from tractor-trailer compatibility problems of reduced balance when used with existing trailer brakes. The agency is aware of little data on the brake balance and trailer compatibility issues for two-axle tractors with improved brake systems, and most of the comments on two-axle tractors were concerns with stability and control rather than issues of balance between steer and drive or tractor and trailer brakes. NHTSA is aware that some two-axle tractors are already being equipped with larger 16.5″ x 5″ steer axle S-cam brakes, and presumably these brakes are providing satisfactory brake balance trailer compatibility in fleet service. While test data cited above shows that two-axle tractors can attain the reduced stopping distances using disc brakes on the steer and drive axles, that data did not consider compatibility with existing

[50] SAE Technical Report, *Comparison of Heavy Truck Foundation Brake Performance Measured with an Inertia Brake Dynamometer and Analyses of Brake Output Responses to Dynamic Pressure Inputs* (SAE Report No. 2005–01–3611, Hoover and Zagorski, Transportation Research Center, Inc.). Available from SAE, and the report is available for review at NHTSA's Technical Reference Division.

trailers (and converter dollies, as two-axle tractors are often used in double- or triple-trailer combinations).

Given the lack of data or other evidence of a problem, we think that Freightliner's arguments in this context involve speculative concerns; consequently, the agency currently has no reason to believe that two-axle tractors with improved brake systems will have compatibility issues. Nonetheless, considering the complexity of brake system interactions and the current lack of available data (as well as for many other reasons, discussed at length below), the agency has decided to provide longer lead time for the requirements of this final rule for two-axle and severe service tractors so as to provide four years of lead time. This will provide truck manufacturers time to develop designs that do not have problems in this area.

The agency similarly received few comments regarding trailer compatibility for severe service tractors. However, both TMA and Freightliner stated that some heavier severe service tractors are limited to low speeds when fully loaded, and if such a tractor were required to comply with shorter stopping distances from 60 mph, the brakes would be over-designed (*i.e.,* be too powerful for their typical usages). At highway speeds with light loads, this could result in excessive wheel lockup.

The agency has already partially addressed this issue by providing a longer, 310-foot stopping distance requirement for high-GVWR severe service tractors. We understand that many of the severe service tractors that require escort vehicles and low speeds when loaded to GVWR fall into this category, or have a GAWR over 29,000 pounds, and thus are excluded from FMVSS No. 121 entirely. In addition, because the overall brake balance problem for the widely-varying loading condition already exists for these vehicles, we believe that installation of improved brake systems on severe service tractors would have only an incremental (and minimal) effect on brake balance and trailer compatibility.

iii. Cargo Securement

A comment from OOIDA stated concern that the proposed requirement of shorter stopping distances would increase the g-forces acting upon a truck's load to the point where such forces exceed the conditions specified in standards for cargo securement under Federal Motor Carrier Safety Administration (FMCSA) regulations. Under the relevant provisions of FMCSA's cargo securement requirements, 49 CFR 393.102(a)(1) provides that tiedown assemblies (including chains, wire rope, steel strapping, synthetic webbing, and cordage) and other attachment or fastening devices must be designed, installed, and maintained to ensure that the maximum forces acting on the devices do not exceed the manufacturer's breaking strength under a 0.8g deceleration in the forward direction. These requirements were adopted in a September 27, 2002 final rule (67 FR 61212) and became effective on January 1, 2004. The purpose of this FMCSA requirement is to reduce crashes caused by incidents of shifting and falling cargo.

In response to OOIDA's comment, the agency reviewed deceleration rates from tractor tests with improved brake systems to determine whether the cargo securement limits had been reached. Agency testing indicated that under FMVSS No. 121 testing in the loaded-to-GVWR condition with an unbraked control trailer, deceleration rates of approximately 0.65g were typical. However, as noted by Freightliner in its comments, such a tractor is capable of higher deceleration rates when operating with a normal load on a braked trailer. Freightliner stated that tests of such a combination vehicle showed that it was able to stop in 187 feet from a speed of 60 mph, but did not provide deceleration data for this test.

After reviewing the previously-discussed data from VRTC, NHTSA believes that trailers will not exceed FCMSA's cargo securement requirement. The agency analyzed stopping data for a two-axle tractor equipped with disc brakes at all wheel positions, towing a 53-foot van trailer which was also equipped with disc brakes. The tractor and trailer had normal ABS control of all wheels, and had the shortest measured stopping distance of all tractor-trailer combination tests at VRTC. In the test, the tractor steer axle was loaded to 11,000 pounds; its drive axle was loaded to 22,700 pounds, and the tandem trailer axles were loaded to 34,000 pounds (loaded-to-highway weight). This combination stopped from 60 mph in a distance of 186 feet. NHTSA reviewed the deceleration rate during the stop and notes that deceleration was fairly constant at approximately 0.8g once steady-state deceleration was achieved (approximately 0.6 seconds after the full treadle application).[51] We do note that there were momentary spikes of higher and lower deceleration (typical for data traces of this type), with the highest peak at 0.89g for a very short duration. However, the accelerometer was mounted on the tractor frame, and it is NHTSA's belief that the acceleration peaks were anomalies likely due to vibration, as it would not possible for a massive object such as a loaded tractor or trailer to have acceleration rate changes indicated by the peaks. Therefore, the agency has concluded that the highest deceleration rate by a tractor with improved brakes was slightly below 0.8g, thus remaining under the deceleration specified by FMCSA's cargo securement requirement.

The agency also reviewed deceleration data for the VRTC test tractor in the unloaded condition, and we arrived at similar conclusions. The unloaded stopping distance for this tractor-trailer combination was 191 feet (a longer stopping distance than 187 feet, and thus producing even less g-forces on deceleration), which indicates that both in the loaded and unloaded condition the limits of tire adhesion have been reached. The slightly longer stopping distance in the unloaded condition is likely due to additional cycling of the ABS on both the tractor and trailer compared to the loaded-to-highway weight testing.

iv. Testing Procedures

1. Brake Burnish Issues for Tractors With Improved Brake Systems

As discussed in this section, brake burnishing is the process of wearing in the friction components of foundation brakes (brake linings and brake drums or disc rotors), which is necessary to allow the friction surfaces to reach a close-to-normal operating condition prior to conducting stopping distance and grade-holding tests. Currently, in FMVSS No. 121, the burnish procedure is specified in S6.1.8. This procedure involves subjecting a tractor to a series of 500 brake "snubs" (*i.e.,* applications of the brake) from an initial speed of 40 mph to a final speed of 20 mph. Virtually all heavy vehicles (trucks, tractors, and buses) use this burnish procedure. Prior to September 1, 1993, vehicle manufacturers were able to use an alternate burnish procedure, which conducted the snubs from higher initial speeds.[52] The primary difference between these two procedures is the temperature at which the brake operates during the burnish. The current procedure is frequently referred to as a "cold burnish," because the brake temperatures typically reach only 300–400 degrees Fahrenheit (F), whereas the

[51] Docket # NHTSA–2005–21462–39, p. 28.

[52] *See* 53 FR 8190.

old procedure is known as a ''hot burnish,'' as the temperatures typically reached 500 degrees F or more. The reason the agency changed from the hot to cold burnish procedure is that when heavy vehicles are operated on the road under normal conditions, the brakes may never reach the same temperatures that are reached under the hot burnish procedure. Therefore, the real world brake performance may have been lower than that tested under FMVSS No. 121 before September 1993.

In the March 14, 1988 final rule establishing the brake burnish procedures, NHTSA stated that given ''consistent research findings about the temperatures to which drum brakes are subjected during normal driving, the agency concludes that a burnish that subjects drum brakes to significantly higher temperatures cannot be said to be representative of normal driving conditions. By allowing the drum brakes to be heated to temperatures well in excess of those encountered during normal driving, the burnish procedures would ideally condition the drum brakes. However, the agency is more interested in the braking capability of vehicles when the brakes are in the condition they are most likely to be when used on the roads than in the maximum braking capability of a braking system if the brakes are ideally conditioned.'' *See* 53 FR 8194.

Several commenters recommended that changes to the burnish procedure be made in relation to the agency's overall efforts to achieve a reduction in stopping distances for truck tractors. Specifically, comments on this issue were raised by HDBMC, which recommended changes to the current burnish procedure that would allow the brake linings to be burnished at higher temperatures than the current burnish procedure produces (essentially a return to the pre-1993 requirements). While the agency has considered the comments relating to burnish procedure, it has decided not to make any changes to that procedure in this rulemaking, for the reasons that follow.

HDBMC recommended in its comments that NHTSA reinstate an optional temperature in FMVSS No. 121, as permitted prior to September 1, 1993, to use the hot burnish procedure. HDBMC stated that in order to achieve the proposed reduction in stopping distance, many tractors will be equipped with higher torque steer axle brakes. In addition, the commenter stated that there tractors will also likely be equipped with wider rear axle brakes (arguing that because NHTSA is mandating a 30-percent reduction in stopping distance, most vehicles will be using wider drive axle drum brakes or disc brakes). As a result, the commenter reasoned that steer axle brakes will do more of the work during burnish, thus lowering the temperature on the drive axle brakes. If wider drive axle drum brakes are used, HDBMC continued, this will result in further lowering of the drive axle brake temperatures. These lower temperatures could result in insufficient brake burnishing on the drive axle brakes. If this were the case, higher friction brake linings on the drive axle brakes may be required, likely resulting in higher maintenance costs and less end-user satisfaction.[53] Further, HDBMC indicated that the decreased lining contact on the drive axles may negatively impact parking brake drawbar pull performance. HDBMC provided an example where a tractor with standard (15″ × 4″) steer axle drum brakes was able to achieve 8,800 pounds of parking brake force, while with enhanced (16.5″ × 5″) steer axle drum brakes it produced only 8,000 pounds of force.

According to HDBMC, therefore, if NHTSA required the improved stopping distances without altering the burnish procedure to provide better burnishing, vehicle manufacturers would have to provide highly unsatisfactory brake linings in order to meet the standard, which would be unfit then for on-road use. Therefore, HDBMC suggests that the burnish procedure be altered.

As discussed in the rulemaking cited above concerning burnish, the agency believes it is appropriate to test the braking capability of vehicles when the brakes are in the condition they are most likely to be when used on the roads. For this reason, we do not believe it would be appropriate to modify the burnish procedure so that it is less reflective of the conditioning experienced by brakes in the real world. However, we have analyzed whether the proposed reduced stopping distance requirements, coupled with the ''cold burnish'' procedure, would result in the problems suggested by HDBMC. For reasons discussed below, we believe these problems will not occur.

NHTSA has reviewed the agency's data from the Radlinski testing in order to consider this issue. This test used the current cold burnish procedure in preparation for testing a typical three-axle tractor with enhanced S-cam drum brakes at all wheel positions, and that vehicle achieved a 30-percent reduction in stopping distance with a good margin of compliance. Based on the review of all of the test data for this vehicle, as well as the simple fact that the vehicle was able to achieve the required stopping distances using the cold burnish procedure, the agency concluded that the current procedure adequately conditioned the foundation brakes in preparation for conducting the remainder of the FMVSS No. 121 test sequence.

A review of the three-axle tractor tests conducted by Radlinski provides insight into the brake lining condition and temperatures of improved braking systems during and after the cold burnish procedure. Comparing two tests using the same brake lining (Spicer EES 420 linings on the steer and drive axles, with ArvinMeritor cast iron drums) at two drive axle GAWRs (34,000 and 40,000 pounds) showed that the lining contact patterns on the drive axle brakes (the percentage of the lining surface that is in full contact with the brake drum) after burnish appeared to be slightly better at the higher 40,000-pound GAWR. Steer axle burnish contact patterns for the two test conditions were approximately the same. Drive axle lining temperatures for the two test conditions throughout the burnish showed slightly higher temperatures for the 40,000-pound GAWR test (average approximately 400 degrees F) than for the 36,000-pound GAWR test (average approximately 380 degrees F), with the highest temperatures occurring at the end of the burnish sequence. Steer axle burnish temperatures were approximately the same for both test conditions and averaged around 280 degrees F.

Parking brake force was also adequate using the current burnish procedure. The average parking brake force (forward and rearward drawbar pulls, four tests with one-quarter wheel revolution per test, with parking brakes on the forward drive axle only) slightly favored the lower drive axle GAWRs. Although lining contact patterns were about the same for the front drive axle (which is not the one equipped with the parking brakes), overall, the tests at the higher GAWR had slightly more lining contact among both drive axles, which is consistent with the slightly higher burnish temperatures. Parking brake performance measured by the drawbar method[54] showed that with the tests conducted at 36,000 pounds GAWR, the margin of compliance was

[53] According to comments by TMA, aggressive high friction brake linings designed to meet strict performance criteria can produce unsatisfactory results when used in real-world applications. For example, in one scenario, TMA suggested that overly aggressive brake linings could glaze over under normal use conditions. This could lead to brake chatter and the subsequent failure of numerous components. TMA Comment from April 14, 2006, available at NHTSA–2005–21462–34).

[54] FMVSS No. 121, S5.6.

approximately 35 percent. The margin of compliance for the tests with the drive axles rated at 40,000 pounds GAWR was approximately 20 percent.

During the loaded-to-GVWR service brake stops from 60 mph, the tests with the drive axles at 36,000 pounds GAWR and Type 20 brake chambers on the steer axle showed that steer axle brake temperatures were typically 30 to 40 degrees F lower than the drive axle lining temperatures (that averaged around 180 degrees F) during the first half of the stop. However, the steer axle temperatures during the second half of the stop increased to approximately the same temperatures as the drive axle brakes. When tested with Type 24 brake chambers on the steer axle, temperature trends during the stop were similar, except that the steer axle brakes were approximately 20 degrees F hotter than for the tests with Type 20 steer axle brake chambers. In both cases, the steer axle brake temperatures increased more than the drive axle temperatures over the duration of the stops.

The agency has concluded from reviewing the brake temperatures during the burnish, and the brake temperatures and stopping distance data during the loaded-to-GVWR tests, that under the various combinations of drive axle GAWRs, brake chamber sizes, and slack adjusters that were reviewed, the vehicle appeared to perform optimally in all regards. The parking brake drawbar test margins of compliance were also good, with the tests at the lower GAWR having slightly better compliance margins. In sum, the test results revealed that the current burnish procedure provided adequate burnishing for tractors with improved braking systems to meet both service brake stopping distance requirements as well as parking brake requirements.

The agency also recognizes that the results from tests conducted by Radlinski may not be as applicable to two-axle or severe service tractors. However, agency stopping distance testing on these tractors indicated that installation of disc brakes generally would be required in order to meet the improved stopping distance requirements. Agency tests with disc brakes showed that there were no apparent brake burnish problems, and disc brakes are generally less sensitive to the burnish procedure because of the geometry of the linings and rotors. Disc brakes' linings and rotors are manufactured with flat friction surfaces that mate well when assembled on the vehicle. Thus, there is little wear-in necessary to achieve full lining to rotor contact, and the brakes readily achieve full torque-generating capability under the existing FMVSS No. 121 burnish procedure.

VRTC testing of two-axle and severe service tractors demonstrated that these vehicles are able to achieve the required stopping distances using the cold burnish procedure. VRTC tests on a two-axle tractor with a 148-inch wheelbase, using all disc brakes, yielded a 200-foot stopping distance and good parking brake performance. Tests on the same tractor with a hybrid braking system yielded a 223-foot stopping distance.[55] Preliminary tests of the three-axle severe service surrogate tractor (*i.e.,* a single-unit truck) with a hybrid brake configuration (disc brakes on the steer axle and standard 16.5″ x 7″ drum brakes on the drive axles) showed mixed results. After the burnish procedure, the drive axle brakes showed less contact area after burnishing than when the truck was tested with drum brakes on the steer axle, supporting HDBMC's argument. However, the test results for the hybrid configuration showed higher parking brake drawbar forces on the drive axles when compared to tests of the all-drum brake vehicle that had more drive axle lining contact area after burnish.[56] Based on the test results, it is evident that the current FMVSS No. 121 brake burnish procedure provides adequate burnishing to conduct the required tests for stopping distance and parking brake pull.

In summary, based upon available data, NHTSA has decided to maintain its prior rulemaking decision amending FMVSS No. 121 to require the use of the cold burnish procedure. The agency is not aware of an actual problem with the burnish procedure for typical three-axle tractors. The agency's testing revealed that all types of tractors were able to meet the required stopping distances using the existing cold burnish procedure. Furthermore, there is no evidence that the current burnish procedure is not indicative of real-world braking conditions. Therefore, we see no need to make any changes to the burnish requirements of FMVSS No. 121.

2. Brake Dynamometer Test Requirements

In the NPRM, the agency requested recommendations on potential modifications to the brake dynamometer requirements of FMVSS No. 121. These requirements test brake retardation force, power, and recovery under strict conditions. The agency received a variety of responses to this request. The majority of commenters stated that they recommend no changes to the dynamometer requirements. However, NHTSA received one comment (ArvinMeritor), suggesting the addition of an optional dynamometer procedure. For the reasons discussed below, the agency has considered the comments, and has decided that no action is necessary or appropriate at this time.

Currently, the requirements of paragraph S5.4.2, *Brake power,* apply to all foundation brakes for all air-braked vehicles covered under FMVSS No. 121. Under the standard, after burnishing, the fade portion of the test specifies ten consecutive snubs from 50 to 15 mph at a deceleration rate of 9 ft/sec^2, followed by a hot stop from 20 mph at a deceleration rate of 14 ft/sec^2. After the hot stop, 20 brake recovery stops from 30 mph at a deceleration rate of 12 ft/sec^2 at one minute intervals are made.[57] Brake pressure limits are placed on the fade and recovery requirements, while the hot stop does not have an upper air pressure limitation.

ArvinMeritor requested that NHTSA modify the dynamometer test procedure to allow the option of conducting a series of six 60 mph 100 psi stops at the conclusion of the 350 degree F dynamometer burnish.[58] ArvinMeritor stated that it believes the torque data obtained from these stops would be closer to the brake torques obtained during the vehicle stopping distance test and, therefore, would provide a more accurate stopping distance calculation. Currently, it states, because the temperatures in the dynamometer tests significantly exceed those generated during the stopping distance tests, the dynamometer performance data do not always correlate directly with the actual vehicle test results. According to ArvinMeritor, the optional stops, conducted before the brakes are burnished at the high temperatures,[59]

[55] VRTC testing of the two-axle tractor with all drum brakes revealed problems with replacement brake linings, but the agency has yet to determine how much of the problem is due to burnish procedure versus lining properties. This test yielded two different stopping distances (241 feet versus 332 feet) with original and replacement brake linings. When the replacement linings were machined to better match the curvature of the drums, they achieved similar stopping distances, leading NHTSA to believe that the cause is related to the lining properties, and not the burnish procedure. Regardless, neither lining was able to achieve a 30 percent reduction in stopping distance with a 10 percent margin of compliance.

[56] Currently, additional brake research is underway on this vehicle to determine stopping distance and brake burnish effect interactions with enhanced drum brakes.

[57] These requirements do not apply to the steer axle of tractors.

[58] *See* S6.2.6.

[59] Subsequent to this procedure, the brakes are burnished at a temperature between 450° and 550°.

would provide data that better correlate with data from the actual tests, where the brakes have undergone similar lower-temperature burnishing.

While there is some cause to believe that allowing an additional six stops from 60 mph would provide useful information for modeling purposes, as ArvinMeritor asserts, NHTSA does not have enough information to adopt this recommendation. ArvinMeritor did not describe what the test conditions would be for these optional stops (such as the initial brake temperature or intervals between stops), but we assume they would be conducted with an initial brake temperature between 150 and 200 degrees F, with a cool-down to that initial temperature between stops. If so, the optional stops would probably not have much influence on the remainder of the dynamometer test requirements, since those stops occur in much higher temperature ranges. However, such stops could have an influence on the brake retardation force requirements in S5.4.1, if the 60 mph optional stops resulted in additional higher temperature burnishing beyond the required burnish procedure. The agency would need more information on the potential benefits and ramifications of this procedure prior to amending the standard to specify a manufacturer option in this area.

Two commenters (HDBMC and Haldex) recommended that there be no changes made to the current dynamometer requirements. Both stated that the current requirements do not limit the amount of steer axle brake torque. (Haldex also mentioned that there is no limit in drive axle brake torque.) As the increases in stopping distance will largely be achieved through increasing steer axle brake torque, both commenters stated that this aspect of the requirements should not be changed. A third commenter (Bendix) stated that it is conducting dynamometer testing and would be willing to provide this information to NHTSA on a confidential basis upon completion of its testing program, although this information has not been received.

TMA commented that the agency could not make any changes to the dynamometer requirements without first issuing a separate NPRM, as no specific changes to these requirements were proposed in the NPRM for this rule. TMA stated that if the agency did go through with a separate rulemaking to modify the dynamometer requirements, it would likely need to have a different effective date than the one mandated in this final rule. In that case, according to TMA, the effect would be to undo all the work TMA member companies will need to do to respond to the current final rule, since designs will have been tailored to meet the currently-proposed requirements. TMA stated that any component change can greatly influence performance of the braking system, and as a result, TMA members require a 10-year stability period between rulemakings that affect brake system design in order to amortize development and investment costs. While this comment does not substantively address the issue of possible changes to the dynamometer requirements, the agency has taken TMA's concerns into consideration.

Based on the comments received and our assessment of this issue, the agency has decided not to modify the dynamometer test requirements. TMA's concerns notwithstanding, the agency believes that, if necessary, it would be better to consider revisions to the dynamometer requirements in a future rulemaking effort separate from the current tractor stopping distance rulemaking.

v. Stopping Distances at Reduced Initial Test Speeds

HDBMC and Bendix commented that in the NPRM, the 20 percent and 30 percent stopping distance reduction values in Table II of FMVSS No. 121 for test speeds below 60 mph did not take into account the brake system reaction time and average deceleration. Thus, under the agency's proposed stopping distance requirements for a 30 percent reduction in stopping distance from an initial speed of 20 mph, the commenters stated that an average deceleration as high as 0.95 g would be necessary (with an allowance for a 10 percent margin of compliance in stopping distance). According to the commenters, this deceleration rate is not achievable with existing truck braking and tire technology.

The agency has reviewed the tables of stopping distances provided by HDBMC and Bendix in their respective comments. In the case of HDBMC, it did not indicate what equations or methods it used to derive their recommended tables. For example, the agency could not determine what was occurring during the brake system reaction time (for 0.36, 0.45, and 0.54 second reaction times). Bendix provided similar recommendations but again it did not describe how its recommended tables of stopping distance were derived. The agency believes that because both commenters recommended stopping distances at reduced test speeds that are much longer than what the agency had proposed, the commenters' recommendations are not accounting for the buildup in deceleration that the agency's data indicate does occur during the initial brake pressure increase during typical stopping distance tests using a full treadle valve brake application. Nevertheless, after consideration of this issue the agency is providing the following analysis and revised stopping distance stables for tests conducted at reduced test speeds.[60]

For this analysis, we are using the stopping distance equation that was derived by researchers at the VRTC. The equation is as follows:

$$S_t = (\tfrac{1}{2}\, V_o\, t_r) + ((\tfrac{1}{2})\, V_o^2;/a_f) — ((1/24)\, a_f\, t_r^2;)$$

Where:

S_t = Total stopping distance in feet

V_o = Initial Speed in ft/sec

t_r = Air pressure rise time in seconds

a_f = Steady state deceleration in ft/sec^2

The complete derivation of this equation is included in the docket.[61] For the final rule, we selected an air pressure rise time of 0.45 seconds that is equal to the brake actuation timing requirement in S5.3.3. This requirement specifies that for a truck (including a truck-tractor), the air pressure in the brake chambers must reach at least 60 psi within 0.45 seconds.

The agency reviewed three test plots of deceleration versus time for tractor tests it conducted at VRTC to determine if the plot characteristics matched the stopping distance equation and the pressure rise time selected for this final rule. The three plots are included in the docket.[62] The first plot is for the Sterling 4x2 tractor equipped with disc brakes at all wheel positions and coupled to a braked 53-foot van trailer with tandem axles also equipped with disc brakes. The vehicle was loaded to typical highway weight (*i.e.,* steer axle 11,000 pounds; drive axle 22,700 pounds, tandem trailer axles 34,000 pounds) that is slightly below the GVWR for each vehicle. This combination represents the best-performing unit that was tested at VRTC, and it had a 60 mph stopping distance of 186 feet. As the plot shows, the steady-state deceleration was slightly less than 0.8g for the duration of the stop. The 0.8g deceleration was reached within approximately 0.5 seconds from the point of brake application. This deceleration and stopping distance are believed to be the best obtainable for a tractor-trailer

[60] We note that the neither the notice of proposed rulemaking, nor the previous rulemaking on this issue (53 FR 8190), contained detailed information on how the stopping distances for reduced initial test speeds were derived.

[61] *See* Docket No. 2005–21462–39, p. 18.

[62] *See* Docket No. 2005–21462–39, p. 28.

combination vehicle using all production equipment (tires, antilock braking system, air disc brakes, *etc.*) available at the present time.

The next two plots included from VRTC tests are for tractors that achieved a stopping distance of approximately 250 feet. These were used to determine the steady-state deceleration required to achieve this stopping distance. The second plot[63] is for a Volvo 6x4 tractor equipped with disc brakes on the steer axle and S-cam drum brakes on the drive axles, and it was coupled to an unbraked control trailer. The tractor was loaded to GVWR and was also braking the extra 4,500 pounds on the control trailer axle. The stopping distance for this vehicle from 60 mph was 249 feet and the steady state deceleration was approximately 0.45g. The plot shows that this tractor achieved the 0.45g deceleration rate at approximately 0.4 seconds.

The third plot is for a Peterbilt 6x4 tractor equipped with enhanced S-cam drum brakes on the steer axle and standard S-cam drum brakes on the drive axles, loaded to GVWR with an unbraked control trailer. The 60-mph stopping distance was 250 feet, and the deceleration varied slightly from approximately 0.48g at the midpoint of the stop to approximately 0.56g near the end of the stop. The deceleration during the stop was not exactly stead state since the deceleration rate increased towards the end of the stop. The rate at 0.45 seconds was approximately 0.36g.

The plots for the second and third tests, the Volvo and Peterbilt tractors respectively, demonstrate that for a 250-foot stopping distance requirement, deceleration rates in the range of 0.45g to 0.56g would be achieved by actual vehicles. It appears that the Volvo had a slightly faster application timing, and thus had a lower steady-state deceleration rate than the Peterbilt while attaining approximately the same stopping distance.

Using the VRTC equation for stopping distance, we derived the following three tables of stopping distance for three requirements in this final rule: (1) Standard service tractors loaded to GVWR plus 4,500 pounds on the unbraked control trailer axle; (2) severe service tractors loaded to GVWR plus 4,500 pounds on the unbraked control trailer axle; and (3) all tractors tested in the lightly-loaded vehicle condition. Note that the table for severe service tractors contains the same values currently in FMVSS No. 121 for single-unit trucks loaded to GVWR, but we are reproducing this table here to show the estimated deceleration levels with a 0.45-second pressure rise time.

TABLE I—STOPPING DISTANCE CALCULATIONS FOR TWO- AND THREE-AXLE TRACTORS WITH A GVWR OF 70,000 POUNDS OR LESS, AND TRACTORS WITH FOUR OR MORE AXLES AND A GVWR OF 85,000 POUNDS OF LESS, IN THE LOADED-TO-GVWR CONDITION. (BRAKE SYSTEM REACTION TIME IS 0.45 SECONDS)

Initial vehicle speed		Steady-state deceleration		Stopping distance
(mph)	(ft/sec)	(ft/sec²)	(g's)	(ft)
20	29.3	18.00	0.56	30
25	36.7	18.00	0.56	45
30	44.0	17.50	0.54	65
35	51.3	17.00	0.53	89
40	58.7	17.00	0.53	114
45	66.0	16.80	0.52	144
50	73.3	16.80	0.52	176
55	80.7	16.80	0.52	212
60	88.0	16.80	0.52	250

TABLE II—STOPPING DISTANCE CALCULATIONS FOR THREE-AXLE TRACTORS WITH A GVWR GREATER THAN 70,000 POUNDS, AND TRACTORS WITH FOUR OR MORE AXLES AND A GVWR GREATER THAN 85,000 POUNDS, IN THE LOADED-TO-GVWR CONDITION. (BRAKE SYSTEM REACTION TIME OF 0.45 SECONDS)

Initial vehicle speed		Steady-state deceleration		Stopping distance
(mph)	(ft/sec)	(ft/sec²)	(g's)	(ft)
20	29.3	15.00	0.47	35
25	36.7	14.65	0.45	54
30	44.0	14.15	0.44	78
35	51.3	13.90	0.43	106
40	58.7	13.75	0.43	138
45	66.0	13.60	0.42	175
50	73.3	13.45	0.42	216
55	80.7	13.40	0.42	261
60	88.0	13.35	0.41	310

[63] Docket No. 2005–21462–39, p. 29.

TABLE III—STOPPING DISTANCE CALCULATION FOR ALL TRACTORS IN THE UNLOADED CONDITION. (BRAKE SYSTEM REACTION TIME OF 0.45 SECONDS.)

Initial vehicle speed		Steady-state deceleration		Stopping distance
(mph)	(ft/sec)	(ft/sec^2)	(g's)	(ft)
20	29.3	19.80	0.61	28
25	36.7	19.40	0.60	43
30	44.0	18.80	0.58	61
35	51.3	18.10	0.56	84
40	58.7	18.10	0.56	108
45	66.0	17.95	0.56	136
50	73.3	17.95	0.56	166
55	80.7	17.95	0.56	199
60	88.0	17.95	0.56	235

We compared the calculated values for the 60 mph, 250-foot stopping distance requirements in Table I for a typical tractor to those test vehicles described above, in order to determine if the actual and calculated decelerations are similar. The calculated steady-state deceleration from the table with an initial test speed of 60 mph is 0.56g of deceleration, and this compares to 0.45g for the Volvo (that had a quicker response time, and thus slightly lower steady-state deceleration than the Peterbilt), and 0.48 to 0.52g for the Peterbilt (which had a slower response time, and thus a slightly higher steady-state deceleration than the Volvo). These values are similar to the 0.52g calculated in Table I, and therefore the agency believes the equation used to calculate the stopping distances is valid. We did not perform similar analyses for stopping distances conducted at other initial test speeds, because we did not conduct any testing at reduced test speeds. Only tests from an initial speed of 60 mph were conducted at VRTC.

We do not understand the basis for the concerns raised by HDBMC and Bendix in their comments about the proposed stopping distances requiring abnormally high deceleration levels. As shown in the tables of calculated stopping distances, the maximum required deceleration for an unloaded tractor at an initial speed of 20 mph is 0.61g. Even with a ten percent added margin of compliance, the actual performance would not appear to need to be greater than 0.67g. As described above, for the tests on the Sterling tractor operated with a braked van trailer, deceleration of almost 0.8g was attained at highway weight. Our tests of unloaded tractors indicated that nearly similar stopping distance performance was attained in the bobtail mode, an in each case a margin of compliance substantially greater than 10 percent was achieved when the vehicle was tested from an initial speed of 60 mph. It appears to us that HDBMC and Bendix could be using a method such as a free-roll during pressure rise that would assume no braking during the initial pressure rise. However, these commenters did not provide enough detail in the comments for the agency to thoroughly evaluate their claims. In any event, for the reasons discussed above, we believe that the new stopping distance calculations for the lower initial test speeds properly take into account brake actuation periods, and do not require excessive rates of deceleration.

vi. Comments Regarding Foreign Trade Agreements

A comment from the government of the People's Republic of China requested that Chinese manufacturers be given a longer transitional period for implementation of improved stopping distance requirements, citing the Agreement on Technical Barriers to Trade.[64] China cited clause 12.3 of the Agreement, which reads:

> Members shall, in the preparation and application of technical regulations, standards, and conformity assessment procedures, take account of the special development, financial and trade needs of developing country Members, with a view to ensuring that such technical regulations, standards and conformity assessment procedures do not create unnecessary obstacles to exports from developing country Members.

In its comment, China quoted the agency in stating in the NPRM that ''improvements in truck tractor stopping distance performance may involve more than simply increasing the power of foundation brakes, as changes might be required to suspensions and frames, *etc.,* to handle the higher braking torque without decreasing vehicle durability and safety.'' Further, China noted that the requirements of the Chinese National Standards on truck stopping distance (GB7258–2004 and GB12676–1999) are significantly less stringent than the stopping distances proposed by NHTSA. Finally, China cited the fact that disc brakes—along with larger capacity drum brakes, electrically controlled braking systems, and anti-lock braking systems—were only starting to be used on a limited number of vehicles in China. All of these factors, China stated, should be taken into consideration in a decision whether to give Chinese manufacturers a longer transitional period for implementation of the improved stopping distance requirements.

We have carefully considered China's comments. In responding, we begin by noting that, in the U.S., the applicable FMVSSs are the same regardless of where a motor vehicle or item of motor vehicle equipment is manufactured. Therefore, any extension of lead time would not be limited to Chinese manufacturers but would be available to all manufacturers irrespective of where they manufacture truck tractors for the U.S. market. While we carefully consider the issue of necessary lead time in establishing and amending FMVSSs, we also recognize that extending lead time can also result in the delay of safety benefits.

We note that while China highlighted substantial differences between the Chinese and proposed U.S.

[64] A summary of the treaty on the Web site of the World Trade Organization reads, ''[t]his agreement will extend and clarify the Agreement on Technical Barriers to Trade reached in the Tokyo Round. It seeks to ensure that technical negotiations and standards, as well as testing and certification procedures, do not create unnecessary obstacles to trade. However, it recognizes that countries have the right to establish protection, at levels they consider appropriate, for example for human, animal or plant life or health or the environment, and should not be prevented from taking measures necessary to ensure those levels of protection are met. The agreement therefore encourages countries to use international standards where these are appropriate, but it does not require them to change their levels of protection as a result of standardization.'' Available at *http://www.wto.org/english/docs_e/legal_e/ursum_e.htm#dAgreement.*

requirements regarding stopping distance requirements for heavy truck tractors, it did not provide specific information explaining why particular Chinese manufacturers would need additional time to comply with the new stopping distance requirements. There are many other substantial differences in vehicle safety regulation between the two countries, and we believe that a manufacturer building vehicles otherwise compliant to the U.S. FMVSSs would likely be capable of making the relatively minor modifications in brake design required by the upgraded performance requirements in this final rule, consistent with the lead time provided in this final rule.

With specific regard to extended lead time, we note that as discussed above, the agency is providing longer lead time, relative to that proposed in the NPRM, of four years for two-axle and severe service tractors. This relates to the additional design and testing work that must be done on these tractors to ensure that they can meet the improved stopping distances while maintaining good stability and control of the vehicles at issue. Therefore, Chinese manufacturers, like other manufacturers, will have longer time to undertake the design and testing necessary to meet the improved standards for these classes of truck tractors.

However, we believe that two years is adequate lead time for manufacturers to design standard three-axle tractors that can meet the improved stopping distance requirements. We note that standard three-axle tractors that already comply with the 30 percent reduction in required stopping distance are being manufactured and used on public roads in this country already. NHTSA has determined that these tractors can be improved to meet the enhanced requirements with relatively little design work, as compared to other classes of heavy truck tractors. We also believe that extending the lead time for these vehicles would inappropriately delay the safety benefits of this final rule.

vii. Miscellaneous Comments

Several commenters expressed concerns regarding the current state of heavy truck tractor maintenance. Brake Pro, Haldex, and HDBMC all commented that current vehicle maintenance procedures in many cases do not maintain braking systems at the same level as original equipment. Brake Pro added that aftermarket and foreign-produced brake lining material may be less efficient than materials included as original equipment. While these may be valid concerns, they are outside the scope of this rulemaking. This rulemaking addresses only new vehicles and the equipment sold on new vehicles; it does not apply to maintenance procedures once the vehicles are sold to end users.

In-service performance requirements for brake systems on commercial vehicles are covered under the Federal Motor Carrier Safety Administration's (FMCSA's) Federal Motor Carrier Safety Regulations (FMCSRs), as cited in the Code of Federal Regulations at Title 49, Part 393, Section 52, *Brake Performance.* That regulation sets service and emergency brake stopping distance requirements for various categories of passenger- and property-carrying commercial motor vehicles from an initial speed of 20 mph. It also includes minimum vehicle deceleration requirements for service brake systems. While it may be appropriate to set new standards for tractors that will be required to comply with shorter stopping distance requirements, it is not clear how that would be done at the present time, given the influences of trailer braking and operating weight versions the FMVSS No. 121 testing that is performed at full GVWR using an unbraked control trailer. Presumably, additional research or study would need to be conducted to derive proposed revisions to the FMCSRs. However, that work has not yet been performed.

A comment from an individual (Mr. John Kegley) requested that the new rule mandate that all Class 8 trucks have engine or exhaust brakes. Similarly, a comment from Mr. Timothy Larrimore suggested that the regulation should mandate that all trucks have four axles. Based on the data presented above, it is our belief that modifying the stopping distance requirements is the best way to achieve safety benefits, while still permitting manufacturers to use their own discretion in how they meet those requirements. We are not adopting these commenters' suggestions.

Finally, a comment from Mr. Roger Sauder suggested that instead of mandating new stopping distance requirements, the agency should focus on informing the public about proper driving techniques in the presence of large vehicles. We are not adopting this suggestion. We note that currently, such public education projects are already in place. Further, the data presented above indicate that reducing the stopping distance of heavy trucks will result in a substantial reduction in injuries and property damage prevented.

viii. Costs and Benefits of Shorter Tractor Stopping Distances

1. Estimated Benefits of a 30 Percent Reduction in Stopping Distance

In the Final Regulatory Impact Analysis (FRIA), the agency estimates that substantially greater safety benefits will be attained with a 30 percent reduction in required stopping distance compared to the benefits for a 20 percent reduction. For the 30 percent reduction scenario, the agency estimates that 227 fatalities and 300 serious injuries (AIS 3–5) will be prevented by improving the stopping distance requirement. For the 20 percent reduction scenario, the agency estimates that only 91 fatalities and 127 serious injuries would be prevented.[65] The differential in estimated reduced property damage is even greater, with approximately five times the property damage prevented for the 30 percent case versus the 20 percent case ($205 million compared to $39 million).[66] In estimating the numbers of property damage-only (PDO) vehicle involvements, crashes, and injuries, figures were derived from the agency's 2004–2006 GES database and the number of fatalities was determined from the agency's 2004–2006 FARS database. A more detailed comparison between the two alternatives, using a 7% discount rate, is laid out in the table below:[67]

[65] *See* FRIA, at VI–6.

[66] *See* FRIA, at VI–7. We note that these figures in 2007 dollars discounted at 3%.

[67] *See* FRIA, at VI–13.

ANNUAL COSTS AND BENEFITS IN MILLIONS OF 2007 DOLLARS DISCOUNTED AT 7% FOR 30% REDUCTION IN STOPPING DISTANCE

Costs (in millions)			Benefits (in millions)			Net benefit			Net cost			Cost per ELS		
Low	High	Most likely	Property damage	ELS	Mone-tized	Low	High	Most likely	Low	High	Most likely	Low	High	Most likely
$27	$192	$54	$169	212	$1,293	$1,271	$2,872	$1,410	−$141.4	$22.9	* −$115.1	N/A	$0.1	N/A

* The PDO benefits were greater than the costs, which resulted in a negative number.

ANNUAL COSTS AND BENEFITS IN MILLIONS OF 2007 DOLLARS DISCOUNTED AT 7% FOR 20% REDUCTION IN STOPPING DISTANCE

Costs (in millions)			Benefits (in millions)			Net benefit			Net cost			Cost per ELS		
Low	High	Most likely	Property damage	ELS	Mone-tized	Low	High	Most likely	Low	High	Most likely	Low	High	Most likely
$19	$134	$48	$32	87	$531	$426	$1,082	$512	−$12.9	$101.6	$15.4	N/A	$1.1	$0.2

The FRIA estimates there are 864 fatalities, 15,614 non-fatal injuries and 17,621 PDO crashes occurring annually in which the front of a braked truck tractor strikes another vehicle. It is estimated that reducing the stopping distance of truck tractors will reduce the following subsets of those crashes: (1) Rear-end, truck striking passenger vehicle (4 percent of total passenger car occupant fatalities); (2) passenger vehicle turned across path of truck (8 percent); and (3) straight path, truck into passenger vehicle (generally side-impact crashes at roadway junctions; 14 percent). The total percentage of all passenger vehicle occupant fatalities for these crash types was 26 percent. In addition, it is possible that some of the head-on collisions could be reduced in severity, since improvements in the braking capability of large trucks could reduce impact speeds.[68]

The reduction in required stopping distance also produces substantial benefits in property damage reduction. Using a three percent discount rate, the agency believes that $205 million of property damage will be prevented annually (present value of property damage savings over the lifetime of these vehicles) with the 30 percent required reduction in stopping distance. Using a seven percent discount rate, the resulting figure is $169 million in property damage prevented.

Some commenters (Advocates, IIHS) stated that the agency should mandate not only the 30 percent reduction in required stopping distance, but also mandate the use of disc brakes in truck tractors. These commenters also stated that disc brakes have certain characteristics (namely resistance to fading at high temperatures) which would provide additional benefits that enhanced S-cam drum brakes would not, even if they provided equivalent torque in the FMVSS No. 121 testing requirements. Accordingly, the commenters argued that these benefits should be factored into the cost-benefit analysis.

NHTSA, however, does not have data on the benefits of disc brakes beyond the benefits of similar-performing drum brakes. We note that FMVSS No. 121 is a performance-based standard, and any type of foundation brake that can meet the stopping distance and other requirements of the standard are permitted. Thus, it is not design-restrictive with respect to the type of foundation brake used to meet the requirements.

In a comment, Freightliner and TMA suggested that two-axle tractors present less of a need to reduce stopping distances than standard three-axle tractors do. Freightliner and TMA stated that two-axle tractors represent 10 percent of air-braked tractors produced annually, but are only involved in 3.4 percent of fatal crashes involving tractors. Because of this low fatality rate, the commenters claim, these vehicles should not be included in the agency's rulemaking to require shorter stopping distances. International also commented that it believes two-axle tractors should be excluded from the rulemaking. Although International did not cite the fatality involvement rates in its comments, it stated that it was an active participant in the preparation of TMA's comments.

TMA included in its comments a report on Class 8 truck tractor crash statistics performed by the University of Michigan Transportation Research Institute (UMTRI) using its Trucks Involved in Fatal Accidents database for the years 1999 through 2003.[69] This submission presented an alternative data set, which purportedly showed that the proportion of fatalities from these types of accidents is only 21.2 percent. The agency notes, however, that the UMTRI study was restricted to Class 8 (heavy truck tractors with a GVWR greater than 33,000 pounds) vehicle crashes, which would account for the slight disparity between the figures cited by TMA and NHTSA.

Table 7 of the UMTRI report shows the type of road (interstate, U.S. route, State route, county road, *etc.*) on which the Class 8 tractor fatal involvements occurred, as well as the tractor type. The data indicate that two and three-axle tractors have similar crash rates, and that they occur on different types of roads in similar frequencies. According to this submission, two-axle tractor crash data regarding road type for Class 8 tractors were quite similar to those for typical three-axle tractors. Only slightly fewer fatal crashes occurred among two-axle tractors on interstates (29 percent) compared to three-axle tractor fatal crashed occurring on interstates (34 percents). Crashes among the two vehicle configurations were nearly the same for U.S. and State routes, and slightly higher for two-axle tractor crashes on county roads (seven percent) versus typical three-axle tractors (five percent).

The agency does not agree with TMA that two-axle tractors are under-represented in fatal crashes to a degree that would warrant their being excluded from this final rule. Table 3 of the UMTRI report indicated that there were 724 Class 3 through 7 tractors in the sample (most if not all of these would be two-axle Class 7 tractors with a GVWR between 26,001 and 33,000 pounds, and would be in the lower combination weight applications such as beverage delivery), compared to the 534 crashes of Class 8 two-axle tractors

[68] *See* FRIA, at II–4.

[69] *See* Docket No. NHTSA–2005–21462–26, TMA submission of April 14, 2006.

(GVWR greater than 33,000 pounds) in the sample that was used in its analysis. Thus, more than half of the two-axle tractors involved in fatal crashes are missing from UMTRI's analysis because they were not Class 8 tractors (the report states that only Class 8 tractors were used in the analysis). Therefore, we believe that the data indicate that two-axle tractors are represented in fatal crashes to a similar extent as three-axle tractors.

2. Cost of Improved Brake Systems

Because the agency does not know the specific methods that truck manufacturers would use to upgrade tractor brake systems to meet the new requirements, in developing the NPRM the agency used an array of foundation brake upgrades to estimate the increased costs for the brake system improvements. The highest cost of complying with shorter stopping distance requirements would be realized if all tractors were equipped with disc brakes rather than the current S-cam drum brakes, and the lowest cost would be realized if all tractors could meet the new requirements if they were equipped with enhanced (larger) S-cam drum brakes. Both methods have been demonstrated to provide sufficient improvements in braking performance for typical three-axle tractors, while agency testing and data completed after the publication of the NPRM show that the disc brake approach would be required to meet the 30 percent reduction in required stopping distance for certain less common configurations of tractors (*i.e.,* severe service and two-axle tractors).

In quantifying the costs to comply with the reduced stopping distance requirements, in the FRIA, the agency used as a basis the costs of installing improved brake systems on new truck tractors. NHTSA also determined that currently, approximately ten percent of tractors have enhanced S-cam drum brakes installed on the steer axle, and three percent of tractors have enhanced S-cam drum brakes installed on the drive axles. Therefore, in determining the costs of upgrading to improved brake systems, we calculated the costs of upgrading 90 percent of all steer axles and 97 percent of all drive axles. Commenters also indicated that approximately 82 percent of all tractors are typical three-axle tractors (similar to the tractors from the Radlinski and VRTC tests). TMA and Freightliner stated that typical three-axle tractors comprise 82 percent of annual tractor production and ATA stated that such tractors comprise 81 percent of production. Freightliner commented that two-axle tractors comprise ten percent of tractor production, and severe service tractors comprise seven percent (although there may be a rounding error as Freightliner's statements on total production for the three types of tractors add to 99 percent).

With regard to standard three-axle tractors, based on the VRTC test report and the three test reports [70] from Federal Mogul and Motion Control Industries, the 30 percent reduction in required stopping distance could be met by using larger S-cam drum brakes or disc brakes at all wheel positions on tractors. The agency believes that the cost to install larger drum brakes would be much lower than the cost to install air disc brakes, although we do not have specific cost information on the various modifications to truck tractor braking systems. In the PRIA, the agency estimated that the cost for larger S-cam drum brakes is $75 for the steer axle [71] and $50 for each drive axle [72] to meet the 30 percent reduction requirement. For typical three-axle tractors, which make up about 82 percent of annual production, we estimated $175 ($\$75_{steer} + 2 \times \$50_{drive} = \$175$) for larger drum brakes. In its comments regarding the PRIA, Freightliner stated that larger drum brakes at all wheel positions would be $222. However, that manufacturer did not break costs associated with steer and drive axles. Due to limited data, for purposes of our cost estimates in the FRIA, we assumed that the cost for larger S-cam drum brakes is $85 for the steer axle and $65 for each drive axle ($215 for typical three-axle tractors).[73] Although the estimated $215 is lower than Freightliner's $222 cost (about three percent lower), we would expect that when larger quantities of brakes are produced the cost will be lower than the current $222.[74] The agency estimates that if manufacturers were to install enhanced drum brakes at all wheel positions, the total cost of this rulemaking would be $27 million ($211 [75] per vehicle).[76]

Costs for disc brakes are estimated to be higher than those for enhanced S-cam drum brakes.[77] The agency does not have specific cost information on disc brakes, but assumes, based on the current average pricing of disc brakes, that the cost would be $500 per axle (either steer or drive axles). If all affected vehicles are equipped with disc brakes to meet the requirement, the agency estimates that the associated incremental cost would be about $192M (or $1,475 per truck tractor, considering that approximately 82 percent of truck tractors have three axles) to fit disc brakes at each wheel position of the 130,000 truck tractors manufactured each year.[78] Freightliner also provided comments on the cost of disc brakes, indicating that the incremental costs of upgrading to disc brakes on all axles would be $1,627 for three-axle tractors and $963 for two-axle tractors. These figures are not significantly different from those used in the FRIA, and again we would expect that if larger quantities of brakes are produced the cost would be lower than the current $500 per axle, as suggested by the IIHS in its comments.

In its analysis, the agency also considered the cost of installing hybrid brake systems on all truck tractors. If all applicable vehicles are equipped with front disc and rear larger S-cam drum brakes, the associated cost of the rulemaking would be about $80M (or $613 per vehicle).[79]

Finally, in the FRIA, the agency provides a best estimate of the incremental cost. This scenario assumes that for typical three-axle tractors, manufacturers would comply with the reduced stopping distance requirements through use of the least costly means available, *i.e.,* the use of enhanced drum brakes at all wheel positions. For two-axle and severe service tractors, which make up approximately 18 percent of all tractors, manufacturers would need to use disc brakes at all wheel positions. The total cost of these improvements, which consist of upgrading standard three-axle tractors to enhanced S-cam drum brake configurations and upgrading two-axle and severe service tractors to all-disc brake configurations, would be an average cost of $413 per vehicle, or about $55.4 million total

[70] Test Report Nos. RAI–FM–20, RAI–MC–04, AND RAI–FM–21.

[71] The size increases from 15″ x 4″ to 16.5″ x 5″ or 16.5″ x 6″.

[72] The size increases from 16.5″ x 7″ to 16.5″ x 8⅝″ or 16.5″ x 8″.

[73] We note that this figure is in 2005 dollars.

[74] FRIA, V–1.

[75] Figures for the estimated incremental cost per vehicle take into consideration the fact that 10 percent of tractors currently in production are equipped with larger drum brakes at the steer axle, and 3 percent are equipped with larger drum brakes at the drive axle. *See* FRIA [V–2]. Further, we note that this figure is in 2007 dollars.

[76] FRIA, E–4.

[77] FRIA, V–3.

[78] Some of the typical three-axle tractors may need disc brakes on the steer axle only, and many of these tractors may be able to comply by upgrading to enhanced drum brakes (the lowest-cost option). Thus it is unlikely that the total cost to implement the requirements would be close to the high-end cost estimate in the FRIA (which was to install disc brakes on all tractors).

[79] FRIA, V–4.

annual costs. However, we also note that a small number of commercial truck tractors (approximately three percent, all of which are standard three-axle tractors) already comply with the 30 percent reduction in required stopping distance. Subtracting the cost of those vehicles from the total implementation cost of the rule yields a total incremental cost of $53.7 million.[80]

3. Additional Costs Incurred Resulting From Improved Brake Systems

The NPRM also asked for information on tractor components other than the foundation brakes (*e.g.,* frames and suspension) that may need to be modified to meet shorter stopping distance requirements of 20–30 percent. Specifically, the agency was seeking to identify additional costs or weight penalties that might be required to meet the new stopping distance requirements. While numerous commenters discussed potential additional costs that could result from the use of improved brake systems in truck tractors, relatively little specific information was supplied on vehicle modifications that may be required to equip tractors with more powerful foundation brakes. TMA cited chassis structural analysis, design, and validation, but did not elaborate on the costs or scope of these issues. TMA also stated that more powerful brakes may require tuning with regard to brake noise, vibration, and modifications to the ABS. Freightliner stated that if two-axle tractors are fitted with disc brakes, electronic stability control systems may be needed to reduce instability during hard braking events. Haldex stated that routine vehicle modifications (*e.g.,* tires, suspensions, chassis structure) would be most effectively addressed by the vehicle manufacturers.

On the issue of weight penalties for improved brake systems, Bendix provided data on drum brake weights versus disc brake weights. It stated that the heaviest drum brakes weigh more than the lightest disc brakes, while the heaviest disc brakes weigh more than the lightest drum brakes. It stated that for a three-axle tractor equipped with all disc brakes, total vehicle weight could increase by 212 pounds, or could decrease by 134 pounds, compared to an all drum braked tractor, depending on which disc or drum brakes are used for comparison. ArvinMeritor stated in its comments that the new brakes will weigh more, although it did not provide a specific value. WABCO, on the other hand, stated that the weight of a disc brake is equivalent to the weight of high performance drum brakes.

After evaluating all comments and available data, we estimate that the improved brakes may add a small amount of weight to the vehicle, resulting in slight additional fuel consumption and possible loss of revenue by displacing cargo-carrying capability, but that those costs cannot be determined from the available data. Overall, however, we believe those costs to be very small.

4. Summary of Costs and Benefits Estimates

The FRIA calculates cost and benefits ratios for larger drum brake, disc brake, and hybrid disc/drum brake tractor configurations. As part of this analysis, the agency estimated Net Cost per Equivalent Life Saved (NCELS) for such scenarios. A wide range of estimates are provided because of the uncertainty in knowing in advance exactly which brake system improvements will be employed to meet the new requirements. The agency's estimates of costs and benefits are summarized in tables presented below. We note, for reasons discussed earlier, that while manufacturers can meet the upgraded requirements with larger drum brakes for a significant majority of tractors, it is likely that disc brakes will be needed for two-axle and severe axle tractors (comprising approximately 18 percent of tractors).

ESTIMATED ANNUAL SAFETY BENEFITS

Percent reduction in stopping distance	Fatalities reduced	Serious injuries reduced
30%	227	300

PROPERTY DAMAGE PREVENTED

[In millions]

Percent reduction in stopping distance	3% Discount	7% Discount
30%	$205	$169

INCREMENTAL COSTS

[2007 Dollars]

30% Percent reduction in stopping distance	Larger S-cam drum at all wheel positions	Disc brakes at all wheel positions	Front disc and larger rear S-cam drum	Most likely combination
Total Cost	$27M	$192M	$80M	$54M
Cost Per Vehicle	211	1,475	613	413

NET COST PER EQUIVALENT LIFE SAVED

[For 30% reduction in stopping distance, in millions]

Brake system	3 Percent	7 Percent
Larger S-Cam Brake	NB	NB
All Disc Brake	NB	$0.108

[80] *See* FRIA, at V–5.

NET COST PER EQUIVALENT LIFE SAVED—Continued

[For 30% reduction in stopping distance, in millions]

Brake system	3 Percent	7 Percent
Front Disc and Larger Rear S-Cam Drum	NB	NB
Most Likely Combination	NB	NB

NB = Net Benefits (Property damage benefits exceed the costs).

ix. Lead Time

NHTSA is specifying differing compliance dates for typical three-axle tractors on the one hand, and two-axle and severe service tractors on the other. The agency has described the available test data for typical three-axle tractors with improved brake systems, showing that compliance with the new stopping distance requirements can be readily achieved. Therefore, the agency is requiring a compliance date that is about two years from the date of publication of this final rule for typical three-axle tractors (*i.e.,* three-axle truck tractors with a GVWR less than or equal to 59,600 pounds).[81]

The lead time for all two-axle tractors, and severe service tractors with a GVWR greater than 59,600 pounds, is approximately four years from the date of publication of this final rule. As previously described, available test data indicate that two-axle tractors can meet a 250-foot loaded-to-GVWR stopping distance requirement with improved brake systems. However, additional lead time is needed to more fully evaluate new brake systems to ensure compatibility with existing trailers and converter dollies when used in multi-trailer combinations, and to minimize the risk of vehicle stability and control issues, particularly on shorter wheelbase two-axle tractors. For severe service tractors, the agency described the available test data and analyses indicating that vehicle improvements are available that would make the new 250-foot and 310-foot loaded-to-GVWR stopping distance requirements attainable. However, only limited development work relevant to reduced stopping distance has been performed on these vehicles to date. As several commenters indicated, additional lead time is needed for complete testing and validation of new brake systems for these vehicles to ensure that full compliance can be achieved, without compromising control, stability, and comfort elements important to end users.

IV. Rulemaking Analyses and Notices

a. Vehicle Safety Act

Under 49 U.S.C. Chapter 301, *Motor Vehicle Safety* (49 U.S.C. 30101 *et seq.*), the Secretary of Transportation is responsible for prescribing motor vehicle safety standards that are practicable, meet the need for motor vehicle safety, and are stated in objective terms.[82] These motor vehicle safety standards set the minimum level of performance for a motor vehicle or motor vehicle equipment to be considered safe.[83] When prescribing such standards, the Secretary must consider all relevant, available motor vehicle safety information.[84] The Secretary also must consider whether a proposed standard is reasonable, practicable, and appropriate for the type of motor vehicle or motor vehicle equipment for which it is prescribed and the extent to which the standard will further the statutory purpose of reducing traffic accidents and associated deaths.[85] The responsibility for promulgation of Federal motor vehicle safety standards has been delegated to NHTSA.[86]

Based upon the agency's research, the agency determined that a substantial number of fatalities and injuries result annually from collisions between combination trucks (*i.e.,* tractor trailers) and light vehicles. The agency further determined that a 30 percent reduction in heavy truck tractor stopping distance is both technologically and financially achievable and could prevent a substantial number of these identified fatalities and injuries. In developing this final rule amending the relevant requirements of FMVSS No. 121 to reduce heavy truck stopping distance, the agency carefully considered the statutory requirements of 49 U.S.C. Chapter 301.

First, this final rule reflects the agency's careful consideration and analysis of all issues raised in public comments on the agency's December 2005 notice of proposed rulemaking. In responding to the issues raised in the comments, the agency considered all relevant motor vehicle safety information. In preparing this document, the agency carefully evaluated relevant, available research, testing results, and other information related to various air brake technologies. In sum, this document reflects our consideration of all relevant, available motor vehicle safety information.

Second, to ensure that the heavy truck stopping distance requirements remain practicable, the agency evaluated the potential impacts of the proposed requirements in light of the cost, availability, and suitability of various air brake systems, consistent with our safety objectives and the requirements of the Safety Act. As explained in detail in the FRIA, this final rule adopts a 30 percent reduction in stopping distance for the overwhelming majority of tractors, which corresponds to the most stringent of the requirements proposed in the NPRM. (For the remaining one percent (mostly severe service tractors with high GVWRs), the final rule adopts a requirement for a 13 percent reduction in stopping distance beyond the standard's existing levels.) Our analysis of the available data and public comments shows that it is practicable for the subject vehicles to achieve the newly required reduction in stopping distance using available technology. In sum, we believe that this final rule is practicable and will increase the benefits of FMVSS No. 121, including prevention of deaths and injuries associated with many types of crashes involving heavy truck tractors.

Third, the regulatory text following this preamble is stated in objective terms in order to specify precisely what performance is required and how performance will be tested to ensure compliance with the standard. Specifically, this final rule modifies the performance requirements specified in Table 2 of Standard No. 121, without substantively altering the standard's test procedures. The standard's test procedures continue to delineate carefully how testing will be conducted,

[81] As stated above, "typical three-axle tractors" have a steer axle GAWR less than or equal to 14,600 pounds and a combined drive axle GAWR less than or equal to 45,000 pounds. Summing these GAWRs yields a GVWR that is equal to or less than 59,600 pounds.

[82] 49 U.S.C. 30111(a).

[83] 49 U.S.C. 30102(a)(9).

[84] 49 U.S.C. 30111(b).

[85] *Id.*

[86] 49 U.S.C. 105 and 322; delegation of authority at 49 CFR 1.50.

including applicable brake burnish and dynamometer procedures. The agency continues to believe that this test procedure is sufficiently objective and will not result in any uncertainty as to whether a given vehicle satisfies the requirements of the FMVSS No. 121.

Fourth, we believe that this final rule will meet the need for motor vehicle safety by making certain modifications that will reduce heavy truck stopping distances, thereby permitting the driver to potentially avert crash-related fatalities and injuries.

Finally, we believe that this final rule is reasonable and appropriate for motor vehicles subject to the applicable requirements. As discussed elsewhere in this notice, the modifications to the standard resulting from this final rule will further the agency's efforts to prevent the injuries, fatalities, and property damage associated with crashes involving heavy truck tractors and other vehicles. NHTSA has determined that enhanced foundation brakes used to meet the requirements of this final rule offer an effective means to prevent (or mitigate the severity of) many of these crashes. Accordingly, we believe that this final rule is appropriate for covered vehicles that are or will become subject to these provisions of FMVSS No. 121 because it furthers the agency's objective of preventing deaths and serious injuries.

b. Executive Order 12866 and DOT Regulatory Policies and Procedures

Executive Order 12866, ''Regulatory Planning and Review'' (58 FR 51735, October 4, 1993), provides for making determinations whether a regulatory action is ''significant'' and therefore subject to OMB review and to the requirements of the Executive Order. The Order defines a ''significant regulatory action'' as one that is likely to result in a rule that may:

(1) Have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or Tribal governments or communities;

(2) Create a serious inconsistency or otherwise interfere with an action taken or planned by another agency;

(3) Materially alter the budgetary impact of entitlements, grants, user fees, or loan programs or the rights and obligations of recipients thereof; or

(4) Raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive Order.

We have considered the impact of this action under Executive Order 12866 and the Department of Transportation's regulatory policies and procedures. Given that the estimated costs of this final rule could exceed $100 million, this action has been determined to be economically significant under the Executive Order and accordingly has been reviewed by the Office of Management and Budget. Further, this rulemaking action has been determined to be ''significant'' under the Department of Transportation's Regulatory Policies and Procedures (44 FR 11034; February 26, 1979).

As discussed above, there are a number of simple and effective manufacturing solutions that vehicle manufacturers can use to meet the requirements of this final rule. These solutions include installation of enhanced drum brakes, air disc brakes, or hybrid disc/drum systems. The costs will vary depending on which solution is selected. We believe the most likely low cost scenario would be for a significant majority of tractors to use enhanced drum brakes, with about 18 percent needing to use more expensive disc brakes. Under this scenario, annual costs would be about $50 million. If disc brakes were used for all tractors, annual costs would be $178 million.

Once all subject heavy truck tractors on the road are equipped with enhanced braking systems, we estimate that annually, approximately 258 lives will be saved and 284 serious injuries will be prevented. In addition, this final rule is expected to prevent over $140 million in property damage annually, an amount which alone is expected to exceed the total cost of the rule.

The agency has prepared and placed in the docket a Final Regulatory Impact Analysis.

c. Regulatory Flexibility Act

Pursuant to the Regulatory Flexibility Act (5 U.S.C. 601 *et seq.,* as amended by the Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996), whenever an agency publishes a notice of rulemaking for any proposed or final rule, it must either prepare and make available for public comment a regulatory flexibility analysis that describes the effect of the rule on small entities (*i.e.,* small businesses, small organizations, and small governmental jurisdictions) [87] or certify that the rule will not have a significant economic impact on a substantial number of small entities. In order to make such a certification, the agency must conduct a threshold analysis. The results of that analysis must be included in a statement that accompanies the certification and provides the factual basis for making it.

NHTSA has considered the effects of this final rule under the Regulatory Flexibility Act. I certify that this final rule will not have a significant economic impact on a substantial number of small entities. The basis for this certification is that the vast majority of truck tractors manufactured in the United States are produced by five vehicle manufacturers, none of which is a small business. The remaining volume of heavy truck tractors (about 1 percent) is produced by final-stage manufacturers, which may be small businesses. However, it is our understanding that these final-stage manufacturers rarely make modifications to the tractor's braking system; instead, they rely upon the pass-through certification provided by chassis manufacturers. Accordingly, we do not believe that this final rule will have a significant economic impact on truck tractor manufacturers that are classified as small businesses.

Regarding the impacts on brake manufacturers, we are aware of six original equipment air brake manufacturers. However, none of them is classified as a small business. In any event, due to the fact that the rule will generally necessitate installation of more advanced (and higher priced) drum and disc brakes, we anticipate that the final rule will result in a positive economic impact upon brake manufacturers regardless of business size.

d. Executive Order 13132 (Federalism)

NHTSA has examined today's final rule pursuant to Executive Order 13132 (64 FR 43255, August 10, 1999) and concluded that no additional consultation with States, local governments, or their representatives is mandated beyond the rulemaking process. The agency has concluded that the rule does not have federalism implications, because the rule does not have ''substantial direct effects on the States, on the relationship between the national government and the States, or on the distribution of power and the responsibilities among the various levels of government.''

Further, no consultation is needed to discuss the preemptive effect of today's rule. NHTSA's safety standards can have preemptive effect in at least two ways. First, the National Traffic and Motor Vehicle Safety Act contains an

[87] The Small Business Administration's regulations at 13 CFR Part 121 define a small business, in part, as a business entity ''which operates primarily within the United States.'' (13 CFR 121.105(a)).

express preemption provision: ''When a motor vehicle safety standard is in effect under this chapter, a State or a political subdivision of a State may prescribe or continue in effect a standard applicable to the same aspect of performance of a motor vehicle or motor vehicle equipment only if the standard is identical to the standard prescribed under this chapter.'' 49 U.S.C. 30103(b)(1). It is this statutory command that unavoidably preempts State legislative and administrative law, not today's rulemaking, so consultation would be unnecessary.

Second, the Supreme Court has recognized that State requirements imposed on motor vehicle manufacturers, including sanctions imposed by State tort law, can stand as an obstacle to the accomplishment and execution of a NHTSA safety standard. When such a conflict is discerned, the Supremacy Clause of the Constitution makes the State requirements unenforceable. *See Geier* v. *American Honda Motor Co.,* 529 U.S. 861 (2000). NHTSA does not currently foresee any potential State requirements that might conflict with today's final rule. Without any conflict, there could not be any implied preemption.

e. Executive Order 12988 (Civil Justice Reform)

With respect to the review of the promulgation of a new regulation, section 3(b) of Executive Order 12988, ''Civil Justice Reform'' (61 FR 4729, February 7, 1996) requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) Clearly specifies the preemptive effect; (2) clearly specifies the effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct, while promoting simplification and burden reduction; (4) clearly specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. This document is consistent with that requirement.

Pursuant to this Order, NHTSA notes as follows. The preemptive effect of this rule is discussed above. NHTSA notes further that there is no requirement that individuals submit a petition for reconsideration or pursue other administrative proceeding before they may file suit in court.

f. Executive Order 13045 (Protection of Children From Environmental Health and Safety Risks)

Executive Order 13045, ''Protection of Children from Environmental Health and Safety Risks'' (62 FR 19855, April 23, 1997), applies to any rule that: (1) Is determined to be ''economically significant'' as defined under Executive Order 12866, and (2) concerns an environmental, health, or safety risk that the agency has reason to believe may have a disproportionate effect on children. If the regulatory action meets both criteria, the agency must evaluate the environmental health or safety effects of the planned rule on children, and explain why the planned regulation is preferable to other potentially effective and reasonably feasible alternatives considered by the agency.

Although this final rule is an economically significant regulatory action under Executive Order 12866, the problems associated with crashes involving heavy trucks and other vehicles equally impact all persons riding in a vehicle, regardless of age. Consequently, this final rule does not involve decisions based upon health and safety risks that disproportionately affect children, as would necessitate further analysis under Executive Order 13045.

g. Paperwork Reduction Act

Under the Paperwork Reduction Act of 1995 (PRA), a person is not required to respond to a collection of information by a Federal agency unless the collection displays a valid OMB control number. There are not any information collection requirements associated with this final rule.

h. National Technology Transfer and Advancement Act

Section 12(d) of the National Technology Transfer and Advancement Act of 1995 (NTTAA), Public Law 104–113, (15 U.S.C. 272) directs the agency to evaluate and use voluntary consensus standards in its regulatory activities unless doing so would be inconsistent with applicable law or is otherwise impractical. Voluntary consensus standards are technical standards (*e.g.,* materials specifications, test methods, sampling procedures, and business practices) that are developed or adopted by voluntary consensus standards bodies, such as the Society of Automotive Engineers. The NTTAA directs us to provide Congress (through OMB) with explanations when we decide not to use available and applicable voluntary consensus standards. The NTTAA does not apply to symbols.

There are no voluntary consensus standards related to heavy truck stopping distance available at this time. However, NHTSA will consider any such standards as they become available.

i. Unfunded Mandates Reform Act

Section 202 of the Unfunded Mandates Reform Act of 1995 (UMRA) requires Federal agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or Tribal governments, in the aggregate, or by the private sector, of more than $100 million annually (adjusted for inflation with base year of 1995 (so currently about $118 million in 2004 dollars)). Before promulgating a NHTSA rule for which a written statement is needed, section 205 of the UMRA generally requires the agency to identify and consider a reasonable number of regulatory alternatives and adopt the least costly, most cost-effective, or least burdensome alternative that achieves the objectives of the rule. The provisions of section 205 do not apply when they are inconsistent with applicable law. Moreover, section 205 allows the agency to adopt an alternative other than the least costly, most cost-effective, or least burdensome alternative if the agency publishes with the final rule an explanation of why that alternative was not adopted.

As discussed in that notice, this final rule amending FMVSS No. 121 is not expected to result in the expenditure by State, local, or Tribal governments, in the aggregate, of more than $118 million annually, but it may result in an expenditure of that magnitude by vehicle manufacturers and/or their suppliers. In the final rule, NHTSA has adopted a performance requirement for most heavy truck tractors to reduce stopping distance by 30 percent from the standard's previous levels (with approximately one percent of heavy truck tractors with an extremely high GVWR which will be required to achieve a stopping distance 13 percent below previous levels); we believe that this approach is consistent with safety, and it should provide a number of choices regarding the means used for compliance (*e.g.,* enhanced drum brakes, all-disc brakes, or hybrid drum/disc brakes), thereby offering flexibility to minimize costs of compliance with the standard. As noted previously, the agency has prepared a detailed economic assessment in the FRIA. In that assessment, the agency analyzed the cost-benefit analysis of both a 20 percent and a 30 percent reduction in required stopping distance. Although the 30 percent requirement does cost more to implement, the benefits estimated in the 30 percent reduction scenario far outweighed those identified in the 20 percent reduction scenario.

j. National Environmental Policy Act

NHTSA has analyzed this rulemaking action for the purposes of the National Environmental Policy Act. The agency has determined that implementation of this action will not have any significant impact on the quality of the human environment.

k. Regulatory Identifier Number (RIN)

The Department of Transportation assigns a regulation identifier number (RIN) to each regulatory action listed in the Unified Agenda of Federal Regulations. The Regulatory Information Service Center publishes the Unified Agenda in April and October of each year. You may use the RIN contained in the heading at the beginning of this document to find this action in the Unified Agenda.

l. Privacy Act

Please note that anyone is able to search the electronic form of all comments received into any of our dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, *etc.*). You may review DOT's complete Privacy Act Statement in the **Federal Register** published on April 11, 2000 (Volume 65, Number 70; Pages 19477–78), or you may visit *http://docketsinfo.dot.gov/.*

List of Subjects in 49 CFR Part 571

Standard No. 121, Air-brake systems.

■ In consideration of the foregoing, NHTSA is amending 49 CFR Part 571 as follows:

PART 571—FEDERAL MOTOR VEHICLE SAFETY STANDARDS

■ 1. The authority citation for Part 571 of Title 49 continues to read as follows:

Authority: 49 U.S.C. 322, 30111, 30115, 30117, and 30166; delegation of authority at 49 CFR 1.50.

■ 2. Section 571.121 is amended by revising S5, adding S6.1.18, revising Table II, and adding Table IIa after Table II to read as follows:

§ 571.121 Standard No. 121; Air brake systems.

* * * * *

S5. *Requirements.* Each vehicle shall meet the following requirements under the conditions specified in S6. However, at the option of the manufacturer, the following vehicles may meet the stopping distance requirements specified in Table IIa instead of Table II: Three-axle tractors with a GVWR of 59,600 pounds or less that are manufactured before August 1, 2011; two-axle tractors that are manufactured before August 1, 2013, and tractors with a GVWR above 59,600 pounds that are manufactured before August 1, 2013.

* * * * *

S6.1.18 *Fuel tank loading.*

The fuel tank(s) is (are) filled to 100 percent of rated capacity at the beginning of testing and is (are) not less than 75 percent of rated capacity during any part of the testing.

* * * * *

TABLE II—STOPPING DISTANCE IN FEET

Vehicle speed in miles per hour	Service brake						Emergency brake	
	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
20	32	35	30	35	38	28	83	85
25	49	54	45	54	59	43	123	131
30	70	78	65	78	84	61	170	186
35	96	106	89	106	114	84	225	250
40	125	138	114	138	149	108	288	325
45	158	175	144	175	189	136	358	409
50	195	216	176	216	233	166	435	504
55	236	261	212	261	281	199	520	608
60	280	310	250	310	335	235	613	720

Note:

(1) Loaded and Unloaded Buses.

(2) Loaded Single-Unit Trucks.

(3) Loaded Tractors with Three Axles and a GVWR of 70,000 lbs. or less; or with Four of More Axles and a GVWR of 85,000 lbs. or less. Tested with an Unbraked Control Trailer.

(4) Loaded Tractors with Three Axles and a GVWR greater than 70,000 lbs.; or with Four or More Axles and a GVWR greater than 85,000 lbs. Tested with an Unbraked Control Trailer.

(5) Unloaded Single-Unit Trucks.

(6) Unloaded Tractors (Bobtail).

(7) All Vehicles except Tractors, Loaded and Unloaded.

(8) Unloaded Tractors.

TABLE IIA—STOPPING DISTANCE IN FEET: OPTIONAL REQUIREMENTS FOR: (1) THREE-AXLE TRACTORS WITH A GVWR OF 59,600 POUNDS OR LESS MANUFACTURED BEFORE AUGUST 1, 2011; (2) TWO-AXLE TRACTORS MANUFACTURED BEFORE AUGUST 1, 2013; AND (3) TRACTORS WITH A GVWR OF MORE THAN 59,600 POUNDS MANUFACTURED BEFORE AUGUST 1, 2013

Vehicle speed in miles per hour	Service brake				Emergency brake	
	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9	PFC 0.9
	(1)	(2)	(3)	(4)	(5)	(6)
20	32	35	38	40	83	85
25	49	54	59	62	123	131
30	70	78	84	89	170	186
35	96	106	114	121	225	250
40	125	138	149	158	288	325
45	158	175	189	200	358	409
50	195	216	233	247	435	504
55	236	261	281	299	520	608
60	280	310	335	355	613	720

Note: (1) Loaded and unloaded buses; (2) Loaded single unit trucks; (3) Unloaded truck tractors and single unit trucks; (4) Loaded truck tractors tested with an unbraked control trailer; (5) All vehicles except truck tractors; (6) Unloaded truck tractors.

* * * * *

Issued: July 20, 2009.

Ronald L. Medford,

Acting Deputy Administrator.

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