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Recommended Practice for Transit Bus In-Service Brake System Performance Testing

Approved March 10, 2005
APTA Bus Brake Working Group

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APTA Bus Standards Committee

Abstract: This recommended practice provides guidelines for testing transit bus air brake system performance.

Keywords: brake performance, brakes, deceleration, bus brake, transit bus, stopping, PBBT

Note: Document previously numbered as APTA-BTS-SS-RP-001-05, working group abbreviation update to reflect change from Suspension Systems to Brake & Chassis

Introduction

(This introduction is not a part of APTA BTS-BC-RP-001-05 Recommended Practice for Transit Bus In-Service Brake System Performance Testing)

This Recommended Practice for Transit Bus In-Service Brake System Performance Testing reflects the consensus of the APTA Bus Standards Program members on the items, methods, and procedures that have provided the best practice based on the experiences of those present and participating in meetings of the Program Task Forces and Working Groups. Recommended practices are voluntary, industry-developed, and consensus-based practices that assist equipment suppliers, vehicle and component manufacturers, and maintenance personnel in the construction, assembly, operation, and maintenance of transit bus vehicles. Recommended practices may include test methodologies and informational documents. Recommended practices are non-exclusive and voluntary; they are intended to neither endorse nor discourage the use of any product or procedure. All areas and items included therein are subject to manufacturers' supplemental or superceding recommendations. APTA recognizes that for certain applications, the practices, as implemented by operating agencies, may be either more or less restrictive than those given in this document.

This recommended practice provides guidelines for transit bus in-service brake system performance testing. APTA recommends the use of this recommended practice by:

- Individuals or organizations that inspect and maintain transit buses
- Individuals or organizations that contract with others for the inspection and maintenance of transit buses
- Individuals or organizations that influence how transit buses are inspected and maintained.

Test results must meet or exceed Federal, State, or other local regulatory agency requirements if different from the recommendations outlined in this document.

Participants

The American Public Transportation Association (APTA) greatly appreciates the contributions of the Bus Transit Standards Brake System Working Group, who provided the primary effort in the drafting of the Recommended Practice for Transit Bus In-Service Brake System Performance Testing.

Contents

Recommended Practice for Transit Bus In-Service Brake System Performance Testing

1. Overview

This document establishes a recommended practice for transit bus in-service brake performance testing. Individual operating agencies may modify these guidelines to accommodate their specific equipment and mode of operation.

Test results must meet or exceed Federal, State, or other local regulatory agency requirements if different from the recommendations outlined in this document.

1.1 Scope

This recommended practice provides system performance testing guidelines for heavy duty transit buses equipped with air drum brakes. This document only covers braking force and deceleration aspects of brake testing. Interlock and emergency brake systems are not covered in this document.

1.2 Purpose

The purpose of this recommended practice is to provide a uniform method and criteria for testing and verification of transit bus brake system performance.

2. References

This recommended practice should be used in conjunction with the following publications.

Commercial Vehicle Safety Alliance (CVSA), Out-of-Service (OOS) Criteria.

DOT Federal Motor Vehicle Carrier Safety Administration, Title 49, Part 393, published in the Code of Federal Regulations.

New Jersey Transit F&SE, Title 39 16:53-3.20 Brakes, Items 55-60 paragraph (a).

49 CFR 571.121, Code of Federal Regulations, Title 49: Volume 5, Part 571, "Federal Motor Vehicle Safety Standards, Section 121, "Air Brake Systems," 2002.

3. Definitions, abbreviations, and acronyms

For the purposes of this recommended practice, the following terms, definitions, abbreviations, and acronyms apply.

3.1 Definitions

3.1.1 burnishing: A process where brake lining surface and brake drum surface are conditioned after reline.

3.1.2 power stroke: The dimensional change in brake chamber stroke between the fully released and fully applied measurements while maintaining 90 to 100 psi air pressure in the air brake system.

3.2 Abbreviations and acronyms

CVSA	Commercial Vehicle Safety Alliance
DOT	Department of Transportation
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standard
GAWR	gross axle weight rating
GVWR	gross vehicle weight rating
OEM	original equipment manufacturer
OOS	out-of-service
PBBT	Performance Based Brake Testers

4. Test provisions

4.1 Training

The operating agency and/or their maintenance contractors should develop and execute training programs that provide employees with the knowledge and skills necessary to perform the tasks outlined in this recommended practice safely and effectively.

4.2 Frequency of testing

The minimum frequency of tasks should comply with OEM/operating agency recommendations and local, state, and federal requirements.

4.3 Tools

A minimum of one of the following tools are recommended for the in-service testing of transit bus brake systems:

– Mechanical decelerometer (e.g. Tapley meter) (See Annex C)

– Electronic decelerometer (e.g. Vericom, Fraser, etc.) (See Annex C)

– Performance Based Brake Testers (PBBT) approved by FMCSA (See Annex D)

Additional tools as recommended by the OEM or as used by the transit industry may also be used.

4.4 Conditions

A suitable, location for a brake road test is one in which the road surface is reasonably level, dry, and free of road debris, sand, gravel, or oil, and where traffic conditions will safely permit the required actions.

Road conditions different from those noted above may affect results.

The following conditions are recommended for the testing of transit bus in-service systems:

- Passenger load – none
- Air tank pressure - vehicle governed cutout pressure at the beginning of the test
- Tire pressure - manufacturer recommended pressure
- Retarder - off (if possible) until the entire test is complete

4.5 Personal protective equipment

Personal protective equipment, as required by the operating agency, should be worn at all times during testing.

4.6 Safety

All appropriate safety precautions should be followed at all times during testing.

5. Tests

5.1 Wedge brakes – CVSA out of service – road side

Test wedge brakes where combined movement of both brake shoes exceeds 1/8”.

Example: The brake lining to drum clearance on the top shoe is 3/32” and the clearance on the bottom shoe is 1/32”. Under this criteria, the brake would not be in an out of service condition, because the total of the top and bottom clearance does not exceed 1/8”.

5.2 S-CAM brake power stroke measurement

Prior to road testing a power stroke measurement of each brake adjuster should be made. The power stroke must not exceed the CVSA readjustment limits for the chamber size.

The measurement procedure may be modified for each agency’s requirements but should contain the following steps:

a) Measure from the brake chamber face to the center of the clevis pin with the service brake and the parking brake fully released. Repeat at all wheel locations.

b) Make a full service brake application while maintaining 90-100 psi air system pressure (dash gauge is acceptable) and hold it.

c) While holding the application, re-measure from the brake chamber face to the center of the clevis. Repeat at all wheel locations.

d) The power stroke measurement is the difference between the brakes fully applied and brakes fully released. Record calculations.

If the power stroke does not exceed the CVSA power stroke limits for the chamber size, then the power stroke inspection is complete.

If the power stroke exceeds the allowable stroke for the chamber size the cause of the overstroke condition must be identified and corrected. If the vehicle is equipped with automatic slack adjusters and measurements exceed the power stroke limits in Table 1, follow manufacturer's recommendations to repair deficiencies. The power stroke should then be retested to confirm compliance.

Table 1 - Power stroke limits

Chamber size	Power stroke limits (inches)	Power stroke limits (mm)
9	1 3/8	35
12	1 3/8	35
16	1 3/4	45
16LS	2	51
20	1 3/4	45
20LS	2	51
24	1 3/4	45
24LS	2	51
24ELS	2 1/2	64
30	2	51
30LS	2 1/2	64
30 DD3	2 1/4	57
36	2 1/4	57

5.3 Burnishing

Burnishing is recommended following replacement or reassembly of foundation brake components.

The burnishing procedure may be modified for each agency's requirements.

See Annex B for details.

5.4 Service brake road deceleration test

Each operating agency may determine the number of tests used and the pass/fail criteria for the road deceleration test.

CAUTION:

Vehicles may pass the deceleration requirements but other conditions may affect the total stopping distance such as:

a) Application delay timing

   A brake pedal sensor triggering device can be used to determine the delay time of the brake application, which may vary due to changes in the pneumatic or foundation brake systems. Application delay time is defined as the amount of time from when the brake pedal sensor is triggered until the vehicle reaches the set point deceleration. Comparison of the delay time within similar model buses and the delay time obtained during the test may provide an indication of the status of the air system.

b) ABS system faults

   Crossed wheel sensors, modulator valves, or apply and hold wiring of the modulator valves can all increase stopping distances and not trigger fault codes. Care should be taken to check for these problems as well as addressing recognized faults.

5.4.1 Mechanical device

If deceleration capability of the service brake system is tested with a mechanical deceleration measurement device, the peak efficiency of 60% (0.6 g) should be achieved from an initial speed of approximately 20 miles per hour.

5.4.2 Electronic device

If the deceleration capability of the service brake system is tested with an electronic deceleration measurement device, an average in-stop deceleration rate of at least 0.528g should be achieved from the initial set point until the vehicle makes a complete stop from an initial speed of approximately 20 miles per hour. The deceleration reading may vary with a different initial set point.

5.5 Parking brake road deceleration test

The purpose of the parking brake is to hold the vehicles in a static condition on a grade. For practical purposes the deceleration tests for the parking brake in Sections 5.5.1-5.5.3 may be used.

5.5.1 Mechanical device

If the deceleration capability of the parking brake system is tested with a mechanical deceleration measurement device a peak efficiency of 17% (0.17g), achieved from an initial speed of approximately 20 miles per hour, is recommended.

5.5.2 Electronic device

If the deceleration capability of the parking brake system is tested with an electronic deceleration measurement device, an average deceleration rate of at least 15% (0.15g) from an initial negative g of 10% (-0.1g) until the vehicle makes a complete stop from 20 miles per hour.

NOTE – It may be necessary to adjust the initial set point of your electronic device to negative 0.1g.

5.6 Brake system performance test using PBBT (Performance Based Brake Tester)

When using a PBBT, a brake system test must be conducted in accordance with the testing procedure outlined in the PBBT OEM technical manual. For additional information on performance brake testing, see *49 CFR 393*[1], as published in the Federal Register Rules and Regulations.

On a given axle the difference in brake forces, left to right, must not exceed 30 percent at the point of wheel lockup.

5.6.1 Brake force while measuring weight

Transit bus brakes may be tested on a PBBT (that meets the US DOT specifications for such devices) as an alternative to a 20 mph vehicle test with a decelerometer. The recommended minimum braking force as a percentage of actual vehicle weight is 52.8%.

5.6.2 Brake force while measuring primary control pressure

During the PBBT test, primary control line service pressure can be measured and each service brake chamber should meet the criteria indicated in Table 1 of Annex D.

By using GAWR and GVWR to provide a basis for the requirements, the loaded braking capability of the vehicle is estimated.

[1] For references in Italics, see Section 2.

NOTE –See Annex D for a more detailed description of bus brake testing while using a PBBT.

5.6.3 Parking brake test

If the deceleration capability of the parking brake system is tested with a PBBT measurement device, a deceleration rate of at least 0.15 g is required. Deceleration is calculated by adding the parking brake forces measured on a PBBT and then dividing by the GVWR of the vehicle.

5.7 Correction of deficiencies

Deficiencies uncovered during transit bus in-service brake system performance testing should be corrected and documented in accordance with operating agency procedures and/or OEM recommendations.

5.8 Documentation

Testing should be documented on a standard form (electronic or paper) and be reviewed and filed in accordance with operating agency procedures.

Annex A

(informative)

Bibliography

[B1] CVSA

[B2] 396.17-25, Appendix G to Subchapter B, Subpart C- Brakes

[B3] 49 CFR 396.17-25, Code of Federal Regulations, Title 49: Volume 65, Part 393, Sections 17-25, 2002.

[B4] 49 CFR 393.40-53, Code of Federal Regulations, Title 49: Volume 65, Part 393, "Brake Performance Requirements for Commercial Motor Vehicles Inspected by Performance-Based Brake Testers," Sections 40-53, 2002.

Annex B

(informative)

Burnishing

The burnishing procedure establishes the compatibility between the lining material and the drum. For optimal use of any given brake system, the brake shoes and drum have to be compatible with each other. This is achieved by a combination of rubbing speed, temperature, air pressure, and inertia. Burnishing is also influenced by the lining and drum material chemistries.

B.1 Burnishing advantages

a) Gradually eliminates any thermal shock in the drum

b) Eliminates residues that are near the lining and drum surfaces, thereby reducing new lining fade

c) Establishes a layer of transfer film a few microns thick on the drum surface (Otherwise, when using a freshly ground drum without the transfer film, the main friction force comes from cutting, plowing, or scoring of the lining surface. This leads to inconsistent braking effectiveness.)

d) Mates the drum and lining surfaces for an improved contact area

e) Reduces lining glazing and drum high spots

B.2 Burnishing procedure

Burnish procedures may be modified for each agency's requirements, but should be similar to the following steps:

a) Using the service brake, slow the vehicle from 20 to 5 mph at approximately 0.3 g deceleration, or a moderate brake application. Repeat this process 10 times (snubs) at regular intervals of approximately 500 ft. or 0.1 mile without stopping the vehicle.

   CAUTION: Do not permit wheel lock up.

b) After the tenth brake application (snub), make one complete stop from 20 to 0 MPH.

c) Compare drum temperature differential immediately after burnishing. Any drum that is significantly cooler (approximately 50°F side to side, 100°F front to rear) than the others indicates a lack of braking effort. Inspect the vehicle for brake defects and perform necessary repair. After repairs have been made, repeat burnishing.

Annex C

(informative)

Comparison of measuring devices

In order to put the braking performance (i.e. stopping distances) of a transit bus in the proper perspective, it is important to first understand the differences between the various instruments used to measure stopping distance. The stopping distance determined with an electronic brake tester (such as Vericom or Fraser) will always be greater than that recorded by a mechanical brake tester (such as a Tapley meter) and less than that recorded by a fifth wheel. Testing on transit buses at Radlinski and Associates, Inc. (RAI) have indicated that the Tapley meter using peak deceleration gave 20 mph stopping distance estimates 5 to 9 feet shorter than the electronic brake tester using average deceleration and the electronic brake tester gave 20 mph stopping distance estimates 3 to 5 feet shorter than the fifth wheel.

These differences in stopping distance are related to how the three devices determine stopping distance. The fifth wheel measures stopping distance as specified by federal regulations (FMVSS No. 121, FMCSR 393.52) and SAE Recommended Practices which all define stopping distance as the distance traveled from first movement of the brake pedal until the vehicle reaches a stop. The fifth wheel system counts revolutions of a trailing wheel that has a known circumference. The system triggers (starts counting distance) when the pedal is first moved. A switch on the brake pedal senses this movement. The system also determines vehicle speed from the rate of trailing wheel rotation when the pedal is first moved and throughout the stop. Initial speed information is then used to provide a “corrected stopping distance” or distance that would result if the vehicle was traveling at exactly some speed (20 mph in this case). The formula in SAE Recommended Practice J299 is used to make this correction.

Electronic brake testers measure braking rate (deceleration) with an electronic accelerometer, a device that senses rate of speed change, and then it uses these data to calculate stopping distance. It does not measure stopping distance directly but uses a mathematical process known as double integration to compute the distance. It does not start recording data until the deceleration reaches the threshold setting and as such does not measure what happens at the beginning of the stop (i.e. from first movement of the pedal until the vehicle braking rate reaches the threshold setting).

The mechanical brake tester is a pendulum device that measures deceleration but it only saves (records) a value that represents the maximum deceleration reached during the stop. The scale of the mechanical brake tester is calibrated in percent g and stopping distance in a side-by-side fashion but the distance that corresponds to a given percent g value assumes that the peak deceleration is maintained during the entire stop and that there is no application time to reach this level.

In summary, the fifth wheel measures stopping distance directly while the electronic and mechanical brake testers measure deceleration and then compute stopping distance from this deceleration information. Because the electronic brake tester records deceleration over most of the stop and uses all of this data in the computation process, it provides a more accurate measure of actual stopping distance than does the mechanical brake tester but the electronic tester does miss the distance traveled at the beginning of the stop until the vehicle reaches the threshold setting.

The fact that the three devices produce different results does not mean that they are not useful for measuring or comparing brake performance. In the testing conducted at RAI, they all ranked different levels of braking performance in the same way indicating that they do provide good *relative* measures of braking performance. ***The problem arises in comparing the absolute value of their measurements.*** Since the electronic and mechanical testers actually measure deceleration, it makes more sense to report their measurements in terms of deceleration and not stopping distance, as they do not measure "true" stopping distance. Furthermore, the mechanical tester measures peak deceleration whereas the electronic tester measures both peak and average deceleration. Peak and average are both good measures of braking performance, but they are different values and cannot be compared. However, the average deceleration more accurately predicts the actual stopping distance.

> *New Jersey Transit's Title 39 regulation*[2] has a stopping distance requirement that a bus must stop from 20 mph in less than 22.5 feet. This distance was originally established when the DOT and transit properties were using Tapley meters and represents a peak deceleration reading of 0.6g. Since testing at RAI has shown that a Vericom, using average deceleration, will give 5 to 9 feet longer stopping distance than a Tapley on the same vehicle with the same brakes, vehicles that would meet the requirement using the Tapley meter might be marginal or not meet the requirement when an electronic tester is used to determine stopping distance. This does not mean the brakes are defective, only that the test instrument being used is producing a different "number" that is longer.
>
> A more reasonable approach would be to use peak deceleration rate or average deceleration rate as the pass-fail criteria, not stopping distance. New York State has actually changed their brake regulation for buses to take into account the differences in mechanical devices that measure peak deceleration and electronic devices that measure average deceleration. Under 720.4 (Z)(1)(b) Service Brakes, of the New York State DOT regulations a mechanical device (like a Tapley) must measure a peak efficiency of at least 60% (0.6 g) from an initial speed of approximately 20 mph. If an electronic device (like a Vericom or Fraser) is used, an average deceleration rate of at least 0.528 g must be obtained from an initial speed of approximately 20 mph.

RAI has recently tested several transit buses used in New York and New Jersey. Below are three figures showing the stopping distance comparison between a fifth wheel, Vericom 2000, Vericom 3000 and Tapley meter for three different transit buses with three different wheelbases under several test configurations. Also included are average deceleration and peak deceleration charts. Data was recorded from the fifth wheel, Vericom, and Tapley simultaneously during each stop. The target speed for all the stops was 20-mph. The buses were at empty weight for all the stops. The data plotted is the average of six stops.

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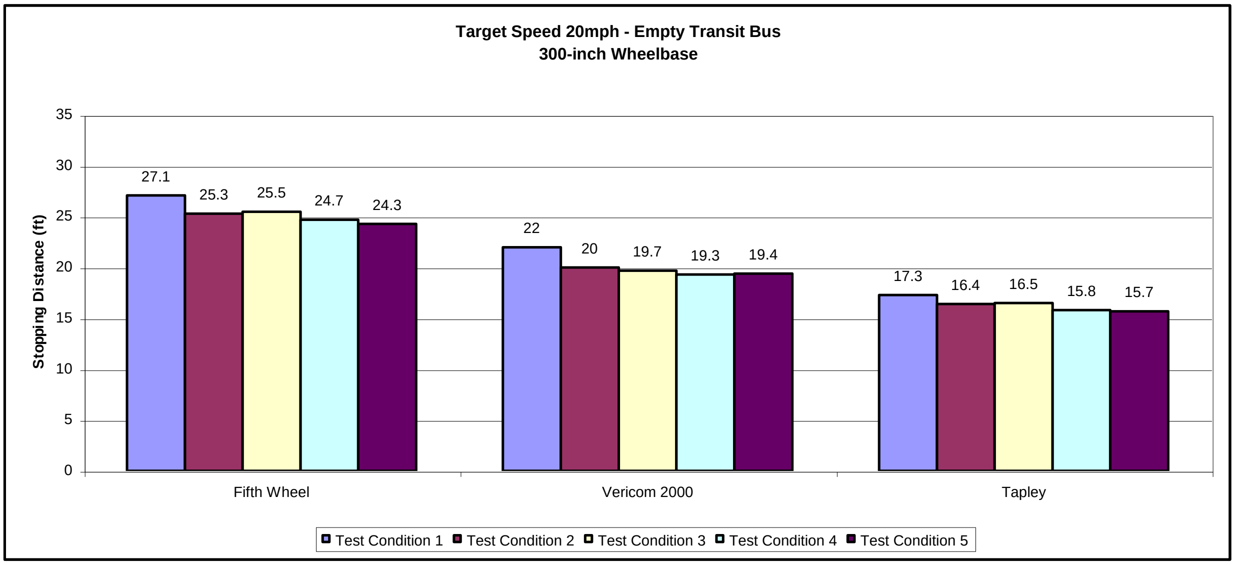
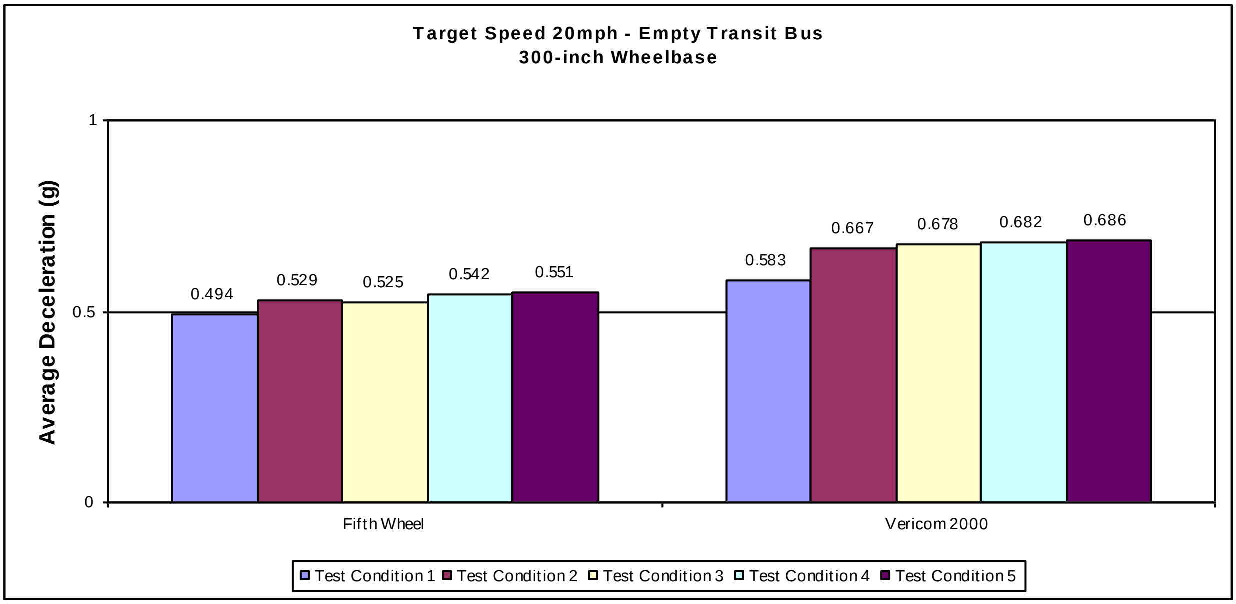
[2] For references in Italics, see Section 2.





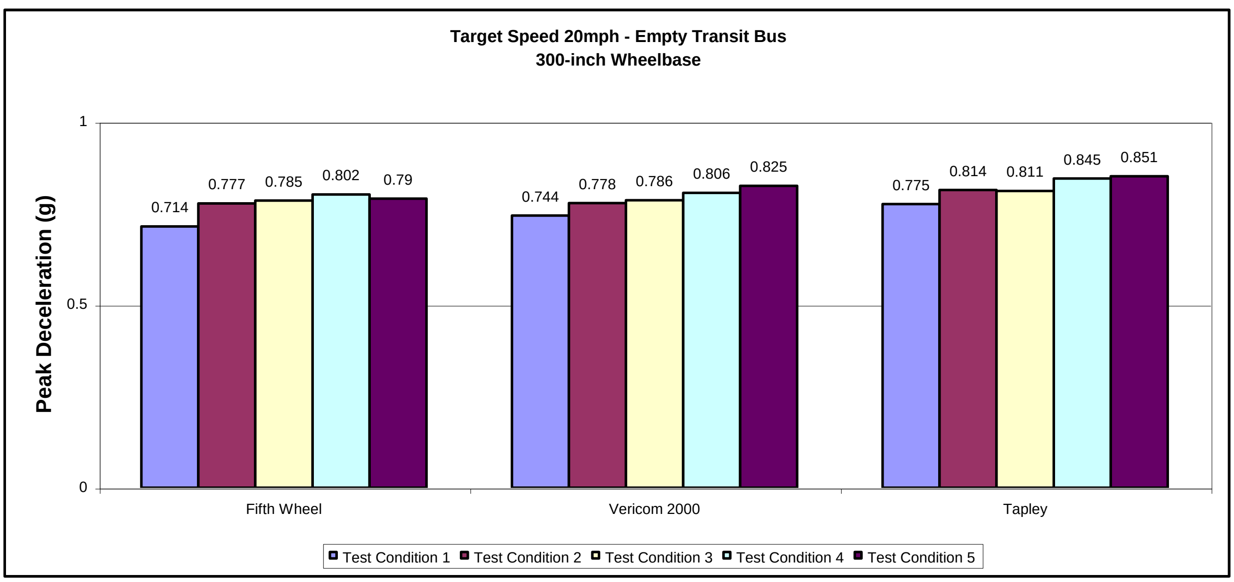
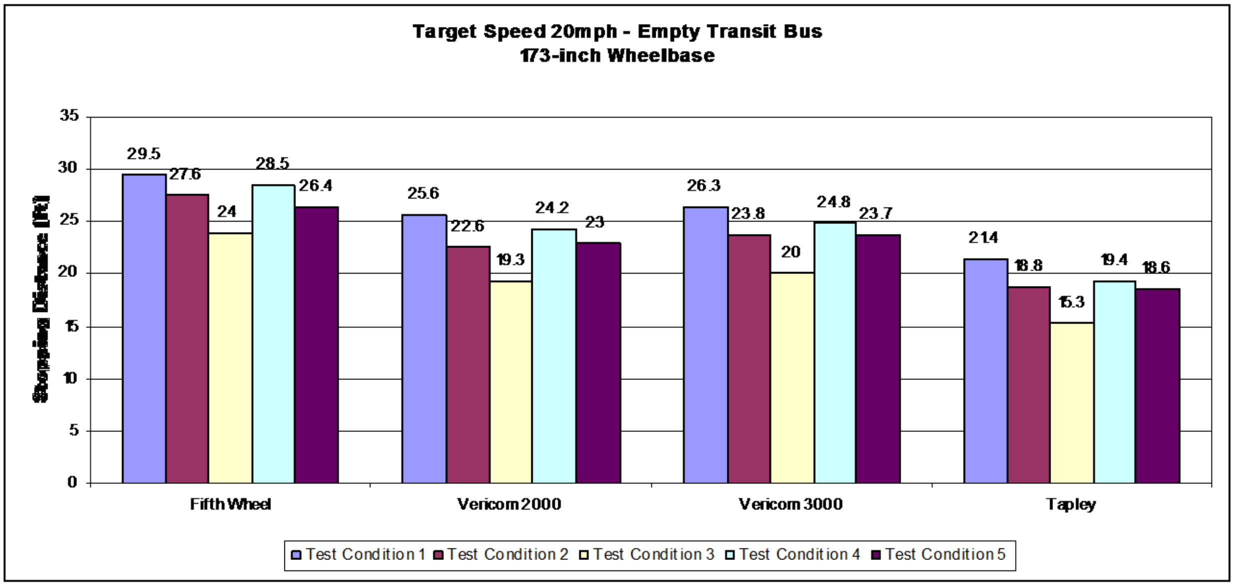
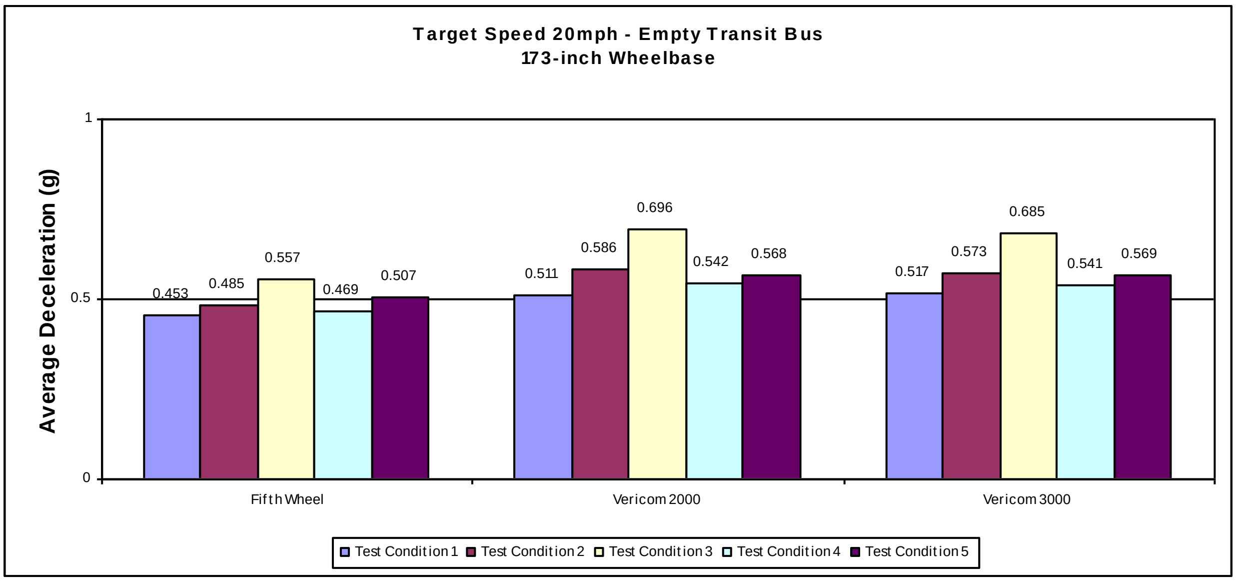


Figure 1 – Long wheelbase transit bus





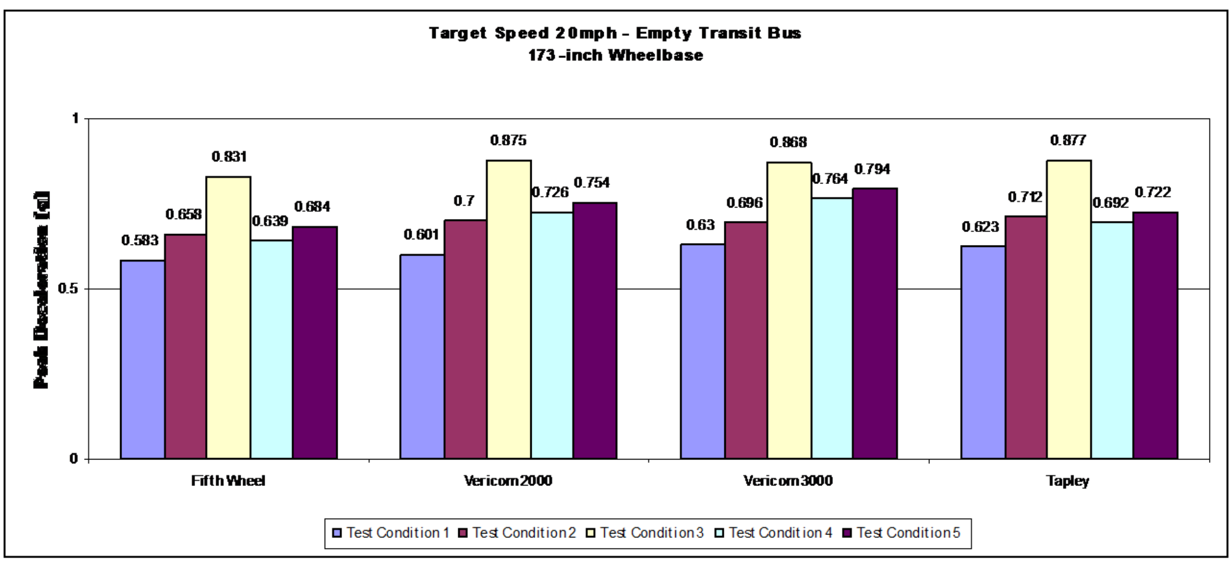
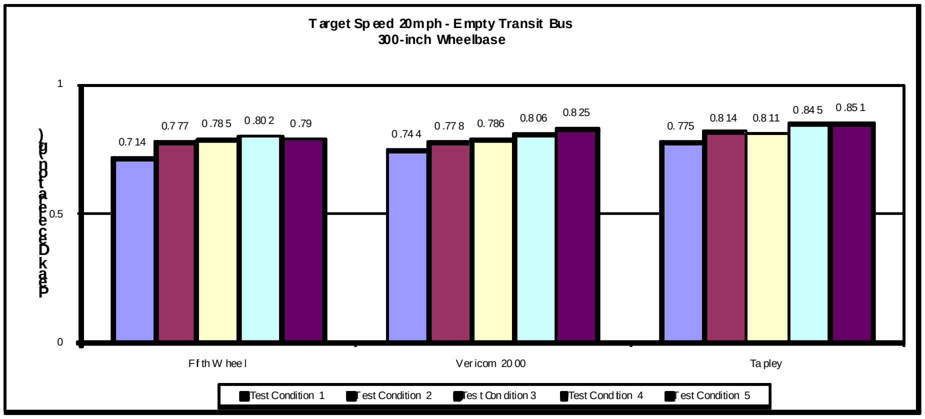
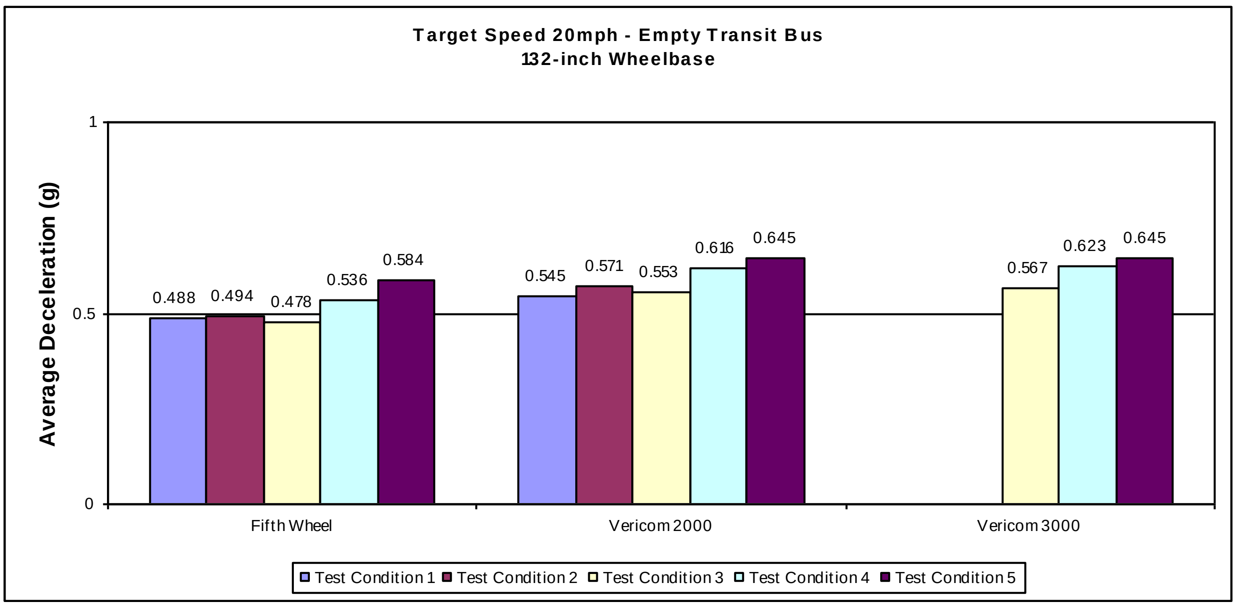


Figure 2 – Medium wheelbase transit bus





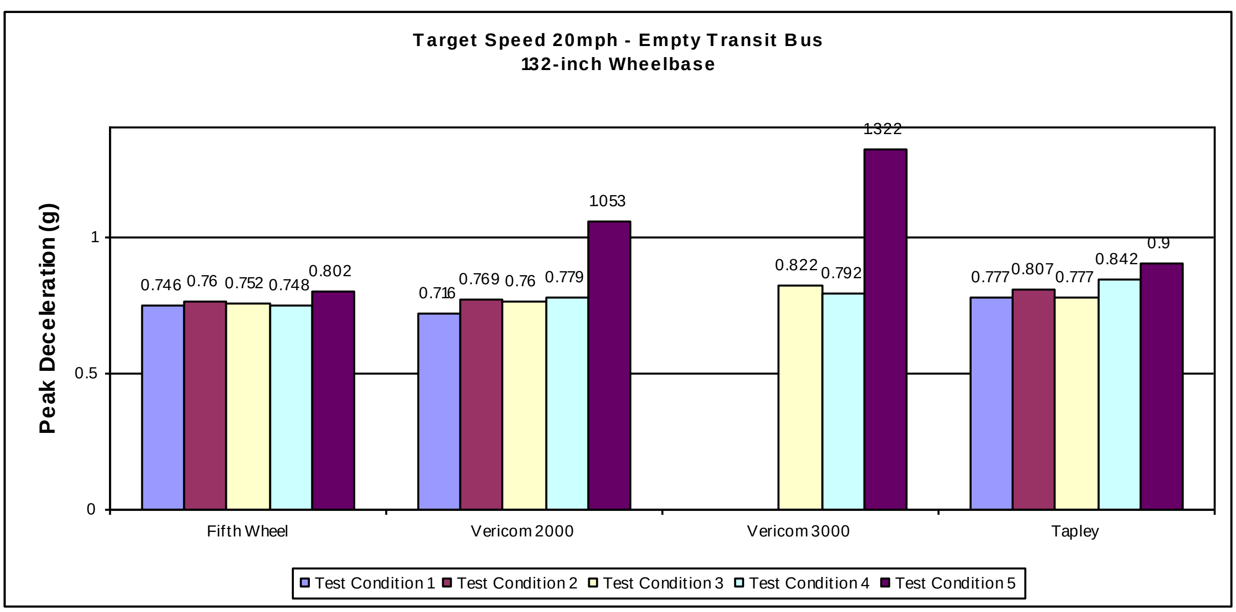


Figure 3 – Short wheelbase transit bus

Annex D

(informative)

Use of performance based brake testers to verify brake performance

D.3 Background

The Federal Motor Carrier Safety Administration of the US DOT has issued a modification to the Federal Motor Carrier Safety Regulations (effective date February 5, 2003) that allows the use of a PBBT (that meets certain DOT specifications) to determine compliance with the brake performance requirements of section 393.52.

Section 393.52 requires that the brake forces on the vehicle must be capable of producing a vehicle deceleration of at least 0.435g (14 ft/sec^2). If the total of the maximum brake forces for individual wheels measured on a PBBT are greater than 0.435 times the vehicles weight, the vehicle then meets the deceleration requirement of s.393.52.

Historically, the transit industry has also used deceleration as a measure of brake performance, but the requirements that are typically implemented require a deceleration greater than that specified in FMCSR 393.52.

Some properties use a Tapley meter with a 22.2-foot requirement. This actually corresponds to a peak deceleration of 0.6g or peak brake efficiency of 60%. Others use a Fraser or Vericom or some other electronic decelerometer with a requirement of 0.528g average deceleration. In either case this is significantly higher deceleration and brake performance than required by the FMCSR.

D.4 Advantages of using a PBBT to measure brake performance

PBBTs offer a number of advantages over a road test:

a) The test can be run indoors and is not affected by weather

b) The test is safer (no moving vehicles or traffic issues)

c) There is no damage to the tires or suspension

d) They can measure performance at each individual wheel and can identify exactly where the problem is located

e) They are fast and can check service brakes, parking brakes and ABS function, all in less than 10 minutes

f) They can measure front to rear brake force balance and threshold pressures in order to assess wear balance issues

g) They can measure left/right balance in order to determine the source of steering pull complaints

h) They can measure rolling resistance in order to identify dragging brakes or bad wheel bearings

D.5 Discussion of braking requirements when using a PBBT

D.5.1 Service brake effectiveness

The current deceleration requirement of 0.435g in the FMCSR 393.52 has historically been considered too lenient by transit operators and the requirement to be used with PBBTs needs to be higher to satisfy transit needs. European countries generally require that deceleration be at least 0.5g based on PBBT measurements, but this is for annual inspections as opposed to random road-side inspections where the FMCSR apply (and must therefore allow for some degradation between annual inspections).

FMVSS 121, the brake standard for new vehicles, requires that each brake on a vehicle meet certain dynamometer requirements using a laboratory device known as an inertia dynamometer. Table 1 below shows the brake effectiveness requirements from FMVSS 121.

Table 1 - FMVSS 121 dynamometer requirements - brake effectiveness at 50 mph

Pressure (psi)	Retardation Ratio
20	0.05
30	0.12
40	0.18
50	0.25
60	0.31
70	0.37
80	0.41

Retardation ratio is simply the brake force divided by the rated wheel load (GAWR/2). If all of the wheels on the vehicle developed a retardation ratio of exactly 0.41 at 80 psi, then the deceleration of the vehicle at 80 psi would be 0.41 g.

It is proposed that the FMVSS 121 requirements in Table 1 be used with a PBBT to serve as one of the pass-fail criteria for service brake force at each wheel. Since the FMVSS 121 requirements in Table 1 are for a 50 mph stop and the measurements on a PBBT are usually made at 5 mph or less, using such a criteria on a PBBT actually allows for some degradation from the new vehicle requirement. This is because brake force increases as speed is reduced and the PBBT would be expected to produce a higher brake force than the inertia dynamometer. Some degradation from the new vehicle requirements is reasonable and in addition FMVSS 121 requires that brakes be burnished to a very specific temperature-controlled procedure that may not be representative of transit operations.

D.5.2 Side-to-side (left/ right) balance on service brake forces

Experience has shown that left to right brake force differences across an axle that exceed 30 percent indicate that something is wrong with the brake that has the lower force. European-based PBBT requirements use the 30 percent as pass-fail criteria and in fact some countries set this limit at 20 percent for the steering axle.

It is proposed that the 30 percent criteria be used to identify a brake problem in the transit requirements for PBBTs.

D.5.3 Parking brake forces

FMVSS 121 requires that a vehicle at full load (GVWR) must hold on a 20 percent slope. It is proposed that for transit, this value be set at 15 percent to allow for some degradation, which is normal for the spring brake assemblies.

Grade holding is calculated by adding the parking forces measured on a PBBT and then dividing by the GVWR of the vehicle.

D.6 Test results

RAI tested a 30-foot transit bus with a GVWR of 33,000 lbs. The unit was tested because the bus would not meet the 0.528g average deceleration requirement for a 20-mph stop, when measured with an electronic decelerometer. The attached charts in Figure 1 show the retardation ratio calculated from brake force measured on a PBBT divided by GAWR/2 for each brake. The curves show the PBBT retardation ratio before and after the bus was repaired. When the retardation ratio from the PBBT fell below the FMVSS 121 50-mph retardation requirement, the bus would not meet the average deceleration requirement for a 20-mph stop measured with an electronic decelerometer. When the retardation ratio was above the FMVSS 121 requirement, the bus met the 20-mph average deceleration requirement of 0.528g.

D.7 Specific recommendation

Transit bus brakes may be tested on a PBBT (that meets the US DOT specifications for such devices) as an alternative to a 20 mph vehicle test with a decelerometer.

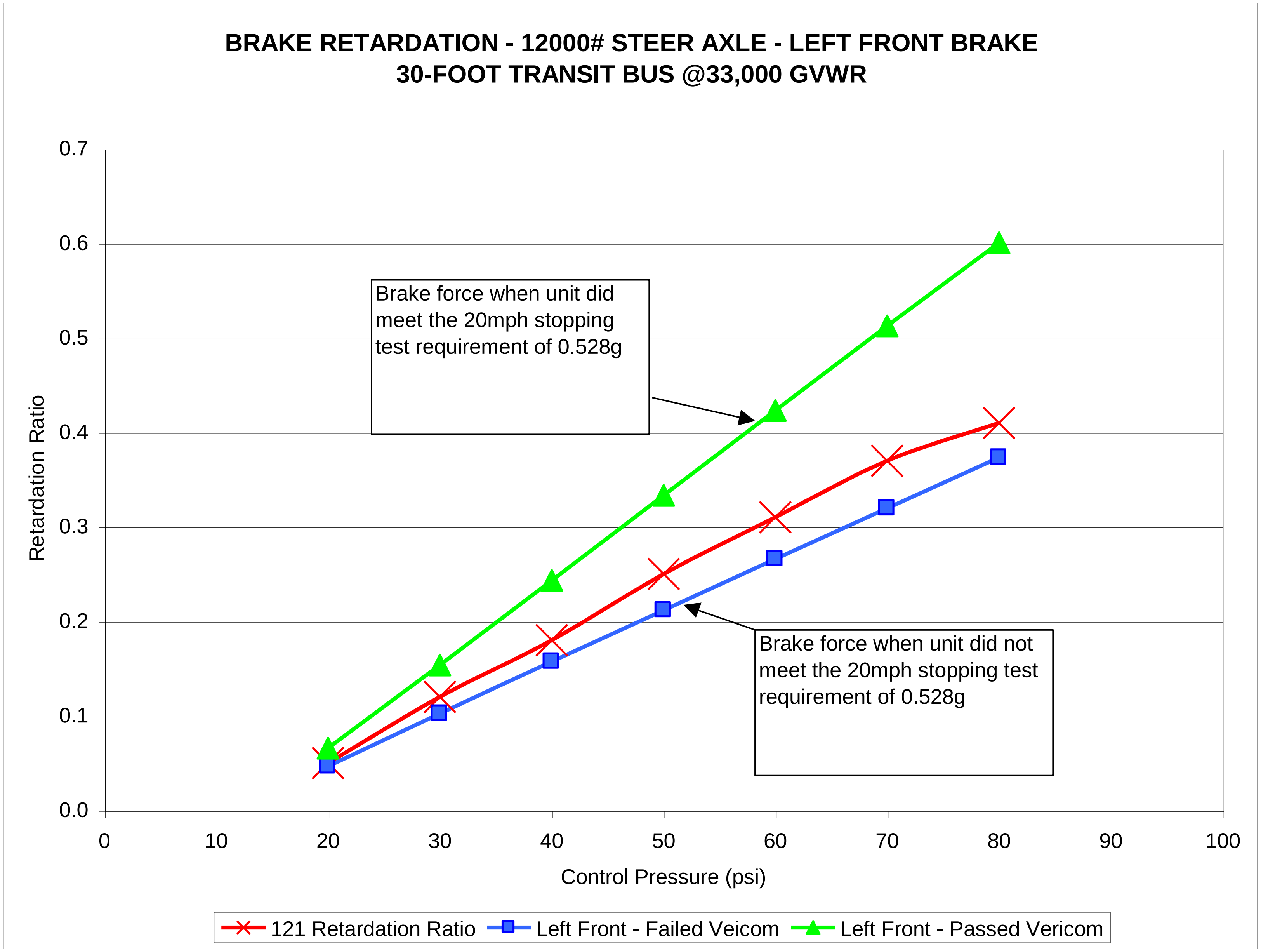
During the PBBT test, each service brake must develop brake forces that exceed those values shown in the table of retardation values in FMVSS 121 (see table 1 in Section D.5.1). These required retardation values must be based on rated wheel weight (GAWR/2).

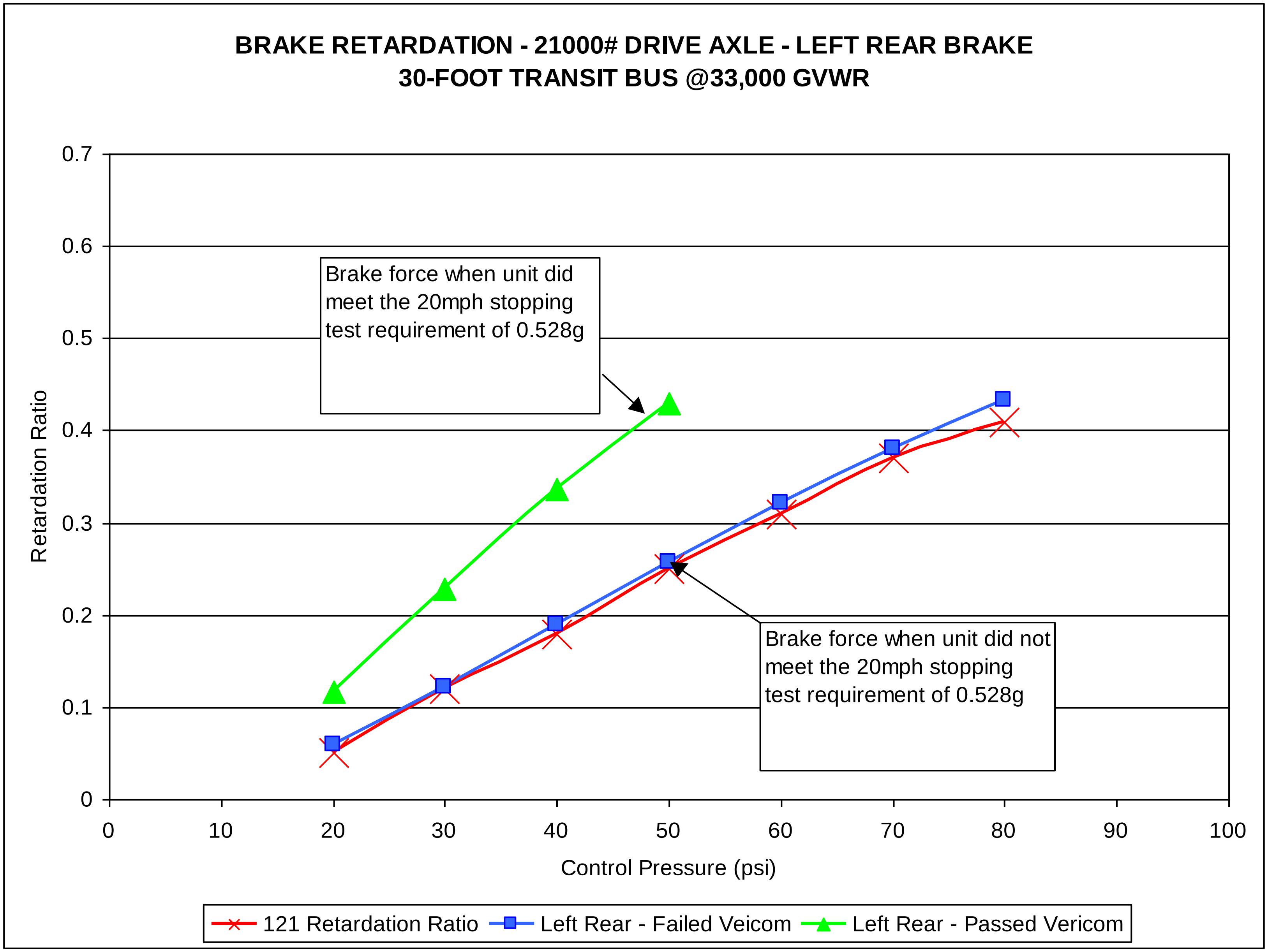
On a given axle the differences in brake forces, left to right, must not exceed 30 percent at the point of lock wheel up. Percent difference is equal to the difference in brake forces divided by the higher of the two forces times 100.

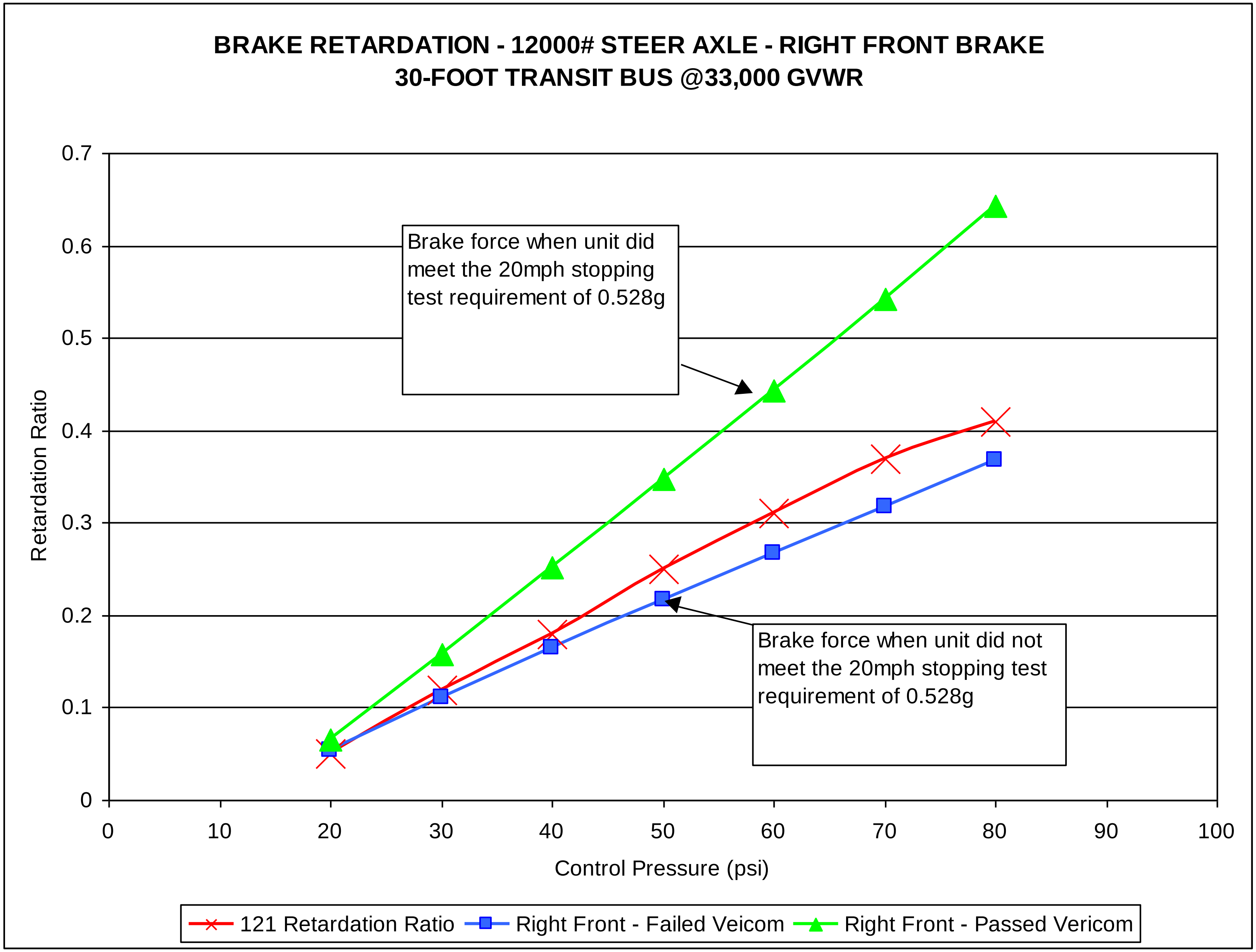
The total of the brake forces developed by the parking brakes must be equal to or exceed 15 percent of the GVWR.

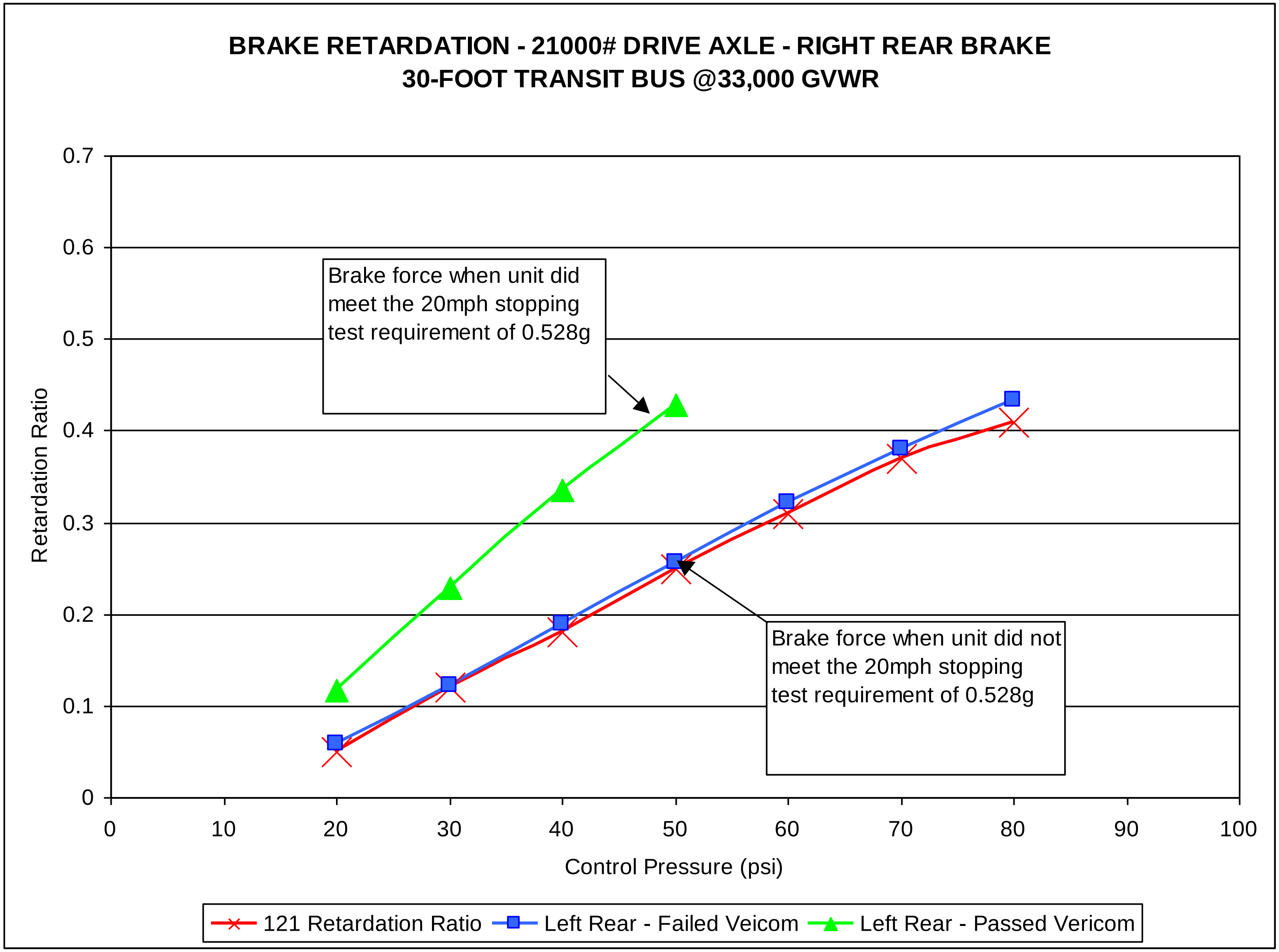
NOTE – By using GAWR and GVWR to provide a basis for the requirements, the loaded braking capability of the vehicle is determined. In addition, it is then not necessary to actually measure the weight of the bus with the PBBT. Eliminating the need for weight measurement reduces the initial cost of the equipment and also reduces the cost for maintenance and calibration. GAWR and GVWR are the parameters used when designing brakes.

Measurement of brake pressure is necessary during the test in order to give a measure of brake effectiveness. The FMCSR PBBT test does not measure pressure and as such may miss brake problems that result in driver complaints. Pressure can be easily measured in the primary control line by installing a quick coupler and leaving it in place (if the bus does not already have one). Each time the bus is tested, the pressure transducer provided with the brake tester is installed during the test. Both wireless and cable style transducers are available.


BRAKE RETARDATION - 12000# STEER AXLE - LEFT FRONT BRAKE
30-FOOT TRANSIT BUS @33,000 GVWR
Retardation Ratio
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
10
20
30
40
50
60
70
80
90
100
Control Pressure (psi)
Brake force when unit did meet the 20mph stopping test requirement of 0.528g
Brake force when unit did not meet the 20mph stopping test requirement of 0.528g
121 Retardation Ratio
Left Front - Failed Veicom
Left Front - Passed Vericom


BRAKE RETARDATION - 21000# DRIVE AXLE - LEFT REAR BRAKE
30-FOOT TRANSIT BUS @33,000 GVWR
Brake force when unit did meet the 20mph stopping test requirement of 0.528g
Brake force when unit did not meet the 20mph stopping test requirement of 0.528g
Retardation Ratio
Control Pressure (psi)
121 Retardation Ratio
Left Rear - Failed Veicom
Left Rear - Passed Vericom


BRAKE RETARDATION - 12000# STEER AXLE - RIGHT FRONT BRAKE
30-FOOT TRANSIT BUS @33,000 GVWR
Retardation Ratio
Control Pressure (psi)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
10
20
30
40
50
60
70
80
90
100
Brake force when unit did meet the 20mph stopping test requirement of 0.528g
Brake force when unit did not meet the 20mph stopping test requirement of 0.528g
121 Retardation Ratio
Right Front - Failed Veicom
Right Front - Passed Vericom


BRAKE RETARDATION - 21000# DRIVE AXLE - RIGHT REAR BRAKE
30-FOOT TRANSIT BUS @33,000 GVWR
Retardation Ratio
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Brake force when unit did meet the 20mph stopping test requirement of 0.528g
Brake force when unit did not meet the 20mph stopping test requirement of 0.528g
0
10
20
30
40
50
60
70
80
90
100
Control Pressure (psi)
121 Retardation Ratio
Left Rear - Failed Veicom
Left Rear - Passed Vericom