The Engineering Society
For Advancing Mobility
Land Sea Air and Space®

Product of the
Cooperative Engineering Program

SAE J1854 JUN88

Brake Force/ Distribution Performance Guide — Commercial Vehicles

SAE Recommended Practice
Issued June 1988

Submitted for Recognition as an American National Standard

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space ®

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TRUCK AND BUS PRACTICE

SAE J1854

Issued June 1988

BRAKE FORCE/DISTRIBUTION PERFORMANCE GUIDE - COMMERCIAL VEHICLES

1. INTRODUCTION:

The performance guidelines specified in this SAE Recommended Practice represent the accumulation of information available from investigations of the brake system performance of air braked towing trucks, truck-tractors, truck-trailers, converter dollies, and combinations of these type vehicles. Because these guidelines are based on data limited by voluntary submissions of equipment and information, and testing was limited to specific conditions, they may not necessarily represent optimum performance for all vehicles under all operating conditions. Therefore, the values specified in this recommended practice are target values; all targets are mean values except for the one minimum value specified.

2. SCOPE:

This SAE Recommended Practice establishes performance guidelines for the threshold pressure and brake force output of the brakes on the axles of air braked towing trucks, truck-tractors, truck-trailers, and converter dollies with GVWRs over 10 000 lb designed to be used on the highway in combination with other air braked vehicles of this type in commercial operations.

3. PURPOSE:

The purpose of this recommended practice is to establish target threshold pressures and brake force outputs with reference to brake application pressures as measured at the rear control line gladhand of truck-tractors and towing trucks, the front control line gladhand of non-towing trailers, and the front and rear control line gladhand of towing trailers and dollies.

4. TEST PROCEDURE:

Tests to determine the brake force output of vehicles to be used in combinations and the brake force distribution of combination vehicles shall be conducted in accordance with SAE J1505. The brakes of newly manufactured vehicles built to be used in combinations shall be burnished prior to testing according to the burnish procedure specified in Section 6.1.8.1 of Federal Motor Vehicle Safety Standard No. 121, Air Brake Systems.

5. PERFORMANCE GUIDELINES:

5.1 Newly Manufactured Vehicles Used in Tractor/Trailer or Truck/Trailer Combinations,

5.2 Threshold Pressure (Average of the brake apply and release pressures measured as specified in paragraph 6.3 of SAE J1505): 6 lbf/in^2

5.1.2 Brake Force Output at 40 lbf/in^2:

5.1.2.1 Tractor or Towing Truck Steer Axles: 0.20 X GAWR (Minimum)

5.1.2.2 Single axles with GAWRs of 16 000 to 20 000 lb: 4600 lb

5.1.2.3 Axles of an "axle system" whose GAWR divided by the number of axles is from 16 000 to 20 000 lb: 4600 lb

RATIONALE:

GENERAL:

In May, 1985, the SAE approved Recommended Practice J1505, Brake Force Distribution Test Code - Commercial Vehicles, which established a test procedure for determining the brake force compatibility of heavy air braked vehicles used in combination. This procedure was developed to provide the trucking industry with a procedure for determining brake force balance which is more accurate than the procedure set forth in SAE J225, Brake System Torque Balance Test Code - Commercial Vehicles. SAE J1505 is not a replacement for SAE J225 because SAE J225 can be a useful tool for determining gross brake force compatibility in those circumstances where the available intrumentation/factilities are not suitable for conducting tests in accordance with SAE J1505.

SAE J1505 is designed to be used by vehicle/component manufacturers and fleets/owners to accurately determine the brake force compatibility of vehicles in service and by vehicle manufacturers to determine whether or not the brake systems on their new vehicles will be compatible with the brake system on other vehicles with which they will be connected to form combination vehicles. This new vehicle compatibility determination, however, can only be made if there are established performance values to accompany the performance tests which manufacturers can use as guidelines. SAE J1854 is proposed to provide these guidelines in terms of target values.

BURNISH:

The braking performance of new vehicles with new brake linings is generally not as consistent as with burnished linings and not the same as the performance of vehicles in service. To correct for this, the proposed SAE J1854 specifies that the brakes be burnished prior to conducting the SAE J1505 tests. The burnish proposed is the burnish specified in Federal Motor Vehicle Safety Standard (FMVSS) 121. This burnish was selected as it is believed to be the most common burnish in use by manufacturers. Using this burnish should minimize the amount of effort required by manufacturers in determining compliance of their vehicles with SAE J1854 guidelines since the vehicles, in many cases, will already have been subjected to the FMVSS 121 burnish for other testing purposes.

THRESHOLD PRESSURE:

One of the two performance tests specified in SAE J1505 is the test for determining threshold pressure. The threshold pressure test is the simplest of the two tests requiring very little instrumentation. The target values for the threshold pressure is specified as 6 lbf/in^2.

A threshold pressure of 6 lbf/in^2 is proposed based on the following:

1. The threshold pressure tests conducted on in-service vehicles by the TTBRG in support of the subcommittee's efforts showed the average threshold pressure for the 15 trucks to be 6.1 lbf/in^2 and the average for the 27 trailers/dollies to be 4.9 lbf/in^2.

2. Threshold pressure tests conducted by nine trailer manufacturers (3 in 1985 and 6 recently) produced average threshold pressure values of 3.9, 4.3, 5.0, 5.0, 5.2, 5.2, 5.5, 5.5 and 6.9 lbf/in^2. Trailer manufacturers providing data were Budd, Dorsey, Fruehauf, Great Dane, Lufkin, Strick, Trailmobile, Thuerer, and Utility.

There is a division within the subcommittee between whether the threshold target should be 5 or 8 lbf/in^2. With over 2 million heavy truck-tractors and trailers in service, it is impossible to test enough vehicles to determine the average threshold value statistically. In support of the 8 lbf/in^2 target is data on a group of trucks which shows an average threshold pressure of 8.6 lbf/in^2. Also, for trailers, there is survey data showing the average crack pressure for the relay valves used on trailers to be 5.0 lbf/in^2 which some say can be added to the 3 lbf/in^2 average brake chamber threshold pressure to get an average theoretical threshold pressure for trailers of 8 lbf/in^2. Supporting the 6 lbf/in^2 position is the consistency of the data in 1 and 2. In addition, an analysis of the TTBRG test data shows one manufacturer to frequently use relay valves with high crack pressure and when a sample only includes these vehicles, the average threshold pressure is over 8 lbf/in^2; however, for a random sample such as the TTBRG 15 truck sample (which included three trucks with high crack pressure valves), the threshold value is closer to 6 lbf/in^2. Also, proponents of 6 lbf/in^2 claim that the theoretical average threshold pressure for trailers must be calculated using relay valve performance curves and not the crack pressures; when this is done using the performance curve for a relay valve with a crack pressure of 5 lbf/in^2, the threshold value for trailers calculates to be close to 5 lbf/in^2.

Although the available test data indicates that the average threshold pressure for trailers is less than 6 lbf/in^2, a lesser threshold pressure is not proposed because the data for trucks indicates an average threshold pressure of 6 lbf/in^2. It should be easier to raise threshold pressures than reduce them.

The threshold pressure for the front steer axle brakes of trucks is proposed to be the same as for the other brakes of the truck since a vehicle generally performs best in braking maneuvers when all of the brakes apply and release together. This also optimizes brake life.

BRAKING FORCE:

The major part of SAE J1505 specifies a test procedure for determining the brake force output of each axle of a combination vehicle. The brake force output is determined at 15, 20, and 40 lbf/in^2.

This proposed document specifies a target value for only the 40 lbf/in^2 brake force output. This is done to simplify the design goals. It is considered acceptable, at this point, since the shape of all brake force curves are generally the same up to 40 lbf/in^2. Therefore, given present day technology, specifying performance at the two end points (threshold and 40 lbf/in^2) should adequately describe the desired performance.

This proposed document also only specifies one braking force for brakes used on single axles (other than truck steer axles) in the 16 000 to 20 000 lb GAWR range and for each axle of a tandem axle set in the 32 000 to 40 000 lb GAWR range. These ratings are common axle ratings on tractors and trailers which are often randomly mixed to form various combination vehicles. Setting one value for these axles can make equal braking possible on each axle regarless of the GAWR rating (within the specified range). The proposed range is not unusual, as axle manufacturers commonly put enough brakes on axles to qualify them for 20 000 lb GAWR (40 000 lb tandem GAWR) ratings even though the axle may be given a lower GAWR for other reasons such as tires, suspension, etc. The TTBRG test data confirms this; for trailers, it shows 34 000 lb tandem axles providing more braking force than 40 000 lb tandems and 16 500 single axles providing as much braking force as 20 000 lb axles. For tractors, the TTBRG data shows the average brake force for single axles rated at 20 000 lb or more to be 3500 lb and for each 17 000 lb axle of 34 000 lb tandem to 3800 lb.

At first it appears that setting one target value for a range of axle ratings to get good heat/wear balance in normal everyday brake applications may compromise emergency braking performance by promoting premature wheel lock up on the axle with the lowest GAWR. However, a closer look shows the effect on emergency braking, at worse, to be a wash because combinations are not generally loaded proportionally to their GAWRs. Combinations are usually loaded, to the degree practical, so that the load is distributed equally among the axles with a weight biased toward the drive axles (and forward trailer axles of doubles combinations). For example, a tandem axle combination loaded to the 80 000 lb limit, has the 34 000 lb limit load on each tendem regardless of the GAWRs. On the negative side, when tandem axle vehicles are combined with single axle vehicles, the tandem axles could prematurely lock up if each axle is loaded to the legal limit. For empty combinations where the trailer axles are typically 20 - 40% lighter than the truck rear axles, the range proposal would provide better emergency braking performance (compared to brakes proportioned to GAWRs) when the trailer axles have the higher GAWRs and worse performance, but to a lesser degree, when the tractor rear axles have the higher GAWRs.

BRAKING FORCE: (Continued)

The 40 lbf/in^2 brake force target value proposed for the single axle range of 16 000 to 20 000 lb is 4600 lb and for the tandem axle 32 000 to 40 000 lb range is 9200 lb. These brake forces represent a retardation of 0.23 for 20 000 lb single axles and 40 000 lb tandem axles. These target values are based on the performance presently specified by SAE J992, Brake System Performance Requirements - Truck, Bus, and Combination Vehicles, and the minimum brake force required by the dynamometer requirements of FMVSS 121 for a 20 000 lb trailer axle. The attached sheet shows how the proposed values were derived from these requirements. The SAE J992 analysis indicates that each drive and trailer axle of a 5-axle combination vehicle grossed to the 40 000 lb legal limit and conforming (12 000 lb front steer axle with a 0.20 brake retardation) should be capable of developing, at 37.5 mph and 40 lbf/in^2, a braking force of 4400 lb which is a retardation of 0.22 for 20 000 GAWRs. The FMVSS 121 dynamometer data analysis indicates that a retardation of 0.21 is needed to meet the requirements of 121; adding a 10% tolerance increases value to 0.23. This 10% tolerance is less than the 15% brake manufacturers say they need but the TTBRG data indicates the calculated 0.21 may be a little high; this data shows some axles which had to have been manufactured to the requirements of 121 as having retardations of only 0.14 which is low even considering the lack of burnish. The average retardation for trailer axles with GAWRs of 20 000 lb or more was about 0.2.

Axles with GAWRs less than 16 000 or greater than 20 000 are not included in the proposed range because it would make the range too broad and the brake force for the lower rated axles too high. Also, except for 23 000 GAWR single axles, axles with GAWRs outside this range are not commonly on the on-highway vehicles interchanged commercially with other vehicles to form combination vehicles. The subcommittee has a separate task designed to resolve the problem with the 23 000 lb axle which involves the establishment of dual ratings.

The 40 mph brake force value proposed for the steer axles of trucks is proportionally a smaller value (0.20 times the GAWR) than for other axles in view of the controversy within the industry about front wheel brakes. The proposed value, however, is a minimum value instead of a nominal value as proposed for other axles. A minimum value is provided in order to permit the use of larger front wheel brakes when desired.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

SAE J1505 MAY85, Brake Force Distribution Test Code - Commercial Vehicles

APPLICATION:

This SAE Recommended Practice establishes performance guidelines for the threshold pressure and brake force output of the brakes on the axles of air braked towing trucks, truck-tractors, truck-trailers, and converter dollies with GVWRs over 10 000 lb designed to be used on the highway in combination with other air braked vehicles of this type in commercial operations.

CORRELATION with J992

The SAE Recommended Practice J992 specifies that combination vehicles be capable of decelerating from 20 mph at a rate of 9.5 +/- 1.5 fpsps with an application pressure of 42 psi. This target deceleration of 9.5 fpsps translates to a retardation of 9.5/32.2 or 0.30. However, since the J992 deceleration requirement includes rolling resistance (rr) and the J1854 requirement does not, the rr for the average speed of 15 mph must be subtracted out. The rr for an 80000 lb combination using the formulas being proposed in the new J1489, Heavy Truck Retarder Downhill Performance Mapping Procedure, is 600 lb which is a retardation of 600/80000 or 0.01. Subtracting this retardation due to the rr gives a braking retardation target requirement of 0.29. Since the 0.29 retardation is at 15 mph instead of 37.5 mph as in J1505 and since brake output decreases with speed (estimated from brake dynamometer data to drop 15% when the speed is increased 30 mph, 20 to 50 mph) the retardation at 37.5 mph must be less by 11%. This reduces the retardation required at 37.5 mph to 0.29/1.11 or 0.26. Also, since the pressure in J992 is 42 psi instead of 40 psi, the target retardation must drop another 0.01 (based on the TTBRG data which indicates a drop in retardation of 0.01 for every 2 psi change in pressure in the 30 to 40 psi range). This then gives a vehicle target retardation value of 0.25 for J992.

Computing the retardation for each drive and trailer axle requires consideration of proportionately low retardation provided by the front steer axle. If a combination grossed to the 80000 lb legal limit has a 12000 lb front axle with a 0.20 retardation, the four drive and trailer axles must provide ([0.25 x 80000] less [0.20 x 1200]) lb or 17600 lb of braking; 4400 lb for each axle. While this is a retardation of 0.26 based on the actual 17000 lb axle loading, it is a retardation of only 0.22 based on the 20000 lb GAWR.

RETARDATION REQUIRED OF TRAILER AXLES TO MEET FMVSS 121 DYNAMOMETER REQUIREMENTS

FMVSS 121 has required a minimum brake torque output for new trailers for over 12 years with the requirement remaining unchanged for the last 11 years. The 121 requirements are based on a brake chamber pressure instead of a control line gladhand pressure but at pressure of 40 psi the two are generally equal. FMVSS 121 specifies brake torque output at pressures from 20 to 80 psi but the design point for manufacturers is usually the 80 psi value since it is the severest requirement. Available dynamometer data indicates that for actual brake configurations, the brake torque developed at 80 psi is generally about 2.1 times as much as the brake torque developed at 40 psi. Therefore the requirement for 80 psi must be divided by 2.1 to get the minimum being provided by manufacturers at 40 psi which is 0.41/2.1 or 0.20 (the actual retardation value required in 121 at 40 psi is 0.18). Also, since the dynamometer requirement in 121 is at 50 mph whereas the J1504 speed is 37.5 mph, the retardation must be corrected upward 6% (dynamometer data indicates a 15% brake torque difference difference between 20 and 50 mph). This then gives a minimum retardation of 0.21 at 40 psi and 37.5 mph for brakes complying with 121 dynamometer requirements. This is 10% lower than the 0.23 target value proposed for J1854.

ATTACHMENT for RATIONALE (8/18/87)