SURFACE VEHICLE RECOMMENDED PRACTICE

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Off-Vehicle Brake Testing for Service Brakes Over 10000 Pounds GVW
Air, Hydraulic, and Mechanical Actuation

RATIONALE

This document has been revised to remove a table and make editorial changes.

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1. SCOPE

1.1 Purpose

Subject document is specifically intended for service brakes and service brakes when used for parking and/or emergency brakes (only) that are commonly used for automotive-type, ground-wheeled vehicles exceeding 4536 kg (10000 pounds) gross vehicle weight rating (GVWR). Subject specification provides the off-vehicle procedures, methods, and processes used to objectively determine suitability of tactical and combat ground-wheeled vehicle brake systems and selected secondary-item brake components (aka aftermarket or spare parts), including brake “block” for commercial applications only, specifically identified within subject document. Subject specification is primarily based on known industry and military test standards utilizing brake inertia dynamometers. Targeted vehicles and components include, but may not be limited to, the following:

a. Civilian, commercial, military, and militarized-commercial ground-wheeled vehicles such as cargo trucks, vocational vehicles, truck tractors, trailers, and specialized support and engineering equipment under the generic heading of ground vehicle “dry” brake systems (GVDBS).

b. Hydraulic, air, and mechanical “dry” disc brake and drum brake systems when used as service brakes, including service brakes (only) when used as emergency and/or parking brakes.

c. Hydraulic, air, and mechanical “dry” disc brake pad assemblies and rotor assemblies.

d. Hydraulic, air, and mechanical “dry” drum brake shoe assemblies and drum assemblies.

e. Hydraulic, air, and mechanical brake “block” when intended for use on 1.1.a. through 1.1.d., except for those vehicles, pad assemblies, and shoe assemblies specifically procured for military use and/or tested under ATPD-2354. It must be noted that the U.S. Government’s Military Services buys only assemblies and doesn’t normally use “brake block” and relined brake shoes/pads; therefore, testing using separate brake “block” was specifically excluded from ATPD-2354 by the original authors.

1.2 Classifications

For the purposes of this specification, GVDBS brakes may be “dry” only, and either disc or drum types may be used as a single type on a ground vehicle or in combinations of both types on the same vehicle, such as drum/drum, disc/disc, or disc front/drum rear. Disc brakes may be mechanical, hydraulic, or air-actuated, with single or multiple piston calipers. Drum brakes may be mechanical, hydraulic, or air-actuated, with single or dual actuators, and may be generally divided into the following categories: hydraulic, single, and dual-wheel cylinders (actuators); air-actuated S-cam; and air-actuated single- or dual-actuator “wedge” brakes.

a. Type 1-1a: “Hydraulic” disc brakes, without separate emergency/parking brake

b. Type 1-1b: “Hydraulic” disc brakes, with “mechanical” emergency/parking brake combination (dual-actuator)

c. Type 1-2a: “Air” disc brakes, without separate emergency/parking brake

d. Type 1-2b: “Air” disc brakes, with “mechanical” emergency/parking brake combination (dual-actuator)

e. Type 1-3: “Mechanical” disc brakes, stand-alone only

f. Type 2: “Hydraulic” drum brakes, single and dual-servo (wheel cylinders)

g. Type 3-1a: “Air” S-cam drum brakes - single-actuator; single brake chamber with separate emergency/parking brake

h. Type 3-1b: “Air” S-cam drum brakes - single-actuator; dual brake chamber for service and emergency/parking (spring brakes)

i. Type 3-2a: “Air” wedge drum brakes - single-actuator and dual-actuator types when only one actuator is used; single brake chamber with separate emergency/parking brake

j. Type 3-2b: “Air” wedge drum brakes - single-actuator and dual-actuator types when only one actuator is used; dual brake chamber for emergency/parking (spring brakes)

k. Type 3-3a: “Air” wedge drum brakes - dual-actuator; single brake chamber with separate emergency/parking brake

l. Type 3-3b: “Air” wedge-type drum brakes - dual-actuator; dual brake chamber for emergency/parking (spring brakes)

1.3 Limited Applicability

Subject specification is intentionally limited to ground vehicle and support equipment “dry” disc and drum brake systems when used as service brakes and/or service brakes used as emergency or parking brakes; therefore, the type of actuation and media for actuation is mainly used within subject specification as a discriminator for determining which standard test procedure is most applicable.

1.4 No FMVSS Conflict/Impacts

Subject specification does not, nor was it intended to, serve as a replacement for mandatory U.S. and similar governmental wheeled vehicle on-vehicle testing under U.S. Federal Motor Vehicle Safety Standards (FMVSS) or similar U.S. federal road and off-road vehicle standards.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

The documents listed in this section will be specified in Sections 3, 4, and 5 of this document. This section does not include documents cited in other sections of this document or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they will meet all specified requirements of documents cited in this document, whether or not they may be listed.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J160 Swell, Growth, and Dimensional Stability of Friction Materials and Noise Insulators when Exposed to Elevated Temperatures

SAE J379 Gogan Hardness of Brake Lining

SAE J840 Test Procedures for Shear Strength of Automotive Brake Pads and Brake Lining Assemblies

SAE J2115 Air Brake Performance and Wear Test Code, Commercial Vehicle Inertia Dynamometer

SAE J2334 Laboratory Cyclic Corrosion Test

SAE J2468 High-Preload Deflection and Compressibility Test Procedures for Friction Materials

SAE J2598 Automotive Disc Brake Pad Natural Frequency and Damping Test

SAE J2627 Braking System Definitions - Truck and Bus

SAE J2684 FMVSS 105 Inertia Brake Dynamometer Test Procedure for Vehicles Above 4540 kg GVWR

SAE J2707 Wear Test Procedure on Inertia Dynamometer for Brake Friction Materials

SAE J3080 Inertia Dynamometer Rotor Crack Test Procedure for Air Disc Brakes

2.1.2 U.S. Government Publications

The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

2.1.2.1 Federal Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

The Federal Standardization Manual

2.1.2.2 Code of Federal Regulations (CFR) Publications

Available from United States Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

Federal Motor Vehicle Safety Standards (FMVSS) 49 CFR Parts 571.105, 571.121, and 571.135

2.1.2.3 Department of Defense Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

FED-STD-595 Colors Used in Government Procurement

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests

MIL-STD-961 DoD Standard Practice for Defense Specifications (Note: Material specifications)

MIL-STD-962 Defense Standards Format and Content (Note: Test specifications and handbooks)

MIL-STD-1366 Interface Standard for Transportability Criteria

2.1.2.4 Military Publications

For copies of the items below and subject ATPD, contact the appropriate Procurement Contracting Officer (PCO), or the U.S. Army Tank-Automotive Research, Development and Engineering Center (TARDEC), ATTN: AMSRD-TAR-E/CM/DM/STND Mail Stop #268, 6501 East 11 Mile Road, Warren, MI 48397-5000, or by email at DAMI_STANDARDIZATION@conus.army.mil.

ATPD-2354 (All changes/revisions), Off-Vehicle Brake Testing for Military and Militarized Commercial Ground Vehicles over 3500 kg (7716 U.S. Lbs.) Gross Vehicle Weight Rating (GVWR)

ATPD-2383 (All changes/revisions), Commercial and Military Off-Vehicle Brake Testing for Ground Vehicles over 4536 kg (10000 U.S. Lbs.) Gross Vehicle Weight Rating (GVWR)

Tank-Automotive and Armaments Command Purchase Descriptions (ATPD)

Test Operational Procedure (TOP) - Braking, Wheeled Vehicles (TOP/MTP) 2-2-608

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM B117 Standard Practice for Operating Salt Spray (Fog) Apparatus

ASTM E10 Standard Test Method for Brinell Hardness of Metallic Materials

2.1.4 ISO Publications

Copies of these documents are available online at https://webstore.ansi.org/.

ISO 611 Road Vehicles - Braking of Automotive Vehicles and Their Trailers - Vocabulary

ISO 6310 Road Vehicles - Brake Linings - Compressive Strain Test Method - Second Edition

ISO 6312 Road Vehicles - Dimensions of Motor Vehicles and Towed Vehicles - Terms and Definitions - First Edition

ISO/IEC 17025 General Requirements for the Competence of Testing and Calibration Laboratories

ISO 22574 Road Vehicles - Brake Linings Frictions Materials - Visual Inspection

ISO 26865 Road Vehicles - Brake Linings Friction Materials - Performance Test Procedure for Commercial Vehicles

ISO 26866 Road Vehicles - Brake Linings Friction Materials - Standard Wear Test Procedure for Commercial Vehicles with Air Brakes

2.1.5 Economic Commission for Europe (ECE) Regulations/Publications

Available from United Nations Economic Commission for Europe, Palais des Nations, CH-1211, Geneva 10, Switzerland, Tel: +41-0-22-917-12-34, www.unece.org.

ECE R90 (aka R 90) Replacement Friction Materials

2.1.6 JSAE Publications

Available from Society of Automotive Engineers of Japan, 10-2 Gobancho, Chiyoda-Ku, 102-0076 Japan, Tel: +81-3-3262-8211, https://www.jsae.or.jp/en/.

JASO C407 Braking Device - Dynamometer Test Procedures

2.1.7 Industry Publications

Available from Bosch Automotive Books/Manuals, Robert Bosch Gmbh, Postfach 30 02 20, D-70442, Stuttgart, Germany; or SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

Bosch Automotive Brake Systems, First Edition, 1995 (Table 6, Page 20 or its successors - equation reference only)

2.2 Order of Precedence

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable federal laws and regulations, unless a specific exemption has been obtained by the user(s).

3. DEFINITIONS

In addition to those listed in this section, definitions, symbols, and abbreviations (acronyms) used in this specification are listed in: (1) SAE J2627, (2) MIL-STD-810, (3) within each individual included specification contained in the subject document, and (4) Appendix B within this document. When required, other nonstandard definitions, terms, and acronyms may be used and must be identified and fully defined by the "RA" (see 3.1) and/or the participating testing activity.

3.1 REQUESTING ACTIVITY ("RA")

The inclusive term "RA," as used within subject specification, will be defined as the responsible corporate-level management, or corporate-level engineering authority, or corporate-designated internal vehicle design authority, or similar (non-procurement) "Officer of the Corporation" who has the legal authority to direct the conduct of testing and analysis within the requirements of subject specification except for governmental and military-peculiar acquisitions, for which a specific, but similar, definition of "ESA" (engineering support activity) is contained in paragraph 3.1 of ATPD-2354. Procurement offices/activities, other administrative and quasi-procurement offices/activities, test activities, and other similar subordinate organizations are specifically excluded from this definition as they do not have the engineering expertise and/or legal approval authority required for brake systems and their subcomponents.

3.2 STANDARDS DEVELOPING ORGANIZATION(S) (SDO/SDOS)

The term "Standards Developing Organization" (SDO/SDOs) is self-explanatory and refers to organizations such as SAE, ANSI, ISO, etc., with limited exceptions, such as the Technology and Maintenance Council of the American Trucking Association (TMC/ATA). Refer to: http://www.ansi.org/internet_resources/standards_devel_organizations.

4. GENERAL TECHNICAL REQUIREMENTS

4.1 Design and Intended Use

Subject standard is designed to provide objective, accurate, and repeatable data for physical characterization and quantifiable test performance of ground vehicle major brake systems and/or the following specified component assemblies: disc brake rotors and pads, drum brake drums, and brake shoes (assemblies only). Objectives will be accomplished through the application of the standardized and multilayered processes, characterizations, and quantitative testing described within subject specification.

a. It will be presumed for the purposes of subject specification that the OEM test samples are representative of those originally qualified as part of the vehicle brake system originally tested and approved for production vehicle FMVSS compliance verifications; vehicle system and component verification and/or qualification testing; or "RA"-designated (see 3.1) "OEM substitutes" when the original OEM parts are no longer available, have been obsoleted by circumstances that preclude availability beyond the control of the "RA" (see 3.1), or are no longer suitable for testing due to age, condition, or known defects.

b. Potential alternative suppliers will be forewarned that friction performance characteristics that are notably different than the OEM items, or "RA"-designated (see 3.1) alternatives, may be unacceptable due to concerns with "pitch" (rear-to-front bias) and "yaw" (side-to-side bias), regardless of intended/unintended use on the same or different axles. This concern was one of the primary reasons why emphasis has been placed on the "standard" dual-ended brake dynamometer testing.

4.1.1 Minimum Acceptable Performance

Even though subject specification is not a "pass-or-fail" document, the minimum acceptable performance by any potential alternative supplier will be "equal to or better than" the average of the three OEM test sample items for all requirements, except for the following, when not already specified by the applicable federal regulations, item-specific part drawing specification, catalog description, or any other readily identifiable requirement of the OEM parts:

a. Material requirements, to include hardness

b. Friction material and composition

c. Noise, vibration, and harshness (NVH)

d. FMSI configuration (number), if the alternate product is fully functional without kits or restriction with the OEM parts

e. Voluntary industry standards for performance, wear, and marking; e.g., “edge codes” and similar

f. Cold-weather operations below -29 °C (-20 °F), unless specified by the “RA” (see 3.1)

g. Military and civilian types of preservation, packaging, and marking; temporary and permanent

h. Witness marks and/or wear indicators

i. Dust(ing) and color

4.1.2 Prohibit Previous Unreliable Acceptance Practices

The previous practices of acceptance or qualifying by “similarities,” or application by extension across a broad or limited range of vehicle types, weights, or performance characteristics, is specifically discouraged and should not be permitted by the responsible “RA” (see 3.1).

4.1.3 “Standard” and “Optional” Testing

Observations, measurements, and tests will be divided into two categories: (1) “standard” (minimum) required and (2) “optional” (additional) tests that may be required by the responsible “RA” (see 3.1).

4.1.4 Potential Use as a “Pass-Fail” Document

Subject specification may be used as a “pass-or-fail” requirements document, in whole or in part, by specific written direction of the “RA” (see 3.1). In this particular circumstance, it then becomes the sole responsibility of the requesting “RA” (see 3.1) to designate acceptable measurement values, range of values, and pass-fail exit criteria beyond that already required by 4.1.

4.1.5 R&D Use Encouraged

The use of this specification for GVDBS (off-vehicle) R&D and product development engineering activities is to be encouraged, and the requirement for maximum use of actual hub-end/brake hardware as fixturing is not applicable for this type of use only.

4.1.6 Use of Previously Acquired Test Data

Previously acquired test data that was performed to subject specification for the purposes of establishing the baseline performance of OEM products, or “RA”-designated (see 3.1) OEM substitutes, may be used with prior “RA” (see 3.1) approval in order to prevent duplications, accelerate the testing program, and reduce costs. Any deviation or change from the previously (“RA”-approved or “RA”-accepted) conducted testing and item configuration precludes reuse of that data; new testing must be conducted. The authority to allow this exception is solely the responsibility of the responsible “RA” (see 3.1) and will not be delegated.

4.2 Current and Subsequent Revisions of Included Specifications

The “RA” (see 3.1) will specify the required revision and date for all included specifications for the test plan and/or test activity as part of the contract or ordering data.

4.3 Test Costs, Scheduling, and Intellectual Property (IP)

Except when specified otherwise by contractual instruments, the “RA” (see 3.1) is fully responsible for assignment of test costs and test scheduling to include acquisition of required OEM items, tooling and fixturing, and spare parts. In addition, it’s recommended that the “RA” (see 3.1) will retain sole ownership of any intellectual property (IP), test data and test reports, and resulting fixturing and hardware produced, unless specified otherwise by ordering data or contract language or when specified for government-funded procurements for which IP rights are defined by federal laws and regulations.

4.4 Laboratory/Test Facility Qualifications

All laboratories, test activities and facilities, and testing companies should comply with the requirements of ISO/IEC 17025 and objective quality evidence of same provided to the “RA” (see 3.1) prior to start of testing. This requirement should NOT be waived or modified regardless of country of origin of the test activity(s). The following minimum capabilities must be certified/registered to the test activity used by the “RA” (see 3.1) as indicated within this paragraph and shall not be delegated to or from another test activity in order to claim compliance to subject paragraph.

a. Required: Testing of automotive and heavy ground vehicle brake systems and subsystems

b. Required: Testing of automotive and heavy ground vehicle brake components

c. “Required” for vehicle system-level testing and “desired” for component-level testing: Testing of automotive and heavy ground vehicles

4.5 General Laboratory Test Methods (GLTM)

4.5.1 GLTM will be in accordance with (IAW) MIL-STD-810, paragraph 5, or similar “RA”-approved (see 3.1) international standards.

4.5.2 Instrumentation will be certified or calibrated and of sufficient range and durability to accurately report and/or record all values produced under the requirements of subject specification.

4.6 Brake/Hub-Ends and “Mirror Image” Parts

Whenever possible, the use of non-steering brake/hub-end componentry is preferred over the same sized steering (axle) types, unless those individual parts to be characterized/tested (drums, shoes, rotors, or pads) are different from the rest of that series/type vehicle brake assemblies or components on the same model/series vehicles. This statement is not intended to include items on the same vehicle model/series whose sole difference is being a mirror image for each side of a vehicle or which may include an integrated e-brake function (e.g., HMMWV calipers are different styles front to back, but rotors and pads are the same).

4.7 Test Methods

4.7.1 Method “A” Process/Procedure (aka “Primary”)

Method “A” will be performed in accordance with Appendix C, Table C1 or Table C2, as applicable. It is the primary method used for all non-regulatory, off-vehicle commercial wheeled vehicle brake system testing, including aftermarket and replacement (spare) parts, and requires the use of the following:

a. The OEM axle and/or brake manufacturer’s weight capacity for the highest weight-rated brake/hub-end assembly, differential-mounted brake assembly, and independently sprung hub-ends for the specific vehicle model or vehicle model application that uses the parts to be tested is preferred.

b. When specified by the “RA” (see 3.1), the following alternate method will be used, but is not recommended, and is specifically prohibited for any vehicle brake system and its components that are used on independently sprung hubs and/or for military and other off-road vehicles. The alternate method uses computed values based on advertised GVWR and/or gross combination vehicle weight (GCVW) and gross axle weights rating (GAWR) instead of 4.7.1.a.

c. The vehicle tire size(s) and its OEM manufacturer's published data or adjusted data per the "special care" comment within this paragraph, static loaded radius (SLR), load rating, approved rim size and type, and other pertinent design/performance information which produces the worst-case scenario within the vehicle series using the same brake components/rating. Special care will be taken to adjust for geared hubs, viscous couplings, or any other device that changes the effective final drive ratio between the brakes and wheel/tire contact surface are used; e.g., wheel-ends (geared hubs).

d. Fixturing will be fabricated from the specified vehicle application OEM wheel-end componentry to simulate on-vehicle mounting/use. The "RA" (see 3.1) may allow exact duplicates of the required production vehicle parts to be used as test fixturing, but only under the fully documented special circumstances resulting from war, natural disasters, labor disruption, or similar nonavailability.

e. For the purposes of subject specification, the term "brake/hub-end hardware" will also include any actuation and adjustment devices; e.g., disc brake calipers.

4.7.1.1 In the absence of verifiable OEM-specified weight ratings required to determine test values and parameters, the "RA" (see 3.1) will determine and provide the individual brake/hub-end ratings based on all vehicle system braking performance requirements; e.g., hill-hold, slopes, fording, and similar. In addition, the "RA" (see 3.1) will make the results of such determinations available to the test activity in order to ensure that both consistency and repeatability are maintained between previous, current, and subsequent testing to subject specification.

4.7.1.2 Comparison Testing of Two or More Different Pad/Shoe and Rotor/Drum Combination Assemblies

The "RA" (see 3.1) will direct the comparison testing of two or more friction material and mating surface devices (rotors and drums) in combination; e.g., OEM foundation brake shoes and companion drum combination versus a proposed Brand "X" combination. In this particular circumstance (only), the "RA" (see 3.1) should direct performance of the test(s) in accordance with Appendix C, Table C1 along with not less than three test sample combinations in accordance with the "Optional" Crack Test and Strength Test described in Appendix E. Responsibility for test costs and funding, all or in part, will be at the sole determination of the "RA" (see 3.1).

4.7.1.3 Preferred Use of Appendix C, Table C1, for Multicomponent-Type Testing

Appendix C, Table C1 (with and without Appendix E, Crack Test and Strength Test), should be the preferred testing methodology used when the test objectives cover paired component "sets" being tested or compared to other paired component sets; e.g., pad/rotor or shoe/drum combinations.

4.7.2 Method "B" Process/Procedure (aka "Overload")

Method "B" is for nonstandard vehicle loading only, including aftermarket spare parts. When specified by the "RA" (see 3.1), Method "B" will be performed the same as Method "A" using actual axle/hub-end parts as test fixturing, except that Method "B" is specifically for testing purposes when the OEM manufacturer's specified ratings are intentionally exceeded for test and demonstration purposes (only). OEM vehicle, axle, brake assembly, or brake component manufacturer/potential alternative supplier(s) will not be required to perform to Method "B" for the purposes of product qualification or acceptance. In addition, the "RA" (see 3.1) will identify to the test activity all known additional safety, performance, and environmental hazards Method "B" testing presents. The opportunity for the testing of mating part combinations provided to the "RA" (see 3.1) in 4.7.1.2 will apply for Method "B" too.

4.7.3 Method "D" Process/Procedure (aka R&D or "Developmental")

When specified by the "RA" (see 3.1) or "RA"-approved (see 3.1) developmental activities, Method "D" is performed the same as Method "A," except the following:

a. The "RA" (see 3.1) will direct performance of the test(s) in accordance with Appendix C, Table C1 or Table C2, as applicable, along with not less than three test sample combinations in accordance with the Crack Test and Strength Test described in Appendix E.

b. Method "D" is specifically for R&D purposes only.

4.7.3.1 Method “D” testing recognizes that nonstandard or fabricated components may be used for testing and test fixturing. Brake system components, performance, design parameters, and exit criteria should be specified prior to testing but may not be available due to the lack of firm requirements normally associated with a production vehicle system.

4.7.3.2 Prior to start of testing, the “RA” (see 3.1) or cognizant design and testing authority will identify to the tester all known or anticipated additional safety, performance, and environmental hazards Method “D” testing will present.

4.8 Mandatory Characterization/Comparison Test Sequencing for Product Comparison Determinations

The following mandatory sequence of events will be used to characterize, evaluate, and provide sufficient objective evidence required to make a reasoned determination of brake system and/or component acceptability by the “RA” (see 3.1).

4.8.1 Characterization of GVDBS by Vehicle Types and OEMs

Characterize by observations, inspections, and/or tests for each ground vehicle brake system and/or its components, or alternate components similarly approved for use, within targeted vehicle’s weight class, model, type, and OEM or depot-level manufacturer.

4.8.2 Characterization of OEM (or Approved Designated Similar) Components through Standardized Testing

Characterize by standardized testing each desired ground vehicle brake system and/or its components or alternate components similarly approved for use. The “RA” (see 3.1) will determine which OEM or current supplier will be used for the baseline design and performance characterizations when the original OEM or OEM supplier is no longer available or multiple approved sources of supply are being used.

4.8.3 Characterizations of Proposed Replacement Components through Standardized Testing

Characterize by standardized testing each proposed alternative ground vehicle brake system and/or its components, or alternate components similarly approved for use, within the same constraints/limitations of 4.7.1 and 4.7.2.

4.8.4 Characterization of Proposed Alternatives if/when “Mixed” with OEM through Standardized Testing

Characterize by standardized testing each proposed ground vehicle brake system and/or its components, or alternate components similarly approved for use, if/when component mixing will occur or may be presumed to occur by field users within the same constraints and limitations of 4.7.1 and 4.7.2; e.g., replacing front axle(s) drum brake systems with disc brake systems on the same vehicle.

4.8.4.1 In accordance with established and approved replacement and maintenance procedures for that vehicle type, “mixed” is defined as the installation of differing manufacturer’s parts or the use of different specification parts by the same or different manufacturers with the OEM or OEM-designated parts and includes: (1) shoe/pad pairs or individual rotors/drums mixed on different hub-ends of the same axle and/or mixed on different axles on the same vehicle (for example, disc brake pad assemblies should be replaced by axle sets, and replacement by hub-end is generally not recommended but becoming more common through the use of dressed or filled replacement caliper assemblies), and (2) rotor and drum assemblies are commonly replaced by hub-end, even in the military, although certain applications may replace in axle pairs, especially when there is significant side-to-side differences in wear and/or physical damage.

4.8.4.2 This type of characterization is to determine mutual compatibility on the same vehicle platform. It also specifically includes mixing of pads or shoes by hub (only) on the opposing ends of the same axle and mixing on multiple axles on the same vehicle platform regardless of those normal maintenance procedures. Of particular concern is the potential for actual or perceived brake/vehicle performance degradation characterized by “fade” (non-heat generated and/or unexpected extended stopping distances), “pitch” (rear-to-front bias/weight transfer), “yaw” (side-to-side bias/weight transfer), “pull” (diagonal bias from front or rear brakes), and inability to maintain “lane compliance” during stopping.

4.8.5 Conduct Comparative Analysis of Results to Support Suitability Determination by the “RA” (see 3.1) or Equivalent

Conduct comparative analysis of results (apples to apples), which will enable the “RA” (see 3.1) to make a reasoned determination of acceptability for use separately and/or “mixed” with OEM systems and componentry, except for those vehicle brake systems that are specifically covered by ATPD-2354. For R&D and similar activities, detailed technical data will be provided to the “RA” (see 3.1) and/or engineering test sponsor for appropriate action.

4.8.6 Post-Test Suitability Determination for Proposed Use by Each Vehicle Types/Models by the “RA” (see 3.1)

Rationale, self-explanatory.

4.9 Test Sequence(s)

The sequence of individual tests and observations will be in accordance with subject specification, unless specified otherwise or approved in advance by the “RA” (see 3.1) for Methods “A,” “B,” and “D.” Regardless of the sequence used, testing will be conducted in such a manner as to (1) provide all the data elements or reporting required by each test, (2) prevent the degradation or negation of any subsequent test(s) on the same test sample or series, and (3) not skew or attempt to misguide the test results in favor of one product or another.

4.10 Test Sample(s) Quantities and Origin

4.10.1 Responsibilities

The acquisition, repair, and/or replacement of all items for testing and test support should be solely the responsibility of the “RA” (see 3.1) and will be not less than the quantities and types described in the applicable sections within this paragraph and the applicable appendices. Although it’s desirable to have these proposed parts randomly selected from available components of the same part number, manufacturer, and lot, this may prove highly problematic and is therefore desired, not required.

4.10.2 OEM or Other “RA”-Designated Substitutes for Baseline Items

OEM or other “RA”-designated (see 3.1) baseline items should be supplied to or by the test activity in the following quantities and to the applicable requirements of 4.10.3.a. through 4.10.3.d. Whenever possible or economically viable, designated OEM parts will be randomly selected from series production lots of the same part number, production lot (if available), and manufacturer.

4.10.3 Test Sample Recommended Pretest Stockage

All test samples and supporting hardware will be of the same origin and manufacturer, part number/NSN, physical configuration, formulation, metallurgy, and in a “green,” new, and unused condition as would be available on OEM newly manufactured vehicles and/or commercial off-the-shelf and preinstalled condition for use. The use of bulk friction material and/or separately supplied friction materials and brake block for coupon-type testing is acceptable, except when specified otherwise by the “RA” (see 3.1). It’s recommended that coupons for friction material and metallurgical testing should be made from manufacturer-assembled assemblies to better approximate the in-use configuration. Except when specified by the “RA” (see 3.1), Method “D” (only) is specifically exempted from the requirements of this sub-paragraph. The following is a recommended list of minimum numbers and quantities of test samples for guidance and cost estimation purposes only.

a. Disc brake pads testing: 20 axle sets (40 pairs) of disc brake pad assemblies (only) for OEM baseline and each candidate item proposed by potential alternative supplier(s), plus 30 each OEM disc brake rotor assemblies.

b. Disc brake rotors testing: 30 each disc brake rotor assemblies for OEM baseline and each candidate item proposed by potential alternative supplier(s), plus 10 axle sets (20 pairs) of OEM disc brake pad assemblies.

c. Drum brake shoe assemblies testing: 20 axle sets (40 pairs) of drum brake shoe assemblies (only) and an equivalent number of hardware kits if not already provided with/as part of the drum brake shoe assembly pairs for OEM baseline and each candidate item proposed by potential alternative supplier(s), plus 30 each OEM brake drum assemblies.

d. Drum brake drums testing: 30 each brake drum assemblies for OEM baseline and each candidate item proposed by potential alternative supplier(s), plus 10 OEM axle sets (20 pairs) of OEM brake shoe assemblies and an equivalent number of hardware kits, if not already provided with/as part of the drum brake shoe assembly pairs.

e. Disc brake rotors and drum brake shoes may be integral to or available separately from the hub assembly. As a cost-savings measure and when available separately, rotors and drums may be procured separately from the hubs in the same quantities identified in 4.10.3.a. through 4.10.3.d. as "assemblies," plus not less than four separate hubs/hub assemblies needed to complete the disc/drum-to-hub-to-dynamometer mounting fixture (adapter or direct) connection to enable dynamometer use.

4.10.4 Test Support Items Recommended for "Standard" Testing

a. Disc brakes: Not less than two calipers and companion mounting hardware of each type and for each side of the designated vehicle series/type targeted; four or more caliper repair kits if commercially available as separate kits or parts; and sufficient OEM or replacement brake mounting hardware to replicate three or more actual vehicle mountings on dynamometers along with appropriate tester fabricated adaptive hardware, including at least two complete parking brake actuation setups.

b. Drum brakes (hydraulic): Not less than six wheel cylinders of each type and for each side of the designated vehicle series/type targeted; two spare wheel cylinders; and sufficient OEM or replacement brake mounting hardware (including backing plates) to replicate three or more actual vehicle mountings on dynamometers along with appropriate tester fabricated adaptive hardware, including at least two complete parking brake actuation setups. An OEM or "RA"-approved (see 3.1) equivalent backing plate will be used instead of any fabricated or substitute backing plates for Methods "A" and "B."

c. Drum brakes (S-cam and single-actuator "wedge" types): Not less than three brake chambers of each type and for each side, not to exceed eight total air brake chambers and connecting hardware (including S-cam) on designated vehicle system and sufficient OEM brake mounting hardware to replicate three or more actual vehicle mountings on dynamometers, including at least two complete emergency brake actuation setups. OEM or "RA"-approved (see 3.1) equivalent backing plates will be used instead of any fabricated or substitute backing plates for Methods "A" and "B."

d. Drum brakes (double-actuator "wedge" types): Not less than six brake chambers of each type and for each side, not to exceed 12 total air brake chambers and connecting hardware on designated vehicle system and sufficient OEM brake mounting hardware to replicate three or more actual vehicle mountings on dynamometers, including at least two complete emergency brake actuation setups. OEM or "RA"-approved (see 3.1) equivalent backing plates will be used instead of any fabricated or substitute backing plates for Methods "A" and "B."

4.11 Test Sample Requirements for R&D (Method "D") and "RA"-Approved Sustainment Engineering Projects

Test sample requirements for R&D (Method "D") and "RA"-approved (see 3.1) sustainment engineering projects will be "as required" using 4.10 as a general guide and recommendation.

4.12 Temporary Corrosion-Resistant Substances (Oil, Wax, etc.)

Subject processes may be used in packaging and preservation of test samples. Each test item should be inspected for temporary corrosion-resistant substances (oil, wax, etc.) used in packaging and preservation and, if present, removed in a nondestructive manner that will not affect the conduct and results of subsequent inspections and tests. Permanent and semi-permanent coatings (e.g., anodizing, paint over-spray, and similar) that do not affect the pretesting inspection processes and would naturally be worn off during the burnishing procedures will not be removed prior to burnishing due to the harsh processes required to complete this task.

4.13 Characterization of Brake Systems and Components by Vehicle Types and OEMs

The responsible "RA" (see 3.1) will provide appropriate values when: (1) information is unavailable from OEM, and/or (2) multiple values are possible due to variation in configuration or usage, and/or (3) a nonstandard configuration or usage (mission) scenario is required. In addition, the recommended presumed weight of each vehicle occupant should be not less than 200 pounds or higher weight(s) from MIL-STD-1366.

4.13.1 Special Emphasis

It's the responsibility of the "RA" (see 3.1), the test activity, and any potential alternative supplier to ensure all timing and proportioning devices are identified and this information is provided to the tester prior to start of test. A specific example is the HMMWV-ECV Series that has multiple proportioning valves in the same brake system and in non-traditional locations.

4.13.2 Minimum Dataset Supplied by "RA" (see 3.1)

In addition, the following information will be the minimum dataset made available by the cognizant "RA" (see 3.1):

a. Sufficient detailed technical and logistical data to ensure the right OEM parts are used for testing to include, but not be limited to, the following, if known: national stock numbers (NSN); ordinance/military part numbers (OPN/MPM); contractor part numbers; commercial and government entity (CAGE) codes; prior contract numbers and dates; vehicle build orders/sheets; identifying colors and marks; manufacturer's codes, such as casting numbers; frictional material "edge codes;" and friction material manufacturer's identification (FMSI) codes.

b. FMVSS definitions of GVWR, GCVW, LLVW (lightly loaded), and similar will be used appropriately.

c. Axle, hub-end, and brake ratings.

d. Proportioning and/or timing devices, methodologies, and objectives.

e. The maximum speed (Vmax) for the vehicle will be specified by the "RA" (see 3.1) in writing, unless specified otherwise within a specific test procedure included in subject document.

f. Maximum/minimum brake system pressures, to include all residual pressures.

g. Gearbox reduction/overdrive ratio; e.g., Hummer H1 "downstream" geared hubs.

h. Tire size(s) and static loaded radius (SLR) at GCWR and GCVW.

i. Brake system split: type and loading (percentiles), along with numbers and types of proportioning devices.

j. Specify required burnishing procedures if other than those specified within subject specification or those desired in addition to, or in lieu of, FMVSS 105, 121, and 135.

k. Alternate points of contact for the "RA" (see 3.1).

l. Additional information from the responsible OEM or specialty vehicle system engineering authority or management may be required if OEM vehicle and componentry is not available for use, not intended to be used for this application (targeted vehicle system), and/or has been subsequently modified by a specialty aftermarket contractor, post-manufacture modification, or user-ordered upgrade.

m. Additional information, as determined by the responsible "RA" (see 3.1).

4.14 Characterization of OEM (and Similarly Approved) Components

OEM (and similarly approved) components will be characterized through the use of standardized testing for each type and style as described in 4.8 and the standard testing requirements shown in the applicable appendices to subject specification.

a. When specified by the "RA" (see 3.1), any optional testing, additional testing, or additional test samples beyond that recommended by subject specification will be specified in the appropriate contract or purchase order.

b. When sufficient, verifiable characterization data has been obtained through previous testing and approved test report, the "RA" (see 3.1) may waive some or all of the OEM (and similarly approved) components portion of the required testing to prevent duplicative effort and reduce costs.

4.15 Characterizations of Proposed Replacement Components

Characterizations of proposed replacement components will be the same as for OEM (and similarly approved) components required in 4.6.

a. The required number of test samples cannot be less than that specified by 4.11, but may exceed that minimum number if required by the responsible “RA” (see 3.1); this requirement cannot be waived.

b. When specified by the “RA” (see 3.1), any optional testing, additional testing, or additional test samples beyond that identified as “required” by this specification must be specifically addressed by the “RA” (see 3.1) within the contract, purchase order, or other similar ordering documents.

4.16 Characterization of Proposed Replacement Components when Mixed with OEM

Same as 4.6, except that proposed replacement components will be “mixed” as follows: the responsible “RA” (see 3.1) may specify additional “optional” testing of other “mixed” combinations and/or in multiple combinations when there’s more than one “RA”-approved (see 3.1) OEM or other supplier item(s) only when such additional “optional” testing does not impact or delay the “RA” (see 3.1) original test and reporting schedules, unless specified otherwise by the contract or purchase order.

a. Hydraulic-actuated disc brake pads (only) will be evaluated by axle sets only and will be considered “mixed” for analysis purposes only when being compared with other axles on the same vehicle or trailer.

b. All other brake components, except as defined in 4.16.a., will be considered “mixed” when different configurations/brands are used on opposing sides of the same axle, from axle to axle on the same vehicle or trailer with two axles, and from axle to axle in multiple combinations on the same vehicle or trailer with three or more axles. No items of the same type but different manufacturers or sources will be mixed on the same axle hub-end; e.g., do not mix brake pads or shoes on the same brake/hub-end.

c. The required number of starting test samples should not be less than that specified by 4.11, and this requirement should not be waived except under the circumstances described in 4.1.5. The minimum number of test samples may be increased when required by the “RA” (see 3.1).

4.17 Conduct Comparative Analysis of Results to Support Suitability Determination

4.17.1 Prior to report(s) submittal to the responsible “RA” (see 3.1) or acquisition activity for (final) suitability determinations, the testing activity will compile and collate the test data into a readily readable and brief-able format and provide recommendations as to the suitability of both the baseline items and the proposed items when used in the specified vehicle configuration (see 4.6).

4.17.2 Upon receiving the interim or final report from the testing activity, the responsible “RA” (see 3.1) will review and determine suitability-for-use for each proposed item, convey those results to the appropriate acquisition authorities, and supply the proposed item’s management a “pass-fail”-type decision with supporting narratives.

4.18 Suitability Determination for Proposed Use by Each Vehicle Types/Models

When subject specification is used as intended, the approval-for-use or acceptance resides solely with the cognizant “RA” (see 3.1), except for government military systems and components that are specifically covered by ATPD-2354.

4.19 Applicable System and Secondary-Item Component Types for Suitability Determinations

All ground-wheeled vehicle “brake systems” and components to include service brakes and service brakes when used for parking and/or emergency brakes for vehicles and trailers above 4536 kg (10000 pounds) GVWR and combination vehicles for which one or more segments exceed this same GVWR.

4.20 Tiering of Specification and Standards

The following document types used for the conduct of testing for subject specification will be: (1) designated as the principal (baseline) requirements, (2) all "first-tier" requirements therein will be applicable to this specification, and (3) design and performance data identified in commercially based standards, practices, and specifications as "General Notes" and "Notes" (e.g., ASTM, CIDs, and similar) will be required for the purposes of design and performance criteria, government and contractor-conducted testing, and other verification activities. The author's objective in requesting what would normally be considered (by the government and similar) as secondary/tertiary-level and referenced information is due to the nonavailability of sufficiently defined or on-point traditional requirements documents that would satisfy the necessary technical and administrative requirements.

a. Commercial item descriptions (CID) in accordance with the Federal Standardization Manual.

b. U.S. MIL-Standards in accordance with MIL-STD-961 and MIL-STD-962.

c. U.S. Army TACOM "ATPDs" similarly formatted as 4.20.a. and 4.20.b.

d. SAE, TMC/ATA, and similar U.S.-based organizations.

e. ANSI, ASME, ASTM, IEEE, and similar U.S.-based organizations.

f. ISO, EC, ECE, JASO, DIN, and similar non-U.S. and/or international organizations.

g. Other specified commercially based specifications/requirements, such as Link Testing Procedures.

h. Other specified regulatory-based requirements, such as FMVSS (49 CFR 571 Series), EPA, OSHA, UL, NSF, and NOAA.

4.21 (Reserved for Future Use and to Provide Continuity with Original U.S. Army TACOM ATPD-2354 and ATPD-2383.)

4.22 Ordering Data and Test Reports, Including Minimum Data and Rationale Requirements

The preparation and submittal of test reports is critical to the ability of the "RA" (see 3.1) to make a reasoned decision as to acceptability of alternative systems and products. Therefore, the following minimum requirements for ordering data and test reports, including minimum data and rationale requirements, will be used for reports submitted to the "RA" (see 3.1). Reporting due that may be duplicative (same additional) requirements already in test procedures within subject specification is neither desired nor required.

a. Title, number, and date of commercial and military specifications.

b. Type of component(s) tested and source of OEM vehicle and component data if not obtained as a result of testing during this contract or purchase order.

c. Reporting requirements if other than "RA" (see 3.1) format.

d. Ownership, confidentiality, security, and similar security requirements for intellectual property (IP).

e. Distribution requirements when interim or final reports are constrained by the previous item.

f. Delivery requirements and distribution for pictures, facsimiles, artwork, drawings, and similar, either as separate deliverables or as a consequence of the test reporting processes.

g. All data covering test samples to include starting mass (weight) for each test sample used in new "green" unused condition, wear, including remaining usable thickness/mass calculations; temperature readings; and frictional performance, crack and strength, noise, "dusting" mass loss and color comparisons (see 5.10), and similar information on the tested parts (test samples) if not already required by the test specification itself; e.g., parallelism issues (see Appendix E, Crack and Strength Test).

h. All data covering mating parts to include starting mass (weight) for each test mating parts used in new “green” unused condition, wear, including remaining usable thickness/mass calculations; temperature readings; and frictional performance, crack and strength, noise, “dusting” mass loss and color comparisons (see 5.10), and obvious physical deformities on the mating parts to those being tested, if not already required by the test specification itself; e.g., parallelism issues (see Appendix E, Crack and Strength Test).

i. All raw inspection, material certification, and testing data used to substantiate the tester’s observations and conclusions/analysis, compiled or listed in an industry-common format or programming, preferably using Microsoft Excel or similar.

j. Graphs, pictorials, and photographic evidence in support of the data and, by extension, the offeror’s or test activity’s conclusions.

k. A listing for each test sequence performed detailing the amount of external airflow (CFM) and speed (mph), if any, for each test sequence, unless specified otherwise by the “RA” (see 3.1) or required within the test being conducted; e.g., HMMWV-ECV dyno testing airflow should be nil.

l. Identify the specific burnishing method for each test that requires burnishing (see 5.8).

m. A copy of the ISO 17025 registration/certification in effect at contract award or purchase order issuance to provide objective quality evidence of compliance with 4.4.

n. The process, rationale, and decision protocols for the collation, compilation, and evaluation of test data will be provided to include the use of appropriate algorithms, any associated or additional programming, and/or the computational processes for all electronic (computer) programming, such as “Minitab©” and similar. Sufficient technical and operational information will be supplied by the offeror or test activity as part of the primary post-test reporting (e.g., Final Test Report) to enable the “RA” (see 3.1) to be able to review both the raw data inputs and summary finding in the same or similar manner as the offeror or test activity to include actual re-computation of all raw and compiled data supplied by the offeror or test activity.

4.23 Post-Test Retention and Disposition of Test Samples

Test samples and mating parts will be retained by the test activity at the discretion of the “RA” (see 3.1), but consideration for retention for a specified length of time post-testing should be made in anticipation of additional observations and analysis. Disposal will be in accordance with local regulations at the location of disposal and should be at the direction of the test activity as long as no liabilities are attached to the “RA” (see 3.1).

4.24 Inertia Calculations Requirement

4.24.1 Method #1 (Preferred Method)

The “RA” (see 3.1) will specify inertia calculations for ground-wheeled vehicles using the brake/hub-end rating of the worst-case axle on the targeted vehicle system (only).

Special Requirements/Instructions: This method is required for any vehicle with or without off-road performance requirements that has independently sprung wheel-end suspensions, e.g., Hummer H-1® and military HMMWV series and all vehicles subject to ATPD-2354 and its subsequent versions.

4.24.2 Method #2

The “RA” (see 3.1) may specify inertia calculations for ground-wheeled vehicles using the GAWR of the worst-case (heaviest) inertia using the same components on the targeted vehicle system (only).

4.24.3 The “RA” (see 3.1) may allow the use of 110% of the GAWR for commercial vehicles (only) without independently sprung wheel-ends only when: (1) the brake/hub-end ratings aren’t available, (2) they have no off-road or cross-country performance requirements, and (3) they are not used for military or similar end users; e.g., commercial over-the-road (OTR) straight cargo trucks, vans, truck tractors, trailers, tractor/trailer combinations, and similar.

4.25 ”Air” Disc Brake Testing

Specific test requirements for “air” disc brakes on ground-wheeled vehicles over 10000 GVW have generally not been developed or adopted for industry-wide use at the time of release of subject document. Therefore, except as specified in the appendices of subject document, “air” disc brakes shall be tested the same as “air” drum brakes until such time SAE, ISO, or a consensus standard within the braking industry is established that is suitable for its intended use and implemented within a subsequent revision of subject document.

5. DETAILED TECHNICAL REQUIREMENTS AND TEST PROCEDURES

All test requirements and tests are identified within Section 5 and the attached appendices.

a. Those standards/test procedures listed in parenthetical (x) within each test plan table may be substituted with prior written approval of the responsible “RA” (see 3.1) or commercial equivalent.

b. When specified by the solicitation, contract, purchase order, or work order, additional tests beyond or different than those already listed as “optional” may be included if: (1) they are fully described by text or reference, (2) applicable values and ranges are supplied by the “RA” (see 3.1), (3) they do not negatively impact the performance and schedule for the standard test requirements, and (4) they are fully funded by the “RA” (see 3.1).

c. For vehicle applications with some type of regenerative braking or electric power plants that will affect the operation of the foundation brakes, consult with the “ESA” and/or the “RA” (see 3.1) on the methods prior to commencement of testing.

5.1 Mandatory and Optional Tests for Military, Militarized-Commercial, and All Vehicles with Off-Road Performance Requirements

ATPD-2354 shall be used for all vehicles of subject types, unless specified otherwise by: (1) the cognizant U.S. government authority for military vehicles, aka engineering support activity (ESA) vehicle system engineer, or (2) the “RA” (see 3.1), for non-governmental contracts only, as applicable.

5.2 Tests for Pads and Shoes Assemblies

Wheeled vehicle disc brake pad assemblies, drum brake shoe assemblies, and brake “block” are listed in Appendix C, Table C1.

5.3 Tests for Rotor and Drum Assemblies

Wheeled vehicle disc brake rotors and drum brake drums for all types are listed in Appendix C, Table C2.

5.4 Options within Each Test Standard/Specification

It’s not the intent of subject specification to limit the options of the potential alternative suppliers or testers by specifying each test requirement within each mandatory test specification or process. The sole requirement that will be applied when multiple options are provided within a specification, standard, test, or procedure is that a choice made is allowed by the “RA” (see 3.1) and each test sample will be tested the same. For example: “SAE J160 allows either a hot-plate or oven test, SAE J2468 allows either a disc pad or a coupon to be tested, and in SAE J2598 do you use part A or B?” The "RA" (see 3.1) decides which method is selected or defers to its test activity provider, but all test samples assigned to the same test requirement are tested the same.

5.4.1 The risk here is to the “RA” (see 3.1) in that if they decide to use Test Procedure “1” instead of “2,” then any subsequent use of the results/information generated would be self-limiting and/or unavailable for any follow-on proposals or procurements of the same item.

5.4.2 When the test choice is not obvious, or the decision is made to use one of the options that may be less well-known or not used industry wide, and/or a consensus can’t be obtained between the participating parties, the “RA” (see 3.1) will arbitrate and issue guidance or a decision to preclude the necessity and potential expense of a retest/“no-go” decision at the end of testing.

5.5 Component Wear Limits and/or Mandatory Replacement Criteria

Component wear limits and/or mandatory replacement criteria as specified by the most current vehicle maintenance manuals (preferred) or by the "RA" (see 3.1) may not be exceeded during the course of testing, except during the Crack and Strength Tests (see Appendix E). Sufficient leeway should be provided by the "RA" (see 3.1) to the testing activity to allow such events as long as they do not negatively impact the safe conduct of testing and the performance and scheduling for subsequent test requirements. Should specific direction be given to the tester to intentionally exceed wear limits and replacement criteria by the "RA" (see 3.1), the "RA" (see 3.1) will conduct an engineering analysis of the potential impacts and identify to the tester all additional safety, performance, and environmental hazards such testing presents prior to start of that portion(s) of the testing.

5.6 Hill-Hold/Slope Performance Comparison Test

5.6.1 An off-vehicle, breakaway torque test will be performed in order to develop comparative data for OEM and each alternative item by a slope/hill-hold performance simulation of service brakes and service brakes when also used for the vehicle's parking brakes. The purpose of this test is to determine the relative values (maximum output torque) between the OEM baseline and each candidate item, and simulated vehicle performance in accordance with FMVSS is neither required nor desired as part of this test and evaluation. Test samples will be properly burnished in accordance with 5.8, preferably after the Wet Effectiveness and Performance Test (see 5.7), but may be conducted at any point deemed appropriate by the testing activity, unless specified otherwise by the "RA" (see 3.1).

5.6.2 The testing will consist of a series of inertia brake dynamometer tests simulating actuation of the service and parking brakes separately (without compounding) at the required force (air or spring pressure), then a rotational force (static torque) applied to either the drum or input shaft until slippage is observed/detected, and the resulting value(s) recorded for later comparative analysis and/or conversion to an equivalent slope/grade level.

5.6.3 Using an inertia brake dynamometer and full-sized hub-end brake component parts, testing will be performed on not less than three test samples of OEM and each candidate item for each of the engagement methods used by the designated vehicle braking system: mechanical, which may include trailer "surge" brakes; mechanical over hydraulic (e.g., military HMMWV-ECV rear disc brakes); hydraulic; air-actuated; and air-actuated with mechanical-spring brakes (most medium-heavy truck, tractors, and trailers). For all but light trailers or dolly sets with surge brakes only, not less than two engagement methods of the applicable types are required for each test sample.

5.6.4 Actuation force values will be provided by the "RA" (see 3.1) and should cover the actual (not theoretical) range and maximum pressure/mechanical force available for each type actuator on the vehicle brake system. The required value for all air-brake systems will be 65 to 120 psi, at ambient temperatures, measured at the actuator(s).

5.6.5 The "RA" (see 3.1) will designate the appropriate values based on a single-vehicle GVWR, and GCVW for a towing vehicle (aka "prime movers"), that will be able to perform the requirement without use of the trailer brakes. For reference purposes only, the simulated maximum slope value for U.S. military combat and tactical wheeled vehicles, including trailers and dolly sets, will be not less than 60% per the appropriate vehicle specification.

5.6.6 When the Hill-Hold/Slope Test is conducted separately or as a stand-alone procedure, the following requirements apply:

a. Test samples will be burnished prior to testing in accordance with 5.8.

b. Upon completion of such testing, the test samples will be considered unserviceable and unusable for follow-on or additional testing or demonstrations. The use or reuse on any operational vehicle or non-operational historical or display vehicle is specifically prohibited. Disposal by the test activity will include rendering the test samples unusable for any other use and in accordance with local regulations for disposal of this type of item.

5.7 Wet Effectiveness Comparison Test (WECT)

A WECT will be conducted on not less than three brake/hub-end samples of the OEM/baseline and not less than three brake/hub-end of each candidate item. This off-vehicle test will be conducted to the on-vehicle FMVSS 105 wet effectiveness testing for all "air" and "hydraulic" systems, regardless of GVWR, and both the test procedure used and results obtained/observed will be fully detailed in the Final Test Report supplied by the test activity. Failure to provide test data, procedures, and rationale used to analyze test output data to the "RA" (see 3.1) will constitute a failure to perform by the potential alternative supplier or test activity and will be cause for rejection of the test data or test report.

5.8 Brake Burnishing

Unless specified otherwise by the "RA" (see 3.1), brake burnishing will be conducted as follows using the brake/hub-end rating of the worst-case targeted vehicle axles, regardless of whether the target vehicle or brake components are military or commercially based, unless specified differently by the "RA" (see 3.1). See 4.13.2 for additional instructions.

a. Appendix C, Tables C1 and C2, for disc and drum brakes will be in accordance with the requirements of the applicable FMVSS procedures (e.g., 105 or 121).

b. The burnishing procedures in Appendix E will be conducted as written.

c. The burnishing procedures for SAE J2115 and SAE J2522, as applicable, will be conducted as written.

d. The burnishing procedures for the Hill-Hold/Slope Tests will be in accordance with the applicable FMVSS procedures (e.g., 105 or 121).

e. The burnishing procedures for the Wet Brake Effectiveness Tests will be in accordance with applicable FMVSS procedures (e.g., 105 or 121).

f. When the same parts are used for follow-on or subsequent tests, such as immediately after the completion of each test sample's performance portion of the SAE J2115 or SAE J2522 testing (as appropriate) when the Wet Brake Effectiveness testing is normally performed (recommended), the test samples will receive additional, cleanup burnishing in accordance with FMVSS 105 (32 snubs or one cycle) or FMVSS 121 (50 snubs), as appropriate, unless specified otherwise in that test procedure. Wear-out/replacement criteria of 5.5 will also apply.

5.9 Crack Test and Strength Test for Rotors and Drums (CT&ST) (see Appendix E)

CT&ST will be conducted in accordance with Appendix E of subject specification, and each will be conducted separately, not sequentially as normally done under a similar ISO specification.

5.9.1 "Required" CT&ST for Rotors and Drums

CT&ST should be "required" under the following circumstances:

a. Whenever internal design changes by the OEM vehicle, OEM original equipment suppliers, or aftermarket component manufacturers for brake systems and/or component parts that have become unavailable due to nonavailability from the original source(s), design or performance obsolescence, design insufficiency, and/or statutory or regulatory changes.

b. Whenever engineering analysis and testing data is required on the actual or mating parts; and/or alternative rotor/drum metallurgical and/or physical configuration changes are proposed, including by potential alternative suppliers; and/or when "reverse engineering" is required to replicate, develop alternative replacements, or validate unconfirmed performance requirements for same.

c. Whenever alternate friction materials are proposed that are considered to be potentially physically damaging within the published OEM wear-out/replacement criteria, other than wear, or when the friction material testing itself indicates that probable physical damage/failure by the targeted mating rotor/drum would occur or vice versa.

d. Whenever comparison testing is required of friction material (pads/shoes) and mating surface devices (rotors and drums) in combination; e.g., matched OEM foundation brake shoes/companion drum combination versus a proposed Brand "X" combination (see 4.7.1.2).

5.9.2 “Optional” CT&ST for Rotors and Drums

CT&ST should normally be considered “optional,” except as described in 5.9.1, and may be conducted independently of other tests described in subject specification. Even though CT&ST are highly desirable for engineering and logistical analysis, test costs may be a significant factor and CT&ST should be considered under a “best value” basis, as opposed to a routine addition to a brake testing program.

5.10 Brake Dust(ing) Color and Mass Loss

Quantification of friction material and mating surface “dusting” (mass loss) and its color for each test sample of both OEM and offeror-supplied test samples will be conducted during each test series that produces material loss/wear (“dusting”).

5.10.1 Brake Dust “Color”

Subject will be reported within the test results when an obvious visual difference occurs between the OEM and the alternative item during testing. Color determination will be a subjective, visual observation and may use the Pantone Scale, FED-STD-595, or any industry-accepted color scale. The offeror and/or test activity will seek guidance from the “RA” (see 3.1) on what could or should be defined as “obvious visual difference” because such information is important to prevent or answer field comments/complaints whenever a new item appears that “doesn’t look the same.”

5.10.2 Brake Mass Loss (“Dust Propensity”)

Subject will be reported with the test results and will be determined by the average of the loss of the two pads or brake shoes, as applicable, plus two times the rotor/drum loss. Using this method standardizes the methodology for comparison of like items and compensates for the fact that rotor material has a higher impact on the actual dust that sticks to the vehicle’s parts (most importantly, the wheel).

$$(\text{Inpad/Lead Shoe Loss} + \text{Outpad/Trail Shoe Loss}) \div 2 + 2 \times (\text{Rotor/Drum Loss}) = \text{Mass Loss} \quad \text{(Eq. 1)}$$

5.10.3 Brake Component Mass Transfer

The test activity will make periodic visual observations, physical measurements, and report same in the Final Test Report (FTR) of any (*) visually discernable and detrimental cross-transfer of pad/shoe friction materials and/or rotor/drum wear surface materials.

5.10.4 Corrosive Effects and Generation of Hazardous Materials as a Result of Brake Dust

The “RA” (see 3.1) will identify to the test activity all known additional safety, performance, and environmental hazards testing presents prior to start of testing and, in addition, direct identification of actual and/or potentially dangerous and/or hazardous materials to be specifically identified in the FTR based on the applicable material safety data sheet (MSDS) and HAZMAT that may result of the required testing itself. The test activity will make periodic visual observations during testing and report in the FTR any visually discernable corrosion and/or oxidation on all surfaces exposed to brake dust during testing.

5.11 Corrosion Testing (Optional)

The “RA” (see 3.1) should specify either targeted specific areas/components or more general corrosion testing. Due to the lack of industry-accepted or universally accepted common test specifications, the “RA” (see 3.1) must determine and specify in the ordering documents the type and duration of each selected test or procedure. The following procedures are provided for reference only for one specific problem area, friction material corrosion, which results in bonding to the mating surface (rotor/drum), and/or a brake component’s “corrosion recovery test.”

5.11.1 The Primary (Preferred) Method of Corrosion Testing

Subject will be performed as follows:

a. The "RA" (see 3.1) will specify one to three test samples each of the OEM and each proposed alternative item for post-SAE J2522 or SAE J2115 supplemental Corrosion Testing, as appropriate, which will be completed after the Wet Effectiveness Testing.

b. After the SAE J2522 or SAE J2115 is completed, including the final inspection, conduct a minimum of seven 1-day corrosion cycles, or any other number of cycles indicated by the "RA" (see 3.1) using SAE J2334 (automatic or manual mode), including pre- and post-corrosion inspections and (digital) pictures per the SAE J2334 instructions. During these corrosion cycles, the parts will be appropriately mated together using a commonly accepted method with the pads held to the braking surface of the rotor or shoes held to the braking surface of the drum.

c. After the final corrosion cycle and inspection is completed, the paired test items will perform another SAE J2522 or SAE J2115 test, as appropriate, excluding the burnish cycle. The test activity will take sufficient measures to ensure the mating surfaces to the inertia brake dynamometer fixturing and peripheral equipment are properly protected from being corroded.

d. The "RA" (see 3.1) may modify the corrosion cycle or the corrosion environment to accommodate other/additional specific testing or evaluation requirements.

e. Using this method demonstrates how the brake performs pre- and post-Corrosion Test related to break performance, torque variation, corrosion removal during use ("self-cleaning"), or any actual/potential corrosion-induced mechanical failures - all without having to increase the total number of test samples required for "mandatory" testing. Without doing post-corrosion dynamic testing, it is impossible to speculate in what matter the corroded materials will react with regard to performance, wear, and noise.

5.11.2 The alternate method of Corrosion Testing will be performed as follows: Same as 5.11.1, except that the testing will be done independently of any other testing using "green," new test samples and mating parts properly burnished in accordance with 5.8.a., unless specified otherwise by the "RA" (see 3.1). The "RA" (see 3.1) may modify the corrosion cycle, slurry chemistry, or corrosion environment to accommodate other or additional specific testing or evaluation requirements. Using this method does not fully demonstrate how the brake performs pre- and post-Corrosion Test and could increase the total number of test samples required for subject specification's "optional" testing. It should be noted that doing post-Corrosion Test dynamic testing with this method is problematic and will preclude analysis with regard to performance beyond simulated initial installation on vehicles.

5.11.3 Corrosion Testing may be treated as a separate test, done independently of subject specification, in which case 5.11.2 is the preferred method due to lower costs.

5.12 Appendices - Detailed Test Procedures

Appendices are provided to give specific directions on applicable test procedures, some of which required either modification for intended use within subject document from an originally sourced document and/or were specifically developed to fill known voids in generally accepted test procedures within the brake manufacturing and testing community as of the date of the original U.S. Army TACOM ATPD-2354 and ATPD-2383, the general basis for this document. Please note that any values expressed in non-metric units in the appendices were left that way intentionally and should be converted (if required) using internationally recognized procedures and values.

6. NOTES

6.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY SAE TRUCK AND BUS BRAKE SYSTEMS COMMITTEE

APPENDIX A - INERTIA-DYNAMOMETER TESTING MATHEMATICAL CALCULATIONS AND EQUATIONS

Table A1 - Inertia-dynamometer testing mathematical calculations and equations

Item	Brake Type	Use	Equation	Definition	Units
a	All	Two-axle pitch	$2•(T_f+T_r)/(W•rr)$	Total vehicle deceleration	m/s^2
GAWR	All	Vehicle parameter		Gross axle weight rating or double of hub-end weight rating, whichever is greater for military vehicles	kg
$GAWR_f$	All	Vehicle parameter two-axle		Gross axle weight rating front axle or double of hub-end weight rating, whichever is greater for military vehicles	kg
$GAWR_r$	All	Vehicle parameter two-axle		Gross axle weight rating rear axle or double of hub-end weight rating, whichever is greater for military vehicles	kg
T	All	Generic corner torque output	I•a/rr	Brake torque based on deceleration	N•m
T_f	All	Generic corner torque output two-axle	I_f•a/rr	Torque for front brake based on deceleration	N•m
T_r	All	Generic corner torque output two-axle	I_r•a/rr	Torque for rear brake based on deceleration	N•m
I	All	Corner parameter	$(GAWR•rr^{2)}/2$	Test inertia	$kg•m^2$
I_f	All	Corner parameter two-axle	$(GAWR_f•rr^{2)}/2$	Test inertia for front corner	$kg•m^2$
I_r	All	Corner parameter two-axle	$(GAWR_r•rr^2)/2$	Test inertia for rear corner	$kg•m^2$
μ	Disc	Corner friction material effectiveness	$T_{f,r}/(2•n•p•A_p•r_{eff}•\eta)$	Coefficient of friction	-
n	Disc	Corner parameter		Number of caliper pistons	-
A_p	Disc	Corner parameter		Piston area	cm^2
r_{eff}	Disc	Corner parameter		Rotor effective radius	cm
η	Disc	Corner parameter		Caliper efficiency (nominal = 1)	-
p	All	Corner value		Brake pressure	bar
φ	All	Two-axle pitch and yaw	$T_r/(T_f+T_r)$	Brake distribution factor	-
χ	All	Vehicle parameter two-axle	h/L	Center of gravity factor	-

Table A1 - Inertia-dynamometer testing mathematical calculations and equations (cont.)

Item	Brake Type	Use	Equation	Definition	Units
ψ	All	Vehicle parameter two-axle	W_r/W	Weight ratio factor	-
h	All	Vehicle parameter		Center of gravity height measured from the ground	m
L	All	Vehicle parameter two-axle		Wheel base	m
rr	All	Vehicle parameter	SLR/i	Equivalent rolling radius = static loaded radius	m
SLR	All	Vehicle parameter		Static loaded radius	m
i	All	Vehicle parameter		Axle-to-hub gear ratio i = 1.92 for HMMWV i = 1.00 for all non-geared hubs	-
W	All	Vehicle parameter		Total vehicle weight	kg
W_r	All	Vehicle parameter two-axle		Rear axle static weight = $GAWR_r$	kg
Front bias	All	Two-axle pitch	$\mu_{tf} > \mu_{tr}$		-
Rear bias	All	Two-axle pitch	$\mu_{tr} > \mu_{tf}$		-
Front lockup	All	Two-axle pitch	$\mu_{tf} > \mu_{peak}$		-
Rear lockup	All	Two-axle pitch	$\mu_{tr} > \mu_{peak}$		-
μ_{tf}	All	Two-axle pitch	$(1-\varphi)\cdot a/(1-\psi+\chi\cdot a)$	Front axle adhesion utilization	
μ_{tr}	All	Two-axle pitch	$a\cdot\varphi/(\psi-\chi\cdot a)$	Rear axle adhesion utilization	-
μ_{peak}	All	Generic value		Tire-to-road adhesion limit at 90 km/h per Table 6, page 20, Automotive Brake Systems, Bosch, 1995	-
$C_{S\text{-}cam}$	S-cam drum	Corner friction material effectiveness	T_{out}/T_{in}	External brake factor S-cam drum	-
T_{out}	S-cam drum	Corner friction material effectiveness		Measured torque output from dynamometer test	N•m
T_{in}	S-cam drum	Corner friction material effectiveness	$A_c\cdot p\cdot l_s$	Calculated input torque	N•m
A_c	All air brakes	Corner friction material effectiveness		Air chamber nominal area	cm^2
l_s	S-cam drum	Corner friction material effectiveness		Slack adjuster operating length	m
C_{wedge}	Wedge drum	Corner friction material effectiveness	$T_{out}/(r\cdot A_c\cdot p)$	External brake factor simplex wedge drum	-

Table A1 - Inertia-dynamometer testing mathematical calculations and equations (cont.)

Item	Brake Type	Use	Equation	Definition	Units
r	Drum brakes	Corner friction material effectiveness		Brake drum radius at the braking surface	cm
C_{disc}	Air-disc	Corner friction material effectiveness	$T/(2 \bullet l_r \bullet p \bullet A_p \bullet r_{eff} \bullet \eta)$	External brake factor air-disc	-
l_r	Air-disc	Corner friction material effectiveness		Air-disc caliper lever ratio	-
C_{drum}	Simplex hydraulic drum	Corner friction material effectiveness	$T/(p \bullet A_p \bullet r \bullet \eta)$	External brake factor simplex hydraulic drum	-

APPENDIX B - ABBREVIATION LIST

%	Percent (X/Y)
°C	Degrees - Celsius
°F	Degrees - Fahrenheit
0.0”	Inches - U.S.
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATPD	“TACOM”-Managed Purchase Descriptions
bar	Pressure - Metric
CID	Commercial Item Description (see Federal Standardization Manual)
cm	Centimeter - Metric
CT&ST	Crack Test and Strength Test for Rotors and Drums
DAPS	Document Automation and Production Service
DIN	Deutsches Institut für Normung e.V. (German Institute for Standardization
DTV	Disc (Rotor) Thickness Variation
EC/ECE	European Community/European Commission for Europe
ECV	Enhanced Capability Vehicle
EPA	Environmental Protection Agency (U.S.)
ESA	Engineering Support Activity (Military/Governmental)
FEMFM	Federation of European Manufacturers of Friction Materials
FMCSR	Federal Motor Carrier Safety Regulations
FMSI	Friction Materials Standards Institute
FMVSS	Federal Motor Vehicle Safety Standards (U.S.)
ft	Feet - U.S.
FTR	Final Test Report
GCVW	Gross Combination Vehicle Weight (Rating)
GLTM	General Laboratory Test Methods
GVDBS	Ground Vehicle Dry Brake Systems

GVWR	Gross Vehicle Weight Rating
h	Hour (Time)
HMMWV	High Mobility, Multipurpose Wheeled Vehicle
Hz	Hertz
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IP	Intellectual Property
ISO	International Organization for Standardization
ITOP	International Test Operational Procedures
JASO	Japanese Automotive Standards Organization
k	Kilometer - Metric
kHz	Kilohertz
lb	Pounds - U.S. (Weight/Mass/Pressure)
Lbs.	Pounds - U.S. (Weight/Mass/Pressure)
LLVW	Lightly Loaded Vehicle Weight
m	Meter - Metric
MIL-DTL	Military Standard - Detailed Requirements
MIL-PRF	Military Standard - Performance Requirements
MIL-STD	Miliary Standard - General Use
mm	Millimeter - Metric
mph	Miles per Hour - U.S.
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NVH	Noise, Vibration, and Harshness
OEM	Original Equipment (or Vehicle) Manufacturer
OPTEC	Operational Test and Evaluation Command (Army User Testing)
OSHA	Occupational Safety and Health Administration (U.S.)
OTR	Over-the-Road (normally commercial vehicles)
psi	Pounds per Square Inch - U.S.

R&D	Research and Development
RA	Requesting Activity
SDO	Standards Development Organizations
sec, s*	Seconds (Time)
SIC	Secondary-Item Components (“Replacement Parts”)
SLR	Static Loaded Radius (Tires)
STM	Standard Test Methods
TMC/ATA	Technology and Maintenance Council of the American Trucking Association
TOP	Test Operational Procedures (normally military)
UL	Underwriters Laboratories (U.S.)
U.S.	United States of America
WECT	Wet Effectiveness Comparison Test

APPENDIX C

Table C1 - Test plans for disc brake pad assemblies, drum brake shoe assemblies, and brake block

ITEM	ATPD-2383 (MIL-SPEC) Test Plan TYPE OF TEST Disc Pads and Brake Shoes PHYSICAL AND DIMENSIONAL PROPERTIES	Notes	Heavy-Duty Urban Refuse Urban Buses Heavy Construction (Non-OPTEC)	Medium-Duty School Buses Urban Delivery Coach Buses Medium Straight Truck and Vans Interstate Buses	Light-Duty Light Urban Delivery Postal Small Buses	OTR Class 5-8 Trucks Class 8 Tractor-Trailer (FMCSR and Similar)	Non-Automotive Trailer Used in Combination with Prime Movers Above 3500 kg GVWR
1	Material identification/certifications	1	CoC/Lab Results	CoC/Lab Results	CoC/Lab Results	CoC/Lab Results	CoC/Lab Results
2	Visual inspection	2	ISO 22574	ISO 22574	ISO 22574	ISO 22574	ISO 22574
3	Critical dimensions verifications		STM	STM	STM	STM	STM
4	Shear strength adhesion/bonding (-40 °C) non-riveted	3	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)
5	Shear strength adhesion/bonding (750 °F) (400 °C) non-riveted	3	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)	SAE J840 (ISO 6312)
6	Compressibility, ambient	5, 6	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)
7	Compressibility, elevated temperature	5, 6	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)	SAE J2468 (ISO 6310)
8	Gogan hardness (grandfathered parts)		SAE J379	SAE J379	SAE J379	SAE J379	SAE J379
9	Hardness on metallic parts (rotor, drum, shoe, backing plate)		ASTM E10	ASTM E10	ASTM E10	ASTM E10	ASTM E10
10	Thermal swell and growth	5	SAE J160	SAE J160	SAE J160	SAE J160	SAE J160
11	Natural frequency		SAE J2598	SAE J2598	SAE J2598	SAE J2598	SAE J2598

Table C1 - Test plans for disc brake pad assemblies, drum brake shoe assemblies, and brake block (cont.)

ITEM	ATPD-2383 (MIL-SPEC) Test Plan TYPE OF TEST Disc Pads and Brake Shoes INERTIA-DYNAMOMETER FRICTION COUPLE PERFORMANCE, NOISE, AND DURABILITY	Notes	Heavy-Duty Urban Refuse Urban Buses Heavy Construction (Non-OPTEC)	Medium-Duty School Buses Urban Delivery Coach Buses Medium Straight Truck and Vans Interstate Buses	Light-Duty Light Urban Delivery Postal Small Buses	OTR Class 5-8 Trucks Class 8 Tractor-Trailer (FMCSR and Similar)	Non-Automotive Trailer Used in Combination with Prime Movers Above 3500 kg GVWR
12	Friction Behavior and Performance Assessment	7	SAE J2115 (ISO 26865)	SAE J2684 Hydraulic SAE J2115 Air (ISO 26865)	SAE J2684	SAE J2115 (ISO 26865)	SAE J2684 Hydraulic SAE J2115 Air (ISO 26865)
13	Hill-Hold Test	7	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)
14	Fade Test (conducted concurrently with Performance Test)	7	SAE J2115 (ISO 26865)	SAE J2522 Hydraulic SAE J2115 Air (ISO 26865)	SAE J2522	SAE J2115 (ISO 26865)	SAE J2522 Hydraulic SAE J2115 Air (ISO 26865)
15	Wear and Durability	7, 9	SAE J2806, Appendix D	SAE J2806, Appendix D	SAE J2806, Appendix D	SAE J2806, Appendix D	SAE J2806, Appendix D
16	Wear Versus Temperature	7	SAE J2115 (ISO 26866)	SAE J2707 Hydraulic SAE J2115 Air (ISO 26866 Air)	SAE J2707A	SAE J2115 (ISO 26866 Air)	SAE J2707 Hydraulic SAE J2115 Air (ISO 26866 Air)
17	Wet Effectiveness and Performance (FMVSS 105)	7	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)

NOTES:
1. Certificate of Conformance and/or certified lab reports for all non-OEM parts.
2. Federation of European Manufacturers of Friction Materials, www.femfm.com.
3. Test allows to cut sample to accommodate machine and fixturing capabilities. Does not apply to riveted assemblies.
4. (Reserved)
5. Assessment test to define product variability in preparation for other type of tests or product monitoring.
6. Useful to product monitoring, internal voids, and noise propensity evaluation.
7. Requires vehicle-specific parameters.
8. (Reserved)
9. Can include rotor wear measurement as a predictor of wheel dust for disc brakes.

Table C2 - Test plans for disc brake rotor and drum brake assemblies

ITEM	ATPD-2383 Test Plan TYPE OF TEST Rotors and Drums PHYSICAL AND DIMENSIONAL PROPERTIES	Notes	Heavy-Duty Urban Refuse Urban Buses Heavy Construction (Non-OPTEC)	Medium-Duty School Buses Urban Delivery Coach Buses Medium Straight Truck and Vans Interstate Buses	Light-Duty Light Urban Delivery Postal Small Buses	OTR Class 5-8 Trucks Class 8 Tractor-Trailer (FMCSR and Similar)	Non-Automotive Trailer Used in Combination with Prime Movers Above 3500 kg GVWR
1	Material identification/certifications	1	CoC/Lab Results	CoC/Lab Results	CoC/Lab Results	CoC/Lab Results	CoC/Lab Results
2	Visual inspection	2	STM	STM	STM	STM	STM
3	Critical dimensions verifications		STM	STM	STM	STM	STM
4	Hardness on metallic parts (rotor, drum, shoe, backing plate)		ASTM E10	ASTM E10	ASTM E10	ASTM E10	ASTM E10
5	Lateral/radial runout: DTV measurement (rotor only)		STM	STM	STM	STM	STM
	INERTIA-DYNAMOMETER FRICTION COUPLE PERFORMANCE, NOISE, AND DURABILITY						
6	Friction Behavior and Performance Assessment	7	SAE J2115 (ISO 26865)	SAE J2522 Hydraulic SAE J2115 Air (ISO 26865)	SAE J2522	SAE J2115 (ISO 26865)	SAE J2522 Hydraulic SAE J2115 Air (ISO 26865)
7	Hill-Hold Test	7	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)	SAE J2806, para. 5.6 (ECE R90)
8	Fade Test (conducted concurrently with Performance Test)	7	SAE J2115 (ISO 26865)	SAE J2522 Hydraulic SAE J2115 Air (ISO 26865)	SAE J2522	SAE J2115 (ISO 26865)	SAE J2522 Hydraulic SAE J2115 Air (ISO 26865)
9	Wear and Durability	7, 9	SAE J2806, Appendix D	SAE J2806, Appendix D	SAE J2806, Appendix D	SAE J2806, Appendix D	SAE J2806, Appendix D

Table C2 - Test plans for disc brake rotor and drum brake assemblies (cont.)

ITEM	ATPD-2383 Test Plan TYPE OF TEST Rotors and Drums INERTIA-DYNAMOMETER FRICTION COUPLE PERFORMANCE, NOISE, AND DURABILITY	Notes	Heavy-Duty Urban Refuse Urban Buses Heavy Construction (Non-OPTEC)	Medium-Duty School Buses Urban Delivery Coach Buses Medium Straight Truck and Vans Interstate Buses	Light-Duty Light Urban Delivery Postal Small Buses	OTR Class 5-8 Trucks Class 8 Tractor-Trailer (FMCSR and Similar)	Non-Automotive Trailer Used in Combination with Prime Movers Above 3500 kg GVWR
10	Wear Versus Temperature	7	SAE J2115 (ISO 26866)	SAE J2707A Hydraulic SAE J2115 Air (ISO 26866 Air)	SAE J2707A	SAE J2115 (ISO 26866 Air)	SAE J2707A Hydraulic SAE J2115 Air (ISO 26866 Air)
11	Wet Effectiveness and Performance (FMVSS 105)	7	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)	SAE J2806, para 5.7 (JASO C407)
12	Crack and Strength Tests (see 4.25 for “air” disc brakes)	7	SAE J3080 SAE J2806, para. 5.9 and Appendix E	SAE J3080 SAE J2806, para. 5.9 and Appendix E	SAE J3080 SAE J2806, para. 5.9 and Appendix E	SAE J3080 SAE J2806, para. 5.9 and Appendix E	SAE J3080 SAE J2806, para. 5.9 and Appendix E

NOTES:
1. Certificate of Conformance and/or certified lab reports for all non-OEM parts.
2. Federation of European Manufacturers of Friction Materials, www.femfm.com.
3. (Reserved)
4. (Reserved)
5. (Reserved)
6. (Reserved)
7. Requires vehicle-specific parameters.
8. (Reserved)
9. Can include rotor wear measurement as a predictor of wheel dust for DBS.

APPENDIX D - OFF-VEHICLE INERTIA DYNAMOMETER TEST PROCEDURES FOR PERFORMANCE, WEAR, AND NOISE

(Refer to U.S. Army Top 2-2-608, aka Laurel Mountain and Jennerstown Testing)

D.1 SCOPE

The purpose of this procedure is to evaluate specific components or brake assemblies for braking performance, fade, endurance, structural integrity, and wear characteristics when subjected to simulation on an inertia dynamometer based on vehicle test data from a 25-mile stretch of U.S. Route 30 in western Pennsylvania, east of Laurel Mountain.

D.2 PROCEDURE

This procedure was written from the test data derived from the driving pattern indicated. Some simplifications were made in order to accommodate a dynamometer test environment. This test procedure can be used for both hydraulic and air actuated brake systems. This test procedure is intended for ground-powered wheeled vehicles, divided into three nominal weight rating categories:

a. Procedures for vehicles up to 12000 pounds of GVW.

b. Procedures for vehicles above 12001 pounds and below 45000 pounds of GVW.

c. Procedures for vehicles above 45001 pounds of GVW.

D.3 GENERAL INSTRUCTIONS

D.3.1 Test Conditions

D.3.1.1 The designated “RA” (see 3.1) will specifically identify the required Test Procedure (see D.4) within this appendix to use for the test.

D.3.1.2 This procedure is written for single- or dual-ended testing:

a. For single-ended testing, use the inertia at the brake combining static loaded radius and the wheel-end load rating.

b. For dual-ended testing in a front-and-rear configuration, set up the appropriate rear proportioning valve, when applicable, and use half the test vehicle weight for the inertia calculation.

c. For dual-ended testing in a left-and-right configuration, use the inertia at the axle combining static loaded radius and the appropriate axle load rating.

D.3.1.3 Before starting the dynamometer, complete a “pretest operator checklist” per internal procedures.

D.3.1.4 During all phases of this procedure, any unusual performance characteristics such as noise or sparks will be noted in the “Operator Comments Sheet.”

D.3.1.5 Direct cooling air at the brake(s) as needed to ensure efficient operation during the burnish cycle. Cooling air during the Laurel Mountain and Cross Country sections will be less than 3 mph.

D.3.1.6 When appropriate, or directed by the “RA” (see 3.1), measure the noise level and frequency using an appropriate noise analyzer or recorder.

D.3.1.7 In the event of availability of vehicle test data, and directed by the “RA” (see 3.1), the test cycle may be changed.

D.3.2 Setup

a. The brake will be mounted as close to being in service as possible.

b. One thermocouple will be installed in the rotor/drum 0.020 inch below the braking surface. Also, install one thermocouple 0.080 inch below the braking surface on each brake lining as close to the center of the rubbing area as possible.

c. During the test and in real time, record the rotor/drum and pad/lining temperatures, brake torque, air/hydraulic pressure, speed, and effectiveness/BEF.

d. During the test, record peak noise level and frequency for the 2 to 17 kHz range.

D.3.3 Operation

a. Brake burnishing. Unless specified otherwise by the “RA” (see 3.1), brake burnishing will be conducted in accordance with the requirements of FMVSS 105 or FMVSS 121, as applicable, based on the actual (or proposed for Methods “B” and “D” only) GVW rating of the targeted vehicle system, regardless of whether the target vehicle system is military or commercial. Refer to ATPD-2354, paragraph 5.8.

b. Unless otherwise specified, the rate of rise (ramp rate) of air pressure will be 240 psi/s during all sections of the test or 2500 psi/s for hydraulic brakes.

c. Unless pressure level for 200-pound pedal force is supplied, pressure limit will be set to 120 psi for air brakes and 2500 psi for hydraulic brakes.

d. IBT is defined as the “initial brake temperature” and is the temperature of the outer pad, brake off.

e. The dynamometer will be configured to collect temperature #1 as the inner/leading lining, #2 as the trailing/outer lining, and #3 as the rotor or drum, as appropriate.

f. Test parameters will be controlled within 2% of set-point values.

g. Unless otherwise specified, test inertia should be calculated based on the unladen axle load and the maximum tire size applicable for the brake being tested.

h. When indicated, brake will be adjusted following written manufacturer’s recommendation. Mounting bolts and critical components will be paint-marked for inspecting movement or loosening during the test.

i. Wear measurements will be made following customer’s instructions or test activity’s internal practice, before and after the test.

j. If the brake is below temperature, perform applications from 40 to 20 mph at 10 ft/s^2.

D.4 SPECIFIC INSTRUCTIONS/TEST PROCEDURES

D.4.1 Brake Burnishing

Refer to ATPD-2383, paragraph 5.8.

D.4.2 Test Procedure for Vehicles Up to 12000 Pounds of GVWR

Table D1 - Test procedure for vehicles up to 12000 pounds of GVWR

190. Laurel Mountain Fade Snubs				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
18	40	20	8 ft/s^2	≤150 °F first snub. Remaining snubs 14 seconds.
200. Laurel Mountain Hot Stop				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	40	0.5	14.4 ft/s^2	28 seconds after last fade snub.
Pre-Laurel Mountain Inspection				
- Measure test items and companion parts thickness, with/without backing. - Weigh test items and companion parts. - Take photos of the test items and companion parts.				
1000. Laurel Mountain Cross Country Cycle (stops numbers in parentheses)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
12 (1-12)	40	20	7.5 ft/s^2	≤150 °F first snub. Remaining snubs 19 seconds.
1 (13)	40	20	5.5 ft/s^2	28 seconds
5 (14-18)	30	20	6.5 ft/s^2	28 seconds
2 (19-20)	40	20	5.5 ft/s^2	28 seconds
4 (21-24)	40	20	7.5 ft/s^2	28 seconds
9 (25-33)	40	20	6.5 ft/s^2	28 seconds
10 (34-43)	40	20	6 ft/s^2	125 seconds
36 (44-79)	35	25	8 ft/s^2	15 seconds
13 (80-92)	40	20	6.5 ft/s^2	70 seconds
1 (93)	40	0.5	15 ft/s^2	70 seconds
10 (94-103)	40	20	6.5 ft/s^2	37 seconds
3 (104-106)	40	20	7 ft/s^2	37 seconds
6 (107-112)	40	20	6.5 ft/s^2	37 seconds
2 (113-114)	40	20	5.8 ft/s^2	37 seconds
4 (115-118)	40	20	6.8 ft/s^2	37 seconds
1 (119)	40	20	5.5 ft/s^2	37 seconds
Repeat the Laurel Mountain Cycle for a total of four times; one Cross Country Cycle. Then perform the Post-Laurel Mountain Cycle.				
Post-Laurel Mountain Cycle				
1500. Post-Laurel Mountain Cross Country Cycle Effectiveness (20 mph)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	20	0.5	200 psi-hydraulic 20 psi-air	≤150 °F
1	20	0.5	400 psi-hydraulic 40 psi-air	≤150 °F
1	20	0.5	600 psi-hydraulic 60 psi-air	≤150 °F
1	20	0.5	800 psi-hydraulic 80 psi-air	≤150 °F
1	20	0.5	1000 psi-hydraulic 100 psi-air	≤150 °F
1	20	0.5	1200 psi-hydraulic 120 psi-air	≤150 °F

1	20	0.5	1400 psi-hydraulic	≤150 °F
1	20	0.5	1600 psi-hydraulic	≤150 °F
1	20	0.5	1800 psi-hydraulic	≤150 °F
1	20	0.5	2000 psi-hydraulic	≤150 °F
1600. Post-Laurel Mountain Cross Country Cycle Effectiveness (40 mph)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	40	0.5	200 psi-hydraulic 20 psi-air	≤150 °F
1	40	0.5	400 psi-hydraulic 40 psi-air	≤150 °F
1	40	0.5	600 psi-hydraulic 60 psi-air	≤150 °F
1	40	0.5	800 psi-hydraulic 80 psi-air	≤150 °F
1	40	0.5	1000 psi-hydraulic 100 psi-air	≤150 °F
1	40	0.5	1200 psi-hydraulic 120 psi-air	≤150 °F
1	40	0.5	1400 psi-hydraulic	≤150 °F
1	40	0.5	1600 psi-hydraulic	≤150 °F
1	40	0.5	1800 psi-hydraulic	≤150 °F
1	40	0.5	2000 psi-hydraulic	≤150 °F
1700. Post-Cross Country Cycle Fade Snubs				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
18	40	20	8 ft/s^2	≤150 °F first snub. Remaining snubs 14 seconds.
1800. Post-Laurel Mountain Fade Hot Stop				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	40	0.5	14.4 ft/s^2	28 seconds after last fade snub.
Post-Laurel Mountain Cycle Inspection				
- Measure test items and companion parts thickness, with/without backing. - Weigh test items and companion parts. - Take photos of the test items and companion parts.				
Repeat the Laurel Mountain Cross Country Cycle two more times, for a total of three Cross Country Cycles.				
Test is complete.				

D.4.3 Test Procedures for Vehicles Above 12001 Pounds and Below 45000 Pounds of GVWR

Table D2 - Test procedures for vehicles above 12001 pounds and below 45000 pounds of GVWR

190. Laurel Mountain Fade Snubs				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
30	30	25	8 ft/s^2	≤150 °F first snub. Remaining snubs 14 seconds.
200. Laurel Mountain Hot Stop				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	40	0.5	14.4 ft/s^2	28 seconds after last fade snub.
Pre-Laurel Mountain Inspection				
- Measure test items and companion parts thickness, with/without backing. - Weigh test items and companion parts. - Take photos of the test items and companion parts.				
1000. Laurel Mountain Cross Country Cycle (stops numbers in parenthesis)				
3 (1-3)	35	30	7.5 ft/s^2	≤150 °F first snub. Remaining snubs 19 seconds.
3 (4-6)	35	30	5.5 ft/s^2	28 seconds
10 (7-16)	30	25	6.5 ft/s^2	28 seconds
6 (17-22)	35	30	5.5 ft/s^2	28 seconds
12 (23-34)	30	25	7.5 ft/s^2	28 seconds
4 (35-38)	35	30	6.5 ft/s^2	28 seconds
20 (39-58)	30	25	6.5 ft/s^2	28 seconds
12 (59-70)	35	30	6 ft/s^2	125 seconds
45 (71-115)	30	25	8 ft/s^2	15 seconds
16 (116-131)	35	30	6.5 ft/s^2	70 seconds
1 (132)	40	0.5	15 ft/s^2	70 seconds
20 (133-152)	30	25	6.5 ft/s^2	37 seconds
6 (153-158)	35	30	7 ft/s^2	37 seconds
5 (176-180)	35	30	5.8 ft/s^2	37 seconds
10 (181-190)	30	25	6.8 ft/s^2	37 seconds
3 (191-193)	35	30	5.5 ft/s^2	37 seconds
Repeat the Laurel Mountain Cycle for a total of four times; one Cross Country Cycle. Then perform the Post-Laurel Mountain Cycle.				
Post-Laurel Mountain Cycle				
1500. Post-Laurel Mountain Cross Country Cycle Effectiveness (20 mph)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	20	0.5	200 psi-hydraulic 20 psi-air	≤150 °F
1	20	0.5	400 psi-hydraulic 40 psi-air	≤150 °F
1	20	0.5	600 psi-hydraulic 60 psi-air	≤150 °F
1	20	0.5	800 psi-hydraulic 80 psi-air	≤150 °F
1	20	0.5	1000 psi-hydraulic 100 psi-air	≤150 °F
1	20	0.5	1200 psi-hydraulic 120 psi-air	≤150 °F

1	20	0.5	1400 psi-hydraulic	≤150 °F
1	20	0.5	1600 psi-hydraulic	≤150 °F
1	20	0.5	1800 psi-hydraulic	≤150 °F
1	20	0.5	2000 psi-hydraulic	≤150 °F
1600. Post-Laurel Mountain Cross Country Cycle Effectiveness (40 mph)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	40	0.5	200 psi-hydraulic 20 psi-air	≤150 °F
1	40	0.5	400 psi-hydraulic 40 psi-air	≤150 °F
1	40	0.5	600 psi-hydraulic 60 psi-air	≤150 °F
1	40	0.5	800 psi-hydraulic 80 psi-air	≤150 °F
1	40	0.5	1000 psi-hydraulic 100 psi-air	≤150 °F
1	40	0.5	1200 psi-hydraulic 120 psi-air	≤150 °F
1	40	0.5	1400 psi-hydraulic	≤150 °F
1	40	0.5	1600 psi-hydraulic	≤150 °F
1	40	0.5	1800 psi-hydraulic	≤150 °F
1	40	0.5	2000 psi-hydraulic	≤150 °F
1700. Post-Cross Country Cycle Fade Snubs				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
30	30	25	8 ft/s^2	≤150 °F first snub. Remaining snubs 14 seconds.
1800. Post-Laurel Mountain Fade Hot Stop				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	40	0.5	14.4 ft/s^2	28 seconds after last fade snub.
Post-Laurel Mountain Cycle Inspection				
- Measure test items and companion parts thickness, with/without backing. - Weigh test items and companion parts. - Take photos of the test items and companion parts.				
Repeat the Laurel Mountain Cross Country Cycle two more times, for a total of three Cross Country Cycles.				
Test is complete.				

D.4.4 Test Procedures for Vehicles Above 45001 Pounds of GVWR

Table D3 - Test procedures for vehicles above 45001 pounds of GVWR

180. Laurel Mountain Fade Snubs				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
25	30	25	8 ft/s^2	≤150 °F first snub. Remaining snubs 14 seconds.
190. Laurel Mountain Hot Stop				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	35	0.5	11 ft/s^2	28 seconds after last fade snub.
Pre-Laurel Mountain Inspection				
- Measure test items and companion parts thickness, with/without backing. - Weigh test items and companion parts. - Take photos of the test items and companion parts.				
1000. Laurel Mountain Cross Country Cycle (stops numbers in parenthesis)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
3 (1-3)	35	30	7.5 ft/s^2	≤150 °F first snub. Remaining snubs 19 seconds.
3 (4-6)	35	30	5.5 ft/s^2	28 seconds
6 (7-12)	30	25	6.5 ft/s^2	28 seconds
4 (13-16)	35	30	5.5 ft/s^2	28 seconds
6 (17-22)	30	25	7.5 ft/s^2	28 seconds
3 (23-25)	35	30	6.5 ft/s^2	28 seconds
13 (26-38)	30	25	6.5 ft/s^2	28 seconds
6 (39-44)	35	30	6 ft/s^2	125 seconds
10 (45-54)	30	25	8 ft/s^2	15 seconds
10 (55-64)	35	30	6.5 ft/s^2	70 seconds
1 (65)	40	0.5	10 ft/s^2	70 seconds
13 (66-78)	30	25	6.5 ft/s^2	37 seconds
4 (79-82)	35	30	7 ft/s^2	37 seconds
11 (83-93)	30	25	6.5 ft/s^2	37 seconds
2 (94-95)	35	30	5.8 ft/s^2	37 seconds
7 (96-102)	30	25	6.8 ft/s^2	37 seconds
2 (103-104)	35	30	5.5 ft/s^2	37 seconds
Repeat the Laurel Mountain Cycle for a total of four times; one Cross Country Cycle. Then perform the Post-Laurel Mountain Cycle.				
Post-Laurel Mountain Cycle				
1500. Post-Laurel Mountain Cross Country Cycle Effectiveness (20 mph)				
Number of Stops	**Braking Speed (mph)**	**Release Speed (mph)**	**Control Level**	**Cycle Control**
1	20	0.5	200 psi-hydraulic 20 psi-air	≤150 °F
1	20	0.5	400 psi-hydraulic 40 psi-air	≤150 °F
1	20	0.5	600 psi-hydraulic 60 psi-air	≤150 °F
1	20	0.5	800 psi-hydraulic 80 psi-air	≤150 °F
1	20	0.5	1000 psi-hydraulic 100 psi-air	≤150 °F
1	20	0.5	1200 psi-hydraulic 120 psi-air	≤150 °F