SAE International™ SURFACE VEHICLE RECOMMENDED PRACTICE

J2718	REAF. SEP2010
Issued 2006-02	
Reaffirmed 2010-09	
Superseding J2718 FEB2006	

Test for Tire Quasi-Static Longitudinal Force vs. Longitudinal Displacement and Quasi-Static Lateral Force vs. Lateral Displacement

RATIONALE

J2718 has been reaffirmed to comply with the SAE 5-Year Review policy.

1. SCOPE

This SAE Recommended Practice describes application of two closely related test procedures, which together determine the linear range longitudinal and lateral stiffnesses of a statically loaded non-rotating tire. The procedures apply to any tire so long as the equipment is properly sized to correctly conduct the measurements for the intended test tire. The data are suitable for use in determining parameters for road load models and for comparative evaluations of the measured properties in research and development.

NOTE: Herein, road load models are models for predicting forces applied to the vehicle spindles during operation over irregular pavements. Within the context of this document, forces applied to the pavement are not considered.

1.1 Procedures

Two closely related procedures are applied. In each procedure the contact center of a loaded tire on a locked spindle and its wheel center are displaced horizontally one with respect to the other so as to generate shear force versus shear deflection data. In the first procedure the displacement is purely longitudinal, parallel to the X'-axis in the SAE Tire Axis System. In the second procedure the displacement is purely lateral, parallel to the Y'-axis in the SAE Tire Axis System. These procedures are spelled out in the body of this document.

1.2 Test Machines

This document is test machine neutral. It may be applied using any type of test machine capable of fulfilling the requirements stated in this document. The test machine must be capable of accommodating the tire sizes to be tested.

2. REFERENCES

2.1 Applicable Publications

The following publications form part of the specification to the extent specified herein. Unless otherwise indicated the latest revisions of all publications shall apply.

2.1.1 SAE Publications

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

SAE J2047 Tire Performance Technology

SAE J2429 Free-Rolling Cornering Test for Truck and Bus Tires

2.1.2 OSHA Publication

Available from Rubber Manufacturers Association, 1400 K Street, NW, Suite 900, Washington, DC 20005, Tel: 202-682-4800, www.rma.org.

OSHA 1910.177 Servicing Multi-Piece and Single Piece Rim Wheels (Available in wall chart form as #TTMP-7/95)

2.1.3 ISO Publication

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 17025 General requirements for the competence of testing and calibration laboratories

3. DEFINITIONS

The definitions that follow are of special meaning in this document and are either not contained in other Recommended Practices or are worded somewhat differently in this practice.

3.1 Shear Deflections

Shear deflections are changes in the relative horizontal position between the contact center and the projection of the wheel center onto the road plane. Deflections may arise either due to horizontal translation of the contact center or the wheel center or both. They are considered equivalent regardless of source.

3.1.1 Longitudinal Deflection (δ_X)

The relative horizontal position between the contact center and the projection of the wheel center onto the road plane is changed only parallel to the SAE X'-axis.

3.1.2 Lateral Deflection (δ_Y)

The relative horizontal position between the contact center and the projection of the wheel center onto the road plane is changed only parallel to the SAE Y'-axis.

3.2 100% Load

100% load is the test requester specified reference load.

3.3 Test

A test is the execution of the procedure described in this document one time on one tire at a single set of test conditions.

3.4 Test Program

A Test Program is a designed experiment involving multiple tests of the type described in this practice.[1]

4. NOMENCLATURE

Table 1 lists the symbols used in this document. For definitions not in Section 3 of this practice please see SAE J2047.

TABLE 1 – SYMBOLS DEFINED

Symbol	Defined Term
δ_X	Longitudinal Deflection
δ_Y	Lateral Deflection
F_X	Longitudinal Force
F_Y	Lateral Force
F_Z	Normal Force
p	Inflation Pressure
σ	Standard Deviation (Note Subscripts)

5. LABORATORY QUALITY SYSTEM REQUIREMENT

The laboratory performing the procedure specified in this document shall have a quality system either conforming to ISO 17025 or which can be shown to be functionally equivalent to ISO 17025. The elements of such a system are assumed below and are not, therefore, specifically called out within this practice.

6. APPARATUS

The required apparatus consists of a loading machine with the characteristics noted and test wheels.

6.1 Loading Machine

The loading machine consists of a tire loading and positioning system, a measuring system, a flat surface simulated roadway, and the space housing the machine, which shall be maintained at 22 °C ± 2 °C.

6.1.1 Loading and Positioning System

The system shall maintain the tire with the tire/wheel plane within ±0.10° of perpendicular to the simulated roadway during all loading. Loading shall produce normal forces accurate to within ±1.0% of the test machine's full-scale normal force range. The machine's full-scale normal force range shall allow imposition of loads equivalent to at least three times the 100% load.

During the procedures described in this document, the machine's hub must be fixed with respect to rotation about the wheel spindle.[2] The unintended relative shear motion between the hub and roadway at highest applied shear force shall be 2% or less of total shear displacement existing at the displacement limit defined in the next paragraph.

---

[1] There are many experimental possibilities: repeated tests of the same tire, tests of the same tire under multiple test conditions, tests of tires with different specifications (design details), application of this test as part of a series of different tests, etc.

[2] This freedom from substantial rotation (less than 0.1° at the highest applied longitudinal force) may be obtained either by having a spindle without a rotational degree of freedom or by providing a lock in the case of a spindle with a rotational degree of freedom.

The system shall be capable of generating longitudinal and lateral shear displacements between the wheel center and the contact center. This may be done by translating the hub parallel to the SAE X' and Y' axes or by translating the simulated roadway parallel to SAE X' and Y' axes. The system shall allow translation sufficient to reach shear force magnitudes equal to one-third of the applied normal force at three times the 100% load.

6.1.2 Measuring System

The system shall measure normal force (F_Z) to within ±0.5% of the test machine's full-scale normal force range, lateral force (F_Y) to within ±0.5% of the test system's full scale lateral force range, longitudinal force (F_X) to within ±0.5% of the test system's full scale longitudinal force range[3], lateral displacement (δ_X) within ±0.5 mm, and longitudinal displacement (δ_Y) within ±0.5 mm.. The system shall have a normal force range that allows measurement of forces equivalent to those existing at 300% of the client specified 100% load.

6.1.3 Simulated Roadway

The simulated roadway shall be a smooth flat surface, free of loose materials and deposits. It shall be coated with a 120-Grit abrasive material. The material of which the roadway itself is made is unimportant so long as the roadway satisfies the following criteria.

6.1.3.1 The roadway shall be large enough to fully support the tire footprint throughout this test.

6.1.3.2 The roadway and its supporting structure shall be sufficiently rigid so as to not change appreciably in either transverse or longitudinal orientation or in curvature under the machine's maximum applied normal force. Appreciably implies that roadway deformation will be sufficiently small so as to not cause the machine to be unable to satisfy the requirements of Sections 6.1.1 or 6.1.2.

6.2 Test Wheels

Test wheels shall meet the dimensional tolerances of original equipment wheels supplied on new vehicles and shall have the rim profile specified for the test tire by the appropriate tire and rim standards association, for example, the Tire and Rim Association, Inc.

NOTE: Wheel stiffness may have a discernable influence on the results. At this time, the presence of this effect has not been established. Further, there is not now a recognized way to appropriately characterize wheel stiffness for use in this document. It is planned to address this question by research carried out prior to the five-year review of this practice.

7. CALIBRATION[4]

Calibrate all measuring system components in accordance with the mandates of the written plan required by the laboratory quality system referenced in Section 5. Calibration must exercise all measuring system components over substantially their full range of application and must be performed not less than once each year. The reference standards and instruments used in measuring system calibration shall be traceable to the National Institute of Standards and Technology or the appropriate national standards organization in countries other than the United States. Calibration certificates for reference standards and instruments shall be valid at the time the system is calibrated. These must be on file in the testing laboratory's files when the system's calibration is performed. Gains, offsets, and other pertinent performance measures and comments on system behavior during calibration shall be kept permanently on file within the testing laboratory's archives and be available to customers on request.

[3] Should the measuring system sense multiple forces and moments, the output shall be corrected for load cell interaction by a matrix method conceptually equivalent to that discussed in SAE J2429.

[4] If required, Section 7 of SAE J2429 provides an expanded discussion of the question of calibration in the case of a conceptually parallel measuring system designed to simultaneously sense three forces and two moments.

8. PREPARATION OF APPARATUS

Preparation of the apparatus shall ensure that the test equipment meets its calibration at the outset of each test program. The precise process control method used to verify readiness of the apparatus is likely to be unique to an individual test site, but must be specified in writing within the quality system of the laboratory. The results of process control experiments shall be available to test requesters.

9. SELECTION AND PREPARATION OF TEST TIRES

9.1 Selecting the Tires for Good Comparability

The purpose of the test must be carefully borne in mind when selecting test tires since tire properties depend on numerous factors besides the tire design and materials. It is especially important to properly account for storage history (SAE 810066) and previous work history (SAE 770870). Due to the many complex questions that the test defined in this document may be used to address, specific tire selection recommendations can only be made for the case in which different tires are to be compared for design or materials effects. In that case, all test tires should be of approximately the same age, have been stored under essentially identical conditions, have experienced approximately the same exercise history, and have been sampled from production lots with similar statistical characteristics.

9.2 Inflation Pressure

The inflation pressure will significantly affect the stiffnesses of a tire. Therefore, the appropriate test inflation pressure must be specified by the requester and set to within ± 5 kPa by the testing laboratory. Because tires typically operate at a temperature higher than that of the ambient air, operating inflation pressure is usually higher than cold inflation pressure. If the purpose of testing is to simulate the running state, then the inflation pressure used in the test must be equivalent to the on-road operating inflation pressure.

9.3 Tire Preparation

Clean the tire surface of dirt, loose material, or other contaminants. Mount the test tire on the tire and rim standards organization specified rim.[5] For rim wheels used on large vehicles such as trucks, tractors, buses, and off-road machines, mounting and demounting shall be done in accordance with the practices specified in (OSHA 1910.177). (OSHA 1910.177) does not apply to the servicing of rim wheels used on automobiles or on pickup trucks or vans utilizing automobile tires or truck tires designated “LT”. The wheels used shall meet the specifications noted in Section 6.2.

9.4 Sample Size

Typically, a single tire selected at random from among the group of tires in each specification is an adequate sample if the goal is parametric data for producing a tire model. However, should the desire be to determine differences between tire specifications at a stated level of accuracy it will be necessary to use statistically valid sample sizes and to employ appropriate statistical analyses of the results to define the differences among specifications.

10. TEST PROCEDURES

The two procedures differ only in terms of the direction of relative displacement and the force and displacement components which are reported using a particular procedure.

10.1 Prior to Performing the Procedures

The test tire and wheel assembly with the tire properly inflated and prepared for testing shall be mounted on the test machine.

---

[5] The Tire and Rim Association, Inc. is an example of a tire and rim standards organization.

10.2 Longitudinal Stiffness Procedure

The intent of this procedure is to produce F_X versus δ_X data at a given F_Z preload as described in the remainder of Section 10.2.

10.2.1 Tare the measurement system.

10.2.2 Load the Tire Along a Single Radius[6]

Load the tire to one-half of the 100% load.

10.2.3 Subject the Tire to a δ_X Displacement Ramp

Increase the relative X-displacement between the contact center and the wheel center until a longitudinal force equivalent to 30% of the test load is reached.

10.2.3.1 Displacement Rate

The displacement rate shall be between 0.3 and 0.9 mm/sec.

10.2.3.2 Data Acquisition Rate

Force and displacement data shall be recorded at a rate sufficient to produce 50 or more approximately equally spaced data sets during the displacement ramp. All recorded data channels shall be simultaneously sampled and held.

10.2.4 Unload the Tire

Unloaded the tire when the 30% longitudinal force level has been reached.

10.2.5 Repeat Sections 10.2.1 – 10.2.4 for the 100% load.

10.2.6 Repeat Sections 10.2.1 – 10.2.4 for a load of twice the 100% load.

10.2.7 Repeat Sections 10.2.1 – 10.2.4 for a load of three times the 100% load.

10.3 Lateral Stiffness Procedure

The intent of this procedure is to produce F_Y versus δ_Y data as described in the remainder of Section 10.3.

10.3.1 Tare the measurement system.

10.3.2 Load the Tire Along a Single Radius[6]

Load the tire to one-half of the 100% load.

10.3.3 Subject the Tire to a δ_Y Displacement Ramp

Increase the relative Y-displacement between the contact center and the wheel center until a lateral force equivalent to 30% of the test load is reached.

---

[6] Differences in stiffness along different radii are expected to be quite small, so there is not a need to repeat the test at multiple radii. The procedures may create modest test induced changes in tire properties due to the Mullins effect or perhaps damage to the tire reinforcing cords or their bonds to the compounds, if testing is extended into the nonlinear and slide regions. Also, if the procedures are extended far enough to induce appreciable slip, abrasion of the tread surface would produce slightly altered properties.