



SURFACE VEHICLE RECOMMENDED PRACTICE

J2730™

MAY2025

Issued 2006-08
Revised 2021-01
Reaffirmed 2025-05

Superseding J2730 JAN2021

Dynamic Cleat Test with Perpendicular and Inclined Cleats

RATIONALE

This document was edited for clarity, to elucidate its relationship to SAE J2812, to replace the cross-sectional view of the mounted cleat, and to remove a time-sensitive statement about on-going research that is no longer applicable.

SAE J2730 has been reaffirmed to comply with the SAE Five-Year Review policy.

TABLE OF CONTENTS

1.	SCOPE	3
2.	REFERENCES	3
2.1	Applicable Documents	3
2.1.1	SAE Publications	3
2.1.2	ISO Publications	3
2.1.3	OSHA Publications	3
3.	DEFINITIONS	4
4.	NOMENCLATURE	6
5.	LABORATORY QUALITY—SYSTEM REQUIREMENT	6
6.	APPARATUS	7
6.1	Environmental Vibration and Isolation	7
6.1.1	Machine Resonance Evaluation	9
6.1.2	Back Path Transmission Evaluation	12
6.2	Loading System	14
6.3	Measuring System	15
6.3.1	Instrumented Spindle	15
6.3.2	Loaded-Radius Instrumentation	16
6.4	Data Acquisition	16
6.4.1	Time Sampled	16
6.4.2	Spatially Sampled	17
6.5	Test Surface	17
6.6	Test Cleats	17
6.7	Test Space	18

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7.	CALIBRATION	18
8.	PREPARATION OF APPARATUS	18
9.	SELECTION AND PREPARATION OF TEST TIRES	18
9.1	Selection of Tires for Good Comparability	18
9.2	Inflation Pressure	19
9.3	Tire Preparation	19
9.3.1	Inertia Data.....	19
9.4	Sample Size	19
10.	TEST PROCEDURE	19
10.1	Tire Mounting	19
10.2	Loaded Radius Determination	19
10.3	Test Speeds	20
10.4	Test	20
11.	DATA PROCESSING AND REPORTING	20
12.	DATA REPEATABILITY AND REPRODUCIBILITY	21
13.	NOTES	22
13.1	Revision Indicator.....	22
Figure 1	The SAE parallel axis system	4
Figure 2	SAE parallel axis system forces and moments.....	5
Figure 3	Test machine schematic	7
Figure 4	Illustration of the amplitude effect of a machine resonance.....	8
Figure 5	Illustration of the phase effect of a machine resonance	9
Figure 6	Inputting an F_Y impulse with a modal hammer	10
Figure 7	Inputting an F_X impulse with a modal hammer	10
Figure 8	Inputting an F_Z impulse with a modal hammer	11
Figure 9	Inputting both F_Y and M_X impulses with a modal hammer	11
Figure 10	Inputting both F_Y and M_Z impulses with a modal hammer.....	12
Figure 11	Inputting an F_Y impulse into the back path with a modal hammer	12
Figure 12	Inputting an F_X impulse into the back path with a modal hammer	13
Figure 13	Inputting an F_Z impulse into the back path with a modal hammer	13
Figure 14	Inputting both F_Y and M_Z impulses into the back path with a modal hammer	14
Figure 15	Inputting both F_Y and M_X impulses into the back path with a modal hammer	14
Figure 16	Cross-sectional view of mounted 90 degree cleat	17
Figure 17	Example data for two channels.....	21
Table 1	Symbols defined.....	6
Table 2	Minimum load cell capacities based on force and moment	16
Table 3	Load cell capacity example	16
Table 4	Data file layout	21

1. SCOPE

This SAE Recommended Practice describes a test method for measuring the forces and moments generated at a high frequency response spindle when a rolling tire impacts a cleat. The cleat is configured either with its crest perpendicular, 90 degrees, to the path of the tire or optionally with its crest inclined at an angle to the path of the tire. The carriage to which the spindle is attached is rigidly constrained in position during each test condition to provide a good approximation to fixed loaded radius operation. The method discussed in this document provides impact force and moment time histories essentially free from variations due to tire non-uniformities. The method applies to any size tire so long as the equipment is properly scaled to 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 surfaces, paved or otherwise. Within the context of this document, forces applied to the road or terrain surface are not considered.

2. REFERENCES

2.1 Applicable Documents

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 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 J2047	Tire Performance Technology
SAE J2429	Free-Rolling Cornering Test for Truck and Bus Tires
SAE J2710	Modal Testing and Identification of Lower Order Tire Natural Frequencies of Radial Tires
SAE J2717	Tests to Define Tire Size (Geometry), Mass, Inertias
SAE J2818	Keyword Protocol 1281

Marshall, K., Phelps, R., Pottinger, M., and Pelz, W., "The Effect of Tire Break-In on Force and Moment Properties," SAE Technical Paper 770870, 1977, <https://doi.org/10.4271/770870>.

Pottinger, M. and Marshall, K., "The Effect of Tire Aging on Force and Moment Properties of Radial Tires," SAE Technical Paper 810066, 1981, <https://doi.org/10.4271/810066>.

Potts, G. and Knuth, E., "Dynamic Force Measurement System (DFMS)† for Tires," SAE Technical Paper 2001-01-0790, 2001, <https://doi.org/10.4271/2001-01-0790>.

2.1.2 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 17025	General Requirements for the Competence of Testing and Calibration Laboratories
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2.1.3 OSHA Publications

Available from U.S. Department of Labor/OSHA, 200 Constitution Avenue, Washington, DC 20210, Tel: 800-321-6742, www.osha.gov/pls/publications/pubindex.list.

OSHA 1910.177	Servicing Multi-Piece and Single Piece Rim Wheels (available in wall chart form as #77NP-799)
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3. DEFINITIONS

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

3.1 THE PARALLEL AXIS TIRE COORDINATE SYSTEM

This system is the one defined in SAE J2710 extended to allow tire rotation.

The loaded tire for the purpose of this document is defined as a tire/wheel assembly attached to the spindle. The spindle is considered to be substantially rigidly supported in the longitudinal, lateral, and vertical directions¹. The tire is free to rotate about the spindle. The tire is loaded in contact with the reaction (test machine) surface to produce a tire footprint. The principal directions are defined in terms of a right-handed Cartesian coordinate system with its origin at the intersection of the spindle and the wheel plane. The three axes are defined as follows and illustrated in Figure 1.

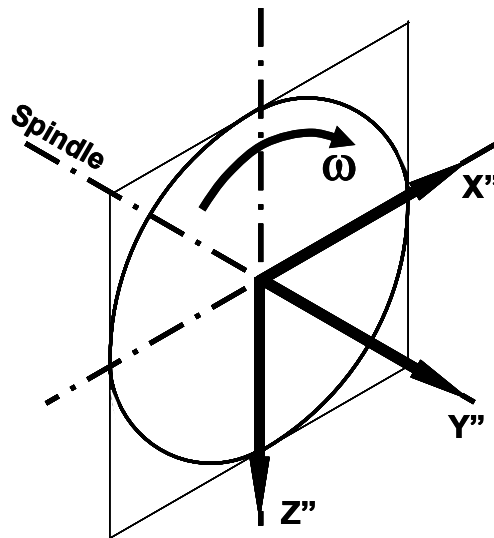


Figure 1 - The SAE parallel axis system

3.1.1 PARALLEL SYSTEM LONGITUDINAL AXIS, X''

The parallel system longitudinal axis is parallel to the SAE X''-Axis as defined in SAE J2047. It is positive in the direction of rolling as indicated in Figure 1.

3.1.2 PARALLEL SYSTEM LATERAL AXIS, Y''

The parallel system lateral axis is parallel to the SAE Y''-Axis as defined in SAE J2047. Its positive sense is to the right as viewed from behind the Y''-Z'' Plane.

NOTE: In the case of a tire without inclination, as assumed in this document, Y'' lies along the spindle center line with a positive sense to the right.

3.1.3 PARALLEL SYSTEM VERTICAL AXIS, Z''

The parallel system vertical axis is perpendicular to the road plane with a positive sense into the road surface. It is parallel to the SAE Z''-Axis as defined in SAE J2047, but the origin of the vertical axis is at the center of the tire not at the road surface.

NOTE: The tire is assumed to have no inclination in this document in which case Z'' lies in the wheel plane.

¹ The vertical direction is sometimes referred to as the normal or radial direction dependent on the context.

3.1.4 SPIN VELOCITY, ω

The tire spin velocity is about the spindle, which is coincident with the Y"-Axis in the case considered in this document.

3.2 THE TIRE FORCES AND MOMENTS

In this document, the forces and moments originate at the origin of the double primed axis system. They are shown in Figure 2 and are defined below. They are considered as being forces and moments applied to the spindle by the vibrating tire/wheel assembly. After this section and use in Table 1, these forces and moments are simply referred to as tire forces and moments. This is done for reasons of simplicity. In the definitions, these forces and moments are named to clearly associate them with the parallel axis system. These are the only forces and moments under discussion in this document.

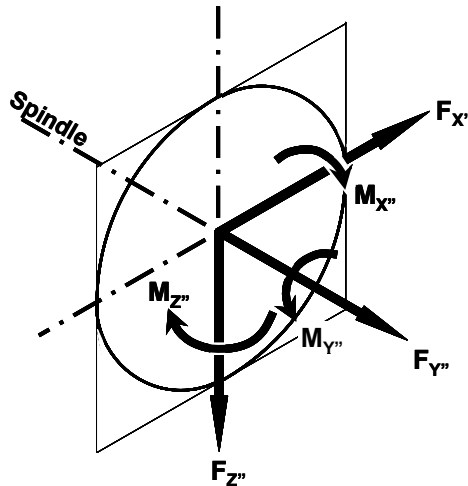


Figure 2 - SAE parallel axis system forces and moments

3.2.1 PARALLEL AXIS LONGITUDINAL FORCE, $F_{X''}$

The parallel axis longitudinal force is along the X"-Axis. It is positive in the direction of the positive X"-Axis. The force acts from the tire onto the spindle.

3.2.2 PARALLEL AXIS LATERAL FORCE, $F_{Y''}$

The parallel axis lateral force is along the Y"-Axis. It is positive in the direction of the positive Y"-Axis. The force acts from the tire onto the spindle.

3.2.3 PARALLEL AXIS NORMAL FORCE, $F_{Z''}$

The parallel axis normal force is along the Z"-Axis. It is positive in the direction of the positive Z"-Axis. The force acts from the tire onto the spindle.

3.2.4 PARALLEL AXIS OVERTURNING MOMENT, $M_{X''}$

The parallel axis overturning moment is about the X"-Axis. It is positive clockwise about the positive branch of the X"-Axis. The moment acts from the tire onto the spindle.

3.2.5 PARALLEL AXIS ROLLING RESISTANCE MOMENT, $M_{Y''}$

The parallel axis rolling resistance moment is about the Y"-Axis. It is positive clockwise about the positive branch of the Y"-Axis. The moment acts from the tire onto the spindle.²

² The rolling resistance moment is included for completeness, but is neither measured nor utilized in this document.

3.2.6 PARALLEL AXIS ALIGNING MOMENT, M_z

The parallel axis aligning moment is about the Z'' -Axis. It is positive clockwise about the positive branch of the Z'' -Axis. The moment acts from the tire onto the spindle.

3.3 TRAVEL DISTANCES

3.3.1 ANGULAR DISPLACEMENT OF THE TIRE, Φ

The angular displacement about the spindle defined to be zero at the instant the data acquisition trigger occurs.

3.4 TEST

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

3.5 TEST PROGRAM

A test program is a designed experiment involving a set of the tests described in this practice.³

4. NOMENCLATURE

Table 1 lists the symbols used in this document. For further information on items not in Section 4 of this practice, please refer to SAE J2047.

Table 1 - Symbols defined

Symbol	Defined Term
$F_{X''}$	Parallel system longitudinal force
$F_{Y''}$	Parallel system lateral force
$F_{Z''}$	Parallel system normal force
Φ	Tire angular displacement
$M_{X''}$	Parallel system overturning moment
$M_{Y''}$	Parallel system rolling resistance moment
$M_{Z''}$	Parallel system aligning moment
p	Inflation pressure
R_L	Tire loaded radius
t	Time
V	Test velocity
ω	Tire spin velocity
Ω	Test roadway spin velocity

5. LABORATORY QUALITY—SYSTEM REQUIREMENT

The laboratory performing the procedures 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.

³ 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.

6. APPARATUS

The required apparatus consists of a test machine with a round test surface capable of rolling test tires at the velocities defined in the test conditions (see 10.3). The test surface shall allow mounting of test cleats one at a time, as specified in this practice. The machine shall have an instrumented spindle capable of measuring three forces (F_x , F_y , and F_z) and two moments (M_x and M_z) developed during tire impact with a test cleat. The instrumentation also measures tire angular displacement, Φ , using absolute encoders. Figure 3 is a schematic of such a machine. Appropriate data-acquisition equipment is considered to be part of the apparatus. The space housing the loading machine is also considered to be part of the apparatus.

Vibration initiated by the tire/cleat impact process and outside sources is so important in this document that vibration requirements are discussed explicitly in 6.1, the first subsection in this part of the practice.

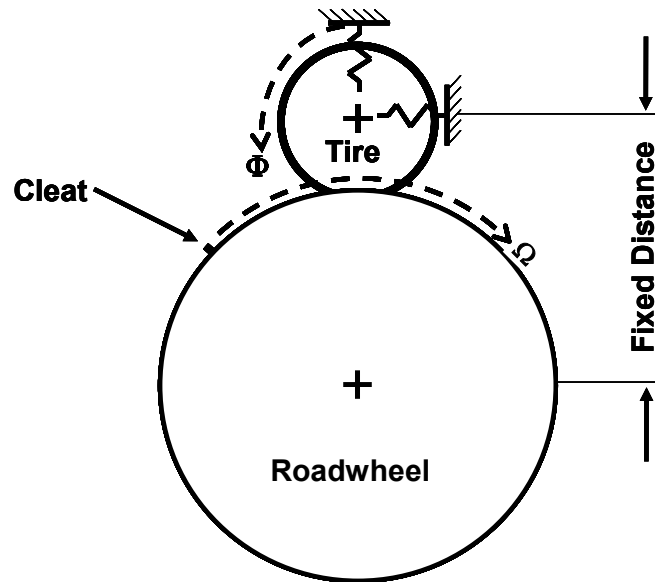


Figure 3 - Test machine schematic⁴

6.1 Environmental Vibration and Isolation

Tire/cleat impact in the case of a rigidly constrained spindle, as is used in this test, generates very significant dynamic forces. The instrumented spindle will respond to force signals regardless of whether they reach it directly from the tire/wheel system, as is desired, from the test surface through the machine frame, or from a source in the laboratory environment through the floor and then the machine frame.

The machine's planned environment should be tested for significant structure borne vibration arising from the laboratory environment prior to installation.⁵ If no such vibration is found, the machine can be mounted on a normal foundation. If significant, environmentally associated vibrations are discovered, two courses are open. The first is to ascertain whether there are predictable periods when the environmental vibrations are at a low enough level to permit testing. Is there enough usable time to permit adequate machine use? If enough usable time exists, an operational schedule adjustment may resolve the problem. If scheduling cannot mitigate the problem, a second course is as follows, an adequate vibration isolated machine foundation should be designed by a machine isolation expert, and the cleat impact machine installed on it. In very bad cases, both isolation and scheduling may have to be pursued. In any case, environmental vibration monitoring should continue during machine use to warn of environmental changes that may affect test results.

⁴ An external drum machine is shown, as an example. An internal drum machine is also acceptable.

⁵ Significance is a judgment that should be made by a competent expert in machine isolation.