



Tire Effective Rolling Radius

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To describe the test equipment requirements, test methodology, and data formatting to uniformly supply tire Force and Moment (F&M) data supporting the construction of Effective Rolling Radius (ERR) tire models.

1.2 Applicability.

1.2.1 All passenger car, light truck, commercial, and compact spare tires.

1.2.2 Only F&M properties determined from new, unused tires are appropriate for tire design validation to Component Technical Specification (CTS) requirements.

1.2.3 Tire F&M properties for vehicle simulations may require quantifications of tires in their current state for purposes of aligning vehicle simulation results to objective vehicle test results.

1.3 Remarks.

1.3.1 The tire F&M properties are important to various vehicle simulation groups, since these tire properties will dictate to a great extent the vehicle's response to specific control inputs.

1.3.2 The F&M properties are a key element within the CTS for tires and in the validation of specific tire design to those requirements.

1.3.3 Tire F&M properties are dependent upon almost every physical characteristic of a tire including the tire structure, compounds and tread design.

1.3.4 Tire F&M properties are also dependent upon the usage environment such as the load, inflation pressure, rim width, speed, state of wear, ambient, tire and test surface temperatures, tire age, storage history and usage history.

1.3.5 The quantification of tire F&M properties requires the measurement of the net resultant forces and moments from stresses within the tire footprint area. This implies the footprint dynamics on the measurement equipment must be similar to those experienced under actual vehicle operation. Therefore, a flat surface machine using a textured surface is required for the quantification of tire F&M properties.

1.3.6 Since the tire F&M properties are dependent upon many factors, the measurement equipment, surface curvature, surfaces texture, and procedures must be in substantial agreement to demonstrate the correlation of the test results.

1.3.7 This procedure involves a specific sequence of mechanical solicitations of the test tire with data collection under both steady state and dynamic conditions.

1.3.8 This test procedure will combine slip angle, inclination angle, applied load, inflation pressure, speed, and slip angle rates as inputs to the tire during the test sequences.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

SAE J1594

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2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Component Technical Specification (CTS)
- European Tire and Rim Technical Organization (ETRTO) Yearbook
- MTS Systems Corporation, Eden Prairie, Minnesota, www.mts.com
- The Tire and Rim Association (T&RA) Yearbook

3 Resources

3.1 Facilities. Laboratory test facility capable of running equipment in 3.2.

3.2 Equipment. The equipment used to measure F&M tire properties is a dynamic version of the MTS Flat-Trac, or equivalent (available through MTS Systems Corporation based in Eden Prairie, Minnesota). The equipment must be properly maintained and calibrated to traceable standards.

3.2.1 The flat test surface consists of an adhesive backed abrasive surface that is bonded to a steel belt. This material is 120 grit 3M-ite. This product is used to approximate the tire's response to a typical road surface. In order to more closely represent the road surface, the surface macro texture is reduced through a stoning process and broken in prior to the initial use. See Appendix D, Sections D1 thru D6, for the details regarding new surface preparation.

3.2.2 The transducer system must measure the five forces and moments generated by the tire, as well as the slip and inclination angles, and the loaded radius.

3.3 Test Vehicle/Test Piece.

3.3.1 Tire Test Specimen. The test tire must be free of all tags, tape, stones, or any other foreign material in the tread area. This procedure requires a new tire. However, the test requester may choose to test previously used tires to meet specific data needs. It is recognized new and previously used tires will yield different test results.

3.3.2 Test Wheel. The wheel must be selected properly to facilitate correct test results. Consider 3.3.2.1 thru 3.3.2.4 when selecting the proper test wheel.

3.3.2.1 The wheel width must match that requested on the test request.

3.3.2.2 The wheel must have the proper rim flange contour for the test tire as required by appropriate standardizing body, e.g., European Tire and Rim Technical Organization (ETRTO) or equivalent.

3.3.2.3 A spindle adaptor must exist to interface with the wheel bolt circle and pilot area to facilitate the mounting of the wheel on the test machine.

3.3.2.4 A spacer set must exist to make the wheel plane coincident with the center of the machine's coordinate system.

3.3.3 Test Surface. The roadway surface must be free of foreign material including, but not limited to, oils, rubber dust and other deposits from previous usage.

3.3.4 Sample Size. The primary purpose of this test procedure currently is to generate data for fitting a tire model. A single tire is considered sufficient for this purpose.

3.3.5 Multiple Tests per Specimen. Conducting multiple tests on a single specimen, or retesting, is acceptable.

3.4 Test Time. For passenger car and light truck tires.

Calendar time:	1 day
Test hours:	0.5 hours
Coordination hours:	0.5 hours

3.5 Test Required Information. All information needed to facilitate the physical test using this procedure is provided through a Tire Test Request within the Global Tire Wheel Test System (GTWTS). For the user's convenience, a partial list of critical information is provided in 3.5.1 and 3.5.2 for the tire and the test conditions.

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3.5.1 Test Tire.

- Tire size
- Service description
- Construction number
- Load rating
- Supplier (Tire Manufacturer)

3.5.2 Test Conditions.

- Inflation pressure: The inflation pressure will be the warm operating inflation pressure for the intended application vehicle. This will typically be 20 kPa above the placard pressure for passenger car tires and 35 kPa above placard for light truck or commercial tires. The test will generate data at multiple inflation pressures based off of the inflation pressure given on the Tire Test Request. For split pressure placards, multiple tests should be run to generate the appropriate data sets and resulting tire models.
- Rim width
- Front axle weight (driver + equipment)
- Rear axle weight (driver + equipment)

3.6 Personnel/Skills.

3.6.1 Test operators must be trained in the safe operation of the measurement equipment. The measurement equipment, by necessity, involves moving parts and loading mechanisms which must be understood and operated using proper safety precautions.

3.6.2 Operators must be trained in the selection of test components and fixtures to facilitate the proper testing of the tires.

3.6.3 Operators must be trained to observe, and correct when necessary, the test surface condition. The surface condition and contamination level directly impact the quality of the test results.

4 Procedure

4.1 Preparation.

4.1.1 Inspect the tire bead and the bead seat of the wheel to ensure this interface is free of damage, defects and foreign material. Clean or replace test pieces as necessary.

4.1.2 Use only a thin film of an approved mounting lubricant to facilitate proper tire mounting and bead seating. Excessive mounting lubricant can cause slippage at the tire and rim interface during testing.

4.1.3 Inspect the bead area of the mounted tire and wheel assembly to ensure the tire bead is firmly seated on the wheel.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient temperature in the room where the measurement equipment is operating shall be controlled to $21\text{ }^{\circ}\text{C} \pm 3\text{ }^{\circ}\text{C}$ to minimize the thermal gradients within the test equipment and instrumentation.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 The standard test condition cycle includes a speed sweep from 20 km/h to 150km/h, back to 20 km/h.

4.2.2.2 Load conditions will be dependent on the vehicle information provided to the GTWTS system in the test request. The vehicle type, tire load capacity, and vehicle axle weights are used to calculate the load conditions.

4.2.2.3 Inflation pressure test conditions are chosen based on the tire type and are used to generate data over a range of inflation pressures typical to that tire type and load range.

An overview of the test sequence is provided in Appendix A, Table A1.

4.2.3 Test Sequencing.

4.2.3.1 The test sequences of load, speed, pressure, slip angle and camber angles are documented in Appendix B, Table B1.

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4.2.3.2 The test begins with a free rolling condition, to mechanically break in the tire structure, and build heat in the carcass and tread areas.

4.2.3.3 The test will then step through specific load, speed, pressure, slip angle and camber angle combinations designed to measure the loaded radius properties of the tire.

4.3 Instructions.

4.3.1 Mount the test tire on the test rim.

4.3.2 Wait at least the prescribed time to allow for stabilization of the tire structure to the test environment.

4.3.3 Mount the test assembly onto the test equipment using the proper adapter and spacers.

4.3.4 Select the end level test procedure created specifically for the tire test request being executed.

4.3.5 Start the test procedure on the equipment.

4.3.6 Wait for the test to complete, while monitoring the progress of the test until complete.

4.3.7 Remove the test assembly from the equipment.

4.3.8 Send the resulting data files to GTWTS for data processing using Tire - Wheel System (TWS) Test Services software. The expected data files include the files created by the MTS software with the extensions of "data", "info" and "log".

5 Data

5.1 Sampling and Filtering.

5.1.1 Data are to be collected and written to a data file as a complete time history without interruption.

5.1.2 The sampling rate shall be 100 Hz or greater using simultaneous sample and hold or bursting techniques. If the bursting technique is used, then the burst sample rate must be at least an order of magnitude higher than the base sample rate.

5.1.3 Anti-alias filtering techniques appropriate to the machine design and this procedure are expected to be employed.

5.1.4 All filtered data signals are expected to utilize the same filter design to prevent different phasing relationships across the filtered data channels.

5.1.5 The minimum required list of data channels to be provided to GM are given in Appendix C, Table C1. Other data channels may be provided in addition to the required channels.

5.2 Calculations.

5.2.1 The raw data analysis detailed in 5.2.1.1 thru 5.2.1.4 assumes the data are either acquired or has been preprocessed such that the following statements regarding the raw data, or machine generated test results, are true.

5.2.1.1 Data are represented in International System of Units (SI) with appropriate tare measurements subtracted and gain factors applied.

5.2.1.2 Data sign conventions are consistent with the SAE International tire coordinate system as described in SAE J1594.

5.2.1.3 The data were collected using the data acquisition method described in 5.1.

5.2.1.4 Data were collected while the equipment control system had control of the test and the machine response was sufficient such that the error between the command signals and the test conditions realized was small.

5.2.2 The data file provided by this test procedure will be reformatted into a GM version of the standard Tydex formatted data files in preparation for fitting to an effective rolling radius tire model. The modeling of the resulting tire data will not be a part of this procedure.

5.3 Interpretation of Results. Not applicable.

5.4 Test Documentation. All electronic data file formats are defined by the GTWTS. The file format details can be obtained from the global test coordinator for TWS or referenced from the GM TWS internal website. All previous test data file formats are now obsolete.

When a test request is submitted in GTWTS, the tester will receive via email a copy of the Test Request in Portable Document Format (PDF) form, input files and datasheets (as applicable), and Extensible Markup

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