



Force and Moment Transient Steer

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. This standard describes in general terms, the tire testing method required to evaluate a tire against specified steering and handling criteria. The objective is to evaluate a tire for its transient steering performance to changes in dynamic slip angle dependent on progressive path travel. The test method employs dwell-point frequency changes (cycles per meter of travel) in slip angles simulating low G acceleration maneuvers within 2.5 m/s² (0.25 G).

1.2 Applicability. This standard is restricted to controlled laboratory tests on passenger and light truck tires.

2 References

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

2.1 External Standards/Specifications.

SAE J670

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- European Tyre and Rim Technical Organisation (ETRTO) Yearbook, (Current Year)
- MTS Systems Corporation, Eden Prairie, Minnesota (www.mts.com)
- Tire & Rim Association (T&RA) Yearbook (Current Year)

3 Resources

3.1 Facilities. Any test facility (General Motors or outside) that is providing data to GM for the Tire Transient Test. Any outside testing facilities must have demonstrated an acceptable correlation with GM, prior to submitting data into the test system.

3.2 Equipment. The equipment used to measure Force and Moment (F and M) tire properties is a dynamic version of the MTS Flat-Trac, or equivalent (available through MTS Systems Corporation based in Eden Prairie, Minnesota).

3.2.1 The equipment must be properly maintained and calibrated to traceable standards.

3.2.2 The flat test surface consists of an approved abrasive material adhered to a steel belt.

3.2.3 Mechanical inputs during the test include the inflation pressure, roadway velocity, slip angle, camber angle, and radial position which are to be controlled through a closed-loop feedback system. The control system must demonstrate dynamic performance sufficient to achieve the required input magnitudes and rates.

3.2.4 The roadway control system must be capable of dynamically controlling the speed, direction, and tracking of the roadway.

3.2.5 The transducer system must measure the six (6) forces and moments generated by the tire, as well as the slip and camber angles, the loaded radius, spindle and roadway speeds per coordinate system defined in SAE J670, and various temperatures.

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3.2.6 The data acquisition system must acquire the output from the transducers and ultimately produce outputs presented as scaled engineering units.

3.2.7 The data acquisition method utilized for this procedure will be time-based at a rate of at least 100 Hz, with simultaneous sampling across all channels.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Specimen. Test tires must be free of all tags, tape, stones, or any other foreign material in the tread area and be in new, unused condition.

3.3.2 Test Wheel. The wheel must be selected properly to facilitate correct test results. The wheel must be of the correct diameter, the width must match that requested on the test request, and the rim flange contour must be approved by the appropriate standardizing body (e.g., reference European Tyre and Rim Technical Organisation (ETRTO) Yearbook (current year), The Tire & Rim Association (T&RA) Yearbook (current year), or equivalent.)

3.3.3 Test Surface. The flat test surface must be free of foreign material including, but not limited to oils, rubber dust, and other deposits from previous usage. The flat surface abrasive material is 120 grit 3M-ite. The surface macro texture is reduced prior to the initial use, requiring eight (8) passes of the stoning roller over the surface before use, or equivalent.

3.3.4 Sample Size. One (1) tire is required.

3.4 Test Time.

Calendar time: 1 day

Test time: 0.3 hours

Coordination time: 0.5 hours

3.5 Test Required Information. All information necessary is provided through a completed Tire Test Request within the Global Tire-Wheel Test System (GTWTS). A partial list of critical information required to complete the Tire Test Request is provided in 3.5.1 and 3.5.2 for the tire and the test conditions.

3.5.1 Test Tire.

- Tire Size (should include prefix and suffix letters).
- Service Description (e.g., 98H, 120/124R).
- Construction Number.
- Load Range (e.g., SL, XL, LL, C, D, E).
- Supplier (tire manufacturer name).

3.5.2 Test Conditions.

3.5.2.1 Rim Width. Shall be the expected production wheel width.

3.5.2.2 Nominal Load. Vehicle load on a front tire under normal, two (2) passenger, loading conditions. For split pressure placards, the vehicle load for each test pressure is based on the corner load applicable to that pressure.

3.5.2.3 Inflation Pressure. The inflation pressure is the warm operating inflation pressure for the intended application vehicle. This is typically 20 kPa above the placard pressure for passenger car tires and 35 kPa above placard for light truck or commercial tires. For split pressure placards, multiple tests are required, one (1) corresponding to each placard pressure.

3.5.2.4 Speed. Test speed is 3 km/h. This relatively low speed is required to accommodate the frequency response of the steerable actuators to achieve path frequencies producing significant tire transient responses. The dominant effects of tire transients are related to those of path frequency with time dependencies as second-order influences. Limitations of the steerable frequency response of typical laboratory tire test machines like those of MTS, precludes steerable path frequencies as prescribed in this test procedure at highway usage speeds.

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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 Store the tires prior to test in a staging area with the ambient temperature within $\pm 5^\circ\text{C}$ of the test room temperature for at least 24 h prior to testing.

4.1.2 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.

4.1.3 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.

4.1.4 Mount the test tire on the test wheel.

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

4.1.6 Inflate the tire and wheel assembly 30 kPa above the required test inflation pressure, and allow the tire to stabilize at room temperature prior to testing while the previous tire is being tested.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient temperature in the room where the measurement equipment is operating shall be controlled to $21^\circ\text{C} \pm 3^\circ\text{C}$ to minimize the thermal gradients within the test equipment and instrumentation. The room temperature gradients should also be within the equipment manufacturer recommendations which will typically be $< 1^\circ\text{C/h}$.

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.

4.2.3 Test Sequencing.

4.2.3.1 Each transient test will require the running of a warmup, pretest, warmup, and a transient test. See Table 1, for Test Type and Test Procedure information.

Table 1: Test Sequences

	Test Type	Test Procedure
Warmup	Appendix A, Table A1	Appendix C, Table C1
Pretest	Appendix A, Table A1	Appendix B, Table B1
Warmup	Appendix A, Table A1	Appendix C, Table C1
Transient Test	Appendix D, Table D1	Appendix E, Table E1

4.2.3.2 Each tire used will be conditioned prior to testing using the appropriate tire warmup procedure.

4.2.3.3 Each tire used must run a pretest to establish the testing conditions for the Transient Test. An overview of the pretest is in Appendix F, Table F1.

4.2.3.3.1 If less than 30 minutes elapses between the start of the pretest and the start of the Transient Test, the second Warmup procedure can be omitted.

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4.2.3.4 The transient test consists of three (3) unique loading scenarios. Within the loading scenarios there are thirteen (13) unique slip angle driven frequencies. Driven frequencies are selected to avoid proximity to any of the periodic tire orders, thereby eliminating interference from the tire periodic non-uniform force variation. The slip angle range, frequency set points, slip angle cycles, and vertical position corresponding to load, will require input from the pretest dataset. An overview of the transient test is in Appendix G, Table G1.

4.2.3.4.1 The slip angle values for the three (3) loads will be determined by finding the slip angle range required to generate equivalent 2.5 m/s^2 (0.25 G) vehicular lateral acceleration centered about a zero force midpoint. Individual third order polynomial fits for Steps 1 through 3 of the pretest (Appendix B, Table B1) are recommended for the determination of corresponding tire forces and slip angle ranges.

4.2.3.4.2 Slip angle driven frequencies (cycles/second) are automatically adjusted based on path frequency (cycles/meter) to allow for separation from 1st through 5th order tire force harmonics for the three (3) loading scenarios. Mean Revolution Per Kilometer (RPK) values from pretest conditions 34 through 36 (Appendix B, Table B1) are used for determination of frequencies that will be avoided. Required separation of frequencies between test and tire harmonics can be found in Appendix H, Table H1. Transient test driven frequencies that violate the separation criteria will be adjusted from the base frequency to comply with the separation criteria.

4.2.3.4.3 Slip angle cycles at the driven frequencies (cycles/second) need to meet specific duration requirements. Reference Appendix H, Table H1. These are required to achieve adequate resolution in the separation of frequency content in the resulting Fast Fourier Transform (FFT) of the time domain signal. These sample times support the separation of excitation frequencies and harmonics of periodic force variation described previously.

4.2.3.4.4 The three (3) loading conditions for the transient test are based on the pretest vertical load vs. loaded radius. The transient test is conducted at fixed loaded radius to avoid variation in vertical position of the tire, as might occur from fluctuations of tire loads responsive to the slip angle changes and evolutionary tire motions. These positions are determined by taking the mean Loaded Radius (RL) of conditions 34 through 36 of the pretest (Appendix B, Table B1).

4.2.3.4.5 If MTS test equipment is used for the transient test, a Transient Procedure generation program is available from Tire and Wheel Systems.

4.3 Instructions.

4.3.1 Mount the test tire on the test rim.

4.3.2 Mount the test assembly onto the test equipment, ensuring the wheel plane coincides with the machine centerline so the forces and moment will be reported correctly in the resulting data.

4.3.3 Select the pretest procedure created specifically for the tire test request being executed.

4.3.4 Start the pretest procedure on the equipment.

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

4.3.6 Use data generated from pretest to generate test conditions for the transient test.

4.3.7 Start the transient test procedure on the equipment.

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

4.3.9 Remove the test assembly from the equipment.

4.3.10 Repeat 4.3 until all conditions (e.g., inflation pressures) and tires have been tested.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results.

5.2.1 Sampling and Filtering.

5.2.1.1 Data is collected and written to data files during the active sections of the testing.

5.2.1.2 The sampling rate is 100 Hz using simultaneous sample.

5.2.1.3 Anti-alias filtering techniques appropriate to the machine design and this procedure are expected to be employed. A 300 Hz elliptical anti-aliasing filter is recommended for all F and M and slip angle channels.

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5.2.1.4 All recorded data signals are expected to utilize the same filters to eliminate relative gain and phasing of signals due to filter induced characteristics.

5.2.1.5 See Appendix J, Table J1 for required data acquisition channels.

5.2.2 Data Reduction. Approved testers will receive a copy of the Software (S/W) required to reduce the data to salient parameters. A summary of the processing is outlined in Figure 1.

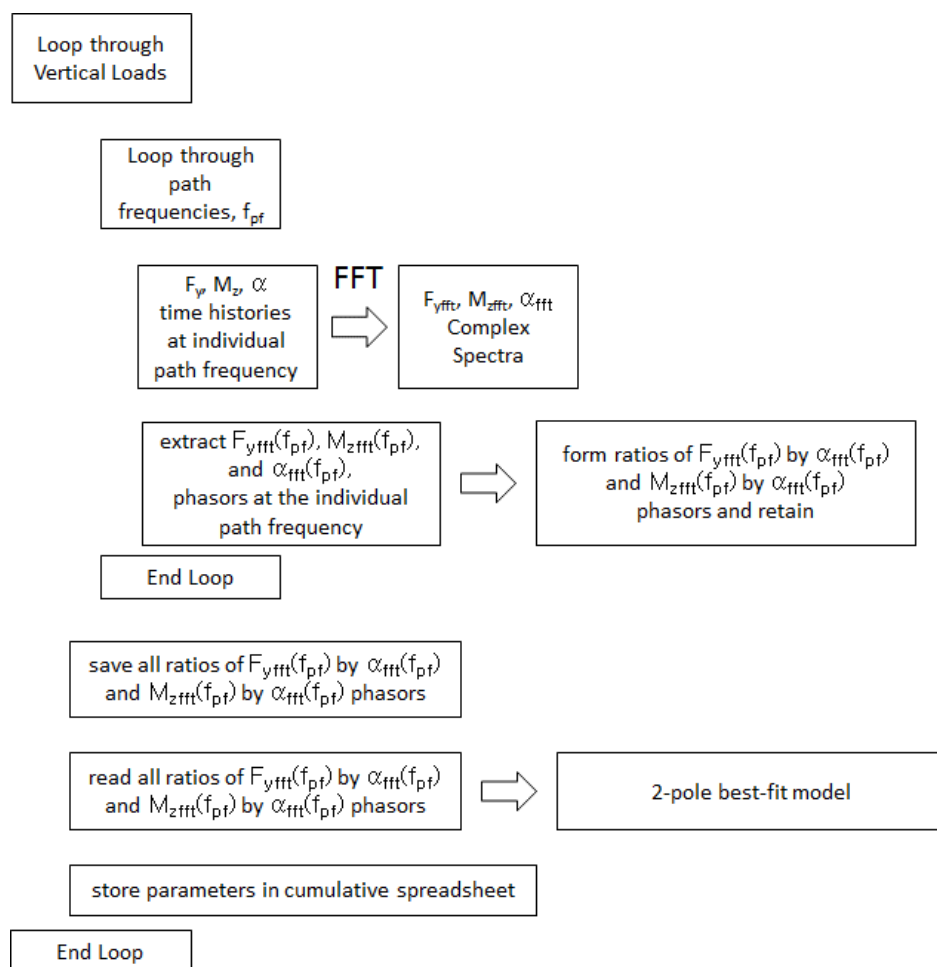


Figure 1: Data Processing Flow Chart

5.3 Test Documentation.

5.3.1 Data Summaries.

5.3.1.1 Individual Load Case Data Reduction. The results of data fitting for each individual load at the multiple path frequencies is shown in Figure 2. This spreadsheet is automatically generated during the operations shown in Figure 1 and includes the measured vs. calculated phasors at various path frequencies.

5.3.1.2 Cumulative Data. The results of the individual loads are also automatically saved in an appended spreadsheet (appends the most recent data to the existing accumulated summaries) during the processing shown in Figure 2. The identification of the test record is presented in the first column of the spreadsheet containing the Tire-Wheel System (TWS) Test request number. The list of corresponding parameters is stored in this spreadsheet and is provided in Appendix K, Table K1. Each row represents an individual load case. This data is also uploaded to the TWS database.

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Figure 2: Data Reduction Spreadsheet Example (Part 1 of 2)

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Figure 2: Data Reduction Spreadsheet Example (Part 2 of 2)

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