



CompTire Force and Moment Test

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 the CompTire model.

1.2 Applicability.

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

1.2.2 Only F&M properties determined from new, unused tires are appropriate for the CompTire model.

1.2.3 This test procedure will generate significant wear to the tread surface of the tire and, therefore, is not valid to quantify F&M properties of tires in a worn state.

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 Tire F&M properties are dependent upon almost every physical characteristic of a tire including the tire structure, compounds, and tread design to name a few. Tire F&M properties are also dependent upon the usage environment such as the load, inflation pressure, rim width, speed, state of wear, ambient, surface texture, temperatures, tire age, storage history and usage history. This is pointed out to emphasize the need to be diligent in the selection of test tires, their storage conditions, and attention to detail in following good test practices outlined in this procedure.

1.3.3 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.

2 References

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

2.1 External Standards/Specifications.

SAE J670e

2.2 GM Standards/Specifications.

GMW16590

2.3 Additional References.

- European Tire and Rim Technical Organization (ETRTO) Yearbook, (Current Year)
- GM Data Approval Application
- MTS Systems Corporation, Eden Prairie, Minnesota (www.mts.com)
- National Tire Research Center, Alton, Virginia
- Tire & Rim Association (T&RA) Yearbook (Current Year)
- TYDEX-Format Description and Reference Manual, Release 1.3

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3 Resources

3.1 Facilities. National Tire Research Center, Alton, Virginia.

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).

3.2.1 A MTS Flat-Trac LTRe (model of test equipment) is required to evaluate the full range of tires used on passenger cars and light trucks.

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

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

3.3 Test Vehicle/Test Piece.

3.3.1 Tire Test Specimen. The new tires must be free of all tags, tape, or other foreign material in the tread area.

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 Tire and Rim Technical Organization (ETRTO) Yearbook (Current Year), 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 passes of the stoning roller over the surface before use, or equivalent.

3.3.4 Sample Size. Five tires are required, four test tires and a spare.

3.4 Test Time.

Calendar time: 1 day

Test hours: 5 hours

Coordination hours: 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 (Be specific, prefix and suffix letters are important)
- Service Description (e.g., 98H, 120/124R)
- Construction Number (Contact Integration Engineer, Tire Development Engineer, or Design Release Engineer (DRE))
- Load Range (e.g., SL, XL, LL, C, D, E)
- Supplier (Tire Manufacturer)

3.5.2 Test Conditions.

- 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. 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 are required, one corresponding to each placard pressure.
- Rim Width. Expected to be the rim width used in vehicle production.
- Nominal Load. Vehicle load on a front tire under normal loading conditions. For split pressure placards, the vehicle load for each test pressure is based on the corner load applicable to that pressure.

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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 ± 5 °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 Inspect the bead area of the mounted tire and wheel assembly to ensure the tire bead is firmly seated on the wheel.

4.1.5 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.

4.1.6 Using a paint pen or similar instrument, place an arrow on the sidewall of the tire pointing at the location of the valve stem of the wheel. The relative location of this mark to the valve stem is to be noted at test completion.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient temperature in the room where the measurement equipment is operating shall be controlled to $21\text{ °C} \pm 3\text{ °C}$ 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 determination of the test conditions is discussed in 3.5.

4.2.3 Test Sequencing.

4.2.3.1. Each tire used will be conditioned prior to testing using the appropriate tire warm-up sequence based on the tire type and intended vehicle application.

4.2.3.1.1 In general, the tire type will dictate the magnitude of the maximum slip angle excursions executed during the sequence. This maximum slip angle is targeted to be approximately 75% of the slip angle at which the tire achieves peak lateral force at the nominal test load. The tire type classifications for the purpose of choosing the warm-up sequence are passenger car tires, performance tires, and tires used on light trucks.

4.2.3.1.2 Passenger car tires are those used on passenger car vehicles with a speed rating of V (240 km/h (149 mph)) or lower.

4.2.3.1.3 Performance tires are those tires used on passenger car vehicles with a speed rating of W (270 km/h (168 mph)) or higher, including Z rated tires.

4.2.3.1.4 Tires used on light trucks can include both passenger car tires and light truck or commercial tires. The distinguishing factor is the intended application is on a light truck vehicle.

4.2.3.2 Following the tire warm-up sequence, each of the four test tires will be tested with a series from one to three specific test sequences as defined further by the Appendices C thru E (inclusive of all Tables). The test sequences for each of the test tires are defined as End Level test procedures as shown in Appendix B, Table B1, and are designed to solicit tire responses to specific inputs to the tire while managing the overall state of the tire to the extent possible (e.g., tire temperature, tread temperature and tread wear).

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4.2.3.3 There are three different test sequences depending on the tire type being tested. The test sequence can be chosen from Table 1.

Table 1: Test Sequences by Tire Classification

Test Tire Type	Test Sequence Location
Passenger Car Tires, Speed Symbol V or Lower	Appendix C (Table C1)
Performance Tires, Speed Symbol W or Greater	Appendix D (Table D1)
Tires for Use on Light Truck Vehicles	Appendix E (Table E1)

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 is coincident with the machine centerline so the forces and moment will be reported correctly in the resulting data.

4.3.3 Select the test procedure created specifically for the Tire Test Request being executed.

4.3.4 Start the test 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 Note the location of the mark denoting the valve stem location on the sidewall of the tire. Record in the test log if the mark no longer is coincident with the valve stem.

4.3.7 Remove the test assembly from the equipment.

4.3.8 Send the resulting data files to GM. Those files include the files created by the MTS software with the extensions of ".tare", ".log", ".info", ".data", ".793info", ".report", and ".inertial".

4.3.9 Repeat 4.3 until all tires have been tested as required by the test sequence information found in 4.2.3.3.

5 Data

5.1 Sampling and Filtering.

5.1.1 Data is to be collected and written to a data file as a complete time history with minimal interruption required while the test equipment is updating the test instructions for the different test sequences.

5.1.2 The data acquisition is to be set up to match the specifications listed in Appendix A, Table A1.

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 A, Table A1. Other data channels may be provided in addition to the required channels as required by the test site executing the procedure.

5.2 Calculations.

5.2.1 The processing in 5.2.2 assumes the data is either acquired or has been preprocessed such that the statements in 5.2.1.1 thru 5.2.1.4 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 J670e for those channels reporting in the SAE International tire coordinate system. Each channel for which a coordinate system is required must have the coordinate system reported in the data file.

Note: SAE J670e defines the legacy tire coordinate system that is used in the modeling and simulation software and is referenced in Appendix A, Table A1. The current version of SAE J670 is different than this legacy coordinate system, and should not be referenced.

5.2.1.3 The data is collected using the data acquisition method described in Appendix A, Table A1.

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

5.2.2 The data files provided by this test procedure will be reformatted into a GM version of the standard TYDEX formatted data files by the GM Data Approval Application in preparation for fitting to the GM CompTire model.

5.2.3 The modeling of the resulting tire data is not part of this procedure.

5.3 Interpretation of Results. Not applicable.

5.4 Test Documentation. The test results documentation should include the following file types with the extensions of:

- .tare: MTS system generated text file containing the tare measurements from the equipment
- .log: MTS system generated text file containing the time history of events during the test
- .info: MTS system generated text file containing all relevant details of the test sequence, control, and data acquisition for the test
- .data: MTS system generated Remote Procedure Call (RPC) binary file containing the metadata and data acquired from executing the test
- .793info: MTS system generated text file containing the settings for the Model 793 control system
- .report: MTS system generated text file
- .inertial: MTS system generated text file containing the inertial measurements used for inertial compensation

Note: For data being loaded into the Global Tire-Wheel Test System (GTWTS), submit electronically the test results data files (Extensible Markup Language (XML) format) and other supporting files listed in 5.4. GMW16590 defines the electronic file details (e.g., file types, file naming convention, and detailed file formats) for the GTWTS.

5.4.1 The XML files will be generated by the GM Data Approval Application at Tire-Wheel System (TWS) for the data generated by this procedure.

5.4.2 The time history data will be converted into a series of data files following the TYDEX formatting rules. An example TYDEX data file header is shown in Appendix U, Table U1. (Reference TYDEX-Format Description and Reference Manual, Release 1.3.)

5.4.3 A large number of TYDEX data files will be generated from a full test, perhaps more than 500 files can be expected from a single CompTire test. An example list of files is shown in Appendix V, Lists V1 thru V4. These files are separated into four categories by the primary forces recorded in each file.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Cold Inflation Pressure: The pressure of the contained air mass within a tire that has been allowed to thermally stabilize to the prevailing ambient temperature. A tire may be considered stabilized after remaining at rest for a minimum of 1.5 h while shielded from direct sunlight.

Light Truck and Commercial Tire: Refers to the tire type, not the vehicle application. Light Truck and Commercial tires are intended primarily for use on load bearing or multi-purpose vehicles.

LTRe: Specific model designation of the MTS Flat-Trac equipment.

Passenger Car Tire: Refers to the tire type, not the vehicle application. Passenger car tires are intended primarily for use on passenger vehicles. However, these tires may also be used on light truck and multi-purpose vehicles.

TPC: File Format Extension

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7.2 Acronyms, Abbreviations, and Symbols.

DRE	Design Release Engineer
ETRTO	European Tire (and) Rim Technical Organization
F	Force
F&M	Force and Moment
GSSLT	Global Subsystem Leadership Team
GTWTS	Global Tire-Wheel Test System
HIL	Hardware in the Loop
IA	Inclination Angle
LT	Light Truck
RPC	Remote Procedure Call (computer program protocol)
SI	International System of Units
T&RA	Tire and Rim Association
TWS	Tire-Wheel System
XML	Extensible Markup Language

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

Test to GMW17359

9 Release and Revisions

This standard was originated in March 2015. It was first approved by Chassis Tire and Wheel Global Subsystem Leadership Team (GSSLT) in May 2015. It was first published in May 2015.

Issue	Publication Date	Description (Organization)
1	MAY 2015	Initial publication.

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Appendix A

Table A1: Data Acquisition Description and Channel List

***** Data Acquisition Information *****				
CONFIGURATION NAME	GMW16337 E010Hz 256 MORE			
AUTHOR	HMC			
LOCKED	FALSE			
CREATION DATE	1/24/13 9:29 PM			
LAST MODIFIED DATE	8/11/14 11:38 AM			
BUILD DATE	8/8/14 8:56 AM			
ACQUISITION MODE	TIME_SAMPLED			
ACQUISITION CLOCK	INTERNAL			
SAMPLE RATE	256 Hz			
ACQUISITION FILTER	elliptic 10 Hz 5 pole			
FILTER DEFINITION	elliptic LP Pass (7.9 Hz, 0.001) Stop (20.15 Hz, 0.001)			

CHANNEL NUMBER	CHANNEL DESCRIPTION	COORDINATE SYSTEM (OR SOURCE)	UNITS	Required (Yes/No)
1	SA Command - Slip Angle Command	SAE Legacy	deg	Yes
2	SA Filtered - Slip Angle Filtered	SAE Legacy	deg	Yes
3	IA Command - Inclination Angle Command	SAE Legacy	deg	Yes
4	IA Filtered - Inclination Angle Filtered	SAE Legacy	deg	Yes
5	Pt Command - Inflation Pressure Command	Common	kPa	Yes
6	Pt Unfiltered - Inflation Pressure Unfiltered	Common	kPa	Yes
7	Vr Command - Roadway Velocity Command	Common	km/hr	Yes
8	VRctlr Unfiltered - Roadway Velocity Unfiltered	Controller	km/hr	Yes
9	Vr Filtered - Roadway Velocity Filtered	Common	km/hr	Yes
10	Vsd Command - Spindle Drive Velocity Command	Common	rpm	Yes
11	Vsd Filtered - Spindle Drive Velocity Filtered	Common	rpm	Yes
12	Vsd Unfiltered - Spindle Drive Velocity Unfiltered	Common	rpm	Yes
13	Vs Filtered - Spindle Velocity Filtered	Common	rpm	Yes
14	TW Command - Wheel Torque Command	SAE Legacy	N-m	Yes
15	Tw Filtered - Wheel Torque Filtered	SAE Legacy	N-m	Yes
16	SR Command - Slip Ratio Command	Common		Yes
17	Sx1 Filtered - Longitudinal Slip Ratio Filtered	SAE Legacy		Yes
18	Sx1 Unfiltered - Longitudinal Slip Ratio Unfiltered	ISO-W		Yes
19	RL Command - Loaded Radius Command	SAE Legacy	mm	Yes
20	RL Filtered - Loaded Radius Filtered	SAE Legacy	mm	Yes
21	RLctlr Filtered - Loaded Radius Filtered	Controller	mm	Yes
22	FZctlr Command - Vertical Load Command	Controller		Yes
23	Fy Command - Lateral Force Command	SAE Legacy		Yes
24	Yb Filtered - Belt Position Filtered	Common	mm	Yes
25	Ta Filtered - Ambient Temperature Filtered	Common	degC	Yes
26	Tb Unfiltered - Bearing Temperature Unfiltered	Common	degC	Yes
27	Tst1 Unfiltered - Tire Surface Temp 1 Unfiltered	Misc	degC	Yes
28	Tst2 Unfiltered - Tire Surface Temp 2 Unfiltered	Misc	degC	Yes
29	Tst3 Unfiltered - Tire Surface Temp 3 Unfiltered	Misc	degC	Yes
30	Tst4 Unfiltered - Tire Surface Temp 4 Unfiltered	Misc	degC	Yes
31	Tst5 Unfiltered - Tire Surface Temp 5 Unfiltered	Misc	degC	Yes
32	Tst6 Unfiltered - Tire Surface Temp 6 Unfiltered	Misc	degC	Yes
33	Tst7 Unfiltered - Tire Surface Temp 7 Unfiltered	Misc	degC	Yes
34	Tst8 Unfiltered - Tire Surface Temp 8 Unfiltered	Misc	degC	Yes
35	Tst9 Unfiltered - Tire Surface Temp 8 Unfiltered	Misc	degC	Yes
36	FXtd Filtered - Longitudinal Force Filtered	SAE Legacy		Yes
37	FYtd Filtered - Lateral Force Filtered	SAE Legacy		Yes
38	FZtd Filtered - Normal Force Filtered	SAE Legacy		Yes

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CHANNEL NUMBER	CHANNEL DESCRIPTION	COORDINATE SYSTEM (OR SOURCE)	UNITS	Required (Yes/No)
39	MXtd Filtered - Overturning Moment Filtered	SAE Legacy	N-m	Yes
40	MYtd Filtered - Rolling Resistance Moment Filtered	SAE Legacy	N-m	Yes
41	MZtd Filtered - Aligning Moment Filtered	SAE Legacy	N-m	Yes
42	Vt Filtered - Trajectory Velocity Filtered	SAE Legacy	km/hr	Yes
43	UDA1 Command - User D/A 1 Command	User	volts	Yes
44	PMInVCVr V Cmd - Power Manager Input Valve Command Vr V Cmd	Controller		Yes
45	PMInVCVsd V Cmd - Power Manager Input Valve Command Vsd V Cmd	Controller		Yes
46	PMOutVCVr V Cmd - Power Manager Output Valve Command Vr V Cmd	Controller		Yes
47	PMOutVCVsd V Cmd - Power Manager Output Valve Command Vsd V Cmd	Controller		Yes
48	Idb Unfiltered - Belt Motor d Current Unfiltered	Misc		Yes
49	Iqb Unfiltered - Belt Motor q Current Unfiltered	Misc		Yes
50	Nmb Unfiltered - Belt Motor Speed Unfiltered	Misc	rpm	Yes
51	Tmb Unfiltered - Belt Motor Torque Unfiltered	Misc	N-m	Yes
52	Tmbcmd Command - Belt Motor Torque Command Command	Misc	N-m	Yes
53	Vmb Unfiltered - Belt Motor Voltage Unfiltered	Misc	volts	Yes
54	Pten Unfiltered - Belt Tensioning Pressure Unfiltered	Misc	MPa	Yes
55	Ptracf Unfiltered - Belt Tracking Pressure (front) Unfiltered	Misc	MPa	Yes
56	Ptracr Unfiltered - Belt Tracking Pressure (rear) Unfiltered	Misc	MPa	Yes
57	Tlcwi Unfiltered - Load Cell Water Temp In Unfiltered	Misc	degC	Yes
58	Tlcwo Unfiltered - Load Cell Water Temp Out Unfiltered	Misc	degC	Yes
59	Tmt Unfiltered - Machine Tire Temp Unfiltered	Misc	degC	Yes
60	Tsmbde Unfiltered - Spindle Motor Bearing DE Temp Unfiltered	Misc	degC	Yes
61	Tsmbnde Unfiltered - Spindle Motor Bearing NDE Temp Unfiltered	Misc	degC	Yes
62	Ids Unfiltered - Spindle Motor d Current Unfiltered	Misc		Yes
63	Tmscmd Command - Spindle Motor Torque Command Command	Misc	N-m	Yes
64	Vms Unfiltered - Spindle Motor Voltage Unfiltered	Misc	volts	Yes
65	Tsmwi Unfiltered - Spindle Motor Water In Temp Unfiltered	Misc	degC	Yes
66	Tsmwo Unfiltered - Spindle Motor Water Out Temp Unfiltered	Misc	degC	Yes
67	SP Unfiltered - Spin Angle Unfiltered	Common	deg	Yes
68	Fy Unfiltered - Lateral Force Unfiltered	SAE Legacy		Yes
69	Fx Unfiltered - Longitudinal Force Unfiltered	SAE Legacy		Yes
70	Fz Unfiltered - Normal Force Unfiltered	SAE Legacy		Yes
71	My Unfiltered - Rolling Resistance Moment Unfiltered	SAE Legacy	N-m	Yes
72	MXm Unfiltered - MX Moment Unfiltered	Machine	N-m	Yes
73	MZm Unfiltered - MZ Moment Unfiltered	Machine	N-m	Yes
74	FD Filtered - Drag Force Filtered	SAE Legacy		Yes
75	SR Unfiltered - Slip Ratio Unfiltered	Common		Yes
76	Vr Unfiltered - Roadway Velocity Unfiltered	Common	km/hr	Yes
77	MZctr Filtered - MZ Moment @ Wheel Center Filtered	Whl Heading	N-m	Yes
78	MZpat Filtered - MZ Moment @ Contact Patch Filtered	Whl Heading	N-m	Yes
79	MXctr Filtered - MX Moment @ Wheel Center Filtered	Whl Heading	N-m	Yes
80	MXpat Filtered - MX Moment @ Contact Patch Filtered	Whl Heading	N-m	Yes
81	TWctr Unfiltered - Wheel Torque Unfiltered	Controller	N-m	Yes
82	VRctr V Cmd - Roadway Velocity V Cmd	Controller		Yes
83	SRctr V Cmd - Slip Ratio V Cmd	Controller		Yes
84	Iqs Unfiltered - Spindle Motor q Current Unfiltered	Misc		Yes
85	SROutCmd Unfiltered - Slip Ratio Output Command Unfiltered	Controller		Yes
86	SROutFFterm Unfiltered - Slip RatioOutput FFterm Unfiltered	Controller		Yes
87	SROutGainScale Unfiltered - Slip RatioOutput Gain Scale Unfiltered	Controller		Yes
88	SROutPIDterm Unfiltered - Slip RatioOutput PIDterm Unfiltered	Controller		Yes
89	IA Unfiltered - Inclination Angle Unfiltered	SAE Legacy	deg	Yes
90	RL Unfiltered - Loaded Radius Unfiltered	SAE Legacy	mm	Yes
91	SA Unfiltered - Slip Angle Unfiltered	SAE Legacy	deg	Yes
92	Tbsf Filtered - Spindle Front Bearing Temp Filtered	Common	degC	Yes

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CHANNEL NUMBER	CHANNEL DESCRIPTION	COORDINATE SYSTEM (OR SOURCE)	UNITS	Required (Yes/No)
93	Tbsr Filtered - Spindle Rear Bearing Temp Filtered	Common	degC	Yes
94	Trdmtrstr Unfiltered - Temp Roadway Motor Stator Unfiltered	Machine	degC	Yes
95	Tedcwi Unfiltered - Elect Drive Cooling Water In Temp Unfiltered	Misc	degC	Yes
96	Tedcwo Unfiltered - Elect Drive Cooling Water Out Temp Unfiltered	Misc	degC	Yes
97	Re Unfiltered - Effective Rolling Radius Unfiltered	Common	mm	Yes
98	SR Filtered - Slip Ratio Filtered	Common		Yes
99	MZtd Unfiltered - Aligning Moment Unfiltered	SAE Legacy	N-m	Yes
100	MZtd Unfiltered - Aligning Moment Unfiltered	Z down	N-m	Yes
101	Tw Unfiltered - Wheel Torque Unfiltered	SAE Legacy	N-m	Yes
102	Rwposenc Unfiltered - Position Encoder Roadway Unfiltered	Machine		Yes
103	Spdlposenc Unfiltered - Position Encoder Spindle Unfiltered	Machine		Yes
104	Pactret Unfiltered - Pressure Actuator Return Unfiltered	Machine	MPa	Yes
105	Pactsup Unfiltered - Pressure Actuator Supply Unfiltered	Machine	MPa	Yes
106	YBctlr Command - Belt Position Command	Controller	mm	Yes
107	YBctlr Filtered - Belt Position Filtered	Controller	mm	Yes
108	YBctlr V Cmd - Belt Position V Cmd	Controller		Yes
109	YBctlr Unfiltered - Belt Position Unfiltered	Controller	mm	Yes
110	Trdwyrvest Unfiltered - Torque Roadway Drive Estimate Unfiltered	Machine	N-m	Yes
111	Yb Command - Belt Position Command	Common	mm	Yes
112	Yb Unfiltered - Belt Position Unfiltered	Common	mm	Yes
113	Sx2 Unfiltered - Longitudinal Slip Ratio Unfiltered	SAE Legacy		Yes
114	Sx2 Filtered - Longitudinal Slip Ratio Filtered	SAE Legacy		Yes
115	FXm Unfiltered - FX Force Unfiltered	Machine		Yes
116	FYm Unfiltered - FY Force Unfiltered	Machine		Yes
117	FZm Unfiltered - FZ Force Unfiltered	Machine		Yes
118	FXmcal Unfiltered - FXCal Force Unfiltered	Machine		Yes
119	FYmcal Unfiltered - FY Cal Force Unfiltered	Machine		Yes
120	FZmcal Unfiltered - FZ Cal Force Unfiltered	Machine		Yes
121	FXwb Unfiltered - Fx Water Bearing Unfiltered	Machine	degC	Yes
122	IAm Unfiltered - Inclination Angle Unfiltered	Machine	deg	Yes
123	IAm Filtered - Inclination Angle Filtered	Machine	deg	Yes
124	RLm Unfiltered - Loaded Radius Unfiltered	Machine	mm	Yes
125	RLm Filtered - Loaded Radius Filtered	Machine	mm	Yes
126	SAm Unfiltered - Slip Angle Unfiltered	Machine	deg	Yes
127	SAm Filtered - Slip Angle Filtered	Machine	deg	Yes
128	Xaccel Filtered - X Acceleration Filtered	Spindle Accels and Velocities		Yes
129	Yaccel Filtered - Y Acceleration Filtered	Spindle Accels and Velocities		Yes
130	Zaccel Filtered - Z Acceleration Filtered	Spindle Accels and Velocities		Yes
131	ThetaXvel Filtered - X Angular Vel Filtered	Spindle Accels and Velocities	deg/sec	Yes
132	ThetaXaccel Filtered - X Angular Accel Filtered	Spindle Accels and Velocities		Yes
133	ThetaZaccel Filtered - Z Angular Accel Filtered	Spindle Accels and Velocities		Yes
134	ThetaZvel Filtered - Z Angular Vel Filtered	Spindle Accels and Velocities	deg/sec	Yes
135	a1xm Unfiltered - Measured Accel 1 (x) Unfiltered	Measured Accels		Yes
136	a3zm Unfiltered - Measured Accel 3 (z) Unfiltered	Measured Accels		Yes
137	a2ym Unfiltered - Measured Accel 2 (y) Unfiltered	Measured Accels		Yes
138	a4xm Unfiltered - Measured Accel 4 (x) Unfiltered	Measured Accels		Yes
139	a5ym Unfiltered - Measured Accel 5 (y) Unfiltered	Measured Accels		Yes
140	a6zm Unfiltered - Measured Accel 6 (z) Unfiltered	Measured Accels		Yes
141	a7zm Unfiltered - Measured Accel 7 (z) Unfiltered	Measured Accels		Yes
142	a8im Unfiltered - Measured Accel 8 (i) Unfiltered	Measured Accels		Yes

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Appendix B

Table B1: MTS Test Definition Test Type Description

***** End Level Test Type *****			
TYPE NAME	PME GM Final Versions IC Linear		
AUTHOR	KRE		
LOCKED	FALSE		
CREATION DATE	1/15/15 9:58 PM		
LAST MODIFIED DATE	1/16/15 9:38 AM		
DEFAULT SEGMENT SHAPE	Linear		
INERTIAL COMPENSATION	ON		
INFLATION PRESSURE	Controlled		
CAPPED PRESSURE MODE			
NORMAL MEAN VALUE MODE			
SPINDLE DRIVE	Installed		
Control	Control Description	Control Channels	Mode
1	Time	sgnTime	Absolute
2	Vertical Load	sgnFZ	%Reference
3	Inflation Pressure	sgnPT	%Reference
4	Roadway Velocity	sgnVB	Absolute
5	Inclination Angle	sgnIA	Absolute
6	Slip Angle	sgnSA	Absolute
7	Slip Ratio	sgnSR	Absolute

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Appendix C

Table C1: Passenger Car Sequences

Tire 1				
Sequence Name:		Pass-Car-Load-Rad-Final.tsq		
Estimated Total Time:		936 sec		
Estimated Total Distance:		19.27 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	Pass-Warmup-Final.tpf	Appendix F
2	TPF	1	Loaded-Radius-Final.tpf	Appendix Q
Tire 2				
Sequence Name:		Pass-Car-FX-Seq-Final.tsq		
Estimated Total Time:		4164 sec		
Estimated Total Distance:		114.54 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	Pass-Warmup-Final.tpf	Appendix F
2	TPF	1	SS-FX-520-IA-Final.tpf	Appendix M
3	TPF	1	Swept-Sine-Fx-All-Loads-Final.tpf	Appendix N
4	TPF	1	SS-FX-830-IA-HIL-Final.tpf	Appendix P
Tire 3				
Sequence Name:		Pass-Car-FY-Seq-Final.tsq		
Estimated Total Time:		2674 sec		
Estimated Total Distance:		73.26 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	Pass-Warmup-Final.tpf	Appendix F
2	TPF	1	SS-FY-025-IA-Pass-Car-Final.tpf	Appendix J
3	TPF	1	Swept-Sine-FY-All-Loads-Final.tpf	Appendix K
4	TPF	1	SS-FY-038-IA-HIL-Final.tpf	Appendix L
Tire 4				
Sequence Name:		Pass-Car-FxFy-Seq-Final.tsq		
Estimated Total Time:		5281 sec		
Estimated Total Distance:		146.02 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	Pass-Warmup-Final.tpf	Appendix F
2	TPF	1	SS-FxFy-025-IA-Final.tpf	Appendix R

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Appendix D

Table D1: Performance Sequences

<i>Tire 1</i>				
Sequence Name:		Perf-Load-Rad-Final.tsq		
Estimated Total Time:		921 sec		
Estimated Total Distance:		18.72 km		
	Type	Passes	Entry Name	Location
1	TPF	1	Perf-Warmup-Final.tpf	Appendix G
2	TPF	1	Loaded-Radius-Final.tpf	Appendix Q
<i>Tire 2</i>				
Sequence Name:		Perf-FX-Seq-Final.tsq		
Estimated Total Time:		4149 sec		
Estimated Total Distance:		114.12 km		
	Type	Passes	Entry Name	Location
1	TPF	1	Perf-Warmup-Final.tpf	Appendix G
2	TPF	1	SS-FX-520-IA-Final.tpf	Appendix M
3	TPF	1	Swept-Sine-Fx-All-Loads-Final.tpf	Appendix N
4	TPF	1	SS-FX-830-IA-HIL-Final.tpf	Appendix P
<i>Tire 3</i>				
Sequence Name:		Perf-FY-Seq-Final.tsq		
Estimated Total Time:		2659 sec		
Estimated Total Distance:		72.85 km		
	Type	Passes	Entry Name	Location
1	TPF	1	Perf-Warmup-Final.tpf	Appendix G
2	TPF	1	SS-FY-025-IA-Perf-Car-Final.tpf	Appendix S
3	TPF	1	Swept-Sine-FY-All-Loads-Final.tpf	Appendix K
4	TPF	1	SS-FY-038-IA-HIL-Final.tpf	Appendix L
<i>Tire 4</i>				
Sequence Name:		Perf-Fx-Fy-Seq-Final.tsq		
Estimated Total Time:		5266 sec		
Estimated Total Distance:		145.47 km		
	Type	Passes	Entry Name	Location
1	TPF	1	Perf-Warmup-Final.tpf	Appendix G
2	TPF	1	SS-Fx-Fy-025-IA-Final.tpf	Appendix R

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Appendix E

Table E1: Light Truck Sequences

<i>Tire 1</i>				
Sequence Name:		LT-Load-Rad-Final.tsq		
Estimated Total Time:		966 sec		
Estimated Total Distance:		19.97 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	LT-Warmup-Final.tpf	Appendix H
2	TPF	1	Loaded-Radius-Final.tpf	Appendix Q
<i>Tire 2</i>				
Sequence Name:		LT-FX-Seq-Final.tsq		
Estimated Total Time:		4194 sec		
Estimated Total Distance:		115.37 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	LT-Warmup-Final.tpf	Appendix H
2	TPF	1	SS-FX-520-IA-Final.tpf	Appendix M
3	TPF	1	Swept-Sine-Fx-All-Loads-Final.tpf	Appendix N
4	TPF	1	SS-FX-830-IA-HIL-Final.tpf	Appendix P
<i>Tire 3</i>				
Sequence Name:		LT-FY-Seq-Final.tsq		
Estimated Total Time:		2736 sec		
Estimated Total Distance:		74.99 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	LT-Warmup-Final.tpf	Appendix H
2	TPF	1	SS-FY-025-IA-LT-Final.tpf	Appendix T
3	TPF	1	Swept-Sine-FY-All-Loads-Final.tpf	Appendix K
4	TPF	1	SS-FY-038-IA-HIL-Final.tpf	Appendix L
<i>Tire 4</i>				
Sequence Name:		LT-FxFy-Seq-Final.tsq		
Estimated Total Time:		5311 sec		
Estimated Total Distance:		146.72 km		
Sequence	Type	Passes	Entry Name	Location
1	TPF	1	LT-Warmup-Final.tpf	Appendix H
2	TPF	1	SS-FxFy-025-IA-Final.tpf	Appendix R

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Appendix F

Table F1: Passenger Car Warm-up Final

***** End Level Test Type *****			
TYPE NAME	PME GM Final Versions IC Linear		
AUTHOR	KRE		
LOCKED	FALSE		
CREATION DATE	1/15/15 9:58 PM		
LAST MODIFIED DATE	1/16/15 9:38 AM		
DEFAULT SEGMENT SHAPE	Linear		
INERTIAL COMPENSATION	ON		
INFLATION PRESSURE	Controlled		
CAPPED PRESSURE MODE			
NORMAL MEAN VALUE MODE			
SPINDLE DRIVE	Installed		
Control	Control Description	Control Channels	Mode
1)	Time	sgnTime	Absolute
2)	Vertical Load	sgnFZ	%Reference
3)	Inflation Pressure	sgnPT	%Reference
4)	Roadway Velocity	sgnVB	Absolute
5)	Inclination Angle	sgnIA	Absolute
6)	Slip Angle	sgnSA	Absolute
7)	Slip Ratio	sgnSR	Absolute
***** End Level Procedure *****			
PROCEDURE NAME	Pass Warmup Final		
TYPE NAME	PME GM Final Versions IC Linear		
AUTHOR	KRE		
LOCKED	FALSE		
CREATION DATE	1/16/15 9:38 AM		
LAST MODIFIED DATE	1/16/15 9:41 AM		
TOTAL TIME	283 sec		
TOTAL DISTANCE	7.44 km		
ROADWAY VELOCITY DIRECTION	Positive		
CAPPED PRESSURE	0 kPa		
VERTICAL LOAD MEAN	0 N		

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