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SURFACE VEHICLE STANDARD

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Pneumatic Tire/Wheel/Runflat Assembly Qualifications for Military Tactical Wheeled Vehicles

RATIONALE

This SAE Standard was developed as a guide to all branches of the Department of Defense to evaluate tire/wheel/runflat systems and related vehicle performance. This revision is to update information to reflect current state-of-the-art technology and testing experience.

FOREWORD

This specification was developed by the SAE Truck and Bus Military Industry Tire Task Force and is intended for military use by all branches of the Department of Defense. It is designed to be used with the "Administrator's Manual for use with SAE J2014 (R) Pneumatic Tire/Wheel/Runflat Assembly Qualifications for Military Tactical Wheeled Vehicles," which contains the information needed to evaluate and measure tire/wheel/runflat systems and changes in vehicle performance. The manual contains criteria by which a tire, wheel, and/or runflat device will be judged as having passed or failed for these applications.

This specification shall remain open for comments and recommendations by the user(s) and shall be reviewed or revised periodically by the SAE Truck and Bus Military Industry Tire Task Force when necessary to incorporate adopted comments, recommendations, and advancements in government and industry tire technology.

1. SCOPE

This SAE Standard applies to all combinations of pneumatic tires, wheels, or runflat devices (only as defined in SAE J2013) for military tactical wheeled vehicles only as defined in SAE J2013. This applies to original equipment and new replacement tires, retread tires, wheels, or runflat devices.

This document describes tests and test methodology, which will be used to evaluate and measure tire/wheel/runflat system and changes in vehicle performance.

All of the tests included in this document are not required for each tire/wheel/runflat assembly. The Government Tire Engineering Office and Program Office for the vehicle system have the responsibility for the selection of a specific test(s) to be used. The selected test(s) should be limited to that required to evaluate the tire/wheel/runflat system and changes in vehicle performance. Selected requirements of this specification shall be used as the basis for procurement of a tire, wheel, and/or runflat device for military tactical wheeled vehicles.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE 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 J57 Sound Level of Highway Truck Tires

SAE J1015 Tonne Kilometer per Hour Test Procedure

SAE J1269 Rolling Resistance Measurement Procedure for Passenger Car, Light Truck, and Highway Truck and Bus Tires

SAE J1441 Subjective Rating Scale for Vehicle Ride and Handling

SAE J2013 Military Tire Glossary

SAE J2181 Steady-State Circular Test Procedure for Trucks and Buses

SAE J2704 Tire Normal Force/Deflection and Gross Footprint Dimension Test

2.1.2 Military Publications

Available from the U.S. Army, Combat Capabilities Development Command, Ground Vehicle Systems Center Tire Engineering FCDD-GVS-ES (MS-268), 6501 East 11 Mile Road, Warren, MI 48397-5000.

Administrator's Manual for use with SAE J2014 (R) Pneumatic Tire/Wheel/Runflat Assembly Qualifications for Military Tactical Wheeled Vehicles

2.1.3 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM E274 Standard Test Method for Skid Resistance of Paved Surfaces Using a Full Scale Tire

ASTM E501 Standard Specification for Standard Rib Tire for Pavement Skid-resistance Tests

ASTM E1136 Standard Specification for P195/75R14 Radial Standard Reference Test Tire

ASTM F1016 Standard Practice for Linear Tire Treadwear Data Analysis

ASTM F1805 Standard Test Method for Single Wheel Driving Traction in a Straight Line on Snow and Ice-Covered Surfaces

ASTM F2493 Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire

ASTM F2803 Standard Test Method for Evaluating Rim Slip Performance of Tires and Wheels

2.1.4 ISO Publications

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ISO 2631 Mechanical Vibration and Shock - Evaluation of Human Exposure to Whole-Body Vibration

ISO 18106 Passenger Car, Commercial Vehicle, Truck and Bus Tyres - Methods for Measuring Snow Grip Performance - Loaded New Tyres

ISO 28580 Passenger Car, Truck and Bus Tyre Rolling Resistance Measurement Method - Single Point Test and Correlation of Measurement Results

2.1.5 Code of Federal Regulations (CFR) Publications

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

49 CFR 571.119 New Pneumatic Tires for Motor Vehicles with a GVWR of More than 4536 kilograms (10,000 pounds) and Motorcycles

2.1.6 European Tyre and Rim Technical Organization (ETRTO) Publications

Available from the European Tyre and Rim Technical Organization, Rue Defacqz 78/80, 1060, Brussels, Belgium, Tel: +32-2-344-40-59, www.etrto.org.

ETRTO Standards Manual

ETRTO Engineering Design Information

2.1.7 The Japan Automobile Tyre Manufacturers' Association (JATMA) Publications

Available from The Japan Automobile Tyre Manufacturers Association, No. 33 Mori Bldg. 8th Floor, 3-8-21 Toranomon, Minato-Ku, Tokyo, Japan, 105-0001, Tel: 81-3-3435-9094.

JATMA Yearbook

2.1.8 Scandinavian Tire and Rim Organization Publications

Available from the Scandinavian Tire and Rim Orgnaization, Rådhusgatan 15, 742 43 Öregrund, Tel: +46 173 30273.

STRO Data Book

2.1.9 The Tyre and Rim Association of Australia Publications

Available from the Tyre and Rim Association of Australia, C/- Coghlan Corporate Services Pty Ltd, Suite 1, Hawthorn House, 795 Glenferrie Road, Hawthorn, Victoria, 3122, Australia, Tel: +61 3 9818 0759, www.tyreandrim.org.au.

Standards Manual

2.1.10 National Atlantic Treaty Organization (NATO) Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

AVTP-03-160W Dynamic Stability

AVTP-03-170 Facilities

AVTP-13-30W Tyre

2.1.11 The Tire and Rim Association Publications

Available from The Tire and Rim Association, Inc., 4000 Embassy Parkway, Suite 390, Akron, OH 44333, www.us-tra.org.

The Tire and Rim Association Yearbook

The Tire and Rim Association Engineering Design Information

The Tire and Rim Association Military Supplement

2.1.12 Unified Soil Classification System Publications

Refer to Technical Memorandum Number 3 357, April 1960 (Reprinted May 1957), and NATO Reference Mobility Model procedure available from U.S. Army Engineering Research Development Center (ERDC), Corps of Engineers, 3909 Halls Ferry Road, Vicksburg, MS 39180.

2.1.13 Recreational Off-Highway Vehicle Association (ROHVA) Publications

Available from the Recreational Off-Highway Vehicle Assocation (ROHVA), 2 Jenner, Suite 150, Irvine, CA, 92618-3806, Tel: (949) 255-2560, www.rohva.org.

American National Standard for Recreational Off-Highway Vehicles (ANSI-ROHVA)

2.1.14 NIST Publications

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

NIST Handbook 44

2.1.15 FINABEL European Army Interoperability Centre Publications

Available from European Army Interoperability Centre, Quartier Reine Eliszbeth, Rue d'Evere 1, B-1140 Brussels, Belgium, Tel: +32 (0)2 441 79 38.

FINABEL Agreement No. A.20.A

2.1.16 Test Operations Procedure (TOP) Publications

Available from Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Ft. Belvoir, VA, 22060-6218.

TOP 01-1-010A Vehicle Test Course Severity (Surface Roughness)

TOP 1-1-014 Ride Dynamics

TOP 2-2-002 Dynamic Stability, Handling and Steering

TOP 02-2-610 Gradeability and Side Slope Performance

2.1.17 Engineer Research and Development Center (ERDC) Publications

Available from the United States Army Engineer Research and Development Center (ERDC), 3909 Halls Ferry Road, Vicksburg, MS 39180-6199, www.erdc.usace.army.mil.

ERDC/GSL SR-13-2 Procedures for One-Pass Vehicle Cone Index (VCI_1) Determination for Acquisition Support

2.1.18 American Association of State Highway and Transportation Officials (AASHTO) Publications

Available from American Association of State Highway and Transportation Officials (AASHTO) 555 12th Street NW, Suite 1000, Washington, DC 20004, Tel: (202) 624-5800, www.transportation.org.

3. DEFINITIONS

Definitions for this document are included in SAE J2013.

4. TECHNICAL REQUIREMENTS

4.1 List of Tests and/or Inspections

A cross reference of inspections and tests for new and retreaded replacement tires is shown in Table 1.

Table 1 - Test for new and retreaded replacement tires/wheels/runflat systems

Title/Subject	SAE J2014 and Administrator's Manual References	Test Procedure (Appendix A, Industry Test)
List of Tests and/or Inspections	4.1	---
Mixed Fitment Testing	4.2	---
Retreadability	4.3.1	---
Repairability	4.3.2	---
Treadwear Indicators	4.3.3	---
Tire Imbalance Limits	4.3.4	---
Ozone Resistance	4.3.8	Section A.21
Tire Traction	4.4.2	Section A.1
Vehicle Evasive Maneuver	4.4.3	Section A.2
Bead Unseating	4.4.4	Section A.3
Rolling Resistance	4.4.5	SAE J1269
Dimensional Criteria	4.4.6	---
Mechanical Reliability (Off-Road Durability)	4.4.7	Section A.4
Tire Treadlife Durability	4.4.8	Section A.5
Comparative Stopping Distance	4.4.9	Section A.6
Tire Single Wheel Skid Resistance	4.4.10	ASTM E274
Rim Slip (Tire Indexing)	4.4.11	ASTM F2803
Load Deflection	4.4.12	SAE J2704
Mission Profile Runflat	4.4.13	Section A.7
Paved Runflat	4.4.14	Section A.8
Curb Impact	4.4.15	Section A.9
Half Round	4.4.16	Section A.10
Ride Quality	4.4.17	Section A.11
Mission Profile Speed Evaluation	4.4.18	Section A.12
High Speed Evaluation	4.4.19	Section A.13
Steady State Dynamic Stability	4.4.20	SAE J2181
Tire Underbody Impingement	4.4.21	Section A.14
Convoy Escort	4.4.22	Section A.15
Vehicle Cone Index	4.4.23	ERDC GSL SR-13-2
Mission Profile Terrain Definitions	4.4.24	Section A.16
Current Terrain Definitions	4.4.25	Section A.17
Coarse Grain Soil Gradeability	4.4.26	Section A.18
Road Departure Recovery	4.4.27	Section A.19
Side Slope Evaluation	4.4.28	Section A.20

4.2 Mixed Fitment Testing

Mixed fitment testing shall follow the standard fitment testing. If the standard fitment results indicate that a candidate tire/rim/runflat system does not qualify, then a mixed fitment evaluation is not necessary. The government program office shall work with the testing agency to determine the mixed fitment test scenarios.

Following the standard fitment, each group (including the reference if planned to be mixed with the candidates in the field) will be given a rank order rating starting with one being the best performing for a particular test.

Mixed fitment should consider the particular test and placement of the best performing and worst performing tires. An example of the test order is shown in the following table. An example for a handling test of a two-axle vehicle with three candidate tires and one control tire:

Table 2 - Tire placement (tire ranking)

LF	RF	LR	RR
1	1	4	4
1	1	3	3
2	2	4	4
2	2	3	3

A mixed fitment test plan with multi-axle vehicles would follow a similar methodology. Additional mixed fitment testing can be conducted to include combinations left to right, opposing corners, or multiple different tires if so required.

The results for each mixed fitment will be compared to the reference standard fitment results. For pass/fail criteria, refer to the Administrator's Manual.

4.3 Design and Construction

The design and construction of the tire/rim/runflat assemblies shall meet the description listed in the Administrator's Manual.

4.3.1 Retreadability (New Tires Only)

The retreadability of the tires shall meet the description listed in the Administrator's Manual.

4.3.2 Repairability (New Tires Only)

The repairability of the tires shall meet the description listed in the Administrator's Manual.

4.3.3 Treadwear Indicators

The treadwear indicators of the tires shall meet the description listed in the Administrator's Manual.

4.3.4 Tire Imbalance Limits

The tire/rim/runflat assembly imbalance limits shall meet the description listed in the Administrator's Manual.

4.4 Performance

The tire or retread, manufacturer provides certification that the tire meets the requirements listed in Table 1 of the Administrator's Manual, before proceeding with the following testing.

4.4.1 Tire Traction

Purpose: This is a test to determine the traction characteristics of the candidate tire when compared to the reference tire on severe off-road conditions.

When specified, a tire traction test shall be conducted to determine traction performance of the tire(s) under specified conditions as described in Appendix A, Section A.1, to determine tire performance in mud, sand, ice, and/or snow. For pass/fail criteria, refer to the Administrator's Manual.

4.4.2 Vehicle Evasive Maneuver

Purpose: This test procedure is intended to be used as a field test procedure; however, the basic criteria are also intended to provide a standard reference for simulation of the basic maneuvers through various mathematical modeling techniques. This document provides a procedure and instructions for instrument and equipment, vehicle preparation, and test of single and combination vehicles. This procedure provides a method to evaluate the stability of vehicles under simulated highway and/or secondary and gravel road conditions. Loss of stability is of primary concern.

When specified, a wet and dry pavement and/or gravel road evasive maneuver test shall be conducted to determine the tires' performance under specified conditions as described in Appendix A, Section A.2, to determine tire performance on wet and dry pavement. For pass/fail criteria, refer to the Administrator's Manual.

4.4.3 Bead Unseating

Purpose: A test method to determine tire slip (tire indexing), air loss, or bead unseating when operated at the minimum recommended inflation pressure.

When specified, a bead unseating test shall be conducted as described in Appendix A, Section A.3. For pass/fail criteria, refer to the Administrator's Manual.

4.4.4 Rolling Resistance

Purpose: This procedure applies to the laboratory measurement of rolling resistance of pneumatic passenger car, light truck, and highway truck and bus tires. The procedure applies only to the steady-state operation of free-rolling tires at zero slip and inclination angles.

When specified, to determine conformance to this section, a rolling resistance test shall be conducted in accordance with SAE J1269. For pass/fail criteria, refer to the Administrator's Manual.

4.4.5 Dimensional Criteria

Purpose: The purpose of these procedures are to compare the candidate tire, wheel, or runflat dimensions with the control tire, wheel, or runflat.

4.4.5.1 Tire

When specified, the following measurements of the candidate tire shall be compared to the reference/control: overall diameter, section width, tire weight, centerline tread depth, tread width, revolutions per mile, and bead width. Tire measurements shall be taken at rated inflation pressure. A minimum sample size of four shall be recorded with average reported. Revolutions per mile shall be taken at the rated inflation pressure and load for the tire, unless otherwise specified. A minimum of three runs shall be recorded for the revolutions per mile. As an option, a clearance check of the tire on the vehicle may be performed.

4.4.5.2 Rim/Wheel

When specified, the following measurements of the candidate wheel shall be compared to the reference/control. A minimum sample size of four shall be recorded with average reported. As an option, a clearance check of the wheel on the vehicle may be performed. As an option, compatibility of the runflat or tire or hub with the wheel may be performed for fitment (mounting trial). The rim contour must conform to TRA, ETRTO, or JATMA standards for the control wheel.

4.4.5.2.1 Rim Characteristics

Flange height; flange width; bead seat width, diameter, angle; valve hole diameter, position (location), hole depth, wall angle; drop well position, width, depth, diameter.

4.4.5.2.2 Disc Characteristics

Mounting surface diameter; disc thickness at hub/stub; bolt hole diameter (mounting number and assembly number); bolt circle diameter.

4.4.5.2.3 Wheel Characteristics

Weight, offset, center-hole diameter.

4.4.5.3 Runflat

When specified, the following measurements of the runflat shall be compared to the reference/control runflat: outside diameter, inside diameter, overall width, runflat cap width, bead lock dimensions (if applicable), minimum clearance with valve when mounted on wheel. A minimum sample size of four shall be recorded with average reported. As an option, compatibility of the wheel or tire or valve with the runflat may be performed for fitment (mounting trial).

For pass/fail criteria, refer to the Administrator's Manual.

4.4.6 Mechanical Reliability (Off-Road Durability)

Purpose: This is a test to determine a tire/wheel/runflat's ability to withstand sustained operation on severe off-road conditions.

When specified, testing shall be conducted as described in Appendix A, Section A.4, for the tire/wheel/runflat system durability in off-road conditions.

4.4.7 Tire Treadlife Durability

Purpose: This is a test to determine the tire/wheel/runflat assembly system's(s') treadlife durability using the vehicle mission profile requirements.

When specified, to assure conformance to the treadlife durability requirements, the test shall be conducted on the courses required for the mission profile as specified on the original equipment or a revised mission profile requirement and in accordance with Appendix A, Section A.5. For pass/fail criteria, refer to the Administrator's Manual.

4.4.8 Comparative Stopping Distance

Purpose: This on-vehicle test is used to compare the stopping distance of the reference/control and candidate tire.

When specified, testing shall be conducted in accordance with Appendix A, Section A.6. For pass/fail criteria, refer to the Administrator's Manual.

4.4.9 Tire Single-Wheel, Skid Resistance

Purpose: This test method establishes the standard procedure for measuring the skid resistance of paved surfaces by the use of a specified full-scale automotive tire. This test method utilizes a measurement representing the steady-state friction force on a locked test wheel as it is dragged over a wetted pavement surface under constant load and at a constant speed while its major plane is parallel to its direction of motion and perpendicular to the pavement. The values measured represent the frictional properties obtained with the equipment and procedures stated herein. These values are intended for use in evaluating the skid resistance of a pavement relative to that of other pavements or for evaluating changes in the skid resistance of a pavement with the passage of time.

When specified, a single-wheel, tire skid resistance test shall be conducted using procedures as established in ASTM E274. The vehicles, loads, inflation pressures, and tires shall be adjusted to tactical military tire requirements. This test shall be conducted on wet pavement at 64 km/h (40 mph). An ASTM E501 tire shall be used to define the test surface. This is the recommended procedure for evaluating tire braking performance, versus 4.9.

4.4.10 Rim Slip (Tire Indexing)

Purpose: This test method is performed to determine the amount of rotational slip occurring at the tire/wheel interface while under heavy longitudinal load conditions. This movement of the tire on the wheel is also known as tire indexing. This test method is suitable for research and development purposes where tires are compared during a single series of tests. They may not be suitable for regulatory statutes or specification acceptance because the values obtained may not necessarily agree or correlate either in rank order or absolute performance level with those obtained under other environmental conditions on other surfaces or the same surface after additional use.

When specified, the tire/rim/runflat assembly shall be tested in accordance with ASTM F2803. For pass/fail criteria and requirements for each vehicle application, refer to the Administrator's Manual.

4.4.11 Load Deflection

Purpose: This test is a method for determining the vertical force and deflection properties of a non-rolling tire and the associated contact patch length and width. The method applies to any 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.

When specified, testing shall be conducted in accordance with SAE J2704 using loads and inflation pressures appropriate for the vehicle mission. Inclusion of the runflat device in the wheel assembly is optional. The load and deflection shall be tabulated to determine the spring rate for each tire. The percent deflection shall be calculated using the section height minus the rim flange height.

4.4.12 Mission Profile Runflat

Purpose: The purpose of the mission profile runflat test is to ensure that the tire/wheel/runflat assembly can withstand rifle fire and allow continuous mobility of the vehicle for a specified distance, speed, and terrain type.

When specified, testing shall be conducted in accordance with Appendix A, Section A.7. For pass/fail criteria, refer to the Administrator's Manual.

4.4.13 Paved Runflat

Purpose: The purpose of the paved runflat test is to ensure that the tire/wheel/runflat assembly can withstand rifle fire and allow continuous mobility of the vehicle over a paved surface for 30 miles at 30 mph. This test is also used to determine the deflated system's thermal relationship at the tire-runflat interface and its ability to withstand a minimum of 30 miles of operation.

When specified, testing shall be conducted in accordance with Appendix A, Section A.8. For pass/fail criteria, refer to the Administrator's Manual.

4.4.14 Curb Impact

Purpose: The purpose of this test is to evaluate if the candidate component adversely affects the vehicle occupants' health and/or comfort and to establish whether or not the candidate prematurely degrades the tire, after impacting an 8-inch curb at a 0 degree and 45 degree angle of approach.

When specified, testing shall be conducted in accordance with Appendix A, Section A.9. For pass/fail criteria, refer to the Administrator's Manual.

4.4.15 Half Round

Purpose: The objective of half round testing is to determine a candidate assembly's effects on the vehicle's suspension while driving over 6-, 8-, 10-, or 12-inch half round obstacles. Half round performance is determined by calculating the maximum speed the vehicle can traverse the obstacle before achieving 2.5 g of peak vertical acceleration at the driver's seat or CG location. TOP 1-1-014 defines the 2.5 g as the maximum allowable acceleration without posing significant risk to occupant health and safety.

When specified, testing shall be conducted in accordance with Appendix A, Section A.10. For pass/fail criteria, refer to the Administrator's Manual.

4.4.16 Ride Quality

Purpose: The objective of the ride quality test is to determine if there is any adverse ride, handling or stability characteristics attributable to the candidate assembly. Ride quality performance is quantified by determining the maximum speed the vehicle can traverse a repetitive roughness course, before achieving 6 W of absorbed power at the base of the driver's seat and/or using the weighted acceleration over wave number spectrum (WNS) representative roughness courses and the exposure time of 2 hours, after which occupant health risks are likely criteria from ISO 2631. TOP 1-1-014 defines 6 W as the maximum sustainable absorbed power the human body can endure for eight hours before injury and/or physical damage occur.

When specified, testing shall be conducted in accordance with Appendix A, Section A.11. For pass/fail criteria, refer to the Administrator's Manual.

4.4.17 Mission Profile Speed Evaluation

Purpose: The objective of the mission profile speed evaluation test is to determine if there are any adverse ride, handling, or stability characteristics attributable to the candidate assembly.

When specified, testing shall be conducted in accordance with Appendix A, Section A.12. For pass/fail criteria, refer to the Administrator's Manual.

4.4.18 High Speed Evaluation

Purpose: The objective of high speed testing is to investigate the effect of combined vibration and environmental forces on the candidate assemblies.

When specified, testing shall be conducted in accordance with Appendix A, Section A.13. For pass/fail criteria, refer to the Administrator's Manual.

4.4.19 Steady State Dynamic Stability

Purpose: This test procedure is used to determine the steady-state directional control response of vehicles by measuring steady-state cornering behavior. Due to the wide range of operational conditions to which a vehicle can be subjected, the results of this testing do not provide a complete description of a vehicle's total dynamic behavior; in particular, the procedure does not test the vehicle's response during transient maneuvers. To fully assess a vehicle's total dynamic behavior, it would be necessary to conduct other test procedures in order to evaluate the vehicle's performance as a whole. The extent of instrumentation and the required accuracy of the measurement will be dependent on the goals of the personnel conducting the test. If it is desired simply to determine the general performance characteristics of a vehicle, then this test can be conducted with minimal instrumentation and test item preparation. This test establishes a uniform procedure for determining the steady-state directional control response of trucks, buses, and combination vehicles.

When specified, testing shall be conducted in accordance with SAE J2181. Results shall be graphed as shown in SAE J2181 Appendix C, Figure C1. Each candidate tire/rim/runflat system group shall be tested and compared to the reference/control to determine any changes in handling characteristics. Mixed fitment and tests at different weight up to and including maximum test weight are recommended. For pass/fail criteria, refer to the Administrator's Manual.

Tire underbody impingement purpose: This is a vehicle-specific tire test that evaluates the potential for destructive impingement of tires on underbody structures. The test imposes full lock steer at full jounce. The test also imposes full rebound at full lock steer, testing the strain relief design of hoses and cables attached to the tire/wheel, e.g., central tire inflation system (CTIS).

When specified, the test is shown in Appendix A, Section A.14.

4.4.20 Convoy Escort

Purpose: This test procedure is intended to evaluate the thermal durability of a tire operating non-stop at a constant high speed for one tank of fuel on a paved road at high ambient temperature.

When specified, testing shall be conducted in accordance with Appendix A, Section A.15. For pass/fail criteria, refer to the Administrator's Manual.

4.4.21 Vehicle Cone Index

Purpose: The objetive of the vehicle cone index (VCI) test is to ensure that the soft soil mobility capability of the vehicle as determined through the VCI metric and associated test has not changed as a result of the installation of the candidate tire and/or runflat and as a result of lack of self cleaning, stiffness, tire construction, and/or compounds.

When specified, testing shall be conducted in accordance with ERDC GSL SR-13-2. Course preparation shall be completed using the guidelines established in ERDC-GSL-SR-13-2. To establish the range of cone index (CI) conditions that should be targeted for testing, tire contact pressure calculations can be performed to reach an approximate contact pressure in pounds per square inch (psi). The worst case (highest) tire contact pressure (psi) can be used as a starting point for the CI (psi) conditions that the field should exhibit at the anticipated critical layer.

For pass/fail criteria, refer to the Administrator's Manual.

4.4.22 Coarse Grain Soil Gradeability

Purpose: The objective of this test is to determine that the vehicle's ability to ascend dry coarse grain soil grades, such as those encountered in sand dunes, has not been negatively impacted when equipped with the candidate tire and/or runflat assembly. Tire-ground contact pressure distribution has a large influence on coarse grain soil traction due to the shearing properties of the soil. Vehicle performance during the evaluation should be characterized to ensure the candidate tire does not decrease the capability to ascend grades or exhibit undesirable performance characteristics such as traction hop.

When specified, testing shall be conducted in accordance with Appendix A, Section A.17. For pass/fail criteria, refer to the Administrator's Manual.

4.4.23 Road Departure Recovery

Purpose: The objective of this test is to determine the performance of a wheeled vehicle equipped with the candidate tire/wheel/runflat assembly when negotiating an evasive or emergency maneuver that requires the vehicle configuration to exit the primary travel road surface (paved or secondary), transition along the road shoulder, and then return to that road surface.

When specified, testing shall be conducted in accordance with Appendix A, Section A.18. For pass/fail criteria, refer to the Administrator's Manual.

4.4.24 Side Slope Evaluation

Purpose: The objective of the side slopes evaluation is to verify proper vehicle operation on natural side slopes when equipped with the candidate tire/wheel/runflat assembly. Stability, performance, and controllability will be evaluated while traversing 30% and 40% side slopes. TOP 2-2-610 and TOP 2-2-002 may be used as guides.

When specified, testing shall be conducted in accordance with Appendix A, Section A.19. For pass/fail criteria, refer to the Administrator's Manual.

5. NOTES

5.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE TRUCK AND BUS TIRE COMMITTEE

APPENDIX A - TESTS

A.1 TIRE TRACTION TEST (SEE 4.4.2)

This test determines the driving traction performance of the tire(s) relative to the reference/control tire tested under similar specified conditions.

A.1.1 Purpose

The driving traction performance of the reference/control tire shall be used as a basis to compare the performance of the candidate tire(s). Tests shall be conducted on one or more of the surface conditions (mud, sand, and snow) for both the reference/control and candidate tire tests. Desired surface conditions shall be selected in advance of the testing. Test results shall be used to determine the tractive coefficient[1] and/or mobility of both the reference/control tire and candidate tire. The tractive coefficient or maximum mobility from the tests shall be comparatively evaluated. One of three test methods is used for this determination: (1) the single-wheel traction test, (2) the drawbar pull test, or (3) virgin snow mobility test. The single-wheel traction test is the preferred method for measuring traction. Drawbar pull tests may be used when single-wheel traction testing is not available. Virgin snow mobility testing is used to identify virgin snow performance.

A.1.2 Facilities

Tests shall be conducted on courses prepared to the following specifications:

A.1.2.1 Soil Tests

At least two courses for each selected condition shall be required to provide a large enough area to accommodate testing. The test sections shall be uniform, level, relatively smooth, with no vegetation, a minimum of twice the tire's section width on both sides of the tire by 150 m (500 feet) long for single wheel tests and 6 m (20 feet) wide by 90 m (300 feet) long for drawbar tests. Prior to testing, the courses shall be prepared to a uniform depth and strength and exhibit no evidence of previous usage. Cone penetrometer measurement(s) shall be taken in a crosshatch pattern in undisturbed/virgin soil, not exceeding 3 m (10 feet) to determine uniformity of compaction. Soil samples shall be collected at three locations in the test courses at the surface, and 150 mm (6 inches) in depth.

A.1.2.2 Soft Fine-Grained Soil

The test section shall consist of fine-grained soil such as silt (ML or MH, as defined by the Unified Soil Classification System [USCS]) or clay/clay loam (CL or CH). The course dimensions shall be determined based on vehicle dimensions, suggested dimensions are approximately 250 m long and 100 m wide. The homogeneous soil test area should be at least 750 mm (30 inches) deep with consistent moisture content across the entire usable test area. Additional depth may be required depending on the tire size and associated sinkage.

Prior to the start of testing an appropriate test area will be identified based on the soil strength (CI) and moisture content. A flat, level area will be used for all testing. For each test lane five cone index soil measurements will be taken in the direction of travel and two across the width of the test section to create a soil compaction matrix of the test area. The soil will be prepared to provide a consistent test surface for each vehicle. Soil preparation (watering/drying/tilling) will continue until the desired soil conditions are achieved. The soil shall be prepared with the following target soil parameters:

- 0 to 3 inch layer, 0 < CI < 40
- 3 to 6 inch layer, 40 < CI < 100
- Depth greater than 6 inch, CI > 100

The moisture content shall be measured in at least three locations in the test section at 0 to 25 mm (0 to 1 inch), 25 to 75 mm (1 to 3 inches), and 75 to 150 mm (3 to 6 inches) depths. Course soil conditions will be spot-checked daily. A sufficient number of samples shall be taken to represent the full test area.

[1] Tractive coefficient is defined as the longitudinal force from the tire divided by vertical load.

A.1.2.3 Dry Coarse-Grained Sand

This test section shall be consist of sand (SP or SW, as determined by USCS). The depth of the soil shall be at least 750 mm (30 inches), tilled to at least 200 mm (8 inches), and dried to a moisture content of less than 2.0% in the top 75 mm (3 inches) of sand. The cone index at the 75 mm (3 inches) depth shall not exceed 100. Density and moisture should be measured in at least three locations and included in the test report.

A.1.2.4 Packed Snow Snow

A sufficient amount of snow shall be compacted such that a first untracked pass of the test exhibits a sinkage of at least one tread depth. If compaction or grooming is necessary to obtain the required snow surface, the test course can be aged before testing begins. Temperatures at 25 mm (1 inch) below the test surface shall be between -12 °C (+10 °F) and -4 °C (+25 °F). Each test shall be conducted in a fresh, previously untrafficked test surface. Snow course preparation is extremely critical for obtaining valid results. Course preparation and snow compaction measurements using CTI snow compaction gauge are made as specified in ASTM F1805. The Standard Reference Test Tire (SRTT) (specifications ASTM E1136 or F2493) shall be used to monitor course conditions in accordance with ASTM F1805, ensuring compliance with the specified traction range of 0.23 to 0.38 for medium pack snow.

A.1.2.5 Ice

The ice surface shall be constructed on flat, level ground by repeated application of water in small increments onto the frozen ground in order to achieve at least a 25 mm (1 inch) thick ice layer. Alternatively, a frozen body of water can be used if the ice is determined to be thick enough to support the weight of the vehilce. The ice surface should be smooth and consistent without dimples or ridges. The ice surface should be maintained by application of thin coats of water or sweeping the surface to keep any loose snow from accumulating on top. Temperatures at 25 mm (1 inch) below the test surface shall be between -20 °C (-4 °F) and 0 °C (+32 °F). The Standard Reference Test Tire (SRTT) (specifications ASTM E1136 or F2493) shall be used to monitor (and report) course conditions in accordance with ASTM F1805.

A.1.2.6 Virgin Snow

The virgin snow area shall consist of an open, flat ground area with accumulated virgin (undisturbed) snow of equal depth or naturally occurring snowdrifts. Snowdrifts typically vary in height depending upon the ambient weather conditions and can approach depths up to 5 feet on top of a hard-packed base. The snow drifts should not provide abrupt changes in snow depth but may gradually deepen when traversing into the field. The course is representative of snow covered, flat fields without vehicle traffic.

Prior to the initiation of virgin snow mobility testing, potential evaluation areas will be visually identified based on uniform or gradually increasing snow depths, snow density, and general location for recovery access. Test lanes that meet the following criteria shall be identified.

- Approximately 100 feet long (dependent on snowfall depth availability) and at least as wide as the test vehicle
- Less than 2% slope hard-packed base
- Exhibit a generally constant or increasing snow depth with respect to longitudinal distance from the starting point
- Exhibit sufficient depth to cause vehicle immobilization

A.1.3 Test Vehicle

A.1.3.1 Single Wheel Tests

A test bed capable of providing single, driven tire traction shall be equipped with an instrument package capable of measuring the longitudinal and vertical wheel forces as well as the velocity of the test wheel and ground speed. The capability of logging of the data at a minimum sampling rate of 10 samples per second is required. The driving test tire shall be positioned to eliminate the test tire tracking another tire through the test course, unless otherwise specified by the reference test specification.

A.1.3.2 Drawbar Pull Tests

The appropriate tactical test vehicle shall be equipped with the reference/control or candidate tire(s) in all wheel positions. The test vehicle shall be run together with a dynamometer vehicle of adequate size and load to permit controlling the test vehicle speed. The connection between the vehicles shall be a cable or a tow bar parallel to the ground containing a load cell capable of measuring the drawbar force. Instrumentation recording the drawbar force, time, wheel speed(s), and ground speed shall be installed in the dynamometer vehicle. Sampling rate for the previous measurements shall be a minimum of 10 samples per second.

A.1.3.3 Virgin Snow Mobility Tests

The appropriate tactical test vehicle shall be equipped with the reference/control or candidate tire(s) in all wheel positions. The vehicle shall have functioning recovery points and/or equipment. The test vehicle shall be run at least one run with each tire configuration during a givien test session.

A.1.4 Instrumentation

Longitudinal and vertical forces on the test, along with test wheel and vehicle speeds, shall be measured within 2% accuracy as established by annual National Institute of Standards Technology (NIST) traceable calibration.

A.1.4.1 Snow Compaction Penetrometer and Trafficability Cone Penetrometer

Refer to ASTM F1805 for the method. Use the CTI snow compaction gauge as identified in ASTM F1805. Refer to the NATO Reference Mobility Model procedure for instructions for the use of the trafficability cone penetrometer.

A.1.4.2 Virgin Snow Instrumentation

The following equipment will be used during this evaluation.

- Calibrated tire pressure gauge
- Digital video cameras
- Digital photographic camera
- Tape measure
- Straightedge (4 feet x 2 inches x 1/4 inch)
- Snow shovel
- Snow density measurement kit
- CTI gauge
- Weather data logger, ambient temperature, relative humidity
- Inclinometer

A.1.5 Preparation for Tests

All transducers and instrumentation must be calibrated according to recognized procedures.

A.1.5.1 Tires

Two new tires for the single wheel tests and two new tires for each tire position for the drawbar test shall be recommended as test samples for each variable. These samples shall be production tires (or pre-production), inspected by the tire/retread manufacturer to be free of anomalies and conforming to applicable standards of manufacture. The tires shall be free of mold flash, lubricants, and shall have tread labels removed. In addition, test and reference/control tires shall not have any force or run-out grind.

A.1.5.2 Rim/Wheels

The tires shall be mounted on rim/wheels specified in the TRA Yearbook and/or Military Supplement and/or Engineering Design Information, or ETRTO Standards Manual for the size being tested, unless the military specification requires a rim/wheel that differs from the TRA Military Supplement recommendation. In the latter case, the military specification will apply. Rims must be compatible with pressure and the test vehicle. Inspect and measure test rims to assure they comply with the applicable rim standard (see 4.4.6.2).

A.1.5.3 Inflation Pressure

Tire pressures shall be per the applicable technical manual based on the mission profile (unless otherwise specified).

A.1.5.4 Break-In

An initial break-in period of 160 km (100 miles), shall be run at the maximum vehicle speed, not to exceed 90 km/h (55 mph) on a dry, paved surface at the highway inflation pressure.

A.1.5.5 Initial Tire Measurements

The tires shall be inspected and measured following the break-in. Measurements shall be at three locations around the periphery of each tire and shall include: tread depth at crown and shoulders, section width, tread radius, tread arc width, and outside diameter.

A.1.6 Test Procedure

A.1.6.1 Test Tire/Wheel/Runflat Assembly Preparation

Operate electronic test equipment as required for stabilized results.

A.1.6.2 Test Tire/Wheel/Runflat Assembly Temperature

Assembly should be at ambient temperature and shielded from direct sunlight before testing.

A.1.6.3 Test Tire/Wheel/Runflat Assembly Load

The test vehicle shall be loaded so that each individual static test tire load(s) is within +5% of the maximum tire load for the intended vehicle (unless otherwise specified). The single wheel tests shall measure the average dynamic tire load for a series of test runs for calculation of tractive coefficients.

A.1.6.4 Inflation Pressure Adjustment

Adjust air inflation pressure immediately before testing to the specified test inflation pressure from +7 to 0 kPa (+1 to -0 psi).

A.1.6.5 Test Tire/Wheel/Runflat Assembly Identification

Record tire identification and other data, including date, time, ambient temperature, test surface temperature, type of test surface, etc.

A.1.6.6 Single Wheel Method

The test vehicle shall be equipped with either the reference/control or candidate tires, and the load adjusted to the static load requirement. Operation shall be at a ground speed of 8 km/h ± 0.8 km/h (5 mph ± 0.5 mph) driven by the test wheel and controlled by the action of the operator on the brakes of the non-test wheels. The vehicle shall enter the test area, and the operator engages a throttle actuator while maintaining a ground speed of 8 km/h ± 0.8 km/h (5 mph ± 0.5 mph). The actuator shall be adjustable to allow at least 1.5 seconds for a wheel-speed acceleration from 4 to 25 km/h (2.5 to 15 mph). Testing will be conducted with a control tire at the beginning and end of each test sequence or test matrix and every third test in between. A minimum of ten of these spin-ups shall be made with each test sample and control tire with a coefficient of variation of less than five for sand/pavement/snow, and less than 15 for mud.

A.1.6.7 Constant Speed, Gradually Increasing Slip Drawbar Method

For each test, the test vehicle shall be positioned outside the test course and immediately in front of and connected to the dynamometer vehicle with a cable or drawbar. The test vehicle shall operate in the lowest gear for a ground speed of approximately 4 km/h (2.5 mph) at its optimum engine rpm for maximum torque and proceed into the test course lane with no load on the drawbar. While keeping a constant forward speed, load shall be gradually applied to the drawbar by the dynamometer operator, increasing the power necessary for the test vehicle to maintain the required ground speed. The test vehicle shall gradually increase/modulate engine rpm as necessary while progressing from a zero or no load slip condition to a high load/max slip condition, all while maintaining a constant over the ground speed. Immediately following completion of the first test, the vehicles shall be repositioned at the beginning of the test lane offsetting the tracks of the prior test(s). A minimum of three drawbar tests shall be conducted.

A.1.6.8 Single-Pass to Immobilization Procedure (Virgin Snow)

Prior to starting the test, attention should be given to the forecasted meteorological conditions for the day to ensure there is no snowfall, extreme thermal evolution, or high winds predicted. If the ambient conditions are not expected to be consistent for a long enough time to test both the reference and candidate tires, the reference should bracket the test tire to account for any course evolution. Starting at the entrance to the virgin snow mobility test area with the lowest recorded snow depth, the test vehicle will be operated across the area in a straight line at less than 5 mph. Care should be taken to hold constant speed and maintain a straight line with minimal steering corrections.

External observers will monitor the vehicle progress. At the point of immobilization—defined as loss of forward motive capability, typically exhibited by excessive wheel slip—the observers will signal to the vehicle operator to release the throttle. If the vehicle traverses the entire course without immobilization, a new test lane will be chosen with greater snow depth. This single pass run shall be repeated once to verify consistency.

The following snow measurements shall be taken at the point of immobilization. All measurements should be taken in undisturbed snow and with sufficient distance from the vehicle so that any plowed snow, or snow bulbs, are not a part of the measurements, unless otherwise stated.

- Four in situ snow depth measurements: one at the centerline of the front and rear-most axles, and one each on right and left sides of the vehicle.
- Two snow pits including in situ snow density measurements: one on the opposite side of the vehicle’s exhaust exit and at the midpoint of the vehicle, and one at the front bumper within approximately 12 inches.
- Meteorological data at the approximate time of immobilization.
- Snow CTI readings in the virgin snow and in the wheel imprint directly behind the rear tires.
- Cone penetrometer or Rammsonde profile readings in the virgin snow and the imprint behind the vehicle to quantify the snow compaction characteristics from the bottom of the tire to the frozen ground.

A.1.6.8.1 Snow Depth Measurement Procedure

Except where specified otherwise, snow depth measurements shall be taken using the following procedure.

1. Inspect the probe to ensure it is straight and free of damage.

2. Insert the probe into the snow with the primary axis normal to the ground plane.

3. Apply steady downward force until the frozen ground has stopped movement.

4. After movement stops, grip the probe at the surface of the snow to provide a temporary mark on the straightedge.

5. With a positive grip, remove the probe from the snow.

6. Record the distance between the end of the probe and hand to determine snow depth.

7. If the probe stops progression prematurely, perform another measurement in the immediate vicinity to determine if the reading was due to a foreign object obstructing the measurement path.

A.1.6.8.2 Snow Density Measurement Procedure

To measure the density of the snow, it will be necessary to obtain a known volume of snow and find the mass of the snow sample. Density is defined as mass divided by volume. A snow sampling kit will be utilized to conduct snow density measurements. Snow samples will be taken to determine the snow density. Note that two snow density tests will be required for each immobilized test run. The snow density profiles will be taken on the opposite side of the vehicle's exhaust exit and at the midpoint of the vehicle, as well as at the front bumper. Samples will be taken every 15 cm of snow depth up to 90 cm (as applicable by maximum snow depth mobility of the test vehicle) starting from the surface, using the following procedure.

1. Dig a vertical snow pit down to the frozen ground showing a smooth, flat surface of the entire snow depth.

2. Cut the vertical face of the snow pit with the snow saw provided in the test kit. This vertical face will be the location for all samples to be taken at each layer.

3. Begin at the top layer. Clearly identify which layer is being sampled. Firmly push the snow sampling device into the vertical snow face of the layer using the edges of the device as push points. Then cut the excess snow utilizing a metal shave plate to dress off the front face of the device.

4. Record the snow density, in grams per cubic centimeter (g/cm^3), of the snow within the sampling device.

5. Empty the snow collection device and repeat until all layers have been sampled.

Figure A1 shows an example image of the snow density measurement/snow pit procedure.

Figure A1 - Snow density measurements in snow pit
(photo credit: Nevada Automotive Test Center)

A.1.7 Test Results

A.1.7.1 Single Wheel Tests

Both tabular and graphical data from the ten runs shall be obtained expressing the tractive coefficient of the reference/control tire and the candidate tires as a function of slip velocity. The mean peak tractive coefficient shall be shown as well as the area of the traction curve from 2 to 16 km/h (1 to 10 mph) slip velocity. A statistical analysis showing standard deviation and coefficient of variation of the peak and area for the group of runs is also made. The mean coefficient of friction shall be calculated using the method described in ASTM F1805. The candidates shall be compared to the reference tire using the gradient traction performance index (TPI) described in ASTM F1805.

A.1.7.2 Drawbar Test

Traction in terms of tractive coefficient at various slip values for each test shall be obtained from the test records and plotted as tractive coefficient versus percent wheel slip ([wheel speed - ground speed]/ground speed x 100). A curve shall be drawn through the data to produce the performance curve for each test condition. The highest tractive coefficient value between 0% and 90% slip from the performance curve shall be determined from the tests. Values for candidate tires and reference/control tires for the same surface condition shall be used to compare tire performance, with candidate tires rated as a percentage of the reference/control tire performance.

A.1.7.3 Virgin Snow Mobility Test

At the point of immobilization, all snow measurements will be recorded using the format in Table A1, and the data will be analyzed to determine average snow depth and snow density. Average snow depth for both runs will be determined by averaging all depth measurements taken beside the vehicle and will be considered the maximum virgin snow depth capability of the test vehicle. Digital photographs and video footage also will be used as supplemental reference to document the results of the evaluations. The average snow depth and density should be compared between the candidate and reference tires. The average snow density measured for each configuration set of data shall be within 15% of each other. The snow depth at the point of immobilization should be used to compare performance, with candidate tires rated as a percentage of the reference tires snow depth performance.

Table A1 - Virgin snow mobility data sheet

					Depth from Snow Surface	0 to 15 cm	15 to 30 cm	30 to 45 cm	45 to 60 cm	60 to 75 cm	75 to 90 cm
Run #	Side	Location	Snow Depth cm	Rut Depth cm		Snow Density g/cm^3	Snow Density g/cm^3	Snow Density g/cm^3	Snow Density g/cm^3	Snow Density g/cm^3	Snow Density g/cm^3
	L/R	Front axle									
	L/R	Front axle									
	L/R	Rear axle									
	L/R	Rear axle									
	L/R	Front axle									
	L/R	Front axle									
	L/R	Rear axle									
	L/R	Rear axle									
Average											

A.2 VEHICLE EVASIVE MANEUVER TEST (SEE 4.4.3)

A.2.1 Purpose

This test procedure is intended to be used as a field test procedure; however, the basic criteria are also intended to provide a standard reference for simulation of the basic maneuvers through various mathematical modeling techniques. This document provides a procedure and instructions for instrumentation and equipment, vehicle preparation, and test of single and combination of vehicles. This procedure provides a method to evaluate the stability of vehicles under simulated highway conditions where loss of stability is of primary concern.

A.2.2 Facilities

A.2.2.1 Surface Conditions

Paved Surface: The course shall be flat, level (not to exceed 1% grade) concrete or blacktop, large enough to contain the course shown in Figure A3. Adequate acceleration and deceleration lanes and an adequate safety zone on each side of the course are also required. When performing the wet evasive maneuver, the surface shall be wetted by external means either with a watering truck or sprinkler trickle watering system. The water depth shall not to exceed 1 mm (0.05 inch). In any case, there shall be no dry spots on the test course immediately prior to and during the test. Repeating the test on a gravel surface is optional depending on the vehicle mission profile.

Gravel Surface: The road shoulder should be sufficiently stable to support the vehicle load without significant rutting. It is recommended that standard American Association of State Highway and Transportation Officials (AASHTO), American Society for Testing and Materials (ASTM), and other geotechnical engineering guidelines are followed in the characterization of the gravel surface compaction level. The general recommended practice for road base is to maintain the relative density of the shoulder material in the range of greater than 90%. Where the recommended compaction level is not attainable due to localized factors the engineer should determine and document the existing soil conditions to ensure repeatability of soil strength and surface conditions.

Measurements of the relative density can be made in-situ using devices such as a nuclear densitometer (e.g., Troxler) or in a lab after the maximum compaction is determined using conventional laboratory methods.

A.2.2.2 Surface Coefficients

The paved road and gravel road surface coefficients are measured using ASTM E274 and ASTM F1805, respectively, as guides with the ASTM E1136 or F2493 reference tire. Testing will be conducted on a dry and wet surface for the paved course and on a dry surface for the gravel course.

The paved surface skid resistance measurement test speed shall be 40 mph. The recommended peak skid number (SN) for the dry paved surface is greater than 90 and wet paved surface is greater than 70, measured using ASTM E274 as a guide with the ASTM E1136 or F2493 reference tire.

The recommended peak friction coefficient for the gravel is between 0.5 and 0.7, measured using ASTM F1805 as a guide with the ASTM E1136 or F2493 reference tire.

The wind velocity shall not exceed 16 km/h (10 mph) and both velocity and direction shall be recorded in the test results.

A.2.2.3 Calculation of Test Course Dimensions

See Figure A3 for course calculations.

The test may be repeated on a gravel surface depending on the vehicle mission profile.

A.2.3 Test Vehicle

Vehicles to be tested shall be serviced in accordance with manufacturers' recommended procedures.

Payloads shall be loaded and secured to obtain gross vehicle weight (GVW) in accordance with normal military practice. Additional testing with abnormal payloads should be considered (i.e., loads with high center of gravity, live loads, such as partially full tank trucks, etc.). It is strongly recommended that reasonable loads of these types be investigated to assure stable operation under normal usage. In particular, van bodies should be loaded with a payload distributed throughout the van interior such that the center of gravity of the payload is in the center of the van volume vertically, transversely, and longitudinally. Consideration should be given to testing with representative "worst-case loads" with the load off-center transversely.

A.2.4 Instrumentation

A calibrated device shall be used to measure vehicle speed ±0.3 km/h (±0.2 mph).

A.2.5 Test Preparation

NATO recommended pylons and dimensions are applicable (see Figure A3). Vertical pylons of expendable or deformable material shall be used to mark the course as indicated by the "dots" on Figure A1. Pylons shall be sufficiently high to assure visibility to the driver and without contacting the pylon.

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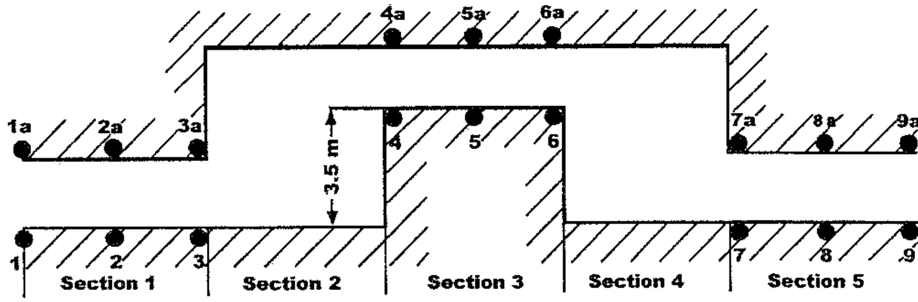
ANNEX A



Lane - change track dimensions

Section 1 : Length = 15 m
Width = 1.1 vehicle width + 0.25 m

Section 2 : Length = Overall length of vehicle*) + 24 m

Section 3 : Length = 25 m
Width = 1.2 vehicle width + 0.25 m

Section 4 : Length = Overall length of vehicle + 24 m

Section 5 : Length = 15 m
Width = 1.1 vehicle width + 0.25 m

*) Overall length of vehicle, measured at 0.50 m from the ground.

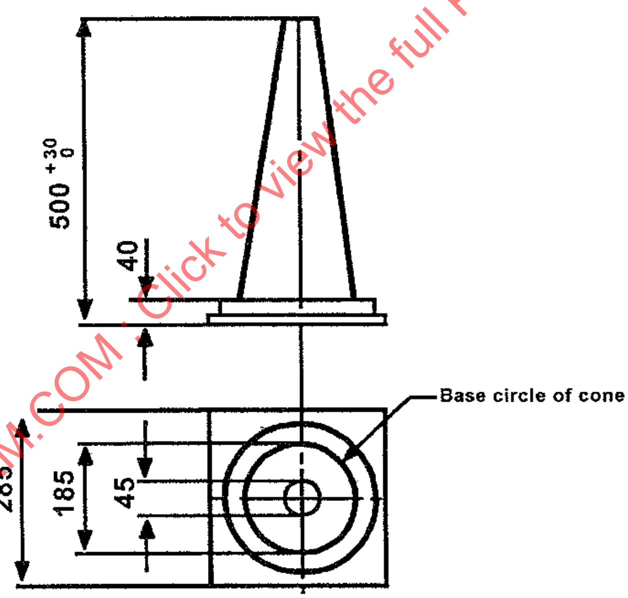


Figure A3 - Course layout and cone dimensions (mm)

A.2.6 Test Procedure

A.2.6.1 Maximum Test Speed

The vehicle shall be driven by a competent test driver well trained and thoroughly familiar with the test vehicle. Successive trials shall be conducted through the test course at gradually increasing speeds to determine the maximum constant speed at which the vehicle (or vehicle combination) can negotiate the course, without contacting any of the pylons or other loss of control. Testing to begin at a target speed of 32 km/h (20 mph). Increase the speed of each run by 8 km/h (5 mph) increments until the operators experience indicates the speed is near end limit. As the speed approaches end limit the speed is increased in 2 mph increments until the end limit speed as been determined. Repeat runs shall be made until the test director is satisfied that the maximum speed has been defined within ±3 km/h (±1.5 mph). The test driver shall be permitted to call any run invalid based solely on his/her judgment.

A.2.6.2 Observers

Observers shall be stationed to:

a. Observe all wheels of the vehicle(s) to note any “lift-off.”

b. Observe any contact between the vehicle and the pylons.

Testing shall include mixed fitment (candidate and reference tires) on same vehicle when applicable to address loss of stability concerns (see 4.2).

A.2.7 Test Results

A.2.7.1 Vehicle Configuration

The configuration of each vehicle payload combination tested shall be recorded in the format shown in Figure A4. (Additional columns should be added as needed for vehicle combinations consisting of more units.) Payload center of gravity and moments of inertia are desirable when available. When these detailed data are not available, a full description of the payload shall be included and as a minimum the individual axle loads shall be recorded for each payload configuration.

For each test run, the data in Figure A5 shall be recorded.

A.2.7.2 Required Data

The results shall include:

a. Average speed: km/h (mph)

b. Cone contact for each run (if any)

c. Area of vehicle that contacted cone(s)

d. Wind speed: km/h (mph)

e. Wind direction

f. Ambient and surface temperature: °C (°F)

Configuration code (for cross-reference) ____________________

Vehicle Description:

Truck/Tractor	Trailer/Semi-Trailer
Make: ____________________	Make: ____________________
Model: ____________________	Model: ____________________
Year Mfr'd: ____________________	Year Mfr'd: ____________________
Serial No.: ____________________	Serial No.: ____________________
Weight as tested: ____________________	Weight as tested: ____________________
Wheelbase: ____________________	Wheelbase: ____________________

Axle Loading: Note axle type in heading (i.e. steer, drive, steer/drive, or tag)

	Axle 1 – Type _____	Axle 2 – Type _____	Axle 3 – Type _____	Axle 4 – Type _____
Suspension Type				
Axle Rating				
Actual Left Load				
Actual Right Load				
OR Total Load				

Continued	Axle 5 – Type _____	Axle 6 – Type _____	Axle 7 – Type _____	Axle 8 – Type _____
Suspension Type				
Axle Rating				
Actual Left Load				
Actual Right Load				
OR Total Load				

Payload narrative description:

____

____

Centers of gravity (estimate if actual not available)

Truck (x): ____________	Truck payload (x): ____________	Truck with payload (x): ____________
Truck (y): ____________	Truck payload (y): ____________	Truck with payload (y): ____________
Truck (z): ____________	Truck payload (z): ____________	Truck with payload (z): ____________
Trailer (x): ____________	Trailer payload (x): ____________	Trailer with payload (x): ____________
Trailer (y): ____________	Trailer payload (y): ____________	Trailer with payload (y): ____________
Trailer (z): ____________	Trailer payload (z): ____________	Trailer with payload (z): ____________

x = longitudinal y = transverse z = vertical

Figure A4 - Descriptive information

Date: ____________ Wind velocity: ___________ Direction: _______________ Friction coefficient: _______________

Configuration code: __________ Run number: __________ Direction: __________ Start from right or left: ___________

Section dimensions: (1)_____________________ (2)_____________________ (3)______________________

(4)_____________________ (5)_____________________

Average Vehicle speed at entry: _________________________ Average Vehicle speed at exit: __________________________

Pylons displaced (record area/number): Entry ______ / ______ : Straightaway ______ / ______: Exit ______ / ______

Wheel lift-off observed: ____

Comments: ____

____

Figure A5 - Test data

A.3 BEAD UNSEATING TEST (SEE 4.4.4)

A.3.1 Purpose

A test method to determine tire slip (tire indexing), air loss or bead unseating when operated at the minimum recommended inflation pressure.

A.3.2 Facilities

The test course layout shall have an equal radius “figure 8” configuration of predetermined asymmetrical curvatures on a level-graded surface within 0.5% grade. Numbers 1 through 8 indicate the position of the pylons. Pylon dimensions are described in A.2.5.1, Figure A3. (See Figure A6.)

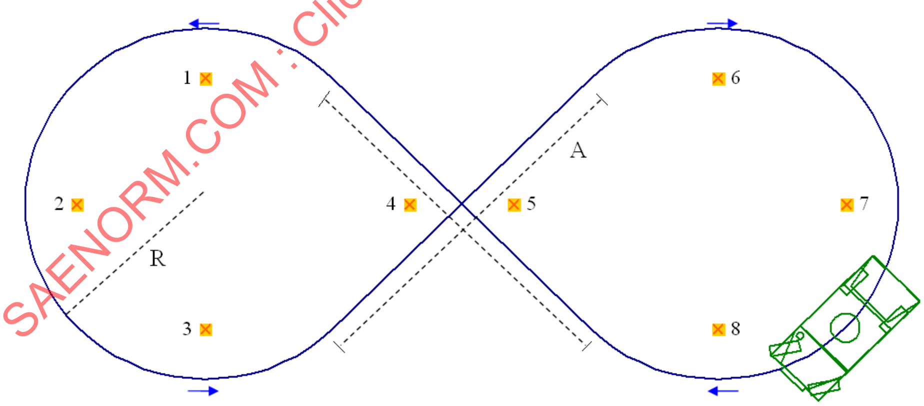


Figure A6 - Bead unseating test

A.3.2.1 Test Course Radius of Curvature (R)

The outer one-half of the opposing curvatures bisected by the length of the course is to be:

The radius at the centerline of the vehicle’s front axle travel path which is produced by steering the vehicle at 90% of its specified full-lock turn.

A.3.2.2 Dimension A

Where “A” is about two times the vehicle wheelbase (A ≈ 2WB).

The course layout is two off-set circles (R) connected by two short crisscrossing straights (A).

A.3.2.3 Test Course Base Material

The test course shall be constructed of sand. The test tire travel path shall be pre-rutted to a depth equal to one-half the tire’s section height at the outside sidewall.

A.3.2.4 Course Grained Soil (Sand)

This test section shall be constructed of sand (SP or SW, as determined by Unified Soil Classification System [USCS]). The depth of the soil shall be at least 750 mm (30 inches), tilled to at least 200 mm (8 inches), and dried to a moisture content of less than 2.0% in the top 75 mm (3 inches) of sand. The cone index at the 75 mm (3 inches) depth shall not exceed 100.

A.3.3 Test Vehicle

The test vehicles shall be loaded so that each individual static test tire load(s) is within ±5% of the maximum tire load for the intended vehicle (unless otherwise specified).

A.3.3.1 Speed

a. A device to measure actual ground speed.

b. A lap time measurement device.

A.3.3.2 Inflation Pressure

A calibrated pressure gauge.

A.3.3.3 Rim Contour/Bead Seat Diameter

TRA disc tape (or equivalent) for bead seat diameter and TRA rim contour gauges (or equivalent) for other rim dimensions relating to tire fitment.

A.3.3.4 Load Scales

Mechanical or electronic weight scales with 2% full-scale accuracy.

A.3.3.5 Environmental Measurements

Ambient temperature and percent relative humidity to be recorded at the beginning and end of each test sequence.

A.3.3.6 Cone Penetrometer

To measure cone index (CI) of test area berm soil before and after each test sequence.

A.3.4 Test Procedure

A.3.4.1 Tire/Wheel/Runflat Assemblies

Inspect and measure test rims to assure they comply with the applicable rim standard (see 4.4.6.2).

All tires and runflat devices shall be mounted for this test using the same procedures. Record maximum inflation pressure required to seat the beads. Inflated tires at test pressure should be stored for at least 24 hours prior to mounting on vehicle.

Test tires shall be broken in by operating them on a hard surface road for 160 km (100 miles) at test load and maximum test inflation pressure at 80 km/h ± 8 km/h (50 mph ± 5 mph) average.

A.3.4.2 Test Tire/Wheel/Runflat Assembly Positions

Test tire/wheel/runflat assemblies shall be mounted on both front steering positions. Any non-test wheel positions shall have tire/wheel/runflat assemblies of the same size, inflation pressure, and normal maximum load distribution.

A.3.4.3 Test Sequence

Test sequence shall start at the intersection of the “figure 8” and proceed clockwise into the first turn. Constant test speed shall be achieved after first “figure 8” lap. Cumulative lap timing for six laps at constant speed shall begin after first lap is completed.

A.3.4.4 Inflation Pressure

Cold tire pressures shall be set at the minimum recommended inflation pressure immediately prior to the start of the six-lap sequence.

Measure inflation pressures and the tire rim rotational displacement (tire movement relative to the rim at the top of the rim flange) at the completion of the six-lap sequence.

If the inflation pressure of the reference/control tire at the conclusion of its run is lower by 7 kPa (1 psi) below the cold inflation pressure at the start of the test, reinflate to the cold inflation pressure. Then rerun the reference/control tire at the next lowest speed increment.

Dismount and disassemble tire/wheel/runflat assemblies to check for and document foreign matter.

A.3.4.5 Test Vehicle Constant Speed Limit

With the reference/control tires installed, the test vehicle speed shall be increased incrementally until the maximum, controllable safe speed has been reached or air loss of 7 kPa (1 psi) has occurred.

A.3.5 Test Results

A.3.5.1 Data Reduction

Data reduction should include:

a. Average speed: km/h (mph)

b. Total distance to air loss: km (miles)

c. Total time to air loss: seconds

d. Measured air loss: kPa (psi)

e. Measured rotational displacement distance of the bead on the rim (arc length): mm (inch)

f. Measured rut depth: mm (inch)

g. Measured ambient and surface temperature: °C (°F)

h. Measured inflation pressure at start and finish: kPa (psi)

i. Measured cone index (CI) of the test area berm soil before and after each test sequence

A.4 MECHANICAL RELIABILITY/(OFF ROAD DURABILITY) TEST (SEE 4.4.7)

A.4.1 Purpose

This is a test to determine a tire/wheel/runflat assembly system's ability to withstand sustained operation on severe off-road conditions.

A.4.2 Facilities

The test course(s) shall be comprised of disjunctive sections of obstacles in a natural environment developed to be discrete, repeatable, and unavoidable. The test course will be a mix of 30% secondary with severe washboard, 30% rock terrain, and 40% cross-country terrain.

A.4.2.1.1 Selecting Test Course (See A.5.3)

The durability course will be selected with the following characteristics as a guideline.

a. Washboard: Amplitude 25 to 100 mm (1 to 4 inches), frequency 200 to 900 mm (8 to 36 inches).

b. Rock terrain: Irregular shaped stone embedded in clay soil with rock size 75 to 150 mm (3 to 6 inches) and protruding 25 to 150 mm (1 to 6 inches) high, at a random spacing frequency of no less than 11 stones per m^2 (1 stone per ft^2).

c. Cross-country: A combination of hills and curves across terrain with embedded stones at a random spacing frequency of no less than 6.6 stones per m^2 (0.6 stones per ft^2). The cross-country shall have a section of rutted trail with stones embedded for direct impingement of the tread and sidewall.

A.4.3 Test Vehicle

The vehicle must be capable of meeting test criteria.

A.4.4 Instrumentation

Profiling equipment or a profiling vehicle equipped and instrumented to continuously measure and record the forces and accelerations will be required to quantify the courses. A measuring device for ground speed will be required for distance measurements along the courses.

The test vehicle will be equipped with kilometer per hour (mile per hour) recording devices, either cable or electronically driven, calibrated to ±2% to provide documentation of test miles achieved.

A.4.5 Test Preparation

A.4.5.1 Tires

Reference/control and candidate tires will be tested on each surface condition.

A.4.5.2 Rims/Wheels/Runflat Devices

The tires shall be mounted on rim/wheels specified in the TRA Yearbook and/or Military Supplement and/or Engineering Design Information, or ETRTO Standards Manual for the size being tested, unless the military specification requires a rim/wheel that differs from the TRA Military Supplement recommendation. In the latter case, the military specification will apply. Rims must be compatible with pressure and the test vehicle. Inspect and measure test rims to assure they comply with the applicable rim standard (see 4.4.6.2).

Runflat devices: Runflats shall be installed in the tire/rim assemblies as required. The runflat devices shall be installed according to the manufacturer's recommendations and marked in a way to identify any slip relative to the rim (tire indexing). All fasteners will be torqued to the manufacturer's recommendations and marked to indicate any change due to testing.

A.4.5.3 Inflation Pressure

Tire pressures shall be per the applicable technical manual based on the mission profile (unless otherwise specified).

A.4.5.4 Break-in

Each of the test samples shall be driven at maximum vehicle speed (not to exceed 90 km/h [55 mph]) on a dry paved surface for 160 km (100 miles) inflated to the highway tire pressure.

A.4.5.5 Initial Measurements

The tires shall be inspected and measured following the break-in. Measurements shall be at six locations around the periphery of each tire and shall include: tread depth at crown and shoulders, section width, tread radius, tread arc width, and outside diameter. Runflat device measurements shall include: overall diameter, foot width, inner diameter, and overall bead lock width.

A.4.6 Test Procedure

A.4.6.1 Test Conditions

A.4.6.2 Tire/Wheel/Runflat Assembly Loads

The test vehicle shall be loaded so that each individual static test tire's load(s) is within ±5% of the maximum tire load for the intended vehicle (unless otherwise specified).

A.4.6.3 Test Cycle

The test tires will be run in sequence of 145 km (90 miles) of secondary (washboard), 145 km (90 miles) of rock terrain, and 193 km (120 miles) of cross-country. This sequence will be repeated to complete a 966 km (600 mile) cycle.

A.4.6.4 Measurement and Recording Data

In addition to the initial tire measurement, each tire shall be measured and inspected at the end of each 966 km (600 mile) cycle. Inspect to establish casing growth, cutting, chipping, bruising, and modes of air loss in accordance with the administration manual failure and performance criteria. This data and the average velocity/mileage calculations will be entered on a test data sheet. At 1932 km and 3864 km (1200 miles and 2400 miles), the tire(s) should be removed from the rim and inspected.

A.4.6.5 Test Duration

A maximum of four cycles for a total of 3864 km (2400 miles) shall be run for acceptable durability of the tires.

A.4.7 Test Results

The distances traveled shall be determined by the measured course length. Odometer readings will be recorded for each course segment for reference. Time for each cycle shall be measured from start to finish of each segment of the test route as recorded on the recording device and driver's log. A segment is defined as the completion of a terrain type and the initiation of the subsequent terrain type.

For purposes of this specification, a road hazard—such as a nail puncture through the tread area—will be repaired using commonly accepted practices of the industry. Within this specification, typical hazards associated with road building, road maintenance, and long term road and terrain degradation (pot holes, washboard, exposed rock, etc.) due to vehicle traffic and environmental errosion may be included in the test condition. A road hazard that cannot be repaired will not be counted against the candidate tire. Road hazards are defined as repairable or non-repairable penetration(s) resulting in air loss or cutting or penetrating damage to the casing from man-made debris on the roadway (such as nails, staples, bolts, screws, glass, metal fragments, wire, fencing material, etc.). This test is not intended to simulate damage from battlefield debris. Specifically excluded from this definition are natural materials 100 mm (4 inches) or less that may either deliberately or accidentally been placed in the roadway (such as stones or rocks). For pass/fail criteria, refer to the Administrator's Manual.

The number of tire failures from the reference and candidate groups is the main metric of performance for this evaluation. A road hazard that cannot be repaired will not be counted against the candidate tire. Road hazards are defined as repairable or non-repairable penetration(s) resulting in air loss or cutting or penetrating damage to the casing from man-made debris on the roadway (such as nails, staples, bolts, screws, glass, metal fragments, wire, fencing material, etc.). Specifically excluded from this definition are natural materials 100 mm (4 inches) or less that may either deliberately or accidentally been placed in the roadway (such as stones or rocks).

A.5 TIRE TREADLIFE DURABILITY TEST (SEE 4.4.8)

A.5.1 Purpose

This is a test to determine the tire/wheel/runflat assembly system's treadlife durability using the vehicle mission profile requirements.

A.5.2 Facilities

A.5.2.1 Test Vehicles

The vehicle (or vehicles if using more than one) used for tire treadlife testing shall be the production or prototype vehicle designed for and specified with the tire size being tested. A suitable alternate can be used provided it has similar vehicle characteristics and suspension system as the production vehicle, has limited service miles, and is properly aligned.

A.5.2.2 Tire/Wheel/Runflat System

A reference/control tire/wheel/runflat system is required for comparison and these tire/wheel/runflat systems must be rotated between vehicles maintaining the same wheel position to experience equal test mileage on each road service condition on all vehicles in the test.

A.5.3 Instrumentation

Profiling equipment or a profiling vehicle equipped and instrumented to continuously measure and record the forces and accelerations will be required to quantify the courses. A measuring device for ground speed will be required for distance measurements along the courses.

A.5.4 Test Course

The test duration shall be a minimum of 16100 km (10000 miles) or the system specification tire mileage requirement. The test surfaces should reflect the mission profile contained in the system specification for the vehicle, for example: 25% paved, 25% rough gravel, 30% level cross-country, and 20% hilly cross-country.

A.5.5 Test Preparation

A.5.5.1 Tires

An appropriate number of tires for the vehicle, including spares, are required for test. These samples shall be production or pre-production tires free of anomalies and conforming to the manufacturer's standards.

A.5.5.2 Rims/Wheels

The tires shall be mounted on rim/wheels specified in the TRA Yearbook and/or Military Supplement and/or Engineering Design Information, or ETRTO Standards Manual for the size being tested, unless the military specification requires a rim/wheel that differs from the TRA Military Supplement recommendation. In the latter case, the military specification will apply. Rims must be compatible with pressure and the test vehicle. Inspect and measure test rims to assure they comply with the applicable rim standard (see 4.4.6.2).

A.5.5.3 Runflat Devices

Runflats shall be installed in the tire/rim assemblies as required. The runflat devices shall be installed according to the manufacturer's recommendations and marked in a way to identify any slip relative to the rim (tire indexing). All fasteners will be torqued to the manufacturer's recommendations and marked to indicate any change due to testing.

A.5.5.4 Break-in

An initial break-in period of not less than 160 km (100 miles) and no more than 480 km (300 miles) shall be run on a dry, paved surface at the highway inflation pressure.

A.5.5.5 Initial Measurements

Each tire shall be inspected and measured following the break-in. Measurements shall be made at a minimum of six equally spaced locations around the periphery of the tire for: tread depth at crown and shoulders, section width, tread radius, tread arc width, outside diameter, and tread profile. Runflat device measurements shall include: overall diameter, cap width, inner diameter, overall bead lock width. Refer to SAE J2013.

A.5.6 Test Procedure

A.5.6.1 Test Conditions

Test courses and the percent mileage on each surface selected for treadwear test shall reflect the mission profile of the vehicle. Refer to Administrator's Manual for listing of tactical vehicles' mission profiles.

A.5.6.1.1 Tire Load

The vehicle load shall reflect the system specification of the vehicle, if known. Unless otherwise specified, 75% of mileage shall be at the maximum GVW of the test vehicle and the remaining 25% of mileage shall be at curb weight plus 50% of payload. The payload shall be placed evenly over the vehicle cargo area.

A.5.6.1.2 Inflation Pressure

Each tire pressure shall be per the applicable technical manual based on the mission profile (unless otherwise specified). Different pressures may be used for highway, cross-country, and mud, sand, and snow conditions.

A.5.6.1.3 Cycle

Each mileage cycle should contain the required mission profile percentage. The wheel assemblies shall be run in sequence for each specified surface condition and vehicle load condition. The cycle should be established so that wheel assemblies are rotated between vehicles at four equally spaced mileage intervals. Each candidate and reference/control wheel assembly being tested shall be rotated between vehicles maintaining the same wheel position to experience equal test mileage on each road service condition on all vehicles in the test. Each wheel assembly's mileage and the vehicle's maximum, minimum and average speed over the test course shall be recorded at each measurement interval.

A.5.6.1.4 Measurement and Data Recording

All tires shall be measured at the start of the test and at eight to 10equally spaced mileage intervals to correspond with driver shift changes, vehicle maintenance schedules, and tire rotations. At each measurement interval the tires should be inspected for damage, scuffing, chipping, and air loss, etc., in accordance with the administration manual failure and performance criteria. Each tire tread condition shall be photographed at the start of the test, mid-point, and test completion. Each tire's mileage and maximum, minimum, and average vehicle speed shall be recorded at each measurement interval.

A.5.6.1.5 Tire Tread Depth Measurements

The tread depth shall be measured and recorded when the tire is new, after 24 hours growth at rated inflation then adjusted to test tire pressure, and at approximately 1600 km (1000 mile) intervals. The tire's sidewall will be marked at a minimum of six equally spaced locations starting at a point adjacent to the DOT or tire serial number. These marks are to be located so they are not worn away or scuffed off during the test. Tread depth measurement must not be taken at treadwear indicators (measurement device must bridge both sides of the groove for accurate measurement).

A.5.7 Test Results

Measure the tread depth for each groove at each measurement point. Determine the amount of tread depth reduction for each measurement, at a given mileage interval, by subtracting the latest measurement from the tread depth at 0 km (mile) and record in 0.025 mm (0.001 inch). Calculate and record the tread depth reduction at each mileage measurement interval.

The fuel economy of each group of candidate assemblies shall be tracked to ensure comparable results between candiadate and referance groups. The fuel economy shall be calculated by using the vehicles odomoter or distances recorded from the instrumentation pacakge and dividing by the total volume of fuel consumed during the testing. Due to variabilty in vehicle idling durations and other vehicle performance differences, this measurement is an approximate method for determining whether the candidate tire/wheel/runflat assembly has a significant impact on the fuel economy over the mission profile.

A.5.7.1 Tire Rate of Wear

The wear rate in km/mm (mile/mil), will be determined by dividing the kilometers (miles) traveled for that interval by the millimeters (mils) of rubber worn away. This procedure will be followed for each measurement point on each groove at each of the six (minimum), equally spaced measurement locations. The tire's average wear rate will be calculated by adding the wear rates of all measurement points and dividing by the total number of measurements for that individual tire. In a case where only three grooves are present, the center groove will be measured and recorded twice. The overall average wear rate for all tires of a given design in the test will be determined by summing the wear rates for all tires and dividing by the total number of tires.

The overall average wear rate will be plotted and compared for both the candidate and reference/control tire at each mileage measurement interval. This graph should be used to establish a wear comparison between the candidate and reference/control tire and as a signal for test or measurement of abnormalities that can occur at a given measurement mileage point. Also, by mutual agreement (between the military and tire manufacturers), the tire wear comparison can be used to stop the test.

A.5.7.2 Percent Tread Consumed

This is a calculation to determine pass/fail, the overall average percent of tread consumed must be determined for the candidate tires and the reference/control tires.

The percent of tread consumed will be determined for each of the six (minimum), equally spaced measurement points on each groove of the tires as follows:

For tread depth measurements in metric units, the metric percent tread consumed use Equation A1:

$$\%\text{ Tread Consumed} = \frac{(\text{OTD} - \text{RTD})}{(\text{OTD} - 3.175)} \times 100 \quad \text{(Eq. A1)}$$

For tread depth measurements in U.S. customary units, the U.S. customary percent tread consumed use Equation A2:

$$\%\text{ Tread Consumed} = \frac{(\text{OTD} - \text{RTD})}{(\text{OTD} - 0.125)} \times 100 \quad \text{(Eq. A2)}$$

where:

OTD = original tread depth in 0.025 mm (0.001 inch)

RTD = remaining tread depth in 0.025 mm (0.001 inch)

0.125 = 4/32 inch, which is military worn tire removal criterion

The tire's average percent of tread consumed will be calculated for each tire by adding the percent of tread consumed at all measurement points and dividing by the total number of measurements for that tire. The overall average percent of tread consumed for all tires of a given design in the test will be determined by summing the tire's average percent of tread consumed for all tires and dividing by the total number of tires.

A.6 COMPARATIVE STOPPING DISTANCE TEST (SEE 4.4.9)

A.6.1 Purpose

This on-vehicle test is used to compare the stopping distance of the reference/control and candidate tire.

A.6.2 Facilities

The same test site and conditions as close as possible shall be used for testing both the reference/control and the candidate tire/wheel/runflat assemblies. Refer to ASTM F1805 for definitions of winter surfaces if comparitive stopping distance is to be conductedon snow and/or ice surfaces. Appendix A.1, Sections A.1.2.4 and A.1.2.5, give surface properties and preperation requirements for snow and ice testing.

A.6.3 Vehicle Preparation

A.6.3.1 Tire Payload

The test vehicle shall be loaded so that each individual static test tire load(s) is within ±5% of the maximum tire load for the intended vehicle (unless otherwise specified).

A.6.3.2 Vehicle Tires

The test vehicle shall be equipped with a full set of the same tires (excluding spares). The tires shall have between 160 km and 480 km (100 miles and 300 miles) of wear on them prior to conducting the brake test. Testing shall include mixed fitment (candidate and reference tires) on same vehicle when applicable to address loss of stability concerns (see 4.2).

A.6.3.3 Rims/Wheels

The tires shall be mounted on rim/wheels specified in the TRA Yearbook and/or Military Supplement and/or Engineering Design Information, or ETRTO Standards Manual for the size being tested, unless the military specification requires a rim/wheel that differs from the TRA Military Supplement recommendation. In the latter case, the military specification will apply. Rims must be compatible with pressure and the test vehicle. Inspect and measure test rims to assure they comply with the applicable rim standard (see 4.4.6.2).

A.6.3.4 Runflat Devices

Runflats shall be installed in the tire/rim assemblies as required. The runflat devices shall be installed according to the manufacturer's recommendations and marked in a way to identify any slip relative to the rim (tire indexing). All fasteners will be torqued to the manufacturer's recommendations and striped to indicate any change due to testing.

A.6.3.5 Vehicle Brakes

Test vehicle brakes and brake system shall be checked and adjusted for proper working condition as specified by the vehicle manufacturer. The brake lining/pad and drum/disc surfaces shall be clean and dry (free from contamination that might reduce friction) and inspected to ensure that the minimum amount of material is present in accordance with the manufacturer's recommendations.

A.6.4 Instrumentation

The test vehicle shall be equipped with fifth wheel or other high-resolution true ground speed and distance-measuring device. The vehicle shall also be equipped with a data recorder for recording speed, time versus braking distance (data to be taken from initial brake application to complete stop of the vehicle). A brake pressure actuated electrical switch shall be installed in the vehicle brake system. The fifth wheel and brake pressure switch shall be wired to the data recorder so that the readings are initiated by application of the brakes, and are continued until release of the brakes. A brake pedal force instrument is optional.

A.6.4.1 Inflation Pressure

The inflation pressure for all tires shall be adjusted when cold. Air pressure in each tire shall be that recommended for the load at the vehicle's maximum highway speed.

A.6.5 Test Preparation

A.6.5.1 Test Conditions and Test Speed

For testing on a paved surface testing shall be conducted on a straight, paved roadway, free of loose material with a slope that is less than 1%. The paved surface temperature shall be less than 60 °C (140 °F) during testing.

For testing on packed snow or ice surfaces, each test shall be conducted in a fresh test area. Snow and ice course preparation is extremely critical for obtaining valid results. Course preparation and snow compaction measurements using CTI snow compaction gauge are made as specified in ASTM F1805. The Standard Reference Test Tire (SRTT) (specifications ASTM E1136 or F2493) shall be used to monitor course conditions in accordance with ASTM F1805.

Vehicle speeds for the brake test shall be as required by the vehicle's end item specification. Unless otherwise specified, test speeds shall be at 64 km/h (40 mph) and 97 km/h (60 mph), on dry pavement, and 64 km/h (40 mph) and 97 km/h (60 mph) on wet pavement. If the vehicle top speed is less than 105 km/h (65 mph), test at 64 km/h (40 mph), and the top speed of the vehicle minus 6 to 13 km/h (4 to 8 mph).

A.6.5.2 Test Procedure

Accelerate the vehicle to above the required test speed. With automatic or manual transmission in gear and engaged, allow vehicle to coast and slow down to the required speed as indicated by the fifth wheel. At the required speed, apply brakes at maximum effort. A predetermined brake pedal force may be used for consistent maximum braking. Record any unusual handling characteristics that occurred during braking. Repeat the test traveling in the opposite direction. Repeat the test for a minimum of three runs in each direction. Allow sufficient time between each run to prevent brakes and tires from overheating. Testing of candidate and the reference/control tires shall be conducted in equivalent atmospheric conditions using the same test vehicle, instrumentation, and test site.

A.6.5.3 Test Results

The tire average stopping distance shall be an average of the distances recorded using a minimum of six data points within ±3 seconds (standard deviation).

a. Speed at point of brake application: ±0.3 km/h (±0.2 mph)

b. Stopping distance: ±0.3 m (±1 foot)

Information documenting test control (optional):

c. Time to stop: ±0.1 second

d. Pedal force: ±2 kg (±5 pounds)

e. Deceleration rate (measured): 0.3 m/s (±1 ft/s)

f. Static wheel load: ±2% of reading

g. Tire inflation pressure: ±14 kPa (±2 psi) at start of each sequence

h. Road surface temperature: ±1 °C (±2 °F)

i. Tire tread surface temperature: ±1 °C (±2 °F)

j. Ambient temperature: ±1 °C (±2 °F)

k. Wind speed and direction: ±0.4 m/s (±1.5 ft/s)

A.6.6 Mix Fitment Recommendations

If multiple candidates and/or multiple tire/rim/runflat assemblies are previously qualified for the vehicle, a mixed fitment is recommended.

A.7 MISSION PROFILE RUNFLAT TEST (SEE 4.4.13)

A.7.1 Purpose

The purpose of the mission profile runflat test is to ensure that the tire/wheel/runflat assembly can withstand rifle fire and allow continuous mobility of the vehicle for a specified distance, speed, and terrain type.

A.7.2 Facilities

Refer to the administrator's manual for the required total miles.

All dynamic testing will be videotaped. The video recording will include a time stamp and will not be edited. Photographs of all test articles and ancillary parts (e.g., bolts, washers, nuts, etc.) will be taken before and after testing.

A.7.3 Test Vehicle

The vehicle shall be the production or prototype vehicle designed for and specified with the tire size being tested. A suitable alternate can be used provided it has similar vehicle characteristics and suspension system as the production vehicle, has limited service miles, and is properly aligned.

A.7.4 Instrumentation

- A device to measure actual ground speed
- A device to measure distance traveled
- A device to measure the ground and tire surface temperature

A.7.5 Test Preparation

Prior to testing all tires and wheels will be marked to determine tire rotation relative to the wheel.

Two or more samples of each tire and wheel/runflat device group will be damaged in accordance with FINABEL 20.A.5 or A.20.A standard.

If the candidate runflat system is a multi-segmented device containing radial breaks (breaks perpendicular to circumference), the punctured quadrant will contain a segment mating surface. Punctured tires will be installed on the right side of the vehicle, on the front and rear axles, or on multiple axles as required.

A.7.6 Test Procedure

Testing will occur with ambient temperatures above 20 °C (68 °F). When applicable, any large, loose rock of approximately 6 inches or greater will be removed from the test courses and it will be ensured that all courses are dry and free from standing water.

If severe circumferential breaks in the tire assemblies (such as the tread breaking away from the sidewall) cause interference with the vehicle underbody or its operation, the vehicle will be stopped. The time, temperature and mileage shall be recorded.

If the test involves a fabric body ply tire, the tread may be cut away if requested by the testing sponsor. Prior to and at the conclusion of tread removal the time, tire temperature and ground temperature will be recorded. Down time will be minimized as much as possible to maintain test assembly temperatures. After tread removal the time, tire temperature and ground temperature will be recorded. Testing will then be immediately resumed with the runflat fully exposed.

Thermal profiling measurements will be conducted initially, at three evenly spaced locations throughout the test course, and at the conclusion of testing. These measurements will include ambient temperature, ground temperature and tire (outer sidewall shoulder junction and tread) or exposed runflat temperatures for all test assemblies.

A.7.7 Test Sequence

- Primary road
- Secondary road
- Trail (depending on mission profile)
- Cross country

Mileage for each condition shall be proportional to the mission profile for the vehicle system.

A.7.8 Test Results

Testing will be terminated upon the occurrence of any of the following:

- Inability of the operator to maintain control of the vehicle
- Inability of the vehicle to be operated safely
- Inability of the vehicle to maintain continuous mobility
- Reduction in speed not attributed to measurement interval
- Any of the wheel rims contacting the ground
- Irreparable vehicle damage is imminent
- Completion of required mileage accumulation

The post-test inspection will include a system tear down. Any remaining deflated tire, wheel and runflat parts will be recovered and inspected for slip, wear and damage. The inspection will also include examination of the wheels for bent or damaged flanges, tire-to-wheel slip (tire indexing), and tire beads and/or runflat spacers dislodged from the wheel. For pass/fail criteria, refer to the Administrator's Manual.

A.8 PAVED RUNFLAT TEST (SEE 4.4.14)

A.8.1 Purpose

The purpose of the paved runflat test is to ensure that the tire/wheel/runflat assembly can withstand rifle fire and allow continuous mobility of the vehicle over a paved primary road surface for 30 miles at 30 mph.

A.8.2 Facilities

The surface used for this evaluation shall consist of primary roads as described in the mission profile. The course shall be flat, level (not to exceed 1% grade) concrete or blacktop. Adequate acceleration and deceleration lanes and an adequate safety zone on each side of the course are also required.

All dynamic testing will be videotaped. The video recording will include a time stamp and will not be edited. Photographs of all test articles and ancillary parts (e.g., bolts, washers, nuts, etc.) will be taken before and after testing.

A.8.3 Test Vehicle

The vehicle shall be the production or prototype vehicle designed for and specified with the tire size being tested. A suitable alternate can be used provided it has similar vehicle characteristics and suspension system as the production vehicle, has limited service miles, and is properly aligned.

A.8.4 Instrumentation

- A device to measure actual ground speed
- A device to measure distance traveled
- A device to measure the ground and tire surface temperature

A.8.5 Test Preparation

Prior to testing, all tires and wheels will be marked to determine tire rotation relative to the wheel.

Two or more samples of each tire and wheel/runflat device group will be damaged in accordance with FINABEL 20.A.5 or A.20.A standard.

If the candidate runflat system is a multi-segmented device containing radial breaks (breaks perpendicular to circumference) the punctured quadrant will contain a segment mating surface. Punctured tires will be installed on the right side of the vehicle, on the front and rear axles, or on multiple axles as required.

A.8.6 Test Procedure

Testing will occur with ambient temperatures above 20 °C (68 °F). When applicable, any loose rocks will be removed from the test courses and it will be ensured that all courses are dry and free from standing water.

If severe circumferential breaks in the tire assemblies (such as the tread breaking away from the sidewall) cause interference with the vehicle underbody or its operation, the vehicle will be stopped. The time, temperature, and mileage shall be recorded.

If the test involves a fabric body ply tire, the tread may be cut away if requested by the testing sponsor. Prior to and at the conclusion of tread removal the time, tire temperature and ground temperature will be recorded. Down time will be minimized as much as possible to maintain test assembly temperatures. After tread removal the time, tire temperature and ground temperature will be recorded. Testing will then be immediately resumed with the runflat fully exposed.

Thermal profiling measurements will be conducted initially, at three locations throughout the test course, and at the conclusion of testing. These measurements will include ambient temperature, ground temperature, and tire (outer sidewall shoulder junction and tread) or exposed runflat temperatures for all test assemblies.

A.8.7 Test Results

Testing will be terminated upon the occurrence of any of the following:

- Inability of the operator to maintain control of the vehicle
- Inability of the vehicle to be operated safely
- Inability of the vehicle to maintain continuous mobility
- Reduction in speed not attributed to measurement interval
- Any of the wheel rims contacting the ground
- Irreparable vehicle damage is imminent
- Completion of required mileage accumulation

The post-test inspection will include a system tear down. Any remaining deflated tire, wheel, and runflat parts will be recovered and inspected for slip, wear, and damage. The inspection will also include examination of the wheels for bent or damaged flanges, tire-to-wheel slip (tire indexing), and tire beads and/or runflat spacers dislodged from the wheel. For pass/fail criteria, refer to the Administrator's Manual.

A.9 CURB IMPACT TEST (SEE 4.4.15)

A.9.1 Purpose

The tire/wheel/runflat assemblies will be tested to evaluate if the candidate component adversely affects the vehicle occupants' health and/or comfort and to establish whether or not the candidate device prematurely degrades the tire, after impacting an 8-inch curb at a 0 degree and 45 degree angle of approach. Occupant comfort is quantified by measuring the peak vertical acceleration experienced at the base of the driver's seat. TOP 1-1-014 specifies 2.5 g as the maximum vertical acceleration that can be attained without posing risk to occupant health and safety.

A.9.2 Facilities

An 8-inch curb that is similar to a typical curb dimension is recommended which conforms to NATO AVTP 03-170 specifications. Testing may be done on any sized curb required by the administrator's manual or other source.

A.9.3 Test Vehicle

The test vehicle shall be inspected to ensure that no previous testing has degraded the suspension or ride height that may affect the outcome of the results. Mount tire/wheel/runflat assemblies in all wheel positions.

A.9.4 Instrumentation

Speed and a driver's seat base accelerometer measured at a minimum of 500 Hz. All accelerometer data shall be filtered using a 30 Hz low pass filter in accordance with TOP 1-1-014.

A.9.5 Test Preparation

Tires will be X-rayed prior to assembly and after a post-test teardown inspection. Pre- and post-test X-rays will be compared in order to quantify damage to the tire structure as a result of testing.

Vehicle springs will be measured before and after test groups of each candidate to prevent unnoticed spring sag, which would impact the results of the evaluation.

Prior to testing all tires and wheels will be marked to determine tire rotation relative to the wheel. All assembly fasteners will be marked so that movement can be visually identified.

A.9.6 Test Procedure

Height, weight, and gender of the vehicle driver will be documented in the test log.

Test tire inflation pressure(s) will as specified by test sponsor; for example, cross country, highway, etc.

All testing will be videotaped. The video recording will include a time stamp and will not be edited. Photographs will be taken of the wheel assembly including ancillary parts (bolts, washers, nuts, etc.) before and after testing.

The curb will be painted prior to each run in order to identify the point of contact with the tire. After each curb impact, the marking will be transferred to the lower sidewall for future inspection.

The test vehicle will be driven over the curb obstacle at a 0 degree angle of approach (perpendicular to obstacle) while a constant speed is maintained. The initial speed will be determined by operator experience and will be chosen to induce less than 2.5 g of vertical acceleration at the base of the driver's seat. Speed and acceleration data will be acquired for a sufficient period to capture the entire event and vehicle response. The test run will be repeated with the speed increasing in 2 mph increments until a minimum of 2.5 g of vertical acceleration is achieved.

Collected acceleration data will be post-processed with a 30 Hz low-pass filter in accordance with TOP 1-1-014. The speed and peak acceleration will be plotted for each run and a power law regression line will be applied to the data. The speed at which exactly 2.5 g is achieved will be interpolated from this regression line.

After achieving required speed, repeat interpolation procedure five additional times so as to produce five consecutive independent estimates of speed. Standard deviation of these six speed values shall be less than 1 mph. Test shall be repeated at a 45 degree angle of approach on the driver side of the vehicle. Candidate runflat shall be subjected to the same speed and "number of curb impacts" as the control runflat.

At the immediate end of dynamic testing, prior to disassembly, a pressure gauge with a threaded valve stem will be attached to the inflation valve of each tire. Tire pressure and ambient temperature will be recorded immediately after testing, 24 hours static, 48 hours static, and 2 weeks static. Due to the possibility of the pressure gauge inaccuracies, at the conclusion of the 2 weeks, the gauge will be checked against a master gauge and an offset applied if necessary. In the event that a leak occurs and it is found to be due to the gauge, the tire will be re-inflated to the test pressure and the 2 week time period will be restarted.

At the end of all curb impact testing each tire will undergo a post-test inspection that will include a system tear down. The runflat device, wheel, and inside of the tires will be inspected for damage or other anomalies. Assembly fasteners will be checked for adequate torque with paint markings and wheels will be checked for damaged or bent flanges.

A.9.7 Test Results

The candidate assembly must meet the failure criteria requirements of SAE J2014 Administrator's Manual, 4.4.15:

All results will be compared to the reference wheel assembly to determine changes in performance. For pass/fail criteria, refer to the Administrator's Manual.

A.10 HALF ROUND TEST (SEE 4.4.16)

A.10.1 Purpose

The objective of half round testing is to determine a candidate assembly's effects on the vehicle's suspension while driving over 6-, 8-, 10-, or 12-inch half round obstacles. Half round performance is determined by interpolating the maximum speed the vehicle can traverse the obstacle before achieving 2.5 g of peak vertical acceleration at the driver's seat or CG location. TOP 1-1-014 defines the 2.5 g as the maximum allowable acceleration without posing significant risk to occupant health and safety.

A.10.2 Facilities

Testing will be conducting over a half round as described in TOP 1-1-014. The height of the half round will be determined by the maximum the vehicle is capable of traversing without significant damage to the vehicle suspension/underside.

A.10.3 Test Vehicle

The test vehicle shall be inspected to ensure that no previous testing has degraded the suspension or ride height that may affect the outcome of the results. Mount tire/wheel/runflat assemblies in all wheel positions.

A.10.4 Instrumentation

Speed and a driver's seat base accelerometer measured at a minimum of 500 Hz. All accelerometer data shall be filtered using a 30 Hz low pass filter in accordance with TOP 1-1-014.

A.10.5 Test Preparation

Tires will be X-rayed prior to assembly and after a post-test teardown inspection. Pre- and post-test X-rays will be compared in order to quantify damage to the tire structure as a result of testing.

Vehicle springs will be measured before and after test groups of each candidate to prevent unnoticed spring sag, which would impact the results of the evaluation.

Prior to testing all tires and wheels will be marked to determine tire rotation relative to the wheel. All assembly fasteners will be marked so that movement can be visually identified.

Test tire inflation pressure(s) will be as specified by test sponsor; for example, cross country, highway, etc.

A.10.6 Test Procedure

Height, weight, and gender of the vehicle driver will be documented.

All testing will be videotaped. The video recording will include a time stamp and will not be edited. Photographs will be taken of the wheel assembly including ancillary parts (bolts, washers, nuts, etc.) before and after testing.

In accordance with TOP 1-1-014, the vehicle will be driven over the half round obstacle while a constant speed is maintained. The vehicle will be orientated perpendicular to the half round so both front tires hit simultaneously. The initial speed will be determined by operator experience and will be chosen to induce less than 2.5 g of vertical acceleration at the base of the driver's seat. Speed and acceleration data collection will start before the front tires encounter the obstacle and will be stopped after the rear tires have passed over the half round. The speed will then be increased in 2 mph increments until a minimum 2.5 g of vertical acceleration is achieved at the driver's seat base. If excessive speeds are required to achieve the 2.5 g that affects vehicle limitations, the test shall be reevaluated.

If steering has to be used while traversing the half round (other than for keeping the vehicle perpendicular to the obstacle) the test results will not be considered valid and the run will be repeated.

Collected acceleration data will be post-processed with a 30 Hz low-pass filter, in accordance with TOP 1-1-014. The speed and peak acceleration data will be plotted for each run and a power law regression will be applied to the data. The speed at which exactly 2.5 g is achieved will be interpolated from this regression line.

At the end of all half round testing each tire will undergo a post-test inspection that may include a system tear down. The runflat device, wheel and inside of the tires will be inspected for damage or other anomalies. Assembly fasteners will be checked for adequate torque and wheels will be checked for damaged or bent flanges.

A.10.7 Test Results

The candidate assembly must meet the failure criteria requirements of SAE J2014 Administrator's Manual, 4.4.16:

All results will be compared to the reference wheel assembly to determine changes in performance. For pass/fail criteria, refer to the Administrator's Manual.

A.11 RIDE QUALITY TEST (SEE 4.4.17)

A.11.1 Purpose

The objective of the ride quality test is to determine if there is any adverse ride, handling or stability characteristics attributable to the candidate assembly. Ride quality performance is quantified by determining the maximum speed the vehicle can traverse a root mean square (RMS) repetitive roughness course, before achieving 6 W of absorbed power at the base of the driver's seat and/or using the weighted acceleration over wave number spectrum (WNS) representative roughness courses and the exposure time of 2 hours, after which occupant health risks are likely criteria from ISO 2631. TOP 1-1-014 defines 6 W as the maximum sustainable absorbed power the human body can endure for 8 hours before injury and/or physical damage occur.

A.11.2 Facilities

Testing for absorbed power will be conducted over RMS ride quality courses as described in TOP 1-1-014. RMS courses typically vary between 0.5 inch and 4 inches RMS, depending on the vehicle application.

Testing for weighted accleration and exposure time will use WNS roughness courses ranging in roughness from 0.5 inches to 4 inches RMS. The WNS courses represent a broader range of terrain to more accurately encompass mission profile operation. The WNS courses include high coherence (HC) and low coherence (LC) terrain, coherence being a measure of uniformity between the left and right wheel paths. Low coherence denotes courses in which the wheel paths are non-uniform, which tends to induce lateral acceleration, roll, and yaw to the vehicle dynamics. WNS courses also vary in the spatial frequency characteristics of the course—with dominant frequencies on the high end of the spectrum, such as washboard and embedded rock, or on the low end, which is representative of rolling terrain. It should be understood that while the mission profile courses are referred to as high and low coherence, both coherence conditions are considerably lower than the RMS courses, which have almost identical profiles with regard to displacement and phase for the left and right wheel paths.

A.11.3 Test Vehicle

The test vehicle shall be inspected to ensure that no previous testing has degraded the suspension or ride height that may affect the outcome of the results.

A.11.4 Instrumentation

Speed and a driver's seat base triaxial accelerometer measured at a minimum of 500 Hz. All accelerometer data shall be used to calculate absorbed power and weighted acceleration in accordance with TOP 1-1-014.

A.11.5 Test Preparation

Tires will be X-rayed prior to assembly and after a post-test teardown inspection. Pre- and post-test X-rays will be compared in order to quantify damage to the tire structure as a result of testing.

Vehicle springs will be measured before and after test groups of each candidate to prevent unnoticed spring sag, which would impact the results of the evaluation.

Prior to testing all tires and wheels will be marked to determine tire rotation relative to the wheel. All assembly fasteners will be marked so that movement can be visually identified.

A.11.6 Test Procedure

Height, weight, and gender of the vehicle driver and any additional occupants will be documented in the test log.

Test tire inflation pressure(s) will be as specified by test sponsor; for example, cross country, highway, etc.

All testing will be videotaped. The video recording will include a time stamp and will not be edited. Photographs will be taken of the wheel assembly including ancillary parts (bolts, washers, nuts, etc.) before and after testing.

In accordance with TOP 1-1-014 the vehicle will be driven over the RMS or WNS course while a constant speed is maintained. The initial speed will be determined by operator experience and chosen to induce less than 6 W of absorbed power at the base of the driver's seat or acceleration less then 1.73 m/s^2 in any axis which correlates to the 2 hour exposure limit. Speed and acceleration data collection will begin when the rear axle crosses the entrance to the course and end when the front axle crosses the exit. The speed will be increased in 2 mph increments until a minimum of 6 W of absorbed power or 1.73 m/s^2 in any axis is achieved at the driver's seat base . The speed and absorbed power data will be plotted for each run and a power law regression applied to the data. The speed at which exactly 6 W is achieved will be interpolated from this regression line.

Whereas RMS ride quality analysis focuses on the vertical axis only, additional analysis using weighted acceleration in all three axes will be used as the evaluation metric, per ISO 2631, Mechanical Vibration and Shock - Evaluation of Human Exposure to Whole-Body Vibration, Part 1: General Requirements, dated 1 May 1997. Power law regression lines are used to determine the minimum speed at which any one axis exceeds 1.73 m/s^2 of weighted acceleration, which corresponds to an exposure time of 2 hours, after which occupant health risks are likely.

The 6 W/weighted acceleration speed will be plotted as a function of RMS/WNS terrain roughness to determine a ride quality curve for each test configuration.

At the end of ride quality testing, each tire will undergo a post-test inspection including a system tear down. The runflat device, wheel, and inside of the tires will be inspected for damage or other anomalies. Assembly fasteners will be checked for adequate torque and wheels will be checked for damaged or bent flanges.

A.11.7 Test Results

The candidate assembly must meet the failure criteria requirements of SAE J2014 Administrator's Manual, 4.4.17:

All results will be compared to the reference wheel assembly to determine changes in performance. For pass/fail criteria, refer to the Administrator's Manual.

A.12 MISSION PROFILE SPEED EVALUATION TEST (SEE 4.4.18)

A.12.1 Purpose

The objective of the mission profile speed evaluation is to determine if there are any adverse ride, handling, or stability characteristics attributable to the candidate assembly. Mission profile ride quality performance is quantified by determining the maximum speed the vehicle can traverse a mission terrain course, before achieving 6 W of absorbed power at the base of the driver's seat. TOP 1-1-014 defines 6 W as the maximum sustainable absorbed power the human body can endure for eight hours before injury and/or physical damage occur. Additionally, the acceleration and turning radius of the vehicle are to be evaluated on mission profile terrain to determine adverse operational performance attributed to the candidate assembly. For the mission profile evaluation, course speeds are set with the reference assembly and rerun with the candidate at the same speed. Additional runs may be done at a higher speed as required.

A.12.2 Facilities

Testing will be conducted over terrain defined in the administrator's manual. Course selection must be repeatable.

A.12.3 Test Vehicle

The test vehicle shall be inspected to ensure that no previous testing has degraded the suspension or ride height that may affect the outcome of the results.

A.12.4 Instrumentation

Speed and a driver's seat base accelerometer measured at a minimum of 500 Hz. All accelerometer data shall be used to calculate absorbed power in accordance with TOP 1-1-014.

A.12.5 Test Preparation

Tires will be X-rayed prior to assembly and after a post-test teardown inspection. Pre- and post-test X-rays will be compared in order to quantify damage to the tire structure as a result of testing.

Vehicle springs will be measured before and after test groups of each candidate to prevent unnoticed spring sag, which would impact the results of the evaluation.

Prior to testing all tires and wheels will be marked to determine tire rotation relative to the wheel. All runflat fasteners will be marked so that movement can be visually identified.

Test tire inflation pressure(s) will be as specified by test sponsor; for example, cross country, highway, etc.

A.12.6 Test Procedure

Height, weight, and gender of the vehicle driver and any additional occupants will be documented in the test log.

All testing will be videotaped. The video recording will include a time stamp and will not be edited. Photographs will be taken of all test article including ancillary parts (bolts, washers, nuts, etc.) before and after testing.

In accordance with TOP 1-1-014, the vehicle will be driven over the mission profile course while a constant speed is maintained. The initial speed will be determined by operator experience and chosen to induce less than 6 W of absorbed power at the base of the driver's seat. Speed and acceleration data collection will begin when the rear axle crosses the entrance to the course and end when the front axle crosses the exit. The speed will be increased in 2 mph increments until a minimum of 6 W of absorbed power is achieved at the driver's seat base or until the maximum speed allowable is attained due to safety or course limitations.

Once the max speed is determined for the mission profile course, a max effort acceleration evaluation should be conducted. The acceleration runs should start with the vehicle at a dead stop and accelerate up to the max speed for that course. Average time to reach the max course speed should be measured. Acceleration evlatuations shall be repeated at least two times for each candidate/reference assembly on each mission profile terrain type. Subjective traction characteristics (i.e. wheel slip, traction hop, etc) and vehicle traction control response should be recorded in the test log.

The minimum turning radius of the vehicle on mission profile terrrain shall be evaluated while the vehicle is configured for each terrain type that is being tested on (i.e. cross country terrain requires vehicle use cross country CTIS/drivetrain settings). The turning radius should be done at slow speed (less than 5 mph) and should be repeated at least two times for each candidate/reference assembly on each mission profile terrain type. Any adverse effects to turning and handling should be noted in the test log.

When testing over the mission profile course the ride quality limit of the vehicle may not be achievable due to traction and mobiliy limitations. When this occurs the test director will set the test speed basd on traction, mobility, ride quality and safe operation of the vehicle.

At the end of ride quality testing, each tire will undergo a post-test inspection including a system tear down. The runflat device, wheel, and inside of the tires will be inspected for damage or other anomalies. Assembly fasteners will be checked for adequate torque and wheels will be checked for damaged or bent flanges.

A.12.7 Test Results

Results of the candidate and reference assembly at identical mission profile speeds will be compared to determine any change in absorbed power at the driver's seat base. On courses that both the candidate and reference assemblies were able to reach 6 watts will be compared based on their 6 W speeds.

The candidate must meet the failure criteria requirements of SAE J2014 Administrator's Manual, 4.4.18:

All results will be compared to the reference wheel assembly to determine changes in performance. For pass/fail criteria, refer to the Administrator's Manual.

A.13 HIGH SPEED EVALUATION TEST (SEE 4.4.19)

A.13.1 Purpose

The objective of high speed testing is to investigate the effect of combined vibration and environmental forces on the candidate assemblies.

A.13.2 Facilities

The course shall be flat, level (not to exceed 1% grade) concrete or blacktop. Adequate acceleration and deceleration lanes and an adequate safety zone on each side of the course are also required.

A.13.3 Test Vehicle

The vehicle shall be the production or prototype vehicle designed for and specified with the tire size being tested. A suitable alternate can be used provided it has similar vehicle characteristics and suspension system as the production vehicle, has limited service miles, and is properly aligned.

A.13.4 Instrumentation

An instrumentation package shall be installed in the test vehicle to support the high speed evaluation:

- Ground speed
- Distance

A.13.5 Equipment

The following equipment is needed to support testing:

- Calibrated infrared thermometer
- Infrared thermal imaging camera (optional)
- Ambient temperature sensor
- A device to measure actual ground speed
- A device to measure distance traveled
- A device to measure the ground and tire surface temperature

A.13.6 Test Preparation

Prior to testing, all assembly bolts, nuts, and fasteners will be marked with paint to indicate movement. Tires and wheels will be marked to determine tire rotation relative to the wheel.

A.13.7 Test Procedure

Testing will be conducted with an ambient temperature of at least 20 °C (68 °F).

The test vehicle will be driven at the maximum speed of the vehicle, tire or runflat system, whichever has been identified as the limiting factor, for a total of 100 miles. Acceleration (full throttle acceleration) and deceleration (hard stops from full speed at every temperature stop without tire lockup) will occur throughout measurement intervals.

Thermal profiling measurements will be taken immediately before the test begins and at 24 km (15 miles), 72 km (45 miles), 121 km (75 miles), and 161 km (100 miles). Measurements will include ambient temperature, ground temperature, and tire temperature (outer sidewall, shoulder junction, and tread) for all wheel assemblies.

At the conclusion of testing, all test assemblies will be removed from the vehicle and inspected in detail for failures and anomalies. This inspection will include dismounting the tire from the wheel for examination of bead area and inner liner, measuring torques for lock nuts and lug nuts and inspecting the runflat device (including all fasteners) for damage, looseness, movement relative to initial marking, or any abnormalities that would cause the device not to perform its function.

A.13.8 Test Results

The candidate assembly must meet the failure criteria requirements of SAE J2014 Administrator's Manual, 4.4.19. Any anomalies during test shall be noted.

All results will be compared to the reference wheel assembly to determine changes in performance. For pass/fail criteria, refer to the Administrator's Manual.

A.14 TIRE UNDERBODY IMPINGEMENT TEST (SEE 4.4.21)

This test requires a paved incline of between 16 degrees and 25 degrees (28.7 to 46.6% slope). When properly executed, the test imposes full jounce and full rebound with simultaneous full-lock steer, both right and left, on each front tire, all at creep speed. In so doing, maximum tire displacement relative to the chassis and body occurs, producing a "worst-case" scenario for contact of the tire with underbody vehicle structures.

The test consists of four maneuvers. The resulting matrix of front axle tire displacements produced is:

A.14.1.1 Manuever 1 (Forward up the Ramp from the Right), Figure A7

Right tire: full right steer, full jounce.

Left tire: full right steer, full rebound.

A.14.1.2 Maneuver 2 (Forward up the Ramp from the Left), Figure A8

Right tire: full left tire, full rebound.

Left tire: full left steer, full jounce.

A.14.1.3 Manuever 3 (Reverse up the Ramp from the Right), Figure A9

Right tire: full left steer, full jounce.

Left tire: full left steer, full rebound.

A.14.1.4 Maneuver 4 (Reverse up the Ramp from the Left), Figure A10

Right tire: full right steer, full rebound.

Left tire: full right tire, full jounce.

A.14.2 Maneuver 1

Park 90 degrees to the ramp, with the right front tire about 2 feet away from the right lower corner of the ramp. Steer full right and drive forward very slowly. Stop when the left front tire is nearest to full rebound. The vehicle should be approximately balanced on the right front and left rear tires. The observer should then check for under body impingement of both front tires.

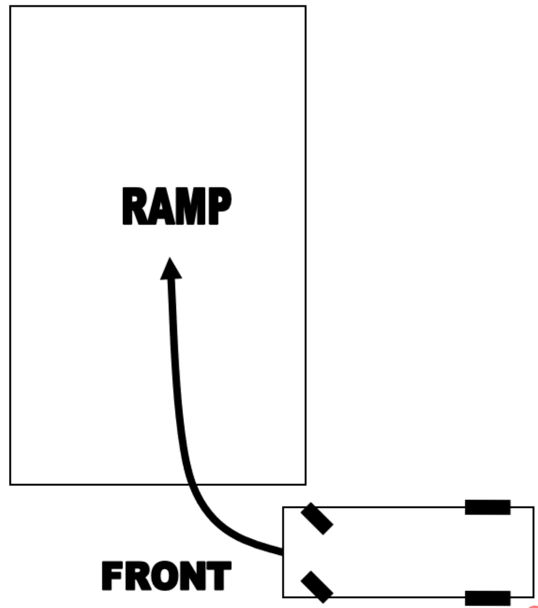


Figure A7 - Maneuver 1 - tire underbody impingement test

A.14.3 Maneuver 2

Park 90 degrees to the ramp, with the left front tire about 2 feet away from the left lower corner of the ramp. Steer full left and drive forward very slowly. Stop when the right front tire is nearest to full rebound. The vehicle should be approximately balanced on the left front and right rear tires. The observer should then check for under body impingement of both front tires.

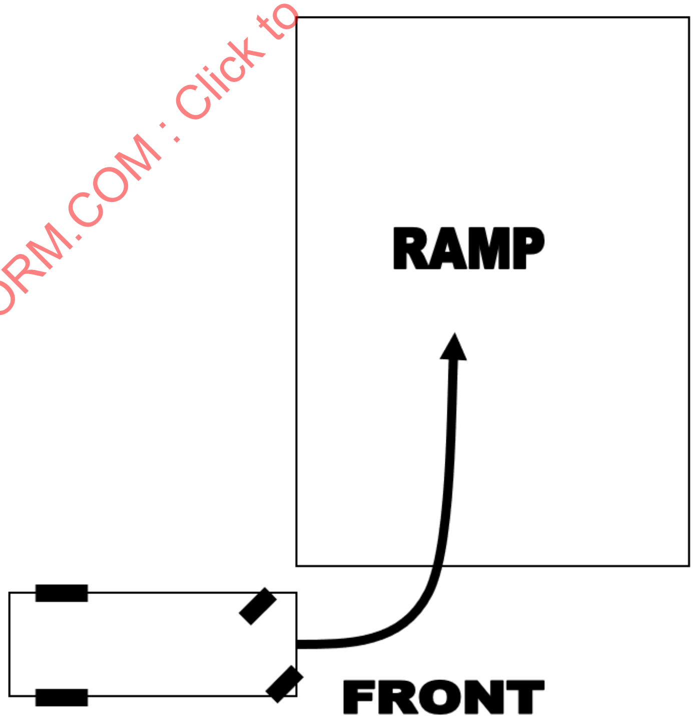


Figure A8 - Maneuver 2 - tire underbody impingement test

A.14.4 Maneuver 3

Park 90 degrees to the ramp, with the left rear tire about 2 feet away from the right lower corner of the ramp. Steer full left and reverse very slowly. Stop when the left front tire is nearest to full rebound. The vehicle should be approximately balanced on the left rear and right front tires. The observer should then check for under body impingement of both front tires.

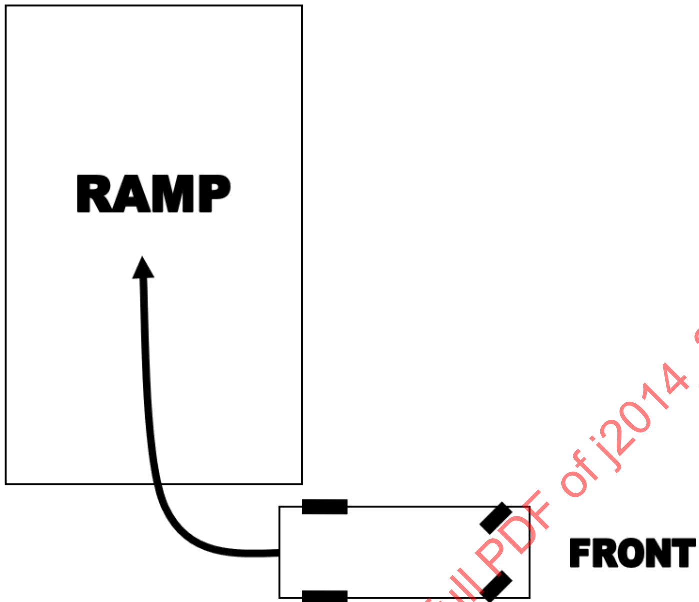


Figure A9 - Maneuver 3 - tire underbody impingement test

A.14.5 Maneuver 4

Park 90 degrees to the ramp, with the right rear tire about 2 feet away from the left lower corner of the ramp. Steer full right and reverse very slowly. Stop when the right front tire is nearest full rebound. The vehicle should be approximately balanced on the right rear and left front tires. The observer should then check for under body impingement of both front tires.

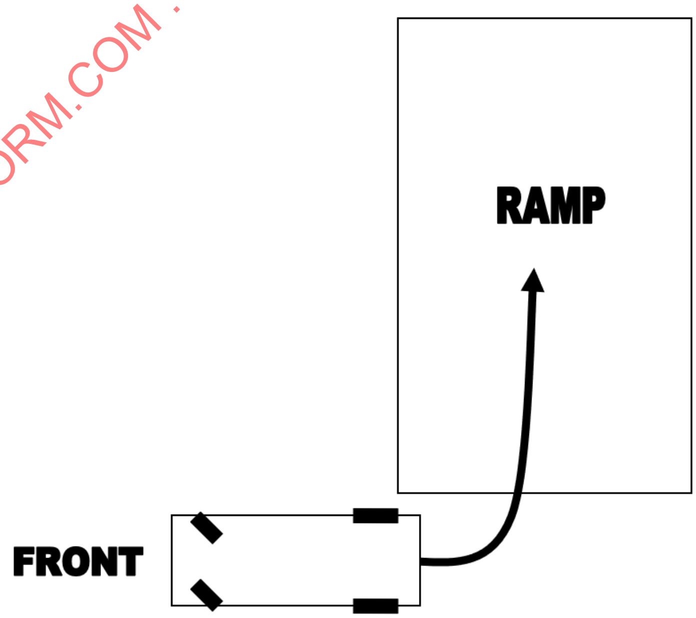


Figure A10 - Maneuver 4 - tire underbody impingement test

A.14.6 Test Results

The candidate assembly must meet the failure criteria requirements of SAE J2014 Administrator's Manual, 4.4.21. Any anomalies during test shall be noted.

A.15 CONVOY ESCORT TEST (SEE 4.4.22)

A.15.1 Purpose

This test procedure is intended to evaluate the thermal durability of a tire operating non-stop at a constant high speed for one tank of fuel on a paved road at high ambient temperature.

A.15.2 Facilities

A paved road capable of supporting continuous operation at specified speed for approximately 480 km (300 miles), e.g., a test course or a public interstate.

A.15.3 Test Vehicle

Any vehicle that is of interest to the investigator may be used. The air flow around the vehicle should represent that which will be encountered in the field, e.g., vehicle armor which inadvertently shields some of the tires from convective air flow during convoy operation.

A.15.4 Instrumentation

- Device to measure ambient temperature
- Minimum of two thermocouples with associated instrumentation/read out device
- Slip ring couplings to connect the thermocouples to the instrumentation

A.15.5 Test Preparation

Road Surface: Dry, paved (asphalt or concrete).

Ambient Temperature: 27 °C (80 °F) minimum.

Load: The maximum static load expected to be experienced at that wheel position.

Inflation Pressure: The inflation pressure that will be used on the vehicle of interest.

Thermocouple Placement: At the base of the tread in the center of the tread, and at the base of the tread on the tire's shoulder. It is anticipated that the thermocouples will be inserted into tight-fitting holes drilled at the base of the tread. These holes should not penetrate into the tire carcass. In the case of a tread pattern consisting of blocks, the holes should be drilled at the base of the appropriate blocks with the thermocouple inserted to the approximate center of the base of the block.

A.15.6 Test Procedure

Test Speed: A single speed that is expected to be the maximum speed for continuous use of the vehicle, e.g., 97 km/h (60 mph).

Test Distance/Duration: One tank of fuel.

A.15.7 Test Results

Ambient Temperature Correction: Normalize the recorded data to the ambient temperature of interest via SAE J1015, 7.2. This technique adds to the test data 60% of the difference between test ambient and the ambient temperature of interest. This technique is limited to differences of ±10 °C (20 °F) between test ambient and the ambient of interest.

A.16 MISSION PROFILE TERRAIN DEFINITIONS (SEE 4.4.24)

A.16.1 Purpose

The following terrain definitions have been provided to augment vehicle mission profile data which has not been updated, does not have sufficent level of detail or is not provide in the vehicle spefication such as for the winter mission profile. The definitions include the RMS range as well as the WNS equations to provide improved terrain roughness definition.

WNS represents road roughness data as a straight-line relationship on a log-log plot with spatial power spectral density in ft^2/cycle/ft on the y-axis and wave number in cycle/ft on the x-axis. This is a technique for measuring and monitoring long sections of various terrain types which could be encountered during mission operations or used during validation testing. The terrains and mathematical representations include paved roads, trails and untracked cross country terrain and roads, trails and courses used for operational and developmental test activities.

The terrain definitions need to be combined with the percent of each terrain type, payload condition and average speed over the terrain to complete the vehicle misson profile definition required for testing.

A.16.2 Facilities

Prior to the development of the MTVR, the terms used to define terrain roughness were vague and ambiguous word definitions that gave vehicle designers limited subjective guidance on what level of mobility was expected. Note that the vaguest definition is for “cross-country.” Cross-country terrain has the widest variance as to the actual “ground” surface condition ranging from mud to sand to exposed rock to grasslands. Each surface condition has unique characteristics that will impact how a vehicle must negotiate them and it is the generally considered the most difficult military terrain to traverse.

Since all vehicles must operate over the same “ground,” WNS provides a common terrain definition applicable across all ground vehicle systems. Individual vehicles are differentiated by the amount of time and the achieved speeds, they are expected to operate on/over each terrain type or their “Mission Profile.” For example, the MTVR mission profile is 10% primary roads, 20% secondary roads, 30% trails, and 40% cross-country (10/20/30/40) while the LVSR is 40/45/10/5, and the JLTV is 30/30/20/20. Even passenger cars can have a “mission profile” although it would be predominately primary roads, with some secondary, and no trails/cross-country.

The key is every military vehicle can function on any given terrain type determined to be part of their profile, since those terrain type definitions are consistent across all vehicles. Some will spend less time than others on the rougher terrains at different speeds, but all can ultimately operate on any terrain type with other military vehicles, if required.

Percentage of operation mission profile helps define reliability, availability, maintainability, and durability (RAM-D) requirements.

A.17 CURRENT TERRAIN DEFINITIONS (SEE 4.4.25)

The following terrain definitions are the current definitions used to describe the attributes of these terrain types found across ground vehicle operating environments.

A.17.1 Primary Roads

There are three types of primary roads, high quality paved, secondary pavement, and rough pavement. All may consist of two or more lanes, all weather, maintained, hard surface (paved) roads with good driving visibility used for heavy- and high-density traffic. These roads have lanes with a minimum width of 9 feet (2.75 m), road crown to 2 degrees, and the county and state legal maximum GVW/GCVW is ensured for all bridges.

- Secondary pavement can include significantly degraded concrete, macadam concrete or asphalt pavements (potholes, alligator cracking, freeze/thaw breakup).

- Rough pavement consists of two-lane roads with degraded shoulders, and marginal subgrades which produce long wavelength swells and additional degradation of the surface.

Table A2

Surface	WNS	RMS
High Quality Paved Road (Figure A11)	$G_{xx}(n) = 1.4 \times 10^{-8}\ (n)^{-2.5}$	0.02-0.15
Secondary Pavement (Two Lane Paved Road) (Figure A12)	$G_{xx}(n) = 1.9 \times 10^{-7}\ (n)^{-2.5}$	0.1-0.25
Rough Pavement (Degraded Paved Road) (Figure A13)	$G_{xx}(n) = 8.0 \times 10^{-7}\ (n)^{-2.5}$	0.15-0.5

Figure A11 - High-quality paved roads
(photo credit: Nevada Automotive Test Center)

Figure A12 - Secondary pavement
(photo credit: Nevada Automotive Test Center)

Figure A13 - Rough pavement, severely degraded
(photo credit: Nevada Automotive Test Center)

A.17.2 Secondary Roads

There are three types of secondary roads; loose surface, loose surface with washboard and potholes, and Belgian block. These roads are one or more lanes, all weather, occasionally maintained, varying surface (e.g., large rock, crushed rock, and gravel) intended for medium-weight, low-density traffic. These roads have no guarantee that the county and state legal maximum GVW/GCVW is assured for all bridges. Because they are trafficked roads, they develop dominant amplitudes as described below.

- Loose surface roads with washboard have a peak amplitude of 5.0×10^{-3} ft^2/cycle/ft at 0.3 to 0.5 cycle/ft (2 to 3 foot wavelengths).

- Loose surface roads with a high density of potholes have a peak amplitude of 9.0×10^{-3} ft^2/cycle/ft at 0.1 to 0.2 cycle/ft (5 to 10 foot wavelengths). Generally, washboard occurs in operational areas that are dry, whereas pothole gravel roads occur in wet operational areas.

- Belgian Block secondary roads have a peak amplitude of 8.0×10^{-2} ft^2/cycle/ft at 0.083 cycle/ft (12 foot wavelengths) and these wavelengths are 180° out-of-phase left to right that produces a racking input to the vehicle. The cobblestone blocks dominate the amplitude of the wavelengths at 1 cycle/ft.

Table A3

Surface	WNS	RMS
Loose Surface (Figure A14)	$G_{xx}(n) = 3.0 \times 10^{-5} (n)^{-2.0}$	0.6
Belgian Block (Figure A15)	$G_{xx}(n) = 4.0 \times 10^{-6} (n)^{-2.5}$	0.3-0.6
Loose Surface with Washboard and Potholes (Figure A16)	$G_{xx}(n) = 4.0 \times 10^{-6} (n)^{-2.4}$	0.6-1.2

Figure A14 - Loose surface
(photo credit: Nevada Automotive Test Center)

Figure A15 - Belgian block
(photo credit: Nevada Automotive Test Center)

Figure A16 - Washboard and potholed
(photo credit: Nevada Automotive Test Center)

A.17.3 Trails

Trails are one lane, unimproved, seldom maintained loose surface roads, intended for low-density traffic. Trails have no defined road width and can include large obstacles (boulder, logs, and stumps) and no bridging. These are surfaces having an RMS value varying between 1.0 inches and 3.4 inches.

Table A4

Surface	WNS	RMS
Trails (Figure A117)	$G_{xx}(n) = 4.6 \times 10^{-4} (n)^{-1.9}$	1.0-3.4

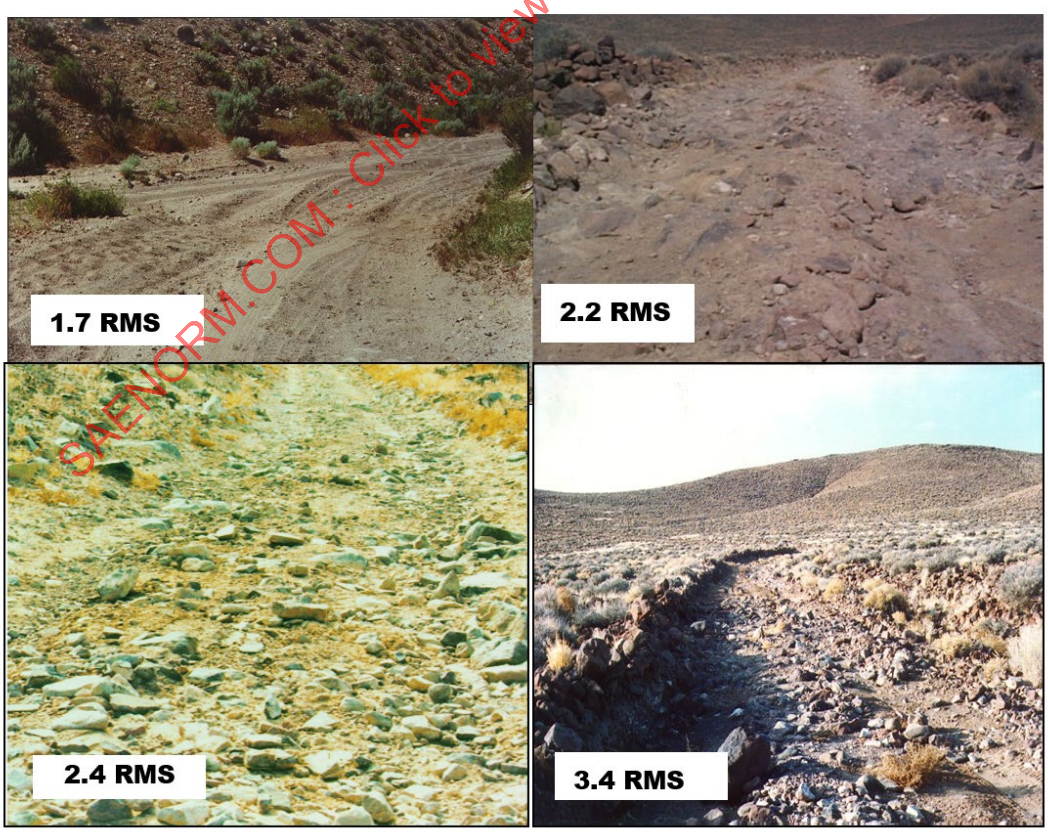


Figure A17 - Trails
(photo credit: Nevada Automotive Test Center)