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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 02-2-698
DTIC AD No.

9 September 2015

RUNFLAT TESTING

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1. SCOPE.

a. This Test Operations Procedure (TOP) describes the test procedures used for analyzing runflat performance, and should be used for general guidance unless otherwise instructed by the U.S. Army Test and Evaluation Command (ATEC) Systems Team (AST) or test sponsor.

b. A runflat is a device whose purpose is to extend a vehicle's mobility following the loss of air pressure in one or more tires. A runflat is usually an insert installed in an automotive vehicle's pneumatic tires, but can also refer to a tire that serves the same purpose without the use of an insert. Runflats function by providing a minimal rolling radius, thus ensuring adequate traction and acceptable longevity over a specified maximum speed and range of operations. Runflats, though they provide immediate mobility following a flat, are usually designed to only be used in emergency situations, as their use results in the degradation of the tire and the tire must subsequently be replaced.

c. Runflat testing can be broken into two general tests as described in Society of Automotive Engineers (SAE) J2014^{1*}: paved tests and mission profile tests. When determining compliance to speed and distance requirements, paved testing should be performed unless stated otherwise.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

<u>Item</u>	<u>Requirement</u>
Level Paved Road	A paved road closed to other traffic, with a grade not exceeding 1 percent, and curves and bank angles such that the vehicle's lateral acceleration does not exceed 0.02 <i>g</i> 's (acceleration due to gravity) when operated at 30 miles per hour (mph).
Endurance Test Courses	Mission profile test courses (TOP 01-1-011A ² and the test vehicle's Operational Mode Summary/Mission Profile (OMS/MP)) that allow the vehicle to traverse most or all required terrain types within the test period without having to come to an extended stop.

*Superscript numbers correspond to Appendix B, References.

2.2 Instrumentation.

<u>Devices for Measuring</u>	<u>Permissible Measurement Uncertainty</u>
True Ground Speed and Distance	0.5%
Ambient Temperature	1.0 °Celsius (C)
Tire Surface Temperature	2.0 °C
Road Surface Temperature	2.0 °C
Temperature Close to Test Positions (optional)	1.5 °C

3. REQUIRED TEST CONDITIONS.

3.1 Test Selection.

a. Coordinate with the test sponsor and/or the AST to determine whether to perform the paved or mission profile runflat test. When determining compliance to requirements, the paved runflat test should be performed (unless stated otherwise).

b. If speed and/or distance are not specifically listed in the test requirements documents, the runflats should be tested using the paved runflat test for a distance of 48.3 km (30.0 miles) at 48 km/hr (30 mph).

3.2 Course Selection.

When performing runflat testing, courses should be closed to other traffic for the duration of test due to the sometimes hazardous disintegration of the tires at high speeds. For the paved runflat test, a paved road should be selected with less than 1 percent gradient and no sharp turns (in order to maintain desired test speed). If performing the mission profile runflat test, map out a continuous route of the desired distance that will come closest to the test vehicle's mission profile.

3.3 Payload Configuration.

The test vehicle should be payloaded to obtain desired load condition, keeping in mind overall weight and center of gravity (CG). If specific guidance is not provided by the test sponsor, payload the vehicle to gross vehicle weight rating (GVWR).

3.4 Tire Assemblies.

The test vehicle should be equipped with tires that have at least 50 percent tread life remaining. Unless otherwise instructed, all tires should be flattened for the test on the heavier lateral side of the vehicle; if the weight happens to be evenly distributed laterally, flatten the tires on the right

side of the vehicle. For vehicles equipped with dual wheels, flatten both the inner and outer tires. One of two methods can be chosen for flattening the tires as follows:

a. The first method for flattening the tires is to shoot the tires (while mounted) with seven rounds of 7.62-millimeter (mm) North Atlantic Treaty Organization (NATO) caliber ammunition from a distance of 50 meters (164 feet) in accordance with (IAW) FINABEL 20.A.5³ and SAE J2014 in order to simulate a combat flat. The tires should be mounted on the wheel assembly with the runflat installed, and the wheel assembly should be removed from the vehicle. If the runflat is a multi-segmented device containing radial breaks, the punctured quadrant should contain a segment mating surface. The seven shots should be fired perpendicular to the tire and within a 90-degree quadrant; five of the shots should enter the tire in the outer sidewall and two of the shots should be fired into the top of the tread (see Figure 1).

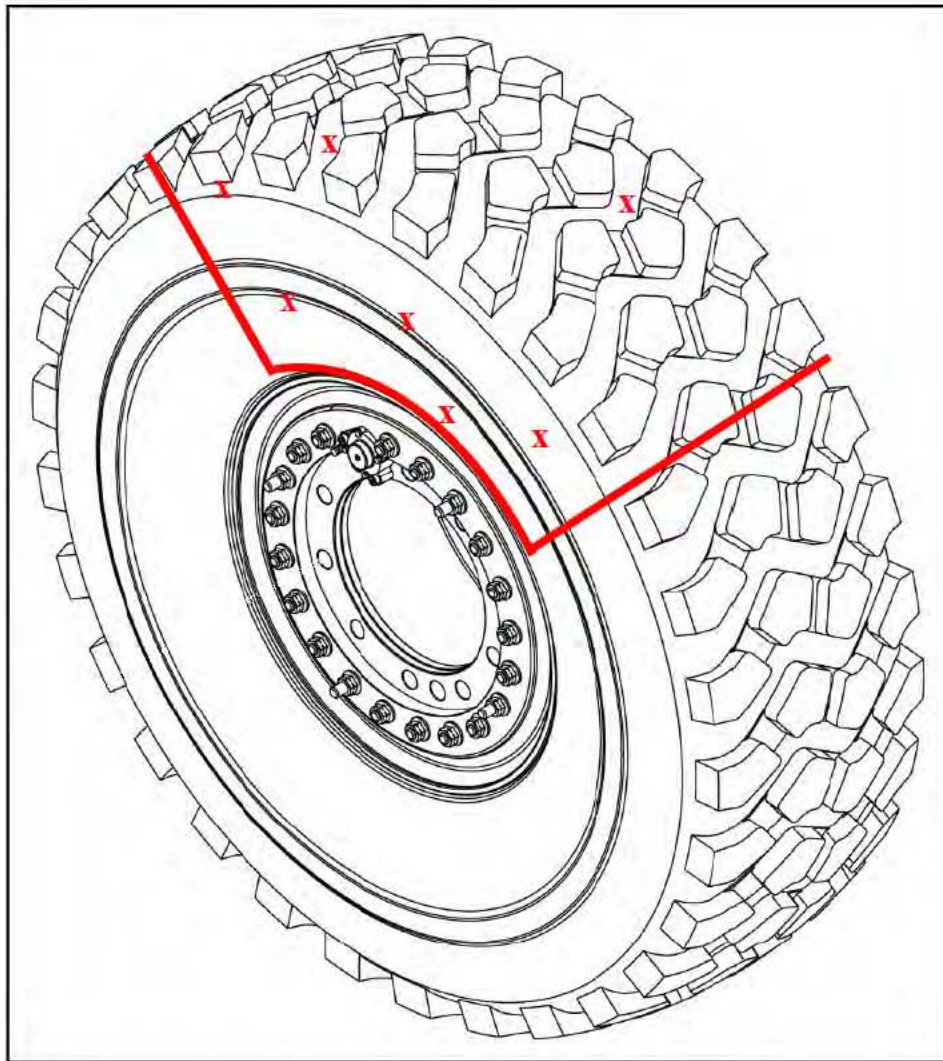


Figure 1. Seven shots in a 90-degree quadrant (five in sidewall and two in tread).

(1) Mark the tires for the shot positions: for the sidewall shots, the marked locations should be circumferentially spaced covering areas of equal angle (in the center of 18-degree sections within the 90-degree section) and radially placed in the center of sections of equal area between the rim flange and the beginning of the tread shoulder; for the tread shots, the shots should again be circumferentially spaced (in the center of 45-degree sections) and laterally with one shot in the center and one shot halfway to the outside tread shoulder. Note that for runflat comparison tests, it is extremely important that the shot locations are repeatable for every tire. The damaged wheels should then be reinstalled onto the vehicle at the test site so as not to drive on the tires prior to the commencement of the test.

(2) The benefit from choosing the FINABEL method to flatten the tires is that it will test the runflat's ability to perform after taking combat shots. The downsides to choosing this method are twofold: it does not represent the most likely starting scenario for heat buildup in the tires (the tires will be cold); and it is possible to shoot the runflats at slightly different locations so as to reduce testing repeatability (e.g., in a comparison test, a runflat from one manufacturer may have been directly shot at a segment mating surface, while a runflat from another manufacturer might not have been).

b. The second method for flattening the tires is to remove the valve cores using a valve core removal tool to simulate a puncture flat. This should be done at the test site, after the tires are warmed up and just prior to the start of test. The benefit from choosing this method is that the tires will be in a realistic warmed up condition at the start of test and that test conditions will be more repeatable than shooting tires from a distance; the downside to this method is that the runflats will not be subject to combat shots.

3.5 Environmental Conditions.

Ambient temperature plays an important role during runflat tests, in that heat buildup adversely affects the longevity of the tires. Therefore, ambient temperatures should abide between 20 °C (68 °Fahrenheit (F)) and 38 °C (100 °F), and ideally be as close to the SAE standard temperature of 25 °C (77 °F) as possible. Test conditions should also be dry (no precipitation or standing water), and with average sustained wind speeds not exceeding 24 kilometers per hour (km/hr) (15 miles per hour (mph)).

3.6 Safety Considerations.

a. Have at least two fire extinguishers on-hand during a runflat test. It is not uncommon for a fire to occur during the course of, or immediately following, the runflat test (or any time a runflat is used). Should a fire occur, test personnel should immediately call the fire department and try to extinguish the fire.

b. Tires that have operated on a runflat for any significant distance are compromised and should never be refilled with air. Serious injury could occur if a tire blows at high pressure while being filled. Ensure a plan is in place prior to test for how the tires will be changed; options include towing the vehicle on a flatbed trailer to the maintenance facility or having spare tires and tools on hand to change the tires at the test site. Additionally, to ensure accidental inflation

cannot occur, clearly mark any tires that have been tested on their runflats with “REMOVE FROM SERVICE – TESTED ON RUNFLAT”.

c. Tires sometimes separate catastrophically during the performance of a runflat test. Though personnel are not in danger, any vehicle systems in the vicinity of the tire could be damaged, sometimes resulting in locked or nonfunctional brakes, damaged lights, or other hazardous conditions.

4. TEST PROCEDURES.

4.1 Tire, Runflat, and Wheel Specifications.

Photograph each of the test items (wheel, tire, and runflat). Obtain model and serial numbers for the test items, if possible. Record the Department of Transportation (DOT) codes of the tires to ensure they are being used prior to the expiration date; any tire older than 60 months should not be tested. Measure the tread on the test tires to ensure at least 50 percent of the tread remains; tread should be measured at the four quadrants of the tire at three lateral locations (inside, center, and outside), for a total of 12 tread measurements per tire.

4.2 Test Photographs and Video.

Photograph the flattened wheel positions prior to the start of test. Mount video cameras to obtain real-time video of the flattened tires in order to help analyze the condition of the tire and runflats during the course of the test.

4.3 Warm-up Procedure.

If using the valve core removal method for flattening the tires, prior to flattening the tires, warm up the vehicle by driving for at least 30 minutes at 48 km/hr (30 mph).

4.4 Vehicle Configuration.

The test vehicle’s configuration should be set to the normal configuration used for the given terrain type IAW the vehicle’s Technical Manual (TM). For example, if testing on a paved road, the vehicle operator should not engage the transfer case lock or differentials. Some vehicles equipped with Central Tire Inflation System (CTIS) will have a procedure to disable CTIS in the case of a runflat situation; consult the vehicle’s TM and ensure the CTIS is set to runflat mode.

4.5 Pre-test Measurements.

Measure the maximum temperature of the flattened tires and the temperature of the road surface where the vehicle will be operating immediately prior to the start of test.

4.6 Test.

a. Paved Test: Perform the runflat test at the required speed and distance (using Global Positioning System (GPS), not the vehicle's speedometer or odometer, to monitor speed and distance). During operations, test personnel should actively monitor vehicle speed, distance, temperatures near the wheels, and video of the wheels; test personnel should be prepared to communicate with the test vehicle operator if any hazardous conditions present themselves.

b. Mission Profile Test: Perform the test over the vehicle's mission profile terrains at speeds 5 mph slower than the jury ride speed (though not exceeding the TM's maximum allowable speed for the runflat). If possible, operate on terrain types from roughest to smoothest (cross-country, trails, secondary, paved).

4.7 Conditions for Ending Test.

The runflat test should be ended upon occurrence of any of the following:

- a. Inability of the operator to maintain control of the vehicle.
- b. Inability of the vehicle to be operated safely.
- c. Inability of the vehicle to maintain continuous mobility.
- d. Reduction in speed below test target.
- e. Any of the wheel rims contacting the ground (signifying internal loss of runflat).
- f. Separation of tread from wheel carcass, which is indicative of imminent damage (at no point will the tread be cut away from the tire to continue testing unless specifically approved by the test sponsor).
- g. Completion of required mileage accumulation.

4.8 Post-test.

Measure and record the maximum temperatures of the flattened tires immediately after ending the test. Measure the temperature of the road surface at the same location where it was measured prior to the start of test. Photograph the tires and surrounding area on the vehicle. Observe for signs of damage to the vehicle or wheels that was caused by operation on the runflats, and report any discrepancies in break-out Test Incident Reports (TIRs). Break down the tires to inspect and photograph any discrepancies with internals of the flattened tires.

5. DATA REQUIRED.

- a. Wheel, tire, and runflat models; Tire DOT codes.

- b. Photograph of the shot locations (if applicable) and of the vehicle with flattened tires prior to test.
- c. Payload and vehicle configuration.
- d. Pre-test tread measurements (four quadrants X three lateral measurements).
- e. Date and time.
- f. Meteorological conditions (ambient temperature, precipitation, and average wind speed).
- g. Duration (distance) of warm-up period prior to flattening tires (if applicable).
- h. Tire locations flattened (wheel positions).
- i. Tire maximum temperature immediately before and after the test.
- j. Ground temperature immediately before and after test.
- k. Video of the flattened tire positions.
- l. Duration (distance) and speed of the test (broken down by terrain type, if applicable).
- m. Reason for ending test.
- n. Test Vehicle Operator's subjective comments on handling.
- o. Results of post-test inspection.
- p. Photographs of wheel positions and any runflat-related damage after test.

6. PRESENTATION OF DATA.

- a. Data are presented in TIRs and a final report. Data generally consist of the results of the test (usually distance traveled as compared to a requirement) and photographs documenting vehicle condition at the completion of test (including any failures that resulted due to operations on the runflats). If appropriate, provide plots showing a deviation from normal operations that resulted in a premature ending to the test; for example, a spike in heat at one of the wheel locations accompanied by a decrease in vehicle speed would be indicative of a damaged brake line.
- b. Examples of data presentation are presented in Figure 2 and Table 1.



Figure 2. Sample of post-test photographs of left front and left rear wheel assemblies.

TABLE 1. SAMPLE RUNFLAT TEST RESULTS

PARAMETER	MEASUREMENT/OBSERVATION	
Runflat Model		
Tire Model and DOT codes (age)		
Wheel Model		
Duration of Run Flat Test		
Vehicle Operator's Comments		
	PRE-TEST	POST-TEST
Ambient Temperature		
Ground Temperature		
Left-Front Tire Temperature		
Left-Rear Tire Temperature		

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APPENDIX A. ABBREVIATIONS.

AD No.	Accession Number
AST	ATEC Systems Team
ATEC	U.S. Army Test and Evaluation Command
C	Celsius
CG	center of gravity
CTIS	central tire inflation system
DOT	Department of Transportation
DTIC	Defense Technical Information Center
F	Fahrenheit
<i>g</i>	acceleration due to gravity
GPS	Global Positioning System
GVWR	gross vehicle weight rating
IAW	in accordance with
km/hr	kilometers per hour
mm	millimeter
MP	Mission Profile
mph	miles per hour
NATO	North Atlantic Treaty Organization
OMS	Operational Mode Summary
SAE	Society of Automotive Engineers
TIR	Test Incident Report
TM	Technical Manual
TOP	Test Operations Procedure

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APPENDIX B. REFERENCES.

1. SAE J2014 Pneumatic Tire/Wheel/Runflat Assembly Qualifications for Military Tactical Wheeled Vehicles, 22 March 2013.
2. TOP 01-1-011A Vehicle Test Facilities at Aberdeen Test Center and Yuma Test Center, 27 February 2012.
3. FINABEL Agreement No. A.20.A (20.A.5), Pneumatic Combat Tires, February 1997.

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APPENDIX C. APPROVAL AUTHORITY.

CSTE-TM

9 September 2015

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 02-2-698, Runflat Testing, Approved for Publication

1. TOP 02-2-698, Runflat Testing, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP describes the test procedures used for analyzing runflat performance, and should be used for general guidance unless otherwise instructed by the U.S. Army Test and Evaluation Command (ATEC) Systems Team (AST) or test sponsor. A runflat is a device whose purpose is to extend a vehicle's mobility following the loss of air pressure in one or more tires. A runflat is usually an insert installed in an automotive vehicle's pneumatic tires, but can also refer to a tire that serves the same purpose without the use of an insert.

2. This document is approved for publication and has been posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at <https://vdls.atc.army.mil/>.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Range Infrastructure Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: U.S. Army Yuma Proving Ground, Yuma Test Center, 301 C Street, Yuma, Arizona 85365-9498. Additional copies can be requested through the following website: <http://www.atec.army.mil/publications/topsindex.aspx>, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.