



Mojacar Durability Test for Brake Systems (Noise, Wear, Judder)

1 Introduction

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

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

1.1 Purpose. Test standard describes the evaluation of brake noise and judder behaviour (main focus) as well as performance and wear under normal driving conditions.

1.2 Applicability. This standard is applicable to all passenger and light trucks for low-metallic brake lining applications only. This standard is not applicable with Non-Asbestos Organic (NAO) material front applications. This standard may be applicable to applications with low-metallic front linings and NAO rear lining, if requested.

1.3 Remarks. The MOJACAR Test (Spain) is the final Validation (after successfully passed Drive test) of an entire brake system separate into five modules. Mojacar is predestined for brake noise evaluation due to unique weather relation (ocean, mountain: dry and wet climate). The Mojacar run is well known by European car manufactures and car enthusiastic magazines also.

For European customers all OEMs are proceeding that test.

Recommended values (e.g., drag torque, wear) stated in this standard are based on a long experience by car testing to avoid customer complaints. For further requirements see VTS template.

The Mojacar validation run on open roads is separated in five parts:

1st Part: 2150 km trip from Opel Rüsselsheim (ITDC) to Mojacar (Spain) to validate DTV performance under unbraked conditions.

2nd Part: 185 km public road course in the area of Mojacar to validate noise and wear, repeated 4 times per day until 5000 km are reached.

3rd Part: 4000 km unbraked ride on motorway to validate DTV.

4th Part: Same as Part 2.

5th Part: 2150 km trip from Mojacar to Opel Rüsselsheim (ITDC) to validate DTV performance under unbraked conditions.

Noise search is performed in different pressure ranges under different temperature conditions. Temperature range of the rotor is between (+20 to +400) °C.

Noise is evaluated subjectively as well as objectively. Data of rotor temperature, system pressure, noise frequency and level is recorded with measurement systems (e.g. Link or Head Acoustics).

Pad and disc wear is only calculated with the mileage accumulated in 2nd Part and 4th Part.

For more information see:

Appendix A: Location plan & Figure A1 (Road map)

Appendix B: DTV & LRO Plot

Appendix C: Noise Summary Plot

Appendix D: Brake Rotor Temp. Front and Rear

Appendix E: Example of a wear calculation Front Axle - Disc

Appendix F: Example of a wear calculation Rear Axle – Drum

Appendix G: Example of a drag torque measurement record (Disc)

Appendix H: “Mojacar” Lining Life Requirements (Average Value)

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Appendix J: "Mojacar" Noise Requirement

Appendix K: Procedure to detect "Moan-", "Groan-" Noise

Appendix L: Example of a drag torque presentation

Appendix M: Example of a "Judder" evaluation table

Appendix N: Evaluation sheet (subjective)

Figure N1: Course of the road

Brake lining life may be predicted by dynamometer wear versus temperature data or from brake data obtained during proving ground vehicle durability testing combined with wear models. Brake noise may be evaluated with dynamometer or vehicle objective noise tests.

This standard should only be used for wear measurements and noise ratings when other data are not available or this standard has been requested by the program. Refer to GMW15319 "Subjective Brake Noise Evaluation" for noise rating definitions (see Appendix J).

2 References

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

2.1 External Standards/Specifications.

FMVSS 135

2.2 GM Standards/Specifications.

GMW14264

GMW15319

2.3 Additional References.

Best Practices: The supplier shall work with the GM responsible engineer to comprehend this requirement.

Global Document Management System

Vehicle Subsystem Technical Specification

3 Resources

3.1 Facilities.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.1.3 Open road in Mojacar (Spain).

3.2 Equipment.

3.2.1 Accelerometer.

3.2.2 Brake rotor/drum thermocouples or brake lining thermocouples. Rotor or drum temperature may use surface or embedded thermocouples. Linings may use embedded thermocouples. The measurement of the brake temperatures may be made with an external thermocouple. See GMW14974 (Thermocouple Installation in Brake Rotors and Brake Drums) also.

3.2.3 Brake Line Pressure Gauge.

3.2.4 Brake Line Pressure Transducers (optional).

3.3 Test Vehicle/Test Piece.

3.3.1 The specific vehicle chosen for testing shall be representative with respect to brake system, tire, suspension and mass distribution properties.

3.3.2 If equipped with an antilock brake system (ABS) or other braking control systems, these systems should be correctly calibrated for the vehicle and tire/wheel units and should be functional during test.

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3.4 Test Time.

Calendar time: 25 days
Test hours: 16 h each day
Coordination hours: 4 days

3.5 Test Required Information.

3.5.1 The brake system should be in new condition. If the brake hardware is production intent, the hardware on the vehicle can be tested in its current condition. New brake hardware (linings and rotors/drums) may be installed if requested by the test engineer.

3.5.2 The tires for the testing should be in new condition.

3.5.3 The brake system is a safety system and may under no circumstances feel insufficient during the test.

3.5.4 If new driving situations are found that are critical for noise and or judder, these situation should be noted in the test record.

3.6 Personnel/Skills. An experienced, trained brake tester capable of performing the vehicle setup and driving instructions is required.

4 Procedure

4.1 Preparation.

4.1.1 Document information about the vehicle (year, model, style, engine and powertrain), the brake system components, and tires (size, make, type, and test pressure) in the test record.

4.1.2 Thermocouple brake rotors, drums or linings as requested.

4.1.3 Measure initial thickness of all brake linings, rotors, and drums. Indicate the locations of the measurements in the test record.

4.1.4 Calibrate the thermocouples.

4.1.5 Install the brake components and check all brake adjustments.

4.1.6 If the brake line pressure gauge or the optional brake line pressure transducers are requested, perform the following:

4.1.6.1 Install the instrumentation needed to perform a floor check: Pedal force, accelerometer, booster vacuum transducers (directly at the booster inlet) and data acquisition system. Perform a floor check.

4.1.6.2 Install brake line pressure transducers, if requested and perform a floor check.

4.1.6.3 Compare the pedal travel at 90 N pedal forces in the floor check with line pressure transducers to the same travel in the floor check before the installation of brake line pressure transducers. If the pedal travel increased, use floor checks and brake bleeds, as required, to restore pedal travel to the pre-instrumentation level.

4.1.7 Complete the installation of instrumentation.

4.1.8 Ensure that correct tire size and make are fitted. Set tire pressure as specified for specific vehicle test weight.

4.1.9 Perform a brake burnish following instructions from the test engineer. The default brake burnish is the burnish specified in Federal Motor Vehicle Safety Standard 135 (FMVSS 135). The FMVSS 135 brake burnish should be done with vehicle loaded to GVWR.

4.1.10 Measure the vehicle test weights and per wheel weight distributions. The vehicle weight should be the heaviest curb vehicle weight (100 % option) for the tested brake size plus driver plus 1/1 fuel tank plus 1/2 payload, except for delivery vans that should be at 2/3 maximum payload.

4.2 Conditions.

4.2.1 Environmental Conditions. The ambient temperature for testing is (+5 to +39) °C which are the ambient temperatures in Spain.

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

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4.2.2.1 Radio off during testing.

4.2.2.2 All windows should be open 15 cm minimum.

4.2.2.3 Air conditioning fan setting restricted to off or low position during noise testing.

4.2.2.4 Do not overuse the engine brake due to consideration of the traffic.

4.3 Instructions.

4.3.1 The open road test modules should be run following instructions applied by test engineer. Appendix A and B are sketches of the schedules. Obtain maps and any additional instructions from the test engineer.

4.3.2 One time per week, a wet brake test is to be performed. The vehicle should be run through a water splash (or if not possible wet the rotor by using an aerosol can) to wet the rotors, drums and linings on front and rear brakes. Then park the vehicle for an 8 h soak (overnight). Perform the following tests with cold brakes after the 8 h soak:

4.3.2.1 Make four cold brake applies with a speed < 10 km/h and a deceleration of < 0.1G.

4.3.2.2 Make two brake applies with vehicle in reverse with a speed < 10 km/h and a deceleration of < 0.1G.

4.3.2.3 Drive to ramp of $\approx 12\%$. Test vehicle in both a nose up and nose down position for brake groan noise with both the service brake apply and the emergency/park brake apply. Also observe the grade holding performance of the emergency/park brake.

4.3.3 Run the modules in the requested order (see paragraph 1.3) until 18 000 km of usage has been accumulated, unless otherwise specified in the test request.

Suggested test order, see paragraph 1.2.

4.3.4 Document test information including total elapsed test time, weather conditions, etc. See example reporting sheet for ratings and information in Appendix D.

4.3.5 Record subjective noise ratings during the appropriate schedules as described in the subjective brake noise procedure. Note the audible noise behaviour in the car and outside a car.

4.3.6 Measure the thickness of all brake linings, rotors, drums and disc thickness variation for the rotors (drums $\rightarrow$ out of roundness). The locations of the initial thickness measurements should be the same. See example reporting sheet for wear measurements in Appendix D in Figures D2 thru D4. Measurement interval for DTV: 0 km, 2500 km, 5000 km, 7500 km, etc. (see Appendix O).

4.3.7 Measure the brake drag torque at 0 km, 2500 km, 5000 km, 7500 km, etc. until 18 500 km. The measurement shall be performed as follows:

- Drive the vehicle 1 km at slow speed without any brake application. Measure drag torque on a hoist with disengaged transmission.
- Apply the brake pedal to 6000 kPa three times in 6 s. Measure drag torque.
- Mark five wheel rotations.
- Measure drag torque.

4.3.8 Observe the brake dust on the wheel rims every day of testing. Take photographs for evaluation after 2500 km, 5000 km, and 10 000 km and so on, if the brake dust is visible.

4.3.9 At 10 000 km, examine brake system for any leakage, brake hose or pipe witness rub marks, caliper operation, etc.

5 Data

5.1 Calculations.

5.1.1 Calculate the minimum and maximum noise ratings and the average rating over the 10 000 km, unless otherwise instructed.

5.1.2 Calculate the lining life within 2 mm safety margin.

5.1.2.1 For lining life prediction do not calculate with the complete mileage. Part #1, #3, #5 do not take into consideration.

5.1.3 Calculate the rotor and drum maximum wear. Wear 3 mm for ventilated and 2 mm for solid rotors. Drums 1.5 mm maximum related to diameter. Part #1, #3, #5 do not take into consideration.

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5.1.4 Recommended drag torque caliper (Valid for paragraph 4.3.7, item a.) only - without transmission and bearing):

- a. Front Axle ≤ 3 Nm
- b. Rear Axle ≤ 2 Nm (or for an axle not driven by engine)
- c. Car on a hoist - No bearing load. See Vehicle Subsystem Technical Specification if no other information is available.
- d. Measure the drag torque with pushed back linings to get the caliper drag torque only.
- e. See Appendix G, Example of a drag torque measurement record (disc)

5.2 Interpretation of Results. Compare test results to applicable technical specifications or Best Practices.

- Using the methods in this standard, comparisons to the following measurements are suggested during the testing.
- Vented rotor wear: 3 mm maximum.
- Solid rotor wear: 2 mm maximum
- Drum wear: 1.5 mm maximum.
- Brake drag torque: 3 Nm/2 Nm maximum (see paragraph 5.1.4).

5.3 Test Documentation. Publish test record according to GM corporate protocol using the Evaluation Report template and Engineering Document Management (EDM) system or its successor.

6 Safety

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

7 Notes

7.1 Glossary. Not applicable.

7.2 Acronyms, Abbreviations, and Symbols.

ABS	Antilock Brake System
EDM	Engineering Document Management
FA	Front Axle
RA	Rear Axle

8 Coding System

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

Example:

Test to GME17289

9 Release and Revisions

This standard was first approved and released in November 2014.

Issue	Publication Date	Description (Organization)
1	NOV 2014	Initial publication. (Brakes Integration Brakes Development Team)

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Documents
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Appendix A: Location Plan - "Wegbeschreibung zur Geräusuche Mojacar-Lubrin Kurs"

Note: Map and detailed driving instructions available from test facility. An English version of the road map is available from the test facility.

(Distance ≈ 182 km, Duration 3 h 45 minutes ^{Note 1)})

0.0 Abfahrt Werkstatt Hotel Parador

Geräusuche kalt

an Ausfahrt Hotel Parador links abbiegen

0.6 Kreisverkehr Ausfahrt Richtung Mojacar

1.6 Kreisverkehr Ausfahrt Richtung Mojacar (Pueblo)

2.5 aus Kreisverkehr Mojacar (Pueblo) rechts abbiegen Richtung Turre **(AL 6111)**

in Turre der Hauptstraße folgen Richtung **A7**

14.0 Ausfahrt aus Kreisverkehr Richtung **Autobahn Almeria A7**

30.5 Ausfahrt aus **Autobahn A7** bei **KM 504** Richtung Sorbas **(AL1102)**

40.7 links abbiegen Richtung Sorbas (N 340a)

43.7 Ausfahrt aus Kreisverkehr Richtung Poligono Industrie

Geräusuche warm

Ausfahrt aus Kreisverkehr Richtung Uleila **(AL4101)**

56.0 rechts abbiegen Richtung Lubrin **(AL5102)**

65.2 links abbiegen Richtung Lubrin **(A1101)**

70.7 rechts abbiegen Richtung Bedar

Geräusuche Straße Richtung Beda warm

71.4 drehen und zurück

72.1 rechts abbiegen Richtung Lubrin

72.4 links abbiegen Richtung Lubrin

- Pause -

Geräusuche kalt

72.9 zurück aus Lubrin

73.4 links abbiegen Richtung La Rambla **(A1101)**

und weiter auf **(A1101)**

92.0 rechts abbiegen Richtung Almeria durch Kreisverkehr **(AL7106)** El Palces

94.5 rechts abbiegen und folgen auf **(AL7106)**

100.2 rechts abbiegen auf Autobahn Richtung Almeria **A7**

105.7 Ausfahrt bei KM 537 rechts abbiegen Richtung Cuevas **(A332)**

109.7 links abbiegen Richtung EL Martinette

110.2 links abbiegen Richtung Cementerio / Industrie

an Tankstelle rechts abbiegen

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Documents

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Geräuschsuche warm

- 111.6** zurückkommend Richtung El Marinette - Cuevas
- 112.5** am Stoppschild links abbiegen in nächsten Kreisverkehr einfahren
- 113.0** aus Kreisverkehr rechts abbiegen Richtung Pulpi - Cartagena (**A332**)
- 120.4** vorbei an Autobahn weiter auf (**A332**)
- 123.2** links abbiegen Richtung Pulpi (**A1201**)
- 132.0** rechts abbiegen Richtung Pulpi (**A1201**)
- 133.2** Ausfahrt aus Kreisverkehr Richtung Pulpi (Sur)
- 135.8** rechts abbiegen Richtung San Juan
- 138.3** Ausfahrt aus Kreisverkehr Richtung San Juan (**A1205**)
- 144.0** Ausfahrt aus Kreisverkehr Richtung San Juan folgend 5x Kreisverkehr

Geräuschsuche warm Medical Center

- danach am Kreisverkehr rechts abbiegen Richtung Cuevas
- 150.5** links abbiegen Richtung Cuevas
 - 151.4** links abbiegen Richtung Villarroos - Garrucia (**AL7107**)

Ab jetzt keine Bremse mehr

- 164.8** im Kreisverkehr Richtung Garrucia (**AL707**)
- 168.5** Ausfahrt aus Kreisverkehr Richtung Garrucia folgend 3x Kreisverkehr
- 170.3** Ausfahrt aus Kreisverkehr Richtung Parkplatz Consum

Geräuschsuche kalt

- 171.0** Ausfahrt aus Kreisverkehr Richtung Garrucia - Vera folgend 4x Kreisverkehr
- 174.0** Ausfahrt aus Kreisverkehr Richtung Mojacar
- 176.8** links abbiegen Richtung Mojacar
- 177.2** Ausfahrt aus Kreisverkehr rechts Richtung Mojacar folgend allen Kreisen
- 182.0** rechts einbiegen Hotel Parador

Note 1: Alle Angaben sind abhängig von der Genauigkeit des Tachos und können leicht abweichen.

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