Grossglockner Mountain Schedule for Brakes

1 Introduction

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

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

1.1 Purpose. To evaluate brake system performance directly affected by the high thermal strain encountered on an Alpine test with objective measurement and subjective evaluations.

1.2 Applicability. This test can be used to evaluate characteristics of an individual component(s) or the entire brake system. This includes cooling behavior and heat conductibility for rims, wheel covers, wheel bearings, and drive joints. This test can be used to evaluate the drive joint boot's thermal resistance. The test is also a part of the European total durability test program. This test procedure is for vehicles sold in the European market in combination with DOT4 brake fluid only (maximum allowed brake fluid temperature is 190 °C, including soak).

1.3 Remarks. Brake system characteristics are measured while the brakes are subjected to the thermal loads encountered under Alpine conditions. Heat balance between front and rear brakes is also assessed.

Thermal performance validation and development of the brake system should be done using brake thermal models, brake equilibrium temperature tests, and fade tests. The Grossglockner test is not required for validation of the mountain descent requirements in the technical specifications. The Grossglockner test should only be used for validation when the Program Integration Team has evaluated thermal test and analysis results and decides the Grossglockner test is required.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14927

3 Resources

3.1 Facilities. The test is carried out at Grossglockner, about 15 km south of Zell (Austria). All the testing starts at Edelweissspitze and ends at Maut Ferleiten. Appropriate testing period is end of May to beginning of October.

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.

3.2 Equipment.

3.2.1 Data acquisition: System capable of collecting data channels at 100 Hz (e.g., Jurid D3/D4 system, B&S data system or equivalent).

3.2.2 Direct/Alternating converter: Jurid D3 or equivalent.

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3.2.3 Transducers:

3.2.3.1 Pressure transducer (hydraulic system pressure), 0 bar to 200 bar.

3.2.3.2 Pedal travel transducer, 0 mm to 200 mm.

3.2.3.3 Thermocouple cable, type K (0 °C to 1000 °C).

3.2.3.4 Accelerometer, 0 m/s^2 to 10 m/s^2.

3.2.3.5 Vehicle speed transducer, 0 km/h to 200 km/h.

Note: All instrumentation is to be calibrated as required; record instrument details and date of calibration in the test record.

3.3 Test Vehicle/Test Piece. Not applicable.

3.4 Test Time.

Calendar time:	5 days
Test time:	16 hours
Coordination time:	16 hours

3.5 Test Required Information. Not applicable.

3.6 Personnel/Skills. Trained brake technician or engineer to perform instructions in section 4.

4 Procedure

4.1 Preparation.

4.1.1 Build or verify that the test vehicle's brake apply system conforms to the desired specifications.

4.1.2 Install thermocouples in the rotors for disc temperature and in the caliper bleeder nipples for brake fluid temperature. Other thermo cables are installed in an appropriate way for requested component temperature measurements (e.g., brake hose, bearing, etc.) Optional: Install thermocouples in the brake pads. Optional: Install disk surface temperature probe.

Note: Temperature balance between front and rear axle brake corners shall be requested. Install thermocouples at both front and rear brake corners.

4.1.3 Install brake drums and/or rotor, friction material and brake springs as specified by requesting engineer. Measure baseline thicknesses of the new pads and rotors/drums. See Appendix A, Figure A2 for measurement points.

4.1.4 Install thermocouple to measure ambient temperature.

4.1.5 Install pressure transducer. Hydraulic system pressure is measured in the primary circuit.

4.1.6 Install pedal stroke transducer between pedal and knee protection panel.

4.1.7 Prepare the brake system per GMW14927. Bleed brake system as necessary.

4.1.8 Install accelerometer as close to the center of gravity of the vehicle as possible. Make certain accelerometer is mounted securely.

4.1.9 Install instrumentation and data recorders as requested. Verify the measurement equipment is properly calibrated and in good working order.

4.1.10 Check that the Antilock Brake System (ABS) is functioning. The ABS is to be active unless otherwise specified.

4.1.11 Ballast the vehicle weight to maximum vehicle weight unless otherwise specified.

4.1.12 Install the wheels and tires. The wheels/rims on the test vehicle should represent the production to intent wheels or wheel/trim combinations with the smallest wheel vent area being released with the test brake system. Use this worst case brake cooling condition unless otherwise specified.

4.1.13 Install body trim for worst case cooling unless otherwise specified.

4.1.14 Measure the coefficient of friction of the brake pads with control measurements at Proving Grounds (PG) Dudenhofen or equivalent PG.

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4.1.15 If requested, measure the front axle residual (drag) torque for the following conditions: after pumping the brake pedal three (3) times to 60 bar; after five (5) revolutions of the wheel; and after driving 1 km without braking. If requested, measure the piston displacement forces of the brake calipers.

4.2 Conditions.

4.2.1 Environmental Conditions.

4.2.1.1 Dry road (except for pad wear, which can be carried out when the road is wet).

4.2.1.2 Minimal wind speed.

4.2.1.3 Outer temperature 20 °C nominal. Adjustment for ambient temperature is performed in the Jurid D3/D4 data acquisition plotting program for the brake fluid temperature channel. The following equations are used for the adjustment:

- T1 = 20 °C requested ambient temperature
- T2 = Test ambient temperature = $(C_{start}+°C_{end})/2$
- T1 to T2 = $°C_{adjustment}$ = Temperature adjustment.

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

4.3 Instructions.

4.3.1 Test Selection. The test is a 40 minute test that represents the slow cautious driver. The test request should specify the number of runs.

4.3.2 Descent Preparation.

4.3.2.1 The vehicle shall be driven uphill to the top of the pass without braking and with average lateral acceleration in the curves.

4.3.2.2 Measure the pedal travel loss after driving uphill without braking. Switch the measuring equipment on and measure the pedal travel by slowly depressing the pedal up to 120 bar (or the specified test pressure) or to the maximum possible pressure.

4.3.2.3 Depress and release the brake pedal quickly three (3) times up to 60 bar line pressure. Then measure the pedal travel by slowly depressing the pedal up to 120 bar (or the specified test pressure) or to the maximum possible pressure.

4.3.2.4 Before every series of downhill test runs, calibrate the measuring devices and make a test chart recording. Start downhill test when all brake temperatures are < 30 °C.

Note: If, during the descent, the brake fluid temperature exceeds 190 °C after adjustment for ambient temperature delta, abort the test.

Note: If loss of the service brake occurs during the test, shift the transmission to the lowest selectable gear, stop the vehicle, and abort the test. The vehicle should not proceed down the mountain until the service brake is back to normal effectiveness.

4.3.2.5 Refer to Appendix A, Figure A1 for the driving schedule.

4.3.3 Descent Test.

Note: Review instructions in 4.3.3, thru 4.3.5 before actually performing the Descent Test.

4.3.3.1 During descent, evaluate events such as brake fade, brake squeal, differences in temperature between left and right hand brakes according to protocol. Note events in test record.

4.3.3.2 During descent, modulate braking force in order to keep the specified speed and timing intervals.

4.3.3.3 Make first descent (time = t_{start}). Follow driving schedule in Appendix A, Figure A1.

4.3.3.4 Stop vehicle after descent at a location for a stationary parked car soak, locate the soak shields immediately after parking. See Appendix A, Figure A4 for a sketch of soak shields. The height and width of the shields should be approximately 100 cm by 100 cm. The shields should be placed approximately 15 cm from the wheels. Measure pedal travel directly after the test is ended at time (t_{STOP}) at 10 bar and 120 bar hydraulic pressure. If brake system cannot obtain at least 100 bar immediately after the descent, note this in the test record.

4.3.3.5 Measure pedal travel 7 minutes later (t_{STOP} + 7 minutes) at 10 bar and 120 bar hydraulic pressure.

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