



Hill Start Test

1 Introduction

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

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

1.1 Purpose. This Test Procedure describes the method for testing clutch disc and clutch lining assembly, in order to verify the energy absorption capacity of the clutch during hill starting.

This Test Procedure is developed for the baseline market (see Appendix D and GMW15751). If the proving ground or weather conditions during test execution lead to engine performance deviations and losses (e.g. by intake temperature) this must be reported by the executing test engineer (see paragraph 4.3.1).

In general the engine performance for the regional market conditions shall be considered in the layout of the clutch system and transmission ratio and the used simulation tools. Therefore the performance values in dependence of outer temperature and altitude of the engine shall be provided by engine development area.

If it is necessary to execute clutch tests for other markets (intermediate/severe), the test grade and/or payload shall be adapted accordingly (see Appendix D).

In order to estimate the necessary payload the following tool can be used. It can be found on the website under tools ("Severity calculator, hill start"):

<https://gmweb.gm.com/sites/ECDQ/DQ/SitePages/Home.aspx>

If the necessary test weight leads to an unacceptable gross axle weight rating concerning safety the test weight shall be reduced accordingly. Deviations shall be communicated and noted in the test report.

1.2 Applicability. This Test Procedure is applicable to all vehicles with manual transmission, and relates to all engine types (petrol and diesel).

The Test Procedure refers to vehicles with and without trailer load capacity. This means only one test process shall be performed.

1.3 Remarks. This standard is a GMPTE-harmonized Test Procedure, and it has been developed for use within GMPWT. This standard consists of two parts; applicable to vehicles with and without trailer load capacity.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW15628

GMW15751

GMW16905

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.

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3.1.3 Test Track. Hill tracks with a constant grade according market requirements (see Appendix D). The grade shall be constant for a road length that is sufficient for a complete vehicle launch.

3.2 Equipment.

3.2.1 Data recording device for the following measurements:

3.2.1.1 Mandatory Sensors.

- gear box oil temperature
- ambient temperature (if not covered otherwise)
- air temperature in the clutch housing near upper circumference of clutch pressure plate
- air temperature in the clutch housing at the CSC / release bearing
- clutch pedal travel sensor or bus-signal
- speed of gearbox input shaft
- engine speed on bus or sensor at flywheel
- engine torque (bus)
- longitudinal car acceleration (if engine torque not available)

Minimum Sampling rate:

For temperatures 1 Hz, for others 100 Hz

Resolution of the AD-converter: ≥ 16 bit

3.2.1.2 Optional Sensors.

- accelerator pedal position (bus)
- AC Signal (bus)
- vehicle speed (bus)
- brake signal

3.2.2 Attached tachometer and speedometer.

3.2.3 New standard tires according to release.

3.2.4 Writing material.

3.2.5 Stop watch.

3.2.6 Measurement equipment to measure the clutch pedal characteristic (according to GMW15628).

3.2.7 Optional instrumentation is to be determined by the responsible test engineer.

3.3 Test Vehicle/Test Piece. Test vehicle with clutch and manual transmission. Engine calibration milestone level for test execution: 65 % or greater. Vehicles with and without trailer load capacity, can be used for testing, during different development phases. Hydraulic clutch actuation components according to representative development phase. The engine performance shall be checked prior to test in order to ensure the specified engine torque and power (see paragraph 4.3.1).

3.3.1 Vehicles without Trailer Load Capacity. The test vehicle shall be equipped with:

3.3.1.1 Transmission according to specification.

3.3.1.2 Two new clutch sets near to lower clamp-force tolerance (if available), each with a new flywheel, according to specification and two new CSC.

3.3.1.3 Payload up to the permissible gross weight, including driver (maximum axle load on the drive shaft).

3.3.1.4 Tires with largest friction area according to vehicle specifications. Maximum allowed tire wear 25 % of pattern depth.

3.3.2 Vehicles with Trailer Load Capacity. The test vehicle shall be equipped with:

3.3.2.1 Transmission according to specification.

3.3.2.2 Two new clutch sets near to lower clamp-force tolerance (if available), each with a new flywheel, according to specification and two new CSC.

3.3.2.3 A towing hook for maximum allowed trailer weight.

3.3.2.4 Tires with largest friction area according to vehicle specifications. Maximum allowed tire wear 25 % of pattern depth.

3.3.2.5 A trailer for maximum allowed trailer weight, or a vehicle to be towed, simulating a loaded trailer.

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3.4 Test Time.

Calendar time: 6 days

Test hours: 24 h

Coordination hours: 3 days

3.5 Test Required Information. Possible sources are:

- VTS (Vehicle Technical Specifications)
- SSTS (Sub System Technical Specifications)
- ADV Plan
- SOR (statement of requirements)
- Application engineer
- Development Groups / Design Release Engineer
- Drawings / CTS (Component Technical Specifications)

3.6 Personnel/Skills.

3.6.1 Trained test driver to run the test. The person has to fulfill the following criteria:

- Very experienced in driving vehicles with a manual transmission
- Able to sensitively modulate the clutch pedal, gas pedal and parking brake (manual and electric) at the same time
- Instructed from a driver who is experienced in this Test Procedure
- Has already demonstrated the ability to launch a vehicle with GVW/GCVW load at hill grades

3.6.2 Experienced Test Engineer to evaluate results.

3.6.3 Skilled mechanic to mount and dismount test parts according valid process requirements, e.g. counter force free installation. The mechanic shall be skilled in clutch and DMF system technology.

4 Procedure

4.1 Preparation.

4.1.1 Vehicles without Trailer Load Capacity.

4.1.1.1 Verify transmission and clutch system according to the requirements. Pay attention to the clutch pedal travel and adjust or bleed the hydraulic system if necessary.

4.1.1.2 Ballast the test vehicle to maximum allowed weight according to specification.

4.1.1.3 Adjust the tire pressure according to permissible gross weight load.

4.1.1.4 Fill in the documentation of the test vehicle in "Test data". See Appendix A.

4.1.2 Vehicles with Trailer Load Capacity.

4.1.2.1 Verify transmission and clutch system according to the requirements.

4.1.2.2 Ballast the test vehicle and trailer to maximum allowed load according to recommended load specification. Drawbar loads (500 ± 50) N.

4.1.2.3 Adjust the tire pressure according to specifications for vehicle and trailer with maximum load conditions.

4.1.2.4 Fill in the documentation of the test vehicle in "Test data". See Appendix A.

4.2 Conditions.

4.2.1 Environmental Conditions. The hill test shall be performed on a dry test track with appropriate inclination, normally 12 %, 17 %, 22 % and 30 %. The length of the track should be sufficient to perform a complete launch at the given gradient (see paragraph 4.3.8.9).

If the program VTS requires a maximum grade < or > 22 %, the test grade should be adjusted to reflect the VTS requirement. The program-specific VTS requirement can be more severe, e.g. for SUV, where customer might expect more than he would expect from a passenger car or it might be more relaxed in case FE is rated higher than Hill Start Capability. If there is no target within VTS/SSTS the minimum target grade is 20 %. For the global projects the target grade is 22 % beginning with Global Epsilon project.

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

4.2.2.1 The program VTS target requires AC to be switched on or off. This might especially be interesting for borderline applications without automated AC shut off. If there is no target within the VTS/SSTS, AC has to be switched on during test.

4.3 Instructions. Unless otherwise specified (e.g. by VTS) the test shall be performed in following sequences. The Hill-Start test shall be run in two loops. A new clutch system is required for every loop.

1 a) First loop for trailer applications

- 5 launches forward with cold vehicle and new clutch system (see paragraph 4.3.5)
- Run in of clutch (see paragraph 4.3.6)
- 5 launches forward (see paragraph 4.3.8)
- 5 launches reverse (see paragraph 4.3.9)
- 5 launches with trailer (see paragraph 4.3.10)

1 b) First loop for non trailer applications

- 5 launches forward with cold vehicle and new clutch system (see paragraph 4.3.5)
- The run in of clutch (see paragraph 4.3.6)
- 5 launches forward (see paragraph 4.3.8)
- 5 launches reverse (see paragraph 4.3.9)
- 5 launches forward instead of launches with trailer (see paragraph 4.3.11)

2 a) Second loop for trailer applications

- 5 launches forward with cold vehicle and new clutch system (see paragraph 4.3.5)
- The run in of clutch (see paragraph 4.3.6)
- 5 launches forward (see paragraph 4.3.8)
- 5 launches reverse (see paragraph 4.3.9)
- 5 launches with trailer (see paragraph 4.3.10)
- Additionally if possible up to 15 additional launches with trailer to evaluate the robustness of the clutch system (see paragraph 4.3.12)

2 b) Second loop for non trailer applications

- 5 launches forward with cold vehicle and new clutch system (see paragraph 4.3.5)
- The run in of clutch (see paragraph 4.3.6)
- 5 launches forward (see paragraph 4.3.8)
- 5 launches reverse (see paragraph 4.3.9)
- 5 launches forward instead of launches with trailer (see paragraph 4.3.11)
- Additionally if possible up to 15 additional launches forward without trailer to evaluate the robustness of the clutch system (see paragraph 4.3.12).

The minimum release recommendation requirement is fulfilled if the 1st and 2nd loop are finished successfully according paragraph 5.2 with at least 2 launches rearwards and without the additional launches executed in the second loop, if there is no other VTS or SSTS target.

4.3.1 Check Engine Torque (on vehicle bench). Especially required, if the ambient temperature is higher than specified in market requirements (see Appendix D). The test shall only be performed with correct engine torque.

4.3.2 Check engine performance by calculating engine torque on bench:

$$M_{\text{Eng}} = \frac{P_{\text{Engine}}}{2\pi \times n}$$

4.3.3 Install new transmission (if necessary) and new completely measured clutch system with lower tolerance clamp force (see Appendix B).

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4.3.4 Check of pedal travel and force before the test according to GMW15628. If necessary readjust and/or bleed hydraulic clutch system and fix vehicle on test bench. In order to make sure that pedal travel value correlates between GMW15628 vs. drive recorder compare both measurement results. In case of deviation readjust drive recorder settings in regard to pedal travel.

4.3.5 Customer delivery Trailer Loading Simulation.

4.3.5.1 Test weight: Vehicle Curb Weight + 150 kg including Driver.

4.3.5.2 Transport the test vehicle to the test facility with 22 % grade (if not available, adjustment by modification of test weight). The transport to the test facility guarantees that the clutch system is in nearly unused condition.

4.3.5.3 Perform 5 launches forward (normal engaging time of (1 to 2) s) at an engine speed of $0.35 \cdot n_{\text{fuel cut off}}$, each within 1 minute and at 22 % grade.

4.3.5.4 Perform compressed warm judder test (similar GMW16905) by driving one launch at 0 %, 8 % and 12 % grade in forward and rearwards respectively.

4.3.5.5 Determine Disengagement Reserve. After judder test perform determination of disengagement point. Start the engine and await stabilization of idle speed. Start measurement system. Tighten the parking brake to ensure the vehicle not to move. Push the clutch pedal down to the bottom. Shift halfway into reverse gear. Smoothly release the clutch pedal while slightly moving the shift lever forward and backward until the first scratching noise from the transmission can be heard. The disengagement point is obtained by slowly disengaging until the clutch disconnects engine and transmission, no scratching noise from the gears can be heard and no pulsation at the shift lever can be felt. Keep clutch pedal at this position. This is the disengagement point. Fill in Appendix A the pedal travel from disengagement point to down position of clutch pedal.

4.3.6 Run in the test vehicle with 20 launches (normal engaging time of (1 to 2) s) at 0 % grade at $0.3 \cdot n_{\text{fuel cut off}}$ with vehicle curb weight + 150 kg including driver.

4.3.7 Cool Down Procedure. If necessary, drive the vehicle in the highest gear and low engine rpm until the transmission oil temperature has reached a typical constant transmission oil temperature (e.g. (+80 to +90) °C for M20/32). Air temperature in the clutch housing near upper circumference of clutch pressure plate should be in the range of (+90 to +100) °C.

4.3.8 Mandatory Cycles Forward.

4.3.8.1 Determine required hill start grade and test weight according program VTS market requirements. As an example see appendix D for load condition = "GVW" and direction = "Forward".

4.3.8.2 Minimum acceleration speed (AC switched on if there is no specific VTS/SSTS target).

Perform determination of hill start engine rpm without trailer in 1st gear: Drive into the uphill grade (forward) without stopping. Reduce the speed until it is just possible to accelerate the vehicle on the hill by full throttle. This is the minimum vehicle acceleration speed.

4.3.8.3 Hill start engine speed (min^{-1}) (AC switched on if there is no specific VTS/SSTS target).

The hill start engine speed (min^{-1}) shall be selected in the range from the engine speed at minimum vehicle acceleration speed $+500 \text{ min}^{-1}$, up to 3000 min^{-1} maximum. The optimum engine speed depends on the engine torque characteristic and pedal map; generally a lower speed shall be selected.

4.3.8.4 (AC switched on if there is no specific VTS/SSTS target).

Execute five (5) launches forward with hill start engine speed (see paragraph 4.3.8.3) within 5 minutes (e.g. 1 launch/minute), no trailer. VTS determines number of launches for borderline applications that have to be considered for release recommendation.

4.3.8.5 Drive the complete vehicle up onto the start of the inclination with the selected gradient, pull the hand brake, clutch pedal released, gear in neutral and engine at idle.

4.3.8.6 Press clutch pedal and engage the 1st gear. Release the handbrake and perform the first hill start.

4.3.8.7 The starting speed (see paragraph 4.3.8.3) shall be maintained at a constant level by juggling the clutch and accelerator pedal.

4.3.8.8 The clutch shall be fully engaged as soon as the minimum vehicle speed for acceleration is reached (see paragraph 4.3.8.2).

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