



Dual Mass Flywheel (DMF) Impact 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.

- Test of start ability in cold and warm conditions
- Check of dual mass flywheel (DMF in the following) start-angle in cold and warm conditions
- Test of the DMF Torque Impact
- Check of fuel cut functionalities

1.2 Applicability. This standard is applicable for testing all FWD, AWD and RWD transmissions with dry friction clutch systems and Dual Mass Flywheel.

1.3 Remarks. This standard is executed in order to check the robustness of Dual Mass Flywheel applications and the functionality of software algorithms which should protect the DMF during abusive driving maneuvers as well as customer relevant driving conditions.

One part of this Test Procedure is release relevant (paragraphs 4.3.1 to 4.3.6), the other part (paragraphs 4.3.7 to 4.3.11), is only performed in order to judge robustness vs. further defects or customer complaints.

If deviations are detected during these maneuvers, it should be aimed for an improvement and customer relevance should be assessed based on market requirements. Result should be documented in the test report.

A positive test result after execution of paragraphs 4.3.1 to 4.3.6 is necessary for the release.

For a full validation program the test shall be executed two times. The additional paragraphs 4.3.7 to 4.3.11 is only conducted during the 2nd test execution.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14264

GMW15628

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 Circular track.

3.1.4 Hill track with gradient $\approx 12\%$ for fluent downhill resonance drive (see paragraph 4.3.4). Hill track with gradient $\approx 20\%$ for launch stall maneuvers (see paragraph 4.3.5).

3.1.5 Cooling chamber.

GM Confidential

© Copyright 2016 General Motors Company All Rights Reserved

December 2015

Page 1 of 14



Documents
Document Sharing Hub

3.1.6 Facility with altitude of 300 m maximum vs. sea level. This is a requirement for all startability maneuvers and DMF start angle measurements.

3.2 Equipment.

3.2.1 Data recording device for the following measurements:

- gear box oil temperature
- clutch pedal travel sensor (or bus)
- speed of gearbox input shaft
- engine speed at flywheel
- accelerator pedal position (bus, optional)
- speed of secondary DMF side, if possible
- injection signal, if necessary (optional)

For speed signals a sampling rate of 10 kHz or higher is recommended.

3.2.2 Attached tachometer and speedometer.

3.2.3 Standard tires.

3.2.4 Writing material, a paper copy each of Appendix A and Appendix C.

3.2.5 Torsional vibration measurement system (e.g. Rotec, AFT Tornado, etc.).

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

3.2.7 Optional instrumentation shall be determined by the responsible Test Engineer.

3.3 Test Vehicle/Test Piece.

3.3.1 Any vehicle with clutch and manual transmission and ≥ 65 % engine calibration level. Vehicle Curb Weight + 150 kg including driver.

3.3.2 Transmission, assembled according to specification.

3.3.3 Hydraulic clutch actuation components (including peak torque limiter (PTL)) and pedal box (including springs) according to development phase.

3.3.4 Two new and measured DMF near to lower friction tolerance, if available, otherwise nominal. Two new and measured clutch sets near upper clamp force tolerance (if available). Two new CSCs.

Especially for low rpm maneuvers (e.g. engine stall) it is recommended to measure the angular acceleration of the primary & secondary DMF side. Therefore a special measurement DMF is recommended.

For vehicles with Stop/Start system a measurement DMF is recommended. For new applications paragraph 4.3.2.6 should be executed once out of the typically two tests using a measurement DMF. This will enable analysis of start angle for a clutch pedal initiated engine start.

For impact calculation using energy method, see paragraph 5.

3.3.5 The engine type and the vehicle equipment according to the development phase. The vehicle shall be checked concerning engine torque before test.

3.3.6 The worst case engine fuel quality, especially ethanol share, for all intended sales markets has to be considered for this test procedure. If in doubt, an in-country validation is recommended.

3.4 Test Time.

Calendar time: 10 days per one of the typically two executions

Test hours: 24 h

Rebuild & installation of equipment: 24 h

Coordination hours: 32 h

3.5 Test Required Information. Possible sources are:

- SOR (Statement of Requirements)
- VTS (Vehicle Technical Specifications)
- SSTS (Sub System Technical Specifications)
- CTS (Component Technical Specifications)

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

December 2015

Page 2 of 14

- ADV Plan (Analysis Development Validation)
- VCRI (Validation Cross Reference Index)
- Application engineer
- Development Groups
- Drawings

3.6 Personnel/Skills.

- Skilled with MT components and specifically for this test trained test driver to run test.
- Skilled with MT components test Engineer to evaluate results.
- Skilled mechanic to mount and dismount the test parts according to valid process requirements (for MT systems).
- For test component measurements in-house: Skilled mechanic to determine component characteristics.

4 Procedure

For a full validation program the test according to GMW15630 shall be performed twice.

The first execution consists of maneuvers:

- 4.3.1 to 4.3.6
- 4.3.12
- 4.3.13

The second execution consists of maneuvers:

- 4.3.1 to 4.3.6
- 4.3.7 to 4.3.11
- 4.3.12
- 4.3.13

For each test execution a new DMF and clutch set is required.

4.1 Preparation.

4.1.1 Check fuel, engine oil, cooling fluid, tire pressure and transmission oil level.

4.1.2 Check of pedal travel and force before the test according to GMW15628. If necessary readjust and/or bleed hydraulic clutch system.

4.1.3 Prepare data sheet.

4.1.4 Activate measurement equipment.

4.2 Conditions.

4.2.1 Environmental Conditions. The test shall be performed on a dry circular track and dry hill track.

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. The release relevant test portion consists of paragraphs 4.3.1 to 4.3.6.

4.3.1 Check of start ability and start/stop-angle in cold condition.

4.3.1.1 Cool down the test vehicle in cooling chamber to -30 °C (-25 °C), battery with 75 % (80 %) capacity load.

For the exact start ability test conditions consult the SSTS and VTS (data in brackets for diesel applications).

4.3.1.2 Start the engine and run in idle for 15 s. Then stop the engine without pressed clutch pedal by switching key off. Measure the DMF displacement angle and execute a noise evaluation of start and idle performance according to GMW14264 (GM Subjective Rating Scale) in parallel. Repeat this procedure after 1 minute for additional 4 times.

4.3.1.3 Repeat paragraph 4.3.1.2 with aborted starts (slipping key) and double check if extended crank function is implemented in order to check the possibility of start-hanging of the DMF in the resonance area.

Between two aborted start maneuvers start the engine normally and let the engine idle for 10 s, then shut down the engine. If a tendency towards start hanging can be observed, additional starts are required for deeper investigation. Especially in this case slight variation in timing of the slipping event is recommended.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

December 2015

Page 3 of 14

4.3.2 N&V Evaluation including Start Measurement. Execute an N&V evaluation according to Appendix C including start measurement and displacement angle of the dual mass flywheel in ambient condition of (+15 to +20) °C and then hot condition (for engine coolant (+90 to +100) °C and transmission oil temperature (e.g. $\approx +80$ °C for M20/32)).

Check the torsional isolation of the DMF in idle and during wide open throttle acceleration in all gears starting from "drive idle engine speed" (e.g. angular acceleration 2nd order of engine (for 4 cylinder engine) vs. transmission input shaft plus displacement angle between primary and secondary side signal) up to $\approx \frac{2}{3}$ of maximum engine speed.

It is also possible to check the N&V behavior between different steps of the test.

It is recommended to execute this evaluation and measurement by or together with N&V experts.

4.3.2.1 Check of start ability and start angle in warm conditions (test vehicle with temperature of (+15 to +20) °C cooling water temperature/transmission oil temperature, full battery):

Start the engine and run in idle for 15 s. Then stop the engine without pressed clutch pedal by switching key off. Measure the DMF displacement angle and execute a noise evaluation according to GMW14264 (GM Subjective Rating Scale) in parallel. Repeat this procedure after 1 minute for additional 4 times.

4.3.2.2 Repeat paragraph 4.3.2.1 with aborted starts (slipping key) and double check if extended crank function is implemented in order to check the possibility of start-hanging of the DMF in the resonance area.

Between two aborted start maneuvers start the engine normally and let the engine idle for 10 s, then shut down the engine.

If a tendency towards start hanging can be observed, additional starts are required for deeper investigation. Especially in this case slight variation in timing of the slipping event is recommended.

4.3.2.3 On highway or circular track: Drive the vehicle until reaching a stabilized transmission oil temperature (e.g. $\approx +80$ °C for M20/32).

4.3.2.4 Start the engine and run in idle for 15 s and stop the engine without pressed clutch pedal by switching key off. Measure the DMF displacement angle and execute a noise evaluation according to GM rating system in parallel. Repeat this procedure after 1 minute for additional 4 times.

4.3.2.5 Repeat paragraph 4.3.2.4 with aborted starts (slipping key) and double check if extended crank function is implemented in order to check the possibility of start-hanging of the DMF in the resonance area.

Between two aborted start maneuvers start the engine normally and let the engine idle for 10 s, then shut down the engine.

If a tendency towards start hanging can be observed, additional starts are required for deeper investigation. Especially in this case slight variation in timing of the slipping event is recommended.

4.3.2.6 For vehicles with Stop/Start system: Repeat paragraph 4.3.2.4 with Stop/Start system initiated start (e.g. by clutch pedal actuation).

4.3.3 DMF Impact Check.

4.3.3.1 Accelerate the vehicle in 3rd, 4th, 5th and 6th gear until reaching $n = n_{\text{fuel cut off}} \times 0.6$. Release the gas pedal and simultaneously depress the clutch pedal. When the engine speed is at idle, release the clutch pedal by letting the clutch pedal snap (see paragraph 7.1). Measure the angular acceleration of the primary DMF side for impact torque calculation on primary side.

4.3.3.2 Repeat paragraph 4.3.3.1 four (4) additional times.

4.3.4 Resonance Drive.

4.3.4.1 Drive downhill (≈ 12 % gradient) and slow down the car with the brake in the 3rd gear while giving simultaneous wide open throttle until reaching the DMF resonance speed. Drive in the DMF resonance also by modulating the engine rpm with the brake pedal, then stall the engine (e.g. 3 stalls every 30 s). The complete resonance time in the 3rd gear shall be 90 s.

During the test the fuel cut off function of the engine control must work continuously. A re-injection / re-ignition shall be avoided by the ECU in order to prevent impacts for the DMF (e.g. if the fuel cut function is activated at 500 min⁻¹ and the vehicle is accelerated during the resonance drive to higher rpm's like 800 min⁻¹ the re-injection / ignition shall be avoided.)

If the function is not ok the test engineer shall decide if the test should be aborted.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

December 2015

Page 4 of 14

4.3.4.2 Repeat paragraph 4.3.4.1 in the 4th gear. The complete resonance time in the 4th gear shall be 90 s.

4.3.4.3 Repeat paragraph 4.3.4.1 in the 5th gear. The complete resonance time in the 5th gear shall be 90 s.

4.3.4.4 Repeat paragraph 4.3.4.1 in the 6th gear. The complete resonance time in the 6th gear shall be 90 s.

4.3.5 Launch Stall.

4.3.5.1 Stall the car during launch at $\approx 20\%$ grade in 1st gear by quickly engaging the clutch in order to force a stall while giving WOT in parallel. Engagement speed shall be sufficient to really stall the engine. Measure the angular acceleration of the primary DMF side for impact torque calculation on primary side.

4.3.5.2 Repeat paragraph 4.3.5.1 five additional times.

4.3.5.3 Repeat paragraphs 4.3.5.1 and 4.3.5.2 in reverse gear.

4.3.6 N&V evaluation including start measurement. Execute paragraph 4.3.2 again to achieve the comparable status after the release relevant test maneuvers.

If the status after the release relevant test portion has degraded to a level below VTS target, the test engineer shall clarify with the DMF DRE, if the not release relevant test portion should be performed with this part.

The not release relevant test portion consists of paragraphs 4.3.7 to 4.3.11. They are conducted additional to the release relevant test portion during the 2nd test execution.

4.3.7 Emergency Stall.

4.3.7.1 Drive the car in the 1st gear until reaching 30 km/h. Abruptly release the gas pedal and stall the engine by stepping on the footbrake with maximum load and maximum actuation speed without de-clutching. Measure the angular acceleration of the primary DMF side for impact torque calculation on primary side. If the impacts during the emergency stalls are above the supplier lifetime borderline, customer relevance should be assessed based on market requirements.

The possibility of further DMF hardware or protection software improvements shall be checked.

For low rpm maneuvers (e.g. engine stall) it is recommended to measure the angular acceleration of the primary and secondary DMF side of DMF with measuring device for impact calculation using energy method, see paragraph 5.1.1.

4.3.7.2 Repeat paragraph 4.3.7.1 for five additional times.

4.3.7.3 Repeat paragraphs 4.3.7.1 and 4.3.7.2 in 2nd, 3rd, 4th, 5th and 6th gear. If vehicle speed exceeds 30 km/h with engine's idle speed release the accelerator pedal and perform abrupt stall without de-clutching while in idle control.

4.3.8 Shifting Check 2nd to 5th Gear.

4.3.8.1 Drive the vehicle in 2nd gear and shift into the 5th gear. Choose the rpm value in the 2nd gear in order to reach a target rpm value in 5th gear which is near to the highest driveline resonance ((250 to 600) min⁻¹). During the shift maneuver it is necessary to give WOT in parallel during engaging the clutch. The clutch engagement should be performed with the standard clutch engagement technique.

Measure the angular acceleration of the primary DMF side for impact torque calculation on primary side. This test part is executed in order to check for a defect potential by mis-shifting in customer hands.

4.3.8.2 Repeat paragraph 4.3.8.1 for nine (9) additional times.

4.3.9 Clutch Engagement during Crank.

4.3.9.1 With engine off and transmission in neutral gear, push the clutch pedal down to the highest point that will allow the engine to start (not 100 % clutch pedal travel). Start the engine with the key or start button. As engine begins to crank, release the clutch pedal to $\gg 50\%$. Push the clutch pedal to the floor. Check if start hanging with engine vibration occurs and measure the DMF impacts.

In addition: Release the pedal and check if the clutch pedal hangs at $\gg 50\%$.

4.3.9.2 Repeat paragraph 4.3.9.1 for nine (9) additional times.

4.3.10 Speed Bumper Simulation.

4.3.10.1 Drive the car on Proving Ground, e.g. on circular track, in 3rd gear engaged at $\gg 1500$ min⁻¹ and slow down the car with the brake. After reaching the powertrain resonance area (and below engine idle speed), push the clutch pedal and keep the clutch pedal for (1 to 1.5) s in order to reduce the vehicle speed and corresponding transmission input speed.

GM Confidential

© Copyright 2015 General Motors Company All Rights Reserved

December 2015

Page 5 of 14