



Valvetrain and Camdrive Start-up Noise Test Procedure

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.

In an effort to ensure complete customer satisfaction with Global Propulsion Systems (GPS) products this test procedure has been written.

1.1.1 The purpose of this test procedure is to have a common and consistent methodology for identifying any propensity for unusual valvetrain or cam drive noises upon engine start-up and the period shortly thereafter. These may be noises that occur at the first start of the day, after an overnight soak, or after an extended period of time. Also included is any noise subsequent to a hot re-start after relatively brief periods of the engine being off and vehicle marshaling (or taxi stand vehicle cycles) where the engine is briefly operated followed by a soak. Conventional engine starts, automatic stop-start, and hybrid engine starts are considered within this procedure.

1.1.2 This document defines the test means and methods to be followed to subjectively evaluate the noise performance of primarily hydraulic actuated engine components such as (but not limited to):

- Valvetrain hydraulic lash adjusters.
 - Roller Hydraulic Valve Lifters (RHVL) (pushrod engines).
 - Roller Hydraulic Valve Deactivating Lifters (DEAC) (Active Fuel Management (AFM) Lifters (pushrod engines)).
 - Stationary Hydraulic Lash Adjusters (SHLA), both single and dual feed (Over Head Camshaft (OHC) and Dual Over Head Camshaft (DOHC) engines).
- Cam drive hydraulic chain tensioners.
- Balance shaft chain tensioners (and gears).
- Cam phasers.
- Hydraulically or electrically controlled mechanisms for valve-lift control and AFM.

1.1.3 This procedure does not establish, nor recommend, limits of acceptability. These are to be determined between the Lead Noise Engineer (LNE) and the product team.

1.2 Applicability. This test protocol is to be conducted as part of the normal development process. It is applicable for all new designs as well as for iterative changes that may affect the hydraulic system or the relevant subsystem components. This procedure applies to both gasoline and diesel engines.

1.3 Remarks. Upon starting of contemporary engines (both conventional and hybrid), the lube system supplies oil to galleries and the hydraulic components (see 1.1.2). These hydraulic components must be charged with sufficient oil volume and pressure to function properly. Any delay or deficiency in the lube supply or reservoirs to retain lube may lead to unwanted start-up sounds. Depending upon the system design, the lube may drain with varying degrees from the feed passages and component reservoirs. Thus, upon starting the engine, there may be a time lag for the oil pump to purge the galleries and hydraulic elements of entrained air. A period of **rattle-like** noises may result while the entire lubrication conduits are re-pressurized and before all the components are functioning and controlling in normal fashion.

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With the advent of hybrid and auto start/stop technology, a hot engine may have aerated oil. After numerous restarts, the entrained air may cause intermittent malfunction to the hydraulic elements resulting in a brief period of noise.

Therefore, it is the ultimate intent of this test procedure to ensure that all parts of the design are robust against noise incidence and that the process of recharging of the lube supply and purging of air is transparent to the customer.

1.4 Security. Should testing be done by an outside company or other non-GM organization, the following guidelines should be carefully followed regarding release of information associated with this work.

Information that can be shared freely includes:

- The required content of the test (soak procedure, start-up procedure, instrumentation and placement, etc.), or a separate document which gives this information.
- The test reliability and/or variability to be expected for this procedure.
- The required sample size or related criteria to establish testing confidence.
- Any compromises which the testing company will be allowed to make in order to expedite the testing or minimize expenditures.
- Recommendations for continued testing when problems arise.
- Recommendations for alternate or post analysis if necessary.
- Requirements for reporting results to GPS.

Information that may *not* be released includes:

- Details about how the test reliability was determined.
- Details relevant to the development and/or selection of the test modes and schedules.

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

2.3 Additional References. None.

3 Resources

3.1 Facilities. Measurements described in this procedure shall be obtained using one of the following:

- Semi-anechoic engine dynamometer cell.
- Idle buck in a semi-anechoic test room (or quiet outside).
- Full vehicle in semi-anechoic car test room (or chassis dynamometer room) or quiet outside.

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.

Note: Preferably all setups should employ an automatic transmission, but manual transmissions maybe required for specific applications.

Note: Capability to chill the engine down to -20 °C may be required.

3.2 Equipment.

3.2.1 Accelerometers. Single axis, or if more convenient, the normal axis of a triaxial accelerometer. Examples include Models No. 357A07 and HT356B01 from supplier PCB Piezotronics, Incorporated.

3.2.1.1 Frequency response of 10 kHz minimum.

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3.2.1.2 Dynamic range of $\pm 1000G$ minimum.

3.2.1.3 Attachment using dental cement or equivalent. Stud mounting may be required for cold test conditions.

3.2.1.4 Locations (all externally mounted).

Note: Logistical deviations are to be prescribed by the LNE. Locations should be screened or probed in some manner such as using a stethoscope.

3.2.1.4.1 Valvetrain noise. One (1) accelerometer per cylinder head near center of cam cover rail, outboard on either intake or exhaust sides (not on cam cover). Orientation is to be parallel to cylinder axis.

3.2.1.4.2 Cam drive (chain tensioner) noise. One (1) accelerometer located on cylinder case (block) closest to each chain tensioner (e.g., three (3) accelerometers for DOHC stepped drive). Accelerometers are not to be mounted on front cover if at all possible. Front cover bolts may be permitted. Orient as practical and/or for best signal.

3.2.1.4.3 Cam phaser noise. One (1) accelerometer per cylinder head at structural front and center near deck face if possible. Orient as practical and/or for best signal.

3.2.1.4.4 Balance shaft tensioner noise. One (1) accelerometer on lower cylinder case closest to path from tensioner. For example, if balance shaft drive is at rear, locate the accelerometer on the transmission bulkhead. Similarly, for a front drive balancer, locate the accelerometer on the front side of the block, near the pan rail. Orient as practical and/or for best signal.

Note: The cam drive and balancer drive accelerometer can be one and the same if on same end of engine.

3.2.2 Microphones.

3.2.2.1 Typical microphone type is a 12.7 mm ($\frac{1}{2}$ in) (nominal transducer diameter) pressure or free field (e.g., B&K Precision Corporation, 4191/92 or 4188/89, respectively). A quantity of four (4) microphones minimum are required, with frequency response up to 20 kHz minimum. Microphones shall be oriented (relative to projected sound field) according to their type: grazing incidence (pressure type); normal incidence (free field type).

3.2.2.2 Locations: Use standard Engine Level Allocation Test (ELAT) locations for engine dynamometer and idle buck setups. Use standard Powertrain Level Allocation Test (PLAT) locations for full vehicle evaluations.

3.2.3 Temperature Measurement Equipment. Appropriate equipment shall be used to measure ambient air temperature and engine coolant temperature at start of test. Engine oil sump temperature shall be measured, via drain plug or dipstick thermocouple.

Note: For vehicle tests, the instrument panel coolant temperature gage reading is sufficient.

3.2.4 Engine Speed and Timing Measurement Equipment. Cam and crank position sensors shall be used to measure crank position, one (1) or more cam positions, and engine speed.

3.3 Test Vehicle/Test Piece.

Note: Product team and LNE can modify these specifications as deemed appropriate, but must record justification for doing so.

3.3.1 Engine Oil. The oil should be the type and viscosity as recommended for the engine. The oil must be near end of life (used) oil (i.e., at near maximum oil change interval).

3.3.2 Engine Build.

Note: All specifications are for when the engine is assembled new, before break in.

3.3.2.1 Chain length. All chains (cam drive and balancer drive) shall be at maximum build tolerance (center to center specification) and expected end of life elongation to simulate maximum tensioner extension.

3.3.2.2 Tensioner leak-down (if specified). All hydraulic tensioners in engine shall be at maximum specification (i.e., fast leak).

3.3.2.3 Phaser lock-pin backlash. Each phaser shall be at maximum design backlash specification.

3.3.2.4 RHVL or SHLA (Lash Adjuster) leak-down. As a set, should be at fastest (maximum) design leak-down rate.

3.3.2.5 DEAC (AFM) RHVL or switching rocker arm engagement pin clearance. As a set, should be at maximum design limit.

3.3.2.6 Crank and cam bearing clearances are acceptable for this test as nominal or as-built.

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3.3.2.7 Oil pump output. The oil pump should be built with worst case components to meet minimum design flow and pressure requirements if applicable. Continuously variable oil pumps should be set to the production intent pressure setting during the test.

3.4 Test Time.

Calendar time: 4 w
 Test time: Not applicable
 Coordination time: Not applicable

3.5 Test Required Information.

General assessment and rating of disturbance at start-up.

While objective data will be recorded via the specified accelerometers and microphones, the overall Noise, Vibration and Handling (NVH) performance of the design will be rated by qualified personnel. The noise performance rating will be based on the Generic Subjective Rating Scale (Figure 1). Reference GMW14264 for further information.

Specifically, during the start-up evaluation, experienced assessors will be listening for any and all suspect noise and make note of it on the template provided in Appendix A, Data Sheet A1. Noise documentation should include the following content and notations.

- Descriptive noise character (e.g., rattle, knocking, tapping, clatter, ticking, etc.)
- Time noise developed (e.g., approximately 4 s after start-up).
- Duration (dwell) of noise interval (e.g., lasted for approximately 20 s).
- Approximate engine rpm.
- Probable or suspect source (component and/or where radiated from; e.g., rattle-like clatter emanating from front of area of engine, probably chain tensioner).
- Additional commentary worthy of note.

Quite likely any noise(s) will vary or other sources will simultaneously occur. Similarly, some noise(s) will be of very short duration and/or come and go. Thus, it will prove beneficial to listen to the recorded microphone and accelerometer data to provide additional impressions.

Figure 1: Generic Subjective Rating Scale

Generic Subjective Rating Scales		
Rating	Performance	Disturbance
10	Excellent	None
9		
8	Good	Trace
7		
6	Fair	Moderate
5		
4	Poor	Annoying
3		
2	Bad	Severe
1		
0	Not Applicable (Component cannot be rated, not functioning, missing, etc.)	

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