



GM Stochastic Pre-ignition Test Monitoring System

Introduction

The GM stochastic pre-ignition test procedure (GMSPI)¹ measures an oil's tendency to pre-ignite during high load operation in a turbocharged engine. GMSPI is a part of GM's dexos™ 1 engine oil specifications.

Definitions

Configuration – an engine installed on a test stand.

Day – Monday through Friday, excluding federal holidays, company holidays, or scheduled facility shutdown periods.

LCL – lower control limit

Qualification – the process whereby an engine installed on a test stand demonstrates the capability to discriminate between reference oils of differing performance levels.

SPI – stochastic pre-ignition

TMC – ASTM Test Monitoring Center

UCL – upper control limit

Reference Oils

- A. Two reference oils will be provided by GM and stored at TMC. The reference oil will be labeled GMPI01 (high SPI) and GMPI02 (low SPI). TMC will dispense reference oils to the laboratory as needed. In addition to the TMC quality monitoring system, GM will measure oil properties and will report the results to TMC.
- B. Test methods used by GM for oil analysis will be the following:
 1. Additive profile (GM proprietary method)
 2. Differential scanning calorimetry (DSC): ASTM D6186
 3. Elemental analysis by ICP: ASTM D5185
 4. Kinematic viscosity at 40°C (KV40): ASTM D7279
 5. Kinematic viscosity at 100°C (KV100): ASTM D7279
 6. High temperature high shear viscosity at 150°C (HTHS150): ASTM D5481

¹GMW17244

7. Oxidation: DIN 51 453
8. Thermogravimetric analysis (TGA): ASTM E1131
9. Water content: ASTM E2412

C. GM will measure initial reference oil batches for the following:

1. Additive profile
2. DSC
3. HTHS150
4. ICP (B, Ba, Ca, Fe, K, Mg, Mo, Na, P, S, Si, Zn)
5. KV40
6. KV100
7. Oxidation
8. TGA
9. Water content

D. GM will measure reference oil batches every 6 months for the following:

1. DSC
2. Oxidation
3. Water content

E. Gm will measure reference oil batches every 12 months for the following:

1. Additive profile
2. ICP
3. KV40
4. KV100

Test Measurement Parameters

The critical test measurement parameter is the number of peak pressure pre-ignition events.

Test Stand Qualification Criteria

One test stand at a single laboratory has been approved to run GMSPI. Every time a new or rebuilt engine is installed on the test stand, the laboratory will need to prove that the configuration can distinguish between 2 oils of differing performance.

A. Qualifying a New Configuration

1. The useful life on an engine is 300 hours for a new or rebuilt engine configuration. The laboratory must use daily engine health data to determine if the current engine has reached the end of its useful life before 300 hours.

- (a) The laboratory may delay replacing or rebuilding an engine so not to break up 5 consecutive tests on the same candidate oil provided the first test of the sequence is started prior to 300 hours of engine run time.
2. The laboratory must consult GM before replacing or rebuilding the current engine except as noted below. GM must approve new engine configurations.
 - (a) The laboratory is permitted to replace or rebuild an engine at its discretion if the following condition are met:
 - i. The engine has experienced a mechanical failure that cannot be repaired by replacing external parts or
 - ii. GM personnel cannot be reached within 2 days (excluding weekends or holidays no more than 2 days in length) or
 - iii. The engine has exceeded 250 hours of run time.
 - (b) In the event that the laboratory replaces an engine at its discretion, GM thereafter will approve the configuration as soon as possible.
3. Once a new or rebuilt engine has been installed and is ready for testing, the laboratory must provide written notification to TMC of the new engine. TMC will provide a reference oil testing sequence within 2 days of receipt of the notification.
4. Upon receipt of the reference oil test sequence from TMC, the laboratory must complete testing within 10 days in the sequence specified by TMC.
5. The laboratory will run 5 sequential, operationally valid tests each on reference oils GMPI01 and GMPI02 uninterrupted by non-reference oil tests. The laboratory must report each individual reference oil result along with operational parameters to the TMC, who will perform all calculations necessary for the qualification process.
6. A test is operationally valid if:
 - (a) The test is run in accordance with GMSPI and is not terminated before its designed conclusion.

- (b) Every controlled engine operating parameter meets its respective Quality Index.

7. TMC will determine pass/fail for reference oil GMPI01 as follows:

- (a) Calculate the square root of each result.
- (b) Calculate the average of the 5 results from 7(a).
- (c) Use the value from 7(b) to determine if GMPI01 is within control limits.
 - i. If the GMPI01 value is above the LCL and below the UCL, the engine passes qualification on GMPI01 reference oil.
 - ii. If the GMPI01 value is on or beyond the LCL or UCL, the engine fails qualification on GMPI01.

8. TMC will determine pass/fail for reference oil GMPI02 as follows:

- (a) Calculate the square root of each result.
- (b) Calculate the average of the 5 results from 8(a).
- (c) Use the value from 8(b) to determine if GMPI02 is within control limits.
 - i. If the GMPI02 value is above the LCL and below the UCL, the engine passes qualification on GMPI01 reference oil.
 - ii. If the GMPI02 value is on or beyond the LCL or UCL, the engine fails qualification on GMPI021.

9. An individuals, moving range chart will be used to monitor configuration performance on reference oil GMPI01.

- (a) R chart for the moving range
 - i. A value for the mean of the moving range, R_{bar} , will be provided for GMPI01. The mean will be recalculated every 20 tests, incorporating each new set of data.

ii. The upper control limit is defined as: $3.267*(R_bar)$

iii. The lower control limit is 0.

(b) X chart for the mean

i. A value for the mean of pre-ignition events, X_bar , will be provided for GMPI01. The mean will be recalculated every 20 tests, incorporating each new set of data.

ii. The upper control limit is defined as: $(X_bar) + 2.66*(R_bar)$.

iii. The lower control limit is defined as: $(X_bar) - 2.66*(R_bar)$.

(c) An assignable cause exists if any of the following occur:

i. A point on the R chart is on or beyond the UCL.

ii. A point on the X chart is on or beyond the UCL.

iii. A point on the X chart is on or beyond the LCL.

iv. Eight consecutive points on the X chart fall on one side of the mean.

10. An individuals, moving range chart will be used to monitor configuration performance on reference oil GMPI02.

(a) R chart for the moving range

i. A value for the mean of the moving range, R_bar , will be provided for GMPI02. The mean will be recalculated every 20 tests, incorporating each new set of data.

ii. The upper control limit is defined as: $3.267*(R_bar)$

iii. The lower control limit is 0.

(b) X chart for the mean

- i. A value for the mean of pre-ignition events, \bar{X} , will be provided for GMPI02. The mean will be recalculated every 20 tests, incorporating each new set of data.
 - ii. The upper control limit is defined as: $(\bar{X}) + 2.66*(\bar{R})$.
 - iii. The lower control limit is 0.
- (c) An assignable cause exists if:
 - i. A point on the R chart is on or beyond the UCL.
 - ii. A point on the X chart is on or beyond the UCL.
 - iii. A point on the X chart is on or beyond the LCL.
 - iv. Eight consecutive points on the X chart fall on one side of the mean.
11. If a configuration fails to qualify after the first attempt, the laboratory, when it is ready to continue with qualification, will request another reference oil testing sequence from TMC. The laboratory must complete reference oil testing within 10 days of receipt of the testing sequence from TMC.
12. If a configuration fails to qualify after 2 attempts, the laboratory and TMC will together investigate the cause and develop an action plan. TMC may request the assistance of GM in the investigation and development of an action plan. Once the laboratory submits an attestation to TMC that the action plan has been implemented, TMC will provide a reference oil testing sequence within 2 days of receipt of the notification. The laboratory must resume qualification starting at A.4.
13. After receipt of all reference oil results, TMC will provide written confirmation of the outcome to the laboratory within 2 days. The laboratory is permitted to start candidate oil testing immediately upon receipt of an affirmative confirmation.
14. A laboratory must notify TMC of an invalid test due within 2 days of occurrence. An operationally invalid test requires the laboratory to submit an action plan to TMC within 5 days after notification, identifying the problem, indicating the action to be taken, and providing a time line for implementation.

- (a) In the event of a known root cause with a straight forward solution, the laboratory may, at its own discretion, implement the action plan and continue the reference oil sequence pending the decision of TMC. In this case the laboratory will submit the action taken and all available reference oil results to TMC with the invalid test notification.
15. TMC will provide a written reply approving/disapproving the action plan to be taken within 5 days of receipt of the report.
- (a) TMC may consult GM regarding approving/disapproving the action plan.
 - (b) In the event of a known root cause with a straightforward solution that in the opinion of TMC does not represent a systemic problem and is approved by TMC, the laboratory will be allowed to complete the original reference oil sequence.
 - (c) For all other invalid tests, if TMC approves the action plan, the laboratory must submit an attestation to TMC once the action plan has been implemented. Upon receipt of the attestation, TMC will provide a reference oil testing sequence within 2 days of receipt of the attestation. The laboratory must resume qualification starting at A.4.
 - (d) If TMC disapproves the action plan, the laboratory must submit a second plan to TMC specifying the new action to be taken. This iterative process will continue until the action plan is satisfactory. If TMC approves the action plan, the laboratory must submit an attestation to TMC once the action plan has been implemented. Upon receipt of the attestation, TMC will provide a reference oil testing sequence within 2 days of receipt of the notification. The laboratory must resume qualification starting at A.4.
16. If a configuration experiences 2 operationally invalid tests during the course of engine qualification that in the opinion of the laboratory or TMC represent a systemic problem or have no readily identifiable root cause, the laboratory, TMC, and GM will together develop an action plan. Once the laboratory submits an attestation to TMC that the action plan has been implemented, TMC will provide a reference oil testing sequence within 2 days of receipt of the notification. The laboratory must resume qualification starting at A.4.

Release and revision history

Issue	Date	Description
1	June 2015	Initial release
2	January 2016	Revised A.2 and B.4 to reflect engine replacement once approximately 500 hours of run-time have been accumulated.
3	July 2016	Revised section B.2-B.5 to allow TMC discretion in assigning reference oils and B.8 to modify reference oil sequence.
4	August 2017	Revised Introduction to reflect applicability only to dexos 1. Revised section A to define useful engine life as 300 hours and include rebuilt engine. Eliminated section B pertaining to intermediate reference oil testing.