GM Oxidation and Deposit Test Monitoring System

Introduction

The GM oxidation and deposit test (GMOD)[1] is an engine test that measures oil's resistance to oxidation during high temperature operation. GMOD is a part of GM's dexos™ engine oil specification.

This document describes the test monitoring system used to qualify new and evaluate existing test stands. Each test stand will be monitored individually. Control chart methods used to monitor stand performance will be instituted on a temporary basis until a more comprehensive study evaluating different options can be completed.

Definitions

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

LCL – lower control limit

PR – phosphorus retention

PVIS – percent viscosity increase.

Qualification – the process to enter the monitoring system whereby a test stand demonstrates the capability to assess, within precision limits, the performance of reference oils.

Test stand – an engine mounted on a dynamometer in a laboratory.

TMC – ASTM Test Monitoring Center

UCL – upper control limit

WPD – weighted piston deposits

Reference Oils

Three reference oils, labeled GMOD01, GMOD02 and 434-2 will be provided by TMC for reference test purposes. These oils are provided only for GMOD reference test purposes. Any other use of these oils must be approved by GM and TMC. These oils and/or retains are not to be sold or distributed to other parties. No analysis beyond what is permitted in the test

procedure is allowed. All reference oils are to be stored in a climate controlled facility and not exposed to temperature extremes or outside conditions.

Test Measurement Parameters

The critical test measurement parameters are:

1. Percent viscosity increase
2. Weighted piston deposits
3. Phosphorus retention

Test Stand Qualification Criteria

Multiple test stands at several laboratories have been approved to run GMOD. A laboratory desiring to include a new test stand in the GMOD monitoring system will have the test stand go through a qualification process.

A. New Test Stand Qualification

1. To qualify a test stand for monitoring, the laboratory must first submit a request for inspection form to TMC for each stand it intends to qualify. A mutually acceptable inspection date will be scheduled by TMC, GM, and the laboratory. TMC and GM will inspect the test stand for conformance to the installation set up protocol described in the test procedure. The laboratory should make every effort to have all new test stands inspected during one visit. TMC and GM will not return to inspect another test stand prior to 45 days after the previous inspection unless agreed to by TMC and GM.

2. TMC and GM will inform the laboratory after completing the inspection whether the test stand conforms to the installation set up protocol. TMC will send written confirmation to the laboratory within 5 days of the inspection.

3. If the stand does not conform, TMC will provide written notice of required modifications within 5 days after completing the inspection. The laboratory must provide written documentation and, where necessary, photos of the modifications made to the test stand within 10 days of receiving the TMC notification. If the laboratory fails to provide documentation within 10 days, the stand will be ineligible to qualify until documentation is received plus 30 days. TMC and GM may require further modifications and documentation until both are satisfied that the test stand is in conformance. The 10 day time limit will remain in effect for each iteration. At any time, TMC and GM at their discretion may arrange another inspection visit to the laboratory.

4. Only a test stand conforming to the set up protocol is permitted to begin the qualification process.

5. The laboratory seeking qualification of a test stand must provide written request for reference oil assignment to TMC. Upon receipt of the reference oil assignment, the laboratory must complete testing within 30 days in the sequence specified by TMC. If a laboratory does not complete reference oil testing on a stand within the allotted time, the stand will be ineligible to qualify for 30 days from the end of the completion period. After 30 days, the test stand may request another reference oil assignment.

6. A laboratory may decide to stop qualification testing on a test stand at any time during reference oil testing provided written notice is submitted to TMC. The test stand will be ineligible to qualify for 30 days from receipt of the notice. After 30 days, the test stand may resume qualification starting at A.5.

7. A test stand undergoing qualification must prove it is capable of accurately measuring the performance of 2 reference oils. A minimum of 2 consecutive operationally valid reference oil tests, with no out of control results in Shewhart individual Y_i control charts for PVIS or WPD are required to qualify a stand. The two tests shall consist of 1 test each on reference oils randomly selected by TMC.

    (a) The laboratory must report each individual reference oil result along with operational parameters within 5 days of test completion to the TMC, who will perform all calculations necessary for the qualification process. TMC will report the disposition of the result (pass/fail, operationally valid/invalid) within 5 days of receipt or results.

8. A test is operationally valid if:

    (a) The test is run in accordance with the procedure and is not terminated before its designed conclusion.

    (b) The number of hours the test stand is allowed to be under conditions not allocated by the test procedure is no more than 24.0. This includes both time when the engine is not running (downtime) and time when the engine is not running according to test procedure (off-test condition time).

    (c) The number of engine restarts, excluding those allocated by the test procedure, is no more than 3.

(d) Every controlled engine operating parameter meets its respective Quality Index (QI). Data must be collected in accordance with the guideline issued in the "Data Acquisition and Control Automation II Task Force Report" (July 17, 1997).

9. A laboratory must notify TMC of an invalid test. 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. An action plan must be submitted regardless of whether the stand will continue with qualification. If a laboratory fails to submit an action plan to TMC within the allotted time, no additional testing is permitted on the stand until 365 days from the date of stoppage of test.

10. TMC will provide a written reply approving/disapproving the action to be taken within 5 days of receipt of the report. If TMC approves the action, the laboratory must submit an attestation to TMC within 10 days indicating the action has been implemented. The test stand may then resume qualification starting at A.5. If a laboratory fails to submit the attestation within the allotted time, the test stand will not be permitted to continue with qualification until 30 days past the completion date of the invalid test. If TMC disapproves the action plan, the laboratory must submit a second plan to TMC within 5 days of TMC's reply specifying the new action to be taken. This iterative process will continue until the action plan is satisfactory. If the laboratory does not submit a second or subsequent action plan within 5 days, no additional testing is permitted until 365 days from the date of the last disapproval. Restarting qualification is contingent on the laboratory submitting an attestation to TMC that the required action plan has been implemented. After submitting an action plan, a laboratory may choose to withdraw the test stand from the qualification process upon written notice to TMC. Continuation of qualification testing can only occur after 30 days from the date of receipt of the withdrawal notice. Restarting qualification is contingent on the laboratory submitting an attestation to TMC that the required action plan has been implemented.

11. If a test stand experiences 2 operationally invalid tests during the course of qualification, 30 days must pass from the date of stoppage of the last run before further qualification testing can resume. Qualification may resume starting at A.5 contingent on the laboratory submitting an attestation to TMC that the required corrective action has been taken.

12. TMC will determine the pass/fail criteria of a test stand based on the results of reference oil tests using the control chart outlined in B.6(a):

    (a) Control limits for existing stands shall be used for determining pass/fail.

    (b) If PVIS and WPD are within the LCL and UCL, the stand passes qualification on the reference oil.

    (c) If PVIS and WPD are on or beyond the LCL or UCL, the stand fails qualification on the reference oil.

    (d) In the event of a failed result, the laboratory may run one subsequent consecutive run on the same reference oil. The average value(s) for both parameters must meet the requirements of section A.12(b) in order to pass qualification.

13. If a test stand fails to qualify after the first attempt, the laboratory must submit a report to TMC explaining the reasons for the failed reference tests. Once TMC is satisfied the test stand is ready for another attempt, the laboratory may resume qualification starting at A.5.

14. After receipt of all reference oil results, TMC will provide written confirmation to the laboratory within 5 days whether the test stand is qualified. The test stand is permitted to start candidate oil testing immediately upon receipt of an affirmative confirmation.

B. Existing Test Stand Monitoring

1. An existing qualified test stand must run a reference oil test after no more than 15 candidate test starts or no later than 120 days following the completion of the last reference oil test, whichever occurs first. TMC will randomly assign one reference oil to a test stand.

2. All reference oil test results must be reported to TMC within 5 days of completion of test. If a test stand does not run the reference test on time or if the laboratory informs TMC that the test stand will not continue with monitoring, the test stand will be removed from the monitoring system and will be prohibited from requalification starting in A.5 for 60 days from the date of violation/notification.

3. An operationally invalid test on reference oil requires the laboratory to submit an action plan to TMC within 5 days of stoppage of test, identifying the problem,

indicating the action to be taken, and providing a time line for implementation. An action plan must be submitted regardless of whether the stand will continue in the monitoring system. Failure to submit an action plan to TMC within the allotted time will result in removal of the test stand from the monitoring system for 365 days from the date of stoppage of test.

4. TMC will provide a written reply approving/disapproving the action to be taken within 5 days of receipt of the report. If TMC approves the action, the laboratory must submit an attestation to TMC within 10 days indicating the action has been implemented. The test stand may then resume qualification starting at A.5. If a laboratory fails to submit the attestation within the allotted time, the test stand will not be permitted to continue with qualification until 30 days past the completion date of the invalid test. If TMC disapproves the action plan, the laboratory must submit a second plan to TMC within 5 days of TMC's reply specifying the new action to be taken. This iterative process will continue until the action plan is satisfactory. If the laboratory does not submit a second or subsequent action plan within 5 days, no additional testing is permitted until 365 days from the date of the last disapproval. Restarting qualification is contingent on the laboratory submitting an attestation to TMC that the required action plan has been implemented. After submitting an action plan, a laboratory may choose to withdraw the test stand from the qualification process upon written notice to TMC. Continuation of qualification testing can only occur after 30 days from the date of receipt of the withdrawal notice. Restarting qualification is contingent on the laboratory submitting an attestation to TMC that the required action plan has been implemented.

5. TMC, with consultation from General Motors, will review all invalid test declarations to determine if a reason for an invalid test represents a systemic pattern within a stand. Re-occurring evidence and the frequency of invalid tests by a laboratory will be a strong factor in determining the need for removing a stand from the monitoring system. A laboratory will be required to provide detailed explanations for the cause of an invalid test and the action taken to prevent re-occurrence.

6. TMC will use four control charts to monitor individual test stand performance for PVIS, WPD, and PR.

    (a) Shewhart chart for severity of standardized test result

        i. Plot the variable Y_i on the y-axis and test order on the x-axis.

        ii. $Y_i = (T_i - \text{Mean}) / \text{Stdev}$, where

Y_i = standardized test result at test order i

T_i = test result at test order i

Mean = average for the respective reference oil

Stdev = standard deviation for the respective reference oil

iii. UCL = 2.0

iv. LCL = -2.0

(b) Shewhart chart for precision of standardized test result

i. Plot the variable H_i on the y-axis and test order on the x-axis.

ii. $H_i = [(\text{sqrt}(|Y_i|) - 0.822] / 0.349$, where

Y_i = standardized test result at test order i

$Y_0 = 0$

iii. UCL = 2.0

(c) Exponentially weighted moving average (EWMA) for Y_i

i. Plot the variable Z_i on the y-axis and test order on the x-axis.

ii. $Z_i = (0.2)\ Y_i + (0.8)\ Z_{i-1}$

iii. $Z_0 = 0$

iv. UCL = 0.67

v. LCL = -0.67

(d) Exponentially weighted moving average (EWMA) for H_i

i. Plot the variable U_i on the y-axis and test order on the x-axis.

ii. $U_i = (0.2)\ H_i + (0.8)\ U_{i-1}$

iii. $H_0 = 0$

iv. UCL = 0.67

7. A test stand fails a reference oil test if:

   (a) A point for Y_i, H_i, Z_i, or U_i is on or beyond the UCL for PVIS or WPD.

   (b) A point for Y_i, or Z_i is on or beyond the LCL for PVIS or WPD.

8. In the event of a failed test, the laboratory may run one subsequent consecutive test on the same reference oil. The average of the combined values for PVIS and WPD must be within the control limits as described in section B.6 in order to pass.

9. If the laboratory chooses not to run a subsequent consecutive test or if the average of the two tests still produces a failing result, the stand will immediately cease candidate testing. TMC, GM, and the laboratory will convene to determine the course of action. If an action plan is necessary, the laboratory will provide attestation to TMC that the plan has been implemented, and TMC will provide written notice that the said action is satisfactory before the laboratory can commence candidate testing.

Reference Oils and Parameters

PERCENT VISCOSITY INCREASE (PVIS)
Unit of Measure: Ln(PVIS)

Reference Oil	Mean	Standard Deviation
434-2	4.4245	0.33008
GMOD01	4.3201	0.17583
GMOD02	4.0608	0.40031

WEIGHTED PISTON DEPOSITS
Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
434-2	5.87	0.608
GMOD01	5.26	0.693
GMOD02	4.77	0.715

PHOSPHORUS RETENTION
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
434-2	73.81	1.854
GMOD01	81.86	3.123
GMOD02	82.85	3.480

Release and revision history

Issue	Date	Description
1	April 2016	Initial release
2	Oct. 2016	Modified B.1 to clarify reference period. Modified 6 to include PR in stand performance. Modified 6(b) replacing R_i with H_i. Deleted 7(c), runs test.
3	Dec. 2016	Editorial correction in B.6.(a) and B.6.(b): description of chart type. Editorial change in B.6.(d) and B.7.(a): change Q_i to U_i.