



## **GM Turbocharger Coking Test Monitoring System**

### **Introduction**

The GM turbocharger coking test procedure (GMTC)<sup>1</sup> measures an oil's tendency to form deposits on internal turbocharger parts during engine operation. The GM turbocharger coking test is a part of GM's dexos<sup>TM</sup> 1 and dexos<sup>TM</sup> 2 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 correctly evaluate a reference oil for turbocharger coking.

TMC – ASTM Test Monitoring Center

UCL – upper control limit

### **Reference Oils**

Two reference oils will be provided by GM and stored at TMC. The reference oils will be labeled GMTC01 (high coking) and GMTC02 (low coking). TMC will dispense reference oils to the laboratory as needed.

### **Test Measurement Parameters**

The critical test measurement parameter is percent change in turbocharger outside coolant passage temperature at 1800 cycles.

### **Test Stand Qualification Criteria**

Multiple test stands at a single laboratory have been approved to run the GM turbocharger coking test. If a new test stand is installed, the laboratory will need to prove that the configuration can correctly evaluate one reference oil for turbocharger coking.

<sup>1</sup>GMW17299

A. Qualifying a New Configuration – Engine Replacement

1. The laboratory must consult GM before replacing an engine on an existing test stand. GM must approve the resulting new configuration before testing can begin.
  - (a) Installation of a new engine on an existing test stand does not require reference oil testing.
2. The laboratory is permitted to replace an engine at its discretion if the following condition are met:
  - (a) The engine has experienced a mechanical failure that cannot be repaired by replacing external parts or
  - (b) Oil consumption from the previous test exceeds 1.5 g/h (total test time) or
  - (c) GM personnel cannot be reached within 2 days (excluding weekends or holidays no more than 2 days in length)

In the event the laboratory replaces an engine at its discretion, GM thereafter will approve the configuration as soon as possible.

3. After the engine has been replaced, the laboratory must provide written notification to TMC of the new configuration.

B. Qualifying a New Configuration – New Test Stand

1. The laboratory must consult GM before installing a new test stand. GM must approve the new configuration before testing can begin.
2. Once a configuration is ready for testing, the laboratory must provide written notification to TMC of the new configuration. TMC will assign GMT01 within 2 days of receipt of the notification.
3. The laboratory will run one operationally valid test on GMT01. The laboratory must report the reference oil result along with operational parameters within 2 days of test completion to the TMC, who will perform all calculations necessary for the qualification process.
4. A test is operationally valid if:

- (a) The test is run in accordance with the test procedure and is not terminated before its designed conclusion.
  - (b) Every controlled engine operating parameter meets its respective Quality Index.
- 5. TMC will determine pass/fail for GMTCC01 as follows:
  - (a) If the GMTCC01 result is between the respective X chart UCL and LCL, the configuration passes qualification.
  - (b) If the GMTCC01 result is on or beyond the respective X chart UCL or LCL, the configuration fails qualification.
- 6. If a failing result is obtained, the laboratory must rerun GMTCC01. The average of the 2 results will be used to determine conformance.
- 7. If the average still fails, the laboratory, TMC and GM will investigate the cause and develop an action plan. Once the laboratory submits an attestation to TMC that the action plan has been implemented, TMC will assign GMTCC01 within 2 days of receipt of the notification. The laboratory will resume qualification starting at B.3.
- 8. After receipt of all GMTCC01 results, TMC will provide written confirmation to the laboratory within 2 days whether the configuration is qualified. The laboratory is permitted to start candidate oil testing immediately upon receipt of an affirmative confirmation.
- 9. 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.
- 10. TMC will provide a written reply approving/disapproving the action plan within 5 days of receipt of the report.
  - (a) TMC may consult GM regarding approving/disapproving the action plan.
  - (b) 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 for testing within 2 days of receipt of the attestation. The laboratory will resume qualification starting at B.3.

- (c) 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 will resume qualification starting at B.3.

11. If a configuration experiences 2 operationally invalid tests during the course of engine qualification that in the opinion of the laboratory or TMC represents 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 will resume qualification starting at B.3.

#### C. Monitoring an Existing Configuration

1. Each configuration will be monitored by TMC through annual reference oil testing.
2. Reference oil testing consists of a single run on one reference oil assigned to a configuration by TMC.
  - (a) For the first reference oil test, all configurations will run GMTCC02.
  - (b) For the second reference oil test, all configurations will run GMTCC01.
  - (c) For subsequent reference oil tests, TMC will randomize GMTCC01 and GMTCC02 among the configurations.
3. The first reference period for a configuration begins when GM provides a notice of approval to TMC.
4. The length of a reference period will be 365 days.

- (a) For the first reference period, GM, TMC, and the laboratory will work together to stagger reference oil testing to minimize the number of configurations testing at the same time.
  - (b) After the first reference period, all configurations will run a test no later than 365 days from the start of the previous reference oil period.
- 5. All reference test results must be reported to TMC within 2 days of completion of test. The result will be plotted on control charts as described below.
- 6. An individuals, moving range chart will be used to monitor each configuration's performance.
  - (a) R chart for the moving range
    - i. A value for the mean of the moving range,  $R_{\text{bar}}$ , will be provided for GMTCC01 and GMTCC02. The mean will be recalculated every year, incorporating each new set of data.
    - ii. The upper control limit is defined as:  $3.267 \cdot (R_{\text{bar}})$
    - iii. The lower control limit is 0.
  - (b) X chart for the mean
    - i. A value for the mean of percent coolant out temperature,  $X_{\text{bar}}$ , will be provided for GMTCC01 and GMTCC02. The mean will be recalculated every year, incorporating each new set of data.
    - ii. The upper control limit is defined as:  $(X_{\text{bar}}) + 2.66 \cdot (R_{\text{bar}})$ .
    - iii. The lower control limit is defined as:  $(X_{\text{bar}}) - 2.66 \cdot (R_{\text{bar}})$ .
- 7. An assignable cause exists if any of the following occur:
  - (a) A point on the R chart is on or beyond the UCL.
  - (b) A point on the X chart is on or beyond the UCL.
  - (c) A point on the X chart is on or beyond the LCL.

- (d) Eight consecutive points on the X chart fall on one side of the mean.
8. If a control chart indicates an assignable cause exists, the laboratory cannot continue with candidate oil testing in that configuration. The laboratory and TMC will together investigate the assignable cause and develop an action plan. The laboratory or 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 assign a reference oil for testing. The laboratory must begin the reference test with 2 days of receipt of the assignment.
  9. A test is operationally valid if it meets the criteria listed in B.4. A laboratory must notify TMC of an invalid test 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.
  10. TMC will provide a written reply approving/disapproving the action to be taken within 5 days of receipt of the report.
    - (a) TMC may consult GM regarding approving/disapproving the action plan.
    - (b) 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 assign a reference oil to the configuration. The laboratory must begin reference tests within 2 days of receipt of the assignment.
    - (c) 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 randomly assign one reference oil to the configuration. The laboratory must begin reference tests within 2 days of receipt of the assignment.
  11. The TMC, in consultation with 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 to suspend the stand from

candidate oil testing. A laboratory will be required to provide detailed explanations for the cause of an invalid test and the action taken to prevent the re-occurrence.

**Release and revision history**

June 2015	Rev. 0	Initial release
December 2015	Rev. 1	B.2 and B.7 revised to have TMC assign GMTC01 to a new test stand for qualification. Designations “high coking reference oil” and “low coking reference oil” replaced by codes GMTC01 and GMTC02, respectively.