

TOP TIER DETERGENT GASOLINE DEPOSIT CONTROL PERFORMANCE STANDARD Revision E – March 2017

1. Scope

1.1 Performance Description. This document describes the deposit control performance of an unleaded gasoline at the retail level that minimizes deposits on fuel injectors, intake valves, and combustion chambers.

2. References

Note: Only the latest versions of standards are applicable or as indicated.

2.1 ASTM International (American Society for Testing and Materials)

D 86 D 381 D 1319 D 2622 D 4806 D 4814 D 4815 D 5453 D 5580 D 5845 D 6201 D 6550 D 6729

2.2 California Air Resources Board (CARB)

Advisory letter (April 19, 2001).

Test Method for Evaluating Intake Valve and Combustion Chamber Deposits in Vehicle Engines (March 12, 1999).

2.3 Coordinating European Council (CEC)

CEC F-16-T-96

2.4 Code of Federal Regulations (CFR)

Parts 79 and 80

2.5 International Organization for Standardization (ISO)

ISO 17025, General Requirements for the Competence of Testing and Calibration Laboratories

2.5 General Motors (GM)

TOP TIER fuel injector fouling vehicle test

2.6 Southwest Research Institute (SwRI)

Intake Valve Sticking Test in GM 5.0L V-8

3. Definitions

3.1 "Independent Laboratory" - a mechanical and/or chemical testing organization which is accredited by a national or international accreditation agency such as the American Association for Laboratory Accreditation for testing competence in mechanical and chemical testing or ISO 17025 "General Requirements for the Competence of Testing and Calibration Laboratories"; provided, however, that an Independent Laboratory cannot be affiliated with a TOP TIER Licensee, a fuel marketer or the manufacturer of any additive package approved for use in TOP TIER Detergent Gasoline.

4. Standards

4.1 Retail Gasoline Performance Standards. The deposit control performance of unleaded gasoline conforming to section 4 of this document shall be met at the retail level in all grades of gasoline sold by a fuel company in all marketing areas of a selected nation. In addition, conformance to the standards shall mean gasoline sold in the selected nation shall not contain metallic additives, including methylcyclopentadienyl manganese tricarbonyl (MMT).

4.2 Deposit Control Additive Requirements. The deposit control additive used to meet the performance Standards described in 4.3 shall meet the substantially similar definition under Section 211(f) of the Clean Air Act. Also, the additive shall be certified to have met the minimum deposit control requirements established by the U.S. Environmental Protection Agency (EPA) in 40 CFR Part 80. Lastly, the additive shall be registered with the EPA in accordance with 40 CFR Part 79.

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4.3 Deposit Control Initial Performance Standard. All performance testing and fuel composition analysis shall be conducted by an Independent Laboratory. Initial deposit control performance shall be demonstrated using the tests shown below.

4.3.1 Intake Valve Keep Clean Initial Performance Standard

4.3.1.1 Test Method. Intake valve deposit (IVD) keep clean performance shall be demonstrated using ASTM D 6201, *Standard Test Method for Dynamometer Evaluation of Unleaded Spark-Ignition Engine Fuel for Intake Valve Deposit Formation*. Tests demonstrating base fuel minimum deposit level (4.3.1.2) and additive performance (4.3.1.3) shall be conducted using the same engine block and cylinder head. All results shall be derived from operationally valid tests in accordance with the test validation criteria of ASTM D 6201. IVD results shall be reported for individual valves and as an average of all valves.

4.3.1.2 Base Fuel. The base fuel shall conform to ASTM D 4814 and shall contain commercial fuel grade ethanol conforming to ASTM D 4806. All gasoline blend stocks used to formulate the base fuel shall be representative of normal territory refinery operations and shall be derived from conversion units downstream of distillation. Butanes and pentanes are allowed for vapor pressure adjustment. The use of chemical streams is prohibited. The base fuel shall have the following specific properties after the addition of ethanol:

1. Contain enough denatured ethanol such that the ethanol content is no less than 8.0 and no more than 10.0 volume percent as measured by ASTM D 4815 or D 5845. In markets with lower fuel ethanol content, fuel matching the market conditions of fuel ethanol content can be used upon approval.
2. Contain no less than 8 volume percent olefins as measured by ASTM D 1319 or D 6729.
3. Contain no less than 28 volume percent aromatics as measured by ASTM D 1319 or D 6729.
4. Contain no more than 80 mg/kg sulfur as measured by ASTM D 2622 or D 5453.
5. Produce a 90% evaporated distillation temperature no less than 290°F as measured by ASTM D86.
6. Produce IVD no less than 500 mg averaged over all intake valves.
7. A Certificate of Analysis showing both the detailed test fuel composition results and source should accompany the additive results package. This certificate should also contain the unwashed and washed gum level of the base fuel according to ASTM D381.

4.3.1.3 Demonstration of Performance. The base fuel from 4.3.1.2 shall contain enough deposit control additive such that IVD is no more than 50 mg averaged over all intake valves. Results for individual valves and an average shall be reported. The unwashed gum level of the fuel containing deposit control additive shall be determined according to ASTM D 381 and reported.

4.3.2 Combustion Chamber Deposit Initial Performance Standard

4.3.2.1 Test Method. Combustion chamber deposits (CCD) shall be collected and weighed along with IVD using ASTM D 6201, *Standard Test Method for Dynamometer Evaluation of Unleaded Spark-Ignition Engine Fuel for Intake Valve Deposit Formation*. ASTM D 6201 does not contain a procedure for collecting and measuring CCD. Adapting a scrape and weigh procedure developed by CARB is recommended (see referenced test method dated March 12, 1999). Results for individual cylinders and an average shall be reported.

4.3.2.2 Base Fuel. Combustion chamber deposits shall be measured for the base fuel from 4.3.1.2.

4.3.2.3 Demonstration of Performance. The base fuel from 4.3.1.2 treated with additive at the concentration meeting the standard found in 4.3.1.3 shall not result in more than 140% of the average CCD weight for the base fuel without additive.

4.3.3 Intake Valve Sticking Initial Performance Standard

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4.3.3.1 Test Method. Intake valve sticking tendency shall be determined using either the 1.9 L Volkswagen engine (Wasserboxer according to CEC F-16-T-96) or the 5.0 L 1990-95 General Motors V-8 engine (SWRI IVS test). Two options are available for demonstrating intake valve sticking tendency.

4.3.3.2 Option 1. The valve-sticking tendency of the test fuel by itself will not have to be demonstrated prior to testing the candidate additive. The following shall be required of all tests:

1. Test fuel shall be either the same as in 4.3.1.2 or CEC valve sticking reference fuel.
2. Concentration of deposit control additive in the test fuel shall be at least twice the amount determined in 4.3.1.3.
3. Test temperature shall be -20°C.
4. Three 16-hr cold soak cycles, each followed by a compression pressure check, shall constitute a complete test.

4.3.3.2.1 Demonstration of Performance. A pass shall result in no stuck valves during any of the three cold starts. A stuck valve is defined as one in which the cylinder pressure is less than 80% of the normal average cylinder compression pressure.

4.3.3.3 Option 2. The valve-sticking tendency of the test fuel together with an additive known to cause valve sticking shall be demonstrated prior to testing the candidate additive. The following shall be required of all tests:

1. Test fuel shall be either the same as in 4.3.1.2 or CEC valve sticking test reference fuel.
2. An additive known to cause valve sticking shall be selected, and, when blended into test fuel, shall demonstrate valve sticking tendency as follows: (a) for the Volkswagen engine, at least two valves shall be stuck; (b) for the GM engine, at least three valves shall be stuck.
3. Tests demonstrating performance of the candidate additive shall be conducted at a concentration that is at least three times the amount determined in 4.3.1.3
4. Test temperature shall be -20°C.
5. One 16-hr cold soak cycle followed by a compression pressure check shall constitute a complete test.

5. Process to Attain TOP TIER Detergent Gasoline Status

5.1 Submission of Test Results. A fuel company desiring TOP TIER Detergent Gasoline status shall forward the test results issued by the Independent Laboratory (“Test Results”) to the following address:

Center for Quality Assurance
Attn: TOP TIER™ Licensing Program
4800 James Savage Rd.
Midland, MI 48642 USA
Telephone: +1 989-496-2399
Facsimile: +1 989-496-3438
Email: TopTier@CenterForQA.com

5.2 Notification of receipt. The Test Results shall be reviewed by GM Powertrain and, if deemed acceptable in its sole discretion, the fuel company will be provided a TOP TIER License Agreement for their execution. Only upon complete execution of the TOP TIER License Agreement by both the fuel company and GM shall the fuel company be entitled to begin use the TOP TIER name in connection with the distribution, promotion and sale of their gasoline, pursuant to the terms and conditions of the TOP TIER License Agreement.

6. Release, Effective Date, and Revisions

6.1 Release. This document was first released in April 2004.

**TOP TIER DETERGENT GASOLINE
DEPOSIT CONTROL PERFORMANCE STANDARD
Revision E – March 2017**

6.2 Revisions. Revision B is effective May 2008.
Revision C is effective February 2015.
Revision D is effective May 2016.
Revision E is effective March 2017.

Revision	Date	Description of change
A	March 2008	Modified document to reflect new license agreement; removed attestation forms.
B	May 2008	Changed minimum sulfur limit to 24 mg/kg.
C	February 2015	Removed Fuel Injector Fouling Initial Performance Standard requirement; Changed ethanol limit from 8.0-10.0% up to 10% \pm 1%; Changed sulfur to a maximum limit of 80 mg/kg; Removed base fuel requirement for proof of 75% olefin and 60% sulfur content from FCC streams; Added requirement to provide full base fuel composition analytical results and gum values
D	May 2016	Changed contact to CQA for submission of results Changed reference in option 1 valve-sticking to 4.3.1.3 (TOP TIER Concentration) from Injector Fouling concentration reference.
E	March 2017	3.1 Modified from A2LA to Independent Laboratory with further definition to accommodate international laboratory accreditation. 4.3.1.2 Base Fuel: ethanol changed to 8-10% to align with CARB and to market ethanol outside US.