

**STATE OF CALIFORNIA
AIR RESOURCES BOARD
STATIONARY SOURCE DIVISION**

[insert date of adoption]

**TEST METHOD FOR EVALUATING FORMATION OF INTAKE VALVE AND
COMBUSTION CHAMBER DEPOSITS IN MOTOR VEHICLES**

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COMBUSTION CHAMBER DEPOSITS IN MOTOR VEHICLES

A. PURPOSE

This test method is used to evaluate a gasoline formulation's potential to form intake valve deposits and combustion chamber deposits. The test method follows the procedure in ASTM D 5500-97 with modifications specified in section D below to incorporate testing for combustion chamber deposits (CCDs) and to address technical procedural issues associated with ASTM D 5500-97.

B. SUMMARY OF TEST METHOD

This test method is designed to measure intake valve deposits (IVDs) and CCDs from a single vehicle test run. This test method requires following ASTM D 5500-97 for vehicle preparation and mileage accumulation (except for modifications noted in Section D) After mileage is accumulated, the cylinder head is removed and the CCDs are scraped and measured. Additional steps incorporated into the ASTM D 5500-97 have been included to provide guidance to obtain piston and cylinder head deposits. After CCD measurements are made, then the intake valves are removed from the cylinder head and deposit weights are determined in accordance with ASTM D 5500-97.

C. TEST METHOD USE

This test method is to be used to measure IVDs and CCDs in the same test run. Additionally, this test method may be used to independently measure IVDs and CCDs.

D. TEST PROCEDURE

Follow ASTM D 5500-97 with the following modifications to incorporate steps to obtain CCD

weight measurements. [Note: Additions to the ASTM D 5500-97 test method are indicated in underline and deletions are indicated in ~~strikeout~~]

I. Section 1. Scope, change the following:

1.1 This test method covers a vehicle test procedure for ~~evaluation~~ evaluating the formation of intake valve deposits and combustion chamber deposits (CCDs) ~~formation~~ of unleaded spark-ignition engine fuels . . . Chassis dynamometers shall not be used for this test procedure ~~as the BMW NA/SwRI IVD Test was not intended to be applicable to chassis dynamometers and since~~ no correlation between road operation and chassis dynamometers has been established for either CCD or IVD.

II. Section 4. Summary of Test Method, change the following:

Section 4.4 After the required mileage (10.4.5) has been accumulated, the cylinder head is removed from the engine and ~~disassembled.~~ the CCDs are scraped and removed from the piston top and cylinder head surface for each cylinder. The CCDs are then weighed. ~~and~~ The cylinder head is then disassembled and the intake valves are weighed, visually assigned merit ratings, and photographed. Operational and mechanical criteria are then reviewed to determine if the test shall be considered valid.

III. Section 5. Significance and Use, add the following:

5.1 *Test Method* — It was determined through field testing that intake valve deposits could adversely affect the driveability of certain automobiles. . . Minimizing intake valve deposits may be necessary to maintain vehicle driveability and tailpipe emissions control.

It was also determined that accumulation of CCDs may cause octane requirement increase, CCD interference, and an increase in NOx emissions. This test method is based on established automotive testing laboratory test methods.

5.1.1 *State and Federal Legislative and Regulatory Action* — Legislative activity and rulemaking primarily by California Air Resources Board and the Environmental Protection Agency necessitate the acceptance of a standardized test method to evaluate the intake system and combustion chamber deposit forming tendency of an automotive spark-ignition engine fuel.

IV. Section 8. Preparation of Apparatus, change the following:

Section 8.2.4.1 Piston crowns and bore crevices shall be cleaned with a gasket scraper, fine wire brush, or similar tools. Do not allow debris to fall into the water jacket or oil passages. Care shall be exercised so that the piston crowns and bore crevices are not damaged during cleaning. A shop-type vacuum cleaner or compressed air may shall be used to evacuate the loose carbon from the piston and piston/bore crevice.

Section 8.5.5.1 Flow Specification-Individual Injectors— Individual injectors shall be flow tested at 310 ± 1.4 kPa (45 ± 0.2 psi) using Stoddard solvent or isoctane at 15 to 25°C (59 to 77°F). Individual injectors shall have flow rates as follows (310 kPa, 15.6°C):

isoctane	2.03 to 2.09 g/s (0.0716 to 0.0737 oz/s)	<u>1.94 to 2.06 g/s (0.0684 to 0.0727 oz/s)</u>
Stoddard solvent	2.30 to 2.36 g/s (0.0811 to 0.0832 oz/s)	<u>1.89 to 2.01 g/s (0.0667 to 0.0709 oz/s)</u>

Flow rates shall be adjusted for test conditions of fluid temperature and pressure.

Section 8.7.1.1 Coolant system integrity shall be checked to conform to the following specifications:

Pressure valve opens at	90 to 110 kPa (13 to 16 psig)
Vacuum valve opens at	90 to 110 kPa (13 to 16 psig) <u>5.06 to 10.13 kPa (1.5 to 3.0 in Hg)</u>

V. Section 9. Test Procedure, add the following:

9.5.1.5 Determination of total cylinder CCD weight -- Upon removal of the cylinder head, measure the masses of IVD and CCD from the vehicle. Total cylinder CCD mass shall be reported as the sum of the deposits collected individually from the piston top, cylinder head, and intake valve face for each cylinder. Determination of piston top CCDs are contained in steps 9.5.1.5.1 through 9.5.1.5.4. Determination of cylinder head and valve face CCDs are contained in steps 9.5.1.5.5 through 9.5.1.5.9.

9.5.1.5.1 With piston positioned slightly below Top-Dead-Center (TDC), scrape cylinder block deck surface with gasket scraper, and wipe with a rag. The objective is to produce a ring around each piston that tape will readily adhere to without picking up contamination. Do not use power equipment.

9.5.1.5.2 A deposit collector with a smooth non-absorbent inside surface is attached to the cylinder block with a continuous seal that does not allow deposits to slide between the deposit collector and the cylinder block. The collector is designed to contain any deposits that become airborne from scraping.

9.5.1.5.3 With piston at TDC, remove deposits from the piston top using stainless steel or other metal lab instruments that will not erode during use. Use a stainless steel wire brush to remove remaining deposits off the piston top. Continue brushing until all deposits are removed and only varnish remains. After scraping the piston top, move piston slightly below TDC and brush the deposits which are collected at the top of the cylinder wall into the deposit collector.

9.5.1.5.4 After scraping is completed, carefully remove the deposit collector, and allow the deposits to accumulate in the deposit collector, where they can be poured into preweighed containers for piston deposit weight determination. Deposits from each piston are to be placed in

individual containers.

9.5.1.5.5 Remove spark plug from the cylinder to be scraped. Install a blanked off spark plug that has had its electrodes removed and been filled with solder.

9.5.1.5.6 Place cylinder head on work bench with combustion chamber side facing up. Scrape off gasket material from around the combustion chambers with a gasket scraper and wipe with a rag. The objective is to produce a ring around each combustion chamber that tape will readily adhere to without picking up contamination. Do not use power equipment.

9.5.1.5.7 A deposit collector that has a smooth non-absorbent inside surface is attached to the cylinder head with a continuous seal that does not allow deposits to slide between the deposit collector and the cylinder head. The collector is designed to contain any deposits that become airborne from scraping.

9.5.1.5.8 Remove deposits from the combustion chamber and intake valve faces using stainless steel or other metal lab instruments that will not erode during use. As the deposits are scraped, they can be brushed into the deposit collector with a soft bristle brush. Use a stainless steel wire brush to remove remaining deposits off the combustion chamber. Continue brushing until all deposits are removed and only varnish remains.

9.5.1.5.9 After scraping is completed, carefully remove the deposit collector, and allow the deposits to accumulate in the collector, where they can be poured into preweighed containers for cylinder head deposit weight determination. Deposits from each piston are to be placed in individual containers