

## Supplemental C13 Measurements

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The following measurements are recommended to be taken for all tests to help identify the cause of increased oil consumption on C13 deposit tests with low deposit levels. These measurements should be reported in a supplementary measurement summary attached to official reports.

1. Ring Mass Loss
2. Ring End Gap
3. Ring to Piston Side Clearance
4. Liner Surface Roughness
5. Liner Polish Rating

### Ring Measurements

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#### 1. Pre-test Procedure

- 1.1 Prior to measuring rings, identify the cylinder number by a series of small axial notches filed in the top inside diameter corner, to the left of the ring gap, with the gap oriented at 12:00. Be careful not to raise a burr while marking the ring.
- 1.2 Clean the rings according to the C13 test procedure.
- 1.4 Weigh the top rings, second rings, and oil rings on a scale capable of a resolution of 1 mg. Include the oil ring expander in the oil ring weight.
- 1.5 Measure ring end gaps for the top ring, second ring, and oil ring using a taper gauge with the ring individually confined in a 130.048-mm (5.120-in.) diameter gage and through a cutout of no more than 15.0 mm (0.59 in.) in length. Be careful not to raise a burr while inserting the ring.
- 1.6 Measure ring to piston side clearances using a modified liner with a cutout for feeler gauge and record the minimum and maximum side clearance. The ring gaps should be located in the 2 O'clock position. Measure the side clearance, at a minimum, of 12, 3, 6 and 9 O'clock to determine the minimum and maximum clearance.

#### 2. Post Test Procedure

- 2.1 Rate the carbon deposits on the rings according to the procedure.
- 2.2 Weigh the top rings, second rings, and oil rings on a scale capable of a resolution of 1 mg. Include the oil ring expander in the oil ring weight. This weight will include the carbon deposits. Special care should be taken to preserve the carbon deposits after the rings have been rated.
- 2.3 Re-install the rings onto the test piston from the same cylinder. Measure ring to piston side clearances using a modified liner with a cutout for feeler gauge measurements at 90 degree intervals. The ring gaps should be located in the 2 O'clock position. Measure the side clearance at 12, 3, 6 and 9 O'clock.
- 2.4 Remove the rings from the piston and place the rings in a blaster, and blast the carbon coated surfaces with a walnut shell medium until the carbon has been removed the rings.
- 2.5 Mix a solution of 2500 mL water and 50 mL Natural Orange18 (or equivalent) in a container. Place the rings in the solution, and then place the container into an ultrasonic cleaner for 15 min.

Visually inspect the rings for cleanliness. If carbon remains on the rings, soak the rings for an additional 5 to 10 min in the ultrasonic cleaner.

2.6 Rinse the rings in hot water immediately after removing them from the cleaning solution.

2.7 Spray the rings with solvent and then spray the rings dry with air. Rinse in pentane. Do not handle rings with bare hands. Use gloves or plastic covered tongs.

2.8 Weigh top rings, second rings, and oil rings on a scale capable of a resolution of 1 mg.

Include the oil ring expander in the oil ring weight.

2.9 Measure ring end gaps for the top ring, second ring, and oil ring with the ring individually confined in a 130.048-mm (5.120-in.) diameter gage and through a cutout of no more than 15.0 mm (0.59 in.) in length. Be careful not to raise a burr while inserting the ring.

## Liner Surface Roughness

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USING THE PRECISION DEVICES, INC. MICROANALYZER 2000

Rev. 001 8-26-2002

Recommended data processing program: OmniSurf

### Pre-Test Liner Measurements

1.1 Pre test measurements should be performed after the liners are cleaned as per the C13 procedure.

1.2 Pre test measurements should be taken every 90° for a total of 4 traces. The trace is run from 60-40mm (+/- 2mm) below the top of the liner top surface.

### Post-Test Liner Measurements

2.1 During engine teardown after test the liner should be marked to indicate the orientation towards the front of the engine. After the liner is removed, the liner shall be permanently marked every 30° (use the clock face positions numbered in a clockwise direction) with an engraver, center punch or similar tool. Looking at the top of the sleeve, the front shall be the 12 o'clock position.

2.2 The Liner should be lightly wiped with solvent to remove loose deposits and oil. The carbon deposits on the upper portion of the piston are not intended to be removed before the measurements are taken.

2.3 The trace is run from 60-40mm (+/- 2mm) below the top of the liner top surface.

2.4 The following settings are for the Omnisurf program and the Microanalyzer 2000. Set the Trace Velocity to 0.25 mm/s and data spacing to .25µm. Use the Least Squares Line setting for Form removal. Set the Robust Filter, Form-following spline, roughness filter .80mm and the short wavelength filter to .80µm.

### Reporting

3.0 Report the following outputs before and after test for each liner as an average of all traces for that liner and as an average of all liners for that engine: R, Ra, Rp, Rpc, Rpk, Rk, Rv and Vo.

## Liner Polish Ratings

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It is recommended that any liners with visible polishing be rated according to the CAT 1P bore polish rating instructions (ASTM D6681 A.13.4). The locations of the polished zones can be correlated to the location of polished deposits on the piston to determine the root cause and location of potential oil consumption increases.