

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
D4857 (Y350M2) ASTM TC Sequence I Test Procedure  
Title / Validity Declaration Page**

Form 1

Version 20020128

Conducted

|  |             |
|--|-------------|
|  | I = Invalid |
|  | V =Valid    |

|  |                         |
|--|-------------------------|
|  | RO = Reference Oil Test |
|  | NR = All Other Test     |

| Test Number              |  |                   |  |
|--------------------------|--|-------------------|--|
| <b>Engine No.:</b>       |  | <b>Engine Run</b> |  |
| <b>EOT Time:</b>         |  | <b>EOT Date:</b>  |  |
| <b>Reference Oil</b>     |  | <b>CYLINDER:</b>  |  |
| <b>Non Reference Oil</b> |  | <b>CYLINDER:</b>  |  |
| <b>Formulation/Stand</b> |  |                   |  |
| <b>Alternate Codes:</b>  |  |                   |  |

In my opinion this test \_\_\_\_\_ been conducted in accordance with the Test Method D4857 and the appropriate amendments through information letter system. The remarks included in this report describe the anomalies with this test.

Submitted By:

\_\_\_\_\_

Testing Laboratory

\_\_\_\_\_

Signature

\_\_\_\_\_

Typed Name

\_\_\_\_\_

Title

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation**  
**D4857 (Y350M2) ASTM TC Sequence I Test Procedure**  
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Form 2

|                                  |                    |                  |
|----------------------------------|--------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>   | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b> |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>   |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>   |                  |
| <b>Formulation / Stand Code:</b> |                    |                  |

|  | Form No. |
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**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
D4857 (Y350M2) ASTM TC Sequence I Test Procedure  
Objective / Summary of Procedure  
Form 3**

**Objective**

This procedure is designed to evaluate the performance of a two-cycle engine lubricant relative to engine cleanliness when tested in a two cylinder motorcycle engine. Particular attention will be given to the following characteristics.

1. Piston Skirt Varnish
2. Piston Ring Sticking
3. Spark Plug Fouling
4. Preignition
5. Combustion Chamber Deposits
6. Exhaust Port Blocking

**Summary of Procedure**

The engine selected for this evaluation is a Yamaha RD350B air-cooled, two cylinder, two-cycle engine with the following specifications:

|                             |                                      |
|-----------------------------|--------------------------------------|
| Displacement                | 21.18 cu. in. (347 cm <sup>3</sup> ) |
| Cylinder Bore               | 2.250 in. (64 mm)                    |
| Stroke                      | 2.126 in. (54 mm)                    |
| Compression Ratio           | 6.6:1                                |
| Piston / Cylinder Clearance | 0.004 in.                            |
| 1st Oversized Pistons       |                                      |

The separate cylinder arrangement of this engine, with individual intake and exhaust systems for each cylinder, allows an evaluation of the benchmark reference oil and non-reference oil simultaneously.

A 2-h break-in is completed before the test begins, At the start of test and prior to each cycle, the engine is idled for five min. The transmission is in fourth gear during testing. The test operates on the following cyclic schedule:

|                             | Phase I   | Phase II           |
|-----------------------------|-----------|--------------------|
| Engine, r/min               | 220 ± 200 | 6000 ± 5           |
| Engine, bhp                 | 0         | 8.5 ± 0.5          |
| Air / Fuel Ratio            | ----      | 12.0 ± 0.20        |
| Spark Plug Gasket Temp., °F | Record    | 375 ± 5            |
| Exhaust Temp., °F           | Record    | Approx. 1240 ± 140 |
| Duration, min.              | 5         | 25                 |

This is repeated five times for 150 min. test time.

The engine is then shut down for a minimum of 60 min. to complete one cycle.

This cycle is repeated eight times for a total running time of 20-h .

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
D4857 (Y350M2) ASTM TC Sequence I Test Procedure  
Objective / Summary of Procedure  
Form 3a (continued)**

The Data Acquisition System used to support this test operation meets the Automated Systems requirements Phase I data is sampled every 10s and 6 data points are averaged during the last minute of Phase I to provide a reading. Phase II data is sampled every 10s and 112 data points are averaged during the last eighteen min. to provide a reading. All parameters are acquired and averaged by the Automated Data Acquisition System.

At the conclusion of the test, the engine is disassembled, examined and rated (according to appropriate CRC manuals).

At the June 22, 1999 Section D02.B0.06 meeting, the Section agreed to change the reference oil, used as both the calibration and benchmark reference oil from TMC 600 to TMC 606. Since this reference oil performs differently than the previous benchmark reference oil on second ring sticking, the Section also approved the implementation of a correction factor of -2.45 merits to be applied to the benchmark reference oil (TMC 606) second ring sticking results, when run with the non-reference oil. The correction factor was adjusted from -2.45 to -1.85 at the June 2000 Section D02.B0.06 meeting.

The following are the criteria for non-reference oil approval purposes:

In the test two runs are normally made, exchanging the oils between cylinders after the 20 h run, and the means of the ratings for the non-reference and benchmark reference oils are compared. A pass may be given to the non-reference oil without making the second run if the following conditions all exist after the first run:

Piston varnish rating for the non-reference oil is equal to or better than the benchmark reference oil.

Second ring sticking merit rating for the non-reference oil are 9.0 or better.

No incidence of preignition.

Not more than one incident of plug fouling with the non-reference oil.

Exhaust port blocking for the non-reference oil is not more than 5% greater than for the benchmark reference oil.

No scuffing or other lubricant related damage.

When the cross-over run must be made, the following conditions apply:

Piston Skirt-Varnish - The mean piston varnish rating of a non-reference oil shall be not more than 0.5 point below that of the benchmark reference oil.

Ring Sticking - The mean rating of the second rings of the non-reference oil pistons shall be not more than 0.5 point below that of the benchmark reference oil.

Preignition - Any occurrence of preignition in the non-reference oil cylinder shall constitute a failure.

Spark Plug Fouling - Not more than two more occurrences per complete test (2 runs) with the non-reference oil than with the benchmark reference oil.

Exhaust Port Blocking - The percentage of the exhaust port area blocked by deposits in either run of the test shall not be more than 10% greater for the non-reference oil than for the benchmark reference oil.

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
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**Test Result Summary**

Form 4

|                                  |                           |                  |
|----------------------------------|---------------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>          | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b>        |                  |
| <b>Reference Oil :</b>           | <b>Industry Oil Code:</b> | <b>Cylinder:</b> |
| <b>Non Reference Oil:</b>        | <b>Industry Oil Code:</b> | <b>Cylinder:</b> |
| <b>Formulation / Stand Code:</b> |                           |                  |
| <b>Date Test</b>                 | <b>Start Time:</b>        |                  |
| <b>Stand No.:</b>                | <b>Test Length:</b>       |                  |

| <b>Test Information</b> | <b>Cylinder 1</b> | <b>Cylinder 2</b> |
|-------------------------|-------------------|-------------------|
| Laboratory Oil          |                   |                   |
| Fuel Type               |                   |                   |
| Fuel / Oil Ratio        |                   |                   |

| <b>Engine Inspection</b> |                         | <b>Cylinder 1</b> | <b>Cylinder 2</b> |
|--------------------------|-------------------------|-------------------|-------------------|
| Piston Varnish           | Thrust                  |                   |                   |
|                          | Anti-Thrust             |                   |                   |
|                          | Average                 |                   |                   |
|                          | Ring Land               |                   |                   |
|                          | Undercrown              |                   |                   |
| Wristpin                 | Varnish                 |                   |                   |
|                          | Condition               |                   |                   |
|                          | Bearing Varnish         |                   |                   |
|                          | Bearing Condition       |                   |                   |
| Cylinder Liner Varnish   |                         |                   |                   |
| Ring Sticking            | Top Ring                |                   |                   |
|                          | Second Ring             |                   |                   |
|                          | -1.85 Correction Factor |                   |                   |
| Deposits                 | Piston Crown            |                   |                   |
|                          | Cylinder Head           |                   |                   |
|                          | Exhaust Port Blocking   |                   |                   |
|                          | Exhaust Port Blocking   |                   |                   |
| Piston Scuffing          | Thrust                  |                   |                   |
|                          | Anti-Thrust             |                   |                   |
| Cylinder Liner Wear      |                         |                   |                   |
| CRC Demerit Number       |                         |                   |                   |

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
D4857 (Y350M2) ASTM TC Sequence I Test Procedure**

**Ring Land Ratings**

Form 5

|                                  |                    |                  |
|----------------------------------|--------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>   | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b> |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>   |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>   |                  |
| <b>Formulation / Stand Code:</b> |                    |                  |

| <b>Ring Lands - Carbon Ratings</b> |                       |                   |         |                   |         |
|------------------------------------|-----------------------|-------------------|---------|-------------------|---------|
| <b>Deposit Type</b>                | <b>Deposit Factor</b> | <b>Cylinder 1</b> |         | <b>Cylinder 2</b> |         |
|                                    |                       | Area %            | Demerit | Area %            | Demerit |
| HC                                 | 1.000                 |                   |         |                   |         |
| MHC                                | 0.750                 |                   |         |                   |         |
| MC                                 | 0.500                 |                   |         |                   |         |
| LC                                 | 0.250                 |                   |         |                   |         |
| VLC                                | 0.150                 |                   |         |                   |         |
| Carbon Rating (demerits)           |                       |                   |         |                   |         |

| <b>Ring Lands - Lacquer Ratings</b> |                       |                   |         |                   |         |
|-------------------------------------|-----------------------|-------------------|---------|-------------------|---------|
| <b>Deposit Type</b>                 | <b>Deposit Factor</b> | <b>Cylinder 1</b> |         | <b>Cylinder 2</b> |         |
|                                     |                       | Area %            | Demerit | Area %            | Demerit |
| BL                                  | 0.100                 |                   |         |                   |         |
| DBRN                                | 0.075                 |                   |         |                   |         |
| AL                                  | 0.050                 |                   |         |                   |         |
| LAL                                 | 0.025                 |                   |         |                   |         |
| VLAL                                | 0.010                 |                   |         |                   |         |
| RL                                  | 0.001                 |                   |         |                   |         |
| Lacquer Rating                      |                       |                   |         |                   |         |
| Clean                               | 0                     |                   |         |                   |         |

|                                |  |  |
|--------------------------------|--|--|
| <b>Zonal Rating (demerits)</b> |  |  |
|--------------------------------|--|--|

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
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**Ring Ratings**

Form 6

|                                  |                    |                  |
|----------------------------------|--------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>   | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b> |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>   |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>   |                  |
| <b>Formulation / Stand Code:</b> |                    |                  |

| Cylinder Number | Ring Number | NMMA Rating | -1.85 Correction Factor <sup>A</sup> | Visual Rating | Adjusted Rating <sup>B</sup> |
|-----------------|-------------|-------------|--------------------------------------|---------------|------------------------------|
|                 |             |             |                                      |               |                              |
|                 |             |             |                                      |               |                              |
|                 |             |             |                                      |               |                              |
|                 |             |             |                                      |               |                              |
|                 |             |             |                                      |               |                              |
|                 |             |             |                                      |               |                              |

<sup>A</sup> A correction factor of -1.85 merits is applied to the benchmark reference oil (TMC 606) second ring sticking results, when run with the non-reference oil.

<sup>B</sup> The adjusted ring rating is calculated by averaging the NMMA ring rating and the visual ring rating. The visual ring rating is calculated by assessing the total number of degrees the ring visually appears to be stuck in the groove. The normal NMMA ring ratings are then applied as though the ring is firmly stuck over the area, even though in most cases rings in this condition can be forced to move through the application of varying amounts of pressure.

# Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation D4857 (Y350M2) ASTM TC Sequence I Test Procedure

## Operational Summary

Form 7

|                                  |                    |                  |
|----------------------------------|--------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>   | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b> |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>   |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>   |                  |
| <b>Formulation / Stand Code:</b> |                    |                  |

| Parameters                                | Phase I |         |         | Phase II |         |         |
|---|---------|---------|---------|----------|---------|---------|
|   | Maximum | Minimum | Average | Maximum  | Minimum | Average |
| Engine Speed, r/min                       |         |         |         |          |         |         |
| Dynamometer Speed, r/min                  |         |         |         |          |         |         |
| Observed Load, hp                         |         |         |         |          |         |         |
| Corrected Load, hp                        |         |         |         |          |         |         |
| Air / Fuel Ratio #1                       |         |         |         |          |         |         |
| Air / Fuel Ratio #2                       |         |         |         |          |         |         |
| Air Flow #1 lb / h                        |         |         |         |          |         |         |
| Air Flow #2 lb / h                        |         |         |         |          |         |         |
| Fuel Flow #1 lb / h                       |         |         |         |          |         |         |
| Fuel Flow #2 lb / h                       |         |         |         |          |         |         |
| <b>Pressures</b>                          |         |         |         |          |         |         |
| Fuel Pressure #1, psi                     |         |         |         |          |         |         |
| Fuel Pressure #2, psi                     |         |         |         |          |         |         |
| Intake Air Pressure, in. H <sub>2</sub> O |         |         |         |          |         |         |
| Barometric Pressure, in. Hg               |         |         |         |          |         |         |
| <b>Temperatures, ° F</b>                  |         |         |         |          |         |         |
| Spark Plug #1                             |         |         |         |          |         |         |
| Spark Plug #2                             |         |         |         |          |         |         |
| Cylinder Liner #1                         |         |         |         |          |         |         |
| Cylinder Liner #2                         |         |         |         |          |         |         |
| Exhaust #1                                |         |         |         |          |         |         |
| Exhaust #2                                |         |         |         |          |         |         |
| Fuel #1                                   |         |         |         |          |         |         |
| Fuel #2                                   |         |         |         |          |         |         |
| Intake Air, Carburetor                    |         |         |         |          |         |         |
| Intake Air Dew Point                      |         |         |         |          |         |         |
| Ambient                                   |         |         |         |          |         |         |





**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation**  
**D4857 (Y350M2) ASTM TC Sequence I Test Procedure**  
**Phase II Air Fuel Ratio Plots**  
Form 9

|                                  |                    |                  |
|----------------------------------|--------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>   | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b> |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>   |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>   |                  |
| <b>Formulation / Stand Code:</b> |                    |                  |

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation**  
**D4857 (Y350M2) ASTM TC Sequence I Test Procedure**  
**Phase II Spark Plug Plots**  
Form 10

|                                  |                    |                  |
|----------------------------------|--------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>   | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b> |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>   |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>   |                  |
| <b>Formulation / Stand Code:</b> |                    |                  |

**Two-Stroke-Cycle Gasoline Engine Lubricant Evaluation  
D4857 (Y350M2) ASTM TC Sequence I Test Procedure  
Test Fuel Analysis (Last Batch)  
Form 11**

|                                  |                          |                  |
|----------------------------------|--------------------------|------------------|
| <b>Lab:</b>                      | <b>EOT Date:</b>         | <b>End Time:</b> |
| <b>Engine No.:</b>               | <b>Run Number:</b>       |                  |
| <b>Reference Oil</b>             | <b>Cylinder:</b>         |                  |
| <b>Non Reference Oil</b>         | <b>Cylinder:</b>         |                  |
| <b>Formulation / Stand Code:</b> |                          |                  |
| <b>Supplier</b>                  | <b>Batch Identifier:</b> |                  |

| <b>Measurement</b>            | <b>Specs.</b> | <b>Analysis</b> | <b>Test Method</b> |
|-------------------------------|---------------|-----------------|--------------------|
| Gravity, °API                 |               |                 |                    |
| Color                         |               |                 |                    |
| Doctor Test                   |               |                 |                    |
| Copper Corrosion, 3h @ 212 °F | 1 Maximum     |                 | D 130              |
| Reid Vapor Pressure, psig     |               |                 |                    |
| Research Octane Number        |               |                 |                    |
| Motor Octane Number           |               |                 |                    |
| (Research + Motor) / 2        |               |                 |                    |
| Total Sulfur, % Weight        | 0.04 - 0.05   |                 | D 2622             |
| Gum, mg/100 mL                |               |                 |                    |
| Oxidation Stability, min      |               |                 |                    |
| Lead, g/gal                   |               |                 |                    |
| <b>Distillation, °C</b>       |               |                 |                    |
| IBP                           | Report        |                 | D 86               |
| 10%                           | Report        |                 | D 86               |
| 50%                           | Report        |                 | D 86               |
| 90%                           | 282 - 338     |                 | D 86               |
| EP                            | Report        |                 | D 86               |
| Recovery, %                   |               |                 |                    |
| <b>Pona, % vol</b>            |               |                 |                    |
| Paraffins + Napthenes         |               |                 |                    |
| Olefin                        | Report        |                 | D 1319             |
| Aromatics % Vol.              | 28 - 33       |                 | D 1319             |