Certification Procedure Manual

for

FC-W® and FC-W Catalyst Compatible®

Four-Stroke Cycle, Water-Cooled Gasoline Engine Lubricants

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Contents

I. INTRODUCTION

Many recreational industries whose power needs have been well served in the past by compact, conventional two-stroke cycle gasoline engines are now experiencing a rapid influx of new technologies. These new technologies are taking the form of direct fuel injection two-stroke cycle engines and four-stroke cycle engines. Many of these new technologies have grown from a need to reduce exhaust emissions.

Specifically, the development of larger and more advanced four-stroke cycle outboard engines has had the biggest recent impact on the nature of marine engines. In the past, four-stroke cycle engines have mainly been limited to inboard and inboard/outboard (sterndrive) boats, and the smaller output range of the outboard motor market.

Recently introduced, larger 4 and 6 cylinder four-stroke cycle outboard engines are now taking the place of some conventional two-stroke cycle outboard engines. The duty cycles of marine engines have always discriminated these engines from over-the-road light and heavy duty automotive engines. In particular, the lubrication demands of marine engines are unique. High loads, high speeds, and exposure to high levels of humidity and salt water are just a few of the unique characteristics of an engine in the marine environment.

Aware of the particular lubrication requirements of four-stroke cycle engines in the marine market and their increasing use, the National Marine Manufacturers Association Oil Certification Committee developed the four-stroke cycle engine oil specification, NMMA FC-W®.

Then four-stroke cycle engines with exhaust after-treatment began to appear as a result of growing interest and legislation in reducing marine engine emissions. In recognition of emerging four-stroke cycle engines with catalysts in the marine market and their unique lubrication demands, the National Marine Manufacturers Association Oil Certification Committee initiated the development of a new four-stroke cycle engine oil specification, NMMA FC-W Catalyst Compatible®.

This specification follows in the long and successful tradition of BIA TC-W, NMMA TC-WII®, NMMA TC-W3®, and NMMA FC-W® to assist boaters and manufacturers in identifying four-stroke cycle engine oils which have been specially formulated to withstand the rigors of use in marine engines. The NMMA FC-W Catalyst Compatible® specification is intended to support the industry in providing long term durability, power and overall consumer satisfaction with marine engines utilizing catalyst after-treatment.

II. GENERAL

Procedures and Tests

In order to certify an engine oil for NMMA FC-W® or FC-W Catalyst Compatible®, a marketer must follow the procedures and meet the test requirements as specified below.

Note: All referenced SAE, ASTM, and CRC and other engineering specification documents and procedures used in this manual shall be those in effect as of April 1, 2004.

Procedures. In order to assure quality control, the marketer must enter into and comply with a licensing agreement with NMMA, including payment of an annual fee, as established by the NMMA Oil Certification Committee.

Tests. The tests defined here are intended to evaluate the lubricant:

- Identification
- Kinematic Viscosity @ 100°C
- Cold Crank Simulator Viscosity
- MRV-TP1 Viscosity
- Foam, Sequence I, II and III
- Foam / Aeration, Sequence IV
- Shear Stability
- High Temperature High Shear Viscosity
- FC-W® Rust Test
- Noack Volatility
- Filter Plugging (EOFT)
- Yamaha 115 hp General Performance Engine Test (GPET)

This Certification Procedure Manual details the means by which a candidate lubricant can qualify for Service FC-W® or FC-W Catalyst Compatible®. The qualities of the candidate lubricant must be equal to or better than those of reference lubricants, or within the tolerances as specified.

III. CANDIDATE CERTIFICATION

Certifying laboratory. Test laboratories shall be approved by the NMMA Oil Certification Committee to conduct any or all FC-W® or FC-W Catalyst Compatible® tests and to certify the results.

Certification of Candidate Lubricants. The candidate lubricant sponsor shall submit a complete and successful test result report to NMMA for FC-W® or FC-W Catalyst Compatible® certification.

Certification Marks. Upon certification by a designated laboratory and execution of a licensing agreement with NMMA, the applicable NMMA Oil Certification Mark (FC-W® or FC-W Catalyst Compatible®) must be applied to all registered oil containers (bottles, cans, drums, etc.), and the NMMA FC-W® or FC-W Catalyst Compatible® oil registration number must be used on all oil container packaging.

While NMMA FC-W Catalyst Compatible® oils will also meet the requirements of FC-W®, a marketer must choose which mark to place on the container and pay the appropriate licensing fee. Only one mark may be placed on a container, but oils that are licensed as FC-W Catalyst Compatible® may also state that they meet the requirements of and can be used in place of FC-W® oils.

IV. IMPROPER USE OF REGISTERED MARK

Licensed Oils. For oils displaying an improper label or unauthorized labeling data, NMMA will inform the Marketer to cease and desist the violation and will request verification that the violation has been corrected. The Marketer will be required to provide a copy of all labels reflecting the correction of the registered mark violation. If the violation has not been corrected in reasonable time, NMMA may terminate the license agreement.

Non-Licensed Oils. For oils not licensed by NMMA and displaying the NMMA trademark or claiming to meet the NMMA FC-W® or FC-W Catalyst Compatible® specification, NMMA will inform the Marketer to cease and desist the unauthorized labeling immediately and will take such action as appropriate under the circumstances.

V. ENFORCEMENT AND CONFORMANCE TO LICENSE REQUIREMENTS

If supporting evidence demonstrates that an FC-W® or FC-W Catalyst Compatible® certified oil does not meet the technical requirements (specifications) of the applicable NMMA engine oil standard or has documented field performance problems, NMMA will attempt to work directly with the marketer to remedy the nonconformity and to take such additional corrective actions as appropriate on a voluntary basis. In the event the matter cannot be satisfactorily resolved, NMMA will terminate the license and take other action as is appropriate under the circumstances.

VI. REVOCATION OF LICENSE FOR UNSATISFACTORY PERFORMANCE

As noted above, the license may be revoked for unsatisfactory field performance.

VII. REAL OR IMPLIED WARRANTIES

NMMA makes no expressed or implied representation or warranty that any lubricant certified by NMMA satisfies any manufacturer's warranty.

VIII. FC-W® and FC-W CATALYST COMPATIBLE® TESTS

A. Identification Tests

The following tests will be used to characterize a candidate oil, and will reference the ASTM test methods shown.

- Kinematic Viscosity @ 40°C (ASTM D445)
- Viscosity Index (ASTM D2270)
- Specific Gravity (ASTM D1298 or D4052)
- Total Base Number (ASTM D2896)
- Total Acid Number (ASTM D664)
- Sulfur Content (ASTM D5453, D2622, D4294 or D6443)
- Nitrogen Content (ASTM D5291 or D5762)
- IR Spectrum (ASTM E168)
- SAE Viscosity Grade (SAE J300)
- Elemental Analysis (ASTM D4951, D4927, D4628 or D5185)

ACCEPTANCE and REPORTING REQUIREMENTS for FC-W®:

All Identification test results are report only.

ACCEPTANCE and REPORTING REQUIREMENTS for FC-W CATALYST COMPATIBLE®:

While NMMA FC-W® requires only that the results of the elemental analysis be reported, NMMA FC-W Catalyst Compatible® places limits on the phosphorus and silicon results from the elemental analysis:

- A candidate oil must contain at least 0.06 mass% but no more than 0.08 mass% phosphorus.

- A candidate oil must contain no more than 0.002 mass% silicon.

B. Kinematic Viscosity @ 100°C

Reference ASTM D445 Kinematic Viscosity Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

A candidate oil must meet the viscosity grade requirements of SAE J300.

The Kinematic Viscosity shall be reported in this test report.

C. Cold Crank Simulator Viscosity

Reference ASTM D5293 Cold Crank Simulator Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

A candidate oil must meet the viscosity grade requirements of SAE J300. The Cold Crank Simulator Viscosity shall be reported in this test report.

D. MRV-TP1 Viscosity

Reference ASTM D4684 MRV-TP1 Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

A candidate oil must meet the viscosity grade requirements of SAE J300. MRV-TP1 Viscosity shall be reported in this test report

E. Foam, Sequence I, II and III

Reference ASTM D892 Foam Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

A candidate oil shall not exceed the following requirements for Sequence I, II and III Foam testing.

Sequence I, ml initial/ml after settling:	10 / 0
Sequence II, ml initial/ml after settling:	50 / 0
Sequence III, ml initial/ml after settling:	10 / 0

F. Foam/Aeration, Sequence IV

Reference ASTM D6082 Foam Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

A candidate oil shall not exceed the following requirements for Sequence IV Foam testing.

Sequence IV, ml initial/ml after settling for 1 minute: 200 / 50

G. Shear Stability

Reference ASTM D6278 Shear Stability Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for FC-W®:

The shear stability of the candidate oil after 30 cycles is report only.

ACCEPTANCE and REPORTING REQUIREMENTS for FC-W CATALYST COMPATIBLE®:

The shear stability of the candidate oil after 30 cycles must meet the Kinematic Viscosity at 100°C listed for the respective viscosity grade of the candidate oil:

≥5.6 for XW-20 and SAE 20
≥8.5 for XW-30 and SAE 30
≥11.5 for XW-40 and SAE 40
≥15.0 for XW-50 and SAE 50
≥20.1 for XW-60 and SAE 60

H. High Temperature High Shear Viscosity

Reference ASTM D4683 test method for HTHS Viscosity for specific instructions. The NMMA FC-W® and FC-W Catalyst Compatible® requirements demand that the HTHS Viscosity @150ºC of the candidate oil be evaluated after the oil has undergone 30 cycles of shear in the ASTM D6278 Shear Stability test.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

The HTHS Viscosity of the candidate oil after 30 cycles of shear shall be equal to or greater than 3.3 cP.

I. FC-W® Rust Test

SCOPE:

This procedure describes a standard test for evaluating the corrosion protection performance of engine oils.

OBJECTIVE:

The objective of this test is to provide a standard method for making a qualitative evaluation of the corrosion protection performance of engine oils. This test compares the protection of coupons cut from actual cylinder liners in a humid salt environment, and is intended to provide an indication of how well an oil formulation protects cylinder bores from rust.

TEST PARAMETERS:

1) This is a 24 hour corrosion test conducted using a salt fog humidity cabinet per ASTM B117 (5 ±1% Sodium Chloride, cabinet temp maintained at 95 +2/-3°F)

2) Iron test coupons for this test are per Mercury Marine P/N 892143 or OHT P/N OHT4T-001-1

3) The test coupon hanger is made per Mercury Marine P/N 892144-001

4) The drip deflector is made per Mercury Marine P/N 892145

5) The coupon, hanger, and deflector are assembled for test per Mercury Marine assembly drawing 892143A01

6) Reference Oil is stored in a 1 quart plastic container.

7) Recommend a 1 quart candidate oil sample (1 pint minimum).

8) Ultrasonic cleaning solution is 4 ounces of Dirl-Lum 603 alkaline detergent per gallon of water at a temperature of 150 – 175°F.

PROCEDURE:

1. Four test coupons are used for each oil being evaluated. Prior to test each coupon must be engraved with the test request number and oil identification near the bottom of the test sample on the back (non-evaluation) side relative to its orientation while hanging in the test chamber.

2. All test coupons (candidate and reference) for a given test must be run at the same time to ensure that salt fog cabinet condition variations do not influence the results.

3. Coupons must not be touched with bare hands during the cleaning, testing and post test evaluation.

4. Hang coupons on a rack and place them in an Ultra Sonic parts cleaner for 2 hours to totally remove all oils and foreign matter from the coupons. The cleaning solution used for ultrasonic cleaning is a mixture of 4 ounces of Dirl-Lum 603 soap per gallon of distilled water. The bath temperature is to be 150-175°F. A new cleaning solution is to be used for every test.

5. Remove each sample from the ultra-sonic cleaner, one at a time, and follow Steps 6-9 for each coupon.

6. Thoroughly rinse both sides of the coupon with hot water (52.2ºC / 126ºF or greater).

7. Thoroughly rinse both sides of the coupon with Precipitation Naphtha to remove water. A Certificate of Analysis for the Precipitation Naphtha is shown in Appendix A.

8. Repeat the rinsing using acetone to remove the Naphtha. (Take care not to touch coupons with hands or allow contact with any other foreign substances.)

9. Hang coupons on rack to dry in a climate controlled area and allow them to stabilize to room temperature for 30 minutes or less. (Take care to keep the coupons separated.)

10. Completely submerge each coupon in its corresponding oil sample and agitate for 10 seconds.

11. Remove coupon and allow it to drain for 10 seconds.

12. Resubmerge coupon in the oil sample for one minute, lightly agitating the oil.

13. Remove the coupon from oil sample. Coupons are hung in room air to drain for 2 hours.

14. Assemble each coupon, hanger and drip deflector per Mercury Marine Assembly drawing 892143A01. Place all test coupons in salt fog chamber controlled per ASTM B117 (5 ± 1% Sodium Chloride, cabinet temperature maintained at 95 +2/-3°F, salt fog collection rate of 1.0 – 2.0 ml per hour (with a pH of 6.5 – 7.2)) for 24 ± 0.5 hours. Randomize the placement of the test samples in the humidity chamber to reduce the influence of localized environmental differences within the chamber.

15. Upon completion of the 24 hour test, remove the coupons from the salt fog cabinet, and thoroughly rinse them with petroleum naphtha to displace the oil. Next, rinse with distilled water to displace the salt. Finally, rinse with acetone to displace water and temporarily stabilize the condition of the coupons.

16. Rate the coupons immediately after the final rinse of the post-test cleaning procedure. Use either the template with 2% divisions or the Block style in the rating process (attached).

17. Dip the rated coupons in Mobilarma 245 to provide long term protection from continued rusting. Hang the dipped coupons for no more than 30 minutes to allow the excess oil to drip off. Wrap the coupons in vapor barrier paper and return to the originally supplied bag.

18. Document the results of the test by taking color photographs of each sample at identical distance, angle and lighting. The coupons are removed from the bag and vapor barrier paper and set up for photographing without blotting or wiping. Photograph the group of 4 coupons from each oil tested (candidates and reference) at one time.

REFERENCING CRITERIA

This test procedure shall be periodically referenced. The referencing interval shall be 6 months. The test is considered to be satisfactorily referenced if:

a. Reference Oil 5973 average rating falls between 20-40% inclusive, and
b. Calibration Oil 49P52Z average rating falls between 40-60%, inclusive.

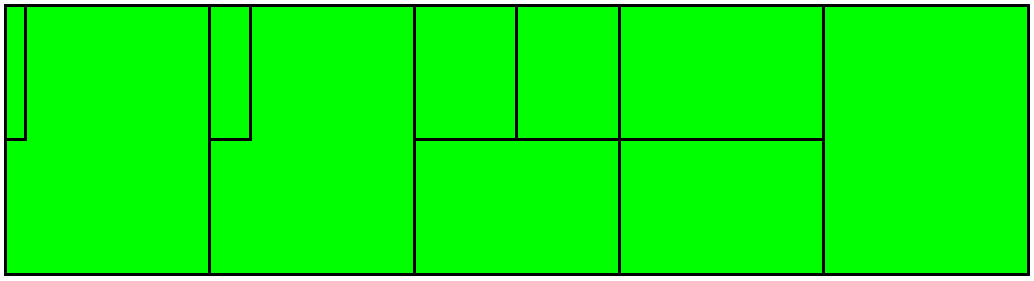
ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

The candidate oil must provide the same or better average corrosion protection performance as Reference Oil 5973. At the discretion of the rater, a coupon shall be discarded if deemed to be an outlier, but no more than one coupon may be discarded from each set of four coupons per oil.

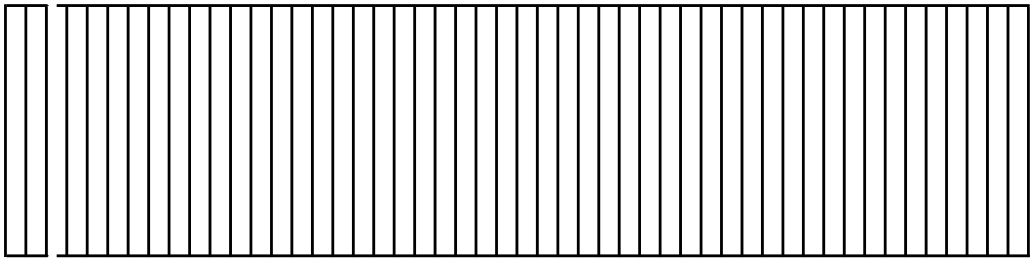
Coupons are to be evaluated on the basis of the area covered by the corrosion, and not by the intensity of the corrosion

FC-W® Rust Panel Rating Templates
As approved 12/3/2003.

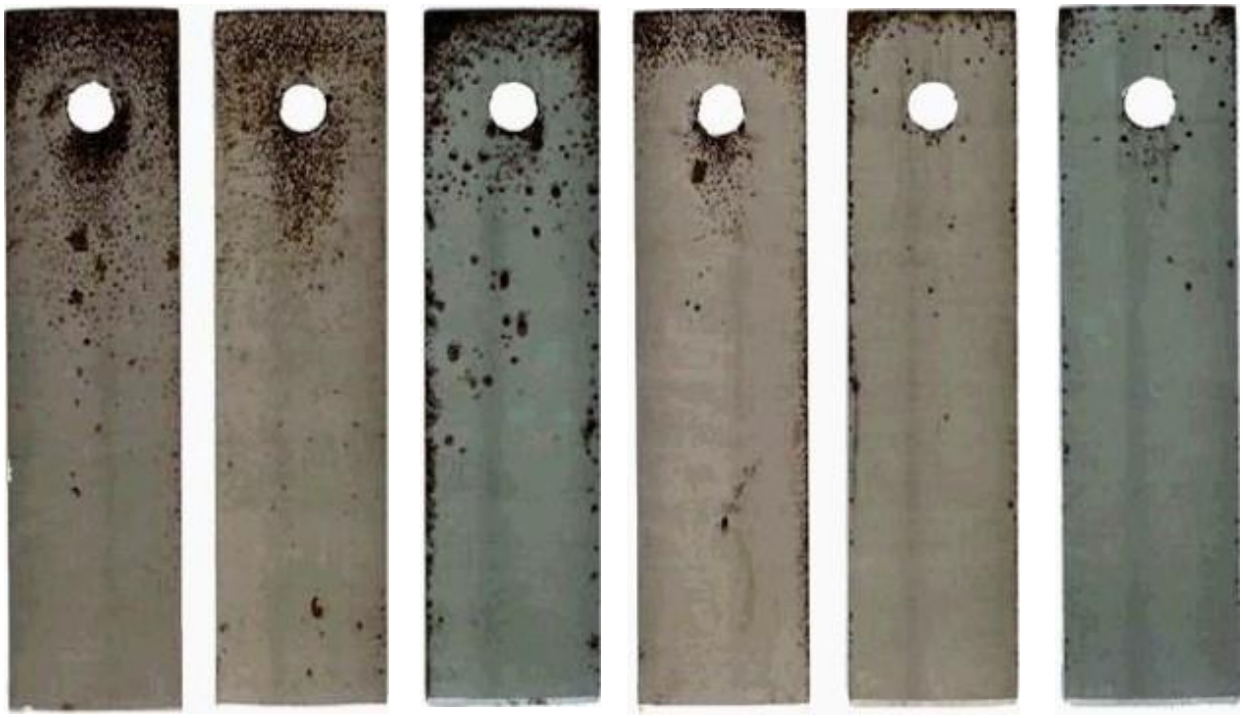
Blocked Style Template:



2% Style Template:

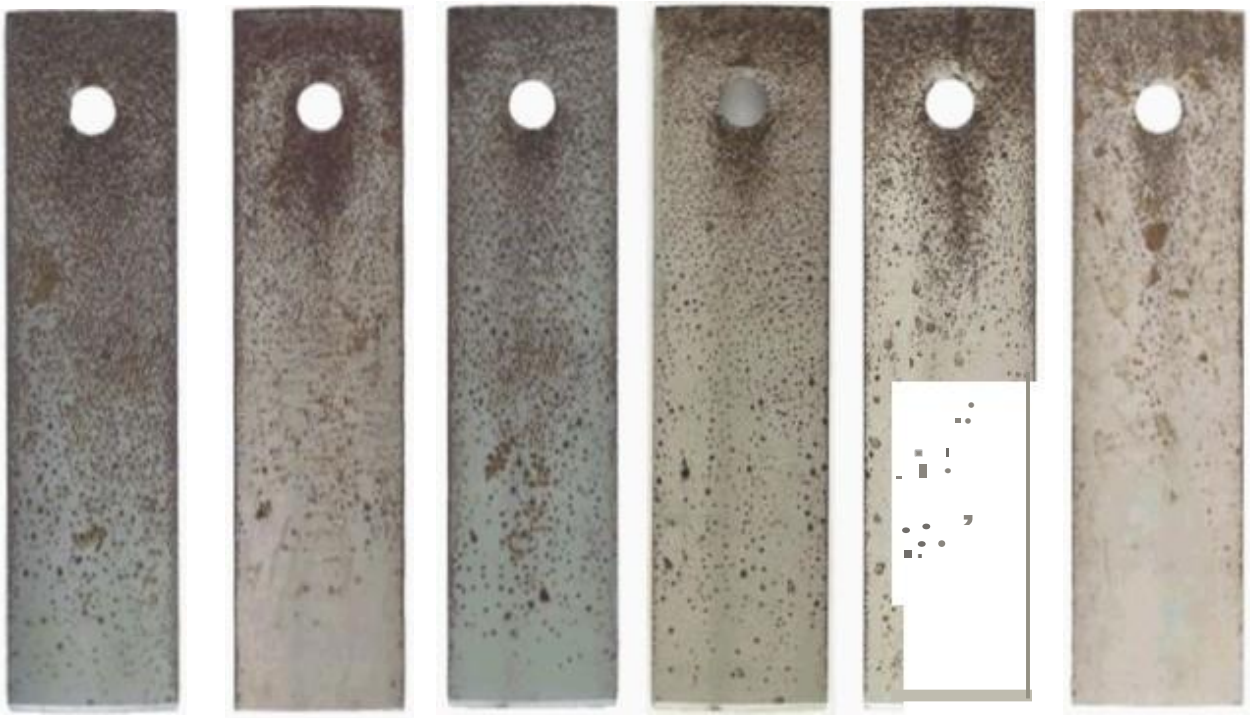


SwRI Rating of Rust Coupons
Actual Size of DRAFT SAMPLE



10% 8% 6% 4% 2% 1%

SwRI Rating of Rust Coupons
Actual Size of DRAFT SAMPLE



40% 35% 30% 25% 20% 15%

J. Noack Volatility

Reference ASTM D5800 test method for Noack Volatility for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for FC-W®: The

candidate oil results for Noack Volatility are report only.

ACCEPTANCE and REPORTING REQUIREMENTS for FC-W CATALYST COMPATIBLE®:

The candidate oil results for Noack Volatility percentage are required to be ≤22%.

K. Filter Plugging (EOFT)

Reference ASTM D6795 Engine Oil Filterability Test for specific instructions.

ACCEPTANCE and REPORTING REQUIREMENTS for both FC-W® and FC-W CATALYST COMPATIBLE®:

The candidate oil shall provide no more than 50% reduction in flow rate.

L. Yamaha 115 HP General Performance Engine Test (GPET)

Section:

1. Scope
2. Reference Documents
3. Summary of Test Method
4. Significance and Use
5. Engine Assembly, Modification, and Apparatus
6. Reagents and Materials
7. Precision and Bias
8. Operating Procedure
9. Engine Disassembly and Inspection
10. Test Site Acceptance
11. Reference Results/Frequency
12. Candidate Pass/Fail Criteria

1. SCOPE:

1.1) This procedure evaluates the general performance of a Four-Stroke Cycle, Water-Cooled outboard engine lubricant when subjected to a fuel dilution level of greater than 7% during the course of operation.

1.2) Various engine components will be inspected post-test to determine if wear or damage has occurred.

1.3) The scope of this procedure does not address every safety aspect regarding the use of materials and reagents recommended. Users must inform themselves and others involved of the potential hazards encountered in testing lubricants in gasoline-fueled engines.

2. REFERENCE DOCUMENTS:

2.1) Yamaha Model 115 Service Manual Part #LIT-18616-02-18, 68V-28197-Z9-11, for F115Y & LF115Y.

2.2) Yamaha Four Stroke 115 HP Parts Catalog. Model Year 2003 for F115TLRB, TXRB, TJRB, and LF115TXRB.

2.3) CRC Rating Manual No. 21

2.4) ASTM: D445-100C (Visc).
D445-40C (Visc).
D664 (Acid).
D3525M-FDG (Fuel Dilution).
D4739-TBN (Base).
D5185 (Elements).

2.5) NMMA FC-W® Product Approval System (PAS)

2.6) NMMA FC-W Catalyst Compatible® Product Approval System (PAS).

Each of these documents can be obtained from the respective organization.

3. SUMMARY OF TEST METHOD:

3.1) The test is run in an outboard engine test tank using a Yamaha 115 Hp four-stroke outboard engine. A trimmed propeller is used as a loading device to control the engine speed at wide-open throttle.

3.2) A test is comprised of three primary segments: ten hours of cyclic break-in, ninety hours of cyclic endurance testing, and ten hours of steady

state wide-open throttle. Oil samples are taken at the end of break-in, and test hours 25, 50, 75, 90, and at the end of test. The level of fuel dilution of the samples is monitored during the test. Fuel dilution is required to reach a minimum of 7% by the 50th test hour, and remain at or above 7% until the 90th test hour. If the fuel dilution reaches 15%, then the test lab should confirm the absence of non-oil related causes.

3.3) Various engine components are inspected at the end of testing as a means of determining the general performance of a lubricant.

4. SIGNIFICANCE AND USE:

4.1) This procedure is intended to evaluate the general performance of lubricants designed for use in four-stroke cycle outboard engines. It is intended to verify that a four-stroke cycle outboard engine lubricant that has met either the "FC-W® Approval Demonstration Program Requirements" of the NMMA FC-W® Product Approval System or the "FC-*W Catalyst Compatible® Approval Demonstration Program Requirements"* of the NMMA FC-W Catalyst Compatible® Product Approval System, will perform adequately in a four-stroke cycle outboard engine where an increased propensity for corrosion and fuel dilution has been identified as a field concern.

5. ENGINE ASSEMBLY, MODIFICATIONS, AND APPARATUS:

5.1) This test method uses a standard Yamaha 115Hp Four-Stroke outboard engine. Model number F115TXR-68VX.

5.2) A new, complete cylinder head assembly and cylinder block assembly are required for each test. Part numbers are 68V-W009A-01-1S and 68V-W009B-03-1S respectively.

5.3) The chassis, lower unit, and accessories may be reused provided the maintenance criteria of the service manual are followed.

5.4) The fuel injectors should be cleaned, and then flow and pattern tested before each test to ensure uniformity.

5.5) No modifications to the engine, essential engine components, or accessories are permitted.

5.6) A factory thermostat is required. Modifications to the factory "open cooling system design" are not permitted. Engine cooling is supplied through the factory inlet passages on the lower unit, using industrial-grade engine flushing device.

5.7) An oil sampling valve may be installed in the oil pressure tap at the top of the engine. The volume of the valve and all associated plumbing must not exceed 120 cc's (~4oz's). The installation of thermocouples and transducers to monitor the engine parameters are permitted.

5.8) The test must be conducted in a test tank unless an alternate method is approved by the NMMA OCC.

5.9) Engine speed must be controlled using a machined propeller (Mercury propeller P/N 48-77338A45-11P).

5.10) The relative humidity of the combustion air supply must be controlled to 75% ±5%.

6. **REAGENTS AND MATERIALS:**

6.1) Benchmark Oil: NMMA 4T -115B (benchmark)

6.2) Calibration Oil: Not specified at this time.

6.3) Sponsored Candidate Oil: Minimum of 2½ gallons required.

6.4) Test Fuel: Haltermann Sequence VG Mark II (SVGM2) is required.

6.5) Engine Assembly Oil: The cylinder head assembly and cylinder block assembly are lubricated at the factory. Additional lubrication should not be required. In the event additional lubricant is required to safely build the engine, NMMA 4T – 115B is to be used sparingly so the potential impact to the performance of the candidate lubricant is minimized.

7. **PRECISION AND BIAS**:

7.1) No precision statement can be made as of 1/04.

7.2) No bias can be established as of 1/04.

8. OPERATING PROCEDURE:

8.1) Break-In Procedure:

8.1.1) The break-in must be run with the oil to be tested, using a new engine as described in section 5. Fill the engine with 4400 cc's of test oil. Let the engine soak for 20 minutes. Record the dip stick reading using the top hash mark as the reference point. The level should be within 1/8" of the top hash.

8.1.2) The break-in incorporates three phases. Within each phase there are multiple stages. All of the stages within a phase are to be completed before continuing to the next phase of the break-in.

8.1.3) Run the break-in according to the parameters of Table I. At the end of break-in, bring the engine to idle, purge 120 cc's (~4 oz) of oil, then take a 60 cc (~2 oz) oil sample.

8.1.4) Stop the engine, return the 120 cc purge to the engine, and let the engine soak for 20 minutes. At the end of the 20 minute soak, record the dip stick reading using the top hash mark as the reference point.

8.1.5) The 60 cc sample must be analyzed using ASTM D3525M-FDG to determine the level of fuel dilution. The remaining analyses of section 2.4 may be performed optionally for candidate oils but is required for reference oils.

8.1.6) Do not add additional test oil during the break-in, or at the end of break-in. The first opportunity to add oil is the 25 hour interval of the endurance portion of the test.

TABLE I

1:1reaK-m:I"nase 11s per ormea once Tor a total oT 1hour.

BK-Pn 1-stage I - Iale 1		
PARAMETERS	Average	Pis/Min
Duration, min's	5.0	na
Engine Speed, rpm	700.0	50.0
Fuel Flow, lbs/hr	3.0	0.5
Oil Pressure, psi	70.0	10.0
Coolant In, 0F	65.0	Max
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply,0F	70.0	10.0
Ull ::>ump, ·..-	14U.U	Max

BK-Pn 1-stage 11-<!UUU-1		
PARAMETERS	Average	Pis/Min
Duration, min's	55.0	na
Engine Speed, rpm	2000.0	100.0
Fuel Flow,lbs/hr	8.0	2.0
Oil Pressure, psi	75.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Ull ::>ump, "r	It\U.U	Max

: reaK-m: I"nase 11 is repeatea o umes Tor a total 0T 1hour.

Bk-Ph 11-Stage I - 3000-1		
PARAMETERS	Average	Pis/Min
Duration, min's	9.0	na
Engine Speed, rpm	3000.0	100.0
Fuel Flow, lbs/hr	13.0	2.0
Oil Pressure, psi	75.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply,0F	70.0	10.0
u11 ::>ump, ·..-	L4U.U	IMax

BK-Ph 11-Stage II - WOT-1		
PARAMETERS	Average	Pis/Min
Duration, min's	1.0	na
Engine Speed, rpm	6000.0	200.0
Fuel Flow,lbs/hr	55.0	5.0
Oil Pressure, psi	90.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
lull ::>ump, "r	LOU.U	IMax

: reaK- n: ase 111 is repeateo o umes or a onu o o ours.

Bk-Ph 111-Stage I – 2000-2		
PARAMETERS	Average	Pis/Min
Duration, min's	11.0	na
Engine Speed, rpm	2000.0	100.0
Fuel Flow, lbs/hr	8.0	2.0
Oil Pressure, psi	70.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply,0F	70.0	10.0
Ull ::>ump, ·..-	It\U.U	Max

Bk-Ph 111-Stage II - 3000-2		
PARAMETERS	Average	Pis/Min
Duration, min's	11.0	na
Engine Speed, rpm	3000.0	100.0
Fuel Flow,lbs/hr	13.0	2.0
Oil Pressure, psi	80.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Ull ::>ump, "r	LIU.U	Max

1:11\-I"n 111-stage III - 4UUU-1		
PARAMETERS	Average	Pis/Min
Duration, min's	11.0	na
Engine Speed, rpm	4000.0	100.0
Fuel Flow, lbs/hr	23.0	2.0
Oil Pressure, psi	80.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply,0F	70.0	10.0
Ull ::>ump, ·..-	LLU.U	Max

t:IK-I"n 111-:stage IV - vvu 1-<		
PARAMETERS	Average	Pis/Min
Duration, Min's	5.0	na
Engine Speed, rpm	6000.0	200.0
Fuel Flow,lbs/hr	65.0	5.0
Oil Pressure, psi	75.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Ull ::>ump, "r	LfU.U	Max

t:IK-I"n 111-:Stage IV - 4UUU-<!		
PARAMETERS	Average	Pis/Min
Duration, min's	11.0	na
Engine Speed, rpm	4000.0	100.0
Fuel Flow, lbs/hr	23.0	0.5
Oil Pressure, psi	80.0	10.0
Coolant In, oF	60.0	5.0
Coolant Out, oF	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply,"F	70.0	10.0
Ull ::>ump, ·..-	L.5U.U	Max

t:IK-I"n 111-:stage v - uuu-		
PARAMETERS	Average	Pis/Min
Duration, min's	11.0	na
Engine Speed, rpm	3000.0	100.0
Fuel Flow,lbs/hr	13.0	2.0
Oil Pressure, psi	80.0	10.0
Coolant In, oF	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, "F	70.0	10.0
Ull ::>ump, "r	LIU.U	Max

8.2) Test Procedure:

8.2.1) The endurance portion of the test procedure incorporates two phases. Phase I cycles through stages I-VII fifty-four times, for a total of ninety hours, before continuing to the next phase. Phase II is a ten hour wide-open throttle, steady state condition.

8.2.2) Using the test oil that remains in the engine upon completion of the break-in, run the endurance portion of the test according to the parameters of Table II.

8.2.3) The parameters of Table II must be controlled to the deviation percent criteria specified in Section VIII of either the FC-W® Product Approval System or the FC-W Catalyst Compatible® Product Approval System.

8.2.4) At the 25, 50, 75, 90, and 100 hour intervals, bring the engine to idle, purge 120 cc's (~4 oz) of oil, then take a 60 cc (~2 oz) oil sample.

8.2.5) Stop the engine, return the 120 cc purge to the engine, and let the engine soak for 20 minutes. At the end of the 20 minute soak, record the dip stick reading using the top hash mark as the reference point.

8.2.6) A maximum of 700 cc's of new test oil may be added at the 25, 50, and 75 hour intervals, for a total of 2100 cc's, in attempting to bring the level back to the original hash mark recorded at the end of break-in. No oil additions are permitted after the 75 hour interval.

8.2.7) Each of the 60 cc samples must be analyzed using ASTM D3525M-FDG to determine the level of fuel dilution. The remaining analyses of section 2.4 may be performed to further monitor a lubricant's performance.

8.2.8) At the end of testing, the engine must be disassembled and inspected.

8.2.9) The oil pump shall be inspected every four test runs replaced after every 10 test runs. Oil pressure will be monitored during each test and if a noticeable oil pressure drop occurs, the oil pump shall be replaced accordingly.

ABLE II

Test: Phase I Stages I-VII are repeated 54 times for a total of 90 hrs, then Phase II Stage I is run at Wide Open Throttle for a total of 10 hrs.

Ph 1-Stage I - Idle 1		
PARAMETERS	Average	Pis/Min
Duration, min's	40.0	na
Engine Speed, rpm	700.0	50.0
Fuel Flow, lbs/hr	2.5	0.5
Oil Pressure, psi	65.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	140.0	Max

Ph 1-Stage II - WOT-1		
PARAMETERS	Average	Pis/Min
Duration, min's	6.0	na
Engine Speed, rpm	6000.0	200.0
Fuel Flow, lbs/hr	60.0	5.0
Oil Pressure, psi	85.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity %	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	270.0	Max

Ph 1-Stage III - 2400-1		
PARAMETERS	Average	Pis/Min
Duration, min's	6.0	na
Engine Speed, rpm	2400.0	100.0
Fuel Flow, lbs/hr	8.0	2.0
Oil Pressure, psi	70.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	210.0	Max

Ph 1-Stage IV- Idle 2		
PARAMETERS	Average	Pis/Min
Duration, min's	20.0	na
Engine Speed, rpm	700.0	50.0
Fuel Flow, lbs/hr	2.5	0.5
Oil Pressure, psi	65.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity %	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	150.0	Max

Ph 1-Stage V- 4800		
PARAMETERS	Average	Pis/Min
Duration, min's	14.0	na
Engine Speed, rpm	4800.0	100.0
Fuel Flow, lbs/hr	33.0	2.0
Oil Pressure, psi	80.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	230.0	Max

Ph 1-Stage VI - 2400-2		
PARAMETERS	Average	Pis/Min
Duration, min's	6.0	na
Engine Speed, rpm	2400.0	100.0
Fuel Flow, lbs/hr	8.0	2.0
Oil Pressure, psi	70.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity %	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	210.0	Max

Ph 1-Stage VII - 3600		
PARAMETERS	Average	Pis/Min
Duration, min's	8.0	na
Engine Speed, rpm	3600.0	100.0
Fuel Flow, lbs/hr	17.0	2.0
Oil Pressure, psi	80.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity%	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	215.0	Max

Ph 11-Stage I - WOT-II		
PARAMETERS	Average	Pis/Min
Duration, Min's	600.0	na
Engine Speed, rpm	6000.0	200.0
Fuel Flow, lbs/hr	60.0	5.0
Oil Pressure, psi	75.0	10.0
Coolant In, 0F	60.0	5.0
Coolant Out, 0F	130.0	10.0
Relative Humidity %	70.0	5.0
AirSupply, 0F	70.0	10.0
Oil Sump, 0F	270.0	Max

9. ENGINE DISASSEMBLY AND INSPECTION:

9.1) When the test is completed, the engine is disassembled and the following components are cleaned and inspected.

a) Cam lobes
b) Cam caps
c) Cam journals
d) Cam bearing
e) Piston rings
f) Piston
g) Con rod bearing
h) Cylinder bore
i) Main bearing
j) Crank journals
k) Fuel pump lobe, reference only

9.2) The specifications of the service manual may be used as a guide in determining the performance of the lubricant relative to the reference oil.

9.3) Rating manuals CRC 20 and 21 are used as guides to assess engine cleanliness.

10. TEST SITE ACCEPTANCE:

10.1) A test lab shall run two consecutive NMMA FC-W® Y115 Hp General Performance reference tests using NMMA 4T – 115B reference oil.

10.2) Results shall be reviewed with, and approved by, the NMMA OCC prior to acceptance of the test site.

10.3) Acceptance results shall also be submitted to the Office of Test Data Administration (OTDA).

11. REFERENCE RESULTS / FREQUENCY:

11.1) The components of 9.1 must not have any excessive wear or any damage such as scuffing, spalling, scoring, or ring wiping.

11.2) Using rating manuals CRC 20 and 21 as guides, the amount of carbon deposits, varnish, sludge and other distress must be deemed insignificant to the general performance of the engine.

11.3) Once a test site is approved by OCC, subsequent reference results shall continue to be comparable to the results approved for "Test Site Acceptance" in Section 10.

11.4) Reference Frequency: A reference test on NMMA 4T – 115B is required if more than one year has elapsed since the last reference test.

12. CANDIDATE PASS/FAIL CRITERIA for both FC-W® and FC-W CATALYST COMPATIBLE®:

12.1) The candidate results must meet the criteria specified in Section 11.1 and 11.2, and in general, be comparable to, or better than the results of the most recent reference test.

12.2) If the candidate is clearly comparable to, or better than the most recent reference test, it is a "Pass." If the candidate is clearly worse than the most recent reference test, it is a "Fail." If the candidate is a border-line result, the specifications of Service Manual Part #LIT-18616-02-18, 68V-28197-Z9-11 for Yamaha Model F115Y & LF115Y may be used to assist the laboratory in determining if the candidate is deemed a "Pass" or "Fail."

12.3) In the event the results determined by the laboratory are unsatisfactory to the sponsor, the results and associated hardware will be examined by the OEM, and the OEM will deem the candidate a "Pass" or "Fail."

IX. READACROSS PROTOCOL

A. Applicable read-across information for FC-W® is in Section IX of the NMMA FC-W® Product Approval System.

B. Applicable read-across information for FC-W® Catalyst Compatible is in Section IX of the NMMA FC-W Catalyst Compatible® Product Approval System.

X. GENERAL PRACTICES

A. For FC-W®, the general practices of the NMMA FC-W® Product Approval System shall apply.

B. For FC-W Catalyst Compatible®, the general practices of the NMMA FC-W Catalyst Compatible® Product Approval System shall apply.

XI. SUBMITTAL REPORT

A. An example FC-W® test summary and report is attached as Appendix B.

B. An example FC-W Catalyst Compatible® test summary and report is attached as Appendix C.

NMMA FC-W® and FC-W CATALYST COMPATIBLE® CERTIFICATION PROCEDURE MANUAL ANNEX

NMMA GPET Reference Oil 4T-115B
Source/Supplier: Infineum USA, L.P.

NMMA Rust Reference Oil 49P52Z
Source/Supplier: On file at NMMA

NMMA Rust Reference Oil 5973
Source/Supplier: Infineum USA, L.P.

Ultrasonic Cleaning Solution
Dirl-Lum 603
Blue Wave Ultrasonics
960 S. Rolff St.
Davenport Ia. 52802
Ph 800.373.0144
www.bluewaveinc.com

Appendix A

Certificate of Analysis for Precipitation Naphtha

Chevron Phillips Chemical Company LP

DATE OF SHIPMENT
01-05-04

CUSTOMER PO NO.
444816G

SALES ORDER NO.
5818297

2 X 54 GALLON DRUM

MFG DATE: 05-2002

SHELF LIFE: UNDETERMINED

CERTIFICATE OF ANALYSIS

PRECIPITATION NAPHTHA ASTM
LOT 2EPPNA01

TESTS	RESULTS	SPECIFICATIONS	METHOD
Corrosion, 3 hrs @ 50°C	1A	1 Max	ASTM D-130
API Gravity, 60 °F	71.95	70 – 73	ASTM D-287
Color Saybolt	+30	+30 Min	ASTM D-156
Acidity of Dist Residue	Neutral	Neutral	ASTM D-1093
Total Sulfur, ppm	0	100 Max	ASTM D-3120
Aniline Pt. °F	136.0	136 – 140	ASTM D-611
DISTILLATION, °F @760 mmHg			**ASTM D-86**
IBP	134.2	122 Min	
50%	175.7	176 Max	
EP	234.6	250 Max	

D. G. Doerr / teh
D.G. Doerr
Fuels Unit Team Leader

KNC: clg
01/05/2004

Appendix B
FC-W® Test Procedure Summary and Submittal Report Form

Oil Code: _____

Circle test method used if more than one is allowed

FC-W® Identification Testing

		Limits	Test Results
KV @ 40°C, cSt	ASTM D445	Report only	
Viscosity Index	ASTM D2270	Report only	
SG @ 60/60°F	ASTM D1298 or D4052	Report only	
TBN, mg KOH/ml	ASTM D2896	Report only	
TAN, mg KOH/ml	ASTM D664	Report only	
Elementals	ASTM D4951, D4927, D4628 orD5185		
Barium, mass%		Report only	
Boron, mass%		Report only	
Calcium, mass%		Report only	
Magnesium, mass%		Report only	
Molybdenum, mass%		Report only	
Phosphorous, mass%		Report only	
Silicon, mass%		Report only	
Zinc, mass%		Report only	
Sulfur, mass%	ASTM D5453, D2622, D4294 or D6443	Report only	
Nitrogen, mass%	ASTM D5291 or D5762	Report only	
IR Spectrum	ASTM E168	Report only	

Statement of SAE Viscosity Grade

Based on Viscosity Grade Testing		Report only	

FC-W® Viscosity Grade Testing

KV @ 100°C, cSt	ASTM D445	Per J300: _____	
CCS, cP @ _____	ASTM D5293	Per J300: _____	
MRV-TP1, cP @ _____	ASTM D4684	Per J300: _____	
MRV-TP1, Yield stress	ASTM D4684	NYS	

FC-W® Performance Bench Testing

Foam, Seq. I, ml	ASTM D892	10/0 max	
Foam, Seq. II, ml	ASTM D892	50/0 max	
Foam, Seq. III, ml	ASTM D892	10/0 max	
Foam, Seq IV, ml	ASTM D6082	200/50 max	
Shear Stability, %	ASTM D6278	Report only	
HTHS (after D6278), cP	ASTM D4683, D4741 or D548	≥ 3.3	
Rust, %	NMMA FC-W® method	≤ Ref Oil	
Noack Volatility, %	ASTM D5800	Report only	
EOFT, % change	ASTM D6795	≤ 50	

FC-W® Engine Testing

115 HP GPET	NMMA FC-W® method	Must pass	

Appendix C
FC-W Catalyst Compatible® Test Procedure Summary and Submittal Report Form

Oil Code: _____

Circle test method used if more than one is allowed

FC-W® Identification Testing

		Limits	Test Results
KV @ 40°C, cSt	ASTM D445	Report only	
Viscosity Index	ASTM D2270	Report only	
SG @ 60/60°F	ASTM D1298 or D4052	Report only	
TBN, mg KOH/ml	ASTM D2896	Report only	
TAN, mg KOH/ml	ASTM D664	Report only	
Elementals	ASTM D4951, D4927, D4628 orD5185		
Barium, mass%		Report only	
Boron, mass%		Report only	
Calcium, mass%		Report only	
Magnesium, mass%		Report only	
Molybdenum, mass%		Report only	
Phosphorous, mass%		0.06 - 0.08	
Silicon, mass%		≤ 0.002	
Zinc, mass%		Report only	
Sulfur, mass%	ASTM D5453, D2622, D4294 or D6443	Report only	
Nitrogen, mass%	ASTM D5291 or D5762	Report only	
IR Spectrum	ASTM E168	Report only	

Statement of SAE Viscosity Grade

Based on Viscosity Grade Testing	Report only	

FC-W® Viscosity Grade Testing

KV @ 100°C, cSt	ASTM D445	Per SAE J300:		
CCS, cP @ _____	ASTM D5293	Per SAE J300:		
MRV-TP1, cP @ _____	ASTM D4684	Per SAE J300:		
MRV-TP1, Yield stress	ASTM D4684		NYS	

FC-W® Performance Bench Testing

Foam, Seq. I, ml	ASTM D892		10/0 max	
Foam, Seq. II, ml	ASTM D892		50/0 max	
Foam, Seq. III, ml	ASTM D892		10/0 max	
Foam, Seq IV, ml	ASTM D6082		200/50 max	
Shear Stability, %	ASTM D6278		Report only	
Shear Stability, cSt	ASTM D6278	Per Sect. VIII-G:		
HTHS (after D6278), cP	ASTM D4683, D4741 or D548		≥ 3.3	
Rust, %	NMMA FC-W® method		≤ Ref Oil	
Noack Volatility, %	ASTM D5800		≤ 22	
EOFT, % change	ASTM D6795		≤ 50	

FC-W® Engine Testing

115 HP GPET	NMMA FC-W® method	Must pass	