

# PRODUCT APPROVAL SYSTEM

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## ***Summary of Revisions***

*This list indicates revisions to the standard when compared with the previously published version. It is not intended to be used independently of the standard. It should be used for informational purposes and as a guide to the official requirements contained in this standard. It is the responsibility of the user to read and understand the complete standard.*

*The main changes in this revision the NMMA Certification Test Manual, TC-W3 as compared with the previous edition dated 4/21, are:*

- *April 2021 – added the ASTM D3228 to the nitrogen test, updated the Lubricity (AF-27) Test Site Acceptance and Lubricity (AF-27) Reference Frequency torque delta to .0226 - .1356NM.*
- *June 2022 Removal of the AF-27 Lubricity procedure.*

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## **I. NMMA Product Approval System**

The NMMA Product Approval System is a system of practices and procedures covering the execution of customer programs, and the maintenance of engine test consistency.

The objective of the NMMA Product Approval System shall be to maintain consistent TC-W3® performance testing and thereby ensure the quality of candidate oils meeting TC-W3® performance specifications.

The following NMMA Product Approval System shall reference the following additional procedures and documents:

1. NMMA certification test for TC-W3® two-stroke-cycle gasoline engine lubricants.
2. Office of Test Data Administration manual.
3. NMMA Oil Certification Committee charter.

## **II. Organization**

### **A. Oil Certification Committee (OCC)**

The Oil Certification Committee shall have the following responsibilities:

1. Meet on a regular basis to:
  - Review recommendations made by its subcommittees.
  - Review reference data collected by the Office of Test Data Administration.
  - Maintain and consider any changes to the NMMA protocol for licensing of candidate oils.
  - Consider requests for allocations of funding for test development or improvement.
2. Vote on approval of above items.
3. Report and make recommendations to the NMMA Engine Manufacturers Division Board on matters requiring Board approval.

### **B. Office of Test Data Administration (OTDA)**

The OTDA shall perform the following functions:

1. Maintain data management systems and communications with sponsors and test sites for registration and cataloguing of candidate oils and candidate and reference engine tests.
2. Register and record all candidate oils, candidate bench and engine tests, and reference bench and engine tests.
3. Maintain a secure data management system to store results of bench and engine tests run on candidate and reference oils.
4. Receive and record results for all candidate bench and engine tests and reference engine tests, per the OTDA manual.
5. Upon test sponsor's request, supply a listing of candidate test runs registered on a specific oil code to NMMA and the test sponsor.
6. Provide data contained in the reference oil database to NMMA for the purpose of evaluating engine test precision and accuracy and/or consistency of TC-W3® reference oils.

### **C. NMMA Oil Surveillance Subcommittee (OSS)**

The Oil Surveillance Subcommittee shall perform the following functions:

1. Report to the Oil Certification Committee.
2. Meet on a regular basis to review and monitor reference oil test results compiled by Office of Test Data Administration (OTDA).
3. Analyze data contained in the reference oil database provided to NMMA by OTDA for the purpose of evaluating engine test precision and accuracy and/or consistency of TC-W3® reference oils.
4. Report to NMMA Oil Certification Committee on the status of key test issues.
5. Maintain and update the Product Approval System, as required.

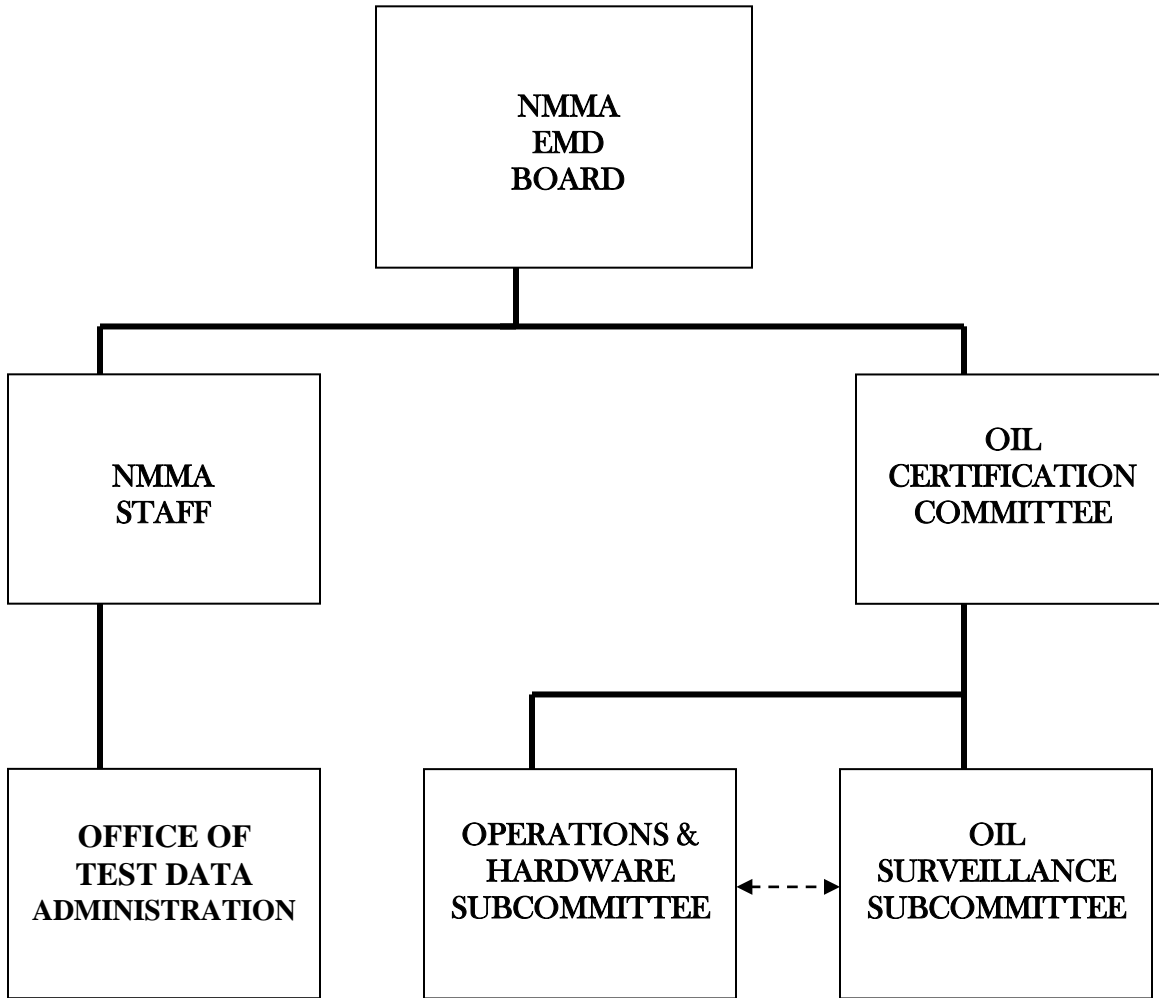
### **D. Operations and Hardware Subcommittee (OHS)**

The Operations and Hardware Subcommittee shall perform the following functions:

1. Report to the Oil Certification Committee.
2. Make technical recommendations to the Oil Certification Committee on:
  - Test precision and severity improvements through test operation, hardware, or engine build-up techniques.
  - Test hardware variation improvements.
  - Written test procedures accuracy.
  - Other related areas.

# Organization

## E. Organization Chart



### **III. Participating TC-W3® Test Sites**

<b>Engine Test</b>	<b>I</b>	<b>SWRI</b>
Lubricity (Y50)		X
Preignition		X
Mercury 15 HP		X
Johnson 40 HP		X

X = Approved by the OCC for product testing

I: Intertek

SWRI: Southwest Research Institute



#### **IV. General Practices**

1. All product certification testing shall be carried out per the most current specification document entitled "NMMA Certification Test for TC-W3® Two-Stroke-Cycle Gasoline Engine Lubricants".
2. All engine testing for product approval shall be conducted in labs approved by the Oil Certification Committee (OCC), referenced per TC-W3® procedures, and participating in Office of Test Data Administration (OTDA) registration and reporting requirements.
3. Testing of a candidate in a particular test shall only commence following proper registration of that candidate oil with OTDA. OTDA shall assign a registration number to the candidate oil, which shall be used to track any testing conducted on that candidate oil. Only one registration number shall be assigned to an individual candidate oil.
4. Any change in a candidate oil formulation shall necessitate a new OTDA registration number and complete testing of the new oil, except where approved solvent substitution or readacross guidelines are met.
5. The choice of test laboratory for any individual test shall be made by the sponsor.
6. The test laboratory shall supply the results of all tests initiated by registration with OTDA to both the sponsor and OTDA.
7. The test laboratory shall register all engine test reference runs with OTDA, and shall supply the results of all such reference runs to OTDA. These reference results shall be included by OTDA in a database for determining and monitoring engine test precision.
8. The test laboratory may deem that a particular test was operationally invalid or may terminate a test due to mechanical problems. If this occurs, the test shall not be included as a reportable failure. However, the results shall be included in the end of program summary to NMMA.
9. All candidate oil test results submitted to the OTDA, or to the NMMA for oil certification purposes, shall be owned by the OTDA; however, candidate oil test results shall not be used, divulged or discussed by other than the test sponsor without the test sponsor's express permission.

The NMMA may review candidate oil test results for discussion with the test sponsor.

Statistics involving candidate oils may be compiled by the OTDA at the request of the OCC if all of the following conditions are met:

- The data population shall be sufficiently large, and diverse in test sponsors.
  - The statistics shall be the result of analysis of the entire data population. A listing of the data used in the analysis shall not be performed.
  - Statistics on data from individual test sponsors shall not be provided, even if coded.
10. All scuffing and ring wiping test results and pass/fail criteria shall be expressed to the nearest single digit, while all ring sticking and piston deposit test results and pass/fail criteria shall be expressed to the nearest tenths. The ASTM rounding method in E29 shall be used as the basis for rounding results to the appropriate precisions. The test sites, however, may use a greater number of significant digits in calculating results so long as the final results are reported to the above precisions.
11. The Oil Certification Committee may declare any NMMA TC-W3® test out of control upon recommendation of either the Oil Surveillance Subcommittee (OSS) or the Operations and Hardware Subcommittee (OHS). The reasons for such a decision may include (but are not limited to):

Lack of discrimination between references  
Poor repeatability/reproducibility

The Oil Certification Committee may declare any NMMA TC-W3® test unavailable to the industry upon recommendation of either the OSS or the OHS. The reasons for such a decision may include (but are not limited to):

Lack of uniform hardware  
Lack of approved fuel  
Lack of available test sites  
Lack of reference oil

Once a test (or tests) are declared out of control or unavailable to the industry, the NMMA shall provide Provisional Licenses to any applicant satisfying all other tests and requirements during the period that the test (or tests) are out of control or unavailable to the industry.

Once testing is resumed, the OCC shall determine the time frame within which the industry must complete the Provisional approvals.

## **V. Acceptance of New RSF (Ring Sticking Fuel) Batch**

1. For each new batch of ring sticking fuel produced by the fuel supplier, refer to Figure V-1 for approval process. Note: A test lab may combine two or more batches of RSF fuel to form a new lab batch of RSF fuel, but that new lab batch must be qualified per the following procedures prior to its use for candidate testing.
2. For the 15 HP test, a test lab shall run one 15 HP test using the RSF batch on both the low and high reference oils in order to qualify its use in the 15 HP test in that lab:

NMMA 93738 Low reference oil

NMMA 71591 High reference oil

The tests need not be run concurrently.

Based on the current NMMA-specified separation requirements, adequate separation shall be demonstrated between the low and high reference oils with the new RSF batch in any lab wishing to use the new RSF fuel for its candidate evaluations.

3. Each test lab shall be allowed to vary fuel flow rate as required within approved limits to control test severity and achieve separation between the high and low reference oils.
4. Each lab shall report results to the Office of Test Data Administration (OTDA), and operational and summary results to the NMMA Oil Surveillance Subcommittee (OSS) and the Oil Certification Committee (OCC).
5. A test lab need not qualify the fuel in more than one test. However, a test lab shall only use fuel for testing in a test in which the fuel has been qualified.
6. If adequate results cannot be achieved in attempting to qualify a new RSF fuel batch, a test lab may request that the OCC consider having the fuel supplier reprocess the fuel.
7. The NMMA staff shall monitor the inventory of TC-W3® RSF-4 reference fuel with input from both the test sites and the fuel supplier.

## **VI. Test Site Acceptance Procedures**

### **A. Mercury 15 HP Test Site Acceptance**

1. The test lab shall run two (2) consecutive sets of Mercury 15 HP tests on both the low reference oil NMMA 93738 and the high reference oil NMMA 71591. A set is one high reference and one low reference run. Concurrent testing is not required. Results shall be evaluated based on the following criteria:

NMMA 71591 (high reference oil)

The oil shall pass per the current specification.

NMMA 93738 (low reference oil)

The oil shall fail due to compression loss from deposit-induced ring sticking.

2. Results shall be reviewed with and confirmed by the NMMA oil certification committee (OCC) prior to acceptance of the test site.
3. Acceptance results shall also be submitted to the Office of Test Data Administration (OTDA).

### **B. Johnson 40 HP Test Site Acceptance**

1. The test lab shall run two (2) consecutive sets of Johnson 40 HP tests on both the low reference oil DF-413 and the high reference oil NMMA 93738. A set is one high reference and one low reference run, both run concurrently. The intent of the test is for the high reference oil to give better results than the low reference oil. Results shall be evaluated based on the following criteria:

- The high reference oil NMMA 93738 shall exceed the low reference oil DF-413 in both average top ring sticking and average piston deposits.
- The high reference oil NMMA 93738 average top ring sticking rating shall fall within the range of 8.0 to 9.8, inclusive.
- The high reference oil NMMA 93738 average piston deposit rating shall fall within the range of 7.6 to 9.8, inclusive.

2. Results shall be reviewed with and confirmed by the OCC prior to

acceptance of the test site.

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

### **C. Lubricity (Y50) Test Site Acceptance**

1. The test lab shall run two (2) consecutive sets of TC-W3® Lubricity (Y50) tests on both the low reference oil NMMA 93738 and the high reference oil XPA 3259. A set consists of the low reference oil NMMA 93738 run against the high reference oil XPA 3259 with the XPA 3259 acting as the test reference. The intent of the test is for the high reference oil to give lower torque drop than the low reference oil. Results are evaluated based on the following criteria:

The difference in torque drop between the low reference oil NMMA 93738 and the high reference oil XPA 3259 shall fall within the range of 0.31 - 1.31 in-lbs., inclusive.

2. Results shall be reviewed with and confirmed by the OCC prior to acceptance of the test site.
3. Acceptance results shall also be submitted to the Office of Test Data Administration (OTDA).

### **D. Preignition Test Site Acceptance**

1. The test lab shall run two (2) consecutive preignition tests on reference oil NMMA 93738. The intent is for the results to be repeatable between the two tests. Results shall be evaluated based on the following criteria:

Each test shall be operationally valid, and each shall have no greater than three major preignitions.

2. Results shall be reviewed with and confirmed by the OCC prior to acceptance of the test site.
3. Acceptance results shall also be submitted to the Office of Test Data Administration (OTDA).

## VII. Test Referencing Frequencies

### A. Mercury 15 HP Referencing Frequency

After ten valid OTDA-registered candidate oil runs, or twelve months after the last high reference run, or 24 months after the last high and low reference pair runs, whichever comes first, test sites shall run NMMA 71591, which shall pass on all test criteria, and NMMA 93738, which shall fail in the area of compression loss.

Run Schedule

\* 1 2 3 4 5 6 7 8 9 10 \* 11 12 13 14 15 16 17 18 19 20 \*

\* Referencing required with high and low reference oils.

If the high and low reference oil runs do not pass and fail, respectively as noted above, the test lab shall rerun the reference pairs until acceptable results are achieved. It is allowable to vary fuel flow, within NMMA-defined ranges, in order to obtain the NMMA-defined severity levels. If fuel flow or other test variables are not altered, an unacceptable reference may be rerun. Valid candidate oil runs cannot be made until acceptable reference results are obtained.

### B. Johnson 40 HP Referencing Frequency

After every fourth program run (defined as a candidate oil run alongside the high reference oil NMMA 93738), or twelve months after the last reference pair, whichever happens first, participating test sites shall run the low reference oil DF-413:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16  
\* \* \* \* \*

\* Run low reference in addition to high reference.

Separation between the high and low reference oils in either ring sticking or piston deposits need not be achieved to continue running candidate oils.

The high reference oil NMMA 93738 average top ring sticking rating shall fall within the range of 8.0 and 9.8, inclusive, and the average piston deposit rating shall fall within the range of 7.6 and 9.8, inclusive. However, if the NMMA 93738 reference is declared mechanically or operationally invalid, the pass criteria for concurrent candidates may be based on the weighted (50, 30, 20) average of the previous three references run in that same lab, where the most recent reference receives the highest weighting.

### **C. Lubricity (Y50) Reference Frequency**

A reference set shall be run at the following times:

1. Immediately after an engine overhaul;
2. After 20 candidate runs;
3. Before starting a candidate run, if the stand's last accepted reference date is twelve or more months prior to the candidate test start date.

A reference set shall consist of the low reference oil NMMA 93738 run against the high reference oil XPA 3259, with the XPA 3259 acting as the test reference. The NMMA 93738 torque drop shall exceed that of the XPA 3259, and the torque drop delta shall fall within a range of 0.31 - 1.31 in-lbs., inclusive.

### **D. Preignition Reference Frequency**

A reference shall be run at the following times:

1. Immediately after an engine overhaul;
2. After 10 candidate runs;
3. Before starting a candidate run, if the stand's last accepted reference date is twelve or more months prior to the candidate test start date.

A reference set shall consist of an operationally valid run of reference oil NMMA 93738 having no greater than three major preignitions.

### VIII. Operational Test Validity for Engine Testing

1. This procedure applies only to 15 HP and 40 HP tests.
2. The test must be conducted according to the written test procedure and modifications recommended by the Test Surveillance Panel and approved by the Oil Certification Committee.
3. Total duration of unscheduled shutdowns during the test shall not exceed 48 hours, with no individual shutdown exceeding 24 hours. There shall be no limit on the number of individual shutdowns during the test. A shutdown shall be defined as a period during which the engine is at 0 rpm.
4. The occurrence of outliers in critical test parameters during the test (based on hourly readings) and the magnitude of such occurrences shall be weighted for each critical test parameter in the calculation of the deviation percentage. The deviation percentage for an individual critical test parameter shall be defined as:

$$D.P. = \Sigma \left[ \frac{|\text{Amt. out of spec}|}{\text{Spec Range}} \times \frac{\text{Hrs. out of spec}}{\text{Test Length Hrs.}} \right] \times 100$$

5. An out-of-spec reading shall be considered to have been an outlier for the full interval since the previous in-spec reading.
6. For each primary critical test parameter, the deviation percentage shall not exceed 5.0% over the entire test. For each secondary critical test parameter, the deviation percentage shall not exceed 10.0% over the entire test. The following shall be the list of critical test parameters:

	<u>Primary</u>	<u>Secondary</u>
Idle rpm		X
W.O.T. rpm	X	
Water out temperature	X	
Water temperature delta	X	
Fuel flow	X	
W.O.T. ignition timing	X	
Fuel /oil ratio	X	

7. For rpm parameters, the test length used in the deviation percentage calculation shall be adjusted to reflect the relative time operating at either W.O.T. or idle.



8. For tests which terminate prematurely, the expected full test length shall be used in calculating the deviation percentage.
9. For determining test validity, the deviation percentage for each parameter shall be calculated and considered separately.
10. The test lab shall apply the shutdown and parameter deviation criteria for each test to determine operational test validity or invalidity.
11. Each test report shall state whether the test is operationally valid or invalid, with a reason provided for each invalid test.
12. For operational problems not covered by this procedure, the test lab(s) shall consult with the Oil Certification Committee.

## **IX. Test Hardware Control Guidelines**

1. The purpose of these guidelines is to maintain and improve the quality of test hardware, ensure a consistent quality of hardware, provide accountability and traceability of hardware, promote concurrent hardware turnover, and aid in tracking and quantifying severity and precision trends as related to hardware.
2. Purchases of TC-W3® test engine short block assemblies from OEM's and reference oils from suppliers shall be coordinated by the NMMA based on one-year projected demands from the test sites. Each test site shall be responsible for purchasing and storing its TC-W3® test engine short block assemblies and reference oils. Test sites shall be required to purchase the quantities of TC-W3® test engine short block assemblies and reference oils for which purchase orders have been submitted.
3. The following parts for TC-W3® test engine short block assemblies shall be designated as "critical" to the severity of the 15 HP and 40 HP tests:
  - Pistons
  - Rings
  - Piston rods
  - Crankshafts
  - Cylinder blocks
  - Heads
4. OEM's shall manufacture TC-W3® test engine short block assemblies in a single batch lot to meet the total test sites' demands. The OEM's shall use critical parts from single batch lots in manufacturing the TC-W3® test engine short block assemblies. The OEM's shall also prepare and package the TC-W3® test engine short block assemblies for longer-term storage by the test sites.
5. All TC-W3® test engine short block assemblies shall be serialized and batch coded. Batch codes and serial numbers shall be included in subsequent test reports from the test sites. All parts batches are to be used on a first in - first out basis.
6. All TC-W3® test engine short block assemblies shall be used as received, once they have been inspected and verified as meeting OEM, TC-W3® and test site requirements. Modifications shall be allowed only if specified in the test standard or method, or authorized by the OCC.
7. The test sites shall report to the NMMA staff when they believe they have a six month inventory remaining. The NMMA staff will survey the labs and if

appropriate, initiate the manufacture of a new batch of test parts. The test sites shall also report on parts rejections and reasons for the rejections to the OSS.

8. As a test site approaches the end of a particular batch of TC-W3® test engine short block assemblies, redistribution among test sites may take place if so agreed by those test sites.
9. Test sites shall have the opportunity to evaluate TC-W3® test engine short block assemblies prior to ordering new blocks if substantive design changes have been introduced by the OEM's. The OCC shall determine with input from the OEM's if design changes are substantive.

**X. 1995 Recertification Protocol**

1. An existing TC-W3® approval can be recertified as TC-W3® for 1995 if the formulation passes two consecutive or concurrent Mercury 15 HP tests under the "recertified" test procedure and meets the 1995 TC-W3® 15 HP passing limits. If formulation modifications are required, then basestock and additive readacross protocol procedures should be followed.
2. If a Mercury 15 HP test was registered with the NMMA's OTDA, then it shall be considered as having been run under conditions that are deemed equivalent to recertified conditions. If that test also meets the 1995 Mercury 15 HP passing limits, and the next test (which must run after June 10, 1994) also passes, then the two consecutive pass criteria shall have been met.

## **XI. TC-W3 Readacross Protocol**

1. The TC-W3® Readacross Protocol shall allow companies to obtain new TC-W3® approvals to be issued based on existing TC-W3® approvals with testing necessary to ensure TC-W3® performance.
2. New complete TC-W3® approval programs shall include the following passing TC-W3® test results:
  - Identification
  - Fluidity
  - Miscibility
  - Rust
  - Filterability
  - Compatibility
  - Preignition
  - Lubricity (Y50)
  - Mercury 15 HP
  - Johnson 40 HP
3. A TC-W3® approval must use only paraffinic base stocks from API Groups I or II (or mixtures of the two) in order to be used as the basis for readacross to a new TC-W3® approval. The definitions of base stock groups shall be defined in Appendix E of API Publication 1509 (API Base Oil Interchangeability Guidelines for Passenger Car Motor Oils and Diesel Engine Oils, 15<sup>th</sup> Edition, April 2002.) The introduction of Group III base stocks into a formulation will require readacross testing 1-5.
4. Paraffinic base stocks are defined as Group I and II base stocks having a viscosity gravity constant (VGC) less than or equal to 0.84 and a viscosity index (VI) greater than or equal to 80. Group I and II base stocks not meeting this definition shall be considered to be naphthenic base stocks.
5. A new complete TC-W3® approval program shall be necessary for a formulation involving any of the following:
  - Group IV or V base stocks (or mixtures of the two)
  - Naphthenic base stock

- New or chemically altered additive component
  - Use of different molecular weight PIB
  - Existing additives and/or other components, including base stock used at concentrations outside the range allowed by the Readacross Protocol.
6. The testing required for readacross shall be dictated by the most severe formulation change involved in the readacross, as shown in Table XII-1.
  7. Existing NMMA solvent substitution guidelines shall continue to apply to all TC-W3® approvals:

The NMMA Oil Certification Committee has determined that should a solvent substitution be utilized on a previously approved blend, the following conditions shall be met.

- A. The end and 90% points of the proposed substitute solvent's distillation curve may be no more than 5% greater than the end and 90% points of the certified solvent's distillation curve. The method measuring the distillation curve shall be by ASTM D2887, not D6352.
  - B. Must pass the Miscibility and Fluidity tests.
  - C. A new set of Identification tests must be conducted and submitted to NMMA.
8. The NMMA shall allow up to a 20% additive uptreat in a TC-W3® certified base formulation so long as:
    - The formulation is otherwise essentially unchanged;
    - Requirements of TC-W3® Fluidity, Miscibility, and Identification (including IR scan) are met; and
    - The new formulation receives a new approval number from the NMMA.

The 20% allowable uptreat in additive dosage is relative to the base additive dosage, and may apply for either the total additive package or its individual components; for individual additive components, the increase in each component shall not exceed 20% of the base dosage for that component.

9. Any change in the base stock slate shall require readacross testing 1-5.

## 10. Dyes and Fragrances

Dye: any pigment compound exclusively intended to alter the apparent color of the finished lubricant

Fragrance: any cologne or perfume compound exclusively intended to alter the apparent odor of the finished product

Dyes and Fragrances are used for cosmetic purposes only and are not intended or allowed to have any impact on the technical performance of the finished lubricant.

Once an additive system has successfully completed one full TC-W3® approval, then additional TC-W3® approvals can be obtained for formulation changes and/or different base stocks by following these guidelines:

*Table XII-1*

<u>Readacross Categories</u>	<u>Substitution Limits</u>	<u>Testing Required</u>
Additive DI	Increase in concentration of up to 20%* (Any one component or total package)	1, 2
Pour Depressant	Increase/decrease of the same type up to 1.0% of the finished oil**	1, 2
	Additions/substitutions of different type up to 0.5% of the finished oil	1, 2
Solvent	Increase in concentration up to 20%*	1, 2, 3,
	Decrease in concentration up to 20%*	1, 2
PIB	Increase in concentration up to 25%*	1, 2
	Decrease in concentration up to 25%*	1, 2, 3,
Brightstock	Increase in concentration up to 25%*	1, 2
	Decrease in concentration up to 25%*	1, 2, 3,
Paraffinic 70N to 160N	Increase of up to 25% of finished oil**	1, 2, 3, 4
	Decrease of up to 25% of finished oil**	1, 2, 3, 4
Paraffinic 161N to 350N	Increase of up to 25% of finished oil**	1, 2, 3, 4
	Decrease of up to 25% of finished oil**	1, 2, 3, 4
Paraffinic 351N to 800N	Increase of up to 25% of finished oil**	1, 2, 3, 4
	Decrease of up to 25% of finished oil**	1, 2, 3, 4
Brightstock	Increase up to 10% of finished oil**	1, 2, 3, 4
	Decrease up to 10% of finished oil**	1, 2, 3, 4
Base Stock	Any change in base stock slate	1, 2, 3, 4

Testing Code:

- 1 - Identification and IR
- 2 - Fluidity and Miscibility
- 3 - Lubricity (Y50)
- 4 - Mercury 15 HP

Notes:

- \* Relative change (e.g. component is at 10% in the finished oil; increase of 20% would allow increase to 12% in the finished oil).
- \*\* Absolute change (e.g. component is at 10% in the finished oil; increase of 20% would allow increase to 30% in the finished oil).



NMMA Reference Oils Status Report  
Status Report (2 yr Outlook)

NMMA Reference Oils Status Report															
Status Report (2 yr Outlook)															
4-Jul-22			No Problems												
			Possible Issue												
			Problems												
NMMA				Inventory (Gallon)		FC-W	FC-W	TC-W3	TC-W3	TC-W3	TC-W3	TC-W3	TC-W3	TC-W3	TC-W3
Name	Blended Oil Supplied By	Status	Notes	SwRI	IAR	115hp	Rust	15hp	40hp	CE50	AF27	Preig	Rust	Comp	Filt
4T-115B	Infineum			22.6	0	Benchmark									
49P52Z	Shell			11	1		Calibr.								
5973	Infineum		1	0	<1 pint		Ref.								
71591	Oronite			115	0			High Ref.							
93738	Oronite			28.17	0			LowRef.	High Ref.	Low Ref.		High Ref.	High Ref.	Ref.	Ref.
CITGO 93511	Lubrizol			0	0										Test Oil
DF413	Oronite			54.3	0			Low Ref.							
JATRE-3	JALOS			54.9	0					Low Ref.					
XPA3259	Lubrizol			14.4	0					High Ref.	High Ref.			Ref.	Ref.

Note1: Will need a new reference oil when current drum is depleted.

**TC-W3® PROGRAM SUMMARY**

<p><b><u>ANALYTICAL TEST RESULTS</u></b>                  CSt @ 40 °C                  Sulfated Ash (D874)                  Distillation (D6352)                  Infrared Spectrum (E168)                  Nitrogen, % weight (Kjeldahl ASTM D3228 or Carlo Erba ASTM D5291)                  TBN (D2896)                  Cloud Point °C (D2500)</p>		
<p><b><u>BENCH TESTS RESULTS</u></b>                  Compatibility, % Sediments</p>		<p><b><u>CANDIDATE PASS/FAIL CRITERIA</u></b>                  Homogeneous after mixed separately with each reference oil (*,**) and stored 48 hours</p>
<p>Brookfield (Fluidity) @ -25 °C, cP                  Candidate/Evaluations</p>		<p>Less than 7500 cP</p>
<p>Miscibility @-25 °C, cP inversions                  Candidate/Reference/Evaluation</p>		<p>No more than 10% more inversions than reference*</p>
<p>% Rust, Candidate/Reference/Eval.</p>		<p>Equal to or less than reference*</p>
<p>Filterability, % Change, Candidate/Eval.</p>		<p>Decrease in flow rate not greater than 20%</p>
<p><b><u>ENGINE TEST RESULT</u></b>                  OMC 40 Horsepower Test (98) hours                  Average Piston Varnish, Cand/Ref                  Top Ring Stick, Cand/Ref Evaluation</p>		<p>Equal to or better than reference minus 0.6*                  Equal to or better than reference minus 0.6*</p>
<p>Mercury 15 Horsepower Test (100) hours                  Circumferential Scuffing                  Compression Loss, Candidate Evaluation                  Average Second Ring Sticking                  Average Second Land Deposits                  Ring Wiping                  Needle Bearing Stickiness - Original                  Needle Bearing Stickiness - Proposed</p>	<p><u>1*</u>                      <u>2<sup>nd</sup></u></p>	<p>Two consecutive passes are required                  Equal to or less than 15%                  Less than 20 psig                  Equal to or better than 8.0                  Equal to or better than 6.0                  Less than 5%                  Must pass                  Must pass</p>
<p>Yamaha CE50S Tightening/Lubricity Test                  Torque Drop, Lb.-in.                  Candidate/Reference/Evaluation</p>		<p>Equal to or less than reference** within 90% confidence level</p>
<p>Yamaha CE50S Preignition Test (100 hours)                  Major Preignitions,                  Candidate/Reference/Eval.</p>		<p>Equal to or less than reference*</p>

\* = #93738

\*\* = XPA-3259